



The 2000-Watt Society & Passive House

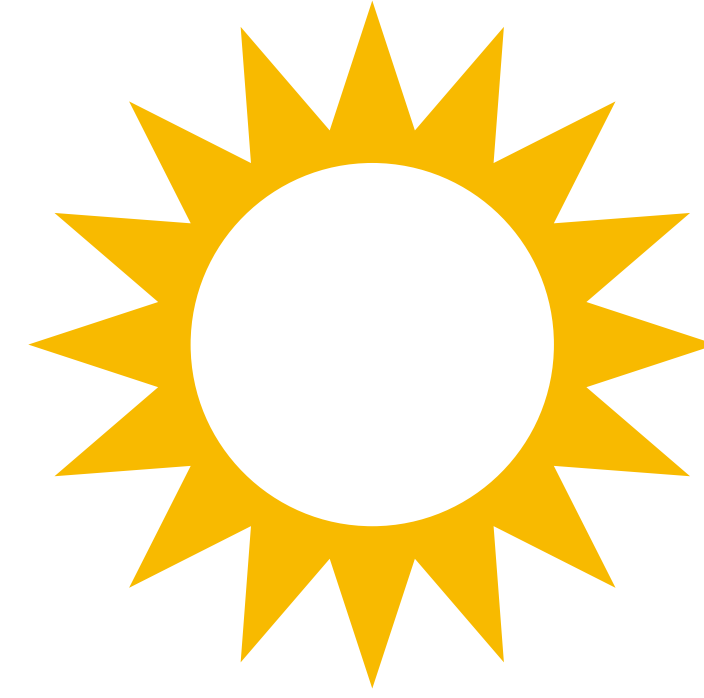
Duluth Energy Design Conference & Expo 2022



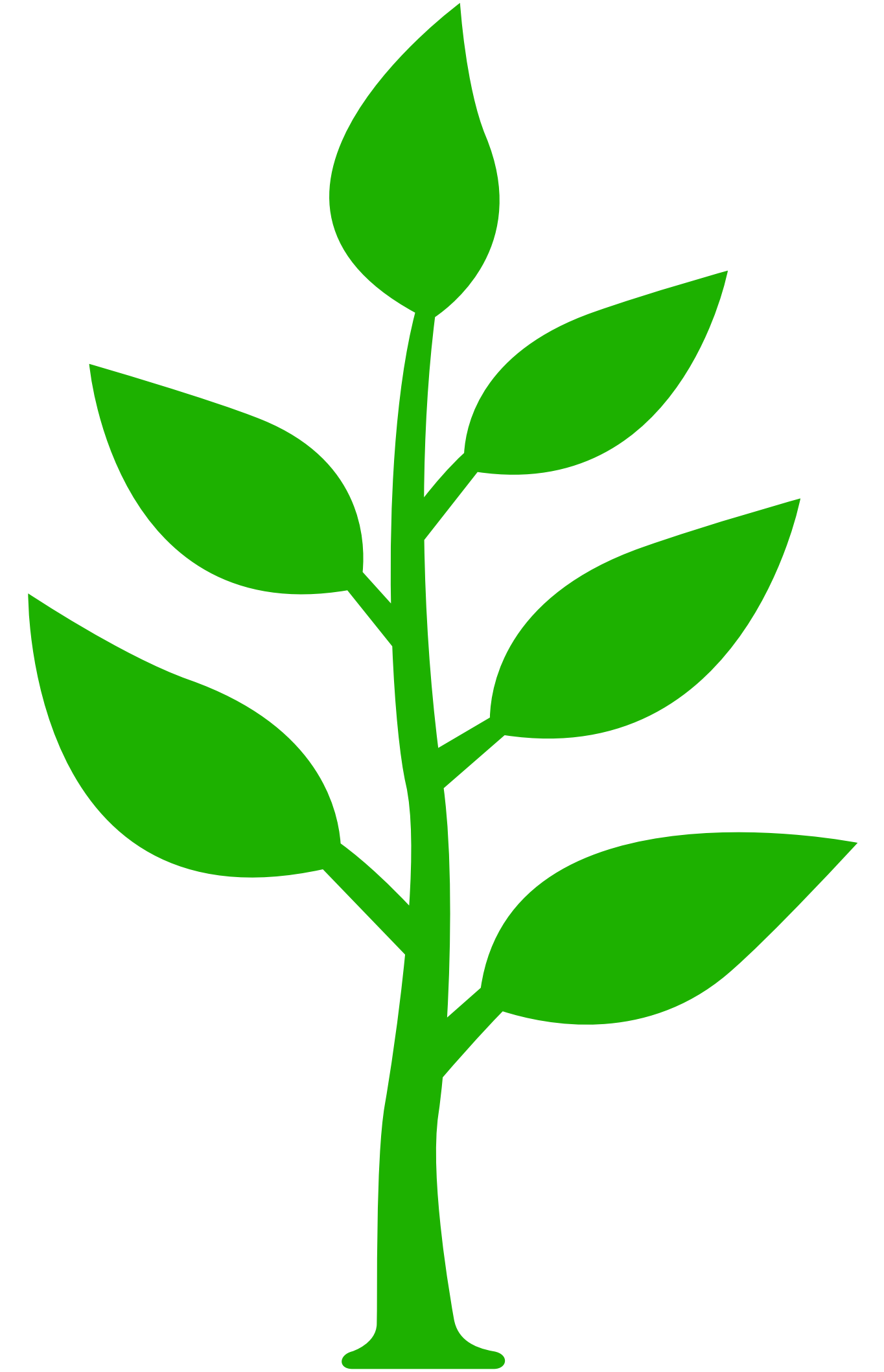


Tim Delhey Eian

Principal TE Studio, Dipl.-Ing., Certified Passive House Designer



Energy is Life



Problem: Climate Change

NEWS

Sea Level to Rise up to a Foot by 2050

NASA, NOAA, USGS, and other U.S. government agencies project that the rise in ocean height in the next 30 years could equal the total rise seen over the past 100 years. (Image Credit: B137 (CC-BY))

FULL STORY



Source: <https://climate.nasa.gov>

CARBON DIOXIDE

↑ 418 parts per million (current)

GLOBAL TEMPERATURE

↑ 1.01 °C since 1880

ARCTIC SEA ICE EXTENT

↓ 13.0 percent per decade since 1979

ICE SHEETS

↓ 427 billion metric tons per year since 2002

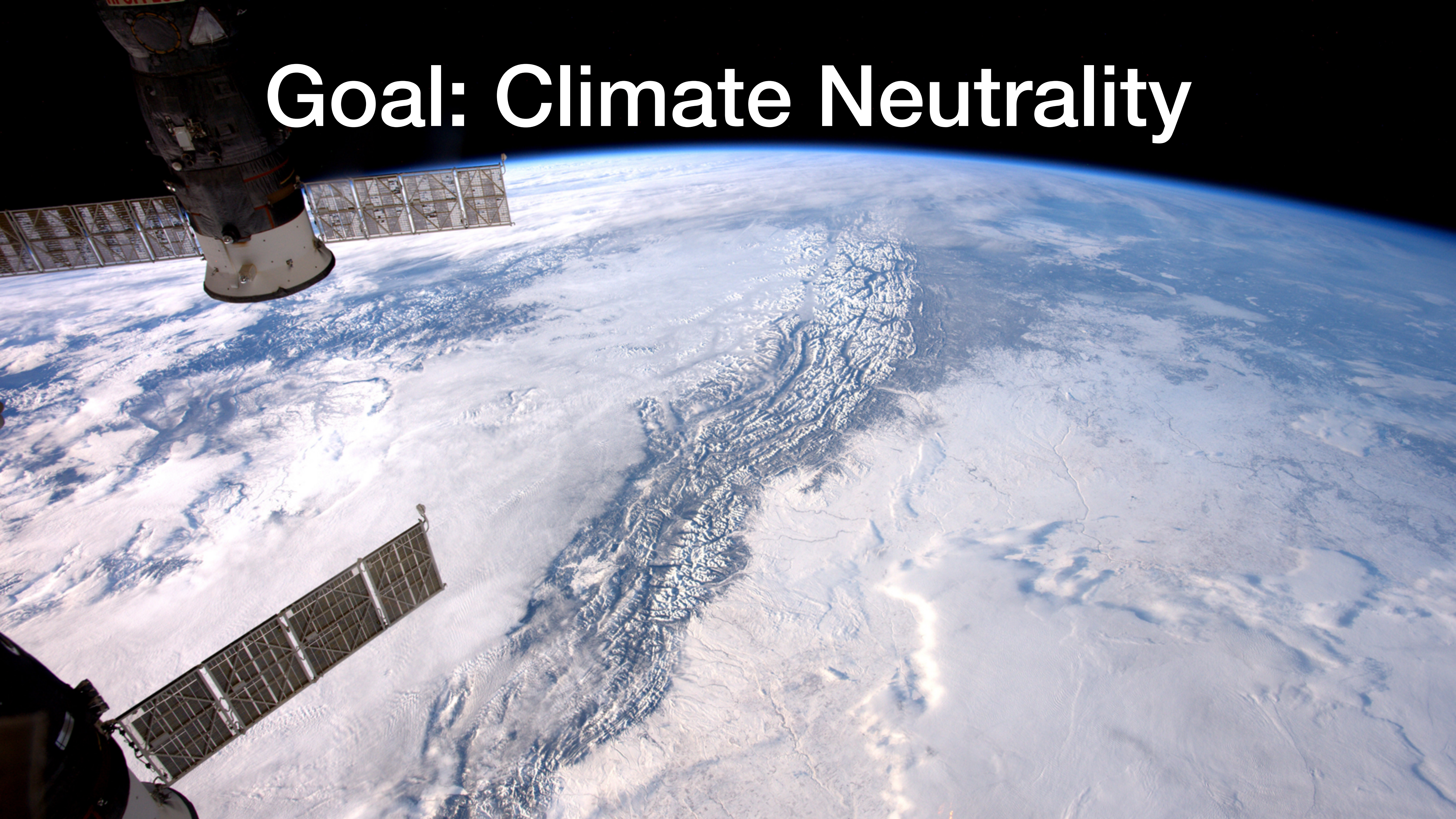
SEA LEVEL

↑ 3.4 millimeters per year since 1993

OCEAN HEAT ADDED

↑ 337 zettajoules since 1955

Goal: Climate Neutrality



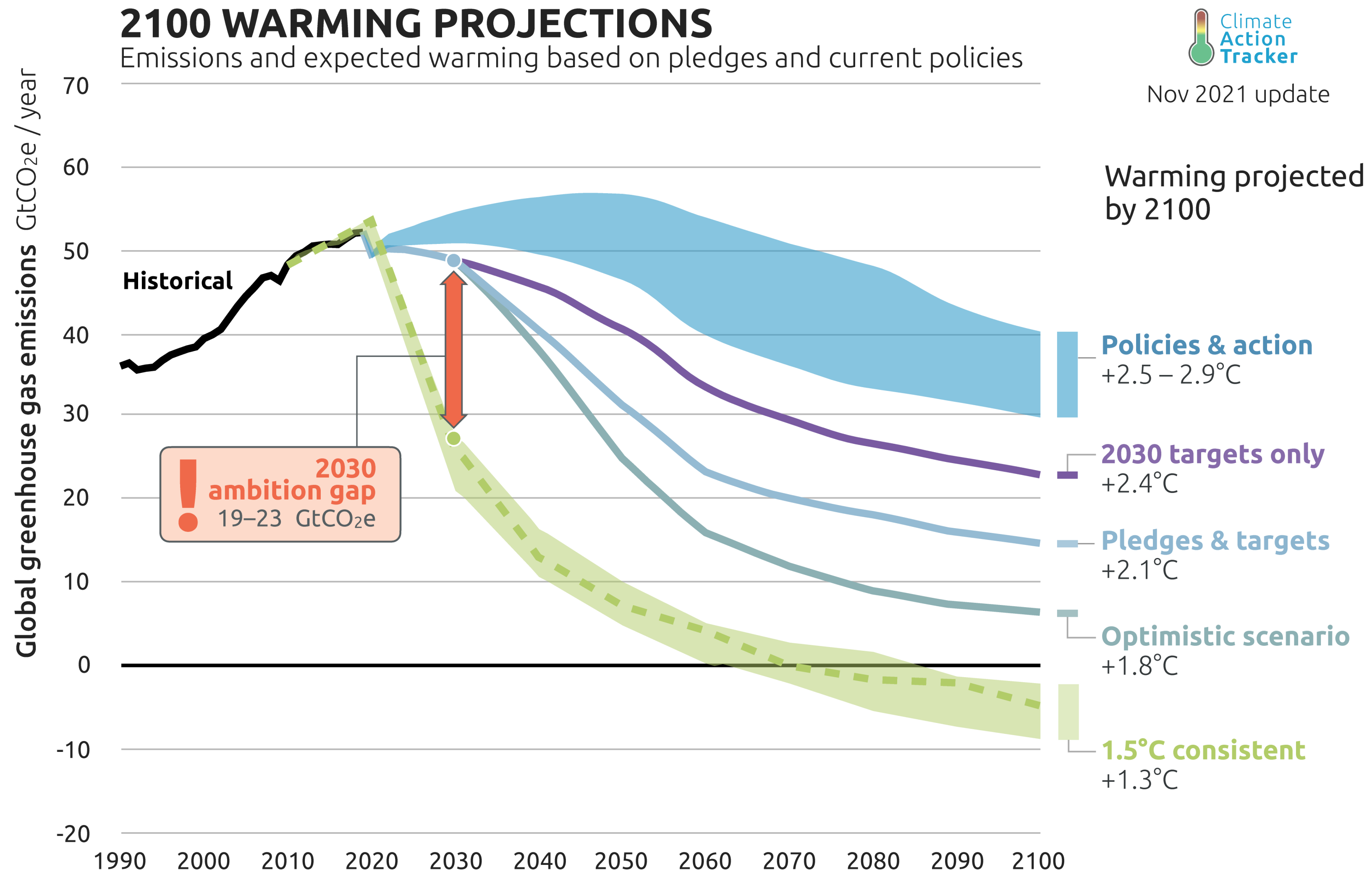
IPCC: Red Alert!



[Credit: NASA]

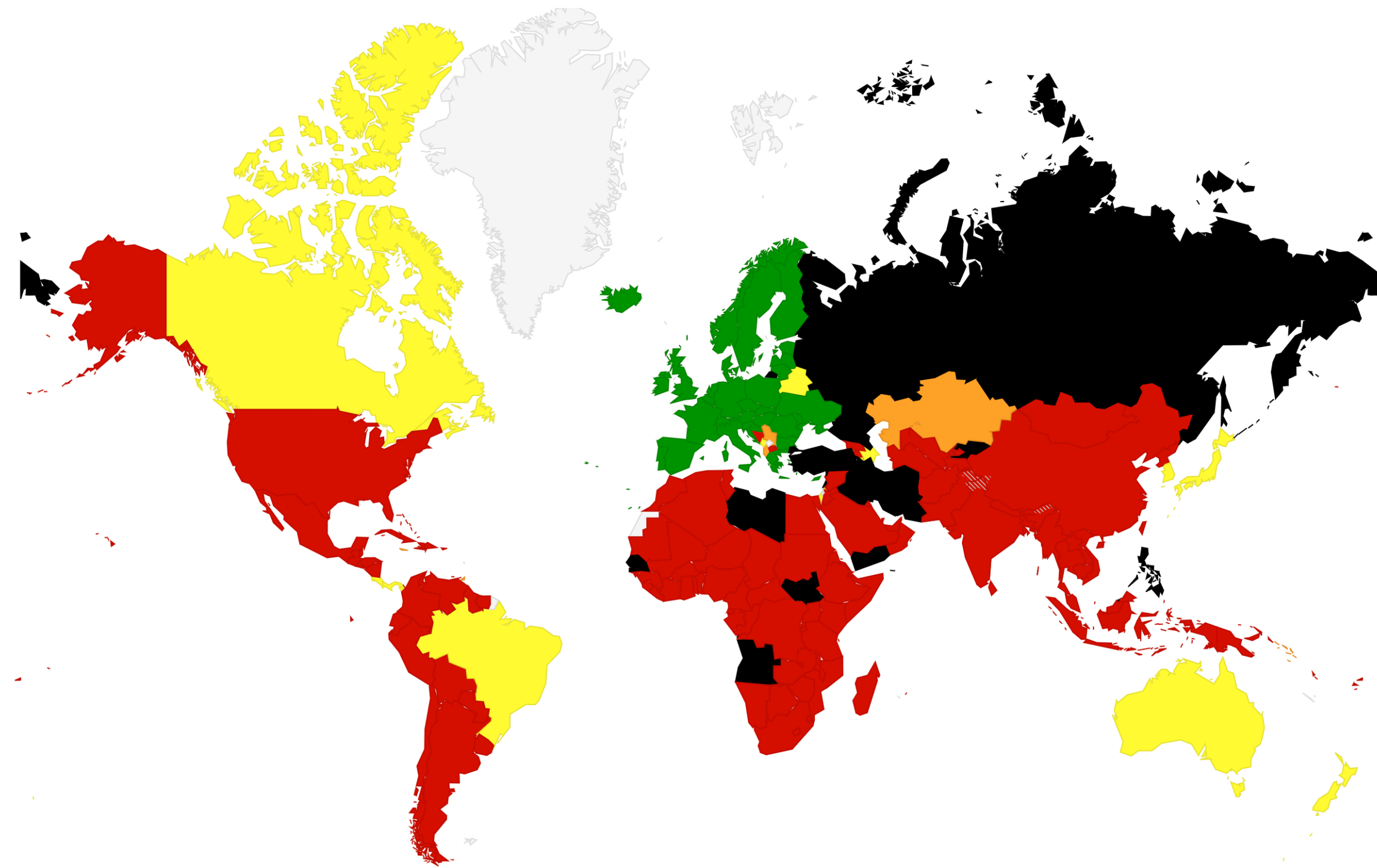
“Recent changes in the climate are widespread, rapid, and intensifying, and unprecedented in thousands of years.”

Climate Change Scenarios



Source: <https://climateactiontracker.org>

Pledges Mostly Insufficient



■ Sufficient

Climate pledges **above or equal to 40%** emission reductions

■ Partially Sufficient

Climate pledges **between 20-40%** emission reductions

■ Partially Insufficient

Climate pledges below **20%** emission reductions and/or **up to 50% conditional**

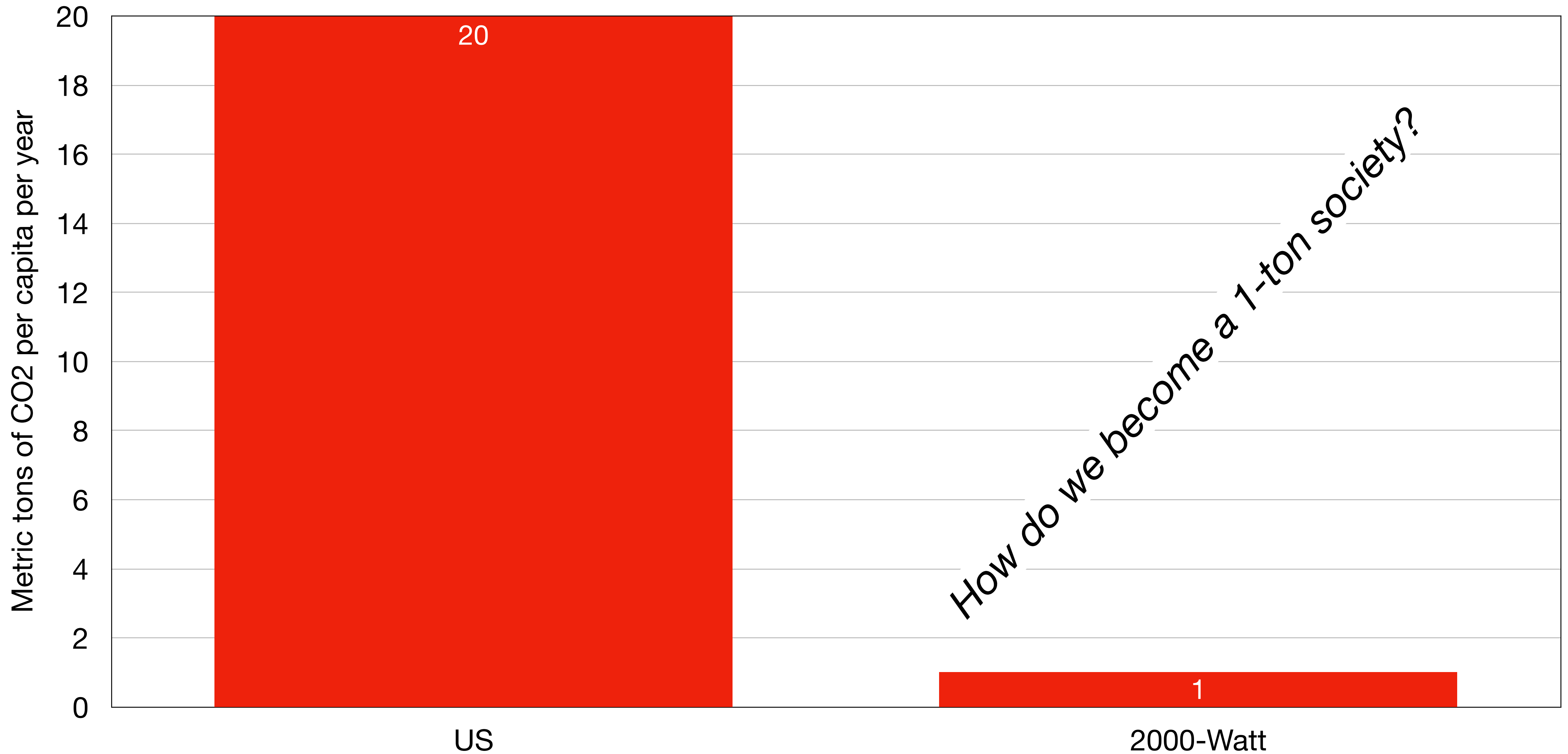
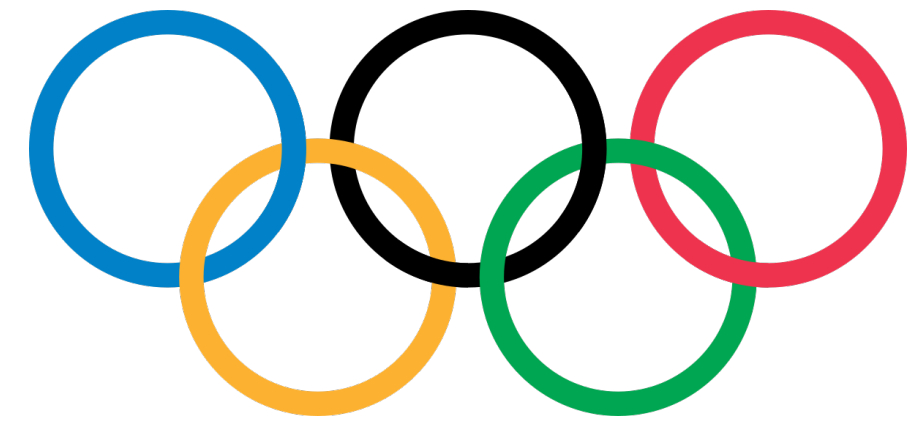
■ Insufficient

Climate pledges with **no emission reduction target**, more than **50% conditional**, with **intensity** target and/or with **Business as Usual (BAU)** target

■ No pledges

Source: <https://feu-us.org>

US Climate “Olympics”



2000-WATT SOCIETY

Vision: 2000-Watt Society

A PROVEN PROCESS FOR
COURAGEOUS CLIMATE

Make your city the 2000-Watt Society in the world.

2000
watt
SOCIETY

ACT UP! CLIMATE CHANGE NOW

One target. Our community. Stepping up now.

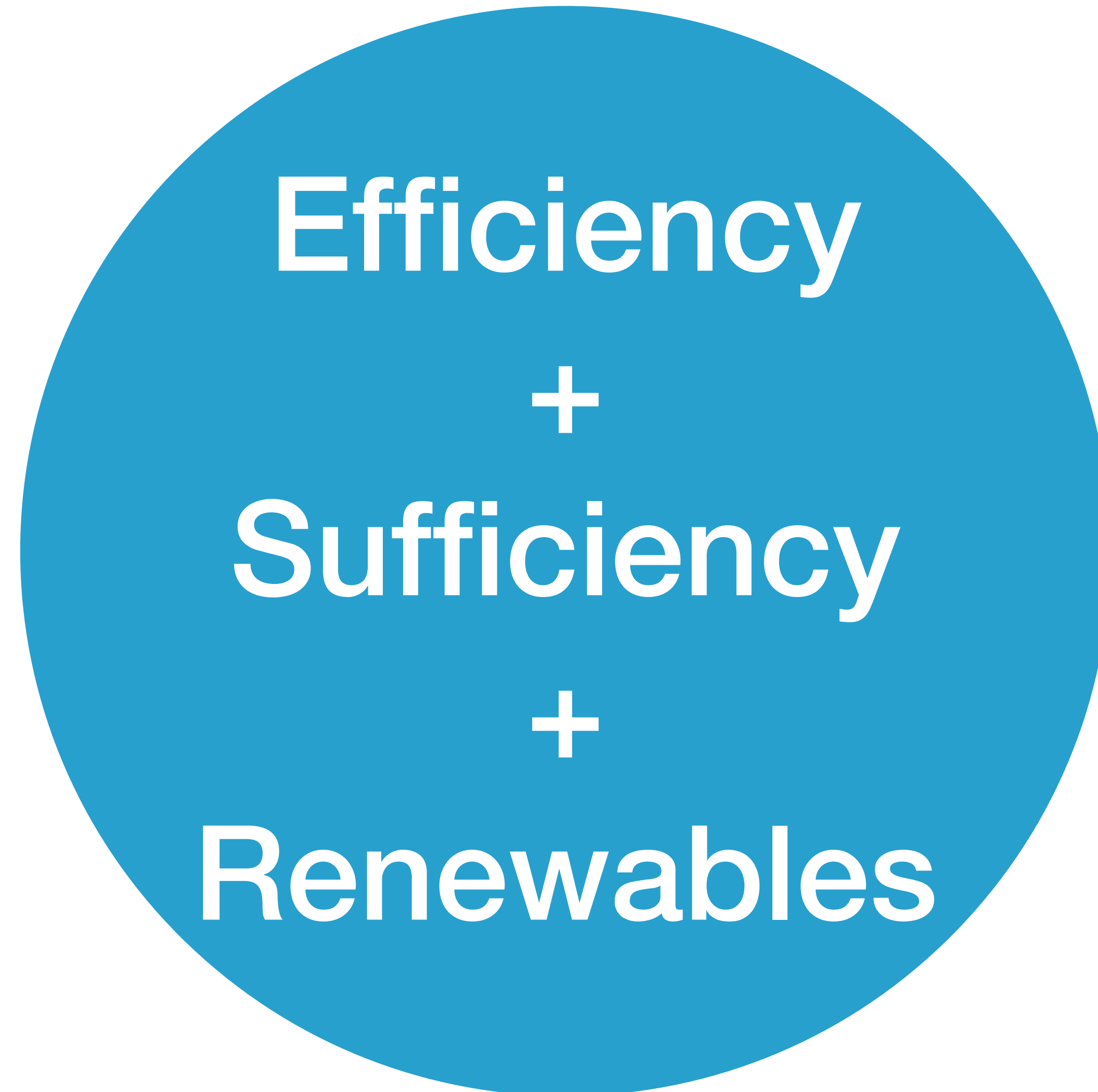


One Target for All

2,000 Watts

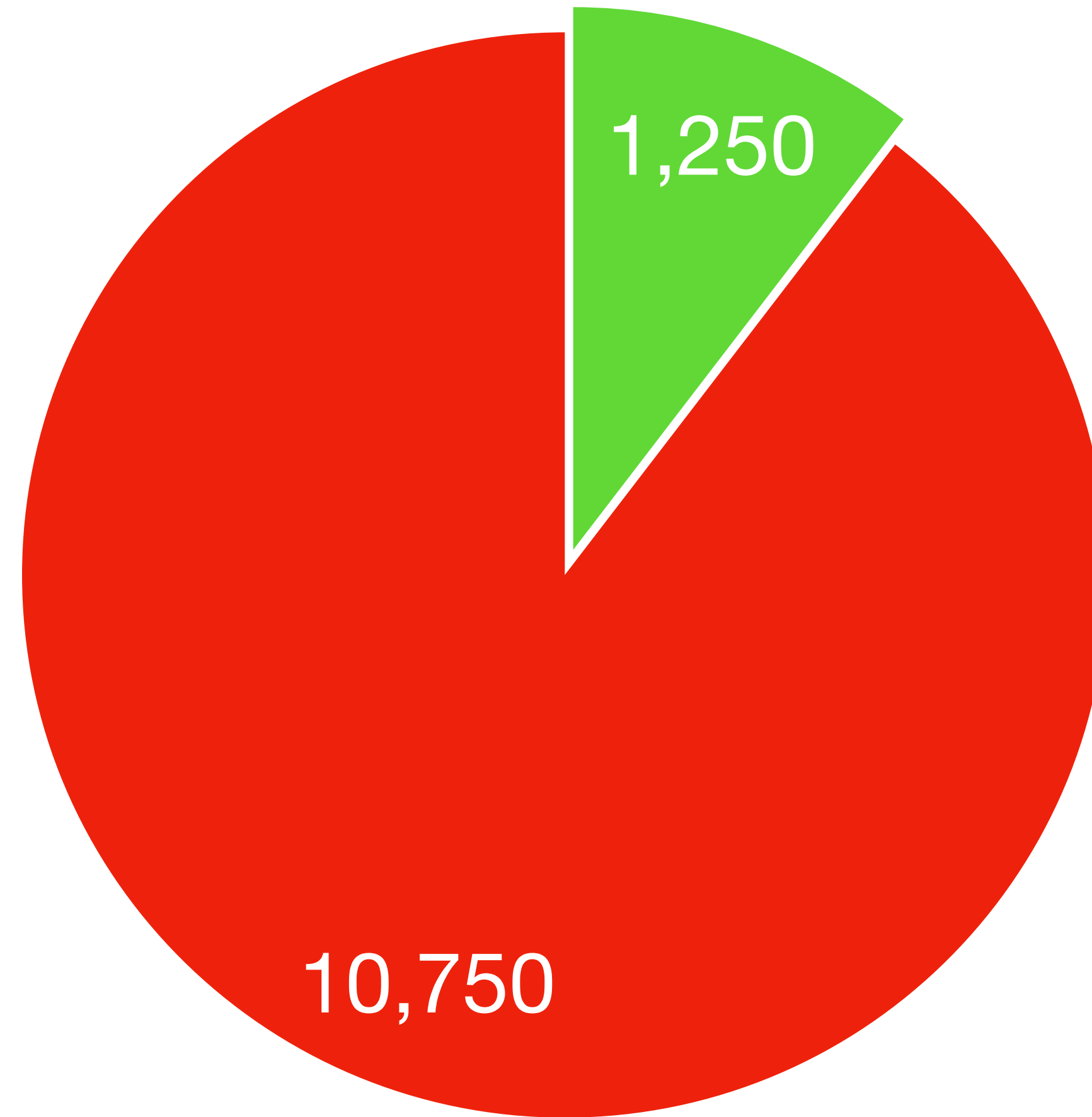
continuous source energy per person

One Strategy for All



The US Challenge

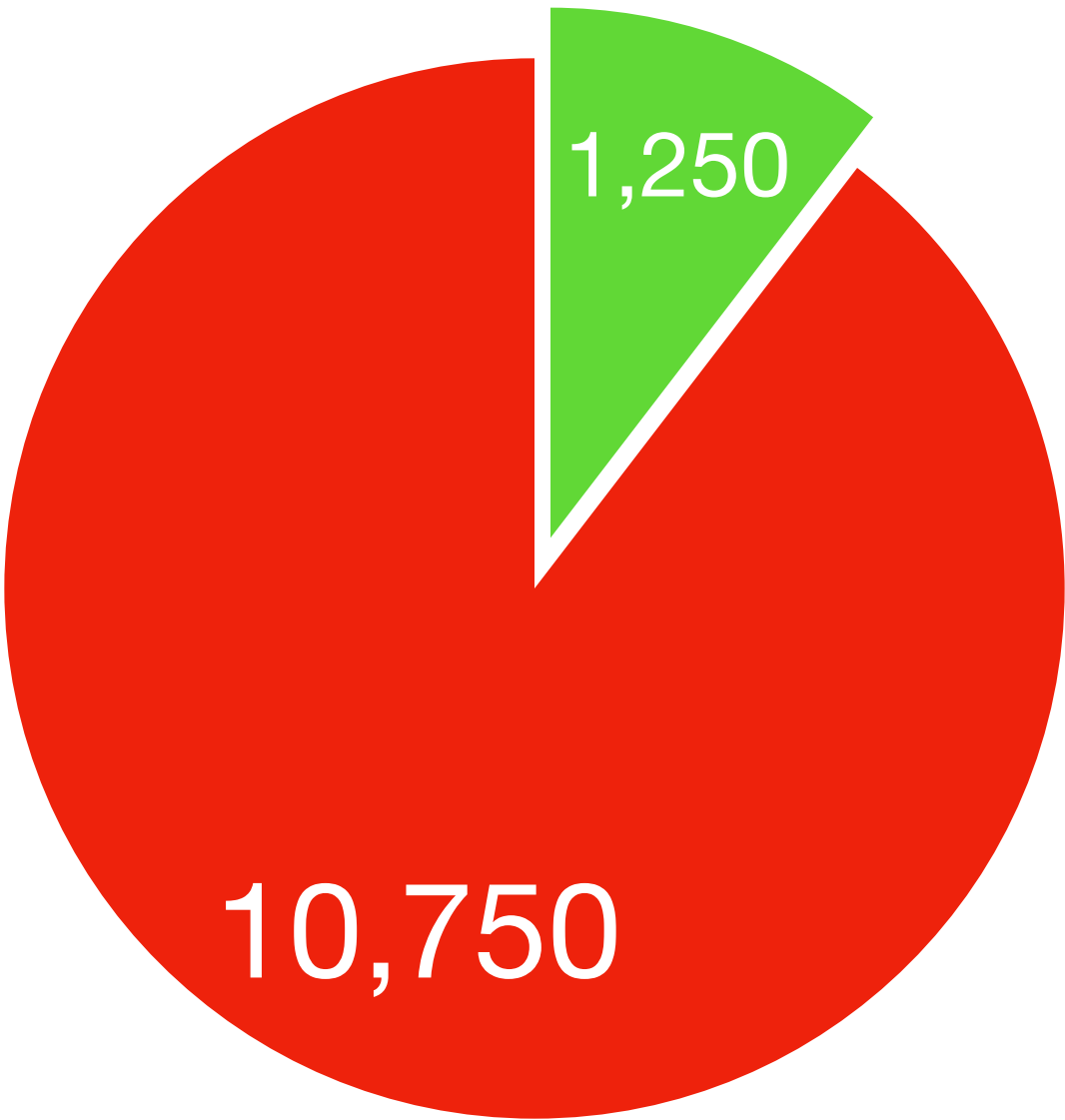
12,000 Watts per Person



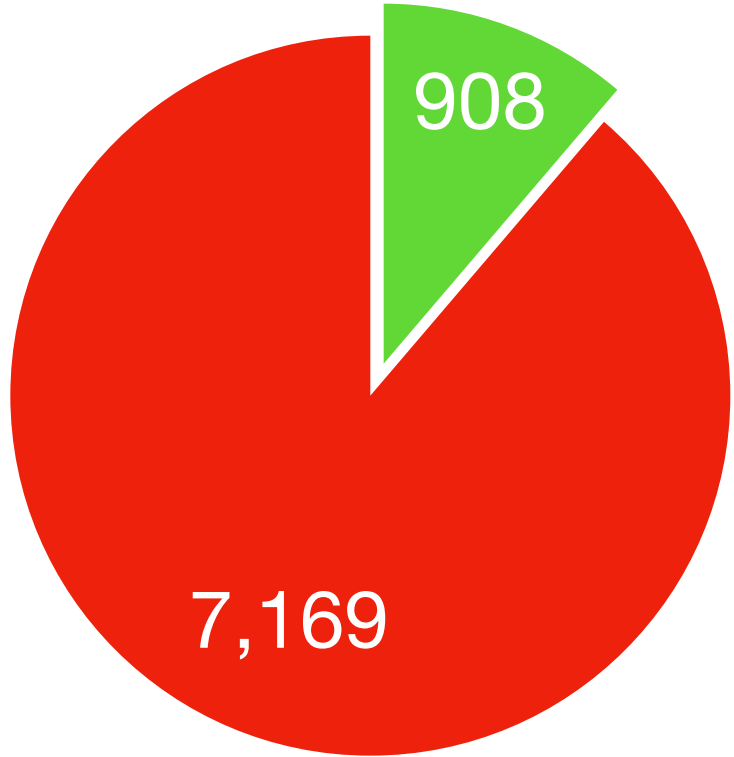
● Clean Energy ● Non Renewable

Realities - Opportunities

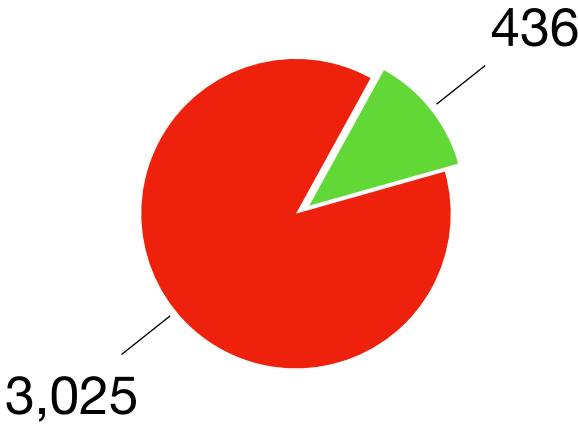
US: 12,000 Watts



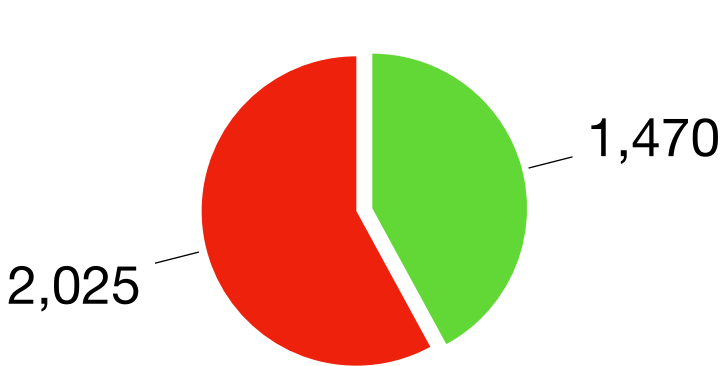
Minneapolis:
8,100 Watts



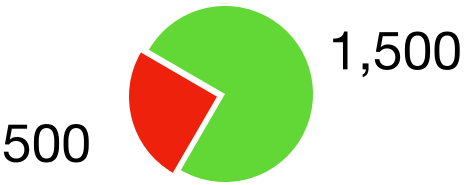
Munich:
3,461
Watts



Zurich:
3,495
Watts



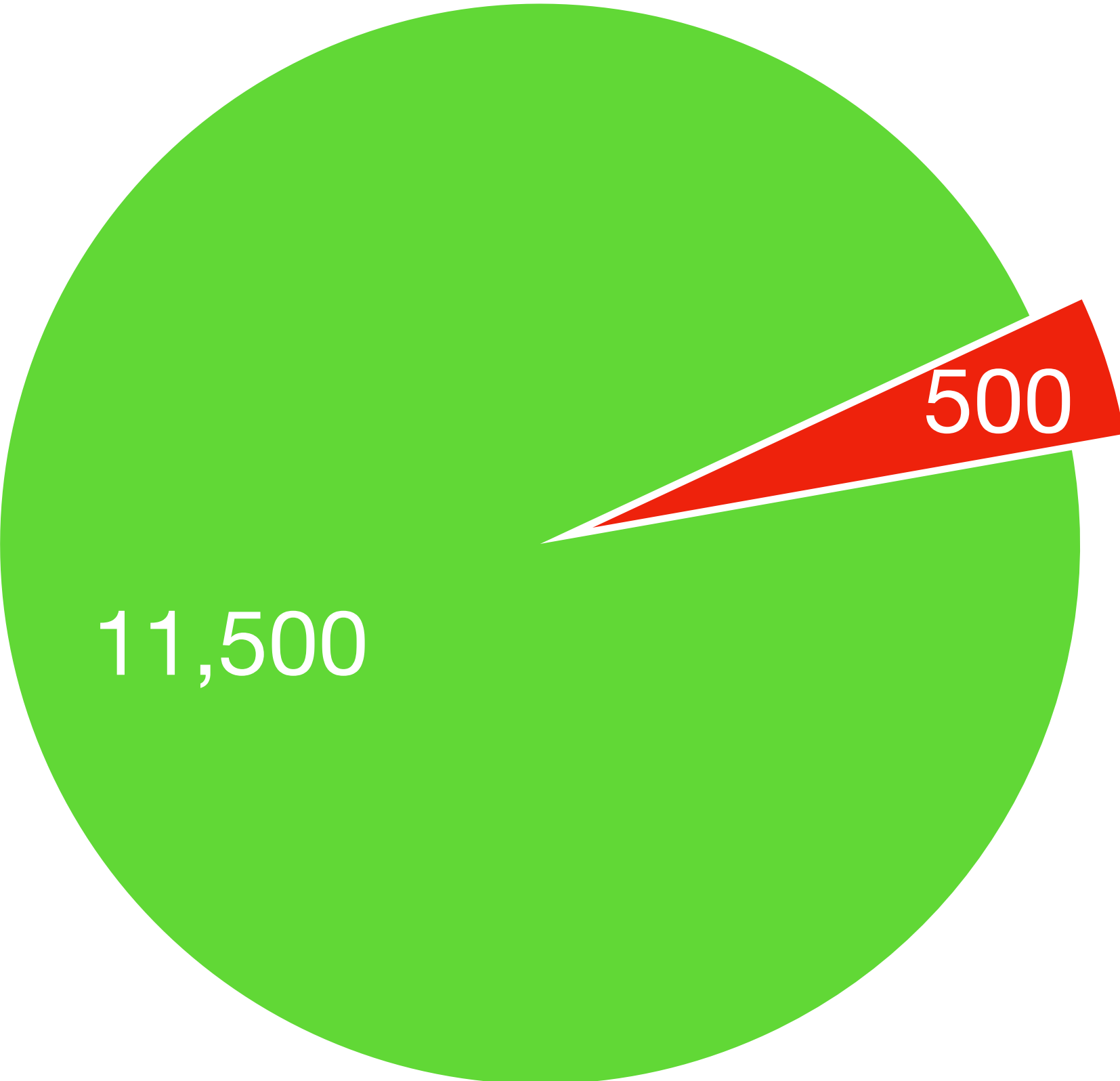
2000
Watt



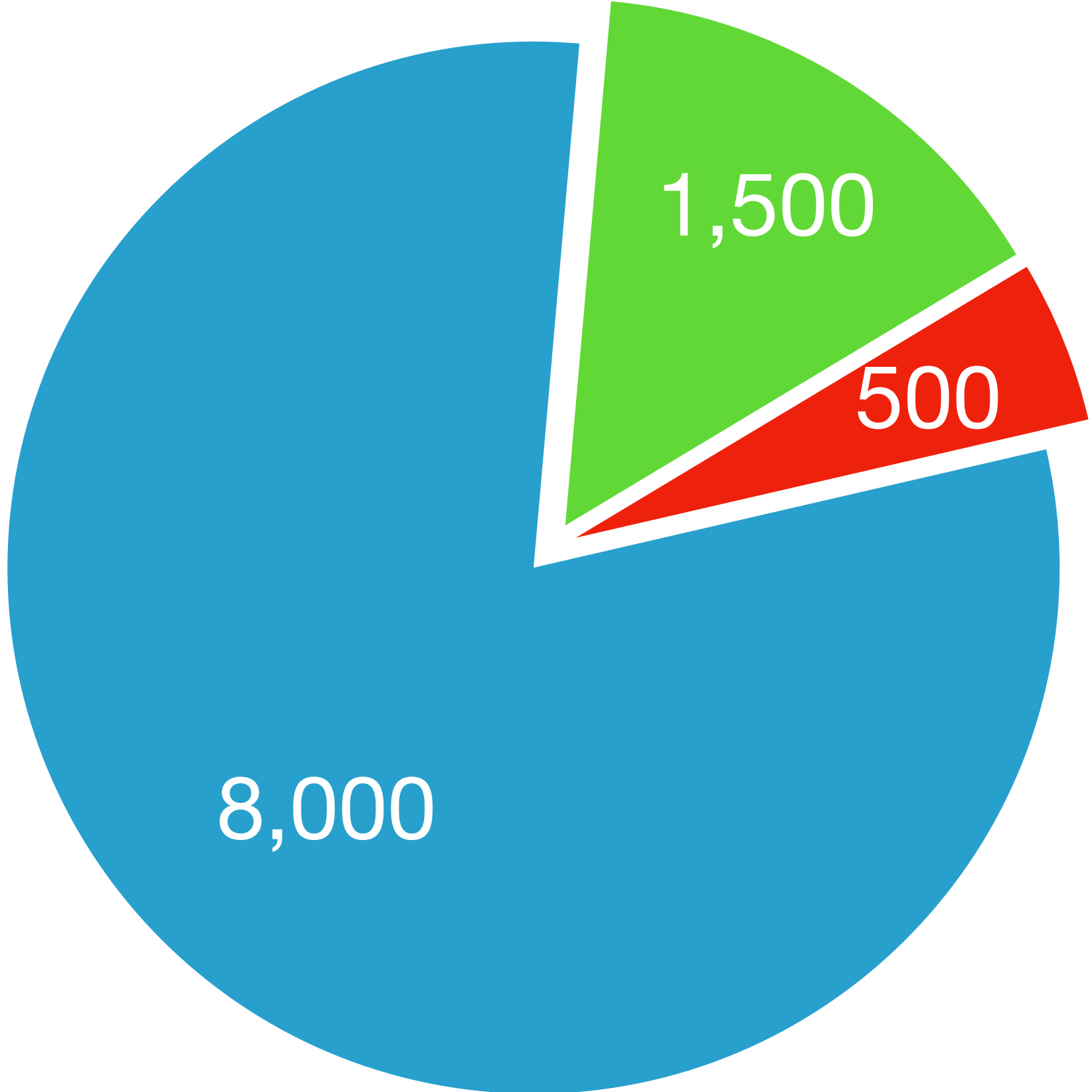
● Clean Energy ● Non Renewable

Which Path Do We Invest In?

Substitution



Efficiency + Sufficiency



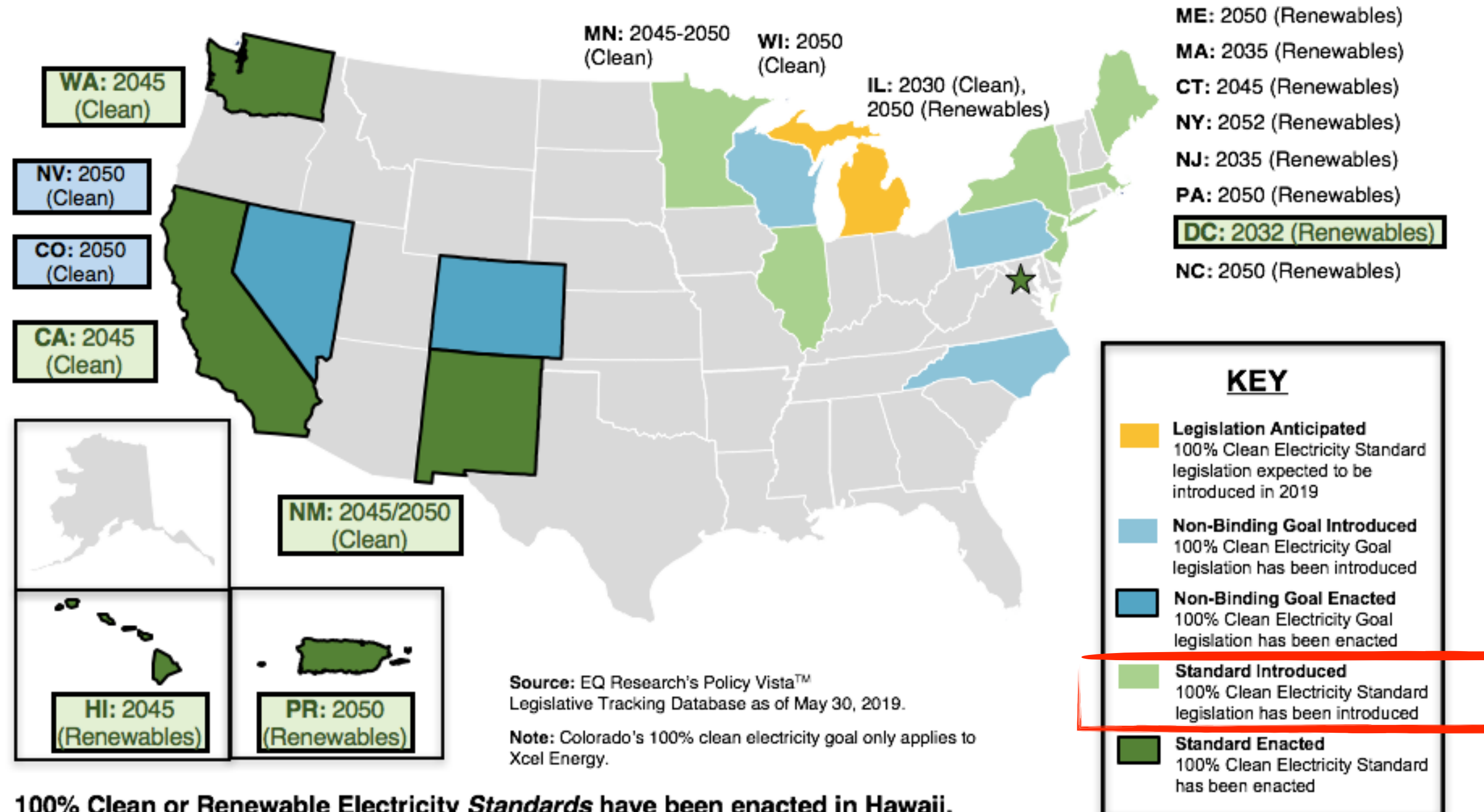
- Clean Energy
- Non Renewable
- Efficiency + Sufficiency

Learning from Minneapolis

Substitution (“Electrify Everything”)

Aspirations

100% Clean or Renewable Electricity Targets *Anticipated, Proposed or Enacted 100% Standards and Goals*

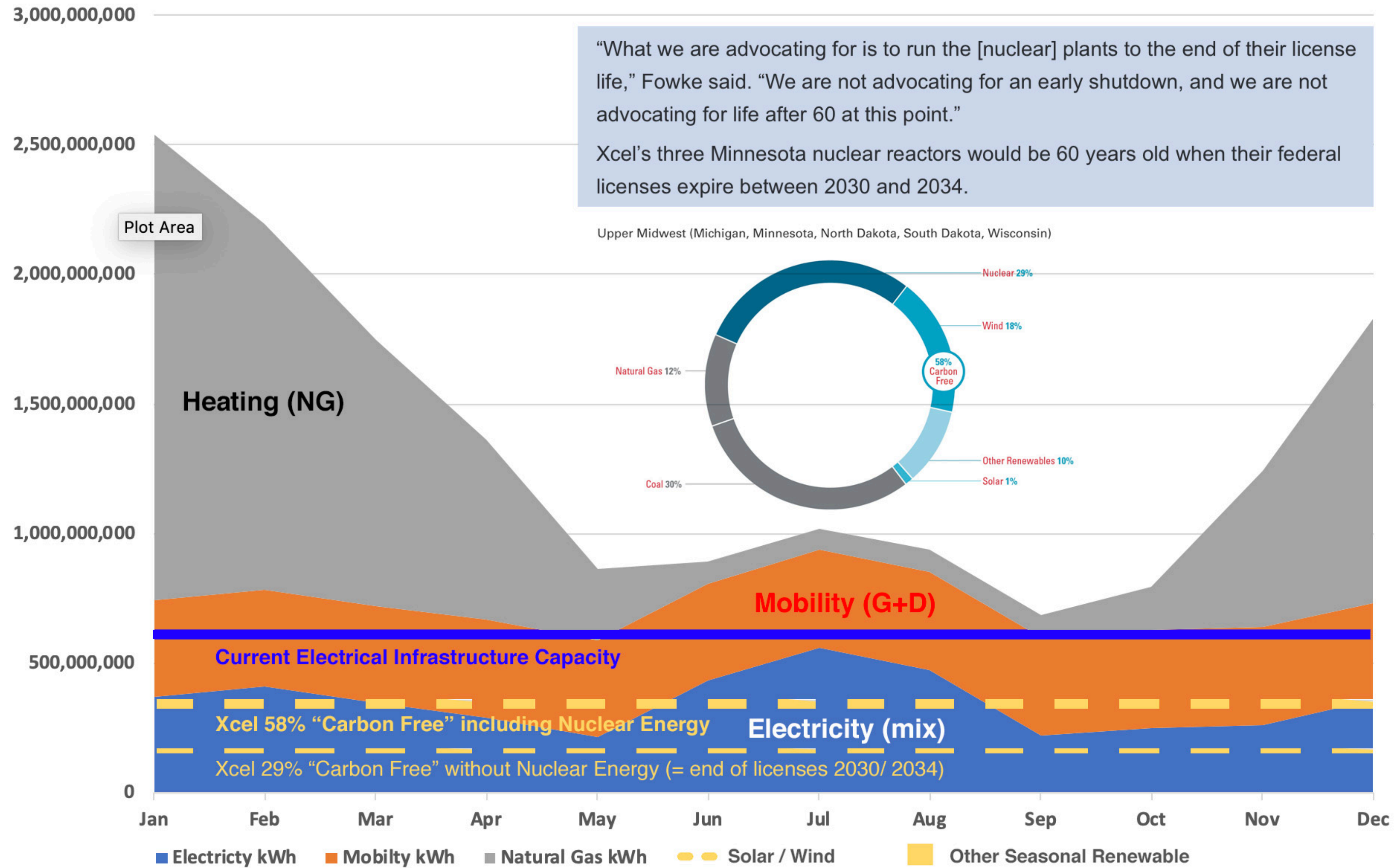


100% Clean or Renewable Electricity *Standards* have been enacted in Hawaii, California, New Mexico, Washington, Puerto Rico, and the District of Columbia.

100% Clean or Renewable Electricity *Goals* have been enacted in Nevada and Colorado.



Current Energy Use



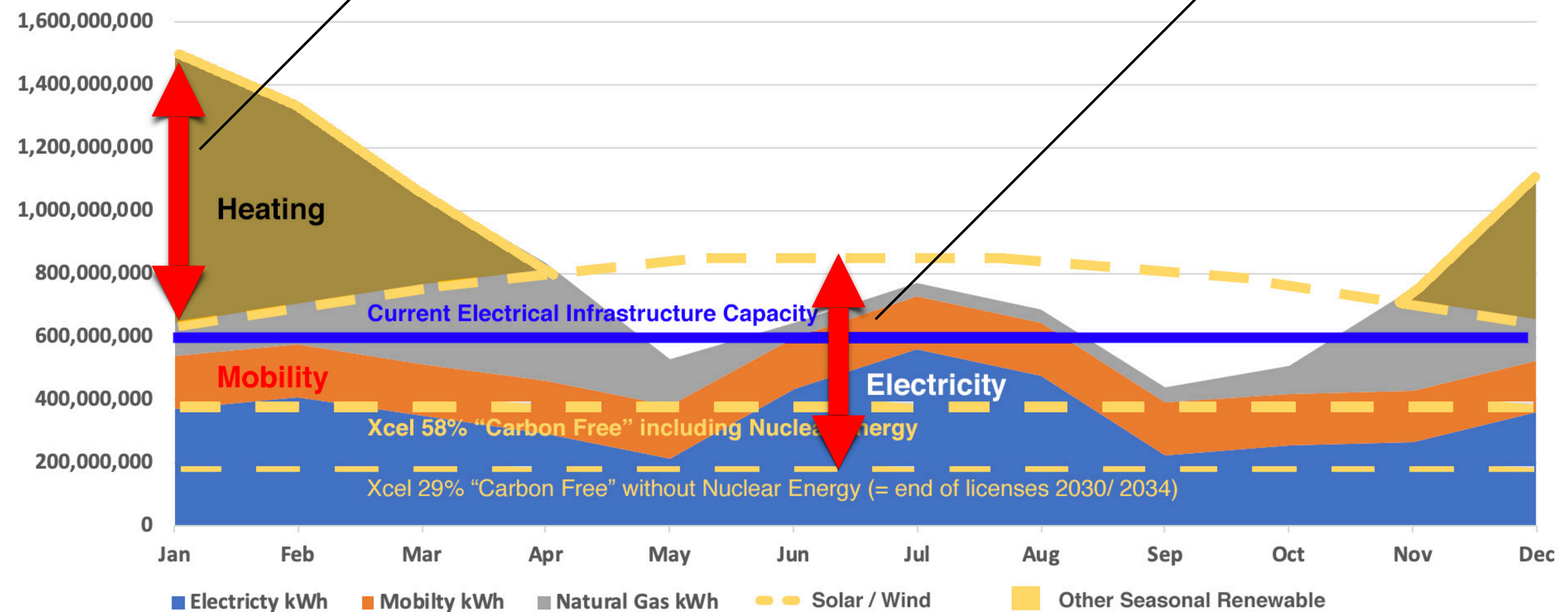
Clean Energy Plan

Substitution: “Electrify Everything”

“What we are advocating for is to run the [nuclear] plants to the end of their license life,” Fowke said. “We are not advocating for an early shutdown, and we are not advocating for life after 60 at this point.”
Xcel’s three Minnesota nuclear reactors would be 60 years old when their federal licenses expire between 2030 and 2034.

ISSUE: Peak heating = massive peak load
Solar and wind cannot meet the demand

COST: We are building a huge clean energy infrastructure

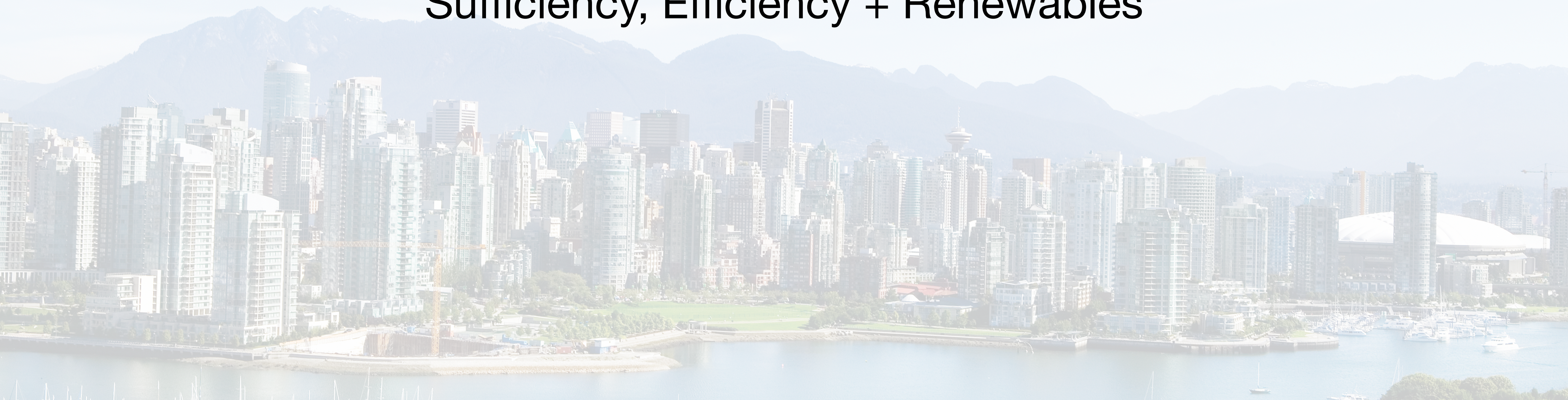


Hey, we have a massive
hill and valley problem!



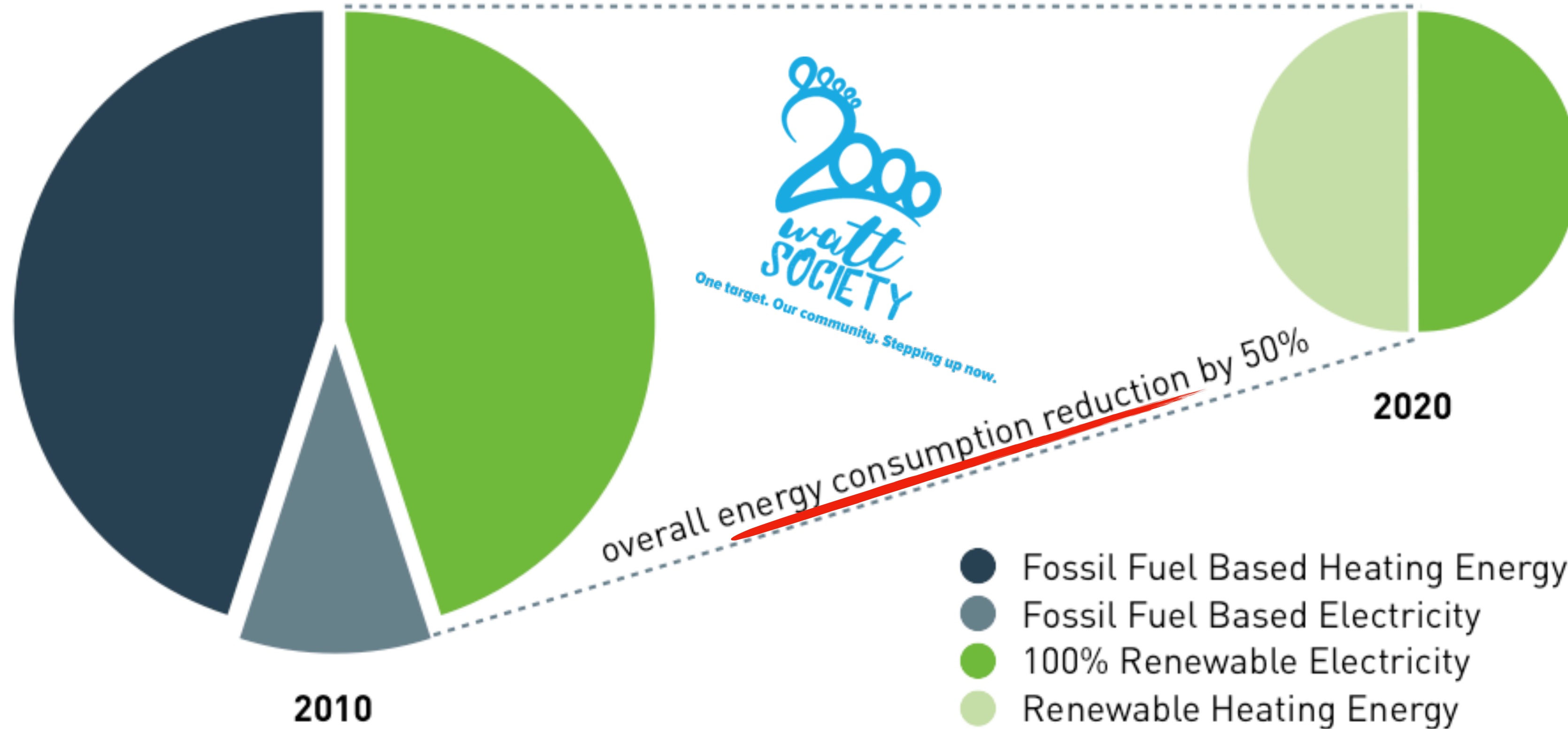
Learning from Vancouver

Sufficiency, Efficiency + Renewables

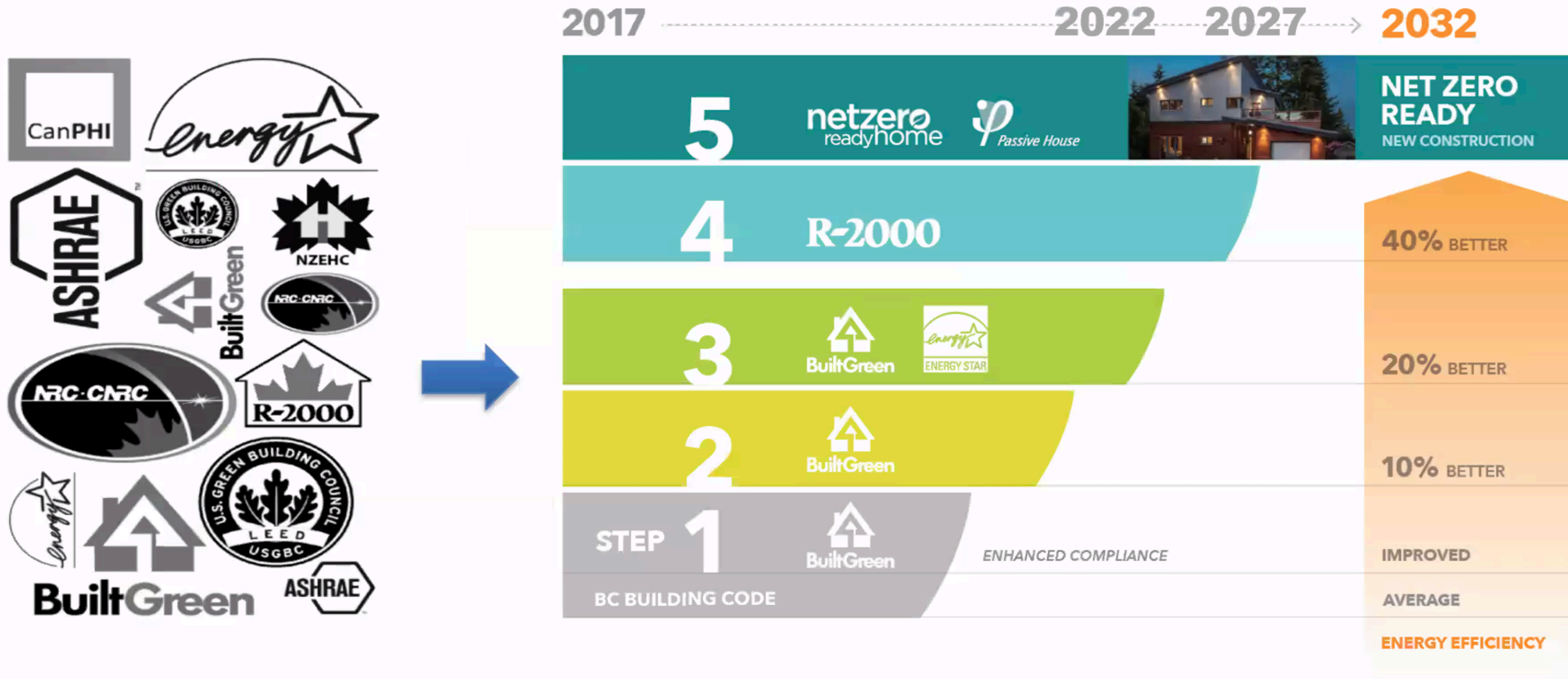


Carbon Framework Plan

“Efficiency+ Sufficiency + Renewables”




Phasing In Efficiency



With Passive House






- Contact
- Shape Your City
- Careers
- Guides

- Green Vancouver**
- Your government
- About Vancouver
- Parks, recreation, and culture
- Home, property, and development
- People and programs
- Streets and transportation
- Doing business

Home > Green Vancouver > Zero emissions buildings > High performance building standards

Green Vancouver

- Climate Emergency Action Plan
- Greenest City Action Plan
- Zero emissions buildings**
 - Green home retrofit plan
 - Zoning amendments to support the Climate Emergency Response
 - High performance building standards**
 - Building catalyst tools
 - Multi-family building energy resources and programs
- Zero Waste 2040
- Climate Change Adaptation Strategy
- Neighbourhood Energy Strategy
- How we are greening City operations



High performance building standards

High performance buildings that meet Passive House and Net Zero Energy certified standards are recognized as pathways to meet Vancouver Building By-law energy requirements, rezoning conditions, and also serve as applicable standards to qualify for a number of discretionary zoning variances.

Catalyst tools

To support innovation and design to high performance building standards, catalyst tools such as additional floor area allowances are available for multi-unit residential projects.

[Find out more about catalyst tools](#)

Energy Flow

Understanding Opportunities and Challenges,
and the sustainable future of Buildings.



Source

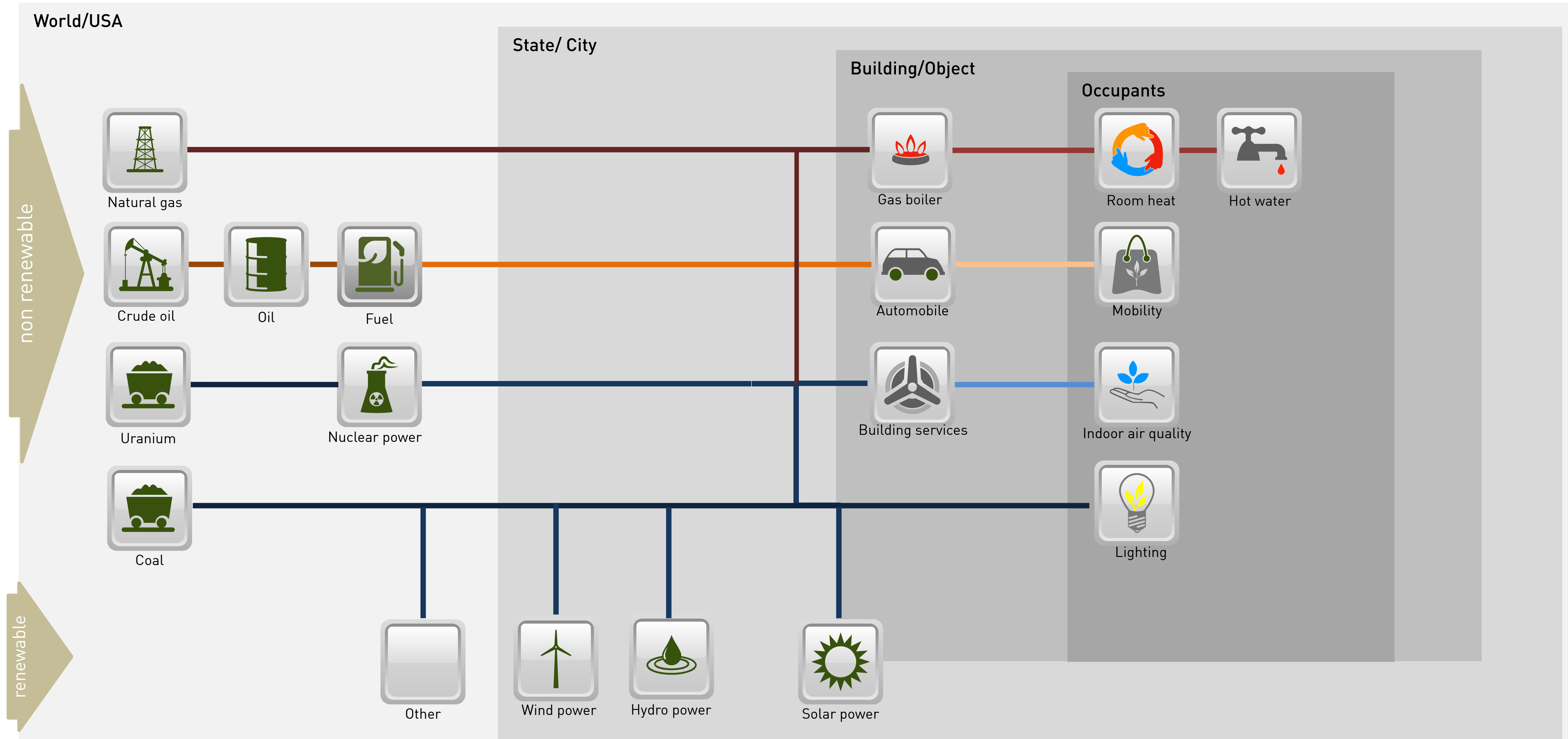
We extract and pollute, or harvest here...

Site

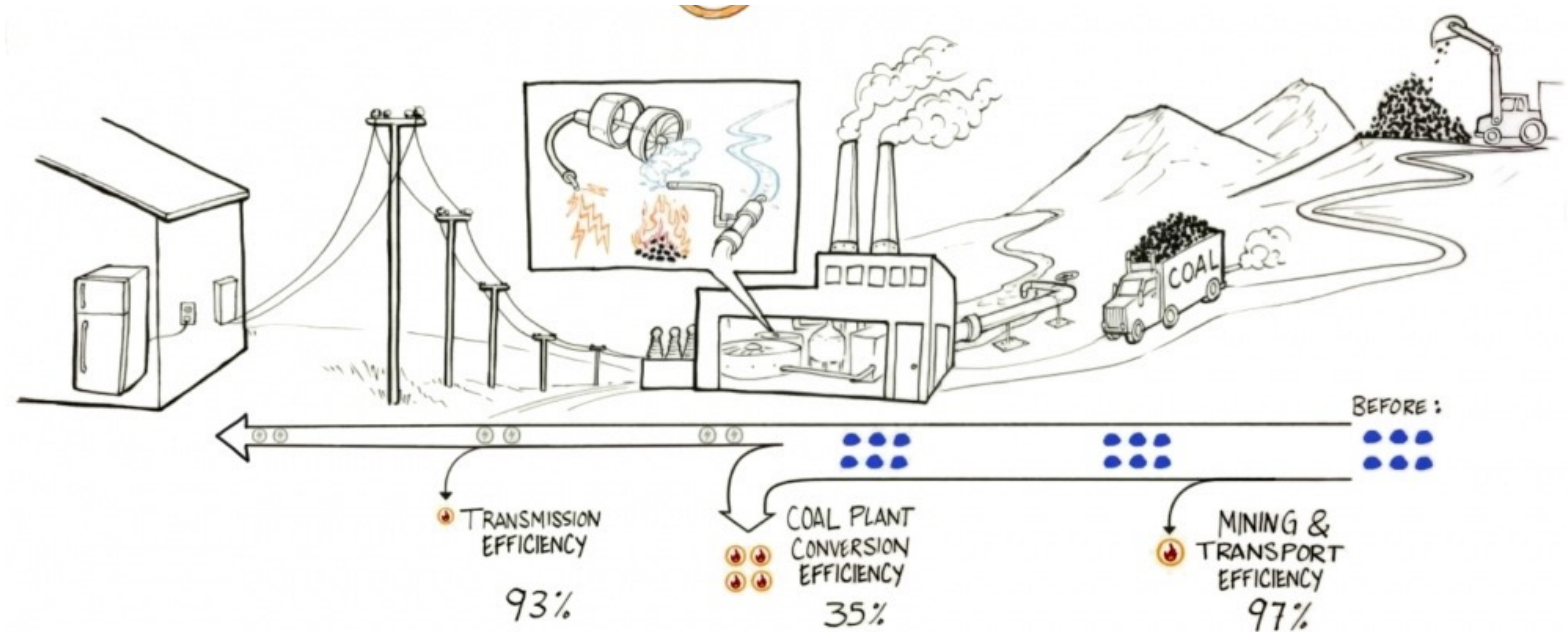
...and pay here...

Useful Energy

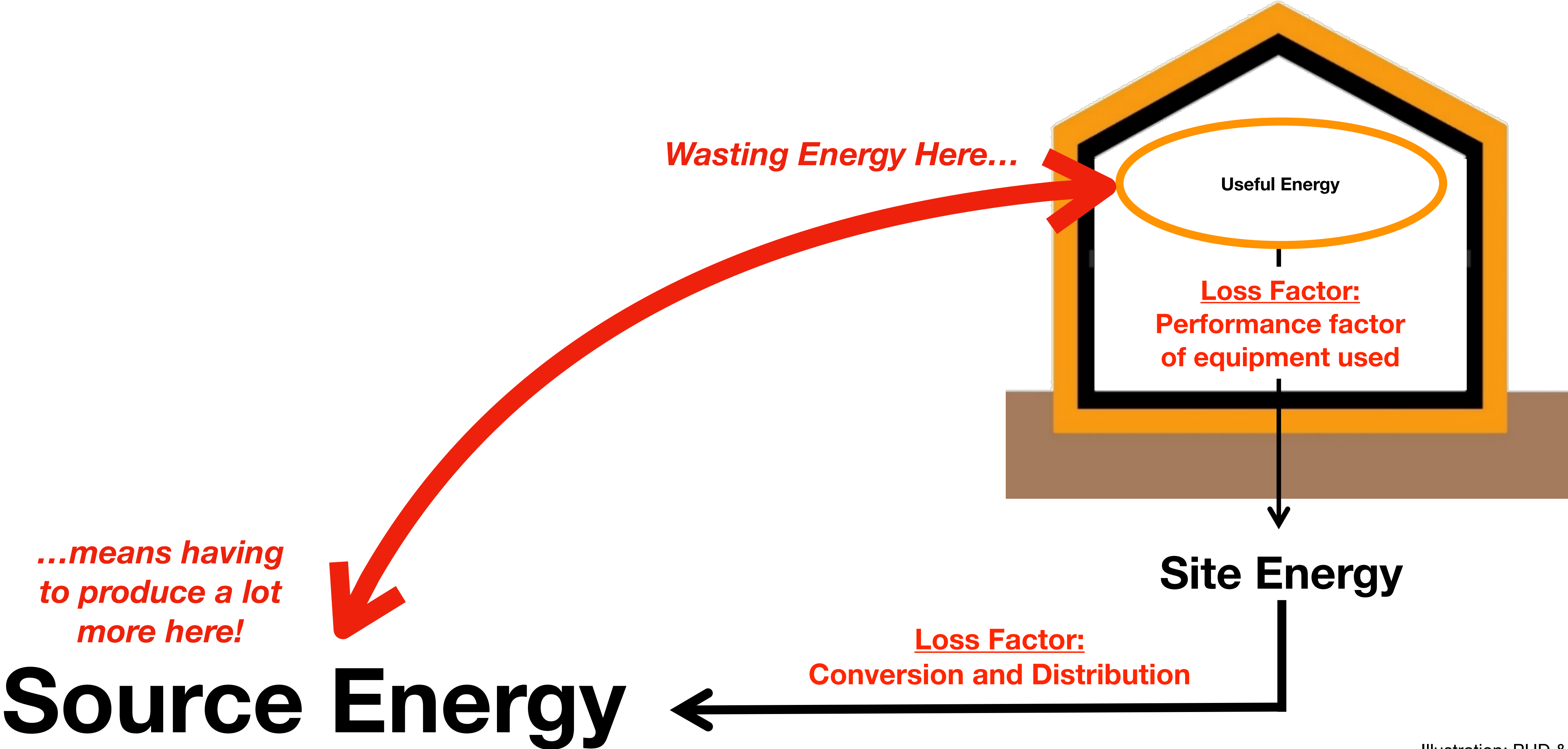
...to satisfy our needs.



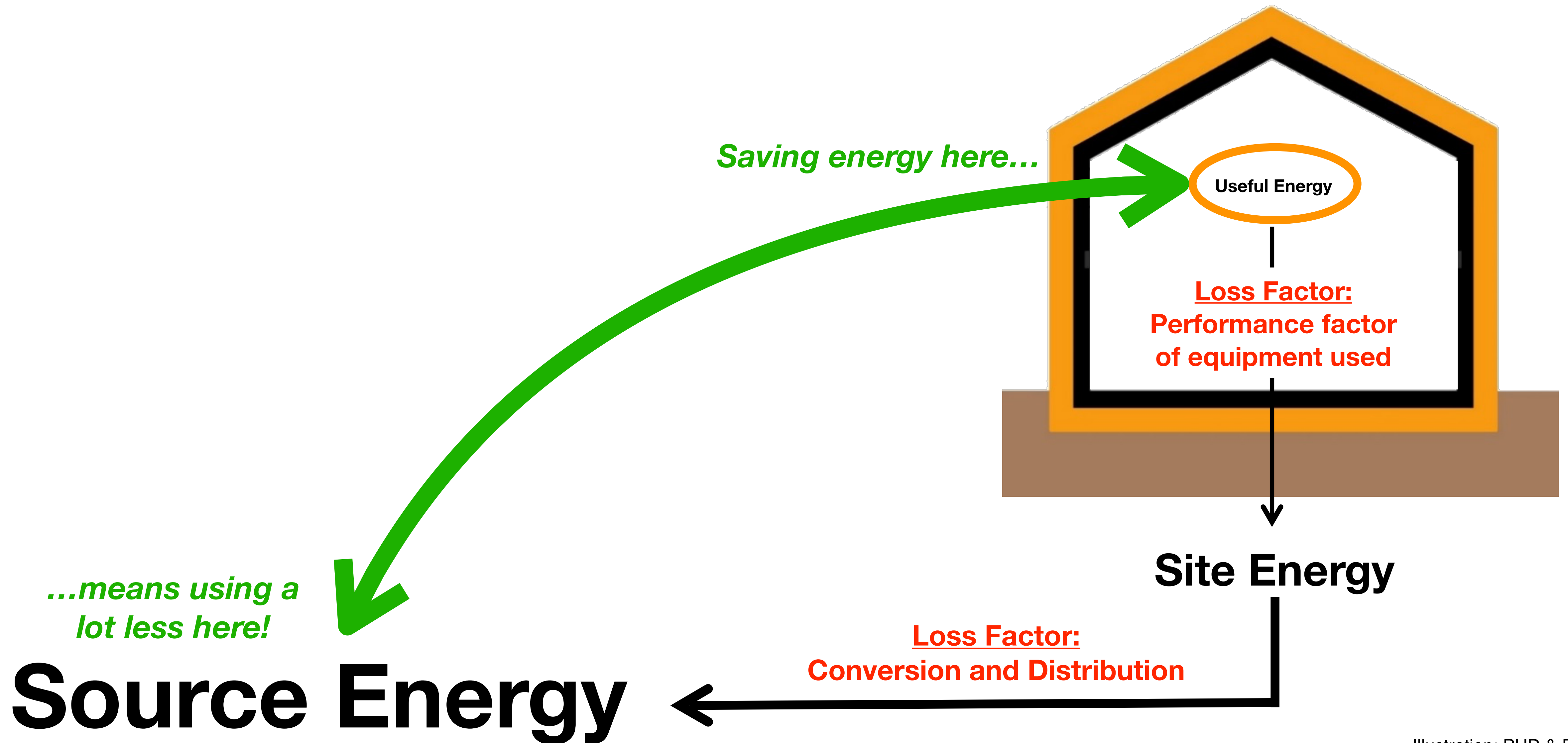
Inefficiencies



Compounding Losses



Multiplying Savings

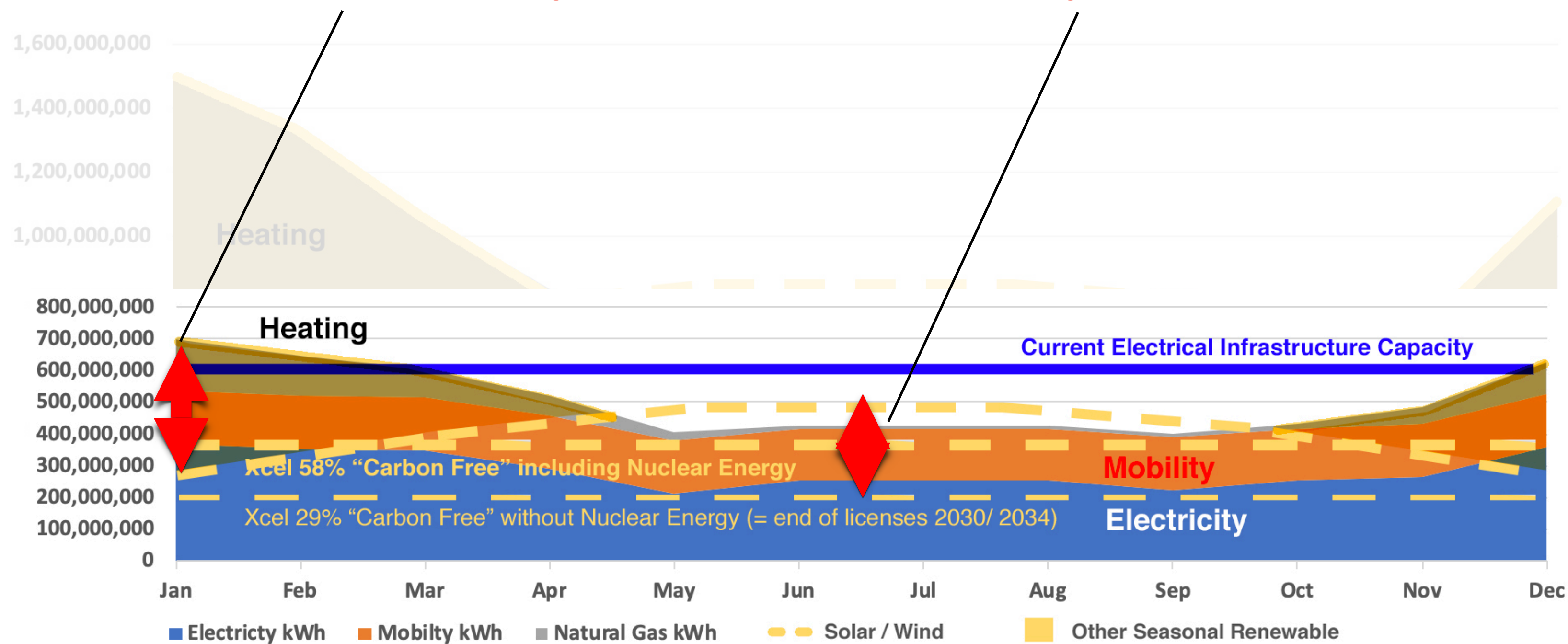


Better Clean Energy Plan

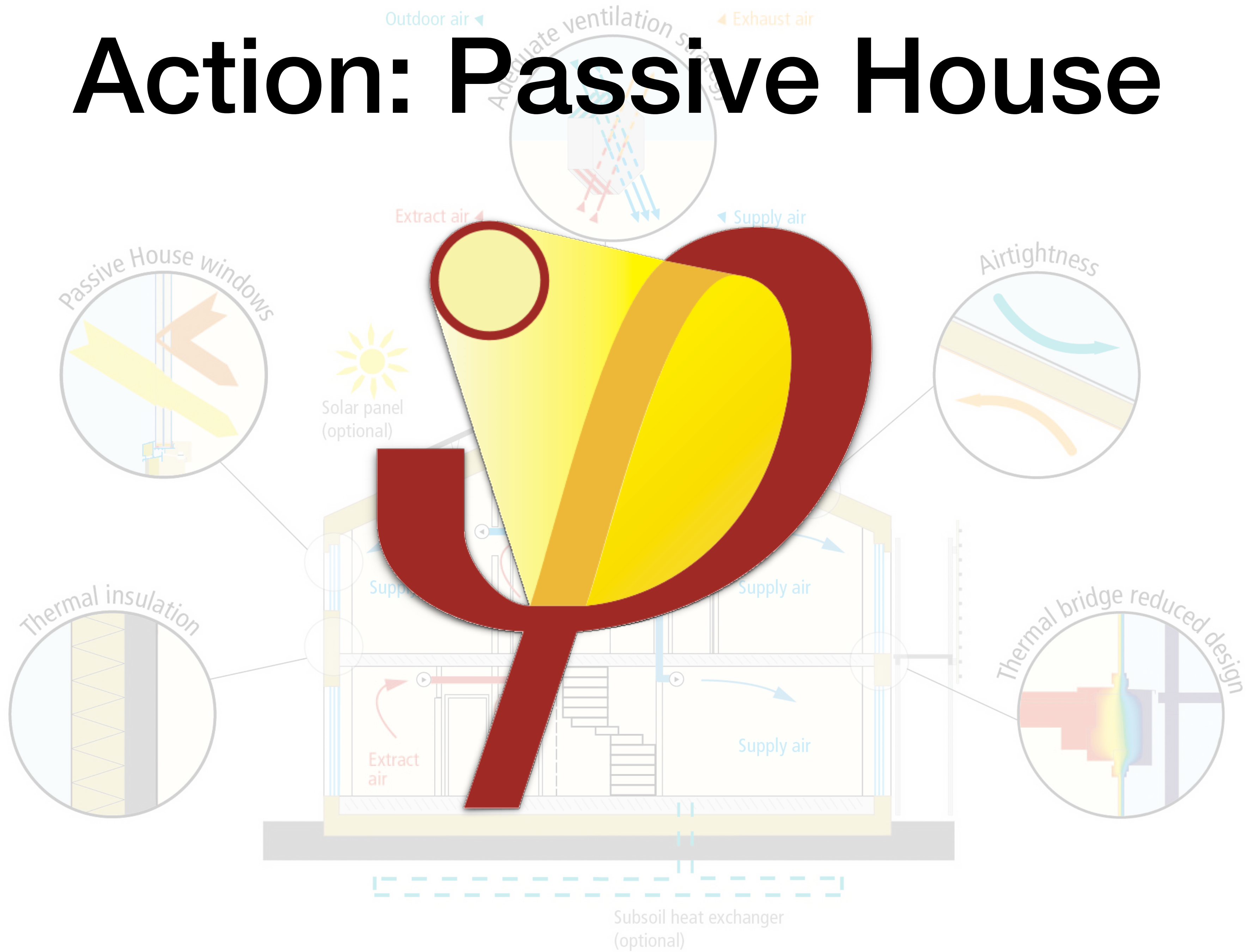
Efficiency First: “Retrofits + Efficiency”

SOLUTION: Massive peak heat load reduction reduces supply and load shifting issues!

COST: We are building a small clean energy infrastructure



Action: Passive House



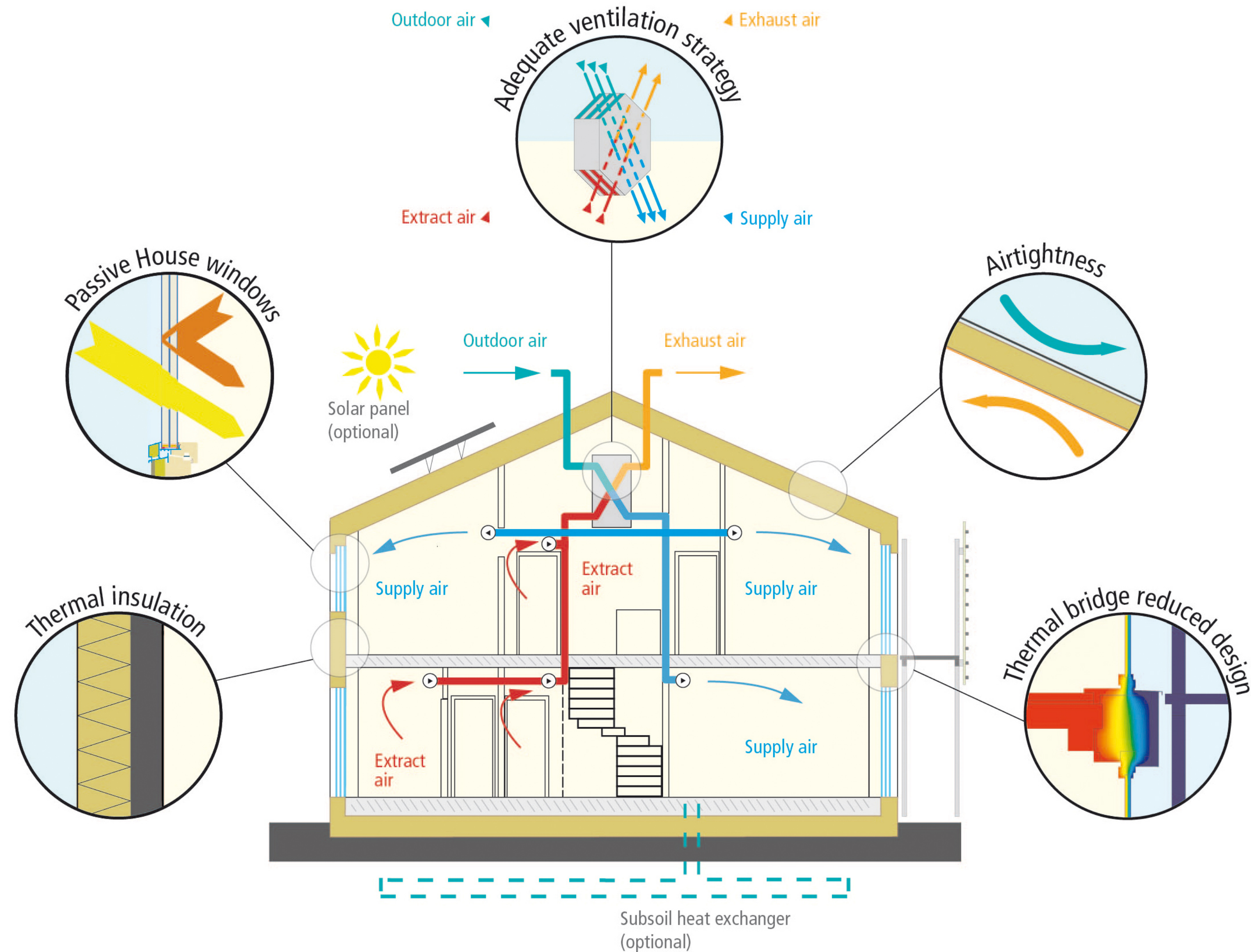
Passive House

Passive House
Explained

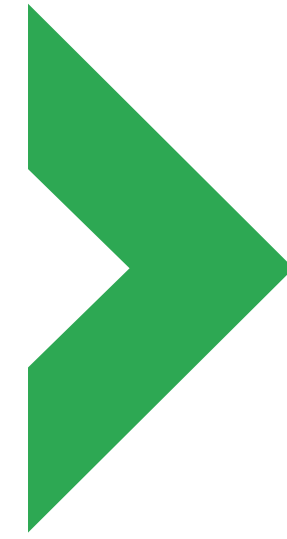
in  90 seconds



5 Basic Science Principles



Paradigm Shift



Passive House...

- Defines the long-term building quality and performance independent of energy supply.
- Reduces the amount of Useful Energy needed to operate the building significantly.



Benefits Multiplied

Energy Efficiency

- = Climate Impact Reduction
- = Human Comfort and Health
- = Resiliency
- = Durability
- = Life Cycle Cost Efficiency
- = Social Justice



Beneficial Electrification



Resource: <https://rmi.org/insight/decarbonizing-homes/>

Beneficial Electrification with Passive House

- Of course, we recognize the implications of an **integrated whole systems approach** – it's called Passive House and the report doesn't shrink from this implication but instead specifically calls out **the Passive House methodology as a core strategy of beneficial electrification.**
- The formula Passive House + Electrification + Renewables is a simple expression of the integration proposed by beneficial electrification.
- The report does a great job of laying out further positive results too: fewer toxins, less pollution, less asthma, allergies, protection from weather extremes, grid resilience, and increased safety for neighborhoods and communities – in particular helping close the gap in health outcomes for low-income communities.

And Embodied Energy



Embodied CO₂ EC3 database

44,000 records

AllMaterials / Concrete / ReadyMix

Product Name * DM0115CA DOWNLOAD Date of Issue * 2019-01-28 Valid Until * 2024-01-28

Also show in Categories

EMBODIED CARBON IMPACT

Declared Unit * 1 m3 Mass per 1 m3 * 2400 kg

Embodied GWP per 1 m3 * 339 kgCO₂e Estimated Uncertainty ± 12 %

kgCO₂e embodied per 1 m3

Manufacturer Specific
Plant Specific
Product Specific
Just in Time
Supply Chain Specific
LCIA Match

Boxplot diagram showing distribution of embodied carbon impact.

PRODUCT SPECIFICATIONS for "DM0115CA"

Product Description * DOT MINOR 3/4" 15FA 3-55L AIR

Product SKU

Product Available In Global

Industry standards

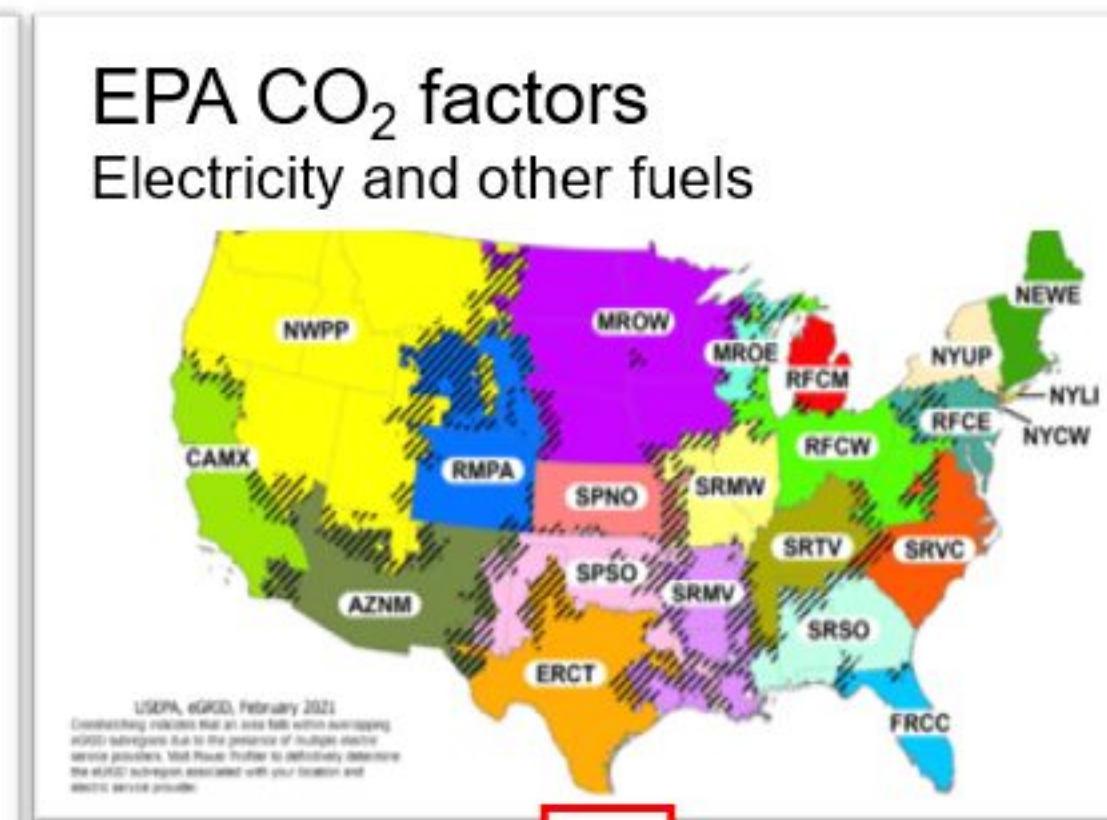
Reference Service Life Compressive Strength 28D 20.7 MPa

Compressive Strength Other Compressive Strength Other Days

Aggregate Size Max 0.75 in AC308 Exposure Class

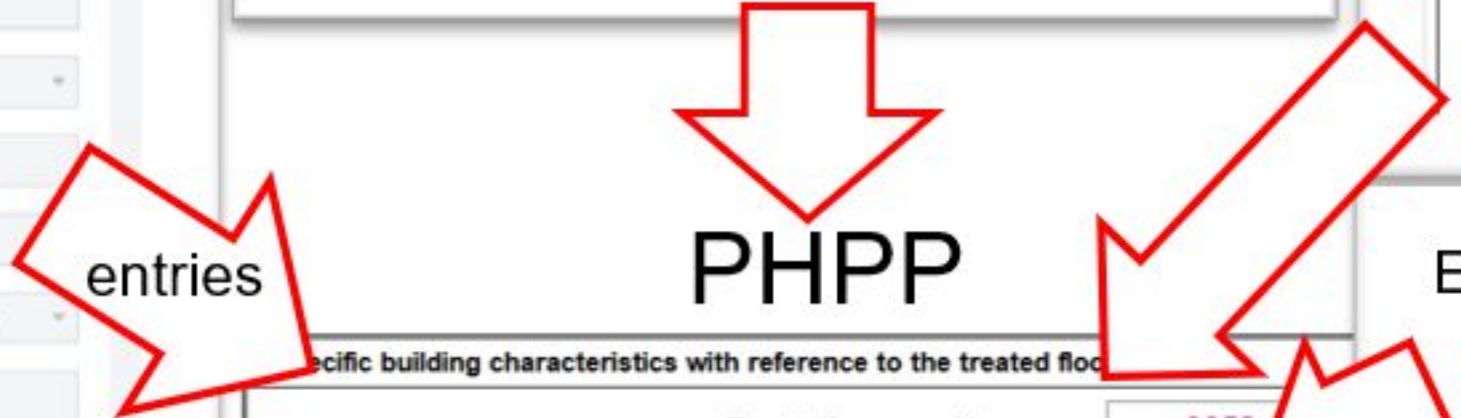
CSA A23.1 Exposure Class EN206 Exposure Class

Min Slump Max Slump



EPA End-of-Life Emissions

Material Type	Material
	Copper Wire
	Mixed Metals
Glass	Glass
Construction Materials	Asphalt Concrete
	Asphalt Shingles
	Carpet
	Clay Bricks
	Concrete
	Dimensional Lumber
	Drywall
	Fiberglass Insulation
	Fly Ash
	Medium-density Fiberboard
	Structural Steel
	Vinyl Flooring



PHPP

Specific building characteristics with reference to the treated floor area

	Treated floor area ft ²	9058
Space heating	Heating demand kBTU/(ft ² ·yr)	1.70
	Heating load BTU/(hr·ft ²)	2.81
Space cooling	Cooling & dehum. demand kBTU/(ft ² ·yr)	3.47
	Cooling load BTU/(hr·ft ²)	2.49
	Frequency of overheating (> 77 °F) %	-
	Frequency of excessively high humidity (> 0.012 lb/lb) %	0.0
Airtightness	Pressurization test result n ₅₀ 1/hr	0.3
Non-renewable Primary Energy (PE)	PE demand kBTU/(ft ² ·yr)	16.51
Primary Energy Renewable (PER)	PER demand kBTU/(ft ² ·yr)	7.97
	Generation of renewable energy (in relation to projected building footprint area) kBTU/(ft ² ·yr)	19.43

End of Life pathway

- % Recycling
- % Combustion
- % Landfill

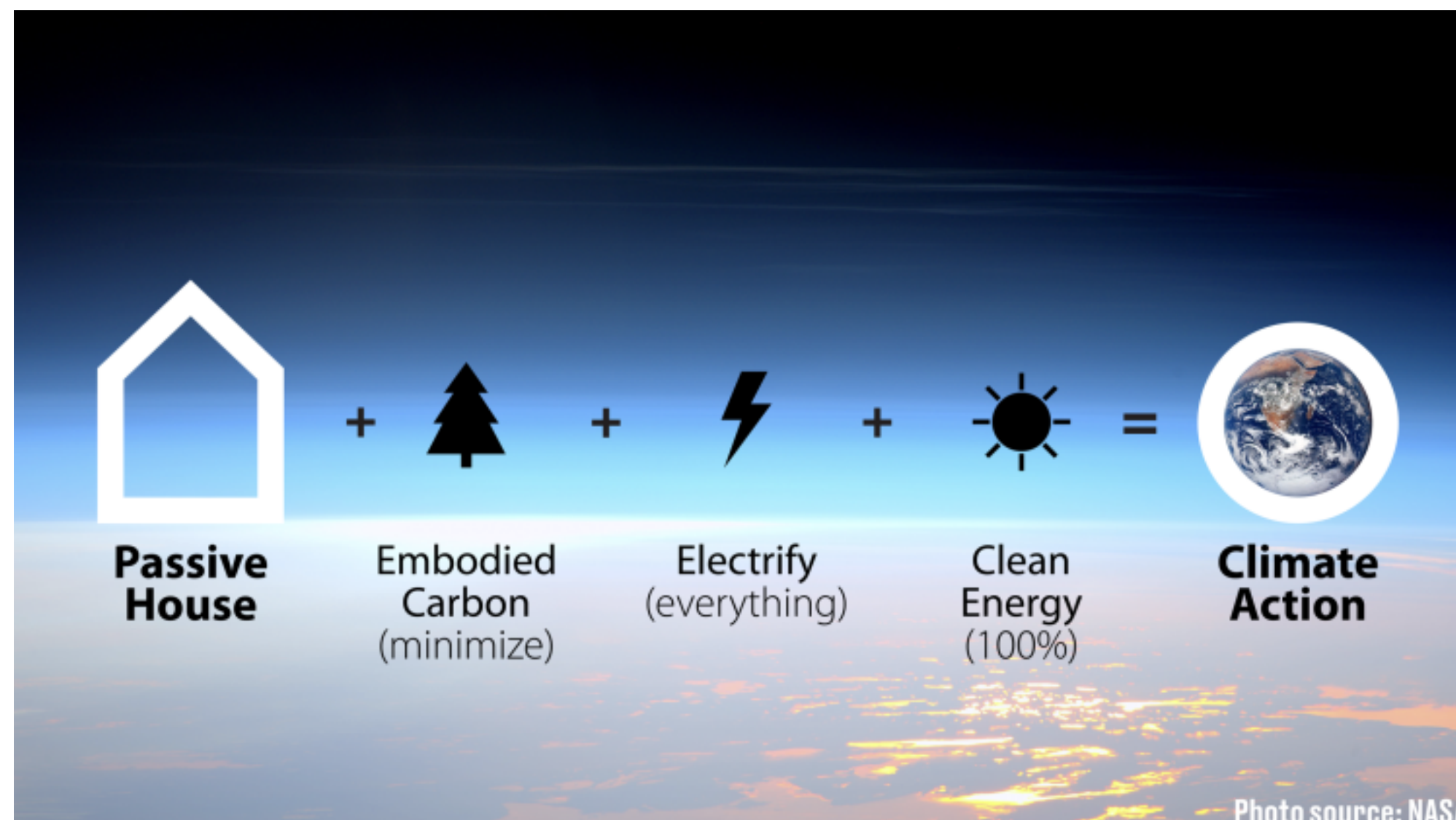
= Foundation for Climate Action

• **Efficiency: The First Renewable Energy**
#EfficiencyFirst



© International Passive House Association

International
PASSIVE HOUSE
Association 



Passive House + **Embodied Carbon (minimize)** + **Electrify (everything)** + **Clean Energy (100%)** = **Climate Action**

Photo source: NASA

Passive House + Renewable Energy

- Passive House is a solar thermal collector and a battery
- Passive House Plus and Premium add an active renewable energy component towards climate-neutrality
- Passive House energy efficiency enables the effective use of renewable energy sources
- #EfficiencyFirst = peak loads in a PH are hugely reduced (in particular the Carbon-laden heating loads)
- Building energy efficiency and reduced peak loads keep a lid on the scale, scope and cost of the clean grid
- Optimizing the system as a whole (demand and supply) offers a powerful approach. However, challenges such as the need for seasonal energy storage remain but are much smaller.



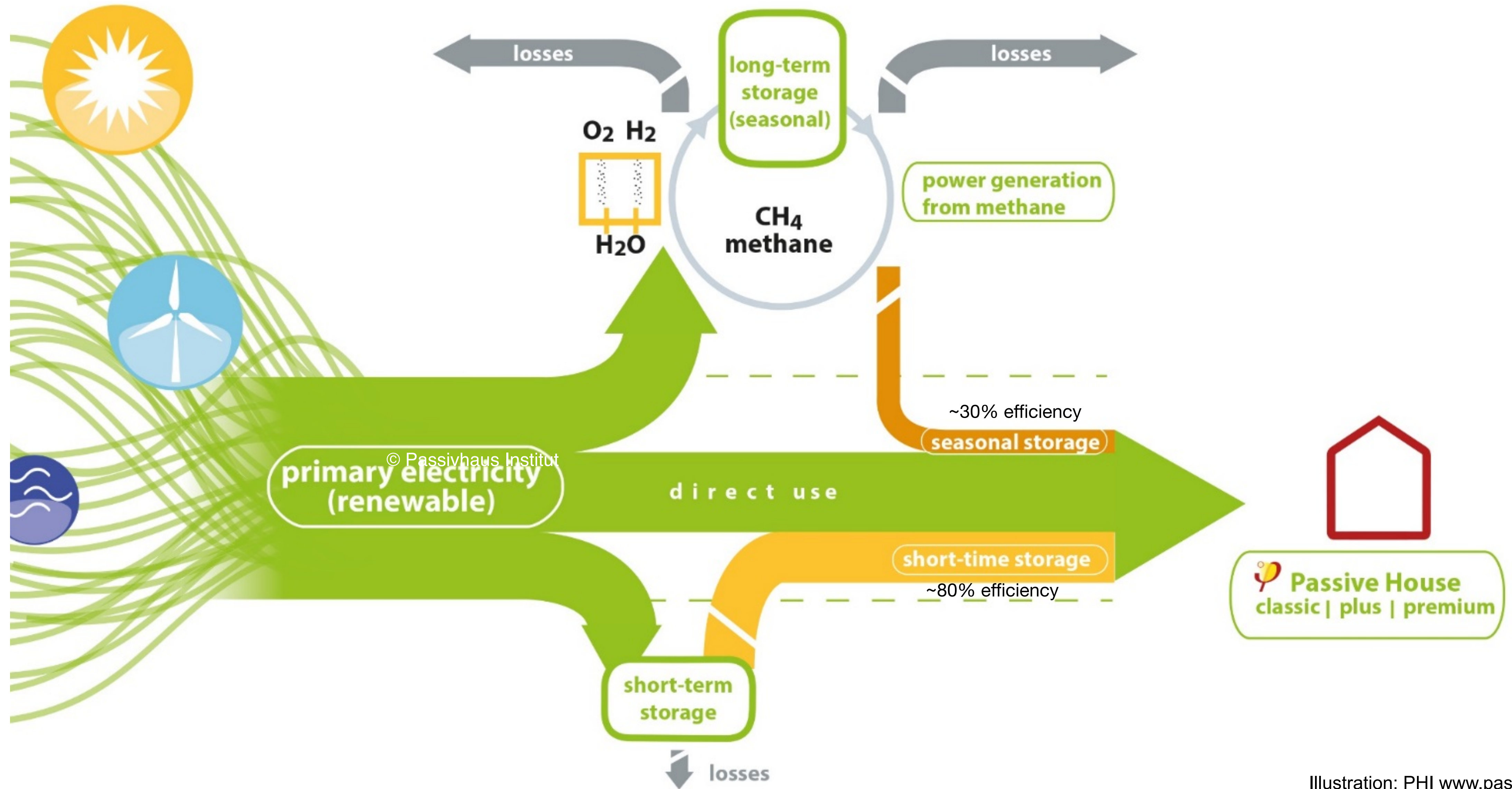
Remember Me?

PER

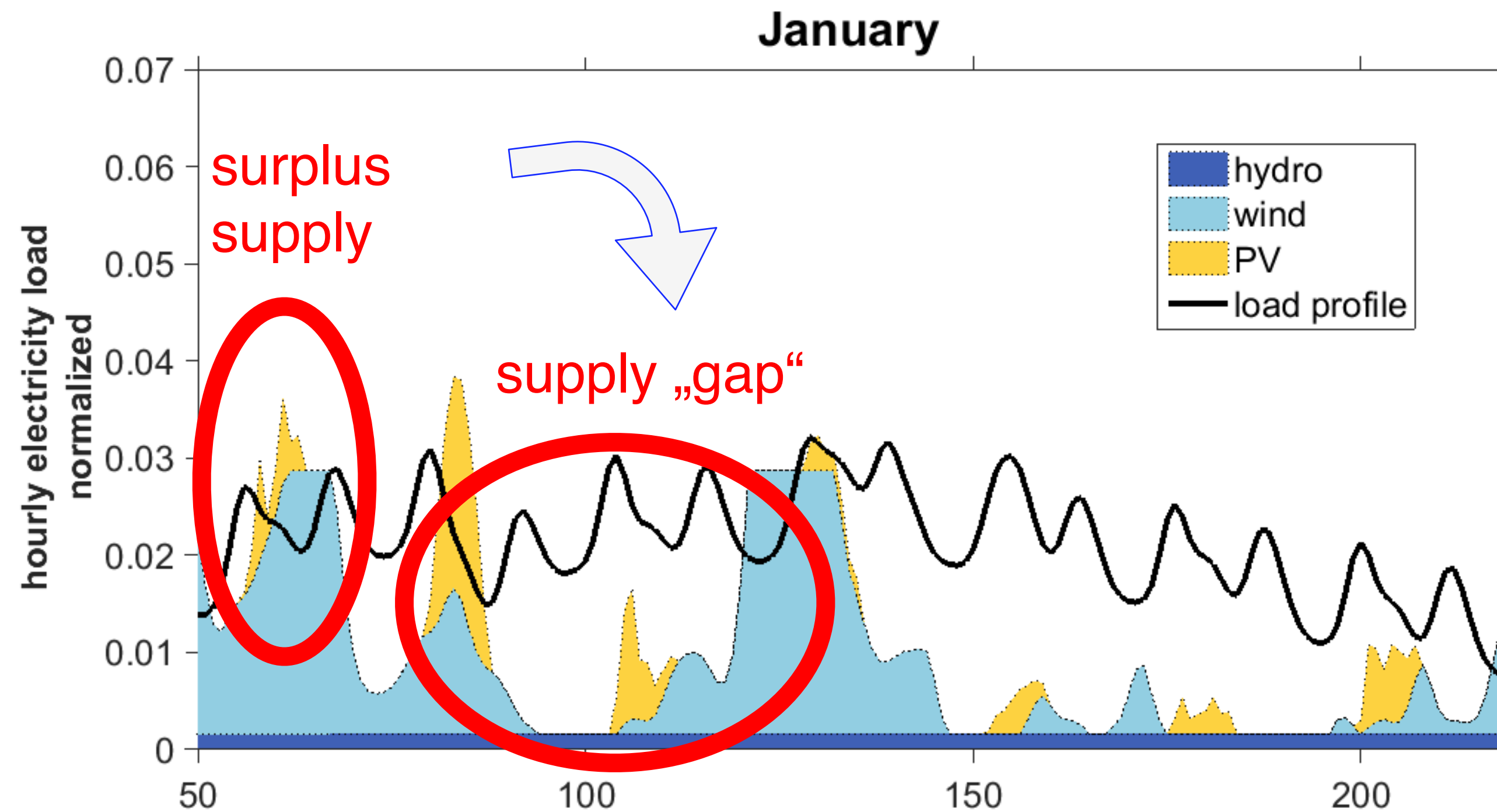
The assessment for a sustainable energy supply

- PER (Primary Energy Renewable) provides an appropriate measure of how much energy needs to be generated sustainably from renewable energy sources in order to provide a given amount of energy to the end user.
- PER thus shows just how efficient different application technologies are in the context of a sustainable renewable energy supply.

The PER Approach



Renewables in Winter



Seattle

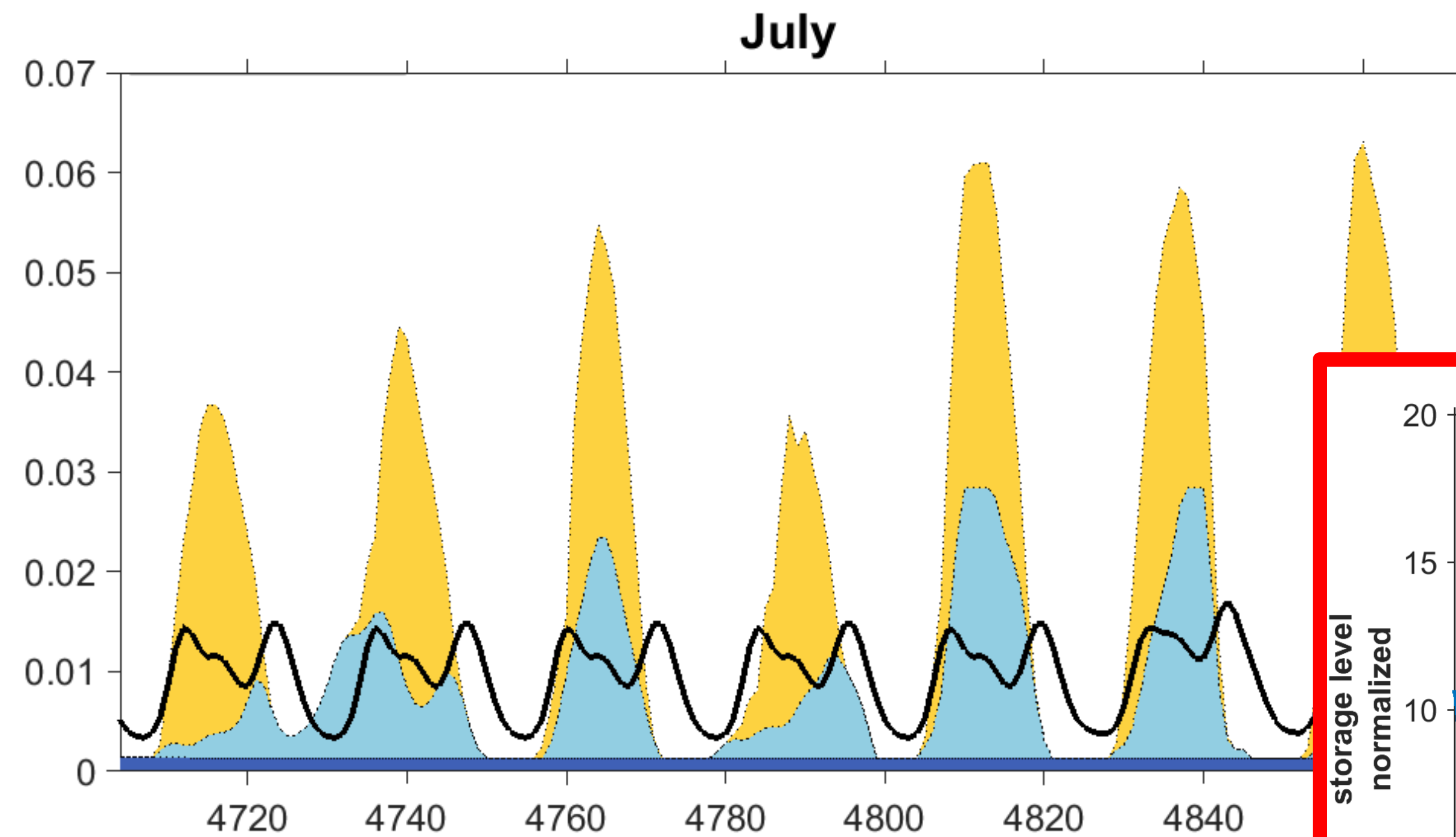
(climate data: TMY3, WMO 727935)

graphs © Passive House Institute

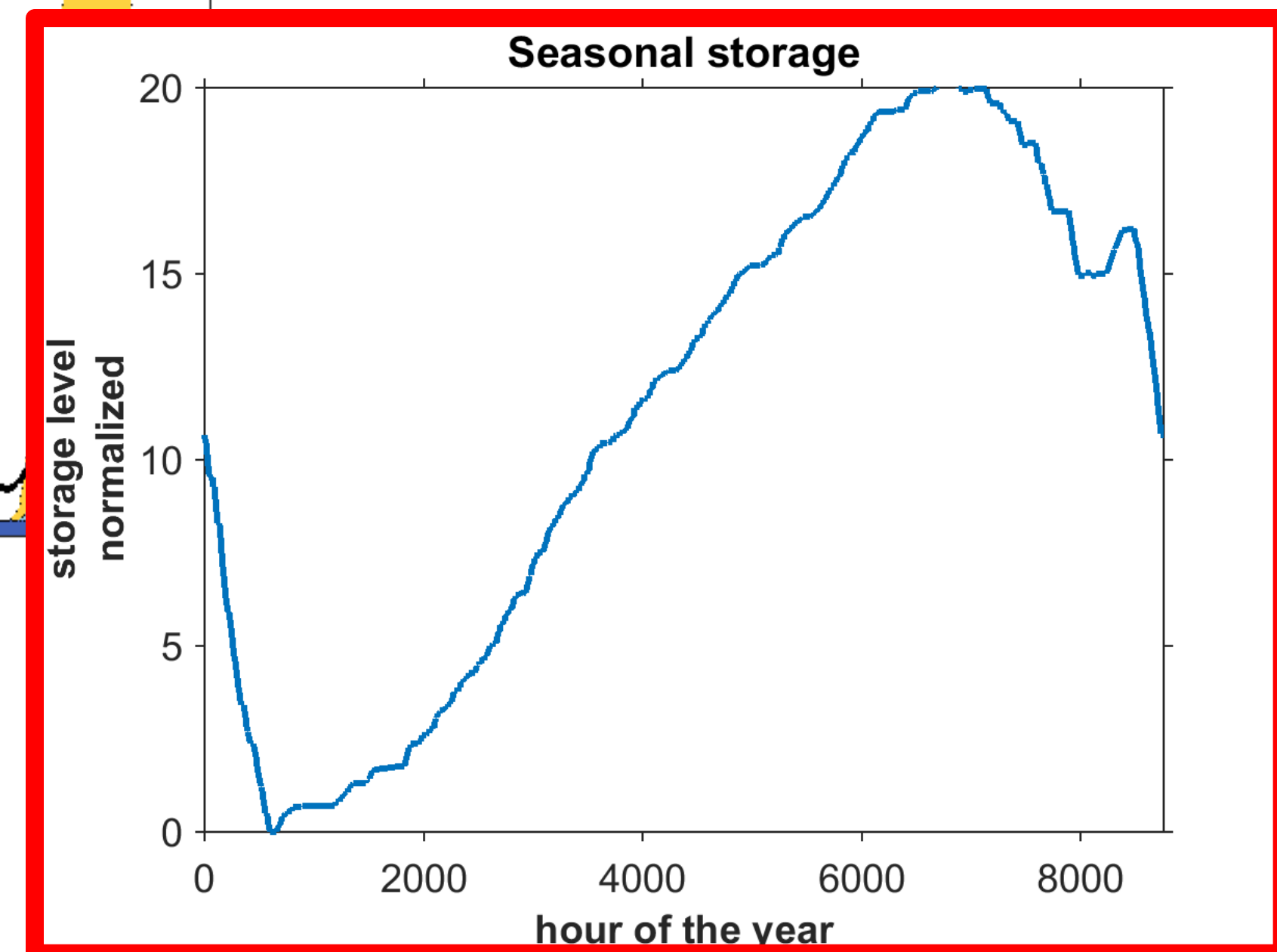
Bridging short-term gaps with efficient storage systems:

- Batteries
- Pump storage
- Thermal storage
- ...

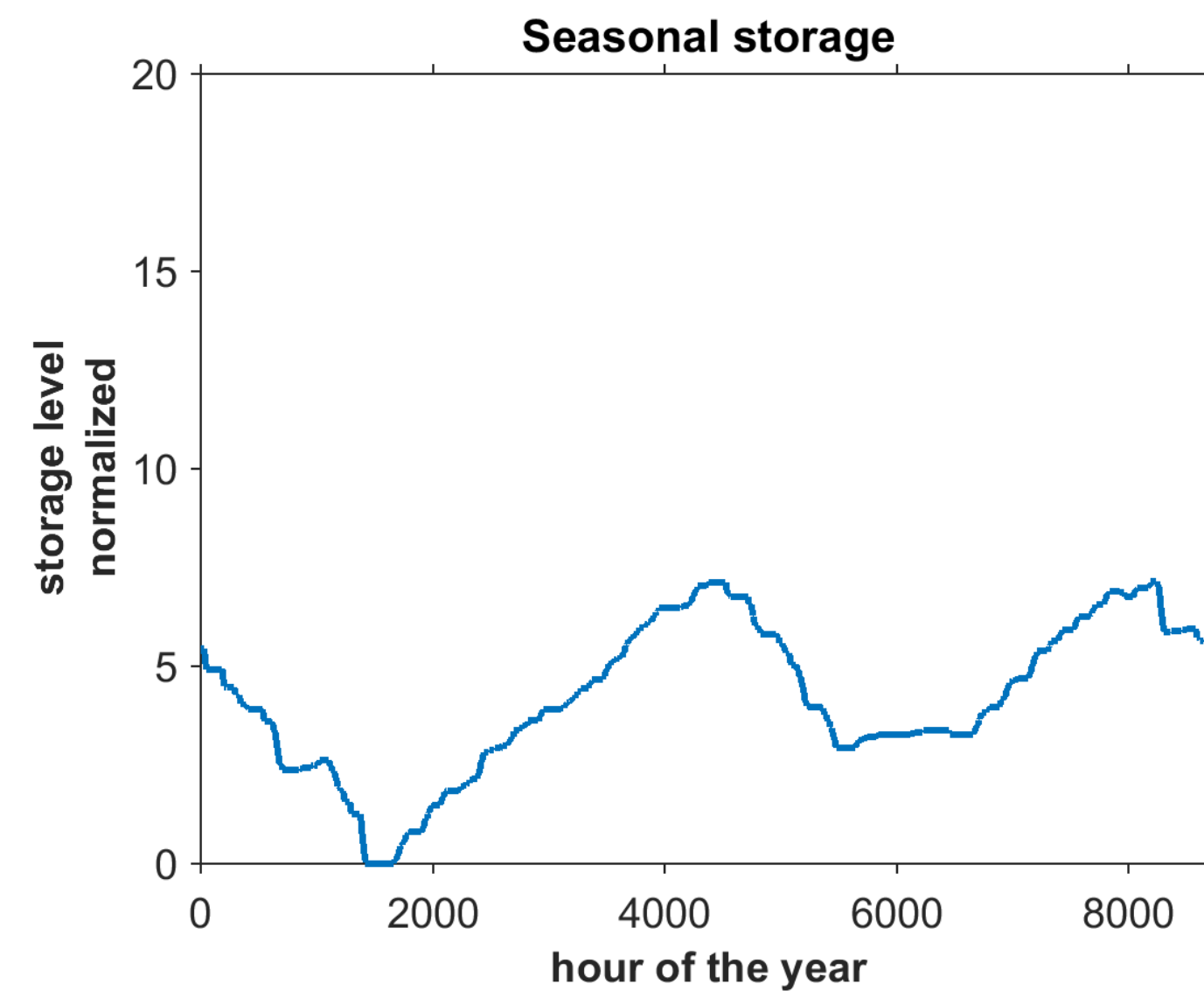
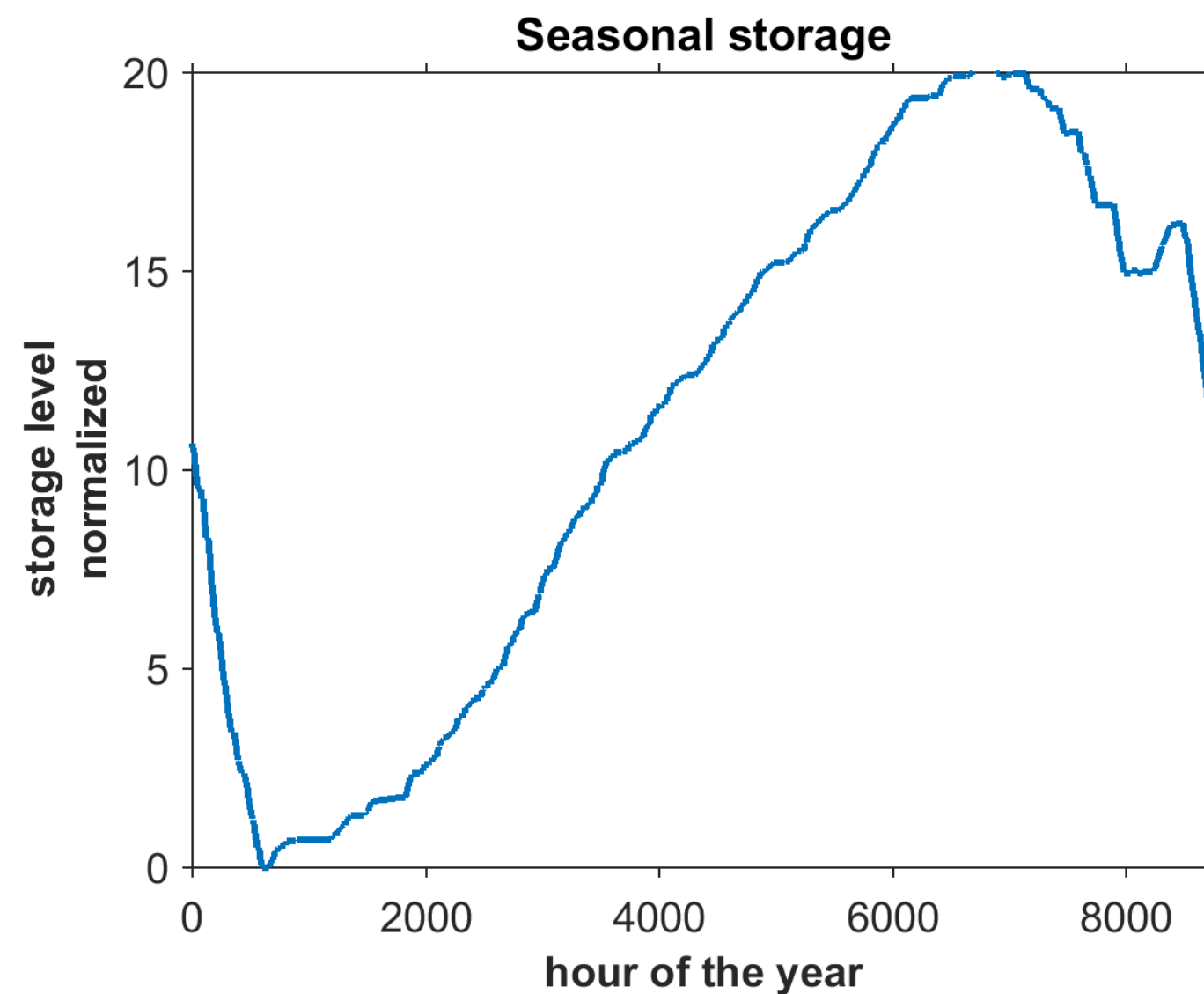
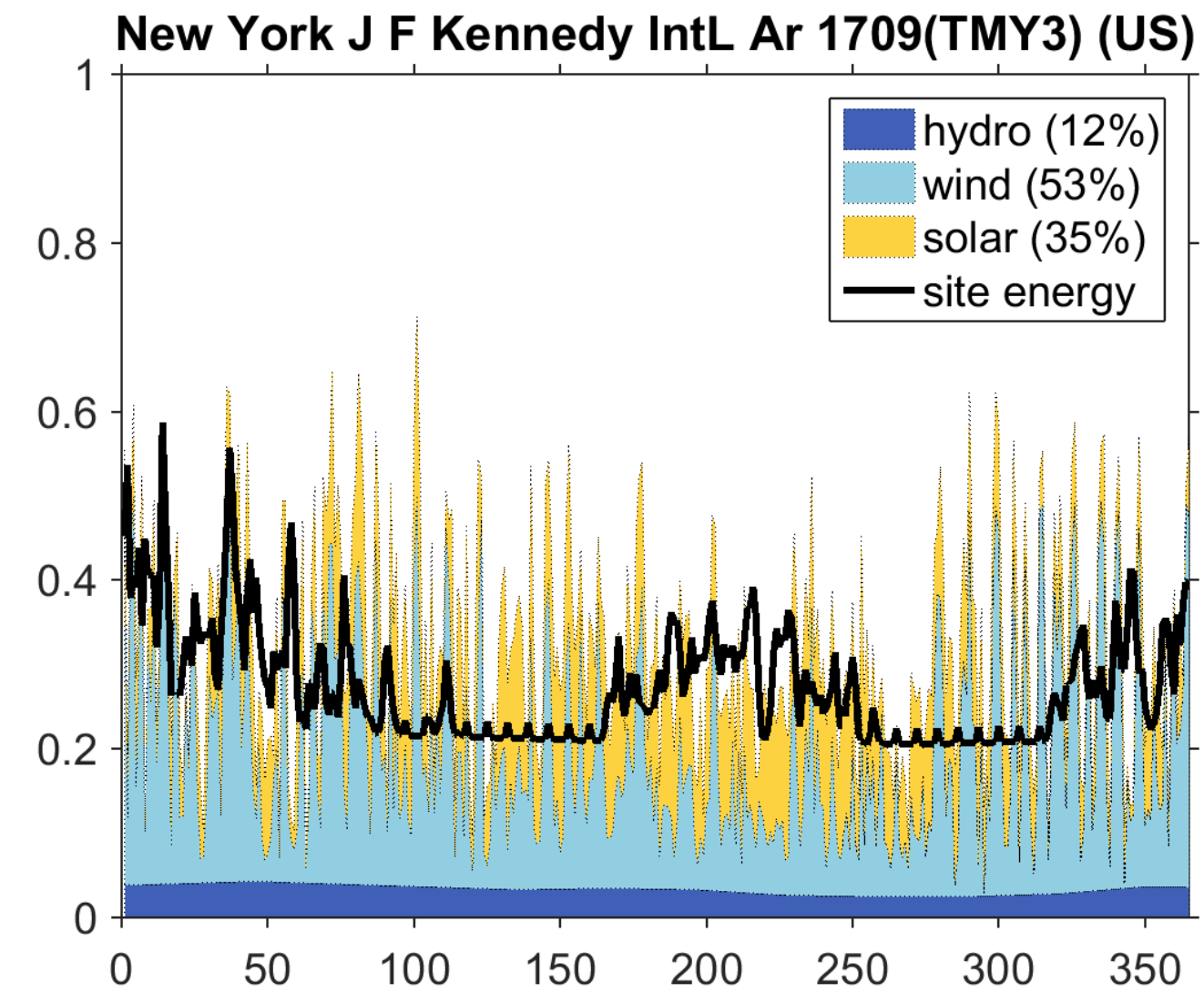
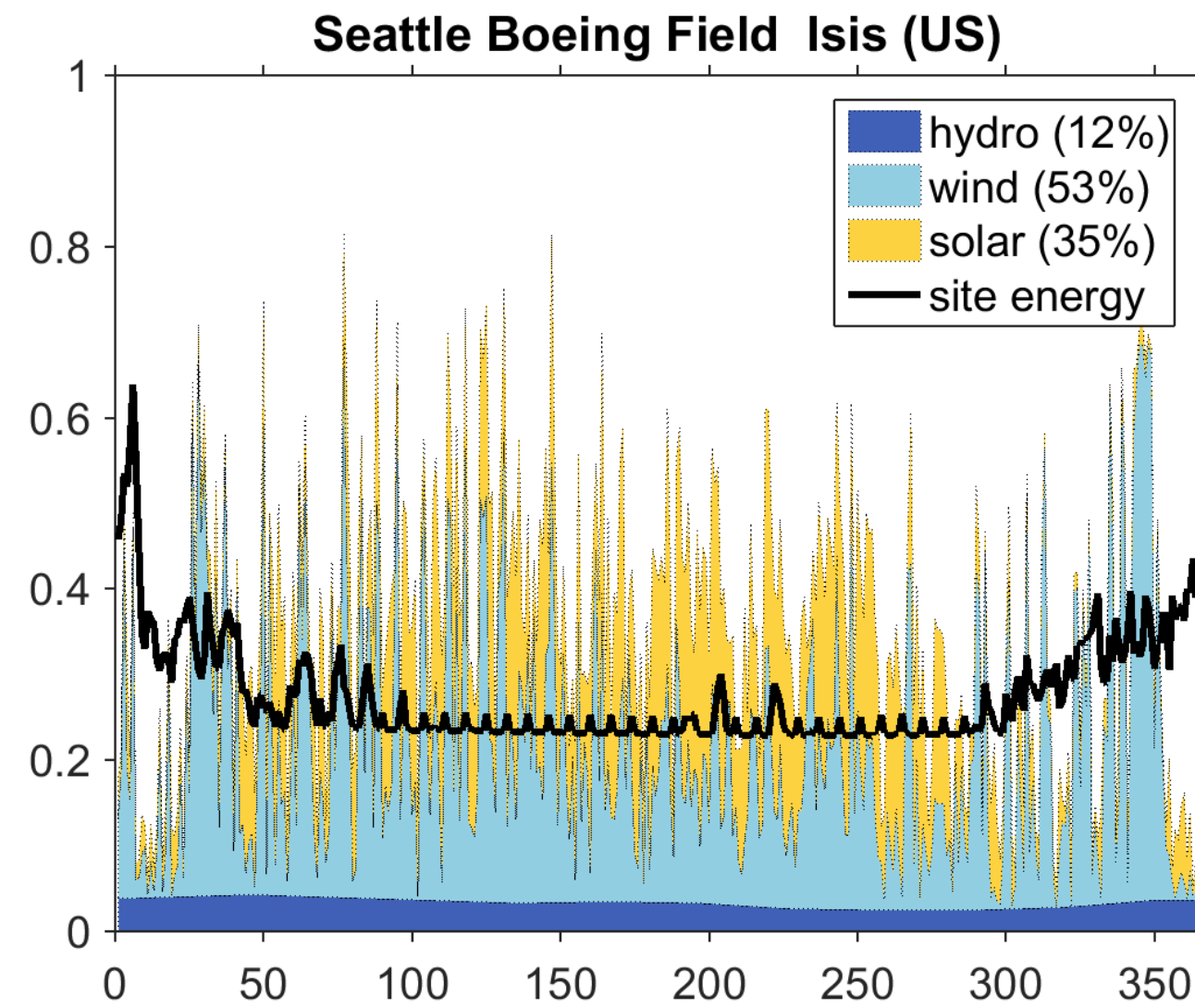
Renewables in Summer



**Energy surplus during summer!!
= Seasonal storage required**



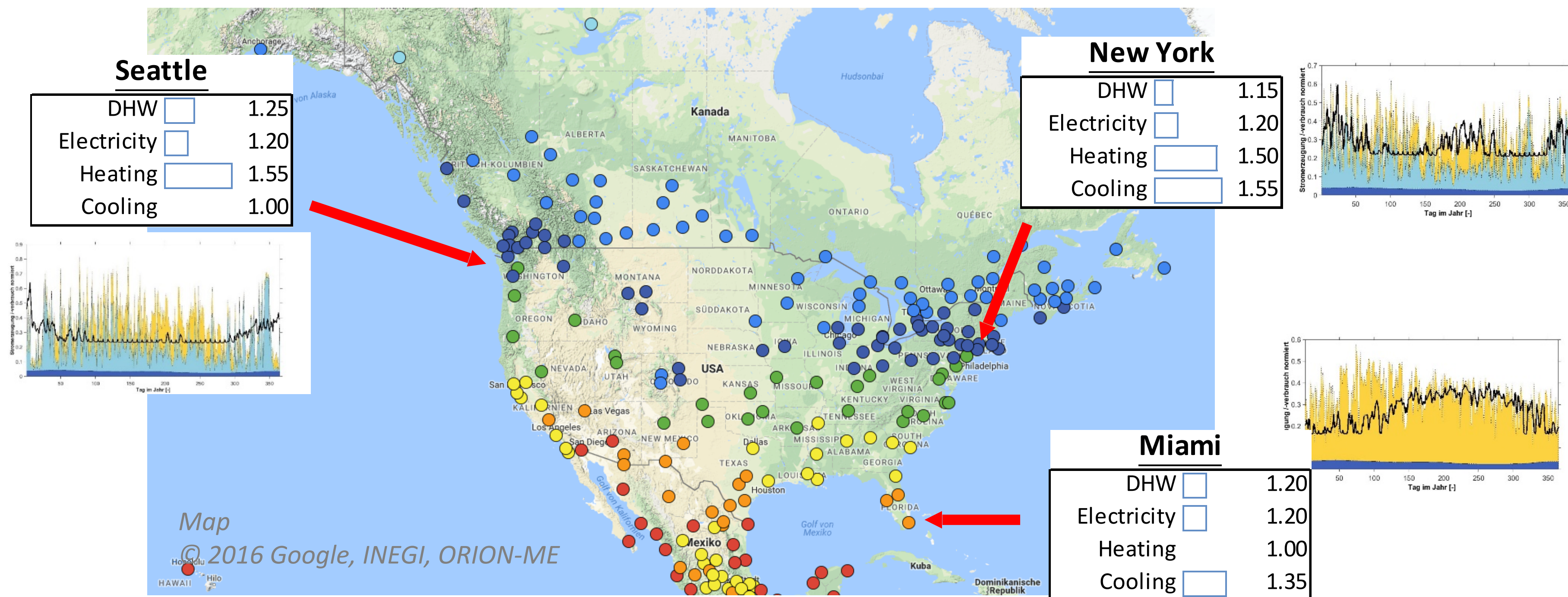
Seasonal Storage



Local Variations

→ PER weighting factors vary for:

1. Different locations
2. Different load profiles (heating, cooling, hot water, electricity)



Enabling an All-Renewable Energy Supply

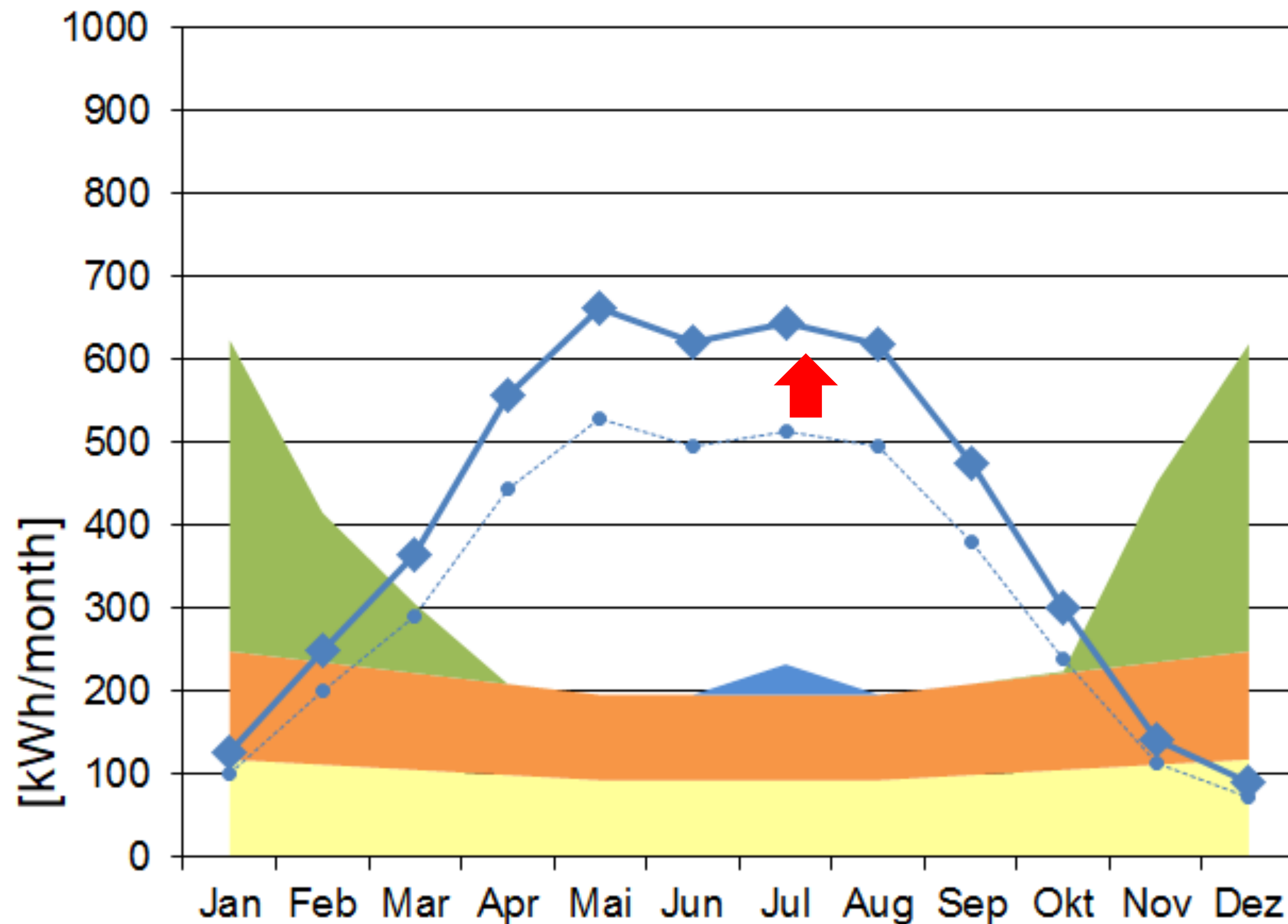
with the PER Approach

- The impact of heating / cooling is weighted in the context of the regional renewable resource availability
(mostly higher impact of heating due to seasonal storage)
- The use of **electricity** is rated more favorably than in a conventional primary energy approach
(especially in combination with heat pump systems)
- The use of **biomass** is only encouraged to a limited budget
(extremely valuable, competitive & limited resource)
- A moderate use of **gas and other fossil fuels** becomes important

Zero Energy?

- Electricity
- Hot water
- Heating
- Cooling
- PV to cover PER demand
- PV for net-zero

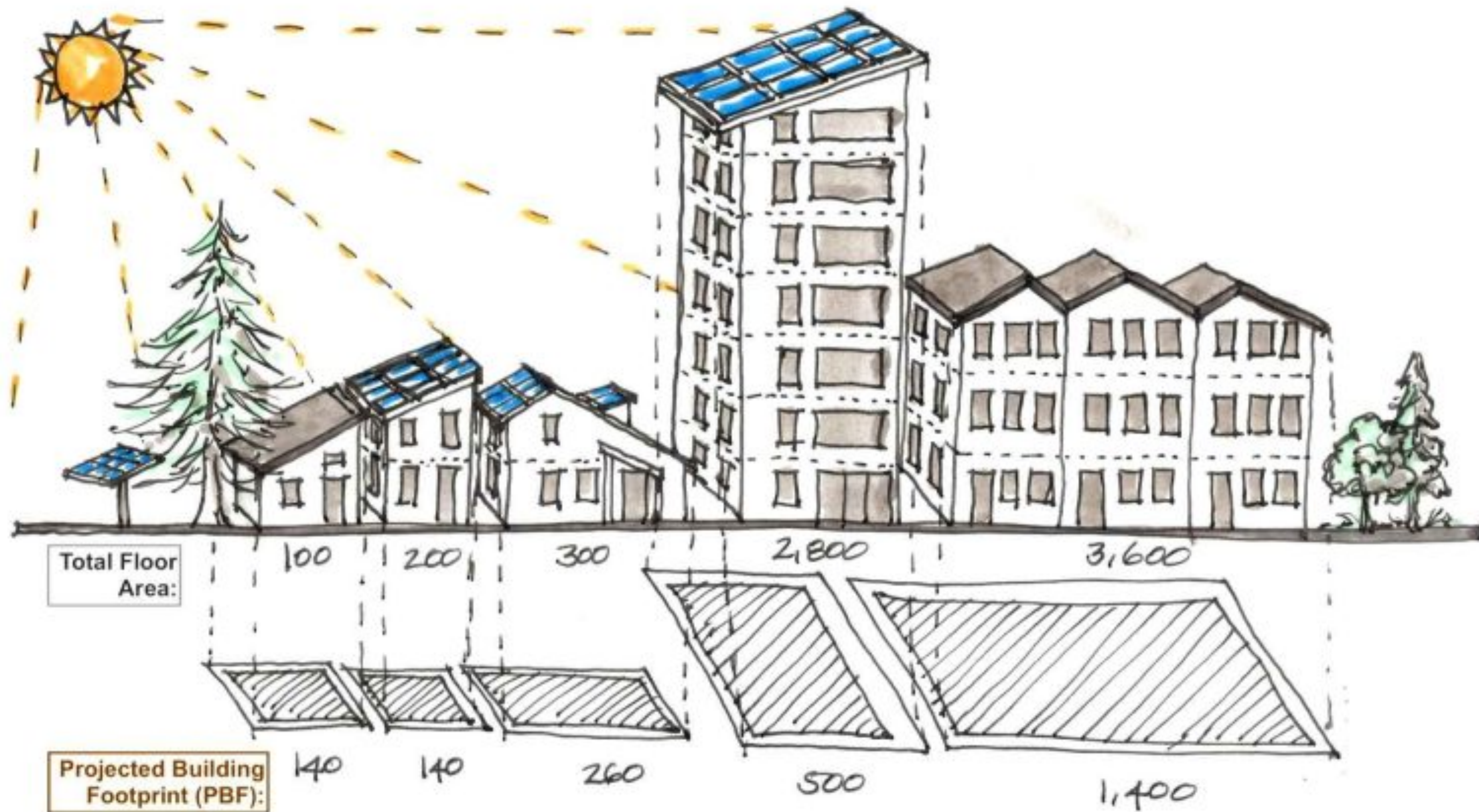
Heating demand	kWh/(m ² a)	15
Cooling and dehum. Demand	kWh/(m ² a)	1
PER demand	kWh/(m ² a)	31



The PER approach takes into account losses, e.g. it's a more „honest“ zero-energy system!

Required PV area
(German climate)
Net-zero = 32 m²
PER-zero = 40 m²

Uniform Accounting



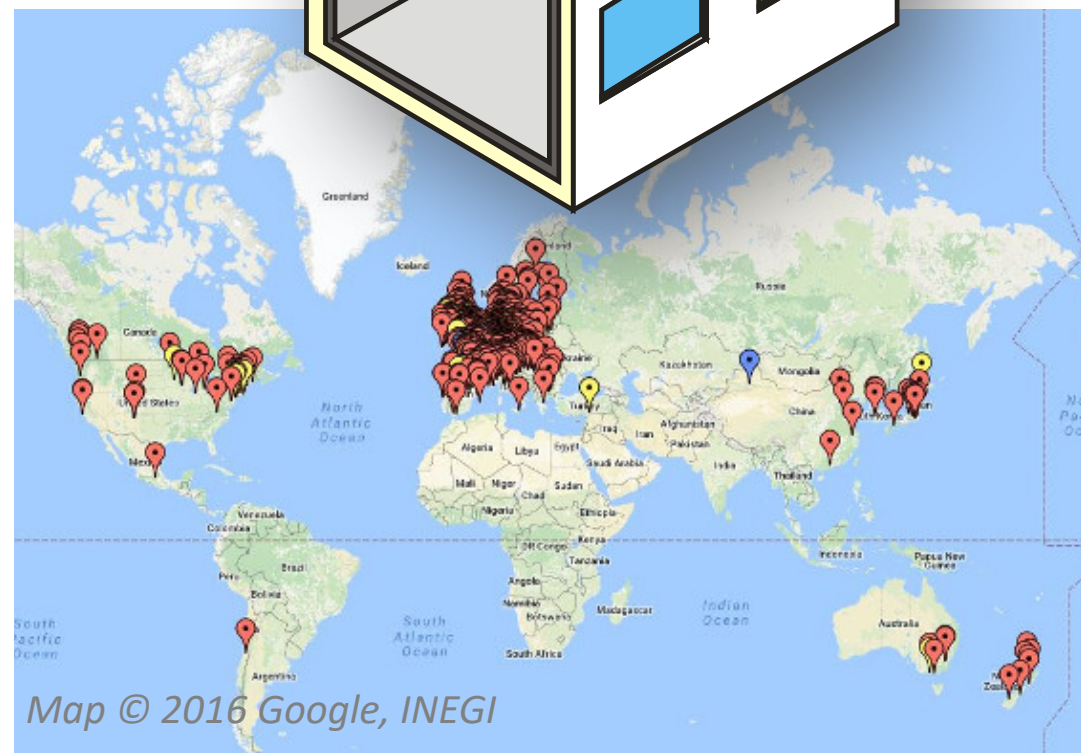
- Net-zero / net-plus energy is often misleading
e.g. multistory buildings are discriminated despite their advantages
- Suggested approach: Independent rating of RE and efficiency.
 - **Building's footprint area as the reference for renewables**
 - **Taking off-site production into account**

Illustration by Bronwyn Barry, Passive House California

PER Applied

Basic requirement: Very low useful energy demand ≤ 4.75 kBTU/(ft² yr)

classic



Map © 2016 Google, INEGI

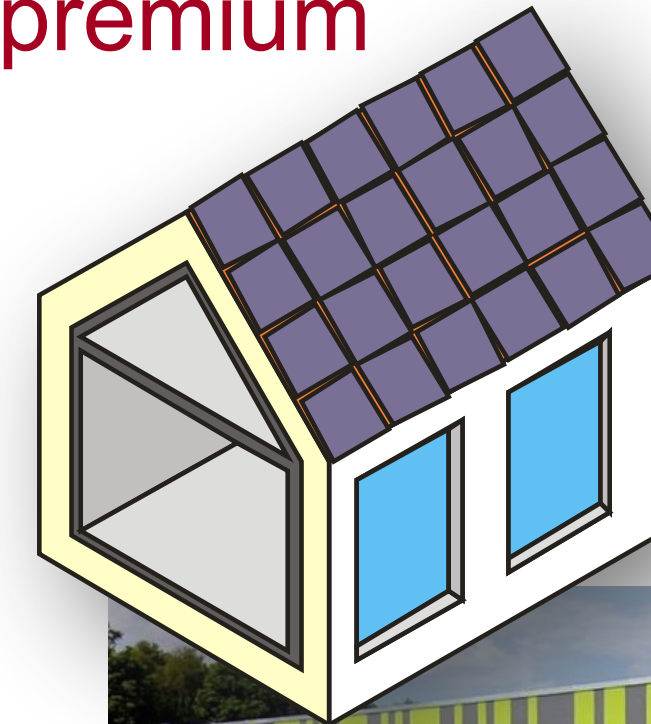
plus



Vienna |
aap.architekten ZT-GmbH



premium



...

+ Renewable energy generation (PER supply)
+ increased overall efficiency (PER demand)



Good Energy Haus

Single Family Home - Minneapolis, MN - 2020

First certified **Passive House Plus** in Minneapolis - New Construction





Good Energy Haus

- Exterior Walls: $U=0,95$ (W/ m²K)
- Slab: $U=0,184$ (W/ m²K)
- Roof: $U=0,079$ (W/ m²K)
- Windows:
 $U_f=0.81$ (W/ m²K), $U_g=0,53$ (W/ m²K), $g=0.55$
- HRV 85% eff
- Airtightness: $n_{50}=0.22$ / h
- Heating load: 19 W/ m²
- Cooling Load: 9 W/ m²
- Primary Energy Demand: 80 kWh/ (m²a)
- PER Demand: 37 kWh/ (m²a)
- Generation of Renewable Energy: 104 kWh/ (m²a)



Peak Load and On-Site Offset

Display monthly summary for: Heat & AC Total

Heat & AC Total [kWh]													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2021	663	733	31 ¹	-	-	-	-	-	-	-	-	-	1427
2020	-	-	-	-	-	-	-	-	-	-	-	294 ²	294

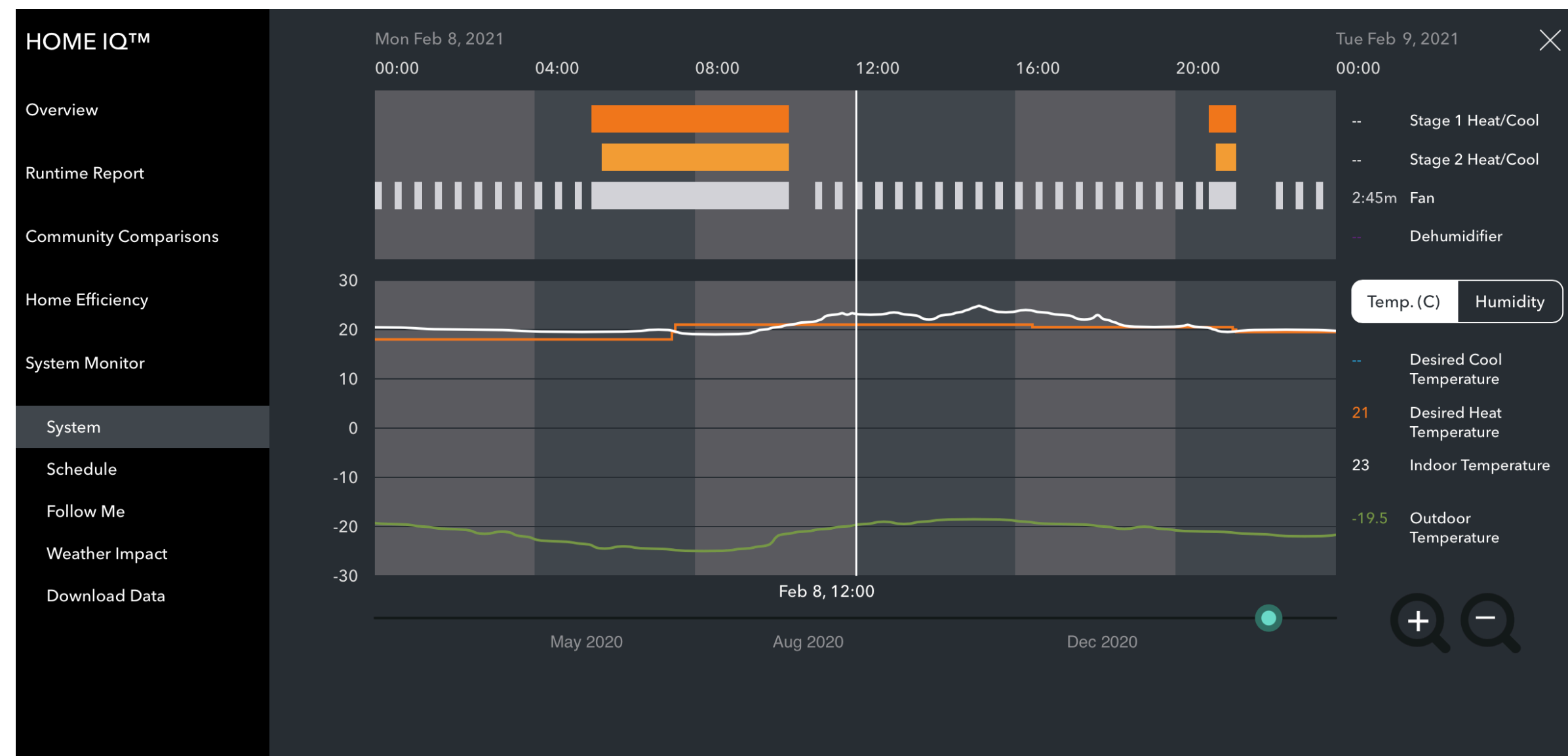
Footnotes:

- ¹: Ending 10:38am Mar 10, 2021.
- ²: Starting 07:02pm Dec 15, 2020.

Monitoring in progress

- Not a full year, yet: About 2,800 kWh/ yr predicted by PHPP for home
- Home and garage on same system (no individual monitoring available)

Since Jan 1st	
-Usage	-9,432.332 kWh
Generation	10,195.136 kWh
Cooking	-366.464 kWh
Dishwasher	-183.775 kWh
DHW	-432.849 kWh
Heat & AC Total	-2,850.765 kWh
Laundry	-503.744 kWh
Media Center	-155.585 kWh
Network	-389.359 kWh
Plug Loads	-2,087.551 kWh
Refrigeration	-259.785 kWh
Vehicle	-1,577.241 kWh
Ventilation	-587.416 kWh
Garage Receipts North	-13.892 kWh
Garage Receipts South	-23.907 kWh




Learning from Good Energy Haus

- Peak heat load reduction achieved
- On-site renewables provide 100% of annual site energy consumption (including transportation)

Passive House delivers sustainable, climate-neutral, cold-climate performance.


Certificate
Certified Passive House Plus



Herz & Lang
Architects & Engineers
House of the Future!

Herz & Lang GmbH
Die Planer für energieeffizientes Bauen
Ritzensonnenhalb 5a
87480 Weitnau, Germany

Authorised by:




Passive House Institute

Dr. Wolfgang Feist
64283 Darmstadt
Germany

Good Energy Haus

Minneapolis, USA



Certified
Passive House
Passive House Institute

classic | plus | premium

Client	[Redacted]
Architect	TE Studio, Ltd. 901 23rd Ave. NE 55418 Minneapolis, United States of America
Building Services	TE Studio, Ltd. 901 23rd Ave. NE 55418 Minneapolis, United States of America
Energy Consultant	TE Studio, Ltd. 901 23rd Ave. NE 55418 Minneapolis, United States of America

Passive House buildings offer excellent thermal comfort and very good air quality all year round. Due to their high energy efficiency, energy costs as well as greenhouse gas emissions are extremely low.

The design of the above-mentioned building meets the criteria defined by the Passive House Institute for the 'Passive House Plus' standard:

Building quality		This building	Criteria	Alternative criteria
Heating	Heating demand [kWh/(m ² a)]	14	≤ 15	-
	Heating load [W/m ²]	19	≤ -	10
Cooling	Cooling + dehumidification demand [kWh/(m ² a)]	6	≤ 15	15
	Cooling load [W/m ²]	9	≤ -	10
	Frequency of overheating (> 25 °C) [%]	-	≤ -	-
	Frequency of excessively high humidity [%]	0	≤ 10	-
Airtightness	Pressurization test result (n ₅₀) [1/h]	0.2	≤ 0.6	-
Non-renewable primary energy (PE)	PE demand [kWh/(m ² a)]	80	≤ -	-
Renewable primary energy (PER)	PER-demand [kWh/(m ² a)]	37	≤ 45	37
	Generation (reference to ground area) [kWh/(m ² a)]	104	≥ 60	48

The associated certification booklet contains more characteristic values for this building.

Weitnau, 30. October 2020
Certifier: Florian Lang - Raphaël Vibert, Herz & Lang GmbH

www.passivehouse.com
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Conclusions

- The 2,000-Watt Society is a strong vision for climate-neutrality, which leads us to optimized investments in efficiency and the clean grid
- The Passive House building energy standard (and EnerPHit for retrofits) provides the foundation for the effective and efficient use of the clean grid with storage
- The Passive House load profile is much more compatible with renewable energy sources with storage than current code, or other standards, which are less efficient
- The Passive House PER approach transparently illustrates “true” net-zero and climate-neutrality in the built environment and leads us down the path of adequate and climate-zone specific load shifting and energy storage solutions

Resources

- 2,000-Watt Society: <https://ourworld.unu.edu/en/2000-watt-society>
- Passive House: <https://passivehouse.com>
- Passive House PER: https://passipedia.org/basics/energy_and_ecology/primary_energy_renewable_per



Thank You!

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