General Presentation on Sustainability and Microgrids

Date: July 2023
Time 1 p.m. EDT

"The Electric Throttle for our Energy Transition."

Community Microgrids

By
The Canadian Association for the Club of Rome
"Our mission is to actively engage the public and decision-makers on key global and Canadian issues by encouraging you to share information; to inform and motivate citizens and decision-makers to take action to limit, stabilize and reverse demands on the global and local ecosystems."

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OLD WAY
NEW WAY

The Three Pillars of Sustainability

1. Environmental benefits
2. Economic benefits
3. Social benefits

Microgrids have the potential to provide many of the local community's needs for sustainability. This depends upon technical and social designs that meet local conditions and available capital investments. All this can be adjusted as conditions evolve and knowledge advances.

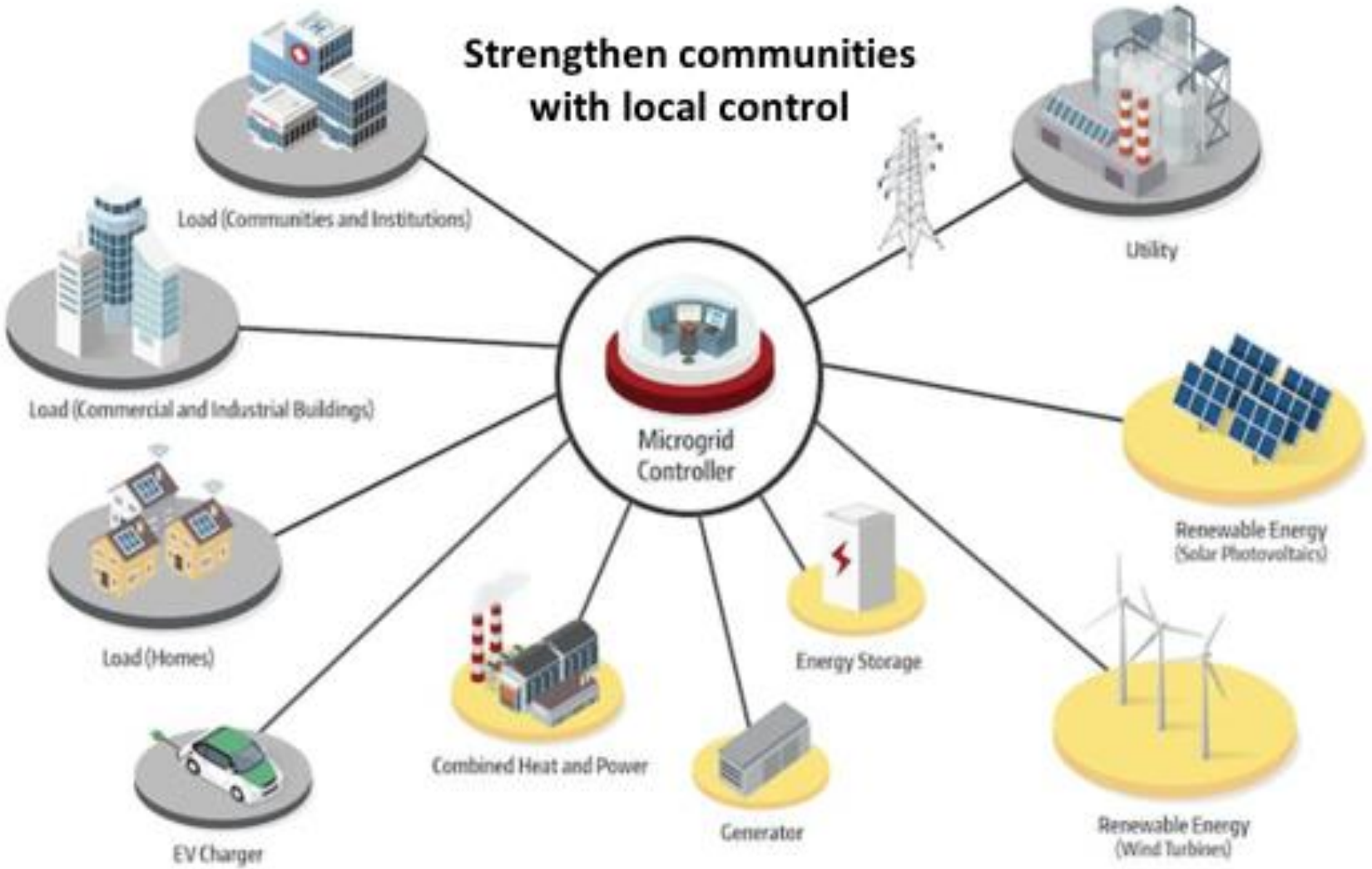
Harnessing is difficult as it requires collaboration and adaptations from the norm.

A Typical Microgrid

A microgrid is a decentralized small version of the main utility grid but may also include thermal energy.

One part or some or all of these parts make up a microgrid.

Typically all these parts are in one geographic local location.



Community Microgrid Characteristics

Aggregation of multiple single-building microgrids in a neighborhood, industrial park, or military base leads to community microgrids. The aggregation of many microgrids and community microgrids results in a > 3 MW virtual power plant (VPP). These are means to restructure the main grid with distributed generation and storage. This democratization of energy is a powerful trend empowering communities and reshaping the energy landscape.

The five major technologies of a typical community microgrid are:

1 – Renewable solar and wind generation with energy efficiency (e.g. passive insulation)
2 – Capturing atmospheric or Geothermal energy using heat pumps
3 – Storage of Electricity (batteries) and Heat Energy (ground)
4 – EVs (electric vehicles) as mobile batteries
5 – Digital Command and Control systems (blockchain, AI, IoT)

Microgrids provide substantial simultaneous winning outcomes for major stakeholders

1. Community residents
2. Building owners
3. Hydro Ottawa (a utility)

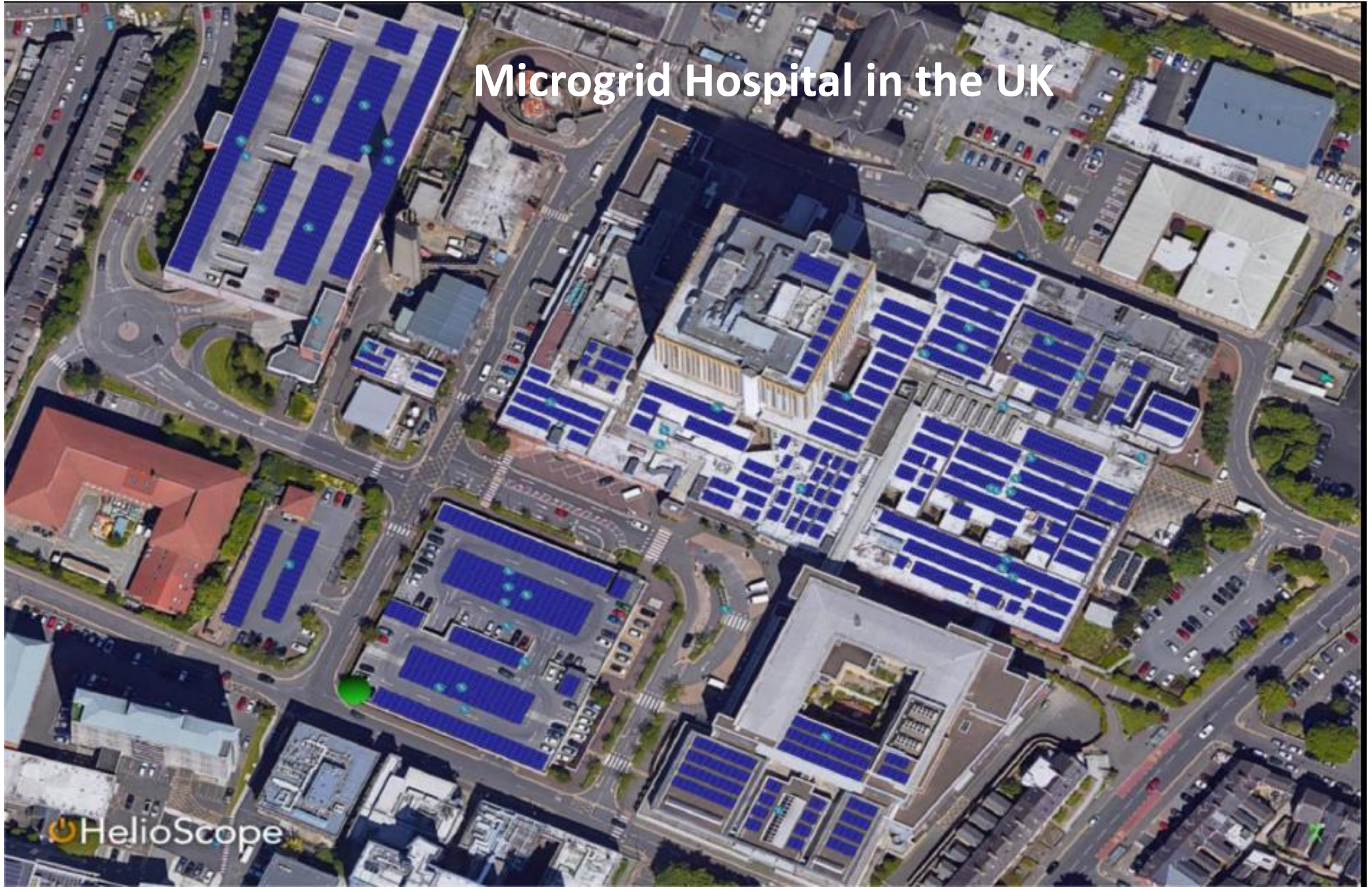
Microgrid in Australia

Battery -


Community Microgrid in the Netherlands


Multiple Building Microgrid in the USA

Microgrid Hospital in the UK




Bus fleet and automotive EV charging with solar canopy and battery storage


Bus Fleet charging, EV charging, Green Hydrogen, and grid energy sales microgrid

Part 1 – Grids and Microgrids

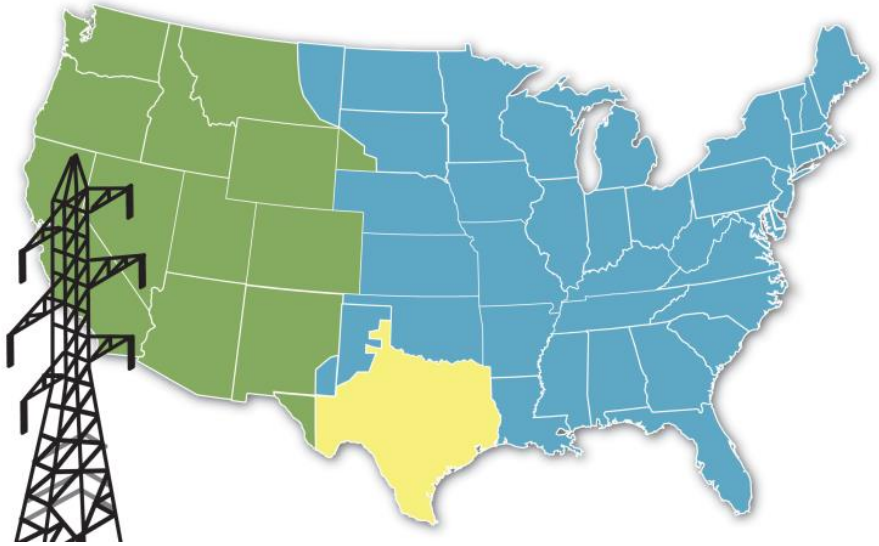
From 1950 to 2021 the North American electricity demand has grown 13 times in size

Microgrids expand the utility grid size and ease congestion

Part 1 - North American Grids: energy sources

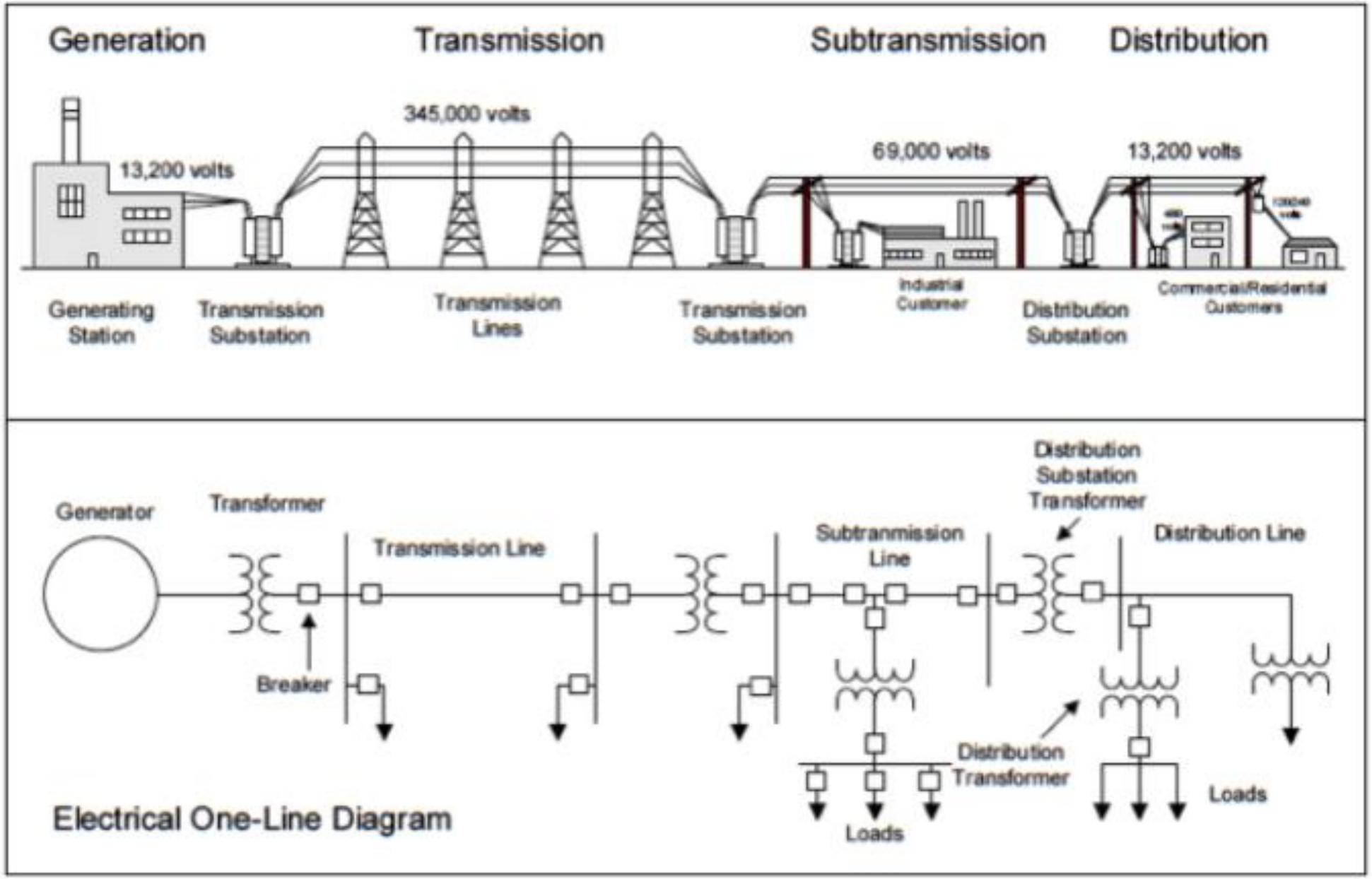
Three North American independent grids in Canada, USA and Mexico

- East
- West
- Texas



- Each State or Province has its own grid ISO (Independent System Operator)

Ontario's Independent Electricity System Operator (IESO) Command and Control Center



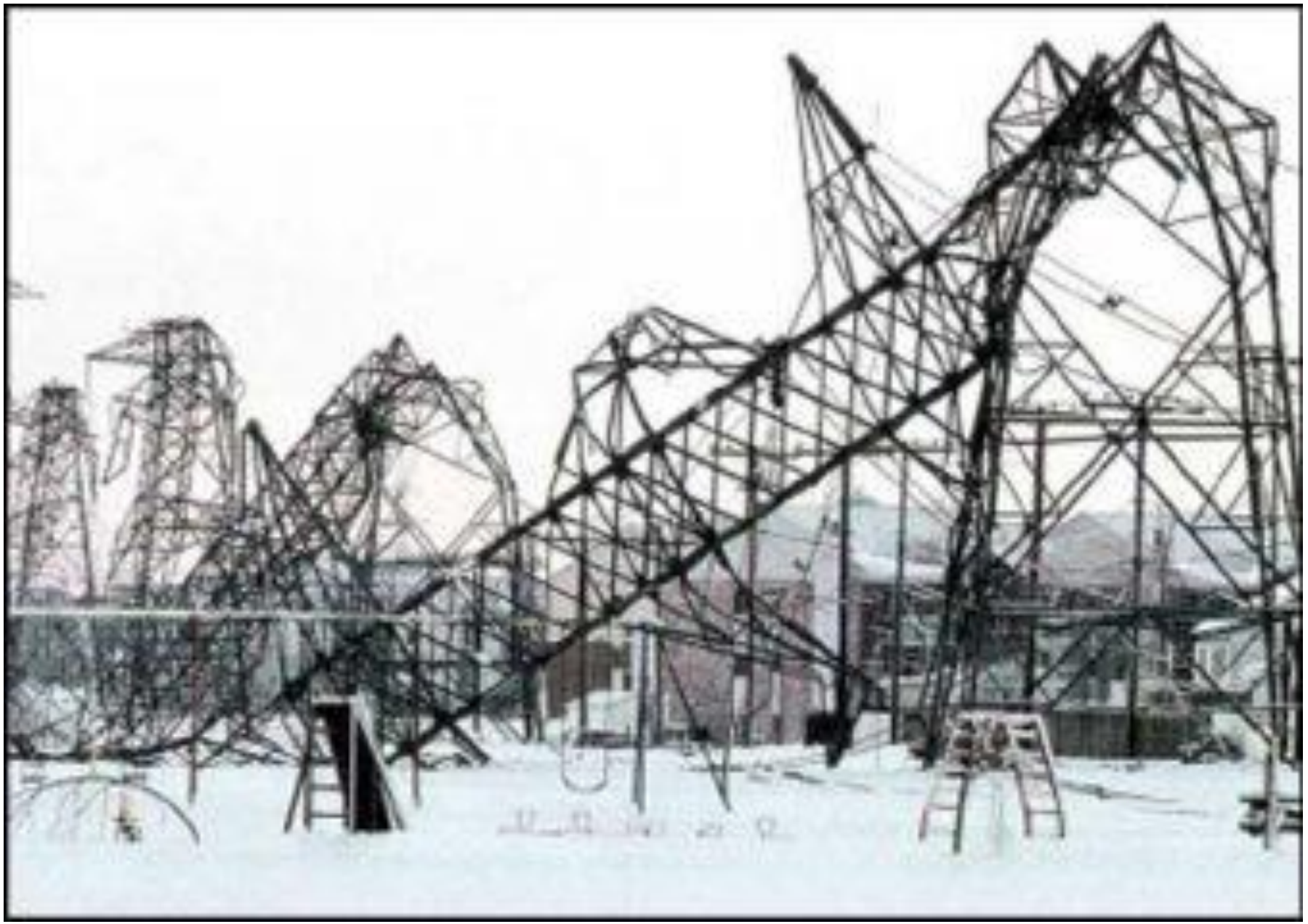
Typical electric power system single-line diagram

Ontario Grid Component Parts

- Substation transformers 3,238
- Transmission Line (using metal towers) 23,000 km
- Distribution transformers 1,102,000
- Distribution Lines 124,000 km
- Power poles (often wood) 10,850,000
- Area covered 961,000 sq km

- What could possibly go wrong with this widely disbursed aging infrastructure?

The ice storm of 1998 (Ottawa area)

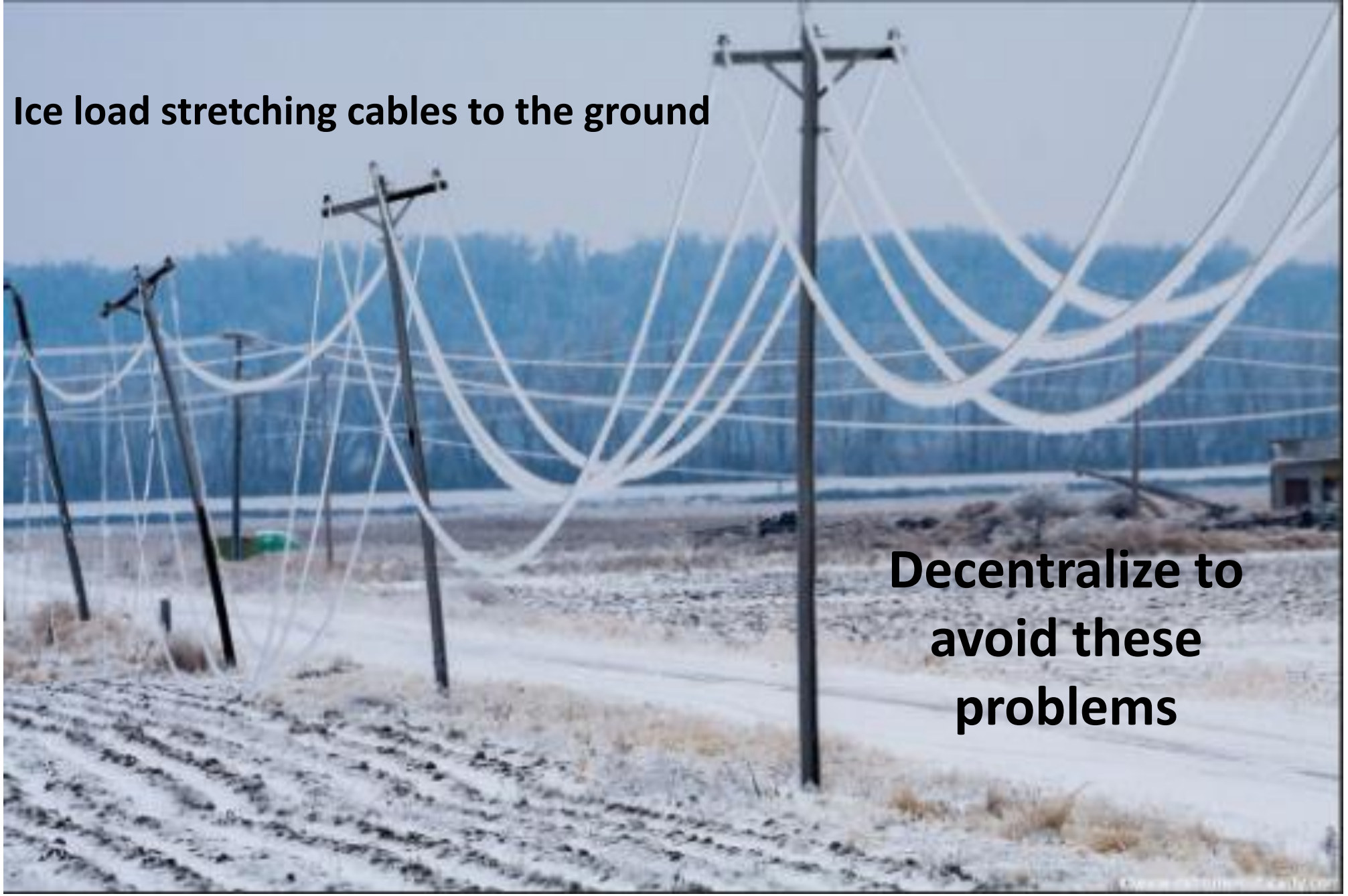


Hydro One transmission towers near the Merivale transformer station photo: Hydro One

Tornado
2018 September 21

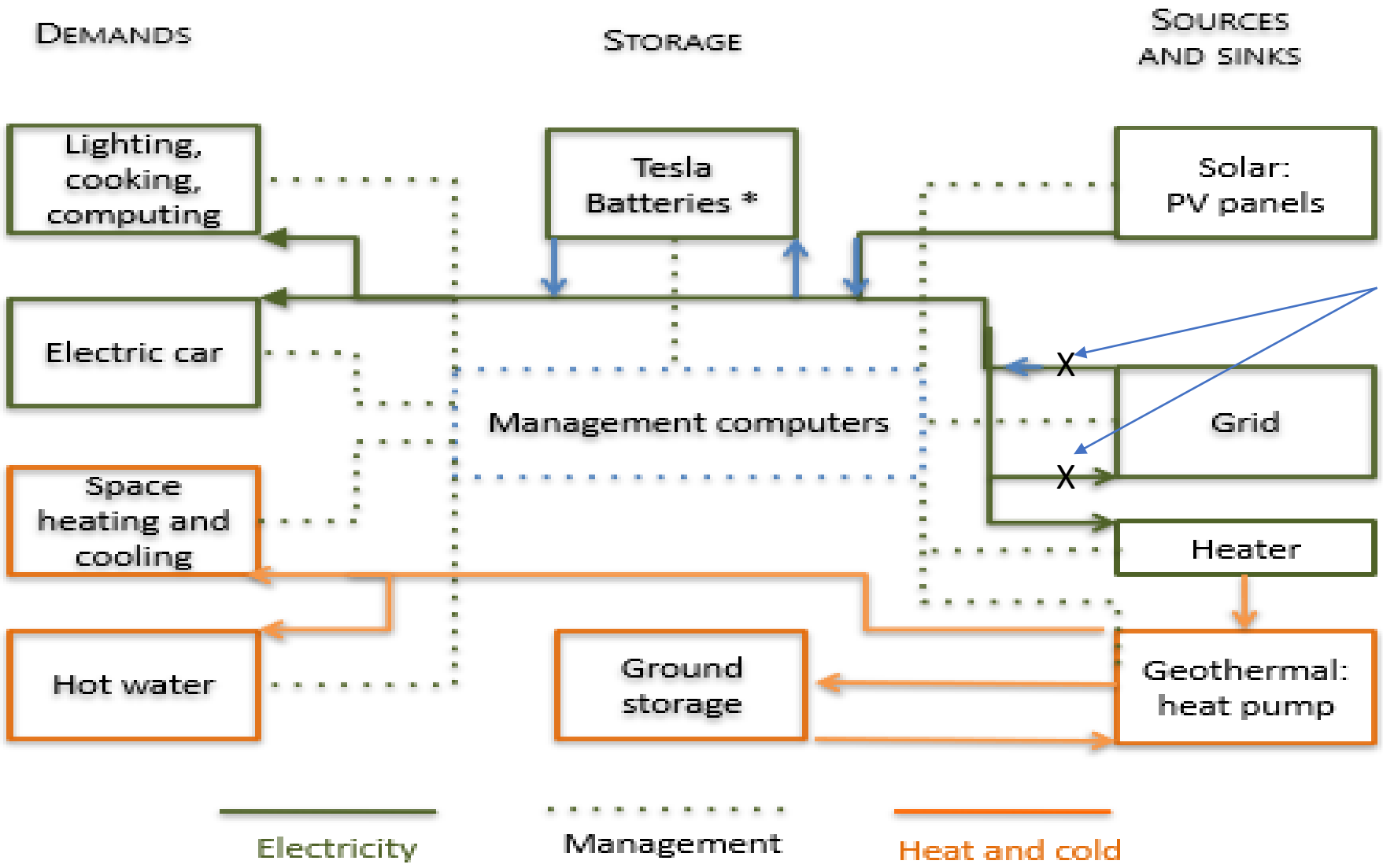
- 137,000 of 332,000 customers without power for more than 48 hours,
- Full repair:
  - 12 weeks and
  - $10 million


Ottawa street the morning after
190 km/h winds (derecho)
21 May 2022


Ice load stretching cables to the ground
Decentralize to avoid these problems

Showcasing the Manotick Microgrid (no burning)

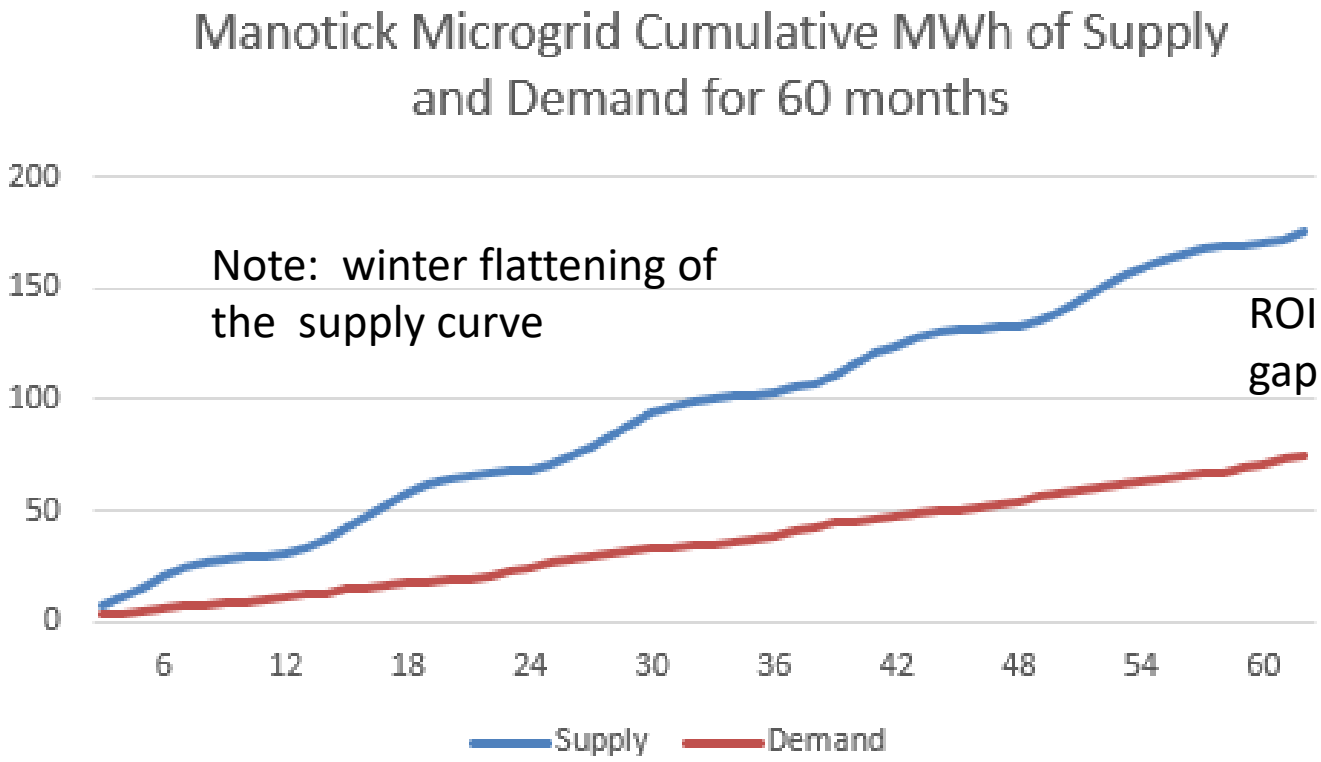
Demand Energy = 82% Thermal + 18% **Electricity**



Island switch either manual, automatic or telephone app

* 2021 Tesla 3 triples the storage

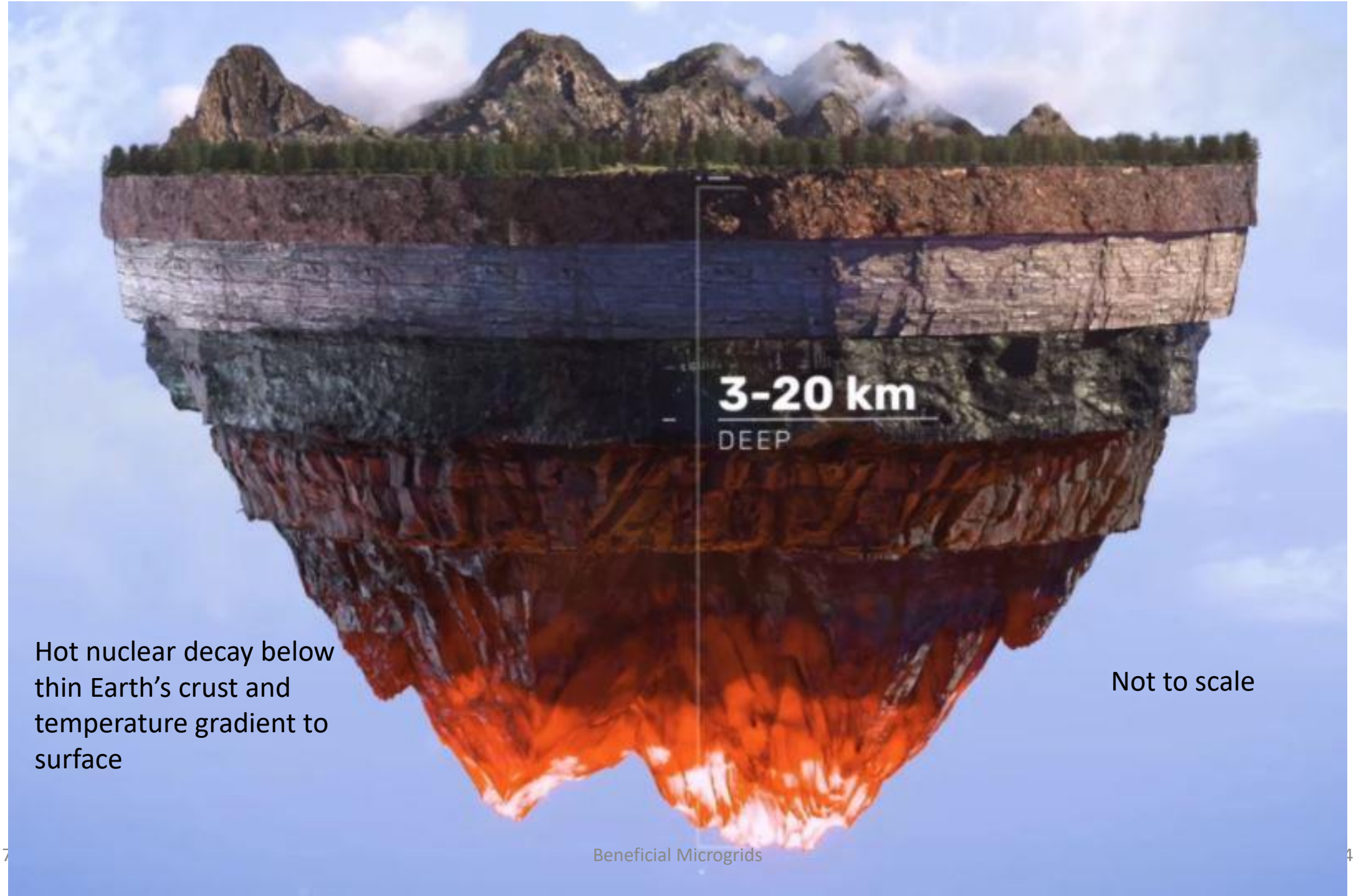
Performance of the Manotick Microgrid



Section 2 : Geothermal

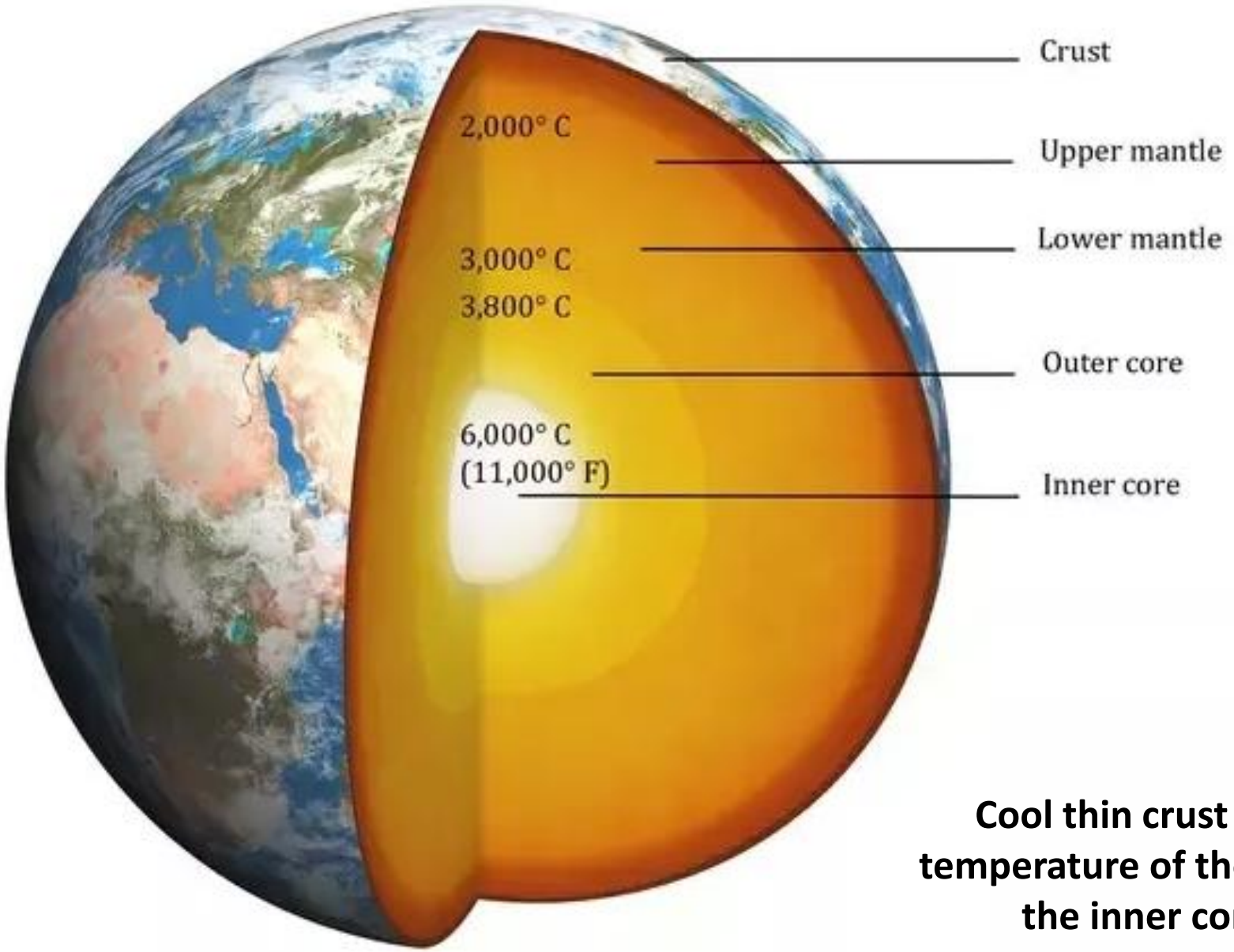
You are standing on vast amounts of energy

Heat Pumps and heat exchangers provide access



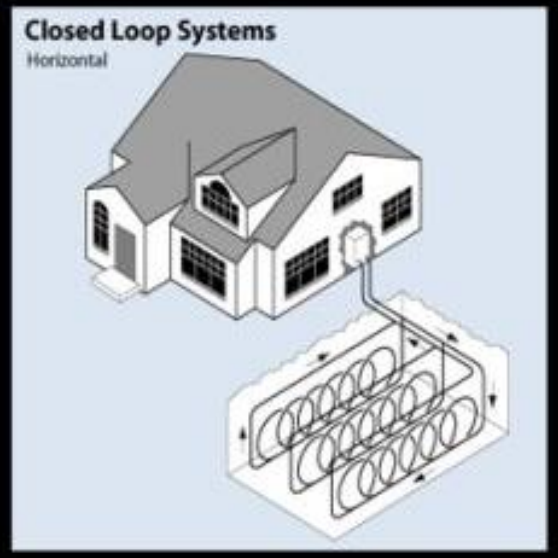
Hot nuclear decay below thin Earth's crust and temperature gradient to surface

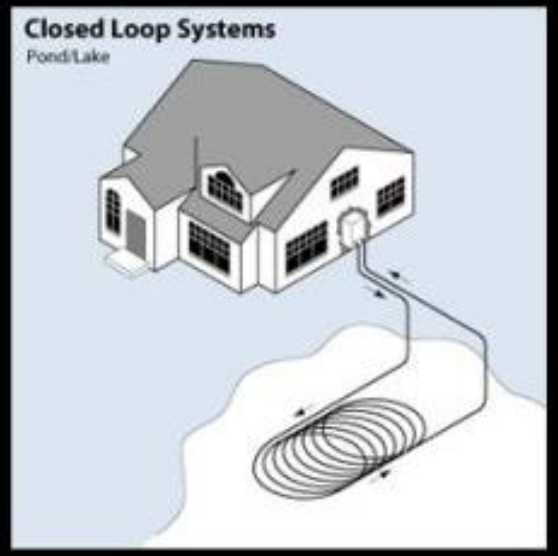
Not to scale

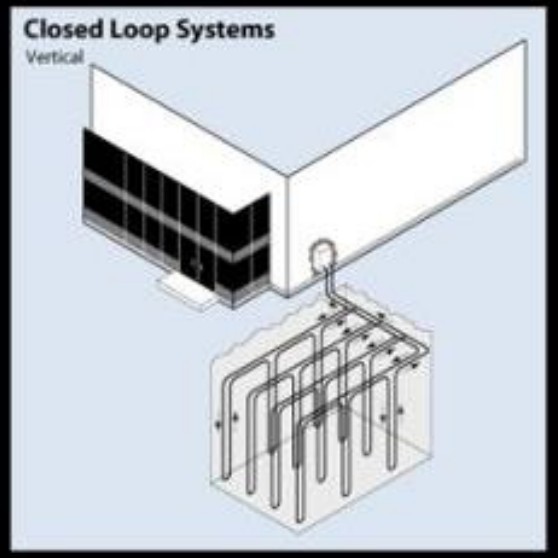


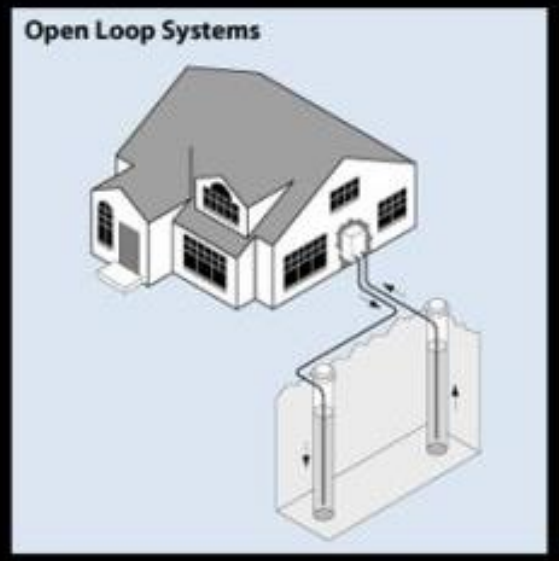
Cool thin crust and temperature of the sun at the inner core

Geothermal Heat Pumps









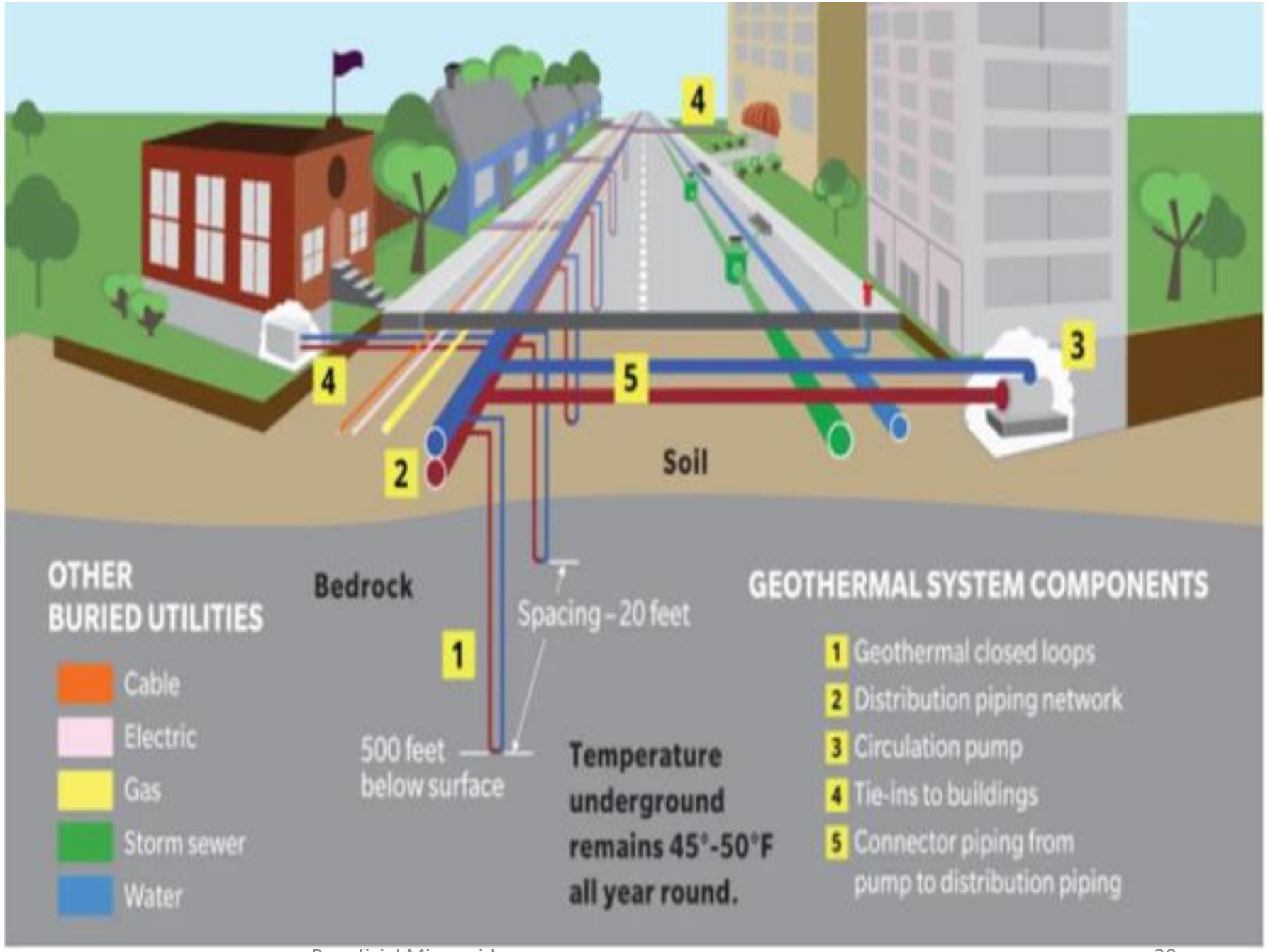
There are four types of geothermal heat pump systems. Three of these—horizontal, pond/lake, and vertical, above—are closed-loop systems. These systems are entirely self-contained.

The fourth type is open-loop. This type of system pumps water directly to and from a well or pond.

The Manotick Microgrid Thermal Battery installation – Svec Coil, May 2018. Leda clay is an aquitard – note vertical trench walls

Geothermal Wall with Actuators and Sensors.

Community microgrid using geothermal heating beside other buried utilities



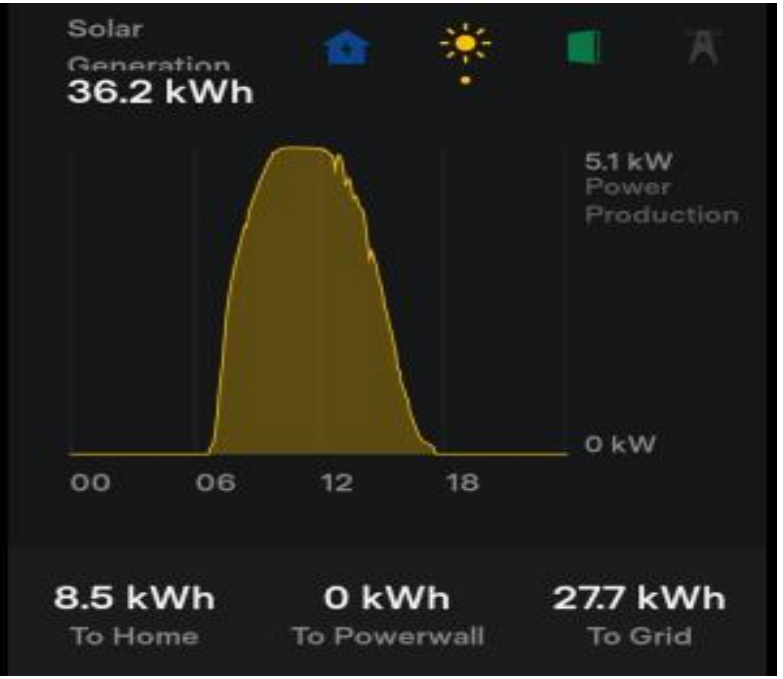
Section 3 : Solar, Wind and Storage

Many natural and creative ways to generate and store energy


Lift off the ground to rooftops

Tesla Solar Roof in Hawaii

Solar Photovoltaic and hot water panels in European Microgrid



Solar energy <u>supply</u> fluctuations

36.2 kWh

Home energy <u>demand</u> fluctuations

Base load plus peaks

24.3 kWh

Grid usage

the fluctuating difference between
demand and supply
-11.9 kWh

Manotick Microgrid 24 hours of energy flows

Using NetMetering on 6 March 2023

Pole Mounted Battery in a Solar rich but cash shy Neighbourhood – A Network of 40 Community Batteries within a VPP

One of 40 community batteries to be distributed as part of a United Energy trial in Victoria.

Why You Can Never Have Too Much Storage – Capacity Management

1. Seasonal variations of sun AZ, EL angles and sunrise to sunset times are worst in the winter which when combined with greater cloud cover and snow covering the arrays, the production is not enough to meet the demand.
2. During daily drawdown of energy, how much to retain for emergencies will force accessing grid supply
3. Once available, how much do you retain for energy arbitrage and when. Buying at 2.5 cents and selling at higher prices means capacity planning and management.
4. How much capacity will you make available to grid ancillary services once available?
5. Decide on the depth of discharge you will permit in non-emergencies. Typically, 20% charge retention is a good rule of thumb to extend the battery lifetime.

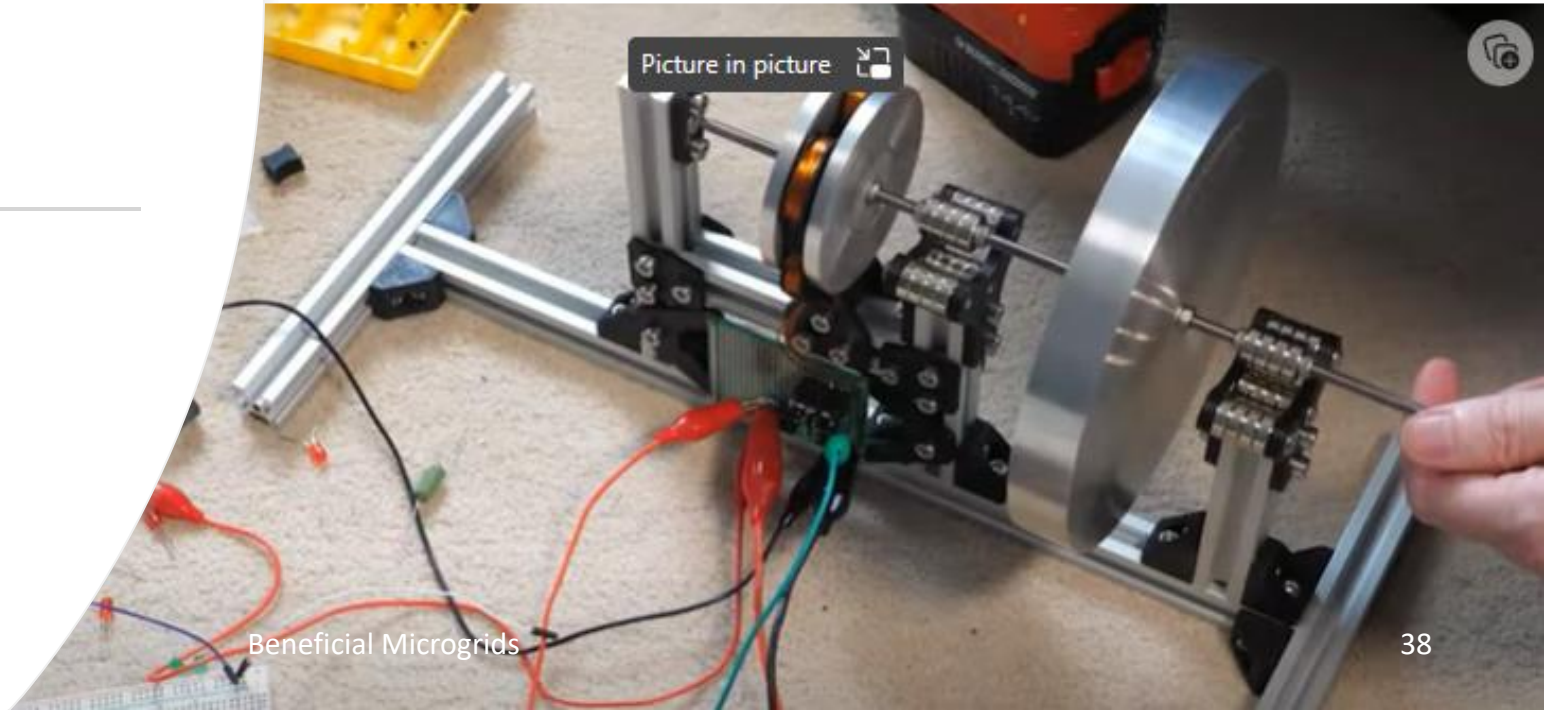
Battery and Storage Uses

1. Excess supply shifting of self-generation energy
2. Energy arbitrage (time of day pricing) and load timing management
3. Plunge pricing is when the entire traded costs are low or high all day due to excess supply or maintenance of the grid.
4. Demand flexibility uses individual load demands moved to optimal times for low grid usage.
5. Joining a Virtual Power Plant for the grid to manage your battery assets including some loads (thermostat, EV charging). This is often a significant Return On Investment

Tesla Megapacks – Utility scale battery storage

1. Interconnection: 480V AC 3 phase
2. Dimensions: W 359 in, D 65 in, H 110 in (shipping container)
3. Weight: 83,996 lbs
4. Power & Energy: 970 kW / 3,878 kWh

Flywheel batteries



Agrivoltaics

Solar Panels are up to 20 C cooler (20 % more efficient) when over crops
The crops are also cooler for less stress and less water required.

Wind and Solar Agrivoltacis farm under construction in the Netherlands

Solar PV with Dual Use of Land
Livestock Partnering with Nature

Vertical Solar Panels

Floating Solar Farm in China

Keeping the water cool for the fish

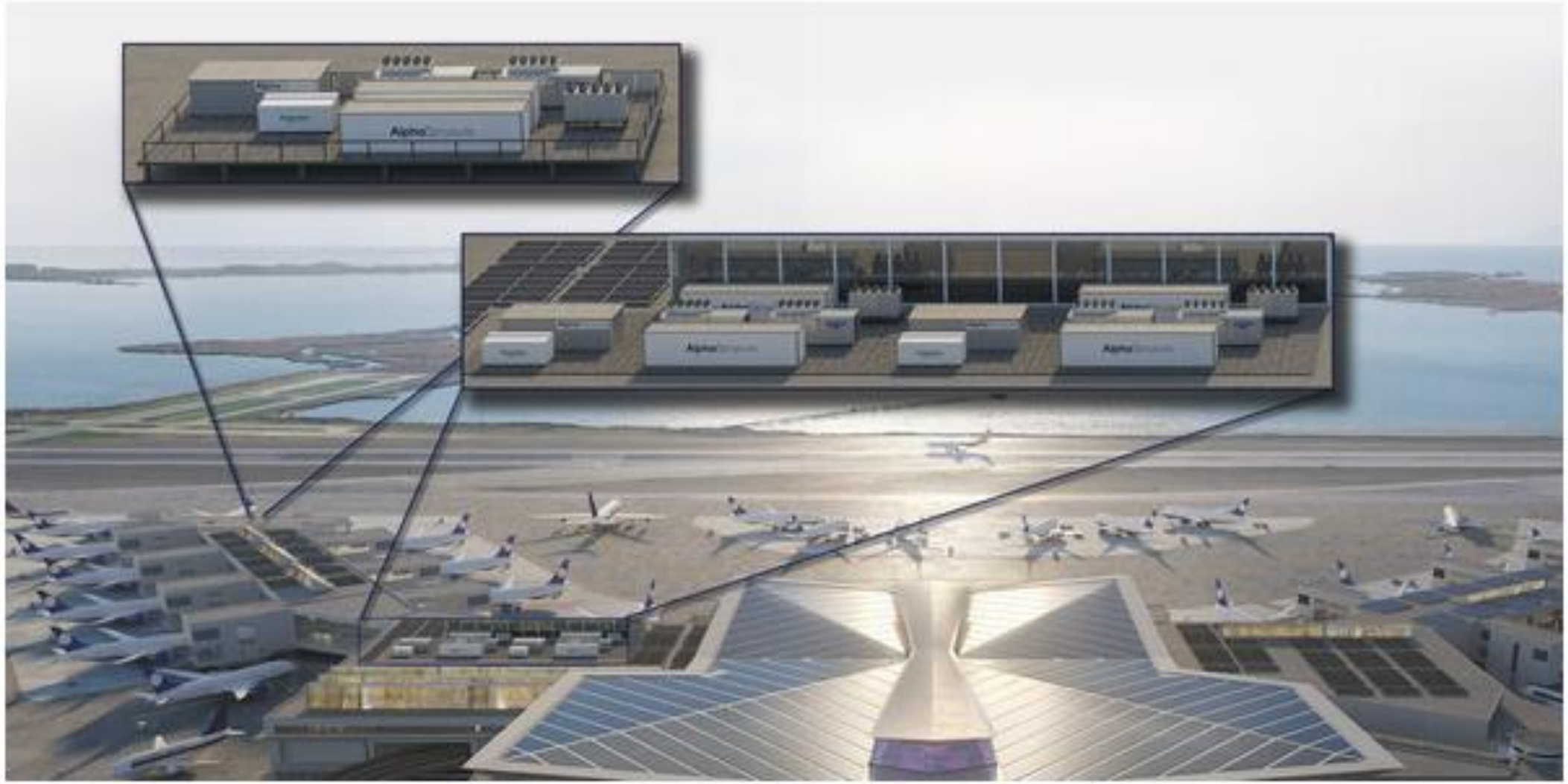
Unique design in Morocco

Mixed Solar and Wind Farm east of LA

Solar and wind alongside roadways in Germany

Service Station (energy station) Microgrid in Massachusetts

solar panels on the canopy, a battery storage unit, and a portable generator connection



The 11.34-MW microgrid at JFK Airport will be delivered through an EaaS solution. (Source: Schneider Electric)

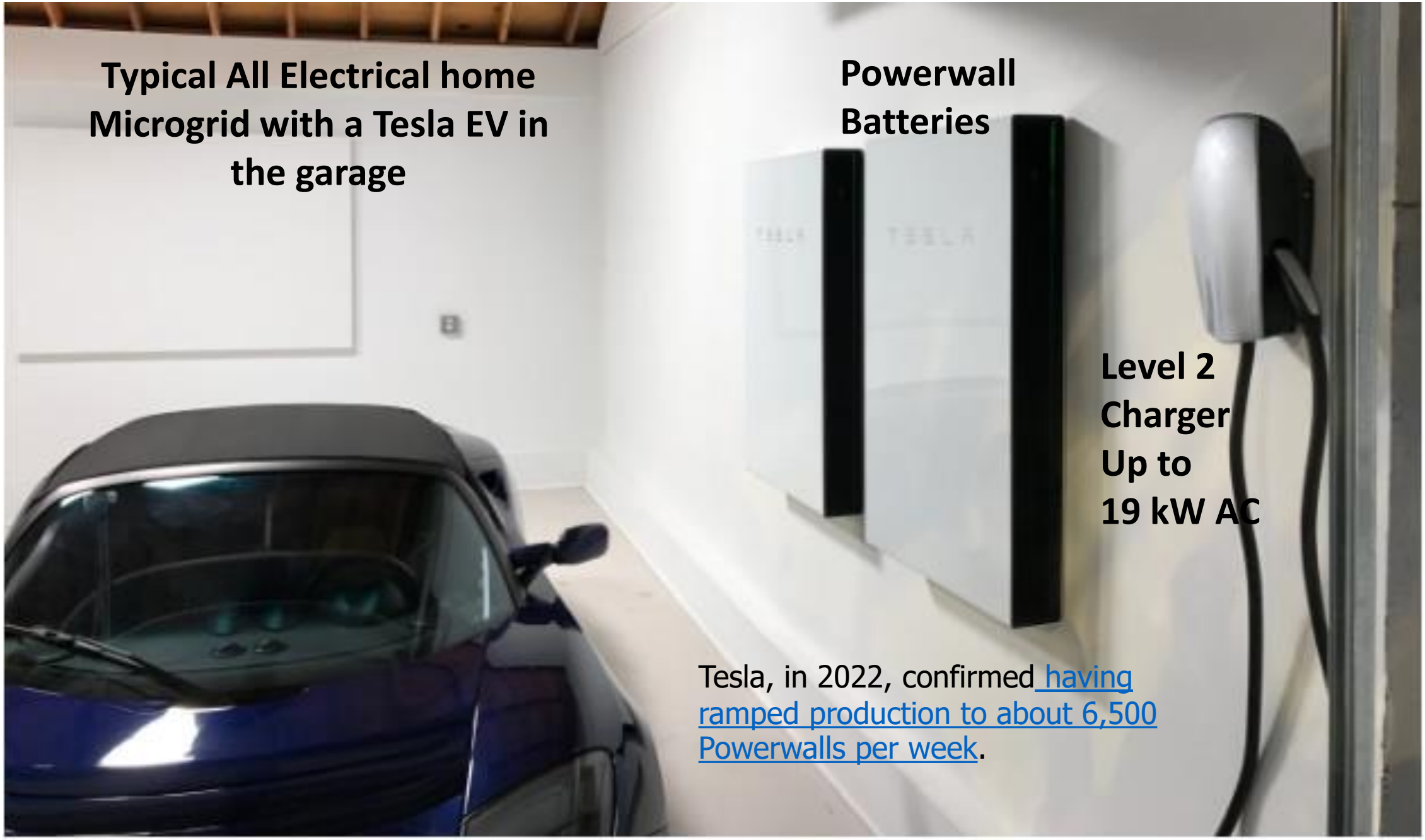
Section 4: Electric Vehicle (EVs)

An amazing addition to a microgrid

Some interesting facts on EVs

- The social cost of GHGs from ICE vehicles
  - Gasoline adds $3.80/gallon - PM2.5-micron particle - healthcare and climate change impacts
  - Diesel adds $4.80/gal social costs
  - Natural gas is twice the diesel social cost
  - Coal electricity is four times the diesel social cost
- Polluters do not pay this price
- EVs, on average from an average grid get the equivalent of 88 miles/gal emissions
- Manufacturing GHGs for EVs are 15% higher than ICE but this is recovered in 18 months of driving
- Buildout of destination chargers – home, work, shopping, hotels, restaurants, etc. is just starting in NA
- Near zero EV emissions when charged from home with renewables (solar or wind)
- There are 70 manufacturers of ZEV buses active in California right now.

- New models yield clearer picture of emissions' true costs (phys.org)


Typical All Electrical home Microgrid with a Tesla EV in the garage
Powerwall Batteries
Level 2 Charger Up to 19 kW AC
Tesla, in 2022, confirmed having ramped production to about 6,500 Powerwalls per week.

Solar canopy over Tesla Supercharging station

Where is the 40,000+ Tesla power station energy coming from?

Also, second life (100 years) used Lithium-Ion batteries


Underground parking lot managed charging stations
TESLA
SUPERCHARGER

Vehicle-to-Grid

Energy on wheels

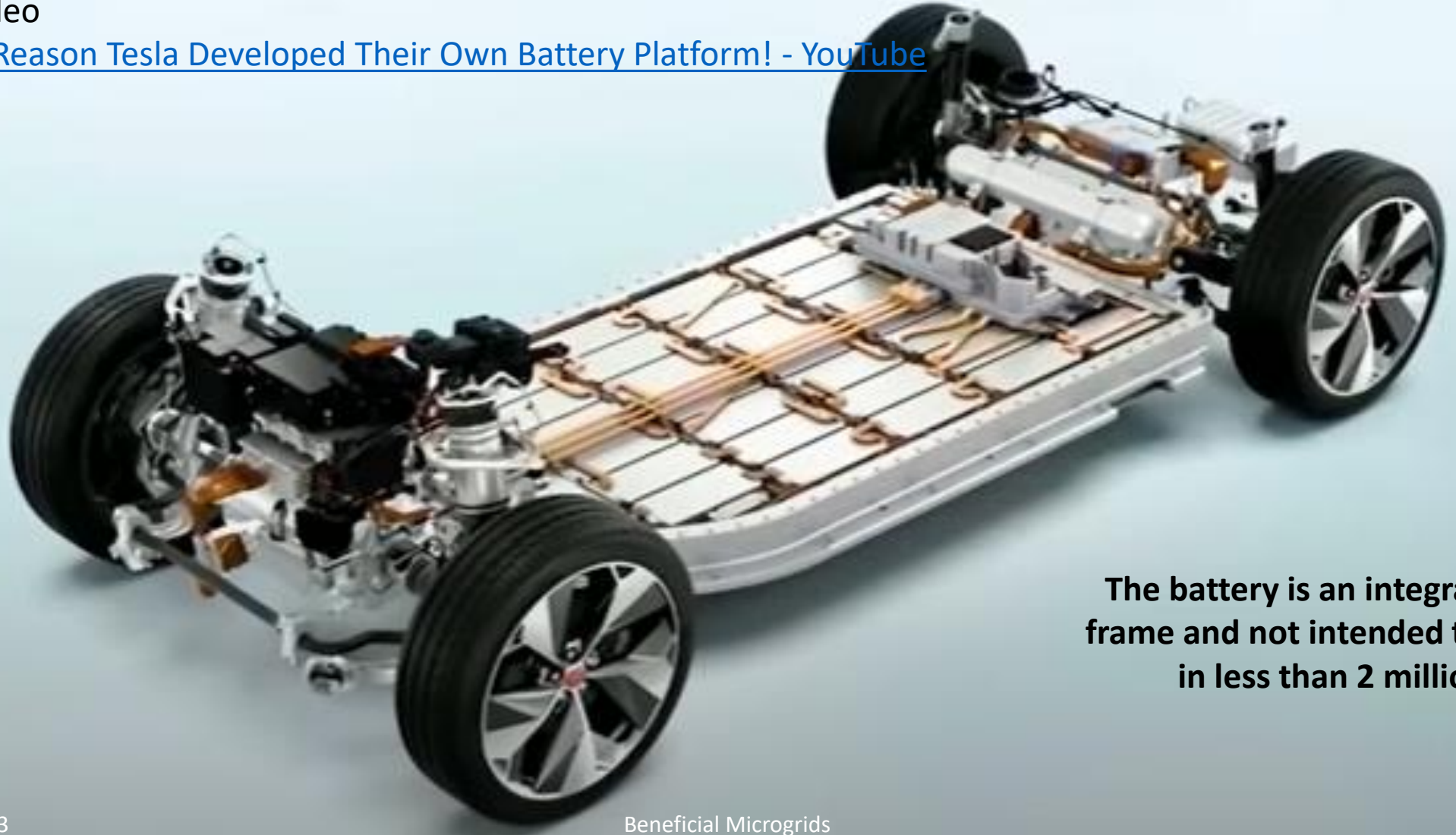
Energy systems
in the age of electric

Electric Vehicle Managed Charging Integration with Microgrids - V2G

- Having a connection to a complaint two way charging point (even away from home) opens the possibility of providing the grid with energy between 5 p.m. and 9 p.m. (peak demand) while earning about $2.00 per delivered kWh. Some utilities have ultra-low late-night rates of $0.025
- During grid outages a compliant EV (battery and computer on wheels) can provide emergency power anywhere within driving range. A mobile load and a mobile supply

Tesla skateboard, battery, frame, motors, computer

An excellent video
(108) The Real Reason Tesla Developed Their Own Battery Platform! - YouTube



The battery is an integral part of the frame and not intended to be replaced in less than 2 million miles


Basic Microgrid EV Charging Station

Vehicle to Everything Charge Points – V2X

- V2X means a vehicle connected via a bidirectional charge point to everything including V2 Home, V2 Grid, V2 Building, V2 Load, and V2 Microgrid.

- Need up to 3 times as many destination charge points as there are EVs so the EV is connected for bidirectional energy management whenever it is not moving.

- Wireless charging, under parking spots, has great potential.

Section 5 : Control system

Hardware and software

Four types of democratized trading software

1. Customer real-time monitor of consumption and controls - Windows, Apple, Linux, Android. Supporting energy literacy, situational awareness, credits for remote generation, efficiencies, survival, and rationing

2. Installer – installation, debug, update, interfaces, operational checks

3. Administrator is the senior manager of a microgrid and community microgrid – load management, EV charging, battery management, bi-directional flows, generator configurations, sales profile to internal microgrid industrial customers, and the grid utility

4. Virtual Power Plant – command and control by the utility and aggregator

By enabling peer-to-peer energy transactions, microgrid trading platforms can help to optimize energy consumption, reduce costs, and improve the overall efficiency of the energy system. Each of these software types includes local utility requirements and cyber security. Also, they maintain historic and real-time logs and blockchain records, AI functionality, Energy as a Service (EaaS) contracts, efficiencies, reports, trends, graphs, error messages, options, version update manuals, financial summaries, exporting raw data, links to suppliers, optimization, and configuration control

Hardware – interfacing challenges

1. Solar, wind, diesel/gas generator time-varying performance

2. Battery discharge and charge profiles, state of charge, wireless charging

3. EVs and opportunities to sell power back to the grid – V2G – flexible in space and time bidirectional flows. Many lifestyle bidirectional charging stations (x3) at destinations

4. Residential and rental high-rise towers building equipment (IoT, security, elevators, specialty considerations)

5. Emergency measures (hospitals, fire departments, police, government control centers)

6. Standards hardening and compliance with the utility and each other (connectors), fire resistance, weather damage, temperature extremes, FMEA, state actor attack threats, vegetation, and animal tolerance, outage islanding switching, flexibility

Section 6:
Stop Burning:
Frontiers of the new climate economy are rapidly expanding

In the beginning, it is all about installation money to most burner people

But there are many benefits to microgrids without burning

Environmental, Economic, and Social

Coefficient of Performance - COP

21 Advantages of Community Microgrids

1. Collecting the sun and geothermal energy available everywhere using open-source business models to lower the centralized energy demand and operating costs for owners, consumers, utilities, the microgrid technology industry, and demands for government subsidies, (Economic Benefit)

2. Reduce poverty by isolating from energy inflation pressures -- cost growth avoidance, maintaining stable predictable cost (say 50 to 70% lower than the utility while trending lower) and optimizing the use of available local resources,

3. Expand social and wealth equity (democratize bias-free energy) for safe healthy families (toxic food, wildfire air quality, water purity, and using UV band C managing viruses, bacteria, and molds),

4. Save lives and human suffering through supply reliability for a secure energy future and improved shelter safety (insurance value). Continuing atmospheric climate and geopolitical catastrophes are a certainty.

5. Improve social resilience and liberation from the fragile utility and climate-fueled disasters (grid instabilities and outages => fear, frustration, inconvenience, heat stress, and damage – food spoilage, flooding, health impacts, and even death) by replacing with a safer shared resource infrastructure,

21 Advantages of Community Microgrids (continued)

6. Support time-shifting energy awareness and deliver on the growing expectations of residents. Encourage their innovation using automation to improve performance with AI-driven insight. Residents have knowledge of continual microgrid energy cost decreases and livelihood opportunities,

7. Provide an opportunity for communities to generate their own distributed technology-based electricity and to sell excess into local virtual power plants using blockchain tokenization,

8. Allow communities to manage their own energy savings, consumption, and reinvestment of profits for local flexibility, independence, and freedom from centralized eco-denialism, cheating, deception, distraction, and single-dimensional ($) politically driven energy decisions,

9. Promote community pride and prestige in their energy democracy by delivering long-term livability, local economic development, and reduction of consumption,

10. Encourage equitable community empowerment and independence through innovation, resident technical/administrative training, product development, and neighbour assistance without the use of commodity-based fossil fuel generators (noise & smell),

21 Advantages of Community Microgrids (continued)

11. Enable communities to sell surplus energy back to the utility using energy arbitrage (trading at maximum demand to stabilize energy prices and reduce the need for fossil fuel generators) while time shifting and spreading their recharging demands over long periods at night,

12. Provides utility ancillary stability (voltage, frequency, and phase following or leading), EV fast charging independence, peaking energy sources, as well as supporting major deferral decisions using geostrategic utility-owned microgrids (resiliency strategies) and utility repair cost avoidance,

13. Provide opportunities for communities to trade energy with other communities, to make a community of communities, or Virtual Power Plant Partnerships (VP3) using common open-source equal access tools, standards, pathways, and procedures when partnering with the grid utilities,

14. Reduce pollution and encourage compatibility with a thriving ecosphere - do no harm and remove human interference in natural processes. Advance the blending of culture and Nature. Stop the destruction of Nature,

15. Deliver the ability to expand the operational versatility of the facility including as a refuse or a culture center during and after weather or geopolitical instability disasters. Prepare to survive.

21 Advantages of Community Microgrids (continued)

16. Reduce greenhouse gas emissions (no fuel burning) – for carbon-sensitive residents seeking climate disaster mitigation simultaneously with rapid adaptation to changing conditions, (Environmental Benefit)

17. Improve shelter security (doorbell, active alarms, and cameras), building envelope isolation from wildfire smoke, extreme atmospheric heat and cold, and flooding, while adding digital security,

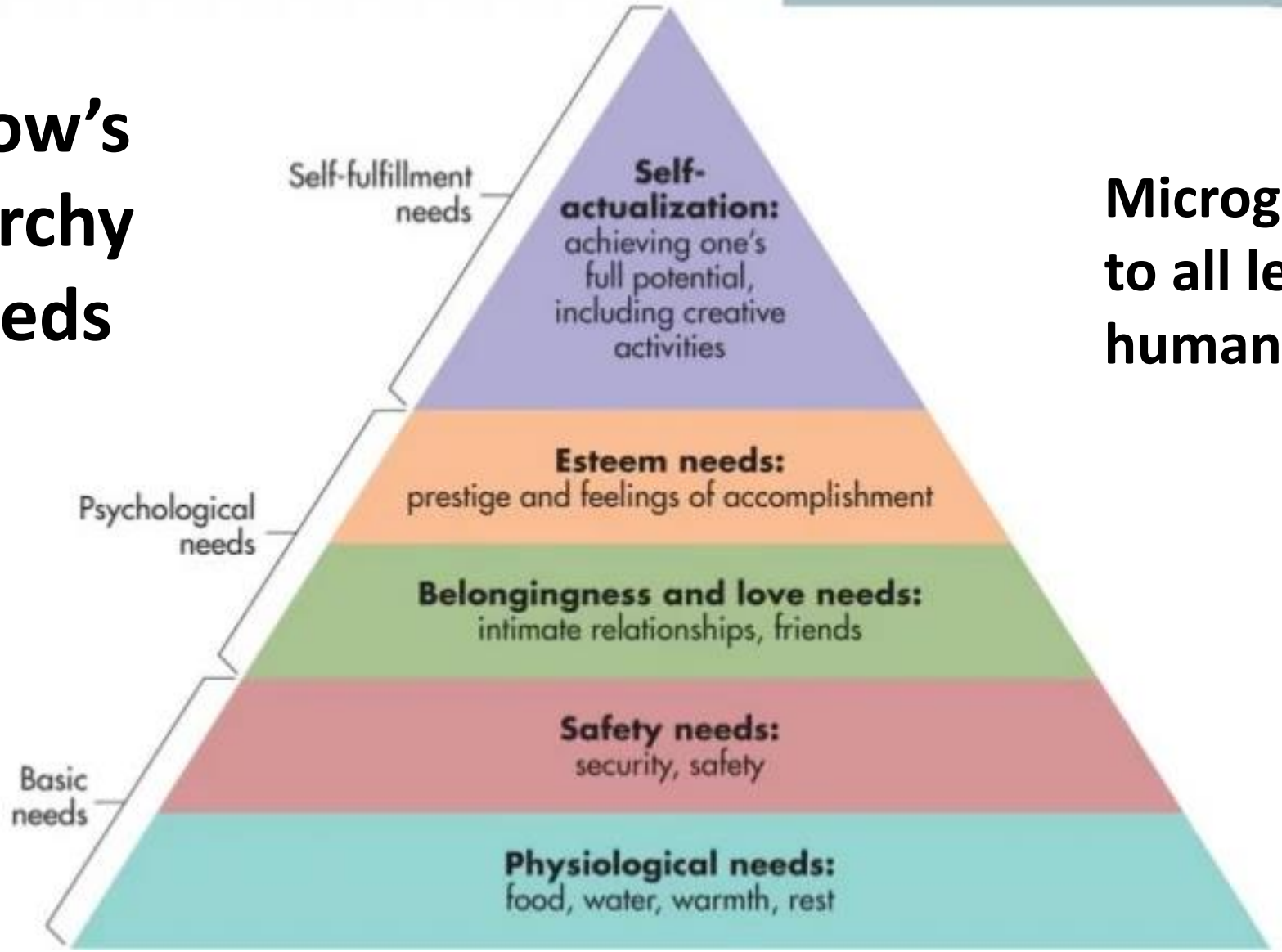
18. Contribute to sustainable development including EV Vehicle to Grid connectivity (distributed batteries and blockchain arbitrage can provide future ROI) and accelerate microgrid proliferation,

19. Isolate and protect microgrid power quality from aging utility infrastructure (voltage spikes damage TV sets, computers, and electronics). "Island" or choosing when to become invisible to the utility,

20. Help Canadians prepare for rapidly growing catastrophe exposure while preventing more extreme climate disruption. Take care of yourself by disrupting "normal" and thriving in low-stress emergency mode,

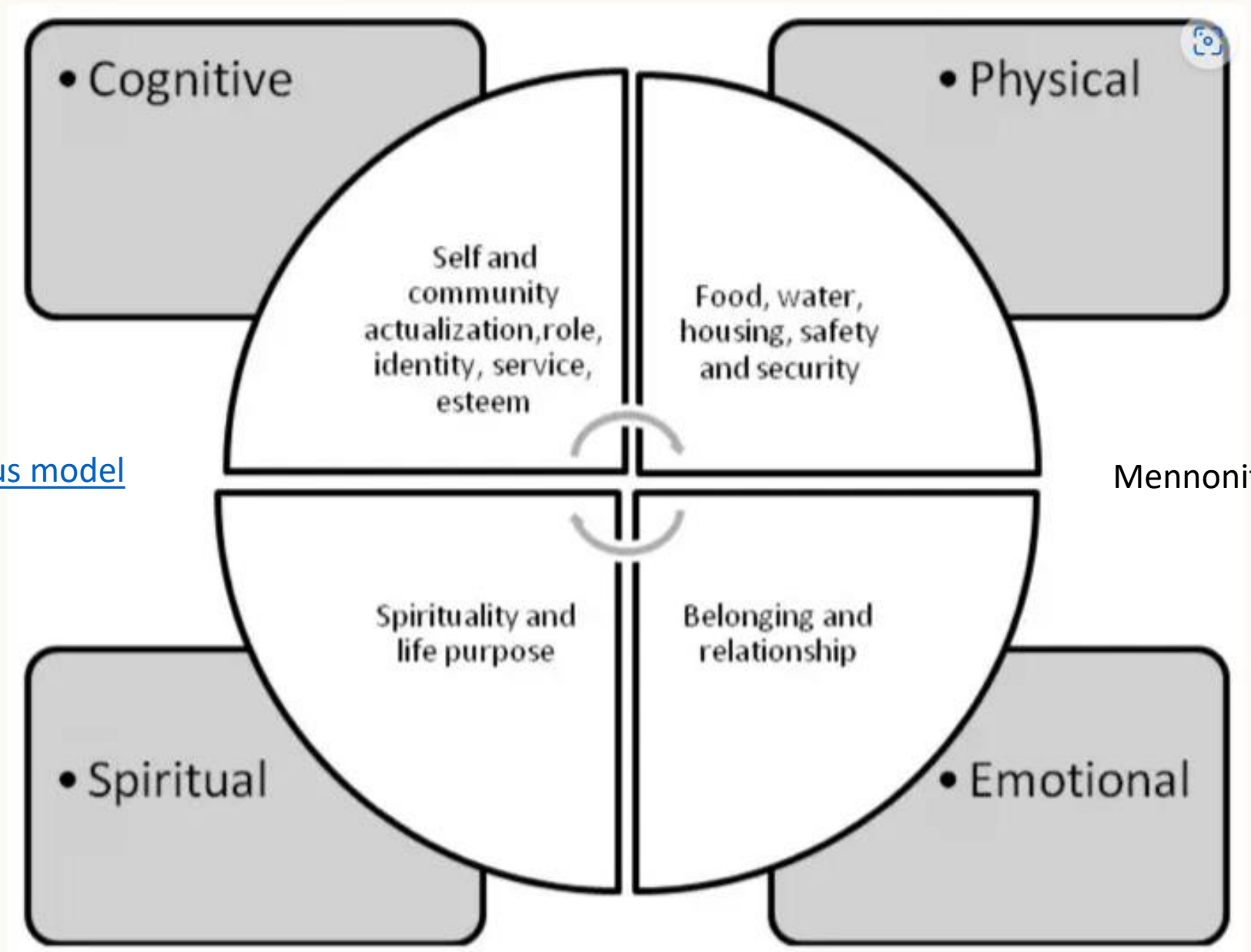
21. Improve life meaning, peace of mind, quality of life, and well-being (Maslow's hierarchy of needs, including mental stress, loneliness, isolation, and values). (Social Benefit)

Maslow's Hierarchy of Needs



Microgrids Add to all levels of human needs

Blackstock represents Cross' ideas in the circular model below:



[Indigenous model]

Mennonite Model

THE END

Of the Old Way