RESOURCE EFFICIENCY FOR SUSTAINABLE DEVELOPMENT:

KEY MESSAGES FOR THE GROUP OF 20

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International Resource Panel

About the International Resource Panel

The International Resource Panel (IRP), a global scientific panel hosted by the United Nations Environment Programme, was created in 2007 to contribute to a better understanding of sustainable development from a natural resources perspective. It provides science-based policy options on how to decouple economic growth from environmental degradation while enhancing human well-being. With more than 20 scientific publications, the work of the Panel has shed some light on growing environmental challenges related to natural resources, their socio-economic implications and potential new pathways towards their sustainable management.

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Contents

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Preface

Natural Resources and the way in which we manage them hold the key to our future. The environment (including our climate), people, and the economy all depend on these. It has now been over a decade since the International Resource Panel (IRP) was launched to contribute to a better understanding of sustainable development from a natural resources perspective. More than 20 scientific publications have been completed and they paint a realistic but hopeful picture if we act now.

Through the work of the IRP, United Nations platforms like the High-level Political Forum, the United Nations Framework Convention on Climate Change (UNFCC), the United Nations Convention on Biological Diversity, United Nations Convention to Combat Desertification and the United Nations Environment Assembly, have all understood the challenges that lie ahead and the need to innovate in the way we consume and produce. They have also expressed support for more rigorous scientific evidence in decision making, especially when it comes to natural resources.

Resource efficiency is one of the approaches proposed by the IRP to decouple economic growth from environmental degradation while enhancing human well-being. Important political groups like the Group of 7 and the Group of 20 have recognised the opportunities that this approach could bring and acknowledged that an efficient and sustainable use of natural resources is vital for the achievement of all Sustainable Development Goals.

The International Resource Panel is honoured to provide scientific insight to the Resource Efficiency Dialogue of the Group of 20. This short document summarizes some of the work done by the IRP in this field, particularly on the status and trends of natural resources in the G20, the economic benefits of resource efficiency, the connections between climate and resources, and good practices and strategies that have been successfully implemented to improve resource efficiency. We trust that it provides scientific evidence for the implementation of the ambitious G20 agenda on natural resource management.

While the existing scientific knowledge is sufficient to initiate urgent policy action, some knowledge gaps should be filled in parallel. Particularly, the assessment of concrete economic opportunities from resource efficiency in the G20 and its social implications within different development contexts. Additionally, assessing options to monitor progress on resource efficiency within existing reporting frameworks like the Nationally Determined contributions of the Paris Agreement or the targets and indicators of the Sustainable Development Goals, could be a priority in future IRP research. We stand ready to provide scientific support to the G20 Dialogue on Resource Efficiency as needed.

Janez Potocnik
Co-Chair
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2

Resource Efficiency and Sustainable Development: Key messages for the G20

G20 countries represent a dynamic group of leading economies with a diverse set of visions and approaches for sustainable development. Member states come from all continents, produce 85 per cent of global economic output, have two-thirds of the global population, and are undertaking 75 percent of international trade[1]. The collective impact of this group could drive large-scale transformation in a direction that can lead us to the achievement of all 17 Sustainable Development Goals.

The International Resource Panel (IRP) prepared this document based on the modelling and findings of several of its scientific publications. More details about this paper can be found under the section "About this Paper". This first chapter provides a summary of the IRP messages on natural resource use and resource efficiency that are relevant to the G20.

Resource demand is increasing at an unsustainable pace. In 1900, the world consumed 7 billion tons of primary materials. By 2017, worldwide consumption of these materials reached 90 billion tonnes. By 2050 primary material use is expected to go up to 186 billion tonnes if current consumption trends continue (Hatfield-Dodds et al. 2017). This accelerated demand for resources has alarming environmental consequences. An estimated 4 out of 9 planetary boundaries have been surpassed, increasing the likelihood of irreversibly changing the way major Earth systems function, including our climate. Over the last few decades, a combination of habitat loss, overexploitation of natural resources, and pollution has led to catastrophic declines in biodiversity (IRP 2017b, p. 17). Ore grades for metals and industrial minerals are declining, and only less than one-third of existing metals have a recycling rate above 50 per cent, while most speciality metals have a recycling rate of less than 1 per cent (IRP 2015a, p.70). Today, 33 per cent of the world's soils are moderately to highly degraded, 20 per cent of aquifers are overexploited, and 29 per cent of 'commercial' fish populations are overfished (IRP 2016b). All of these changes are related to the way in which materials are used in the global economy.

1. https://www.g20.org/en/g20/what-is-the-g20

The G20 is responsible for more than two thirds of global material use and has, on average, higher growth rates for material use than the rest of the world. Following current trends, material use in G20 countries is expected to increase from 65.4 billion tonnes in 2015 to 142.2 billion tonnes by 2050. Sustainable management of materials in G20 countries will be critical to its sustained economic prosperity and the environmental sustainability that underpins it.

There is high inequality in the distribution, availability and use of natural resources and in the exposure to environmental risk factors across world regions and within countries and cities.

High-income countries currently consume 10 times higher quantities of materials per person than low-income countries. The 1.2 billion poorest people account for 1 per cent of the world's consumption, while the billion richest consume 72 per cent of the world's resources. In many cities, more than 30 to 40 per cent of the population is living without access to basic services, and the infrastructure deficit in water supply and sanitation, food supply and transportation places an undue burden on the poor and particularly on women (resulting in poverty, poor access to livelihoods and safety concerns) (IRP 2017b, p. 17). In 2015, about 11 per cent of the world's population were undernourished, more than half of which are in Asia (IRP 2017a, p.68).

As shown in Section 3 of this paper, natural resource use and its environmental impacts are unequally distributed across G20 countries, requiring tailored resource efficiency strategies across the group. Since high-income G20 countries use around 10 times as many natural resources compared to the lower middle income G20 countries, the high-income group will need to significantly invest in reducing their material requirements. Furthermore, the G20 high-income group also relies heavily on materials from abroad creating commensurate environmental pressures and impacts in the countries of origin of the materials.

The pressure on our natural resources will increase due to a growing population, economy and increasingly unsustainable patterns of production and consumption. If we continue current resource consumption trends, food requirements will increase by 60 per cent and water use by 40 per cent by 2030 (IRP 2017a, p.31). Global cropland would need to increase by up to 55 per cent (the equivalent of the size of Brazil) by 2050 (IRP 2014). These are all beyond the limits of the Earth's capacity.

There is potential to address these concerns through increased resource efficiency and productivity. This implies adding greater value to resources, maintaining that value by keeping resources in use for longer, and reducing the environmental impacts associated with the whole life cycle of resources, from their extraction to their disposal. Resource efficiency, identified as a core initiative of the G20, means achieving better economic outcomes and wellbeing while using fewer natural resources and reducing environmental releases, including greenhouse gas emissions – more from less. The concepts of resource and impact decoupling underline this logic[2].

2. *Resource decoupling* means improving human well-being while proportionately reducing resource use. *Impact decoupling* means improving human well-being while proportionately reducing negative environmental impacts.

Resource demand is increasing at an unsustainable pace.

7 bil tons
1970

90 bil tons
2017

186 bil tons
2050

World consumption of primary materials is expected to go up to **186 billion tons** by 2050 if current consumption trends continue.

4/9 planetary boundaries have been surpassed.

Only less than **1/3** of existing metals have a recycling rate above **50%**.

Most speciality metals have a recycling rate of **less than 1%**.

33% of the world's soils are moderately to highly degraded

20% of aquifers are overexploited

29% of 'commercial' fish populations are overfished

There is high inequality in the distribution, availability and use of natural resources across world regions .

Resource consumption per person

in high-income countries >

in low-income countries >

30-40% of urban population is living without access to basic services, while the poor and women bare particular burden.

In 2015, about **11%** of the world's population were undernourished

>50% are in Asia

Resource consumption pie

1% of world's resource consumption comes from the **1.2 billion** poorest people

the billion richest consume **72%** of the world's resources

There is growing scientific evidence of the multiple benefits of resource efficiency. Using materials – biomass, fossil fuels, metal ores and non-metallic minerals – more efficiently has a multitude of benefits. Resource efficiency reduces the speed at which natural resources are depleted. Operating with lower resource inputs reduces the economic vulnerability to price volatility at the global raw material markets and limits the environmental impacts that occur with resource extraction in agriculture, forestry, fishing, mining and quarrying. Improved energy efficiency in the transport sector, for example, may help improve economic resilience with regards to fuel related price volatility.

Lower levels of inputs help reduce waste flows and emissions and reduce costs for producers and consumers. Furthermore, resource efficiency stimulates innovation, the creation of new industries and further economic competitiveness. Ultimately, it is good not only for the environment but also for the economy.

The International Resource Panel modelled the economic and environmental consequences of ambitious resource efficiency and greenhouse gas abatement policies in the G7 (IRP 2017a). Results show that resource efficiency policies and initiatives could:

- reduce natural resource use globally by 28 per cent by 2050, in combination with ambitious global action on climate change, as well as stabilizing per capita resource use at current levels in G7 countries;
- reduce greenhouse gas emissions by an additional 15 to 20 per cent by 2050 (for a given set of greenhouse policies), with global emissions in 2050 falling to 63 per cent below 2015 levels, and emissions in G7 countries in 2050 falling to 74 per cent below 2015 levels, in combination with ambitious greenhouse gas abatement policies;
- more than offset the economic costs of ambitious climate action, so that income is higher and economic growth is stronger than in the 'existing trends' scenario;
- deliver annual economic benefits of USD $2 trillion globally by 2050 relative to existing trends, including benefits of USD $600 billion in G7 nations, while also helping put the world on track to limit climate change to 2°C or lower.

The multiple benefits of resource efficiency policies

reduce natural resource use globally by 28% by 2050

reduce global greenhouse gas emissions by 63% below 2015 levels by 2050

more than offset the economic costs of ambitious climate action

deliver annual economic benefits of USD 2 trillion globally by 2050

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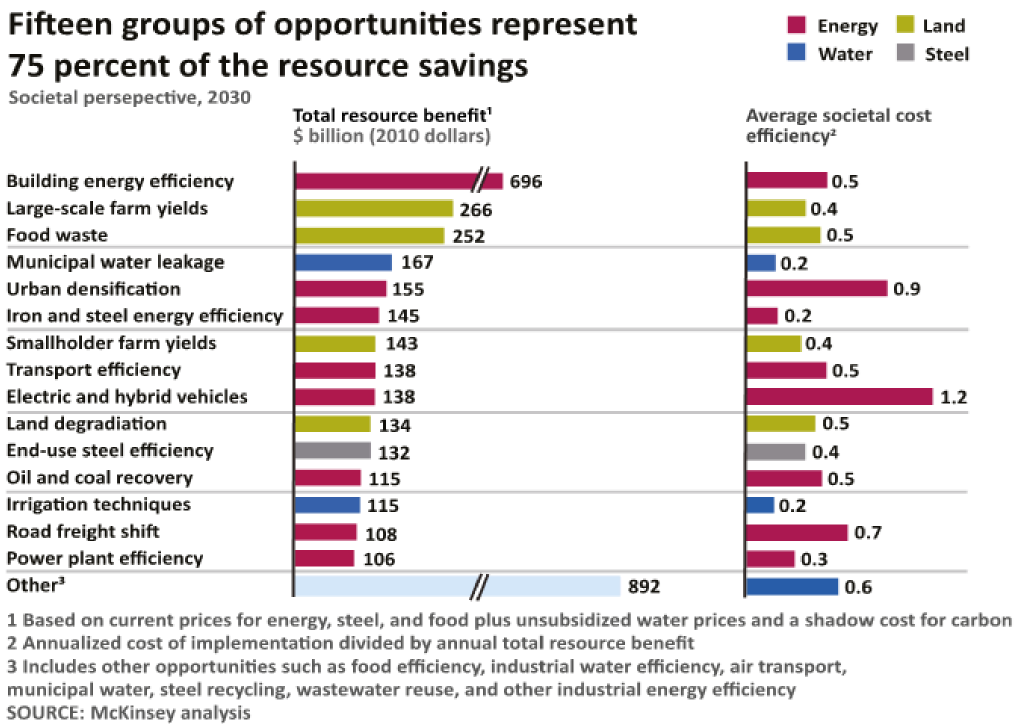
Resource efficiency is a requirement and an opportunity for sustained economic prosperity in G20 countries. According to IRP modelling, resource efficiency strategies could lead to a 7 per cent increase of GDP in the G20 compared to existing trends. If combined with climate mitigation, they may lead to a USD 2.1 trillion increase in GDP by 2050.

Resource Efficiency is practically attainable and there are many opportunities for its improvement in low, middle and high-income countries. It is estimated that 60 to 80 per cent improvements in energy and water efficiency are technically possible and commercially viable in construction, agriculture, food, industry, transport and other sectors compared to conventionally used technologies. This would deliver economic cost savings of 2.9 to 3.7 trillion USD per year by 2030. In 70 per cent of cases, the required resource efficient investment would offer a rate of return greater than 10 per cent per year. Investing some USD 900 billion could potentially generate 9 million to 25 million jobs (IRP 2017a, p.26).

Figure 1: The top 15 categories of resource efficiency potential[3]



Source: IRP 2017a, p.101

3. In this figure, if the number of "Average societal cost efficiency" is smaller than one, then the resource benefit is larger than the implementation cost. If it is 0.5 then the resource benefit is twice the cost, if it is 0.25 then the resource benefit is four times the implementation cost.

As reflected in the final section of this document, many positive experiences within G20 countries illustrate how these opportunities can be materialized.

While resource efficiency has increased in some G20 countries much more needs to be done. The compound effect of improvements by individual countries has not led to improved resource efficiency of the G20 as a whole because of a major shift in production from highly resource efficient economies to less resource efficient ones. The potential for improvement in overall resource efficiency exists but requires well designed policies to facilitate a transition to sustainable consumption and production.

Research for Australia has found that reducing the environmental impacts of production and consumption is mostly determined by social choices and the resulting policy settings and to a much lesser degree relies on individual choices (Hatfield-Dodds et al. 2015). The assessments of the IRP demonstrate that achieving economic and environmental outcomes simultaneously is possible but requires concerted policy effort and carefully selected and designed policies. Resource efficiency is a necessary condition for a sustainability transition but it is not sufficient and will require a dramatic departure from business as usual. Inclusive economic prosperity for all and reduction of environmental impacts will require new paradigms of production and consumption and, in many cases, the redefinition of well-being.

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Box 1

Five Myths about Resource Efficiency

Thanks to recent scientific assessments like the ones carried out by the International Resource Panel, a significant amount of information is now available about the potential and limitations of resource efficiency. The following 5 myths have been debunked through this research:

1. Climate Change is all about energy. The way the global economy manages natural resources deeply influences the Earth's climate. How we extract these resources and how much we make use of them essentially determines GHG emissions. A more efficient use of natural resources is essential for the success of climate action and should be part of climate policies. Without significant improvements in resource efficiency, it will be difficult and substantially more expensive to achieve the Paris agreement target.

2. Resource Efficiency is an environmental strategy only. Resource efficiency strategies go beyond environmental concerns. They can help tackle multiple social, economic and environmental challenges and make significant contributions for the achievement of national sustainable development objectives.

3. Resource Efficiency opportunities are limited and difficult to achieve. As shown in this document, there are many opportunities for different G20 countries to improve resource efficiency. Some of them are already seizing these opportunities (see section 4).

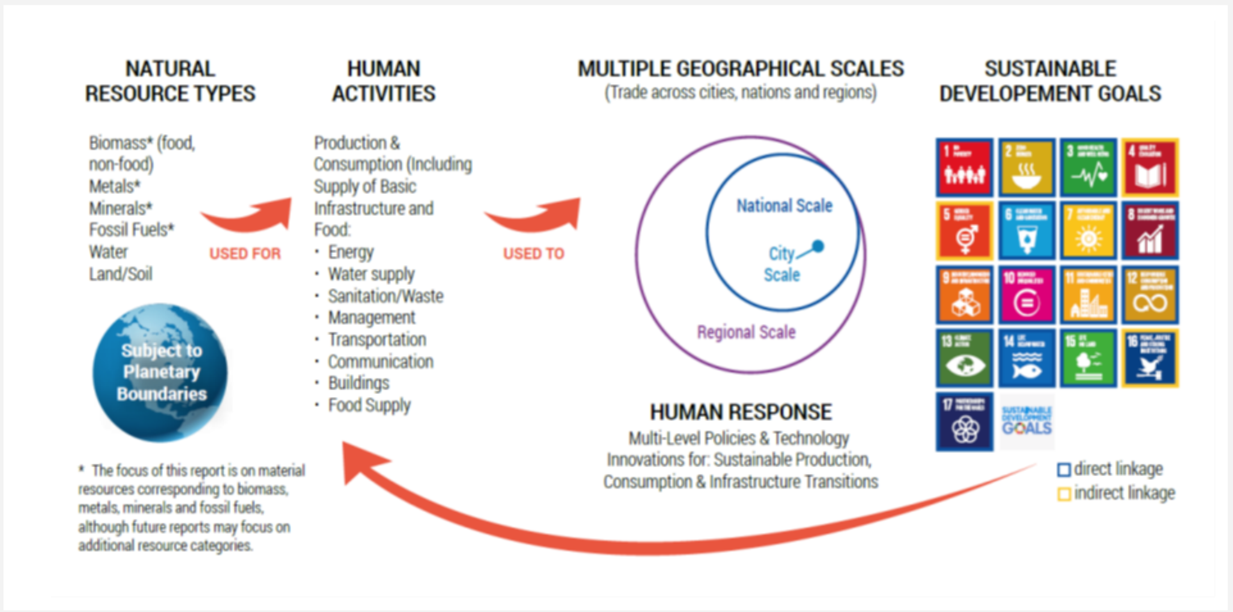
4. Resource Efficiency only concerns governments. Innovation and technology play a critical role in the improvement of resource efficiency. Therefore, it is crucial to ensure the participation of stakeholders capable of turning shared visions into reality and managing resistance to change by clarifying multiple benefits for the actors involved. This implies not only bottom-up changes in the way businesses create value and citizens access, use and dispose of resources, but also top-down changes in the way that policies steer the markets where businesses operate and build the social infrastructure in which citizens live. Consumers also play a key role in driving change. Their lifestyles create demand for products and services. Education can create awareness about how to use that consumer power effectively, as well as provide the incentive for manufacturers to mainstream resource efficiency into their processes (IRP 2017a, p.140).

5. The benefits of Resource Efficiency are very limited. As shown by the IRP modelling results, resource efficiency can have significant economic and environmental benefits (including for climate mitigation and adaptation). In particular, for emerging economies undergoing rapid urbanization and industrialization, resource efficiency policies (combined with urban planning that enables beneficial exchange of materials and energy across different industry and infrastructure sectors in cities) are found to yield economic gains, natural resource conservation, greenhouse gas mitigation and air-pollution reduction.

Sustainable Resource Management and Resource Efficiency are essential for Sustainable Development. Significant improvements on resource efficiency will be necessary to meet the aspirations expressed in the SDGs and the Paris Agreement on climate change. Natural resources are linked to all 17 SDGs, including the reduction of inequalities (SGD 10). The interlinkages manifest in society-environment interactions in the form of consumption and production systems (such as infrastructure provisioning) that are played out at different scales – global, national, regional, and city. Effective action to achieve sustainable development requires a systems approach that accounts for these connections and interactions within and between social, economic, and environmental systems at different scales. In order to meet the objectives of the 2030 Agenda on Sustainable Development, resource efficiency strategies will need to be complemented with measures that can drive resource consumption patterns towards sustainable levels.

Significant improvements on resource efficiency will be necessary to meet the aspirations of G20 countries expressed in the SDGs and the Paris Agreement on climate change. It is an opportunity to boost G20 economies and lower GHG emissions and comply with Nationally Determined Contributions.

Figure 2: Natural resources flow through society via production, consumption and infrastructure provisioning - impacting Sustainable Development Goals at different scales



Source: IRP 2017b, p.18.

Box 2

Interlinkages between Climate Change and Natural Resources

In 2015, the IRP published a paper with the following 10 key messages for policy makers at the United Nations Climate Change Conference held in Paris on 30 November – 12 December:

1. A 'whole system' perspective is crucial in the design and implementation of any policy regime that seeks to mitigate GHG emissions urgently and sustainably.
2. Decoupling economic growth from environmental and resource degradation, and creating a circular economy through reuse, recycling, and remanufacturing are key strategies for reducing both GHG emissions and other environmental and resource pressures.
3. Both de-carbonization of electricity and improvements in the efficiency of electricity use are needed to help achieve the 2-degree Celsius target, and they provide substantial environmental co-benefits, while they can also entail some resource-related trade-offs.
4. Water decoupling offers a major effective strategy to mitigate GHG emissions.
5. Land-use and land-based production systems need to be appropriately designed to greatly improve resource productivity, and thus minimize GHG emissions and environmental damage.
6. Moving towards a more sustainable food system could both reduce GHG emissions and have substantial health benefits.
7. Metals require high amounts of energy but are also essential components of almost all technologies; understanding their environmental impacts, scarcity, and recyclability is crucial for large-scale deployment of low-carbon technologies.
8. Cities and their infrastructure should be designed in ways that are less resource and emission intensive and which create a less polluted, healthier environment for their residents.
9. International trade in resources can have large direct and indirect impacts on energy and water consumption and therefore on GHG emissions and offers significant opportunities to reduce these.
10. More systemic changes are needed (including rethinking of societal values and increased awareness of the environmental perils of overconsumption) to ensure sufficient and more equitable global access to resources.

Source: IRP 2015b

Significant improvements of resource efficiency are essential to meet climate goals in a cost-efficient manner. Whether we seek to reduce greenhouse gas (GHG) emissions by means of mitigation approaches, or we try to secure the sustainability of our food, water, energy and livelihoods through adaptation measures, the appropriate management of natural resources lies at the center of virtually all viable solutions to climate change. Without significant improvements in resource efficiency, it will be difficult and substantially more expensive to keep average global warming below 2 degrees Celsius.

Scenarios developed by the Intergovernmental Panel on Climate Change estimate that global GHG emissions will need to be reduced in the next 30 years between 40 and 70 per cent from 2010 levels, in order to reach the 2-degree Celsius target (IRP 2017a, p.88). A very large part of global energy use (and therefore GHG emissions) is tied directly to the acquisition, processing, transport, conversion, use and disposal of resources. Very significant savings in both energy and emissions are possible at each of these stages in the resource management chain.

Raising resource productivity through improved efficiency and reducing resource waste through measures such as reuse, recycling and remanufacturing can greatly lower both resource consumption and GHG emissions[4]. Such measures also confer additional, highly desirable social benefits such as more equitable access to resources and invaluable environmental gains such as reduced pollution.

4. According to the United Nations Environment Programme (UNEP 2015, p.12) a "10 to 15% reduction in global greenhouse gas emissions could be achieved through landfill mitigation and diversion, energy from waste, recycling, and other types of improved solid waste management. Including waste prevention could potentially increase this contribution to 15 to 20%".

Box 3

Greenhouse Gas Reductions from Resource Efficiency Strategies

The IRP is currently developing a scientific report requested by the G7 to assess the interlinkages between resource efficiency and climate change strategies (to be published in 2019). The initial literature review shows that significant emission reductions can be obtained from various resource efficiency strategies such as more intensive use, lifetime extension of products, light-weight design, reuse, and recycling. The study will focus on GHG savings in personal vehicles and buildings. Electric and electronic equipment as well as plastics in packaging will also be covered. The following are some of the initial findings of this review:

- Buildings can be designed and furnished in a manner to fulfill all required functions while requiring less area and hence less materials and energy for constructing materials. Per capita residential floor area varies between 30 and 70 m2 at a GDP per person of USD 50.000.

- Building lifetimes vary across countries from 25 years (China), 30-40 years (Japan), 50-60 years (US) to more than 100 years (Europe). Building refurbishment requires fewer materials and less energy than new construction. Buildings can be designed to allow for later changes of use.

- An investigation of steel-frame buildings in the UK has shown that less than half of the load-bearing capacity of the steel frames is actually utilized. Assessments often conservatively estimate that the steel in construction can be reduced by 20 per cent.

- Substantial GHG emission reductions can result from using wood in construction, including glued cross-laminated timber for structural elements. The scope of this strategy is limited by the availability of timber.

- Demolition is already an important source of secondary metals. The recovery of materials can be improved, and new technologies may offer ways to recycle concrete.

- Overall, the largest savings in the building sector arise in emerging economies where the building stock is not yet fully developed when space-saving and material-efficient solutions are adopted.

- A significant reduction of the vehicle fleet could be obtained through wide-spread autonomous taxis. With the right design of urban transportation systems, such taxis can be used in a network of public mass transit, thus reducing car use. However, car use might increase, especially in a suburban context, with a lot of empty trips and an increased number of trips as mobility becomes available to those who cannot drive today. The reduction in fleet size can potentially off-set the additional material demand arising from the introduction of electric mobility.

- Light weighting of vehicles is often primarily motivated by fuel savings during operation and radical light-weighting relies on a shift from steel to more energy-intensive materials such as aluminum, magnesium, and carbon-fiber composites. For metals, alloy-specific enhanced recycling can off-set the additional energy use arising from the shift to lighter materials.

- Reuse and remanufacturing of vehicle components such as engines, alternators, and tires are today common place and can save on the order of 60 per cent of manufacturing and material related energy use and emissions, but a trade-off may exist with respect to vehicle performance. Such a trade-off needs to be carefully examined. Similar trade-offs may exist for the lifetime extension of vehicles. An intensification of use, e.g. through sharing and taxi fleets, would change that calculus and enhance the benefit of more durable vehicles and parts.

- Recycling of metals from vehicles is already widespread today and results in significant emission benefits compared to the use of primary materials. A further reduction can be attained both by increasing the degree of recycling (higher fraction of vehicles returned) and through closed-loop, alloy-specific recycling, requiring a better dismantling and sorting.

Resource Efficiency, therefore, should be an integral part of climate policy. One way to achieve this could be through the integration of resource efficiency targets in Nationally Determined Contributions (NDCs). National and international targets for resource efficiency would give policymakers and businesses a greater incentive to prioritize it. A specific resource efficiency target, or a small set of targets covering key resources like materials, water, land and carbon, could be effective in driving performance and establishing a common vision of the future between government, industry and society.

Japan and the European Union have developed and used indicators of resource productivity or resource efficiency. Japan adopted the Direct Material Input (DMI) indicator whereas the EU adopted the Domestic Material Consumption indicator[5]. Both of these indicators measure the direct quantity of material inflows to national economies. Other indicators like the Raw Material Equivalent (RME) take into account the indirect material flows in traded goods resulting from upstream processes such as mining and raw material processing in foreign countries.

5. The Domestic Material Consumption indicator measures the apparent consumption of materials on a national territory (domestic material extraction plus imports minus exports). The Direct Material Input indicator measures the material requirements of production on a national territory (domestic material consumption plus imports of materials).

Box 4

Resource Efficiency Indicators and targets in Japan's Sound Material Cycle Policy

Japan's first Fundamental Plan for Establishing a Sound Material Cycle Society (SMCS) was developed in 2003, together with quantitative targets for resource productivity, cyclical use rate and final disposal amount. These three headline material flow indicators monitor the overall performance of the country. So-called 'effort indicators' are also used for promoting concrete measures and evaluating the progress toward a Sound Material Cycle Society, some of which also have quantitative targets. The plan is revised every five years and the current – third – plan consists of 13 material flow indicators and 41 effort indicators. Resource productivity of fossil fuels has been included since the second plan, to enhance synergies between material and climate policies. Indicators such as the 'ratio of municipalities that adopted unit pricing for household waste' and 'power generation capacity of incineration facilities' have been included to promote concrete actions at the municipal level. A variety of indicators are used to monitor the progress toward a Sound Material Cycle Society from multiple viewpoints and levels. The Central Environment Council of Japan discusses the level of targets and annually reviews progress by monitoring these indicators. The targets of the three headline material flow indicators have been met thus far. The review results are used to improve the programmes for establishing a Sound Material Cycle Society. Indicators and targets are also set under the Waste Management and Public Cleansing Act, as well as individual recycling laws for home appliances, construction materials and food waste.

Source: IRP 2017b, p.52.

Box 5

Indicators of resource use proposed by the European Commission

The European Union uses indicators for material use and material efficiency (resource productivity) for its resource efficiency roadmap, which is one of the building blocks of Europe's resource efficiency flagship initiative and part of the Europe 2020 strategy. EU Member countries report material flow data biannually to the European Statistical Office (Eurostat) which compiles Europe's material flow data and makes the data accessible through its website (IRP 2016a , p.21).

Figure 3: Indicators of resource use proposed by the European Commission

	Territorial perspective	**Consumption/global supply-chain perspective**
Headline indicator		
Resource productivity	GDP/Domestic material consumption (DMC)	N/A
Dashboard of indicators		
Land	Artificial land or built-up area (km²) – available with restrictions in time-series	Indirect land use/embodied land for agricultural and forestry products (²) – to be developed
Water	Water exploitation index (WEI, percent) – available with restrictions on completeness of data and regional/temporal resolution (river basin/intra-annual variations)	Water footprint – to be updated and improved or Embodied water – to be developed
Carbon	GHG emissions (t) – available	Carbon footprint – estimates available from scientific sources

Source: IRP 2017a, p.51.

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3

Material Use and Resource Productivity: Trends in G20 Economies

Materials are the backbone of all economic activities, they serve human wellbeing and contribute to quality of life. Materials include biomass providing food, fodder, energy and feedstocks for industrial processes and timber used in construction or for energy. It also includes fossil fuels used for energy and as feedstocks for chemical processes, metal ores refined to serve an increasing array of technical applications, and metal ores used as structural material in construction, vehicles and machinery.

The way in which materials are used in production and consumption systems also determines the waste flows and emissions that are an unavoidable consequence of the material cycle. Material use has important linkages to environmental impacts across the board including resource depletion, air pollution, changes in ecosystems and human health, biodiversity loss and climate change. The use of materials is also closely related to environmental sustainability outcomes as they determine the overall level of environmental pressures and impacts.

The use of materials across their whole life cycle is governed by a multitude of sectoral policies including for agriculture, forestry, mining, infrastructure and waste management among many others. Developing an information base about material use is of crucial importance for evidence-based policy making in the environmental and sustainability policy domain.

To address the need for information of the policy community, the IRP provides data and indicators on material use, waste, and emissions that are linked to economic data. In doing so, the IRP provides metrics to measure the use of materials at the national economy level. These data sets and indicators, which are available at http://www.resourcepanel.org/global-material-flows-database, allow users to identify important environmental issues, support the process of policy framing, and back-up targets for material management and resource efficiency. They are also suitable for measuring progress of important policy aspirations such as the SDG goals 8.4 'resource efficiency' and 12.2 'sustainable resource management'.

This section draws from the Global Material Flows database of the IRP and the scenario modelling that was undertaken for the G7 in the context of the assessment entitled "Resource Efficiency: Potential and Economic Implications" (IRP 2017a). In this paper, we are presenting a set of indicators that aim to provide information to the G20 resource efficiency dialogue. The data and indicators document:

- The overall level of material use in the G20 economies group by level of income. We use the domestic material consumption indicator[6], which can be interpreted as a proxy for overall environmental pressure and impacts.
- The amount of materials that are required for final demand of a country across the whole supply chain, which is the material footprint indicator. This can be interpreted as a proxy for the environmental pressure of living standards.
- A measure for resource efficiency – i.e. material intensity – which reports on the efficiency at which materials are used for providing goods and services measured in dollars.

The measures selected for this report align with the indicators that have been selected by the Inter Agency Expert Group working on Sustainable Development Goal Indicators to monitor progress towards sustainable development goals 8.4 and 12.2.

Furthermore, G20 countries are divided in 3 groups of countries: lower middle income, higher middle income and high-income as per classification of the World Bank. Lower middle income countries include: India and Indonesia. Higher middle-income countries include Argentina, Brazil, China, Mexico, Russia, and South Africa. High-income countries include the rest of the G20. The IRP was requested to provide historical trends for material use and resource productivity for all of these groups.

6. The most widely applied indicator from material flow accounts is domestic material consumption (DMC). It is used in Eurostat's reporting of material flows for the European Union and for monitoring the Japanese government's progress in establishing a Sound Material Cycle Society. In essence, domestic material consumption measures the apparent consumption of materials on a national territory (domestic extraction plus imports minus exports).

3.1 Trends on Material Use in the G20

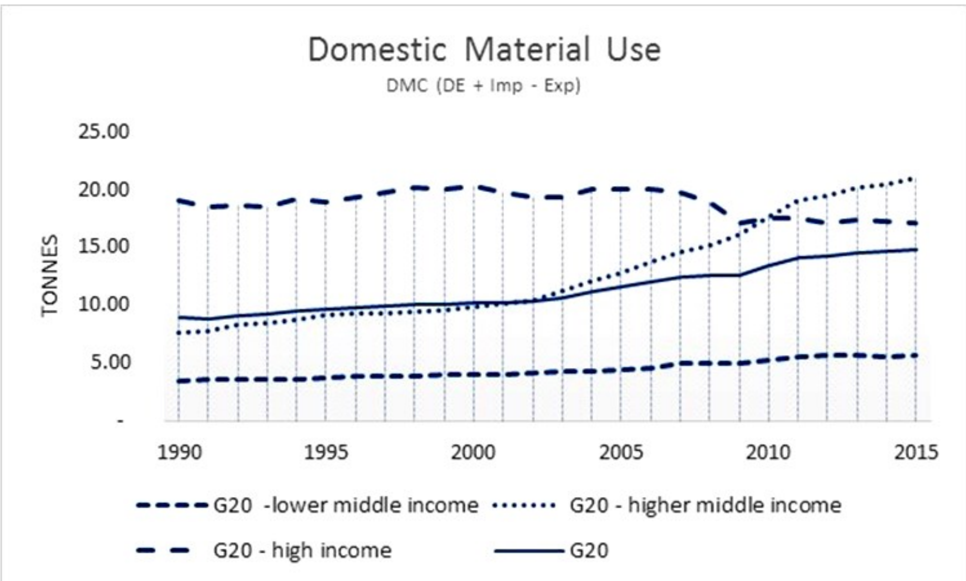
The G20 is responsible for more than two thirds of global material use and has, on average, higher growth rates for material use compared to the rest of the world. Because of this important position of the G20 group as a major material user, efforts to improve resource efficiency and engage in sustainable materials management in G20 countries will have a large effect on global environmental outcomes. The G20 has a significant opportunity to use materials more effectively and efficiently over their entire life cycle by improving their circularity and longevity. Managing materials sustainably in these countries will require profound changes in the way in which society produces and consumes.

Global use of materials – biomass, fossil fuels, metal ores and non-metallic minerals – has grown from 43.2 billion tonnes in 1990 to 87.5 billion tonnes in 2015 which is a yearly average growth of 2.9 per cent. The G20 group used 30.4 billion tonnes or 71 per cent of the global total in 1990 and 65.4 billion tonnes or 75 per cent of the global total in 2015. The average growth of material use in the G20 over the last 25 years was 3.1 per cent.

The fastest growth was incurred by the higher middle income group among the G20 at 4.8 per cent per year between 1990 and 2015, in average. Material use in the high-income group among the G20 only grew by an average of 0.5 per cent per year during this same period of time. These trends have meant that per-capita material use in the higher middle income group has overtaken the higher income group.

The higher middle income group on average used 7.5 tonnes per capita in 1990 and 20.2 tonnes per capita in 2015. During the same period, the higher income group reduced material use from 19 tonnes per capita to 17.3 tonnes per capita in 2015.

Figure 4: Domestic Material Use per capita in the G20 (lower middle income, higher middle income, high-income and G20), 1990 – 2015.



Source: IRP Global Material Flows database

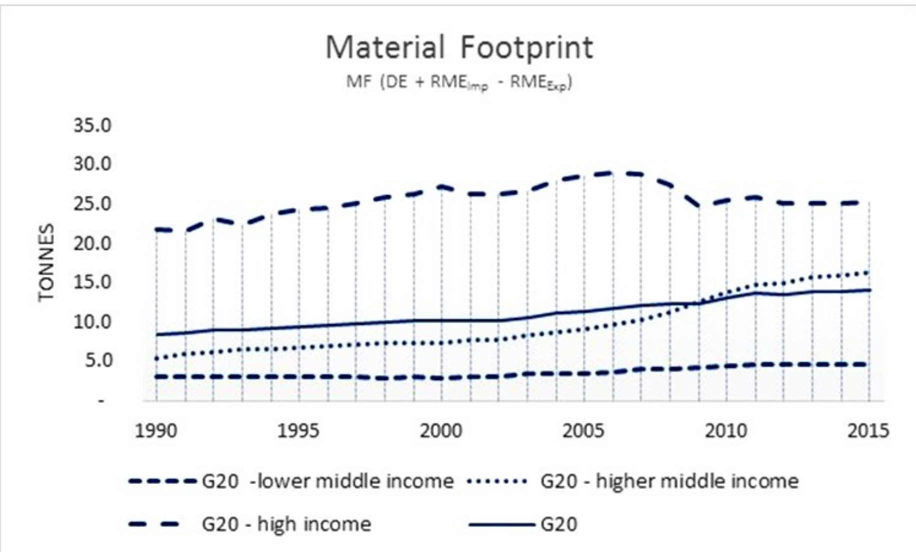
3.2 Material Footprint of final demand in the G20

Material use across the whole supply chain, i.e. material footprint, is unequally distributed across G20 countries with the high-income group among the G20 requiring around 10 times as many natural resources per capita for their final demand compared to the lower middle income group. The material footprint indicator measures the material requirement of final demand wherever primary materials may originate from. This division of whole of supply chain material use among G20 countries leads to an unequal distribution of environmental impacts where lower income countries incur higher environmental damages because of their role as primary material suppliers to the high-income group of the G20. It is obvious that the level of per-capita material footprint of the high-income group among the G20 can also not be generalized for all of the G20 or the rest of the world without massive environmental damages. Thus, the high-income group needs to invest in reducing its material requirements.

Material footprint figures further accentuate the difference between per-capita material use in lower and higher income countries among the G20. The lower middle income countries in 2015 required 4.6 tonnes per capita to support their final demand of household and government consumption and capital investment. This means that 20 per cent of domestic materials are used for producing goods and services abroad and don't contribute to the domestic material standard of living. The higher middle income group shows a very similar ratio leading to a per capita material footprint of 15.7 tonnes, a quarter lower compared to the 20 tonnes per capita domestic use.

For the high-income group among the G20, material footprint figures in 2015 show that the material standard of living requires 25 tonnes per capita; while the Domestic Material Consumption shows a required 17.3 tonnes for domestic use. The high - income group hence relies heavily on materials from abroad creating commensurate environmental pressures and impacts in the countries of origin of the materials and contributing to an unequal distribution across the G20 and the globe.

Figure 5: Material Footprint in the G20 (lower middle income, higher middle income, high-income and G20), 1990 – 2015.



Source: IRP Global Material Flows database

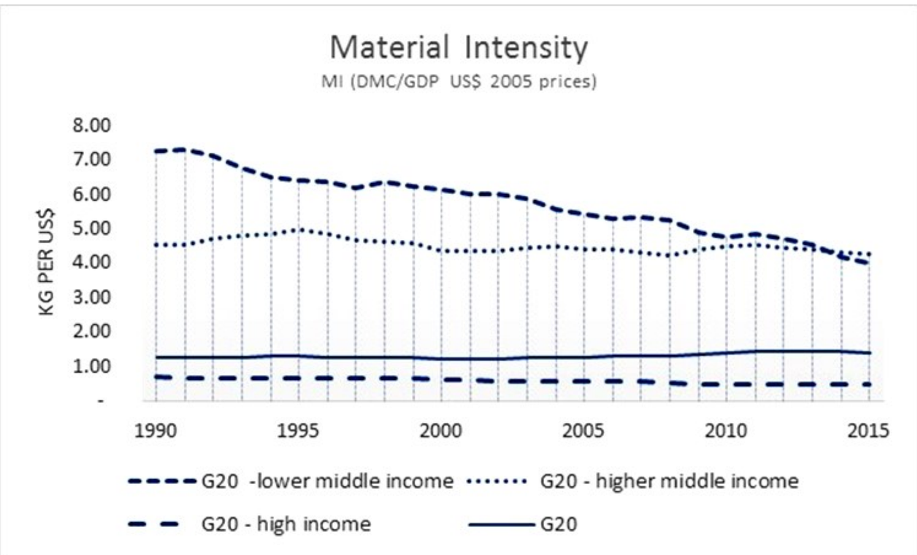
3.3 Trends on Resource Efficiency in the G20

Increasing resource efficiency, i.e. reducing the material, energy, water, carbon emissions and waste used to produce a unit of economic product, is necessary, but not sufficient, for achieving sustainability. There are many ways in which to improve resource efficiency while supporting economic development and employment. The largest potential exists in provisioning systems for housing, mobility, food and energy by increasing the lifetime of infrastructure, improving building performance, investing in renewable energy and sustainable food production supported by sustainable consumption and production policies. In addition, transitioning to environmental sustainability requires changes in consumption especially among higher income groups.

Despite the economic attractiveness of resource efficiency, the overall material intensity of the G20 has not improved for the last two and a half decades. A similar trend is found for the higher middle-income group among the G20 and to some extent also the high-income group. The lower middle income countries have made substantial improvements in reducing the material intensity of their economies which was mostly driven by structural change moving from material intensive primary sector activities to less material intensive services.

The historical trends extracted from the IRP Global Material Flows database show that material use has been increasing in many G20 countries, reaching unprecedented levels, while inequality in sharing the benefits of material use has not been reduced. Low -income countries still benefit less from global resource use than high-income countries. Resource efficiency policies do not solve distribution issues which require additional policy settings. The potential for improving resource efficiency is very high but has not yet been achieved.

Figure 6: Material Intensity in the G20 (lower middle income, higher middle income, high-income and G20), 1990 – 2015.



Source: IRP Global Material Flows database

3.4 Futue Trends in Material Use and GHG Emissions in the G20

A number of scenarios of resource efficiency and climate change mitigation were modelled by the IRP for a report requested by the G7 (IRP 2017a). They offer overall quantitative insights into the resource, greenhouse gas and economic outcomes from climate policy, resource efficiency policy, and a scenario that included both kinds of policy, as explained in Box 6.

Box 6

Scenarios considered in this assessment

The analysis is based on four core scenarios, each representing a specific combination of potential future natural resource use trends and future greenhouse gas emissions pathways, as shown in the figure below.

"Existing Trends" is calibrated to historical trends in per capita natural resource use (biomass, fossil fuels, metal ores and non-metallic minerals), across major world regions, accounting for changes in income and GDP per capita. Greenhouse gas emissions reflect the Paris pledges (INDCs) to 2030, and then follow a global trajectory to 2050 that matches cumulative emissions in RCP6.0, one of four benchmark trajectories for climate forcing used by the IPCC. This emissions pathway is consistent with global temperatures increasing by around 3°C by the end of this century and rising to around 4°C after that.

"Resource Efficiency" assumes the same climate pathway as Existing Trends, but introduces a package of innovations, information, incentives and regulations to promote ambitious but achievable improvements in resource efficiency, and reductions in total resource extractions.

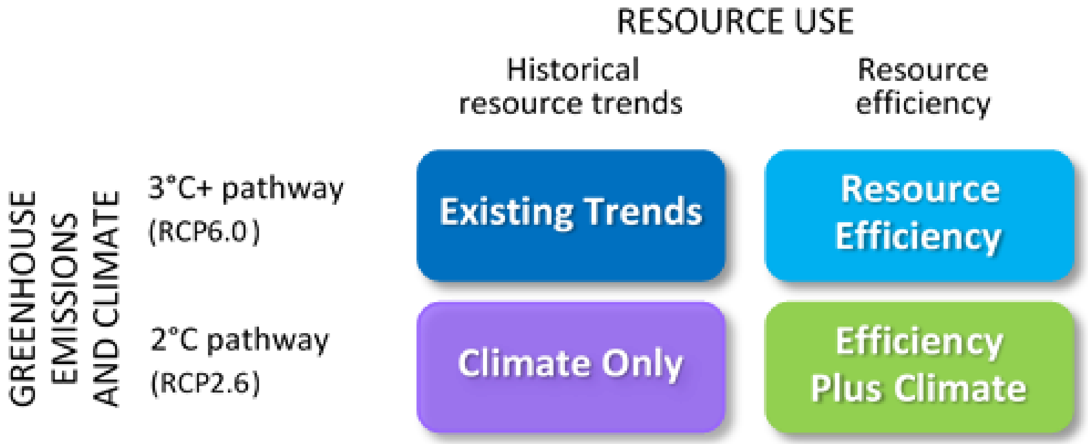
"Ambitious Abatement (Climate Only)" assumes natural resource use follows historical trends, but that the world shifts decisively to a 2°C climate pathway, involving more ambitious emissions reductions from 2020. The modelling imposes stylised global abatement policies that are calibrated to achieve global emissions that match cumulative emissions in RCP2.6 to 2050. This is the lowest of the four IPCC benchmark trajectories, with around a 50:50 chance of limiting temperature increases to 2°C above pre-industrial levels.

"Efficiency Plus Climate" combines the settings for the Resource Efficiency and Climate Only scenarios to explore potential policy interactions. We find synergies between these policies deliver larger reductions in resource use, and larger reductions in greenhouse emissions. This implies a higher chance of limiting climate change to 2°C or lower, as well as larger improvements in other environmental pressures associated with resource use.

Economic outcomes fall between those projected for the Resource Efficiency and Climate Only scenarios, with stronger economic growth than in Existing Trends.

The scenarios are also related qualitatively to the common Shared Socioeconomic Pathways (SSPs), with Existing Trends aligning to SSP2, described as 'middle of the road', while Efficiency Plus Climate aligns to SSP1, described as 'sustainability' / 'taking the green road'.

Figure 7: Scenarios for assessing resource and climate futures



Source: IRP 2017a

The integrated economic, environmental and climate modelling undertaken by the IRP shows that there is substantial potential to achieve economically attractive resource efficiency, reducing natural resource use and boosting economic growth across the G20. Resource efficiency also has substantial co-benefits for climate mitigation and helps offset the short-term cost of climate policy action.

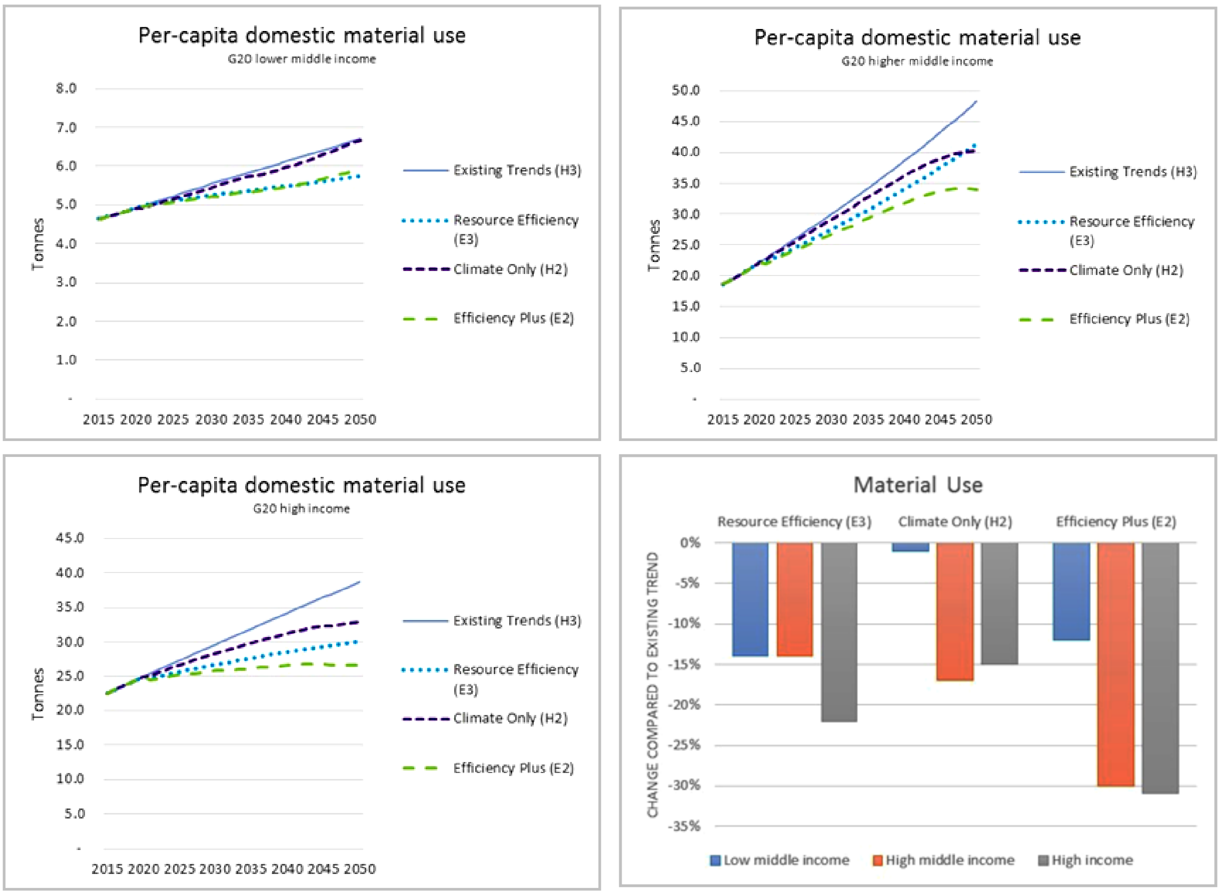
3.4.1 Future Trends in Material Use in the G20

Under Existing Trends, per capita material use in high-income G20 countries is projected to increase from around 22.5 tonnes in 1990 to around 38.7 tonnes in 2050. Growth in higher middle income G20 countries is even more accentuated up from 18.6 tonnes per-capita to around 48 tonnes per capita in 2050. By comparison, lower middle income G20 countries would see per capita material use increase very slowly from a low level of 4.6 tonnes per-capita to just 6.7 tonnes per capita. This would result in an increase of material use in the G20 from 62.5 billion tonnes in 2015 to 142.2 billion tonnes by 2050.

With ambitious policies for resource efficiency, material use would be 14 per cent lower in the low and high middle income group of the G20 and 22 per cent lower in the high-income group. Resource efficiency combined with greenhouse gas abatement policies, material use would be one third lower in high middle and high-income countries in the G20 and 12 per cent lower in the low middle income group.

GDP grows strongly under combined resource efficiency and emission abatement policies (Efficiency Plus) by 1.7 per cent yearly average to 109.3 trillion USD (at 2007 prices) which is 2 per cent higher by 2050 than under Existing Trends.

Figure 8: Scenarios for per capita domestic material use in the G20 (lower middle income, higher middle income and high-income countries), 2015-2050.



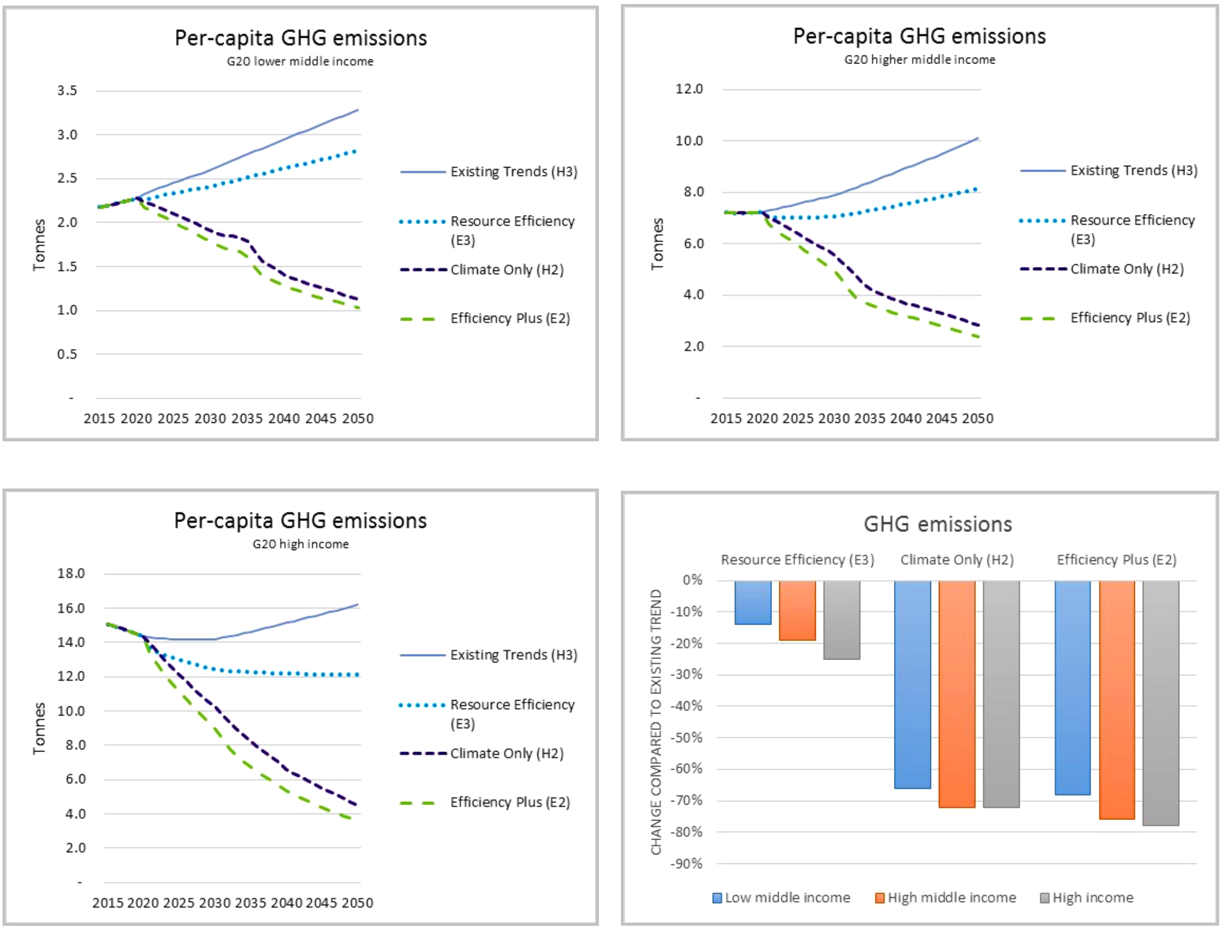
Source: IRP Scenario Modelling, IRP 2017a

3.4.2 Future Trends in GHG Emissions in the G20

The Existing Trends scenario assumes that the COP21 Paris pledges are fully implemented and is compatible with a 3 degree warming scenario. The scenario does not account for additional commitments above the Paris pledges which may in reality become more ambitious over time compared to COP21. According to IRP modelling (IRP 2017a), Greenhouse gas emissions in the G20 group are projected to increase by 21 per cent from 2015 levels by 2050 under Existing Trends.

Resource efficiency and ambitious emission abatement policies combined would see G20 GHG emissions fall by 71 per cent by 2050, compared to a 65 per cent reduction in GHG emissions without resource efficiency. Resource efficiency policies alone would see GHG emissions reduced by 5 per cent compared to 2015 levels by 2050. This demonstrates a co-benefit of resource efficiency for climate policy and the opportunities that arise from linking resource efficiency, energy, and climate policies more closely.

Figure 9: Scenarios for per capita GHG emissions in the G20 (lower middle income, higher middle income and high-income countries), 2015-2050.



Source: IRP Scenario Modelling, IRP 2017a

3.5 G20 Economic Performance and Synergies

The results of the IRP modelling show that resource efficiency provides net economic benefits for G20 nations boosting economic growth. These gains are enabled by investment in innovation to achieve more efficient material use in production systems, jointly with modest increases in investment reflecting lower material cost of consumption. Resource efficiency leads to a 7 per cent higher GDP in the G20 compared to existing trends. This is an expected outcome since higher productivity of material use should have a positive impact on economic activity similar to other factor productivity gains.

Stronger economic growth from resource efficiency more than compensates the slower medium-term economic growth associated with ambitious global action to combat climate change. In combination, resource efficiency and climate mitigation achieve stronger economic growth than the Existing Trends scenario. GDP in the G20 group is USD 2.1 trillion higher in 2050 (USD 434 per person) in the Efficiency Plus scenario compared to existing trends and USD 7.1 trillion higher by 2050 (USD 1,470 per person) in the Resource Efficiency scenario.

Figure 10: Scenarios for GDP in the G20 (lower middle income, higher middle income, and high-income countries), 2015-2050.

Source: IRP Scenario Modelling, IRP 2017a

Resource efficiency creates a rebound effect and contributes to higher economic growth. The economic gains more than offset the initial costs of climate mitigation. The modelling shows that a combination of ambitious policies for resource efficiency and greenhouse gas abatement create favourable economic outcomes. These would be more accentuated if the costs of climate impacts such as flooding, fires heavy winds and heatwaves would be included in the modelling. In this sense the IRP findings represent the minimum gains that are achievable.

The modelling demonstrates the effectiveness of ambitious policies. The results need to be interpreted as a lower minimum of what policies can achieve because the cost of climate impacts has not been fully included in the model. When the cost of climate change and potential price rises of scarce resources will be included in future IRP modelling it is expected that the Efficiency Plus scenario will show further gains in economic attractiveness.

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4

Increasing Resource Efficiency: Opportunities and Best Practices

The model results explained in the previous chapter build a strong case for the combination of resource efficiency and climate mitigation policies. They show that decoupling of human wellbeing and environmental impacts can be achieved in G20 economies with positive impacts on the global economy and the planet.

Resource efficiency can help us progress towards relative and absolute decoupling, and it is possible, practical, and economically attractive. Absolute decoupling is recommended as an aim for high-income nations, with the need to lower average resource-consumption levels, distribute prosperity equally (including for gender equality) and maintain a high quality of life. Strategies toward waste prevention, high-value resource recovery, circular resource flows and adjusting social norms are particularly relevant. Relative decoupling is a key strategy suited to developing economies and economies in transition to raise average income levels and eliminate poverty. These countries should strive to improve their resource efficiency even as their net consumption increases, until a socially acceptable quality of life is achieved. There is an opportunity to fast track sustainable development in such countries (IRP 2017b, p.12).

There is great potential to increase resource efficiency in many sectors of the economy and in major provision systems such as construction, manufacturing and transport. The following examples from G20 countries, extracted mostly from the IRP assessment “Resource Efficiency: Potential and Economic Implications”, evidence the opportunities and best practices for resource efficiency in different economic development contexts. This is an illustrative sample and in no way comprehensive list of all on-going resource efficiency efforts of the G20.

While some efforts have been made, there is still many opportunities for improvement. For resource efficiency to be widely mainstreamed and implemented at a large scale, effective knowledge sharing systems will need to be paired with access to finance and international cooperation, in particular for low -income economies.

4.1 Promoting Multistakeholder Action on Resource Efficiency in Argentina

The Industrial Retrofit Programme (Programa de Reconversion Industrial) is a national environmental policy instrument created by the Ministry of Environment and Sustainable Development of Argentina to promote resource efficiency and the shift to sustainable consumption and production patterns.

This Programme mobilizes different actors from the public and private sector to develop and implement activities that increase resource efficiency, prevent pollution, decrease environmental impacts including GHG emissions, promote technological innovation in production processes, improve the environmental management of companies, and remediate environmental liabilities. Beneficiary sectors include agriculture (e.g. sugarcane and ethanol production, citrus processing), livestock farming (e.g. slaughterhouses, dairy processing), forestry (e.g. pulp and paper, wood-based panels), and energy (e.g. biomass boillers).

As part of the programme, a set of activities are voluntarily agreed between the national and provincial or local authorities and production facilities through an implementation plan and signed agreement. A monitoring and reporting system is developed to ensure the achievement of the agreed objectives. Common Environmental objectives may be included in individual implementation plans for issues concerning a group of actors within one sector or within a given geographical area.

Since 2008, more than 1600 implementation actions have been developed by private actors in coordination with other stakeholders. Some of the most relevant ones are located in the provinces of Tucumán and Misiones. These plans have saved 4,2 million m3 of water per year by promoting reuse for controlled irrigation and composting. They have also contributed to the use of 580,000 tons of biomass per year as fertilizer and avoided some 230,000 tons of ash through the addition of 30 scrubbers for treatment of boiler fumes.

Other impacts of the programme include the development of effluent measurement and monitoring facilities and the optimization of water and solid waste management systems in slaughterhouses as well as the implementation of non-certifiable environmental management systems and the implementation of corporate social responsibility plans that benefit local communities.

Source: Ministry of Environment and Sustainable Development of Argentina.

Facts about the Industrial Retrofit Programme

more than **1600** implementation actions have been developed by private actors

4,2 million m3 of water saved per year

580,000 tons of biomass per year used as fertilizer

avoided **230,000** tons of ash through the addition of **30** scrubbers for treatment of boiler fumes.

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4.2 Transit Oriented Development in Brazil and Canada

Globally, energy consumed directly by the transportation sector (including road, rail, air, water, and pipeline transportation) accounts for 19 percent of total primary energy supply and 64 percent of total oil consumption. The infrastructure, vehicles, and their supply chains that facilitate transportation and fuel supply are major sources of energy and material consumption.

Bus rapid transit (BRT) systems have been implemented in about 160 cities across the world, notably in Latin America where leading countries include Brazil, Colombia and Mexico. China has been a fast adopter of BRT systems in recent years. A transit-oriented development (TOD) approach can be key to ensuring that the social as well as environmental benefits of transport infrastructure investments are maximized and equitably distributed. A balance of roles between the public and private sectors is often an important part of this. Ottawa, Canada, Curitiba, and Brazil are leading global examples of transit-oriented development based around BRT systems.

In both cities, investments in transport technologies and infrastructure were a major part of the strategy. For example, Curitiba's system makes use of cleaner vehicles and fuels, and infrastructure arrangements such as "passing lanes at stations to increase capacity and improve commercial speeds". In both cases, the local governments also had a significant role in setting out the long-term vision for the new urban developments, and using the BRT system as a means to channel growth along well-defined linear corridors. Local governments were proactive in leveraging the benefits of TOD, with additional supporting policies including "zoning reforms, pro-development tax policies, assistance with land assemblage, and supportive infrastructure investments. In Curitiba, local government mandated that all medium- and large-scale urban development be sited along a BRT corridor". Through such means, public policy can be used to guide private sector investments in a way that best leverages the benefits of TOD.

Source: IRP 2017a, p.192.

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4.3 Policy Planning to Promote Resource Efficiency in China

In 2009, the Chinese government made circular economy one of China's major socio-economic development strategies by enacting the Circular Economy Promotion Law. It required the central government and local authorities to compile dedicated circular economy content in their socio-economic development plans. For example, the 12th Five-Year Plan for National Economic and Social Development included a target to raise the country's resource productivity by 15 per cent between 2011 and 2015, and focused in particular on reducing waste. More than 200 national standards were proposed, as well as concrete actions including the "Ten-Hundred-Thousand Demonstration Programme on Circular Economy", with a plan to implement 10 major pilot projects, establish 100 demonstration cities and foster 1000 demonstration enterprises and industrial parks by the end of 2015.

The National Urban Mine Demonstration Base project, which focused on the scale development and industrialization of urban mine utilization (waste iron and steel, non-ferrous metals, plastics and rubber) was one such example. The aim was not to construct new recycling centres for resources, but to upgrade the existing system with the help of fiscal subsidies and policy supports for scaling up, advancing innovation and reducing pollution. To date, 49 Urban Mine Demonstration Bases have been established to collect and treat recycling resources such as waste iron and steel, non-ferrous metals, plastics and rubber. The newly increased capacity for the collection and treatment of recycling resources in these 49 bases is planned to reach more than 40 million tonnes per year. To evaluate the effectiveness of policy measures and strengthen policy enforcement in early 2017, relevant Government departments in China jointly issued the Evaluation Indicator System of Circular Economy Development. The indicator system is built upon the Material Flows Analysis framework and consists of 17 indicators (four focused on inputs, nine on recycling and four on waste output). Resource productivity (based on major constituents of domestic material consumption) and the recycling rate for main waste were selected as the two headline indicators. Evaluation has shown that resource productivity increased by more than 20 percent in 2011–2015, the use of recycling resources reached 246 million tonnes in 2015 and 10 major pilot projects were completed successfully. In particular, the circular transformation of industrial parks, commercialization of remanufacturing, resource regeneration and decontamination processing of kitchen waste were broadened and generalized throughout the period. In May 2017, the Chinese government issued "The Guiding Actions for Circular Development", which includes new actions to promote circular development for 2016-2020.

Source: IRP 2017b, p.58.

Other countries who have taken the lead in policy planning for resource efficiency include Japan with the Sound Material-Cycle Society policy and the European Union with the Circular Economy policy package. The latter identifies five priority areas of action including: plastics, food waste, critical raw materials, construction and demolition, and biomass and bio-based products. The following box shows examples of resource efficiency strategies and initiatives reported by several European countries.

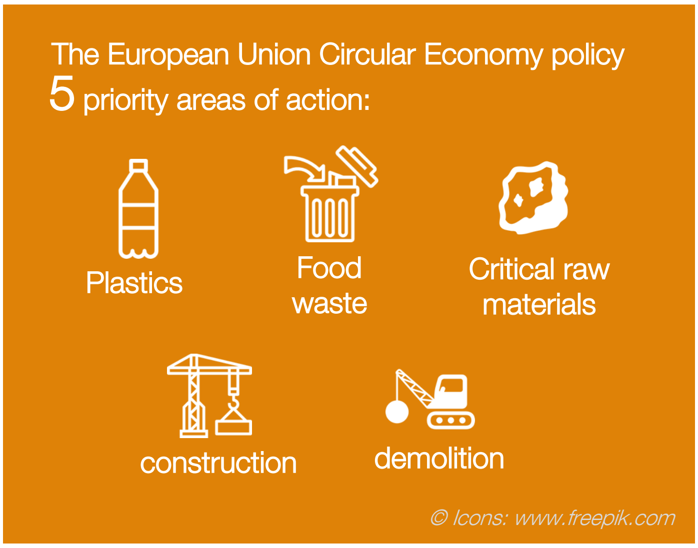


Figure 11: **Examples of Resource Efficiency strategies and initiatives reported by European countries.**

STAGE OF MATERIAL LIFE CYCLE	STRATEGIES AND INITIATIVE REPORTED BY DIFFERENT COUNTRIES
Extraction of raw materials	▪ Reduce the use of primary raw materials (Iceland) ▪ Reduce the impact of material extraction (United Kingdom)
Design of products	▪ Integrate environmental aspects into product design (France) ▪ Extend the lifespan of products (Ireland)
Production and distribution	▪ Extended producer responsibility, for example for waste electrical and electronic equipment, packaging and end-of-life vehicles (Portugal) ▪ Industrial symbiosis and new business models (Sweden)
Consumption and use	▪ Pay-as-you-throw schemes (Belgium) ▪ Changing consumption patterns (Italy)
Reuse, repair, redistribute, refurbish and remanufacture	▪ REPANET and REVITAL initiatives (Austria) ▪ The Scottish Institute for Remanufacture (Scotland, the United Kingdom)
Waste prevention	▪ Secondary Raw Materials Policy (Czech Republic) ▪ Strategies for prevention of waste (Denmark)
Waste management (including recycling)	▪ Separate collection of metal and biowaste to improve recycling rates (Croatia) ▪ Seven goals for the National Waste Management Plan and Waste Prevention Programme (Finland) ▪ Tailor norms or certifications to the circular economy (Netherlands) ▪ Transform waste into resources (Poland)

Source: *IRP 2017b*

4.4 Sustainable Public Procurement as a driver of Resource Efficiency in India

Public procurement accounts for between 8 and 30 percent of a country's GDP (10–15 percent in OECD countries) which gives governments and other public sector entities substantial opportunity to foster resource efficiency. India is the third largest electricity producer in the world. During the year 2016-17, the gross electricity generated by utilities in India was about 1,200TWh. Approximately 88 per cent of the population had access to main power, and a programme is underway to connect the remaining population by March 2019. Lighting itself accounts for about 20 per cent of the total electricity consumption in India. Annually, about 770 million incandescent bulbs are sold annually in the Indian market, all domestically manufactured (2013-14 data).

India launched the Unnat Jyoti by Affordable LEDs for All (UJALA: meaning light in Hindi) in 2015 as a national programme to provide light-emitting diode (LED) bulbs to domestic consumers with a target to replace 770 million incandescent bulbs with LED bulbs by March, 2019. It is the world's largest zero-subsidy domestic LED bulb programme. The main objectives of the Programme are to reduce energy consumption in the lighting sector and to promote LED based efficient lighting products. The programme is intended to promote the use of LED technology at affordable rates to domestic consumers so as to enhance the awareness of consumers about the efficacy of using energy-efficient appliances which in turn could change their buying preferences from low first-cost based purchases to lifecycle cost. The business model hinges on aggregating requirements across the country and procuring LED bulbs at low cost through a nominated agency at the most competitive rates, and then distributing it in a reliable manner. Since the cost of LED bulbs to many domestic consumers may still be too high, the model provides for a smaller upfront cost to be paid, with the balance being adjusted in the electricity consumption bills, over a period of less than one year.

For the longer term, the intention is also to incentivize domestic manufacturing of LED bulbs consistent with the 'Make in India' policy[7] of the Government, by generating demand and moulding consumer preferences. Ultimately, the expectation is that this will enable an ecosystem and models which can not only be replicated in energy-efficient lighting but also other energy using appliances such as fans, refrigerators, ACs, etc. where, the consumer preference for purchase of a substantial section of the population is still usually dictated by cost rather than life cycle costs.

Energy Efficiency Services Limited (EESL), a joint venture of four major government-owned companies: Power Grid, National Thermal power Corporation, Rural Electrification Corporation Limited and the Power Finance Corporation, under the Ministry of Power was selected as the implementation partner for the procurement and distribution. EESL sources its LEDs through bulk procurement in the international market. UJALA's LED bulbs cost only about 50 INR (USD 0.73) and

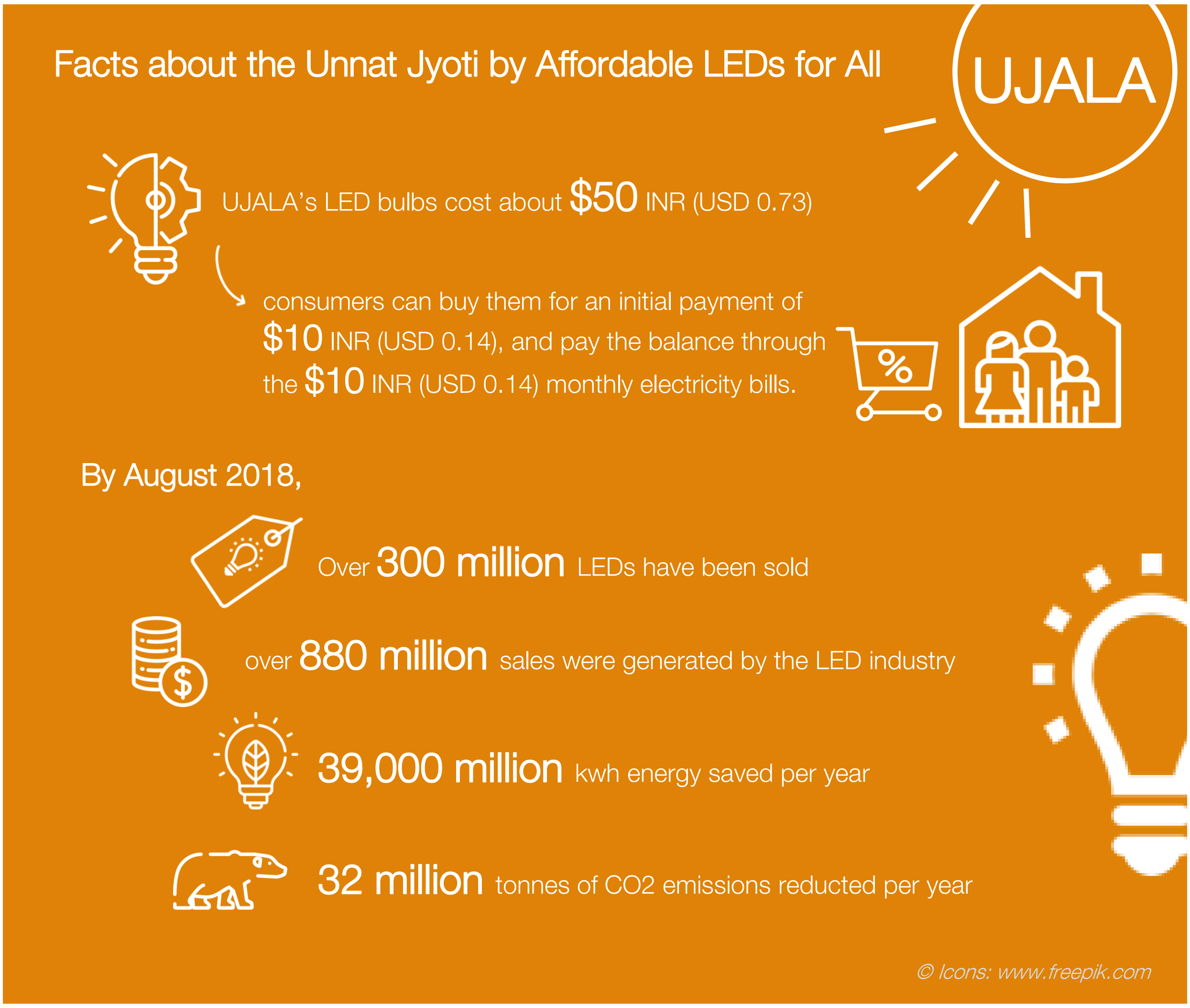
UJALA allows the consumers to buy them for an initial payment of 10 INR (USD 0.14), with the balance being paid through the consumer's electricity bills in equal monthly instalments of 10 INR (USD 0.14). In the first phase, 100 cities were taken up for coverage under the programme. The response was very positive, and the programme has now been extended to the entire country.

According to Government statistics, by August 2018, over 300 million LEDs have been sold under the programme. Sales of over 880 million LEDs are reported by the LED industry as a whole. The estimated saving in energy is 39,000 million kwh per year, with an estimated reduction of 32 million tonnes of CO_2 emissions per year.

The programme has had a significant impact in the entire sector. LED retail market prices for known and accepted brands, used by high-income sectors of society have also come down from approximately 600 INR (USD 8.74) per LED bulb in 2012 to 200 INR (USD 2.91) per LED bulb. This has helped in expanding the market to higher quality segments.

Source: www.ujala.gov.in

7. This initiative was launched in 2014 by the Indian Prime Minister in order to transform India into a global design and manufacturing hub. It is part of a set of nation-building initiatives of the government.



4.5 Reducing waste through Industrial Symbiosis in Japan

The Japanese Eco-Town Programme established 26 eco-towns across Japan. The aim of this government-led programme was to reduce the high levels of waste going to landfill sites and to regenerate local industries. As such, a key strategy was the conversion of waste from one industrial process into a valuable input for another. For example, the Kawasaki eco-town aims to effectively utilize residential, commercial and industrial waste generated in the city and recycle these into raw materials like cement or steel that can be used by industries in the same city. In addition to reducing material waste, it is estimated that the industrial symbiosis strategy in Kawasaki reduced life-cycle carbon emissions by 13.77 percent, mainly from iron and steel, cement and paper manufacture. As a result of government subsidies, 61 recycling facilities have been established across the 26 eco-towns, with a combined capacity of nearly 2 million tonnes of waste per year. For every government-subsidized recycling plant, a further 1.5 unsubsidized plants were built by the private sector, showing that government action can act as a springboard for further private sector-led development of environmental industries.

Source: IRP 2017a, p.172.

4.6 Improvement of Resource Efficiency through a Housing Finance Scheme in Mexico

On a global scale, buildings use around 40 per cent of resources, 25 per cent of water and 40 per cent of energy, and they account for around one third of greenhouse gas emissions. Changes in the planning, design, commissioning, construction, maintenance, refurbishment and end-of-life stage of buildings provide significant opportunities to reduce environmental impacts while providing healthy and safe living and working spaces. Meeting the needs for housing, employment and public infrastructure in a sustainable way is particularly crucial for those countries facing rapid urbanization and urban population growth.

Green Mortgages Mexico is an initiative managed and funded by the Institute for the National Workers' Housing Fund (Infonavit). Infonavit is a public social financial institution, in charge of managing the National Housing Fund ("Fondo Nacional para la Vivienda") and a financing system to ensure access to housing for Mexican workers. The Green Mortgages scheme granted more than 900,000 green mortgages, benefiting more than 3 million people, between 2007 and 2012. Credits targeted primarily towards low-income households have low interest rates (4–10 percent, depending on their income level), which are cross-subsidized by higher income households. Developers build houses with energy-saving materials and use eco-efficient technologies to improve the service quality of water, electricity and gas. Households enjoy a higher quality of life and save about USD 17 on their monthly bills, while spending USD 6 more compared to conventional mortgages. On average, water use decreased by 60 percent, gas by 50 percent and electricity by 40 percent, bringing about reductions of 0.75 tonnes of carbon emissions per household per year. Key aspects for the success of these programmes are the prioritization of low-income dwellers in the receipt of benefits, making programmes easy and free to access and providing short-term social, economic and environmental benefits alongside longer-term ones.

Source: IRP 2017a, p.144.

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4.7 Increasing water efficiency while protecting the poor in South Africa

Water is subsidized in many countries. In 2012, global water subsidies totaled USD 456 billion, leaving little incentive to conserve water. If the utility is unable to capture sufficient revenue to reinvest in the infrastructure, the system can become even more inefficient in the long run, with its financial sustainability undermined. Countries have tried to get these incentives right, by changing water prices, rationalizing water use, promoting investment, and protecting the poor. If the purpose of the subsidy is to protect the access of the poor to water, this can be achieved in cost effective ways, providing funds for reinvestment and maintaining incentives for conservation.

Countries have found ways to protect vulnerable, low-income people from policy-induced price rises. Moving away from generally low and subsidized energy and water prices towards realistic market prices have often been accompanied by policies that provide for preferential low prices for poor families. South Africa has set a good example with its Integrated Water Plan. The Plan involves realistic water prices to encourage private and public investments in water conservation and water supply, while also ensuring that a "lifeline" amount of water is affordable for the poor.

Sources: IRP 2017a, p.251; IRP 2017b, p.62.

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References

Group of 20 (2018). About the G20. https://www.g20.org/en/g20/what-is-the-g20

Hatfield-Dodds, S., H. Schandl, P. D. Adams, T. M. Baynes, T. S. Brinsmead, B. A. Bryan, F. H. S. Chiew, P. W. Graham, M. Gruny, T. Harwood, R. McCallum, R. McCrea, L. E. McKellar, D. Newth, M. Nolan, I. Prosser, and A. Wonhas (2015). Australia is 'free to choose' economic growth and falling environmental pressures. Nature 527(7576): 49-53.

Hatfield-Dodds, S., H. Schandl, D. Newth, M. Obersteiner, Y. Cai, T. Baynes, J. West, and P. Havlik (2017). Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies. Journal of Cleaner Production 144: 403-414.

International Resource Panel (IRP) (2014). Assessing Global Land Use: Balancing Consumption with Sustainable Supply. Bringezu S., Schütz H., Pengue W., O´Brien M., Garcia F., Sims R., Howarth R., Kauppi L., Swilling M., and Herrick J. A report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

International Resource Panel (IRP) (2015a). International Trade in Resources: A Biophysical Assessment. M. Fischer-Kowalski, M. Dittrich, and N.Eisenmenger. A report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

International Resource Panel (IRP) (2015b). The International Resource Panel 10 Key Messages on Climate Change. A paper of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

International Resource Panel (IRP) (2016a). Global Material Flows and Resource Productivity. An Assessment Study of the UNEP International Resource Panel. H. Schandl, M. Fischer-Kowalski, J. West, S. Giljum, M. Dittrich, N. Eisenmenger, A. Geschke, M. Lieber, H. P. Wieland, A. Schaffartzik, F. Krausmann, S. Gierlinger, K. Hosking, M. Lenzen, H. Tanikawa, A. Miatto, and T. Fishman. A report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

International Resource Panel (IRP) (2016b). Food Systems and Natural Resources. Westhoek, H, Ingram J., Van Berkum, S., Özay, L., and Hajer M. A report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

International Resource Panel (IRP) (2017a). Resource Efficiency: Potential and Economic Implications. Ekins, P., Hughes, N., et al. A report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

International Resource Panel (IRP) (2017b). Assessing global resource use: A systems approach to resource efficiency and pollution reduction. Bringezu, S., Ramaswami, A., Schandl, H., O'Brien, M., Pelton, R., Acquatella, J., Ayuk, E., Chiu, A., Flanegin, R., Fry, J., Giljum, S., Hashimoto, S., Hellweg, S., Hosking, K., Hu, Y., Lenzen, M., Lieber, M., Lutter, S., Miatto, A., Singh Nagpure, A., Obersteiner, M., van Oers, L., Pfister, S., Pichler, P., Russell, A., Spini, L., Tanikawa, H., van der Voet, E., Weisz, H., West, J., Wiijkman, A., Zhu, B., Zivy, R. A Report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

International Resource Panel (IRP) (2019, to be published). Initial insights from the report "Resource Efficiency and Climate Change: A request from the group of 7". A report of the International Resource Panel.

United Nations Environment Programme and International Waste Management (2015). Global Waste Management Outlook. Nairobi.

India, Ministry of Power. Unnat Jyoti by Affordable LEDs for All. www.ujala.gov.in

About this paper

This paper from the International Resource Panel (IRP), was prepared at the request of Argentina, holder of the G20 Presidency in 2018, to serve as scientific input for the discussions of the G20 Resource Efficiency Dialogue. It draws upon research completed by the IRP, including an assessment entitled “Resource Efficiency: Potential and Economic Implications, A report of the International Resource Panel”. It includes extracts from published IRP reports as well as messages from an upcoming IRP publication as per the list of references. It provides a summary of the latest scientific information on resource efficiency, its economic potential and the connections it has with climate change. The data analysis for the G20 was prepared by Heinz Schandl (CSRIO) based on existing IRP modelling. The text was prepared by Maria Jose Baptista (UN Environment) and Heinz Schandl with inputs from Edgar Hertwich (Yale), Vijay Kumar (TERI) and the Ministry of Environment and Sustainable Development of Argentina. We are grateful for valuable comments received from Panel members Jeffrey Herrick (USDA Agricultural Research Service); Marina Fischer-Kowalski (Institute for Social Ecology); Agustin Matteri (UN Environment); Adriana Zacarías (UN Environment); as well as Steering Committee members including Argentina, China, the European Commission, Germany, the Netherlands, the Philippines, and the United States of America.

UN environment

International Resource Panel

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