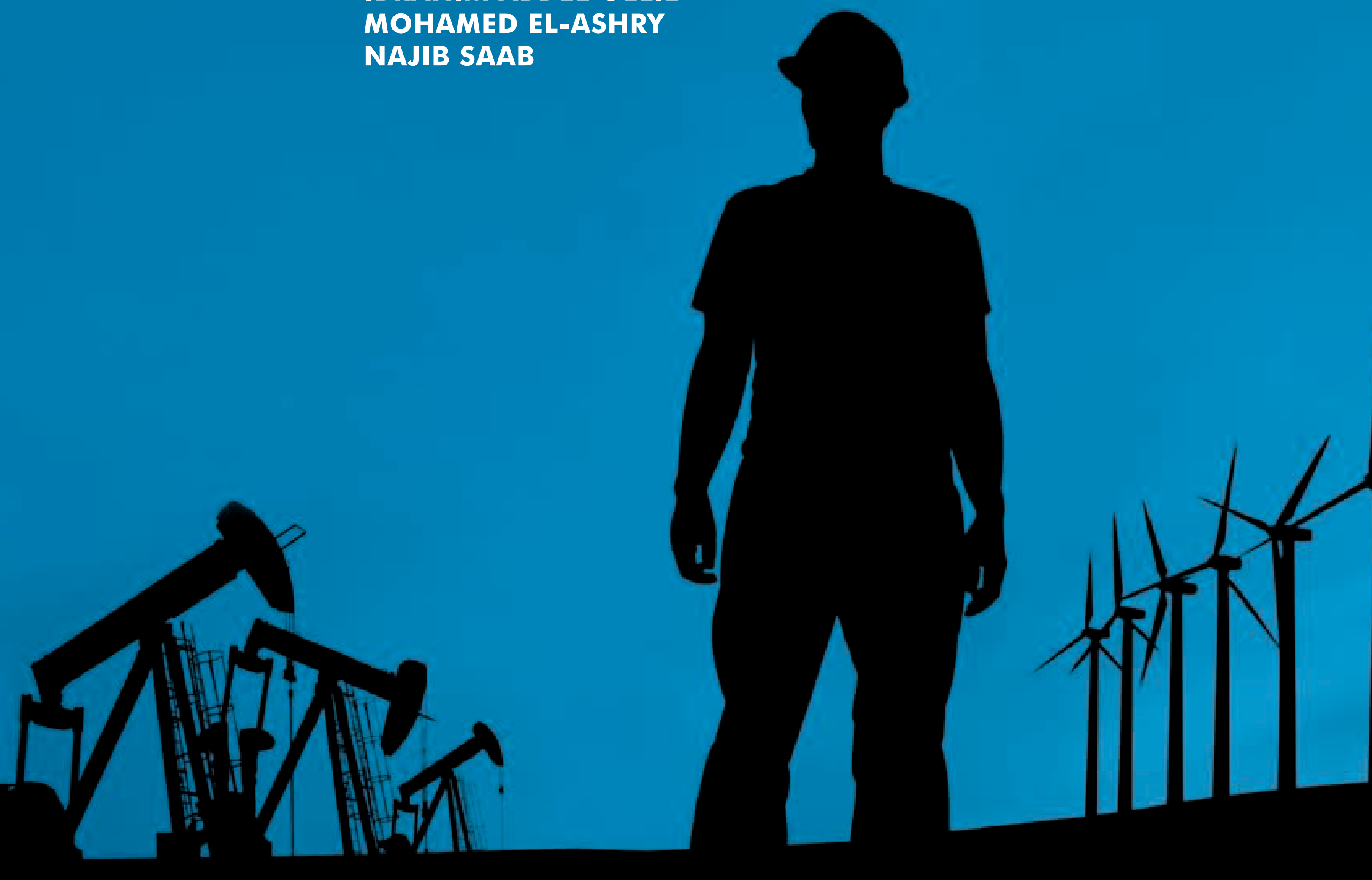
2013 Report of the Arab Forum for Environment and Development

ARAB ENVIRONMENT • 6
SUSTAINABLE ENERGY
PROSPECTS, CHALLENGES, OPPORTUNITIES

EDITED BY:
IBRAHIM ABDEL GELIL
MOHAMED EL-ASHRY
NAJIB SAAB



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ARAB FORUM FOR
ENVIRONMENT AND DEVELOPMENT
AFED

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AFED

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Contents

BOXES

OPINION

Preface

Sustainable Energy is the sixth in the series of annual reports produced by the Arab Forum for Environment and Development (AFED) on the state of Arab environment. The report highlights the need for more efficient management of the energy sector, in view of enhancing its contribution to sustainable development in the Arab region.

The primary aim of the AFED annual reports is to foster the use of science in environmental policy and decision-making in Arab countries. This is a manifestation of AFED's mission to advocate prudent environmental policies and actions based on science and awareness. Since 2008, AFED has produced five reports in the series: *Arab Environment: Future Challenges* (2008), *Impact of Climate Change on Arab Countries* (2009), *Water: Sustainable Management of a Scarce Resource* (2010),*Green Economy: Sustainable Transition in a Changing Arab World* (2011), and *Survival Options: Ecological Footprint (2012)*. AFED reports have gained a reputation as the most credible sources on environment issues in the Arab region, and have triggered policy transformations at the local, national and regional levels. AFED Annual Conference, during which the reports are presented and debated, is equally considered the major environmental gathering in the Arab region, attracting policy makers, business and industry leaders and academics.

The AFED 2013 report aims at: presenting a situational analysis of the current state of energy in the Arab region, shedding light on major challenges, discussing different policy options and, ultimately, recommending alternative courses of action to help facilitate the transition to a sustainable energy future.

To achieve its goals, the AFED 2013 report addresses the following issues: oil and beyond, natural gas as a transition fuel to cleaner energy, renewable energy prospects, the nuclear option, energy efficiency, the energy-water-food nexus, mitigation options of climate change, resilience of the energy sector to climate risk, and the role of the private sector in financing sustainable energy.

A group of leading authors has worked on the report. Drafts were discussed with international panels of experts during consultation meetings, held with the Arabian Gulf University (AGU) in Manama, the Environment Public Authority (EPA) in Kuwait and the Oxford Institute for Energy Studies (OIES) in Oxford, UK.

The AFED 2013 report found that although the Arab region's energy intensity and per capita carbon emissions are among the highest in the world, 35 million Arabs remain without access to modern energy services, mainly electricity. Unlike many parts of the world, however, the Arab region is well endowed with clean, renewable sources of energy, primarily sun and wind. Together with enhanced energy efficiency, these renewable sources can help diversify and power a more sustainable energy future.

Accounting for 36 percent of the region's total GDP, oil and gas continue to be the Arab world's most important natural resources, a status that is unlikely to change any time in the near future. However, more economic diversification is needed to reduce the region's heavy reliance on volatile oil revenues. Climate change concerns and expected reductions in emissions of global greenhouse gases would potentially lead to major shifts in global energy markets towards more efficient low carbon clean energy technologies and sources; Arab countries should be prepared to deal with the consequences.

At the domestic level, the surge in energy demand in response to the region's economic growth, population, and change in life style, does not need to lead to a surge in air pollution, including carbon emissions. Demand management and a radical shift to more efficient use of energy, producing more units of output for less units of energy input, are overdue. A recent study indicates that the Arab region can achieve reduction in energy consumption of 56 percent through the right investment in energy efficiency. It is well past time for the region to embrace the shift to cleaner and renewable energy, which would bring low-carbon economic opportunities, energy security, and a cleaner environment.

As the energy sector plays a major role in meeting water and food needs in Arab countries, from desalination to pumping groundwater, the AFED report places major importance on the energy-water-food nexus. Per capita consumption of fresh water in some arid Arab countries is among the highest in the world, and irrigation efficiency is one of the lowest, at an average of 40 percent. Shifting to efficient practices and renewable sources of energy provides viable options for securing sustainable supply of water and food production for decades to come.

The AFED 2013 report concludes that Arab countries can foster the sustainability of their energy sector by making crucial strategic choices, combining high economic potential with secure and balanced resource management. These choices include improving energy efficiency, exploiting the huge potential of untapped renewable energy resources, and harnessing oil and gas reserves in cleaner and more competent ways. Revenues from oil exports need to be utilized to build regional capacity in developing and acquiring clean and renewable energy technologies, including aggressively exploring carbon capture and storage (CCS).

AFED wishes to thank all those who made this report possible, especially our partners at the OPEC Fund for International Development (OFID), the Islamic Bank for Development (IDB), the Kuwait Foundation for the Advancement of Sciences (KFAS), Environment Agency-Abu Dhabi (EAD), and all corporate and media partners who supported this endeavor. Special thanks are due to the authors and experts who contributed to the contents and appraised the drafts.

It is hoped that AFED through this report can help Arab countries adopt long-term commitments and right policies and investments which would allow them to join the global clean energy club, exporting renewable energy in addition to oil and gas.

October 2013

Najib Saab
Secretary General
Arab Forum for Environment and Development (AFED)

EXECUTIVE SUMMARY

SUSTAINABLE ENERGY IN A CHANGING ARAB WORLD

2013 Report of the Arab Forum for Environment and Development (AFED)

Like in many parts of the world, energy systems in the Arab region, which are dominated by fossil fuels, are not sustainable in economic, environmental or social terms. Although energy intensity and per capita carbon emissions are among the highest in the world, 35 million Arab people are without access to modern energy services, mainly electricity. Unlike many parts of the world, however, the Arab region is well endowed with clean, renewable sources of energy, primarily sun and wind. Together with enhanced energy efficiency and cleaner technologies, those renewable sources can help diversify and power a more sustainable energy future. The 2013 annual report of the Arab Forum for Environment and Development (AFED) on Sustainable Energy in the Arab countries concludes that, with a long-term commitment and the right policies and investments, Arab countries could join the global clean energy club, creating high paying jobs and exporting renewable energy in addition to oil and gas.

The energy sector in the Arab countries plays a critical role in the region's socioeconomic development. Oil and gas revenues have been the major source of income in most of the Arab countries, especially in the Gulf region. According to the Arab Monetary Fund, the oil and gas sector makes up about 36 percent of the total Arab GDP. The share of hydrocarbon revenues in most Arab producers' export earnings ranges from 33 percent in the relatively diversified economy of the UAE to 88 percent in highly export-oriented economies such as Saudi Arabia and Qatar, and more than 97 percent in Algeria and Iraq. Over the past three decades the GCC countries, which are the major Arab oil exporters, have witnessed an unprecedented economic and social transformation. Oil proceeds have been used to modernize infrastructure, create employment, and improve human development indicators.

On the other hand, oil revenues have not been able to spur the kind of economic diversification many Arab producers aspired and continue to aspire to, leaving most of them exceptionally reliant on what have proven to be highly volatile oil revenues. The political turmoil that has toppled several Arab regimes has, furthermore, revealed the vulnerability of regional oil supply to political disruption at times of intra-regional crisis. Yet, oil continues to be the Arab world's most important natural resource, a status that is unlikely to change any time in the near future. Despite the recent discovery of significant oil reserves outside the Arab world (for instance shale oil in the USA, oil sands in Canada, coal-bed gas in Australia, and deep offshore in Brazil), the Arab world is expected to continue to play a key role in global oil markets, dominating international trade in crude oil and holding the bulk of the world's reserve capacity.

Additionally, climate change concerns and expected reductions in emissions of global greenhouse gases would potentially lead to major policy shifts in global energy markets towards more efficient low carbon clean energy sources. While the ongoing UN climate negotiations have not yet reached agreement on a long-term climate regime post-2020, a shift in the national climate policies of some major energy consumers such as the US, the EU, and China toward low carbon development is already taking place, leading to remarkable developments in the global oil market. The OPEC World Oil Outlook (2011) projected that demand for liquid fuels will increase more rapidly in the transportation sector than in any other end-use sector, with most of the growth projected among developing countries, led by China and India. Market penetration of advanced transport technologies and alternative fuels, however, would reduce world oil demand by about 7 million barrels per day by 2035 compared to business as usual.

Arab economies rely heavily on oil and gas to meet more than 97 percent of domestic energy demand, with renewable energy contributing the remaining 3percent. However, the renewable energy market in Arab countries is rapidly expanding, with a diverse range of countries announcing projects and policies to harness the region's abundance of renewable energy resources for economic growth and energy security enhancement. The Arab world's continued reliance on hydrocarbons to meet its own domestic energy needs also raises challenges of a different kind: surging domestic demand for energy implies an increasing drain on the region's oil production, diverting growing shares to domestic markets away from export. Some analysts estimate that Arab oil producers may lose as much as US$90 per barrel of oil used domestically instead of exported.

The growth in energy demand is a corollary to the region's economic growth, industrialization, and change in life style. This surge in demand, however, does not need to lead to a surge in air pollution, including carbon emissions. Demand management and a radical shift to more efficient use of energy, producing more units of output for less units of energy input, are overdue. It is well past time for the region to embrace in a big way the shift to renewable energy-a shift that would bring low-carbon economic opportunities, energy security, and a cleaner environment.

The opportunity cost of a continuation of business-as-usual, in a largely undiversified economy, is increasingly unsustainable, raising the question: what role should oil play in the Arab economies over the long-term? This means that many Arab oil producing countries need to invest considerably more capital and effort into developing incentives for private sector activities which are not limited to oil and energy-intensive industries. Current oil revenues should also play a more active role in enhancing regional capacity in research and development of renewable energy technologies, a trend that has just started in some major oil exporting countries such as the United Arab Emirates and Saudi Arabia.

It is also worth noting that the energy sector plays a major role in meeting water and food needs in Arab countries. Fossil fuel-based combined heat and power plants are commonly used for seawater desalination in the region, which hosts nearly 50 percent of the world's desalination capacity. Heavily subsidized electricity from fossil- fuel power plants is also used as the primary energy source to pump and distribute groundwater. In spite of that, per capita consumption of fresh water in some arid Arab countries is among the highest in the world, and irrigation efficiency is one of the lowest, at an average of 40 percent. Thus, food production in the region continues to rely on expensive, non-renewable energy resources, used in an inefficient manner. Shifting to efficient practices and renewable sources of energy provides viable options for securing a sustainable supply of water resources and food production for decades to come.

Considering Arab countries' relatively large endowment of natural gas resources, the potential of this fuel to help the region both meet its energy needs and manage its global carbon footprint remains under-realized. This is due to a number of factors. Gas pricing policies in the overwhelming majority of Arab countries have kept end-users prices at artificially-low levels, not only contributing to rapid gas demand growth in the region but have also precluded the development of new sources of gas supply. In addition, owing in large part to Arab gas (and energy) pricing policies, attracting the necessary investment to deliver the energy mix that the region requires has been a challenge. With the increasing attractiveness for international oil companies of mature and emerging gas fields in other parts of the world, the need to reform the investment conditions in Arab countries has never been greater.

The Arab region is among the least economically integrated in the world, which impedes the development of viable regional natural gas market. The lack of regional gas trade, with only 11 percent of Arab pipeline gas shipments being exported within the region, means that gas surplus from the Arab region has invariably been traded in far-away markets, depriving gas-short Arab countries from accessing competitively-priced supply from neighbouring countries.

Current trends in energy usage place the Arab economies among the least efficient in the world. There has been no decoupling between economic growth and energy demand in the Arab region in the past decade. Growth in energy consumption has been faster than economic growth; while average annual GDP growth was around 4percent, the annual increase in primary energy and electricity demand has been about 8percent. Fossil fuel subsidies are a major contributing factor to this inefficient use of energy. Arab residential markets, for example, are the most heavily subsidized, with some countries offering an implied subsidy of up to 95 percent for residential energy consumption. Another factor is the prevalence of inefficient electricity infrastructure in most countries of the region. Average Arab electric energy losses in generation, transmission, and distribution, at 19.4 percent are more than twice the world average, at 8.3 percent.

Recognizing the substantial potential gains from energy efficiency, the League of Arab States in 2010 adopted the Arab Energy Efficiency Guidelines, in order to promote cost effective improvements of end use electricity in its member states, through guiding targets, mechanisms, incentives, and institutional frameworks. However, despite many declarations and promises by Arab leaders for more sustainable energy development, today only few countries in the region have published energy efficiency strategies with quantified targets and supporting policy measures. There are many social, economic, and political barriers to energy efficiency in the region that need to be overcome. Energy efficiency can be promoted by influencing consumer behaviour via incentives in order to overcome market barriers. Successful energy efficiency labeling offers a combination of information, awareness, and incentives to encourage consumers to adopt energy-efficiency technologies and producers to invest in technology innovation and meet energy performance standards.

Arab countries have a great potential for renewable energy, including solar and wind, as well as hydro and geothermal in certain locations, which are grossly underutilized. However, the renewable energy market in the Arab region has evolved rapidly in recent years with countries announcing projects and policies. The recent expansion of the region's renewable energy market, as well as the diversity of participating countries, is driven by the need to enhance energy security, address major energy demand growth, and deal with water scarcity. As of early 2013, 64 projects totaling almost 6 gigawatts of new renewable capacity were in the pipeline, a four-fold increase over existing capacity. New investment in renewables totaledUS$1.9 billion in 2012, a six-fold increase compared to 2004. In comparison, US$244 billion was invested in renewable energy globally, the second-highest year ever for renewable energy investments, which cumulatively have totalled US$1.3 trillion since 2006.

Beyond hydropower, which is the leading source of renewable energy for electricity generation in the region, wind energy is the most common source. As of the end of 2012, at least seven Arab countries, with Egypt in the lead, had wind power capacity. Concentrating Solar Power (CSP) will also contribute to the growing share of solar energy in the region. More than 30 percent of the countries operating CSP plants in the world are in Arab countries, namely: Algeria, Egypt, UAE, and Morocco. In March 2013, the United Arab Emirates became a major player in the CSP market when Shams 1, the world's biggest CSP plant with an installed capacity of 100 megawatts (MW), started operation. Likewise, Saudi Arabia has set an ambitious target aiming at meeting 33 percent of its domestic energy needs through renewable sources by 2032.

The right policies help drive the successful integration of larger shares of renewables in the energy mix, which simultaneously benefit the economy and the environment. Twenty Arab countries have policy targets and 16 have enacted some level of renewable energy enabling policies such as feed-in tariffs, fiscal incentives, and public financing. However, as the MENA Renewables Status Report stated: "It remains to be seen the extent to which government ambitions, currently supported largely through public financing, will lead to transparent, long-term, market-driven policies and incentive mechanisms that encourage private sector involvement in deploying renewable generation capacity."

Policy, investment, and business experts alike have noted that the clean energy economy is emerging as one of the great global economic and environmental opportunities of the 21st century. Leaders at the local, state, and national levels around the world are realizing that by harnessing safe, reliable, and clean energy they can create jobs and businesses, enhance energy security, improve air quality and public health, and mitigate climate change. With a long-term commitment and the right policies and investments, Arab countries could join the global clean energy club, creating high paying jobs and exporting renewable energy in addition to oil and gas.

To meet the growing demand for electricity, a number of Arab countries have announced plans to add nuclear power to their energy mix. Oil producing countries consider that adding nuclear power to the energy mix enhances energy security while hydrocarbon reserves are being depleted, in addition to releasing more oil for export, benefiting from the prevailing favourable market prices. Other countries consider nuclear power a solution to overcome their poverty in hydrocarbon resources.

The ability of Arab countries to manage the entire lifecycle of nuclear power is questionable. Critical safety issues remain to be resolved. Apart from the risk of accidents in nuclear power plants, nuclear waste storage and disposal are still unresolved, and would pose serious public health risk. As stated in the 2011 AFED Report, "international concerns about nuclear weapon proliferation associated with nuclear fuel cycle and uranium enrichment have resulted in global restrictions on these technologies, which would force Arab countries to rely on the international supply market for nuclear fuel even if local uranium reserves were available. Furthermore, local technical capabilities to build, operate and maintain nuclear power plants in Arab countries are extremely weak, which raises major energy security, safety, and dependency concerns over the heavy reliance on foreign expatriate labor. Thus, nuclear energy might not be the most viable policy option for long-term energy supply or security in the Arab region." Experience from other parts of the world is instructive. According to the World Nuclear Industry Status Report 2013, "three of the world's largest four economies (China, Germany and Japan), together representing a quarter of global GDP, are now running their economies with a higher share of renewables than nuclear". The same report also noted, "for the first time in 2012, China and India generated more electricity from wind than from nuclear plants."

Carbon dioxide (CO2)emissions related to fuel combustion in the Arab region increased by 247 percent from 1990 to 2010, significantly outpacing population growth over the same period. Over 95 percent of these emissions were related to the use of oil and gas. Although the total contribution of the Arab region to global climate change is only about 5percent,it cannot afford inaction on the global, regional, or national scales, because of its very high vulnerability to projected impacts (as documented in AFED's 2009 report). There is no longer any credible scientific disagreement about the basic facts. Our world continues to warm. According to World Meteorological Organization (WMO), the last decade, 2001-2010, has been the hottest in modern records with 94 countries experiencing the warmest temperatures in the decade. Sea level is rising and Arctic Sea ice is melting years faster than predicted.

A recent report by the World Bank concluded that the effects of climate change are already being observed in many parts of the Middle East and North Africa. Further, the region is projected to be much drier and hotter, and vulnerable to rising sea levels. The report cited the 2006 flooding of the Nile River Basin, as well as the record five-year drought in the Jordan River Basin that ended in 2008. Of the 19 record temperatures in 2010, almost a quarter were in the Arab world, including Kuwait where peak temperatures reached 52.6 degrees Celsius in 2010 and 53.5 in 2011. In 2010, the Arabian Sea experienced its second-strongest cyclone on record, with winds as strong as 230 kilometers per hour that killed 44 people and caused US$700 million in damages in Oman.

The region is already the world's most water-scarce, and with climate change, droughts are expected to turn more extreme, and water scarcity is expected to exacerbate. Also, most forms of energy generation, including nuclear, are vulnerable in some way or another to the effects of climate change. If nuclear power is to be used to mitigate the effects of climate change, it must also be capable of adapting to it, including increasing temperatures, sea level rise, extreme weather events, and water scarcity.

It is in the best interest of Arab countries that strong action is taken at the global level on both mitigation and adaptation. In turn, Arab governments should do their part by developing effective strategies for mitigating and adapting to climate change. In the energy sector, measures to mitigate greenhouse gases (GHGs) emissions cover the supply and demand sides. Measures in the supply side include energy efficiency in power generation and oil refining, use of combined heat and power to produce electricity and water, fuel switching away from carbon fuels, electricity imports though regional electricity networks, reduction of losses in transmission and distribution, and power generation using renewable energy resources such as wind and solar. The synergy between power generation and water desalination is a major theme for efficient use of energy in the Arab region.

Another challenge facing governments in most of the Arab countries is the mobilization of sufficient funds to finance projected growth rates in energy demand. At 202 GW, the installed generation capacity of the 22 members of the League of Arab States constitutes only 4% of international installed generation capacity, according World Bank and Global Energy Observatory 2013 figures. Annual electricity consumption per capita in Arab countries averaged 2,396 kilowatt- hour (kWh) in 2010, reaching as high as 18,319 kWh in Kuwait and as low as 248 kWh in Yemen. Demand growth rates in the past decade ranged between 5 and 10percent per annum and are anticipated to continue to hold at levels between 4 and 8percent in the coming decade. Meeting the demand for electrical power of a growing consumer base — both in terms of size and consumption per capita — requires the steady installation of approximately 24 GW of capacity per annum for the next 10 years. This translates into the mobilization of new investments in excess of US$31 billion per year representing 1.5 percent of the GDP of Arab countries. This funding requirement comes in addition to capital investments in transmission and distribution (T&D) network infrastructure as well as operations and maintenance (O&M) expenditure and fuel subsidies. Under a scenario of continuing economic growth and socio-economic development, the funds required to grow and sustain the power supply infrastructure will exceed the public sector's ability to effectively outlay funds and manage capital projects. It is necessary to attract funding from other sources through innovative approaches that can leverage limited public funds to attract significant private investments.

In recent years, independent power production (IPP) has emerged as the most prominent public-private partnership (PPP) scheme in the region; In 2010 Arab countries had about 40 GW of operating IPP capacity, representing more than US$50 billion of private investments and financing. The experience of the past decade in Saudi Arabia, Abu Dhabi, Qatar, Oman, and Morocco present a solid track record for private sector participation in developing generation capacity. Recently, local IPP developers and commercial banks in these countries have built sufficient capabilities to take a leading role in financing and delivering large scale generation projects across the entire Arab region and beyond.

RECOMMENDATIONS

Arab countries can foster the sustainability of their energy sectors by making crucial strategic choices, which entail high economic potential while at the same time securing balanced resource management. These choices include improving energy efficiency, exploiting the huge potential of untapped renewable energy resources, and harnessing oil and gas reserves in cleaner and more competent ways. Revenues from oil exports need to be utilized to build regional capacity in developing and acquiring clean energy technologies, including aggressively exploring carbon capture and storage (CCS).

The AFED 2013 report puts forward a set of recommendations to help the transition to a sustainable Arab energy sector, mainly urging policy makers to take concerted action across several dimensions:

- Policymakers should mobilize sufficient investment in production capacity to maintain the region's role as a global production leader over the coming decades and provide for the effective use of oil and gas revenues to diversify the region's economics away from continued reliance on fossil fuels and the management of domestic energy demand and supply.

- Policymakers need to reform gas and related energy product pricing mechanisms in such a way as to drive a shift to a sustainable energy system where natural gas can play a greater role in the Arab energy transition and future economic development.

- Policymakers in the Arab region should establish the appropriate enablers for private sector participation in energy supply infrastructure investments, including well-defined policies and a sound regulatory framework. They should build on the already established IPP model with modifications to address a few key limitations. By establishing prudent long-term government liabilities management, building capable regulatory institutions, and deploying methodical project tendering processes, Arab governments can leverage limited public funds to attract significant private sector investments.

- Policymakers need to facilitate the mobilization of local equity and debt financing through supporting the establishment of third-party investment funds, developing more flexible legal instruments (e.g. partnership flips and sale leasebacks), and granting infrastructure developers better access to corporate bond/Islamic Sukuk markets.

- Policymakers/regulators should enable comparability across projects and countries through increased transparency regarding factors influencing investment decisions, including projected investment plans, fuel supply allocations, and remuneration mechanisms.

- Policymakers should phase out energy subsidies and reform energy pricing policies in order to incentivize the rapid deployment of energy efficiency and renewable energy technologies. Leveling the playing field for renewables and reducing reliance on public and "soft" financing would also foster greater private investment.

- Policymakers should effectively implement the Arab Energy Efficiency Guidelines, adopted in 2010, by establishing national energy efficiency strategies with qualified targets, timetables, and supporting policy measures. Governments should also provide public awareness and incentives for adoption of energy efficient technologies and practices.

- Policymakers, in addressing climate change mitigation and adaptation in the energy sector, should:

  - Systematically assess and monitor energy systems to ensure that they are robust enough to adapt to anticipated climate-related impacts.
  - Mainstream climate impact assessment into environmental impact assessment (EIA) and strategic environmental assessment (SEA) for new energy systems' expansion plans.
  - Address energy poverty as an integral part of adaptation strategies.
  - Promote shifting toward decentralized, renewable energy supply system in remote and rural areas.
  - Implement energy efficiency and demand management as an adaptation measure.
  - Develop a new holistic approach to deal with the energy-water-climate nexus in the Arab region.

- Policymakers should embrace cutting-edge sustainable energy technologies as a means of economic and developmental leapfrogging, for business innovation, and for manufacturing of hardware and software, geared towards widespread deployment.

CHAPTER 1

Arab Oil in the Global and Domestic Context

Bassam Fattouh
Laura El-katiri

Like no other region, the Arab world's development trajectory has been shaped by its oil wealth. The region's massive oil reserves have turned Arab producers into the world's most important source of oil supply, integrating the Arab world into the global economy. The region has a dominant position in international trade of crude oil and acts as the oil market's most important swing producer. Oil revenues have also been a key source of wealth for the Arab region as a whole, and have driven the region's socio-economic, as well as its growth, agendas like no other natural resource. Oil still plays a critical role as a domestic fuel, covering around half of the region's own energy needs.

This oil-led development model, however, has come with its own economic caveats: aside from energy-intensive industries, oil seems to have fallen short of generating the kind of economic growth and diversification, including employment-generating private sector development in non-oil activities. The Arab world's continued reliance on oil for around half of its own domestic energy needs also raises challenges of a different kind: surging domestic demand for energy implies an increasing drain on the region's oil production, diverting growing shares to domestic markets away from export. The opportunity cost of a continuation of business-as-usual are increasingly unsustainable, raising the question for what role oil should play in the Arab economies over the long-term. This means many Arab oil producers need to invest considerably more capital and efforts into developing incentives for private sector activity beyond oil and energy-intensive industries.

This chapter concludes that oil will continue to be the Arab world's most important natural resource. The continuingly large share of Arab oil in the world crude oil market, its relatively-cheap to extract massive reserves, and its position as the world's largest spare capacity holder imply that this status is unlikely to change any time in the near future, and in spite of the game-changing technological breakthroughs in unconventional oil technologies in North America. However this prominent position also brings challenges which include timely and sufficient investment in production capacity to maintain the region's role as a production leader over the coming decades; the more effective use of oil revenues to diversify the region's economies away from their continued reliance on the oil sector in Arab oil producers; and the management of domestic energy demand and supply, including through a more diversified regional energy mix.

I. INTRODUCTION

Like no other region, the Arab world's development trajectory has been shaped by its oil wealth. Since oil was first discovered on the Arabian Peninsula during the 1930s, the region's significant reserves have turned Arab producers into the world's most important source of oil supply, integrating the Arab world fundamentally into the global economy. In many instances the region (particularly Saudi Arabia) has also played the role of a supply shock absorber, mitigating the impact of output disruptions originating from within and outside the region. Despite considerable intra-regional differences, oil revenues have also been a key source of wealth for the Arab region as a whole, and have driven the region's socio-economic, as well as its growth, agendas like no other natural resource.

Oil also plays a critical role in the Arab world's domestic energy mix; in the absence of any substantial share of renewables or other alternative sources of energy, oil continues to provide around half of the region's domestic energy needs. The Arab world's rapidly rising demand for oil and oil products over recent decades has emerged as one of the most fundamental challenges facing the region and its energy sectors – through the potential erosion of export capacity in producing countries and the rising fiscal burden incurred by importing Arab economies. The dominant role played by oil in Arab energy consumption is also questionable from an environmental point of view, considering the vulnerability of the region to the negative impacts of excessive pollution and climate change (IPCC/UNEP, 1997; Sowers and Weinthal, 2010).

In addition to rising energy consumption, the Arab world's oil sectors face many other challenges. Investing in existing and newly producing fields to ensure a smooth supply of oil remains a persistent challenge, not least in response to continuing demand uncertainty in main consumer markets – in many cases furthered by the pursuit of energy efficiency measures and policies to reduce the share of oil in the energy mix. Oil revenues have also been unable to spur the kind of economic diversification many Arab producers had aspired to, leaving most Arab oil producers exceptionally reliant on what has proven to be highly volatile oil revenues. The political turmoil that has toppled several Arab regimes has, furthermore, revealed the vulnerability of regional oil supply to political disruption at times of intra-regional crisis. And so, the Arab world demonstrates that regional oil wealth does not come without its own challenges, and it is these challenges and their successful management which will determine the pace and the development path of the region.

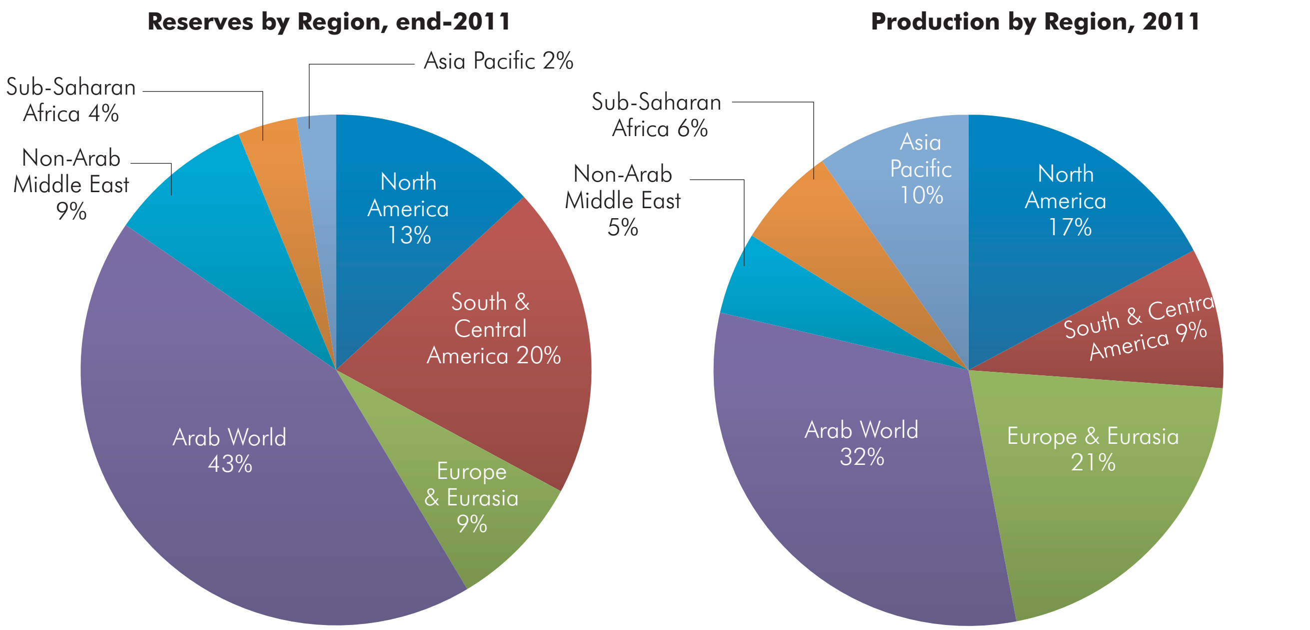
In this chapter we discuss some of the most important themes in the Arab world's use of oil, focusing on the role of Arab oil both in international markets and as a domestic fuel within the Arab world; its role in the region's economic development; and the key challenges the region is likely to encounter in the future management of its oil wealth.

II. THE ROLE OF ARAB OIL IN INTERNATIONAL AND DOMESTIC MARKETS

A. Reserves and Production

The importance of Arab oil cannot be over-emphasized. In 2011, Arab countries held some 713.6 billion barrels, around 43 percent of the world's proven oil reserves (see Figure 1 and Table 1).[1] Of the 22 Arab League members, 16 are producers of oil.[2] The Arab world's combined production in 2011 amounted to over 26 million barrels per day (mb/d), or nearly a third of world oil supply, making the Arab world the world's largest producing region (EIA, 2012). Four of the

FIGURE 1 **WORLD OIL RESERVES AND PRODUCTION BY REGION AT END-2011**



Source: Authors' calculations based on BP (2012)

world's ten largest producers of oil (Saudi Arabia, the UAE, Kuwait, and Iraq) are Arab producers. (Production figures for 2011: BP, 2012). Together with Algeria, Libya, and Qatar, these producers form seven of the 12 member states of the Organization of Petroleum Exporting Countries (OPEC), of which three Arab states (Saudi Arabia, Iraq, and Kuwait) were also founding members.

However, oil endowments differ considerably within the region: the six GCC[3] member states, along with Algeria, Iraq, and Libya, account for nearly 98 percent of the Arab world's total oil reserves, and 93 percent of its total production. Saudi Arabia alone holds more than 265 billion barrels of proved oil reserves, or 16 percent of global total reserves (EIA, 2012).[4] By contrast, oil producers such as Egypt, Syria, Yemen, Sudan and Tunisia hold comparably small reserves, thus generating a considerably lower share of their revenues from oil; Arab economies with low or no proven reserve base – such as Jordan, Morocco, and Lebanon – have been net importers of crude oil and oil products for the bulk of their energy needs.

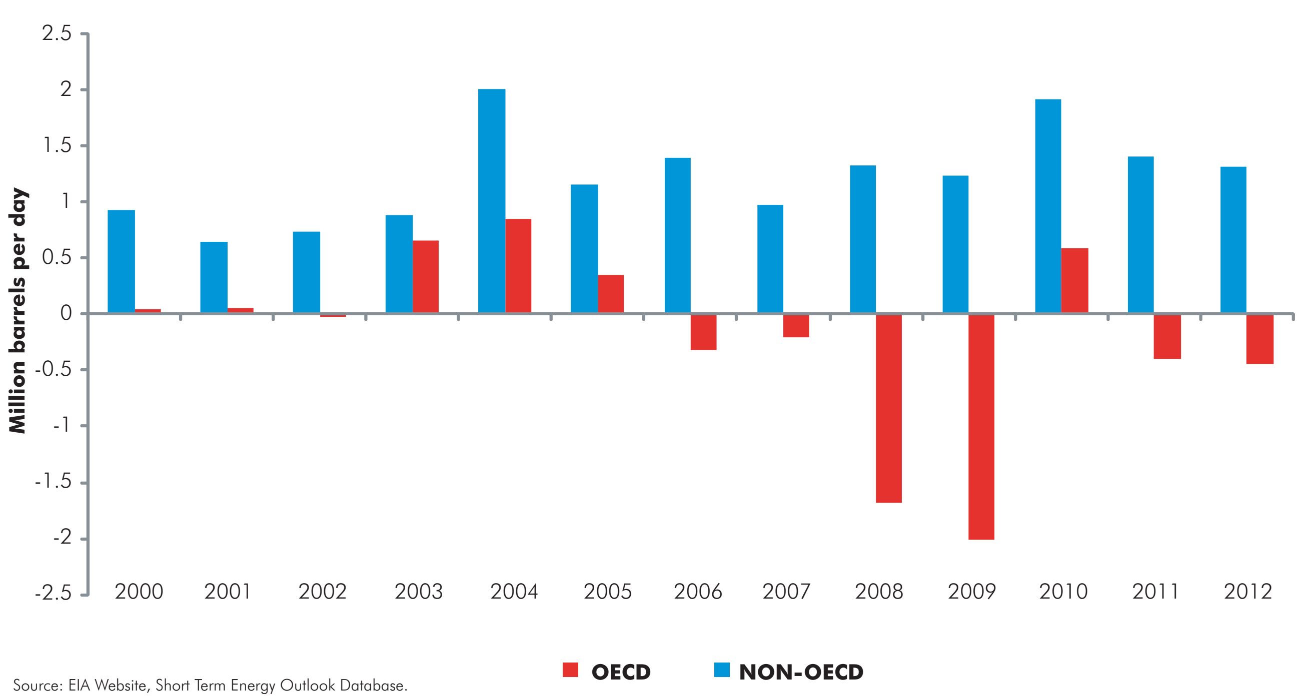
Given the region's key position in the global oil market, the security of Arab oil supplies has been central to oil importers' energy policies. In addition to their high dependency on such a strategic resource, an underlying security concern for importers is that the regular flow of oil may be subject to physical disruptions, limiting the availability of oil supplies and causing sharp rises in prices. Since the big price shocks of the 1970s, it has been widely argued that sharp rises in oil prices have had significant macroeconomic effects on the global economy – see for instance, Hamilton (2009). In addition, the transport and aviation sectors – the lifelines of a modern economy – are still almost totally reliant on refined products. Thus, some analysts consider the most important facet of energy security is that of limiting vulnerability to disruption. Output disruptions in a number of Arab countries such as Libya, Yemen, Syria, and Sudan over the last two years have reinforced these fears, though the impact of such disruptions on oil market dynamics has so far been limited (Darbouche and Fattouh, 2011).

B. Dominance of International Trade and Shift in Trade Dynamics

The significance of the Arab world extends beyond the size of its reserves and its share in world production. Unlike many other producers in the world, Arab producers export the bulk of their oil production, which gives the region a dominant position in international trade of crude oil (see the export–consumption ratios in Table 1). In 2011, the region's exports constituted around 40 percent of the world's crude oil exports, rendering the region the most important source of oil trade movements (authors' calculations based on EIA, 2012). Crude oil exports from the Middle East are projected to reach almost 20 mb/d by 2035 (OPEC, 2012)[(5)] with most of these exports destined to fuel the fast-growing Asian economies. Indeed, one of the most important shifts in oil market dynamics in recent years has been the rapid growth of oil consumption in non-OECD economies. Between 2000 and 2012, oil demand growth in non-OECD countries outpaced that of the OECD in every year (see Figure 2). During this period, non-OECD total liquid fuel consumption increased by around 16 mb/d while OECD consumption dropped by 1.5 mb/d (EIA Website, Short-Term Energy Outlook Database). At the heart of this growth lies China and India, which accounted for more than 45 percent of the incremental change in demand during this period.

This current shift towards non-OECD countries is likely to accelerate as the incomes of households in emerging economies improve, and car ownership rates increase from a low base. The emergence of the non-OECD economies as the main engine of growth in global oil demand has had far-reaching implications on the dynamics of trade flows. This is perhaps best illustrated by the shift in direction of oil flows from Saudi Arabia to the rest of the world. In 2000 the share (from its total exports) of Saudi crude exports to North America, Western Europe, and Asia and the Far East stood at 25 percent, 21 percent, and 45 percent respectively. By 2010, the North American and Western Europe shares fell to 18 percent and 10 percent respectively, while that of Asia and the Far East increased to 64 percent (SAMA, 2011). The drastic shift in the direction of trade flows is likely to have wide geopolitical and economic implications, affecting many

FIGURE 2 SHIFT IN LIQUID FUEL DEMAND DYNAMICS IN OECD AND NON-OECD (YEAR-ON-YEAR, MILLION B/D)



Source: EIA Website, Short Term Energy Outlook Database.

aspects of the oil market, such as the emergence of new trade routes and refining centers (Fattouh and El Katiri, 2012b).

C. Low-Cost Reserves and Spare Capacity

In addition to their position of dominance in international crude oil trade, many of the Arab world's oil reserves, particularly those of the GCC economies, are among the cheapest in the world to find, develop, and produce (with the exception of those in Oman). The IEA estimates that total production costs in Saudi Arabia, Kuwait, and the UAE vary between US$ 3 and US$ 5 per barrel of oil produced, providing the region with a significant competitive advantage over most other producing world regions (IEA, 2005).[6] Furthermore, all the oil market's critical spare capacity is concentrated in three Gulf Cooperation Council (GCC) member states – Saudi Arabia, Kuwait, and the UAE – with Saudi Arabia holding the bulk of the world's available spare capacity. This has allowed Saudi Arabia to act as the oil market's most important swing producer, filling the gap at times of oil supply disruptions or curbing production at times of perceived over-supply, in an attempt to balance the market (Fattouh and Mahadeva, 2013).

TABLE 1 **PROVED OIL RESERVES AND PRODUCTION IN THE ARAB ECONOMIES AT END-2011**

	Proved reserves (bbl)	Share of world reserves (%)	R/P ratio	Production ('000 b/d)	Share in World Production (%)	Ratio Exports: Consumption**
The GCC States	**495.0**	**29.9**	**69.5**	**19,505**	**23.3**	**5.8**
Bahrain	0.1	< 0.05	7.0	47	0.1	5.0
Kuwait	101.5	6.1	97.0	2,682	3.2	7.7
Oman	5.5	0.3	16.9	889	1.1	6.7
Qatar	24.7	1.5	39.3	1,638	2.0	6.0
Saudi Arabia	265.4	16.1	65.2	11,153	13.3	3.8
UAE	97.8	5.9	80.7	3,096	3.7	5.3
Other Major Oil Producers	**202.4**	**12.2**	**110.5**	**5,020**	**6.0**	**4.2**
Algeria	12.2	0.7	19.3	1,884	2.3	4.2
Iraq	143.1	8.7	> 100	2,635	3.2	3.0
Libya	47.1	2.9	> 100	502	0.6	5.5
Other Oil Producers	**16.6**	**< 0.05**	**26.2**	**1,737**	**2.1**	**1.1**
Egypt	4.3	0.3	16.0	706	0.8	0.3
Mauretania	< 0.1	< 0.05	n/a	8	0.0	0.4
Morocco	< 0.1	< 0.05	n/a	4	0.0	0.1
Sudan & S. Sudan	6.7	0.4	40.5	455	0.5	4.1
Syria	2.5	0.2	20.6	331	0.4	0.6
Tunisia*	0.4	< 0.05	n/a	70	0.1	0.9
Yemen	2.7	0.2	32.0	163	0.2	1.4
Total Arab World	**713.6**	**43.2**	**74.4**	**26,262**	**31.4**	**3.3**
World	**1,652.6**	**100.0**	**54.2**	**83,576**	**100.0**	**n/a**

Notes: * Production figure for 2010;
** Ratio for 2008.
Source: EIA (2012).

D. Regional Reserve Depletion

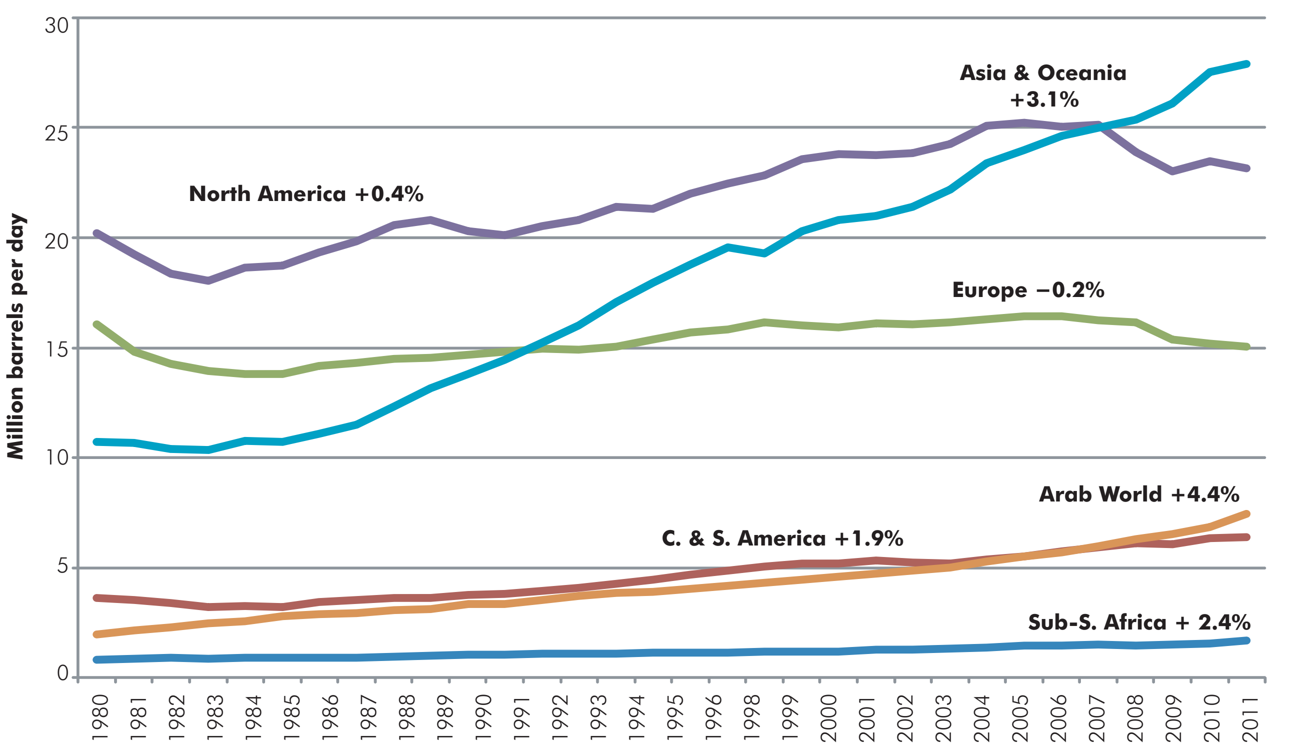
Another distinguishing feature of Arab oil is the longevity of its reserve base, estimated at over 78 years for the Middle East, and more than 40 years for North Africa. Individual oil producers face considerably longer production horizons at current rates of production, for example, Kuwait and the UAE at over 80 years, and Iraq and Libya with more than 100 years (BP, 2012). This picture is not reflective of the entire region, however. For many Arab medium and small reserve holders, the depletion of their oil reserves is, at current rates of production, just a few decades away, and for some even less; the production outlook of Oman, Syria, Algeria, and Egypt is currently estimated at 20 years or less (BP, 2012; El-Katiri 2013, for a detailed discussion).

Even where the increased use of technology could help raise this production estimate, or maintain it at constant levels for some time, the end to these countries' oil production is in sight. In view of this depletion outlook, several Arab oil producers have shifted their policy-focus away from a concentration on oil towards giving a greater weight to natural gas exploration and production, as well as export (Fattouh and Stern, 2011 eds., for a detailed account). However, the gradual loss in oil export revenues – as yet unmatched by natural gas export income – paralleled by the growing domestic demand for oil, will eventually force a growing number of Arab oil producers to shift position from being traditional oil exporters toward becoming oil importers (El-Katiri, 2013).

E. Domestic Oil Consumption

Oil has been the Arab world's main traditional domestic energy source across a number of different economic sectors including power generation, transport, refining, various energy-intensive industries such as aluminum and steel, and for the Gulf states' ambitious fertilizer and petrochemicals industries. More than 98 percent of Arab energy supplies consist of oil and natural gas, with a

FIGURE 3 OIL CONSUMPTION AND 30-YR COMPOUND ANNUAL CONSUMPTION GROWTH RATE BY REGION, 1980–2011



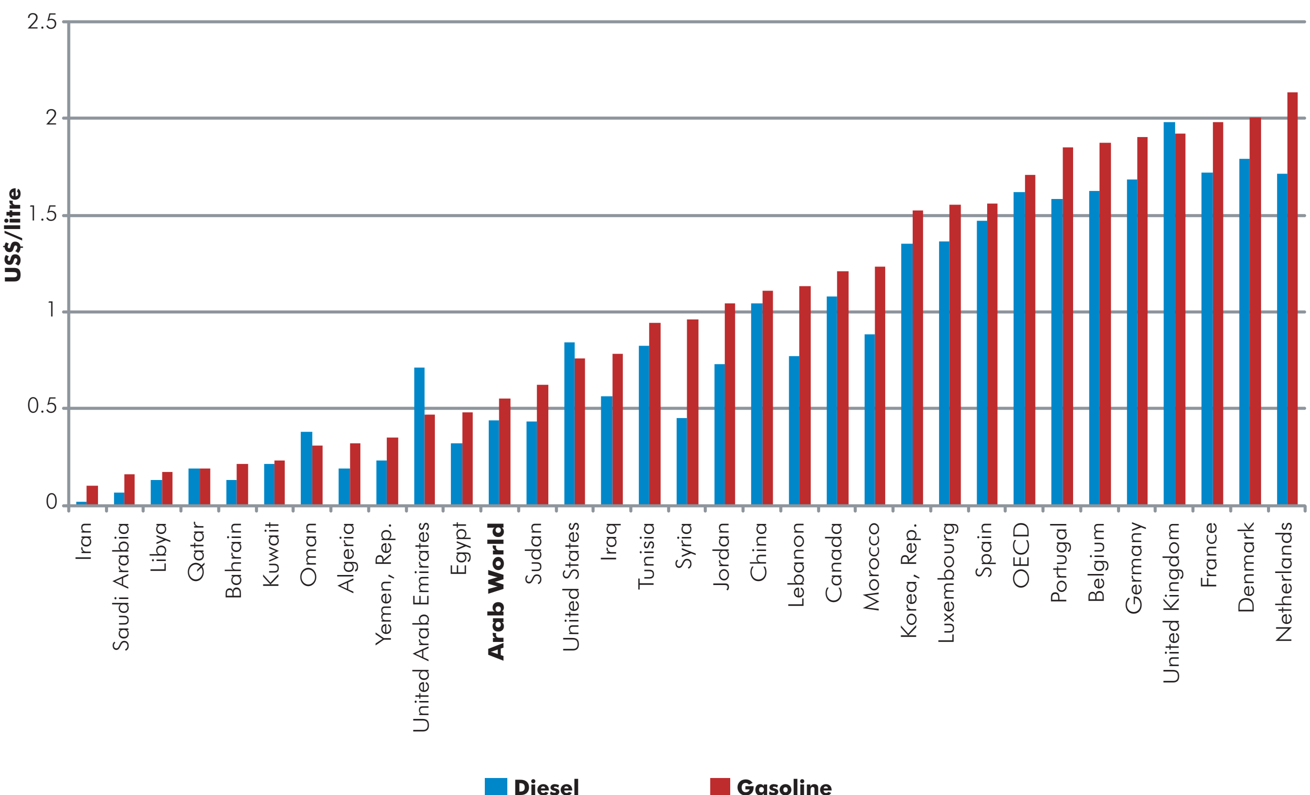
Source: EIA (2012).

marginal share of alternative energies. Oil covers 52.9 percent of the Arab world's energy needs, and natural gas 45.4 percent (AMF, 2011, 81, 89: numbers for 2010). While the role of natural gas has been rising over the past decades, oil continues to account for around half of aggregate Arab energy supply, a higher share than in any other region.

Its demand for oil makes today's Arab world anything but a marginal oil consumer; regional demand for oil has tripled over the past 30 years, from a modest 2 mb/d in 1980 to 6.97 mb/d by 2010 (EIA, 2012), alongside rapidly rising energy consumption rates over the same period across the entire region. At the end of the 2000s, aggregate Arab oil consumption amounted to about 8 percent of world demand, surpassing the, by then, more populous regions Africa and Central and Latin America (see Figure 3). The GCC producers Qatar, the UAE, and Kuwait are today amongst the most energy-intensive economies in the world, as measured by the amount of energy used per unit of GDP (Fattouh and El-Katiri, 2012a). Per capita primary energy consumption in the GCC states today is among the highest in the world, well above the average for the OECD and other industrialized economies. (See World Bank (2012) for comparative data; Fattouh and El-Katiri, 2012b; El-Katiri, 2013.)

The region's rapidly rising oil demand, and its persistence in using oil alongside natural gas over alternative fuels for virtually its entire energy needs, is largely accounted for by economic and industrial growth, a high rate of regional population growth, rapidly rising living standards, and low domestic energy prices. Prices for crude oil and oil products have, in many parts of the Arab world, been among the lowest in the world, as a result of either active subsidy policies implemented by importing governments, or marginal production cost pricing by Arab oil producers. The resulting price disparity between Arab prices for oil and those prevailing in other regions is evident in a cross-country comparison for diesel fuel and petrol, shown in Figure 4.

FIGURE 4 DIESEL AND PETROL PRICES IN SELECTED ARAB AND NON-ARAB COUNTRIES, 2010

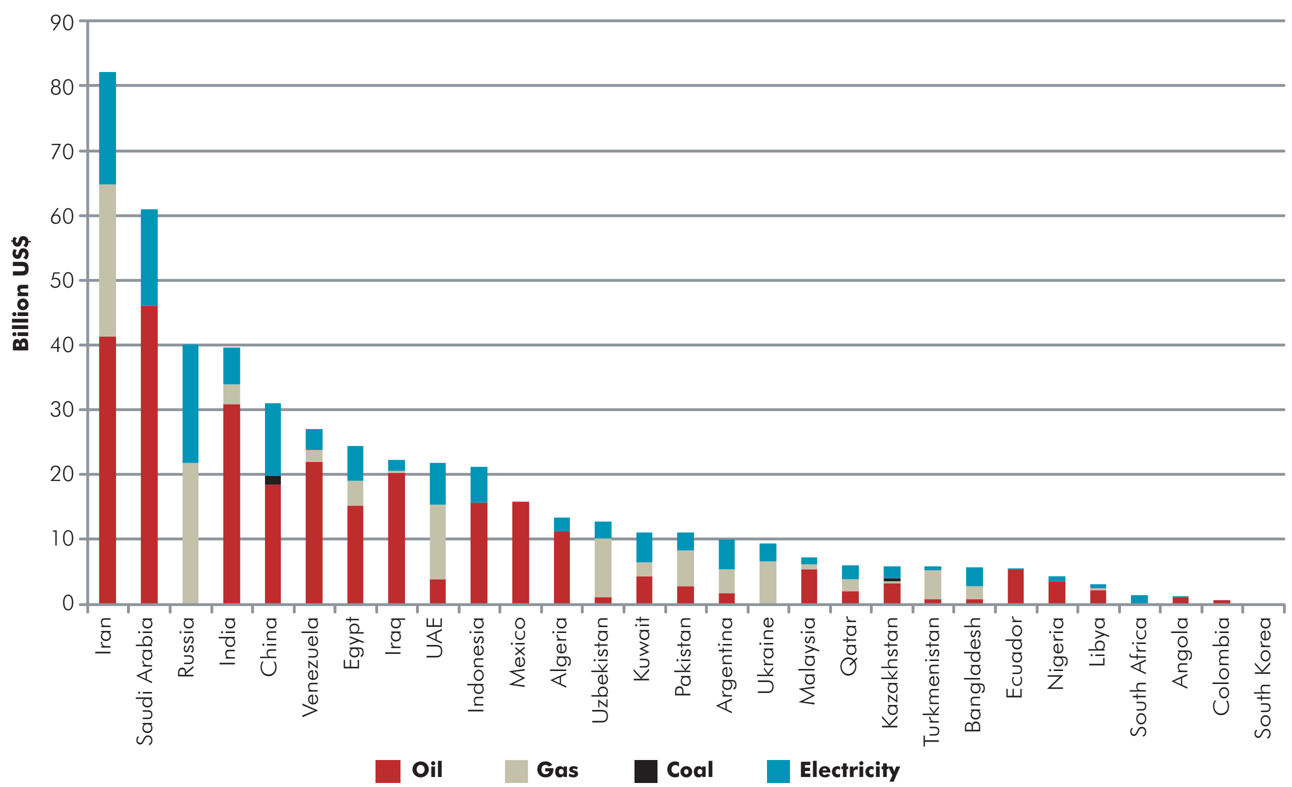


Source: World Bank (2012)

Using the price-gap approach, the IEA estimates the cumulative subsidies on oil and oil products – both explicit, via governmental subsidies, and implicit, found by measuring the difference between the price of crude oil and petroleum products charged domestically, and the price in international markets (in other words the opportunity cost) – at more than US$ 46 billion in Saudi Arabia, US$ 20 billion in Iraq, US$ 15 billion in Egypt, and over US$ 11 billion in Algeria in 2011 (see Figure 5 below). Rising consumption, together with strong international prices, has increased this bill for both oil importers and producers in the Arab world. These IEA figures however should be treated with caution given the many caveats in defining and measuring energy subsidies (Fattouh and El-Katiri, 2012a). This is evident in the disagreement between the major international organizations such as the World Bank, the IEA and OPEC on common definitions of subsidies.[7] Issues such as the production of joint products (for instance crude oil, natural gas and Natural Gas Liquids), the availability of spare capacity in some Arab producing countries, and the ability of key Arab oil exporters to influence international oil prices could affect the measurement of subsidies. This has been recognized in a recent IEA/OPEC/OECD/World Bank (2010) joint report, which notes that 'the price-gap method has limitations which apply particularly in the case of countries with large endowments of energy resources'.

The practice of supplying domestic markets with low-cost oil has also led to many structural demand patterns favouring the use of oil as a fundamental energy source, with most citizens considering the access to cheap petroleum products as their birthright. Similarly, within industry, oil is considered as a low-cost input factor; this discourages investment in efficiency-enhancing technology and investment in new, or the upgrading of existing, facilities favouring

FIGURE 5 ESTIMATED ENERGY SUBSIDIES BY TYPE OF ENERGY (US$ BILLION), 2011



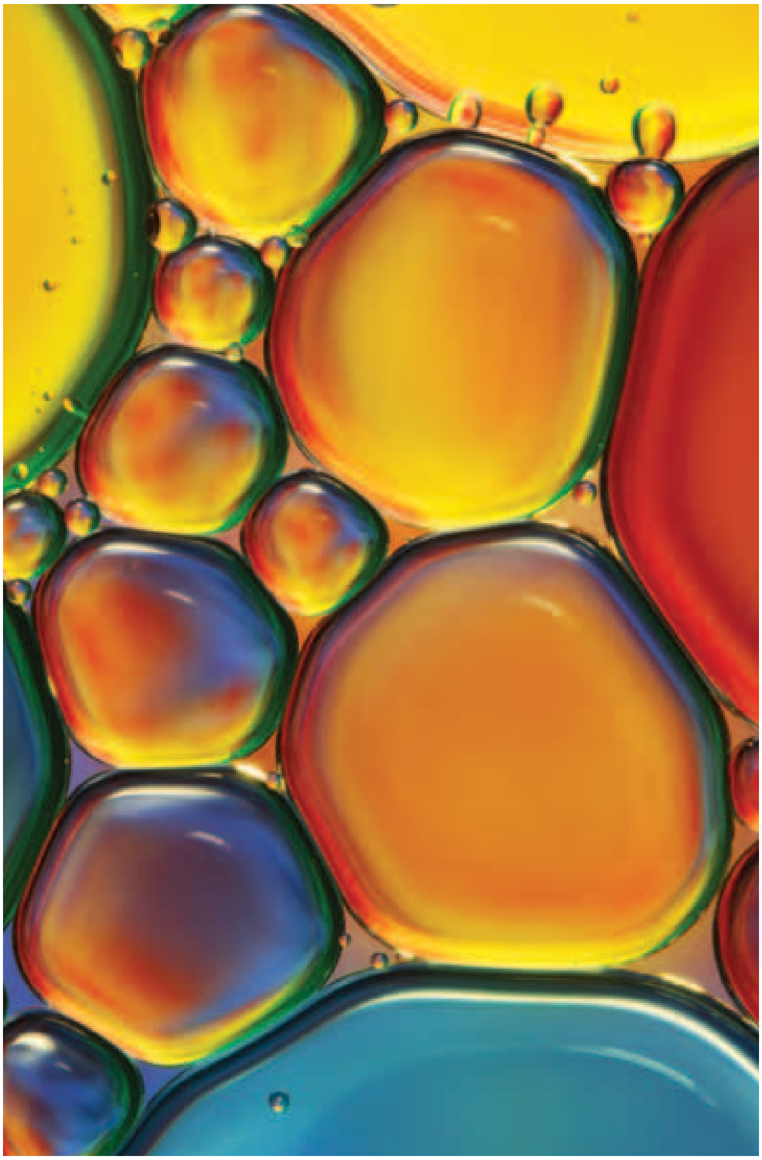
Source: IEA (2012)

the use of alternative fuels whose costs are not subsidized. High-cost initial investment in renewable technologies such as solar power hence appears considerably more expensive relative to oil, which is supplied domestically at very low prices (Fattouh and El-Katiri, 2012a; Fattouh and El-Katiri, 2013; El-Katiri, 2013)

III. OIL AND DEVELOPMENT IN THE ARAB WORLD

The Arab world's oil wealth has undoubtedly made the region a key supplier of world energy resources, but has it helped Arab economies to prosper? The question of whether oil and other natural resources have been more of a blessing, or more of a curse, has been the subject of a large and controversial body of literature (Sachs and Warner, 1995; Sachs and Warner, 1999; Davis, 1995; Stijns, 2005; Brunnschweiler and Bulte, 2008; Bornhorst, Gupta, and Thornton, 2008; Boyce and Herbert Emery, 2011; Gylfason and Zoega, 2006; Ross, M.L., 2001. For a discussion of oil in the Arab context, see Al-Moneef, 2006.) The purpose of this chapter is not to provide a critical review of this voluminous literature, but rather to make the following three general observations: first, resource-rich economies in the region have experienced relatively low per capita GDP growth and high levels of growth volatility. Second, in the case of the GCC economies and to a lesser extent Libya, per capita growth rates alone do not provide an adequate picture of their achieved levels of overall economic development and social welfare, as these countries have maintained a high level of per capita income. Third, some Arab oil and gas producers seem to have used their hydrocarbon revenues to spur economic growth and development in more effective ways than others – see Fattouh and El-Katiri, (2012b) for a detailed discussion. Hence, one should be careful in making wide generalizations about the relationship between oil resources, and growth and development, in the context of the Arab world.

In an attempt to move beyond the simplistic characterization of the oil and gas sector as an "enclave" industry, we use the framework proposed by Hirschman (1958, 1977) to analyse some of the linkages between the energy sector and the wider economy for Arab oil producers.[8] We focus on fiscal linkages, and production linkages, which are split into forward and backward linkages.



A. Fiscal Linkages

Fiscal linkages refer to the rents that the government extracts from the energy sector through a combination of taxes, royalties, and dividends. For many Arab producers, the cost of developing oil reserves is low and hence the size of the rent is relatively massive and constitutes a big fraction of the country's GDP. In countries such as Egypt and Yemen, where oil reserves are developed jointly with foreign oil companies, part of the rent is leaked to foreign investors. Still, the contribution of rents to overall economic activity can be large, especially where the size of the overall economy is small and where few other productive, export-oriented sectors exist.

Fiscal linkages play an important role in shaping the structure and the growth patterns of Arab economies. Through fiscal linkages, a government obtains the revenues that can be used to finance government spending, accumulate hard currency, accumulate savings, or invest to promote other sectors in the economy such the non-oil private sector or the country's infrastructure, human capital, and social programs. The share of hydrocarbon revenues in most Arab producers' export earnings ranges from 33 percent in the relatively diversified economy of the UAE (with a much higher individual share for the main producing emirate Abu Dhabi) to 88 percent in highly export-oriented economies such as Saudi Arabia and Qatar, and more than 97 percent in Algeria and Iraq.[9]

TABLE 2 **THE OIL AND GAS SECTOR'S CONTRIBUTION TO GDP (NOMINAL) AND GOVERNMENT REVENUES IN THE ARAB ECONOMIES, 2010**

	GDP (US$ million)	Hydrocarbon Sector (US$ million)	Share of Hydrocarbon Sector (%)	Share of individual GDP in Total Arab GDP (%)	Share of Hydrocarbon Revenues in total Government Revenues (%)
The GCC States	**1,084,391**	**479,547**	**44.2**	**53.5**	**80.7**
Bahrain	22,945	5,591	24.4	1.1	81.8
Kuwait	124,244	64,009	51.5	6.1	93.8
Oman	63,199	30,118	47.7	3.1	81.7
Qatar	128,593	71,642	55.7	6.3	60.8
Saudi Arabia	447,762	214,145	47.8	22.1	90.4
UAE	297,648	94,042	31.6	14.7	75.9
Other Major Oil Producers	**357,247**	**172,237**	**48.2**	**17.6**	**84.3**
Algeria	161,947	56,185	34.7	8.0	66.3
Iraq	121,335	62,643	51.6	6.0	96.1
Libya	73,965	53,409	72.2	3.6	90.6
Other Oil Producers	**379,108**	**57,638**	**15.2**	**18.7**	**32.7**
Egypt	218,393	29,999	13.7	10.8	9.5
Sudan and S. Sudan	72,519	6,822	9.4	3.6	51.5
Syria	58,898	15,288	26.0	2.9	8.0
Yemen	29,298	5,529	18.9	1.4	61.8
Other Countries	**205,989**	**9,386**	**4.6**	**10.2**	**2.1**
Djibouti	1,109	0	0.0	0.1	n/a
Jordan	26,463	877	3.3	1.3	n/a
Lebanon	39,221	0	0.0	1.9	n/a
Mauritania	3,629	1,166	32.1	0.2	n/a
Morocco	91,314	3,534	3.9	4.5	n/a
Tunisia	44,253	3,809	8.6	2.2	2.1
Total Arab World	**2,026,735**	**718,808**	**35.5**	**100.0**	**70.6**

Source: Arab Monetary Fund (AMF, 2011)

The Arab world's hydrocarbon resources remain unequally distributed, which means that the region's smaller or non-oil and gas producers have benefited significantly less from hydrocarbon-related direct economic growth linkages. Many smaller or non-oil producers in the Arab world, however, have benefited indirectly from the inflow of oil export rents into larger Arab producers via the intensification of intra-Arab investment flows, intra-Arab aid, and Arab labour remittances. At the end of the 2000s, an estimated 5.8 million Arab expatriates were thought to have generated an intra-regional remittance flow worth over US$ 35 billion per year (Fattouh and El-Katiri, 2012b). The most recent available data suggests some 25 percent of expatriate labour in the GCC states was Arab, down from 72 percent during the 1970s but still a significant number (IOM, 2010). The region's overall oil wealth, however, has not been able to foster a higher level of intra-regional trade integration and corporation, particularly in the area of energy (see Fattouh and El-Katiri, 2012b).

B. Forward Linkages

Resources such as oil may also contribute towards economic development by feeding directly into growth-enhancing activity in other, related economic sectors. By providing an essential, low-cost input factor into many energy-intensive and intermediate industries, oil can thus "push" the creation of new value-added industries, which in turn enhance the export value of oil. These "push effects" are often referred to as forward linkages.

The Arab world's petrochemical industries are an important example of the contribution of the oil sector to a country's industrial development. The past three decades have witnessed rapid expansion of the petrochemical industry, transforming the region into a key player in petrochemicals. Most of the petrochemical capacity in the region is concentrated in the Gulf.[10] Within the Gulf, Saudi Arabia accounts for around 50 percent of the region's total production.

The forward linkages through the petrochemical industry have had a number of consequences. The region's position in this key global sector has been enhanced; national champions (such as SABIC in Saudi Arabia) have developed; the attraction of foreign direct investment has been encouraged; the role of the private sector has been promoted by opening the sector to private participation; and the linkages have helped diversify the economy

and the export base, to some extent. The data for 2010 showed that petrochemicals accounted for 6 percent of the total exports of the Arab world and 11.5 percent of intra-Arab exports (AMF, 2011, Figures 8.2 and 8.4).

C. Backward Linkages

Some arguments are also made in favour of the oil sector having a role in "pulling" other local sectors along, particularly those sectors providing input factors to the functioning of the energy sector and its forward production chain. Such "pull effects" are often referred to as backward linkages. The nationalization of oil assets in many Arab oil producing countries in the 1970s and the emergence of national oil companies (NOCs) has put pressure on the NOCs to maximize backward linkages through providing employment for nationals, increasing reliance on local companies, and designing and implementing local content policies. It has also been argued that the oil sector should promote more indigenous private sector activity, especially around complementary activities such as R&D in areas of technology supply, and around the

service company market segment, which provides equipment, technologies, and other services both to the upstream and the downstream sectors.

\However, there are limits to the depth of these linkages. Employment-wise, the energy sector is a capital-intensive sector and is limited in its ability to attract employment. For instance, in Saudi Arabia, the country with the largest oil and gas sector in the Arab world, the number of people employed in the Mining, Oil, Gas and Quarrying sector stood at 85,145 in 2011. This is only 1.1 percent of the total labour force in the private sector (SAMA, 2013, Table 18.8). The role of the oil sector in helping extend Arab countries' domestic private sectors has been arguably limited. Since the nationalization of the oil industry in the 1970s, many oil upstream services have been provided in-house and hence it is possible to argue that the change in ownership has already contributed to the development of backward linkages.

However, while the upstream sector across all oil producers relies heavily on private oilfield services – drilling equipment, technology providers, information technology, security, and logistics – these services continue to be provided to a very large extent by foreign private companies whose technological know-how in many cases exceeds that of domestic service companies. The following quote from Mr. Khalid Al-Falih, the CEO of Saudi Aramco, suggests that there are still many challenges in fostering the linkages between the oil industry and the domestic private sector:

> " … despite many incentives, the national industrial sector has failed to keep pace with the company's growing demands and its contribution to meeting these demands does not exceed 20 to 25% ... Notwithstanding Saudi Aramco's efforts in support of local industries, these industries are hardly adequate. It is our hope that the private sector will play a greater role in promoting the industrialization sector." (Al-Falih, 2009)

IV. EMERGING CHALLENGES

The undoubtedly central role that oil has in both the global and domestic context has rendered a sensible management of the resource all the more important for the Arab world's future growth and prosperity. Many challenges have emerged, however, and the benefits of oil remain unequally distributed within the region, suggesting increased potential for the role of both national and cross-regional approaches in the coming decades.

A. Investment and Prospects for Capacity Expansion

The issue of investment in the energy sector of the Arab world has two inter-related dimensions: local and international. Oil revenues will continue to play an important role in shaping the development path of Arab economies, at least into the foreseeable future. Thus, maintaining a well-functioning oil sector and expanding the oil capacity is of key importance to the region's economic, social, and political stability. For those Arab oil producers with declining oil reserves, investment in higher-technology solutions, in order to prolong the lifecycle of their producing fields, is vital to maximizing the revenues still to be expected from these non-renewable reserves. Furthermore, given the large concentration of oil reserves in the Arab world, investment in the oil sector of the region also has an international dimension, since most international organizations project that much of the increase in global oil demand will have to be met by increasing supplies from Arab OPEC members.

These two dimensions – local and international – highlight the issue of what proportion of the revenues generated from the energy sector should be reinvested to expand the sector's capacity. Until the early 2000s, investment in the energy sector of the Arab world was stagnant (with some notable exceptions such as Qatar which embarked on a massive investment program to develop its gas reserves, and Algeria which revised its legal framework and fiscal terms to attract foreign investment). The large spare capacity and the oil price decline in the 1980s and most of the 1990s threw the energy industry into deep recession, reduced the attractiveness of existing investment plans, and adversely affected the incentive to invest.

Geopolitical issues have also prevented capacity expansion in many Arab countries. For example: the Iran–Iraq war, the Iraqi invasion of Kuwait, the US invasion of Iraq and the lack of security and stability that followed, have prevented these countries from undertaking the necessary investment in their oil sectors. Sanctions against Libya, Iraq, and Sudan have limited their access to technology and foreign capital, and hindered capacity expansion. In Iraq, the domestic conflict which has continued since 2003, as well as legal uncertainty surrounding the hydrocarbon law, has delayed investment and exploration decisions. The political turmoil that has swept across the Arab world since the end of 2010 has resulted in oil output losses in 2011 and 2012. South Sudan's shutdown in oil production in 2012, following the country's secession from the oil-poor North, added to the region's production shortfalls.

In countries such as Kuwait and the small producers such as Yemen and Syria, the relationship between the owner of the natural resource (the government) and the NOC that extracts the resource is highly inefficient, yielding low rates of investment. The capital budget for national oil companies is often quite tight, preventing them from either undertaking new projects or upgrading human capital and technological capabilities. Consequently, NOCs in the Arab world are not of uniform quality, and while some are relatively well-managed and score highly on commercial performance, human resources, and technology, others perform very poorly and have to rely heavily on foreign companies for exploration and development of oil reserves.

Driven by energy security and climate change concerns, many OECD and non-OECD countries have also been encouraging the use of renewable energies – often through a combination of regulations, incentives, subsidies, taxation, moral persuasion, and/or a combination of these instruments – to change the composition of their energy mix to one with a lower carbon content. Oil substitution policies can have a large impact on long-term oil demand since their impact is cumulative and irreversible. Thus, from the perspective of Arab producers, oil substitution policies and taxes on petroleum products are seen as discriminatory, tending to dampen oil demand growth, and reducing Arab producers' export share in the energy mix in the long term. Furthermore, these policies induce great uncertainty about long-term demand for Arab oil discouraging investment.

B. Low levels of Economic Diversification

Up to now, the goal of diversifying the Arab world's economies to levels that render the region less dependent on its oil wealth, or (for some small oil producers and net-importers) on oil-induced remittances and foreign aid, remains largely unachieved. The share of the hydrocarbon sector in many Arab producers' economies continues to be exceptionally high (see shares in GDP in Table 2), defying all previous decades' talk of intentions to reduce this share significantly.

Deferred investment in alternative sectors in the Arab world has been attributed to a number of different factors: the persistence of vertically integrated state-owned companies promoted by state sector-specific policies and of old-style industrial policies; the weakness of private sector enterprise and innovative forces; and the specific features of natural resource-led development patterns whereby the flow of oil revenues often reduces the pressure for change, even in the presence of serious strains on the economic development model, seen in many Arab resource-rich economies (see, for example, Nabli, Keller, Nassif, and Silva-Jauregui, 2005).

Part of this investment argument is seen in the debate surrounding many regional oil and gas producers' strategies of diversification into energy-intensive industries such as refining and petrochemicals production. While seen by producers as a strategy of raising the value-added of their exports, and of diversifying away from crude exports, many critics of this policy suggest such forward linkages reinforce rather than mitigate energy producers' dependence on energy.[11] The fact that many Arab oil producers, such as the Gulf monarchies, Algeria, and Libya, began their industrialization process at a much later stage than many of their neighbors – typically following costly state-coordinated industrialization strategies – has, in the eyes of some development economists, rendered these countries less likely to change their industrial strategies once they are in place, even if the economic outcome is below the optimum level.[12]

Low levels of economic diversification amongst the Arab world's oil and gas producers raise a number of different long-term policy challenges. The most immediate concern relates to the fiscal sustainability of economies (such as some of the GCC states and, particularly, Iraq and Libya) which rely to a large extent on oil and gas revenues. A high rate of dependence on oil and gas revenues reinforces patterns of volatile government revenues, whose level and stability remains outside the control of producing countries. Past research has suggested a high level of reliance on widely fluctuating government revenues as being one key explanatory factor for many Arab oil producers' relatively low per capita income growth rates. This forms part of the argument put forward by those seeing oil more as a curse than an economic blessing (for a discussion of GDP–revenue volatility rates see Makdisi, Fattah, and Limam, 2007; Arezki and Nabli, 2012).

Moreover, high levels of oil and gas sector dependence in Arab producing economies do little to help the region deal with its looming unemployment challenge, the gravity of which has been felt across the entire Arab region – not least since the beginning of the Arab uprisings since late 2010.

C. Rising Domestic Consumption and Export Capability

Perhaps the most pressing challenge confronting the Arab world today is its very own oil demand, which has been rising rapidly since the 1960s alongside rapidly growing energy consumption across the

region's industrial and residential sectors. Rising energy consumption within the region, and the rising (opportunity) cost of oil consumed domestically by exporters and net-importers alike, suggest that past patterns of reliance on oil may no longer be sustainable or serve the region's best long-term interest.

The burning of crude oil by large exporters such as Kuwait and Saudi Arabia has now reached historic volumes. In 2010 Saudi Aramco CEO Khaled Al-Falih expressed his concern about the Kingdom's use of its crude oil resources, arguing that Saudi crude oil exports could fall by as much as 3 million b/d by 2028 should domestic crude oil consumption grow unabatedly for much longer (FT, 2010). These concerns reflect the growing dilemma faced by many Arab oil producers – that of supplying domestic markets with low-cost petroleum products while maintaining or expanding current export volumes.

The reform of domestic oil and energy prices – the most important government tool in managing domestic demand – constitutes a delicate political and economic task, especially in the wake of political uprisings that have struck the region since late 2010. Many Arab governments that have shown some inclination to reform prices are likely to be deterred from increasing fuel prices, to avoid the accompanying socio-economic distress and preserve regime stability. However, the enormous fiscal burden of fuel subsidies has forced many net-importing governments to re-consider their existing pricing policies, which weigh heavily on these governments' budgets. Fuel subsidies, in all Arab oil importing countries, increasingly exceed budgetary capabilities, drawing fiscal resources away from other key sectors such as health and education (Fattouh and El-Katiri, 2012b).

V. CONCLUSION

Oil continues to be the Arab world's most important natural resource, a status that is unlikely to change any time in the near future. Despite the recent discovery of oil reserves outside the Arab world (for instance shale oil in the USA, oil sands in Canada, and deep offshore in Brazil), the Arab world is expected to continue to play a key role in global oil market dynamics, dominating international trade in crude oil and holding the bulk of the world's spare capacity. However, more than a decade into the twenty-first century, Arab oil producers face many challenges. These include: investing in their energy sectors when faced with high uncertainty due to climate change, and energy security policies aimed at reducing oil in the energy mix and dependency on Arab oil; strengthening Arab NOCs' technical and managerial capability; diversifying Arab economies into industries that create jobs for the hundreds of thousands of workers entering the labor market each year; strengthening the forward and backward linkages to enhance the role of the private sector and regional linkages; and diversifying domestic energy sources away from oil and gas towards renewable resources.

Perhaps the region's most fundamental challenges originate domestically, both in the shape of declining reserve bases in some parts of the region, including North Africa's prime exporters Algeria and Egypt; and in the rising domestic oil consumption throughout the region, at rates surpassing most other emerging economies. Far from being immune to the challenge of rising energy consumption, the Arab world is as vulnerable to the effects of wasteful domestic oil consumption and the impact of climate change as many net-importing regions. Hence, the management of Arab domestic energy demand, including the implementation of a potentially painful, and politically risky, reform of domestic energy pricing policies, becomes increasingly important.

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NOTES

1. Collective data sets by BP and the EIA typically quantify regional energy reserves and production under the separate aggregates of "Middle East" and "Africa". In this chapter, we have adapted these aggregates to reflect the Arab world, showing the collective reserves and production of the list of countries covered in this report.

2. The Arab League comprises Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauretania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, the United Arab Emirates, and Yemen.

3. The GCC members comprise Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE).

4. Reserves are proved reserves of crude oil according to EIA data. Production is total annual production of crude oil from domestic reservoirs. EIA (2012).

5. OPEC defines the Middle East as comprising Bahrain, Iran, Iraq, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, UAE and Yemen.

6. In Table 14.2 of a more recent report, (IEA, 2012: World Energy Outlook 2012. International Energy Agency), the capital cost per barrel of capacity for a 500,000 b/d expansion in Saudi Arabia is estimated at US$ 15,000 (2011 US$). The operating costs, which included all expenses incurred by the operator during day-to-day production but excluded taxes or royalties, were US$ 2 to US$ 3.

7. A joint report by IEA/OPEC/OECD/

World Bank for the 2010 G-20 Summit in Toronto notes the existence of a major disagreement among international organizations concerning the choice of the reference price, and consequently 'a commonly agreed definition of subsidies has proven a major challenge in the G-20 context and countries have decided to adopt their own definition of energy subsidies'. IEA, OPEC, OECD, and World Bank (2010).

8. See, for instance, Singer (1950) ("The Distribution of Gains between Investing and Borrowing Countries." American Economic Review, 40(2)) for Singer's seminal contribution. A large number of studies have recently applied this framework to a large number of extractive industries and show that the oil and gas sector can be strongly linked to other sectors, though the depth and extent of these linkages depends on a large array of factors including the institutional development of the country, government policy, and time. For instance, see Mbayi (2011) (Linkages in Botswana's Diamond Cutting and Polishing Industry. MMCP Discussion Paper No 6, Cape Town, the University of Cape Town, and Milton Keynes, the Open University); Mjimba (2011) (The Nature and Determinants of Linkages in Emerging Minerals Commodity Sectors: A Case Study of Gold Mining in Tanzania. MMCP Discussion Paper No 7, Cape Town, the University of Cape Town, and Milton Keynes, the Open University); a specific body of literature examines the oil sector in Nigeria e.g. Oyejide and Adewuyi (2011) (Enhancing Linkages to the Oil and Gas Industry in the Nigerian Economy. MMCP Discussion Paper No 8, Cape Town, the University of Cape Town, and Milton Keynes, the Open University), and Angola Teka (2011) (Backward Linkages in the Manufacturing Sector in the Oil and Gas Value Chain in Angola. MMCP Discussion Paper No 11, Cape Town, the University of Cape Town, and Milton Keynes, the Open University). Al-Moneef (2006) (The Contribution of the Oil Sector to Arab Economic Development. OFID Pamphlet Series No.34, Vienna, 17–21) specifically applies these linkages to the Arab world.

9. These include natural gas export revenues where available, primarily in Algeria, Egypt, Libya, Oman, Qatar, the UAE, and Yemen. Arab gas producers that do not export are thought to generate little direct revenue from the domestic sale of natural gas owing to the low pricing environment, discussed in further detail below. Available statistical data frequently does not allow for a distinction between the two sources of revenue (which are combined under the item "Mining and Quarrying Revenues"), but oil in all cases except Qatar is known to contribute the majority of hydrocarbon export revenues.

10. There is some petrochemical production outside the Gulf, particularly in Egypt, but this is relatively small.

11. Producers of both oil and gas would, in many cases, argue differently; that energy-intensive industries merely make the most valuable use of these domestic natural resources, particularly in the absence of other assets such as large acreages of arable land, a sufficiently large, and skilled local workforce, and an economy big enough to be able to sustain multiple large, internationally competitive industries. Producers' arguments also suggest that the value added by industries such as refining and petrochemicals production exceeds the value of crude exports; and that the revenues for these products are more closely protected against international price fluctuations than exports of crude oil and natural gas. For instance, see SAMBA (2009) (Saudi Petrochemicals Sector: Current Situation and Future Prospects. SAMBA Report Series, Office of the Chief Economist, Economics Department, Samba Financial Group, August 2009). For a critical view, see Luciani (2007) ("The GCC Refining and Petrochemical Sectors." In Gulf Research Centre (2007) Gulf Yearbook 2006–2007, Gulf Research Centre, Dubai).

12. This concept is known in development economics as a "low-equilibrium trap" whereby an economy is stuck at low levels of economic efficiency while a better equilibrium would be possible, assuming all economic agents approve and coordinate their actions accordingly. A low-equilibrium trap might occur because economic structures (such as industrial patterns) are already in place and adaptation costs are high; or because of a massive coordination failure, for instance in economies with few developed institutional structures and high levels of future uncertainty. Rosenstein-Rodan (1943) ("Problems of Industrialization of Eastern and Southeastern Europe." Economic Journal, 53, 202–11).

Natural Gas and Arab Energy Transition

Hakim Darbouche

The use of gas in Arab economies has grown significantly in the last 40 years, accounting for nearly half of the region's primary energy supply in 2012. This expansion in gas demand has been driven by the region's fast-growing electricity needs (8-10 percent per annum) and, in some countries, by growing energy-intensive industrial capacity.

However, considering the relatively-large endowment of Arab countries in natural gas resources, the potential of this fuel to help the region both meet energy needs and manage its global carbon footprint remains under-realized. This is due to three main factors. First, gas pricing policies in the overwhelming majority of Arab countries, keeping end-users prices at artificially-low levels, have not only contributed to rapid gas demand growth in the region but have also precluded the development of new sources of gas supply. While the marginal cost of new supply in almost all Arab countries is estimated to be in the range of 3-6 US$/MMBtu, prevailing gas prices have been fixed at 0.5-3 US$/MMBtu for the best part of the last decade.

Secondly, owing in large part to Arab gas (and energy) pricing policies, attracting the necessary investment to deliver the energy mix that the region requires has been a challenge. With the increasing attractiveness for international oil companies of mature and emerging gas provinces in other parts of the world, the need to reform the investment conditions in Arab countries has never been greater. Thirdly, the lack of regional gas trade, with only 11 percent of pipeline Arab gas shipments being exported within the region, meant that gas surplus from the Arab region has invariably been traded in far-away markets, depriving gas-short Arab countries from accessing competitively-priced supply from neighbouring countries.

Allowing gas to play a greater role in future Arab energy and economic development requires a change of energy policy across the region, focusing on pricing reforms and private sector involvement. This is all the more pertinent considering that gas exploration in a growing number of Arab countries will be focused on unconventional resources, and that these require an overhaul of the State-led business model that has dominated the upstream hydrocarbon sector in the region for the past 40 years.

Gas and related-energy product prices need to be reformed in such a way as to initiate a shift to a sustainable energy system in the long term where natural gas can play a greater role in the Arab energy transition and future economic development. At the same time, liberalising gas prices without improving the involvement of the private sector would be somewhat contrary to the logic of pricing reforms, whose aim is partly to create a competitive environment. Thus, the realisation of the full potential of the Arab upstream gas sector requires innovation and efficiency, and the private sector, working alongside the State as the owner of the resource, can deliver both.

I. INTRODUCTION

As well as traversing a period of political and economic change, most Arab countries are undergoing an energy transition that manifests itself most strikingly in the region's changing role in international energy trade from an important source of supply to a growing demand centre. Natural gas, of which Arab countries hold sizable reserves, has the potential to play an important role in this transition, as a fuel that can help the region both meet its growing energy needs and manage its global carbon footprint.

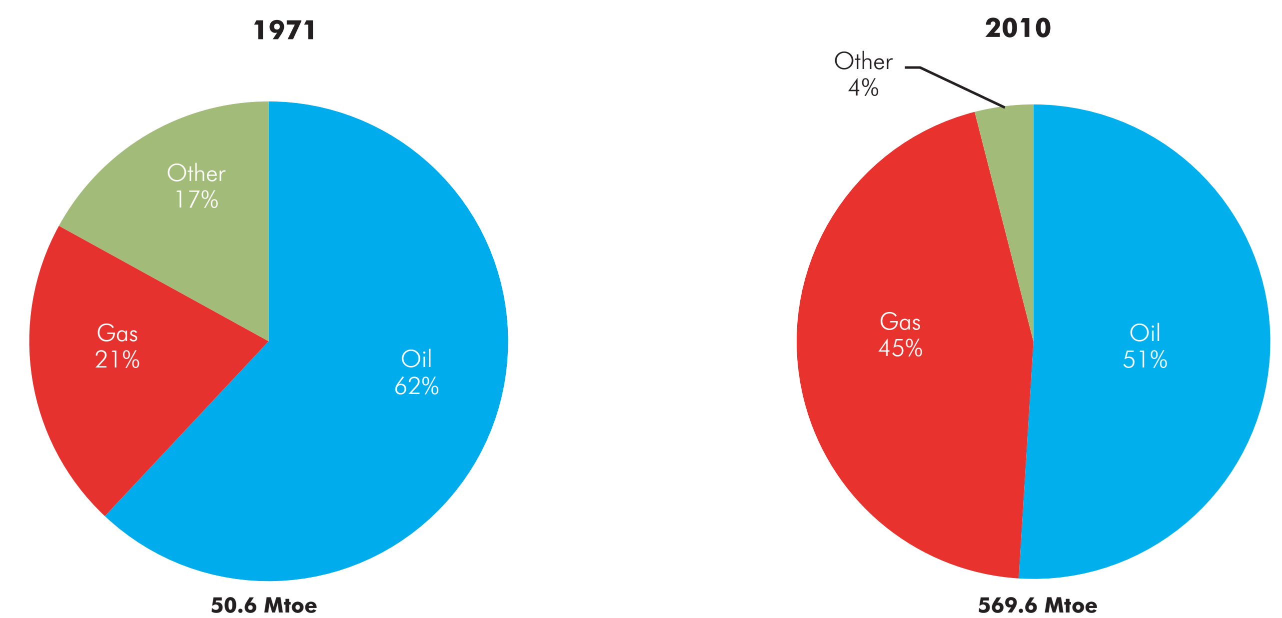
However, the realisation of this potential is contingent upon the timely implementation of sustainable energy policies that take account of the transition taking place locally and the transformation currently underway in global gas markets. Indeed, the growing resource base and production of natural gas globally is having a structural impact on international markets,(1) driving prices downward in North America and forcing a rethink of the fundamentals of pricing in international gas trade in Continental Europe as well as in Asia (Stern, 2012; Ten Kate et al., 2013). These changes could ultimately have an impact on the competitiveness of energy-intensive industries and gas exports of Arab countries, as well as on their ability to attract the necessary investment to develop their gas resources in the long term.

This chapter assesses the potential of natural gas to contribute to the satisfaction of the future energy and economic needs of Arab countries, and identifies the challenges that need to be overcome for this potential to be realised. It argues that reform of the energy policies currently in place in most Arab countries is an urgent requirement for the unlocking of the potential of natural gas as a source of energy, economic development and regional integration.

II. ARAB GAS MARKETS

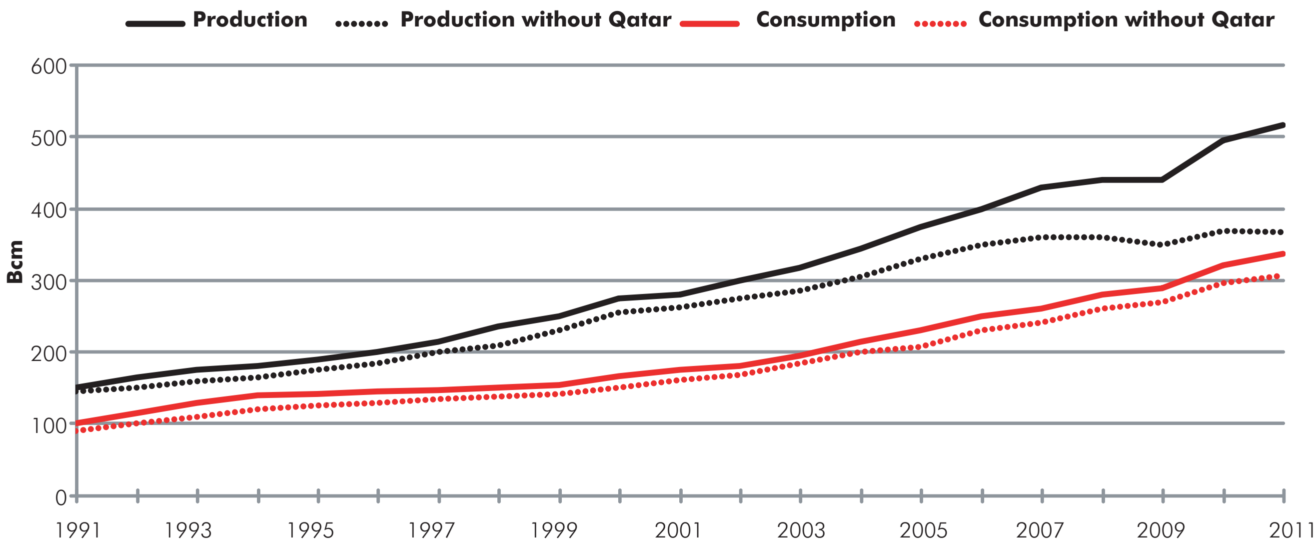
Gas use in Arab countries has grown exponentially over the past 40 years. From a by-product of oil that was considered a nuisance and often flared, natural gas has become the fuel of choice in the stationary sector, primarily power generation. Its share in the region's energy mix increased steadily at the expense of other fuels, particularly oil, reaching almost half of total primary energy supply in 2010, compared to 21 percent in 1971 (Figure 1).

FIGURE 1 ARAB PRIMARY ENERGY SUPPLY, 1971 VS. 2010



Source: IEA (2012)

FIGURE 2 **ARAB GAS SUPPLY/DEMAND TRENDS, 1991-2011**



Sources: BP (2012) and Cedigaz (2012)

Until recently, the extent of the use of gas in Arab economies was mostly a function of the availability of domestic supply and pipeline imports from neighbouring countries. With the distribution of reserves being hitherto conspicuously uneven – Qatar, Saudi Arabia, the UAE and Algeria account for 80 percent of total Arab proven gas reserves[2] – only a handful of countries were in a position to see their demand for gas grow unconstrained. However, a number of factors have in recent years led to the growing use of gas, as a preferred source of primary energy supply, across the region. These include the simultaneous rise of energy demand and the cost of oil-based supply, the increasing accessibility of non-associated gas resources, be they deep offshore, tight or otherwise more difficult and costly to develop, and the improved commerciality of liquefied natural gas (LNG) as a result of expanded global supply and technological development.

Demand for gas in Arab countries has grown by a compound average annual rate of 6.1 percent in the ten years from 2001, reaching some 330 billion cubic meters (Bcm) in 2011(Figure 2). The fastest growing markets have been the Gulf Cooperation Council (GCC) countries and Egypt. The main driver of gas demand growth in these and other Arab countries has been the power sector, followed to varying degrees by the energy-intensive industries, and in particular petrochemicals.

The Arab Union of Electricity estimates that in 2010 gas accounted for more than 51 percent of total fuel consumption in the Arab power sector, with relatively wide variations between countries (Figure 3). As electricity consumption has been expanding on average by 8-10 percent per year since the early 2000s, driven by relatively rapid economic, demographic and urbanisation growth rates in most countries in the region, gas demand has followed a similar trend.

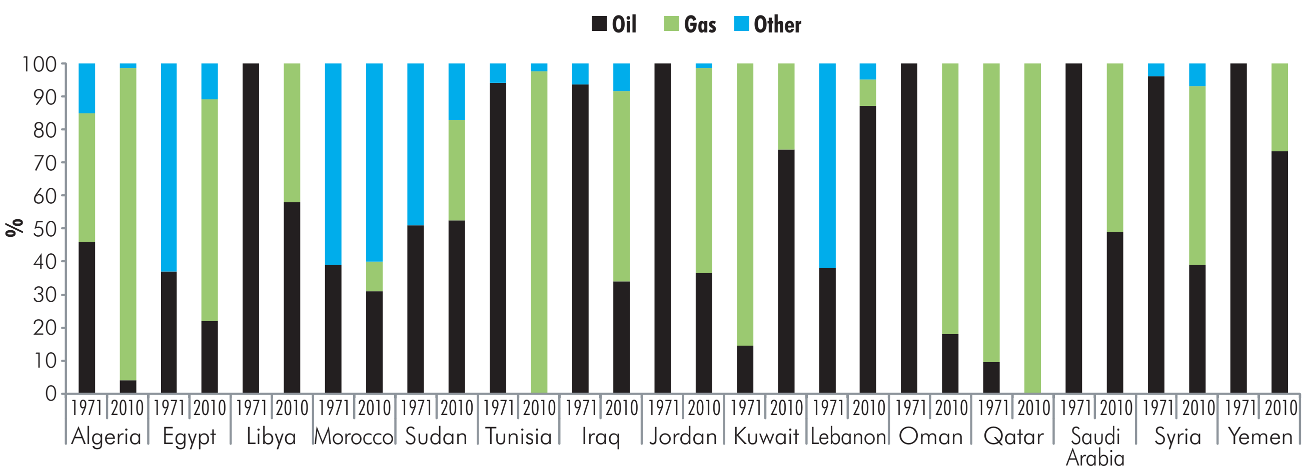
In addition to power generation, large, government-led investment in downstream energy-intensive industries, aimed at creating jobs and promoting economic diversification, has also been a major stimulus for gas demand in some Arab countries. For governments in energy-rich countries, the availability of relatively low-cost gas, coupled with the general absence of other resources, particularly high-end skills and know-how, represents a source of competitive advantage that is almost the only option readily available to attract investment and achieve enunciated development goals. This is the case in Saudi Arabia for instance, where substantial investment in the petrochemicals sector has been made in recent years, leading to the diversion of feed gas away from other sectors, such as power, in order to meet its growing requirements without having to resort to imports of gas.

Underlying Arab gas demand growth are also the administered end-user prices kept at artificially-low levels by governments in the overwhelming majority of countries. These pricing policies are rooted in distributive and developmental logics that were formulated in the 1970s and 1980s, but are for the most part no longer suited for current gas market and socio-economic realities (Darbouche, 2012). At US$ 0.75/MMBtu in Saudi Arabia, US$ 0.8/MMBtu in Kuwait, US$ 0.8-1.50/MMBtu in Oman, US$ 1/MMBtu in Qatar and the UAE to about US$ 0.75/MMBtu in Algeria and US$ 1.25-4/MMBtu in Egypt, gas prices in Arab markets are well below opportunity values, and indeed below the marginal cost of new supply in almost all countries, which is estimated to be in the range of US$ 3-6/MMBtu. Such low prices – among the lowest in the world according to the International Gas Union (2012) – result in distorted consumption patterns, inducing greater demand for gas than would otherwise result if consumers paid the (higher) opportunity price.

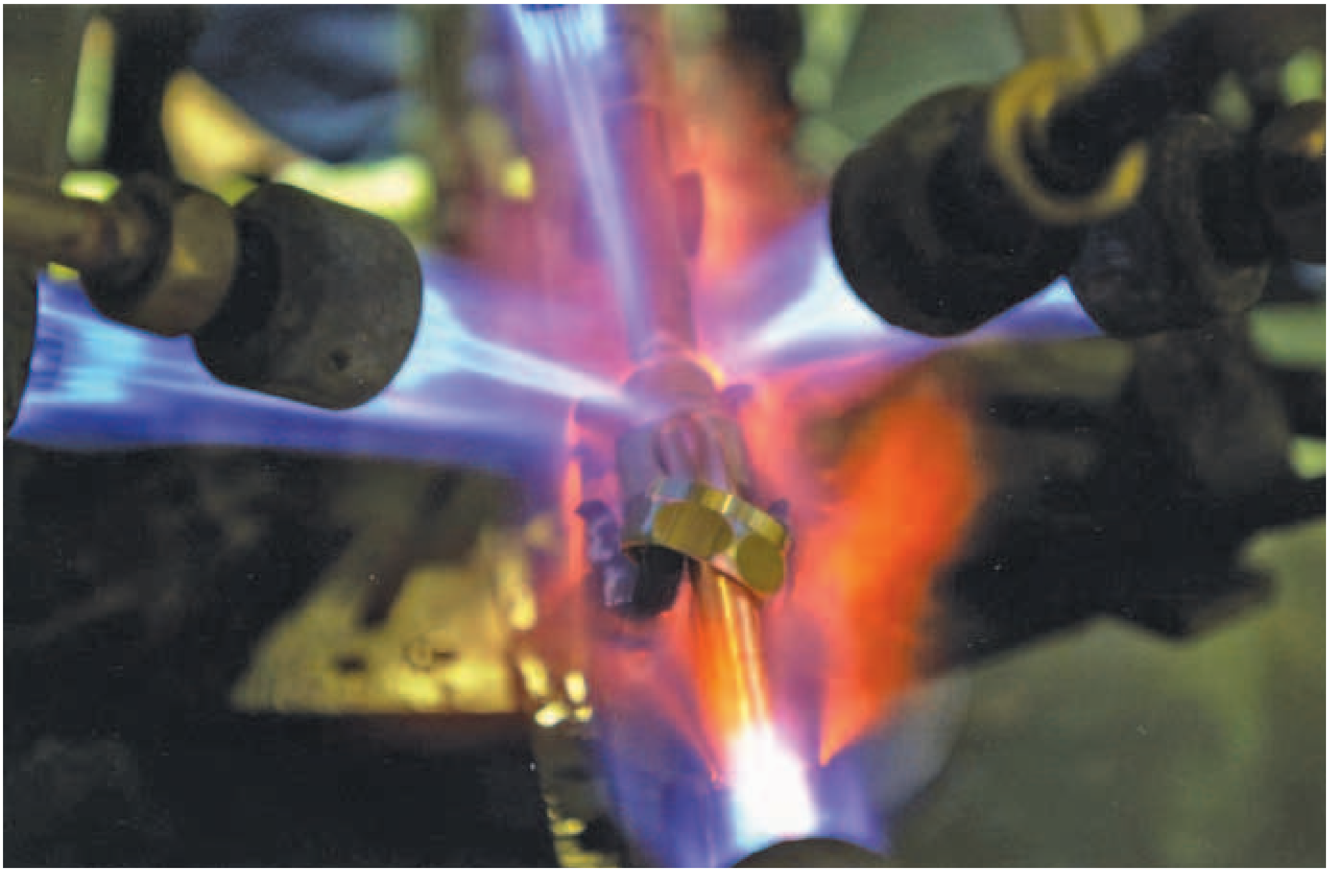
Over the same period, Arab gas production increased by an average annual rate of about 6 percent, reaching over 500 Bcm in 2011 (Figure 2). However, from the mid-2000s, this growth was to a large extent driven by Qatar,[3] which saw its output expand by more than five-fold between 2001 and 2011. Elsewhere, non-associated gas producers Algeria, Egypt and Oman saw their output stagnate, whereas associated-gas production in the GCC was prone to variations in the OPEC-rationed rate of oil output. In Saudi Arabia however, this began to be reversed from 2009 as a result of the shift in the kingdom's upstream gas strategy towards the development of non-associated reserves, which led to a relatively sharp increase in supply in 2009-2011. By contrast, Kuwait and the UAE, which initiated similar shifts in upstream gas policy, have yet to see their efforts materialise.

The slowdown in Arab gas production, outside Qatar and to a lesser extent Yemen, is the result of dwindling mature reserves and lack of investment. With low domestic prices and generally difficult fiscal, commercial and operational conditions facing foreign investors, interest in the Arab upstream gas sector has waned somewhat in recent years. With the end of "easy gas" across the region, Arab countries now have to compete for capital with other parts of the world where gas resources may be just as difficult to develop, but where investment conditions are more attractive. As a result, despite being home to more than a quarter of the world's proven gas reserves, Arab countries' share of international gas exports stands at just 20 percent, and a mere 9 percent if Qatar were excluded.

FIGURE 3 THE SHARE OF GAS IN POWER GENERATION IN SELECTED ARAB COUNTRIES, 1971 VS. 2010



Source: IEA (2012)



Going forward, Qatar seems to be the only Arab country able of increasing its gas exports by 2020, just by debottlenecking its liquefaction capacity, given the moratorium on new export projects based on North Field exploration that is likely to remain in place beyond 2015. In the rest of the region, the gas supply-demand balance will continue to tighten, particularly if no major changes are introduced to the parameters of production and consumption (pricing, investment terms, etc.), resulting in all likelihood in the region – minus Qatar – facing on aggregate a net deficit of gas by 2020.

III. THE ISSUE OF REGIONAL GAS TRADE

The Arab region is among the least economically integrated in the world. This is due to a number of historical factors, most notably the weakness of the private sector and the lack of political willingness to integrate. This could not be more relevant for natural gas, which has been poorly traded among Arab countries, even when gas shortages in gas-rich countries were unknown to the region. To date, only two regional pipeline projects are in operation in the Arab region, namely Dolphin and the Arab Gas Pipeline (AGP),[4] and intra-regional trade – both pipeline and LNG – represented around 12 percent of total Arab gas exports in 2011 (Table 1).

The failure to build an integrated Arab gas market over the years can be attributed to two main factors. The first relates to the fact that, when gas resources were being developed in the oldest exporting countries of Algeria, Libya and the UAE, gas markets in the region were too small to justify investment in regional transport infrastructure. Producers and foreign investors needed the long-term offtake and financial guarantees that larger markets in Europe, Asia and the US could provide in order to justify the sizable capital commitments necessary for the development of export gas projects, both pipeline and LNG. As such, exports to neighbouring countries were at best seen as a possible offshoot prospect relative to the main export projects.

THE ROLE OF THE PRIVATE SECTOR IN DEVELOPING NATURAL GAS IN THE ARAB WORLD

Majid H. Jafar

The natural gas resources of the Arab World present the region with an important opportunity to enhance the sustainable energy policies through reducing both energy costs and carbon emissions while boos ting regional economies and employment. But realising this potential will require the correct policies to be put in place by regional governments, most especially encouraging the role of the private sector through improving the investment framework for exploration and production and tackling wasteful and distorting subsidies in the market for gas.

The Arab World has only just begun to develop its natural gas resources. The region contains over 40% of the world's proven gas reserves, and in fact most of this was discovered in decades past by accident when looking for oil. It is only relatively recently that natural gas has been a sought after energy resource in exploration activities – and the potential for finding more gas is still considerable. For example in Qatar the North Field, now recognised as the world's largest gas field, was left undeveloped for over 20 years when it was first discovered.

Today however it is clearly recognised worldwide that if coal was the fuel for the 19th century and oil for the 20th century, then natural has is clearly the fuel of choice for the 21st century, especially for electricity generation and to fuel industry. This is especially so in the Arab World, with developing economies and fast-growing populations with rising energy needs.

It should also be recognised that natural gas is a clean fuel, with a third of the carbon emissions of coal and none of the dangerous pollutants of nitrous or sulphur oxides. It is also a more affordable fuel, enabling substantial fuel budget savings, and can play an important role as a transition fuel from solid and liquid fuels to renewables and a more sustainable energy mix – a transition that usually takes many decades.

When looking at the developing economies, it is interesting to compare the United States with Europe. The United States, thanks to the shale gas revolution which has enabled a boost in US gas reserves and production and reduced local prices of gas, has also ended up reducing carbon emissions to the lowest level in over 20 years, far exceeding the Kyoto targets to which it had previously refused to commit. And in the process the lower energy costs has also made the US more economically competitive, with heavy industries such as petrochemicals now re-establishing and rivalling GCC production. The US may soon even become an exporter of gas in fact, and all this has been due to a vibrant private sector with many small companies exploring and developing this important sector with the latest technology.

Europe on the other hand, following a policy of subsidising costly and inefficient renewables, has ended up suppressing the proper development of its natural gas sector, and is now forced to import coal from the US to burn for power generation – an irrational policy that has seen energy costs rising fast and carbon emissions increasing instead of decreasing in major economies like Germany. It is therefore very important than the Arab World learns from the experiences of other regions and establishes the best policies from the outset to develop and properly utilise its large energy sources.

The historic state-driven development of the upstream exploration and production sector for natural gas has left the Arab World with the combination of large reserves but relatively low production - with over 40% of proven global gas reserves, but only 20% of global gas output. Consequently, the region has the longest gas 'reserve life' in the world, able to produce at current levels for at least 130 years, compared to the global average of 64 years.

The investment challenge to achieve this energy transformation will be great, and the International Energy Agency (IEA) estimates that this region will need to invest over US$2.2 trillion in the next 25 years to keep oil, gas and power infrastructure up to the required level. Ensuring energy policies most conducive to delivering this investment will better place the region to build on its competitive advantage in sustainable energy policy for the long-term.

The nature of the natural gas industry makes the private sector is uniquely well-placed to play an important role in the development of this crucial industry for the Arab World: the large investment requirements in midstream and downstream sectors such as pipelines and processing equipment, the complex project management requiring commercial as well as just technical skills, and the

natural linkages to heavy industry and petrochemicals. All these call for an enhanced role for the private sector and especially regional companies.

But governments in the region need to urgently make the correct policy choices to encourage private sector investment in this crucial industry, or it will remain unfulfilled potential and the sustainability of economic development will be put at risk. Already we see signs of these risks – with every Arab country today apart from Qatar suffering from gas shortages. Looking at three important regional examples: Egypt's gas production has been declining for the past 4 years while its demand grows 10% annually due to local subsidies, meaning its exports of gas may soon disappear and it may be forced to import expensive gas from abroad. Saudi Arabia burns crude oil in power stations at a cost of over US$100 per barrel and causing pollution and damage to turbines, while it natural gas is sold at the equivalent of US$4 per barrel. And Iraq flares over 1 billion cubic feet of gas per day while most of the country still has only a few hours a day of electricity and homes are forced to consume expensive liquid fuels in generators.

The key requirements are to enhance the investment regulatory regime for the upstream sector to create the proper incentives for the exploration and production of natural gas. These need to recognize the higher capital-intensity of gas investments and the significant infrastructure required in the midstream in terms of processing and pipelines, and the longer payback needed. And better incentives for upstream investment will of course also necessitate a market-related gas price high enough to justify the needed investment over the long-term. This is turn while also will require tackling subsidies to ensure proper market pricing in the downstream sectors such as power and industry market which utilize this important fuel.

The entire gas value chain needs to therefore be recognized and the correct incentives and regulations implemented at each stage to ensure overall success in encouraging the much-needed investment from the private sector in this manner. By doing so, Arab countries will ensure affordable long-term fuel supply for power and industry while achieving more rapid economic growth and employment, and at the same time reducing carbon emissions and facilitating the transition to a more environmentally-sound approach. All these form the basis for a more sustainable energy policy, for which the proper development of the regional gas industry by the private sector is a fundamental pillar.

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TABLE 1 **INTRA-ARAB PIPELINE GAS TRADE**

Pipeline	Source	Destination/ Transit	Nameplate capacity (Bcm/yr)	Deliveries in 2011 (Bcm/yr)	% of Arab exports
Arab Gas Pipeline	Egypt	Jordan Syria Lebanon	7	1.8	0.8
Dolphin	Qatar	Abu Dhabi	33	17.3	9.1
		Oman		2	
Trans-Continental lines					
Trans-Med	Algeria	Tunisia	33	1.8	0.8
GME	Algeria	Morocco	11.5	0.15	0.07
Total			84.5	23.1	10.9

Sources: BP (2012), Cedigaz (2012) and own analysis

Secondly, even as regional gas demand began to expand, the priority for Arab gas exporters remained far-away markets. Often, this was due to the lack of political trust between neighbouring countries, such that the deficit country would be unwilling to depend on its regional rival for imports of a strategic commodity such as gas, or, conversely, that the surplus country would be unwilling to supply its neighbouring competitor with a relatively cheap source of energy. This has been the case in North Africa, where Morocco only started receiving relatively small volumes of gas from Algeria in 2005 as in-kind payment for GME transit fees and in 2011 as contracted imports (Otman and Darbouche, 2011), and in the GCC, where Saudi Arabia would not even consider importing gas from Qatar.[5]

Even in the absence of explicit rivalry between neighbouring countries, the propensity of governments in deficit countries to expect favourable pricing terms from their exporting neighbour has been a major impediment to the development of intra-Arab gas exports in the post-1990s period. This is most pertinent in the case of both the AGP and Dolphin pipeline projects, which having initially benefitted from regional political support, were unable to be optimised subsequently because of the unwillingness of Jordan and the UAE respectively to pay (higher) international market prices for incremental gas shipments they so desperately needed.

By the end of the 2000s, it would appear that most gas-short Arab countries realised that they needed to pay international prices and/or overcome political differences in order to secure gas supplies from neighbouring countries, but this attitudinal shift came somewhat belatedly for some of them. As mentioned above, with the exception of Qatar, no Arab gas producer will be in a position to expand its exports by the end of the 2010s. Several exporters are looking to keep as much as gas as possible domestically to satisfy growing energy needs, and that is likely to translate into less or no exports to neighbouring markets. Deficit countries are left with no option but to import high-priced LNG or develop costly local gas resources in the short to medium term. However, with changing gas market conditions internationally (lower demand in Europe, lower prices in the US, Europe and possibly Asia), Arab gas exporters may in future be forced to turn by default to regional markets for the highest netbacks.

IV. THE ROLE OF GAS IN THE ARAB ENERGY TRANSITION

As mentioned above, the Arab region is home to abundant reserves of conventional gas, with a lot more potential for undiscovered resources (Aïssaoui, 2012). The bottlenecks experienced in recent years in the development of these resources originate primarily in unfavourable "above-ground" conditions, rooted in policy distortions and inefficiencies. With the Arab region being both among the most energy-intensive and the fastest growing energy-consuming economies in the world, according to the World Bank (2009), natural gas has the potential to play a significant role in meeting the region's growing energy needs and improving its energy efficiency. By virtue of its affordability, cleanliness and abundance relative to other fossil fuels, gas can help deliver the needs of Arab countries, be they sustainable energy supply, economic development/diversification or regional integration.

However, the investment challenge associated with delivering the energy mix that the Arab region requires is not insignificant. The IEA in its 2010 and 2011 World Energy Outlook reports estimates that the investment needs of the Middle East[(6)] in the gas sector alone will exceed US$ 600 billion in the period to 2035. APICORP Research estimates suggest that the capital required for the development of the Arab power sector between 2013 and 2017 will be in excess of US$ 213 billion (Aïssaoui, 2013). At a time of increased pressure on government expenditure in most Arab countries in the wake of the "Arab Spring" (Darbouche and Fattouh, 2011), delivering the capital investment needed for the development of adequate gas supply will require a delicate balancing act on the part of Arab governments. In turn, lack of resources will deprive Arab national oil companies (NOCs) of the ability to execute new project, as well as increase their dependence on foreign expertise and investment. However, international oil companies (IOCs) are unlikely to be forthcoming in the absence of attractive investment conditions.

The latter point is particularly relevant in the context of expanding unconventional gas resources globally, particularly in North America. This not only attracts IOCs away from Arab markets if these continue to present more challenging investment conditions than unconventional gas "hotspots" and other emerging gas provinces, such as the East Mediterranean and East Africa, but it could also mean that Arab gas supply loses its competitiveness against more-cheaply produced gas from other regions. This is a particularly threatening prospect for Qatar, which, although its LNG export projects can breakeven at low prices, still needs a minimum levels of returns to be able to meet its domestic and international financial commitments. Arab countries introduce meaningful reforms to liberalise their gas markets, encouraging more private sector involvement and greater efficiency along the value chain, the potential of gas in the region will remain under-realised.

V. RECOMMENDATIONS

Allowing gas to play a greater role in future Arab energy and economic development requires a change of energy policy across the region, focusing on pricing reforms and private sector involvement. This is all the more pertinent considering that gas exploration in a growing number of Arab countries will be focused on unconventional resources, and that these require an overhaul of the State-led business model that has dominated the upstream hydrocarbon sector in the region for the past 40 years.

- ***Pricing reforms***

As alluded to above, the prevailing policies of artificially-low gas prices are not without adverse consequences for the gas sector, the economy as a whole and for social equity in Arab countries. In essence, their outcome is often dislocated from governments' own objectives and indeed from the objectives that ought to guide governments' pricing policies, namely the efficiency of resource allocation, the satisfaction of specific financial targets, and considerations of social equity.

For a start, low prices result in distorted consumption patterns, inducing greater demand for gas than would otherwise result if consumers paid the (higher) opportunity price. They also produce a bias in terms of investment in favour of gas export infrastructure at the expense of the domestic market, in cases where exports of gas are allowed. They can affect government fiscal and trade balances, especially in countries with relatively limited fiscal headroom and resource endowments, and even the long-run growth potential of an economy. And, as is well known, universal subsidies are not the most efficient means of redistributing income, or improving access to energy for the poorer segments of society.

There is generally no consensus on the appropriate market pricing mechanism for gas within the Arab region. Several energy-rich countries in the region do not consider opportunity cost to be the right basis for gas pricing for them, advocating instead the use of the marginal cost of supply plus a depletion premium (Darbouche, 2012). This is a view that has become increasingly accepted recently, even in international fora where the prevailing economic view is that opportunity costs should be the basis of domestic pricing (OPEC, the IEA, OECD and the World Bank 2010). However, there are numerous pricing reform experiments around the world from which lessons can be learnt, in accordance with the needs and prevailing conditions in the respective countries. In the subsidy reform programme introduced by the Iranian government in 2010, but suspended two years later (Amuzegar, 2012), the new pricing mechanism consisted of an up-to-75 percent indexation to the Iranian gas export price index. In Nigeria, new market reforms introduced a multi-tiered pricing system whereby gas would be priced on a cost of supply basis for a "strategic sector" such as power generation, on a product netback basis in industrial sectors where gas is used as feedstock, and on an alternative fuels basis where it is used as fuel.

Oman and Egypt are the only Arab gas exporting countries to have attempted to introduce pricing reforms in recent years, though their efforts, as is usually the case in the region, have focused on price levels rather than price formation. The governments in both countries announced the promulgation of new prices for industrial users, from US$ 1 to US$ 3/MMBtu in Oman and from US$ 3 to US$ 6/MMBtu in Egypt (Darbouche, 2013). While these price increases may provide fiscal and commercial relief for governments and producers in both countries in the short term, they are unlikely to deal with the challenges facing the gas sector in these countries in the longer term. What's more, without addressing the pricing of energy products associated with gas, particularly power and water, in other words in consuming sectors, standalone gas reforms will often have the effect of merely displacing distortions in time and to other parts of the energy system.

Thus, while governments deal with the issue of gas prices in different ways and at varying paces, such that their domestic social, economic and political priorities are protected, it remains important that their reform efforts are aimed at initiating a shift to a sustainable energy system in the long term where natural gas can play a greater role in the Arab energy transition and future economic development.

- ***Private sector***

Liberalising gas prices without improving the involvement of the private sector would be somewhat contrary to the logic of pricing reforms, whose aim is partly to create a competitive environment. The realisation of the full potential of the Arab upstream gas sector requires innovation and efficiency, and the private sector, working alongside the State as the owner of the resource, can deliver both. This is particularly true considering, as mentioned above, that a growing number of Arab countries will be turning to unconventional gas resources as a source of their future energy supply.(7)

Key to international upstream gas success stories in recent years are private sector players. In the US, the shale gas "boom" was driven by a multitude of small- to medium-sized service companies, the most successful of which have since been taken over by IOCs keen to acquire the technology and expertise that they developed over the years. In the East Mediterranean, Noble Energy, an independent US company, transformed almost single-handedly the fortunes of the Levant countries from net energy importers to potentially self-sufficient gas producers. Similarly, the emergence of East Africa as a new gas "frontier" was led by private-sector companies such as Anadarko, BG Group, Cove Energy and Ophir Energy. In the Arab region itself, the most recent success story, Qatar, would not have been possible without the partnering strategy of Qatar Petroleum with international companies. All of this goes to show that the private sector is as important to Arab gas market development as pricing and other market reforms.

VI. CONCLUSION

Energy demand in the Arab region will continue to grow in a sustained fashion in the coming years in the absence of meaningful changes to consumption patterns and energy efficiency. The region's role in international oil and gas trade will be determined by the extent to which domestic supply is able to keep up with demand growth. Based on recent trends, it would appear that the Arab region is headed for an energy transformation that will see it shift increasingly towards becoming a demand centre, with growing import requirements and the bulk of its incremental hydrocarbon production being consumed within the region.

Gas, of which Arab countries hold sizable reserves, has the potential to play a significant role in satisfying the region's energy needs, while at the same time helping it reduce energy intensity and improve efficiency. However, hampered by systemic policy distortions, the use of gas in the Arab region, though growing, remains sub-optimal in a number of countries. To unlock its potential in the long term, energy policies across the region need to be reformed, such that gas prices are more liberalised and private sector players are better able to contribute to delivering value to Arab States and consumers.

While there are emerging signs of a reform drive across the region, efforts remain piecemeal and vulnerable to the effects of socio-economic pressures on governments, particularly in the post-"Arab Spring" environment. More importantly, governments in the region have yet to articulate a clear vision for the sustainable development of their energy systems and the optimisation of their contribution to long-term economic development. As far as gas is concerned, it is as yet unclear whether Arab governments see it as a transition fuel to a more carbon-neutral energy future based on the much-talked-about solar – and to a lesser extent nuclear – power, or as a destination fuel. Until such a vision is expressly formulated, efforts to promote a greater role for gas in the Arab energy transition risk remaining prone to changing conjunctural priorities.

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NOTES

1. According the BP Statistical Review of World Energy (2012), global proven gas reserves increased by almost 50% in the last twenty years, reaching just under 200 trillion cubic meters (Tcm) in 2011, while cumulative production over the same period stood at over 53 Tcm.

2. In 2012, Arab gas reserves were estimated at around 55 Tcm (Cedigaz, 2012).

3. Excluding Qatar, the growth rate of Arab gas supply drops to 3.7%.

4. Algeria's Transmed and Gazoduc Maghreb-Europe (GME) systems are not regional gas pipelines per se, given that they were originally designed as trans-continental systems and that the share of their deliveries to Tunisia and Morocco represents only a fraction of total shipments to European markets.

5. Admittedly, there may be more to Saudi Arabia's gas import policy than just political rivalry with Qatar. For more details, see: Fattouh, Bassam (2011). "The Saudi Gas Sector and its Role in Industrialisation: Developments, Challenges and Options." In Natural Gas Markets in the Middle East and North Africa (eds. Bassam Fattouh and Jonathan Stern). OIES/OUP, Oxford.

6. In other words, including Iran but excluding North Africa, but providing a useful proxy.

7. Algeria, Saudi Arabia, Oman, Kuwait and the UAE are regional frontrunners in the exploration of unconventional gas resources – Algeria and Saudi Arabia are targeting shale gas, Kuwait and Oman tight gas, and the UAE "sour" gas.

Renewable Energy

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The renewable energy (RE) market in the Arab region has evolved rapidly in recent years with a diverse range of countries announcing projects and policies.

Hydro for electricity generation and biomass for cooking and heating are the two dominant RE sources. However, declining cost of modern renewables and increasing costs of fossil fuels foster the promotion of technologies like wind and solar to meet growing energy needs.

With a total of 1 GW of installed capacity, wind is the second largest power source in the region. Egypt is the leader with 550 MW.

Similar to global trends, solar PV has been growing most rapidly in the region, although its share of the total demand is still modest. The United Arab Emirates is the leader in the region in PV electricity generation with 22.5 MW of installed capacity. Egypt, Mauritania, and Morocco follow with about 15 MW each. Algeria, Bahrain, Libya, and Saudi Arabia have around 5 MW of installed capacity.

In 2011, 30 percent of the countries operating CSP plants in the world were located in the Arab region: Algeria, Egypt and Morocco. In 2013, they were joined by the UAE which operates the world's largest CSP plant, Shams 1.

Solar Hot Water Heating accounts for about 4.8 million square meter of collector area, representing 3.3 GWth of installed capacity, most of which is in the net oil importing countries NOIC thanks to successful promotional schemes such as PROSOL and PROMASOL in Tunisia and Morocco.

As of April 2013, 64 projects, totaling almost 6 GW of new renewable capacity were in the pipeline (large hydro excluded) – a 4 fold increase over existing capacity.

As of early 2013, 16 of the 22 Arab countries had enacted at least one RE enabling policy, such as feed-in tariffs, fiscal incentives, and public financing, and 20 now have policy targets, up from 5 in 2007.

New investment in the Arab countries totaled USD 1.9 billion in 2012, a 6 fold increase compared to 2004.

Saudi Arabia, UAE, Egypt, Morocco and Tunisia, in particular, have developed policy frameworks to stimulate local manufacturing and innovation.

The Arab countries RE market is far from having reached its full potential. Today we notice promising signs of development through pipeline projects and increasing political commitments. However, the rising interest and activity in renewables occurs at a time of ongoing regional political uncertainty, raising concerns about the financing of RE. Moreover, several challenges remain to be addressed to decrease reliance on public and soft financing, and foster private investment. If the current efforts are continued, progresses should follow and lead to massive introduction of renewables that will change the energy landscape of the region within the next decades.

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I. INTRODUCTION

The renewable energy (RE) market in the Arab countries[1] is rapidly expanding, with a diverse range of countries announcing projects and policies to harness the region's abundance of RE resources for economic growth and energy security enhancement. While capacity additions and investment remain below those of other regions, recent years have seen a sea-change in government and commercial interest. Significantly, RE is also emerging as a complement to oil and gas reserves for exporting countries. With their strong demographic growth, urbanization, expanding economy, and growing energy intensity, as well as high temperatures and scarce water, the Arab countries are experiencing marked increases in energy and electricity demand. This growth is projected to become even more pronounced over the coming years and puts considerable stress on both domestic fossil fuel imports and export oriented hydrocarbon resources. RE accordingly offers a potentially significant supplement to energy supply, as well as opportunities for economic and social development, industrial diversification, electricity exports, better environmental and carbon footprints, new value-chain activities, a higher value adding use of existing fossil resources, and/or reduced reliance on imports (and exposure to climbing fossil fuel prices).

II. REGIONAL MARKET AND INDUSTRY OVERVIEW

A. Trends in Final Consumption

Total Primary Energy Supply (TPES) reached about 580 Million tons of oil equivalent (Mtoe) in the Arab countries in 2010, a 14.7% increase compared to 2007 (14.7% in the net oil exporting countries (NOEC) and 15.1% in the net oil importing countries (NOIC) respectively), or a 4.7% annual average growth rate over the period. The drivers of increased energy consumption in the region are population growth and increased prosperity, with related increases in demand for liquid and electric fuels, and electricity for domestic use and devices, heating, cooling and desalination of water. RE use increased by almost 20% in the NOIC over the same period of time, and gained market shares over conventional energy sources.

In 2010 the share of renewables in the Total Primary Energy Supply (TPES) of the Arab countries was about 3%. A notable difference existed between NOEC and NOIC. The share of renewables in the TPES of the NOEC was only 2.8%, what was mainly due to Sudan's strong reliance on traditional biomass, whereas this share reached 6.3% in the NOIC. See Table 1.

Biomass for cooking and heating and hydro for electricity generation are the two dominant RE sources in the region. However, not all Arab countries rely on traditional biomass, which has undesirable health and environmental impacts[2] or have access to low cost, baseload hydro power sources. Given declining cost of modern RE technologies and increasing costs of fossil fuels, technologies such as wind and solar have quickly been brought into consideration to meet growing energy needs in the region. Not surprisingly, interest in RE is particularly strong in the NOIC such as Jordan, Morocco, and Lebanon, where price exposure is highest.

The NOEC are more reliant on traditional renewables; hydropower (Iraq and Syria) and biomass (Algeria, Libya, Sudan, and Yemen) to meet their energy needs than the NOIC. Indeed, with the exception of Egypt (wind), growth in modern renewables, essentially wind and solar, is mainly notable in Morocco and Tunisia.

B. Power Sector

As evidenced by the number of projects coming, and their scale (see Table 3), as well as the targets set by most of the countries (see III. Policy Landscape, B. Policy Targets), substantial RE deployment is well underway in the Arab countries for the next two decades. However, for new projects to be successfully implemented and therefore leading to reaching the countries' ambitious goals, transparent, stable and incentivizing policy frameworks are required to reduce uncertainty, and offer mid- to long-term visibility and profitability for investors.

Hydropower is the primary RE source for power generation in the region today. For instance, Egypt has about 2.8 GW of installed capacity and some other countries over 1.5 GW; Iraq, Morocco, and Sudan. Hydro being a mature

TABLE 1 **SHARE OF RENEWABLE ENERGY (RE) IN TOTAL PRIMARY ENERGY SUPPLY (TPES) OF THE ARAB COUNTRIES (2010)**

	TPES (Mtoe)	Renewables (Mtoe)	Share of Renewables in TPES (%)
Algeria	40.4	0.1	0.2
Bahrain	9.8	0.0	0.0
Egypt	73.3	2.8	3.8
Iraq	37.8	0.4	1.2
Kuwait	30.8	0.0	0.0
Libya	21.1	0.2	0.8
Oman	20.0	0.0	0.0
Qatar	47.5	0.0	0.0
Saudi Arabia	149.0	0.0	0.0
Sudan	16.2	11.4	70.7
Syria	23.1	0.2	1.0
United Arab Emirates	61.2	0.0	0.0
Yemen	7.2	0.1	1.5
Total NOEC	**537.4**	**15.2**	**2.8**
Comoros	no data	no data	no data
Djibouti	no data	no data	no data
Jordan	7.2	0.1	1.9
Lebanon	6.4	0.2	3.3
Mauritania	no data	no data	no data
Morocco	16.5	0.8	5.1
Palestine	no data	no data	no data
Somalia	no data	no data	no data
Tunisia	9.5	1.4	14.4
Total NOIC	**39.6**	**2.5**	**6.3**
TOTAL	**577.0**	**17.7**	**3.1**

Source: IEA/OECD (2012). Renewables Information 2012. International Energy Agency, Paris.

technology and its potential relatively limited to exploit in the region, prospects for its further development are not as bright as for other technologies.

Beyond hydropower, wind energy was the most common source of renewable electricity production in the region (Egypt, Morocco, and Tunisia). As of the end of 2012, at least 7 Arab countries had wind power capacity. With 550 Megawatts (MW), Egypt is the leader in the region. It is now followed by Morocco, more than 290 MW, and Tunisia 154 MW, which has experienced strong growth over the last five years with wind power capacity increasing 8-fold from 2008 to 2012.

Although solar energy share remains relatively modest today, it is rapidly growing in the region due to its significant potential. All countries use solar photovoltaic (PV) to meet a part of their electricity demand. The United Arab Emirates is the leader in the region with 22.5 MW of installed capacity. Egypt, Mauritania, and Morocco follow with about 15 MW each. Algeria, Bahrain, Libya, and Saudi Arabia have around 5 MW of installed capacity. It must be noted here that the lack of recent data for solar

TABLE 2 **INSTALLED RENEWABLES CAPACITY DATA IN THE ARAB COUNTRIES**

		Installed Capacity (MW)					
		Solar		Wind	Biomass & Waste*	Geothermal	Hydro
		PV	CSP				
NOEC	Algeria	7***	25*	0*	0**	0**	228*
	Bahrain	5**	0**	0.5**	0**	0**	0**
	Egypt	15*	20*	550*	0**	0**	2,800*
	Iraq	3.5****	0**	0**	0**	0**	1,864*
	Kuwait	1.8***	0**	0**	0**	0**	0**
	Libya	4.8*	0**	0**	0**	0**	0**
	Oman	1***	0**	0**	0**	0**	0**
	Qatar	1***	0*	0*	40*	0*	0*
	Saudi Arabia	~7 (2013)	0**	0**	0**	0**	0**
	Sudan	2***	0**	0**	55.5**	0**	1,590*
	Syria	1***	0**	0**	0**	0**	1,151***
	UAE	22.5*	100 (2013)	0**	3*	0**	0**
	Yemen	1.5*	0**	0**	0**	0**	0**
NOIC	Comoros	0***	0**	0**	0**	0**	1****
	Djibouti	1***	0**	0**	0**	0**	0**
	Jordan	1.6*	0**	1.4*	3.5*	0**	10*
	Lebanon	1*	0**	0.5*	0**	0**	282*
	Mauritania	~15 (2013)	0**	0**	0**	0**	30*****
	Morocco	15*	20*	291*	0**	0**	1,745*
	Palestine	1*	0**	0**	0**	0.023*	0***
	Somalia	0***	0**	5*		0**	
	Tunisia	4*	0*	154*	0**	0**	66*

Source: REN21
*2012 data
**2011 data
***2010 data are rounded to closest MW
****2009
*****2008
Note: 2010 solar PV capacity are Megawatt peak (MWp)

PV, which is notably due to its decentralized characteristic, drives us to an under assessment of its current real development.

Concentrating Solar Power (CSP) will also contribute to the growing share of solar energy in the region. In 2011, 30% of the countries operating CSP plants in the world were in Arab countries, namely: Algeria, Egypt, and Morocco. In 2013, these countries were joined by the United Arab Emirates. The country became a major player in the CSP market when Shams 1, the world's biggest CSP plant with an installed capacity of 100 MW, started operation in March 2013.

While growth of solar technologies is expected to be significant, they will need to overcome environmental challenges; especially water scarcity. Indeed, CSP plants often use water for cooling at the back-end of the thermal cycle and for cleaning dust and sand accumulated on mirrors. Solar panels efficiency is also affected by dust and sand. These requirements may result in

TABLE 3 **PIPELINE PROJECT CAPACITY ESTIMATES BY TECHNOLOGY**

	Installed Capacity in the Pipeline (MW) (number of projects)					
	Solar	**Wind**	**Biomass & Waste**	**Geothermal**	**Small Hydro**	**TOTAL**
Algeria	175 (5)	20 (2)				195 (7)
Bahrain			25 (1)			25 (1)
Egypt	106 (2)	1,070 (5)			32 (1)	1,208 (8)
Libya		610 (5)				610 (5)
Oman	407 (2)					407 (2)
Saudi Arabia	125 (4)					125 (4)
Syria		290 (3)				290 (3)
UAE	113.8 (3)	30 (1)	101 (2)			244.8 (6)
Yemen		60 (1)				60 (1)
Total NOEC	**926.8 (16)**	**2,080 (17)**	**126 (3)**	**0 (0)**	**32 (1)**	**3,164.8 (37)**
Djibouti				50 (1)		50 (1)
Jordan	400 (4)	360 (4)				760 (8)
Morocco	172.7 (3)	1,553.07 (12)	1.6 (1)			1,727.37 (16)
Tunisia	5 (1)	100 (1)				105 (2)
Total NOIC	**577.7 (8)**	**2,013.07 (17)**	**1.6 (1)**	**50 (1)**	**0 (0)**	**2,642.37 (27)**
TOTAL	**1,504.5 (24)**	**4,093.07 (34)**	**127.6 (4)**	**50 (1)**	**32 (1)**	**5,807.17 (64)**

Source: Bloomberg New Energy Finance BNEF (2013) dataset, Clean Energy Investment Trends.
Notes: These figures only include renewable energy power generation sectors for projects greater than 1MW. Programmes for grid access and/or residential PV schemes or solar water heating are not within the scope of the BNEF database and are therefore excluded here. The BNEF dataset does not provide data for Comoros, Mauritania, Somalia, and Sudan.

difficulties in arid areas, in particular in countries where water use is essential for agriculture.

Modern biomass and geothermal for power are the least exploited energy sources in the region. Jordan, Qatar, Sudan and the United Arab Emirates are the only countries with installed capacity for biomass. Palestine is currently the only country with geothermal although Algeria, Djibouti, Saudi Arabia, Sudan, and Yemen have plans in the pipelines. Compared to wind and solar, the deployment of these technologies is not currently expected to expand significantly.

Over 60 active RE projects are under-construction or being planned throughout the Arab countries for a total of almost 6 Gigawatts (GW)(3). The large majority are wind and solar projects: 4.1 GW from wind and almost 1.5 GW from solar. See Table 3.

Projects in the region are dominated by Wind: about 53% of projects and over 70% of renewables capacity in the pipeline, and Solar: 38% of projects and over one-fourth of capacity in the pipeline. Biomass and waste-to-energy projects account for 6% of projects, but only 2% of installed capacity in the pipeline due to the fact that half of them are small scale. There are a few projects in small hydro and geothermal.

Morocco and Egypt noticeably have the greatest projected growth in RE capacity over the coming years, with a mixed wind-solar program in Morocco, and new wind energy capacity installations in Egypt's El-Zeit and Suez areas.

C. Heating and Cooling Sector

Solar Water Heating (SWH) systems play an important role in the region, with about 4.8 million square meters of collector area, representing over 3.3 gigawatt thermal (GWth) of installed capacity, of which most are in the NOIC. It is worth noting that the energy equivalent of SWH installed capacity in the Arab

TABLE 4 **SOLAR WATER HEATING INSTALLED CAPACITY DATA IN THE ARAB COUNTRIES**

		Total Capacity (megawatt thermal MWth)	Total Collector Area (m^2)
NOEC	Algeria (2012)	0.21	300
	Egypt (2012)	525.0	750,000
	Libya (2012)	0.021	30
	Syria (2010)	420.0	600,000
NOIC	Jordan (2012)	350.0	500,000
	Lebanon (2012)	245.0	350,000
	Morocco (2012)	245.0	350,000
	Palestine (2012)	1,120	1,600,000
	Tunisia (2012)	437.5	625,000

Sources: Regional Center for Renewable Energy and Energy Efficiency RCREEE (2013) except for Syria from OME (2012). Solar Thermal in the Mediterranean Region: Solar Thermal Action Plan. Observatoire Méditerranéen de l'Energie. Observatoire Méditerranéen de l'Energie, Nanterre, France.

countries is already more than double that of all other non-hydro RE. The variation in installed capacity between the Arab countries - especially the differences between the most advanced NOIC such as Palestine and Tunisia, and the others – indicate very substantial scope for further increases in SWH applications.

SWH has been a success story in some of the Arab countries, with some exemplary promotional schemes, in particular the PROSOL program in Tunisia and the PROMASOL program in Morocco, both in place for some years now. Jordan, Egypt, Syria are also good examples of countries that have taken advantage of SWH. With its relatively low user cost, simple technology, and quick pay-back period, SWH is a "low hanging fruit" of solar energy. In addition, much of the SWH equipment is manufactured in the region and installation cost accounting for about half of total capital cost accrue to local businesses and employees. The local value added and employment related to SWH is therefore significant.

D. Overview of Existing Regional Cooperation(s) in the Energy Sector

Interest in RE in the Arab countries has been stimulated by the development of some important regional and regionally-based institutions, including the Masdar project in Abu Dhabi; the International Renewable Energy Agency, 159 member countries intergovernmental organization headquartered in Abu Dhabi; the King Abdullah City for Atomic and Renewable Energy (K.A. CARE) in Saudi Arabia; the Qatar Foundation and Qatar National Food Security Programme (QNFSP), which have programs on RE; and RCREEE (Regional Centre for Renewable Energies and Energy Efficiency) based in Egypt. Finally, there are several active NGOs in the region, most of which are concerned mainly with the environmental aspects of RE.

JORDANIANS SELL SOLAR ELECTRICITY TO THE GRID

Khaled Al Khawaja

A new bill allows citizens, factories and institutions to install affordable solar systems and sell their surplus to the Jordan Electric Power Company (JEPCO), making the generation of solar power a new trend in Jordan

Engineer Basman Smeirat can now sell power for 12 piastres per 1 kilowatt, after he installed 16 solar panels at his two-story house in Al Fuheis city near Amman,. The panels can supply all his electric appliances and air conditioners, and even the solar heater, with electricity.

During sunny days, the mirrors can potentially produce up to 4 kilowatts, enough to supply an average household, with the surplus sold to Jordan Electric Power Company (JEPCO). Smeirat, an engineer, says that JEPCO installed a special device to monitor his household electricity consumption and the amount of electricity the panels provide to JEPCO. The electricity which JEPCO provides is consumed at night and during snowfalls, as the solar system is not fully efficient at these times.

Smeirat clarifies that installing the panels cost JD5600 (1JD equals 1.4 USD), to be paid within 5 years. The system would work for more than 25 years and require nothing more than dusting its panels. He indicates that waiving income and sales taxes off these panels helped encourage his family and relatives to install them. The cost used to exceed 10,000 JD, which means that waiving taxes cut 45 percent off the total cost.

Not only did the new system decrease power consumption costs, it has also become a source of income. In the past, the power bill used to range between 75 and 110 JD per month. It has now decreased to less than 13 JD.

Smeirat is not the only producer and seller of solar power in Jordan. In May 2013, seventy five other citizens and institutions were doing the same, pumping 15,000 kilowatts of solar power to JEPCO, and the number is increasing.

Smeirat could not sell power until Article 6 of the new energy bill (number 13, 2012) was issued. This Article permits anyone to directly submit an offer to the ministry or to whomever the government commissions, to invest in renewable energy. Article 10 also states that "any person, building or small renewable energy plant that generates power from renewable energy systems is authorized to sell power to those licensed to provide power, whether wholesale or retail."

There is a demand from citizens and companies to own this free power. However, tax exempts are valid for just the panels, while control devices, cables and panel holders are still taxable. Total dependency on solar power will not be completely realized unless batteries are installed to store power for nights and cloudy weather. This requires the government to decrease their high prices in order to provide an integrated power system.

Scientific studies have shown that solar radiation on each square meter in Jordan generates as much power as one barrel of oil per year. That means each square kilometer can generate as much power as one million oil barrels annually - and one day of solar radiation in the Ma'an governorate can fulfill the world's power needs for one day.

In Jordan, Philadelphia factory is the only producer of solar panels, but most of its production is exported due to low local demand and higher costs its products compared to Chinese products. Jordan generates around 2600 megawatts of electricity. Official statistics show that its power bill reached 3.6 billion JD in 2011 - 18 percent of Jordan's GDP - and had increased to 4.7 billion JD in 2012. Due to the suspension of Egyptian natural gas exports following a series of bombings targeting the Jordanian pipeline in 2011, the government estimated that additional costs of heavy fuel use in power production would be between 3 and 4 million JD daily.

Studies by Electricity Regulatory Commission (ERC) show that if 40 percent of household subscribers install solar power systems of 2 kilowatts each, their total generated power could reach 1750 megawatt/hour, resulting in saving 176 million JD annually, which is 12 percent of total government subsidies to the sector.

ERC states it is leading a "progressive revolution" to install solar panels. Following state universities and facilities and big factories, the government will start installing them in public buildings. A comprehensive media campaign is being run, urging all parties to benefit from these systems. The government has also allocated 66 million JD for renewable energy projects during 2013.

Khaled Al Khawaja is a Jordanian Journalist. The article was published in Al-Bia Wal-Tanmia, June 2013

TABLE 5 **RENEWABLE ENERGY SUPPORT POLICIES AND TARGETS IN THE ARAB COUNTRIES**

National Level (blue) — State Level (green)

		RE targets	RE Strategy or Plan	Regulatory Policies: FIT (incl. premium payment)	Regulatory Policies: Electric utility quota obligation/RPS	Regulatory Policies: Net metering	Regulatory Policies: Biofuels obligation/mandate	Regulatory Policies: Heat obligation/mandate	Regulatory Policies: Tradable REC (Renewable Energy Credit)	Fiscal Incentives: Capital subsidy, grant, or rebate	Fiscal Incentives: Investment /production tax credits	Fiscal Incentives: Reduction in sales, energy, CO_2, VAT, or other taxes	Fiscal Incentives: Energy production payment	Public Financing: Public investment, loans, or grants (incl. R&D)	Public Financing: Public competitive bidding
NOEC	Algeria	X	X	National											National
	Bahrain	X													
	Egypt	X	X			National				National		National		National	National
	Iraq	X	X												
	Kuwait	X												National	National
	Libya	X										National			
	Oman	X								National, State			National, State	National, State	National, State
	Qatar	X												National	
	Saudi Arabia	X												National	National
	Sudan	X	X									National			
	Syria	X		National		National					National			National	National
	UAE	X	X		State			State					State	State	State
	Yemen	X	X												National
	Total NOEC	**13**	**6**	**2**	**1**	**2**	**0**	**1**	**0**	**3**	**1**	**3**	**2**	**7**	**8**
NOIC	Comoros														
	Djibouti	X	X												
	Jordan	X	X	National		National	National					National		National	National
	Lebanon	X	X			National						National			
	Mauritania	X													
	Morocco	X	X											National	National
	Palestine	X	X	National		National						National	National		National
	Somalia														
	Tunisia	X	X			National				National		National		National	
	Total NOEC	**7**	**6**	**2**	**0**	**4**	**1**	**0**	**0**	**1**	**0**	**4**	**1**	**3**	**3**
TOTAL		**20**	**12**	**4**	**1**	**6**	**1**	**1**	**0**	**4**	**1**	**7**	**3**	**10**	**11**

Source: REN21

Three closely linked initiatives in the Arab countries are the DESERTEC Industrial Initiative(4), the MEDGRID consortium, and the Mediterranean Solar Plan (MSP). The DESERTEC initiative aims to export solar power from North Africa to Europe. The MEDGRID consortium aims to develop the necessary grid infrastructure (High Voltage, Direct Current) to allow this to happen. The MSP was launched in 2008 in the framework of the Union for the Mediterranean (UfM). It has two main objectives to be achieved by 2020: developing an additional 20 GW of RE production capacities and achieving significant energy savings throughout the region. Recent socio-political events linked to the Arab Spring in some parts of the Arab countries may, however, temporarily slow down the development of these promising schemes.

III. POLICY LANDSCAPE

A. Overview

A growing number of regional decision makers are aware that RE offers opportunities to renew their energy systems in a way that is safe, secure, non-polluting, non exhaustive, and increasingly accessible, while helping to meet the rising energy

TABLE 6 **OVERALL RE SHARE TARGETS IN THE ARAB COUNTRIES**

		RE overall targets and target dates
NOEC	Algeria	6% of electricity generation by 2015; 15% by 2020; 40% by 2030, of which 37% is solar (PV and CSP) and 3% is wind
	Bahrain	5% by 2020
	Egypt	20% of electricity generation by 2020, of which 12% is wind
	Iraq	2% of electricity generation by 2016
	Kuwait	5% of electricity generation by 2020; 10% by 2030
	Libya	3% of electricity generation by 2015; 7% by 2020; 10% by 2025
	Oman	10% by 2020
	Qatar	At least 2% of electricity generation from solar by 2020
	Saudi Arabia	20% electricity generation by 2032
	Sudan	--
	Syria	--
	UAE	Dubai: 5% of electricity by 2030, Abu Dhabi: 7% of electricity generation capacity by 2020
	Yemen	15% of electricity by 2025
NOIC	Comoros	--
	Djibouti	30% of rural electrification from solar PV by 2017 100% renewable energy by 2020
	Jordan	7% of primary energy by 2015; 10% by 2020
	Lebanon	12% of electrical and thermal energy by 2020
	Mauritania	15% of primary energy (excluding biomass) by 2015; 20% by 2020
	Morocco	42% of installed power capacity by 2020
	Palestine	25% of energy from renewables by 2020; 10% (or at least 240 GWh) of electricity generation by 2020
	Somalia	--
	Tunisia	11% of electricity generation by 2016, 25% by 2030; 16% of installed power capacity by 2016, 40% by 2030.

Source: REN21

TABLE 7(1) **RE CAPACITY TARGETS BY TECHNOLOGY IN THE ARAB COUNTRIES**

		Solar		Wind	Biomass, Geothermal, and Hydro
		PV	CSP		
NOEC	**Algeria**				
	by 2013	6 MW	25 MW	10 MW	--
	by 2015	182 MW	325MW	50 MW	--
	by 2020	831 MW	1,500 MW	270 MW	--
	by 2030	2,800 MW	7,200 MW	2,000 MW	--
	Bahrain	--	--	--	--
	Egypt				
	by 2020	220 MW	1,100 MW	7,200 MW	--
	by 2027	700 MW	2,800 MW	--	--
	Iraq				
	by 2016	240 MW	80 MW	80 MW	--
	Kuwait				
	by 2030	3,500 MW	1,100 MW	3,100 MW	--
	Libya				
	by 2015	129 MW	--	260 MW	--
	by 2020	344 MW	125 MW	600 MW	--
	by 2025	844 MW	375 MW	1,000 MW	--
	Oman	--	--	--	--
	Qatar				
	by 2020		640 MW	--	--
	Saudi Arabia				
	by 2022		17,350 MW	6,500 MW Wind/ Waste-to-energy/ Geothermal	
	by 2032	16,000 MW	25,000 MW	9,000 MW	3,000 MW Waste-to-energy, and 1,000 MW Geothermal
	Sudan				
	By 2031	250 MW	50 MW	320 MW	150 MW Biogas, Solid biomass 80 MW, and 54 MW Hydro
	Syria				
	by 2015	45 MW	--	150 MW	--
	by 2020	380 MW	--	1,000 MW	140 MW Biomass
	by 2025	1,100 MW	50 MW	1,500 MW	260 MW Biomass
	by 2030	1,750 MW	--	2,000 MW	400 MW Biomass
	UAE	--	--	--	--
	Yemen				
	by 2025	4 MW	100 MW	400 MW	6 MW Solid biomass, and 200 MW Geothermal

demand of their rapidly growing populations and potentially offering new economic and social development opportunities.

Twenty out of the 22 countries have RE targets, and a smaller number have established RE support policies, such as feed-in tariffs (FIT) or fiscal incentives. Specific rural electrification policies are mainly found in countries with low rural electrification rates. Other policies include direct state or state agency investment with or without external partners, and various kinds of R&D or scoping work. SWH policies have been important in these countries and have led to significant uptake in most cases, as well as the development of domestic manufacturing and supply chain activities in the region. Systems are low cost and pay-back for consumers are typically rapid.

TABLE 7(2) **RE CAPACITY TARGETS BY TECHNOLOGY IN THE ARAB COUNTRIES**

		Solar		Wind	Biomass, Geothermal, and Hydro
		PV	CSP		
NOIC	**Comoros**	--	--	--	--
	Djibouti	--	--	--	--
	Jordan by 2020	300 MW	300 MW	1,200 MW	--
	Lebanon by 2015 by 2020	-- --	-- --	60-100 MW 400-500 MW	15-25 MW Biogas, and 40 MW Hydro --
	Mauritania	--	--	--	--
	Morocco				
	by 2020		2,000 MW	2,000 MW	2,000 MW Hydro
	Palestine by 2020	45 MW	20 MW	44 MW	21 MW Solid biomass
	Somalia	--	--	--	--
	Tunisia by 2016 by 2030	140 MW 1,500 MW	-- 500 MW	430 MW 1,700 MW	40 MW Solid biomass 300 MW Solid biomass

B. Policy Targets

Over three-fourths of the Arab countries have RE share targets, which vary considerably from a country to another, and fifteen of them have targets by technology. See Tables 6 and 7.

Within the NOEC, Algeria, Egypt and Saudi Arabia are notable in having the most ambitious targets.

When overall targets are examined by technology, it clearly appears that wind and solar are seen as the main promising technologies, largely reflecting the quality of the RE resources in the region. In the choice of solar technologies, CSP, despite its higher current cost per unit of energy, is leading over PV. A number of countries are also setting targets for waste-to-energy, hydro and geothermal energy.

Targets for Solar Heating and Cooling do not often appear in the policy documents for RE, as they are often seen as energy efficiency measures. However, it is clear that a number of countries have increasingly ambitious SWH programmes, which have targets.

EGYPT'S FIRST CSP POWER PLANT IN KUREIMAT

Ibrahim Abdel Gelil

The Solar Atlas of Egypt was issued in 1991, indicating that Egypt, as one of the sun-belt countries, is endowed with high intensity of direct solar radiation ranging between 1970–2600 kWh/m^2/year from North to South. The sunshine duration ranges from 9–11 hours with few cloudy days all over the year.

In February 2008, the Supreme Council of Energy of Egypt, headed by the Prime Minister, approved an ambitious plan to have 20 percent of the total energy generation capacity from renewables by year 2020. As an incentive for the development of renewable energy, the government established a financial mechanism called the Petroleum Fund, where producers of non-fossil fuel electricity receive about 0.33 US cents/kWh. This mechanism accelerates development of renewable energy by sharing with developers the additional export revenues generated from fuel savings derived.

A site at Kureimat, nearly 90km South Cairo, was selected to construct the first Concentrated Solar Power Plant (CSP) in Egypt. The site, which comprises an uninhabited flat desert area, as selected for its high intensity direct solar radiation which reaches 2400 kWh/m^2/year, proximity to the extended unified power grid as well as natural gas pipelines, and proximity to water sources (primarily the Nile River). The project uses parabolic troughs for Integrated Solar Combined Cycle (ISCC) power plant. The trough tracks the sun and focuses solar energy on an absorber pipe located along its focal line to produce the required heat. The entire collector field has to be washed once a week with distilled water. The ISCC project consists of Combined Cycle Island (120 MW) and Solar Island (20 MW) with a total gross power capacity of approximately 140 MW. The project, including equipment,, facilities, interfaces and connections to the Grid, has recently started commercial operation. This resulted in a reduction in carbon dioxide emissions estimated at 20,000 tons per year.

Generally, solar thermal power plants are not yet competitive because of high capital costs and incomplete learning resulting due to the low level of deployment globally. Hence Global Environment Facility (GEF) support through a grant of US$ 49.8 million will help Egypt to cover the incremental cost of the project and bring down the long-term cost of the technology.

The construction of the ISCC Kureimat power plant started in January 2008 and reached commercial operation as a whole in June 2011. The plant is owned by the New and Renewable Energy Authority (NREA) of the Ministry of Electricity and Energy in Egypt. The total installed cost of the plant was about $290 million based on bids awarded and financed by the World Bank, GEF, and Japan Bank for International Cooperation (JBIC).

During construction, most labor force was hired locally and both the Combined Cycle Island as well as the Solar Island contributed to job creation. Road works and modifications of the main access roads, earthwork of leveling the site to erect the steel structures, civil engineering, erection of the solar collectors and excavation works of the electrical building in the Solar Island, were all performed with local manpower. In operation, the plant employs 220 local full time staff, including highly skilled engineers as well as unskilled laborers.

The project was designed to integrate conventional combined cycle gas turbines and solar thermal technology, with the strategic view of contributing towards introducing renewable energy in developing countries. It also aims at demonstrating how de-carbonizing the power sector could be facilitated by the large-scale development of new energy production technologies. It sets a precedent in introducing CSP technology in developing countries through the ISCC configuration, including making a substantial financial contribution to this project. The significant contribution made by the Government demonstrates its ownership of this Project(1). The ISCC plant brings useful lessons in the introduction of CSP technology through hybridization in developing countries by bringing down overall costs to 6-7 US cents/kWh.

Dr. Ibrahim Abdel Gelil, Professor of Sheikh Zayed Chair for Energy and Environment at Arabian Gulf University (AGU) in Bahrain, was CEO of the Egyptian Environmental Affairs Agency (EEAA) and Chairman of the Egyptian Organization for Energy Planning (OEP).

1. World Bank. 2004. Egypt - Solar Thermal Project (GEF). Washington D.C. - The Worldbank. http://documents.worldbank.org/curated/en/2004/02/3521140/egypt-solar-thermal-project-gef

TABLE 8 **SOLAR WATER HEATING TARGETS IN THE ARAB COUNTRIES**

NOEC	**Algeria**	
	by 2015	70,000 m² of collector area
	by 2020	490,000 m² of collector area
	Libya	
	by 2015	80 MW of installed capacity
	by 2020	250 MW of installed capacity
	by 2025	450 MW of installed capacity
	Syria	Installation of 100,000 m² of collector area per year
	UAE (Dubai)	For all new villas and labour accommodations, a SWH system must be installed to provide 75% of domestic hot water requirements.
	Yemen	230 GWth of generation per year
NOIC	**Jordan**	
	by 2015	25% of households equipped (from 14% in 2011)
	by 2020	30% of households equipped
	Lebanon	
	by 2020	1,050,000 m² of collector area
	Morocco	
	by 2020	1,700,000 m² of collector area
	Tunisia	
	by 2016	1,000,000 m² of collector area

Source: REN21

C. R&D Programmes

Throughout the region, R&D programmes for renewable energy begin to emerge. The section below describes the most relevant approaches in the region:

i. Saudi Arabia
Saudi Arabia will tax 1% of renewable energy projects to finance the Solar Energy Research Fund for local renewable energy research and development projects.

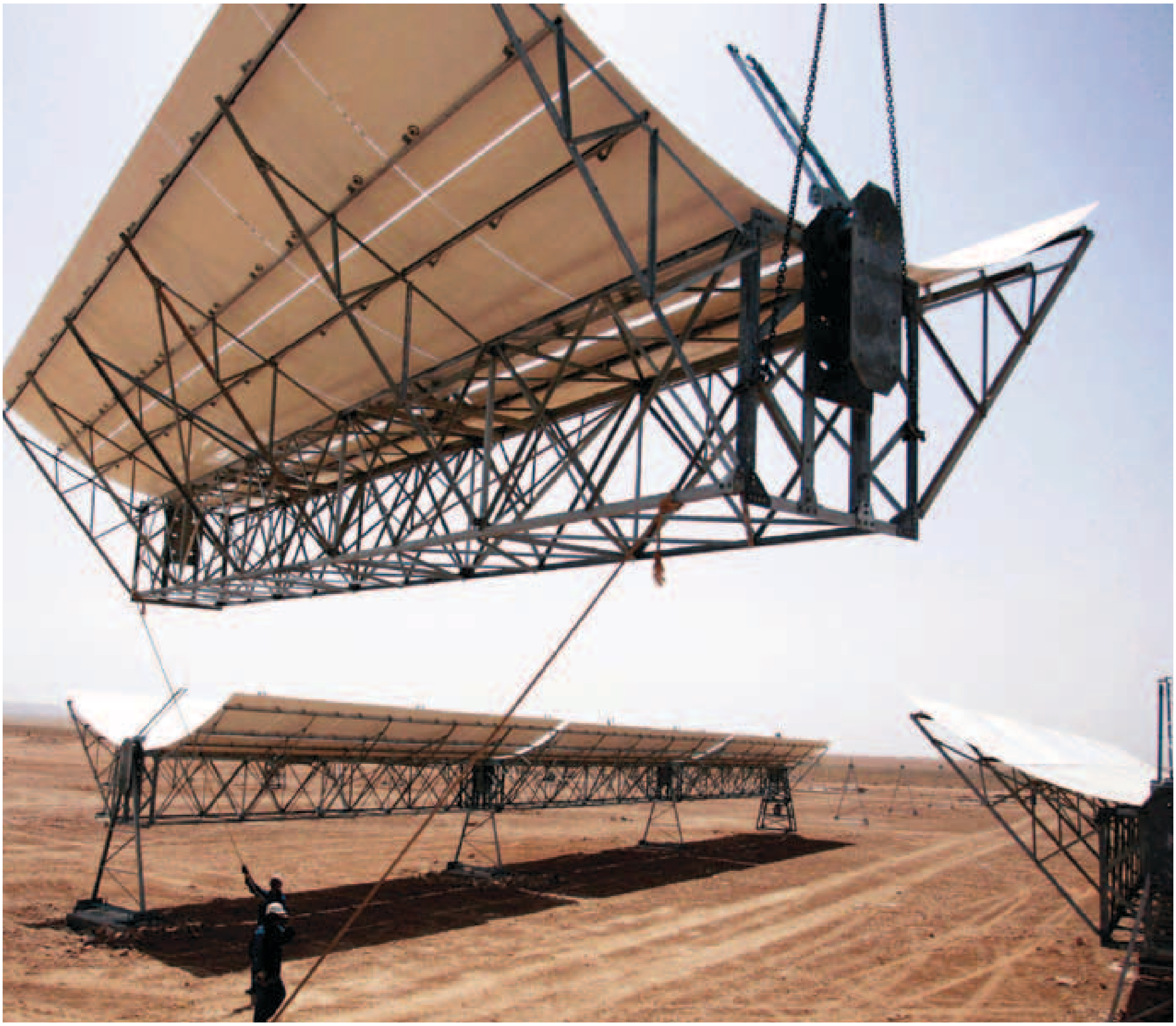
ii. United Arab Emirates
- Abu Dhabi has fostered R&D through the Masdar Institute, which has already produced the region's first-ever patents in clean tech, some with start-up company potential. The Masdar Institute of Science and Technology, in collaboration with IRENA and other partners, commissioned the UAE Solar Atlas.

- The northern Emirate of Ras Al-Khaimah has established a clean-tech campus with Switzerland's respected École Polytechnique Fédérale de Lausanne and a related clean-tech research and demonstration centre run by the Swiss outfit CSEM.

iii. Morocco
Morocco has established several educational, training, and research institutions to create local expertise including:

- National Agency for Renewable Energy and Energy Efficiency (ADEREE), which provides training programmes and R&D activities;
- MASEN, whose main role is to coordinate and implement solar projects in the country;
- Institut de Recherche en Energie Solaire et en Energies Nouvelles (IRESEN), a dedicated institute for research into solar and new energy launched in 2011 with the aim of creating synergies between universities and industrial partners and RD&D opportunities.

iv. Egypt
In Egypt the New and Renewable Energy Authority (NREA) is responsible for technical



evaluation, testing, R&D, and certification of wind turbines, and also aims to undertake training in operation and maintenance.

IV. ARTICLE 9 OF THE EU RENEWABLE ENERGY DIRECTIVE

The Directive of the European Parliament and of the Council (2009/28/EC) on the promotion of the use of energy from renewable sources indicates that one or more EU Member States may cooperate with one or more third countries on all types of joint projects regarding the production of electricity from renewable energy sources. Such cooperation may involve private operators.

Electricity from renewable energy sources produced in a third country shall be taken into account only for the purposes of measuring compliance with the requirements of this Directive concerning national overall targets if the following conditions are met:

a. the electricity is consumed in the Community,

b. the electricity is produced by a newly constructed installation that became operational after 25 June 2009 or by the increased capacity of an installation that was refurbished after that date, under a joint project and

c. the amount of electricity produced and

TABLE 9 **ELECTRIFICATION RATES AND RURAL ELECTRIFICATION, ARAB COUNTRIES, 2005 AND 2010**

		Electrification Rate %		Rural Electrification Rate %
		2005	2010	2010
NOEC	Algeria	98.1	99.3	97.9
	Bahrain	99.0	99.4	94.7
	Egypt	98.0	99.6	99.3
	Iraq	15.0	98.0	94.1
	Kuwait	100.0	100.0	100.0
	Libya	97.0	99.8	99.1
	Oman	95.5	98.0	92.9
	Qatar	70.5	98.7	68.8
	Saudi Arabia	96.7	99.0	94.4
	Sudan	30.0	35.9	28.1
	Syria	90.0	92.7	83.5
	UAE	91.9	100.0	100.0
	Yemen	36.2	39.6	23.1
NOIC	Comoros	-	46.0 [a]	-
	Djibouti	-	50.0 [b]	-
	Jordan	99.9	99.4	98.7
	Lebanon	99.9	99.9	99.2
	Mauritania	-	-	-
	Morocco	85.1	98.9	97.4
	Palestine	-	-	-
	Somalia	-	-	-
	Tunisia	98.9	99.5	98.5

(a): Electricity access rate for Comoros is for 2009 and from IRENA (2011). Renewable Energy Country Profiles Africa. International Renewable Energy Agency, Abu Dhabi.
(b): Electricity access rate for Djibouti is from World Bank (2009). Least Cost Electricity Master Plan, Djibouti (Volume 1 of 2: Main Report).
Sources: IEA/OECD (2006). World Energy Outlook 2006. International Energy Agency, Paris. And IEA/OECD (2012). World Energy Outlook 2012 (Electricity Access Database, Tables 2 and 5). International Energy Agency, Paris.

exported has not received support from a support scheme of a third country other than investment aid granted to the installation.

This provision will potentially have an impact on the development of dispatchable renewable electricity in the MENA countries in the coming years. However, a series of regulatory barriers on both sides of the Mediterranean still need to be overcome.

V. INVESTMENT FLOWS

According to Bloomberg New Energy Finance (2013), new investment in renewables in the Arab countries totaled 1.9 billion USD in 2012, an increase of 56% over 2011 and a 6-fold increase compared to 2004.

RE investments currently show the fastest rate of growth in the energy sector. However, investments in conventional energy will remain very important for the foreseeable future in the Arab countries.

Much of the investment in RE in the region is undertaken by the state or state-owned power companies, sometimes with donor support, especially in the Mediterranean countries. There are, however, also notable cases of joint ventures and some private activity, mainly for public clients and self-production, some of it on a very

large scale. For example, Terra Nex Financial Engineering AG (a wealth management company based in Switzerland) is involved in a large PV project in Oman (400 MW); Italgen SpA (an Italian based producer and distributer of electricity established by Italcementi, one of the largest cement manufacturers in the world) is in a 400 MW wind project in Egypt; France's hydrocarbon supermajor Total and Spain's Abengoa have 20% stakes in the recently commissioned 100 MW Shams 1 CSP project in the UAE. In Morocco, a consortium of Spanish companies, ACWAPower International (a Saudia Arabian company) and the Moroccan Agency for Solar Electricity (MASEN) are advancing a large solar-thermal project (160 MW). The Mediterranean Solar Plan (MSP) and the Desertec Foundation (a German-based foundation supported by 12 major German engineering, finance and utilities companies with RE interests, as well as the German Government[5]) are promoting the idea of significant future exports of surplus electrical energy to the European Union.

The MSP has galvanized support for RE from both sides of the Mediterranean. Since June 2008, over € 5 billion have been made available through the Neighborhood Investment Facility (NIF) for 12 projects in the region. In addition to this, the European Commission provides financial support to the European Investment Bank's Facility for Euro-Mediterranean Investment and Partnership (FEMIP).

VI. OFF-GRID RENEWABLE ENERGY

Most of the Arab countries have high rates of electrical access – 99% or more in 10 of the 19 countries for which data are available. See Table 9. However, only 5 countries have electricity access rates of at least 99% in rural areas, and 6 countries have less than 90% access in rural areas. The most

LOCAL MANUFACTURING AND VALUE CHAINS IN RE

Local content requirements for RE projects are increasingly discussed in the Arab countries. The reason is that employment creation, especially for youth, is one of the drivers of RE in the region. However, policy makers recognize the highly capital intensive nature of most RE, especially solar PV, CSP and Wind which are seen as the main RE technologies for the future in the region. As a result, there is a considerable interest in developing the supply chain and related innovations in RE technologies. This interest is particularly strong in the UAE, Saudi Arabia, Egypt, Tunisia and Morocco.

For instance, in the UAE 66 local companies participated in the construction of Shams 1 CSP plant. In February 2013, Saudi Arabia released a White Paper detailing the proposed competitive procurement process of its K.A.CARE program. Local content is a key criterion in the evaluation of project bids during the various K.A.CARE tendering rounds and will increase from 50 percent or higher, depending on the item or service introductory call, to 60 percent or higher in the first round, and 70 percent thereafter. In 2011, Egypt started to operate its first CSP plant in Kuraymat; about 40 percent of the value of the solar field was generated locally. In Tunisia, 80 percent of SWH systems sold are not imported, what can be notably explained by the government's decision to mandate a quality labelling system called "Qualisol" for installers who want to operate under the PROSOL scheme. In Morocco, the recent tender for a 160 MW CSP plant near Ouarzazate was awarded to ACWA Power, which plans to build the plant with almost 42 percent local content.

However, many challenges still remain. Wind and solar PV markets, although at different stages of development, can be considered relatively mature and competitive, presenting barriers to the entry of new firms. In the growing CSP market, opportunities exist at the lower end of the value chain, but the high-value components remain subject to patents; the few large international companies that own the intellectual rights to these technologies are reluctant to licence them or to establish local manufacturing plants. Further, the renewable energy innovation system in the region is still far from having reached its full potential, despite encouraging signs of new institutions like Masdar.

serious problems of electricity access in rural areas are in Sudan (28%) and Yemen (23%), Comoros and Djibouti.

Off-grid RE is a logical and frequently used solution for remote and rural areas, where providing grid access would be very costly, financial resources are scarce, and there are attractive RE resources.

The success of SWH in several countries with notable financial support models such as PROMASOL in Morocco and PROSOL in Tunisia, can be noted as a kind of off-grid solution since it typically concerns domestic, and sometimes office building, heat rather than electrical power. Donor agencies are also active in this field.

Because viable RE resources are typically located in rural regions, decentralized solutions, especially for serving small communities, are often to preferred on both economic and environmental grounds. Under the right conditions, the RE resources can also be used as a rural economic and social development tool through community ownership and management of energy production and related distribution and maintenance. However, this requires a very deliberate policy design, which thus far has not been given notable consideration in the Arab countries and worldwide.

VII. CONCLUSION

The Arab countries RE market is far from having reached its full potential. Today we notice promising signs of development through pipeline projects and increasing political commitments, which are the first steps towards a sustainable energy future. If the current efforts are continued, investments and progresses should follow and lead to massive introduction of renewables that will change the energy landscape of the region within the next decades.

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NOTES

1. For the sake of comparison, the 22 Arab countries were clustered into two sub-groups, namely:
Net Oil Exporting Countries (NOEC):
Algeria, Bahrain, Egypt, Iraq, Kuwait, Libya, Oman, Qatar, Saudi Arabia, Sudan, Syria, United Arab Emirates, Yemen, and
Net Oil Importing Countries (NOIC):
Comoros, Djibouti, Jordan, Lebanon, Mauritania, Morocco, Palestine, Somalia, Tunisia.

2. The United Nations Sustainable Energy for All Initiative has identified replacement of traditional biomass with modern RE services as an international priority.

3. The following figures are provided by Bloomberg New Energy Finance (BNEF). Pipelines projects include projects announced or which planning has begun (some preliminary development work has been done on the project and/or it has received preliminary approval from local authorities), projects permitted, and projects which financing has been secured or is under construction.

4. Desertec promotes the idea of generating sustainable power from the sites where renewable sources of energy are most abundant, like this is the case, with solar particularly, in the MENA region. According to calculations clean power from the deserts could supply around two-thirds of the MENA region's rising energy demand, while still leaving enough electricity for export, meeting 15% of European consumption. This vision of exporting the benefit of Desertec is sensitive and faces some hostility from local populations.

5. http://www.desertec.org/global-mission/milestones/. In 2009, the Desertec Foundation established the industrial initiative Dii GmbH together with partners from the industrial and finance sectors. Its task is to accelerate the implementation of the Desertec Concept in the EU-Middle East and North Africa region. As a shareholder, the Desertec Foundation closely cooperates with Dii GmbH and its additional shareholders and partners.

THE FUTURE OF ENERGY IN SAUDI ARABIA

Khalid Al Sulaiman

Saudi Arabia's sustainable energy vision, strategy, and execution roadmap together form potentially the cornerstone for energy sustainability in the region, and beyond.

Creating a better future for children and grandchildren, in Saudi Arabia and, indeed, everywhere else in the world, mandates that a workable energy future for all is created; an energy future that has several distinct characteristics. First, it has to be a collective effort. Second, it must be widely accessible. Third, it has to be affordable; and fourth, it must be sustainable.

These unique future energy attributes are exactly what characterizes Saudi Arabia's Vision for the future energy ecosystem that culminated in the creation of King Abdullah City for Atomic and Renewable Energy (K.A.CARE).

1. Collective Effort

From the beginning, an energy future for Saudi Arabia was formulated that is both interlinked and dynamically responsive to the regional as well as the global energy ecosystems, starting with the GCC region, the MENA region, and then the EUMENA region. The value proposition is one of collective effort, and is built upon an economically viable solution for all. Working together is in the best interest of the Saudi energy future, as well as that of the entire world.

The key challenge that the Saudi electricity sector faces is that during the offseason, in winter and parts of the spring and fall, 45% of the installed generation capacity remains idle. This is because cooling constitutes the largest single component of electricity demand, amounting to more than 50% during peak season, and significantly decreases during the offseason. That means that by 2030, when the peak demand will reach 100 Gigawatts (GWs), a whopping 45 GWs of installed capacity, at least, will remain idle.

One approach to tackling this issue is to deploy technologies that peak during the peak season and reduce their output during the off season. Solar energy has this very characteristic, and is an excellent candidate to mitigate part of this challenge. Yet, it cannot do it on its own.

Therefore, we have explored the potential of exporting electricity from the dormant capacity during our offseason to countries with peak demand was explored. Studies showed that grid investments required to wheel electricity generated in Saudi Arabia to the European Union does not exceed 18% of the total investment required to install the generating capacity.

If such a strong interconnection is realized, the overall economic benefits are stark and compelling. If we collectively reduce the need to install generation capacity by, 10-20% with the ability to trade energy collectively, the savings are tremendous.

Energy trading is only one facet of energy cooperation, but is a very important one.

This is the vision of the DESERTEC project that aims to produce renewable energy out of the Arabian deserts, delivering to the local market, and exporting the surplus to Europe. And we, In Saudi Arabia, we are capable of supporting this vision and putting it into practice as part of a collaborative effort.

2. Making it Affordable, Accessible, and Sustainable

Accessible: Practically speaking, there is no location on earth that has no supply of renewable energy; it is only a matter of properly and economically harvesting, transmitting and connecting it.

This is a fundamental premise of profound implications: Energy, in some form or another, is abundantly available in its raw nature, be it sun rays or wind gusts or ocean currents.

Affordable: Sunshine is basically cost-free. Yet, if a country does not develop its own solar energy harvesting systems, or a significant part thereof, that country would essentially be importing solar energy.

It is fortunate that it is not too difficult to make energy harvesting systems affordable for all. This is primarily because a large part of the solar harvesting systems' cost is consumed in the service component of the value chain, including design, engineering, procurement, construction, assembly, operation and maintenance.

For Saudi Arabia, our analysis showed us that we can localize more than 85% of the overall value chain of renewable energy capacity deployed in Saudi Arabia over the next 20 years.

Sustainable: It is natural to think of sustainability as synonymous to the basic concepts of environmental stewardship, human development, and economic viability Sustainability, however, can be even more than that. If the development of the national value chain is done properly, sustainability here means the "security of energy supply". It also means efficiency and conservation, and could be an enabler of other sectors' development.
For example, renewable energy can play a very important role in making water desalination sustainable for countries with no fresh water sources.

For Saudi Arabia, as for many other nations, renewable energy, on utility scale, is a new strategic sector. The opportunity presents itself to maximize and smartly optimize economic development.

One glaring conclusion is clear: no single energy solution fits all situations. However, it is not uncommon to hear strong advocacy of one particular generation technology vis à vis others. This advocacy may very well be good-intentioned.

3. Energy from the Desert

The proposed "2050 Desert Power" document reports the forecasted cost of electricity for the EUMENA region. However, the technology solutions proposed grouped solar and wind generation technologies together.

This merits a revisit. Since wind technology is practically mature, huge cost reductions in CAPEX is not much expected over the next 30 years. If we add to that the fact that high potential wind sources locations are limited, this will surely mean that once the best suitable locations for wind harvesting have utilized, the cost of generating electricity from wind will increase, as is actually shown in the report.

This is not the case for solar energy. The solar resource quality in the solar belt spanning all of the MENA region is rather uniform, and it is among the best in the world. Coupled with this favorable resource condition is the fact that CAPEX of both photovoltaics (PV) and concentrated solar power (CSP) is decreasing rapidly, which means that the more Terawatt-hours one generates from solar energy, the less the cost of electricity would be.

This is in no way a vote of no confidence in wind. On the contrary, we believe that wind technology, especially in our part of the world, lends itself most favorably for coupling with water desalination requirements. The demand on desalinated water is volume-dependent and not time-dependent. And the desalination process boasts of inherent storage feature thereby allowing for wind energy harvesting to take place whenever wind blows across the blades, with hardly any need for active load management or additional storage, that otherwise would have been required for grid stability if wind was to be used for the conventional utility application.

4. Nuclear and Renewable Energy

K.A.CARE was tasked by the Saudi government to introduce renewable and nuclear energy, sustainably, to the Saudi energy landscape, in partnership with other key stakeholders in Saudi Arabia, and beyond.

It is estimated that Peak demand in Saudi Arabia will exceed 120 GWs in 20 years.
However, factoring in the need for respectable operating reserves may keep the required installed generation capacity greater than 120 GWs by 2032.

As mentioned earlier, the key challenges that the Saudi electricity sector faces are the 45% idle installed generation capacity during the off season, and that cooling constitutes 50% of electricity demand during peak season.

Given all those realities and the need for sustainable and economically viable solutions, the comprehensive proposed solution for Saudi Arabia calls for producing 50% of the total energy generated in Saudi Arabia by 2032, from non fossil sources, namely nuclear and renewable energy, thereby reducing total hydrocarbon consumption in the power and desalination sectors by 50% in 20 years.

The total generation capacity that this scenario calls for is to connect to the grid in 20 years 54 GWs of renewable capacity, composed of 41 GWs solar, 9 GWs wind, 3 GWs waste-to-energy, and 1 GW geothermal.

HE Dr. Khalid Al Sulaiman is Vice President for Renewable Energy, King Abdullah City for Atomic and Renewable Energy (K.A.CARE). The text, published in Arabic in Al-Bia Wal-Tanmia in January 2013, was based on a statement by Dr. Al Sulaiman at 2012 DESERTEC conference in Berlin.

Nuclear Power Option

Hans-Holger Rogner
Adnan Shihab Eldin

The Fukushima Daiichi accident initiated by a tsunami triggered a cycle of heightened fears and anxiety about nuclear power. It prompted governments around the world to assess the safety situation of their nuclear fleets or revisit their plans to start national nuclear power programs. Some countries decided to phase out the technology. Other countries decided to postpone the launch of nuclear power programs and put more emphasis on a comprehensive development of their national nuclear infrastructure. While the accident is expected to delay growth in nuclear power, it has not led to a significant retraction of national nuclear power programs globally. The factors that led before March 2011 to the revival in interest have not changed after the accident. Those are: rapidly growing electricity demand, the need for reliable base load electricity at stable and predictable costs, volatile fossil fuel prices, concerns for energy security, and environmental concerns, especially as related to GHGs emissions.

Several Arab countries have also shown an interest in nuclear power despite the fact that these countries hold the largest conventional oil and gas reserves globally. Why then would they consider the nuclear option or, as in the case of the UAE, launch a national nuclear power program with two nuclear power plants already under construction? The factors that rekindled the interest globally are to, a certain extent also, valid for many Arab countries. In addition, at current international market prices oil and gas rich countries can increase overall export revenue by deploying nuclear power domestically and sell the avoided domestic oil and gas use (for electricity generation and desalination) profitably in the international market place.

While there are many promising benefits, there are also demanding challenges and daunting obstacles to overcome on the road to nuclear power. Nuclear power is a highly complex technology. Mastering these to reap its benefits is a challenge. Nuclear power is less forgiving than other energy technologies, requiring persistent discipline in operation and strictest adherence to safety standards. Equally important is competent and effective regulatory oversight. Even technologically advanced countries can have serious weaknesses in their national nuclear programs. In technologically less advanced countries without a well-developed safety culture, the introduction of nuclear power needs to balance the added risk with the benefits. A successful, safe and secure nuclear power program requires a strong and unwavering long term national commitment, with high initial efforts to develop the required infrastructure, especially human resources and an effective and disciplined management system for all components of the nuclear fuel cycle. While technical solutions for the safe and secure ultimate disposal of nuclear waste do exist and are being pursued, lingering doubt and debate will continue globally until several implementations currently underway have been successfully demonstrated.

What is right for the Arab countries depends on the region's national preferences and policy priorities. For now, the unfolding changes in the region are pointing to delays in planning and implementation of nuclear power programs in several Arab countries.

I. INTRODUCTION

A. Overview of nuclear power development

i. Brief history

Although electricity was generated for the first time by a nuclear reactor in 1951 at the EBR-I experimental station near Arco-Idaho in the USA, the grid connection in 1954 of the 5 megawatt electrical (MW) Obninsk Nuclear Power Plant in the former Soviet Union (FSU) marked the dawn of commercial nuclear fission energy. Since then, global nuclear power development evolved through four stages.

The initial prototype plants of the 1950s in the FSU, United Kingdom and the United States led to stage 1, a period of early growth until about 1965, with an average growth rate of about seven reactors per year. In the second stage from 1966 to 1985, the technology quickly spread around the world. By the end of 1973 two-thirds of the 30 countries operating nuclear power plants today had started the construction of their first nuclear plant. The oil crises of 1973-74 and 1979 added further momentum to the global expansion of nuclear power. The second stage of accelerated growth saw an average of 25 construction starts and 18 grid connections per year (see Table 1).

The third stage extended from 1986 to the mid-2000s. In this period, global nuclear power development entered a major downturn dropping to an average of five construction starts (and less at the end of the period). This slowdown was the result of several factors: initially rapidly rising construction costs of nuclear plants, in large part caused by the then prevailing high inflation and interest rates; the Three Mile Island accident (USA, 1979) which severely undermined public confidence in the technology; and nuclear regulators who, responding to the heightened public concerns about nuclear operating safety, mandated plant retrofits and design modifications of plants under construction which caused long construction delays and substantial cost overruns, and led to the suspension and/or cancellation of many projects. Moreover, high energy prices and efficiency policies, introduced in response to the oil crises, reduced base load electricity demand by more than half of the historically observed annual growth rates of 6 to 7 percent in many OECD countries.

Collapsing oil and gas prices in the mid-1980s, the commercialization of inexpensive, modular and high efficiency combined cycle turbines, and electricity market deregulations in many countries further eroded nuclear power's competitiveness and caused additional nuclear project delays and cancellations.[1]

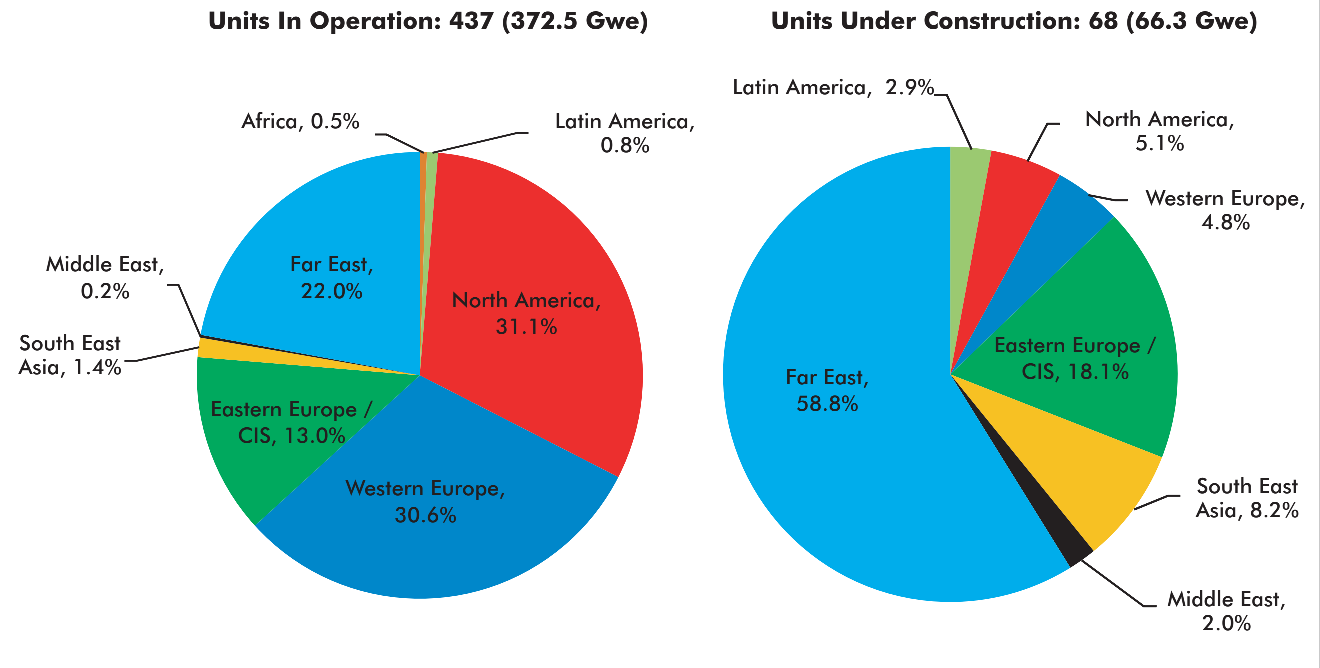
The disastrous accident at the Chernobyl nuclear power plant (Ukraine, 1986) then was "the straw that broke the camel's back". The combined effect of economic woes in many markets, lower than projected demand, excess generating capacity plus rapidly rising public opposition led to a general slowdown in the expansion of nuclear power - except Asia where populous developing countries with high industrialization aspirations or countries with limited indigenous resources but energy security concerns continued a nuclear expansion course.

TABLE 1 THE FOUR STAGES OF CIVIL NUCLEAR POWER DEVELOPMENT

		Construction starts		Grid connections	
		Reactors per year	MW per year	Reactors per year	MW per year
Early growth	1954-1965	7	1,300	4	432
Accelerated growth	1966-1985	25	20,800	18	12,500
Slow growth	1986-2004	5	3,900	9	8,400
Rising expectations	2005-2010	9	8,700	3	2,000

Source: IAEA 2012

FIGURE 1 DISTRIBUTION OF NUCLEAR POWER IN MAJOR WORLD REGIONS - CURRENT GENERATING CAPACITY (LEFT PANEL) AND GENERATING CAPACITIES UNDER CONSTRUCTION (RIGHT PANEL) (AS OF 19 MARCH 2013)



During the third stage, market liberalization and low fossil fuel prices exposed nuclear operators to previously unknown competition, which forced nuclear plant operators to better utilize their assets, shorten maintenance outages and reduce overhead costs. The net result was enormous performance improvements of the global fleet of reactors. By 2005 the global load factor had reached more than 80 percent, up from the 65 percent level prevailing in the early 1990s, which allowed continued growth in nuclear generation, despite aggregate generating capacity expanding only 14 percent over the period.(2)

Competitive economics and good safety records, mirroring the economic performance, led to license extension of up to 20 years and power-uprates, through replacement of aged equipment and safety upgrades in several countries. Still, while existing plants thrived, new builds "waited "except in China, India and, to a lesser extent, Russia.

The fourth stage started in the mid-2000s and lasted until the Fukushima Daiichi accident in March 2011. It was the result of four factors: (a) Rapidly rising energy and electricity demand in large developing countries; (b) steeply ascending fossil fuel market prices to ever higher levels while exhibiting intense volatility; (c) energy security concerns, forgotten for two decades, were back on the political agenda; and (d) the climate change debate and the entry into force of the Kyoto Protocol which brought to the fore the climate mitigation benefits of nuclear power. These factors, plus generally promising nuclear economics and a

TABLE 2 **NATIONAL POLICY RESPONSES TO THE FUKUSHIMA DAIICHI ACCIDENT**

Country	Policy response
Belgium, Germany, Switzerland	Nuclear phase out – no new build
Taiwan	Nuclear phased out announced but plant construction of new builds continues
Japan	Plants under construction suspended, Fukushima 1-4 to be decommissioned, remaining 50 plants successively shut down by 5 May 2012. Two restarts in July 2012. Future use of nuclear power contested. Subsequently, phase out intentions by late 2030s announced.
China	The award of new construction licenses was suspended but lifted again in October 2012 - four new constructions starts in November/December 2012
United Arab Emirates	Construction start of first nuclear power plant in 2012
Belarus, Turkey	First plant ordered
Chile, Indonesia, Malaysia, Morocco, Saudi Arabia, Thailand, Vietnam	Active preparation with final decision delayed or no final decision
Bangladesh, Egypt, Jordan, Ghana, Nigeria, Poland	Continue preparing infrastructure
Italy, Kuwait, Oman, Senegal, Venezuela	Plans to introduce nuclear power cancelled or postponed indefinitely

solid safety record created a positive outlook for nuclear power, leading to what was often referred to as the "nuclear renaissance". Countries with operating nuclear power plants contemplated new nuclear builds while more than two dozen countries currently without nuclear power programmes started preparations for the introduction of the technology into their national energy mixes. By 2010 plant orders and construction starts reached levels not seen for a quarter of a century.

The accident at the Fukushima-Daiichi Nuclear Power Plant (NPP), caused by the extraordinary natural disasters of the earthquake and tsunamis that struck Japan on 11 March 2011, compounded by a poor national regulatory regime and lack of adequate emergency preparedness for the management of severe accidents, brought this trend to an abrupt halt and construction starts dropped to four plants that year compared with the sixteen plants a year earlier.

The period during these four stages was coupled with a steady increase in the volume of nuclear electricity production. Nuclear production increased to about 2,600 terrawatt hour (TWh) by the mid-2000s and has been almost constant over the last ten years. The nuclear share of total electricity production increased to a level of about 17 percent by the late 1980s but since has been falling behind overall growth in electricity generation and consequently its market share slipped to 13.5 percent in 2010 and 12.3 percent in 2011 (IAEA 2012a).

ii. Current status

Until the turn of the century, nuclear power was primarily an industrialized countries' technology. Only a few developing countries introduced nuclear power at a limited scale. Graphically this is shown in Figure 1 (left panel). Looking at plants currently under construction, Figure 1 shows a fundamental shift of the nuclear power momentum to Asia. Here China and India are the countries with the fastest growing nuclear programmes followed by Russia and the Commonwealth of Independent States. The rest of the world, in particular the traditional nuclear power countries of North America and Western Europe, has fallen behind Asia by a wide margin.

iii. The Fukushima impact

The Fukushima Daiichi accident of 11 March 2011 re-ignited the debate about the role of nuclear power in the future global energy mix. Initial government policy responses varied (see Table 2). In a few cases, this prompted the outright cancellation and phase-out of nuclear power (e.g., Germany[(3)]) - policy responses which were in part fuelled by public sentiments and strategic electoral considerations. These developments have pointed towards an even more uncertain future of the technology than before.

As of 19 March 2013 – two years after the accident- 68 reactors were under construction worldwide. This number is the highest since the mid-1990s, despite the sharp drop from 16 construction starts in 2010 to only 4 in 2011 (and a rebound to 7 in 2012).

The Fukushima Daiichi accident, like in the immediate aftermaths of Chernobyl and the Three Miles accidents, triggered a cycle of heightened fears and anxiety about nuclear power. It also stimulated a lot of reflection about the future of nuclear power. Public acceptance has dropped noticeably in several countries. Two years later, acceptance has been on the rise again in some countries, while others are more resolved than before to abandon the technology. Construction starts of new nuclear worldwide slumped in 2011 to early renaissance levels but rebounded in 2012 again. While the accident is expected to delay growth in nuclear power, it has not led to a significant retraction of national nuclear power programmes globally - at least not yet. Indeed, the governments of Bulgaria, Czech Republic, Finland, France, Hungary, Lithuania, the Netherlands, Poland, Romania, Slovakia, Spain and the UK called for a level playing field afforded to all low-carbon emitting technologies for meeting future EU climate mitigation targets. This joint communiqué affirms the position that nuclear power should "play a part in the EU's future low carbon

NUCLEAR PLANT SAFETY AND WASTE DISPOSAL

Excerpts from Towards a Sustainable Energy Future, InterAcademy Council (IAC, 2007) and America's Nuclear Future, Blue Ribbon Commission (BRC, 2012)

"Nuclear power suffers from several difficult and well-known problems that are likely to continue to constrain future investments in this technology. Chief hurdles for primary investors include high upfront capital cost, siting and licensing difficulties, public opposition, and uncertainties regarding future liabilities for waste disposal and plant decommissioning. In addition to -and inextricably intertwined with- these issues, many experts agree that concerns about reactor safety, waste disposal, and nuclear weapons proliferation must be resolved if nuclear technology is to play a prominent role in the transition to a sustainable global energy mix. A further obstacle in many parts of the world relates to the need for significant amounts of capital and considerable institutional capacity and technical expertise to successfully build and safely operate nuclear power plants."

"In sum, nuclear power plants are much more complicated than fossil-fuel power plants, and the consequences of accidents are far greater. In fact, potential dependency on other countries for technological expertise or nuclear fuel may discourage some governments from developing nuclear capacity, even as a desire for technology status or energy security may motivate others in the opposite direction."

"An IEA analysis of nuclear economics shows that various OECD governments already subsidize the nuclear industry by providing fuel-supply services, waste disposal, fuel reprocessing, and R&D funding. Many governments also limit the liability of plant owners in the event of an accident and help with remediation."

"Accidents at Three Mile Island in 1979 and Chernobyl in 1986, as well as accidents at fuel-cycle facilities in Japan, Russia, and the United States have had a long-lasting effect on public perceptions of nuclear power and illustrate some of the safety, environmental, and health risks inherent in the use of this technology (the report was published in 2007, before Fukushima accident). While a completely risk-free nuclear plant design, like virtually all human endeavors, is highly unlikely, the role of nuclear energy has to be assessed in a more complete risk-benefit analysis that weighs all factors, including the environmental impacts of different energy options, their energy security risks and benefits, and the likelihood of future technology improvements…A related challenge is training the skilled personnel needed to construct and safely operate nuclear facilities..." (IAC)

"In recent years, of course, the threat of terrorism has added a new and potentially more difficult dimension to long-standing concerns about the safe and secure operation of nuclear facilities and the transport of nuclear materials."

"Disposing of high-level radioactive spent fuel for the millennia-scale period of time that nuclear waste could present a risk to public safety and human health is another problem that has long plagued the industry and that has yet to be fully resolved in any country with an active commercial nuclear energy program… Without a consensus on long-term waste storage, various interim strategies have emerged… Reprocessing reduces the quantity of waste by more than an order of magnitude and has the potential of reducing the storage time by several orders of magnitude; but even after reprocessing, hundreds of years of safe storage are required. Reprocessing also raises significant proliferation concerns since it generates quantities of plutonium—the essential ingredient in nuclear weapons—that must be safeguarded to prevent theft or diversion for weapons-related purposes."

"Until a long-term solutions can be found, however, the waste issue is likely to continue to present a significant and perhaps intractable obstacle to the significant expansion of commercial nuclear power capacity worldwide."

"The events of Fukushima underscore how important it is to ensure that safe and secure interim storage for spent fuel and high-level wastes is part of an integrated approach to nuclear waste management."

"This generation has an obligation to avoid burdening future generations with finding a safe permanent solution for nuclear wastes they had no part in creating, while also preserving their energy options." (BRC)

InterAcademy Council (2007). "Lighting the way- Towards a Sustainable energy future." IAC Secretariat, Amsterdam.

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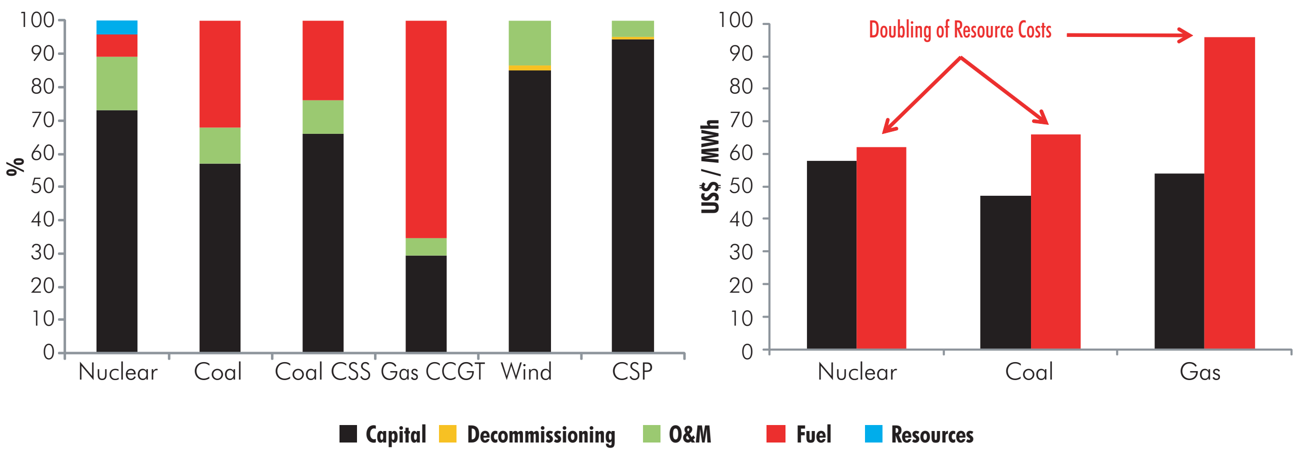
FIGURE 2 SHARES OF COST COMPONENTS IN TOTAL GENERATING COSTS AT A 10% DISCOUNT RATE (LEFT PANEL) AND THE IMPACT OF DOUBLING RESOURCE INPUT COSTS ON GENERATING COSTS



Source: ADAPTED FROM IEA/NEA 2010 AND NEA 2003.

energy mix" (UKG 2013). It also refers to the energy security features and economic benefits of nuclear energy. In the USA construction of 2 AP 1000 reactors (1117 MW each) began in March 2013, which ended a 30 year period of construction draught. Nonetheless, the accident has resulted in a temporal shift in the projected growth of nuclear power over the longer term (see Section IV).

II. DRIVERS FOR NUCLEAR POWER GLOBALLY

In the past countries have turned to the peaceful use of nuclear power for one or more of the following reasons: Limited domestic fossil resources and concerns for energy security, rapidly growing energy and electricity demand, the need for reliable base load electricity generation at stable and predictable generating costs, low environmental impacts (local air pollution and regional acidification) and technological spin offs. More recently nuclear power has often been advanced as an effective climate change mitigation option.

A. Energy security

Nuclear energy enhances energy security due to its low fuel volume which allows for easy stock-piling, i.e., on-site storage of the raw material uranium for the entire life time of the plant. Long-refuelling cycles of 18 to 24 months plus the practice of on-site storage of fuel elements for one refuelling event provides sufficient time to seek alternate suppliers in case of the original supplier defaults on contractual arrangements.

The economics of nuclear power are characterised by large up-front capital costs but low and stable fuel and operating costs - in short nuclear power is expensive to build but cheap to run. Variable operating costs, essentially fuel costs, are a comparative advantage of nuclear power. The share of uranium in nuclear generating cost is about five per cent, the remaining fuel costs include enrichment, fuel element fabrication and spent fuel management costs (see Figure 2 - left panel). Therefore, once construction is completed and plant operation has commenced, nuclear power offers stable and predictable generating costs. Unlike coal and natural gas fired electricity generation, a doubling of resource prices hardly affects total generating costs of nuclear power (see Figure 2 - right panel).

Emerging economies, like China and India, acknowledge that nuclear power is critical for energy security (and also to help alleviate climate change concerns). Energy security has motivated many countries currently without nuclear power to explore the nuclear option alongside renewable technologies to diversify the energy resources mix (World Future Energy Summit 2012).

PEACEFUL NUCLEAR OPTION IN THE ARAB WORLD – THE JORDAN MODEL

Saed Dababneh

In Jordan, as well as in other countries in the Arab region, considerable interest has been devoted during the last few years to the nuclear industry; not only due to its potential use as a power source, but due to the necessity to promote peaceful applications of nuclear sciences as well. In this context, His Majesty King Abdullah II directed the government in 2007 to review and update the national master strategy of energy sector, sanctioned by the Cabinet in 2004, with the aim to meet the Kingdom's energy needs and to achieve energy supply security. Nearly 98 percent of Jordan's energy is produced using imported oil and gas at a cost of nearly one-fourth of the gross domestic product. Continued interruption in the country's Egyptian natural gas supplies forced Jordan to rely on the more costly heavy oil imports, driving electricity subsidies to over US$1 billion. The issue of the country's energy independence consequently surfaced the local and regional policy debate, which obviously has its implications on the country's position amid the political unrest in the region. According to the updated national strategy, a potential scenario to meet the demand in the year 2020 includes the nuclear option in the mix for electricity generation. Moreover, and at an early stage, Jordan's foreseen uranium reserves encouraged officials in 2007 to declare "a transformational opportunity to convert Jordan into a net exporter of electricity by implementing a nuclear program".

There are, however, many hurdles standing in that route. Among other things are the need for skilled human resources, high investment capital cost, the limited suitable sites for nuclear power plants, the lack of adequate bodies of water for cooling, and the clearly volatile regional political climate. Though local university programs, as well as international technical cooperation, have just started to fulfill the minimum of the unambiguous need for capacity building, the other challenges are apparently vigorously hampering the project. The cost, which was anticipated to be partly covered by marketing locally produced yellowcake, is still a critical issue. In 2012, the Lower House of the Parliament found that Jordan's nuclear project is neither based on solid facts, nor is it progressing according to the declared timetable. It was assumed, according to officials, that by 2012 Jordan will start producing 2000 tonnes of U_3O_8 annually, which presumably meant providing the treasury with hundreds of millions of dollars. Jordanian experts early warned this scenario was not realistic; based on the low-grade quality and limited minable quantities, together with the increasing water requirement and environmental impact associated with the huge amount of ores to be processed when the uranium content is low. Consequently, the departure of AREVA in 2012, and before that Rio Tinto, actually marked a hinder to Jordan's uranium mining aspirations. During its four-year presence, AREVA acknowledged these challenges that are facing any feasible extraction of Jordanian uranium deposits, which despite being close to surface level, are found intermittent and at lower-than-standard commercially viable grades, especially with the sharp fall in the uranium price after the Fukushima tragedy. Though some officials told the Parliament, the public and decision makers that the uranium project was feasible, no feasibility study had been actually conducted. For Jordan, which would be highly unlikely to be able to finance a nuclear power plant by itself, this conclusion reinforced the need for foreign partners to take an equity stake and bring with them finance and financial guarantees. Uncertainties on this last option recently pushed officials to explore the possibility of involving the Social Security Corporation in the project. This move triggered a prompt harsh community opposition to be added to the already severe public acceptance problems facing the nuclear power project.

B. Economics

The investment in a NPP amounts to several billion dollars (approximately US$ 2-8 billion depending on design, location, finance, etc.) for a typical 1000 MW nuclear power plant which accounts for some 60 percent to 75 percent of total generation costs. The most recent report of the IEA/NEA "Projected Costs of Generating Electricity" (IEA/NEA 2010) shows a large overlap and spread of specific investment costs (US$/kW) for different electricity generating technologies (see Figure 3-left panel), typically explained by varying local conditions, technology designs as well as regulatory and environmental constraints.

In addition to the high upfront capital cost, long lead time for planning, environmental impact

In another recent development, the multi-year long process to select vendor and technology looks set for more delay, with an official recommendation to select a strategic investor rather than to choose one of the current short-listed (French-Japanese or Russian) bidders. Officials could not further narrow down the list on technical and financial grounds, because vendors were not given a specific site, and there were issues with the proposed sites that were still uncertain. Vendors were therefore unable to provide hard data on costs. The initial site for the reactors on the Gulf of Aqaba was too vulnerable to seismic activity, in addition to political uncertainties, and a planned move inland was opposed by local communities. A third site was then added to the list, but both inland sites require pumped grey water produced by the Khirbet Al Samra Wastewater Treatment Plant. This raised serious questions regarding the feasibility of the cooling scheme, though officials defended the scheme which is based on the experience in Palo Verde, Arizona; the only nuclear plant in the world not located near a body of water. Though warned at an early stage, officials insisted to go ahead with the tender knowing that there are genuine problems, from different aspects, regarding site selection. How can one think about site characterization, which should be part of the tender documentation, if there is no site secured yet? Public acceptance, which is also a key factor, was also not guaranteed.

Though, in principle, nuclear power like any other option should not be excluded from the country's consideration for energy mix, time is a critical parameter. The country's very existence depends on solving the energy crisis (by all means). We should stop arguing, a priori, about what to keep and what to exclude. Only facts, numbers and dates should decide on priorities and percentages in the energy mix. Postponing, or fabricating any achievement, is lethal. Therefore, the consecutive delays associated with the relative lack of transparency and experience in the nuclear program, imply a much more important cost; the opportunity cost of not pursuing other options that could have met Jordan's needs.

Nevertheless, the nuclear challenge should, however, be kept on the table for future consideration. Jordan is acquiring experience in the field, young Jordanians are definitely proving capable of absorbing and even actively promoting different aspects in the nuclear technology, making Jordan one of the Arab countries that could positively contribute to the mutual exchange of expertise, which will be of great benefit to all Arab partners. Jordan as, well as other Arab countries, need to realize the time span required to properly catch up, domestically, in the human resources sector. The legal tools regulating the nuclear field, building a credible and transparent management system, the necessity to create a proper safety culture, the fundamental educational infrastructure, the proper legislative and regulatory frameworks concerning safety, security, emergency preparedness and response, and radioactive waste management planning, among other issues, should all be pursued in a systematic manner.

We should establish the best example for the next generation. We may ultimately need nuclear, but we don't need to "play" nuclear!

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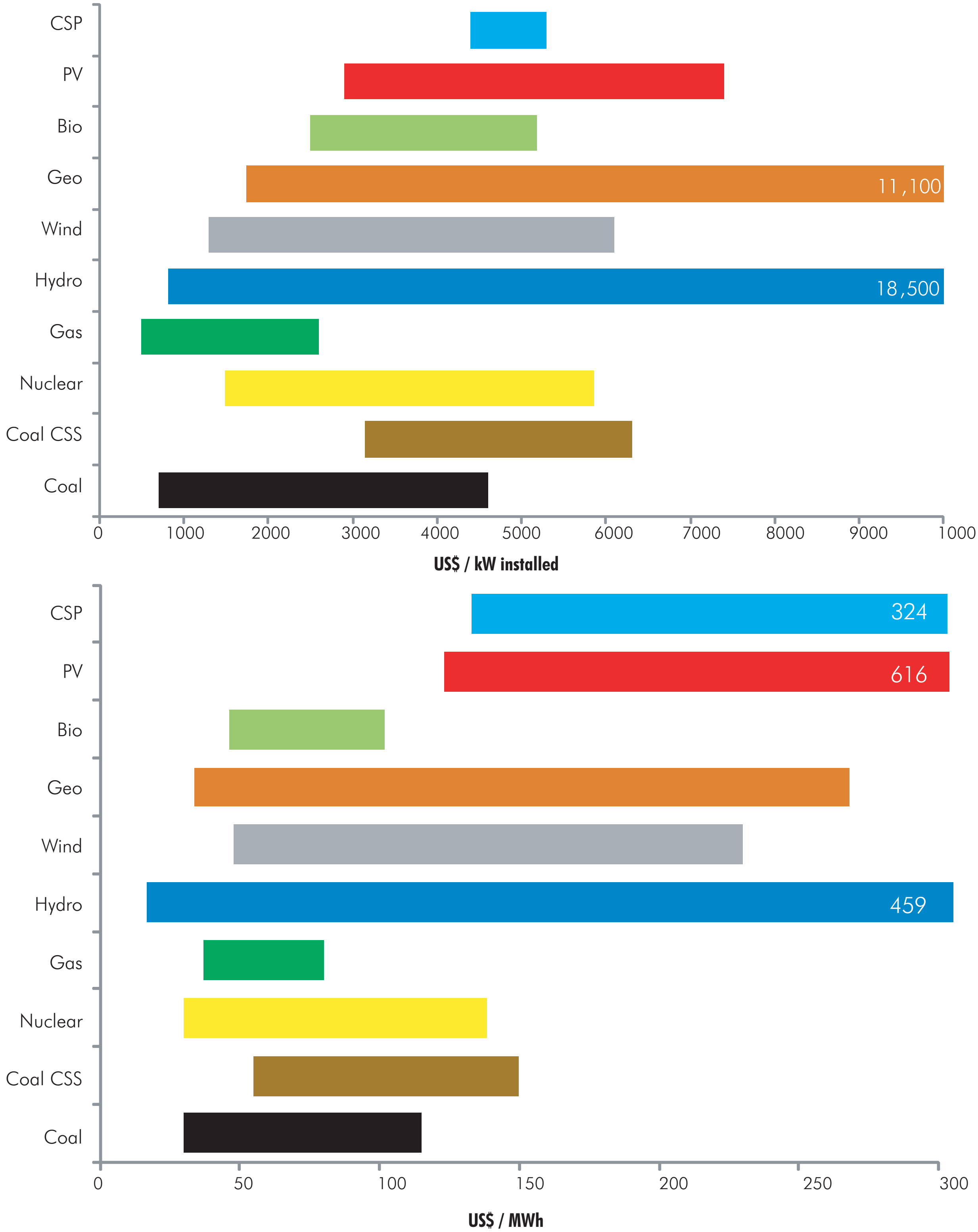
assessments, licensing and public hearing periods, construction, and plant completion on time and on budget, cost sensitivity to interest rates, regulatory and policy risks all pose a challenge (Rogner, 2010). Recent experience with new build in Finland and France with long construction delays and substantial cost overruns have alienated investors and fuelled the suspicion that nuclear power is simply too risky a proposition.

Investment costs are but one consideration - what matters are actual generating costs. Figure 3 (lower panel) shows the ranges of levelized costs of electricity (LCOE) generation of the IEA/NEA report for real discount rates between 5 percent and 10 percent per year. LCOE includes all cost components throughout a technology's life cycle - construction, finance, operation and maintenance, fuel, waste disposal and decommissioning.

FIGURE 3 INVESTMENT COST RANGES PER KW INSTALLED (UPPER PANEL) AND LEVELIZED COSTS OF ELECTRICITY GENERATION (LCOE) IN US$/MWH OF DIFFERENT GENERATING OPTIONS FOR DISCOUNT RATES BETWEEN 5% AND 10% (LOWER)



Source: IEA/NEA 2010.

C. Environmental characteristics of nuclear power – air pollution, GHG emission

On a life cycle basis, the full technology chain for nuclear energy from uranium mining to decommissioning emits only a few grams of GHG per kWh of electricity. The bulk of greenhouse gas emission arises from plant construction and in the upstream fuel stages, with values between 1.5 and 20 g CO_2-eq./kWh. This span is largely due to the type of enrichment processes considered in the various assessments (gaseous diffusion versus gaseous centrifuge) and the extent to which nuclear fuel recycling was accounted for. The enrichment industry has been increasingly switching to gaseous centrifuge technology, which requires only about 2 percent of the energy input needed for gaseous diffusion.

During the operational stage of the reactor GHG emission are negligible - ranging between 0.74 and 1.3 g CO_2-eq./kWh. The GHG emissions associated with downstream activities, such as decommissioning and waste management, range between 0.46 and 1.4 g CO_2-eq./kWh. Cumulative emissions for the studies reviewed by Weisser (2007) lie between 2.8 and 24 g CO_2-eq./kWh. Figure 4 presents a summary of life cycle GHG emissions for a range of power generation technologies and fuels.

In addition to helping to mitigate climate change, the use of nuclear power plants can also avoid emissions of air pollutants other than GHG with negative health and environmental impacts at local and regional scales. In contrast to fossil based electricity generation, nuclear power plants (as well as renewable technologies) emit virtually no air pollutants such as nitrogen oxides (NO_x), sulphur dioxide (SO_2) or particulate (PM_{10}) emissions during operation.

D. Nuclear technology spin-offs

The application of nuclear science and technology reaches far beyond the energy sector. Countries with active nuclear energy programs have also enjoyed numerous economic and social spin-offs from nuclear related R&D. Typical areas of non-energy nuclear applications include cancer diagnosis and treatment, food security, soil productivity, disease prevention and control, water resources, quality control and environmental management.

FUKUSHIMA NUCLEAR DISASTER

Tetsunari Iida

On 11 March 2011 (3.11), the Great East Japan Earthquake and its Tsunami changed the lives of hundreds of thousands of people in Japan forever. The earthquake and tsunami destroyed large part of the northeast coast of Tohoku region of Japan. About 20,000 people died. Among other things, a 12 meter-high tsunami flooded the Fukushima No.1 nuclear plant, cutting the power supply to water pumps cooling the nuclear reactors. This was the largest nuclear disaster since the Chernobyl disaster of 1986 and only the second disaster to measure Level 7 on the International Nuclear Event Scale. It showed once again the inherent risks of nuclear power and exposed the failures in the whole system, even though Japan had its global reputation for excellence in engineering and technology.

A "manmade" disaster "made in Japan"

Both the utility and the Japanese authorities failed not only to prevent the accident but also to respond properly after the accident. Although the Earthquake and Tsunami were historically among the largest, the risks of such scale natural disasters were well known years before. Emergency planning for a nuclear accident was not functional, and the evacuation process became chaotic, which lead to many people being unnecessarily exposed to radiation. Government was simulating radioactive materials spread from Fukushima Daiichi throughout Japan and the North Pacific in real time with real wind data even before and after 3.11 disaster. However, data released only a month later revealed that many people were evacuated exactly in the direction of the most heavily contaminated region.

The Fukushima Nuclear Accident Independent Investigation Commission defined it as a "manmade" disaster, caused by serious deficiencies in the response to the accident by TEPCO (the utility company), regulators and the government as the result of collusion between the government, the regulators and TEPCO, and the lack of governance. Also, they defined it as a disaster "made in Japan", that means the mindset that supported the negligence behind this disaster. So, its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience; our reluctance to question authority; our devotion to 'sticking with the program'; our collectivism; and our insularity. Those mindset and conceit had been produced and reinforced since the 1970s "oil shocks". In quest of national energy security, nuclear elites as bureaucrats put organizational interests ahead of their paramount duty to protect public safety, and nuclear power became an unstoppable force, immune to scrutiny by civil society.

Breaking up the "nuclear myth"

The Fukushima nuclear disaster broke up the "myth" of nuclear safety. Nuclear industries and the government assumed that the "multiple barriers" to be engineered would keep radiation away from the environment and people, but it failed rapidly. In less than 24 hours following the loss of cooling at the first Fukushima reactor, a major hydrogen explosion blew apart the last remaining barrier between massive amounts of radiation and the open air. At any time, an unforeseen combination of technological failures, human errors or natural disasters at any one of the world's reactors could lead to a reactor quickly getting out of control.

Nuclear power was originally described as "too cheap to meter". Before 3.11, owing to massive "propaganda" from the government, electricity monopoly and nuclear industry, this nuclear "myth" had been widely believed to be a cheap alternative to fossil fuels and a necessity for the economy and national energy security. After 3.11, these "myths" were wiped off, but sadly some people still believe in them.

Another myth was a strong belief of security of supply by nuclear power as compared to renewables. This myth was also wiped off through the nation's experience of supply risk of large-scale centralized power when it stopped suddenly after 3.11.

Never ending disaster

Two years after the Fukushima nuclear disaster, over 150,000 people who had been evacuated could not return. They lost nearly everything, with insufficient support and compensation to allow them to rebuild their lives. Families have been split apart, and have lost their homes, jobs and communities.

There are growing concerns that the full scale of the disaster is yet to be seen. There are claims of complacency and a cover-up about radiation effects and consequences. Most worrying are the results of tests carried out on more than 170,000 children who lived in Fukushima. More than 10 cases of thyroid cancer were already found (6 per 100,000), which is obviously higher than that of natural background (average 1-2 per 100,000). Other forms of the disease may not become apparent for a decade. It is also feared that the food chain has been contaminated. Radioactive material has been detected in a range of produce, including spinach, tea leaves, milk and beef, up to 300 kilometers away.

The Fukushima accident is not over and may never end. The radioactive fallout, which remains toxic for hundreds to thousands of years and covers large swaths of Japan, will never be "cleaned up". It will contaminate food, humans and animals forever. The three reactors which experienced total meltdowns will almost certainly never be disassembled or decommissioned, not least because of the enormous amount of radiation they will emit.

In addition, if the reactor No.4 at Fukushima daiichi, which was severely damaged in the original earthquake, should collapse, the massive cooling pool on its roof containing 300 tonnes of extremely radioactive spent fuels could fall to the ground and lose its cooling water. The radioactive rods would spontaneously ignite, releasing further massive amounts of radiation.

Lesson learned

Similar disaster could be experienced in other nuclear plants at Japan East Coast, and did almost happen, such as at the Fukushima No.2, Tokai No.2 and Onagawa nuclear plant. The institutional failures in Japan are a warning to the rest of the world. These failures are the main cause of all past nuclear accidents, including the accident at Three Mile Island and the disaster at Chernobyl.

The failure of the human institutions inevitably led to the Fukushima disaster. The risks of earthquakes and tsunamis were well known years before the disaster. The industry and its regulators reassured the public about the safety of the reactors in the case of a natural disaster for so long that they started to believe it themselves. The tight links between the promotion and regulation of the nuclear sector created a 'self-regulatory' environment that is a key cause of the Fukushima nuclear disaster.

Most countries limit the liability of reactor operators to only a small fraction of real damages, which allows

the nuclear industry to basically escape paying for the consequences of an accident. The Japanese legislation on liability and compensation stipulates that there is no cap on liability for a nuclear reactor operator for damages caused to third parties. However, it does not include any detailed rules and procedures about how and when the compensation will be paid. Nor does it define who is eligible and who is not. TEPCO has so far managed to escape full liability and fails to properly compensate people and businesses that have been dramatically impacted by the nuclear accident. Should larger compensation schemes, which reflect real losses, be established, the cost of nuclear power will skyrocket.

The true risk to be learned from Fukushima disaster is opportunity loss, caused by sticking to nuclear power and the current power structure. This burdened seriously exploring other opportunities and benefiting from the dynamic change outside Japan, especially in the renewables policy and market. Renewables have been rapidly mainstreaming worldwide in the past years. Some consider this as the "fourth revolution for humankind" with its nature of energy shift, technology evolution and regime change into small-scale distributed network type of energy system. This trend could be historical chance for Japan's energy future because of its multiple benefits, especially for post 3.11 Japan.

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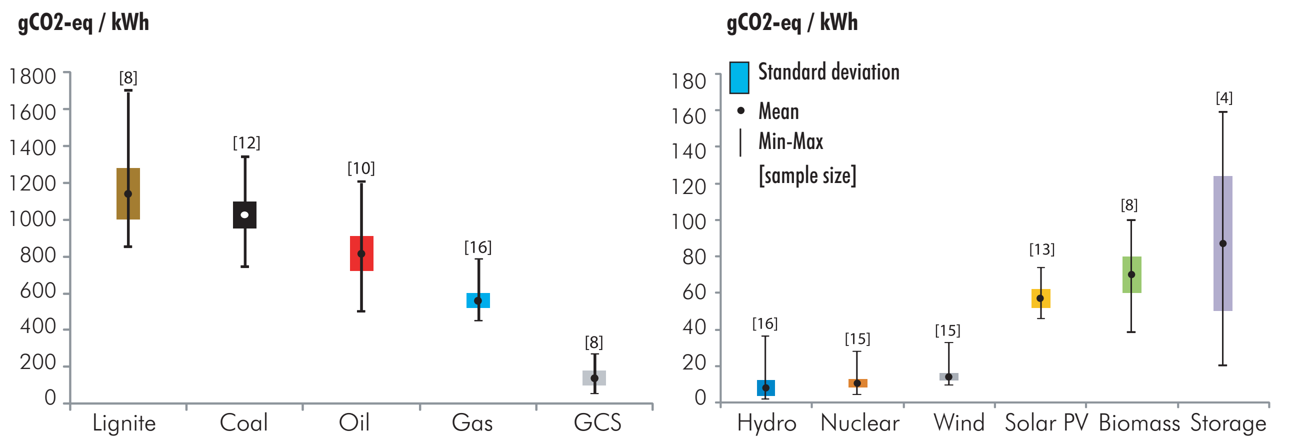
FIGURE 4 LIFE CYCLE GHG EMISSIONS OF DIFFERENT ELECTRICITY GENERATING OPTIONS



Source: WEISSER, 2007

Furthermore, nuclear power, science and technology foster a highly educated and skilled workforce with above average income levels. Depending on the localization factor of plant construction, there are significant economic benefits associated with a national nuclear power programme.

III. ISSUES SURROUNDING NUCLEAR POWER

A. Safety

The essence of nuclear operating safety is the protection of the population, workforce and the environment from ionized radiation. Operating safety, therefore, ranks as the highest priority for nuclear power plant design and operation.

Radiation levels from normal operation of nuclear power plants are significantly low compared with the average radiation exposure from natural and other anthropogenic sources (see Figure 5).

However, things are different, in cases of severe nuclear accidents. Radioactive surface concentrations in the plant vicinity can be high and can last for years or decades, and decontamination is very expensive. In areas further away from the site of the accident, agricultural production and fishing may need to be temporarily suspended. Environmental impacts due to radiation may cause significant economic damages due to suspended economic activity in the affected area. Moreover, non-radiation impacts can be significantly larger than radiation impacts. Nonetheless, a recent UN reports states that "radiological impacts from the expanded use of nuclear power as part of the world's electricity generation mix continue to engender concerns among many policy makers and members of the public regarding the safety of the technology and the appropriateness of its continued use. Such concerns are exacerbated by high profile incidents and serious accidents associated with nuclear energy such as those that occurred at Three Mile Island (1979) in the United States of America, at Chernobyl (1986) in the former Soviet Union, and recently at the Fukushima-Daiichi plant (2011) in Japan"(UN 2011).

The long term health effects from the Chernobyl accident, expressed in terms of increased radiation-induced cancer fatalities in the general public, have been subject to intensive studies. Credible studies point to increases of 4,000 to 30,000 cancer-induced late life deaths(4) which is (outside the small three most exposed groups of workers and evacuees) a statistically insignificant increase from the natural rate of cancer deaths (Garwin and Charpak 2001; Chernobyl Forum 2006). For Three Mile Island, the estimated total number is negligible (less than one). For Fukushima it is expected that the effect will be an order of magnitude less than Chernobyl's (Ten Hoeve and Jacobson 2012). According to a most recent WHO report, "outside the geographical areas most affected by radiation, even in locations within Fukushima prefecture, the predicted risks remain low and no observable increases in cancer above natural variation in baseline rates are anticipated" (WHO 2013). To put these numbers into perspective the OECD Environment Directorate suggests that PM10 particles from fossil fuel combustion caused approximately 960,000 premature deaths in the year 2000 (OECD 2008). Kharecha and Hansen (2013) calculate "a mean value of 1.84 million human deaths prevented by world nuclear power production from 1971 to 2009 with an average of 76,000 prevented deaths/year from 2000 to 2009 (range 19,000–300,000)".

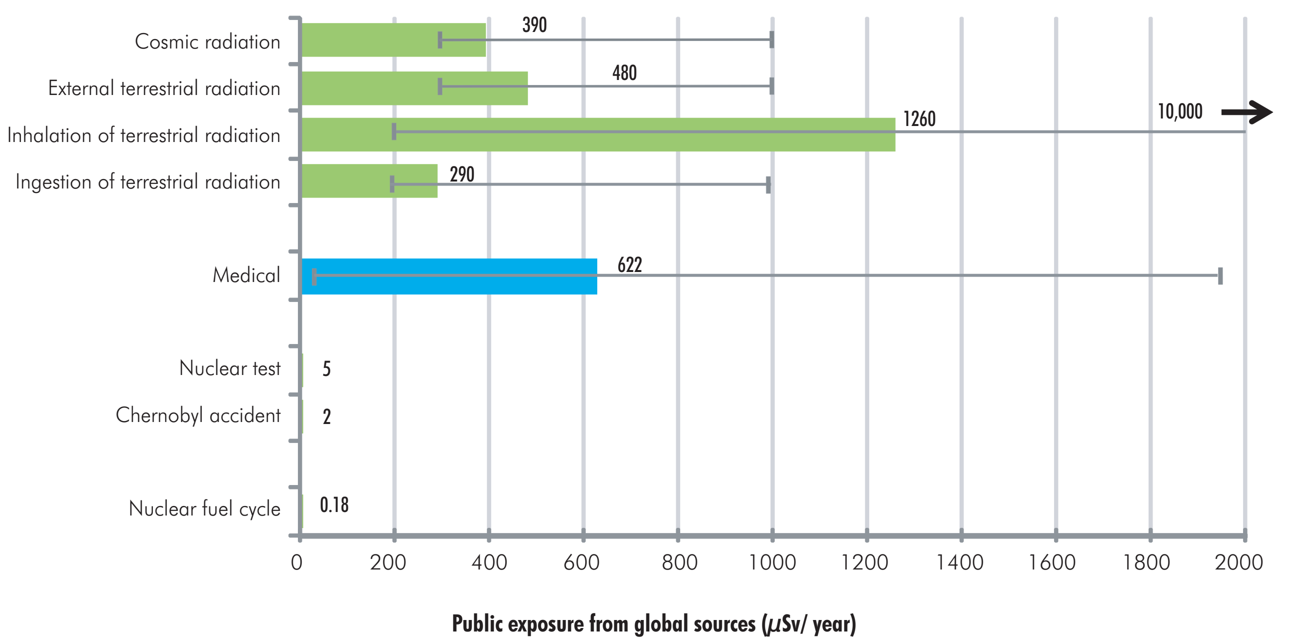
The nuclear accidents reveal the importance of independent, competent and effective nuclear oversight institutions)[(5)].In the case of the Fukushima Daiichi accident, the combination of accident conditions including total station black-out, the loss of essential safety functions (heat sinks) and the effects of "beyond design basis" (BDB) event had not been envisaged and emergency preparedness was lacking (NAIIC 2012). Enforcing such analyses and, if necessary, corrective action are the principal responsibilities of the nuclear regulator - with the ultimate task to order closure of plants failing to meet all safety requirements.

In response to the accident, the IAEA convened a Ministerial Conference on Nuclear Safety in June 2011. IAEA Member States agreed to review the safety of their nuclear power plants with particular focus on strengthening protective measures against extreme BDB events such as earthquakes and tsunamis, ensuring their capability to maintain power and cooling following a BDB event, enhance their arrangements to manage severe accidents and re-examine the design bases for their nuclear power plants, i.e. the assumptions about a predetermined set of accidents to be taken into account.

B. Nuclear waste management

All electricity generating chains generate wastes. The nuclear energy chain produces radioactive waste of different levels of radiotoxicity. Low level wastes (LLW) and intermediate level wastes (ILW) account for the bulk of radioactive waste (some 97–98 percent) and represent only a small proportion of total radioactivity (about 8 per cent). LLW and ILW arise mainly from routine facility maintenance and operations as well as fuel cycle activities. The radioactivity in these wastes ranges from just above nature's background level to more elevated levels. Safe disposal options for LLW and

FIGURE 5 PUBLIC EXPOSURE TO RADIATION FROM GLOBAL SOURCES (AVERAGE SHOWN BY A BAR, AND TYPICAL RANGE SHOWN BY A LINE)



Source: UNSCEAR (2010).

ILW have been in operation routinely for decades in many countries. On a volumetric basis around four-fifths of all the nuclear waste created since the inception of the nuclear industry has already been sent for safe and controlled disposal.

It is this so-called high level waste (HLW) which is a controversial issue in the sustainable development and green growth debates. HLW represents two to three per cent of total nuclear radioactive waste but presents particular challenges in terms of its radiotoxicity and long half-life. HLW is either spent nuclear fuel or separated waste from reprocessing the spent fuel.

Reprocessing of spent fuel drastically reduces the volume of HLW. Reprocessing separates the unused uranium and plutonium produced during reactor operation. The uranium and plutonium are re-used as fuel in reactors, while the separated fission products and minor actinides are treated as HLW. HLW will remain more radioactive than its natural surroundings for thousands of years and must be isolated from the biosphere until the level of radioactivity has decayed to natural background levels. Disposal facilities will need to be monitored and safeguarded for many generations.

From a safety perspective, the nuclear industry has practiced the safe temporary surface storage of spent fuel for more than half a century[6]. Over the last two decades, however, there have been major advances towards the first operating disposal facility (e.g. Sweden and Finland). A number of planned repository projects have been assessed for potential radiation leakage for a period of up to 10 million years. These studies have shown that the released doses are limited to "at most one tenth of a per cent of the exposure to natural radioactivity at the surface" (Taylor, 1996). Yet until HLW disposal facilities have been built and operated successfully and safely for several decades, the nuclear waste debate is likely to continue, which no doubt will influence public acceptance and may delay the introduction and development of nuclear power in many countries.

C. Proliferation

Nuclear energy must not only be safe and economical but also be used solely for peaceful purposes. It is its weapons legacy and the dual nature of nuclear technology that raise concerns. The IAEA has the mandate to reconcile the dual nature - to "accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world" and to ensure that peaceful nuclear energy "is not used in such a way as to further any military purpose".

Nuclear power plants per se are no immediate proliferation risk. Proliferation concerns relate to the nuclear fuel cycle, i.e., uranium enrichment (front-end) and reprocessing of spent fuel (back-end). The technology that facilitates the enrichment to reactor fuel levels (about 3-4 percent U235, from only 0.71 percent for natural uranium), however, can easily be reconfigured to enrich uranium to weapons-grade (about 90 percent U235) - a classical dual use technological process. Advances in enrichment technology have dramatically reduced the footprint as well as the electricity use of enrichment facilities which alleviates covert operations.

Reprocessing presents another proliferation risk, as it separates the fissile plutonium isotope Pu239 which, like U235, is a weapons material at concentrations higher than 93 percent. Pu is a by-product of the U235 fission process. It can be mixed with uranium and recycled as mixed-oxide (MOX) reactor fuel or accumulated for later use in fast breeder reactors. Reprocessing and stockpiling Pu239 is seen by many analysts as the real proliferation risk (von Hippel, 2012) of the nuclear fuel cycle.

The prevention of diversion of nuclear technology or fissile material for non-peaceful purposes is at the core of the IAEA safeguards system and the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). While both have been largely successful, proliferation risks continue to be serious. One significant gap in the NPT is the possibility for a state to acquire enrichment technology and operational expertise for "peaceful" purposes and then withdraw from the treaty to develop nuclear weapons (e.g. North Korea). It has been repeatedly proposed to place all enrichment and reprocessing facilities under multinational control (e.g. international or regional enrichment facilities, international fuel banks, etc.) and implement multinational approaches (MNA) to the management and disposal of spent fuel and radioactive waste. The main objective is to globally limit the number of facilities for enrichment and reprocessing and thus the opportunities for diverting fissile materials for nuclear weapon development. However, none of many MNA proposals has been able to resolve the contentious issue of fairness and to what extent they would encroach on the "unalienable right" of all countries (under NPT) to the development of their own fuel cycles.

The concept of an international fuel bank appears to be a workable compromise. The fuel bank is a stockpile of low enriched uranium under control of the IAEA. Fuel would be made available at market prices on a non-political and non-discriminatory basis to countries that are denied access to fuel for political reasons as long as they are in compliance with their nuclear safeguards obligations. The fuel bank concept contributes to non-proliferation as it provides for nuclear fuel supply security, thus reducing the incentive for the establishment of national enrichment facilities, while not impinging on a country's rights to developing its own fuel cycle technologies. In March 2010, the first fuel bank was formally established by the IAEA and the Russian government, and became operational by the end of 2010(7).

Another aspect not foreseen in the NPT is the emergence of non-state actors (terrorists, criminal groups) and consequently the need to prevent access of such groups to nuclear weapons or radioactive materials for malevolent. Several United Nations Security Council resolutions aim at combating nuclear terrorism address this concern as well as a number of both legally binding and non-legally binding instruments, e.g., the Convention on the Physical Protection of Nuclear Material or the International Convention for the Suppression of Acts of Nuclear Terrorism.

IV. NUCLEAR POWER FOR THE ARAB COUNTRIES

A. Why nuclear power in the oil and gas rich Arab countries?

The Middle East, and Arab countries in particular, hold the largest conventional oil and gas reserves globally. Its production costs are still largely below US$ 10 per barrel equivalent. This raises the question of why a region so well endowed with

low-cost hydrocarbon resources would consider the nuclear option. More precisely is there an economic rationale why the UAE has launched a national nuclear power program (the first two of four reactors are currently under construction) and why others (e.g. Saudi Arabia, Jordan and Egypt) are actively engaged in the preparation of such programmes?(8)

There are several reasons why exploring the nuclear option could have been appealing for some Arab countries:

- Demand for electricity, liquid fuels and desalination, due to water scarcity, has grown very rapidly in all Arab countries, especially the member states of the Gulf

Cooperation Council (GCC), thanks to low and subsidized domestic tariffs and prices, growing population and expanding economies;
- Not all countries of the region are well endowed with conventional hydrocarbon resources, e.g., Bahrain, Jordan, Morocco or Yemen;
- Low cost conventional hydrocarbon occurrences will not last forever and the lowest hanging fruit has been harvested in some countries already;
- Rapidly growing domestic energy demand reduces volumes available for exports (and thus governments' revenues) in the longer run;
- The associated gas share in oil production is often declining –low cost associated gas (with no potential for exports and tied to OPEC production quotas) has been a dominant fuel for electricity generation and desalination in several countries in the region;
- Climate Change concerns are slowly arising; and
- Diversification and economic structural change.

Most Arab countries' economies are dynamic, facing high rates of demand for electricity and desalinated water, as the populations grow and the utilization of low-priced electricity and desalinated water accelerates.

Since the turn of the millennium, annual final electricity demand growth rates for the region average at 7.3 percent - more than doubling electricity demand between 2000 and 2010.

National growth rates vary considerably over this period - from 4.4 percent/yr in Tunisia to 12.3 percent/yr in Qatar. For the countries listed in Figure 6 aggregate demand expanded from 308 TWh in 2000 to 624 TWh in 2010. Using the projections of the World Energy Outlook (IEA 2012a) as a guide, the aggregate final demand will range between 1020 TWh and 1240 TWh by 2030 necessitating net capacity addition between 175 GW and 210 GW.

B. Simple Economic Rationale

A simple calculation demonstrates the economic rationale for nuclear power: A nuclear power plant with investment costs including interest during construction of US$ 6500 per KW and a 5 percent interest rate generates electricity for 72 US$/MWh. A highly efficient combined cycle gas turbine (CCGT) plant operating on light-oil (investment costs 1150 US$/kW) would require an oil price of 50 US$/bbl to break even. In the case of natural gas, the break-even price would be around 8 US$/GJ. Both prices are significantly higher than the subsidized oil and gas prices in most countries in the region and nuclear power is not competitive under these conditions.

Now consider this: Light oil and liquefied natural gas (LNG) are currently traded at much higher prices than these break-even prices. Futures for light oil are around 100 US$/bbl while LNG originating from the Middle East trades around 11 - 13 US$/GJ. The deployment of nuclear power instead of oil and gas for electricity generation would release oil and gas volumes for exports. The extra revenues are more than sufficient to pay for costs of a nuclear power plant. In short, nuclear power is competitive with CCGT as long as average oil export prices are above 50 US$/bbl and LNG above 8 US$/GJ.

C. Concerns and Challenges

While there is a clear economic rationale and other promising benefits for adopting nuclear power, there are also many demanding challenges and stringent requirements that must be met.

Most Arab countries interested in nuclear power are still in the "planning" stage with regard to the deployment of nuclear power for electricity generation and desalination. The exception is the UAE which commissioned four Korean APR-1400 reactors in March 2010 to be built at its Baraka site. It is not expected that other Arab countries will embark on the construction of a nuclear plant much before 2020, with the exception of Saudi Arabia and possibly Egypt and Jordan. For the time being most countries focus on addressing daunting challenges of the development of prerequisite nuclear infrastructure requirements such as human resource development, nuclear education, nuclear safety culture, national nuclear law and nuclear regulation.

D. Nuclear Infrastructure

The introduction of nuclear power requires the establishment of a wide range of infrastructures to ensure the safe and effective operation of nuclear power plants. Currently most Arab countries lack a basic nuclear infrastructure. Key are comprehensive nuclear law (that regulates safety, security, safeguards, and liability), highly qualified and disciplined human resources and efficiently and effectively managed institutions (well protected from political interferences) on all aspects of the use of the technology, an independent and competent nuclear regulatory entity, a deeply rooted safety culture, stakeholder involvement, long-term policies and solutions for nuclear waste management and eventual plant decommissioning and well established and credible emergency preparedness.

While nuclear infrastructure issues are not insurmountable barriers to the introduction of nuclear power, they involve a lengthy preparation process that can last up to ten years and more. They also require substantial financial commitment. While outsourcing parts of the nuclear infrastructure may facilitate fast-track to the introduction of a nuclear power plant, it cannot be a long term solution. Especially nuclear safety and reliability remain national responsibilities. Regional approaches to infrastructure development (rather than individual countries developing them separately) may yield considerable benefits. This may also include the joint ownership of nuclear power plants by several countries.

Economies of scale suggest that embarking on nuclear power means the eventual deployment of more than one nuclear power plant so as to distribute certain fix infrastructure costs (e.g., maintenance, waste management).

Current commercially available reactor technology of 1000 to 1600 MW may not fit the grid capacity of several Arab countries (notwithstanding the fact that these grids are going to be at least twice today's sizes by the time nuclear power can realistically be introduced in 10 to 15 years). Numerous smaller unit sizes are under development and may be commercially available by 2020 to 2025.

Energy security

Other considerations are enhanced energy security through diversification of primary energy sources and the mounting pressure on Arab states to adopt climate mitigation measures and curb national greenhouse gas emissions. Nuclear power can play an important role in this regard but so can the large scale deployment of renewable technologies, once economics and storage considerations are demonstrated, especially photovoltaic (PV) and concentrated solar power (CSP) given the high levels of insolation and the huge extent of desert areas in the region.

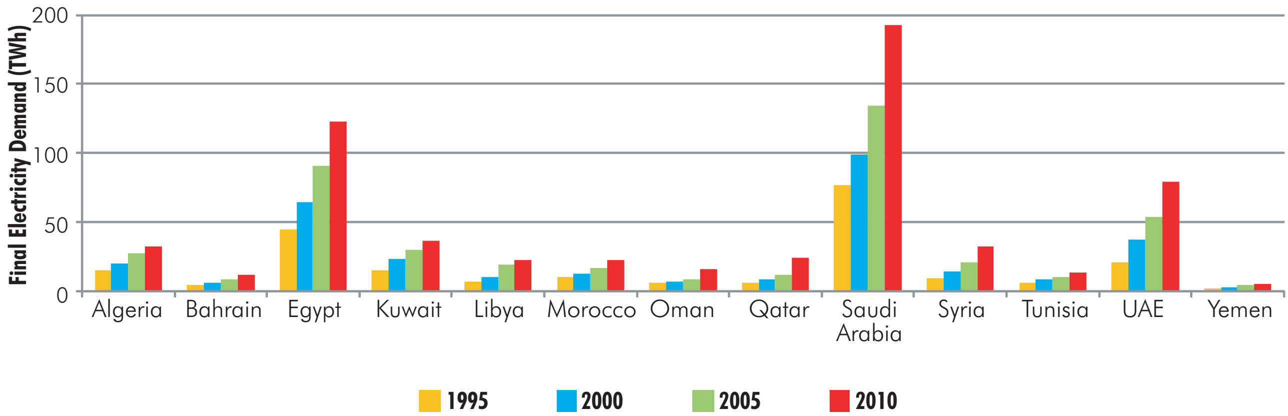
While nuclear power is a means for supply diversification, in an Arab context the technology can represent certain supply security risks. As technology recipients, the Arab countries would be fully dependent on technology and fuel imports from abroad as well as politically motivated restrictions such as the 1-2-3 agreement(9) with the USA(10). This agreement roots in weapons proliferation concerns and essentially excludes domestic fuel cycle activities in the partner country and revokes the 'inalienable right' as stated in Article 4 of the Non-Proliferation Treaty (NPT).

Proliferation concerns

There are also views that expressively link the peaceful nuclear power ambitions in the region to Iran's potential acquisition of a nuclear weapon (Luomi, 2012).

Most countries in the region interested in the adoption of nuclear energy have declared that they are not interested in any domestic fuel cycle activities (except uranium extraction) and that they

FIGURE 6 **FINAL ELECTRICITY DEMAND GROWTH, 1995 TO 2010**



Source: IEA (2012B)

will be fully compliant with their national safeguards obligations. While all Arab countries are part of the NPT regime and have in place comprehensive safeguards agreements with the IAEA, not all have joined the 'Additional Protocol'.[(11)]

National position and stakeholder involvement

A decision to embark on a nuclear power programme should be based upon a national position, with a sound and long term non-partisan energy policy and the fully understandings of the long term (100 years plus) commitments required for a nuclear power programme. Developing a national policy should be based on transparency, accountability and full stakeholder involvement, especially the general public. The risks and benefits of nuclear power versus the risks and benefits of non-nuclear alternatives must be presented in a neutral and transparent manner. Only then public acceptance can be accomplished. Stakeholder involvement, however, is not general practice in most Arab countries.

V. CURRENT AND PLANNED NP PROGRAMMES IN THE ARAB COUNTRIES

In one way or another, almost all Arab countries, large and small, have expressed at least some interest in nuclear power. Starting around 2005, smaller countries like Bahrain, Kuwait, Oman and Qatar without any nuclear infrastructure or nuclear engineering expertise carried out energy studies, signed international nuclear cooperation agreements, gathered information on prerequisite nuclear infrastructure requirements or adhered to international nuclear treaties, protocols and conventions, etc. After the Fukushima Daiichi accident, however, these countries have dropped or suspended their national nuclear plans.

Another group of countries started developing national nuclear infrastructure programmes as early as the 1970s; this list includes Algeria, Libya, Morocco, Syria and Tunisia. These countries have maintained modest nuclear research and education programmes often centred on small research reactors for training purposes, materials testing and radioisotope production. Initial ambitions towards adding nuclear power to their national electricity systems were dampened after the mid-1980s by the Chernobyl accident, low oil and gas prices and economic development below expectation.

All these countries stepped up their national nuclear infrastructure preparations after 2005 - very much in line with the rising expectations of a global nuclear renaissance. The justifications have been rising energy prices, energy security concerns, an expanding economy thus growing demands for electricity and desalination and environmental considerations. All five countries entered into various international nuclear cooperation agreements with the objective of enhancing their nuclear infrastructures, especially

human resource development as well as the creation of nuclear oversight institutions and regulations. Countries with known uranium resources are exploring their eventual extraction usually as integral parts of international nuclear cooperation agreements.

The Fukushima Daiichi accident has had no profound impact on these countries except perhaps a better appreciation of the need for thorough nuclear infrastructure development and implementation. All signs point to an undeterred continuation of planning towards the introduction of a first NPP.

- **Algeria's** current plans are to have a first NPP in operation by 2022 (Sidi Ali 2012) and adding one NPP every five years thereafter. The development of its uranium resources is under consideration.

- **Morocco** has had plans for building its first NPP at the Sidi Boulbra site located on the Atlantic coast and intends to open negotiations with vendors next year. Grid connection is expected between 2022 and 2024. The country has enormous amounts of uranium contained in phosphates estimated at about 6.9 million tonnes uranium (tU) which is larger than currently known global conventional uranium resources (NEA/IAEA 2010, 2012). The feasibility of recovery of uranium as a by-product from phosphoric acid is under investigation with support from France.

- **Tunisia's** nuclear cooperation with France focuses on nuclear electricity generation and desalination. Initial targets of having a first NPP operational by 2020 are no longer publicly maintained, 2025 currently seems more likely. Tunisia's phosphate resources are estimated at higher than 1 billion tonnes of which 100 million tonnes are reserves containing some 50,000 tU. The construction of a pilot plant for the extraction of uranium is in an early planning stage.

- **Libya's** peaceful nuclear technology development intentions were seriously questioned when it declared in 2003 to abandon a clandestine uranium enrichment programme. It regained its nuclear credentials when it signed the Additional Protocol one year later. Since then, numerous nuclear cooperation agreements on the peaceful use of nuclear energy with Libya were signed.

- **Syria** - Between the late 1970s and 1990, Syria undertook several unsuccessful attempts towards the construction of a NPP. It later pursued plans with support from Russia for a NPP and a nuclear seawater desalination facility (Sharp 2007) for operation by 2020. Syria's peaceful nuclear power programme has been seriously contested following an Israeli air strike in 2007 that destroyed Dair Alzour, a facility alleged by U.S. and Israeli intelligence to have been a partially completed 25 MWth gas-cooled graphitemoderated nuclear reactor. Syria claims the site was an unused military building. Lack of resources, the on-going controversy concerning the Dair Alzour site and the civil war make the implementation of a civil nuclear power programme quite unlikely for the foreseeable future.

The final group includes countries either with the most advanced national nuclear infrastructures already in place (Egypt, Jordan and the UAE) or with firm intentions to adopt nuclear power (Saudi Arabia).

- **Egypt** - The nuclear energy program in Egypt is the oldest in the Arab region and dates back to the mid-1950s with the creation of the Atomic Energy Commission. The first research reactor started operation in 1961 followed by the establishment of the Nuclear Power Plant Authority (NPPA) in 1976. Ambitious nuclear energy development plans for both electricity generation and desalination started in the late 1960s and culminated with a target of ten reactors operating before the close of the 20th century (WNA, 2013). However, international cooperation was hampered until 1981 by Egypt's reluctance to ratifying the NPT. After ratification, several projects were tendered with EL-Dabaa as the preferred site for NPPs. The Chernobyl accident of 1986 and collapsing oil and gas prices halted Egypt's quest for nuclear power. In 2008 the NPPA awarded a preconstruction contract for the planning and preparation of a 1200 MW NPP for commercial operation in 2017. By 2010 the entry into operation was pushed back to 2019 while the number of plants online by 2025 was raised to four. Egypt persistently advanced the development of its nuclear infrastructure through international cooperation in the area of human resource development including training in facilities abroad. It also continues to seek to

develop the expertise to maximize the local participation in NPP projects. However, with the onset of the "Arab Spring", all plans are put on hold until the political situation stabilises again. The new government has yet to state its position on nuclear energy, foreign participation and finance (Abou Elhassan, 2012).

- **Jordan** - Jordan imports over 95 percent of its energy needs at considerable expense and adverse impact on it current accounts, making a strong case for the nuclear power option. In addition to energy supply security concerns, Jordan also faces serious shortages in fresh water supplies.

  In the early 2000s', Jordan began to aggressively prepare its nuclear infrastructure following IAEA guidelines and in 2007 established the Jordan Atomic Energy Commission (JAEC) and the Jordan Nuclear Regulatory Commission (JNRC), and initiated comprehensive energy analyses with the aim to plan the introduction of nuclear power at the earliest point in time feasible. Jordan's nuclear strategy called for nuclear power to supply 30 percent of Jordan's electricity demand by 2030, as well as to provide for exports to neighbouring countries.

  In 2009 it contracted a 5 MW Korean research and test reactor as an integral part of its nuclear technology infrastructure (science, education and research) development. In the same year JAEC contracted an international consultancy for a comprehensive pre-construction phase of a 1000 MW nuclear power plant including finding a strategic partner for the finance and operation of the plant.

  After discarding the initially preferred site near the Gulf of Aqaba's coastline for reasons of heightened seismic activity, the new proposed location is the Majdal area some 40 km north of Amman. Cooling water at this inland site far away from the coast or rivers would be provided by a waste water treatment plant using the Palo Verde nuclear generating station in Arizona, USA as a template.
  In May 2012, after evaluating several bids from various vendors, the JAEC announced it had selected two bidders or rather consortiums — Russia's Atomstroyexport (AES-92 VVER-1000 MW) and the Franco-Japanese joint venture Areva-Mitsubishi (1,100 MW Atmea-1) — for further negotiations to build Jordan's first nuclear power plant.

  In early June 2012, Jordan's parliament voted to suspend the country's nuclear power and uranium mining programme pending the completion of further economic feasibility and environmental surveys. In March 2013, JAEC announced that the government would decide the following month which of the two competing consortiums would be selected to build two 1000 MW nuclear reactors at an estimated cost of €12 billion. Possible delays in construction start associated with Syrian civil war are acknowledged.

  A key factor in the selection process will be the financial package offered by the consortiums. The JAEC anticipates a limited recourse arrangement with a debt-equity ratio in the order of least 75-25 with government guarantees on part of the debt and long-term power purchase arrangements. A build-own-operate (BOO) scheme modelled on the Akkuyu nuclear power plant project in Turkey is also considered.

  Jordan's undeveloped uranium resources could help finance its nuclear power program. The countries uranium resources are estimated at 33,800 tU of conventional uranium and up to 120,000 tU unconventional uranium in phosphate rocks (NEA/IAEA, 2012). In order to maximize the value added of uranium extraction, this could eventually also include domestic uranium enrichment. Consequently, Jordan has expressed a preference to keep its enrichment and reprocessing options open. Jordan has signed nuclear cooperation agreements with more than a dozen countries covering nuclear power and desalination, uranium mining and nuclear infrastructure development. It had initialled but not signed a 1-2-3 agreement with the USA. The USA wants Jordan to agree to the "gold standard" precedent set with the USA-UAE 1-2-3 agreement, not to pursue indigenous uranium enrichment or plutonium reprocessing capabilities. The absence of a full nuclear cooperation agreement with the USA prevents Jordan access to US nuclear technology. The Jordanian government maintains that the NPT affords it the right to all capabilities associated with the peaceful nuclear fuel cycle, and is therefore on principle disinclined to sign an agreement holding it to a different standard than most other treaty members (Grossman2013). Jordan has a safeguards agreement with the IAEA and has also ratified the Additional Protocol.

- **Saudi Arabia** - In August 2009, the Saudi government announced that it was considering a national nuclear power programme. The government immediately signed a safeguards agreement with the IAEA but has not ratified the Additional Protocol.

  The King Abdullah City for Atomic and Renewable Energy (KA-CARE) was established in 2010 to advance nuclear and renewable energy. KA-CARE is tasked with the development of all aspects of the nuclear power programme and infrastructure. KA-CARE contracted various international consultancies to help define a national strategy and action plan for the introduction of nuclear power including an operation model, identification of potential sites and the development of technical specifications for a future tender.

  According to KA-CARE, although "hydrocarbons will remain a prime element in the likely electricity mix in 2032" (KA-CARE, 2013), the future supply structure for meeting the expected electricity demand of more than 120 GW in 2032 includes supplies of 17.6 GW of nuclear power and 54 GW of various renewable generating capacities. Nuclear power would then account for about 20 percent of the Kingdom's electricity supply. KA-CARE literature states that the first two NPPs are planned to be on line by 2023/4, to be followed by 2 more per year up to 2032.
  Saudi Arabia has little in terms of a nuclear infrastructure, but is working with the IAEA and other countries to develop human resources in nuclear sciences and research. Although a nuclear regulatory authority has been set up, due to a lack of local regulatory expertise this new institution still falls within the King Abdulaziz City for Science and Technology (KACST), currently responsible for nuclear regulation.

  Saudi Arabia has entered into several international cooperation agreements, especially with France, the Republic of Korea, China and Argentina, covering nuclear infrastructure development, R&D and nuclear power plant construction, maintenance and nuclear fuel supply. KA-CARE continues negotiations with other nuclear technology holders, especially the USA, regarding such agreements. An agreement with the USA (so called 1-2-3 agreement) would most likely need to include the nuclear trade "gold standard", i.e., a verifiable Saudi Arabia pledge not to enrich uranium or reprocess plutonium domestically, similar to what the UAE had agreed to.

- **UAE -** The UAE published its "Roadmap to Success for the UAE Nuclear Power Program" in 2008 which envisaged ten NPPs by 2030. The Emirates Nuclear Energy Corporation (ENEC) became the organization charged with implementing the UAE nuclear energy programme while the Federal Authority for Nuclear Regulation (FANR) was established as the national nuclear regulator.

  In December 2009, ENEC announced that it had selected a consortium led by the Korea Electric Power Corporation (KEPCO) to design, build and assist in the operation and maintenance of four 1,400 MW nuclear power units. One year later ENEC submitted licence applications for units 1 & 2 to FANR which subsequently issued construction licenses in July 2012. Construction of the first two units was subsequently started, with commercial operation expected by 2017. The other three units are scheduled to be completed by 2020.

  As regards nuclear waste management, the UAE pursues a "dual track" strategy

that involves developing a national storage and disposal programme in parallel with exploring regional cooperation options. This also includes the option of fuel leasing and shipping spent nuclear fuel to other countries for reprocessing or storage outside the region.

Rather than following the slow path of first establishing indigenous expertise, the UAE implements and manages its nuclear power programme by outsourcing and contracting services from abroad. Otherwise this fast-track approach of four years between the political decision to go nuclear and the shuffle hitting the ground would have been impossible. The contract with KEPCO provides for extensive training, human resource development, and education programs as the UAE builds the capacity to eventually staff the vast majority of the nuclear energy programme with UAE nationals (IAEA, 2011). While international experts staff FANR and ENEC as well as other key organizations, Emirati nationals are shadowing important positions, and over time, the staffing of these organizations will be taken over by Emirati nationals.

Thanks to the early and transparent communication of its nuclear intentions, the UAE has enjoyed solid international support from technology holding countries. Key was the quick ratification of the Additional Protocol and the USA-UAE 123 agreement in which the UAE explicitly forswears domestic enrichment and reprocessing. This agreement and the high reliance on expertise from abroad in the implementation of the national nuclear programme has been declared as the 'model for the world' by Western policymakers, commonly referred to as the 'gold standard' for newcomers (Kamrava, 2012). Many potential newcomers are not necessarily agreeing to the 'gold standard' as it carries the danger of perpetuating the dependence on foreign expertise and services.

VI. CONCLUSION

Is there a solid case for nuclear power in the Arab countries? While there are many promising benefits, there are also demanding challenges and daunting obstacles to overcome on the road to introducing nuclear power. The answer to this question can only be given in comparison with the alternatives to nuclear power. Dismissing one energy option without specifying its replacement on a level playing field is of no avail. There is no perfect technology without risks and interaction with the environment. Moreover, as much as sustainable development is a dynamic process, technology is also subject to change. Innovation and technology change improve most performance aspects of a technology from the current to the next generation or investment cycle.

From today's perspective, nuclear power advantages include: competitive economics; low life-cycle GHG emissions; energy security, especially during periods of price volatility; stable and predictable generation costs; most externalities are already internalized; small and managed waste volumes; productive use of a resource with no competing uses; firm base load electricity supplies and synergies with

intermittent energy sources (EU, 2003; NRC, 2009; Markandya et al, 2011) For the oil and gas exporting countries of the Middle East, the nuclear power option appears to be competitive economically if the average price of oil over the long term is firmly above 50 US$/bbl and long term LNG export price is above 8 US$/GJ.

Nuclear power is a highly complex technology along many dimensions. Mastering these to reap its benefits is an even more challenging task. Nuclear power is less forgiving than other energy technologies, requiring persistent discipline in operation and maintenance, especially with regard to strict adherence to safety standards and regulatory requirements. Equally important is competent and effective regulatory oversight. The Fukushima Daiichi accident is testimony that even technologically advanced countries can have serious weaknesses in their national nuclear programs. In technologically less advanced countries without a well-developed safety culture, e.g., the Arab region, the introduction of nuclear power needs to balance the added risk with the benefits. Therefore, the development of a successful, safe and secure nuclear power program requires a strong and unwavering long term national commitment, with high initial efforts to develop the required infrastructure, especially human resources and an effective and disciplined management system for all components of the nuclear fuel cycle and related organizations, which is a cumbersome and time-intensive process.

Other aspects of the nuclear power option that need continuous attention are (a) the permanent and safe disposal of HLW - here regional approaches, fuel leasing and take back arrangements are potential alternatives for the region; (b) risks of nuclear weapons proliferation; (c) the physical security of nuclear material and facilities; (d) ensuring highest level of safety in technology design and facilities operation; (e) lower construction costs; and (f) public acceptance of the technology. The current benefits of nuclear power may fade away without further advances ranging from technology innovation and international institutional arrangements to a participatory civil society in nuclear matters. While there is consensus with the nuclear community that technical solutions do exist for the safe and secure ultimate disposal of HLW, lingering doubts will continue in segments of the public mind and decision makers until experience has been accumulated from waste disposal facilities under construction in Sweden and Finland.

Clearly, the Arab countries are also endowed with enormous renewable energy potentials, especially solar energy. Costs of PV and CSP have been declining substantially in recent years - a trend that is expected to continue. Still intermittency of supply remains to be a principal issue. Solar energy needs a companion and nuclear power can, in principle, play that role. Given the diurnal cycle of electricity demand and solar energy insolation, nuclear power might supply base load demand and solar energy the daily intermediate and peak loads which largely match its daily availability. Moreover, electricity is difficult to store, water is not. With reverse osmosis (RO)[12] becoming the desalination technology of choice, nuclear electricity can be used for RO desalination whenever electricity is not required to meet non-desalination demand.

Yet for most Arab countries, the low lying fruit of demand management to curb the wasteful part of current high energy demand and future demand growth is technically easier and more economic. Enhancing energy efficiency and replacing wasteful energy subsidy policies, in particular in GCC countries, with more rational approaches to wealth sharing policies, can reduce by as much as 50 percent of the business-as-usual power capacity growth projected for the 2-3 decades to come. It is truly the low lying fruit that must be implemented first, ahead of increasing supply from any source. The political cost of making unpopular changes to the irrational part of the prevailing energy subsidy policies is far less costly than the costs associated with development of new electricity generation capacity from any source.

Finally, one size does not fit all. Countries differ with respect to their energy needs, their national endowment with energy resources, their energy system infrastructure, technology alternatives, financing options, preferences and risk perceptions. How countries trade off among various specific considerations- e.g., air pollution, dammed rivers, jobs in the mining industry or in the home insulation industry, the risks of a nuclear accident or gas explosion or an oil tanker sinking at its shores or coal mining accidents, the dependency on foreign fuel supplies, and the benefits of affordable electricity – is at least partly a matter of national preference, and thus an area of legitimate disagreement even if everyone were to agree precisely on all the facts. The Arab countries face additional challenges that need to be tackled ranging from a weak R&D capacity, lack of human resources, absent emergency preparedness, non-participating civil society, and a fragile peace and security situation.

All countries use a mix of energy sources, and nearly all countries generate electricity from a mix of technologies. Partly that reflects the march of history, where new technologies replace older ones, but more usually in fits and starts over time, not in one sudden, instantaneous and complete replacement. It reflects the fact that investors disagree about what will prove most profitable, and it reflects the fact that a portfolio of sources reduces risk and vulnerability. Local conditions determine the optimal supply and technology mix which may or may not include nuclear power.

Nuclear power is not for everyone and one size does not fit all. But it will remain or become part of the energy mix in many countries. What is right for the Arab countries also depends partly on the regions' national preferences and priorities as expressed in national politics. For now, there is no doubt that the unfolding changes in the region are pointing to delays in planning and implementation of nuclear power programs in several Arab countries.

Nuclear power is a long-term commitment (on the order of centuries not decades) and will require solid social and-political support. Stable and mature participatory political systems are considered essential to assure such long term national commitment. In the short-run it means committing several billions of US$ for infrastructure, human resource development, and plant construction. It is a commitment to maintaining highest operating safety and security standards. In the longer run it is not only a commitment to safekeeping of nuclear waste and effective nuclear proliferation control schemes, but also the development and implementation of advanced proliferation-resistant fuel cycles and fuel supply assurances MNA schemes. Societies need to understand these commitments as well as the risks and benefits associated with nuclear power, and may as well decide that the benefits are not worth the risks.

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NOTES

1. Nuclear was not the only technology affected by low oil and gas prices: Numerous coal-fired plants suffered a similar fate of construction delays and cancellations.

2. The vastly improved utilization of existing capacities worldwide corresponds to a virtual construction of about thirty-five 1,000 MW nuclear power plants.

3. In 2002, the German government, consisting of the Sozialdemokratische Partei Deutschlands (SPD) and Alliance '90/The Greens introduced legislation that mandated the phase out the use of nuclear energy. This phase-out was revoked by the current coalition government six months before the Fukushima Daiichi accident. In the wake of the accident the same government ruled a new phase-out by 2022.

4. Note: The estimated absolute number of radiation induced fatalities for all but the three most exposed groups is only calculable, not measurable or attributable to the accident.

5. Tsunamis exceeding the 5.7 meter high seawall have been historically reported for the site and surrounding region by considered too unlikely despite recent studies suggesting otherwise.

6. The USA has a repository for transuranic wastes - the Waste Isolation Pilot Plant (WIPP) in New Mexico - in operation for more than a decade. It receives wastes including Plutonium, Americium etc. from the military weapons programme.

7. The UAE and Kuwait contributed US$ 10 million each in support of another US led international LEU Fuel Bank to be managed by the IAEA.

8. Iran is the first country in the Middle East with a nuclear power plant in operation (since 2011).

9. Section 123 of the United States Atomic Energy Act of 1954 defines the principles for cooperation in the area of nuclear energy between the US and any other nation. It requires a bilateral agreement between the USA and the recipient country - a so-called 1-2-3 Agreement. Without such an agreement U.S. firms are not allow engage in nuclear technology transfer to that country.

10. The International Fuel Bank (see Section 3.3) was established to mitigate potential access to nuclear fuel supply concerns.

11. While the NPT foresees IAEA verification in 'declared' (by the Member State) nuclear activities, the Additional Protocol (AP) permits IAEA inspectors access to all parts of a State's nuclear fuel cycle - including uranium mines, fuel fabrication and enrichment plants, and nuclear waste sites - as well as to any other location where nuclear material is or may be present. The AP increases the likelihood of detecting a clandestine nuclear weapons program and to build confidence that States are abiding by their international commitments.

12. RO is electricity operated. The standard multi-stage flush process uses heat often decoupled from co-generation plants which limits the flexibility between heat and electricity.

OPINION

THE NUCLEAR POWER OPTION IN ARAB COUNTRIES

Najib Saab

The earthquake that struck the Iranian Bushehr province in April 2013 reminded us of the nuclear reactor at Bushehr, and raised concerns about possible radioactive leakages. Such fears were to be expected, just two years after the nuclear disaster caused by the tsunami in Fukushima. These concerns had not yet subsided when another more violent quake hit East Iran with tremors felt in the Arabian countries across the Gulf. Scenes of residents fleeing high-rise buildings and taking to the streets in panic in Doha, Dubai and Abu Dhabi were abounding in media.

Fears of radioactive leakage, whether caused by an operational accident, like in Chernobyl and Three Mile Island, or a natural disaster such as Fukushima's, are justified. Accidents do happen in all stages of the energy industry, upstream and downstream. But due to the complex nature of nuclear plants the impacts of any accident would be far deeper and wider than an oil spill incident or an explosion in a gas or oil plant. While the latter can be brought to a closure, consequences of nuclear accidents continue over an unforeseen period. So the residents of the Arabian cities of the Gulf were not to blame for being terrified of the possibility of an accident at the Bushehr reactor on the opposite side, that would transmit radioactive material to the Arab cities through water and air.

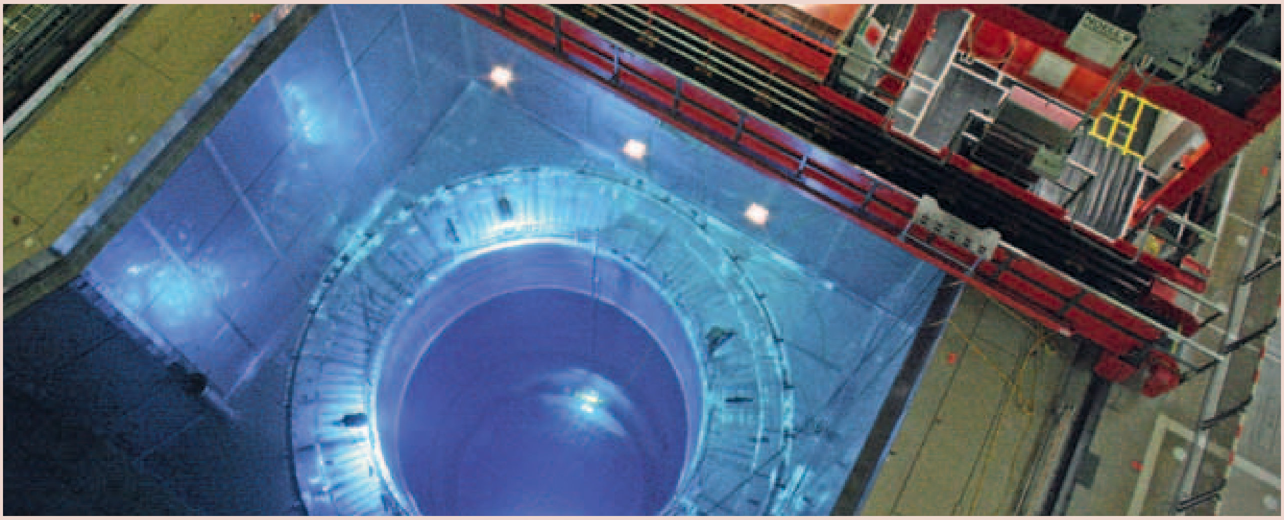
These events revived the debate about nuclear energy in the Arab world. Most Arab countries have shown interest in acquiring nuclear power, at various levels, and belong to two categories. The first group constitutes oil-exporting countries, such as the UAE, Saudi Arabia and Algeria. These countries consider the nuclear option an opportunity for diversifying income sources and enriching the energy mix. It should be noted that as much as 40 percent of oil production in these countries is used locally for power generation and seawater desalination. Using nuclear power for electricity generation will allow them to increase export of oil and secure better positions in the energy markets, long after fossil fuels. On the other hand, non-oil producing countries that aspire to have nuclear energy, such as Jordan and Morocco, consider the nuclear option as a way out of their energy crisis, especially since some of these countries have stocks of uranium, though mostly low-grade. Both groups similarly believe that the possession of nuclear technology promotes scientific research and secures a sort of prestige and higher standing in the international arena.

It is worth mentioning that the Arab states with the highest nuclear commitments, such as Saudi Arabia, Egypt, Morocco and Algeria, have at the same time the highest commitments with respect to renewable energy sources, notably solar energy targets. Saudi Arabia announced a plan to produce 41 Gigawatts from solar energy by 2032, the most ambitious renewable energy target ever. The UAE is investing billions in renewable energy through MASDAR. Morocco and Algeria are at the heart of DESERTEC, the initiative designed to generate solar electricity not only for domestic use but also for export to Europe. These countries believe that the incorporation of nuclear technology into the energy mix provides an additional measure of energy security alongside stabilizing supplies. Proponents say that storage of solar electric power to use overnight, for example, is still an expensive process that can be supported by nuclear energy.

Energy security, in the context of nuclear power, varies among different groups of countries. While countries that have the right to enrich uranium locally can claim a certain level of supply security, the same does not apply to others, including Arab countries. There are restrictions that prevent those from enriching uranium locally, and impose bans on importing it enriched, even if they have uranium ores as in Jordan, Morocco and Algeria. It should be noted, in this respect, that the United States has warned that it would prevent Jordan from using American nuclear technology and would impose wide-ranging sanctions if the country opted to enrich uranium locally.

Investing in nuclear technology to promote scientific research and support development requires as a prerequisite the development of national capabilities for scientific research, particularly local human resources. But some Arab countries have actually chosen the easy path to save time, by outsourcing the whole process, from design, construction, supply of equipment and material, to the manpower needed to operate and maintain security of plants. Although these countries have included in their nuclear plans training programs for national manpower, it is to be seen how fast this could be implemented.

Scientific research, industrial development and security of



energy supplies are justifiable arguments for looking into nuclear energy options. However, the most prominent argument for supporting nuclear energy options in recent years has been that it helps in controlling climate change, because it does not discharge greenhouse gases (GHGs). Proponents of nuclear power say that the world may well find no other alternative to drastically reduce emissions and curb climate change- even just for a bridging period until renewable energy gains more solid grounds. But environmental impacts of nuclear power are not limited to climate change. There has not yet been developed any permanent solution for the ultimate safe disposal of wastes of nuclear reactors. Although the nuclear industry is confident a solution should be found sometime, the operative word to explain the situation is still temporary storage, with the risks of radioactive leakages due to natural disasters and / or human errors. The same applies for calamities in nuclear reactors, resulting from earthquakes, floods and operating errors, noting that the bigger the reactors the greater the related risks. A key question is how prepared Arab countries are for such a scale of disasters? Therefore, all phases of the nuclear cycle should be taken into consideration: construction and operation of reactors, storage and disposal of wastes, and impacts of possible catastrophes.

Fast and immense increase in demand on electricity is often cited as an immediate reason which justifies the nuclear power drive. Prior to funding considerable investments for the construction of new power plants, regardless of the technology to be adopted, be it based on fossil fuels, renewable energy or nuclear, Arab countries must first manage energy demand and improve efficiency. The per capita energy intensity in the Arab Region is twice the world average; energy consumption per capita reaches six times the world average in some GCC countries. The main causes of this situation are the low efficiency levels and the lack of incentives that should encourage saving, mainly as a result of subsidies. After all, increasing production, as the only response to waste and over-consumption, is like supplying an addict with more drugs rather than helping him to quit the damaging habit.

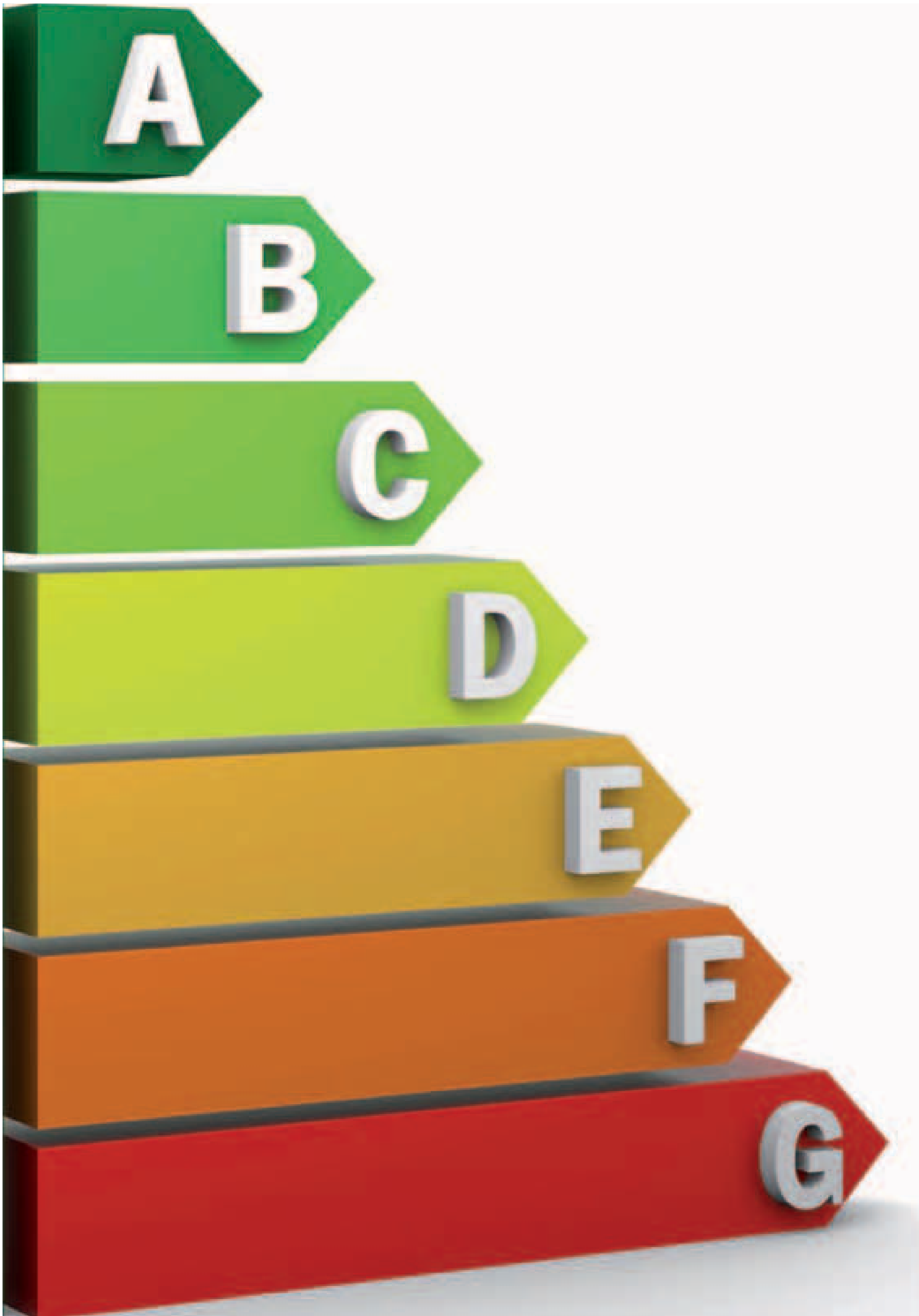
Renewable sources, particularly solar energy, remain the cheapest and most secure option for the Arab countries. The cost of solar power generation is rapidly decreasing and shall be almost equivalent to the costs of fossil fuel-based power generation if subsidies are lifted. Arabs do have solar resources even in much bigger and more sustainable reserves than oil. Both oil and sun can be under national control, and do not have to be imported with restrictions, like enriched uranium. As for hurdles facing the storage of solar electricity for night use, proponents of renewable energy say that a portion of the electricity generated during day can be used to produce hydrogen through electrolysis of seawater, which can in turn be used to obtain electricity, night and day.

Serious analysis of the cost, risk and safety of nuclear power generation relative to conventional and alternative sources should inform government decisions and long-term commitments.

Najib Saab is Secretary General of Arab Forum for Environment and Development (AFED) and Editor-in-Chief of Al-BiaWal-Tanmia (Environment & Development) magazine. This commentary, which was the editorial of the May 2013 issue of the magazine, was simultaneously published in 10 regional newspapers.

Energy Efficiency

Tareq Emtairah*
Farid Chaaban



Current trends in patterns of energy use put the Arab economies among the least efficient ones in global comparisons. There has been no decoupling between economic growth and energy demand in the Arab region in the past decade. Growth in energy consumption has been faster than economic growth during the past decade; average annual GDP growth was around 4%,while the increase in primary energy and electricity demand has been about 8%. This trend implies energy is not being used effectively to produce value within the regional economies. The average primary energy intensity in the region in 2010 constituted about 0.2 Tons of Oil Equivalent (Toe)/$1000, which is slightly above the world average of 0.19 and about 31% higher than the European average of 0.14 Toe/$1000.

Fossil fuel subsidies are a contributing factor to this inefficient use of energy. In Arab electricity markets, price subsidies represent one of the major challenges to progress of efficiency measures. The Arab residential markets are the most heavily subsidized, with some countries offering an implied subsidy of up to 95%. In the transport sector, the average specific energy consumption of private cars in the region remains notably higher than the average consumption in EU countries.

Another factor is the prevalence of inefficient electricity infrastructure in most countries of the region. Average Arab electric energy losses in generation, transmission and distribution (19.4%) are higher than the world average (8.3%) and much higher than the EU average (5.8%), presenting ample opportunity for achieving energy savings.

The potential gains from economically feasible efficiency measures are substantial. Various studies estimated that with implementation of energy efficiency building codes in the Mediterranean countries, the total primary energy savings could constitute 183 Million Toe over the period of 2012 to 2030, with annual CO2 reductions of 82 Million Tons. Reducing losses in the transmission and distribution of electricity to 10% in all countries would save the region some 7,300 MW of power, equivalent to US$5.5 billion of new investments. Transition to efficient lighting (CFLs) in the whole region would generate energy savings of 1.67 TWh per year, and result in 2.56% reduction of CO2 emissions.

Making the transition to more energy efficient economies requires substantial effort. The chapter presents and discusses several recommendations on making this transition through: careful energy planning, introducing cost-reflective electricity tariffs, strengthening compliance and enforcement, and instituting strong institutional framework. Experiences from the region show that countries with dedicated energy efficiency agencies tend to have stronger EE regulatory framework and better EE performance.

* Contributed to this chapter from RCREEE team also: Nurzat Myrsalieva, Brit Samborsky and Ashraf Kraidy.

I. INTRODUCTION

The Arab world is generally characterized by a relatively high level of consumption that, although offset by significant energy production, represents an unsustainable long-term pattern. The region relies almost entirely on fossil fuel for meeting its energy demands and most countries heavily subsidize energy prices. Despite rapidly growing energy demands and declining reserves of fossil-fuel, the region continues to be one of the most energy-intensive regional economies in the world resulting in an increase of associated greenhouse gas (GHG) emissions. With rapid urbanization, and population and economic growth, the trend is towards an even greater rise in energy intensity (El-Katiri, 2012).

Recognizing the importance of energy efficiency (EE), the League of Arab States on 25 November 2010 adopted the Arab Energy Efficiency Guidelines in order to promote cost-effective improvements of end use electricity in its member states through guiding targets, mechanisms, incentives, and institutional framework. However, despite pronouncements by Arab leaders for more sustainable energy development, today only few countries in the region have published energy efficiency strategies with quantified targets and supporting policy measures. There are still many social, economic and political barriers to EE that need to be overcome. This chapter discusses the current trends of energy efficiency in the region, outlines major factors contributing to inefficiency, provides overview of current efforts to overcome challenges and presents pathway to pursue energy efficiency in the region.

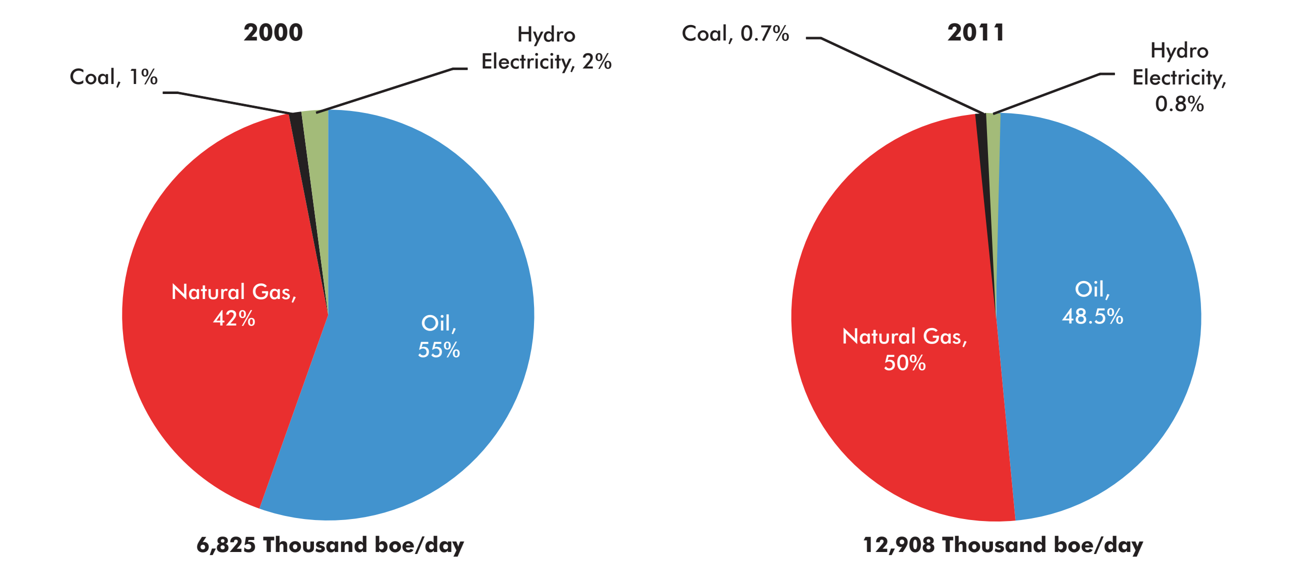
II. CURRENT TRENDS OF ENERGY SUPPLY AND DEMAND

A. Primary and Final Energy Consumption

Energy consumption in the region continues to be dominated by fossil-fuels. In 2011, the primary energy consumption mix was dominated by oil products (48.5 percent) and natural gas (50 percent), with coal (0.7 percent) playing a minor role and hydro electricity (0.8 percent) being the only form of renewable energy to make a measurable impact. As can be observed from Figure 1, the situation has not changed significantly since 2000. The main trend is the increasing use of natural gas, with a relative reduction in share amongst all other sources.

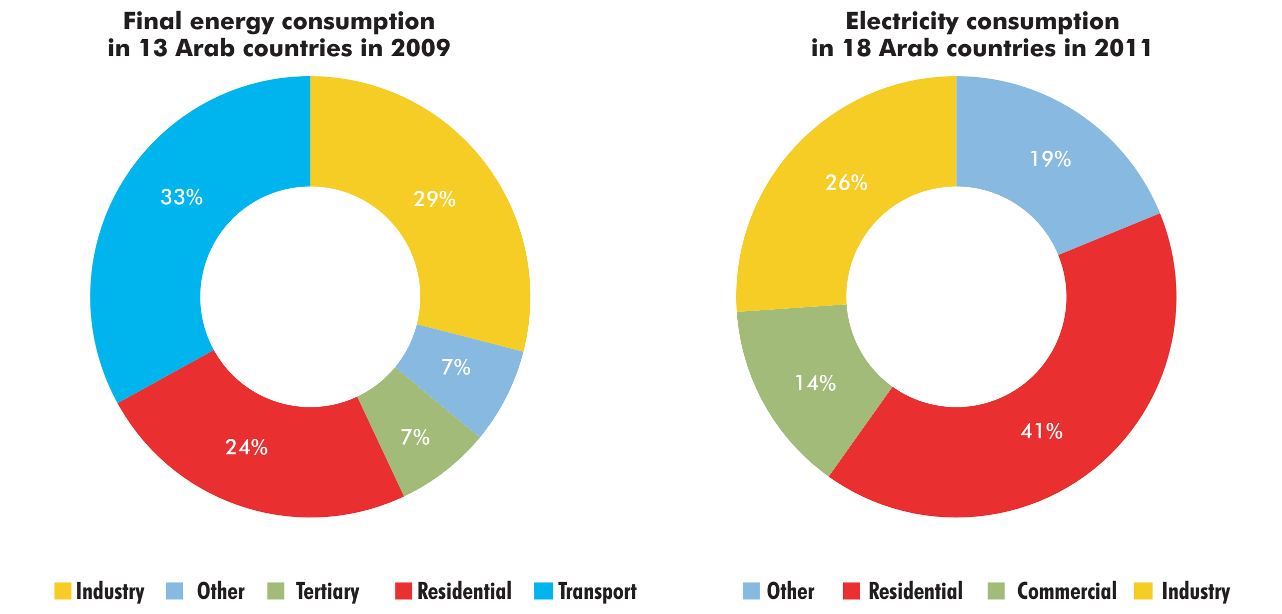
On an absolute basis during the 2000 to 2011 period, the annual regional consumption grew by 89 percent, from 6,825,000 to 12,908,000 barrels of oil equivalent per day (boe/day). Consumption

FIGURE 1 ARAB COUNTRIES' PRIMARY ENERGY CONSUMPTION SOURCES (2000 AND 2011)



Source: OAPEC Annual Statistical Report (2005, 2012)

FIGURE 2 ARAB COUNTRIES FINAL ENERGY AND ELECTRICITY CONSUMPTION



Source: RCREEE & Plan Bleu study (2012); AUE (2011)

of all forms of energy increased over the period, with the exception of hydroelectricity. Such high growth in energy demand has resulted in increased air pollution and concentrations of GHG emissions. In thirteen selected Arab countries, CO_2 emissions from fuel combustion in 2009 constituted three times higher than OECD average (RCREEE & Plan Blue study, 2012). The region has also high levels of local airborne pollution. It is estimated that urban air pollution causes 40,440 premature deaths per year in 8 selected Arab countries. In Egypt alone, the costs of harm due to air pollution constituted 2.1 percent of GDP, accounting for 44 percent of the total costs of environmental degradation in the country (ESMAP, 2009).

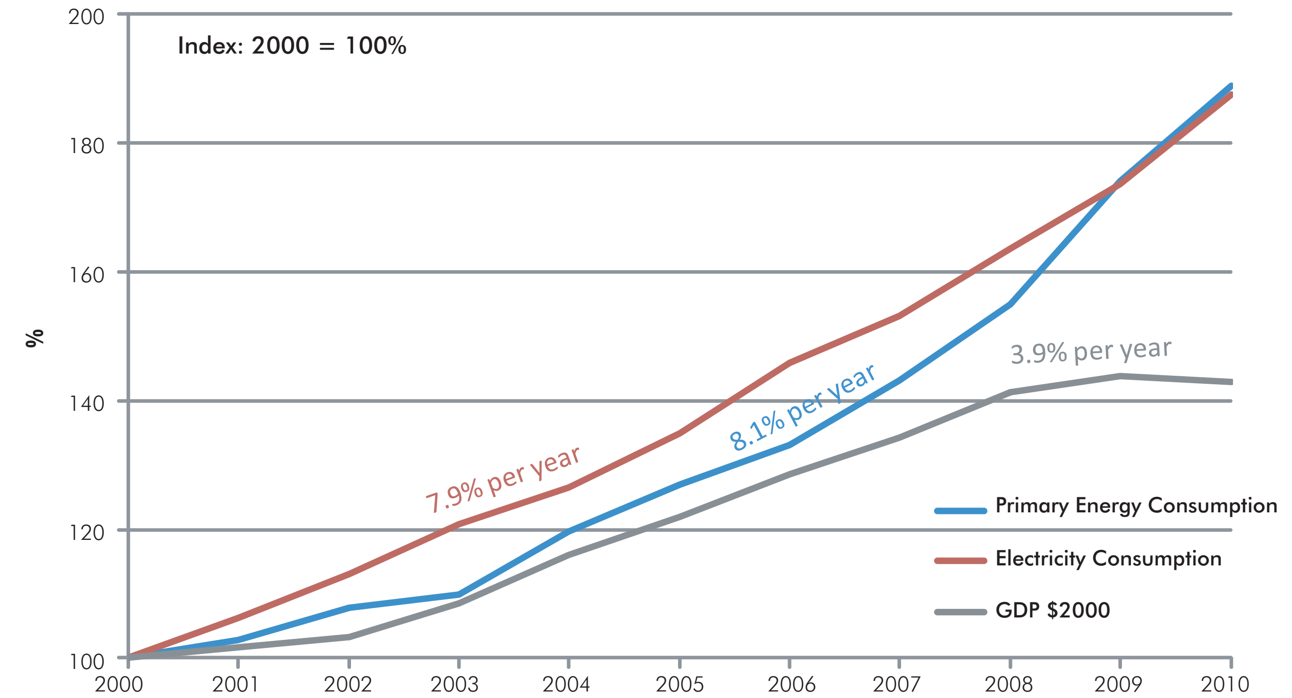
Figure 2 illustrates final energy consumption by sector in 2009 in 13 selected Arab countries. As can be observed from this figure, transport sector accounted for the largest share of total final energy consumption with 33 percent. By fuel type, final energy consumption was dominated by oil products (67 percent); followed by natural gas (15 percent); electricity (17 percent) and coal (1 percent). In the electricity consumption residential sector represents the largest consumer group (41 percent) followed by industry (26 percent).

B. Energy Intensity and Economic Decoupling

As illustrated in Figure 3, there has been no decoupling between economic growth and energy demand in the Arab region in the past decade. In fact, growth in energy consumption has been faster than economic growth during the past decade; average annual GDP growth was around 4 percent, while the increase in primary energy and electricity demand has been about 8 percent. This trend implies energy is not being used effectively to produce value within the regional economies.

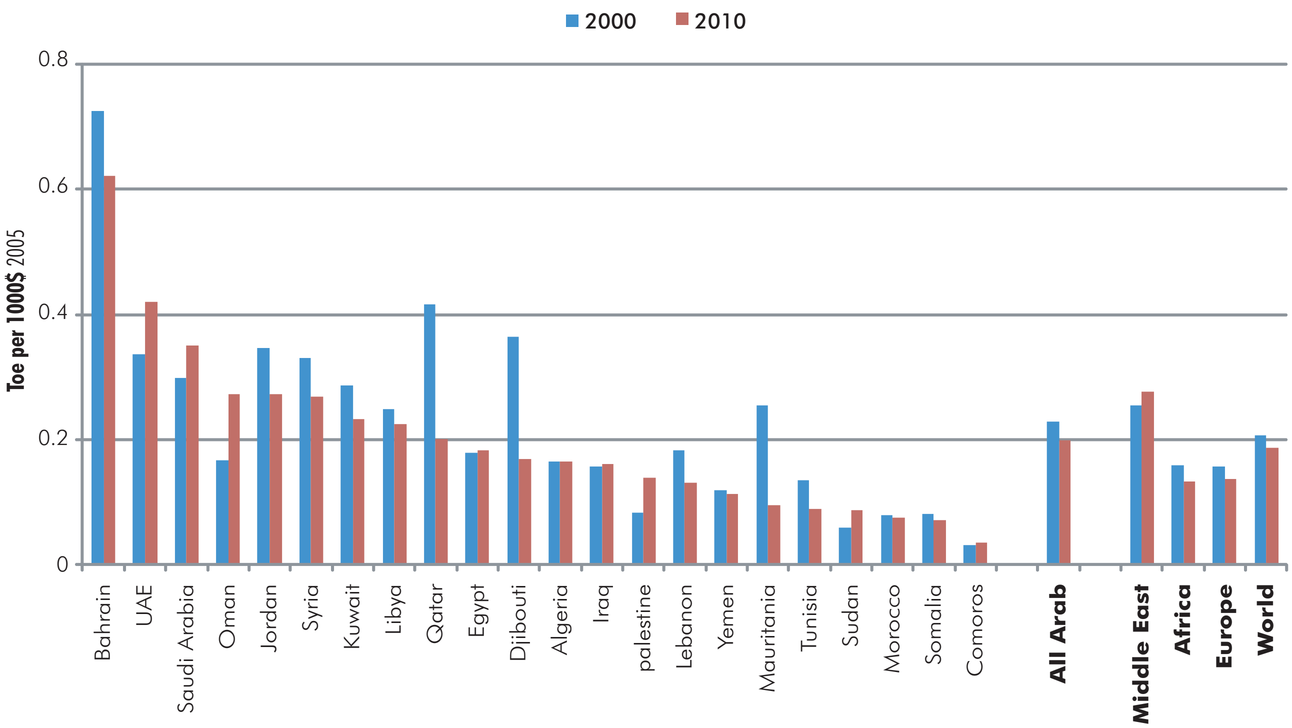
Figure 4 illustrates primary energy intensity of the countries at the macro level. Primary energy intensity is measured as the ratio between the total primary energy consumption and the country's Gross Domestic Product GDP. It measures the amount of energy input required to generate one unit of GDP. By expressing at Purchasing Power Parity (PPP), GDP is adjusted to reflect the differences in the cost of living in different countries (ENERDATA, 2012). The average primary energy intensity in the region in 2010 constituted about 0.2 tons of oil equivalent Toe/1000 US$ 2005 value, which is slightly above the world average of 0.19 and about 31

FIGURE 3 PRIMARY ENERGY CONSUMPTION, ELECTRICITY CONSUMPTION AND GDP TRENDS (2000 TO 2010)



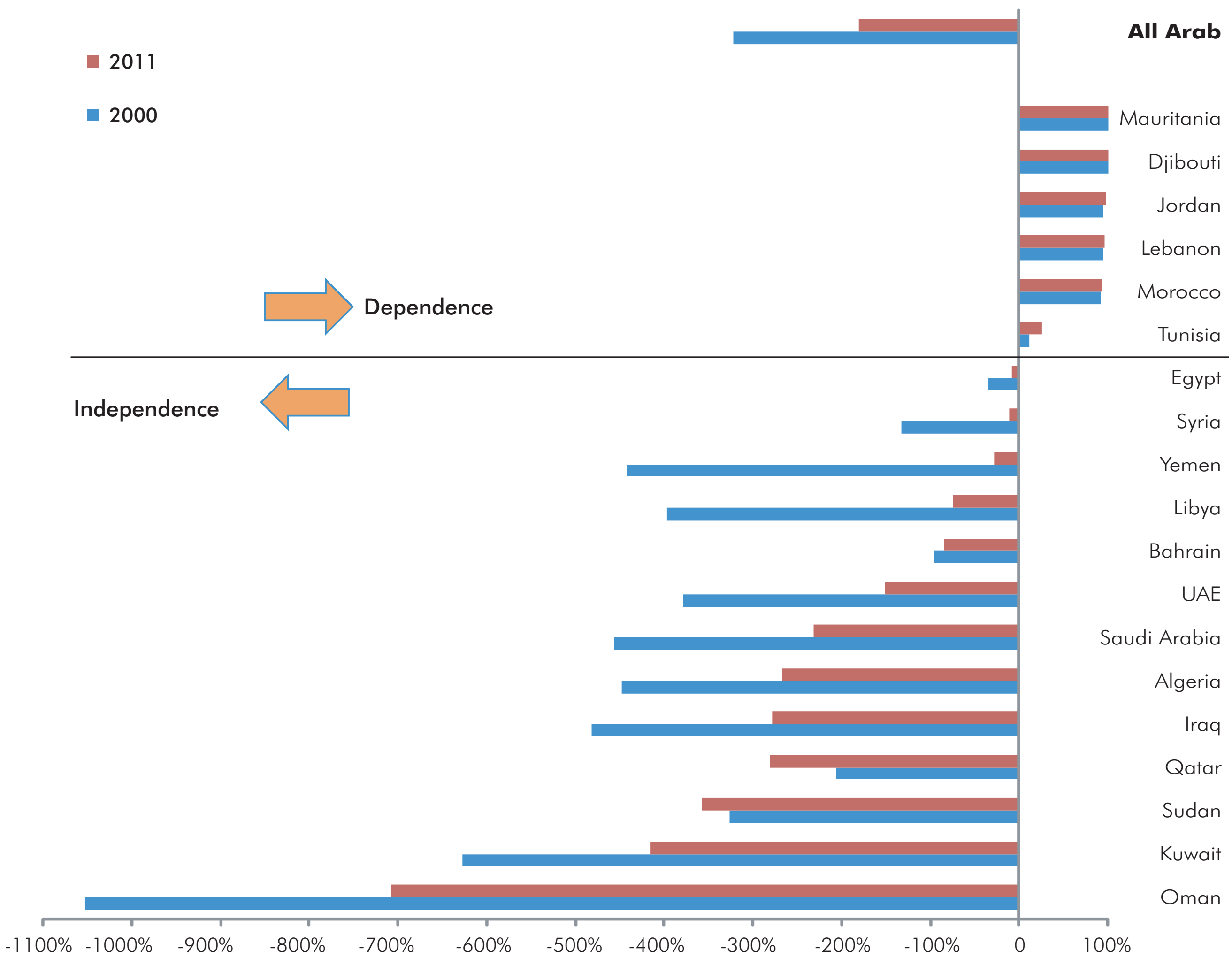
Source: OAPEC (2005, 2007, 2012); EIA (2013); World Bank (2013)

FIGURE 4 PRIMARY ENERGY INTENSITY (TOE/1000 US$ 2005 VALUE) FOR ARAB COUNTRIES (2000 AND 2010)



Source: U.S. Energy Information Administration

FIGURE 5 ENERGY DEPENDENCY RATIO FOR ARAB COUNTRIES (2000 AND 2011)



Source: OAPEC Annual Statistical Report (2005, 2012).

percent higher than the European average of 0.14 Toe/1000 US$ 2005 value. Within the group, results are widely divergent with a factor of 17 separating Bahrain on the high end and Comoros on the low end of energy intensity.

While the trend among most of the Arab countries is a decrease in primary energy intensity, the Middle East region shows an upward trend over the past decade. This can be attributed to the energy-intensive industries in countries that are rich in petroleum resources. Even with this in mind, however, the data indicate that the energy efficiency of these activities is not improving in relation to their contribution to GDP.

C. Energy Dependency

In light of trends of rising energy consumption and declining reserves of fossil fuel, the status of countries as net energy importers and exporters is also changing. Energy dependency ratio is a measure of a country's ability to supply its primary energy consumption needs through domestic energy sources.

As illustrated in Figure 5 below, the general trend for nearly all countries is shifting toward greater energy dependence, including the net exporting states. This dependence is occurring due to a combination of demographic, supply and

demand forces. In some cases, declining domestic energy reserves are the main factor, and elsewhere increasing demand is driving the trend. The only countries with rising energy independence are Qatar and Sudan; in the case of Qatar, it is due in large part to the recent increased exploitation of natural gas liquids, and Sudan began commercially producing oil only in 1993. The general trend invites a serious discussion in Arab countries of the required shift for their economies, and the role that alternative fuels and energy efficiency might play in substituting for their depleting oil resources.

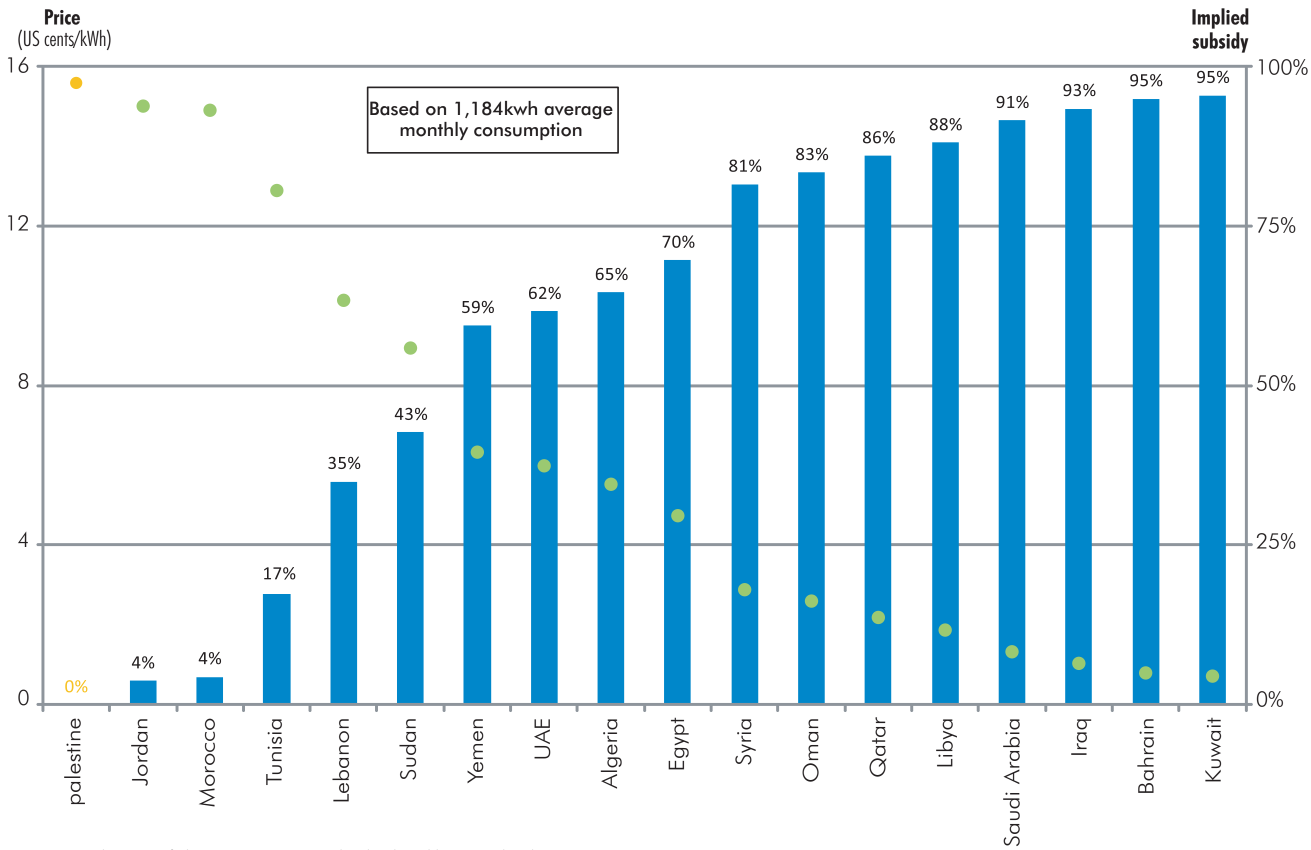
Countries with a high degree of energy independence generally have low motivation to conserve their oil or to switch to another energy source for domestic consumption. The appeal of energy efficiency might be to reduce the lost sales revenue caused by ineffective utilization of energy. For countries in a balanced position, the maintenance of current production levels will allow the national energy bill to be covered. But most of those countries are experiencing declining oil output along with consumption growth, so the trend is downward for self-sufficiency. A third group is almost totally reliant on imports to meet their energy demand, which creates strain on government finances and leads to uncertainty regarding future pricing and availability. Motivation should be high to improve the performance of all energy consuming aspects of their societies, if the price is reasonable. So the motivations can be different between the various Arab countries, but some type of efficiency-related driving force can exist for each.

III. ENERGY PRICING SCHEMES

Appropriate energy pricing is an essential part of energy efficiency policy. Energy subsidies are a major reason for lack of energy efficiency progress in the Arab world. The region has a strong tradition of maintaining relatively low consumer prices for fossil fuel, and subsidies in general constitute on average more than 20 percent of governments' expenditures (ESMAP, 2009). In Egypt, energy subsidies in 2010 constituted 21 percent of the fiscal year's budget and 73 percent of total subsidies (Castel, 2012). All countries in the region subsidize fossil fuel products, and most subsidize electricity (ESMAP, 2009). Fossil fuel subsidies encourage inefficient allocation of scarce resources, wasteful and irrational consumption of energy. Furthermore, they discourage investments and efforts to develop more efficient systems. A natural consequence includes smuggling of petroleum products across countries' boundaries due to price disparities between neighboring countries (El-Katiri, 2012). In 2012, media reported that Gazans had resorted to buying Egyptian black market diesel, which cut the price from US$ 1.85 to as little as US$ 0.67 (Naylor, 2012).

Fossil fuel subsidies constitute a heavy burden on national budgets. In the Arab region, six countries are already experiencing a significant annual budget deficit: Egypt, Syria, Yemen,

FIGURE 6 RESIDENTIAL ELECTRICITY PRICES AND SUBSIDIES BENCHMARKED TO PALESTINE (2011)



Source: Arab Union of Electricity (2012a, 2012b), developed by B. Samborsky/RCREEE

Jordan, Lebanon and Tunisia. The general increase in oil prices is further exacerbating the situation (ESMAP, 2009). In Lebanon, it has been estimated that the electric power utility offers an average subsidy of around 9.78 US cents per kilowatt-hour (kWh) (NEEAPs). At total annual production of around 11,500 gigawatt-hour (GWh) (Policy Paper, MOEW, 2011), the annual deficit created by fuel subsidies is around US$ 1.1 billion. This value is expected to have surpassed US$ 1.4 billion currently, given the increases in prices over the past three years.

In Arab electricity markets, price subsidies represent one of the major challenges to progress of efficiency measures. In almost all segments some subsidy is evident, based on prices paid by end users. This has a negative effect due to the challenge it poses to investment in efficiency. Basic conservation efforts also appear less attractive in markets where subsidies distort the value of energy.

Data on Arab electricity prices for residential and industrial customers are presented in Figures 6 and 7, respectively. These represent a typical customer, based on average monthly consumption from 18 countries in the region. For residential customers the average is 1,184 kWh per month, and for industrial customers the average is 50,113 kWh per month. The price per kWh has been identified for the same consumption level in all countries using local utility rate structures.

The left scale denotes the electricity prices paid in each country. Palestine's prices are used as benchmarks. Palestine has very little generation capacity and receives its electricity from Israel[1]. Energy prices in Palestine are close to international prices and represent approximate actual electricity cost passed through by Israel, which can be compared to neighboring countries. The difference between Palestine's market price and price paid in each country is referred to as the implied subsidy, shown on the right scale.

DEAD SEA DEVELOPMENT ZONE PROJECT – JORDAN

Florentine Visser

The Dead Sea is a unique landscape with great cultural and economic significance for Jordan. Its tourism sector is expected to increase by 14,000 new rooms over the next 20 years. In this fragile ecosystem, such a development needs to be handled with care, which explains why Jordan Development Zones Company sets high environmental standards in the Dead Sea Development Zone Master Plan. For the energy part of it, MED-ENEC provided support through an Energy Efficiency Study, identifying three energy saving packages for the Corniche District, the first stage of the development. Five reference building types were indentified (residential, hotel/3-star, hotel/5-star, resort, and mixed use). For each, three packages (Baseline, Economical and Ecological) were assessed by the Energy Balance Model, based on the EN 13790 standard for thermal performance of buildings.

The baseline package was initially based on the practice of the Jordan Building Code only. The first simulations showed that the cooling and the hot water supply (especially for the hotels and resorts) represent the most significant energy demands.

To reach out above national standards, as part of the environmental ambitions of the project, this baseline was improved with passive, almost no-cost, measures on the design level as optimized orientation, use of light colors, (absorbance rates less than 0.350), window-wall ratio of maximum 15% for west and east facades, 20% for facing elevations, 30% for north orientation, and window shading indicated by a Solar Heat Gain Coefficient (SHGC) of maximum 0.25.

A remarkable finding in this case was that, due to specific climatic conditions (high solar gains resulting in dominant cooling loads and hardly a need for heating), there was no need to increase the thermal resistance of the building envelope. These improvements resulted in a reduction of the final energy consumption of 7% for a 3-star hotel (mainly due to the reduction of the wall window ratio), and 29 % for a residential building (mainly due to external shading). This improved baseline package is to be mandatory for all buildings in the project

The Economical package showed a reduction of the final energy consumption, compared to the Jordanian Building Code, of 47% for the 3-star hotel (mainly due to the solar water heaters), and 64 % for the residential building.This package includes all the passive measures of the baseline plus energy efficient options, stated by certified label, for lighting, ventilation, cooling, and solar thermal for hot water.

The Ecological package includes international best technical practices and increased renewable energy measures, minimizing the final energy consumption to

Arab residential markets are the most heavily subsidized, with some countries offering an implied subsidy of up to 95 percent. Predictably, the countries with the highest energy dependency ratios – Jordan, Lebanon, Morocco, and Tunisia – provide the least subsidies due to economic necessity.

The case of Morocco is noteworthy, specifically in its industrial pricing. Users there are actually paying a premium compared to the price in Palestine, with the highest prices of all Arab countries. This policy decision in Morocco has several drivers, such as proximity and connection to the Spanish market, and legitimate attempts at market reform through progressive policies.

The subsidies of today are the result of policy decisions in the past. It is an inherited problem that both dictates and limits future choices. Keeping electricity prices low is considered a form of social assistance, allowing those who would otherwise not afford it to have access. Despite the clearly understood negative impacts of fossil fuel and power subsidies on the national economy

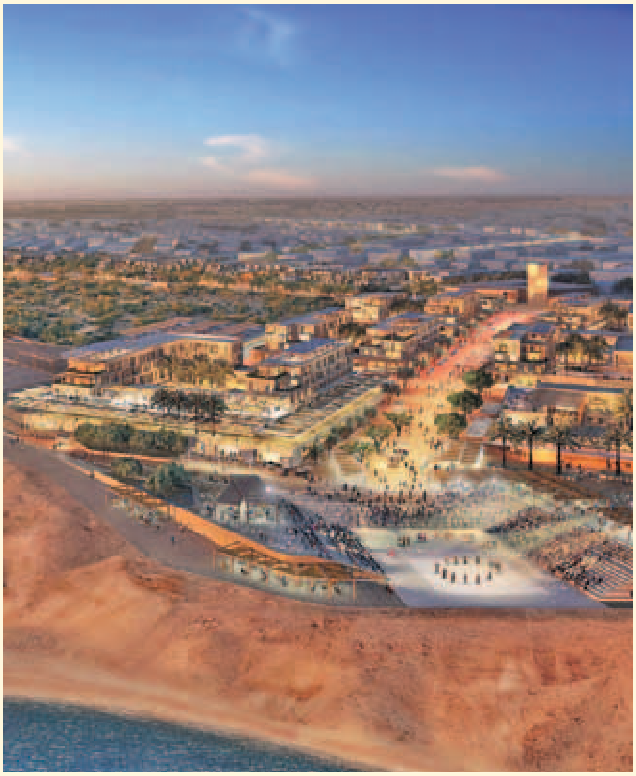
91% for the 3-star hotel, and to 125% for the residential building (becoming an energy supplier to the grid).

The following measures are included on top of the economical package: building envelope air-tightness improvement, lighting systems with LED applications and occupancy sensors, HVAC system with demand controlled ventilation (CO_2 or VOC), heat/cold recovery and most efficient (high temperature and surface) cooling systems (COP 5.5), and Photo Voltaics (PV) for electricity generation.

To make the 'Economical' and 'Ecological' energy saving packages visible, the study proposed to market the packages as Gold (economical) and Platinum (ecological) levels, with a related possible benchmark of final energy consumption in kWh/m^2y, for innovation in design and technology development, as indicated in the below table:

Final Energy Benchmark (kWh/m^2y)	**Economical (Gold level)**	**Ecological (Platinum level)**
Residential (detached or free standing)	50	10
Tourism facility	150	50
Retail (extracted from mixed use)	200	100

More Info:
Dead Sea Development Zone Project by the Jordan Development Zones Co. www.jdz.jo/page.php?pageName=dead-Sea-Development-Zone&pageTitle=Dead Sea Development Zone



Dead Sea Development Zone Commission - Jordan

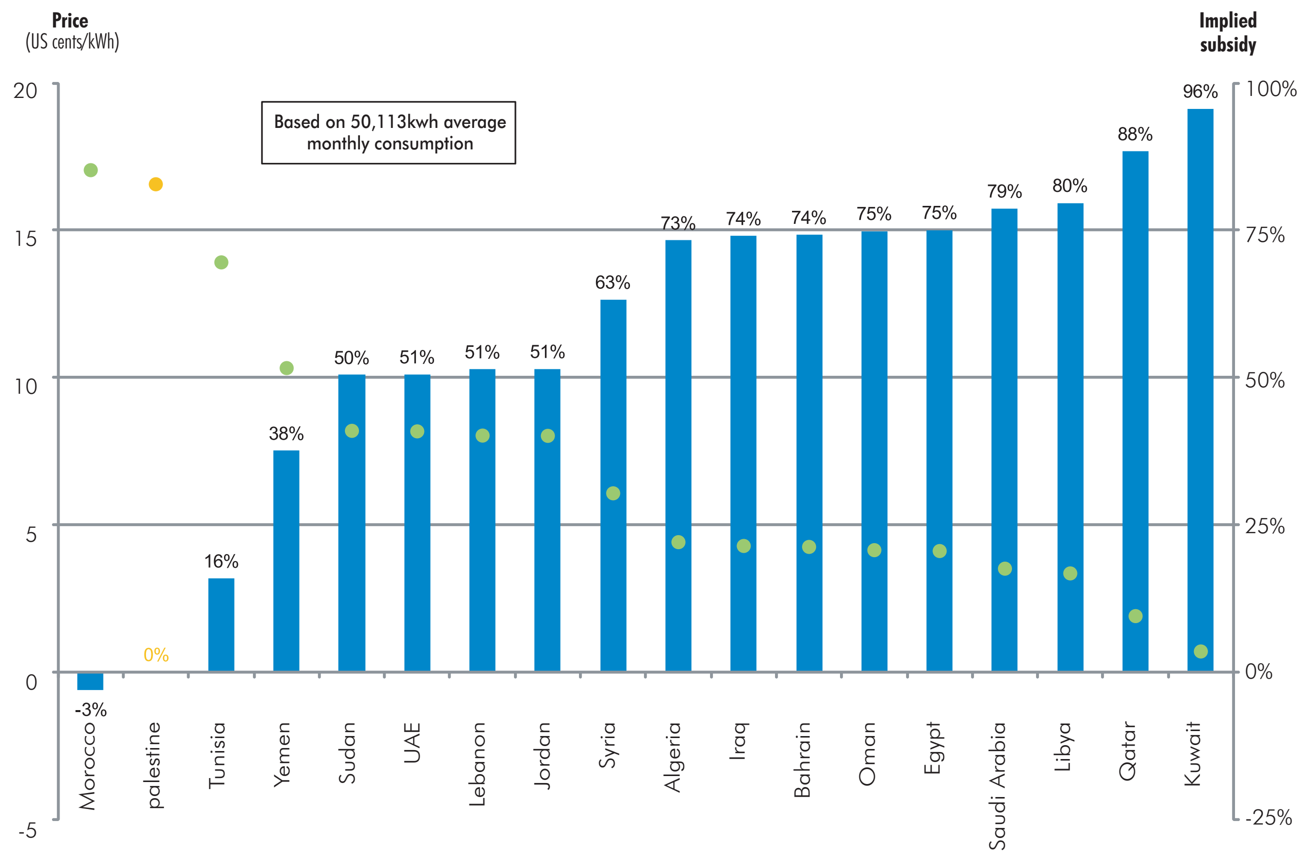
The Dead Sea master plan energy efficiency study was carried for MED-ENEC by Ecofys (Riadh Bahr) can be downloaded from: www.med-enec.eu/sites/default/files/user_files/downloads/2013.03.11%20-Large%20Building%20Projects-%20MED-ENEC%20Report%20EE%20for%20Dead%20Sea%20Masterplan%20JOR.pdf

Florentine Visser, architect, is key expert at Energy Efficiency in the Construction Sector in the Mediterranean (MED-ENEC)

and welfare system, reform of subsidies remains a highly challenging task in most Arab countries. Policy makers often fear public resistance and the impact of increased energy prices on the social well being of the community in general, and the poor in particular. In addition, the lack of transparency about the size of subsidies, their social and economic impacts and the difficulties in identifying the main beneficiaries further complicate initiation of effective and comprehensive energy pricing reform. However, today these reforms are necessary in addressing not only pressing energy needs of the countries, but also in moving toward a more sustainable energy development path in general.

Few of the governments have publicly announced plans to phase out fossil fuel subsidies. In October 2011, Egypt's trade and industry minister announced that government would start the phase-out of subsidies with energy-intensive industries, such as steel and cement (Blair, 2011). The Lebanese government announced, through the Policy Paper for the Electricity Sector

FIGURE 7 INDUSTRIAL ELECTRICITY PRICES AND SUBSIDIES BENCHMARKED TO PALESTINE (2011)



Source: Arab Union of Electricity (2012a, 2012b), developed by B. Samborsky/RCREEE

prepared by the Ministry of Energy and Water in 2010, that the electricity tariff will be gradually restructured and increased (by up to 50 percent) in conjunction with planned improvements in the sector until undisrupted power supply is achieved together with the abolishment of the deficit and a balanced budget for the power utility.

IV. EFFORTS TO IMPROVE ENERGY EFFICIENCY, AND ASSOCIATED CHALLENGES

A. Building Sector

With high rates of urbanization, the building sector represents an important avenue for tapping EE potential and mitigating GHG emissions. Today two thirds of the populations in the Mediterranean countries live in an urban area (MED-ENEC EE building code study, 2012). It is forecasted that this trend will grow to over 75 percent by 2030 (MED-ENEC EE building code study, 2012). Mandatory EE regulations for buildings, if enforced properly, can constitute a strong driving force for the construction industry to start integrating more EE solutions in buildings. Similarly such regulations can have strong leverage on the entire supply chain to start producing more EE construction materials (Feng Liu, 2010). It is estimated that with implementation of EE building codes in the Mediterranean countries the total primary energy savings could constitute 183 million tonnes of oil equivalent (MToe) over the period of 2012 to 2030 with annual CO_2 reductions of 82 million tons (MT) (MED-ENEC EE building code study, 2012).

In the region, many countries have either adopted mandatory and voluntary EE regulations or are in the process of preparing them, but the main problem remains lack of their implementation and enforcement. Responsibility for enforcement usually lies with

TABLE 1 **ENERGY EFFICIENCY REGULATIONS FOR BUILDINGS IN ARAB COUNTRIES**

	Mandatory		
Algeria	Thermal regulations for new buildings (2005)	**Jordan**	EE building code (2009)
Bahrain	Thermal insulation implementation (TII) for buildings above 4 stores (2000)	**Syria**	Building thermal insulation code (2007), effective since 2009
Egypt	EE code for residential buildings (2006); EE code for commercial buildings (2009); EE code for governmental buildings (2011)	**Tunisia**	Minimum EE specifications for administrative buildings (2008); Minimum EE specifications for residential buildings (2009)
	Voluntary		
Iraq	Voluntary reference EE specifications for buildings (2012)	**Palestine**	Voluntary EE building code (2004)
Morocco	Technical specifications for thermal regulations in building (2010);		
	Under preparation		
Lebanon	EE building code	**Tunisia**	Minimum EE performance specifications for hospitals and hotels
Morocco	Technical specifications for building's passive and active components		

Source: RCREEE (2013)

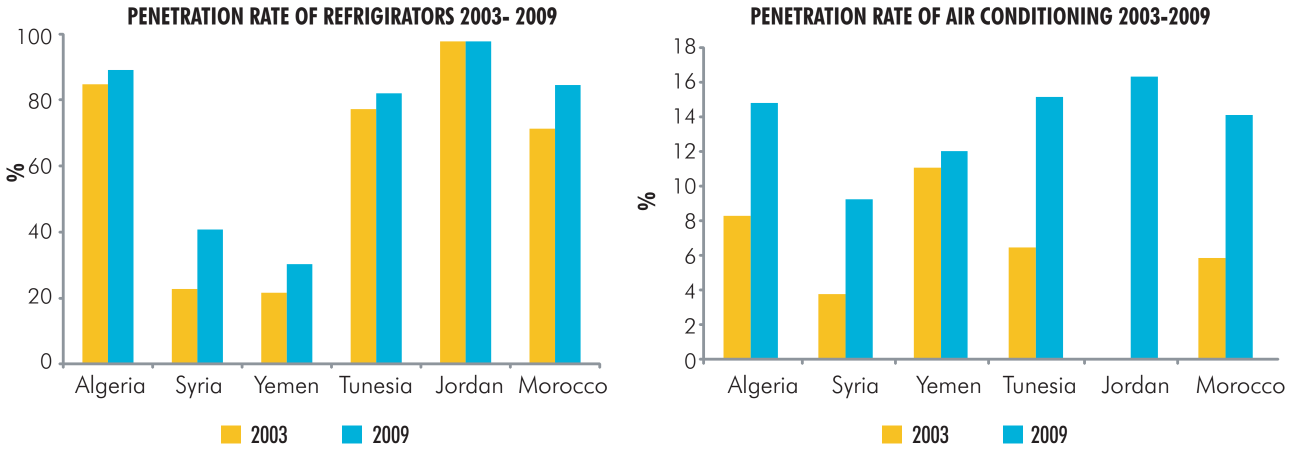
municipalities, which often lack capacity to properly inspect and review site plans, building designs and construction sites. Table 1 illustrates the current status of existing EE regulations for buildings in the region.

Designing, constructing, and renovating buildings according to EE specifications requires upgrading skills, knowledge, and expertise of professionals in the building sector, including architects, designers, contractors, installers and others, which is currently still lacking in the most of the region. In some less developed regions situation is further exacerbated by presence of large number of informal unregulated housing stocks. It has been estimated that in the Mediterranean region such self-constructed houses roughly account for about 30 to 60 percent of existing urban housing stock (MED-ENEC EE building code study, 2012).

In order to ensure compliance with mandatory regulations it is necessary to dedicate sufficient resources to support enforcement, training, and educating stakeholders to meet the technical specifications, developing fair and transparent enforcement mechanisms (Feng Liu, 2010). Experience shows that introducing complementary policies such as financial incentives for EE projects and spreading information about benefits of EE improvements enhances the rate of compliance. In the early stages of market development, demonstration projects play an important role in enhancing the capacity of stakeholders and fostering the uptake of EE solutions in the construction.

As can be observed in Figure 8, with economic growth in the countries the diffusion rate of household appliances has been also steadily growing, contributing to greater energy consumption. In 2009 in Jordan, the growth rate constituted 16 percent, in Tunisia 15 percent, and in Morocco 14 percent. According to the International Energy Agency (IEA) calculations, global energy savings potential in lighting and appliances constitutes approximately 3.7 Gigaton (Gt) CO_2 emissions per year (IEA, 2010). A

FIGURE 8 PENETRATION RATE OF REFRIGIRATORS AND AIR CONDITIONING 2003-2009



RCREEE & Plan Bleu Study: EE Indicators in the Arab Mediterranean Countries (2012)

study conducted in Lebanon by the Lebanese Association for Energy Saving and Environment (ALMEE) evaluating the impact of energy efficient housing estimated the electricity savings of 2,442 kWh per year with net value of US$ 3701 for introducing EE washing machines and refrigerators class A. (MEDENER, n.d.).

To reduce energy consumption of household appliances, many countries around the world have introduced the minimum energy performance standards (MEPS) for household appliances often followed by labeling schemes. MEPS define EE performance threshold for appliances, thereby preventing the entry of inefficient products into the market. The current state of MEPS in the region's countries is shown in Table 2. In the region only a few countries have adopted MEPS for household appliances with relevant labeling schemes and testing facilities, and only one country – Tunisia – monitors the market share of EE appliances. Given the rapid development of the appliance market in the region, governments should promptly address this issue in order to gradually phase out inefficient products from the market.

Greater diffusion of energy efficient lighting technology can significantly contribute to energy savings and reduce peak loads. Various initiatives have been launched in the region to improve EE in the lighting, but these initiatives vary in scale and stages of development (Gelil, 2011). Measures aimed at reducing the cost of compact fluorescent lamps (CFLs) have been the most preferred approach in the region to phasing-out incandescent lamps. Most of such measures include bulk distribution of CFLs at considerably low price or even for free. Lack of high quality CFL bulbs in the market remains one of the challenges to large-scale deployment of CFLs in the region. Poor quality CFLs in the market significantly taints the image of CFL, resulting in great disappointment and distrust among customers, and negatively affecting efforts to promote efficient lighting technologies (Dilip R. Limaye, 2009).

B. Industrial Sector

The industrial sector accounted for almost 30 percent of total final energy consumption in thirteen Arab states in 2009. As can be observed in Figure 9 below, energy sources within the industrial sector are dominated by fossil fuels. On average, 40 percent of the sector's energy needs in 2009 were met by oil products and 37 percent by natural gas. Electricity represented around 22percent of the final energy consumption.

Industry also represents a great avenue for tapping EE potential. For example, in Morocco between 1990 and 2006, 57 energy audits identified 411 EE projects. Twenty five percent of these EE projects had a payback period of less than one year, 50 percent of the projects had payback between 1 to 3 years, 11 percent of projects between 3 and 5 years, and only 14 percent of the projects had payback periods of more than 5 years (Lahbabi, 2013).

TABLE 2 **ADOPTION OF MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS) AND LABELS FOR APPLIANCES**

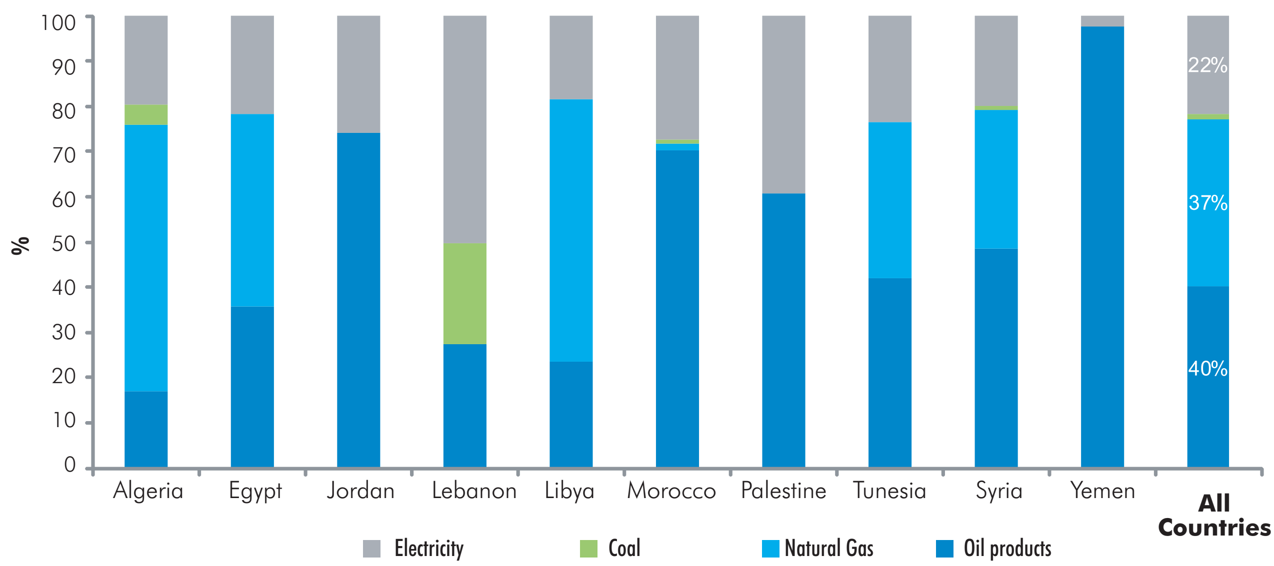
Appliance	Algeria	Bahrain	Egypt	Iraq	Jordan	Lebanon	Libya	Morocco	Syria	Sudan	Tunisia	Palestine	Yemen
Refrigerators	X		X			X			X		X		
Washing machines			X						X				
Air conditioners	X		X			X			X		X		

Source: RCREEE (2013)

\In Tunisia, ETS Nejma Huiles Company (formerly known as Slama Frères) - has experienced benefits by implementing various EE measures. These resulted in energy savings of 2,257 toe/year equivalent to 32 percent of the company's energy consumption, and reducing the energy bill by 36 percent. The payback period was 2 years and 10 months. Implementing a co-generation project in the same plant resulted in energy savings of 1,249 toe/year, which is 17 percent of energy consumption, and reduced energy costs by 25 percent. Payback period was 3 years and 7 months (MEDENER).

Looking ahead, there is EE potential throughout the industrial sector. In Saudi Arabia, converting 3 GW of power generation capacity from open-cycle gas turbines to combined cycle units would increase efficiency from 30 percent to around 50 percent. This could provide oil savings of 14 to 15 million barrels per year and reduce costs by US$ 1.2 billion per year at current oil prices. In desalination and other energy-intensive industries, anticipated reduction in energy consumption through EE is in the range of 5 to 10 percent (Alyousef & Abu-ebid, 2012).

FIGURE 9 **FINAL ENERGY CONSUMPTION OF THE INDUSTRIAL SECTOR IN SELECTED ARAB COUNTRIES IN 2009**



Source: RCREEE & Plan Bleu Study: EE Indicators in the Arab Mediterranean Countries (2012)

ENERGY EFFICIENCY MEASURES AT PETROFAC SHARJAH OFFICE: 18 PERCENT LESS ELECTRICITY

The energy reduction at Petrofac's Al Khan tower building in Sharjah, UAE, led to a saving of more than US$150,000. This cut followed an even larger reduction in 2011, when energy consumption fell by almost a quarter, saving more than US$230,000. The savings resulted from carbon-saving measures that cost little to implement.

Petrofac aims to go on saving energy, and money, at Al Khan. In 2013, to ensure the building management system runs at optimum efficiency, daily reviews will be conducted to check electricity consumption and heating, ventilation and air conditioning. It is hoped that this will lead to further savings of at least 3 percent.

The tower building gross area is 42200 m^2. It has a rentable area of 33000 m^2 (rentable area is Gross area excluding covered parking) with a headcount of approximately 2,200.

Based on material provided by Petrofac, an AFED member.

Taking action through industrial consumers can generate results with a relatively small number of participants, if the appropriate ones are targeted. For instance in Egypt, where more than 40 percent of total energy is consumed by the industrial sector, the energy intensive industries represent 1percent of the number of factories and consume 65 percent of the industry energy share. Clearly, these few consumers can significantly contribute to EE efforts.

To assess energy savings opportunities in regional industries, it is necessary first to collect data about energy consumption patterns through proper energy audits. Energy audits provide the foundation on which future management plans are built and usually constitute data about baseline consumption, operational practices, infrastructural condition of the plant, and potential energy savings opportunities. Energy audits are generally performed by energy service companies (ESCOs), and offer attractive cost savings solutions especially when low- interest loans are available to upgrade the process. In Lebanon, for example, zero- interest loans are being offered by the Central Bank in association with the National Energy Efficiency and Renewable Energy Action (NEEREA). Also, a draft energy conservation law is being discussed that would oblige establishments that consume more than 40 toe annually to conduct energy audits periodically every five years. So far, 58 companies have been audited in Lebanon since 2005 (Lebanese Center for Energy Conservation, LCEC). Other initiatives in the region to improve energy efficiency in the industrial sector include obliging industrial facilities to install energy efficient equipment by charging higher tariffs for reactive power exceeding certain power factors (National Energy Efficiency Action Plan of Sudan).

C. Transport Sector

Population growth in the Arab region, mainly in major cities, paralleled with increased industrialization and economic growth have led to a substantial increase in the size of the transport sector in most countries. According to a study performed by RCREEE jointly with Plan Bleu in 2012 on the Arab Mediterranean countries[2], with results shown in Figure 10, the total vehicle ownership in the thirteen selected Arab countries increased from 8.7 million cars in 2003 to 13.1 million cars in 2009, resulting in a growth rate of 7 percent per year. Although there has been a general decrease in specific energy consumption of cars over the years mostly due to improvements in technology and auto industry manufacturing, the average specific energy consumption of private cars in the region remains notably higher than the average consumption in European Union (EU) countries.

In most countries of the region, the old and inefficient vehicle fleets pose a significant challenge in terms of fuel consumption, safety issues and excessive emissions to the atmosphere. The effects of this trend are increased energy consumption, traffic congestions, deterioration of already limited agricultural communities, reduction in human safety, and resources depletion. Studies have indicated that in mass transport and improved conversion efficiencies of vehicles could have high payback in terms of energy conservation and emissions reduction.

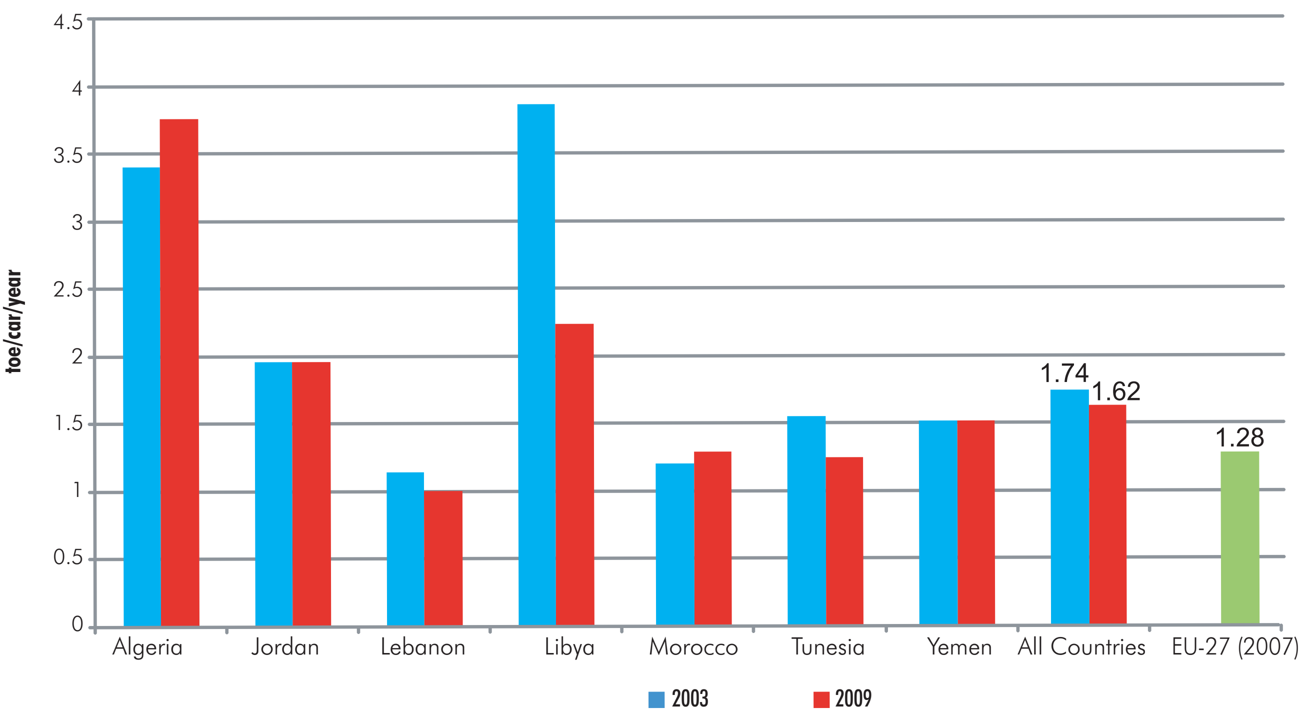
Measures to improve the quality of the fleet have been limited to bans on imports of used vehicles that are older than a set number of years. In Algeria, Tunisia, Palestine and Egypt, used vehicles should not be older than 3 years. Jordan, Yemen, Qatar, and Kuwait set a 5-year limit, whereas Lebanon has an 8-year limit. Other countries have no such restrictions (AFED report, 2011). Most Arab countries have established inspection and maintenance programs to upgrade the fleet, but the effectiveness of these programs vary from one country to another.

Regulations suggested to improve the transport sector include adopting national fuel economy standards, regulating vehicles emissions, and mandating mixed urban planning to institutionalize public and mass transport.

D. Utility and Demand Side Management Initiatives

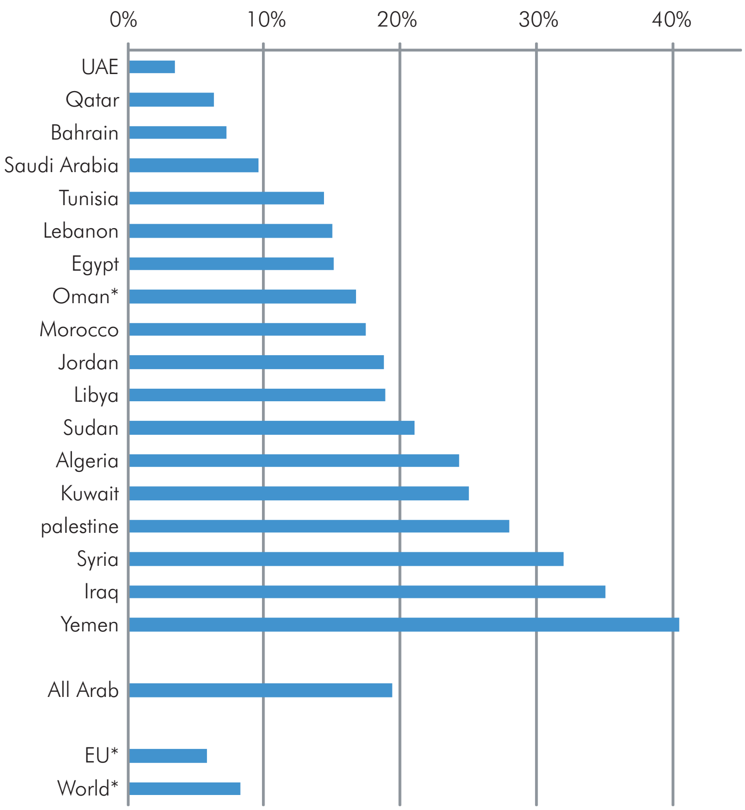
The power sector in general in the region can be characterized as a monopoly. In the most countries the generation, transmission and distribution of electricity largely remain state-owned and state-administered. With general trend of increased energy consumption growth, the share of energy consumption for power generation is also increasing. In selected ten Arab countries, this share has risen from 30 percent in 2003 to 34 percent in 2009. The highest growth has been particularly observed in Lebanon, Jordan, Libya, and Syria with 49 percent, 45 percent and 40 percent respectively (RCREEE & Plan Bleu study: EE Indicators in the Arab Mediterranean Countries 2012).

FIGURE 10 **SPECIFIC CONSUMPTION OF PRIVATE CARS IN SELECTED ARAB COUNTRIES**



RCREEE & Plan Bleu Study: EE Indicators in the Arab Mediterranean Countries (2012)

FIGURE 11 ELECTRIC ENERGY LOSSES IN GENERATION, TRANSMISSION AND DISTRIBUTION (2011)



* Data for Oman, EU and World 2010.
Source: AUE (2012a); World Bank (2013).

As can be observed in Figure 11 below, average Arab electric energy losses in generation, transmission and distribution (19.4 percent) are higher than the world average (8.3 percent) and much higher than the EU average (5.8 percent), presenting ample opportunity for achieving energy savings.

Decreasing the losses in generation and rehabilitating old transmission and distribution networks constitutes a key measure in countries' national energy efficiency action plans. Palestine aims to lower network losses by 3 percent by 2020, which is estimated to save approximately 42 GWh, Sudan identified 8 out of total 23 measures to improve energy efficiency, which is estimated to produce energy savings of approximately 3,349 GWh through improving network loss rates and about 152,116 toe through improving capacity generation of existing power plants during the 2013 to 2016 period (NEEAP of Sudan).

Demand side management activities in the residential sector are almost absent in the region. Very few utilities have taken actions in this area so far. The most notable example has been developed in Morocco, where their 20/20 tariff incentive rewards households that reduce their electricity consumption by 20 percent compared to the same month in the previous year. These customers receive a reduction on their bills of an additional 20 percent of the value of their saved energy costs. By the end of 2011, this incentive had resulted in total electricity savings of 1,770 GWh. The bonus savings are paid by Morocco's Energy Development Fund.

In the industrial sector, demand side management is being mostly implemented through the use of time-differentiated price structures. Table 3 provides details of the countries that have implemented time-of-use pricing, with several different approaches being applied. Results for Morocco indicate that their program has had an impact. The change in consumption patterns at three industrial facilities – the cement producers HOLCIM Settat and HOLCIM Oujda, and steel company SONASID – has reduced system peak load requirements by 76 MW (New National Energy Strategy progress review, January 2013).

E. Potential for Efficiency Gains

A realistic challenge in the drive for energy efficiency is simply quantifying the potential it can offer. Forecasts offer incentives to pursue efficiency activities at all levels – consumer, generator, and state. However, any projections will always provide an incomplete picture of the potential for efficiency gains because the outcomes rely on the creative problem solving of the industry participants.

Some research has estimated that even moderate improvements in energy efficiency could reduce total energy consumption somewhere between 25 to 50 percent below current levels, by 2030. (Hormann, Kuntze & Dib, 2012) Similarly, estimates of improving energy efficiency in the region by 20 to 50 percent could generate an additional 1 percent of GDP. Reducing losses in the transmission and distribution of electricity to 10 percent in all countries would save the region some 7,300 MW of power, equivalent to US$ 5.5 billion of new investments (ESMAP, 2009).

TABLE 3 **TIME-DIFFERENTIATED PRICE STRUCTURES**

Country	Customers	Time-differentiated rates				
Lebanon	High voltage	Night 00:00 - 7:00	Day 7:00-18:30	Peak 18:30-21:30	Night 21:30-23:00	Night 23:00-00.00
Tunisia	High and medium voltage	Day	Peak	Evening	Night	
Morocco	Extra high and high voltage	Mid-peak	Peak	Off-peak		
Syria	Extra high, high and medium voltage	Day	Night	Evening		
Jordan	High and medium voltage	Day	Night			
Algeria		Regular hours	Peak	Night		
Egypt	Extra high voltage and high voltage	Peak	Off-peak			

Source: Electricity Tariffs of States

One example of potential savings is the use of compact fluorescent light bulbs (CFLs). Switching 5 million incandescent bulbs to CFLs in Lebanon would result in savings of about US$ 250 million of investment equivalent of a 250 MW power plant (ESMAP, 2009). Transition to CFLs in the whole region would result in 2.56 percent reduction of CO_2 emissions and generate energy savings of 1.67 terawatt hour per year (TWh/year) (Gelil, 2011).

In Saudi Arabia, considering current growth rates, oil consumption is expected to reach 800 million barrels per year by 2030. If efficiency achieved a 10 percent annual reduction in oil consumption within the Kingdom, by 2030 this would equate to 80 million barrels of oil per year available for export instead of being consumed internally. The additional revenue from oil would be around US$ 6 billion per year at current prices (Alyousef & Abu-ebid, 2012).

Results from Tunisia show the successful implementation of their EE program has achieved energy savings of more than 2,800 kToe since 2004. As a result, over 3,000 new jobs have been created in the energy efficiency and renewable energy field (Lehr, Monnig, Missaoui, & Marrouki, 2012). Adoption of various energy efficiency measures led to a drop in energy intensity from 0.15 Toe/1000 US$ 2005 value in 1990 to 0.12 Toe/1000 US$ 2005 value in 2008 (United Nations, 2013).

For the construction industry, an estimate exists relating to EE building codes in the Mediterranean countries. During 2012 to 2030, 183 MToe can be saved through implementation, with annual CO_2 reductions of 82 MT.

These figures provide guidance for what is possible through EE activities. The true outcomes will be decided by the various actors in the Arab region, who can influence the outcome through their policies and actions.

V. TOWARDS EFFECTIVE ENERGY EFFICIENCY PLANNING IN THE ARAB REGION

Effective energy planning is a critical step in pursuing EE. Energy planning involves various activities including estimating potential for EE, identifying barriers to cost-effective EE investments, setting long-term and intermediate

MORE JOBS WITH ENERGY EFFICIENCY

Kurt Wiesegart

Implementation of Energy Efficiency (EE) offers opportunities for millions of jobs. It also has the potential to provide a boost to local economies, while helping families afford their energy bills, according to MED-ENEC (the program on Energy Efficiency in the Construction Sector in the Mediterranean). For this, investing in EE has a triple win effect: saving energy costs, reducing emissions, and creating jobs. However, attracting investments for sustainable development and combating global warming needs a strong governmental commitment.

Looking at successful experiences, OECD countries are revealing huge opportunities for EE. The 2011 investments in EE amounted to € 140 billion, estimated to create twice as many jobs per each Euro invested compared to fossil fuel-based energy. EE is «big business» for exporting countries such as Germany, Denmark or Netherlands. An example for emerging markets in the MENA region is Turkey. Some 65,000 jobs were created over the past 10 years only by the MED-ENEC pilot project RMI Turkey in the field of efficient building, insulation and geothermal technologies. More than 10,000 craftsmen were trained at the centre. In 2012, more than 50 million m^2 insulation material was applied to building facades making Turkey one of the biggest insulation material markets in Europe/Asia.

It is in the genuine interest of the MENA region to open itselve to such emerging markets. Even more as MENA countries are facing substancial challenges detemined by rising costs for energy imports and subsidies. The main question is: How will investments in energy saving technologies and products be attracted?

Regulation of energy standards and non-subsidised price systems are necessary. Energy audit shemes need to be

enforced. Higher efficiency of energy consumption will reduce depencence on fossil energy imports. And a clear political commitment of the Government for EE will foster the economy, industrial activities and employment.

National Energy Efficiency Action Plans (NEEAPs) play an important role in materialising the large potential for EE and jobs. In cooperation with MED-ENEC, the Lebanese Government has developed and approved the NEEAP. This has been done by MED-ENEC for Palestine, Jordan and Algeria. Rough estimates of job effects of the Lebanon NEEAP are: .

TABLE **ESTIMATE OF EMPLOYMENT EFFECTS OF SELECTED INITIATIVES FROM THE LEBANESE NEEAP[1]**

Initiative	Measure	Duration	Installed Capacity	Saved energy	created jobs
1	EE CFL lamps	2010 – 2012	160 MW	239 GWh/yr	50 -100
4	Solar thermal water heaters	Sept. 2010 -2012	190,000 m^2	26.35 GWh/yr	100 – 150
6	Wind	2010 - 2014	60-100 MW	120-200 GWh/yr	5 – 15
7	Photovoltaic	2011 – 2015	100-200 MW	263-526 GWh/yr	150 – 250
10	EE measures in buildings	2010 – 2015		815 GWh/yr	15,000 - 20,000

Large-scale renovation programmes have multiple benefits:[2]

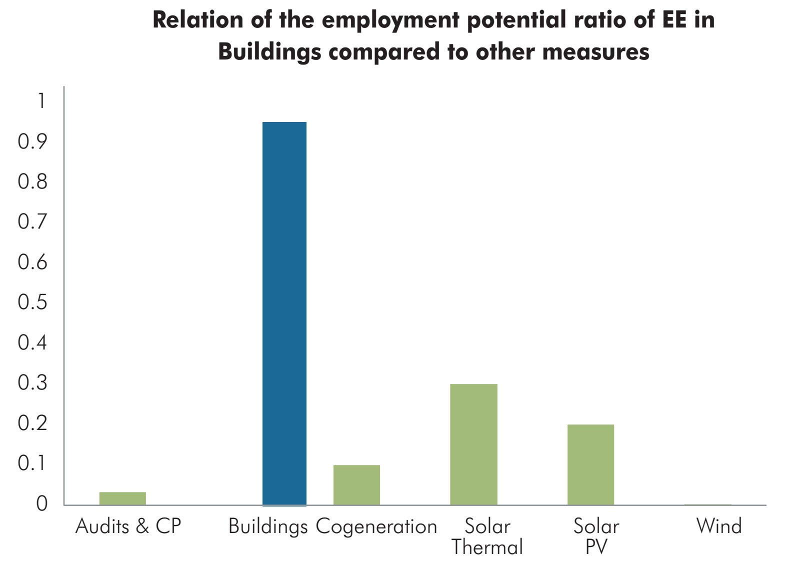
- 85 percent reduction of energy consumption and carbon emission reduction;
- Energy security enhancement by reducing up to 39 percent annual import needs of natural gas;
- Up to 131,000 (direct, indirect) net jobs created by 2020;
- 38 percent of this value: indirect and induced effects in other sectors than construction.

Jobs potencials from efficiency

Implementing EE creates more jobs than «producing» energy. This is true as local production of insulating materials, double glassed windows, solar water heaters and EE lighting are relevant areas of the local economy with side effects for other businesses such as installation, services and maintainance. Such investments pay back by lowering the energy bill and are sustainable, along side boosting local industries and know-how.

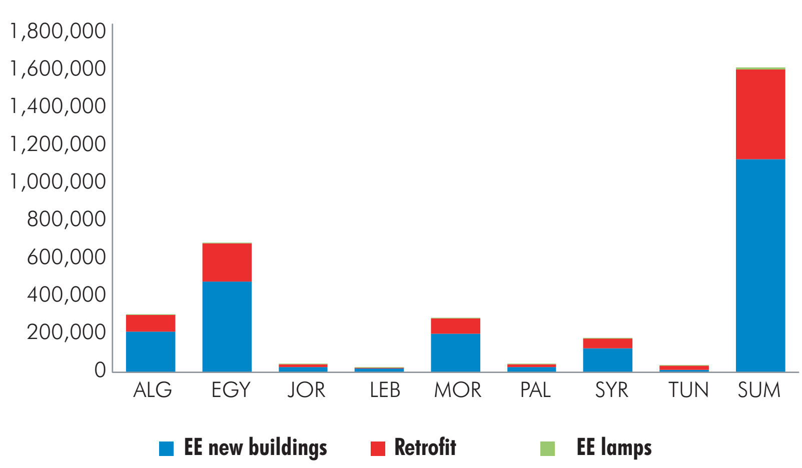
A recent study by GIZ concluded that EE creates more than three times as many jobs in MENA than investment in any renewable energy technology.[3] Figure 1B confirms that investments in building efficiency measures are highly efficient in generating jobs.

FIGURE 1 B **EMPLOYMENT POTENTIAL OF DIFFERENT EE AND RE TECHNOLOGIES**



(Source: GIZ 2012)

FIGURE 2 B **ESTIMATED JOB CREATION OF INVESTMENT IN EE IN BUILDINGS**



(Source: GIZ 2012)

Of course, for people's income, revenues by taxes and advances by education, infrastructure development and transport investments in local production count more than investments based on imported high-tech products. In fact, EE technologies can mostly be manufactured locally, applying, architecture traditions and handcraft knowledge. And comprehensive renovation of buildings is much more labour intensive than other economic recovery activities, e.g. five times more jobs are created than with the same investments in road construction. Developing skills of human resources «at home» will attract other investors in related businesses. The lesson learnt in OECD and newly industrializing countries including Turkey or Bulgaria is: EE has become an important locational factor.

1 Lebanese Ministry of Energy and Water, LCEC (2011) NEEAP 2011-2015
2 Ürge-Vorsatz, D. et al 2010
3 GIZ 2012

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THE ARAB ENERGY EFFICIENCY AND CONSERVATION FRAMEWORK

The Arab Energy Efficiency and Conservation Framework is the first document on the right path towards energy efficiency in the Arab region. It comes as a realization of the increasing demand for different forms of power on one hand, and its increasing prices on the other, which contributes to achieving significant energy savings that could be utilized in economic and social development.

The Framework is a guideline for energy efficiency in terms of action plans and procedures. It offers a 10 year roadmap including goals to be achieved, through setting and implementing a bundle of national plans composed of several procedures.

A 3 year energy efficiency plan kick starts the Framework to realize a short term goal, followed by another 3 year plan before the first one expires, along with implementing the technical procedures implied. That also requires state identification of implementation and monitoring responsibilities for one or more of the new or current bodies or institutions, and after an annual review of the plan, to ensure meeting its goals. In 23/11/2010, the 26th meeting of the Executive Office of the Arab Ministerial Council for Electricity adopted the Framework in Resolution 195.

The previous period has witnessed a lot of achievements related to implementing the Framework and designing national plans for energy efficiency in the Arab countries. The Lebanese Government has officially adopted the national plan for energy efficiency 2011-2015, through Resolution 26 issued in 2011. That was the first comprehensive strategy for energy efficiency and renewed energy in an Arab country. Other Arab countries followed later. The General Secretariat of the Palestinian Government adopted a national plan for energy efficiency and conservation at the end-consumer. Egypt's Government also adopted a plan for the electricity sector in 2012, and Sudan launched the national campaign for energy efficiency. Jordan in turn has set forth a first draft in a workshop with all stakeholders before officially adopting and launching at the national level.

The General Secretariat of the Arab League has received a number of official letters from several Arab countries declaring adoption of the Framework, and expressing willingness to put national plans for energy efficiency. These countries are Bahrain, Algeria, Libya, Kuwait and Yemen. It is projected that all Arab countries would have put their national plans for energy efficiency by the end of 2015.

** The text is based on information from the General Secretariat of the Arab Ministerial Council for Electricity in the Arab League.*

national EE goals and objectives, prioritizing measures, formulating policies, and developing specific action plans. Strategic energy planning allows more efficient tackling of pervasive market barriers and failures that cannot be cured on ad-hoc basis and require strategic holistic approach.

On 25 November 2010, the Arab Energy Efficiency Guidelines were adopted based on the European Directive 2006/32/EC on energy end-use efficiency and energy services (Arab Electricity Ministers, 2010). According to this Guideline Arab states are required to develop National Energy Efficiency Action Plans (NEEAPs) to achieve comprehensive energy savings by 2020. The NEEAPs are to be prepared for a period of three years with an indicative target for energy savings. Countries are also required to assign the responsibility for oversight coordination and reporting to one or more new or existing authorities or agencies (Arab Electricity Ministers, 2010). The NEEAP is to be reviewed annually to make sure that it fulfills its objectives. Additionally Arab Guidelines prescribe Member States to:

- Identify suitable energy efficiency measures to achieve the target (Article III:1)
- Ensure an exemplary role of the public sector (Chapter III)
- Ensure that energy distributors, distribution system operators, and retail energy companies contribute to EE through various measures (Article V)
- Ensure that information about EE measures and mechanism reaches the relevant stakeholders (Article VI)
- Need to revise national legislation impeding or restricting the use of financial instruments (Article VIII)
- Emphasize the need of member states to consider restructuring electricity tariffs to encourage EE (Article IX)
- Provide necessary financial resources to support EE measures (Article X)
- Ensure availability of effective programs for energy audit services by independent bodies such as energy service companies (ESCOs) or electric power distribution companies. (XI)

Today, in the region only five countries officially adopted NEEAPs with specific EE targets: Tunisia, Lebanon, Egypt, Palestine and Sudan. Those countries, along with their targets and responsible agencies, are shown in Table 4. Syria and Jordan have prepared drafts of NEEAPs, but have not officially approved them yet. NEEAPs in Morocco, Libya, Algeria and Bahrain are currently under preparation. Yemen, Iraq, Kuwait, Saudi Arabia and Qatar are in early stages of mobilizing initiatives on preparing NEEAPs.

VI. CONCLUSION AND RECOMMENDATIONS

The Arab region is undergoing many social, political, and economic challenges. Heavy reliance on fossil-fuel in light of rapidly growing population and declining oil reserves makes the region only more vulnerable. Without both an increase of renewable energy share and the pursuit of effective energy efficiency policies, the region might soon face serious energy supply challenges and bigger socio-economic vulnerability. Substantial efforts need to be made in this region to embed energy efficiency in the societies without further harming the already suffering economies. This requires:

a. Careful Energy Planning:

- Measuring energy consumption and estimating EE potential: Solid data on

PHILIPS: SUSTAINABLE LIGHTS AT AL-AIN'S DIABETIC CENTER

Imperial College London Diabetes Centre (ICLDC) is a joint venture between Mubadala, Abu Dhabi and the Imperial College, London to collaborate in healthcare, education and research. The Centre is vital in the efforts to tackle this condition throughout the United Arab Emirates, which has the second highest prevalence of diabetes in the world. In 2011, Mubadala and ICLDC opened their second facility in the UAE, located in Al Ain. Philips was commissioned to provide indoor and façade lighting. The result is a building with 100% energy efficient lighting that truly deserves to be called a green building.

The main lighting challenge was to help achieve higher energy efficiency. At the same time, the required levels of functional lighting for healthcare applications had to be met, whilst incorporating designer's creative inputs. Being a new build project, Philips was able to work with the consultant from inception on the lighting design. This incorporated aspects such as glare free, indirect lighting for indoor and dynamic architectural lighting for outdoor.

LEDALITE Pique recessed luminaires produced by Philips were selected for their semi-indirect, high light-output ratio and optimum power consumption features. This lighting solution gives the ICLDC low light power density, reduced glare (in accordance with local and international standards for healthcare facilities) and quality of light necessary to allow medical staff to perform their tasks comfortably.

In addition, Philips used LuxSpace LED luminaires in the design for the corridors. This application reduced the required light power density (LPD), which was set at 40% lower than ASHRAE standards.

To light the building's unique façade, Color Kinetics Powercore was installed, which combines dynamic scene setting capabilities with a sustainable LED solution. The dynamically illuminated façade and the sustainable light solution with which the interior of this splendid building is equipped unite the harmonious interaction between the attractive architecture and the interior.

The second ICLDC facility in Al Ain now has a cost-effective LED lighting solution suitable for medical staff, patients and visitors. A solution that also helps the facility to establish an iconic image in the Al Ain and set a benchmark within the local healthcare industry for green buildings.

Based on material provided by Philips, an AFED member.

energy end-uses constitutes a basis for proper energy planning. It is recommended making all possible efforts to collect data on energy end-use before formulating energy efficiency policies. Reliable, timely and detailed data on energy end-uses allows proper estimation of energy efficiency potential, understanding the current state of energy consumption, defining baseline and setting proper priority energy efficiency targets (UNDP, 2010). Estimating energy efficiency potential allows identifying areas where the biggest energy efficiency improvements can be made at the lowest economic costs.

- Setting clear EE targets: Extensive review of energy efficiency policies around the world conducted by IEA and the World Energy Council identified clearly defined energy efficiency objectives with specific timelines as one of the attributes of successful energy efficiency strategy (IEA, 2010). Experience in the region with Tunisia has also demonstrated importance of effective energy planning resulting in real energy savings. It is thus recommended for states that have not officially adopted NEEAPs to speed up the process and ensure adopting SMART targets: specific, measureable, ambitious, but realistic and time bound.

b. Introducing Cost-Reflective Electricity Tariffs

When energy prices are low, higher financial incentives are required to stimulate investment in EE projects, more efforts are needed to educate and raise awareness, and greater efforts are needed to ensure the compliance with mandatory EE regulations. Phasing out fossil-fuel subsidies is a precondition to faster and more effective attainment of EE. The good examples from the region to illustrate are cases of Morocco and Palestine. Despite the absence of a

TABLE 4 **ADOPTED NEEAPS IN THE ARAB REGION**

	NEEAP implementation period	EE targets	Mandated Agency overseeing implementation
Egypt	2012-2015	5 percent or 5565.69 GWh	Ministry of Energy and Electricity
Lebanon	2011-2015	5 percent reduction in growth rate	Lebanese Center for Energy Conservation (LCEC)
Palestine	2012-2014	1 percent or 54 GWh	Palestinian Energy and Natural Resources Authority (PEA)
Sudan	2013-2016	12 percent or 775 GWh	Electricity Regulatory Authority (REA)
Tunisia	2005-2007 2008-2011 2013-2016 under preparation	Decrease of energy intensity 3percent per year	National Agency for Energy Management (ANME)

Source: NEEAPs of Egypt, Lebanon, Palestine, Sudan and Tunisia

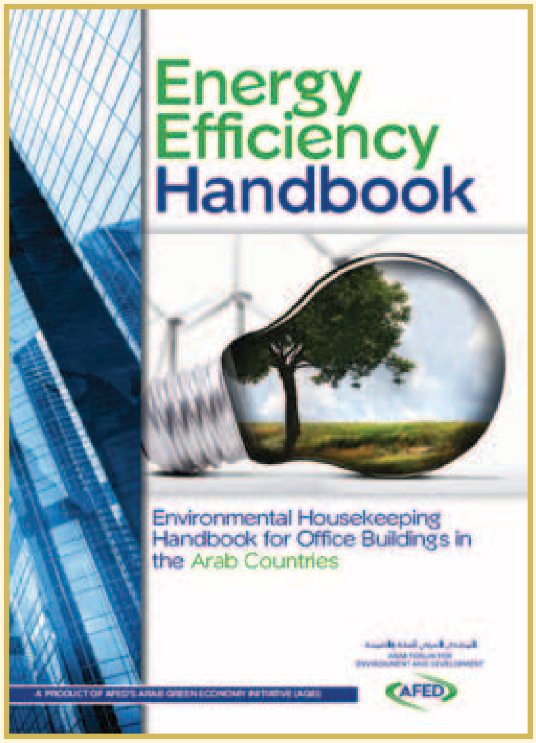
AFED ENERGY EFFICIENCY HANDBOOK

The Energy Efficiency Handbook, produced by Arab Forum for Environment and Development (AFED) in 2012, assists occupants of commercial buildings in Arab countries capture unrealized financial and environmental gains. The handbook presents methodologies for systemically identifying and prioritizing cost-effective investments that result in energy savings for building owners or leaseholders.

Increasingly, companies and government agencies in Arab countries see improving energy efficiency as a critical tactic for cutting costs and greenhouse gas (GHG) emissions. The costs of heating and cooling in inefficiently designed and constructed buildings are putting an increasing financial burden on occupants, particularly in those countries - Jordan and Morocco - where fuel and electricity subsidies are gradually being removed. Even in high-income Arab countries with significant energy subsidies for end-users, supply is unable to meet soaring demand for electricity. End-use energy efficiency in buildings offers a cost effective strategy to reduce electricity consumption compared with, for instance, expansion of supply capacity. In fact, end-use energy efficiency improvements are the surest, cleanest, and least expensive option to meet increased demand.

In Arab countries, buildings account for an average of 35 percent of all final energy consumption, and contribute 35-45 percent of all CO_2 emissions. Most of these impacts occur in the occupancy phase of the building lifetime. Moreover, the building sector is one of the fastest growing sectors in the Arab region. It is projected that a total of US$ 4.3 trillion will be spent on construction in the Middle East and North Africa (MENA) region over the next decade. The bulk of this construction will be directed towards new residential, commercial, and public buildings such as hospitals and schools. Therefore, a common challenge will be the sector's significant use of resources and emissions of CO2. These projections give proof that prudently managing energy consumption in buildings matters significantly.

Global studies have demonstrated that most commercial buildings could cut energy use by 30 percent or more through investments in improved efficiency. Despite the opportunities, few companies in Arab countries have fully invested in cost-effective energy efficiency improvements. A number of barriers prevent these companies from identifying or approving smart efficiency investments. One of the most often cited barriers is the lack of knowledge by companies and end-users about the opportunities that exist and how to take advantage of them.



This handbook offers a roadmap that can be used by office or facilities managers in Arab countries to identify, assess, and prioritize energy investment opportunities that will lower their energy use and hence reduce their carbon footprint. The handbook's primary focus is on the largest consumers of electricity in an office building including heating, ventilation, and air conditioning (HVAC), lighting, water heating, and office equipment such as computers, copiers, and printers. The handbook takes a generalized approach to improving energy efficiency in office buildings, and therefore, users may have to tailor some contents to the specific conditions of their location. In addition to addressing efficiency in electric power use, the handbook contains a chapter to address reducing fuel use by company-owned or company-leased vehicles.

Arab Forum for Environment and Development (AFED)

www.afedonline.org/eeh/eeh-ar.html

TABLE 3 **DEDICATED ENERGY EFFICIENCY AGENCIES IN ARAB COUNTRIES**

Algeria	National Agency for the Promotion and Rationalization of Use of Energy (APRUE)
Morocco	National Agency for the Development of Renewable Energy and Energy Efficiency (ADEREE)
Tunisia	National Agency for Energy Management (ANME)
Lebanon	Lebanese Center for Energy Conservation (LCEC)
Palestine	Palestinian Energy and Natural Resources Authority (PEA)
Syria	National Energy Research Centre (NERC)

Source: RCREEE internal library (2013)

strong regulatory framework, Palestine has the highest rate of solar water heater diffusion rate in the region, where almost 70 percent of households are equipped with solar water heaters; in addition, it has the lowest level of primary energy consumption per dwelling, mostly due to high energy prices. Morocco has relatively low primary energy intensity and one of the best energy efficiency performances of the industrial sector. For example, specific consumption of cement industry in Morocco in 2009 was one of the lowest in the region (88 kgoe/tonne) compared to cement industries in Tunisia (87 kgoe/tonne), Algeria (151 kgoe/tonne) and Yemen (109 kgoe/tonne) (Missaoui et al, 2012).

c. Strengthening compliance and enforcement

The effectiveness of policy instruments depends on their compliance and enforcement. Strengthening compliance and enforcement requires dedicating sufficient resources to support enforcement, training and educating stakeholders to meet the standards, developing fair and transparent enforcement mechanisms (Feng Liu, 2010).

d. Monitoring and Evaluation System

Monitoring, verification, and evaluation of energy savings are necessary in order to evaluate the effectiveness of the policy measure and make appropriate adjustments. Accurate determination of energy savings provides valuable feedback on the effectiveness of energy efficiency measure, enhances the credibility of energy management projects, consequently increasing the confidence of donors and investors and encouraging further investment in EE projects.

e. Strong Institutional Framework

To ensure the planning, design and implementation of these policies, strong institutional capacity is required. Experience from the region shows that those countries with stronger EE regulatory framework and better EE performance are the same ones with dedicated EE agencies. Table 5 lists the countries that currently have dedicated agencies.

Energy efficiency is a multi-decade continuous process that requires taking actions on a systematic, regular basis at all levels by a wide spectrum of stakeholders. To ensure continual attainment of efficiency goals, careful planning is required with robust monitoring and evaluation procedures, accompanied by dedicated resources and strong institutional capacity. Framing more targeted EE policy measures requires measuring energy consumption on a systematic regular basis, estimating EE potential, and ensuring wide stakeholder participation in the formulation of policies.

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NOTES

1. Israel faces the same energy security issues as some Arab countries, being a net importer and relying on supply chains at risk of disruption (Trilnick, 2012). If Israel were to be included in the figures, it would have ranked second highest for residential price, at 14 US cents per kWh, and fifth highest for industrial price, 9 cents per kWh (IEA, 2012b).

2. These countries are RCREEE member states including Algeria, Morocco, Tunisia, Libya, Egypt, Syria, Lebanon, Jordan and Yemen.

Energy Sector:
Mitigation Options of Climate Change

Maher Aziz Bedrous

CO_2 emissions related to fuel combustion in the Arab region increased by 247 percent from 1990 to 2010, significantly outpacing population growth over the same period (+55.77 percent). Over 95 percent of these emissions were related to the use of oil and gas.

As non-annex I countries, Arab states are not required to meet any specific emission reduction or limitation targets in terms of commitments under the UNFCCC, or the Kyoto protocol. However, mitigation measures are already in progress.

Accelerated developments are taking place for introducing renewables; fuel switching in industry and transport; use of combined heat and power; reduction of generation, transmission and distribution losses; domestic and industrial efficiency programs to enable establishment of an economic structure that prioritizes energy efficiency.

The key for Arab countries to mitigation options of climate change is to lay a sound foundation for further evolution to low carbon energy systems. Pathways to achieve high CO_2 mitigation levels comprise the following:

- *Widespread diffusion of zero- and low-carbon energy supply technologies, with substantial reductions in energy intensity.*
- *Comprehensive mitigation efforts covering all major emitters.*
- *Technology and Financial transfers from industrialized countries to support decarbonization.*

According to UNEP most of the developing countries can produce the same volume of commodities by about 40 percent less primary energy. Thus the potential for cutting off primary energy consumption through Energy Efficiency (EE) in the Arab Countries is huge. Renewable Energy also has a high potential of reducing future GHG emissions of the Arab Countries. Those are indigenous resources which have the potential to provide energy services with zero or almost zero emissions of both greenhouse gases and air pollutants. In the long term, the region could potentially shift from exporting fossil fuel to exporting clean energy.

The technological revolution under way in power generation, where advanced systems are replacing steam turbine technologies, does support the long-term goal of near-zero air pollutant and greenhouse gas emissions without complicated end-of-pipe control technologies. Continued use of fossil fuels in a carbon-constrained world requires that carbon capture and storage (CCS) becomes a major carbon mitigation activity.

The widespread interest in nuclear power reflects a broadly shared perception of the need to shift away from fossil fuels because of concerns about climate change. In some countries, such as Egypt, nuclear power also is seen as a way to reduce the dependence on depleted oil and gas or on imported fuels.

Also, within the context of the global carbon market, CDM projects in the Arab countries need to increase in number and scale.

Most importantly, the private sector will lead in developing and deploying most of the effective approaches, but will need a stable governance framework. However, reaching almost zero or even negative GHG emissions will require the Arab countries to embark on rapid introduction of policies and measures to integrate climate change into local and national priorities.

I. INTRODUCTION

Fossil fuels are the predominant primary energy at present in the Arab world, accounting for nearly 98.6 percent of commercial energy use. They are also the dominant fuel for power generation: producing about 93 percent of the Arab World's electricity today (Abdel Gelil et al. 2011) and projected to provide a similar fraction in 2030 under a business-as-usual (BAU) scenario (IEA, 2008c). Today, fossil fuels are the most mature and economic source for power generation. However, they also account for most local pollution and global carbon dioxide emissions. The future of fossil power generation in a carbon-constrained world depends on a compromise between growth in electricity demand and reduction in carbon dioxide emissions (Larson et al. 2012).

Electricity demand has invariably increased along with economic growth in the Arab countries. In 2010, Arab world primary commercial energy supply was 580.3 million tons of oil equivalent (Mtoe), including oil, natural gas, hydropower, and new renewables. Oil and natural gas supplies ranked first with a fraction of 98 percent (IEA, 2012a). Table 1 gives the evolution of total primary energy supply in the Arab countries and the total CO_2 emissions from fossil fuel combustion during the period 1971-2010 (IEA, 2012b).

Although electricity demand has increased all over the world, including the Arab countries, the Gulf Cooperation Council (GCC) countries' demand for electricity has increased at thrice the global average over the last few years; there are different reasons for this anomalous behavior, the main ones being the higher-than-average economic growth rate (reflected in the significant increase of the GCC countries' GDPs), and the policy of encouraging huge development projects in the domestic, service and infrastructure sectors, especially the UAE and KSA (Qader, 2009).

The International Energy Agency (IEA) identified 3 of the GCC countries as those with the highest per capita energy consumption in the world, and furthermore concluded that the six GCC countries contribute approximately to 50 percent of the cumulative Arab countries' CO_2 emissions (IEA, 2012a&b). KSA leads the six GCC countries, followed by UAE, Kuwait, Qatar, Oman, and Bahrain, with a total contribution of 721.2 $MtCO_2$ in 2010. Egypt is ranked the second Arab country with a contribution of 177.6 $MtCO_2$ in 2010, following the KSA (446 $MtCO_2$). The United Arab Emirates (UAE) is the world's third largest emitter of greenhouse gas (GHG) per capita. Rapid rise in CO_2 emissions is related to economic and social development, and the need for energy supply to the continuing development. The same rapid growth in fossil-based electricity generation is recorded in conjunction to the above rapid rise in CO_2 emissions in these countries (see Table 1).

This high dependency of the Arab region on fossil fuel resources raises critical questions, which demand clear answers: Where are we now, and where are we headed? Is a cost-effective climate change mitigation strategy possible?

This chapter highlights the policies needed to implement a cost-effective mitigation strategy in the Arab region as well as technologies and measures that are most appropriate to reducing GHG emissions.

II. MAJOR EMITTERS OF CARBON DIOXIDE IN THE ARAB REGION

Carbon dioxide emissions related to fuel combustion in the Arab region increased by 247 percent from 1990 to 2010, reaching 1,363 Mt, significantly outpacing population growth over the same period

TABLE 1

EVOLUTION OF TOTAL PRIMARY ENERGY SUPPLY (TPES) IN THE ARAB COUNTRIES AND TOTAL CO2 EMISSIONS FROM FUEL COMBUSTION DURING: 1971-2010 (IN MILLION TONNES OF OIL EQUIVALENT-MTOE, AND MILLION TONNES OF CO_2-$MTCO_2$, RESPECTIVELY)

Region		1971	1980	1985	1990	1995	2000	2005	2008	2009	2010
Algeria	TPES	3.5	11.2	17.7	22.2	24.1	27.0	32.4	37.4	40.7	40.4
	TCO_2*	8.9	28.4	43.2	52.7	56.8	63.5	79.6	89.7	99.1	98.6
Egypt	TPES	7.8	15.2	25.7	32.3	35.3	40.7	62.7	71.9	71.4	73.3
	TCO_2	20.3	41.9	64.8	78.4	83.1	101.3	152.6	175.3	172.7	177.6
Libya	TPES	1.6	6.9	10.0	11.3	15.8	16.6	17.6	19.2	21.9	19.1
	TCO_2	3.7	18.6	22.5	27.4	35.1	39.7	42.5	47.0	49.8	51.6
Morocco	TPES	2.4	4.9	5.6	6.9	8.6	10.2	13.1	15.0	15.1	16.5
	TCO_2	6.8	14.0	16.5	19.6	26.0	29.4	40.1	43.5	42.7	46.0
Sudan	TPES	7.0	8.4	9.5	10.6	12.0	13.3	15.1	15.1	15.9	16.2
	TCO_2	3.3	3.7	4.2	5.5	4.6	5.5	9.2	12.4	13.5	13.7
Tunisia	TPES	1.7	3.3	4.2	4.9	5.8	7.3	8.3	9.4	9.0	9.6
	TCO_2	3.7	7.8	9.6	12.1	14.2	18.0	20.2	21.5	21.3	21.9
Bahrain	TPES	1.4	2.8	4.2	4.4	4.9	5.9	7.5	9.2	9.5	9.8
	TCO_2	3.0	7.4	10.4	11.7	11.6	14.1	18.1	22.3	22.8	23.6
Iraq	TPES	4.1	9.6	13.8	19.7	34.5	25.9	26.9	28.5	32.5	37.8
	TCO_2	10.4	27.0	36.8	53.4	97.5	70.3	74.9	73.4	91.9	104.5
Jordan	TPES	0.5	1.5	2.6	3.3	4.3	4.9	6.7	7.1	7.5	7.2
	TCO_2	1.3	4.3	7.4	9.2	12.2	14.4	18.0	18.5	19.3	18.6
Kuwait	TPES	6.1	10.5	14.0	9.1	14.9	18.8	26.4	27.9	30.2	33.4
	TCO_2	14.0	26.6	37.1	28.7	36.1	49.1	70.1	73.9	80.7	87.4
Lebanon	TPES	1.8	2.5	2.3	2.0	4.4	4.9	5.0	5.4	6.6	6.5
	TCO_2	4.5	6.6	6.5	5.5	12.8	14.1	14.5	15.8	19.1	18.6
Oman	TPES	0.2	1.1	2.1	4.2	6.1	8.1	10.8	15.9	14.9	20.0
	TCO_2	0.3	2.2	5.7	10.2	14.7	20.2	28.2	36.5	40.0	40.3
Qatar	TPES	0.9	3.3	5.4	6.2	7.9	10.4	16.9	21.5	23.5	30.2
	TCO_2	2.2	7.7	12.1	14.1	18.7	23.7	37.6	49.8	56.4	66.1
KSA	TPES	7.4	31.1	46.0	59.8	87.5	101.3	145.5	154.1	157.9	169.3
	TCO_2	12.7	99.1	122.6	159.1	207.8	252.8	333.8	387.1	411.4	446.0
Syria	TPES	2.4	4.5	7.8	10.5	12.1	15.8	20.8	23.1	21.2	21.7
	TCO_2	6.0	13.1	21.1	28.2	32.8	39.8	54.9	62.7	57.2	57.8
UAE	TPES	1.0	7.2	13.7	20.4	27.7	33.9	43.2	58.3	60.4	62.1
	TCO_2	2.4	19.1	35.6	51.9	69.6	85.6	108.4	145.6	149.4	154.0
Yemen	TPES	0.7	1.3	1.7	2.5	3.4	4.7	6.6	7.1	7.4	7.2
	TCO_2	1.2	3.4	4.8	6.4	9.3	13.2	18.8	21.1	21.6	21.7

* Total CO2 emissions from fuel combustion in the Arab countries, sectoral approach.
Source: IEA: CO2 Emissions from Fuel Combustion – Highlights, 2012.

TABLE 2 CO_2 EQUIVALENT (CO_2E) EMISSIONS FROM FOSSIL FUEL COMBUSTION IN SOME ARAB COUNTRIES, AS PER THEIR NATIONAL COMMUNICATIONS

Arab Country	National Communication Report	Year of Inventory Calculation	Emissions from Fossil Fuel Combustion (Mt CO_{2e})	Percentage of Total Emissions (%)
Egypt	Second NC, 2010	2000	116.30	60.2
Morocco	Second NC, 2010	2000	32.29	50.9
Sudan	First NC, 2003	1995	16.70	18.7
Tunisia	Initial NC, 2001	1994	15.25	65.3
Bahrain	Second NC, 2012	2000	17.25	77.1
Jordan	Second NC, 2009	2000	14.91	74.0
Lebanon	Second NC, 2011	2000	13.85	74.86
KSA	Second NC, 2010	2000	237.55	92.10
Syria	Initial NC, 2010	2005	58.35	74.00
UAE	Second NC, 2010	2000	116.11	89.60

Source: UNFCCC: Arab National Communication Reports, 2012.

(+55.77 percent) (IEA, 2012b). Over 95 percent of these emissions were related to the use of oil and gas, with oil-based transport and gas-based power generation having the largest growth over the last two decades.

Methane (CH_4) is the second largest GHG contributing to anthropogenic global warming. Energy-related sources in the Arab region include, oil production (from associated natural gas), and natural gas production, transport, and distribution (leaks) (Emberson et al., 2012).

Today, many Arab countries have produced their First and Second National Communications to the United Nations Framework Convention on Climate Change (UNFCCC) using the Global Warming Potential (GWP) and emission factors of the Intergovernmental Panel on Climate Change (IPCC). Carbon dioxide equivalent anthropogenic emissions from fossil fuel combustion were calculated at the values and percentages given in Table 2 (UNFCCC, 2013).

In all Arab countries, the energy usage is the main source of GHG emissions because they are all principally dependent on fossil fuels. Minor shares come from agriculture, industrial processes, land-use change, and agriculture and waste sectors. Table 3 gives the total CO_2 emissions from fossil fuel combustion of the Arab region by sector in 2010.

- **Energy-related activities** are responsible for a major share of anthropogenic emissions of GHGs, other radiative forcing substances, and air pollutants into the atmosphere (see Table 2). Electricity-related GHG emissions, mainly from fossil fuel combustion account for approximately 30-35 percent of total fuel combustion emissions, including carbon dioxide (CO_2), methane (CH_4) and some traces of nitrous oxide (N_2O) (IPCC, 2007d) (Emberson et al., 2012) (see Table-3).

- **The industry sector** in the Arab Countries represents 25 – 50 percent of their GDP. Although the Maghreb Arab Countries do not have high industrial intensity, industrial pollution is dominant. Fast industrial development in the Mashreq Arab Countries has considerably increased the consumption of energy and other raw materials. Some Arab Countries have witnessed fast growth in oil production and refining. This has been accompanied by the establishment of several industries based on oil production. The result has been a significant increase in industrial pollution and GHGs accounting for around 30-33 percent of total fuel combustion emissions (IEA, 2012b).

- **Transport** is comparatively the smallest energy service category when assessed in terms of useful energy. But due to low conversion effi-

TABLE 3 **SECTORAL CO_2 EMISSIONS FROM FOSSIL FUEL COMBUSTION OF THE ARAB COUNTRIES IN 2010, IN MILLION TONNES OF CO_2**

Region	Total CO_2 emissions from fuel combustion	Electricity and heat production	Other energy industry own use	Manufacturing industries and construction	Transport	of which: road	Other sectors	of which: residential
Algeria	98.6	25.0	11.1	12.7	33.3	29.7	16.4	13.1
Egypt	177.6	66.0	14.8	33.4	38.4	35.4	24.9	15.2
Libya	51.6	28.0	3.1	6.3	12.1	12.1	2.2	2.2
Morocco	46.0	16.0	0.8	7.6	10.6	10.6	11.0	4.2
Sudan	13.7	2.7	0.5	2.3	6.8	6.7	1.4	0.8
Tunisia	21.9	7.4	0.1	5.1	6.0	6.0	3.3	1.6
Bahrain	23.6	8.5	4.5	6.8	3.6	3.6	0.2	0.2
Iraq	104.5	50.3	4.0	8.2	29.7	29.7	12.2	12.2
Jordan	18.6	8.4	0.6	2.3	5.2	5.1	2.2	1.3
Kuwait	87.4	48.0	12.2	15.0	11.7	11.7	0.5	0.5
Lebanon	18.6	11.1	-	1.3	5.0	5.0	1.2	1.2
Oman	40.3	15.7	7.9	8.5	6.3	6.3	1.9	0.5
Qatar	64.9	13.9	20.3	21.2	9.2	9.2	0.3	0.3
KSA	446.0	176.9	74.4	86.3	104.4	102.3	4.0	4.0
Syria	57.8	27.6	1.5	8.8	12.2	12.0	7.7	4.4
UAE	154.0	58.4	2.1	67.2	25.7	25.7	0.6	0.6
Yemen	21.7	5.1	3.3	0.9	6.2	6.2	6.2	1.9

Source: IEA: CO_2 Emissions from Fuel Combustion – Highlights, 2012.

ciencies, it stands for some 28 percent in total primary energy. Road transportation (cars, two and three-wheelers, buses and trucks) are the dominant technologies for providing mobility of people and goods (Grubler et al., 2012). The transport-related GHG emissions in the Arab countries account for approximately 20-26 percent of total energy-related emissions in Egypt, Libya, Morocco, Syria, KSA & Lebanon, and for approximately 27-33 percent in Yemen, Jordon, Tunisia, Iraq and Algeria. It becomes lower to 14-17 percent in Kuwait, Qatar, Oman, Bahrain and UEA, but it goes higher in Sudan to approximately 50 percent (IEA, 2012b).

III. TECHNOLOGIES AND MEASURES TO REDUCE GHG EMISSIONS

A. Current Policies and Measures

As non-annex I countries, Arab states are not required to meet any specific emission reduction or limitation targets in terms of commitments under the UNFCCC, or the Kyoto protocol. However, mitigation measures are already in progress.

Various policies and measures related to internalizing reduction of GHG emissions, as advocated in the UNFCCC, have been developed in many Arab countries.

Accelerated developments are taking place for introducing renewables; fuel switching in industry and transport; use of combined heat and power to produce electricity and water; reduction of generation, transmission and distribution losses; domestic and industrial efficiency programs and energy-efficient buildings to enable establishment of an economic structure that prioritizes energy efficiency.

Examples of the current mitigation policies and measures in the Arab countries, summarized in Table-4, are based on those described in national communication reports as well as national plans and country studies documents.

TABLE 4 **EXAMPLES OF POLICIES AND MEASURES IMPLEMENTED AND PLANS ANNOUNCED FOR MITIGATION OPTIONS IN THE ARAB COUNTRIES**

Algeria	• Reducing of gas flaring by 50%. • Building of four gas-CSP plants with total capacity 1700 MW; of which 250 MW solar (will be gradually commissioned through 2015). • Introduction of medium-big scale RE power generation: CSP: 500 MW in 2010 and Wind: 100 MW; Solar PV: 5.1 MW; Solar Thermal: 170MW; Cogeneration: 450 MW by 2015.
Egypt	• Expand access to renewable energy resources to reach a contribution of 20% of the total electrical energy demand by 2020, of which 7200MW wind farms. Today, 547 MW wind farms are operating along the Suez Gulf, 140MW ISGCC is operating at Kureimat and two 100MW each of CSP are announced in Comombo, in addition to two PV 20MW each. • Switching to using natural gas in substitution to oil for power generation. • Enhancing electricity and gas grid-interconnection across borders of neighboring states. • Reinforcing energy efficiency standards, expanding energy efficiency labeling for household appliances, application of energy efficiency code for buildings and disseminating efficient lighting. • Transport sector improvements using natural gas in commercial vehicles; extending the electrified underground transportation to new areas in Greater Cairo; electrification of Cairo- Alexandria Line by 2020; electrification of Cairo - Upper Egypt Line around 2030; intensifying the use of environmentally sound river transport; facilitating the replacement of old taxis; and vehicles utilizing fuel cells are to grow as their economics improve. • Launching a program to build a number of nuclear power generating plants, initiating the necessary steps to have the first 1000MW plant operational by 2017.
Jordan	• A series of BOO-based wind farms at Aqaba, Kamsha, Al-Hareer, Ibrahimya, Fujaij, Ma'an with a total installed capacity of 600-1000 MW by 2020. • Promoting utilization of solar water heaters (SWH) in 50% of household in Jordan by 2020 (the 2008 numbers were about 14%). • Solar PV 300-600 MW by 2020. • Energy saving projects in industrial sector cover ceramic, food and canning, paper, steel, plastic, chemical and mining industries.

Source: UNFCCC: Arab National Communication Reports, http://unfccc.int/nationa_reports/non-annex_i_nal-com/items/2979.php, 2012.

B. Medium- and Long-Term Options

There are multiple means for lowering GHG emissions from the energy system while still providing energy services (Pacala and Socolow, 2004). Energy services are the tasks to be performed using energy. In order to assess the potential contribution of a single mitigation mean, competing mitigation options therefore must be considered as well (IPCC, 2007d).

i. Energy Efficiency

According to UNEP report on Energy Conservation in Developing Countries, (UNEP, ERS-16-16-85), most of the developing countries can produce the same volume of commodities by about 40 percent less primary energy. Thus the potential for cutting off primary energy consumption through Energy Efficiency (EE) in the Arab Countries is huge.

Energy efficiency in the many sectors of the economy is where the Arab region has relatively lagged behind, due to the difficulty of articulating and enforcing the complex and detailed policies required for improving efficiency, in addition to the complexity and higher level of administrative capacity required for pursuing this objective (ESMAP, 2009).

However, several aspects of policy for energy efficiency have been recently proposed and assessed for the Arab countries by the Regional Center for Renewable Energy and Energy Efficiency (RCREEE, 2010).

The assessment indicated that very few countries relatively achieved some progress in every aspect as presented in Table 5.

Tunisia appears to be the only country that has performed well in this regards, with some plausible results to show. Otherwise, countries have taken

	• Introduction of a total 1500 MW oil shale-based power plants during: 2012-2014. • Introduction of a total 1200 MW nuclear power into the national power system during 2020-2030. • 2.3% per year penetration rate for solar thermal applications in commercial and residential sectors.
Saudi Arabia	• Several initiatives to implement energy conservation and to reduce peak load demand. • National Energy Efficiency Program (NEEP). • Thermal Energy Storage (TES) initiative. • Establishing the Center of Research Excellence in RE at KFUPM in 2007. • Hybrid system initiative (wind-diesel). • Solar electricity: 41,000 MW by 2032 (25,000 MW CSP and 16,000 MW PV)([1]) • Many research programs conducted by Saudi Aramco to implement carbon management (CM), including CO_2-EOR. • Saudi Aramco operates the world's largest single gas collection system. • North-South Railway (NSR) project. • 20 km long the Al-Mashaaer Al-Mugaddassah metro line (in operation since 2010). • A lot of R&D projects in the areas of solar energy, clean fuel production, emission reduction and water resources.
United Arab Emirates	• Renewable energy: commitment to deploy renewable energy sources (i.e., solar PV and wind) equal to 7% of the total on-grid power generation capacity by 2020. • Solar CSP 100 MW Shams-1 plant in Abu Dhabi. • Introduction of a single next-generation pressurized water reactor (1,400 MW), followed by three nuclear plants, each of capacity 1400 MW to displace equivalent baseload electricity from natural gas-fired units. • Abu Dhabi Vision 2030 calls for shifts from private modes of transport to public modes and scales this initiative up to the UAE level. • Use of compressed natural gas (CNG) in bus fleets. • The Abu Dhabi MASDAR Initiative is investing heavily in the research, development and integration of technologies that will sharply reduce CO_2 emissions of fossil fuel-fired power generation linked with a carbon capture and sequestration (CCS) network.

scarce steps, but tangible results are almost absent. The only measures observed outside of Tunisia are in Algeria, with respect to the establishment of an energy efficiency law and the dissemination of information; and Egypt, with respect to the establishment of a strategy and targets (Patwardhan et al., 2012).

Over the long term, dramatic gains in efficiency are possible for all the Arab countries at all stages of energy conversion, particularly from useful energy to energy services. Analysis shows that current technologies are not close to reaching theoretical limits, and that improvements of an order of magnitude for the whole energy system may eventually be achieved.

There are basically 2 measures to manage energy demand in the Arab countries: (1) mandate that something should be done or (2) make use of the market and the economic instruments (Table 6). Mandating is typically used to give explicit information or explicit tasks about certain technologies and actors that should be activated, whereas the market acceptance is used when the object cannot be easily identified, but the performance characteristic can be well defined (Lisa Ryan et al., 2011). The task is to keep the energy system working and to shift from carbon-fat to carbon-lean systems.

Industry is the area where the easiest energy efficiency progress may be achieved, because of the large scale of emissions and the concentration in hands of few actors, whose behavior can more easily be influenced and monitored (Luciani, 2012).

In the industrial sector, energy efficiency measures can be broadly split into the following categories:

- widespread adoption of best available technology for new investments;
- retrofit of existing plants to improve energy efficiency;
- optimization of energy and material flows

TABLE 5 **POLICY SCAN OF ENERGY EFFICIENCY IN THE ARAB REGION**

	Strategy and Targets	Energy Efficiency Legislation	Pricing Policy	Energy Efficiency Agencies	Labeling and Standards	Financial Incentives	Energy Efficiency Obligations	Audits and Promotion of ESCOs(*)	Transport and Spatial Planning	Dissemination of Information
Algeria		•			•	•	•			•
Egypt	•				•		•	•	•	
Morocco	•			•						•
Sudan										
Tunisia	•	•		•	•	•	•	•	•	•
Bahrain								•		•
Jordan			•	•	•	•				
Kuwait					•					
Lebanon				•				•		•
KSA					•					
Syria				•				•		
Palestine		•	•							
UAE									•	•

* ESCOs: Energy Service Companies.
Source: RCREEE (2010). "Policies for Efficiency and Renewable Energy in RCREEE Group of Countries"; Cairo, Egypt.

through systems design, quality improvements, lifecycle product design, and enhanced recycling; and
- switch to renewable energy.

The adoption of best available technology and systemic approaches to optimizing the use of energy for industrial processes can yield an efficiency improvement of around 30 percent (IEA, 2007; Price and McKane, 2009; Saygin et al., 2010). Moreover, a switch to 25 percent renewable energy throughout the manufacturing industry yields a 10 percent "efficiency" gain through electrification and reduced used of fossil resources.

Power generation, also, is a key area for energy efficiency. As for Saudi Arabia and the UAE, lower energy efficiency is probably due to the fact that several gas plants are used for meeting seasonal peak demand: these are open-cycle gas turbines rather than combined-cycle (Luciani, 2012).

The synergy between power generation and water desalination is a major theme for efficient use of energy in the Arab region. The optimization of the interface between power generation and water desalination is extremely important and carefully looked at in the region.

The reliance on open cycle gas turbines for power generation and the importance of water desalination are, at the same time, important features that may allow for more efficient deployment of renewable energy sources, such as wind and solar, whose main drawback is intermittency (Luciani, 2012).

With respect to water desalination, the key to achieving higher efficiency is in greater reliance on technologies such as reverse osmosis, which absorb electricity. As water can be stored in large quantities, while electricity cannot, it would be possible to operate the desalination plants at times of low electricity demand and store the water. At times when electricity demand is near its peak, water desalination could be stopped or slowed down, and water demand would be satisfied drawing from the water reservoirs.

Another aspect that has been flagged for attention in the context of energy efficiency is the high level of transmission losses (ESMAP, 2009). The integration of grids across borders is expected to lead to an improvement of transmission efficiency.

The residential sector is also where a relatively larger proportion of energy is used in the Arab countries. The share of the residential sector in total electricity consumption exceeds 50 percent in Kuwait, Saudi Arabia, Bahrain and Oman, and reaches about 40 percent in Egypt. Improving efficiency of electricity consumption in the residential sector has therefore special importance as an instrument to address the excessive growth in electricity demand.

The most important opportunities for energy savings in the residential and commercial sector in the Arab region are to be found in improving the quality of buildings, minimizing the demand for lighting and air conditioning. It would require a major shift in economic strategy to change direction and pursue a substantial improvement of energy efficiency in buildings. Nevertheless, some initiatives signal increased awareness of the problem: the Abu Dhabi Municipality, for instance, has recently launched a major energy efficiency study of the city's buildings' stock[2] (Luciani, 2012).

In the absence of a major improvement in the quality of buildings, it is still possible to pursue greater efficiency in the equipment and technologies that are used for household services. Some countries, such as Egypt and Saudi Arabia, have introduced labeling of appliances for energy consumption, including air conditioning equipment and Frigidaire's, and Abu Dhabi will soon do the same.

The potential for the utilization of alternative technologies is also significant. Solar air conditioning based on adsorption, air conditioning from gas and district cooling are all technologies that have considerable promise.

ii. Renewable Energy

Renewable energy sources (including biomass, solar and wind) that use indigenous resources have the potential to provide energy services with zero or almost zero emissions of both greenhouse gases and air pollutants (Turkenburg et al., 2012).

The Arab region enjoys tremendous renewable energy resources. Saudi Arabia and North Africa have vast stretches of desert areas with abundant sunlight, which can be exploited for the production of solar power. It is quite obvious that CSP is highly

TABLE 6 **APPROACHES, TYPES OF MEASURES, SUITABILITY AND EXAMPLES OF DEMAND-SIDE MANAGEMENT TO IMPROVE ENERGY EFFICIENCY**

Approach	Type		Example of Measure	Suitability for Industry
Mandated	Standards		1. Minimum performance (MEPS)	Small motors, Lighting
			2. Top-runner standard	c.f. Energy Star computers
	"Agreed Actions"		3. Voluntary Agreements	For branches
			4. (Technology) Procurements	LCC Procurement guidelines
	Delegated Actions	By actor	5. Regional bodies	Chambers of commerce
			6. Municipalities	-
		By Means	7. Commitments	For SMEs
			8. Certificates	Quota obligations
Market Acceptance	Price-responsive customers		9. Taxes; Tax reduction	Combined with audits and agreements
			10. Price elasticity (Demand Response)	Common and neutral for all types
	Non-price responsive Customers	"Commoditizing" energy efficiency	11. Energy Services (ESCO) and Performance Contracting (EPC)	Outsourcing and facility management
			12. Labels	-

Source: Schock et al. (2012). "Energy Supply Systems" in GEA; Cambridge University Press, Cambridge, UK.

EFFICIENT LIGHTING SYSTEMS IN THE ARAB REGION

Ibrahim Abdel Gelil

Energy-efficient lighting technologies are economical, commercially viable and technologically available, but due to several barriers, they have not reached their market penetration potential. A growing number of countries in the Arab region have already taken actions to transit to more efficient lighting systems. Replacing incandescent lamps in the residential sector is one of the most obvious and easiest methods to achieve energy-efficiency in the region. The transition to efficient lighting can occur at a very low cost with existing technology and provide immediate results. The UNEP/GEF en.lighten initiative, developed estimates for 130 countries with the objective of calculating the potential electricity savings, CO2 emission reductions and the economic benefits that could be realized from phasing out inefficient lighting and replacing them with compact fluorescent lamps (CFLs). Out of the 130 countries analyzed, 18 were from the Arab region. Eliminating inefficient lighting in the region would save nearly 37.8 Twh of electricity and slash 24.8 Mt of CO2. Lighting consumes nearly 34 percent of the total Arab's electricity consumption. Potential energy savings and CO2 emission reduction varies between different countries based on their pattern of energy demand, fuel mix of electricity generation, and energy efficiency. Lighting represents the highest percentage of electricity consumption in Algeria (41.3 %) and Sudan (35.5%), while Saudi Arabia and Egypt are the largest consumers of electricity and thus have the highest saving potential.

Some Arab countries have already begun initiatives to transition to efficient lighting. These national programs are in various stages of development. To support the transition, countries have formulated different policies and measures and, in most cases the preferred approach has been the implementation of fiscal incentives to reduce the initial cost of the CFLs. Five countries (Egypt, Lebanon, Morocco, Tunisia, and UAE) have already distributed around 30 million CFLs in total. Additionally, some countries like Egypt, Tunisia, and Lebanon have announced that they will ban the sale of all incandescent bulbs by specific target years. Bulk distribution of CFLs is a positive first step forward to develop market for efficient lighting. It highlights the benefits of CFLs such as economic viability, reliability, and efficiency. It also serves to educate the public on the availability of this technology, overcome the barrier of initial high cost of CFLs, increase the demand for CFLs

promising RE technology for power generation in the entire Arab region (see Box on NOOR 1).

Solar photovoltaics, CSP and grid-connected wind installed capacities are growing in many Gulf and North Africa countries. However, renewables share in the Arab electricity production is still humble. Currently, renewable energy sources, including hydro-electricity, supply 1.3 percent of the total Arab region's primary energy demand (Abdel Gelil et al., 2011). For instance, hydro-electricity and new renewables (wind and solar) have contributed 8.2 percent and 1.27 percent, respectively in the total Egypt's electricity generation in 2012 (EEHC, 2012). Even so, it will likely be decades before these new renewables add up to a major fraction of total energy consumption, because they currently represent such a small percentage (GEA, 2012).

As indicated in Table 6 of chapter 3 on Renewable Energy, many Arab countries have already set renewable energy targets to scale up penetration of renewable energy into their national energy mix, some countries have developed national renewable energy strategies, and many countries have adopted a set of policy instruments, such as feed-in-tariff, to foster development of renewable energy resources.

Thus, next to energy efficiency, RE has a high potential of reducing future GHG emissions of the Arab Countries.

Arab countries have the option to invest now in the huge potential of solar and wind power, and should strive to take a leading position in developing and deploying renewable energy technologies in the region and aspire to become major exporters of green energy. (Check chapter 3 of this report for details on renewable energy options to mitigate climate change)

iii. Advanced energy technologies

a. Fossil Energy Technologies

Today, fossil fuels are the most mature and economic source for power generation. Present and future perspective show that a radical transformation of the to encourage suppliers to enter the market, as well as helping to achieve quick and impactful load reduction of the power systems. However, bulk distribution programs are not sufficient to secure sustainable transformation to efficient lighting. These programs should be implemented within a broader and integrated policy framework. Key elements of this integrated approach include: the development of Minimum Energy Performance Standards (MEPS), supporting policies to help restrict supply of inefficient lighting and promote demand of MEPS-compliant products; Monitoring Verification and Enforcement (MVE) mechanisms; and, environmentally sound waste management of CFLs at the end of their life.

Studies reveal significant similarities with regard to policies implemented for the switch to efficient lighting in the region. In almost all the countries examined, they have formulated a comprehensive policy package that; contains energy price reform, strengthens the legislative and institutional framework, provide fiscal incentives, develops standards and labeling schemes, and raises public awareness. Furthermore, almost all of countries in the region have been conducting public awareness campaigns to promote energy efficiency and efficient lighting, even if they don't currently have any programs in place for switching to CFLs. In these cases, the effectiveness of such campaigns in changing consumer opinion and buying habits needs to be measured.

While many countries in the region, such as Morocco, Jordan, Egypt, and Tunisia have already established integrated energy-efficiency strategies, targets or legislation into their national energy policy frameworks, these steps are yet to be taken in other countries like the Gulf States (GCC). Here, heavy energy price subsidies and the abundance of fossil fuels have hindered investment in energy efficiency including efficient lighting.

Reference

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fossil energy landscape is feasible for simultaneously meeting the multiple sustainability goals of wider access to modern energy carriers, reduced air pollution health risks, enhanced energy security, and major greenhouse gas (GHG) emissions reductions.

Fossil fuels will dominate energy use in the Arab region for decades to come. Two facts apply to developing and industrialized countries alike. First, fossil fuels must be used judiciously– by designing energy systems for which the quality of energy supply is well matched to the quality of energy service required, and by exploiting other opportunities for realizing high efficiencies. Second, continued use of fossil fuels in a carbon-constrained world requires that carbon capture and storage (CCS) becomes a major carbon mitigation activity (Larson, E., et al., 2012).

The technological revolution under way in power generation, where advanced systems are replacing steam turbine technologies, does support the long-term goal of near-zero air pollutant and greenhouse gas emissions without complicated end-of-pipe

control technologies. Natural-gas-fired combined cycles (NGCCs) that offer low costs, high efficiency, and low environmental impacts are being chosen wherever natural gas is readily available. Cogeneration is more cost-effective and can play a much larger role in the energy economy-if based on gas turbines and combined cycles rather than on steam turbines.

Reciprocating engines and emerging microturbine and fuel cell technologies are also strong candidates for cogeneration at smaller scales, including commercial and apartment buildings. Imported coal gasification by partial oxidation with oxygen to produce syngas (mainly carbon monoxide and hydrogen) makes it possible to provide electricity through integrated gasifier combined cycle (IGCC) plants with air pollutant emissions nearly as low as for natural gas combined cycles (Larson, E. et al., 2012). Imported coal might be considered a viable alternative for some Arab counties, like Egypt. Coal is unevenly distributed and abundant, and can be converted to liquids, gases, heat, and electricity, although more intense use demands viable CCS technologies if greenhouse-gas emissions are to be limited. (Lepinski et al., 2009).

Methane is a diverse and flexible fuel which, when combusted, provides both heat and/or electricity. It can also be used in the transport sector in the form of CNG, LNG, or compressed or liquefied biomethane.

Fossil fuels other than petroleum can be converted in the Arab region to transportation fuels. Technologies are available and commercially operated today for converting natural gas, coal, or biomass into liquids that closely resemble diesel and gasoline derived from crude oil. Also, there is renewed interest in higher alcohols for both gasoline and diesel blending (GEA, 2012). Furthermore, there is now growing interest in the production of synthetic gasoline from synthesis gas via a methanol intermediate. This is so called methanol-to-gasoline process.

One approach to reducing GHG emissions below petroleum-fuel levels is to exploit negative GHG emissions opportunities to offset the emissions. One important opportunity is synthetic fuels production from biomass with CCS.

In addition, hydrogen is not used as a transportation fuel today, but it is appealing as it allows the

QATAR PETROLEUM: AL-SHAHEEN CLEAN DEVELOPMENT MECHANISM (CDM) PROJECT

Al-Shaheen, implemented by Qatar Petroleum, is a model of a Clean Development Mechanism (CDM) project in the oil sector. The project activity is the recovery and utilization of associated gas produced as a byproduct of oil recovery activities at the Al-Shaheen oil field, which is operated by Maersk Qatar Oil, under agreement with Qatar Petroleum. Prior to 2004, associated gas at the Al-Shaheen oil field was primarily flared, with the remaining gas utilized for onsite consumption (about 3 percent).

The project activities cover recovery and transmission of the associated gas, and ultimately utilization at the gas processing plant.

Captured associated gas is injected into a gas pipeline for transport to Mesaieed gas processing plant. The gas products include dry gas, LPG and condensate, which are utilized for the electricity in the national grid and for local industry consumption. This contributes to Qatar's energy efficiency efforts by increasing the power supply without raising fossil fuel consumption.

Qatar's accession to the Kyoto Protocol on 11 January, 2005, as a non-Annex I nation, made it eligible to the CDM benefits. Subsequently, Qatar Petroleum initiated the formal procedure to register the Al-Shaheen project activity under the CDM. The project, which followed the full cycle of CDM process, was used by Qatar Petroleum as a model for other CDM projects in the Qatari energy and industry sectors.

The project falls under the category of "Fugitive Emissions" from fuels (solid, oil and gas) according to the UNFCCC classification. The approved methodology of "recovery and utilization of gas from oil wells that would otherwise be flared" was applied to this project. The Project Design Document (PDD) was prepared meeting the requirement of base line and monitoring methodology, including economic attractiveness and barriers. The PDD was validated in late 2006, and Al-Shaheen was registered as a CDM project with UNFCCC in May 2007.

The overall responsibility for the monitoring of the project is the Health, Safety and Environment (HSE) Regulation and Enforcement Directorate of Qatar Petroleum. The first Monitoring Report was submitted to UNFCCC in May 2009.

The Project has undergone a comprehensive verification process leading to the issuance of a Certified Emission Reductions (CERs) certificate. The total quantity of Certified Emission Reduction (CER) units issued by UNFCCC's CDM Executive Board to this project are being carried out for selling the CERs generated from the Al-Shaheen in the market.

The success of the Al-Shaheen CDM project is considered a major milestone for the energy and industry sector in Qatar. According to Dr. Mohammed Al-Sada, Minister of Energy and Industry and Chairman & Managing Director of Qatar Petroleum, "At Al-Shaheen, we have comprehensively demonstrated the use of the CDM and technologies to reduce greenhouse gases. I am very positive that its success will encourage more such projects not only in Qatar, but the entire Middle East."

Based on material provided by Qatar Petroleum (QP).
QP is corporate AFED member.

SOLAR DESALINATION IN AL-KHAFJI, SAUDI ARABIA

Hussam Khonkar

King Abdulaziz City for Science and Technology (KACST) is currently building what will be the world's largest solar-powered desalination plant, in the city of Al-Khafji on the shores of the Gulf in Saudi Arabia, next to the border with Kuwait. Work on this green project has been underway since 2011 in response to the King Abdullah Initiative for Solar Water Desalination, which aims at meeting all new desalination requirements of the kingdom from renewable energy.

Saudi Arabia has a paramount challenge in the next 20 years, as it will see its electricity demand almost triple. A key driver for the rise in demand for local oil is the increase in demand for fresh water, which requires building desalination plants. Saudi Arabia has the world's largest installations of water desalination plants, representing more than 18 percent of global production. Approximately, 1.5 million barrels of oil are daily used locally to produce electricity and desalinated water across the Kingdom. Of that total, about 11 percent is used to meet the demand for domestic and industrial water use; while water used for irrigation comes mainly from underground aquifers. Saving oil for export is a vital issue for Saudi Arabia.

Recognizing the challenges, Saudi Arabia has established King Abduallah City for Atomic and Renewable Energy (KA-CARE), which is responsible for managing the atomic and renewable energy deployment. A key objective is to localize the manufacture of key components in order to capture most of the value created in the country. However, the creation of real industry requires technology transfer, education and increased public awareness, just to name a few.

The natural and geographic characteristics of Saudi Arabia make it one of the best regions of the world in terms of the amount of solar radiation. According to data from NASA, Saudi Arabia is the "second sunniest place on earth," behind Chile's Atacama Desert, with solar irradiation levels along the Red Sea coastline north of Jeddah as high as 8.6 Kilowatts-hour per square meter per day (KWh/m2/day). Such high radiation levels are important in ensuring that utilizing solar energy is economically feasible. The goal of the King Abdullah Initiative is to produce fresh water at cost below 1.5 Saudi Riyals per cubic meter, which is less than half the cost of producing fresh water today from diesel using thermal methods, or through reverse osmosis (RO). Turning toward green technology to increase water desalination capacity hence constitutes a strategic move for the future of the country.

Al-Khafji project, expected to be completed by 2014, is the first phase of the King Abdullah's Water Desalination Initiative. At 30,000 cubic meters of water per day, this will be the largest solar desalination plant in the world, and will meet the fresh water needs of approximately 100,000 dwellers of Al-Khafji city. The project will utilize a combination of two technologies: i) poly crystalline silicon flat photovoltaic panels that are mounted on dual-axis tracking to increase the energy production, and ii) ultra-high concentration photovoltaic (UHCPV) panels, which are also mounted on dual-axis trackers. The poly crystalline silicon panels, being the oldest and most established technology, will represent the bulk of the 10MW installation with some UHCPV systems deployed more for experimental purposes. The silicon panels are manufactured at KACST, while the UHCPV systems use state-of-the-art PV technology that was developed jointly by KACST and IBM Research Center in Yorktown Height, NY. The silicon panels have efficiency of 14 percent, while that of the UHCPV panels is more than double. One reason for using the silicon panels to generate the bulk of the electricity for this project is that Al-Khafji location has more global horizontal solar radiation, and low level of direct solar radiation. UHCPV panels can only convert direct solar radiation while silicon panels convert global solar radiation, which is a mix of direct and diffuse.

potential for low emissions of local pollutants and of greenhouse gases, as well as the energy security benefits arising from being able to shift transportation from oil dependence (Larson, E., et al., 2012).

Fluid hydrocarbon fuels Derived from Non-petroleum Feedstocks offer a much cleaner means of providing cooking services than solid fuels. Clean cooking fuels can also be produced from coal and/or biomass via the F-T or methanol-to-gasoline processes.

b. Nuclear Power

Most importantly, because nuclear power can provide energy without emitting conventional air pollutants and greenhouse gases, it is worth exploring if advanced technologies could offer simultaneously

Al-Khafji project will use the excess electricity generated from the solar panels during daytime to feed the electric grid. At night time, electricity will be obtained from the grid. As such, there is no energy storage requirement, and also the variability of electric output due to variations in weather conditions during daytime will not play a factor in the operation of the plant or in its economics. A total of approximately 1500 trackers will be used, which will carry solar panels, where each solar panel is rated at 240 Watts under standard test conditions. These silicon panels have met necessary certification requirements, and are designed to survive for 25 years with minimal degradation under conditions that span from -40°C to +90°C ambient temperature. The panels will be connected to central inverters to convert the DC current generated from the panels to AC current that can then be fed into the grid.

Water desalination will take place by implementing a state-of-the-art nanotechnology for reverse osmosis that was developed jointly by KACST and IBM Research Center. This RO membrane technology is highly resistance to chlorine, salt blockage, high flux, and accumulation of bacteria. The new membrane was named (i-Phobe) for its unique chemical composition of hydrophobic ions, which allows it to change radically when used in different conditions, transforming it into hydrophilic. The new nanomembrane has been developed to efficiently purify water from salts and toxic materials at high flux. It can also resist chlorine and prevent the accumulation of bacteria.

The second phase of the solar desalination initiative will provide 300,000 cubic meters per day of fresh water. Site selection and testing of UHCPV are underway in west coast of Saudi Arabia, where high irradiance solar radiation is more economical for such a system, while a full-scale implementation of solar desalination will be applied in the entire Kingdom. Second and third phases are targeted for 2032. The experience and lessons learned from the first project will be key to the success of this ambitious initiative.

The vision for using solar energy in Saudi Arabia for water desalination is a relevant indicator that resorting to green and sustainable solutions has become a pressing global need, even in the world's most oil-rich countries.

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lower costs, boost public confidence in the safety of nuclear reactors, assure that peaceful nuclear programs are not used for military purposes, and demonstrate effective nuclear waste management practices (UNDP, UNDESA & WEC, 2004).

The widespread interest in nuclear power reflects a broadly shared perception of the need to shift away from fossil fuels because of concerns about climate change (Hipple et al., 2012). In some countries, such as Egypt, nuclear power also is seen as a way to reduce the dependence on depleted oil and gas or on imported fuels.

In terms of countries GDP and national grid capacity, only Arab countries that pass both a US$50 billion annual GDP and a 5-GWe grid capacity screening requirement could plan for acquiring a

SHAMS-1 IN ABU DHABI

World's Largest Concentrated Solar Power Plant

Shams1 solar power station is a 100MW concentrated solar power (CSP) plant located in the western region of Abu Dhabi, U.A.E.

Covering an area of 2.5 square kilometers (km^2), the equivalent of 285 football fields, Shams1 is the largest CSP plant in operation in the world, and the first utility-scale renewable energy power facility in Abu Dhabi. The plant, which was inaugurated in March 2013 and took three years to build at a cost of US$600 million, is expected to be followed by Shams2 and Shams3 stations.

Using parabolic trough technology, with more than 258,000 mirrors mounted on 768 solar collector assembly units, Shams1 generates electricity to power 20,000 homes in the UAE. It displaces 175,000 tons of CO_2 per year, equivalent to planting 1.5 million trees or taking approximately 15,000 cars off the road.

By concentrating heat from direct sunlight onto oil-filled pipes, Shams1 produces steam, which drives a turbine and generates electricity. In addition, the solar project uses a booster to heat steam as it enters the turbine to dramatically increase the cycle's efficiency. The project also includes a dry-cooling system that significantly reduces water consumption, which is a critical advantage in the arid desert of western Abu Dhabi.

The plant is developed by Shams Power Company PJSC, a special purpose vehicle owned 60% by Masdar, Abu Dhabi's renewable energy company, 20% by Total, French energy company, and 20% by Abengoa Solar, Spain's solar energy infrastructure company.

Shams1 is an example of collaboration among companies which can achieve large-scale, clean-energy solutions that help meet the world's growing energy demands.

Al-Bia Wal-Tanmia magazine

first nuclear power plant. Even though the threshold size for a grid required to support a nuclear power reactor has been reduced to 5 GWe, to allow for the possibility of a doubling of the grid capacity before the first nuclear power plant comes online, the grid requirement appears to be the most stringent.

IV. ROLE OF CCS IN FUTURE GHG EMISSIONS MITIGATION

The only technology available to mitigate GHG emissions from large-scale fossil fuel usage is CO_2 Capture and Storage (CCS) (Benson et al., 2012).

Over the longer term, CCS could be used to reduce emissions from sources that are difficult to eliminate in any other way, such as energy intensive industrial processes, natural gas cleanup, hydrogen production, fossil fuel refining, petrochemical industries, and steel and cement manufacturing. The availability of scalable CCS technology by 2020 to 2030 would be most beneficial to providing low-emission energy services from fossil fuels while alternatives are still being developed and scaled-up to meet current and growing energy demands (IPCC, 2007d).

CO_2 EOR (Enhanced Oil Recovery) with CCS is widely regarded as an "early opportunity" to demonstrate the viability of CCS as a climate change mitigation option.[(3)] CO_2 EOR is often referred to as a "win win" technology both in terms of improving recovery factors from oil fields, with the associated economic benefits, and mitigating climate change[(4)] (Heidug, 2012).

The In Salah (Ain Salah) Project in Algeria, initiated by BP, Sonatrech, and Statoil, is the most technologically complex carbon storage project undertaken to date. CO_2 separated from natural gas is pumped back into the flanks of the gas reservoir from which the CO_2 is produced. Due to the low permeability of the reservoir rocks, three horizontal wells (with open intervals of 1000–1500 m) are used to inject CO_2 into the 20- meter thick reservoir at a depth of about 1800 m. Since 2004, about 0.7 $MtCO_2$ /yr have been injected into the reservoir (BRGM, 2009).

In general, those regions with large fossil fuel resources, particularly oil and gas, have the largest storage potential. Given the abundance of oil and natural gas resources in the Arab region (and its lack of coal resources), applications of CCS would be mostly limited to storage from fuel transformation,

and natural gas-fueled power plants (Bedrous, M. A., 2007). In the North Africa Arab countries the main potential for capture is in Algeria, Libya, and to a lesser degree Tunisia, while in Egypt efforts have just started to explore CCS opportunities.[5] Both In Salah Gas and Gassi-Touil projects in Algeria have CO_2 content as high as10 percent with nearby storage reservoirs (Benson et al., 2012). In Libya most of the potential is from offshore fields which can use CO_2 for EOR, while in Tunisia the largest gas field in the country (Miskar) has nearly 13 percent CO_2 content. In the Middle East 60 percent of the proven gas reserves have more than 100 ppm of H_2S and/or 2 percent CO_2 (IEA, 2008b). Other opportunities for capture in the areas are in fuel transformation, particularly gas-to-liquids, as well as in the growth of gas-fired power plants, and in the developing petrochemical sector.

While no detailed study of storage potential has been made in the area, the global assessment performed points to a highly favorable sedimentary environment for the MENA region (which includes 17 Arab countries, in addition to Iran, Turkey and Israel). The Middle East represents the largest future potential for storage in depleted fields, with the five biggest sites having a combined 180 Gt of capacity. The combined storage capacity ranges for the MENA region are estimated at 200–1200 Gt for oil and gas fields and 50–550 Gt for saline formations (IEA, 2008a).

In November 2007, the Organization of Petroleum Exporting Countries (OPEC) announced pledges for a US$ 750 million fund to develop clean energy technologies, in particular CCS, with the participation of Saudi Arabia, Kuwait, Qatar, and the United Arab Emirates. Several initiatives have been started in the region to develop technological capabilities, including the Masdar project, and the recently created Qatar Carbonates and Carbon Storage Research Centre. Many international workshops have been convened in the region to increase awareness and assess which areas of research are most appropriate in the Middle East context. Efforts to promote technology transfer in the region have been led by the Society of Petroleum Engineers and other professional societies, along with OPEC and national organizations (Benson et al., 2012).

The Arab region has the highest potential incremental recovery from CO_2-EOR, with estimates of additional volumes of oil ranging from 80–120 Billion barrels (IEA, 2008a). Given the lack of availability of CO_2 and the incremental cost, attempts to develop this tertiary method in the region are still limited. In 2009 Saudi Arabia announced plans for a CO_2 –pilot project in a water flood of the Arab-D reservoir (Ghawar field) that could be started soon with the injection of 0.8 $MtCO_2$/yr. In the United Arab Emirates, a pilot project (the first in the Middle East) was started by Abu Dhabi Company for Onshore Oil Operations (ADCO) at the end of 2009 for the injection of CO_2 in the Northeast Bab's Rumaitha carbonate reservoir, while a study was launched in 2010 to use CO_2 for EOR in the Lower Zakum oil field in Abu Dhabi (Benson et al., 2012). Also, the Abu Dhabi Future Energy Company (MASDAR) confirmed plans for a major initiative to reduce emissions from UAE by half using CCS. This CCS project has already launched a pilot plant project in which CO_2 is captured from a source and is being injected in one of the oil reservoirs. The project involves close collaboration between the Masdar Institute, Abu Dhabi National Oil Company and its subsidiaries, the Petroleum Institute, and other academic and industrial collaborators from around the world. The first phase of the project would involve the capture of up to 5 Mt CO_2 /yr from three sources (a gas-fired power plant, a steel mill in Mussafah, and an aluminum smelter at Taweelah). The plan also includes the development of a specific pipeline network and the injection in Abu Dhabi National Oil Company's oilfields.

The Arab region has ample and widely distributed storage capacity, which would allow matching sources and sinks relatively easily. What remains to be determined is the potential for the region to host the emissions from nearby European sources.

V. ARAB MITIGATION EFFORTS AND THE GLOBAL CARBON MARKET

The global market includes a range of instruments used to monetize the CO_2 offset value of climate mitigation projects. According to the UNFCCC, the primary carbon markets associated with actual emission reductions include the Clean Development Mechanism (CDM), joint implementation (JI), and voluntary transactions.

The CDM enables Annex I countries to support the development of projects to reduce GHG emissions within developing countries. As of June 2013, a total of 6936 projects were registered, and 71 percent of these were for energy industries (renewable/non-renewable) projects (cdm.unfccc.int).

CDM projects are considered an additional revenue source based on carbon credit sales. The Arab region is an attractive CDM destination as it is rich in renewable energy resources and has a robust oil and gas industry. Surprisingly, Arab countries host very few and declining number of CDM projects with only 47 projects registered till June 2012 (Ernst & Young, 2013). The region accounts for only 0.68 percent of global CDM projects and only around two percent of emission reduction credits. The two main challenges facing many of these projects are: weak capacity in most countries for identifying, developing and implementing carbon finance projects, and securing underlying finance. The registered CDM projects in the Arab countries are primarily located in UAE, Egypt, Jordan, Morocco, Qatar, Syria and Tunisia (see Table-7). Other countries in the region, like Saudi Arabia, Bahrain and Oman, are also exploring opportunities for implementing projects that could be registered under the Kyoto Protocol (Salman Zafar, 2013).

Potential CDM activities could thus be initiated in areas such as energy efficiency, renewable energy applications, industrial efficiency, waste management, industrial processes, cement industry, landfills, the agricultural sector and land use change. Energy-efficiency projects in Egypt and the GCC countries, for instance, could save millions of dollars and reduce tons of CO_2 emissions while qualifying as CDM projects. In addition, renewable energy, particularly solar and wind, holds a great potential for the region, similar to biomass in Asia (Salman Zafar, 2013). In the long term, the region could potentially shift from exporting fossil fuel to exporting clean energy to the rest of the neighboring countries.

Egypt, Saudi Arabia and other OPEC countries have successfully negotiated for the inclusion of CCS as a Clean Development Mechanism, allowing developed countries to offset their emissions.

Nationally Appropriate Mitigation Actions (NAMAs) was considered further. NAMAs could include unilateral pledges made by non-Annex I countries that would receive international climate finance support from various sources such as those

SMART GRID AND ELECTRICAL VEHICLES IN THE GCC COUNTRIES

Wajdi Ahmad and Lana El Chaar

Smart grid has recently caught the interest of governments and utilities alike, stemming from several challenges facing global economies. Power generation sector stands as the highest contributor to greenhouse gas (GHG) emissions, followed by the transportation sector. One way to reduce GHG emissions from power generation is through the introduction of distributed renewable energy resources into the energy mix such as wind and solar. Employing the advances in information and communication technologies will smarten the grid and can potentially reduce outages that may occur. At the same time, many communities are embarking on the introduction of Electric Vehicles (EVs) into their transportation systems in order to improve air quality by reducing tank-to-wheel emissions. Compared to internal combustion engine vehicles, EVs can reduce GHG by up to 34% if the power comes from coal-fired power plants and by 60% if the plant runs on natural gas, according to a study from the Electric Power Research Institute (EPRI) and the Natural Resources Defense Council (NRDC). Such choices seem attractive to the Gulf Cooperation Council (GCC) countries, which stand among the highest in CO_2 emissions per capita on a global scale. The GCC countries' population and industrialization growth, in addition to harsh hot and humid weather leading to liberal usage of decentralized air conditioning systems, have caused a sharp increase in electricity demand); hence upsurge of fossil fueled based power generation which in turn has led to high carbon emissions. Furthermore, the rise in population naturally has a great impact on the transportation sector by incrementing the number of cars on the roads emitting higher GHG. Emissions from the transportation sector in the Middle East countries, including GCC, are estimated to double by 2030.

To generate a clearer understanding on how conventional vehicles produce carbon emissions, consider the following example. As the amount of CO_2 produced from burning one liter of fuel is 2.3kg/L, and if the car travels an average of 20,000km/year, the average quantity of fuel used per year is approximately 1428L. Hence, the total CO_2 emissions produced is estimated at 3284kg per car. If 10,000 conventional cars are switched to EVs, an amount of about 33,000 tonnes/annum of CO_2 can be eliminated. It should be emphasized that such emissions are commonly referred to as tail pipe, or "Tank-to-Wheel" emissions, i.e emissions caused by internal combustion in engines. EVs do not have tail pipe emissions, as they

are propelled by electric motors powered by batteries. However, EVs have a "long tail pipe" that extends all the way to the power plant that generates the electricity required to charge the batteries. The process of generating this electricity is associated with CO_2 emission, commonly referred to as "Well-to-Tank" emissions. In order to minimize such emissions, the use of green and clean energy sources for power generation, needed for battery charging, is necessary.

It should be noted that using renewable energy to charge the EV would eliminate the total, i.e. well-to-wheel emissions. This is in fact a great prospect for the GCC region due to the abundant solar power available that until now has been largely untapped.

The GCC region has a golden opportunity to improve its green image through mass deployment of electric vehicle projects. Moreover, due to their zero noise emissions and engine free characteristics, where no oil change / dumping are required, a cleaner and quieter environment is achieved. Furthermore, with the noted recurrent summer high peak demand in the Gulf region, EVss can be leveraged as a source of energy ultimately helping in matching supply and demand during peak load hour, via so-called vehicle-to-grid (V2G) power supply.

The GCC region has a great potential to achieve sustainability through adoption of smart grid technologies and integration of EV into the transportation system. Utilizing solar energy for EV charging would reduce carbon emission remarkably and help promote low-carbon economy. Mass deployment of EV requires a clear vision, a policy of incentives, public awareness, grid reinforcement, charging infrastructure, and smart solution to manage the charging activity.

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TABLE 7 **EXAMPLE OF REGISTERED SINGLE CDM PROJECTS AND EMISSIONS REDUCTIONS**

Registered CDM Projects (single projects)	Country	$ktCO_2e$/yr 2008-2012
Essaouira wind power project	Morocco	156
Tetouan Wind Farm Project for Lafarge Cement Plant	Morocco	29
"Photovoltaic kits to light up rural households in Morocco"	Morocco	39
Djebel Chekir Landfill Gas Recovery and Raring Project - Tunisia	Tunisia	370
Catalytic N20 destruction project in the tail gas of the Nitric Acid Plant of Abu Qir Fertilizer Co.	Egypt	1066
Onyx Alexandria Landfill Gas Capture and Flaring Project	Egypt	371
Landfill Gas Recovery and Flaring for 9 bundled landfills in Tunisia	Tunisia	318
Zafarana - JICA 120MW Wind Power Plant Project	Egypt	249
Egyptian Brick Factory GHG Reduction Project	Egypt	430
OULJA Landfill gas recovery and flaring	Morocco	32
Waste Gas-based Cogeneration Project at Alexandria Carbon Black Co., Egypt	Egypt	110
Fuel Switching Project of the Aqaba Thermal Power Station (ATPS)	Jordan	397
Dir Baalbeh Landfill Gas Capture Project in Homs	Syria	68
Surac Bagasse Plant Project	Morocco	32
Tal Dman Landfill Gas Capture Project in Aleppo	Syria	65
Reduction of Methane Emissions from Ruseifeh Landfill	Jordan	37
Zafarana KfW IV 80 MW Wind Farm Project, Egypt	Egypt	172
Zafarana 8 –Danida 120MW Wind Power Plant Project, Egypt	Egypt	210
Emissions reduction through partial substitution of fossil fuels with renewable plantation biomass and biomass residues in CEMEX Assiut Cement Plant	Egypt	417
Catalytic N20 abatement project in the tail gas of the nitric acid production plant in G.F.C,Syria	Syria	188
Fuel Switching from Mazout to Natural Gas in Misr Fine Spinning & Weaving and Misr Beida Dyers at Kafr El Dawar	Egypt	45
Tanger wind power project.	Morocco	334

Source: UNFCCC (2013). <cdm.unfccc.int>.

listed above. As such, NAMAs could provide a potential incentive to Arab countries to develop CO_2 EOR with CCS, using co-finance from donors (Heidug, 2012).

VI. CONCLUSION AND RECOMMENDATIONS

The key for Arab countries to mitigation options of climate change is to lay a sound foundation for further evolution to low carbon energy systems.

Because the climate security objective is strongly normative, future energy supply pathways suggest that all the energy sustainability targets can be reached, if appropriate policies are introduced and energy investments are scaled up properly.

Pathways to achieve high CO_2 mitigation levels comprise the following:

- Widespread diffusion of zero- and low-carbon energy supply technologies, with substantial reductions in energy intensity.

- Comprehensive mitigation efforts covering all major emitters.
- Technology and Financial transfers from industrialized countries to support decarbonization.

Most policies that aim at a more sustainable energy supply rest upon four main pillars: more efficient use of energy, especially at the point of end use; increased utilization of renewable energy as a substitute for non-renewable energy resources; accelerated development and deployment of new energy technologies – particularly next-generation fossil fuel technologies that produce near-zero harmful emissions and open up opportunities for CO_2 sequestration, in addition to the new generations of nuclear power; and bio sequestration of carbon in terrestrial ecosystems, including soils and biota.

As a means for potentially decoupling energy demand from economic growth, energy efficiency represents a central lever for policymakers to target. The degree to which efficiency improvements can limit energy demand growth is – by design – one of the main distinguishing characteristics of the pathways. It is possible to improve energy intensity radically through a combination of behavioral changes and the rapid introduction of stringent efficiency regulations, technology standards, and environmental externality pricing, which mitigates rebound effects.

Renewable energy (RE) technologies will play a very important role in reducing GHG emissions, but they alone would not suffice to keep climate change manageable. RE may provide a number of opportunities and cannot only address climate change mitigation but may also address sustainable and equitable economic development, energy access, secure energy supply and reduce local environmental and health impacts.

In addition, the emphasis in Arab countries should be on replacing or upgrading obsolete infrastructure, e.g., via upgrading sites of old fossil fuel power plants with technologies offering additional capabilities and pursuing CCS retrofits. There are four key technology-related requirements essential for transforming the fossil energy landscape: (i) continued enhancement of energy conversion efficiencies, (ii) carbon capture and storage-CCS,(iii) co-utilization of fossil fuel and biomass in the same facilities, and (iv) coproduction of multiple energy carriers at the same facilities.

High priority should be given to encouraging early CCS action, because if fossil fuels are to be widely used in a future carbon constrained world (via coproduction and co-processing with biomass or via any other means), this will only be viable only if the option is available to safely store CO_2 in geological media. The international political framework for early CCS action has already been established and the Arab region should be a contributor.

The availability of advanced generations of nuclear reactor types could be important for filling the gap between reducing dependence on fossil fuels and the deployment of renewable energy. They could also be an important contributor in the future energy mix for stabilizing CO_2 levels (Hipple et al., 2012) as energy demand continues to grow in the Arab region.

The private sector will lead in developing and deploying most of the effective approaches, but will need a stable governance framework, facilitation of physical infrastructure, capital investments, and the social cohesion necessary for economic development and poverty reduction, while protecting public health and the environment. Success depends on the implementation of robust, global public-private partnerships that can achieve unprecedented cooperation and integration inside governments, businesses, and between governments and businesses. To have an effect on the changing and growing energy sector, this must happen rapidly.

Finally, new public policies are needed to facilitate in the near term industrial collaborations between companies that would produce simultaneously fuels and electricity. It would be desirable to identify policy instruments that specify performance rather than technology and maximize use of market forces in meeting performance goals.

Reaching almost zero or even negative GHG emissions in the Arab region remains an extremely ambitious task. Although a successful transformation, if found to be technically possible, will require the Arab countries to embark on rapid introduction of polices and measures toward concerted and coordinated efforts to integrate climate change into local and national policy priorities.

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NOTES

1. Photovoltaic PV-Magazine, 2012 (Source: REN21, 2010).

2. The study is currently being implemented by Masdar in association with Schneider Electric.

3. The Intergovernmental Panel on Climate Change (IPCC) (2005) report Carbon Dioxide Capture and Storage defines early opportunities as projects that [are likely to] "involve CO2 captured from a high-purity, low cost source, the transport of CO2 over distances of less than 50 km, coupled with CO2 storage in a value added application such as EOR." For information on CCS application at high-purity sources, refer to Zakkour and Cook (2010) (IEA-OPEC, 2012).

4. Each incremental barrel of oil produced in a miscible CO2 flood typically requires the net injection of between 0.25 and 0.40 tCO2. Net injection takes account of the CO2 that is reproduced with the oil and recycled (IEA-OPEC, 2012).

5. In early 2012, the World Bank, under the WBCCS Capacity Building Trust Fund (WBCCSTF) (established in 2009), engaged a consortium of consultants lead by ERM to support in assessing the potential application of CCS technologies and strengthen the institutional capacity for planning, preparing and implementing CCS activities in Egypt. The study comprised three key tasks as follows: (1) Technical and economic assessment of CCS potential in Egypt; (2) Analysis of barriers and steps to overcome them; and (3) Capacity building (EEAA, Egypt, 2013).

The Need for Climate Resilient Energy Sector

Ibrahim Abdel Gelil

The Arab energy sector is playing and will continue to play a vital role in socioeconomic development in most Arab countries, especially; those endowed with vast hydrocarbon resources. These hydrocarbon resources have been, for decades, fueling, as well, the global economy. In addition, some Arab countries are blessed with huge potential of renewable energy resources such as solar and wind that have not been fully utilized yet. Though, there are nearly 35 million Arabs with no access to modern energy services. Renewable energy resources could play a major role in improving energy access and eradicating poverty particularly in rural and remote areas.

As a major contributor to GHGs emissions, discussions on climate change and energy usually focus on mitigation efforts; however, energy infrastructure must be also resilient to climate change. Climate change will have direct impacts on both the supply and demand of energy, which require specific responses. Energy infrastructure must also be resilient to climate change and natural disasters. Extreme weather events can result in devastating economic and social impacts on infrastructure. This is especially the case for energy because centralized energy systems tend to serve large populated areas and might be vulnerable to climatic changes.

On the demand side, the Arab region is expected to be warmer and drier, which will increase the use for domestic air-conditioners and desalination plants. In turn, this will have unforeseen effects on energy consumption, for example through rises in summer peaks for cooling. Thus, the impacts of extreme weather events will place further pressure on the electricity distribution networks. A report by the World Bank (World Bank, 2012) predicts that the region faces the worst water scarcity in the world—up to 100 million people could be under water stress by 2050. The Arab countries are expected to see increased temperatures of at least 2° Celsius in 15-20 years; and an increase of +4° C by 2100 is also likely. The region is facing increased risk of floods, droughts, and landslides. Moreover, increases in temperature will exacerbate these climate-related hazards.

Thus, in a changing climate, it is highly recommended to:

Systematically assess and monitor energy systems to ensure that they are robust enough to adapt to anticipated climate-related impacts.

- *Mainstream climate impact assessment into EIA and SEA for new energy systems expansion plans.*
- *Address energy poverty as an integral part of adaptation strategies.*
- *Promote shifting toward decentralized, renewable energy supply system in remote and rural areas.*
- *Implement energy demand management as an adaptation measure.*
- *Develop a new holistic approach to deal with the energy-water-climate nexus in the Arab region*
- *Building awareness and institutional capacity at the regional, national and local levels to minimize climate and other risks.*

I. INTRODUCTION

The Arab energy sector is playing and will continue to play a vital role in socioeconomic development in most Arab countries, especially those endowed with vast hydrocarbon resources. These hydrocarbon resources have been, for decades, fueling, as well, the global economy. In addition, some Arab countries are blessed with huge potential of renewable energy resources such as solar and wind that have not been fully utilized yet. Though, there are nearly 35 million Arabs with no access to modern energy services. Renewable energy resources could play a major role in improving energy access and eradicating poverty particularly in rural and remote areas.

The 2012 International Energy Agency's (IEA) world energy outlook projected Saudi Arabia to remain the largest oil liquids producer in the Organization of Petroleum Exporting Countries (OPEC), with total production reaching 15.1 million barrels per day in 2035. In addition to Iran, Qatar, Saudi Arabia, and the United Arab Emirates produced together 80 percent of the world natural gas supply in 2007, with Qatar projected to lead natural gas producers and exporters in 2035 (IEA, 2012).

Thus, for the coming few decades, resilience of the Arab energy facilities to potential risks of climate change and other natural disasters is vital for both achieving sustainable development for the Arab population as well as ensuring global energy security of supply.

As a major contributor to greenhouse gases (GHGs) emissions, discussions on climate change and energy usually focus on mitigation efforts; however, energy infrastructure must be also resilient to climate change. This chapter will discuss vulnerability and adaptation of the energy infrastructure in the Arab region. It so does by 1) highlighting the vital importance of the resiliency of the Arab energy system to avoid any potential catastrophic disruption of energy supply to the global energy market, 2) assessing vulnerability of the Arab energy system to climate change, 3) discussing the role of energy in community adaptation, particularly for the poor, and 4) identifying available adaptation options to improve resilience of energy infrastructure.

II. IMPORTANCE OF THE ARAB ENERGY SECTOR

As discussed in chapters (1) and (2), Arab countries held around 43 percent of the world's

proven oil reserves and nearly 29 percent of the world's gas reserves. Qatar has the largest Arab's gas reserves amounting to 46.6 percent of total Arab and 13.6 percent of world reserves respectively. Further, Qatar ranked the fourth largest exporter of natural gas and the world's largest exporter of liquefied natural gas (LNG) (OAPEC, 2010).

The Arab world's combined production in 2011 amounted to over 26 million barrels per day (b/d), or nearly a third of world oil supply, making the Arab world the world's largest producing region. Four of the world's ten largest producers of oil (Saudi Arabia, UAE, Kuwait, and Iraq) are Arab producers. Given that key position in the global oil market, securing Arab oil supplies has been vital to major global economies. In addition to their high dependency on Arab oil, an underlying security concern for those importers is that the regular flow of oil may be subject to physical disruptions leading to dramatic economic impacts such as those occurred during the first energy shock of the early 1970s.

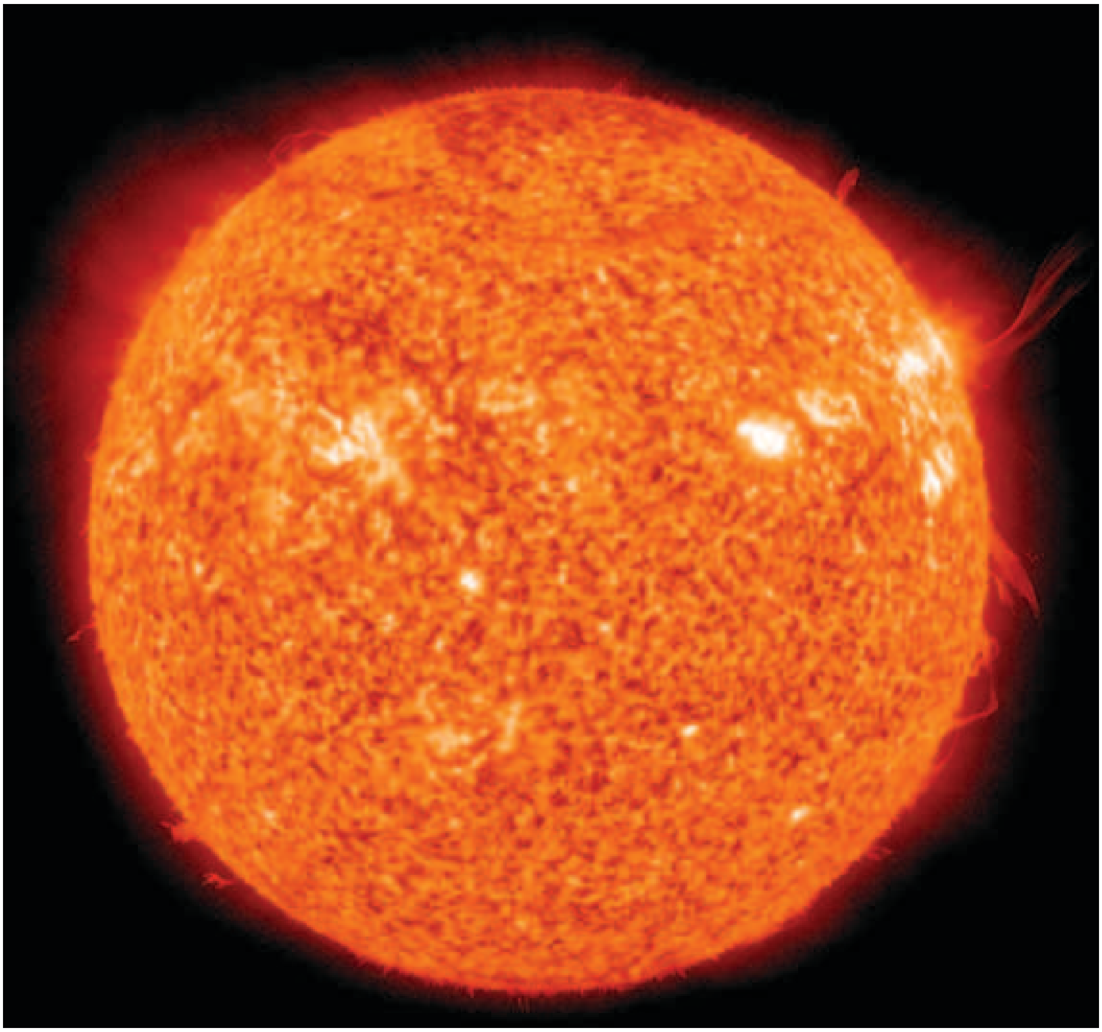
In addition, Oil and gas revenues, estimated at about US$ 719 billion in 2010 have been the major source of income in most of the Arab countries, especially in the GCC region (table 2, Chapter 1). According to the Arab Monetary Fund, the oil and gas sector makes up about 35.4 percent of the total Arab GDP (AMF, 2011). Additionally, the petroleum industry plays an important role in the social and economic development of many Arab countries, both exporters and others that benefit indirectly, either through worker remittances, trade, or bilateral or joint Arab projects (OAPEC, 2009). The Arab Oil and Gas sector offers a tremendous number of job opportunities in different fields, through its exploration, production, transportation, refinery and distribution activities. Over the past three decades the GCC countries, the major oil exporters, have witnessed an unprecedented economic and social transformation. Oil proceeds have been used to modernize infrastructure, create employment, and improve human development indicators. Thus, the GCC countries have become an important center for regional economic growth.

In addition, the Arab countries rely heavily on oil and gas to meet domestic energy demand, they both account for nearly 98.2 percent of the total Arab energy consumption in 2009. It is worth noting that the energy sector has been playing a major role in addressing the water scarcity issue in the region. Fossil-based combined heat and power thermal plants are commonly used for water desalination in the Arab region, which hosts nearly 50 percent of the world's desalination capacity (AFED, 2010). Saudi Arabia is already producing 18 percent of the world's desalinated water, and this is projected to double to meet growing demand (KACST).

Potential impacts of climate change or any other natural disasters on the energy system would have devastating impacts on both the Arab and the global economies.

III. CLIMATE CHANGE IMPACTS ON THE ENERGY SYSTEM

Discussions on climate change and energy usually centre on mitigation efforts because fossil fuels represent nearly 81 percent of the global primary energy supply and the single major contributor to the global GHG emissions (IEA, 2010). Climate change will have direct impacts on both the supply and demand of energy, which require specific responses. Energy infrastructure



must also be resilient to climate change and natural disasters. Extreme weather events can result in devastating economic and social impacts on infrastructure. This is especially the case for energy because centralized energy systems tend to serve large populated areas and might be vulnerable to climatic changes.

On the demand side, the Arab region is expected to be warmer and drier, which will increase the use for domestic air-conditioners and desalination plants. In turn, this will have unforeseen effects on energy consumption, for example through rises in summer peaks for cooling. Thus, the impacts of extreme weather events will place further pressure on the electricity distribution networks. A report by the World Bank (World Bank, 2012) predicts that the region faces the worst water scarcity in the world—up to 100 million people could be under water stress by 2050. The Arab countries are expected to see increased temperatures of at least 2°C in 15-20 years; and an increase of +4°C by 2100 is also likely. The region is facing increased risk of floods, droughts, and landslides. Moreover, increases in temperature will exacerbate these climate-related hazards. Details of the climate impacts on the energy system will follow below.

A. Impacts on Energy Resources

i. Oil and Gas Resources

Oil and gas resources are not likely to be impacted by climate change. On the other hand, climate change may force the shutting down of oil and gas producing facilities in some coastal low-lying areas vulnerable to see level rise. Further, offshore facilities might also be vulnerable to extreme weather events such as storms, which would lead to their shutting down.

RESPONSE OF ARAB STATES TO CLIMATE CHANGE

Although the Arab region is affected by periodic earthquakes and droughts, Disaster Risk Management (DRM) has not been a priority for the region's governments until recently (UNISDR 2011). At the regional level, the League of Arab States (LAS), the Council of Arab Ministers Responsible for the Environment (CAMRE), the United Nations International Strategy for Disaster Reduction (UNISDR), the Regional Office for the Arab States, and the Arab Economic and Social Council have approved a number of recent DRM and CCA initiatives, including the 2007 Arab Ministerial Declaration on Climate Change and the Arab Strategy for Disaster Risk Reduction (ASDRR).

ASDRR is a 10-year strategy with the aim of reducing disaster losses through identification of strategic priorities and enhancement of institutional and coordination mechanisms and monitoring arrangements at the regional, national, and local levels. The key priorities of ASDRR are to integrate DRM into national development planning and policies; strengthen commitment for comprehensive disaster risk reduction (DRR) across sectors; develop capacities to identify, assess, and monitor disaster risks; build resilience through knowledge, advocacy, research, and training; improve accountability for DRM at the sub-national and local levels; and integrate DRR into emergency response, preparedness, and recovery. To achieve these goals, ASDRR aims at entrusting a ministry with strong political power with the DRM mandate. Local initiatives will be prioritized on the basis of their effectiveness in reducing risks to organizations such as grassroots women's organizations.

Meanwhile, individual Arab economies are making progress on the Hyogo Framework for Action (HFA). Egypt, Jordan, Morocco, Syria and Yemen are making advances in systematically reporting disaster losses for 2010. Jordan, Syria, and the Republic of Yemen have recently published national disaster inventories, and other countries are expected to soon follow. Nine Arab economies have completed their HFA progress reports for 2011: Algeria, Bahrain, the Comoros, Egypt, Lebanon, Morocco, the West Bank and Gaza, Syria and Yemen.

LAS, in coordination with a number of Arab regional and international partners, has prepared a draft Arab action plan to address climate change issues in the Arab region. The cross-cutting program on DRM aims to follow up HFA through the integration of DRR in all programs related to adaptation, building and strengthening cooperation with UNISDR at the national and regional levels, and identifying mechanisms and capacities to reduce disaster risk in the planning and implementation of adaptation programs.

World Bank, 2012

ii. Renewable Energy Resources

Renewable energy plays a key role in future low carbon-emission development aimed at limiting global warming. However, its dependence on climate conditions makes it also susceptible to climate change. Although the first part of this "paradox" has been thoroughly studied (IPCC, 2007), the formal knowledge base is still at an early stage of development (Wilbanks, 2007). The Arab region is blessed with huge potential of renewable energy resources especially wind and solar. With average daily sunlight exceeding 8.8 hours, low cloud covers, limited rainfall and abundant free land space, the region has optimal potential for the construction of large-scale concentrated solar power plants (CSP). According to the International Energy Agency, CSP plants in the region could cater to 100 times the combined electricity consumption of MENA and Europe (Khaleej Times, 2011).

iii. Hydropower Generation

Climatic changes are expected to impact river runoffs and will change hydroelectric output. This is particularly significant for countries such as Egypt and Iraq with large hydroelectric capacity. The total installed hydroelectric capacity in the region is 11,683 MW. The amount of electricity that can be generated from hydropower plants depends on the variation in water inflows to the plant's reservoirs. Changing climate conditions can affect the operation of these existing hydropower systems. This is especially valid for those countries, which receives most of their renewable water resources across their borders. For instance, countries that share the Nile have long argued over the use of its waters, repeatedly raising fears that the disputes could eventually boil over into war. This pending water crisis is compounded by water scarcity in Arab region, raising regional concerns about shared water resources and its implications on the energy system. The Energy-water-climate nexus should be paid special attention in the region; this issue will be further discussed below.

iv. Solar Energy

Most of the Arab countries are blessed with huge potential of solar energy resources. A large part of the Arab region falls within the so-called 'sun belt', which benefits from the most energy-intensive sunlight on the globe (in terms of both heat and light). Solar energy resources in the region vary between 1460-3000 KWh/m^2/year. Solar energy generation can be affected by extreme weather events and increased air temperature that can alter the efficiency of photovoltaic (PV) cells and reduce PV electrical generation (Bull, 2007). For example, a 2 percent decrease in global solar radiation will decrease solar cell output by 6 percent overall. The efficiency of CSP generation can be impacted by temperature change. In addition, CSP requires increased water use, and would be vulnerable to aggravated water scarcity due to climate change. Most parts of the Arab region have been identified as well placed to provide huge amount of solar electricity using CSP technology enough to meet the region's electricity demand as well as Europe's. In addition, there are plans to generate large amounts of solar electricity in Arab countries and export portions of it to Europe. The "DESERTEC Industrial Initiative" aims to generate up to 550 GW of electricity over the next 40 years, from installations that will initially be located in Algeria, Morocco, Tunisia, Libya and Egypt and later in the deserts of the Middle East from Turkey to Saudi Arabia and Jordan (DESERTEC Foundation, 2010). Climate-induced water scarcity would severely impact these plans.

Another factor to consider while planning for PV solar systems is the impacts of severe sand storms on the system efficiency. For example, the solar power production at the first and largest solar power plant of the UAE and the region was hit badly due to a weeklong extreme sandstorm that occurred in the summer of 2009. It had reduced the solar energy production by almost 40 percent (Greentecmedia, 2010). More frequent sandstorms would demand for more water for cleaning the PV panels, and thus contribute to water and energy shortages. An issue that needs to be further investigated in planning for solar energy development in the Arab region.

v. Wind Energy

Grid connected wind power at commercial scale of 550 MW exists in Egypt and 280 MW in Morocco (NREA, 2011), while standalone wind units are in use for small applications in Morocco, Jordan, and Syria. Natural seasonal variability of wind speed has a significant impact on the energy produced from wind turbines. Alterations in the wind speed frequency distribution can affect the optimal match between power availability from natural resources and the output of wind turbines. Numerous studies discuss the impacts of climate change on wind power. In this context, climate impact studies on wind power systems should focus on the total exploitable wind resource, indicating the future availability of power generation and identifying/prioritizing areas for site-specific viability assessments. Shifts in the geographical distribution and the variability of wind fields are the main mechanisms by which global climate change impacts wind energy endowments (World Bank, 2011).

B. Impacts on Energy Supply

Energy transformation facilities can be affected by climate change in a variety of ways, as discussed in the following sections. It is worth noting that a major share of the current energy system (and even the energy facilities under construction or planned to be built in the next years) will likely be impacted by potential climate changes given the long life span of energy infrastructure.

i. Oil and Gas Production

Oil and gas production from offshore facilities, as well those located in low-lying coastal areas, can be disrupted by extreme events, such as more intense storms, floods or hurricanes, that can lead to production shutdowns for evacuation to avoid loss of life or environmental damage (API, 2008). Hurricanes in the Gulf of Mexico in 2004 and 2005 resulted in a large number of destroyed and damaged offshore oil and gas structures: more than 125 platforms were destroyed (Oil Rig Disasters). An increase in the frequency, duration, and intensity of such extreme events can therefore have significant impacts on oil and gas production. With more than 120 oilrigs working in the region, potential climate risks need to be cautioned.

ii. Oil Refining

The Arab region hosts about 7.9 million barrel/day of oil refining capacity to meet domestic demand of petroleum products and exports around 3.5 million barrel a day to international market (OAPEC, 2012). Oil refining is also a large water consumer and is thus affected by water shortage. Total water consumption in an average U.S. refinery is estimated at 65 to 90 gallons of water per barrel of crude oil (Energetics, Inc. , 1988). Water demand in oil refineries can also rise as a result of higher temperatures and its use in cooling units. Climate-induced disruptions in Arab refineries would severely impact domestic supply of petroleum products as well as the global energy market.

iii. Thermal Power Plants

Large number of thermal power plants in the Arab region especially in the GCC is located within or near the coastal areas. Additional measures will be needed in vulnerable areas to protect them from sea level rise and the increased threat of flooding. Typically lower levels of precipitation and high temperatures in those areas have a negative influence on the cooling processes of power plants. This effect will be exacerbated due to climate change;

GREEN BUILDINGS IN THE ARAB COUNTRIES: CODES, STANDARDS AND RATING SYSTEMS

Samir R. Traboulsi

Public in the Arab countries is becoming more familiar with the term of Green Building, at different levels. While codes are mandatory, the standards and rating systems remain voluntary tools. There are several parameters that affect the preparation of the legalization process to decide for a code, and the development of standards and rating systems.

On the other hand, the world has been crippled with ongoing financial crisis, coupled with issues of resources depletion. Focus on energy and water sectors, as they are becoming scarce, in addition to environmental degradation, prompted the construction industry to seek avenues of solutions through the construction law, energy efficiency standards, water efficient use and standards, environmental air and indoor quality and other standards related to the environment, and various social and economic factors.

Different types of buildings require different tools to facilitate consistent application of sustainable design principles and to serve as a measure of accomplishment resulting in certifying into categories.

Buildings account to about 35 percent of the total energy consumption in the world. Hence the energy efficiency has led the process for modifying the construction codes in different countries. The price of energy varies between one country and another, which meant that affinity for energy efficiency (mandatory or voluntary) is not the same.

Construction laws or codes are usually old, in most countries dating back to the 1970s, and any attempt to change them usually faces opposition. Clauses of the codes describe generally the followings: footprint of the building, zoning and total built up area and day view glazing.

Recent moves in certain Arab countries attempted to introduce new clauses such as: envelope, mass and glazing, and insulation. Egypt, Tunisia, Jordan, Lebanon, Syria and Bahrain introduced codes which stipulated the construction of multi-layer of outside walls aiming at creating additional barriers against heat gains or heat losses.

Other clauses limiting the ratio of glazing over the façade area to a certain percentage are being considered, also to control heat exchange. Certain buildings were required to provide solar hot water systems, such as in Lebanon and Jordan, as part of the permit application. Secretariats of Ministerial Councils of Electricity and Housing within

even a modest variation in ambient temperature may represent a significant drop in energy supply. The significant amounts of water that are needed to cool thermal power facilities make them vulnerable to fluctuations in water supplies. As discussed earlier, water availability is an issue in the Arab region, which means that some power stations are vulnerable to the aggravated water scarcity in the region. Studies show that in the United States, for example, each KW of electricity generated by a steam cycle process requires around 94.6 liters of water. Adding the potential rise in temperature, more cooling would be required to compensate for losses, mainly caused by evaporation. Heat waves and similar extreme weather conditions may place additional severe limitations on power plant operations. This was exemplified during the heat wave of 2003 in Europe, when availability of cooling water was reduced restricting, when most needed, the energy supply. GCC plans to invest US$ 100 billion for power and desalination system expansions over the next decade (Middle East Economic Engineering Forum), these new plants will have to be carefully designed to comply with climate vulnerable conditions.

iv. Nuclear Power Plants

As discussed in Chapter (4), nuclear power is among the energy sources and technologies available today that could help address the challenge of reducing GHG emissions and mitigate climate change. GHG emissions from nuclear power plants are relatively negligible on life cycle basis compared to other energy supply options.

As such, nuclear power plants are often touted as a solution to climate change; however, the Fukushima accident serves as a warning that far from solving the climate change problem, nuclear power may be highly vulnerable to it. In addition to the different safety aspects of nuclear power plants, which were discussed earlier in this the League of Arab States issued energy efficiency guidelines, and are considering green building codes.

In countries facing shortages in the electricity supply, energy efficiency standards which are published by several organizations become useful tools which encourage voluntary action- mainly as cost-saving measure. They typically address envelope, lighting, appliances and HVAC equipment, in addition to solar collectors for hot water and PV panels. The Energy Efficiency Handbook published by AFED in 2012 is an example of such contributions.

A Kuwaiti version of the ASHRAE 90.1-2010 standard, covering residential low buildings, has been issued. Other countries were indirectly complying with the standards when developing their rating systems. Qatar's QSAS, Jordan's Labeling of Appliances and Lebanon's Thermal Standards are examples of the introduction of energy efficiency standards.

Building rating systems are developed as tools that examine the performance of existing buildings or expected performance of the new building when constructed, and translate that into an overall assessment that allows for comparison.

Several building evaluation tools are either copied and pasted, or developed to focus on different areas of sustainable development components, and are designed for different types and uses of buildings. These mostly use scoring points systems, including energy consumption assessments, water efficiency and water efficient use, life cycle assessment, life cycle costing, energy systems design, performance evaluation, productivity analysis, indoor environmental quality assessments, recycling and other economic and social values, operations and maintenance optimization, whole building design and operations, among others.

The green sustainable building rating system considers several values including the technical basis and assumptions, scoring point methodology to measure building performance, and aspects of a sustainable society.

Lebanon, Jordan, Egypt, Qatar, Saudi Arabia, and U.A.E. green building councils are in different stages to develop such green building rating systems. Success will pave the way to collect the benchmark data enabling the implementation of labeling sustainable buildings in other Arab countries.

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report (see chapter 4), the accident at TEPCO's Fukushima–Daiichi Nuclear Power Plant, which was caused by the earthquake and tsunami that struck Japan in 2011, signaled an additional concern related to the impacts of natural hazards, including extreme weather events, on nuclear power plants. Although the accident in Japan was caused by an earthquake and tsunami, yet the effects of potential climate change could cause very similar problems. Nuclear power plants need access to large volumes of water for cooling that is why nuclear power plants are typically sited near large bodies of water, such as coastal areas.

Coastal areas are generally highly vulnerable to sea level rise. This already poses additional problems for the safety of nuclear plants. Moreover, water scarcity and rising water temperatures can disrupt nuclear power. For instance, during the 2003 heat wave in Europe, reactors at inland sites in France were shut down or had their power output reduced because the water receiving the discharge was already warmer than the environmental regulations allowed (Kopytko, 2011). In another instance in 2012, the cooling water temperatures at a twin-unit nuclear power plant in Illinois exceeded the temperatures originally allowed by four degrees Fahrenheit (~2.22°C). Craig Nesbit a spokesman for Exelon, which owns the plant, stated the following about the incident: "I'm not a climatologist. But clearly the calculations when the plant was first operated in 1986 are not what is sufficient today, not all the time." (Schueneman, 2012).

Climate models predict that droughts will become longer and larger. This is already debated in the US over scarce water resources in regions with nuclear power plants, such as river basins in Georgia, Florida and Alabama.

Another cause for concern is floods. All nuclear power plants are designed to withstand a certain level of flooding based on historical data, but these figures do not take climate change into account. Floods due to sea-level rise, storm surges and heavy rain are projected to increase in frequency and severity.

Within the Arab region's context, the World Bank report concluded that climate change is already happening in many parts of the Middle East and North Africa (World Bank, 2012). Further, the region is projected to be drier and hotter, and vulnerable to rising sea levels. The report cited the 2006 flooding of the Nile River Basin, as well as the record five-year drought in the Jordan River Basin that ended in 2008. Of the 19 record temperatures in 2010, almost a quarter was from the Arab world, including Kuwait where temperatures reached 52.6 °C in 2010 and 53.5 °C in 2011. In 2010, the Arabian Sea experienced its second-strongest cyclone on record, with winds as strong as 230 kilometers per hour that killed 44 people and caused US$ 700 million in damages in Oman. As previously stated, the region is already the world's most water scarce, and with climate change, droughts are expected to turn more extreme, further exacerbating water scarcity.

Thus, most forms of energy generation are vulnerable in some way to the effects of climate change, and nuclear power is among those. The bottom line is that if nuclear power is to be used to mitigate the effects of climate change, it must also be capable of adapting to them. There are serious doubts that it can.

v. Energy Transmission and Distribution

Extreme variations of weather and climate situations can impact the transmission and distribution of power, and the transfer of oil, gas, and other fuels. Distribution systems are vulnerable to extreme weather events such as falling trees for example, due to storms. Falling of power transmission and distribution lines can cause power outages and severe consequences thereof, especially in cases of emergency.

This is also true in the case of oil and gas pipelines, which are extended thousands of kilometers in the Arab region and exposed to storms, storm-related landslides and erosion processes, as well as floods. For example, the Suez-Mediterranean pipeline (Sumed pipeline) is an oil pipeline in Egypt, running from a terminal on the Gulf of Suez to offshore terminal in the Mediterranean Sea. It provides an alternative to the Suez Canal for transporting oil from the Gulf region to the international market. Transports of oil products by road or rail are similarly exposed.

The transfer of energy by sea may face increasing challenges and opportunities. For instance, as the Arctic Sea ice melts at unprecedented rates, new shipping routes will open up. The world's ships are already sailing past western and northern Alaska. In fall 2009, two container ships traveled north through the Bering Strait, escorted by Russian icebreakers. These new routes might have far reaching economic impacts on the Suez Canal, a major contributor to Egypt's foreign revenues (Rogoff, 2011).

C. Impacts on Energy Demand

In addition to climate impacts on energy supply infrastructure, unexpected changes in energy demand may impose stresses on these systems. For example, excessive demand for air conditioning in hot weather may affect the efficiency of energy distribution. Rising temperatures can affect final energy use. The most direct and obvious effect relates to higher temperatures. This can increase demand for cooling (or air conditioning). The performance of motors and engines can also vary with changes in climate parameters.

Climate change can also affect the demands on water and electricity in industries that use refrigeration and cooling, and in agriculture, for irrigation purposes.

i. Cooling in Buildings

In the Arab region, households consume more than a third of all end-use energy. In some parts of the Arab countries, especially in the GCC, excessive use of air conditioning is consuming more than half of final energy consumptions in the residential and commercial sectors. Various empirical studies have found that total energy demand depends on outdoor temperature in a U-shaped fashion: low temperatures correspond to relatively high energy demand (higher energy demand for heating), intermediate temperatures correspond to lower energy demand, and high temperatures correspond

to higher energy demand again (Guan, 2009). More studies need to be conducted to further investigate the impacts of temperature increases on the end use levels, across different economic sectors. Potential climate change and global warming should be factored in when forecasting energy demands in vulnerable regions, including the Arab's.

ii. Energy Poverty

Improved access to energy resources and services plays a crucial role in eradicating poverty, achieving sustainable development, and therefore in improving adaptation capacity of developing countries. Energy and technology choices toward a low carbon energy mix are crucial in addressing climate change in the developing countries as the foundation for their adaptation to climate change. Lack of electricity deprives people of many vital needs, in particular food conservation, education, communication, and health care.

Nearly 35 million people in the Arab countries have no access to modern energy services.
This is strongly associated with poverty in rural areas. The lack of access to reliable and affordable essential energy services is primarily not a result of "underdevelopment", but rather a causal factor of economic poverty, malnutrition, chronic health vulnerability, and insecurity.

Affordable access to energy resources and services impacts positively the quality of life, sustains livelihood, increases the economic opportunities, and consequently reduces demographic pressure on ecosystems, thereby improving adaptation capacity. It is one of the reasons why a more equitable distribution of energy supply in the Arab countries must be seen as an important component of sustainable development and climate change adaptation. Public energy policies are hence urged to focus their efforts on advocating for a more equitable distribution of energy services, allowing communities to equally benefit from them.

In this regard, the long lead-time and high costs needed to extend central energy grids to currently off-grid populations often makes centralized distribution of energy a cost-ineffective option. Decentralized renewable energy systems such as home solar systems and local micro grids, on the other hand, offer a golden opportunity to address the lack of access to energy services in rural and remote areas. Such solutions can thus allow developing adaptive capacity of these communities, while drastically reducing GHG emissions.

Further, renewable energy options create more energy independence, in particular from fossil fuels, and their price volatility. This constitutes a vital issue for many Arab oil importing countries such as Lebanon, Jordan, and Morocco.

The Global Rural Electrification Program (PERG), launched in 1996 by the National Electricity Office (ONE) in Morocco is an exemplary Arab project of scaling up renewable energy use for rural development. The project that came as a public-private partnership (PPP) between ONE and TEMSAOL, a French renewable energy service company, aimed to provide PV solar electricity to over 34,000 rural villages by 2007.

Because of the elevated costs in connecting rural households to central electricity grids, individual photovoltaic Solar Home System (SHS) was the best choice, and communities supplied in that case have become better prepared to meet the challenge of climate change.

IV. ENERGY-WATER-CLIMATE NEXUS

Energy and water systems are dynamically linked. The production, supply and transportation of one resource cannot be achieved without making use of the other (see Box). Further, there is growing scientific consensus that climate change is affecting the supply and quality of both. Thus, more needs to be done to ensure that climate adaptation is integral to future planning, to provide sustainable water and energy futures.

A significant share of energy is used across the Arab world for groundwater abstraction, desalination, treatment, transfer, and distribution. Projected climate change-induced declines in fresh water supplies and increase in demand in the region would increase energy requirements for all these activities. Projected increases in average air and water temperatures and limited availability of adequate cooling water supplies are expected to affect the efficiency, operation, and development of new power plants.

This strong interdependency between energy, water, and climate change makes it imperative that policy formulation be coordinated, particularly with respect to mitigation and adaptation to climate change.

In most cases in the region, energy and water policies are fragmented, spanning across many institutions with little coordination between them; this situation surely requiring an urgent reform. The shift from fossil fuel with considerable water use towards renewable sources would reduce demand for water in the energy sector, which makes it more resilient to climate change.

V. ADAPTATION OPTIONS

Energy systems must be climate-proof, withstanding anticipated climate change and its impacts. This can be achieved by increasing the resilience of the energy system. Options include diversifying energy supply options to ensure security of supply, proper sitting of energy facilities away from vulnerable geographic areas, promoting regional energy integration to share energy resources during emergency situations, and disaster preparedness planning and risk management.

The Region has started to respond to the climate risks. The latter was manifested in the 2007 Arab Ministerial Declaration on climate change and the Arab Strategy for Disaster Risk Reduction (ASDRR) (see Box). In this context, improving energy efficiency and scaling up renewable energy technologies would also be considered to further expand the portfolio of energy options.

Given the slow rate of capital stock turnover in the energy sector and the long lifetime of technology, it is important that energy planners, policy makers, and consumers be well prepared so that necessary adaptation measures are taken.

Climate impact assessment and adaptation should be mainstreamed in the Environmental Impact Assessments (EIA) as well as the Strategic Environmental Assessment (SEA) of the energy sector. Infrastructure projects including energy should take climate proofing into account. This would need developing methodologies for climate-proofing infrastructure.

VI. RECOMMENDATIONS

In a changing climate, it is highly recommended to:

1. Systematically assess and monitor energy systems, to ensure that they are robust enough to adapt to anticipated climate-related impacts.
2. Mainstream climate impact assessment into EIA and SEA for new energy systems expansion plans.
3. Address energy poverty as an integral part of adaptation strategies.
4. Promote shifting toward decentralized, renewable energy supply system in remote and rural areas.
5. Implement energy demand management as an adaptation measure.
6. Develop a new holistic approach to deal with the energy-water-climate nexus in the Arab region

Building awareness and institutional capacity at the regional, national and local levels is essential to minimize climate and other risks.

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WATER, ENERGY, AND FOOD NEXUS IN THE ARAB REGION

Waleed K. Al-Zubari

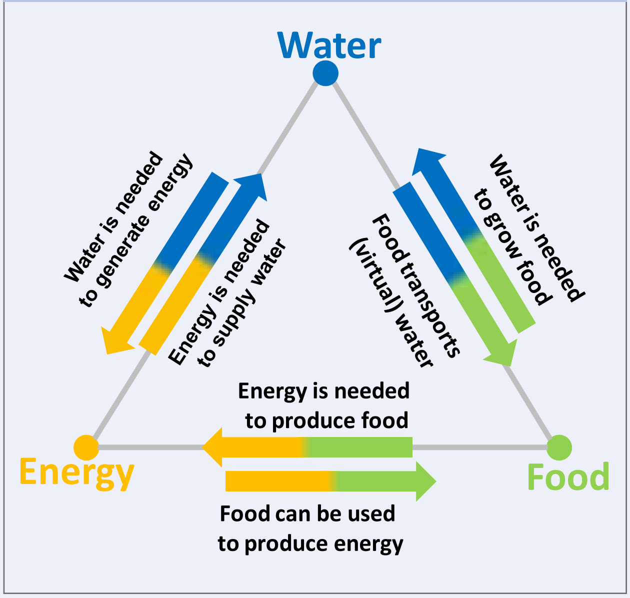
Addressing water scarcity, both natural and human-induced, in the Arab region is considered one of the major and most critical challenges facing the Arab countries. This challenge is expected to grow with time due to many pressing driving forces, including population growth, food demand, unsettled and politicized shared water resources, climate change, and many others, forcing more countries into more expensive water sources, such as desalination, to augment their limited fresh water supplies. The heavy financial, economic, environmental, as well as social costs and burden to be borne cannot be overemphasized.

Furthermore, the water scarcity challenge in the region is being compounded by its multiple nexuses with the various development sectors, such as water and human health, water and environment, water and food, water and energy, and many other interdependencies, which carry within them many cross-cutting issues of human rights, social, economic, legal, technical, political, and security nature. It is therefore important to address much more explicitly the various linkages of the water sector with other sectors like energy, food, health, and economic development as a whole. Moreover, professionals in all sectors should think and act beyond the boundaries of their own sector, to achieve effective and integrated resources planning and management.

Based on the current trends in population growth and their associated water, food, and energy demands in the Arab region, water security, energy security and food security are inextricably linked, perhaps more than any other region in the world, and actions in one area have strong impacts on the others. Hence, a nexus approach that integrates management and governance across these three sectors can improve security issues. This can also support the transition to a green economy, which aims, among other goals, at resources use efficiency and policy coherence. A proper understanding of the nexus will allow decision-makers to develop appropriate policies, strategies, and investments to explore and exploit synergies, and to identify trade-offs among the development goals related to water, energy and food security. Moreover, a nexus perspective increases the understanding of the interdependencies across these three sectors and influences policies in other areas of concern, such as climate change and environment. Among the most important inter-dependencies in the Arab countries is the water energy nexus, where all the socio-economic development sectors rely on the sustainable provision of these two resources. In addition to their central and strategic importance to the region, these two resources are strongly interrelated and becoming increasingly inextricably linked as the water scarcity in the region increases. In the water value chain, energy is required in all segments; energy is used in almost every stage of the water cycle: extracting groundwater, feeding desalination plants with its raw sea/brackish waters and producing freshwater, pumping, conveying, and distributing freshwater, collecting wastewater, along with treatment and reuse. In other words, without energy, mainly in the form of electricity, water availability, delivery systems, and human welfare will not function. It is estimated that in most of the Arab countries, the water cycle demands at least 15% of national electricity consumption[1] and it is continuously on the rise (Khatib, 2010). On the other hand, though less in intensity, water is also needed for energy production through hydroelectric schemes (hydropower) and through desalination (Co-generation Power Desalting Plants (CPDP)), for electricity generation and for cooling purposes, and for energy exploration, production, refining and enhanced oil recovery processes, in addition to many other applications.

The scarcity of fresh water in the Arab region promoted and intensified the technology of desalination and combined co-production of electricity and water, especially in the GCC countries. Desalination, particularly CPDPs, is an energy-intensive process. Given the large market

THE WATER-ENERGY-FOOD NEXUS (UNU, 2013)



size and the strategic role of desalination in the Arab region, the installation of new capacities will increase the overall energy consumption. As energy production is mainly based on fossil-fuels, a finite source, it is clear that development of renewable energies to power desalination plants is needed. Meanwhile, to address concerns about carbon emissions, Arab governments should link any future expansion in desalination capacity to investments in abundantly available renewable sources of energy. There is an urgent need for cooperation among the Arab countries to enhance coordination and investment in R&D in desalination and treatment technologies. Acquiring and localizing these technologies will help in reducing their cost, increasing their reliability as a water source, increasing their added value to the countries' economies, as well as reducing their environmental impacts. Special attention should be paid to renewable and environmentally safe energy sources, of which the most important is solar, which can have enormous potential as most of the Arab region is located within the "sun belt" of the world[2]

Despite the strong relation, the water-energy nexus and their interrelation has not been fully addressed or considered in the planning and management of both resources in many Arab countries. However, with increasing water scarcity, many Arab countries have started to realize the growing importance of the nexus, which has now become a focal point of interest[3], both in terms of problem definition and in searching for trans-disciplinary and trans-sectoral solutions.

There is an obvious scarcity of scientific research and studies in the field of water-energy nexus[4] and the interdependencies between these two resources and their mutual values, which is leading to a knowledge gap on the nexus in the region. Moreover, with climate change deeply embedded[5] within the water energy nexus issue, scientific research on the nexus needs to be associated with the future impacts of climate change. Research institutes and universities need to be encouraged to direct their programs towards understanding the nexus and their interdependencies and inter-linkages. Without the availability of such researches and studies, the nexus challenges cannot be faced and solved effectively, nor can these challenges be converted into opportunities in issues such as increasing water and energy use efficiency, informing technology choices, increasing water and energy policy coherence, and examining the water-energy security nexus.

The water-food linkage represents another important and vital nexus in the Arab countries. Under the current

unstable food security situation (fluctuating energy prices, poor harvests, rising demand from a growing population, the use of bio-fuels and export bans have all increased prices), the ability for the Arab countries to feed their growing population is severely challenged by competition over increasingly limited water resources. Agriculture is currently challenged by competition among sectors on available water resources. While the majority of water in the Arab region is used inefficiently in the agricultural sector (about 85% with less than 40% efficiency), which is not only crucial for food production but also employs a large labor force of rural population, the contribution of agriculture to GDP is significantly low. Hence, and using the argument of higher productivity per drop, voices are increasingly advocating for shift of water resources from agriculture to meet pressing demands of the industrial and municipal sectors. The negative repercussions of that on the agricultural sector and rural population are most evident. However, improving irrigation efficiency can release water for other uses. All of those issues have been discussed in detail in AFED report on water in the Arab egion, Sustainable Management of a Scarce Resource (AFED, 2010).

The Arab countries as isolated entities are far from having enough water to grow sufficient basic food. Thus, the obsession with the idea of self-sufficiency at any cost, which had been predominant in the 1970s and 1980s, has been abandoned. It is no longer rational or sustainable. In fact, the region has been importing more and more food to meet its need. Recent studies have shown that more than half of the food calories consumed in the region is imported and would increase to 64% over the next two decades (World Bank, 2009). An older study in the mid-1990s showed that the food imports of the region were equivalent to 83 billion m3 of virtual water, or about 12% of the region's annual renewable water resources. In fact, the same study has shown that for selected countries, this percentage was much higher: Algeria (87%), Egypt (31%), Jordan (398%), Libya (530%) and Saudi Arabia (580%) (FAO, 2001). With the rise of the population and improvement of lifestyles, one can expect these figures to be much higher today.

A better policy to address national food security can be to improve agricultural production, maximise water productivity, and rely on virtual water trade in food imports. By importing water intensive crops, not only can there be local water savings, there are also energy savings through reduction in withdrawal of irrigation water from deep aquifers (Siddiqi and Anadon, 2011), which could be significant for many Arab countries that have energy intensive groundwater withdrawals, such as the GCC countries. Many of those challenges can be eased by augmenting pan-Arab regional cooperation in food production.

Arab food security could be achieved through regional agricultural integration that combines the relative comparative advantages of all of the Arab countries, such as land and water resources, human resources, and financial resources. Joint agricultural projects could be implemented towards achieving food security for the region as a whole, using advanced agricultural methods supported by active R&D programs in agricultural production as well as effective governance of water and land resources. In April 2008, in a unified effort to address the current food crisis, Arab countries issued the "Riyadh Declaration on Promoting Arab Cooperation to Face the Global Food Crisis"[6] under the auspices of the Arab Organisation for Agricultural Development (AOAD). The Declaration calls for sound trade and investment schemes for enhanced food security in the short and long terms, through public private partnerships and enhanced inter-Arab agricultural trade (FAO, 2009; LAS and AOAD, 2008). Equally, consecutive AFED reports on Water (2010), Green Economy (2011) and Ecological Footprint (2012) reached similar conclusion on the benefits of boosting irrigation efficiency, increasing productivity levels of crops, in combination with regional cooperation, as means to enhance food security (AFED, 2010; 2010; 2012).

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Notes

1. For example, in Saudi Arabia it is estimated that more than 9% of the total annual electric power is consumed only for water production (groundwater extraction and desalination); the additional downstream segments in the water value chain of transmission, distribution, treatment and reuse/disposal add further to this estimate (Siddiqi and Anadon, 2011).
2. It is estimated that if Arab countries used only 5% of their deserts to build concentrated solar power plants, they could satisfy the energy needs of the world (Hmaidan, 2007).
3. e.g., Amman-Cologne Symposium (2011), WSTA 10th Gulf Water Conference (2012), ESCWA's Inter-Governmental Consultation Meeting (2012).
4. Most of the available research is concentrated on the reduction of the cost of desalination in terms of energy consumption with limited number on policy, planning and management.
5. In fact, it is the discourse on global warming that has opened eyes to the much intrinsic links between both resources (Haering and Hamhaber, 2011).
6. The declaration stressed the commitment to enhance Arab cooperation through actions and mechanisms which include (AOAD, 2010):

- Launching an initiative for an "Emergency Arab Food Security Programme".
- Encouraging the public and private sectors and Arab business to invest in joint agricultural projects.
- Commitment of the governments of Arab countries hosting joint Arab agricultural projects to provide facilities, concessions, and promotional guarantees.
- Adopting an "Arab Food Programme".
- Mobilizing efforts and resources to prepare national and joint programmes and projects that help achieve the objectives of the SSAAD.
- Preparation of a plan of action and specific time frame for the coordination of agricultural policies.
- Urging the setting of regulations and legislations governing the use of food and feed crops in the production of bio-fuel.

Financing Energy Supply

The Role of the Private Sector

Tarek El Sayed*
Shihab Elborai*

At 202 GW, the installed generation capacity of Arab countries constitutes only 4 percent of international installed capacity. Demand growth rates in the past decade ranged between 5 and 10 percent per annum and are anticipated to continue to hold at levels between 4 and 8 percent in the coming decade. Meeting the demand for electrical power of a growing consumer base requires the installation of approximately 24 GW of capacity per annum for the next 10 years. This translates into the mobilization of investments in excess of US$ 31 billion per year representing 1.5 percent of the GDP of Arab countries. This funding requirement comes in addition to capital investments in transmission and distribution (T&D) network infrastructure as well as operation and maintenance (O&M) expenditure and fuel subsidies. Under a scenario of continuing economic growth and socio-economic development, the funds required to grow and sustain the power supply infrastructure will exceed the public sector's ability to outlay funds and manage capital projects. It is necessary to attract funding from other sources through innovative approaches that can leverage limited public funds to attract significant private investments.

Our chapter examines the experience of Gulf Cooperation Council (GCC) and North African countries to answer three questions:

- *What form do Public Private Partnerships in power supply infrastructure investments take in the Arab region?*
- *What challenges and barriers arise under current private sector financing models?*
- *What measures should be deployed to overcome current challenges and barriers?*

Recommended policy measures build on the already established IPP model. These include establishing prudent long-term government liabilities management, building capable regulatory institutions and deploying methodical project tendering processes. Policymakers also need to act to facilitate the mobilization of local equity and debt financing through supporting the establishment of third-party investment funds, developing more flexible legal instruments, and granting infrastructure developers better access to corporate bond/Islamic Sukuk markets.

Furthermore, policymakers should enable comparability across projects and countries through transparency regarding factors influencing investment decision including projected investment plans, fuel supply allocations, and remuneration mechanisms. Finally, the long-term financial viability of the power sector as a whole and of renewables in particular, hinges upon the ability of governments to reform electricity tariffs so that they reflect the full economic cost of generating and delivering a kilowatt-hour.

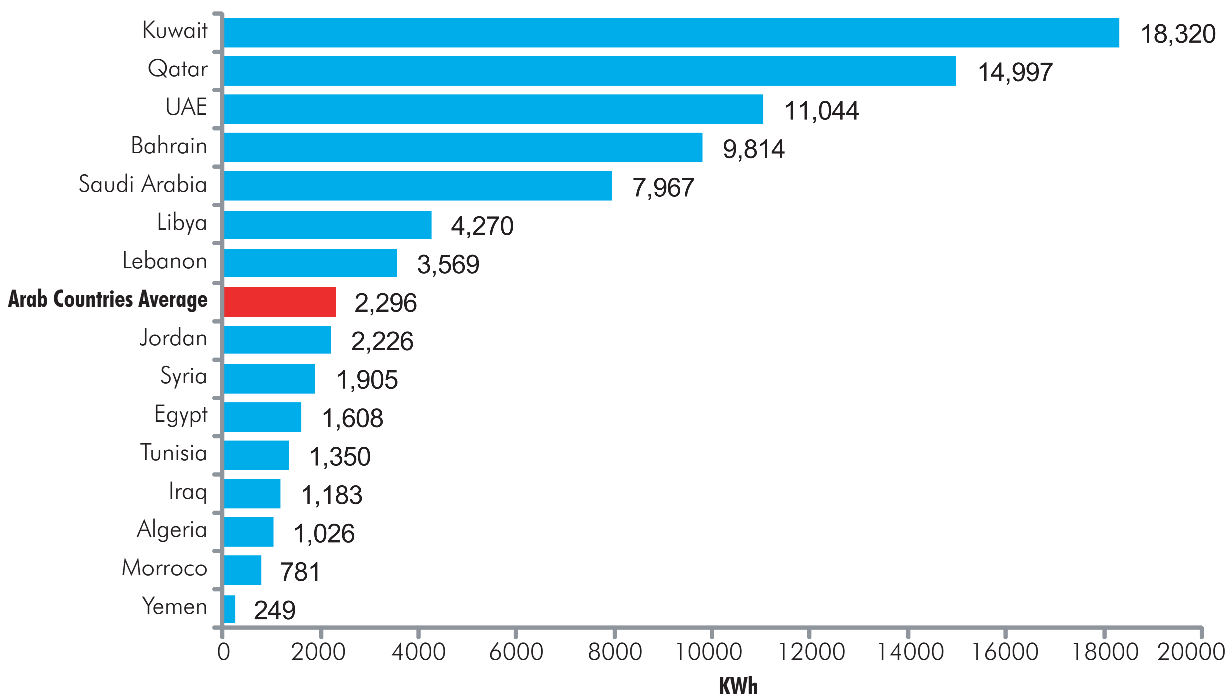
* Booz & Company

I. INTRODUCTION

At 202 GW, the installed generation capacity of the 22 members of the League of Arab States constitutes only 4 percent of international installed generation capacity (less than the combined generation capacity of the Italy and Spain) (World Bank, 2013 and Global Energy Observatory, 2013). Annual electricity consumption per capita in Arab countries averaged 2,396 kWh in 2010, reaching as high as 18,319 kWh in Kuwait and as low as 248 kWh in Yemen (See Figure 1). Demand growth rates in the past decade ranged between 5 and 10 percent per annum and are anticipated to continue to hold at levels between 4 and 8 percent in the coming decade (World Bank, 2013, and Kharbat, 2012). Meeting the demand for electrical power of a growing consumer base — both in terms of size and consumption per capita — requires the steady installation of approximately 24 GW of capacity per annum for the next 10 years. This translates into the mobilization of new investments in excess of US$ 31 billion per year representing 1.5 percent of the GDP of Arab countries. This funding requirement comes in addition to capital investments in transmission and distribution (T&D) network infrastructure as well as operation and maintenance (O&M) expenditure and fuel subsidies. Under a scenario of continuing economic growth and socio-economic development, the funds required to grow and sustain the power supply infrastructure will exceed the public sector's ability to effectively outlay funds and manage capital projects. It is necessary to attract funding from other sources through innovative approaches that can leverage limited public funds to attract significant private investments.

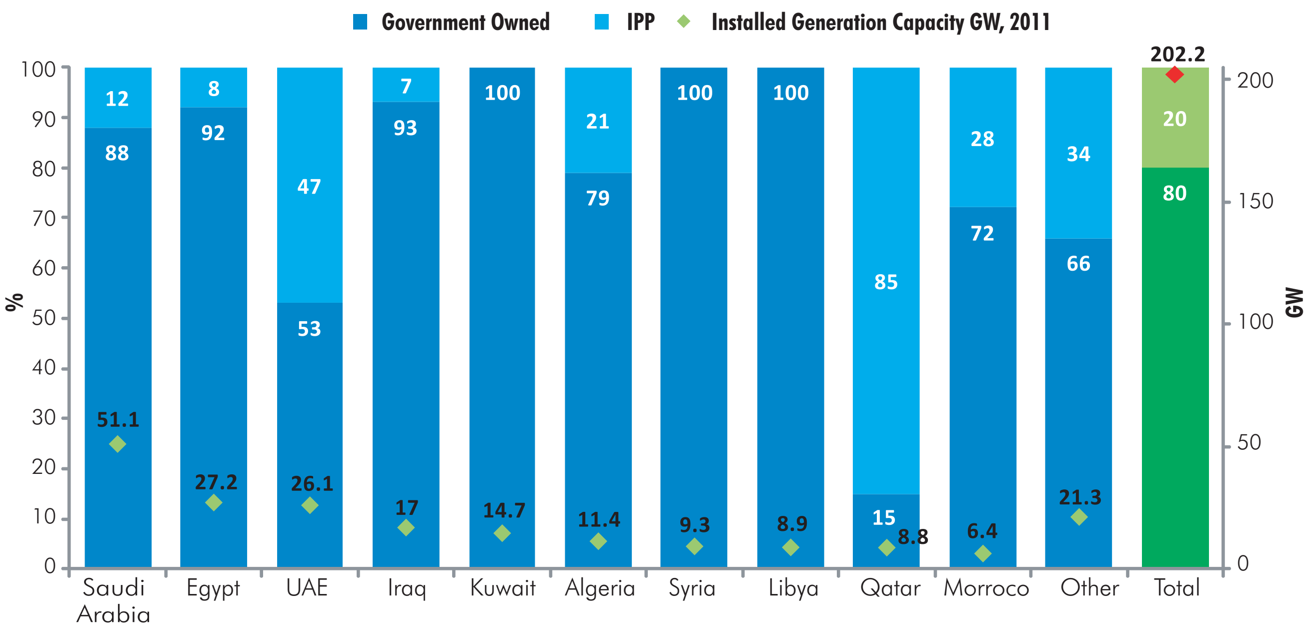
Public Private Partnership schemes range from simple management contracts with limited risk exposure for the private investor, to concessions, divestitures, and GreenfieldBuild Operate Transfer/ Build Own Operate Transfer (BOT/ BOOT) projects where the private investor assumes significant development, construction, and operations risk. In recent years, independent power production (IPP) has emerged as the most prominent PPP scheme in the region; In 2010 Arab countries had about 40 GW of operating IPP capacity representing more than US$ 50

FIGURE 1 ARAB COUNTRIES PER CAPITA ELECTRICITY CONSUMPTION (KWH-2008)



Source: World Development Indicators 2012 Data and Booz & Company analysis

FIGURE 2 SHARE OF IPPS IN INSTALLED POWER GENERARTION CAPACITY IN ARAB COUNTRIES



Source: Arab Union of Electricity Data 2011, and Booz & Company analysis

Billion of private investments and financing. The experience of the past decade in the Saudi Arabia, Abu Dhabi, Qatar, Oman and Morocco present a solid track record for private sector participation in developing generation capacity. Recently, local IPP developers and commercial banks in these countries have built sufficient capabilities to take a leading role in financing and delivering large scale generation projects across the entire Arab region and beyond.

In this context, this chapter aims to provide a holistic perspective on the current situation of energy supply infrastructure investments, the challenges faced by the sector, and different courses of action to meet the requirement of sustainable economic development. It will examine three key questions in turn:

- What form do Public Private Partnerships in power supply infrastructure investments take in Arab region and what are the common themes and variations across countries?
- What challenges and barriers arise under current private sector financing models?
- What measures should be deployed to overcome current challenges and barriers?

II. FINANCING ENERGY SUPPLY INFRASTRUCTURE PROJECTS IN ARAB COUNTRIES[1]

A. Electricity Generation

Greenfield independent power projects (IPPs), and independent power and water projects (IWPPs) have attracted the bulk of private sector investments in the energy supply infrastructure of Arab countries. In particular, GCC countries have increasingly turned to IPPs as an alternative to the traditional government-financed Engineering Procurement and Construction (EPC) turn-key contracting model for developing power plants. Since the construction of the 270 MW Al-Manah power plant in Oman in 1996, IPPs have expanded to Abu Dhabi, Qatar, Bahrain, Saudi Arabia, and recently Kuwait. Across the GCC, more than two dozen IPPs and IWPPs, with a combined installed capacity of more than 20 GW have been financed, built and operated by the private sector. Current expansion plans will bring the privately developed share of aggregate electricity generation in the GCC to about 34 percent (Sarraf, 2010).

NOOR 1: 160 MW CSP PLANT IN MOROCCO

ACWA Power and the Moroccan Agency for Solar Energy (MASEN) are partners in the development of Noor 1, a US$1billion160 MW Concentrated Solar Power (CSP) plant being built in Ouarzazate, Morocco. The project is currently the largest of its type in the world using parabolic trough technology to generate renewable energy, and will be augmented with 3 hours of thermal storage to enable thedispatch of electricity during early evening. The plant, based on a 25 year power purchase agreement, is scheduled to start operation in late 2015.

Noor 1 is a greenfield CSP parabolic trough Independent Power Project (IPP) project, to be developed as the first project for MASEN in a series of several planned developments at the Noor Solar Complex. This complex is set to develop into a 500 MW solar park, incorporating several utility-scale solar power plants using various solar technologies, all of which will be developed on the basis of Build, Own, Operate and Transfer (BOOT). Having achieved financial close in May 2013, the project was inaugurated by His Majesty King Mohammed VI of Morocco who renamed the project "Noor 1".

ACWA Power, as the lead developer, assembled an international consortium that comprises several European organisations which will engineer, procure and construct the plant. The operation and maintenance will be undertaken by NOMAC, a subsidiary of ACWA Power with a portfolio of experience equating to 10,127 MW of power and of 2.216Mm3/day of desalinated water.

The process for selection and funding was managed by MASEN under the scrutiny of the World Bank and other international financing institutions (IFIs). The Project debt is completely financed by IFIs. Loans and grants to MASEN are being provided by the African Development Bank, the French Agency for Development, the European Union, the European Investment Bank, the International Bank for Reconstruction and Development acting as an implementing entity of the World Bank Clean Technology Fund and the German Development Agency.

The electricity tariff offered by the ACWA Power consortium was 28.8% lower than the one offered by the second bidder. Noor 1CSP IPP therefore represents a milestone for CSP parabolic trough technology by demonstrating thatsolar power can be produced at a commercially competitive rate. The tendered bid of USD 0.19/kWh is significantly lower than what has been achieved to date and at the same time narrows the gap between the cost of solar power produced using photo voltaic technology and that of solar thermal technology.

Morocco currently relies heavily on coal and other conventional sources, alongside hydro and wind power parks to meet its energy needs. With the CSP technology used, the project will serve to abate approximately 470,000 tons of CO2 emissions for every year of operation. This project will be a positive factor in offsetting the Moroccan grid peak power demand period, in particular due to its thermal storage. The overall

The basic features of the IPP model are similar across all GCC countries. The state owned utility, ministry of electricity or in some cases an independent authority/single buyer defines the generation capacity expansion plan specifying the location, size, technology and fuel supply for IPP power plants. Private developers compete to for the right to finance, build, and operate the power plant in return for a fixed price long-term power purchase agreement (PPA). Such agreements typically run for 20-25 years on a take-or-pay basis and are backed by either a sovereign guarantee or the credit rating of the off-taker. The government typically retains an equity stake in all IPPs which helps mitigate country and regulatory risks. The risk of fuel price volatility is either mitigated through contractually fixed prices or altogether eliminated from variable O&M costs through energy conversion agreements (ECAs). IPP developers have limited risk exposure under this model, assuming only the risk of financing, constructing, and operating the power plant. Consequently, such projects have ready access to limited-recourse high-leverage project financing from international, regional and local banks with debt ratios reaching as high as 80 percent (Sarraf, 2010).

Within the general framework described above, GCC countries exhibit some variations. For example the government-owned equity stake in Saudi IPPs can be as low as 20 percent whereas projects in Abu Dhabi are typically 80 percent government-owned. Differences also exist in the guarantees provided as well as in the rules for share transfers, public offerings, and termination.

MASEN program is focusing on the sustainable support and integration of local industries. A targeted system of local recruitment and investment in human capital of the local workforce by the project will increase the benefit to the local economy with up to 1,000 workers employed during construction and 60 during operation, in addition to R&D collaboration platform and human capacity development program.

ACWA Power, a privately owned company incorporated in Saudi Arabia, is a developer, investor, co-owner and operator of plants with a contracted gross production capacity of 15,731MW of power and 2.37 million cubic meters of desalinated water per day. ACWA Power is a corporate AFED member.

Based on material provided by ACWA Power, which is AFED member.

Outside the GCC, the private sector has developed generation capacity in several countries including Morocco, Algeria, Tunisia, Egypt, Jordan, and Iraq's Kurdistan region. In Morocco, for example, the IPP program commenced in 1994, resulting in 3 privately owned power plants that supplied 54 percent of total power production in 2010. Compared to other regional IPPs, the Moroccan IPP experience is remarkable for the absence of the sovereign guarantee requirement. Moroccan PPA's provide security arrangements to developers through escrow facilities and letters of credits covering a few months of billings. Another notable feature of Moroccan projects is the diversity of the technologies and fuel mix: Jorf Lasfar is a 1,360 MW coal-fired steam plan, Energie Electrique de Tahaddart is a 384 MW combined cycle power plan running on transit Algerian natural gas, and Compagnie Eolienne de Detroit is 50 MW on-shore wind farm. The IPP program has allowed the Moroccan authorities to divert significant funds and attention to the rural electrification program. Since the inception of the IPP program in 1995, the Moroccan Rural Electrification Program (PERG) increased the rural electrification rate from 18 percent to more than 97 percent in 2011 (ESMAP, 2012).

Although the overall IPP experience in the Arab region has been generally positive – in some countries the results have been mixed. In Egypt, for example, the IPP program started early with three gas-fired steam power plants, with a combined capacity of more than 2 GW, developed in the period between 1996 and 2003 on the basis of 20-year off-take agreements with

TABLE 1 **SELECTED PRIVATE POWER PROJECTS IN ARAB COUNTRIES**

Name	Country	Capacity	Technology	Fuel	Type*	Completion Date
Arzew IWPP	Algeria	318 MW	Steam Turbine	Natural Gas	Greenfield	2005
Hadjret En-Nouss IPP	Algeria	1,260 MW	Combined Cycle	Natural Gas	Greenfield	2010
Skikda IPP	Algeria	880 MW	Combined Cycle	Natural Gas	Greenfield	2005
Addur 1 IWPP	Bahrain	1,234 MW	Combined Cycle	Natural Gas	Greenfield	2011
El Ezzel IPP	Bahrain	950 MW	Combined Cycle	Natural Gas	Greenfield	2007
Hidd IWPP	Bahrain	962 MW	Combined Cycle	Natural Gas	Brownfield	1999/2006
Benha IPP	Egypt	750 MW	Combined Cycle	Natural Gas	Greenfield	TBD
Dairut IPP	Egypt	2,250 MW	Combined Cycle	Natural Gas	Greenfield	TBD
Port Said East IPP	Egypt	682 MW	Steam Turbine	Natural Gas	Greenfield	2003
Sidi Krir IPP	Egypt	682 MW	Steam Turbine	Natural Gas	Greenfield	1999
Suez Gulf IPP	Egypt	682 MW	Steam Turbine	Natural Gas	Greenfield	2003
Erbil IPP	Iraq	1,550 MW	Combined Cycle	Natural Gas	Greenfield	2009
Sulaimaniyah IPP	Iraq	750 MW	Gas Turbine	Natural Gas	Greenfield	2009
Dohuk IPP	Iraq	500 MW	Gas Turbine	Natural Gas	Greenfield	2011
AES IPP	Jordan	380 MW	Combined Cycle	Natural Gas	Greenfield	2009
Amman Asia IPP	Jordan	600 MW	Diesel Engine	Diesel	Greenfield	TBD
Amman Levant IPP	Jordan	250 MW	Diesel Engine	Diesel	Greenfield	TBD
Aqaba Thermal IPP	Jordan	656 MW	Steam Turbine	Heavy Fuel Oil	Brownfield	1985/2007
Hussein IPP	Jordan	363 MW	Steam Turbine	Heavy Fuel Oil	Brownfield	1975/2007
Qatranah IPP	Jordan	380 MW	Combined Cycle	Natural Gas	Greenfield	2011
Rehab Gas IPP	Jordan	357 MW	Combined Cycle	Natural Gas	Brownfield	1994/2007
Risha Gas IPP	Jordan	150 MW	Gas Turbine	Natural Gas	Brownfield	1984/2007
Jorf Lasfar IPP	Morocco	1,360 MW	Steam Turbine	Coal	Greenfield	1994
Compagnie Eolienne de Detroit	Morocco	50 MW	Onshore Wind	N/A	Greenfield	2000
Tahaddart IPP	Morocco	384 MW	Combined Cycle	Natural Gas	Greenfield	2005
Al Ghubra IPP	Oman	484 MW	Combined Cycle	Natural Gas	Brownfield	1995/2006
Al Rusail IPP	Oman	661 MW	Gas Turbine	Natural Gas	Brownfield	1985/2006
Al-Kamil IPP	Oman	273 MW	Gas Turbine	Natural Gas	Greenfield	2002
Barka 3 IPP	Oman	744 MW	Combined Cycle	Natural Gas	Greenfield	2013
Barka 2 IWPP	Oman	728 MW	Combined Cycle	Natural Gas	Brownfield	2007/2009
Barka 1 IWPP	Oman	427 MW	Combined Cycle	Natural Gas	Greenfield	2003
Al Manah IPP	Oman	270 MW	Gas Turbine	Natural Gas	Brownfield	1996
Salalah IPP	Oman	445 MW	Gas Turbine	Natural Gas	Greenfield	2012
Sohar 2 IPP	Oman	744 MW	Combined Cycle	Natural Gas	Greenfield	2013
Sohar 1 IWPP	Oman	585 MW	Combined Cycle	Natural Gas	Greenfield	2007
Mesaieed IPP	Qatar	2,007 MW	Combined Cycle	Natural Gas	Greenfield	2010
Ras Laffan A IPP	Qatar	756 MW	Combined Cycle	Natural Gas	Greenfield	2004
Ras Laffan B IPP	Qatar	1,025 MW	Combined Cycle	Natural Gas	Greenfield	2008

TABLE 1 **SELECTED PRIVATE POWER PROJECTS IN ARAB COUNTRIES**

Ras Laffan C IPP	Qatar	2,730 MW	Combined Cycle	Natural Gas	Greenfield	2011
Sadaf IPP	KSA	250 MW	Gas Turbine	Natural Gas	Greenfield	2005
Tihama ISPP	KSA	1,704 MW	Combined Cycle	Natural Gas	Greenfield	2006
Hajr IPP	KSA	3,927 MW	Combined Cycle	Natural Gas	Greenfield	TBD
Jubail IWPP	KSA	2,743 MW	Combined Cycle	Natural Gas	Greenfield	2010
Rabigh IPP	KSA	1,204 MW	Steam Turbine	Heavy Crude Oil	Greenfield	2013
Rabigh IWSPP	KSA	660 MW	Steam Turbine	Heavy Fuel Oil	Greenfield	2008
Riyadh PP11 IPP	KSA	1,730 MW	Combined Cycle	Natural Gas	Greenfield	2013
Shuaibah IWPP	KSA	900 MW	Steam Turbine	Light Crude Oil	Greenfield	2009
Shuqaiq IWPP	KSA	850 MW	Steam Turbine	Heavy Crude Oil	Greenfield	2010
El-Biban IPP	Tunisia	30 MW	Gas Turbine	Natural Gas	Greenfield	2003
Rades II IPP	Tunisia	471MW	Combined Cycle	Natural Gas	Greenfield	2002
Fujairah 1 IWPP	UAE	881 MW	Combined Cycle	Natural Gas	Brownfield	2004/2006
Fujairah F2 IWPP	UAE	2,000 MW	Combined Cycle	Natural Gas	Greenfield	2010
Shuweihat 2 IWPP	UAE	1,500 MW	Combined Cycle	Natural Gas	Greenfield	2011
Shuweihat 1 IWPP	UAE	1,615 MW	Combined Cycle	Natural Gas	Greenfield	2004
Taweelah A1 IWPP	UAE	1,650 MW	Combined Cycle	Natural Gas	Brownfield	1997/2003
Taweelah A2 IWPP	UAE	780 MW	Combined Cycle	Natural Gas	Greenfield	2001
Taweelah B IWPP	UAE	2,266 MW	Combined Cycle	Natural Gas	Brownfield	1995/2008

* The dates shown for brownfield projects indicate both commissioning and privatization dates
Source: Global Energy Observatory 2013, and Booz & Company analysis

the Egyptian Electricity Holding Company. The program faltered in the wake of the rapid devaluation of the Egyptian pound between 2000 and 2003, which saw the monthly payments by the Egyptian off-taker on the dollar denominated power purchase agreements (PPAs) more than double over the same period of time. This lead Egypt to scrap plans to tender out more than 15 IPP projects; and consequently to the withdrawal of the initial international power plant developers who had invested under the assumption of exploiting economies of scale across multiple power plants. In 2012 Egypt suffered its worst power cuts in decades as a result of a shortfall in generating capacity and bottlenecks in fuel supply. Recent power shortages and concerns about the continuing availability of soft loan from multi-lateral development finance institutions—such as the European development bank, the Arab Fund for Social and Economic Development, and the World Bank–have lead the Egyptian government to revisit the IPP model at least as captive supply for large industrial users. Given previous IPP experience and the currently prevailing business environment in Egypt, investor appetite for IPPs is uncertain (Khamis, 2012).

The IPP model has allowed governments in the region to spread investment expenses over 25 to 30 years through capacity payments, freeing up public funds for investments to reinforce/expand the T&D network, electrify remote rural areas, and pay for other development priorities. Despite higher financing costs compared to government funded plants, the IPPs appear to yield cost structures that are competitive with government funded plants once fuel, O&M, capital expenditure efficiencies are taken into account. Moreover, in contrast to the funding delays, design changes, and overlapping authorities that slow down government developed power plants, IPP developers tend to have better discipline in expediting construction processes to begin generating power – and revenue – as soon as possible. In countries that are constantly trying to keep up with rapidly growing demand, the predictable and short development cycle for IPPs is a significant benefit. Finally, IPPs

COMMERCIALIZING WIND ENERGY IN EGYPT

Ibrahim Abdel Gelil

Egypt enjoys one of the best wind regimes in the world. Since 1988, several pilot and demonstration projects have been installed to gain and accumulate the necessary experience. The first commercial wind farm (5 MW) was established and interconnected with the local grid of Hurghada in 1993, generating about 9 GWh/year. The farm includes 42 wind turbines of different types and sizes. Some components were locally manufactured (towers, blades, other mechanical and electric components).

The first Wind Atlas for the Gulf of Suez was finalized in 2003, identifying 13 sites of high wind speed. In 2005, the Wind Atlas for Egypt was released covering Egypt's entire land area. The purpose of the Wind Atlas was to establish a meteorological basis for assessing Egypt's wind energy resources in six designated regions: the northwest coast, the northeast coast, the Gulf of Aqaba, the Gulf of Suez, the Red Sea, and the Western Desert. Accordingly, the western part of the Gulf of Suez was found to be home to some of Egypt's and the world's best wind resources, with average yearly wind speeds surpassing 7 meters per second, and a potential for some 20,000 MW of wind capacity.

In 2007, Long-Term Plan for Wind Energy Development was announced by the Supreme Council of Energy (SCE), as a comprehensive plan to increase the share of renewable energy (RE) to reach 20 percent of the total electric energy demand by year 2020. According to the plan, it is anticipated to have an installed wind capacity of around 7,200 MW by the year 2020/2021, amounting to 12 percent of the total electricity generated. The objectives of the plan would be achieved through government and private investments. The state-owned projects implemented by the New and Renewable Energy Authority (NREA), the government's entity responsible for promoting RE in Egypt, will have total capacity of 2,375 MW (representing 33 percent of planned total installed capacity). The private sector projects will have total capacities of the remaining 76 percent (4,825 MW). Participation of the private sector will be through the Build, Own, and Operate (BOO) scheme. Although the NREA has traditionally monopolized the development of wind farms through donor-funded projects, the national target has spurred private investments in large wind turbines, and the first prequalification for private-sector developers was under way in late 2009 to build a 250 MW wind farm on a BOO basis. A short list of 10 qualified bidders was identified.

The government offers a package of incentives to attract private investments to the wind energy market. These include exempting renewable energy equipment and spare parts from customs, duties & sales Taxes, signing and guarantying a long term Power Purchase Agreement (PPA) for 20-25 years, and benefiting from carbon credits generated by wind power plants.

So far, wind energy in Egypt has been limited to donor-sponsored projects preceded by a handful of demonstration projects. All of these projects involve grid-connected wind power plants, and the NREA played the role of local project developer. Additionally, plans for two wind farms of 120 MW each, and one 200 MW plant, are being pursued in Zafarana and Gulf of El-Zayt with assistance from Germany, Japan, and Spain.

Currently, Egypt generates about 550 MW of energy from wind power plants, of which 545 MW are generated from the Zafarana wind farm and the remainder from the Hurghada wind farm. The largest project is the Zafarana wind farm located on the West Coast of the Gulf of Suez. The farm houses several wind projects that were developed in several stages and financed in cooperation with development banks from Germany, Denmark, Spain, and Japan.

Despite the high technological specificity of the wind-energy supply chain, Egypt has the infrastructure, existing facilities, and level of technological maturity, readiness, and positioning to support local production of wind-turbine components, such as the gearbox and blades. This is because of accumulated experience as well as the presence of well-established industries for manufacturing transformers, cables and other electrical auxiliaries, and to a much lesser extent gear boxes and converter/inverter units.

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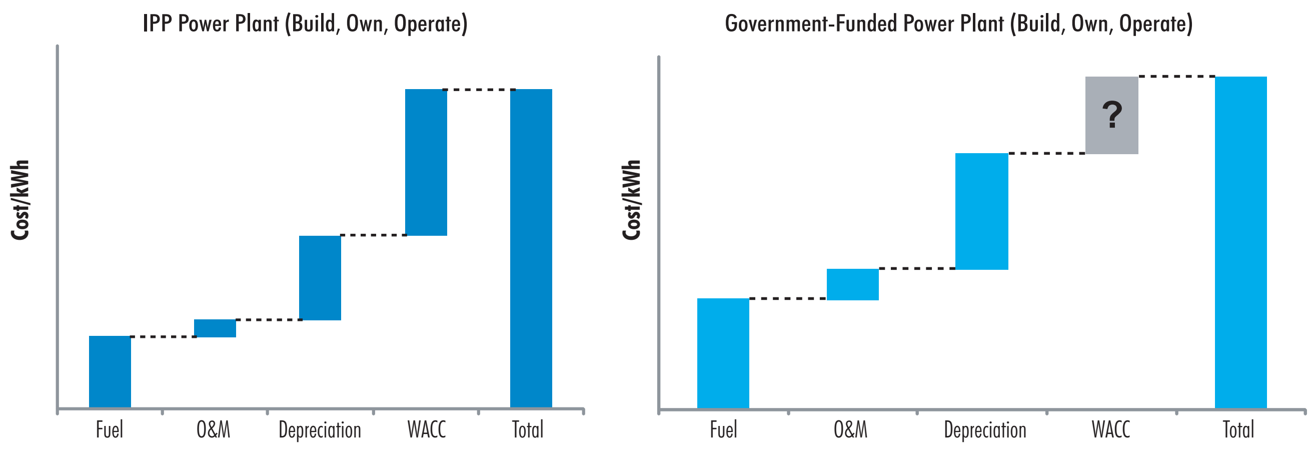
FIGURE 3 **DIFFERENCES IN COST COMPONENTS BETWEEN IPPS AND GOVERNMENT FUNDED PLANTS**



Source: Sarraf et al., 2010

DIFFERENCES IN COST COMPONENTS: IPPS VS. GOVERNMENT-FUNDED PLANTS	
Fuel	• IPPs tend to control their heat rate degradation
O&M	• IPPs show slight advantages as a result of lower manpower, more qualified staff, and better procurement practices, which are partially offset by lower salaries in government-funded plants
Depreciation	• IPPs have tighter control over capital expenditures, with specifications designed to serve the life cycle of the IPP. Comparisons are often difficult due to the increase cost components of IPP tender packages (e.g. jetty and transmission substations)
WACC (Weighted Average Cost of Capital)	• IPPs have higher financing costs, but benchmarking government-funded plants is difficult
Other	• Indirect benefits to the economy are typically not factored into analyse. In the case of an eventual sale, a plant's terminal value would lower the costs of the IPP

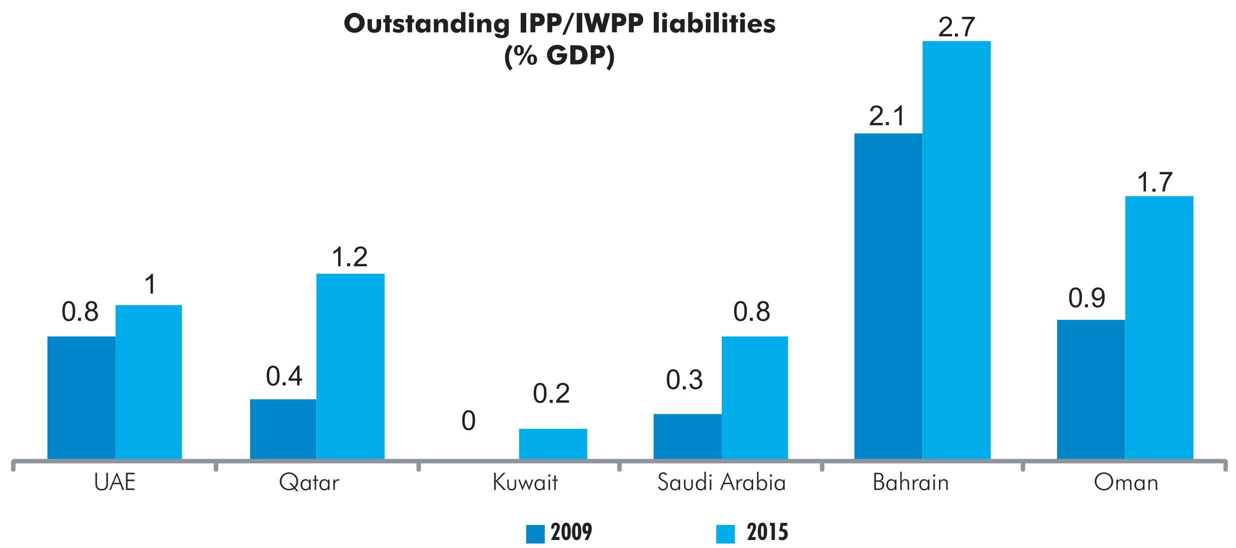
provide governments with operational and financial benchmarks against which to assess the performance of the exiting power plants built and operated by the state-owned utility (Sarraf, 2010).

B. Transmission and Distribution

Unlike power generation, private sector participation in T&D infrastructure investments has been very modest in scale and limited to a few countries. Jordan and Morocco have the most advanced experiences among all Arab countries. Oman has announced tentative plans to privatize Oman Electricity Transmission Company as well as the three distribution companies: the Muscat Electricity Distribution Company, Majan Electricity Company and Mazoon Electricity Company.

Starting in 1999, Jordan horizontally unbundled its centralized electricity utility company and gradually privatized the generation and distribution activities retaining transmission and system control under public ownership. Today three privately owned companies have electricity distribution concessions: Jordan Electric Power Company (JEPCO), Irbid District Electricity Company

FIGURE 4 **CONTINGENT IPP/IWPP LIABILITIES OF GCC GOVERNMENTS**



Source: Sarraf et al., 2010

(IDECO), and Electricity Distribution Company (EDCO). These companies are responsible for developing, maintaining and operating the LV and MV networks to meet subscriber's needs in their area of concession. Electricity tariffs in Jordan range from 8 to 9.5 US cents per kWh which is sufficient to cover the wholesale purchase price of electrical power, as well as the full economic costs of transmission and distribution (Al Amri, 2012, and World Bank, 2013).

Morocco awarded private concessions for providing municipal services including water supply distribution, wastewater collection and electricity distribution for Casablanca in 1997, Rabat in 1999, and Tangiers/Tetouan in 2002. The concessionaires made significant capital investments, increased access to water and electricity, and rolled out an extensive training program for employees. To generate the necessary revenues tariffs were increased to levels more reflective of the economic cost of service inducing customers to conserve their consumption. The concession contract in Morocco protected employees against layoffs or reductions in benefits (World Bank, 2013).

Arab governments are inclined to retain transmission assets and system operations under government control due to strategic and national security considerations. However, high quality transmission infrastructure is a key enabler of private sector participation in power generation and distribution. Power sector reforms and a transition towards an open market depend on the existence of densely interconnected transmission network that gives electricity consumers a choice of multiple suppliers. Transmission infrastructure will also play a role in the transition to a more sustainable economy where renewables for a significant part of the energy mix. Upgrading the existing infrastructure and building new transmission infrastructure that can accommodate solar and wind technologies represents a major challenge to Arab utilities in the coming decade.

While many Arab governments desire private sector participation in distribution they are reluctant to push unpopular electricity tariff reforms. Thus private sector interest in distribution investments is undermined by the inadequate electricity tariff structures prevailing in most Arab countries, as well as a lack of payment discipline and prevalent electricity theft. The risk of politically motivated government intervention in end-user tariff setting makes this sector unattractive for private investors.

III. PRIVATE SECTOR FINANCING CHALLENGES AND BARRIERS[2]

Careful alignment of the goals and incentives of public and private stakeholders is a necessary condition for increasing the participation of private investors in projects to upgrade and expand energy supply infrastructure. The fundamental risk of the Public Private Partnership model, from a government perspective, stems not from any individual project but from the aggregate effects of multiple projects over an extended timeline. An ostensibly rational choice at the project level, can lead to suboptimal outcomes at the sector level, especially in cases where private schemes are used to cover a significant portion of infrastructure investments. From a private sector perspective risks stem from uncertainty around currency exchange, fuel supply, dispatch, default on financial obligations, renegotiation of contractual terms and expropriation. Finally, attracting private investments into renewable energy projects must overcome a unique set of sector-specific hurdles in addition to all the challenges and barriers to investment in conventional infrastructure.

The following sections describe the key challenges and barriers to increased private participation under the currently prevailing conditions:

A. Long-Term Implications of Existing Financing Models

As IPPs take hold in the region and account for an increasingly significant share of installed generation capacity, policymakers need to be prepared to handle three long-term implications that threaten to curtail the advantages provided by private sector involvement.

The first and most straightforward implication is the accumulation of substantial contingent liabilities under the PPAs. Amortization of infrastructure investments through capacity payments spread over 20-30 years will tie up increasing shares of future GDP in implicit off-balance sheet obligations. If governments succeed in investing the freed up capital to create long-term growth in the national wealth that exceed the accumulating liabilities, this strategy can yield great prosperity. However, taken with other long-term liabilities, including public sector salaries, pensions, healthcare, and food/fuel subsidies, PPA obligations may become heavy burdens in a future economy with an abundance of installed generation capacity (Sarraf, 2010).

The second limitation is the bias demonstrated by the current IPP development model towards building base-load power plants that need to run virtually fulltime to provide cheap electricity. Such a trend may cause system operators to struggle to meet daily and seasonal variations in power demand, satisfy network constraints, optimize dispatch, and satisfy contractual commitments to IPPs. An efficient electrical system must strike a balance between multiple technology and fuel types that allows for flexibility in meeting base-load, intermediate and peak demand. Such a balance cannot achieve by exclusively adding IPP units optimized to run at very high capacity factors (Sarraf, 2010).

Finally, the proliferation of IPPs can lock-in the regulatory reform agenda and impede the journey towards a liberalized power market. If the majority of generation assets are covered by long-term PPAs, there will be little room left for open market trading of electricity or bi-lateral agreements between generators and consumers of electricity. Any future reforms to the electricity market will need to first deal with the contractual legacy of IPPs.

B. Infrastructure Project Investment Risk Landscape in Arab Countries

Energy infrastructure investments are long term plays requiring private investors to anticipate and mitigate risks across the span of several decades. Investors attempt to manage these risks through a set of project documents (e.g., power purchase agreement, interconnection agreement, engineering, procurement and construction or engineering, procurement and construction management agreements, land lease agreement, fuel supply or energy conversion agreement and disbursement agreement). They also mitigate risk of contract breach by the government through equity stakes by the host government and local developers and through involving local and international commercial banks as well as in some cases multi-lateral financing agencies in financing the project.

Non-GCC countries are generally perceived by investors as higher risk compared to GCC countries and hence there has been limited appetite for infrastructure investments in these countries by commercial banks. This risk perception leads to prohibitively high returns expectations by investors and financiers reducing the benefits of private sector participation. However, some off-takers in non-GCC countries have demonstrated the effectiveness of creditworthiness and a business friendly environment in attracting foreign investors (e.g., Morocco and Jordan). Moreover, multilateral agencies and development banks have played a strong role in backing private financing of energy infrastructure in Non-GCC countries through non-commercial risk guarantees (e.g., expropriation, breach of contract, war and civil disturbance) (ESMAP, 2012).

From an IPP investor's perspective, fuel is another major area of vulnerability as IPPs are often caught between the primary fuel supplier and the electricity off-taker. GCC countries, that have access to abundant hydrocarbon resources, typically shield the IPP from fuel risk by making the electricity off-taker assume responsibility for securing fuel supply from the primary fuel supplier. This is often formalized through an energy conversion agreement or a fuel supply agreement that removes both fuel price and volume uncertainty. Outside the GCC, in countries where IPP projects usually rely on fuel imports, fuel-supply risk is allocated to the fuel supplier through a "ship-or-pay" delivery guarantee. Fuel-price risk can either be allocated to the off-taker via an indexed pass-through provision or shared between the developer and the off-taker. The Jorf Lasfar IPP in Morocco is an example where the developer has succeeded in securing a reliable and cost competitive supply of imported coal. The formula for compensating reimburses 80 percent of the coal procured by the developer at cost and 20 percent of the coal at the average price of coal imports in the European Union thus providing the developer with a strong incentive to buy coal at a competitive rate.

In the absence, however, of a strong IPP track record, making the private sector developer responsible for securing fuel through direct coordination with the primary fuel supplier typically increases risk perception and delays the financial close of IPP development contracts. For example, in 2010 the Iraqi Ministry of Electricity launched a program to tender out the development of four IPPs with a total capacity of more than 2.7 GW. The ministry contemplated a model where the fuel supply risk was allocated entirely to the project developer. This risk allocation approach proved untenable given the scale of the planned IPP program, and the absence of a track record of successful power purchase agreements (Ministry of Electricity of Iraq, 2010). The Egyptian Electricity Holding Company (EEHC) encountered similar challenges in its recent attempts to reawaken the Egyptian IPP program after a decade long hiatus through schemes that minimize the Egyptian government's exposure to market risk. These schemes include opening up the grid for third-party access and allowing for merchant IPPs to supply large customers by wheeling their production through the national electrical grid. IPP developers would be responsible for securing their own fuel supply and bilateral power purchase agreement; their relationship with the EEHC would be fully defined by an Interconnection and Use System Agreement and a Transmission Use of System charge set by the board of the Egyptian Electricity Regulatory Agency .

C. Renewable energy supply challenges

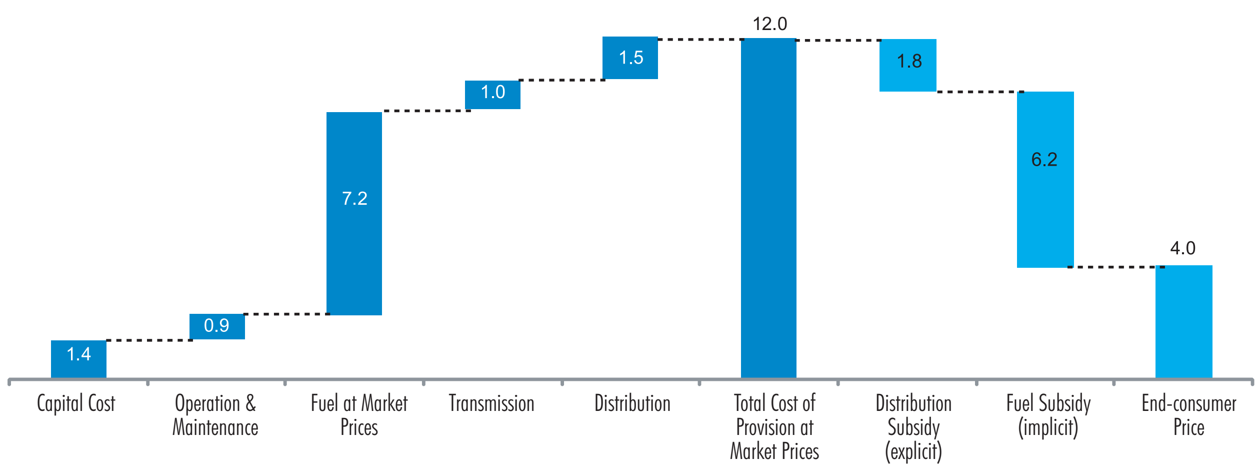
Globally, the renewables sector witnessed a record breaking US$ 257 Billion of investment in 2011, up 17 percent from 2010. In terms of capacity, renewables accounted for 44 percent of new generation capacity added worldwide. Despite this global boom in renewable energy investments, most programs to establish renewable capacity in Arab countries do not have access to adequate funding. In fact only US$ 5.5 Billion, or 2 percent, of global renewables investments were made in the Middle East and Africa region, down 18 percent from 2010. The only exception among Arab countries is Morocco, which invested US$ 1.12 Billion in renewable energy projects in 2011 (McCrone, 2012).

Such limited renewables investment activity stands in stark contrast to the region's ample endowment of solar and wind resources. Arab countries have the world's greatest potential for renewable power generation. Almost 45 percent of the world's potential resource endowment resides in the region; these resources, if tapped, are sufficient to cover more than 3-times the current global demand for electrical power (El-Husseini, 2011).

Arab governments use fuel subsidies to reduce the cost of conventional power generation in order to stimulate economic growth, increase access to affordable electricity, and spread the wealth from oil and gas production. Utilities in the region typically pay around US$ 1 per MMBTU for natural gas, which is roughly equivalent to buying oil at US$ 10 per barrel – a mere fraction of world market prices. As result of this and other direct and indirect subsidies, regional utilities can maintain the cost of conventional electricity generation, transmission and distribution at an artificially low level of 5 to 6 US cents per kWh. Furthermore, in most Arab countries the electricity tariffs, particularly for residential customers, tend to be inadequate to cover even the subsidized costs of production (El-Husseini, 2011).

Private sector participation in the development of renewable energy is critical for accessing the required expertise and capabilities. Private interest is, however, unlikely under current market conditions; Arab governments need to take the lead to make renewables a viable investment. In the absence of an equalizing incentive mechanism that balances the distortions caused by conventional power subsidies, large-scale private investment in renewable energy projects will remain unlikely.

FIGURE 5 COST AND INCOME STRUCTURE OF A TYPICAL ARAB UTILITY (US CENT PER KWh)



Source: El-Husseini et al., 2011

IV. A NEW POLICY FRAMEWORK FOR ENERGY SUPPLY[3]

To systematically address the challenges and overcome the barriers described above, ministries, regulators, and public utilities must undertake a series of initiatives to improve the regulatory environment, facilitate equity and debt financing conditions for energy supply infrastructure projects, promote renewable energy supply investments, and build regulatory capabilities.

A. Improving the regulatory environment

Regulatory reform to introduce private sector participation requires strong political will and commitment, integration with other reform initiatives, and a fair approach to maintaining balance between the interests of investors, the government, and the public. To systematically improve the regulatory environment action is required in four primary areas: Long-term liability management, integrated infrastructure planning, project tendering process,and increasing transparency and comparability across projects
The following sub-sections describe a course of action to reform the regulatory environment for Arab countries in each area.

i. Long-Term Liability Management

As a starting point, ministries of finance should develop an indicator to track the contingent liabilities of IPPs and other energy supply financing schemes as proportion of government revenues and of national GDP. Total exposure to capacity payments as well as other long-term off-balance sheet financial obligations like public sector salaries and benefits, pensions, fuel and food subsidies should be closely monitored under alternative economic growth scenarios to set deliberate boundaries on the accumulation of future liabilities and the use of sovereign guarantees. Governments need to define limits that they feel are appropriate, but decision making should be data-driven and conscious (Sarraf, 2010).

As demonstrated by Saudi Electricity Company and by the Office National de l'Electricité of Morocco, a sovereign guarantee is not required when the off-taker is creditworthy and has a positive contracting track record; other schemes like escrow accounts to cover a few months of billing or third party guarantees/letters of credit are possible (Al Barak, 2013, ONE, 2011, and SEC, 2011).

Allowing long-term bi-lateral agreements between IPPs and large industrial customers and enabling fair third-party access to the transmission network, commonly referred to as "Wheeling," can help contain long-term government liabilities. Incumbent state-owned utilities in Arab countries oppose wheeling since they are loath to relinquish large industrial customers that pay the highest tariffs and cost the least to serve to private operators. However, a win-win value proposition can be devised setting up a system of wheeling charges as well as a contractual obligation to supply excess capacity to serve the system's peak requirement as needed at tariffs that are close to the marginal variable cost of power production. Such a system would pave the way for market liberalization and private sector financing of transmission infrastructure (Sarraf, 2010).

ii. Integrated Infrastructure Planning

The impact of IPPs on the overall economics of the electrical system is strongly dependent on the robustness of system planning, including supply-demand forecasting and transmission system reinforcement/expansion planning. In times of strong growth in the demand for electrical power such issues are masked by chronic shortages in supply that allow for near-full utilization of assets. Poor planning choices only surface in times of overcapacity when the demand for electrical power experiences slower growth rates or shrinks. IPPs become targets for political criticism as their per-unit costs of production increase as contractually fixed capacity payments are spread over a shrinking output. Similarly, transmission constraints combined with the need to run IPP capacity in base-load mode can limit the ability to optimize dispatch across the national system. (Sarraf, 2010)

Arab system planners need to consider the development of intermediate-load and peak-load capacity in addition to building IPPs suited only for base-load operation like the 1,360 MW coal-fired power plant in Jorf Lasfar (Morocco), the 900 MW HFO-fired steam plant in Shuaibah (Saudi Arabia), or 2,007 MW gas-fired combined-cycle plant in

Mesaieed Industrial city (Qatar). An imbalance favoring base-load plant designs will result in rising costs over time and risk of creating stranded generation assets in case electricity demand growth slows down or reverses. Some GCC countries specify particular load-categories and load-service requirements in IPP tenders allowing developers to design the plant and commercial bid that is most appropriate for a particular load-regime (Al Barak, 2013, ONE, 2011, and SEC, 2011).

Moreover, system planners need to develop and publish 5-7 year outlooks on investment requirements in generation, transmission and distribution infrastructure that provide reliable signals to private developers. Clarity on future opportunities will allow developers to plan for the long-term and arrange the necessary financing and technical alliances well in advance. This particularly important to attract investments in transmission infrastructure which typically has longer payback durations and lower returns.

iii. Project Tendering Process

A well designed, transparent bidding process must both allay concerns of corruption and improper awards as well as provide sufficient flexibility to yield projects that are highly competitive in terms of value for money, allocation of risk, promotion of innovative solutions, and reduction of tendering costs. When tendering out concessions, regional utilities need to remain within the accepted boundaries of existing procurement procedures while using more comprehensive evaluation techniques that allow some measure of flexibility in harnessing private sector innovation and efficiencies. The tendering process should be sufficiently flexible to treat a BOOTproject with a highly defined scope and well known cost structure differently from a first-of-a-kind Design Build Finance Operate (DBFO) project that introduces a new or unfamiliar technology.

Utilities should provide information upfront to developers regarding the scale of the tender, the scope of bid evaluation, performance expectations and competition rules. This allows developers to decide a priori whether tendering is in their best interest or not. Utilities should also constantly sound the market through informal consultations with developers. In addition to ensuring that tenders will attract sufficient and diverse interest, such informal communication channels can provide invaluable feedback for reassessing project parameters or reexamining the tendering process.

Finally tenderers should be allowed to submit, if appropriate, variant solutions in their bids that allow them present innovative approaches and technologies. Under such a scheme bidders would submit in effect two bids: one that meets the original conditions and an alternative approach. In order to successfully implement this approach it is important to define the desired outcomes carefully and set minimum required standards for all bidders.

iv. Increasing transparency and comparability across projects

To ensure that PPPs realize gains that are in-line with government and public stakeholder expectations, Arab governments should mandate a Public Sector Comparator that applies for all major government projects. This analytical tool will allow the comparison of life cycle costs, both upfront capital costs as well as ongoing O&M costs, of PPPs to government funded infrastructure and services. The comparator should include a consistent estimate for the cost of capital for government funded projects perhaps based on an estimate of the cost of risk avoided by the government (e.g., the risk of potential project delays), or the opportunity cost of investing in power supply infrastructure instead of other development priorities. Such a tool would be even more powerful if applied consistently to projects across a group of countries in the region as it would give better visibility on investor risk appetites and risk/reward expectations (Sarraf, 2010).

B. Facilitating Equity and Debt Financing Conditions

Sustainable investments in energy supply infrastructure require the mobilization of considerable local equity and debt financing. On the equity side there is limited room for government action besides providing targeted grants to develop strategic projects that are inherently unattractive to private investors due to long maturities or unusually high risks (e.g., transmission infrastructure, and renewables technologies). These grants should be used

sparingly and only as a means for attracting funds from additional sources. Through careful deployment of these grants and other fiscal incentives, Arab governments could encourage long-term institutional investors like large pension funds, insurance companies and development banks to establish funds that specialize in infrastructure investments.

On the debt side, public utilities and private developers need better access to corporate bond and Islamic Sukuk markets. Despite having higher transaction costs, longer lead times and less flexibility than commercial loans, bonds typically offer longer maturities and lower interest rates. More importantly, bonds allow access to considerably larger volumes of funds than commercial lenders can possibly offer. Corporate and project-level bonds would complement corporate and project level commercial loans and allow developers greater flexibility in arranging the most competitive financing for IPPs and other infrastructure investments. For highly strategic transmission projects that face challenges in attracting commercial debt due to an average economic life of 50 years and low returns, governments can intervene on a targeted basis to increase the credit quality of the debt. This can be achieved either through a contingent credit line to guarantee debt service or through creating an additional buffer of subordinated debt by a government lender (Al Barak, 2013).

Public utilities and regulatory authorities should consider giving developers and other investors the flexibility to use creative legal instruments that can vary the risk allocation between majority and minority project partners based on either achieving project milestones or a certain yield threshold (e.g. partnership flips and sale leasebacks arrangements). Such schemes allow the optimal allocation of risk to the private partner that is most capable of managing it at each phase of the project.

C. Promoting Renewable Energy Supply Investments

Unlocking private investments in renewable energy supply starts with a demonstration of political will and commitment to sustainability at the highest level. Arab governments must articulate a clear national strategy for deploying renewable technologies and establish clear and realistic national targets for developing renewable generation capacity. An effective strategy would provide certainty to investors, reduce regulatory risk, and enhance the credibility of any subsequent incentives framework (El Husseini, 2011, and Razavi, 2012). To date only Morocco, Algeria, Tunisia, Egypt and Jordan have officially defined renewable energy targets (REN21, 2013).

Arab governments need to introduce feed-in tariffs, a proven renewable energy incentive mechanism that has had a global track record of success. In contrast to volume setting quota policy tools like renewable portfolio standards (RPS), Feed-in tariffs address the underlying structural distortions by diverting the flow of subsidies from fossil fuels to private sector-lead development of renewable energy. Developers should be encouraged to access international funds like the Green Climate Fund and to leverage the international carbon market to supplement project revenues through Clean Development Mechanism credits (CDM CERs) (Razavi, 2012). Typical international benchmarked feed-in tariffs for utility-scale wind are between 8.7 and 29.4 US cents per kWh and for large Solar PV between 14.2 and 53.4 US cents per kWh (REN21, 2013).

D. Building the capabilities of regulatory authorities

The separation of policymaking, regulation and operations is a relatively recent phenomenon in Arab electricity sectors. Implementation of the initiatives mentioned in the previous subsections requires the development of capabilities and competencies among power sector regulatory authority employees necessary to bring about and sustain significant performance improvement including technical/economic analysis, strategic planning, and management. The foundation of a successful capabilities building program is the establishment of power sector regulation as a profession through continuous training, and standardized formal qualification and certification of employees. This professionalization of the regulatory activities would be more effective if competency standards, training curricula and certifications are implemented on a regional or pan-Arab level.

V. CONCLUSION

The past-decade has profoundly reshaped the energy supply sector in Arab countries; the pace of change will only accelerate in the coming years. Elevated aspirations for socio-economic improvement and economic growth will require substantial investments in generation capacity as well as transmission and distribution networks. At the same time, governments are coming under increased pressure to divert scarce public resources to other development priorities like healthcare and education.

Policymakers in the Arab region must play a fundamental role in establishing the appropriate enablers for private sector participation in energy supply infrastructure investments, including well-defined policies and a sound regulatory framework. They should build on the already established IPP model with modifications to address a few key limitations. By establishing prudent long-term government liabilities management, building capable regulatory institutions and deploying methodical project tendering processes, Arab governments can leverage limited public funds to attract significant private sector investments into building an energy supply infrastructure that can support their long-term economic growth and sustainable development objectives. Policymakers need to act to facilitate the mobilization of local equity and debt financing through supporting the establishment of third-party investment funds, developing more flexible legal instruments (e.g. partnership flips and sale leasebacks), and granting infrastructure developers better access to corporate bond/Islamic Sukuk markets.

Furthermore, policymakers/regulators should enable comparability across projects and countries through increased transparency regarding factors influencing investment decision including projected investment plans, fuel supply allocations, and remuneration mechanisms. Finally, in order to promote the development of renewable energy generation, Arab policymakers need to put in place incentive mechanisms that level the playing field between renewables and conventional technologies that run on heavily subsidized fossil fuels. Indeed, the long-term financial viability of the power sector as a whole and of renewables in particular, hinges upon the ability of governments to phase out subsidies and reform electricity tariffs so that they reflect the full economic cost of generating and delivering a kilowatt-hour.

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NOTES

1. Section II. Financing Energy Supply Infrastructure Projects in Arab Countries
   Sidi Krir IPP was developed jointly by Edison International SpA and InterGen, whereas Port Said and Suez IPPs were developed by EdF. These developers, who had their sights set on taking part in a large IPP program, opted to sell their assets to international investors (respectively to Globeleq and Tanjong Public Limited Company) after less than two years of operations.

2. Section III. Private Sector Financing Challenges and Barriers
   Forecast of contingent IPP/IWPP liabilities, shown in Figure 4, was based on announced IPP / IWPP programs, Booz & Company estimates of capital and operating cost and an average weighted cost of capital WACC of 8 percent

   The analysis of typical utility cost structure, shown in Figure 5, assumes a newly built natural gas combined cycle (NGCC) plant, a fuel price paid by the utility of US$ 1 per MMBtu, a market fuel price of US$ 7 per MMBtu, plant life of 25 years, overnight cost of US$ 700 per kilowatt, and a real cost of capital of 4.5 percent

3. Section IV. A New Policy Framework for Energy Supply
   Saudi Electricity Company, which has a corporate credit rating of AA- from Standard and Poor's, AA- from Fitch, and A1 from Moody's, has had significant success in raising financing through corporate Sukuk. Since 2007 the company has raised more than US$ 5 Billon through multiple 20 year issuances with Coupon rates between SAIBOR + 0.45 percent and SAIBOR +1.6 percent. (SEC, 2011)
   The discussion of renewable energy project financing applies to a large degree to energy efficiency project financing. Such shared and guaranteed savings energy performance contracts involve paying back investment costs for more efficient equipment and technologies through cash flow from energy savings. These technologies are proven and economic if the true cost of fuel and/or electricity is taken into account. However, governments could, for example, contract a private Energy Services Provider, to finance and install solar water heating systems for a public school or group of schools. The private Energy Services provider would have to guarantee that the resulting energy savings will meet or exceed the annual payments to cover capital and operating expenditures. The method for measuring and calculating savings needs to be explicitly defined and agreed upon a priori. The private investor bears the risk of the savings not materializing.

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Acronyms and Abbreviations

AAAID	Arab Authority for Agricultural Investment and Development
ABSP	Agricultural Biotechnology Support Programme
AC	Air-conditioning
AC	Alternating current
ACSAD	Arabic Centre for the Studies of Arid Zones and Drylands
ADA	Arriyadh Development Authority (Riyadh)
ADCO	Abu Dhabi Company for Onshore Oil Operations
ADEREE	The National Agency for Energy Efficiency and the Development of Renewable Energy
ADFD	Abu Dhabi Fund for Development
ADR	Alternative Disputes Resolution
ADWEA	Abu Dhabi Water & Electricity Authority
AED	United Arab Emirates Dirham
AEPC	African Environmental Protection Commission
AEPS	Arctic Environmental Protection Strategy
AEWA	African-Eurasian Waterbird Agreement
AFED	Arab Forum for Environment and Development
AFESD	Arab Fund for Economic and Social Development
AG	Associated Gas
AGERI	Agricultural Genetic Engineering Institute
AGP	Arab Gas Pipeline
AGU	Arabian Gulf University
AHD	Aswan High Dam
AHDR	Arab Human Development Report
AIA	Advance Informed Agreement
AIDS	Acquired Immunodeficiency Syndrome
AIECGC	Arab Investment and Export Credit Guarantee Corporation
AKTC	Aga Khan Trust for Culture
Al	Aluminum
ALBA	Aluminium Bahrain
ALECSO	Arab League Educational, Cultural, and Scientific Organization
ALMEE	Lebanese Association for Energy Saving & Environment
ALOA	Association for Lebanese Organic Agriculture
AMCEN	African Ministerial Conference on the Environment
AMF	Arab Monetary Fund
AMU	Arab Maghreb Union
ANME	National Agency for Energy Management
AoA	Agreement on Agriculture (WTO Uruguay Round)
AOAD	Arab Organization for Agricultural Development
AP	Advanced Passive reactor
AP	Additional Protocol
API	Arab Planning Institute
APR	Advanced Power Reactor
APRUE	National Agency for the Promotion and Rationalization of Use of Energy
AREE	Aqaba Residence Energy Efficiency
ASABE	American Society of Agricultural and Biological Engineers
ASDRR	Arab Strategy for Disaster Risk Reduction

ASR	Aquifer Storage and Recovery
AU	African Union
AUB	American University of Beirut
AUM	American University of Madaba (Jordan)
AWA	Arab Water Academy
AWC	Arab Water Council
AWCUA	Arab Water Countries Utilities Association
b/d	Barrels per Day
BADEA	Arab Bank for Economic Development in Africa
BAU	Business as Usual
Bbl	Oil Barrel
BCH	Biosafety Clearing House
Bcm	Billion cubic meters
BCWUA	Branch Canal Water User Association
BDB	Beyond Design Basis
BDL	Central Bank of Lebanon
BGR	German Geological Survey
BMP	Best Management Practices
BMZ	German Federal Ministry of Economic Cooperation and Development
BNEF	Bloomberg New Energy Finance
BOD	Biological Oxygen Demand
boe	Barrels of Oil Equivalent
BOO	Build-Own-Operate
BOOT	Build Own Operate Transfer
BOT	Build Operate Transfer
BP	British Petroleum
BREEAM	Building Research Establishment Environmental Assessment Method
BRO	Brackish Water Reverse Osmosis
BRS	ARZ Building Rating System
BU	Boston University
C&D	Construction and Demolition
C&I	Commercial and Industrial
CA	Conservation Agriculture
CAB	Centre for Agriculture and Biosciences
CAGR	Compound Annual Growth Rate
CAIP	Cairo Air Improvement Project
CAMP	Coastal Area Management Project
CAMRE	Council of Arab Ministers Responsible for the Environment
CAN	Competent National Authority
CBC	Community-Based Conservation
CBD	Convention on Biological Diversity
CBO	Community-Based Organization
CBSE	Center for the Study of the Built Environment (Jordan)
CCA	Climate Change Adaptation
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Sequestration
CCS	Carbon Capture and Storage
CCS CO_2	Capture and Storage
CD	Compact Disk
CDM	Clean Development Mechanism
CDRs	Certified Emissions Reductions
CEDARE	Centre for Environment and Development for the Arab Region and Europe
CEDRO	Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon
CEIT	Countries with Economies in Transition
CEO	Chief Executive Officer
CEP	Coefficient of Performance
CERES	Coalition for Environmentally Responsible Economics
CERs	Credits
CFA	Cooperative Framework Agreement
CFC	Chloro-Fluoro-Carbon

CFL	Compact Fluorescent Light
CFL	Compact Fluorescent Lamp
CGIAR	Consultative Group on International Agricultural Research
CH4	Methane
CHN	Centre Hospitalier du Nord -Lebanon
CHP	Combined Heat and Power
CILSS	Permanent Interstate Committee for Drought Control in the Sahel
CIRAD	Agricultural Research for Development
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CIWM	Chartered Institution of Wastes Management
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies
CLO	Compost-Like-Output
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CM	Carbon Management
CMI	Community Marketing, Inc.
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CNA	Competent National Authority
CNCA	Public Agricultural Bank
CNG (CNS)	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
$CO_{2e/eq}$	CO_2 equivalent
COD	Chemical Oxygen Demand
COP	Conference of the Parties
CPB	Cartagena Protocol on Biosafety
CPC	Calcined Petroleum Coke
CRS	Center for Remote Sensing
CSD	Commission on Sustainable Development
CSEM	Centre Suisse d›Electronique et de Microtechnique
CSP	Concentrated Solar Power
CSR	Corporate Social Responsibility
CTAB	Technical Center of Organic Agriculture
cum	Cubic meters
CZIMP	Coastal Zone Integrated Management Plan
DALYs	Disability-Adjusted Life Years
DBFO	Design Build Finance Operate
DBO	Design-Build-Operate
DC	Direct current
DED	Dubai Economic Department
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DEM	Digital Elevation Model
DESA	Department of Economic and Social Affairs
DEWA	Dubai Electricity and Water Authority
DFID	UK Department for International Development
DHW	Domestic Hot Water
DII	DESERTEC Industrial Initiative
DMN	Moroccan National Meteorological Office
DNE	Daily News Egypt
DOE	United States Department of Energy
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSIRE	Database of State Incentives for Renewables & Efficiency
DTCM	Dubai Department for Tourism and Commerce Marketing
DTIE	UNEP Division of Technology, Industry, and Economics
DTO	Dublin Transportation Office
DUBAL	Dubai Aluminum Company Limited
E3G	Third Generation Environmentalism
EAD	Environment Agency AbuDhabi
ECA	Economic Commission for Africa
ECAs	Energy Conversion Agreements

ECE	Economic Commission for Europe
ED	Electrodialysis
EDCO	Electricity Distribution Company
EDF	Environmental Defense Fund
EDL	Electricité du Liban
EE	Energy Efficiency
EEAA	Egyptian Environmental Affairs Agency
EEHC	Egyptian Electricity Holding Company
EF	Ecological Footprint
EGBC	Egyptian Green Building Council
EGPC	Egyptian General Petroleum Corporation
EGS	Environmental Goods and Services
EIA	Energy Information Administration
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
EMA	Europe, the Middle East, and Africa
EMAL	Emirates Aluminium Company Limited
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
ENEC	Emirates Nuclear Energy Corporation
ENPI	European Neighborhood and Partnership Instrument
ENSO	El Nĩo-Southern Oscillation
EOR	Enhanced Oil Recovery
EPA	US Environmental Protection Agency
EPC	Engineering Procurement and Construction
EPD	European Patent Office
EPDRB	Environmental Program for the Danube River Basin
EPI	Environment Performance Index
EPSA	Exploration and Production Sharing Agreement
ESAUN	Department of Economic and Social Affairs
ESBM	Ecosystem-Based Management
ESCOs	Energy Service Companies
ESCWA	United Nations Economic and Social Commission for Western Asia
ESI	Environment Sustainability Index
ESMAP	World Bank Energy Sector Management Assistance Program
ETM	Enhanced Thematic Mapper
EU	European Union
EU ETS	European Union Emission Trading System
EVI	Environmental Vulnerability Index
EWRA	Egyptian Water Regulatory Agency
EWS	Emirates Wildlife Society
FACE	Free Air Carbon Enrichment
FANR	The Federal Authority for Nuclear Regulation (UAE)
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FEMIP	Facility for Euro-Mediterranean Investment and Partnership
FFEM	French Fund for Global Environment
FiBL	Research Institute of Organic Agriculture
FIFA	Fédération Internationale de Football Association
FIT	Feed-in-Tariff
FOEME	Friends of the Earth Middle East
FSU	Former Soviet Union
F-T	Fischer-Tropsch process
FTIAB	Packaging and Newspaper Collection Service (Sweden)
G7	Group of Seven: Canada, France, Germany, Italy, Japan, United Kingdom, United States
G8	Group of Eight: Canada, France, Germany, Italy, Japan, Russian Federation,United Kingdom, United States
GAPs	Good Agricultural Practices
GAS	Guarani Aquifer System
GATT	General Agreement on Tariffs and Trade
GBC	Green Building Council

GBIF	Global Biodiversity Information Facility
GCC	Gulf Cooperation Council
GCM	General Circulation Model
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GE	General Electric
GECF	Gas Exporting Countries Forum
GEF	Global Environment Facility
GEMS	Global Environment Monitoring System
GEO	Global Environment Outlook
GERD	Gross Domestic Expenditure on Research and Development
GFEI	Global Fuel Economy Initiative
GFU	Global Facilitation Unit for Underutilized Species
Gha	Global hectare
GHGs	Greenhouse Gases
GIPB	Global Partnership Initiative for Plant Breeding Capacity Building
GIS	Geographical Information Systems
GIWA	Global International Waters Assessment
GJ	GigaJoule
GLASOD	Global Assessment of Soil Degradation
GLCA	Global Leadership for Climate Action
GM	Genetically Modified
GME	Gazoduc Maghreb Europe
GMEF	Global Ministerial Environment Forum
GMO	Genetically Modified Organism
GNI	Gross National Income
GNP	Gross National Product
GPC	Green petroleum Coke
GPRS	Green Pyramid Rating System
GRI	Global Reporting Initiative
GRID	Global Resource Information Database
GSDP	General Secretariat for Development planning-Qatar
GSI IISD	Global Subsidies Initiative
GSLAS	General Secretariat of League of Arab States
GSR	Global Status Report
Gt	Gigaton
GTZ	German Technical Cooperation (Gesellschaft für Technische Zusamm)
GVC	Civil Volunteers' Group (Italy)
GW	Gigawatt
GW	Greywater
GW_e	Gigawatt electrical
GWI	Global Water Intelligence
GWP	Global Warming Potential
GWP	Global Water Partnership
GW_{th}	Gigawatt-thermal
ha	Hectares
HACCP	Hazardous Analysis and Critical Control Points
HDI	Human Development Index
HFA	Hyogo Framework for Action
HFCs	Hydrofluorocarbons
HFO	Heavy Fuel Oil
HIV	Human Immunodeficiency Virus
HLW	High Level Waste
HNWI	High Net Worth Individuals
HVAC	Heating, Ventilation, and Air-Conditioning
I/M	Inspection and Maintenance
IAASTD	International Assessment of Agricultural Knowledge Science and Technology for Development
IAEA	International Atomic Energy Agency
IAS	Irrigation Advisory Service
IC	Irrigation Council

ICAM	Integrated Coastal Area Management
ICARDA	International Center for Agricultural Research in Dry Areas
ICBA	International Center for Biosaline Agriculture
ICC	International Chamber of Commerce
ICGEB	International Center for Genetic Engineering and Biotechnology
ICLDC	Imperial College London Diabetes Centre
ICM	Integrated Coastal Management
ICPDR	International Commission for the Protection of the Danube River
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IDA	International Desalination Association
IDB	Islamic Development Bank
IDECO	Irbid District Electricity Company
IDRC	International Development Research Center
IDSC	Information and Decision Support Center
IEA	International Energy Agency
IEADSM	International Energy Agency Demand-side Management
IEEE	Institute of Electrical and Electronic Engineers
IFA	International Fertilizer Industry Association
IFAD	International Fund for Agricultural Development
IFOAM	International Federation of Organic Agriculture Movements
IFPRI	International Food Policy Research Institute
IGCC	Integrated Gasifier Combined Cycle
IHP	International Hydrology Program
IIED	International Institute for Environment and Development
IIIEE	Lund University International Institute for Industrial Environmental Economics
IIIP	Integrated Irrigation Improvement Project
IIP	Irrigation Improvement Project
IISD	International Institute for Sustainable Development
ILO	International Labour Organization
ILW	Intermediate Level waste
IMC	Istituto Mediterraneo Di Certificazione
IMF	International Monetary Fund
IMO	International Maritime Organization
InWEnt	Capacity Building International-Germany
IO	Input-Output
IOC	International Oil Companies
IPCC	Intergovernmental Panel on Climate Change
IPF	Intergovernmental Panel on Forests
IPM	Integrated Pest Management
IPP	Independent Power Producer
IPR	Intellectual Property Rights
IPTRID	International Program for Technology and Research in Irrigation and Drainage
IRENA	International Renewable Energy Agency
IRESEN	Institut de Recherche en Energie Solaire et en Energies Nouvelles
IRR	Internal Rate Of Return
ISCC	Integrated Solar Combined Cycle
ISESCO	Islamic Educational, Scientific, and Cultural Organization
ISIC	UN International Standard Industrial Classification
ISO	International Organization for Standardization
ISWM	Integrated Solid Waste Management
ITC	Integrated Tourism Centers
ITC	International Trade Center
ITSAM	Integrated Transport System in the Arab Mashreq
IUCN	International Union for Conservation of Nature
IUCN	World Conservation Union (International Union for the Conservation of Nature and Natural Resources)
IWMI	International Water Management Institute
IWPP	Independent Water And Power Producer
IWRB	International Waterfowl and Wetlands Research Bureau
IWRM	Integrated Water Resources Management

JAEC	Jordan Atomic Energy Commission
JBAW	Jordan Business Alliance on Water
JD	Jordanian Dinar
JEPCO	Jordan Electric Power Company
JI	Joint Implementation
JMWI	Jordan Ministry for Water and Irrigation
JNRC	Jordan Nuclear Regulatory Commission
JVA	Jordan Valley Authority
KA-CARE	King Abdullah City for Atomic and Renewable Energy
KACST	King Abdulaziz City for Science and Technology
KAUST	King Abdullah University of Science and Technology
KEPCO	Korea Electric Power Corporation
KFAED	Kuwait Fund for Arab Economic Development
KFUPM	King Fahd University of Petroleum and Minerals
KfW	German Development Bank
KISR	Kuwait Institute for Scientific Research
KSA	Kingdom of Saudi Arabia
KW	Kilowatt
kWh	Kilowatt-hour
LADA	Land Degradation Assessment of Drylands
LAS	League of Arab States
LATA	Lebanese Appropriate Technology Association
LAU	Lebanese American University
LBNL	Lawrence Berkeley National Laboratory
LCC	Life Cycle Costing
LCEC	Lebanese Center for Energy Conservation
LCOE	Levelized Costs of Electricity
LDCs	Least Developed Countries
LED	Light-Emitted Diode
LEED	Leadership in Environmental Design
LEMA	Suez Lyonnaise des Eaux, Montgomery Watson and Arabtech Jardaneh
LEU	Low-enriched Uranium
LGBC	Lebanon Green Building Council
LLW	Low Level Waste
LMBAs	Land and Marine Based Activities
LMEs	Large Marine Ecosystems
LMG	Like Minded Group
LMO	Living Modified Organism
LNG	Liquefied Natural Gas
LowCVP	Low Carbon Vehicle Partnership
LPG	Liquefied Petroleum Gas
LRA	Litani River Authority
LV	Low Voltage
MAAR	Syrian Ministry of Agriculture and Agrarian Reform
MAD	Moroccan Dirham
MALR	Ministry of Agriculture and Land Reclamation
MAP	UNEP Mediterranean Action Plan
MARPOL	International Convention for the Prevention of Pollution from Ships
MASEN	Moroccan Agency for Solar Electricity
mb/d	million barrels per day
MBT	Mechanical-biological treatment
MCM	Million Cubic Meters
MD	Membrane Distillation
MDGs	Millennium Development Goals
MEA	Multilateral Environmental Agreement
MECTAT	Middle East Centre for the Transfer of Appropriate Technology
MED	Multiple-Effect Distillation
MED WWR WG	Mediterranean Wastewater Reuse Working Group
MED-ENEC	Energy Efficiency in the Construction Sector in the Mediterranean
MEES	Middle East Economic Survey

MEMAC	Marine Emergency Mutual Aid Centre
MENA	Middle East and North Africa
MEPS	Minimum Energy Performance Standards
METAP	UNEP Mediterranean Environmental Technical Assistance Program
MEW	Lebanese Ministry of Energy and Water
MGD	Million Gallon per Day
MHT	Mechanical Heat Treatment
MICE	Meetings, Incentives, Conferences, And Events
MIST	Masdar Institute of Science and Technology
MMBTU	One Million British Thermal Units
MMCP	Making the Most of Commodities Programme
MNA	Multinational Approaches
MOQ	Maersk Oil Qatar
MOU	Memorandum of Understanding
MOX	Mixed-Oxide
MPA	Marine Protected Area
MSF	Multi-Stage Flash
MSP	Mediterranean Solar Plan
MSW	Municipal Solid Waste
Mt	Metric tons
MT	Million ton
Mt	Megatons
$MtCO_2$	Million tons of CO_2
Mtoe	Million tons of oil equivalent
MTPY	Metric Tons Per Year
MV	Medium Voltage
MW	Megawatt
MW_h	Megawatt-hour
MW_p	Megawatt-peak
MWRI	Ministry of Water Resources and Irrigation
MW_{th}	Megawatt-thermal
N_2O	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Actions
NARI	National Agricultural Research Institutes
NASA	National Aeronautics and Space Administration
NBC	National Biosafety Committee
NBDF	Nile Basin Discourse Forum
NBF	National Biosafety Framework
NBI	Nile Basin Initiative
NBM	Nile Basin Management
NC	National Communication
NCSR	Lebanese National Council of Scientific Research
ND	Neighborhood Development
NDW	Moroccan National Drought Watch
NEA	Nuclear Energy Agency
NEAP	National Environmental Action Plan
NEEAP	National Energy Efficiency Action Plan
NEEP	National Energy Efficiency Program
NEEREA	National Energy Efficiency and Renewable Energy Action (Lebanon)
NERC	National Energy Research Centre
NF	Nano-Filtration
NFC	Nile Forecast Center
NFP	National Focal Point
NGCCs	Natural-Gas-Fired Combined Cycles
NGO	Non-Governmental Organization
NGV	Natural Gas Vehicles
NGWA	Northern Governorates Water Authority (Jordan)
NIF	Neighborhood Investment Facility
NOAA	National Oceanic and Atmospheric Administration
NOC	National Oil Company

NOEC	Net Oil Exporting Countries
NOGA	National Oil and Gas Authority (Bahrain)
NOIC	Net Oil Importing Countries
NORDEN	Nordic Council of Ministers
NOx	Nitrogen Oxides
NPK	Nitrogen, Phosphates and Potash
NPP	Nuclear Power Plant
NPP	Net Primary Productivity
NPPA	Nuclear Power Plant Authority
NPT	Non-Proliferation treaty of nuclear weapons
NRC	National Research Council
NREL	National Renewable Energy Laboratory
NRW	Non-Revenue Water
NSAS	Nubian Sandstone Aquifer System
NSR	North-South Railway project
NUS	Neglected and underutilized species
NWRC	National Water Research Center (Egypt)
NWSAS	North Western Sahara Aquifer System
O&M	Operation and Maintenance
OAPEC	Organization of Arab Petroleum Exporting Countries
OAU	Organization for African Unity
ODA	Official Development Assistance
ODS	Ozone-Depleting Substance
OECD	Organization for Economic Co-operation and Development
OFID	OPEC Fund for International Development
OIES	Oxford Institute for Energy Studies
OME	Observatoire Méditerranéen de l'Energie
OMW	Olive Mills Wastewater
ONA	Omnium Nord-Africain
ONE	National Electricity Office
ONEP	National Office of Potable Water
OPEC	Organization of Petroleum Exporting Countries
OSS	Sahara and Sahel Observatory (Observatoire du Sahara et du Sahel)
PACD	Plan of Action to Combat Desertification
PC	Personal Computer
PCB	Polychlorinated Biphenyls
PCFPI	Per Capita Food Production Index
PCFV	Partnership for Clean Fuels and Vehicles
PEA	Palestinian Energy and Natural Resources Authority
PERG	Global Rural Electrification Program
PERSGA	Protection of the Environment of the Red Sea and Gulf of Aden
PFCs	Perfluorocarbons
PICs	Pacific Island Countries
PIM	Participatory Irrigation Management
PM	Particulate Matter
PMU	Program Management Unit
PNA	Palestinian National Authority
PNEEI	Tunisian National Program of Irrigation Water Conservation
POPs	Persistent Organic Pollutants
PPA	Power Purchase Agreement
PPIAF	Public-Private Infrastructure Advisory Facility
PPM	Parts Per Million
PPM	Process and Production Methods
PPP	Public-Private Partnership
PPP	Purchasing Power Parity
PPP	Public-Private Partnership
PRM	Persons with Reduced Mobility
PRY	Potential Researcher Year
PTSs	Persistent Toxic Substances
PV	Photovoltaic

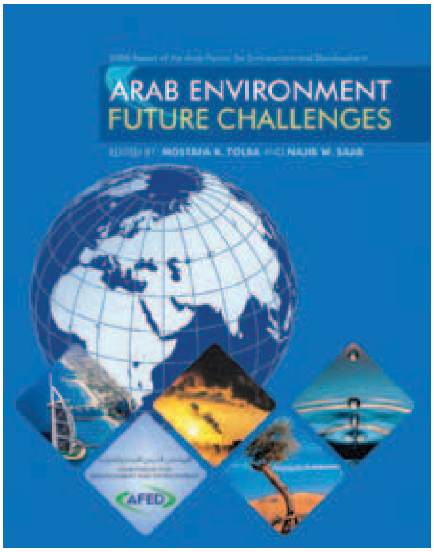
PWA	Palestinian Water Authority
QNFSP	Qatar National Food Security Programme
QP	Qatar Petroleum
QSAS	Qatar Sustainable Assessment System
R&D	Research and Development
RA	Risk Assessment
RADEEMA	Régie autonome de distribution de l'eau et de l'électricité de Marrakech
RBO	River Basin Organization
RBP	Restrictive Business Practices
RCM	Regional Circulation Model
RCREEE	Regional Center for Renewable Energy and Energy Efficiency
RDF	Refuse Derived Fuel
RE	Renewable Energy
REC	Renewable Energy Credits
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
REN21	Renewable Energy Policy Network for the 21st Century
Rep	Republic
RM	Risk Management
RO	Reverse Osmosis
ROPME	Regional Organization for the Protection of the Marine Environment of the sea area surrounded by Bahrain, I.R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates
RPS	Renewable Portfolio Standard
RSA	ROPME Sea Area
RSC	Royal Society of Chemistry (UK)
RSCN	Royal Society for the Conservation of Nature
RSGA	Red Sea and Gulf of Aden
S&T	Science and Technology
SAIC	Science Applications International Corporation
SAP	Strategic Action Program
SCP	Sustainable Consumption and Production
SCPI	Sustainable Crop Production Intensification
SD	Sustainable Development
SEA	Strategic Environmental Assessment
SFD	Saudi Fund for Development
SHS	Solar Home System
SIR	Shuttle Imaging Radar
SIWI	Stockholm International Water Institute
SL	Syrian Pound
SLR	Sea Level Rise
SME	Small and Medium-Size Enterprises
SoE	State of the Environment
SONEDE	Société Nationale d'Exploitation et de Distribution des Eaux
SOx	Sulfur Oxides
SPD	Sozialdemokratische Partei Deutschlands
SPM	Suspended Particulate Matter
SRES	Special Report on Emission Scenarios
SRTM	Shuttle Radar Topography Mission
SWCC	Saline Water Conversion Corporation
SWH	Solar Water Heating
SWRO	Seawater Reverse Osmosis
T&D	Transmission and Distribution
TAC	Technical Advisory Committee
TAR	Third Assessment Report
Tcm	Trillion cubic meters
TDM	Transportation Demand Management
TDS	Total Dissolved Solids
TES	Thermal Energy Storage
TFP	Total factor productivity
TIES	The International Ecotourism Society
TII	Thermal Insulation Implementation

Toe	Tons of Oil Equivalent
TPES	Total Primary Energy Supply
TRAFFIC	Trade Records Analysis for Flora and Fauna in International Commerce
TRI	Toxics Release Inventory
TRIPs	Trade-Related Aspects of International Property Rights
TRMM	Tropical Rainfall Measuring Mission
tU	tones of Uranium
TWh	Terawatt-hour
UAE	United Arab Emirates
UCLA	University of California at Los Angeles
UCS	Union of Concerned Scientists
UF	Ultrafiltration
UfM	Union for the Mediterranean
UHCPV	Ultra-High Concentration Photovoltaic
UHI	Urban Heat Island
UIS	UNESCO Institute for Statistics
UK	United Kingdom
UMA	Union du Maghreb Arabe (Arab Maghreb Union)
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNCHS	United Nations Centre for Human Settlements (now UN-Habitat)
UNCLOS	United Nations Convention on the Law of the Sea
UNCOD	United Nations Conference on Desertification
UNCTAD	United Nations Conference on Trade and Development
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-ROSTAS	UNESCO Regional Office for Science and Technology for the Arab States
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNHCR	United Nations High Commission for Refugees
UNICE	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNISDR	United Nations International Strategy for Disaster Reduction
UNWTO	United Nations World Tourism Organization
UPC	Abu Dhabi Urban Planning Council
UPI	United Press International
USA	United States of America
USAID	United States Agency for International Development
USCCSP	United States Climate Change Science Program
USEK	Université Saint-Esprit De Kaslik
USEPA	United States Environmental Protection Agency
USJ	Saint Joseph University
USPTO	United States Patent and Trademark Office
UV	Ultraviolet (A and B)
VAT	Value-Added Tax
VC	Vapor Compression
VCM	Volatile Combustible Matter
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
VRS	Vapor Recovery System
WACC	Weighted Average Cost of Capital
WaDImena	Water Demand Initiative for the Middle East and North Africa
WAJ	Water Authority of Jordan
WALIR	Water Law and Indigenous Rights
WB	West Bank
WBCSD	World Business Council for Sustainable Development

WBGU	German Advisory Council on Global Change
WCD	World Commission on Dams
WCED	World Commission on Environment and Development
WCMC	UNEP World Conservation Monitoring Center
WCP	World Climate Programme
WCS	World Conservation Strategy
WDM	Water Demand Management
WDPA	World Database on Protected Areas
WEEE	Waste of Electronic and Electrical Equipment
WEF	World Economic Forum
WEI	Water Exploitation Index
WETC	Wind Energy Technology Centre
WF	Water Footprint
WFN	Water Footprint Network
WFP	World Food Programme
WGP-AS	Water Governance Program in the Arab States
WHO	World Health Organization
WIPP	Waste Isolation Pilot Plant
WMO	World Meteorological Organization
WNA	World Nuclear Association
Wp	Watt-peak
WRI	World Resources Institute
WSSCC	Water Supply and Sanitation Collaborative Council
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization
WTTC	World Travel and Tourism Council
WUA	Water User Association
WWAP	World Water Assessment Program
WWC	World Water Council
WWF	World Wide Fund for Nature
WWF	World Water Forum
WWI	First World War
WWII	Second World War
YR	Year

Arab Environment: Future Challenges

2008 Report
of the Arab Forum for Environment and Development



For the first time, a comprehensive independent expert report on Arab environment is released for public debate. Entitled *Arab Environment: Future Challenges*, this ground-breaking report has been commissioned by Arab Forum for Environment and Development (AFED), and written by some of the most prominent Arab experts, including authors, researchers and reviewers. Beyond appraising the state of the environment, based on the most recent data, the policy-oriented report also evaluates the progress towards the realization of sustainable development targets, assesses current policies and examines Arab contribution to global environmental endeavors. Ultimately, the report proposes alternative policies and remedial action.

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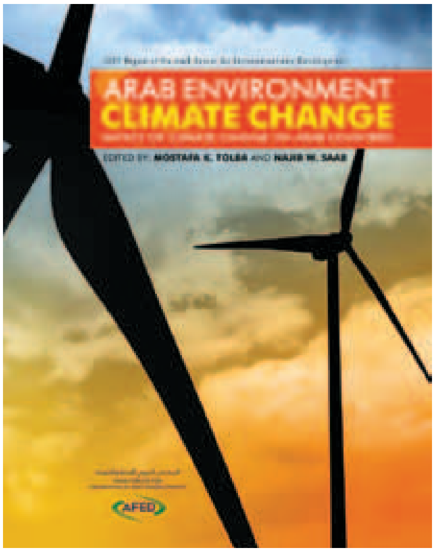
Arab Environment: Climate Change

2009 Report
of the Arab Forum for Environment and Development

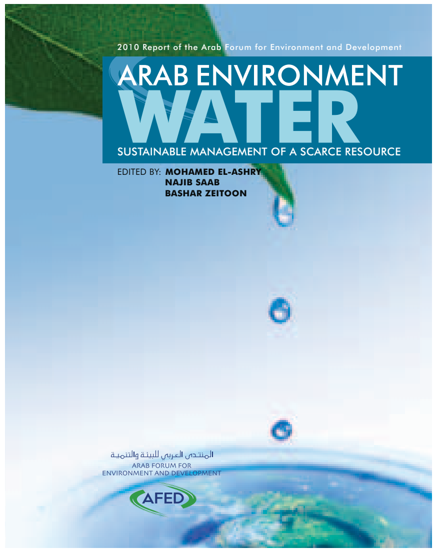


Impact of Climate Change on the Arab Countries is the second of a series of annual reports produced by the Arab Forum for Environment and Development (AFED). The report has been designed to provide information to governments, business, academia and the public about the impact of climate change on the Arab countries, and encourage concrete action to face the challenge.

The report analyzes the Arab response to the urgent need for adaptation measures, and uses the latest research findings to describe the vulnerabilities of natural and human systems in the Arab world to climate change and the impacts on different sectors. In an attempt to help shape adequate policies, the report discusses options for a post-Kyoto regime and outlines the state of international negotiations in this regard.

Arab Environment: Water

2010 Report
of the Arab Forum for Environment and Development



Water: Sustainable Management of a Scarce Resource is the third of a series of annual reports produced by the Arab Forum for Environment and Development (AFED). It follows the publication of two reports, Arab Environment: Future Challenges in 2008 and Impact of Climate Change on Arab countries in 2009.

The 2010 report is designed to contribute to the discourse on the sustainable management of water resources in the arab world and provides critical understanding of water in the region without being overly technical or academic in nature.

The unifying theme is presenting reforms in policies and management to develop a sustainable water sector in Arab countries. Case studies, with stories of successes and failures, are highlighted to disseminate learning.

This report contributes to the ongoing dialogue on the future of water and catalyzes institutional reforms, leading to determined action for sustainable water policies in Arab countries.

Arab Environment: Green Economy

2011 Report
of the Arab Forum for Environment and Development

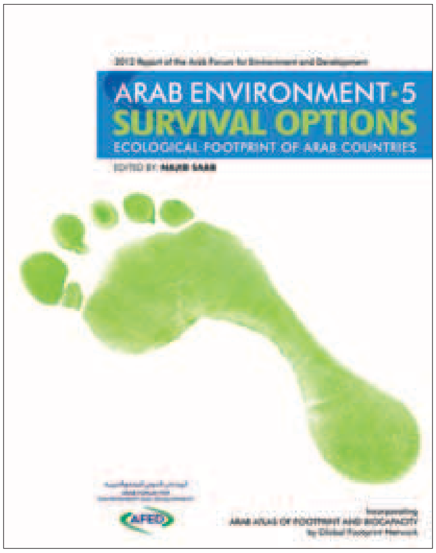
Green Economy: Sustainable Transition in a Changing Arab World is the fourth of a series of annual reports on the state of Arab environment, produced by the Arab Forum for Environment and Development (AFED).

This report on options of green economy in Arab countries represents the first phase of the AFED green economy initiative. Over one hundred experts have contributed to the report, and discussed its drafts in a series of consultation meetings.

The report is intended to motivate and assist governments and businesses in making a transition to the green economy. It articulates enabling public policies, business models, green investment opportunities, innovative approaches, and case studies, and addresses eight sectors: agriculture, water, energy, industry, cities and buildings, transportation, tourism, and waste management.

Arab Environment: Survival Options

2012 Report
of the Arab Forum for Environment and Development



Survival Options-Ecological Footprint of Arab Countries is the fifth in the series of annual reports produced by the Arab Forum for Environment and Development (AFED) on the state of the Arab environment. It examines sustainability choices in Arab countries, based on a survey of people's demand of natural capital and available supply.

The report discusses potential paths to sustainability based on ecological constraints. As a basis for the analysis, AFED has commissioned the Global Footprint Network, the world leader in this field, to produce an Arab Ecological Footprint and Biocapacity Atlas using the most recent data available. The Atlas covers the 22 members of the League of Arab States, as region, sub-regions and individual countries.

The analysis focuses on the challenges posed by the state of food security, water and energy, while considering main drivers such as population and patterns of production and consumption. Ultimately, it prescribes regional cooperation and sound management of resources as the main options for survival in a region characterized by stark variations in ecological footprint, natural resources and income.

Notes