SolarChill backgrounder

Prepared by: Janos Maté
International Coordinator of SolarChill Project
Senior Consultant to Greenpeace International, Political Business Unit

A. SolarChill project description

The SolarChill Project aims to tangibly improve the quality of our environment and human health by delivering affordable, climate friendly, lead storage battery free or "direct drive" solar powered, vaccine cooling and food refrigeration to parts of the world that are without reliable electrical supply.

SolarChill thus bridges health, development and environmental issues. It is an iconic example of how humanity can embrace renewable energy. Moreover, SolarChill demonstrates that health, environment and poverty issues are inextricably interrelated and must be tackled together.

- Up to three billion people live in regions of the world with no electricity or without reliable electrical supply. In those regions maintaining a secure “cold chain” for the delivery of vaccination programs and preserving the safety and integrity of medicines is extremely challenging.

  Consequently, in many regions, vaccination programs and proper health care delivery are very weak or simply do not exist. In regions without reliable electricity, millions of dollars worth vaccines are spoiled each year. These losses are set to increase with ever more expensive vaccines coming on the market.

- Of course, the lack of reliable electricity also impacts negatively on the preservation of food supplies. Refrigeration of food in many regions is simply unavailable, resulting in extensive spoilage.

- Environmental challenge: A related challenge facing us is to meet basic refrigeration needs with environmentally sustainable technologies. Our reliance on environmentally harmful fluorocarbon refrigerants, such as HCFCs and HFCs, play a key role in the dual atmospheric crises of stratospheric ozone layer depletion and global warming.

- In regions without adequate electricity, the cold chain until now has relied on kerosene, gas or solar powered coolers or fridges. Existing solar coolers use lead

batteries to store the energy of the sun. Batteries are a constant source of problems as they easily break down in hot climates. Meanwhile kerosene and gas coolers need a regular supply of fuel, they sometimes catch on fire, emit nauseous fumes, and have been problematic in maintaining the right temperatures.

B. SolarChill project partnership

The SolarChill Project involves a unique, long lasting partnership between seven diverse international organizations.

The Project Partners include the Danish Technological Institute (DTI), German Government Development Agency GTZ ProKlima, Greenpeace International, Programs for Appropriate Technologies in Health (PATH), United Nations Environment Programme (UNEP DTIE), United Nations Children's Fund (UNICEF) and the World Health Organization (WHO).

This Partnership has guided and financed the project along since its inception in 2000, with each of the partners bringing their particular viewpoints and expertise to the project.

The SolarChill Project was co-conceived in 2000 by the United Nations Environment Programme (UNEP) and Greenpeace International. At the same time the Danish Technological Institute was already interested in the development of a solar powered, battery free vaccine cooler. The other Partner organizations were invited to join the Project to provide much needed expertise in vaccine cooling and the use of solar technologies in developing countries.

Greenpeace secured the initial $150,000 start up funds for research and development from the Netherlands National Lottery Commission, and together with GTZ ProKlima and PATH provided additional funding for field-testing. All in all, the Project Partners spent approximately $500,000 and considerable more in in-kind contributions, for research and development.

The SolarChill Project Partners have no commercial interest in the Project. Their sole mandate is to develop this public domain technology, make it freely available to interested manufacturers worldwide, and promote its uptake internationally.

The SolarChill technology was developed at the Danish Technological Institute in concert with the guidance and directions of the SolarChill Partners. The technology development was truly a collaborative process. The SolarChill Project also benefited greatly from the involvement of industry participants, most notably that of Vestfrost and Danfoss Companies from Denmark, and more recently, Palfridge Company of Swaziland.

C. SolarChill technology:

In principle, the SolarChill technology is relatively simple. Solar power from two or three 60 watt or 80 watt solar panels run a direct current compressor. The compressor runs

the refrigerant cycle which in turn produces an ice bank that maintains the required temperature in the cabinet. The power of the sun is essentially stored in an "ice battery". It is basically a contemporary solar version of the old fashioned ice box. A thermostat maintains the units at the required temperatures. The required temperature range for vaccines is between 2 and 8 °C, day and night. The optimum temperature range for perishable food storage is 3 to 5 °C. In low-sun situations, or with power completely disrupted, the thick insulation of the cabinet maintains acceptable temperatures for up to 5 days.

There are two models of SolarChill, a 50 litre unit for vaccine cooling and a 100 litre unit for food refrigeration. Both models operate under the same principles. Larger SolarChill models are already in the planning.

C. Environmental benefits of SolarChill:

SolarChill addresses four environmental challenges: (a) harnessing renewable solar energy to meet human needs; (b) eliminating ozone depleting and potent global warming substances; (c) eliminating reliance on fossil fuels such as kerosene; and (d) eliminating the use of toxic lead batteries.

- **Elimination of use of fluorocarbons:** SolarChill uses hydrocarbons instead of fluorocarbons such as HCFCs and HFCs, for the insulation foam blowing and for the refrigerant. HCFCs and HFCs are super greenhouse gases. There is an emerging consensus that the large scale emissions of HFCs could eliminate the climate co-benefits of the Montreal Protocol's accelerated HCFC phase-out, and undermine the intent of the Kyoto Protocol.

  Used as refrigerants and insulation foam blowing agents, hydrocarbons are safe for the ozone layer and the climate. The hydrocarbon (or Greenfreeze) technology in refrigeration was developed by Greenpeace in 1993. Today there are over 550 million Greenfreeze domestic refrigerators in the world, representing 40 per cent of global refrigeration production.

- **Elimination of the use of a lead battery:** Currently solar vaccine coolers use lead batteries to store energy. SolarChill bypasses the use lead batteries. Lead batteries are a major obstacle to the uptake of solar technology in developing countries. They are expensive, short-lived (especially in hot climates), toxic to produce and difficult to properly dispose in remote regions. A recent survey of solar-powered vaccine refrigerator performance found that over 60 per cent of equipment failures related to battery systems. It is not a question of if a battery will fail, rather when.

- Lead batteries also pose an environmental and health hazard during production, use and disposal. Tens of millions of lead batteries are disposed off in developing countries each year. Often these batteries end up in landfills, or are haphazardly dismantled. Each battery contains approximately 27 pounds or 12.2 kilograms of lead.

75 per cent of global lead production goes into batteries. Lead poisoning can lead to loss of neurological functions, brain damage, deleterious impacts on central nervous system, kidneys, and blood diseases. According to the World Health Organization over 100 million people in developing countries are over-exposed to lead.

- **Elimination of kerosene vaccine coolers:**
  There are approximately 100,000 kerosene vaccine coolers and many more food refrigerators currently in use today. On the average, kerosene vaccine coolers consume between 0.8 to 1 litre of kerosene daily, or 292 to 365 litres annually. One litre of kerosene produces 5.68 pounds of carbon dioxide. Each kerosene vaccine cooler therefore produces between 1, 658 and 2,073 pounds of CO_2 annually.

  The annual global warming contribution of these kerosene vaccine coolers from kerosene consumption is between 75,192 and 94,013 metric tons of CO_2 equivalent. Consequently, the replacement of 5,000 kerosene coolers with SolarChill every year will yield a savings of 201,500 and 252,900 tonnes of CO_2 emissions over a 10-year period.

  Similar estimates can be made for the global warming contributions of kerosene food refrigerators. It is estimated that there are over 2 million off-grid, kerosene and gas refrigerators in developing countries. The potential annual CO_2 emission savings could be between 1,500,000 - 1,880,000 metric tons of CO_2 should all those coolers be substituted by SolarChill food refrigerators. Of course, millions of propane and kerosene refrigerators are also used in off-the grid applications (e.g. recreational cottages, sail boats, remote areas) in developed countries.

D. Cost benefits of SolarChill

The purchase price of SolarChill units, due to the cost of solar panels, is greater than that of kerosene and gas coolers. SolarChill units currently sell for between $US 1,800 and $US 2,800, including solar panels. The price difference between kerosene coolers and SolarChill may be between $500 and $2,000. However, the operational costs of SolarChill are much less as there is no need for weekly refueling.

Kerosene coolers use an average of 0.8 to 1 litre of kerosene daily. The current cost of kerosene varies from country to country. In Nigeria, for example, it is between 81 to 93 US cents a litre. The annual fuel cost of running one kerosene cooler in Nigeria is therefore between $US 295 and $US 340. The pay back time of the higher purchase price of the SolarChill units, is therefore between three to seven years. Over a 20 year lifetime of the units SolarChill will save between $3,835 / $4,420 and $5,015 / $5,780 in overall costs.

The most expensive component (representing about 40 per cen of the price) of both the Vestfrost and the Palfridge units are the solar panels. However, the cost of solar

panels has been on the decline over the past two years.

E. Commercialization of SolarChill

Currently there are four factories producing SolarChill technology based products: Vestfrost in Denmark, Palfridge in Swaziland, Haier in China, and True Energy of UK.

- **Vestfrost SolarChill:** Vestfrost has participated in the SolarChill Project since its inception and today has the leading edge in its manufacture and worldwide marketing. A milestone was reached on March 18, 2010 when the Vestfrost SolarChill cooler, MKSO44, received the WHO Performance, Quality and Safety (PQS) approval.

  Approximately 600 Vestfrost SolarChill units are now installed in 15 countries, in South East Asia, Africa and Latin America, with several hundred more units currently on order. SolarChill coolers are installed in clinics and health centers. They have been purchased for use in refugee camps in Chad and Uganda by Medicine Sans Frontier, as well as by aid agencies working in earthquake hit zones in Haiti.

  The Vestfrost model is prequalified for 20 ºC to 32 ºC ambient temperatures. However, in field tests, the units have operated under lower and higher ambient temperatures ranges of 10 ºC to 42 ºC. The Vestfrost model is priced around 2000 Euros (with the solar panels included).

- **Palfridge SolarChill**: The entire Palfridge fridge factory in Swaziland was converted in 2009 from fluorocarbons to hydrocarbons with funding from GTZ ProKlima. At the same time GTZ also supported Palfridge in the design of its own model of SolarChill, specifically to meet the needs of Africa. Palfridge made several innovative changes to the original SolarChill design.

  The company is now producing a SolarChill vaccine cooler (which is yet to receive WHO PQS approval) that operates in up to 48 ºC ambient temperatures. The Palfridge vaccine cooler model is priced around 1350 Euros, including solar panels. Palfridge is also producing SolarChill upright food refrigerators for domestic and small commercial use at a cost of 1450 Euros.

- **True Energy — Sure Chill Technology:** Sure Chill® technology (inspired by SolarChill project but developed separately) was developed by the UK based True Energy company. The patented technology has received WHO PQS certification. The company reports the following data:

  The Sure Chill units operate in a broad ambient temperature range of (5 °C to 43 °C), and in a wide array of geographical locations with low insolation.

  2 x 230W panels (these are oversized to accommodate 25 per cent degradation over a 20 year period – the construction will ensure a longer life in the field than

a more traditional construction)

The hold over times are over 10 days (250 hrs) at 43 °C and almost 13 days (309 hrs) at 32 °C. Price range spans $US 3,000 to $US 6,000. The company is capable of producing 15,000 units per year, has clients in Asia and Africa, is discussing licensing agreements with companies in India and Africa.

- **Public domain (or open source) technology:** SolarChill technology is in the public domain. The basic principles and design of the technology can be freely transferred. The Vestfrost model has a few technical components that are proprietary. The Palfridge model, having been paid for by GTZ, is entirely in the public domain. The True Energy model is patented

G. **Summary of SolarChill Project Achievements to date:**

- Successfully developed an innovative, cost-effective public domain technology through a cooperative partnership
- Extensive field tests of SolarChill vaccine cooler in Indonesia, Senegal, Cuba and India
- WHO PQS prequalification: the first solar direct drive vaccine cooler in the world
- Initiated commercialization of SolarChill vaccine coolers by one European manufacturer
- GTZ ProKlima, a SolarChill Project Partner, completed a technology transfer project of SolarChill at Palfridge factory in Swaziland
- Inspired development of Sure Chill, a patented technology
- Developed an early prototype of SolarChill food refrigerator
- Initiated outreach and promotion of SolarChill at various international events

H. SolarChill Project recognition:

- On October 4th, 2006 in London, England, the SolarChill project was awarded the prestigious 2006 Cooling Industry Award (the refrigeration industry's "Oscar"), in the Environmental Pioneer category.
- On November 1, 2006 the then President of India, Dr. A.P.J. Abdul Kalam oversaw the installation (for testing purposes) of two SolarChill vaccine coolers in the clinic of the President's official residence estate ("Rashtrapati Bhavan") in New Delhi.

I. Challenges & Opportunities Facing SolarChill

Throughout its history SolarChill has received a steady flow of expression of interest from refrigeration equipment manufacturers, health clinics, and potential small commercial users from many developing countries.

The Project aims to encourage manufacturers worldwide (particularly in developing countries) to take up the production and commercialization of SolarChill. It is expected that the price of the units will be further reduced as manufacturers in developing countries take up production. Still, many challenges remain.

- **SolarChill recognition and market penetration:** The first challenge is to further familiarize the world regarding the existence and availability of SolarChill and to encourage the uptake of the technology for both vaccine cooling and food refrigeration.

  The SolarChill Project has exhibited SolarChill units at some international gatherings (the World Summit on Sustainable Development in Johannesburg, UNEP Ministerial Meetings, Meeting of the Parties to the Montreal Protocol), has installed a few units as demonstration projects in Africa, and has given presentations at various technical meetings and published articles in relevant magazines and journals.

  In this regard, funding dependent, the SolarChill Project plans to conduct large scale demonstration projects, regional outreach programs and technology transfer initiatives.

- **Technical challenges:**
  Working with hydrocarbons: It is unlikely that existing appliance manufactures that are not yet working with hydrocarbons in their general production line of refrigerators or freezers will be able to produce hydrocarbon SolarChill products.

  However, as demonstrated by the Palfridge conversion, once a factory has converted to hydrocarbons, it is feasible for the factory to also produce SolarChill. Moreover, new factories can build in, right from the start, the safety features that are necessary for working with hydrocarbons.

  Service infrastructure: Companies that sell hydrocarbon products, including SolarChill, have to ensure that service technicians are properly trained, and that there is a competent maintenance infrastructure.

  Availability of hydrocarbon refrigerants: In some parts of the world there is an insufficient or non-existent supply of high-grade hydrocarbon refrigerants. This is rapidly changing as the demand for hydrocarbon products is escalating in most parts of the world.

Cost Challenges: The initial price of SolarChill vaccine coolers or food refrigerators is considerably higher than that of kerosene refrigerators, although the operational costs over their lifetime are less. The cost of solar panels represents approximately 60 per cent of the price of SolarChill units. Until these costs come down, either through market forces or through subsidies, the initial costs of SolarChill refrigerators will remain more expensive that of kerosene or standard refrigerators. It is however expected that the costs will decrease with increased competition economy of scale and technological advances in solar technology.

J. Global Environment Facility (GEF) Funding for SolarChill

On November 10, the GEF Council approved $2,728,000 for the SolarChill project. The project will be implemented over three years in Kenya, Swaziland and Colombia.

The aims of the GEF SolarChill Projects are:

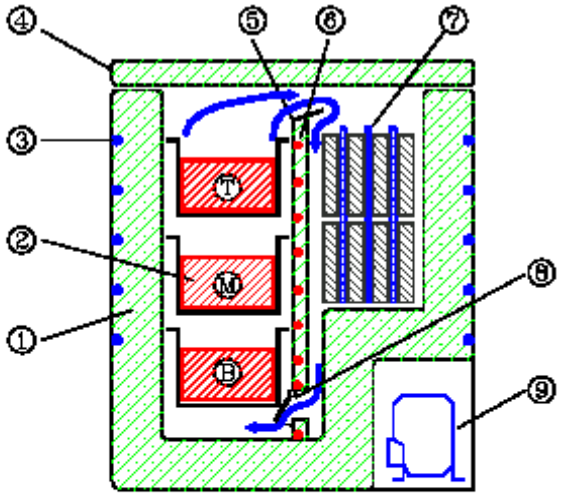
- To conduct large scale tests of the SolarChill vaccine refrigerators through field evaluation of technical performance and user acceptance, and to stimulate interest and investment by the private manufacturing sector.

- To provide meaningful field testing of SolarChill food refrigerator prototypes. To verify technical performance, and user acceptance, and to stimulate interest and investment by the private manufacturing sector.

- To develop market/information, training/capacity building and technology transfer packages for the SolarChill technology and uptake by the manufacturing sectors in Latin America and Africa.

Summary

With adequate funding support SolarChill has the potential to deliver much needed, environmentally sustainable, cooling services to regions of the world that lack electricity . Such services can save lives as well as enhance the quality of life of tens of millions of people.



1. Cabinet wall with 100 mm of insulation (made by Vestfrost)
2. Vaccine packages (in three baskets)
3. Integrated condenser
4. Lid (also 100 mm insulation)
5. Internal wall, insulated
6. Electric heating element, thermostat controlled by temperature in the bottom of the box
7. Evaporator (wire on tube) and ice packs
8. Self-acting damper
9. Compressor (made by Danfoss Compressors)