2 PRODUCT MARKET COMBINATIONS (OVERVIEW)

There is a large demand for chilled and frozen goods in developing countries. In most cases, the electricity for cooling/freezing can be supplied by the grid. If a grid is available, grid connection is usually the most favourable option (low investment, low risk, reasonable operational cost). Only in some cases, especially when there is no grid available, when it is too unreliable or when it concerns a mobile cooling/freezingapplication, renewable energy can be used.
In this chapter, product market combinations (PMCs) where renewable energy (RE) for cooling or freezing can be commercialized are discussed. Furthermore, the economics of renewable energy freezing or cooling are discussed in this chapter.

2.1 DESCRIPTION OF PRODUCT MARKET COMBINATIONS

There are four main areas where renewable energy (RE) cooling/freezing can be commercialised:

1 Convenience and tourism
   - Chilled drinks
   - Ice cream
   - Ice (cubes) for domestic purposes
   - Air conditioning
2 Agriculture and fisheries
   - Ice for fishing
   - Cooling of agricultural crops/fruits and meat
   - Milk cooling
3 Health (vaccines)
4 The production of fridges and other RE cooling appliances in developing countries

The commercialisation of these PMCs largely depends on the local situation: demand for the product and value added due to cooling/freezing, availability of the grid, import taxes, kWh/ fuel cost, transport cost, etc.

2.2 STATE OF MARKET INTRODUCTION OF RE COOLING / ICE MAKING

The following table shows the state of the market introduction of RE technology available for the various PMCs, the scale of the operation and indicates the investment cost vs the variable costs and the desired reliability of the service.

Application	Technology (C= compressor based cooling, A= absorption cooling)	Maturity of the technology (comm.=commercially available , early = prototype) ,	Scale of the operation (small, medium or large)	Investment cost (low, med or High)	Variable cost	Conventional alternative	Desired reliability of service	Described in section
Convenience and tourism								
Chilled drinks	Solar fridge (C) Solar Ice maker (A)	Comm Early	S M	L M	L	Grid, gas/kerosene fridge, ice from grid fridge	+	3.1
Ice cream	Solar fridge (C)	Comm	S-M	L	L	Grid, gas/ kerosene fridge	+	3.1
Ice (cubes) for domestic purposes	Solar fridge (C) Solar Ice maker (A),	Comm Early	S M	L M	L	Grid, gas/kerosene fridge	-	3.1
Air conditioning	Solar Air-co (C)	Just avail.	S	M	L	Grid, diesel	-	3.1
Agriculture and fisheries								
Ice for fishing	Solar freezer (C) Solar (A/C) / Wind-Diesel icemaker (A/C)	Comm Custom made	S M-L	M M-H	L L-M	Grid, diesel ice plant	+	3.2
Cooling of agricultural crops/fruits and meat	Solar fridge (C) Solar (A) / Wind-Diesel cool store (C)	Comm Early Custom made	S M-L	L M-H	L L-M	Grid, diesel	+	3.2
Milk cooling	Solar fridge (C) Solar Ice maker (A)	Comm Early	S M	L M	L	Gas/ kerosene or grid fridges, ice from grid fridge, Diesel	+	3.2
Health (vaccines)	Solar fridge (C)	Comm.	S	L	L	Gas/ kerosene or grid fridges	++	3.3
The production of fridges and ice makers	PV solar compression fridges and solar Ice makers (A)	Comm early.	S-M	M-H	M-H	Gas/ kerosene or grid fridges	+	3.4

table 1: Indication of maturity of the RE cooling/ice-making technology available for the various PMCs, the scale, investment/ variable cost, conventional alternative (competition) and desired reliability.

As can be seen in the table, PV solar fridges is the only 'commercially proven' technology that is available for RE cooling/ice making. Yet even this technology may not be locally available at a reasonable price. The other technologies are still in the prototype/ first series production stage, are just becoming available (only one or two suppliers) or not available as a standard product (custom made/ design).

2.3 RE ENERGY COOLING VS RE ICE MAKING

Freezing (ice making) takes much more energy than refrigeration. This translates into higher investment cost. The purpose of freezing should be well justified. The following table compares ice making and cooling.

Cooling	**Ice making**
Energy requirement depends on quantities produce to be cooled and T	Energy requirement depends on quantities and T but is much higher than for cooling
Low to medium investment, low operational cost. Space requirements.	Medium to high investment cost due to higher energy use than cooling. Good quality water needed. Space required.
RE options: o Absorption cooling with solar thermal (no standard products found commercially available) o Compression cooling with PV/ wind-diesel	RE options: o Absorption cooling with solar thermal collector and absorption cooling (ISAAC). o Compression cooling with PV/ wind-diesel
Solar fridges are widely available, absorption or wind/diesel systems custom made	ISAAC ® solar thermal ice maker is not yet series produced, wind/diesel systems custom made
PV solar air conditioner is just entering the market	Ice can be stored in an insulated room and is its 'own thermostat'
Small mobile applications (vending carts) possible	Ice can be transported and used on location to cool perishable goods

table 2: comparison between RE ice making and cooling.

2.4 RE PRODUCTS AND COMPETITION

The following table compares the RE products with its conventional alternatives. Prices are based on world market prices (US$). Medium and large applications are the local cost are higher as considerable space needs to be available.

	Price range [000's US$]	Cap [L] (or Kgs/ day)	Approx. energy use/cost per day	Brand
Cooling (small)				
PV Solar fridge	1,5- >4	80-200	0 (PV)	Soleco, consul/Elber solar, Global cooling, Sun Frost, etc,
Gas fridge	>0,4	35-250	0,25-0,5 kg of gas	Consul, Electrolux, Dometic
Kerosene fridge	1.5-2,5	40-250L	0,5-1.2 L	Epcamp, Westpoint
PV solar Air-co	3-4			Sunny Airco (Transsolar)
Mobile cool box with ice	0,1-0,2	20	Local ice	Various brands
PV Mobile vending cart for chilled drinks	2-3[1]			Under development at ECN
Cooling (medium/large)				
Grid cool storage	>0,5	Any size	>1kwh	Standard cooling systems widely available or custom made (large systems)
Diesel cool storage	>1	Any size	>5-10 litres diesel	Standard cooling systems w generators widely available or custom made (large systems)
Wind/ diesel	>3-5	Any size	Depends on availability wind	Custom built

[1] Still under development by ECN. ECN aims at a cost price of US$.1200 (withoutPV) when series produced locally.

Solar absorption cooling storage	-	No standard products av.	0	No standard products found available
Ice making (small scale)				
Grid freezer	>0,1	>10	0,1-0,3 US$/kWh	Many brands
Diesel generator + freezer	>0,7	>10	0,1-0,3 US$/kWh	Many brands
Gas fridge/freezer	>0,4	>3	0,25-0,5 kg	Consul, electrolux
Ice making (med-large scale)				
Solar thermal absorbtion	>4-5[2]	50 kgs	0	ISAAC
Wind/ wind- Diesel	>10-20	>1000 kgs	55-85 kWh/ton ice [3], 0,1-0,3 US$/kWh	Ice: AVE, Icebits, wide range of suppliers available Wind: depends on capacity
Grid based ice making (consid. space req'ments)	>5	>1000 kgs	55-85 kWh/ton ice [3], 0,1-0,3 US$/kWh	AVE, Icebits, wide range of suppliers available
Diesel gen. with ice making plant (consid. space req'ments)	>8	>1000 kgs	55-85 kWh/ton ice [3], 0,1-0,3 US$/kWh	AVE, Icebits, wide range of suppliers available

table 3:Indication of costs and capacities of RE products and conventional alternatives. Costs are based on world market equipment prices (excl. taxes, transportation and installation).

Conventional (grid and diesel generator) cooling and ice making equipment is well known and readily available in most countries. RE alternatives are less well known and only available limited. This makes it unlikely for an entrepreneur to start with RE ice making/ cooling unless there are great benefits to it.

2.5 INDICATORS OF MARKETS

The following table gives an overview of the markets for ice making / cooling per PMC.

PMC	Rural areas	Urban areas	Indicators of markets:
Convenience and tourism	X	* **	o High sales of soft drinks, o Tourism (preferably al year around), o Heavy competition.
Agricultural crops and milk	X		o Small scale dairy farming (off grid), o Demand for fresh milk, o (inter)national regulations concerning quality/hygiene, o Heavy competition on market.
Fish	X		o Demand for fresh fish, o Longer (>1 day) fishing trips, o (inter)national regulations concerning quality/hygiene and highly perishable sorts of fish, o Heavy competition on the fish market.
Meat	X		o (inter)national regulations concerning quality/hygiene, o Heavy competition on the meat market.
Fruit	X		o High quality high value (perishable) fruits, o (inter)national regulations concerning quality/hygiene, o Heavy competition on the meat market.
Health	X	***	o National and international health programmes
Production of refrigerators	X		o Demand for gas/kerosene refrigerators

[2] According to the inventor, the ISAAC solar icemaker can be produced at 4-5,000 US$ locally at large scale. Currently they are only built at order at a much higher price.

table 4: Indicators of markets for RE ice making/ cooling. * mobile stalls, **especially in tourist areas, *** urban areas with unreliable grid.

As can be seen in the table, markets for RE ice making / cooling need to be sought in rural off grid areas, with high fuel cost or where high transportation cost make transport of ice expensive.

2.6 ANALYSIS AND SUMMARY

Economics of RE ice making/cooling

- Investment cost of RE cooling and ice making are found to be much higher than for conventional cooling/ ice making, but in general the running cost can be lower.
- Because of the high investment cost, a good occupancy rate will be needed to earn back the investment fast. This requires a good market study, careful planning and logistics and contracting with clients in order to make maximum use of the facility.
- Dedicated loans (on attractive terms) could help RE cooling/ice-making compete.
- When reliability is important, a hybrid system or oversized RE system may well perform better than the grid or a single diesel generator.

Market introduction of RE ice making/cooling

- Few RE cooling products are widely commercially available (only solar fridges)
- Conventional alternatives (diesel/grid) are almost always available and well known.
- Demonstration projects are needed for the other technology/products, aiming at local series production if feasible.
- RE cooling ice making should be introduced as a packet, with energy saving measures/training for the users.