A Hot Market for Renewable Cooling

This is Cool Webinar Series

Thursday April 15, 2021

#ThisIsCool Webinar Series
A Hot Market for Renewable Cooling

Cool Coalition
UN environment programme
IRENA International Renewable Energy Agency
SUSTAINABLE ENERGY FOR ALL

A Hot Market for Renewable Cooling

This is Cool Webinar Series

Opening & Welcome

Lily Riahi
Coordinator, Cool Coalition
UN Environment Programme

A Hot Market for Renewable Cooling

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Special Remarks

Philippe Malbranche
Addition Director General
International Solar Alliance

A Hot Market for Renewable Cooling

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Knowledge Brief Findings

Raising Standards for Off-Grid Appliances

Clotilde Rossi di Schio
Senior Specialist
Policy Team
Sustainable Energy for All

Sustainable Energy for All (SEforALL)

Raising Standards for Off-Grid Appliances

15th April 2021

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MULTI-TIER FRAMEWORK (MTF) FOR HOUSEHOLD ELECTRICITY ACCESS

		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Tier Criteria			Task lighting and phone charging	General lighting and phone charging, television, and fan (if needed)	Tier 2 and any medium-power appliances	Tier 3 and any high-power appliances	Tier 4 and very high-power appliances
Peak Capacity	Power capacity ratings (in W or daily wh)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
			Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
	Or services		Lighting of 100 lmhr/day	Electrical lighting, air circulation, television and phone charging are possible			
Availability	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
	Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs

MTF identifies the key attributes that together determine the "usability" of services.

For electricity, this includes:

- Electricity capacity
- Hours of electricity service received
- Reliability
- Quality
- Affordability
- Legality
- Safety of service

Source: World Bank

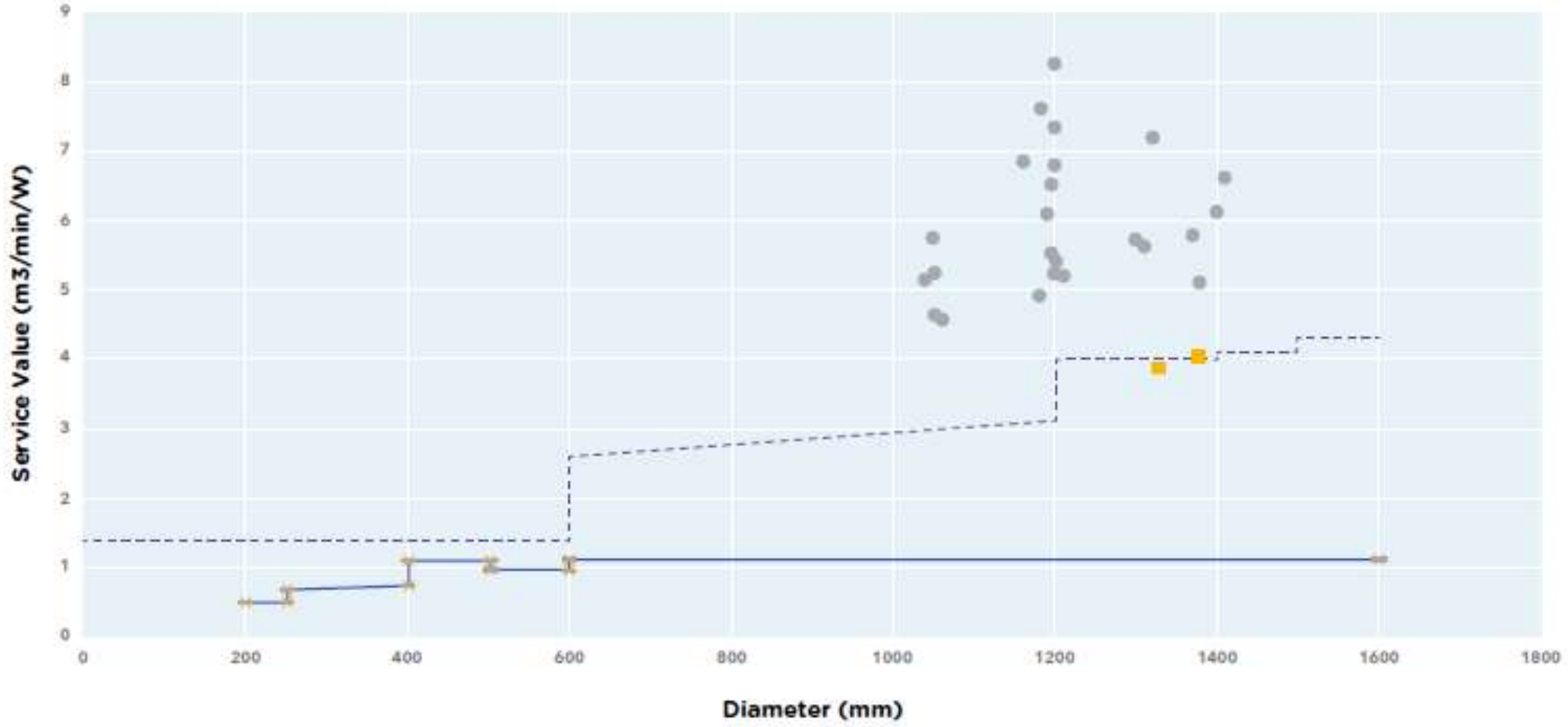
COOLING APPLIANCES AND THE MULTI-TIER FRAMEWORK

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
COOLING APPLIANCES IDENTIFIED IN MTF[6]			Fan	Air Cooler	Refrigerator and Freezer	Air Conditioner
COOLING APPLIANCES IDENTIFIED IN THIS ASSESSMENT		Table fan Air cooler	Table fan Ceiling fan Pedestal fan Air cooler Refrigerator	Table fan Ceiling fan Pedestal fan Air cooler Refrigerator and Freezer Air conditioner	Table fan Ceiling fan Pedestal fan Air cooler Refrigerator and Freezer Air conditioner	Table fan Ceiling fan Pedestal fan Air cooler Refrigerator and Freezer Air conditioner

The MTF uses a tiered approach to measure a household's access to energy (supply side).
This is also useful when we think about cooling appliances and how they fit into each tier (demand side).

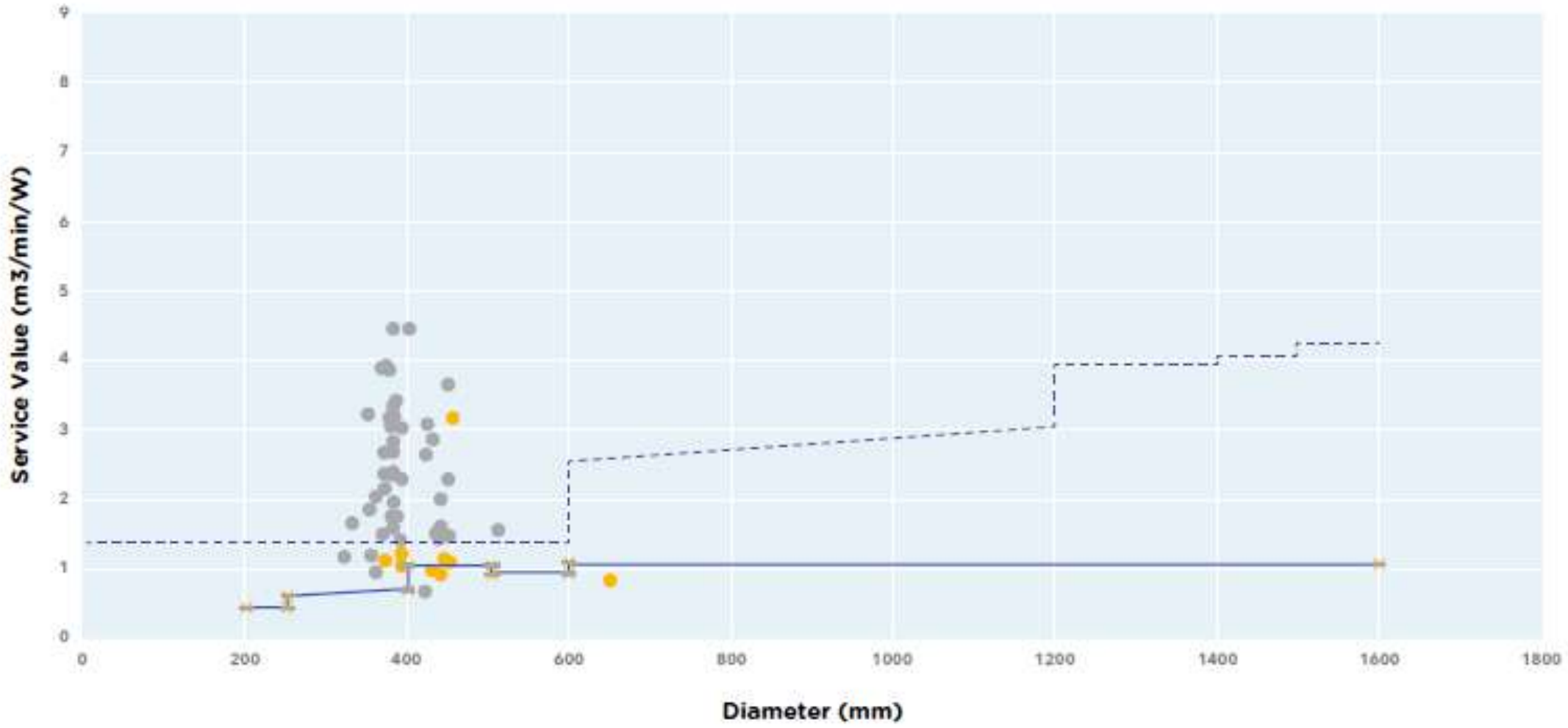
Source: World Bank, SEforALL analysis

CEILING FANS: MTF APPLICABILITY AND EFFICIENCY



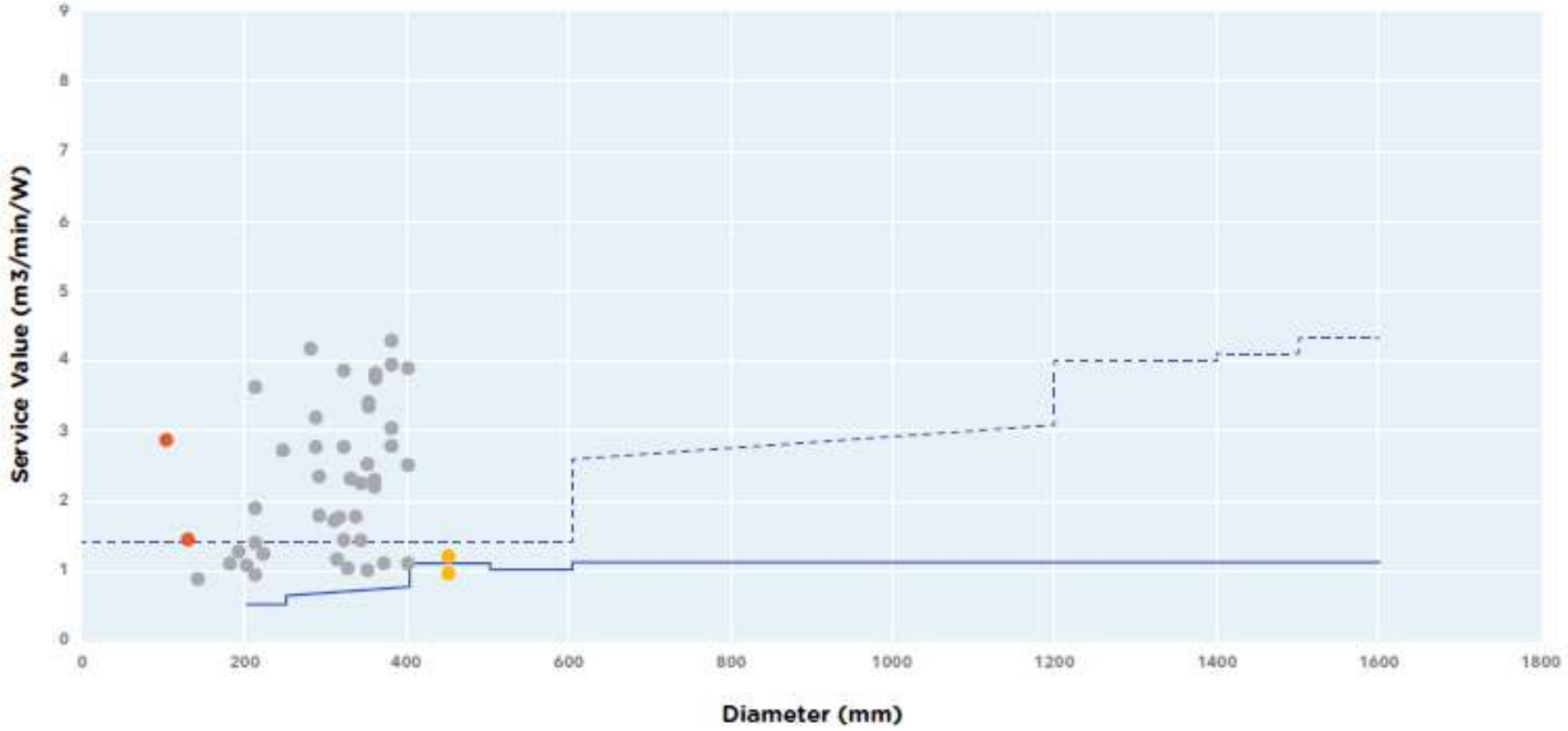
Source: SEforALL

PEDESTAL FANS: MTF APPLICABILITY AND EFFICIENCY



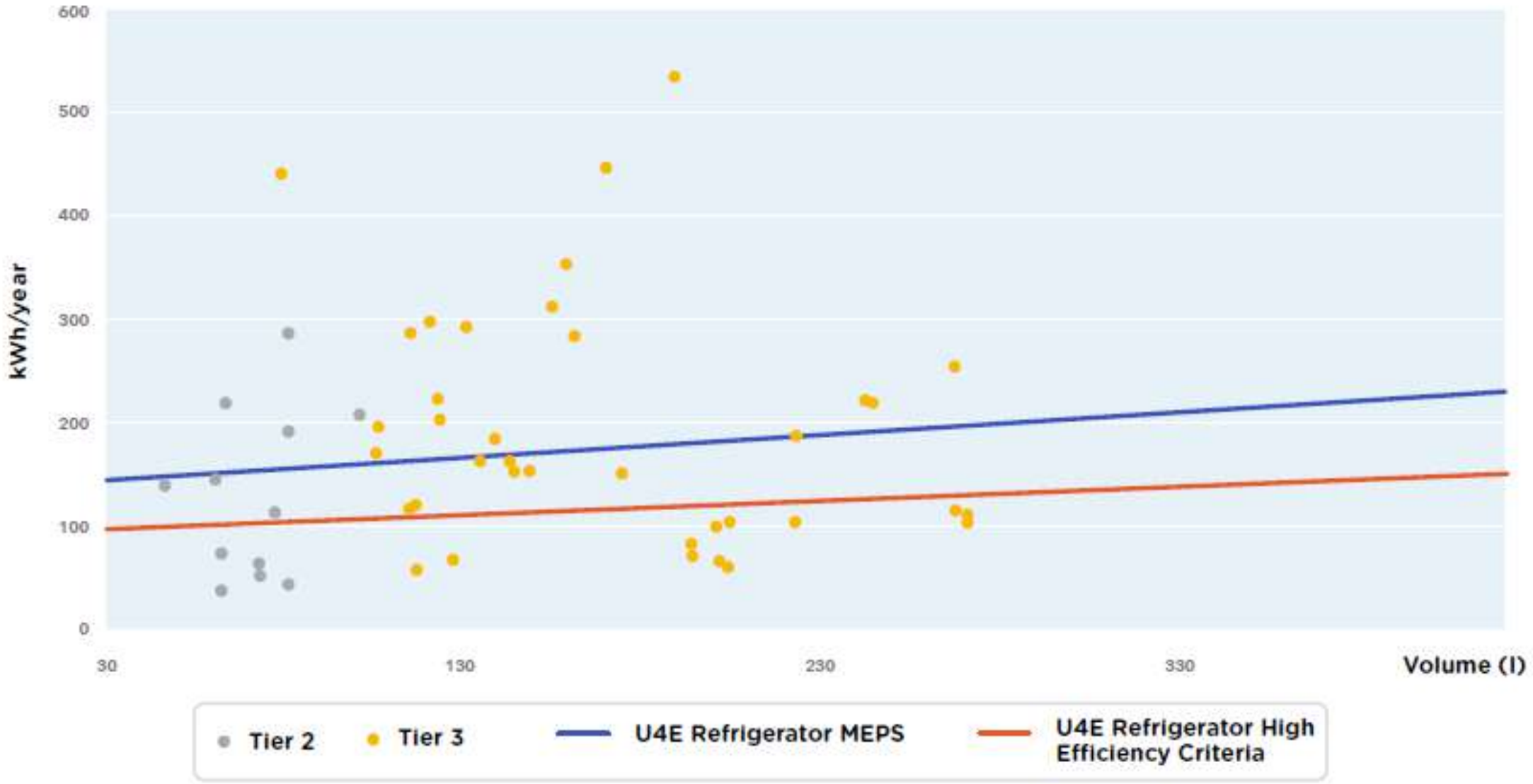
Source: SEforALL

TABLE FANS: MTF APPLICABILITY AND EFFICIENCY



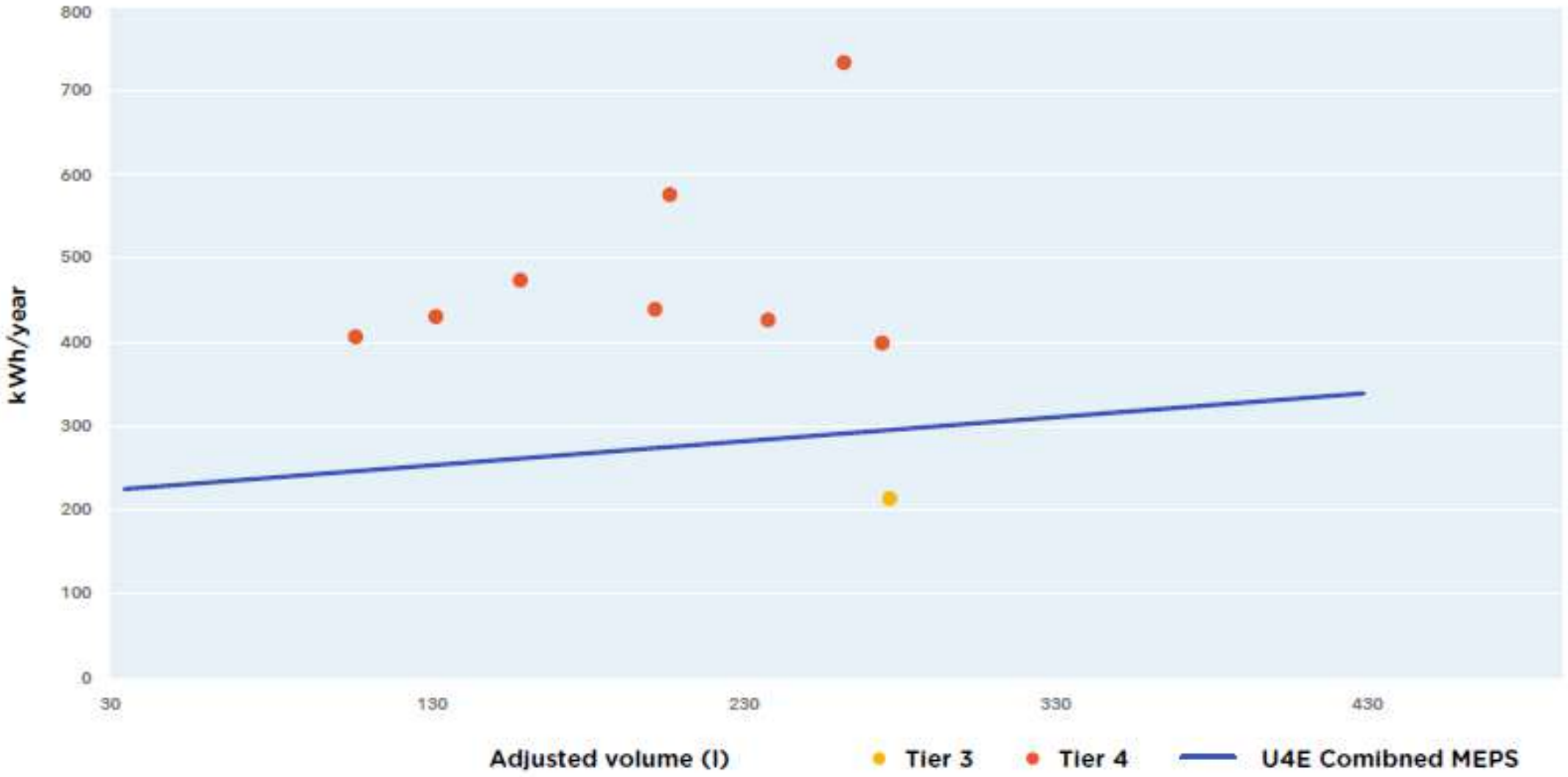
Source: SEforALL

REFRIGERATORS: MTF APPLICABILITY AND EFFICIENCY



Source: SEforALL

REFRIGERATOR/FREEZERS: MTF APPLICABILITY AND EFFICIENCY

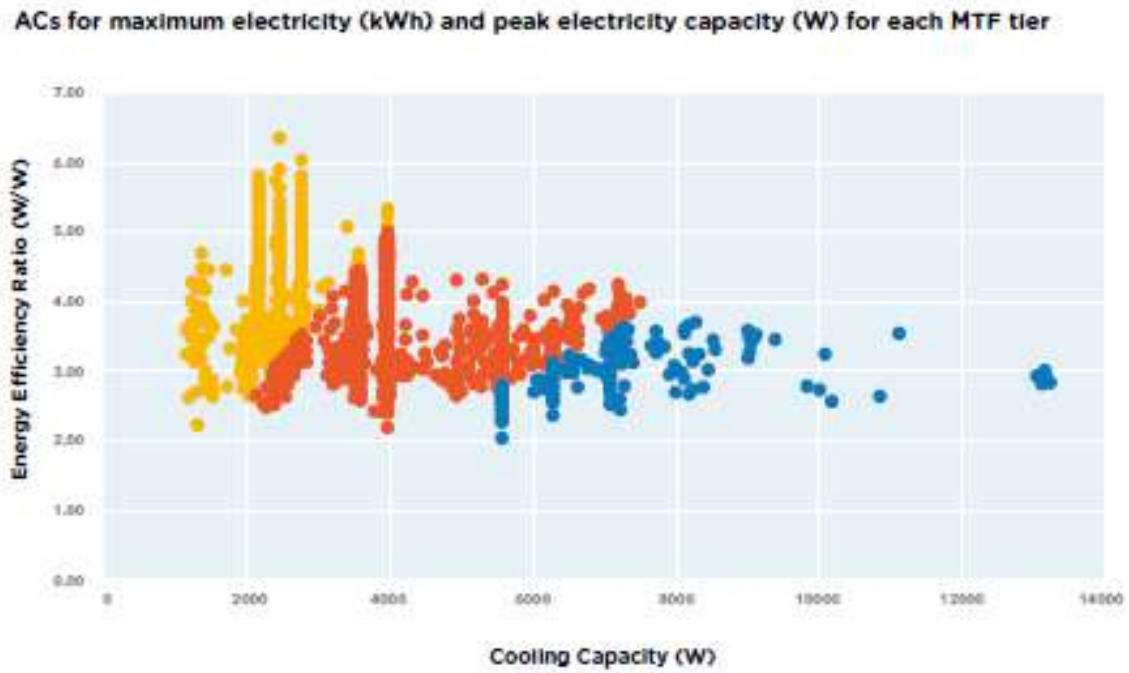


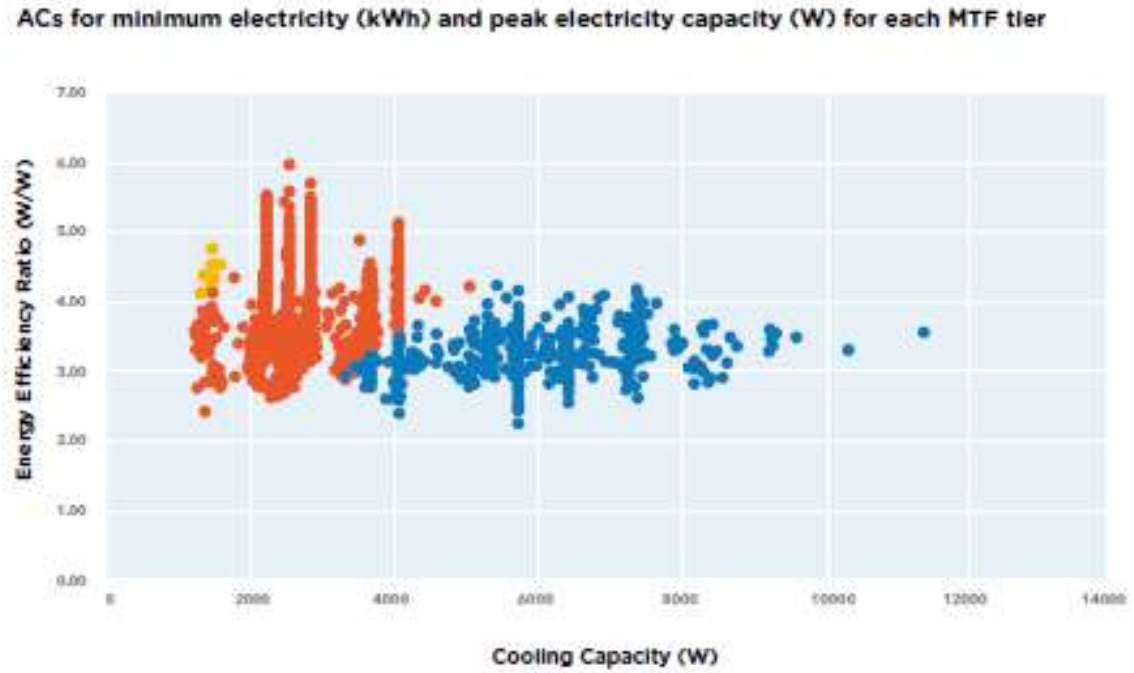
Source: SEforALL

AIR COOLERS: MTF APPLICABILITY AND EFFICIENCY

Source: SEforALL

AIR CONDITIONERS: MTF APPLICABILITY AND EFFICIENCY





Tier 3 Tier 4 Tier 5

Source: SEforALL

OFF-GRID COOLING APPLIANCES QUALITY CRITERIA DEFINITION

A quality criteria framework was designed to stakeholders **differentiate and compare the quality and performance of individual cooling appliances**.

- Efficiency
- Service Delivery
  - Air delivery (fans)
  - Compartment temperature
  - Hours (refrigerators)
- Safety
- Durability
- Environmental
- Consumer protection
  - Performance reporting
  - Truth-in-advertising
  - User manual evaluation
  - Warranty
- Affordability

	MEASUREMENT INDICATORS	INDICATOR DESCRIPTION	RATING A	RATING B	RATING C	NOT RECOMMENDED
MTF COMPATIBILITY	Tier compatibility[7]	Product is compatible with which energy supply tier as defined in the World Bank's MTF[20]	Tier 3 and above			
	Daily hours of operation (hours)	Hours product can operate with the minimum daily energy for a given MTF tier	Min 24			
EFFICIENCY	Efficiency - Energy Efficiency Index (EEI)[21]	Energy consumption relative to United for Efficiency recommended MEPS	X < 0.67	0.67 ≤ X <1	1 ≤ X ≤ 2	X > 2
SERVICE DELIVERY	Fresh food compartment temperature (°C)	Minimum temperature of fresh food compartment	X ≤ 4°C (for food storage)	4°C ≤ X ≤ 12°C (for beverage storage)		X > 12°C
	Freezer compartment temperature (°C)	Minimum freezer compartment temperature measured	-18°C ≤ X < -12°C	-12°C ≤ X < -6°C	-6°C ≤ X ≤ 0°C	X > 0°C
	Autonomy (hours)	Time that the product's compartment stayed within an 8-degree temperature rise (from 4°C to 12°C or 8°C to 16°C), with no external power supply	X ≥ 2 hours	1 hour ≤ X < 2 hours		X < 1 hour
	Pull-down time (hours)	Time required to lower the temperature of a refrigerator compartment from ambient temperature (32°C) to 4°C or 8°C	< 8 hours to reach 4°C	< 8 hours to reach 8°C		> 8 hours to reach 8°C
SAFETY	Safety evaluation	Product meets IEC 60335-1 (general requirements) and IEC 60335-2-24 (particular requirements for refrigerating appliances, ice-cream appliances and ice makers)[22]	Yes			No
ENVIRONMENTAL	Foam blowing agent	Does foam blowing agent comply with Montreal Protocol requirements?	Yes			No
	Refrigerants	Does the product use natural refrigerants?	Yes			No
	Presence of harmful chemicals	Are any of the following chemicals present in product: lead (except in batteries), mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated biphenyl ethers (PBDE)?	No			Yes
CONSUMER PROTECTION	Performance reporting[23]	Daily energy consumption (kWh/24h)	Reported and specifies conditions at which product was tested	Reported		Not Reported
		Voltage (V)	Reported			Not Reported
	User manual evaluation	User manual included (yes/no)	Yes			Not Reported
		Includes instructions on product installation, use, and maintenance	Includes information on installation, use, and disposal	Includes information on installation & use	Includes information on installation	Not included
	Warranty (months)	Warranty duration	36+ months	24 months	12 months	No warranty
		Level of after-sales service provided	Product replacement	Virtual/in-person technician support	Spare parts available	Not provided
Affordability	Refrigerator cost (USD)	Refrigerator cost [USD], based on a minimum order quantity of X	e.g., $500 (minimum order quantity (MOQ): 500)			

Source: SEforALL

RECOMMENDATIONS

- Encourage and incentivize the use of the most efficient, best available off-grid cooling appliances
- Support the use of passive and climate-friendly cooling solutions
- Support information sharing for decision-making
- Design programmes to meet the needs of vulnerable populations
- Adopt and implement standards
- Support testing infrastructure to enable accurate measurement and comparison
- Include measurement and evaluation in programme design
- Deeper technical work related to off-grid appliances

SUSTAINABLE ENERGY FOR ALL

Cool Coalition

#THISISCOOL

CHILLING PROSPECTS

Tracking Sustainable Cooling for All 2021

5 MAY 2021

10:00 ET | 16:00 CET

#ThisIsCool

CAMPAIGN

Over 1 billion people lack access to sustainable cooling and a further 2.2 billion have inefficient cooling. In a warming world, access to sustainable cooling is not a luxury. It is an issue of equity and a service that must be delivered to everyone.

This Is Cool is a campaign to show what can be done across the world to make sustainable cooling a reality.

thisiscool.seforall.org

Sustainable Energy for All (SEforALL)

Raising Standards for Off-Grid Appliances

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A Hot Market for Renewable Cooling

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Panel Discussion

Renewable Energy Technologies for Cooling Applications: Scope and Opportunities

PANELLISTS

Lars Munkøe
Co-founder and Director
PURIX

Moeen Salibe
Senior Director
Smart Operations & Optimization
ENWAVE

Ruth Kimani
Associate
East Africa
CLASP

MODERATOR

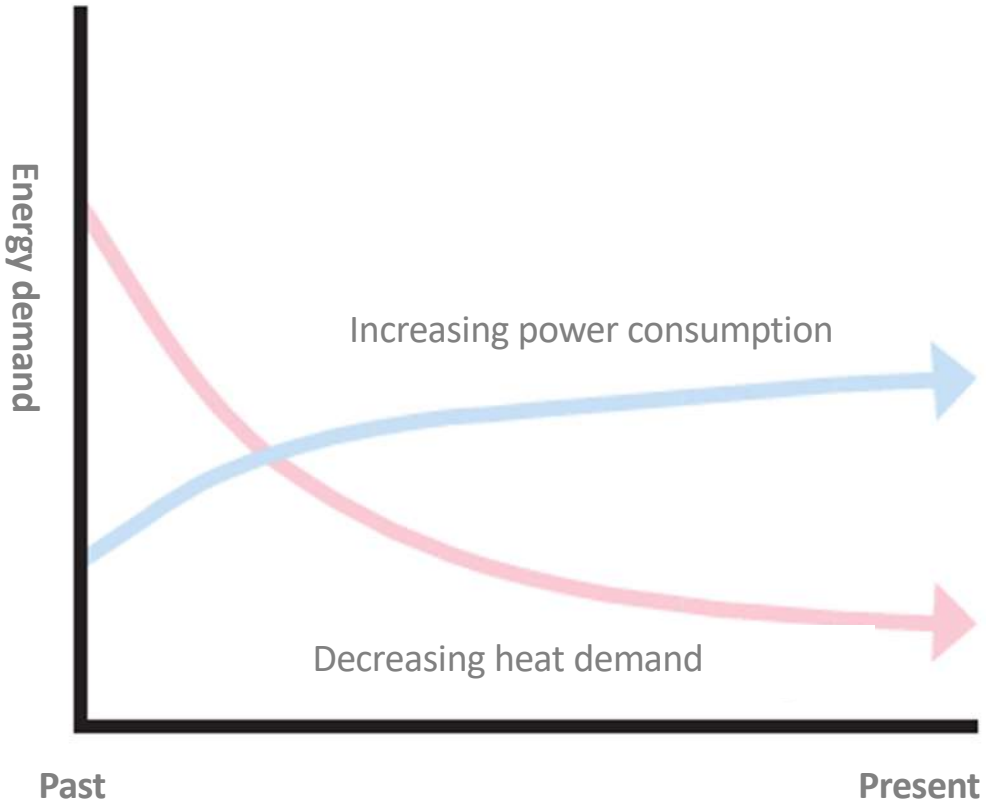
Yong Chen
Program Officer (Lead)
Sustainable Urban Energy
IRENA

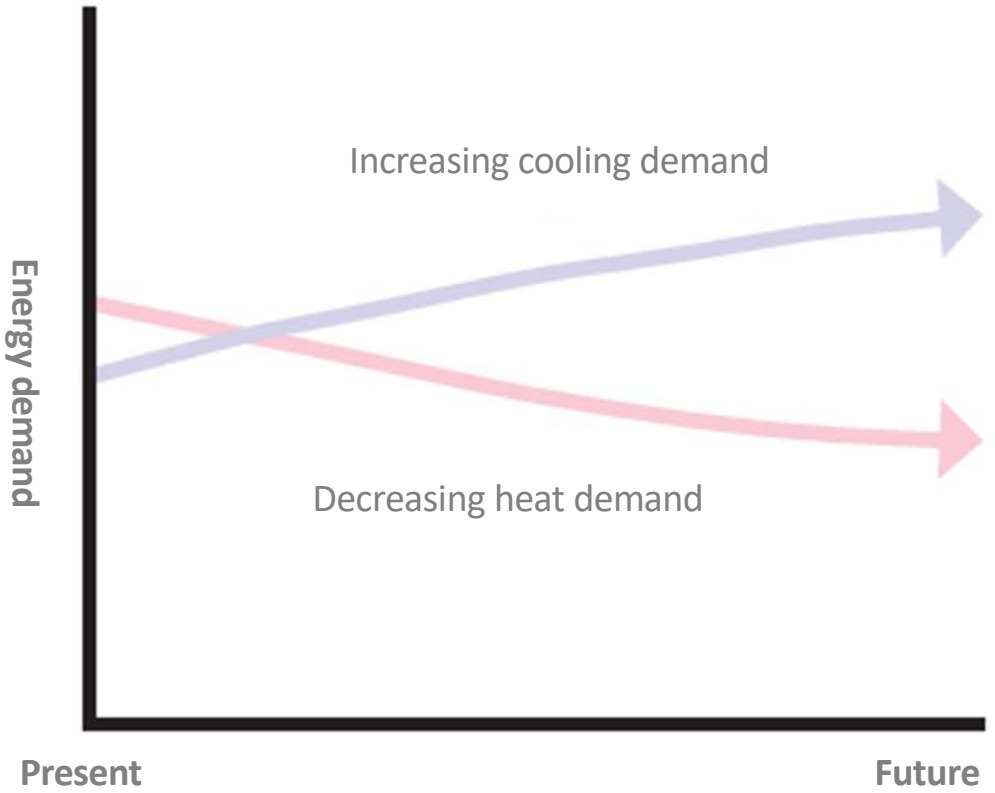
Renewable energy for cooling applications

Scope and opportunities

Lars Munkoe, CEO

Trend of energy demand in buildings





Core challenges of cooling

I.Cooling the fastest growing use of energy in buildings

- High sales growth rate of air conditioners (5.6 bill.units installed by 2050 according to IEA)
- Market drivers is demand for systems with low cooling capacity

II.Global F-gas phase down (Montreal Protocol/Kigali Amendment)

- Need for products applying non-flammable and natural refrigerants (GWP = 0)

III.Climate Change

- Rising GHG emissions related to cooling powered by electricity and F-gases

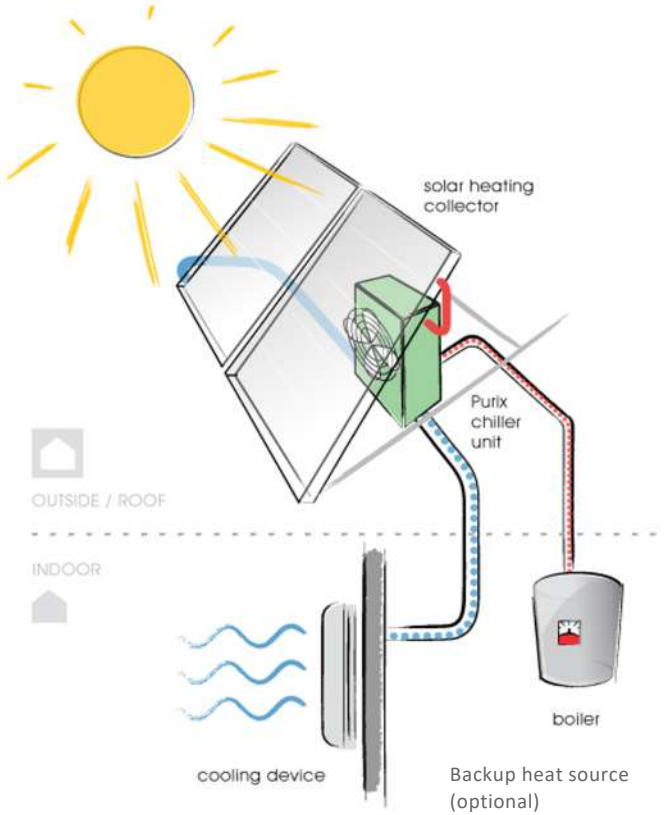
IV.‘Decision to buy’ drivers is low investment vs. annual cost of ownership for Circular Designed products

V.Access to finance of Sustainable technology is still emerging (rental, leasing, Cooling-as-a-service)

Technology benchmark

	PURIX 	Compressor 	Absorption chillers 
Thermal energy source (low temp)	✓	✗	✓
Natural Refrigerants, non-flammable, GWP=0	✓	✗	✓
’Plug&Play’	✓	✓	✗
Capacity <10kW	✓	✓	✗
Multi split design	✓	✓	✗

Response to Sustainable Cooling & a/c



I.Modular Absorption chiller system (LiBr-H_2O), air cooled (Configurable 2,5kW – 160kW)

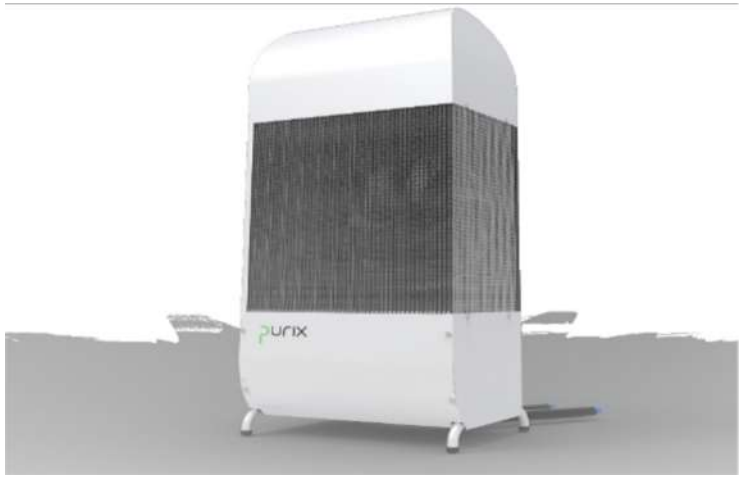
II.Fan coils
(multi split design by default)

III.Heat source
(Solar Collectors, waste heat, central heating or plug-in district heating)

Powered by

Danfoss ZIEHL-ABEGG EMERSON xylem Let's Solve Water ROCKWOOL

Instant District Cooling & Solar Cooling



Solar cooling system

- ✓Turn-key system
- ✓Cooling capacity match with high volume market segment
- ✓Attractive larger systems with modular design concept

Split system - powered by external heat source

- ✓Instant District cooling
- ✓Waste heat utilisation for cooling applications
- ✓Integration with 3rd party solar system manufacturers
- ✓Retrofit with existing solar heating systems

Solar Cooling multi split

Application	Residential air conditioner for villa (retrofit), 2.5kW, Italy
System Design	PURIX A25s with fan coils
Highlights	Use of natural refrigerant R178 (water) 80% Reduced electricity demand 80% reduced GHG emissions 55% reduced annual costs of ownership 3 years simple payback of additional investment

Together for a Green Tomorrow

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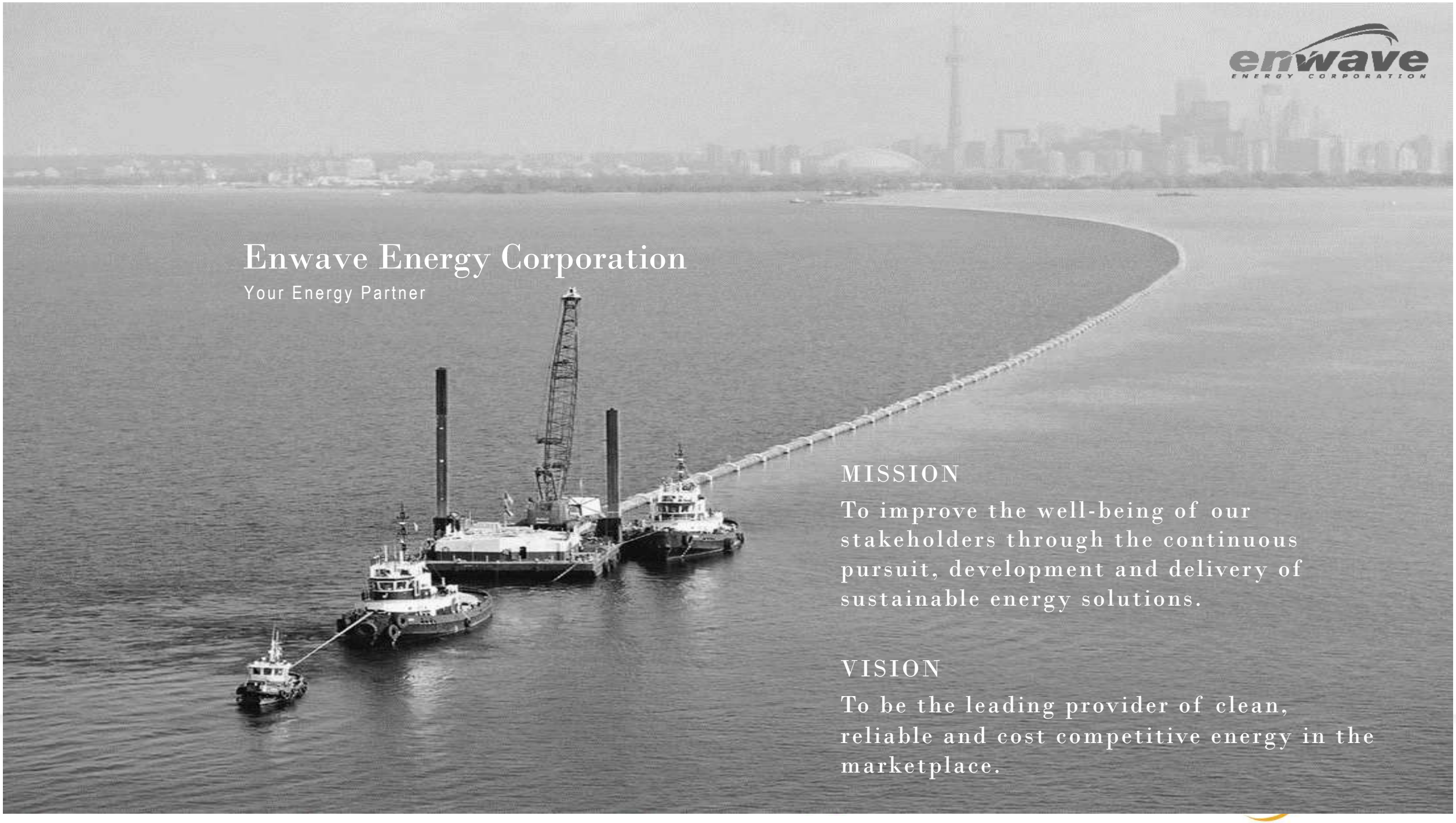


Enwave Energy Corporation

Your Energy Partner

MISSION

To improve the well-being of our stakeholders through the continuous pursuit, development and delivery of sustainable energy solutions.

VISION

To be the leading provider of clean, reliable and cost competitive energy in the marketplace.

District Energy

‘70% of the world’s energy is consumed in cities, half the energy is used for heating and cooling.

District Energy is one of the most effective way to deal with climate change.’

Enwave Across North America

In **12** North American markets with **17** heating plants, **21** chilled water plants, including **Deep Lake Water Cooling**, power generation and other energy technologies

Enwave employs over **400** professionals working in partnership with **700** customers across North America

Deep Lake Water Cooling

1. Pipes draw 4º C water from the deepest part of Lake Ontario. This is then treated to serve the City of Toronto's drinking water supply.

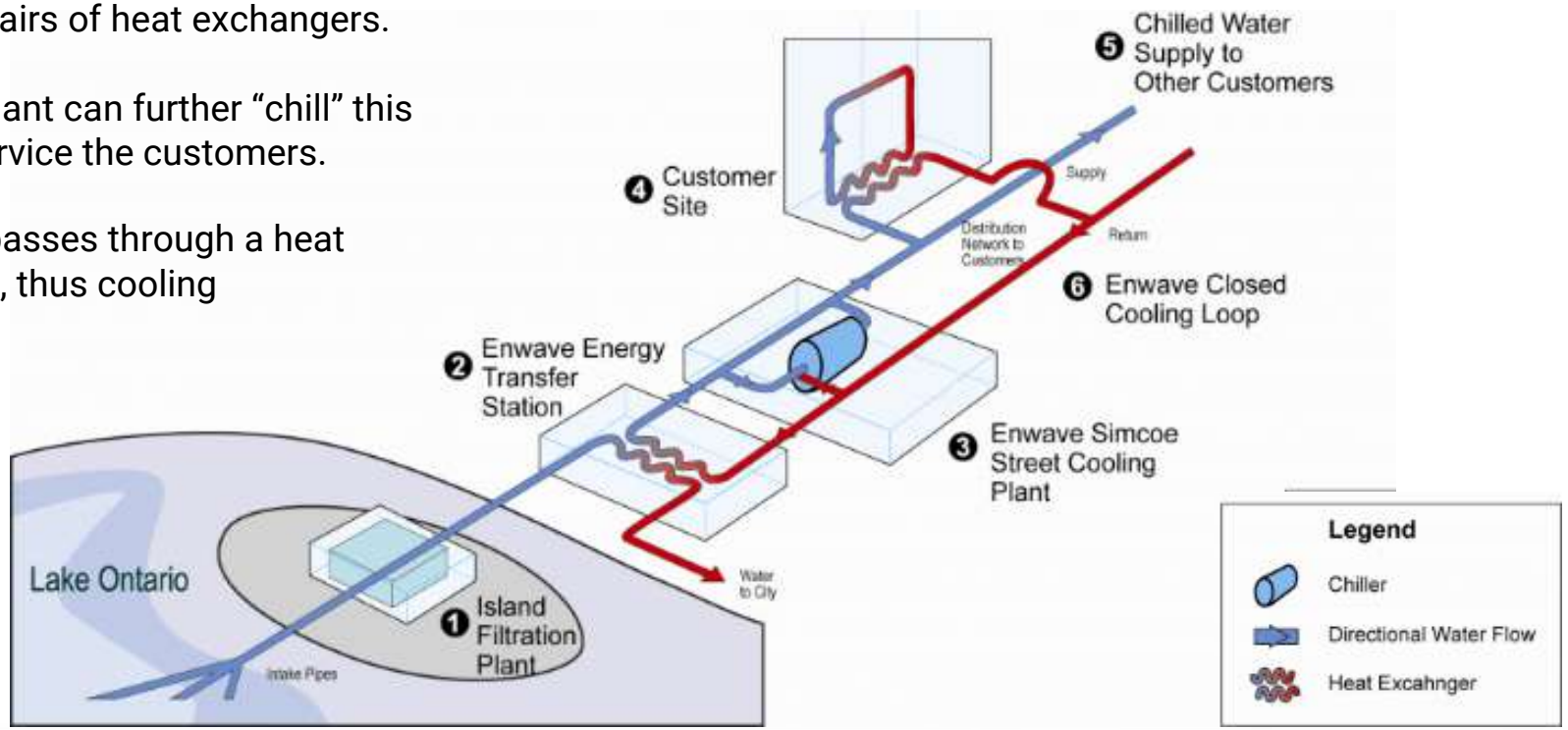
2. At the city's pumping station (Energy Transfer Station), Enwave transfers heat from the buildings into the departing drinking water supply. This is done through 18 pairs of heat exchangers.

3. In the summer, chillers at the Simcoe Plant can further "chill" this water to the required temperature to service the customers.

4. At the customer site, the chilled water passes through a heat exchanger to absorb the building's heat, thus cooling the building.

5. Enwave's chilled water loop circulates to Toronto buildings, supplying chilled water and bringing heat back to the Energy Transfer Station.

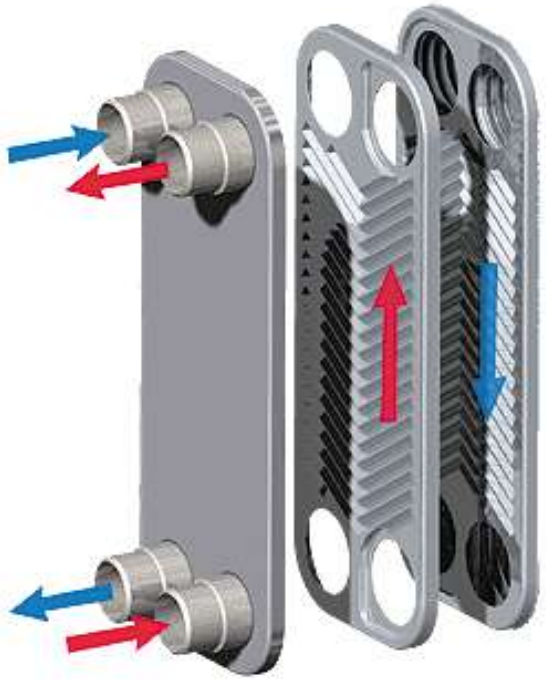
6. The warmed water returns to Enwave's facility where its heat is transferred to the drinking water, and the cycle is repeated.



ETS

36 Plate and Frame Heat Exchangers

70,000 USGPM Flow



Sustainability- The Impact of DLWC

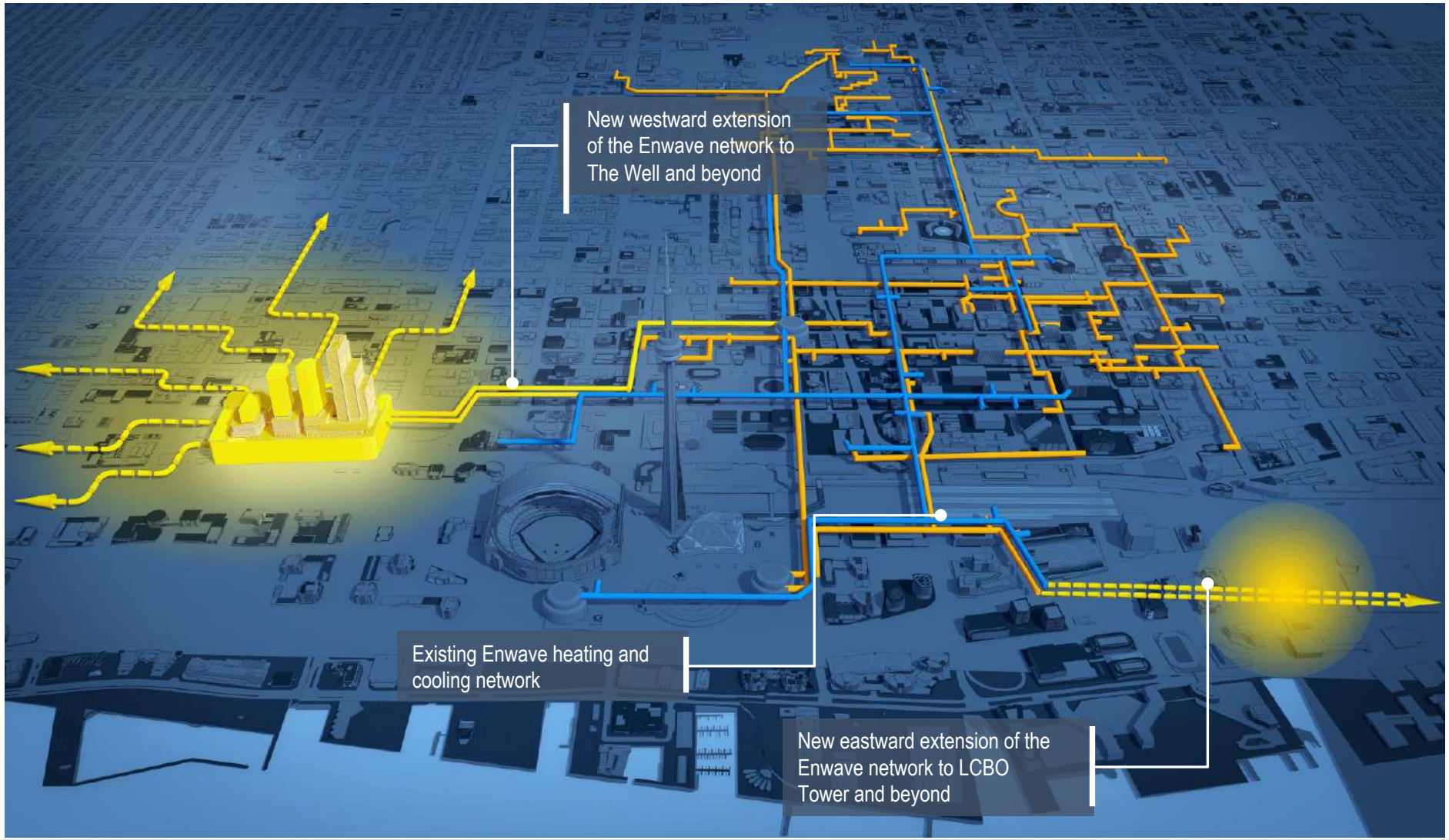
Requires 75% less electricity than typical chillers and has reduced demand in Toronto's downtown core by approximately 61 MW

Waste heat being utilized in an efficient manner to serve new mixed-use developments, results in more than 2,900 MWh of heat and **reduces carbon by over 400 tonnes-CO2annually**

Displaced 1391 Kg of CFCs

No cooling towers required, saving 714 million liters of water (equal 280 Olympic size swimming pool)

Enwave System Expansion

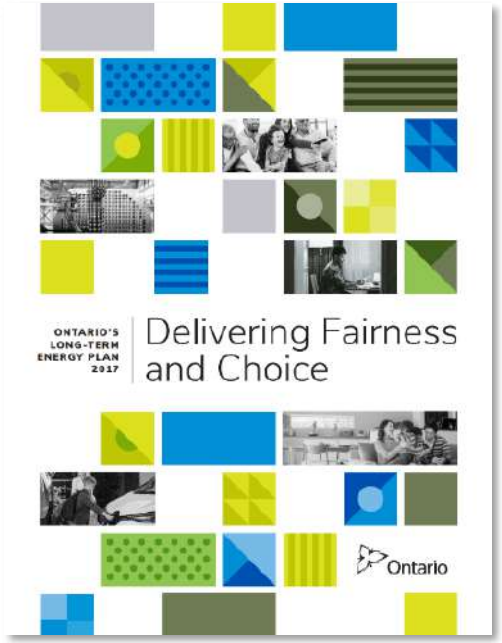


The WELL


SUMMER | Daytime Cooling at
THEWELL
Represents direction of water flow within loop
Cold water feed cools office space by cooling air delivered through under floor air system
Warmer water is returned to Enwave system
Potential for future loop to feed residential
Heat exchange draws warmth from water loop, transferring it back to Enwave return loop
Point of transfer of thermal energy (cold water) between Enwave system and storage tank
One 7.6-million-litre storage tank holding temperature controlled water charged (fed) at night
Cold water is fed from Enwave's Deep Lake Water Cooling system at night, charging (cooling) the water in the storage tank which acts as a thermal battery
Warmer water returned to Enwave system
ALLIED
enwave
RIOCAN


WINTER | Heating at Different Times of the Day at
THEWELL
Represents direction of water flow within loop
Warm water feed conditions office space by warming air delivered through under floor air system
OFFICE LOOP
RESIDENTIAL LOOP
Typical hours of highest use
6:00pm - 6:00am
Potential for future loop to feed residential
Cooler water is returned to Enwave system
RETAIL LOOP
Cooler water returned to Enwave system
One 7.6 million-litre storage tank holding temperature controlled water charged (fed) at night
Point of transfer of thermal energy (hot water) between Enwave system and storage tank
ALLIED
enwave
RIOCAN

Government's Preferred Solution



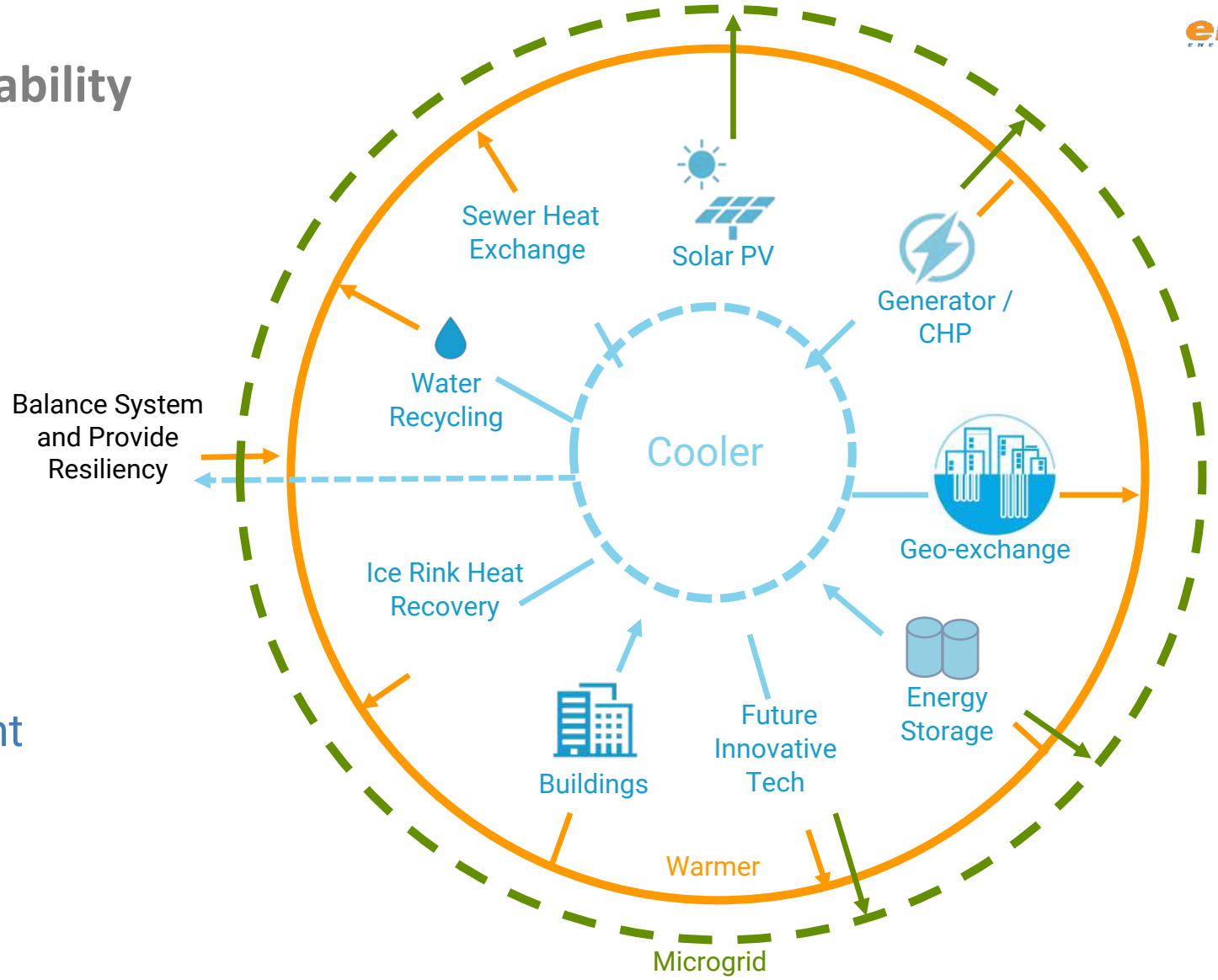
The **Ontario Government** Long Term Energy Plan says: "***Enwave*** *customers benefit from improved costs, lower emissions and increased reliability*" (pg#116)

Ontario

Toronto Hydro will incentivize buildings to choose **Enwave** as the solution for the ever increasing demand on Toronto's electricity grid.

TORONTO HYDRO

Future Proofing and Sustainability



New technologies are continually being added to the system, and Enwave is well positioned to have a significant impact on energy and carbon reduction.

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EFFICIENCY FOR ACCESS

Renewable Cooling Applications: Cold Chain & Cold Storages

4/15/2021

Ruth Kimani, CLASP

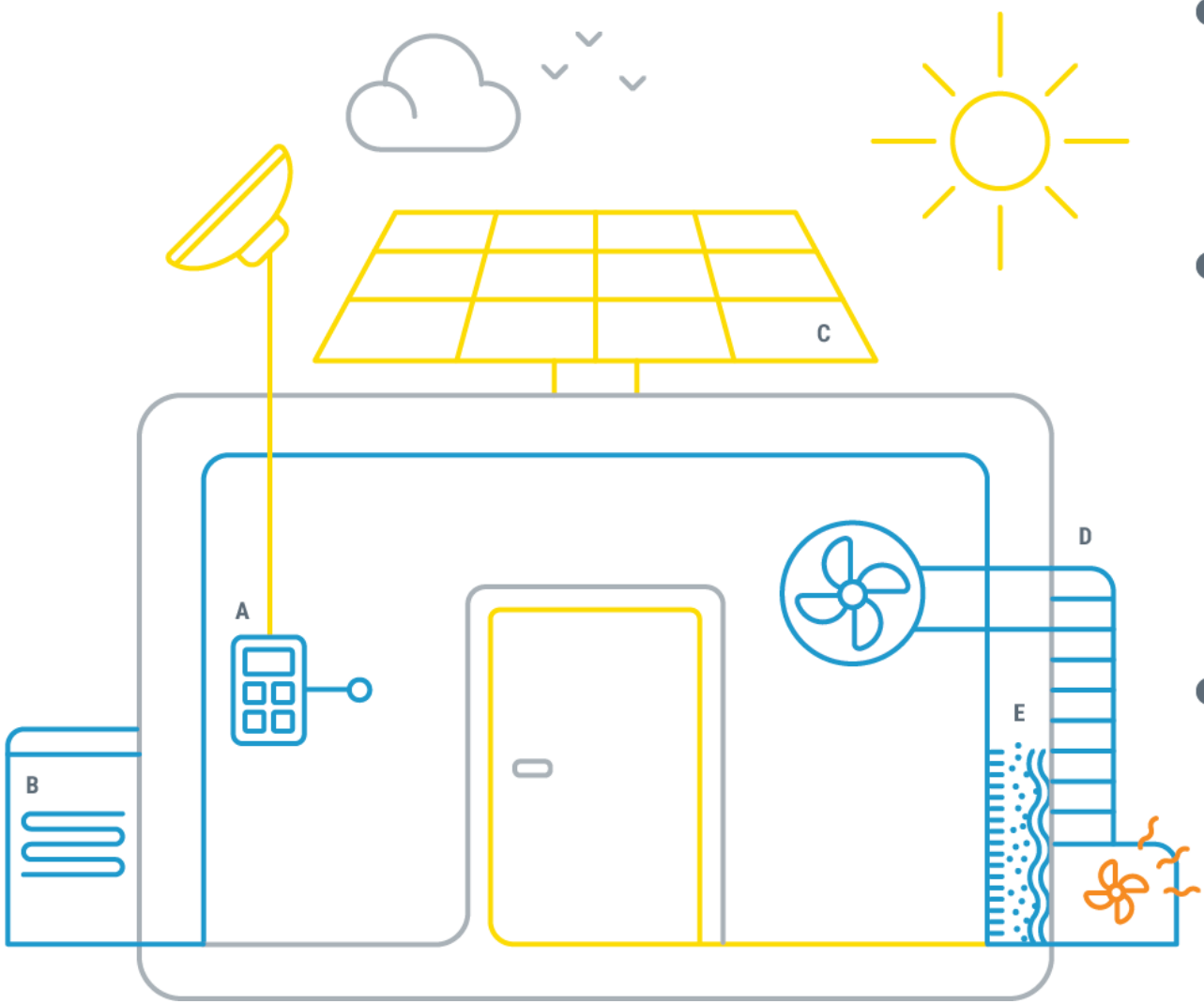
Core Off-Grid Cold Storage Unit Components

A Remote Monitoring and Sensors

- Door openings
- Humidity and temperature
- GSM enabled for real-time updates

B Thermal Storage

- Phase change material embedded in the unit as thermal plates leading to over 24h autonomy
- Battery storage – battery sizing varies considerably by location



C Solar Array

- Typically positioned over the container to create shade
- Sizing ranges from 1.5kW to 8.9 kW
- Nominal voltage is either 24 or 48V

D Cooling Unit

Two types of Cooling Units predominate this space

- Augmented on the shelf split AC Unit – Several companies have developed a charge controller that overrides the lower limitation on a traditional AC unit allowing the unit to operate at the optimal temperature for a given produce
- Bespoke compressor based cooling unit
- Storage size ranges from 9 cbm to 90 cbm. Smaller units are usually deployed in markets

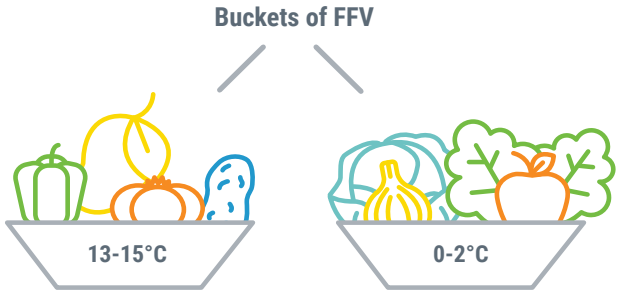
E Insulation

- Poly Urethane Foam (PUF) siding with Aluminum cladding 80-150mm thick
- Recycled shipping container retrofitted with Spray foam
- Clay Bricks with recycled plastic bottles

Types of Cold Chain in Off-Grid Areas

Fresh Fruits, Vegetables, and Flowers

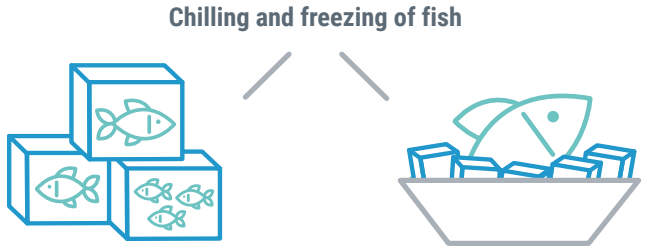
- FFV have significantly different cooling requirements for storage. The following table shows some examples of different cooling requirements for various fruits and vegetables. For example, the recommended storage temperatures for bananas, cucumbers, and tomatoes are somewhere between 10-15°C. However, the recommended storage temperature for apples, cabbages, and lettuce are much lower – close to 0°C.



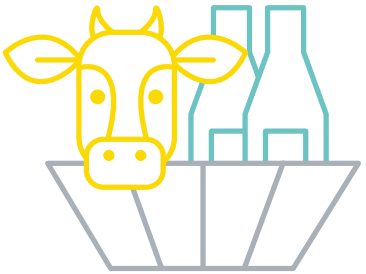
- Pepper, Mango, Tomato, Potato
- Cabbage, Onions, Lettuce, Apples

Meat and Fish

- Meat and fish, once slaughtered and processed, are either frozen or chilled just above freezing as they make the journey to their final resting plate. The cooling process usually begins with one of three approaches: liquid cooling, ice slurry cooling, or combined blast and contact cooling. Fattier fish are typically stored at -21°C while leaner fish is cooled to -18°C. While freezing is the most common approach to fish cold transport, the freezing process can cause ice crystal formation in the protein leading to drip-loss, reduced ability to hold water, and textural deterioration. To avoid the negative effects of freezing some fish cold chains use ice glazes and transport conditions that range from -0.9 – 2°C.

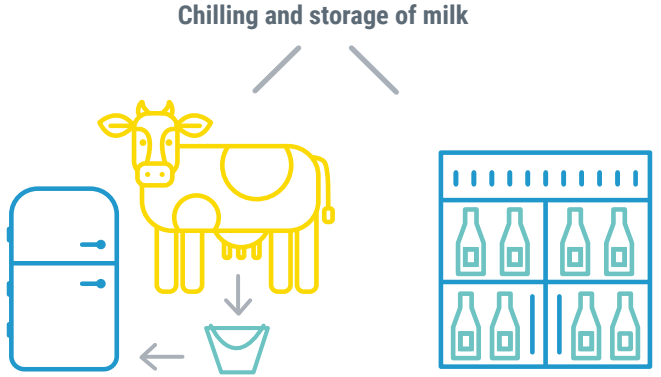


- **Freeze:** -18 to -21°C depending on fat content
- **Chill:** -0.9 – 2°C Flash cooling to just below freezing before transport allows small ice crystals to form limiting textural damage and prolonging shelf life.



Milk Chilling and Storage

- Freshly harvested milk contains few microorganisms. However, the microbial growth will rapidly increase under warm temperature, and international organizations like WHO and FAO have developed detailed guidance on proper chilling and storage of milk to account for this:



- **Stage 1 Milk Chilling:** Freshly produced warm milk cooled to 10°C within two hours and to 4°C within three to four hours after milking.[1]
- **Stage 2 Milk Storage:** Milk stays cool for at least 12 hours with a temperature rise of no more than 1°C at an ambient room temperature of 30°C.[2]

1. FAO. (2016). Technical and investment guidelines for milk cooling centres. Chapter 6. Refrigerated milk cooling tanks.
2. Ibid.

Off-Grid Cold Storage Business Models

Cooling as a Service (CaaS)

- Cooling as a Service is a business model whereby the customer pays for cooling on a usage basis rather than purchasing the cooling equipment directly.[1] This model creates incentives that optimize efficiency and maintenance. In off-grid settings this approach to cooling is particularly attractive due to its low capital intensity and minimal technical capacity requirement for the end user. A traditional **unit sale** business model is uncommon outside of donor supported NGOs and governments. In the off-grid cold storage sector we see companies experimenting with two distinct types of service models:

Pay-as-you-store

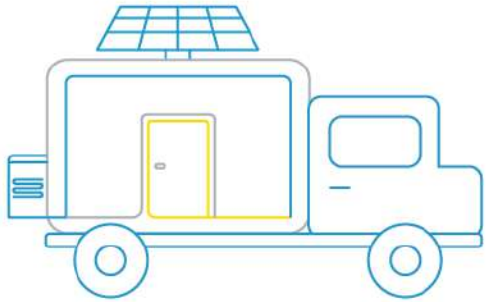
- **Pay-as-you-store models** charge customers per day for an allotted space within the cold storage unit, typically delineated with some type of reusable tray, or crate. This business approach is particularly attractive for small market vendors without access to electricity or safe storage who would like to prolong the shelf life of the perishable goods the sell.

Leasing models

- **Leasing models** are usually offered to larger farms or farming cooperatives that act as aggregators for their members.

- **IoT and Maintenance** - Advanced sensing and IoT controls allow leasing models to be monitored in real time and controlled remotely. This limits leasing risk for the company allows for preventative maintenance. The user benefits from reduced operational oversight, better unit performance and lower operating costs.

- **Portability shared user base** - Some companies build their unit's so they are easily transported. This allows the owner of the unit to take advantage of multiple growing seasons in different geographies, reducing the time it takes to pay off the unit. Users benefit by only paying for cooling during the time of year they need it.

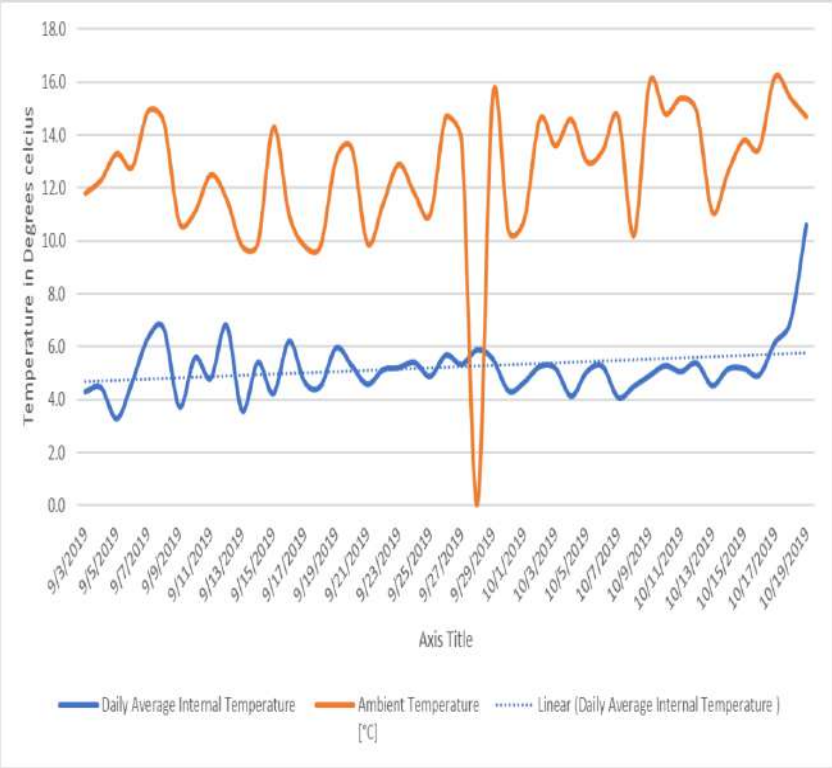


1. KCEP. 2018. Cooling as a Service (Caas). https://www.k-cep.org/wp-content/uploads/2018/07/Cooling-as-a-service-Knowledge-brief-6.7.2018_Final_online_v1.pdf

Performance Challenges

- Power system sizing is a common challenge
- Highly variable levels of load demand

Unit A



Unit B

OGCCC Finalists solutions

Cold Hubs

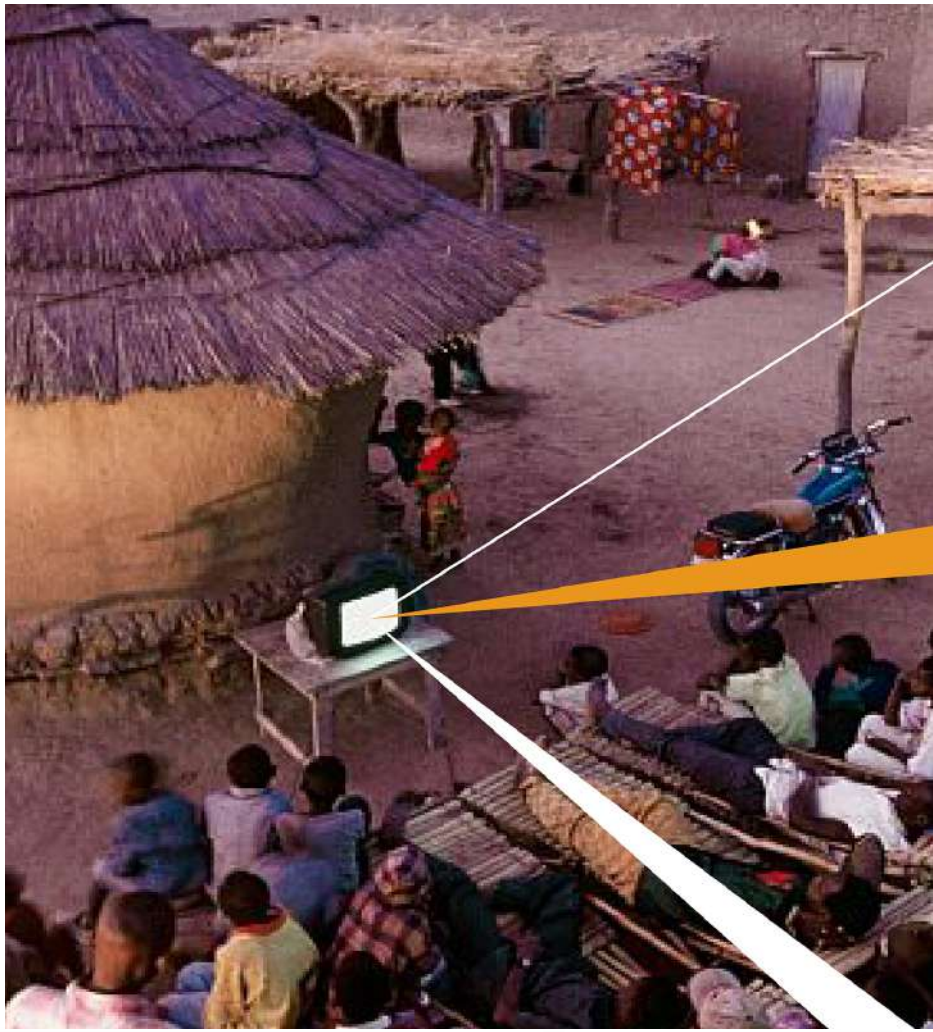
EcoZen Solutions

FreshBox

Ecolife

Efficiency for Access ongoing activities for off-grid cold storage and refrigeration

- Addressing data gaps
  - Laboratory and field testing for refrigerators and cold storages
  - Cold chain market assessment for India, Kenya, and Nigeria
- Testing business models for early-stage technologies
  - Off-Grid Cold Chain Challenge (OGCCC) 2.0
- Driving innovations
  - Efficiency for Access R&D Fund



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THANK YOU

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