



CLEAN
CONVENIENT
INDEPENDENT



ENERGY – 101

SOLAR ENERGY ON THE LAND

Niklas Rusche, 2021-10-27



FNQLSDI
FIRST NATIONS OF QUEBEC AND LABRADOR
SUSTAINABLE DEVELOPMENT INSTITUTE

COVERAGE & OBJECTIVES

- Energy basics
 - What it is
 - How it works
- Small off grid solar
 - For camps, cabins, RVs
 - For beginners
- Science may be simplified
- Does not teach you to do a custom DIY installation!



FIRST NATIONS OF QUÉBEC AND LABRADOR SUSTAINABLE DEVELOPMENT INSTITUTE

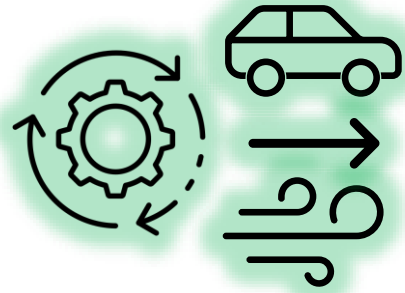


FNQLSDI

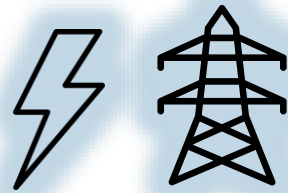
- Founded in 2000 by the Chiefs of the Assembly of First Nations Quebec-Labrador (AFNQL)
- Offer First Nations a dynamic service hub:
- supporting their actions towards maintaining healthy territories and resources
- developing sustainable communities
- promoting the recognition of their rights



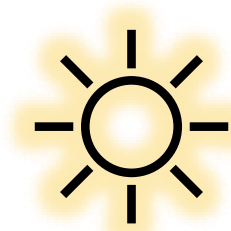
FORMS OF ENERGY



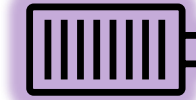
Mechanical



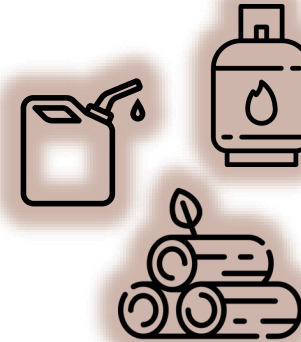
Electric



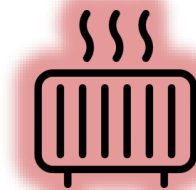
Radiant



Electrochemical



Chemical



Thermal



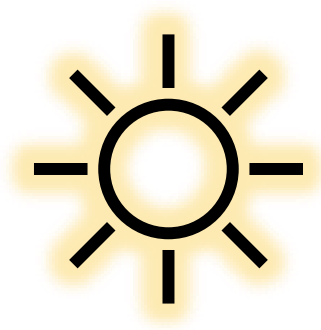
RADIANT ENERGY

Energy of rays:

Photons in movement

For example:

- Light
- Heat radiation
- UV rays



CC-BY-gr33n3gg



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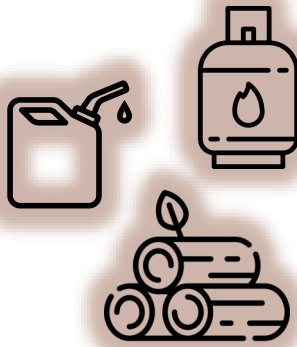


CHEMICAL ENERGY

Everything that can burn, contains chemical energy.

For example:

- Fossil fuels
 - Coal
 - Gasoline
 - Propane
- Biomass
- Food



CC-BY Aapo Haapainen



CC-BY-NC-SA jcarflon



CC-BY-NC dwstucke



CC-BY-NC LexnGer

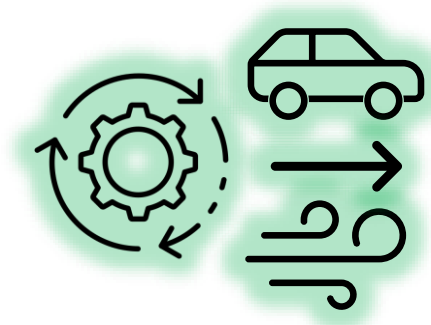


MECHANICAL ENERGY

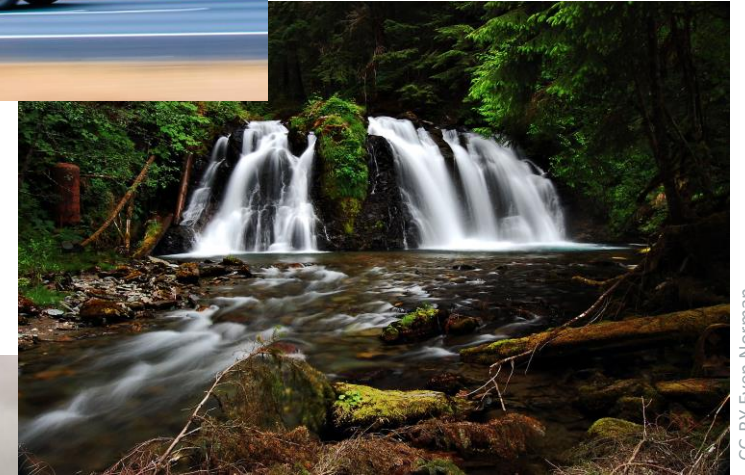
Everything that moves or rotates, possesses mechanical energy.

For example:

- Objects in motion
- Rotating objects
- Water and air in motion



CC-BY Arup Malakar



CC-BY Even Norman



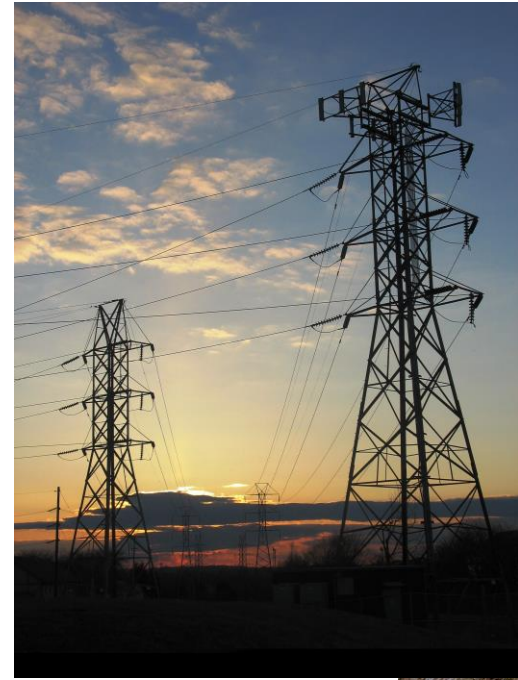
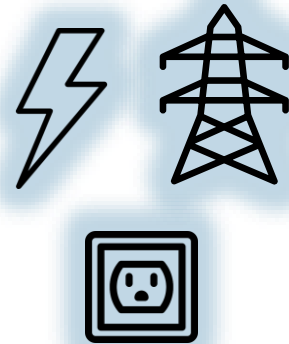
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ELECTRIC ENERGY

Everything we can plug in, or that has a battery, works on electric energy.

- Can be transformed in other forms of energy without little loss
- Difficult to store



CC-BY-NC0ZinOH



CC-BY-NC Paradox Wolf



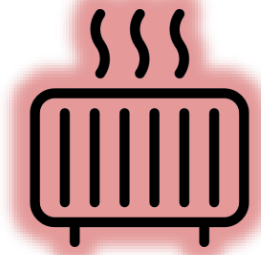
CC-BY Tony Webster



THERMAL ENERGY (HEAT)

Everything warm possesses thermal energy.

- “Low quality” form of energy
- In the end, all forms transform into heat



CC-BY Scott Akermann



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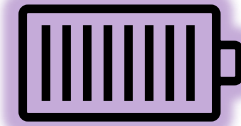
ELECTROCHEMICAL ENERGY

A charged battery contains electrochemical energy.

- Batteries take electricity to charge
- Most recently discovered form of energy



CC-BY Rob Nunn



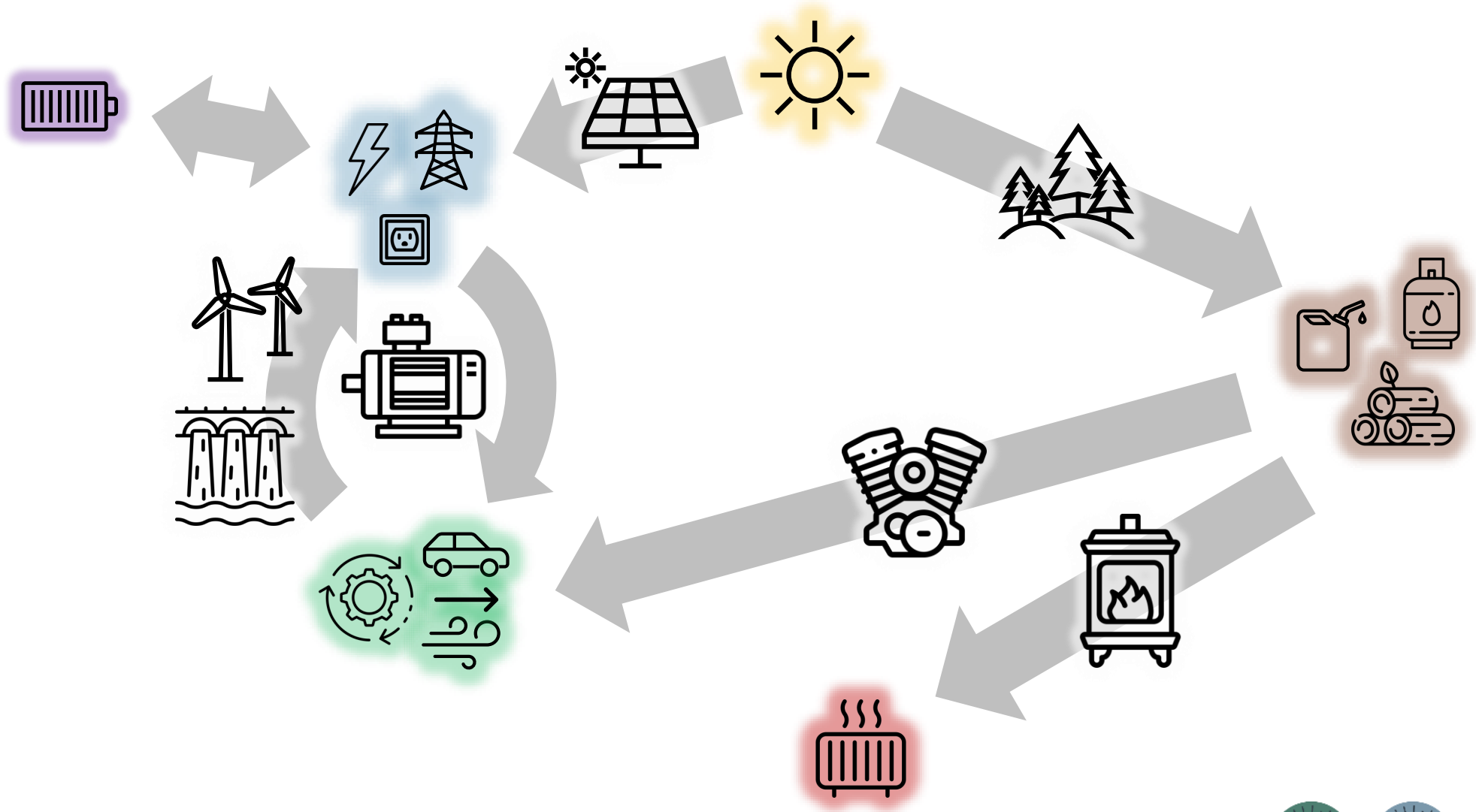
CC-BY-SA Uwe Herrmann



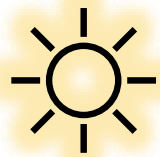
CC-BY RVWithTito.com



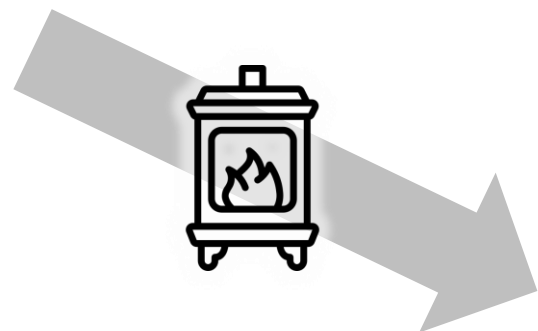
ENERGY TRANSFORMATIONS



HEATING WITH WOOD



CC-BY Aapo Haapanen



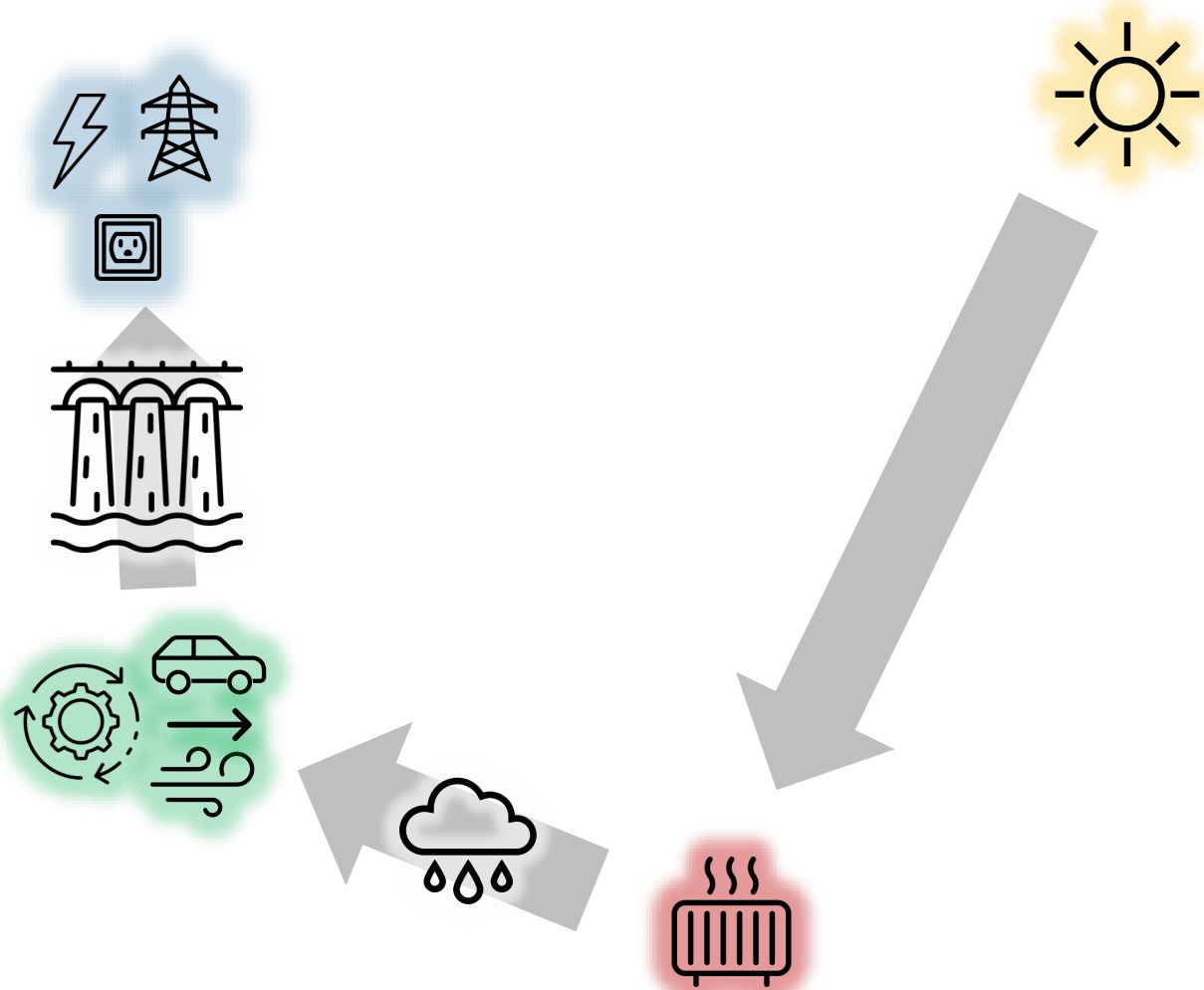
BY-NC-SA JLS Photography Alaska



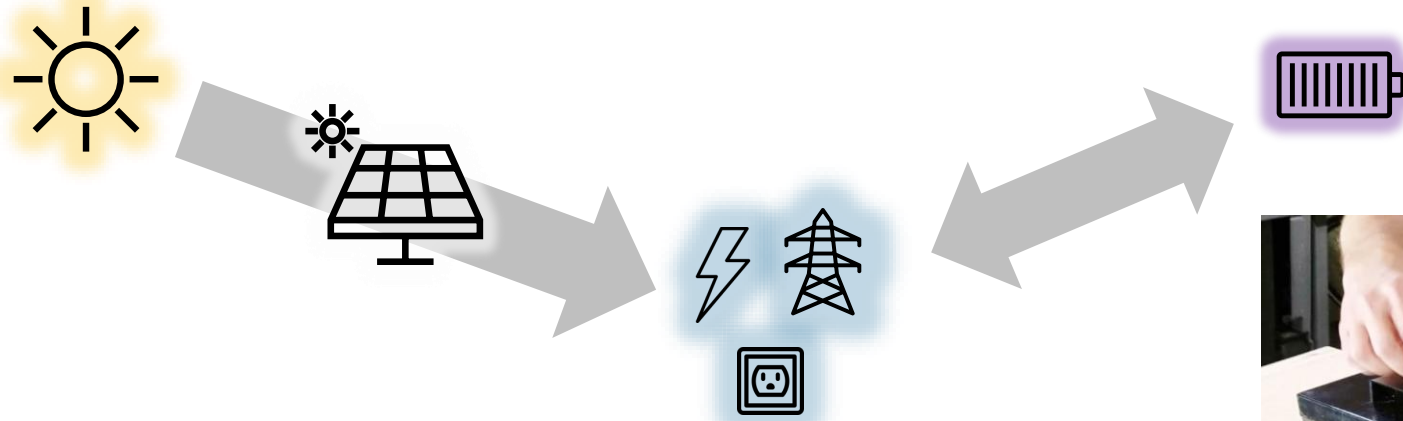
HYDRO ELECTRICITY



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PHOTOVOLTAIC ENERGY



© Relais de la Cache



CC-BY RVWithTito.com



| RULE # 1:

Energy cannot be created or destroyed, just transformed from one form into another.



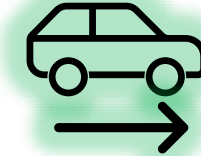
| RULE # 2:

When energy changes form, a part of it is lost as waste heat.

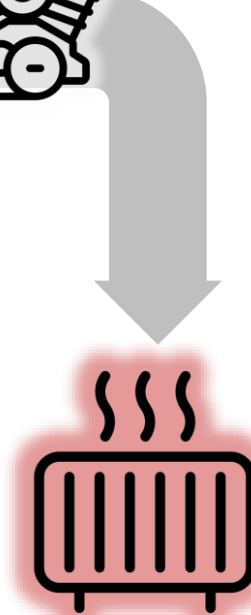


ENERGY IN CARS

COMBUSTION ENGINE

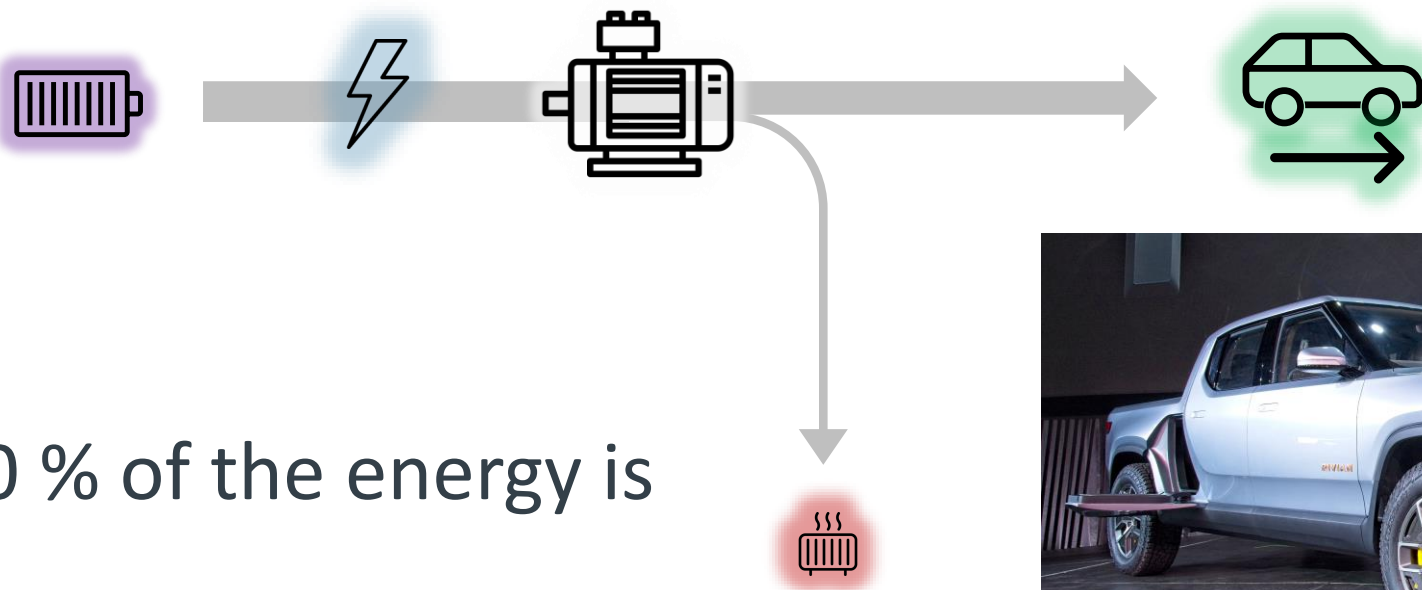


- 80 % of the energy is lost as heat!



ENERGY IN CARS

ELECTRIC MOTOR



- Only 10 % of the energy is lost.



© Rivian Motors



ENERGY AND POWER

- What is the difference?
- How can we measure the two?



ENERGY AND POWER

Energy necessary to boil one liter of water:

100 Wh

$$100 \text{ Wh} / 100 \text{ W} = 1 \text{ h} = 60 \text{ min}$$

$$100 \text{ Wh} / 1000 \text{ W} = 0,1 \text{ h} = 6 \text{ min}$$



Power



UNITS OF ENERGY

- Watthour [**Wh**]
- Kilowatthour [**kWh**]
 - 1 kWh = 1000 Wh
- Kilocalorie [kcal]
- Joule [J] (scientific)
- British Thermal Unit [BTU]



POWER AND ITS UNITS

- Power = flow of energy
- Wattage = power
- Energy per unit of time:
1 watthour per hour = 1 watt
- Units:
 - Watt [**W**]
 - Kilowatt [**kW**] (1 kW = 1000 W)
 - Horsepower [**hp**] (1 hp = 745.7 W)



ENERGY AND POWER

Name of what to measure	Unit of what to measure	Name of what to measure per time	Unit of what to measure per time
Argent	€ (Euro), \$ (Dollar)	Annual salary, Usage fee, ...	\$/h (Dollars per hour), €/a (Euros per year)
Distance	m (meters), km (kilometer), NM (nautical mile)	Speed	m/s (meters per second), km/h (kilometers per hour), kt (knots)
Energy	Wh (watthour) kWh (kilowatthour)	Power	W (1 Watt = 1 J/s), kW (1 Kilowatt = 1 kWh/h), hp (Horsepower)



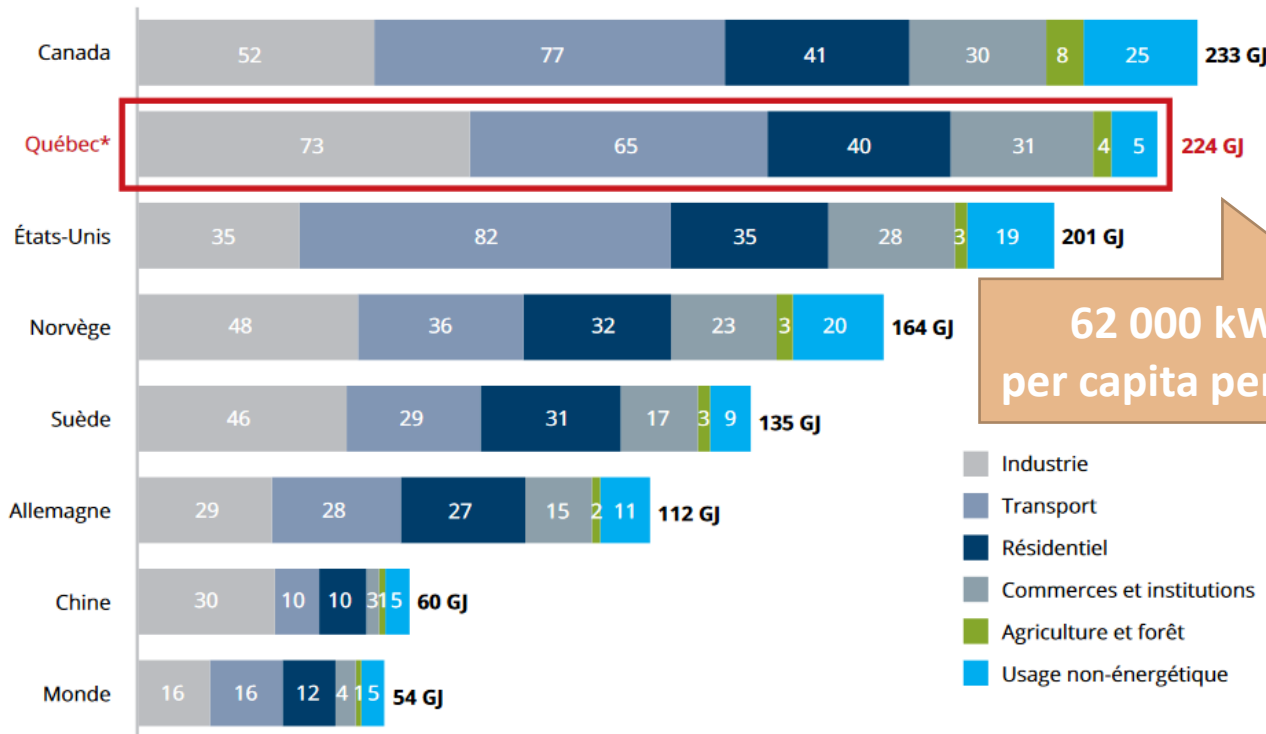
HOW MUCH ENERGY...?

ACTIVITY	ENERGY NECESSARY
Charge a cell phone	11 Wh
Light a room for an hour	10 Wh
Make two toasts	33 Wh
Make a cup of coffee	32 Wh
Take a warm shower	1 400 Wh
Take the car to work (Hyundai Accent, 15 km)	11 160 Wh
Energy contained in a poutine (200 g)	700 Wh
Go up stairs to the next floor	0.6 Wh
Heat an apartment for a day	17 000 Wh
Dry laundry in a clothes dryer	2 600 Wh
Take the car from Québec to Montréal	125 000 Wh
Take the plane from Montréal to Barcelona	2 200 000 Wh



YEARLY ENERGY CONSUMPTION PER CAPITA

GRAPHIQUE 16 • COMPARAISON DE LA CONSOMMATION ÉNERGÉTIQUE PAR HABITANT DU QUÉBEC AVEC CELLE D'AUTRES PAYS, 2018



Sources : AIE, 2020; sauf * pour le Québec (donnée du graphique 2).

Note : Le graphique illustre la consommation énergétique de certains pays du monde. Seuls quatre petits pays ont une consommation par habitant supérieure à celle du Canada : Trinité-et-Tobago, le Qatar, l'Islande et le Luxembourg.



FOSSIL ENERGY

VS

RENEWABLE ENERGY



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- Examples: gasoline, diesel fuel, coal, propane
- Made from crude oil, “fracking”, tar sands, fossil gas

- Examples: photovoltaics, wind turbines, hydro power*
- Uses the sun, wind, rivers



© Apuiat Project

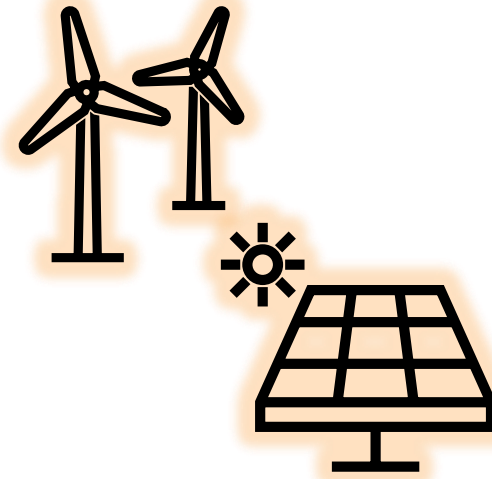


FOSSIL ENERGY

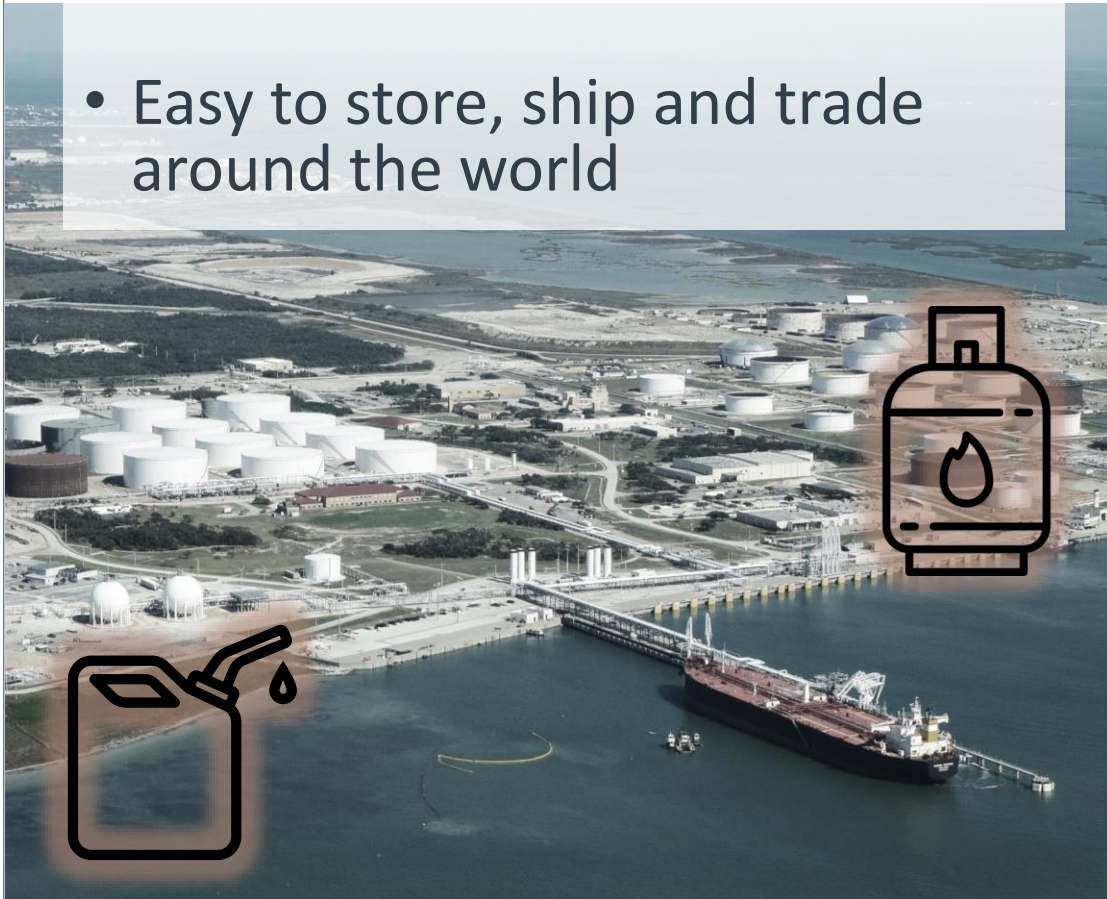
VS

RENEWABLE ENERGY

- Chemical energy: highly concentrated
- Easy to store, ship and trade around the world



- Electric energy: very efficient to use
- Easy to transport in cables
- **Hard to store in large quantities**



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FOSSIL ENERGY

VS

RENEWABLE ENERGY

- Risk of toxic spillage
- Toxic exhaust fumes
- Central, dependence on oil companies



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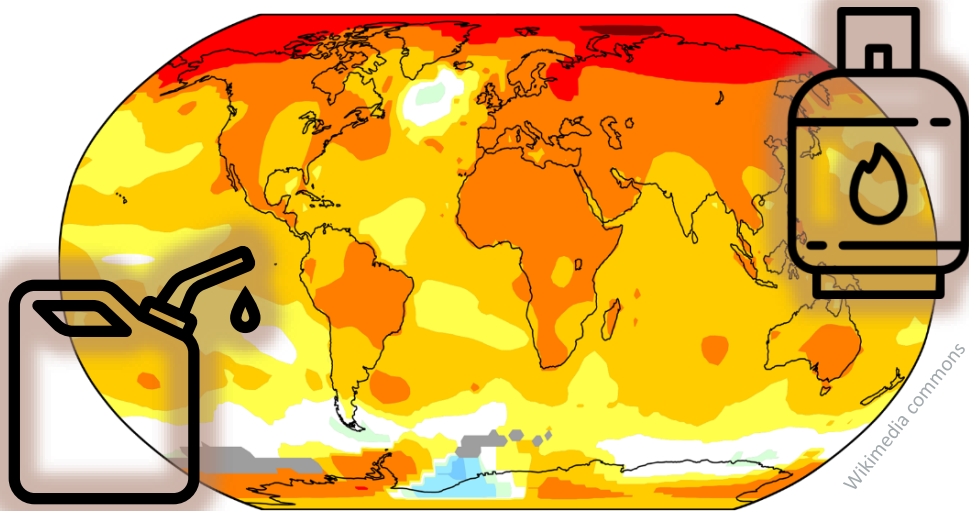
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- No exhaust, no toxic fuel, no spillage
- Decentral, everybody can be a producer



FOSSIL ENERGY VS

- Extraction gets more and more expensive
- Does cause climate change



RENEWABLE ENERGY

- Sun and wind are free, technology advances, prices go only down
- Do not cause climate change



ENERGY TRANSITION

- Climate crisis: We have to act now
- Transition from fossil to renewable energy use
- In all sectors:
 - Electricity production
 - Transport (cars, trains, planes, ships...)
 - Industry (steel, chemical, concrete...)

Advantages

- Improving health
- Reducing pollution
- Economic opportunities
- Keeping global ecosystems from collapsing



ENERGY TRANSITION : CHALLENGES

WHAT'S HOLDING US BACK?

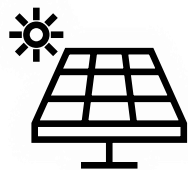
- The scale of what has to change is mind-boggling
- Inertia, resistance to change
- Waiting for a miracle solution, denial
- Lack of information
- Financial interests, old structures



FORMS OF RENEWABLE ENERGY



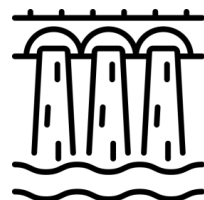
Wind



Solar



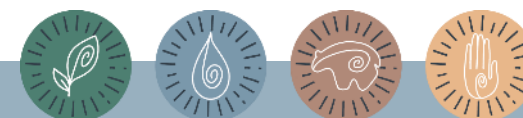
Biomass



Hydro



Geothermal



SOLAR ENERGY (PHOTOVOLTAIC)

- Can convert sunrays into electricity
- Works better when it's cold outside
- Depends on weather
- Prices have dropped in last years
- Least impact amongst all forms of energy
 - Noise, visual, landscape
- Low maintenance



© IDDPNOL

CC-BY David Dodge



WIND ENERGY

- Captures the movement of wind to transform it into electricity
- Often the cheapest form of renewable energy
- Depends on the weather
- The bigger, the better (cheaper)



© 2021 Mif'gmawei Mawioimi Business Corporation



ENERGY FROM THE GROUND

- Deep geothermal energy
 - High temperature
 - Can be used to generate electricity
 - **Non-intermittent**
 - Industrial scale
 - Depends on geological conditions
- Ground source heat pumps
 - Low temperature
 - Used to heat or cool buildings very efficiently with electricity

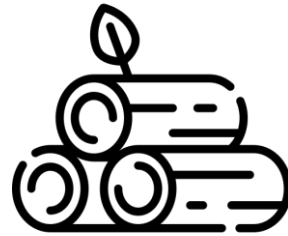


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BIOMASS ENERGY

- Storage of biomass is easy
- Can be used for heating
- Resource (forests) are limited!
- Photosynthesis is inefficient (2%)



BY-NC-SA JLS Photography Alaska



CC-BY Oregon Department of Forestry



CC-BY-NC Aapo Haapanen



HYDROELECTRICITY

- Industrial scale
- **Non-intermittent**
- Ideal in combination with solar or wind (energy storage)
- Destruction of major ecosystems
- Now more expensive to build than alternatives



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| SOLAR ENERGY ON THE LAND

- CLEAN
- CONVENIENT
- INDEPENDENT

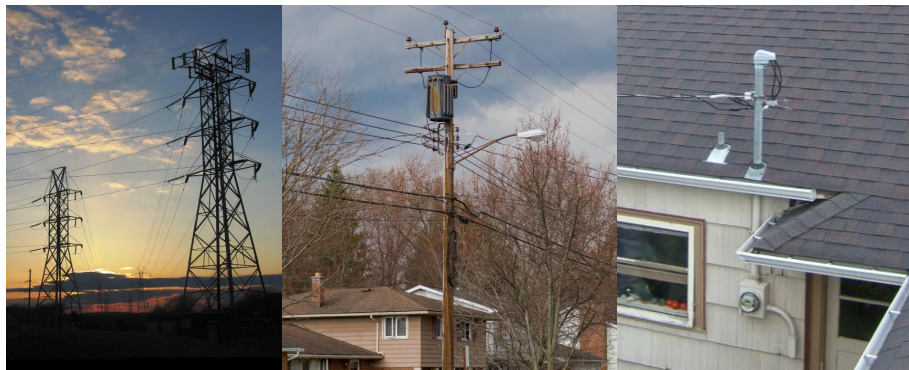
WHERE TO START?



ELECTRICITY ON AND OFF GRID

ON GRID

- 99 % hydro electricity
- Least expensive electricity



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OFF GRID

- Not connected to electricity grid
- Examples: cabins, camps, RVs
- Often powered by propane and generators



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WHERE DO WE NEED ENERGY



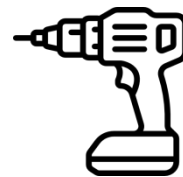
- Lighting
- Electronics
 - Cell phone
 - Television
 - Radio



- Cooling
 - Fridge
 - Freezer

• Others

- Battery chargers e.g. for power tools
- CPAP



• Kitchen

- Stove top
- Coffee makers
- Water kettle
- Microwave oven



• Heating



THE STATE TODAY

Providing energy for my camp/cabin:

● A generator	11
● Solar panels and batteries	1
● Solar panels AND a generator	4
● Others	1



Fuel consumption:
Often up to 1000 l per year

Providing refrigeration for my camp/cabin:

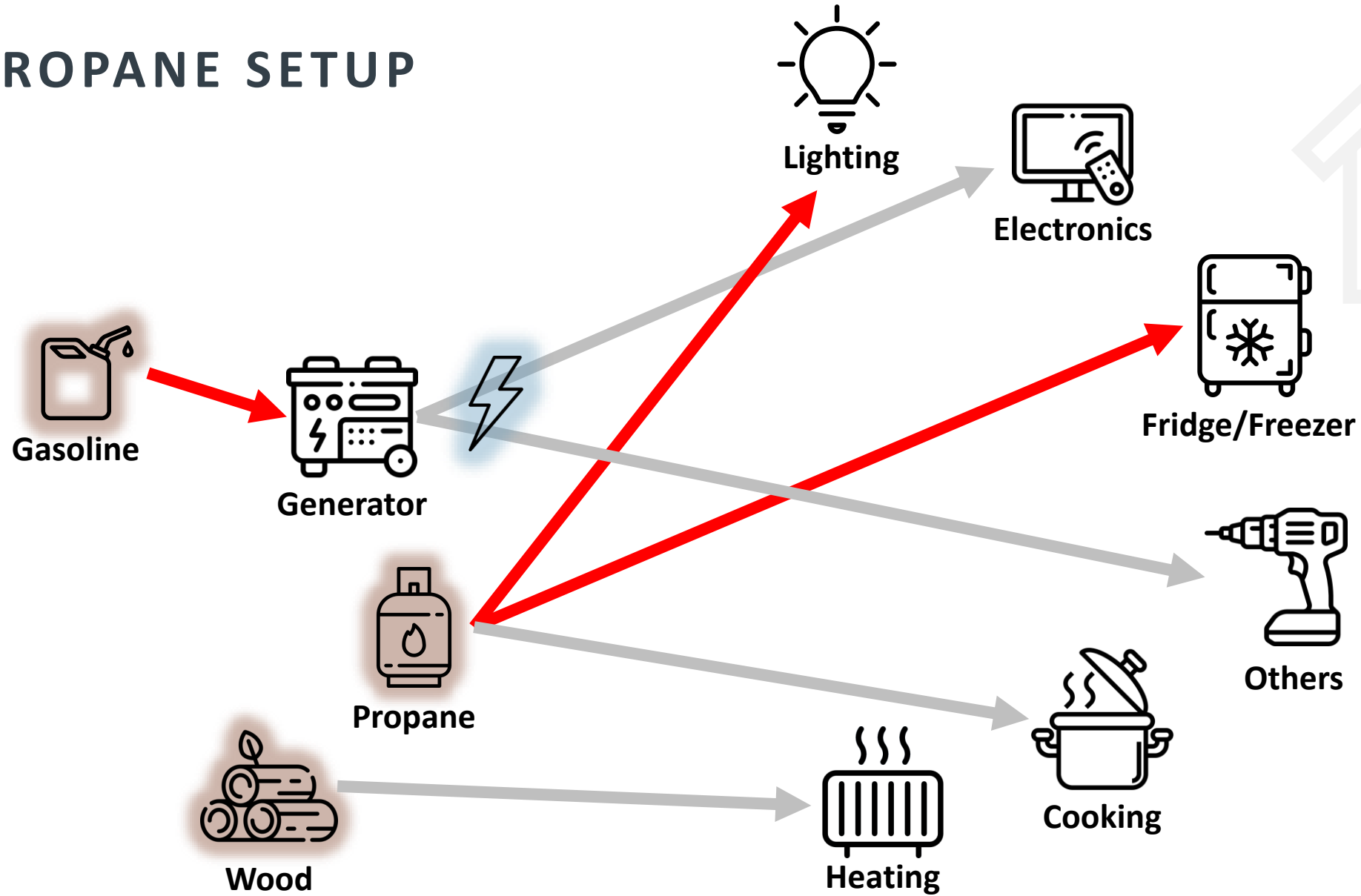
● A domestic fridge (120V)	2
● A propane fridge	9
● A 12 V fridge	1
● An ice box, and I bring ice	3
● Nothing, I don't need it	2



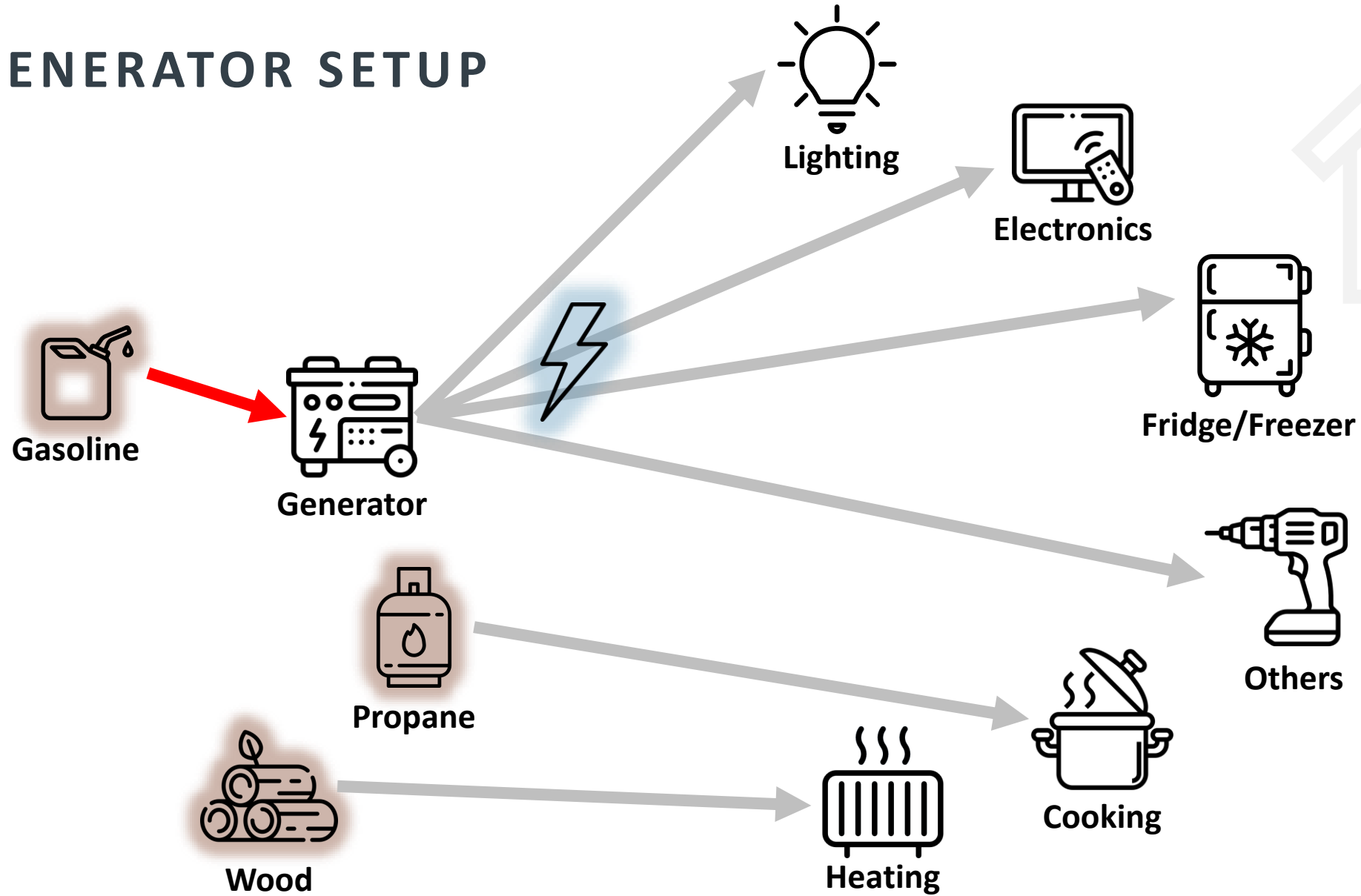
Propane consumption:
Between 200 and 400 pounds per year



PROPANE SETUP



GENERATOR SETUP



GENERATOR

- + High power output
- + Weather independent
- + Inexpensive to buy



BY-SA peupleloup

- Cost of fuel
- Fuel transport and manipulation
- Maintenance
- High standby consumption
- Noisy
- Polluting
- Contributes to global warming
- Extreme waste of energy (80 % and more wasted)



PHOTOVOLTAIC (PV) INSTALLATION

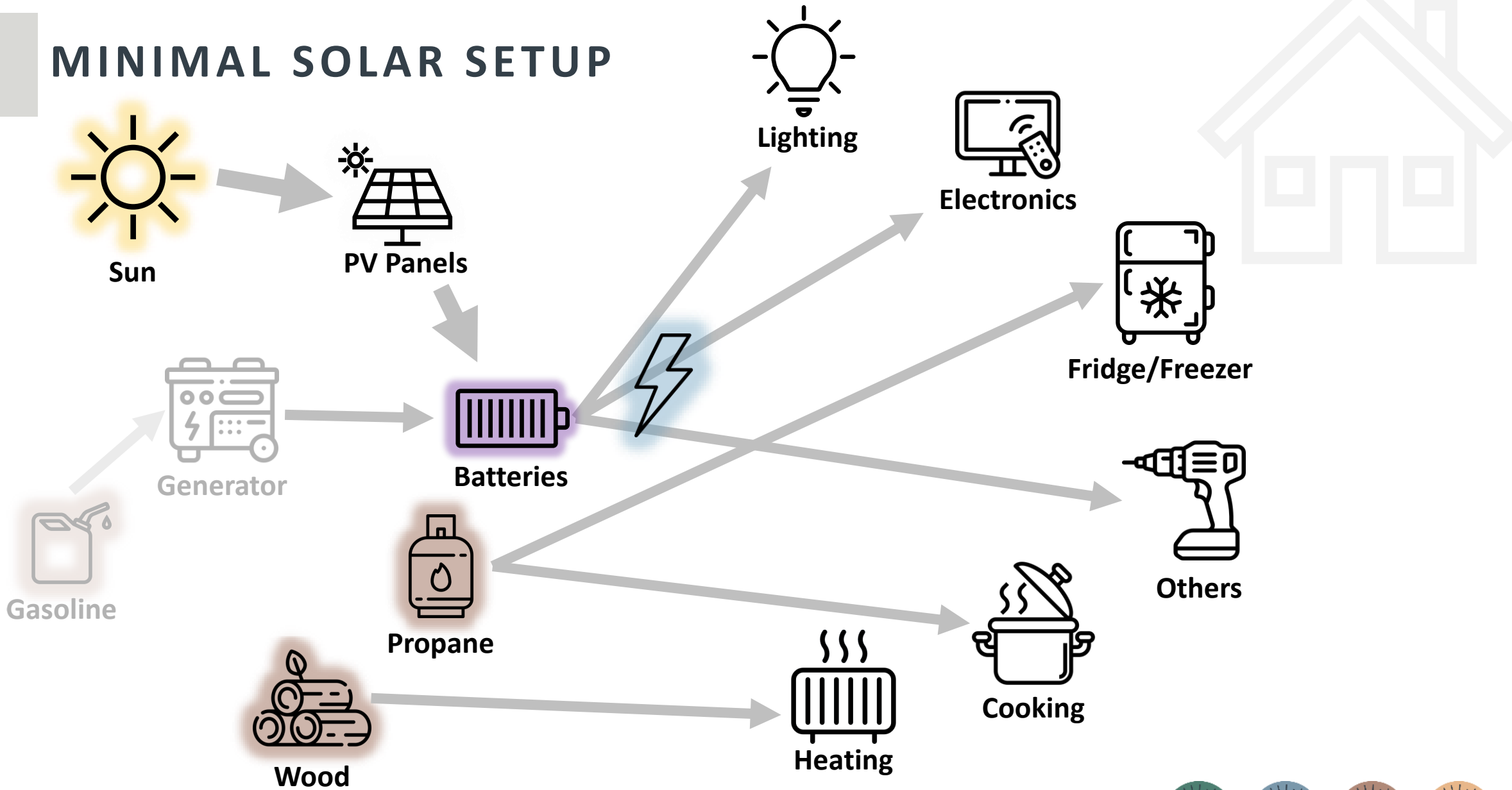
- More expensive to buy than a generator
- Less energy available (cloudy weather!)



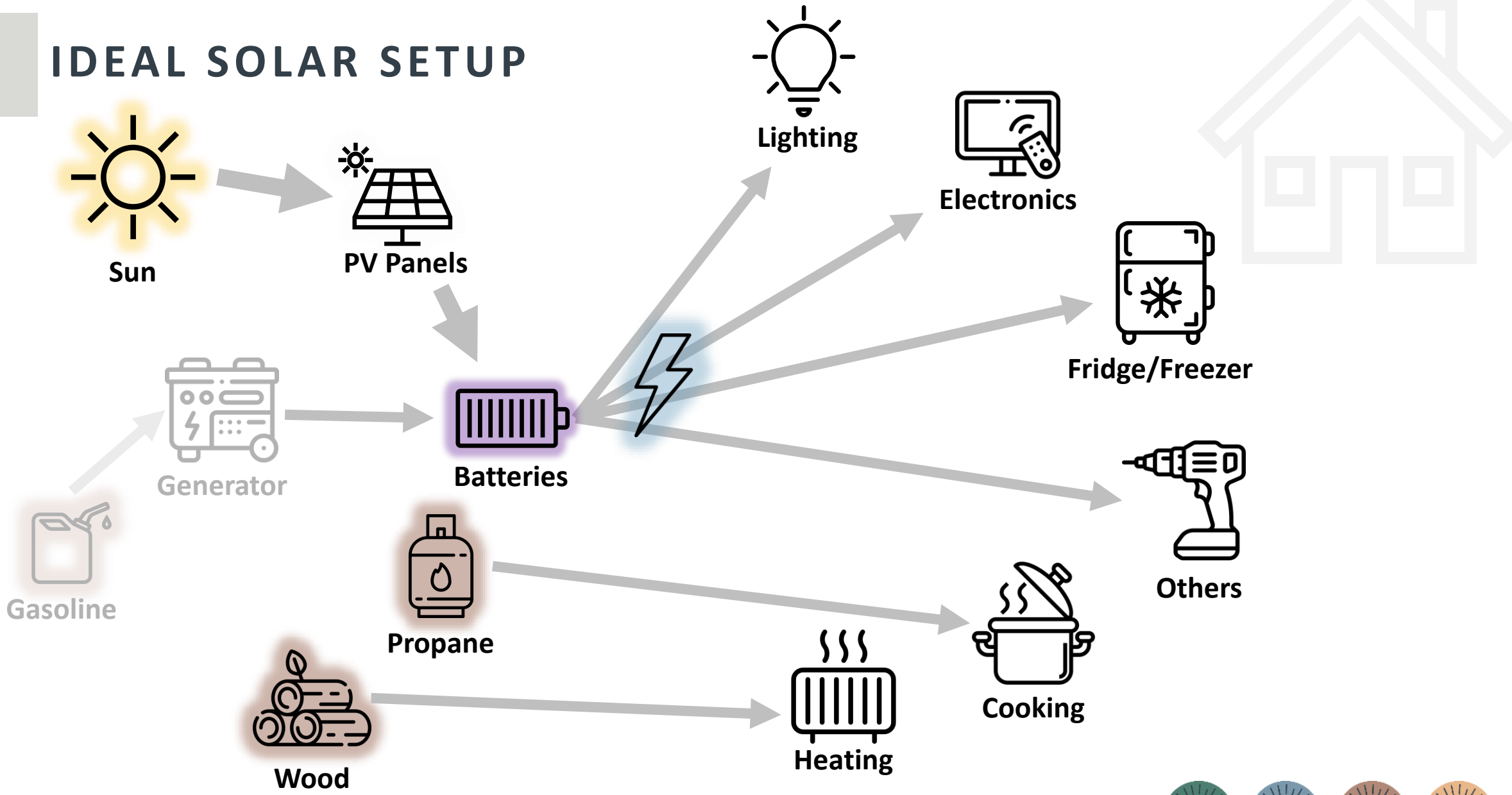
- + No fuel cost
- + No fuel transport and manipulation
- + Little maintenance
- + No stand-by consumption
- + No noise or pollution
- + Long life time of panels and electronic components
- + No contribution to climate change



MINIMAL SOLAR SETUP



IDEAL SOLAR SETUP



THE CHEAPEST ENERGY...

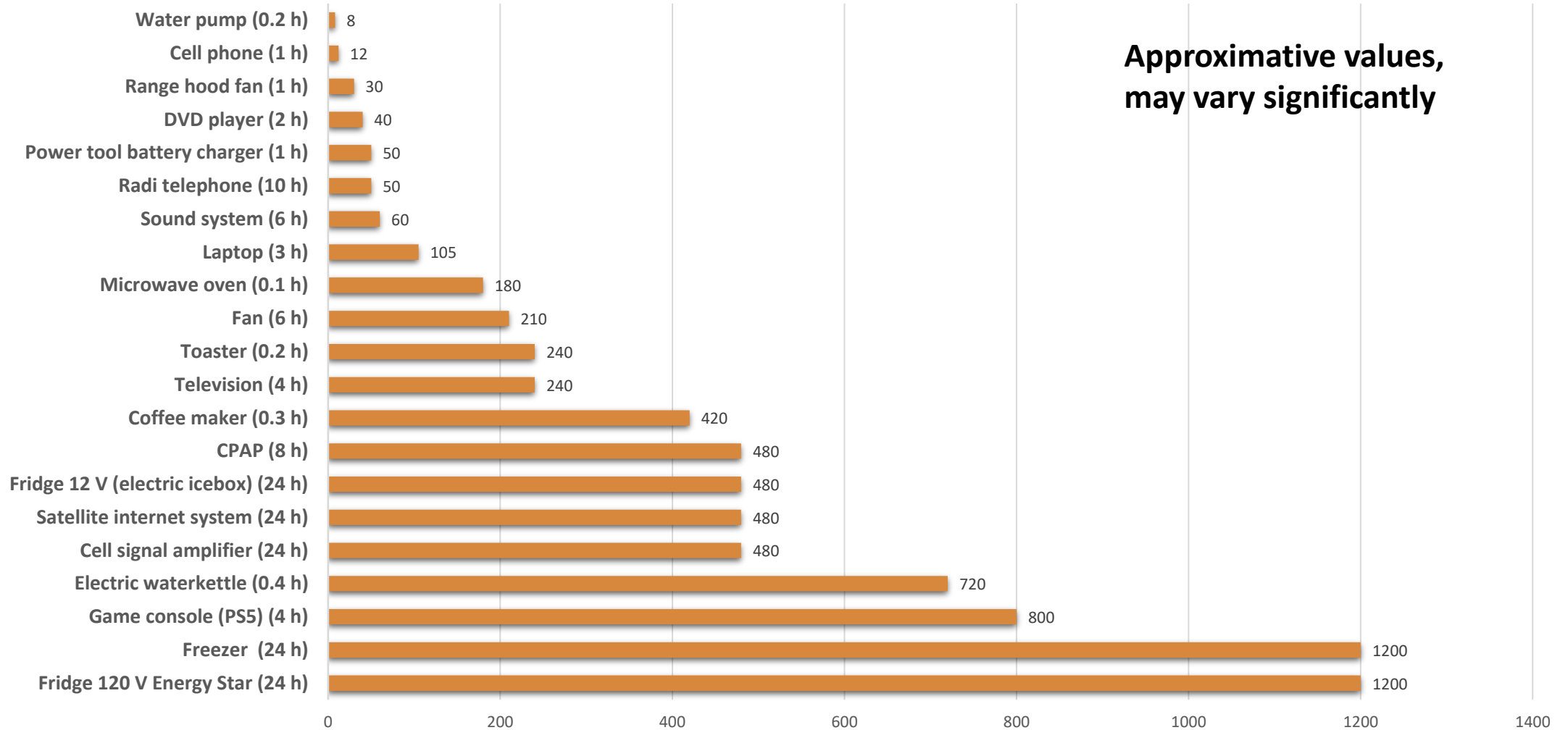
...IS THE ONE WE DO NOT HAVE TO PRODUCE!

STEPS TO GO SOLAR

1. Stop wasteful behaviour
 - Is there useless energy consumption
 - E.g. lamps running during day
2. Use energy intelligently.
 - E.g. use more efficient appliances
3. Size your solar installation

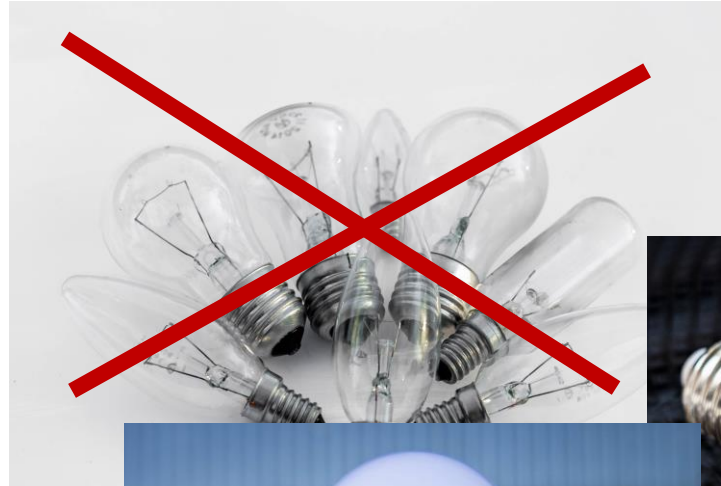


TYPICAL DAILY CONSUMPTION



LIGHTING

- Use LED lighting
 - Fluorescent bulbs use **double** the energy
 - Incandescent bulbs use **10 times** the energy
 - 12 V – LED lights are especially efficient



CC-BY Marco Verch



CC-BY Marco Verch



CC-BY Marco Verch



FRIDGE AND FREEZER

PROPANE REFRIGERATORS

- Expensive to buy and to run
- Require maintenance
- Produce humidity
- Triple-energy-fridges same as propane, very inefficient



12 V FRIDGES / FREEZERS

- Thermoelectric: inefficient!
- With compressor:
 - Very efficient
 - Expensive (niche)



© Unique



© Dometic

Fridge/Freezer 12 V
compressor

Thermoelectric Ice Box
12 V (cool/heat)



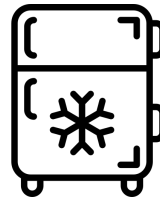
Source: Canadiantire.ca



FRIDGE AND FREEZER

DOMESTIC REFRIGERATORS (120 V)

- Cheaper to purchase
- Needs an inverter
- Less efficient than 12 V fridges
- Less expensive than 12 V fridges
- Choose an efficient model: **ENERGY STAR**



Canada

ENERGUIDE

Energy consumption / Consommation énergétique

332 kWh

per year / par année

This model / Ce Modèle

336 kWh	Type 3	373 kWh
Uses least energy / Consomme le moins d'énergie		Uses most energy / Consomme le plus d'énergie
Similar models compared	12.5 to 14.4 CU. FT. volume in ft. ³ /volume en pi ³	Modèles similaires comparé
Model number	FFHT1425V*	Numéro du modèle

Removal of this label before first retail purchase is an offense (S.C. 1992, c. 30) / cette étiquette avant le premier achat au détail constitue une infraction (L.C. 1992, ch. 30)

The **ENERGY STAR** mark on this EnerGuide label signifies that this is an energy-efficient appliance. Its energy performance meets or exceeds the Government of Canada's high efficiency levels. Use the EnerGuide rating to determine how this appliance compares to other similar models.

La marque **ENERGY STAR** sur cette étiquette EnerGuide signifie que l'appareil est éconergétique et que son rendement énergétique satisfait ou dépasse les niveaux de haute efficacité du gouvernement du Canada. Utilisez la cote EnerGuide afin de comparer le rendement de l'appareil avec celui d'autres modèles similaires.



U.S. Government Federal Law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer
• Automatic Defrost
• Top-Mounted Freezer
• Without Through-the-Door Ice Service

ELECTROLUX
Model: FFHT1425V*
Capacity: 13.9 Cubic Feet

Compare ONLY to other labels with yellow numbers.
Labels with yellow numbers are based on the same test Procedures.

Estimated Yearly Energy Cost

\$40

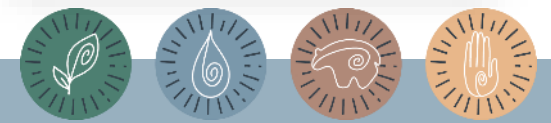
Cost Ranges

Models with similar featured	\$49	\$65
All Models	\$30	\$65

332 kWh
Estimated Yearly Electricity Use

• Your Cost will depend on your utility rates and use.
• Both cost ranges based on models of similar size capacity.
• Models with similar features have automatic defrost, top-mounted freezer, and no through-the-door ice.
• Estimated energy cost is based on a national average electricity cost of 12 cents per kWh.

Ftc.gov/energy A06191446



FRIDGE AND FREEZER... FOR NERDS

PURCHASE

- Too small fridges are inefficient
- Chose fridges without integrated freezers if not needed
- Prefer chest freezers to upright ones
- For parties: cool beverages in ice boxes



USAGE

- Turn temperature up
- Keep the door closed
- Add thermal mass
- Let food cool before putting it in
- Don't use fridge or freezer in winter? (less solar energy)



KITCHEN

Use propane or wood to cook

To avoid:

- Electric water kettle
- Electric coffee maker
- Electric toaster(oven)
- Microwave oven
- **Everything that heats, is an energy hog!**



CC-BY Vee Satayamas



CC-BY Eric Wienke



ELECTRONICS

- Television
 - Prefer **LED** TVs (more efficient)
- Laptop
 - Just plug in to charge, use battery saver mode
- Cell phone
 - Already very efficient!
- Radio(telephone), CB
- **Gaming consoles (PS5, XBOX etc.) are power hungry!**



ANATOMY OF A SOLAR PHOTOVOLTAIC SYSTEM



Photovoltaic Panels

- Transform sunrays into electricity

Batteries & Co

- Store energy
- Make electricity available for use



PHOTOVOLTAIC (PV) PANELS (INSTALLATION)



© IDDPNQL



CC-BY Niklas Rusche

- Ideally point south
- For all season use: angle 60 deg, optimized for winter:
 - Sun is close to horizon
 - Snow can slide off
- For 3 season use: Angle at ~45 deg
- Observe your terrain and identify sunny areas
- In wooded terrain: install on posts or roofs



PV PANELS (INSTALLATION)

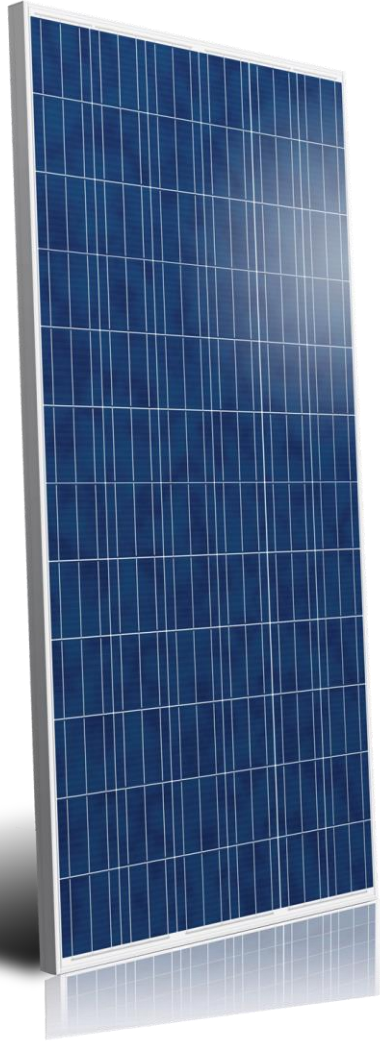
Panoramic picture, 180 degrees



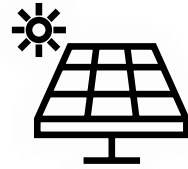
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COMMERCIAL PHOTOVOLTAIC PANELS



CC-BY-NC pngall.com



- Panel power: 300 W and more
- Mass production
- Economy of scale
- Prices have fallen a lot in the last years
- Best power-to-price ratio
- *Bifacial*: good for winter
- Buy at dedicated dealer



PORTABLE SOLAR PANELS



- Foldable glass panels (“briefcase”)
 - Bulky
 - Heavier
 - Most reliable portable option
- Flexible panels
 - Uses plastic film instead of glass
 - Can be fragile (cracks in solar cells)
 - Avoid bending
- Semi-flexible, foldable panels
 - Two smaller flexible panels
 - Easier to transport
 - Easier to avoid bending



ANATOMY OF A SOLAR PHOTOVOLTAIC SYSTEM



Photovoltaic Panels

- Transform sunrays into electricity

Batteries & Co

- Store energy
- Make electricity available for use



BATTERIES & Co (CUSTOM)

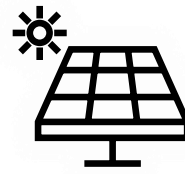
Charge controller
Adjusts voltage and current to not damage the batteries



12 V (DC)



© canbat.com



12 V (DC)



120 V (AC)



Inverter
Transforms 12 V (DC) into 120 V (AC)



120 V (AC)



Generator

Battery charger
To charge batteries with generator on cloudy days

Batteries
Energy Storage



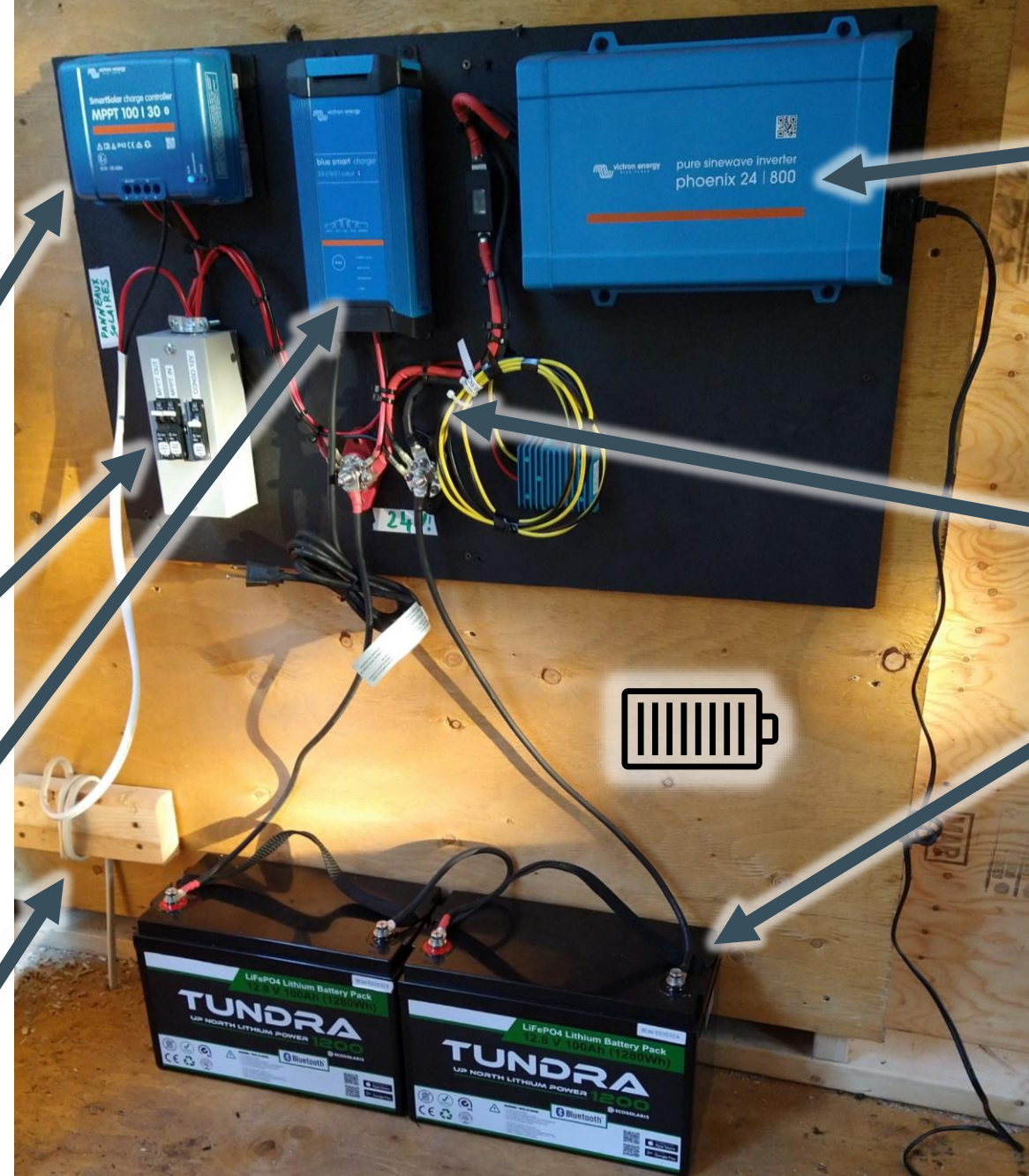
BATTERIES & Co (CUSTOM)

Charge controller
Adjusts voltage and current to not damage the batteries

Fuses/Breakers
Protection against overvoltage

Battery charger
To charge batteries with generator

Cable arriving from solar panels



Inverter
Transforms 12 V (DC) into 120 V (AC)

Cabling

Batteries
Energy Storage

© IDDPNQL



CHARGE CONTROLLER

- PWM: less expensive, less versatile
- MPPT: more expensive, more versatile, more efficient



© Victron Energy

MPPT



© EPSOALR



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PWM



BATTERY CHARGER

- Intelligent 3-level charger
- Suitable for battery type (lead-acid, Lithium)
- More amperage is better
 - Fills up battery quickly
 - Increases efficiency of generator
 - Reduces generator run time



CABLES, BREAKERS, GROUNDING

- Protecting user and equipment
- Out of scope!



LEAD ACID BATTERIES

FLOODED (DEEP CYCLE)

- Heavy
- Least expensive
- Maintenance necessary
- **Can break quickly if not used correctly**



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AGM

- Heavy
- More expensive
- No maintenance necessary
- **Can break quickly if not used correctly**



En.wikipedia.org



LITHIUM BATTERIES

- Generally used in...
 - Cellphones
 - Laptops
 - Cordless power tools
 - Electric bikes
 - Electric vehicles
- Much lighter than lead-acid
- Expensive (in demand)
- Various protections integrated (BMS)
- **Do not work below freezing!**



Best for solar: **LiFePO4** or **LFP**
(*Lithium ferro phosphate*)

- Heavier
- Longer life span
- Safer

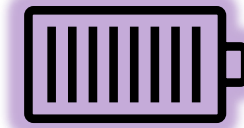


BATTERY CAPACITY

Battery capacity is the amount **energy** the battery can store.

To calculate capacity:

$$\text{Voltage} \times \text{Amp-hours} = \text{Capacity [Wh]}$$



$$12 \text{ V} \times 26 \text{ Ah} = 312 \text{ Wh}$$

The real life capacity is always smaller!



CC-BY-SA Uwe Herrmann



CC-BY-RVWithTito.com



INVERTER

- Converts 12 V (DC) into 120 V (AC) to use domestic appliances
- Look out for *True Sine Wave* or *True Sine*
- Efficiency between 80 et 90 %
- Consider standby consumption
- Fans can get noisy

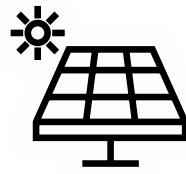


BATTERIES & Co (CUSTOM)

Charge controller
Adjusts voltage and current to not damage the batteries



12 V (DC)



12 V (DC)



Inverter
Transforms 12 V (DC) into 120 V (AC)

120 V (AC)



120 V (AC)



Generator

Battery charger
To charge batteries with generator on cloudy days



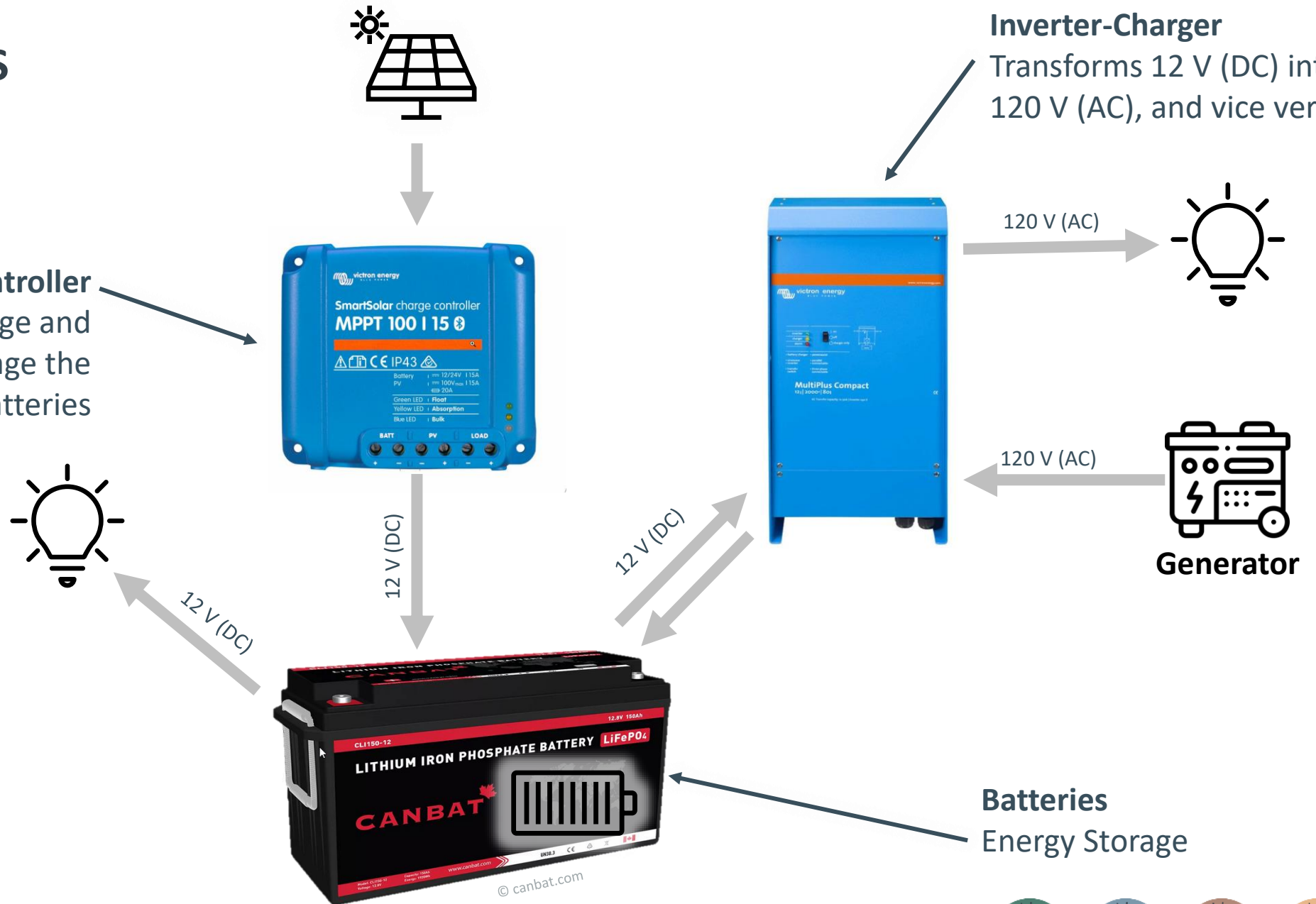
Batteries
Energy Storage



BATTERIES & Co (Inverter-Charger)

Charge controller
Adjusts voltage and current to not damage the batteries

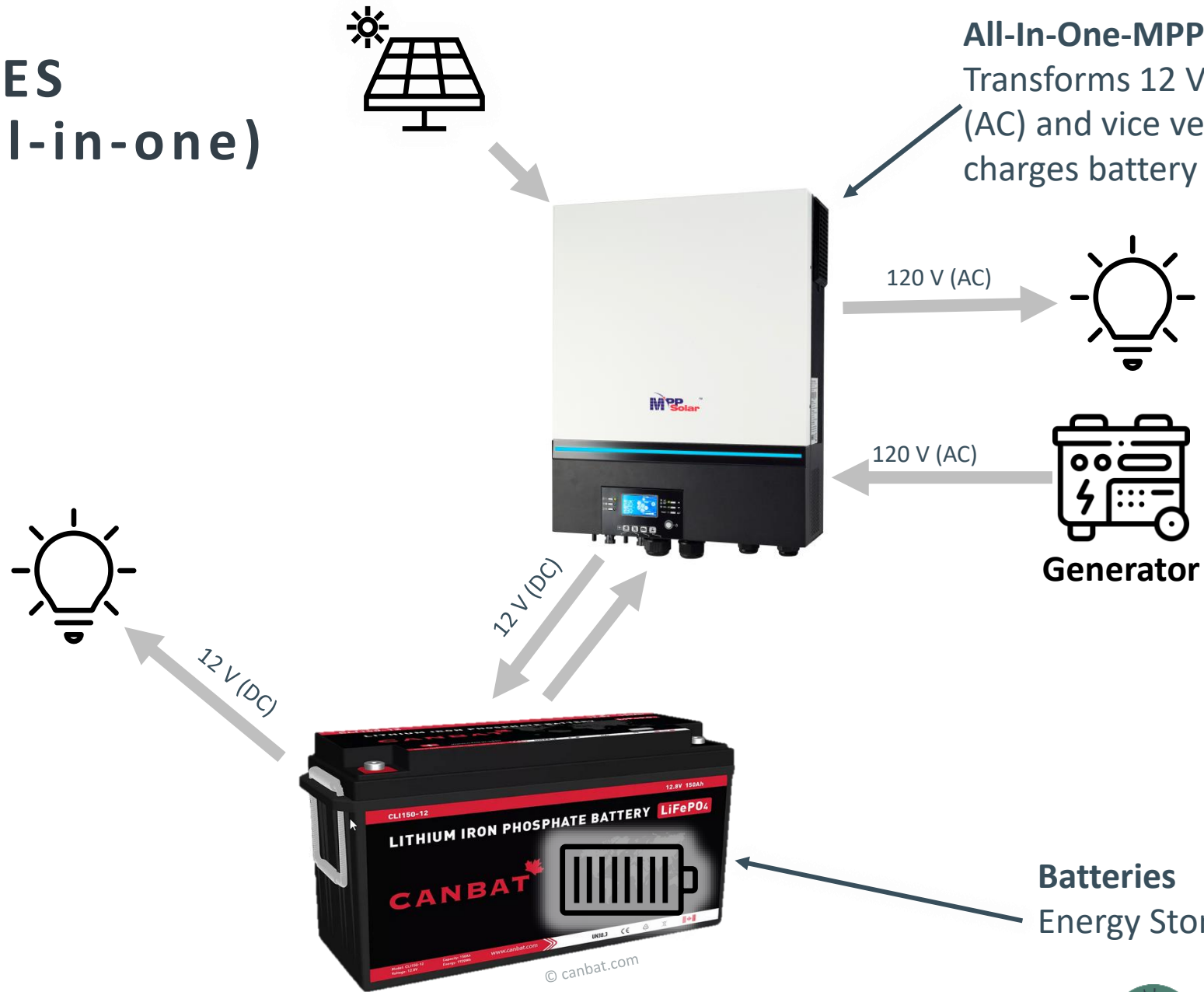
Inverter-Charger
Transforms 12 V (DC) into 120 V (AC), and vice versa



Batteries
Energy Storage



BATTERIES & Co (All-in-one)



All-In-One-MPPT-Charge-Inverter
Transforms 12 V (DC) into 120 V (AC) and vice versa, charges battery from solar

Generator

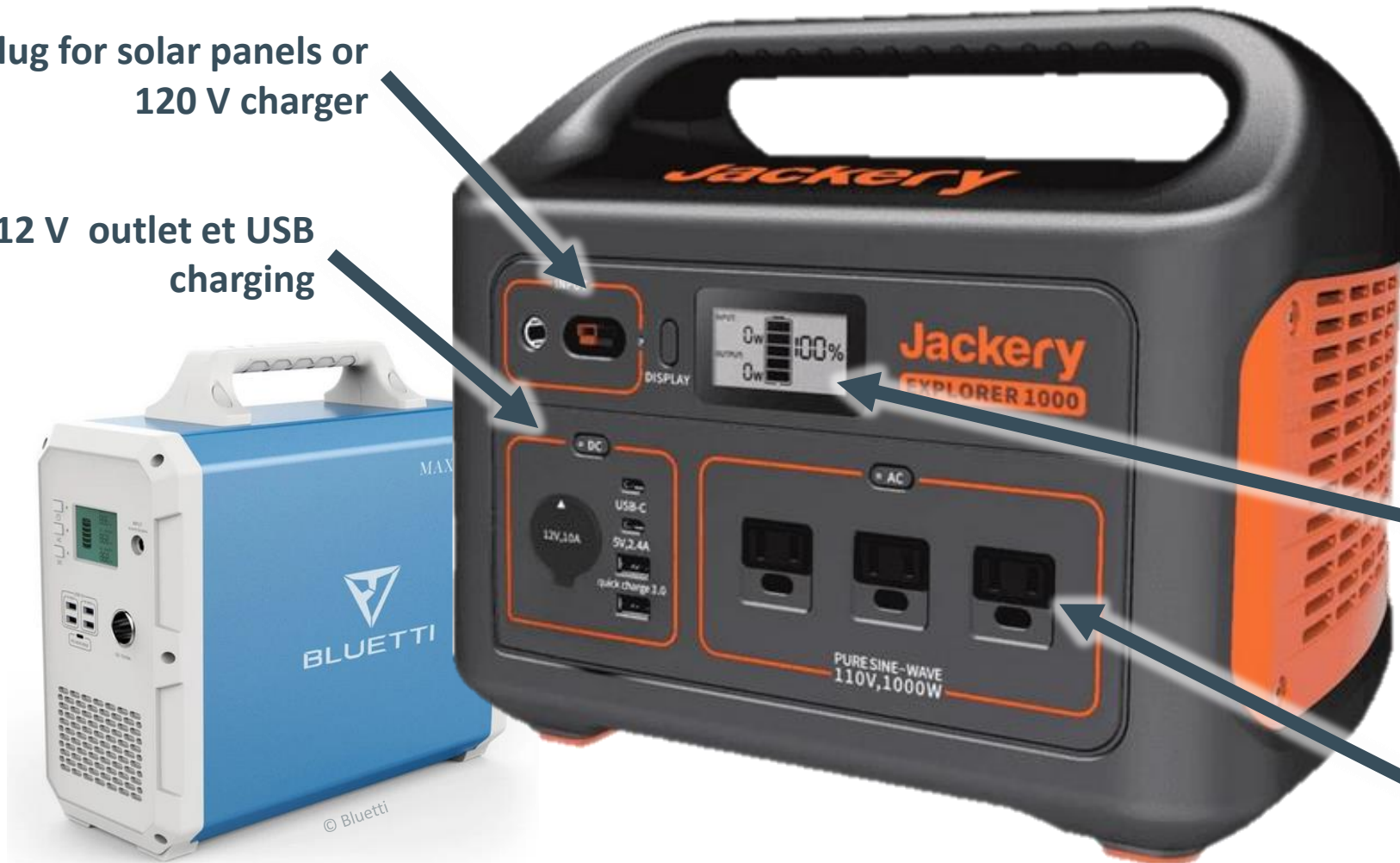
**Batteries
Energy Storage**



SOLAR POWER STATION

Plug for solar panels or
120 V charger

12 V outlet et USB
charging



- Often called “solar generator”
- Price around 1 \$ per Wh

Screen
Display state of
batteries, solar charge
and battery usage

120 V outlets



SOLAR GENERATOR

**Connector on solar panel
(MC4)**
Standard for most panels



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Panel needs to fit solar generator
Panels Voc-Voltage needs to be smaller!



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Connector for solar generator

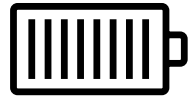
- Variable
- AC adapter plugs in the same way 120 V



BATTERIES & CO

CUSTOM SYSTEM

- Modular
- Components can be replaced
- Better for large installations
- Longer life span
- Can be more expensive (installation!)



SOLAR GENERATOR

- Everything is integrated
- Compact
- Easy to transport (and easy to steal!)
- Easy to plug in
- Fool-proof (integrated protection)
- Difficult to impossible to repair



SIZING

WHAT DO I NEED?

- It depends:
 - 3 or 4 seasons usage
 - Time of use
 - Comfort
 - Future needs
 - Wiggle room
 - Discipline
- Don't lie to yourself!
- If in doubt, buy bigger especially with lead batteries
- Use our Excel-calculator



MEASURING POWER AND ENERGY

- Look up power rating on name plate (not precise!)
- Use an *electricity usage monitor* to measure a device for a day (kWh) (or power draw W)



WHERE TO BUY

For custom systems, batteries, commercial panels:

- Directory of suppliers in Québec
<https://esq.quebec/repertoire/>

For solar power stations, small panels:

- Online (well known online shopping platforms, bluetti.ca)

Don't hesitate to ask us if you're not sure, we're here to help!

nrusche@iddpnql.ca





Thanks for your
attention!

QUESTIONS?



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