UNEP

SolarChill - the vaccine cooler powered by nature

Bringing the promise of the Millennium Development Goals nearer to the people

United Nations Environment Programme

Acknowledgements

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Printed on recycled paper by Nory - Paris

Harnessing sun power to build people power

IRD/Annick Aing

The SolarChill Project aims to help deliver vaccines and refrigeration to regions of the world without electricity or with inadequate electrical supply. SolarChill is developing a versatile refrigeration technology that is environmentally-sound, battery-free, technologically-reliable, affordable and multi-source powered.

The SolarChill Project bridges health, development and environmental issues through practical cooperation between major international organizations, research institutes and industry.

SolarChill prototypes are presently being field tested in Senegal, Indonesia and Cuba. Once the field tests are completed and the technology is deemed to be reliable, the SolarChill technology will be freely made available to the world and will be publicly owned.

Contents

Powered by nature: SolarChill

Refrigeration of vaccines and food is problematic in parts of the world where there is no electricity or where the electricity supply is unreliable.

In these regions vaccines are maintained by either kerosene or battery-based solar refrigeration. Kerosene refrigerators are also used for food preservation. There are significant concerns with both kerosene refrigeration and with the existing generation of solar-vaccine coolers.

IRD/Yves Paris

It is expected that SolarChill technology will improve the cold chain for vaccines as well as provide more reliable refrigeration for perishable foods.

- SolarChill will provide a more reliable, safer and cleaner form of refrigeration than kerosene refrigerators.
- SolarChill technology will improve on existing solar-vaccine cooling technology by bypassing the use of conventional lead batteries which have proven to be a major obstacle to the uptake of solar technology in developing countries.
- SolarChill technology is environmentally-friendly as it does not use any ozone depleting or potent global warming substances.

IRD/Jacques Bonvallot

IRD/Bernard Oses

Spot-light on features

- Prototypes: Upright and chest refrigerator models
- Can be used as a vaccine cooler or as household or small commercial refrigerator
- Energy storage in ice-packs through the use of direct current compressor - no lead battery required
- Powered by 3 X 60W photo-voltaic panel - no contribution to global warming and no electrical grid required
- Energy efficiency through efficient insulation
- R-600 hydrocarbon compressor and cyclopentane blown insulation foam - no contribution to ozone depletion or global warming
- Temperature control through natural convection between ice storage compartment and vaccine compartment - no electronic control devices required
- One SolarChill unit can serve a population of 50,000 people for preserving vaccines
- Expected commercialization price between US$ 1500-2000 (including solar panels) - 50 to 60% cheaper than currently available solar refrigerators meeting World Health Organization specifications
- Upright model has the potential to enter the domestic market in remote, off the grid areas of developed as well as developing countries
- Estimated need in developing countries for vaccine storage purposes is between 10,000 to 20,000 per year
- Potentially high market demand for domestic and small commercial refrigeration applications in regions of developed and developing countries that are off the grid or have unreliable electrical services.

Planting the power: SolarChill history

The challenge of providing environmentally safe and affordable vaccine and food refrigeration in the poorer regions of the world bridges health, development, and environmental issues.

The need for environmentally-friendly and affordable solar vaccine coolers and refrigerators was realized in 1998-2000 through separate discussions between United Nations Environment Programme (UNEP), World Health Organization (WHO) and Greenpeace International (GPI).

Independently, around the same time, the Danish Technological Institute (DTI), funded by the Danish Energy Agency, began the development of a new solar refrigerator that bypassed the use of batteries. DTI worked in cooperation with the Danish refrigerator manufacturer Vestfrost. The direct current hydrocarbon compressor was developed by Danfoss Company of Denmark.

The first meeting of the SolarChill Project Partners was hosted by GTZ Proklima in Eschborn, Germany on May 5, 2001. With an initial decision to proceed with the project, Greenpeace International provided the funds for the development of the first SolarChill prototypes.

The solar panel and vaccinators inspecting vaccines in a SolarChill refrigerator.

Photos from SolarChill field tests at Girisobo, Cuba.

These were exhibited at the World Summit on Sustainable Development in the fall of 2002 in Johannesburg, South Africa.

A second generation of prototypes of the SolarChill Vaccine Cooler went into field testing at the beginning of 2004 in Senegal, Indonesia and Cuba. Ten prototypes of the chest freezer vaccine cooler are being tested under a variety of climatic conditions, 3 units in each of the countries mentioned, and 1 unit at the DTI laboratory in Denmark. The field tests are coordinated by DTI, and overseen in Senegal and Indonesia by PATH, and in Cuba by GTZ. The governments and Ministries of Health of the host countries are active participants in the field tests.

The field tests are scheduled to last for one year. During that time technical data is collected on a regular basis and adjustments are made as required.

Plans call for similar field testing of the upright freezer SolarChill Food Refrigerator in 2005/2006.

IRD/Jean-Jacques Lemasson

Display of SolarChill prototype at WSSD Johannesburg, 2002

Chilling challenges of a changing world

Preserving vaccine

Successful public health programs rely on the availability of high-quality vaccines, which must be continuously cooled to remain effective. Fail-safe refrigeration within a specified range of temperature, from point-of-manufacture to point-of-use, is critical to the effectiveness of any vaccination program.

Fail-safe refrigeration is also vital for maintaining the shelf of some medicines e.g. the liquid forms of antibiotics.

The term “cold chain” refers to a network of fridges, freezers and cold boxes that is organised and maintained by teams of people throughout the world. This network ensures, as much as possible, that vaccines are kept at the proper temperature as they are distributed from the manufacturer to the locations where they are administered. The recommended equipment for storage (cold rooms, refrigerators, freezers) and transport (cold boxes, vaccine carriers) has to comply with a set of performance standards defined by WHO and UNICEF. Maintaining the required vaccine cold chain is problematic in many

IRD/Jean-Yves Meunier

IRD/Marc Bournof

regions of the world that are either off the electrical grid or the electrical supply is unstable. Weak links in the current cold chain in such places results in large quantities of spoiled vaccines each year.

Kerosene vaccine coolers

Currently, in parts of the world where there is no reliable electrical supply, vaccines are most often stored in kerosene refrigerators.

Kerosene refrigerators consume approximately .8 to 1 litre of kerosene daily. They emit the unsavory odor of burning kerosene, they occasionally catch on fire, they need to be regularly fueled up with permanent operating costs, and they are often not reliable for maintaining the required temperature.

Furthermore, they are environmentally harmful as the burning of kerosene contributes to global warming. There are approximately 100,000 kerosene refrigerators in use today around the world for vaccine cooling purposes. It is estimated that one kerosene refrigerator annually emits between 732.9 to 916.1 kg of Co_2 into the atmosphere. Correspondingly, 100,000 kerosene refrigerators will emit approximately between 73 to 91 million kilograms of Co_2 each year.

The current fleet of kerosene refrigerators are aging. SolarChill may prove to be the viable alternative for the orderly replacement of many of these units.

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Solar vaccine coolers

Vaccine refrigerators that can be powered by a variety of energy sources can alleviate the problem of non-existing or insufficient electrical supply. Solar and multi-sourced vaccine coolers can also be of great benefit under emergency circumstances such as natural disasters or war conditions. Multi-sources of energy include solar, wind, bio-fuel and other forms of generation, as well as the electrical grid.

Solar Vaccine Coolers are already in use in parts of the world that lack electricity. These units have proven to be more reliable than their kerosene counterparts.

However, there are only approximately 6,000 solar vaccine coolers around the world today. Two factors that inhibit the wide scale uptake of current generation of solar coolers in developing countries: the reliance on batteries, and the relative high costs.

The problem with batteries is that they often break down, they are expensive to replace, they are heavy, and they are toxic. Batteries need replacement on the average every 3 to 5 to five years. They also require maintenance and be routinely refilled with distilled water.

The cost of present day solar coolers is in the US$ 3500 to US$ 4500 range. In comparison, the cost of the SolarChill package, cooler and solar panels combined, is projected to come in around US$ 1500. The challenge therefore is to bypass the reliance on batteries, to provide the greatest versatility in terms of power supply of any product on the global market and to keep the price affordable.

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Food for all: key is preservation

Without adequate refrigeration everyday staples - milk, eggs, dairy products, meats, fish and vegetables - easily spoil, and food safety is compromised.

Safe food supply is a basic ingredient of human health. Food poisoning - e.g. salmonella, clostridium, and staph infection - can have severe, long term, and sometimes fatal consequences, especially for the most vulnerable segment of the population, the young and the elderly. Adequate refrigeration improves the variety of foods available on a daily basis, which results in better nutritional balance, and greater public health.

The spoilage of food also has serious economic consequences, which are greatly magnified in a poor countries where feeding the population remains a national challenge. In some areas without electricity or with poor electrical supply kerosene refrigerators are used to preserve food. In the long term, solar/multi source powered refrigeration, provided that it can be made available at affordable prices, will have far-reaching benefits in domestic and small commercial refrigeration applications.

Environment: ensuring sustainability

The major environmental concerns regarding all refrigeration technologies are their contribution to ozone layer depletion and global warming. Refrigerators contribute to ozone layer depletion and global warming if they contain ozone depleting and global warming substances in the their insulation foam or in their refrigerant cycle. Their further contribution to global warming depends on their efficiency.

IRD/François Sodter

The challenge therefore is to provide a vaccine cooler and a food refrigerator that does not rely on ozone-depleting or potent global warming substances in the insulation foam or the refrigerant circuit. An additional challenge is to have the built in capacity to power such a refrigerator through renewable energy sources.

Refrigeration: freezing of ozone layer depletion and global warming

Chlorofluorocarbons (CFCs), commonly by the trademark Freon™, have been used worldwide as refrigerants and insulation foam blowing agents in refrigerators since the 1940's. In the 1970's and 80's scientists discovered that the large scale emission of these substances and their eventual molecular breakdown in the atmosphere caused severe ozone layer depletion. They also significantly contribute to global warming.

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When the international community moved to ban the use of CFCs in the 1980's, the chemical industry scrambled to introduce replacement substances such as hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). Both of these substances are environmentally destructive as they are potent global warming chemicals. HCFCs are also ozone depleting substances. CFCs and HCFCs are scheduled to be phased-out world wide under the terms of the Montreal Protocol. HFCs are included in the basket of greenhouse gases whose total emissions must be significantly reduced to protect the global climate under the terms of the Kyoto Protocol.

SolarChill incorporates Greenfreeze technology that uses hydrocarbons in the refrigerant cycle and in the insulation. Hydrocarbons, used in this manner, are safe for the ozone layer and have minimal contribution to global warming.

Solutions towards a sustainable world: SolarChill

SolarChill combines environmentally sound refrigeration with solar energy. There are two models of SolarChill, both utilizing the same technology. The SolarChill Vaccine Cooler is a 50 litre chest freezer model. The SolarChill Food Refrigerator is a 100 litre upright freezer cabinet model.

Breakthrough: technology fostering

No batteries

The unique feature of SolarChill is that the energy of the sun is stored in ice instead of in batteries. An ice compartment keeps the cabinet at desired temperatures during the night. The key to the technology is the use of a direct current (DC) compressor instead of the standard alternating current (AC) compressor used in normal refrigerators, or in other solar coolers.

Thus, the sun's energy is captured by the solar panels and converted to direct current electricity. The DC current starts up the compressor which then runs the refrigeration cycle. Ice is produced in an ice storage compartment. The cool air is then circulated by convection and by a fan into the cabinet and maintained at the desired temperature by a thermostat.

Environmentally friendly

SolarChill incorporates environmentally friendly Greenfreeze refrigeration technology. Greenfreeze was developed and made freely available to the world by Greenpeace in the early 1990s. Greenfreeze utilizes hydrocarbons for the insulation foam and the refrigerant cycle, and thus bypasses the reliance on ozone layer depleting and potent global warming fluorocarbons, such as HCFCs and HFCs. This is the first ever application in the world of a direct current hydrocarbon compressor. SolarChill also symbolizes the

environmental imperative of humanity needing to shift our reliance on fossil fuels as our primary source of energy to renewable energy sources. SolarChill harnesses the power of the sun and turns it into life sustaining refrigeration.

Versatility

A converter enables SolarChill to be powered by multiple sources of energy. In addition to plugging into the electrical grid, SolarChill can also run on independent sources of power, such as solar, wind, biomass and diesel generation.

Affordability

The projected cost of SolarChill vaccine coolers and refrigerators, together with solar panels, will be in the range of US$1500-US$2000 (units produced in Western Europe). This is 40 to 50% lower than existing solar vaccine coolers on the market today. SolarChill is able to reduce the cost of production by using commercially mass produced freezer cabinets, instead of having the cabinets custom made. It is expected that the lifetime maintenance costs with SolarChill will also be considerably less than that of comparable solar vaccine coolers.

Obviously the initial capital lay out for SolarChill refrigerators will be greater than the cost of kerosene refrigerators. However, the difference in purchase price can be recovered during operation of the units. The price of kerosene fluctuates significantly from one region to the next and can cost up to US$1 per litre. Depending on the price of kerosene (which increase with the fluctuations in the price of oil), and the efficiency of the kerosene refrigerator, the cost differential can be recovered within 5 to 8 years. After the cost recovery SolarChill will provide inexpensive cooling.

The initial cost of SolarChill may also decline with the economy of scale, and with variations in manufacturing costs in different parts of the world.

Reaching out: where it is needed

Transfer of SolarChill technology

Once the SolarChill technology is tested and proven to be reliable, it will be made freely available to manufacturers around the world. This will be facilitated through the publication of papers and the sharing of information with interested parties. However, the SolarChill Partners will not accept any legal or financial responsibility, nor accept any liability, for the production and the performance of cooling appliances using SolarChill technology.

Demonstration projects

The SolarChill Project, pending the availability of funding, plans to run a series of demonstration projects in various parts of the world. These projects will be conducted upon the successful completion of the field tests. The purpose of the demonstration projects will be to popularize the SolarChill technology and to attract manufacturers. The Demonstration Projects will take place in rural health centers, remote villages, commercial applications in semi-rural areas, and in emergency situations.

The SolarChill Project invites enquiries from potential funders, sponsors and organizational partners interested in cooperating with the SolarChill demonstration projects.

We hold hands: partnership

The SolarChill Project brings together the expertise and resources of the International Organizations which are the SolarChill Project Partners and major companies which are the Industry Participants. The Project Partners are responsible for the full scope of the SolarChill Project. The Industry Participants provide their technical expertise in accordance with decisions of the Project Partners.

Project partners

All the SolarChill Partners have signed a cooperative agreement, participate in the SolarChill steering committee and have the same rights and obligations.

The SolarChill Partners and their respective roles are:

- Danish Technological Institute: coordinates technology development and field tests;
- Greenpeace International: provides project coordination, environmental input and fund raising;
- Programs for Appropriate Technologies in Health: provides technological assessment and field tests overseeing;
- GTZ Proklima: provides technological assessment, field tests overseeing and fund raising;
- United Nations Children's Fund: provides needs analysis, technical advice and assessment;
- United Nations Environment Program: provides overall technology assessment, policy advice and information dissemination;
- World Health Organization: provides equipment specification, needs analysis and technology advice and assessment.

Industry participants

Though SolarChill benefits from the cooperation of private companies in the development of the technology, the SolarChill Partners are not endorsing the products of any one company, nor have they entered into any commercial relationship with any one company. Industry Participants provide their technical expertise in accordance with decisions of the SolarChill partners.

The Industry Participants and their respective roles are:

- Danish refrigerator manufacturer Vestfrost: in cooperation with DTI, developed and produced the chest freezer prototypes of the SolarChill Vaccine Cooler.

- Danish compressor manufacturer Danfoss: developed and provided the direct current, hydrocarbon compressor used in both prototype models.

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About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

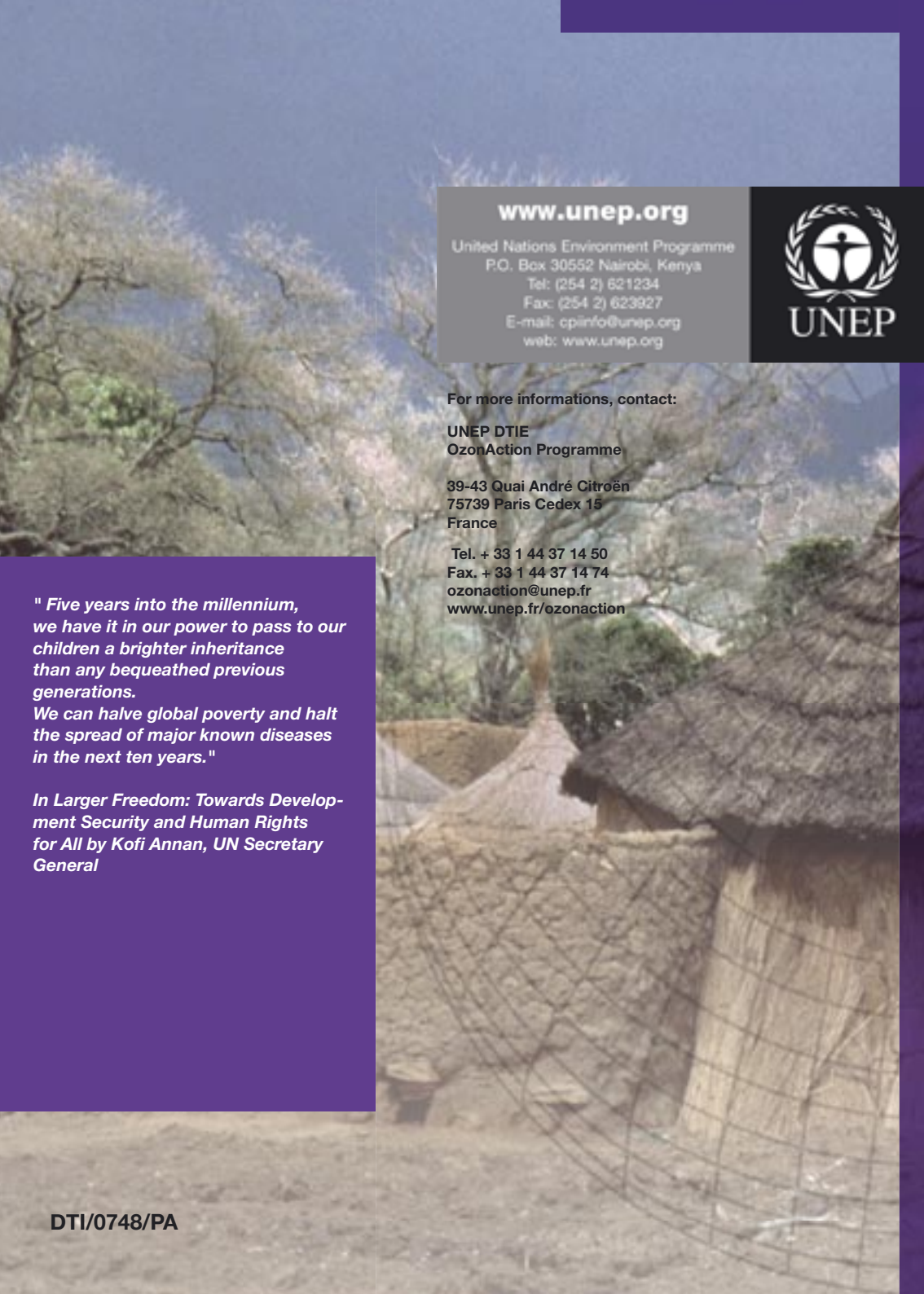
> sustainable consumption and production,
> the efficient use of renewable energy,
> adequate management of chemicals
> the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

- **The International Environmental Technology Centre** - IETC (Osaka, Shiga), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.
- **Production and Consumption** (Paris), which promotes sustainableconsumption and production patterns as a contribution to human development through global markets.
- **Chemicals** (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
- **Energy** (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
- **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
- **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

For more information,
see **www.unep.fr**



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" Five years into the millennium, we have it in our power to pass to our children a brighter inheritance than any bequeathed previous generations. We can halve global poverty and halt the spread of major known diseases in the next ten years."

In Larger Freedom: Towards Development Security and Human Rights for All by Kofi Annan, UN Secretary General

DTI/0748/PA