PhiusGEB + Microgrids:

Tapping into the Synergies Toward Building Decarbonization

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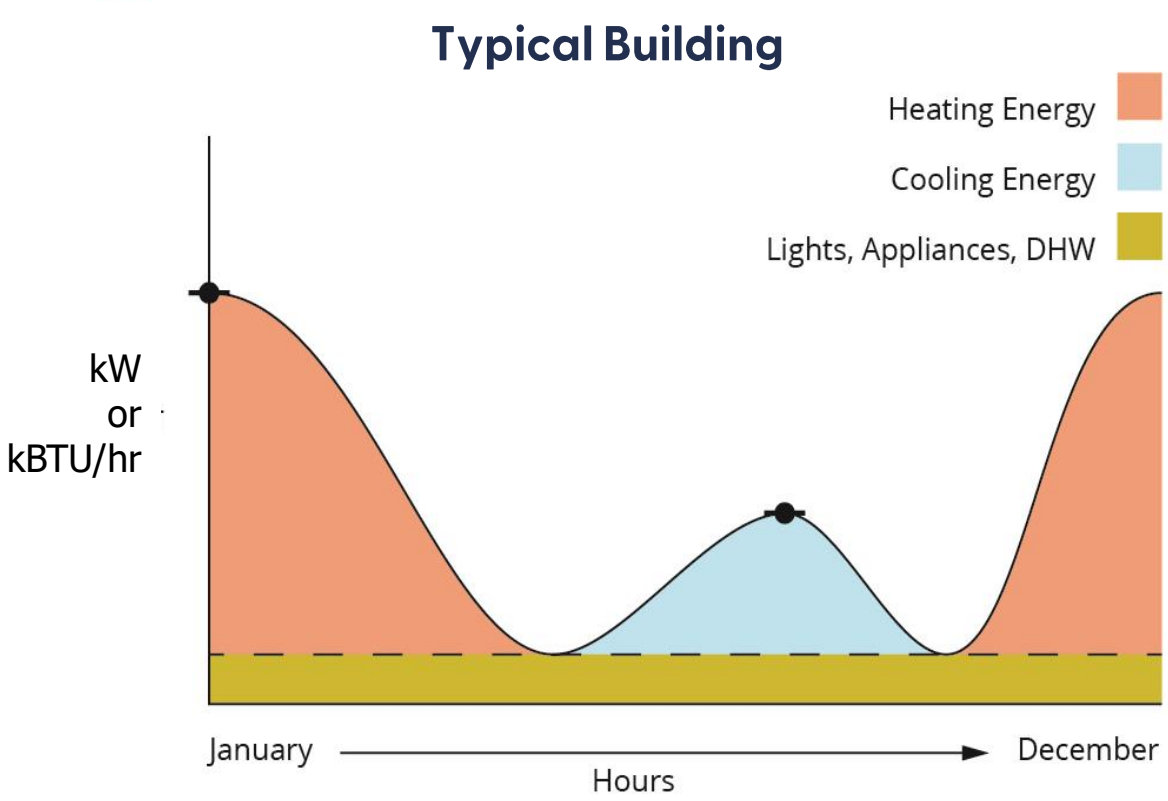
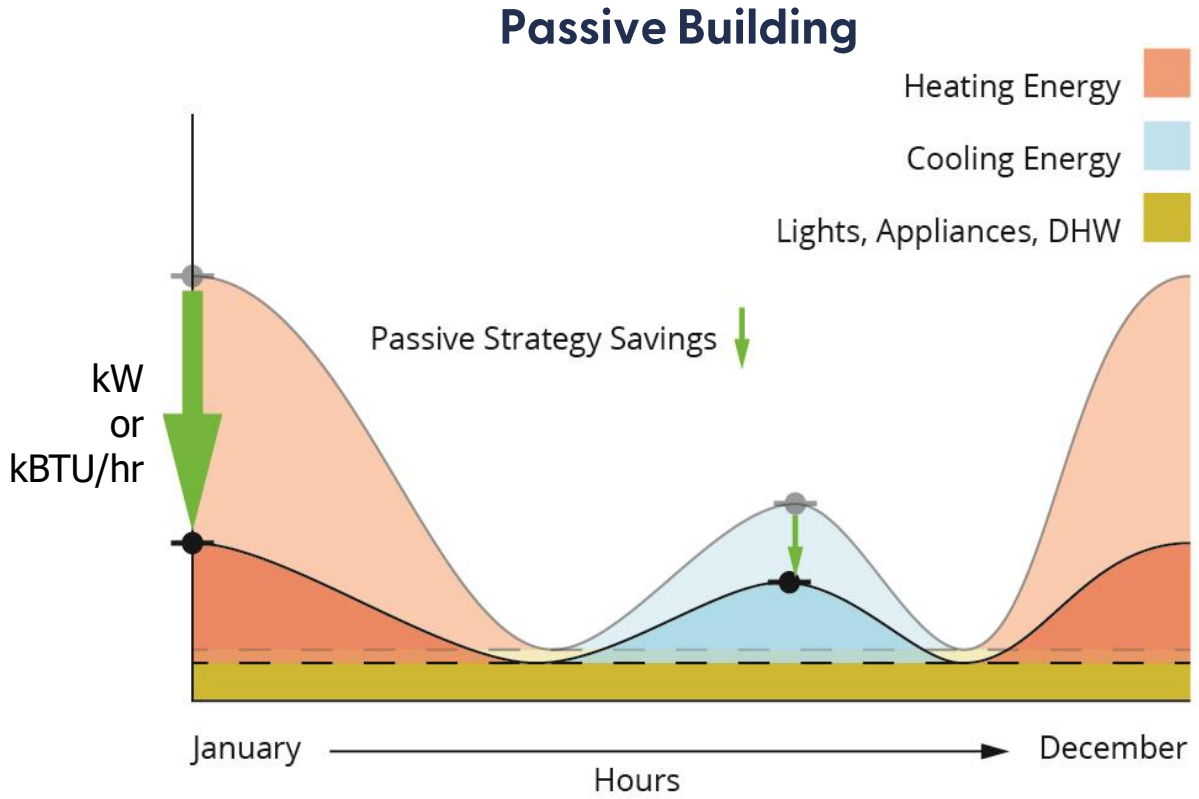
PhiusCon 2022 – Chicago, IL

Passive Building





Annual Energy = kWh/yr (or kBTU/yr) → area under the curve
Peak Power = kW (or kBTU/hr) → point at top of curve

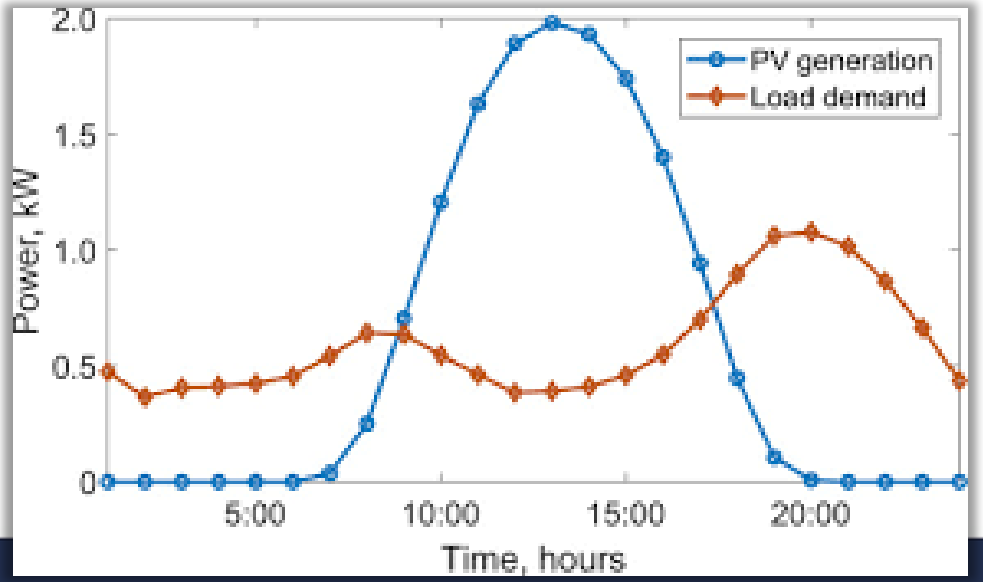
NET SOURCE ENERGY *GOALS*

Phius CORE: Targeting the sweet spot for on-site conservation through passive and active strategies
Phius ZERO: Targeting annual net source zero operational energy

Existing Framework for Phius ZERO

Annual "Net" → all kWh's used are accounted for equally (Phius uses Source Energy as the measurement)

Produce or procure as much renewable as the building uses on an *annual* basis.

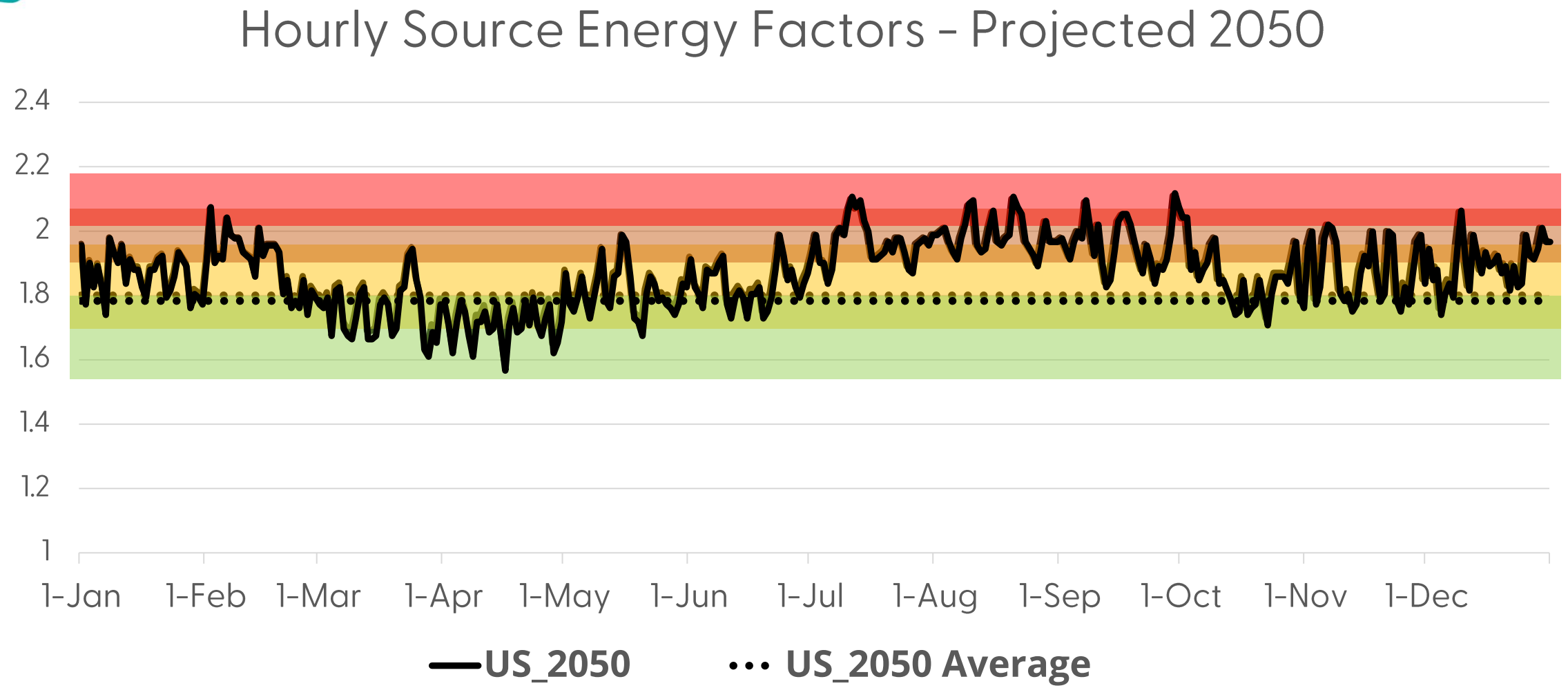


Existing Phius ZERO Framework

Calculating Annual Source Energy

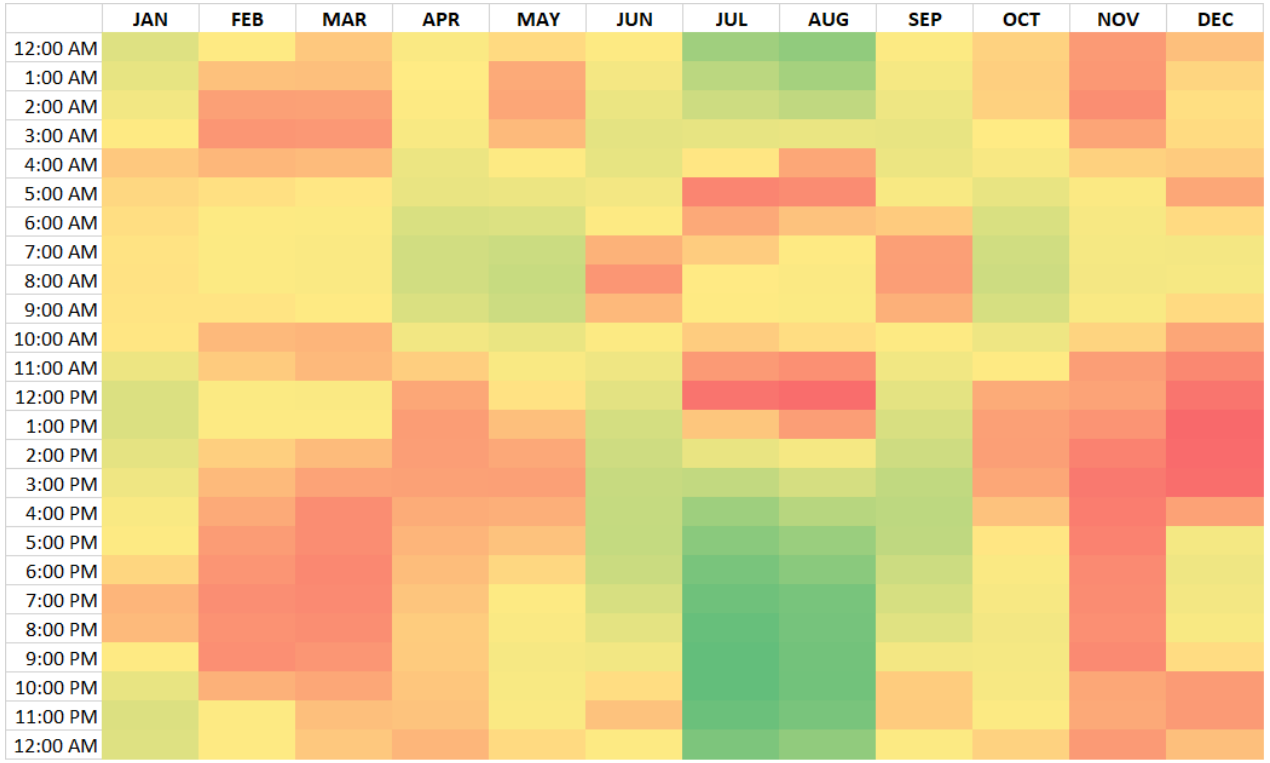
Calculating Annual Source Energy Offset by Renewable Energy

In reality…time of use matters

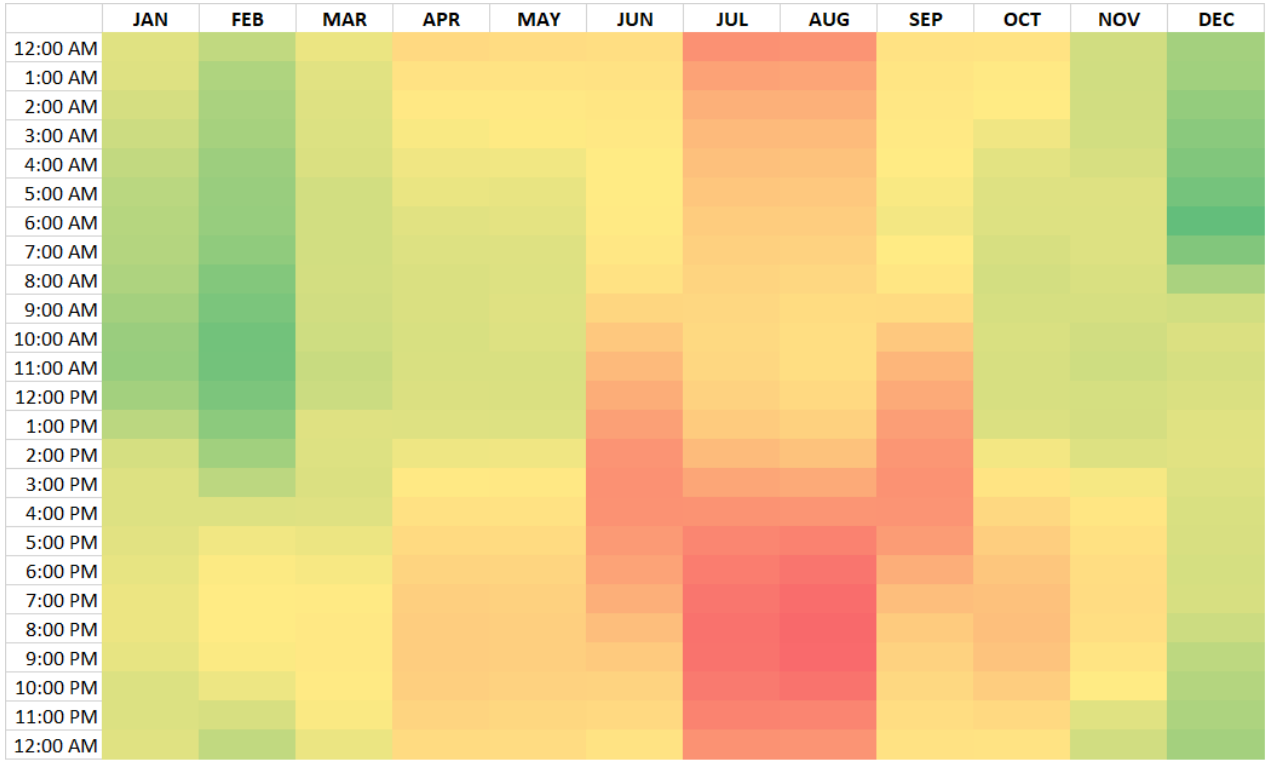


HOURLY MARGINAL CARBON EMISSIONS

CHICAGO, IL - 2019

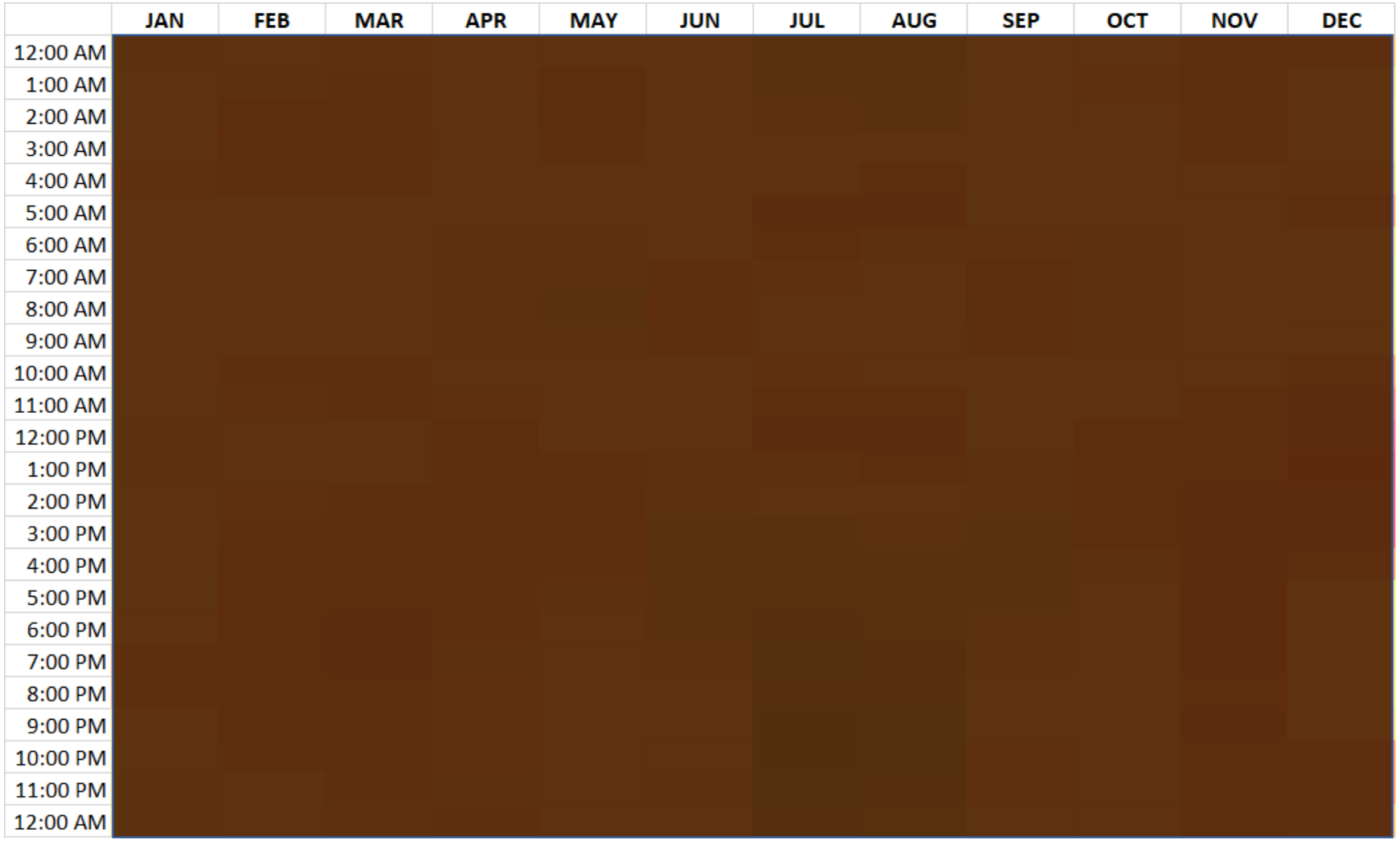


LOS ANGELES, 2019



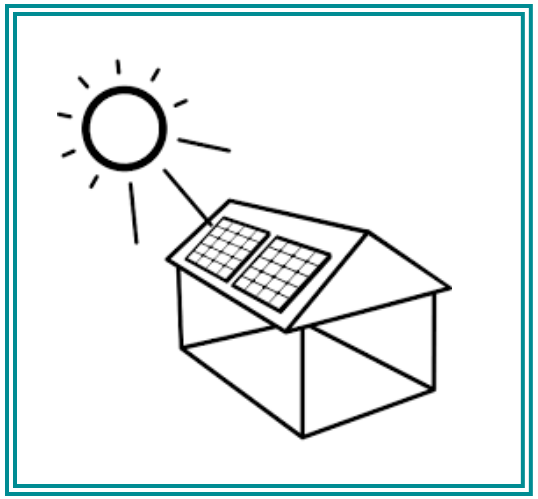
Source: WattTime

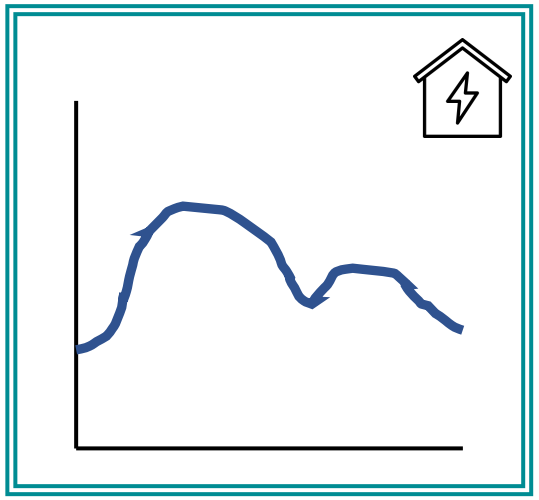
Typical Simplified Source Energy Accounting



Timing is important.

***When** is the renewable energy being produced?*
What grid factor/emissions is it offsetting?

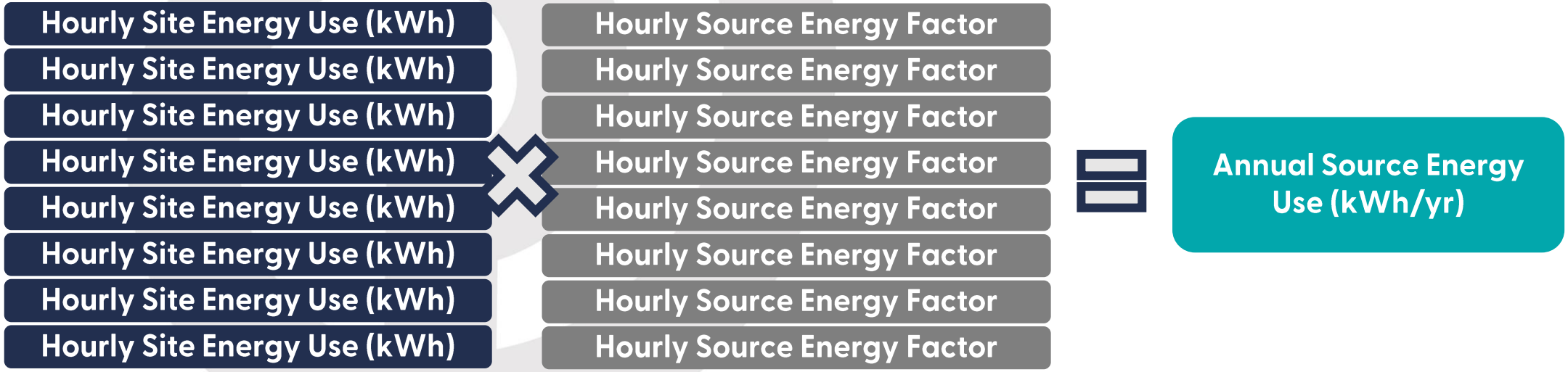




***When** is energy being used?*
What marginal emissions factor is it using?

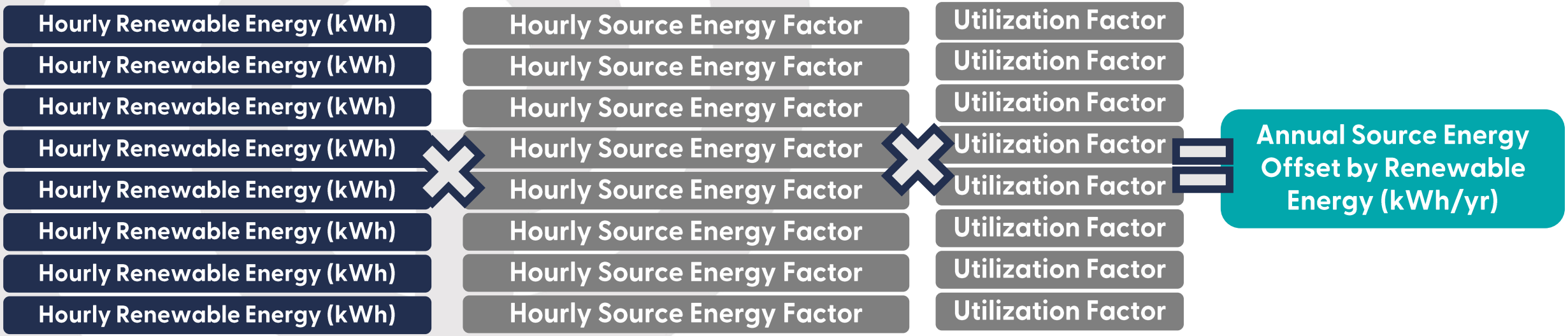
Hourly to Annual Framework

for calculating Annual Source Energy



Hourly to Annual Framework

for calculating Annual Source Energy Offset by Renewable Energy



So, we have an accounting problem…

So what?!

There’s more to it.

Consider the Goals of Phius ZERO →

1st → Achieve a resilient, healthy, low load building and meet Phius CORE

2nd → Go *beyond* Phius CORE to:

- **Further reduce operational CO_2 emissions**
- **Further facilitate more renewable energy resources**
  - **Producing Onsite &**
  - **Procuring Offsite (varying factors)**

'Net Zero' doesn't get to true zero.

How else can we further accomplish these goals?

‘Net Zero’ addresses “how much”

But on its own does not address 2 key concepts that further reduce operational emissions and facilitate grid decarbonization:

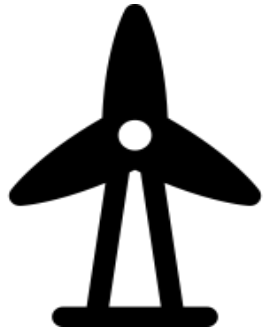
Low Peak Loads

Timing of Energy Use

Phius CORE
Phius ZERO

Grid Decarbonization

Requires thinking beyond the building

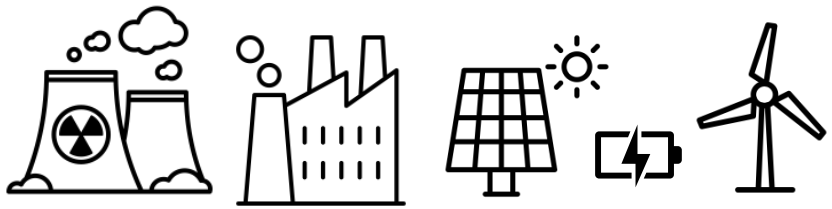


How do the decisions at this scale… Impact the decisions at this scale?

Existing Grid → Changing Grid

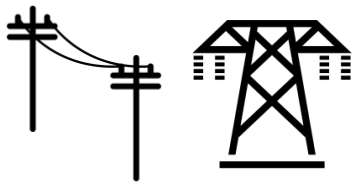
Supply Side

GENERATION CAPACITY



Centralized	De-Centralized
Dispatchable & fossil fuel based	Intermittent & renewable
Significantly over-sized for reliability & to meet peak coincident load	(Ideally) Sized appropriately to meet a 'smart' load

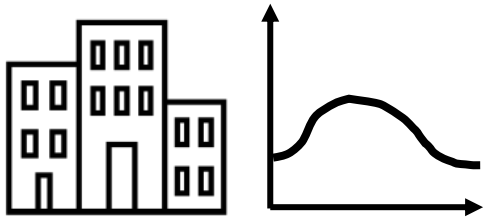
TRANSMISSION + DISTRIBUTION INFRASTRUCTURE



Sized to meet existing supply peak based on *controlled* supply	Must be upgraded, sized to meet *uncontrolled* supply with larger supply peaks

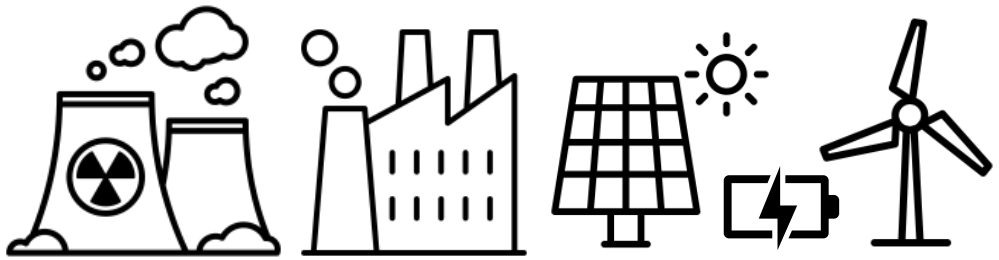
Existing Grid → Changing Grid

Demand Side



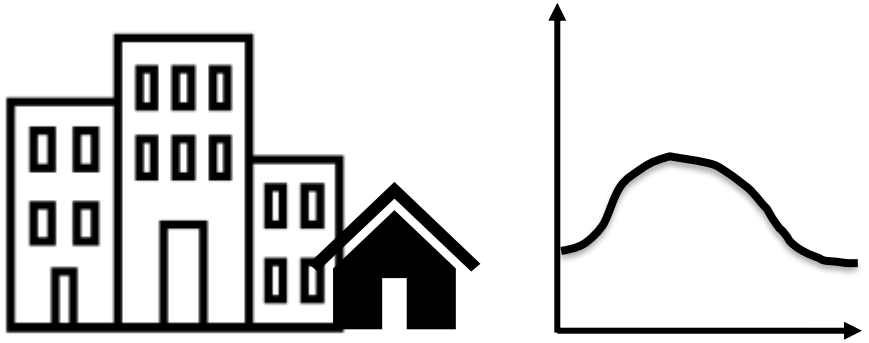
BUILDING LOADS

Inflexible loads	Flexible Loads
Minimal communication with supply side, very little responsive to resource availability	Enhanced communication with supply side, responsive to resource availability
Peak in SUMMER due to air conditioning loads	Peak in WINTER due to electrified heating loads



Supply Side

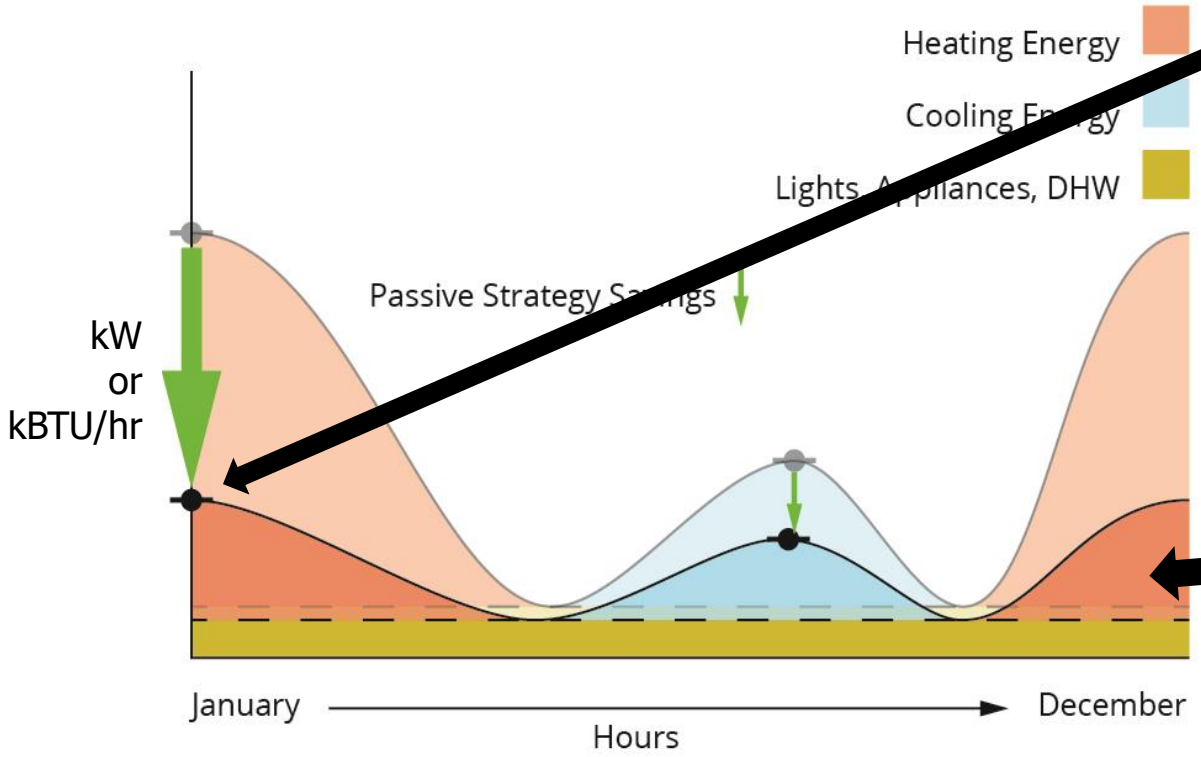
More Control



Demand Side

Less Control

Grid Decarbonization / Renewable Transition



Infrastructure & Capacity ($$)

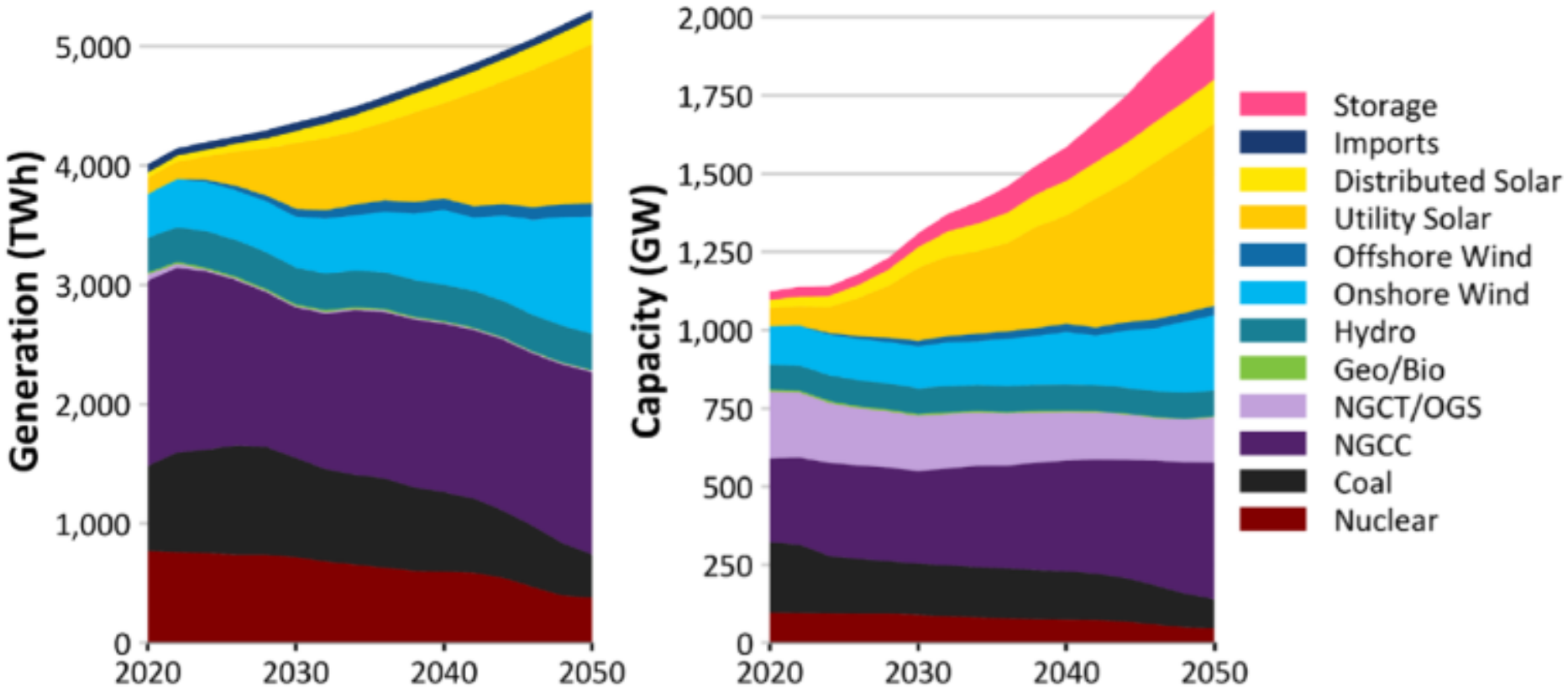
= driven by peak loads

CO_2 Emissions

= driven by how much energy use and timing of use

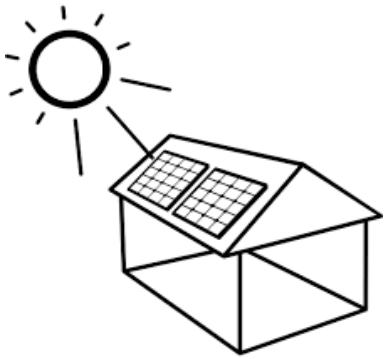
NREL Cambium Model – 2050 Mid Case Scenario for US Grid Electricity Capacity and Generation Mix

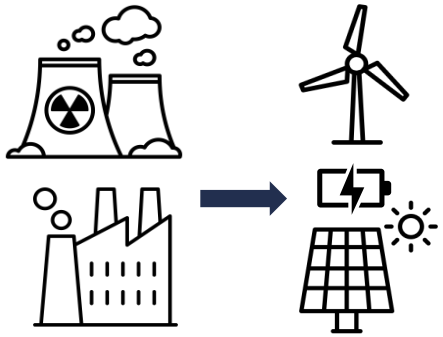
GOAL = Increase Utilization of Renewable Capacity



Decarbonization Movement
Keys to Success

1. Lower loads
2. Make loads flexible and responsive



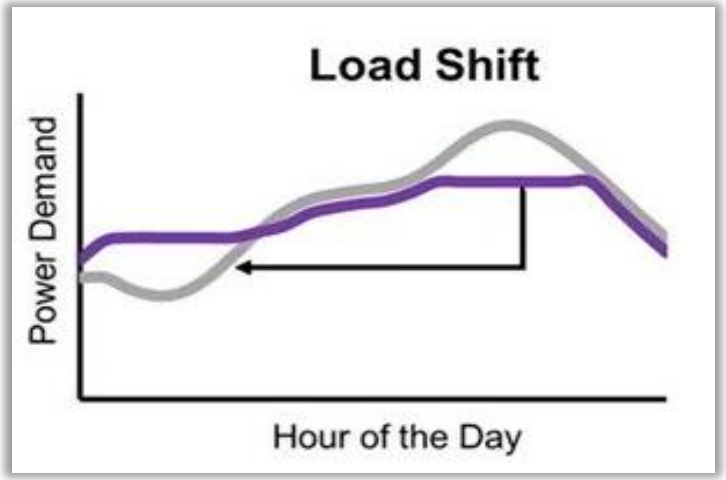


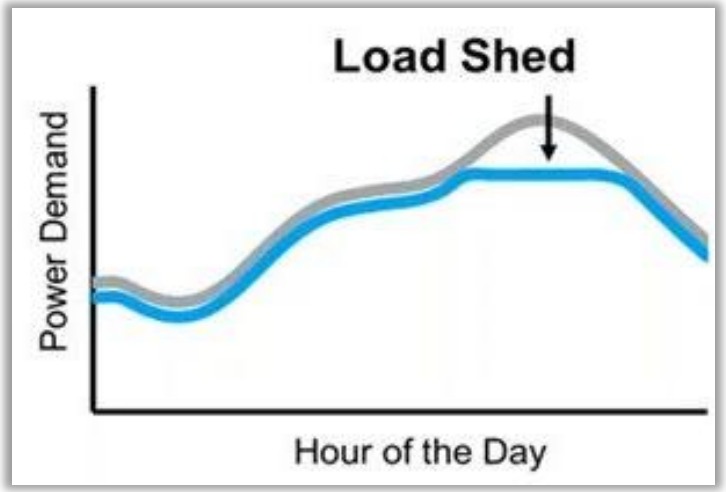
Enable the building loads to be “smart” & responsive to grid signals

GEB =

Grid-Interactive
Efficient
Building

GEBs Toolkit: Load Shifting & Shedding



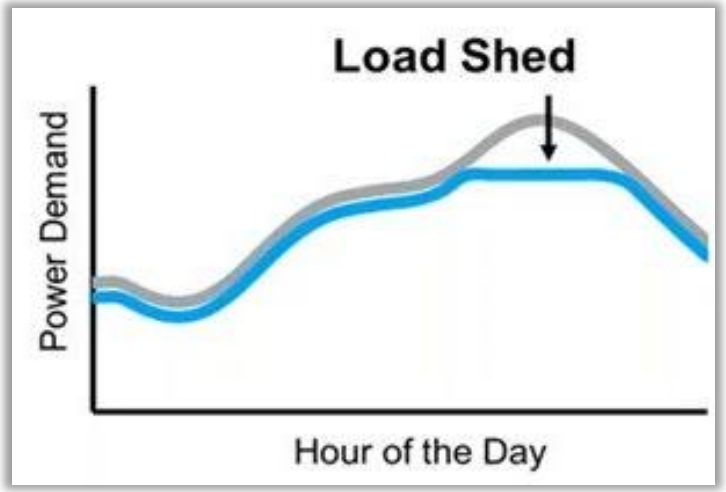


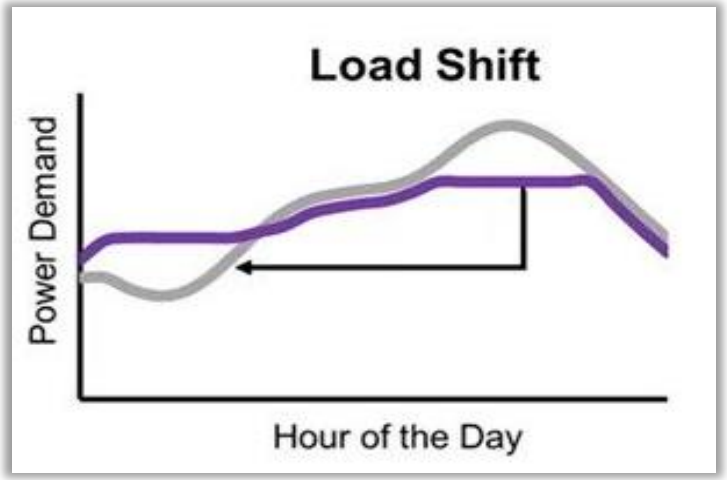
Focus to on **when** buildings are consuming energy as opposed to **how much** energy is being consumed.

Reduce energy use at peaks / times of high grid stress based on response signals.

GEB + Passive Building Synergy

Passive building enclosures makes load shedding and shifting more accessible – adding inherent thermal storage capabilities to the GEB toolkit.





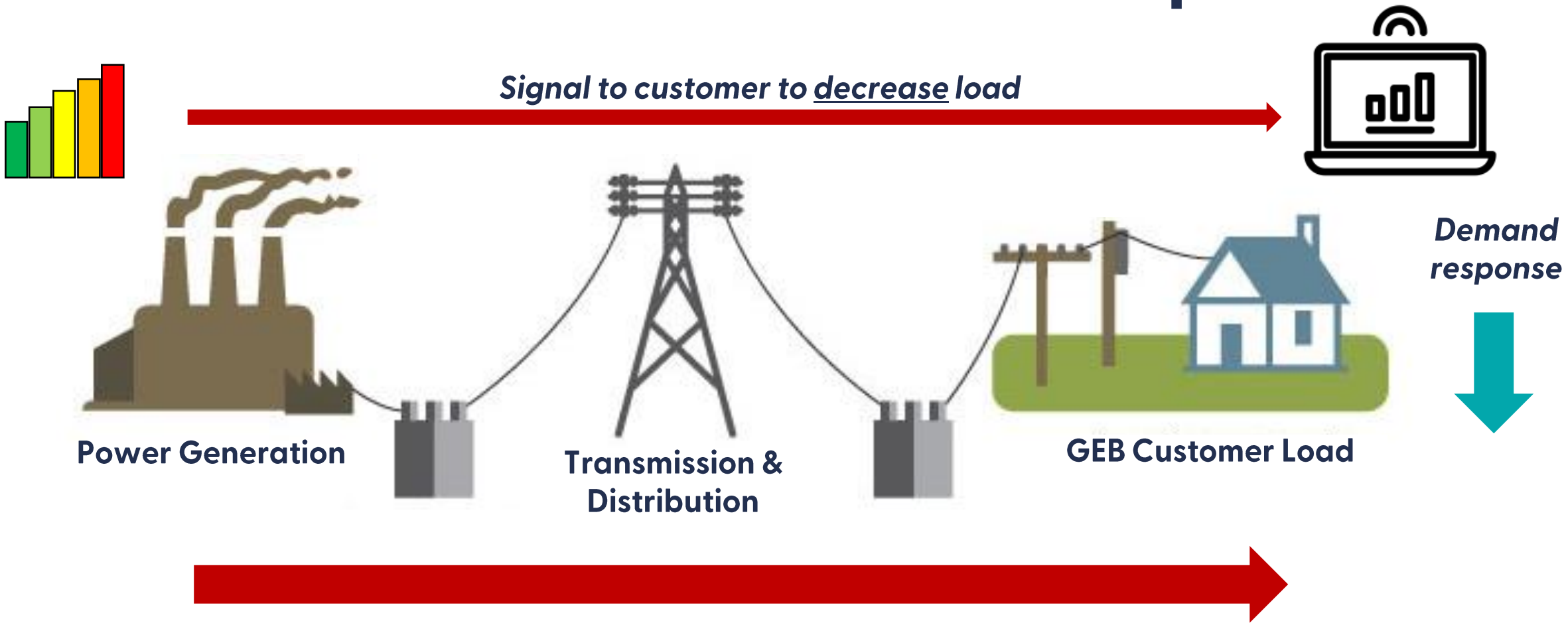
Current Electric Grid Infrastructure

Load increases (one way communication)

Power flow

Source: Adapted from National Energy Education Development Project (public domain)

GEB Scenario – Demand Response



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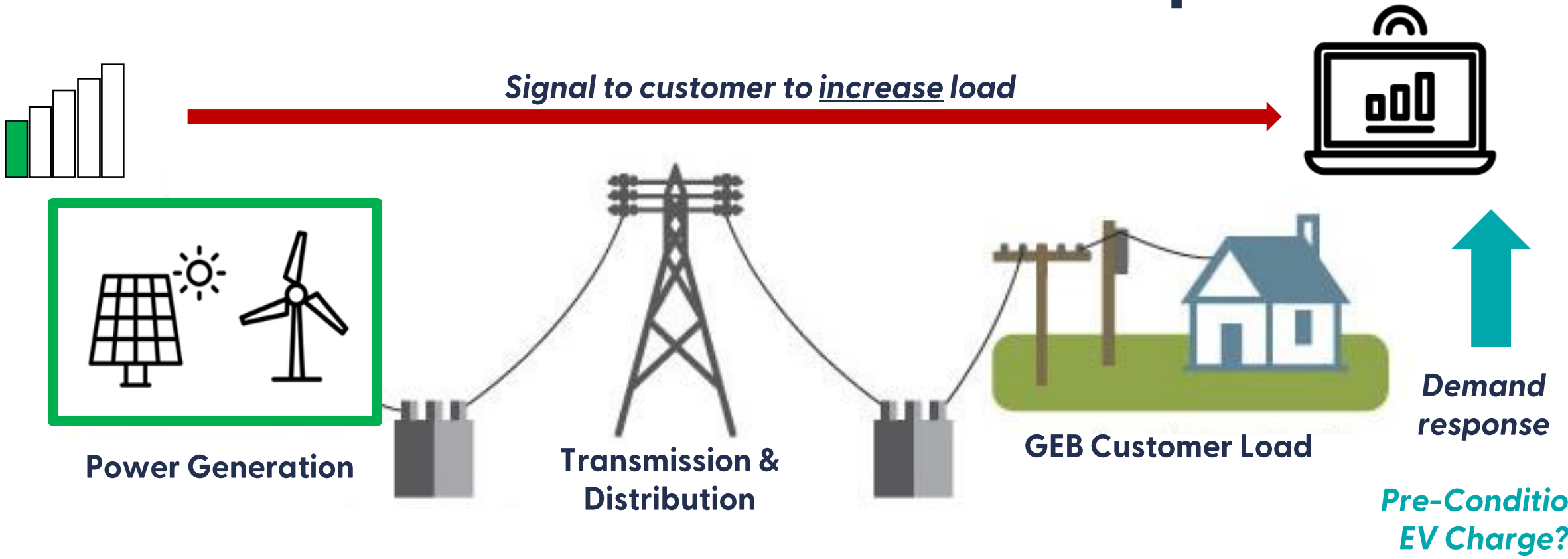
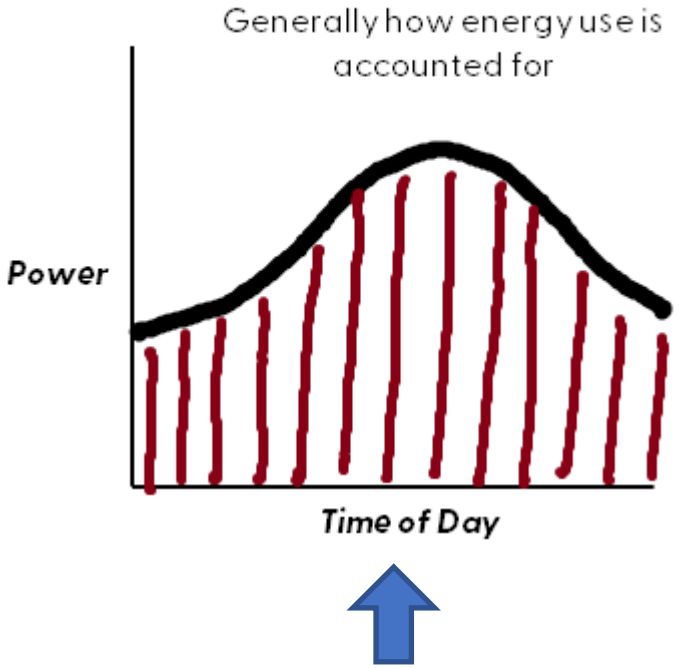
GEB Scenario – Demand Response

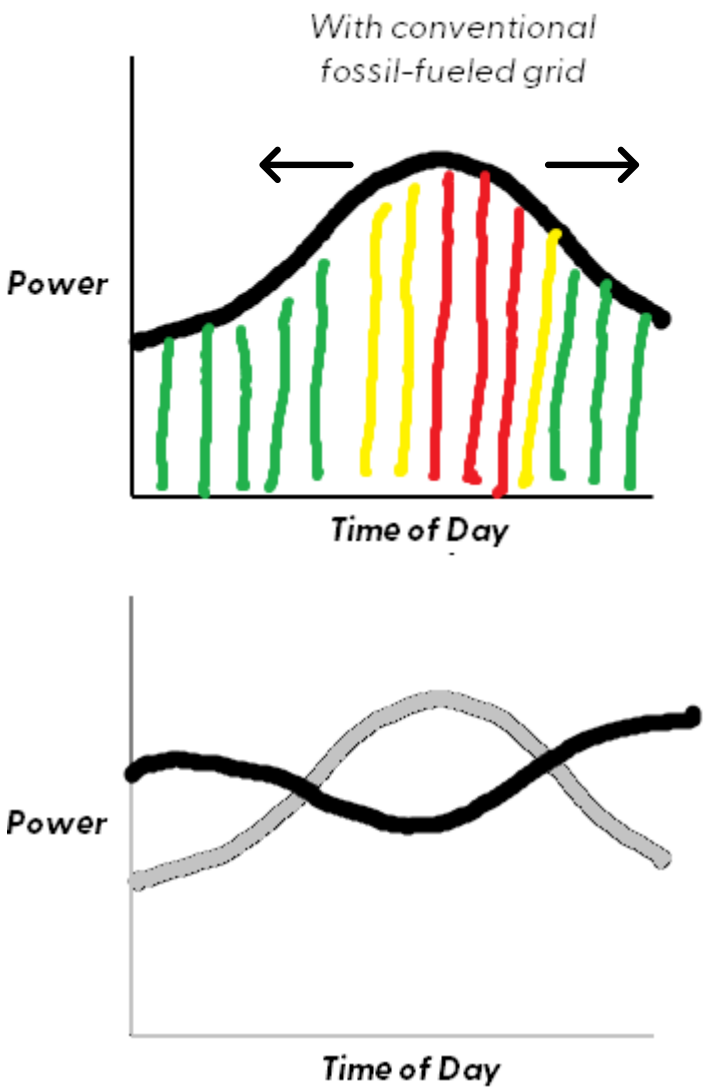


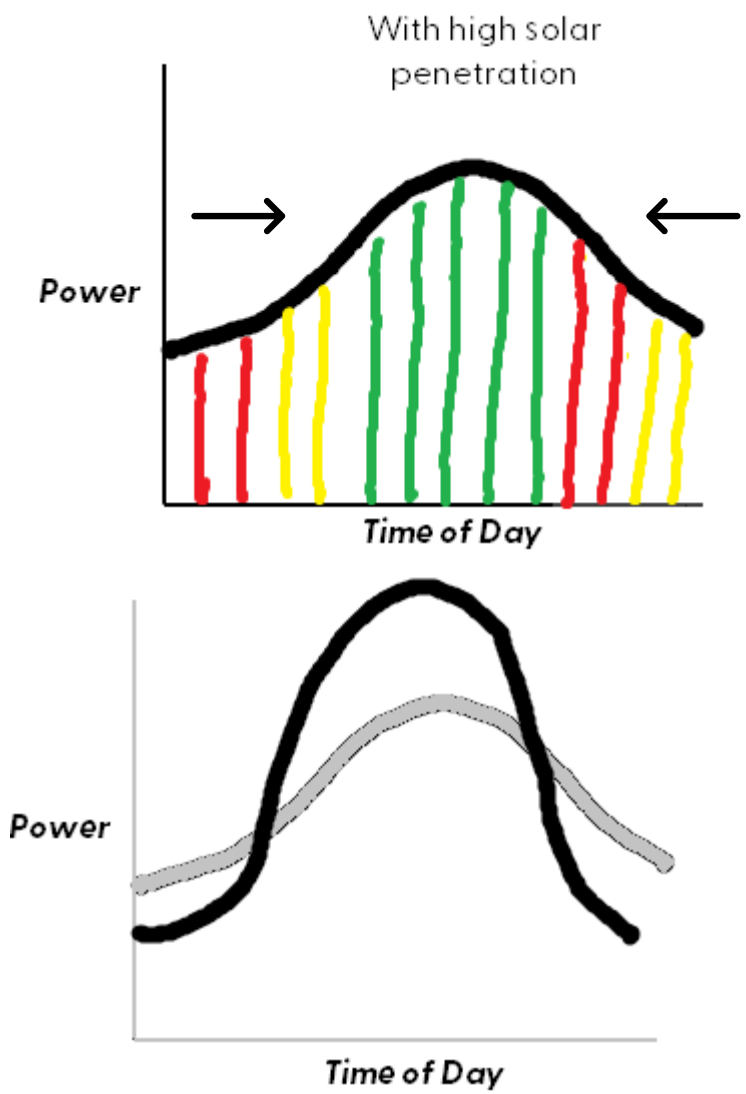
Source: Adapted from National Energy Education Development Project (public domain)

The “when” will become very important.



Typically use flat rate accounting, even though there are varying emission factors based on load profile and grid mix

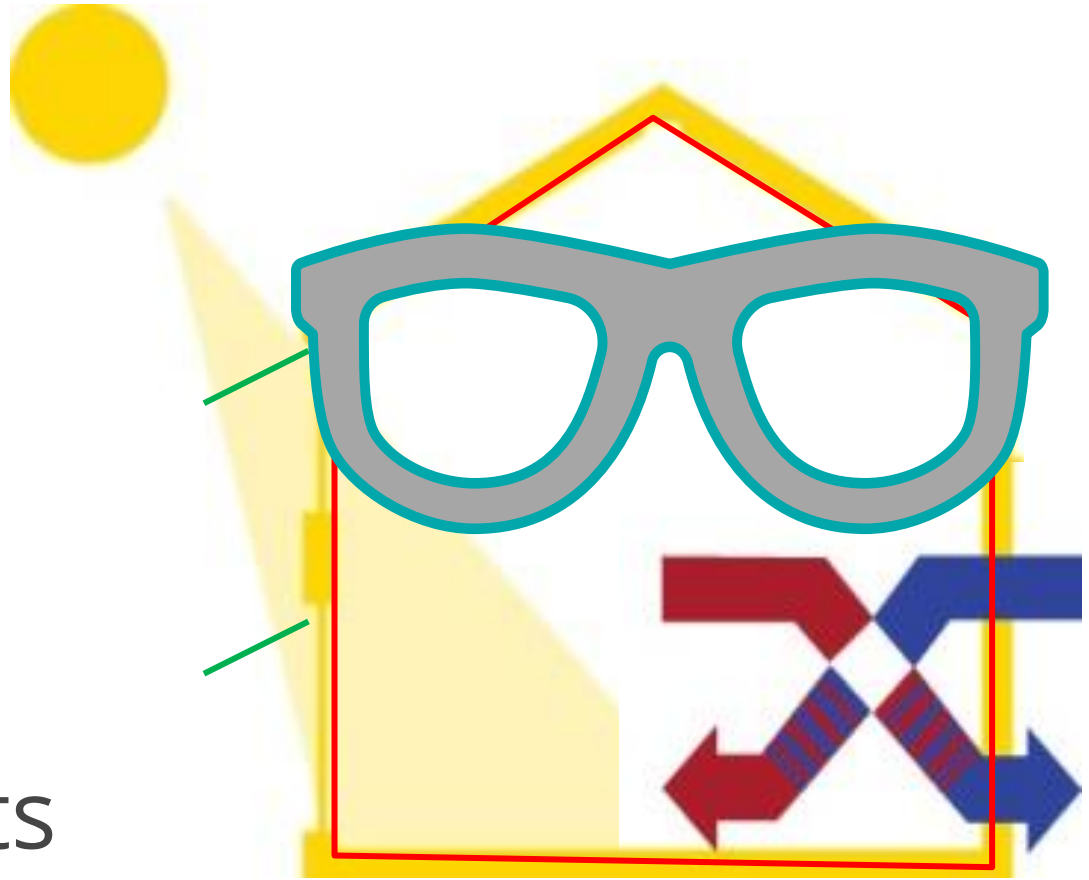




“PhiusGEB” – All About the Load Profile

Phius CORE as a baseline

- Load Flexibility Rating
  - Shave load
  - Increase load
- Critical Loads
- Facilitates Responsiveness
- Generation Components
- Energy Storage components

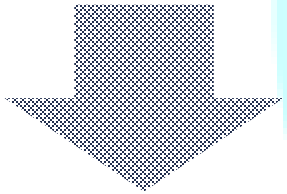


WARNING: Not a real program, yet.

Goals of PhiusGEB

Decrease building energy use & peak loads

Increase building load flexibility & control to align remaining loads with clean or renewable energy



Helps facilitate more renewable energy into grid mix while reducing grid stress/peaks

Reduces amount of renewable energy needed to replace existing power generation & meet future demands

The Opportunity

Phius + GEB =

Energy Efficiency	*Connectivity*
Resilience	*Responsiveness*
Durability	*Smart*
Comfort	*Generation & Storage*
Heating/Cooling Load Flexibility	*Other Load Flexibility*

PhiusGEB

Decarbonization Movement
Keys to Success

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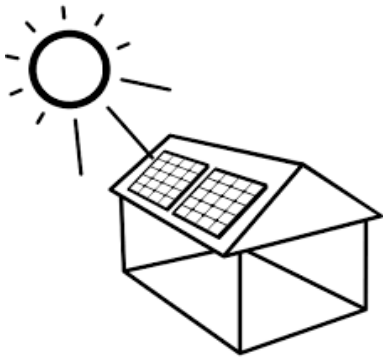
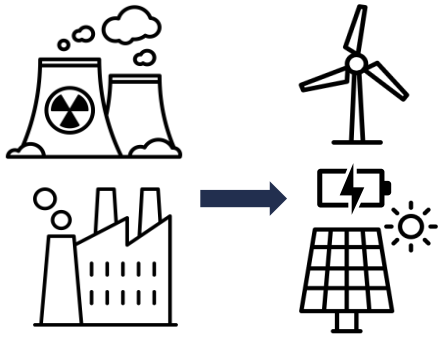
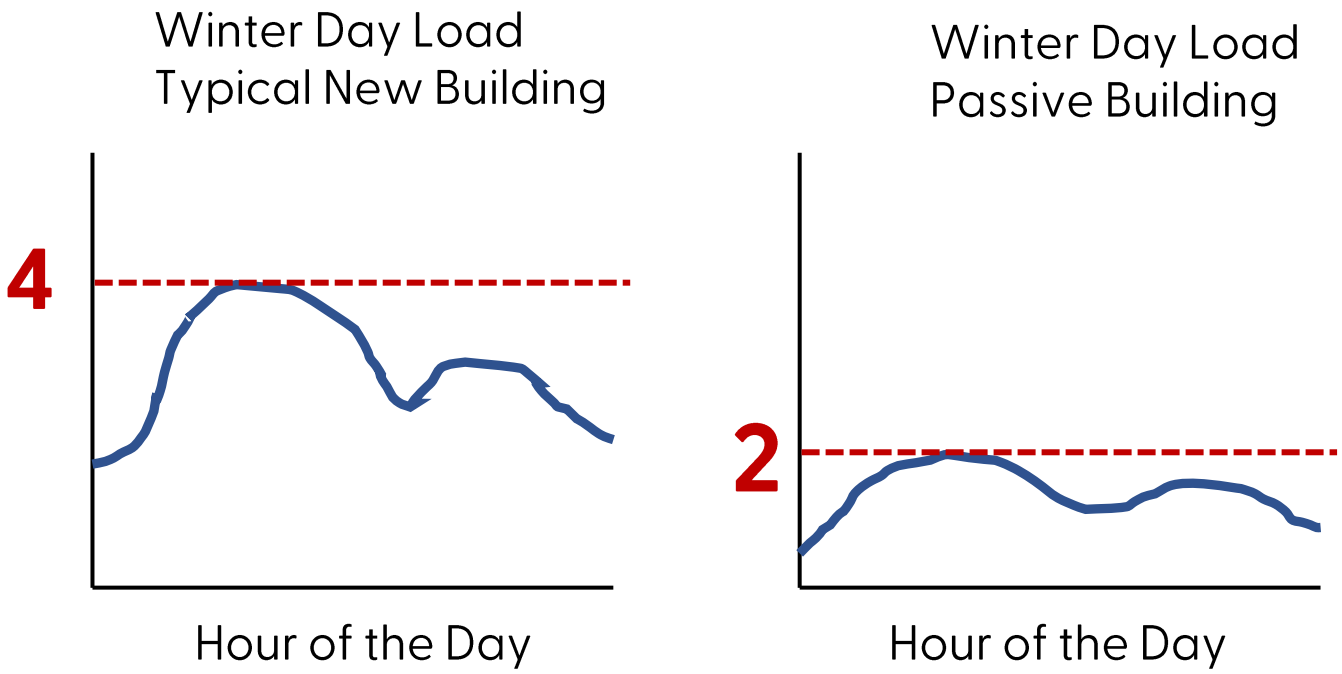




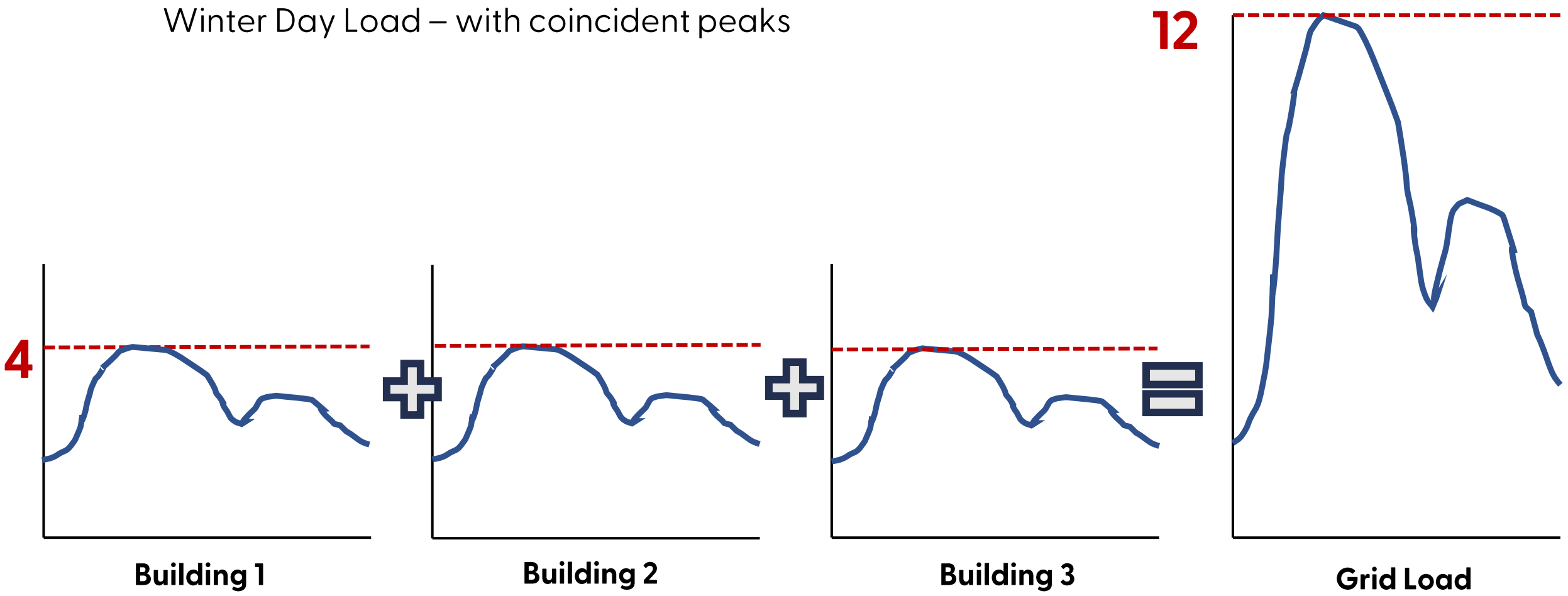
The peak is changing: WINTER IS COMING

Electrifying heating systems in buildings will shift the grid peak to the winter.



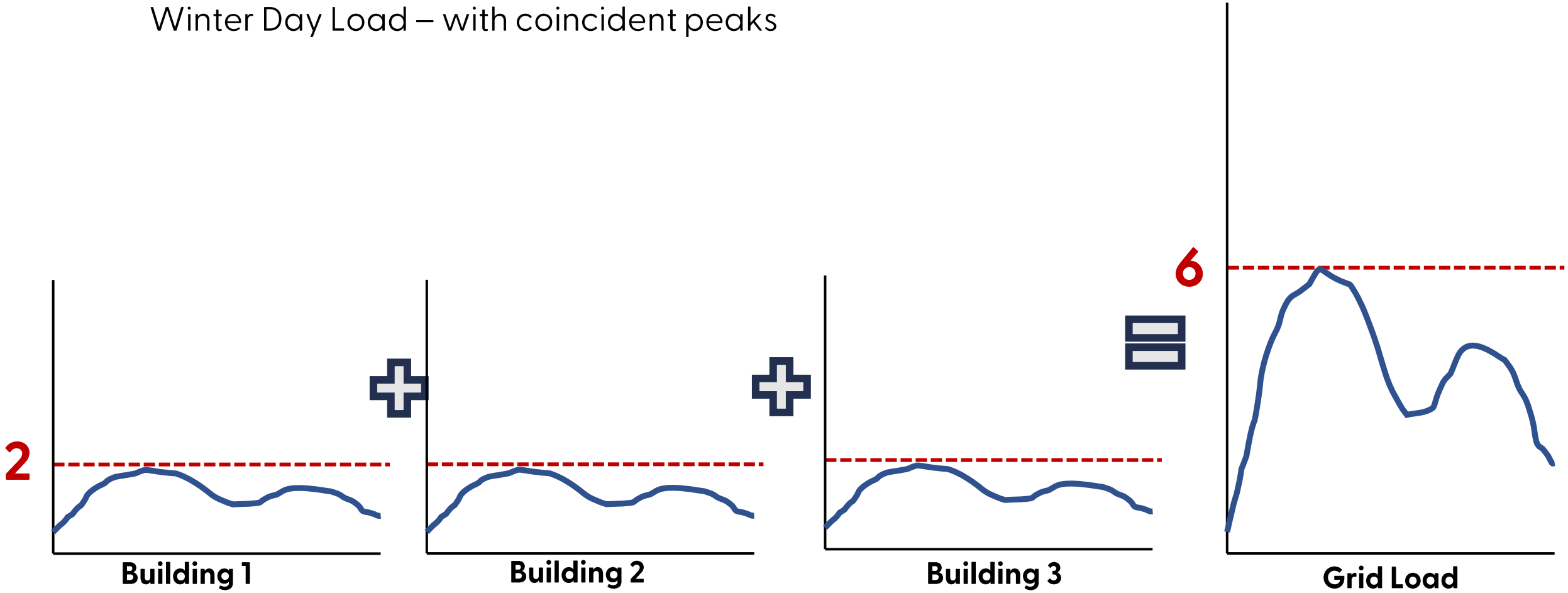
3 *Typical* Building Winter Peaks

Winter Day Load – with coincident peaks



3 *Passive* Building Winter Peaks

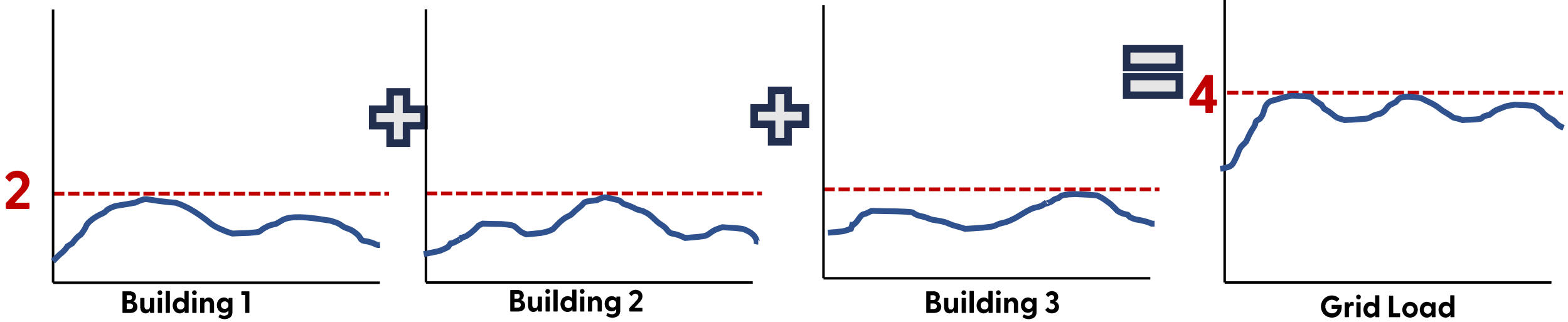
Winter Day Load – with coincident peaks



3 *Passive + GEB* Building Winter Peaks

Winter Day Load – with **GEB load shifting & smart technology**

Passive building enclosure acting as thermal storage.



The Opportunity - PhiusGEB

Phius ZERO + GEB

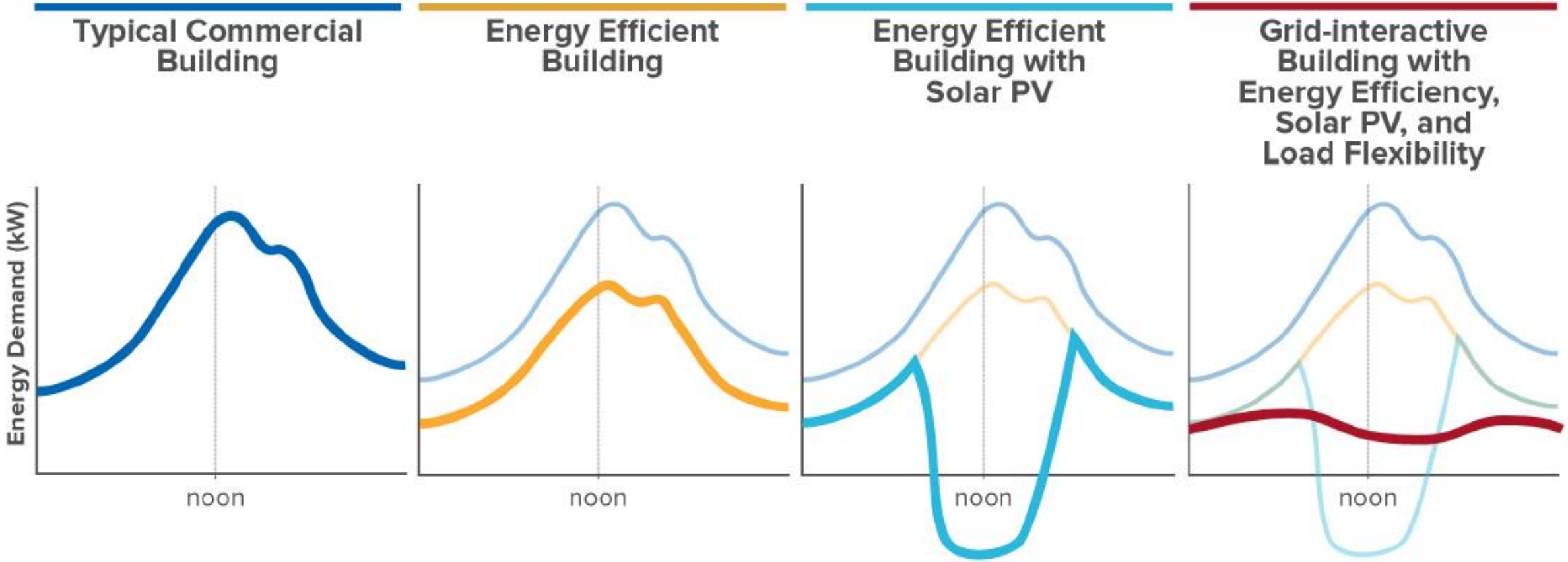


Image Source: RMI/GSA

What else can we do to achieve these goals?

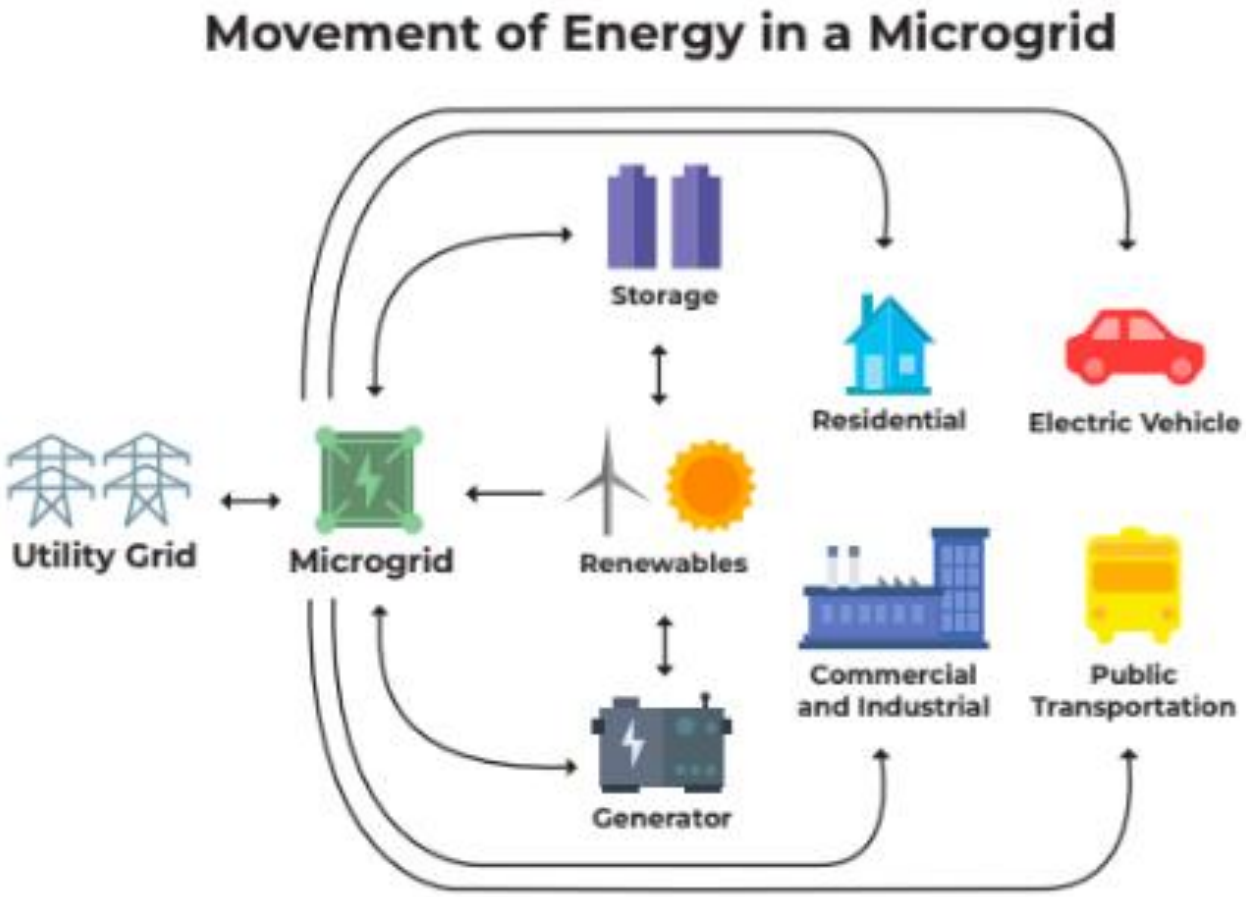
(Further reduce operational emissions + facilitate grid decarbonization?)

Microgrids

From a unidirectional power grid to more of a “mesh” network

Key Components:

- Energy demand from buildings with grid-enabled loads **(maybe PhiusGEBs!)**
- Energy generation
- Energy storage
- Microgrid Energy Manager/Optimization System
- (Optional: Electric Vehicles)



Microgrid Manager:

When 1 kWh is produced, where should it go? Many options.

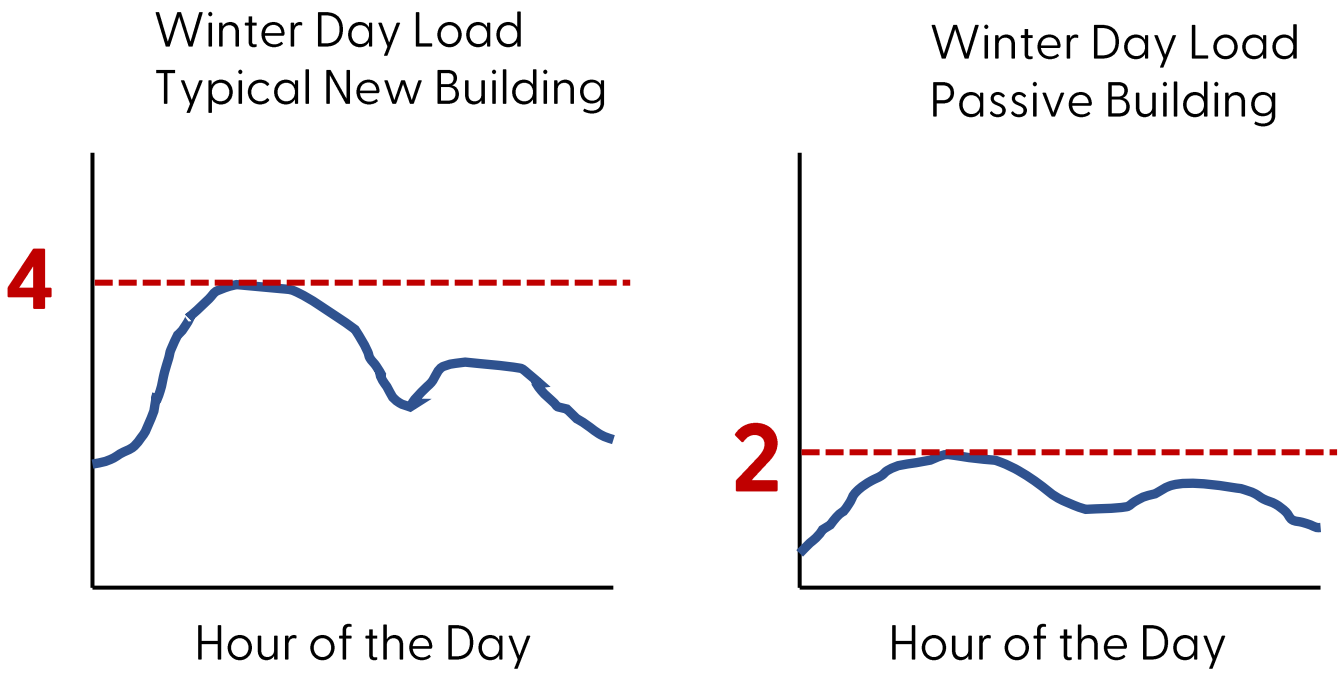
If it's in a time of low supply:
- Serve "most critical load"

If in a time of excess supply:
- Electrical Energy storage (stationary or EVs)
- Shift non-critical load to use it
- Thermal energy storage (condition a space past its setpoint so that load is lower later in the day)

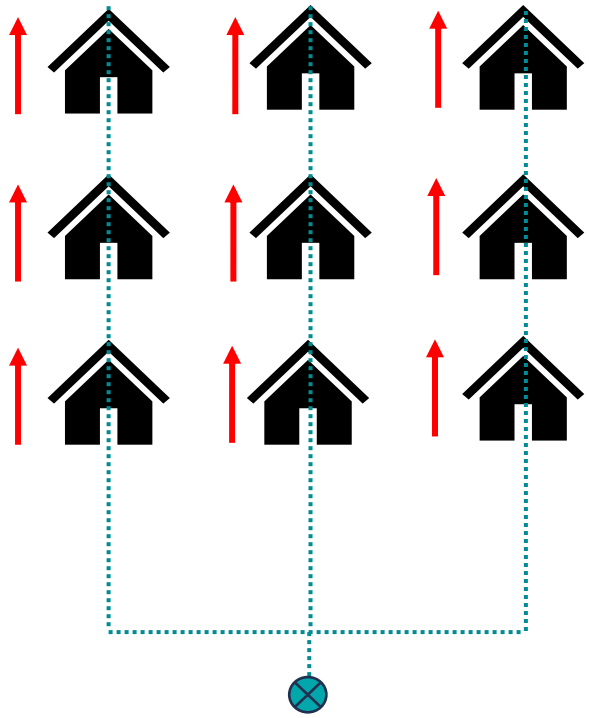
When a building adds a new load, how should it be met?
- Renewable energy
- Storage
- Is it critical, can the building shed the load?
- Main utility grid?

The peak is changing to the WINTER

Electrifying heating systems in buildings will shift the grid peak to the winter.



Baseline Building + Typical Centralized Grid

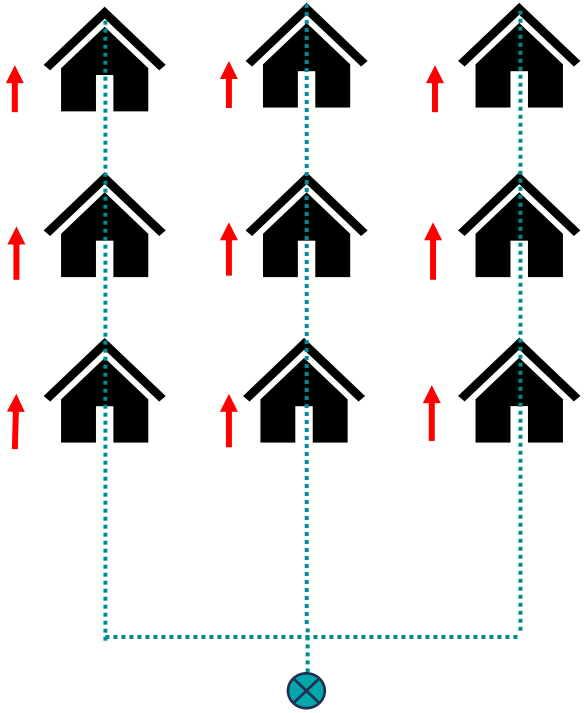


Sum of coincident peaks

Peak per building = 4

Grid peak = 9🏠 x 4 = 36

Baseline Building + Typical Centralized Grid + GEB Load Shifting or Shedding



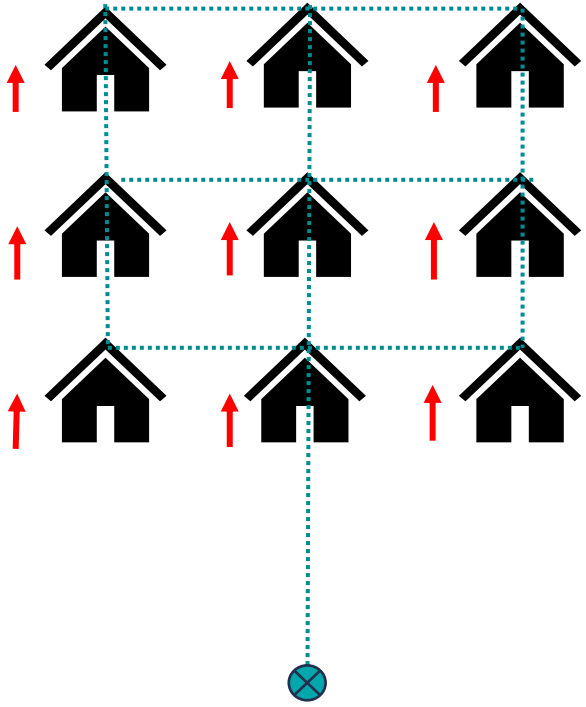
Sum of coincident peaks

Peak per building = 2

Grid peak = 9🏠 x 2 = 18

(Central Grid Signal)

Baseline Building + Microgrid Control + GEB Load Shifting or Shedding



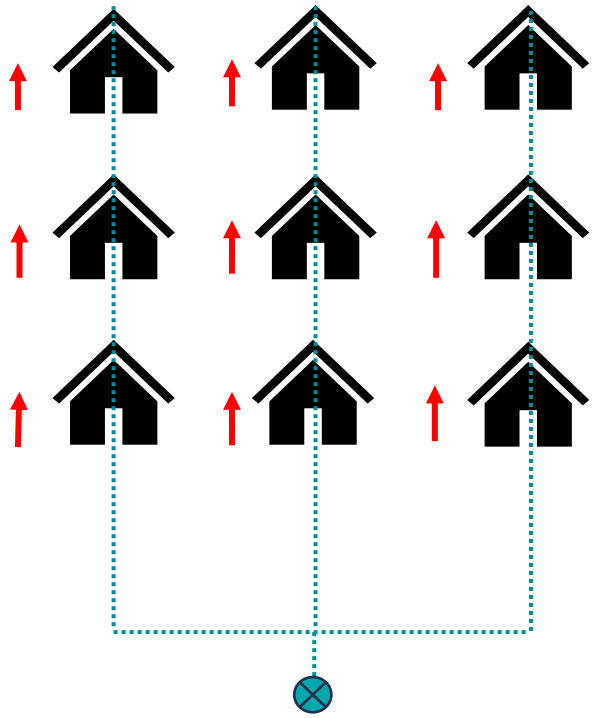
Sum of coincident peaks

Peak per building = 2

Grid peak = 3🏠 x 2 = 6

(Grid Signal + Manager between Buildings)

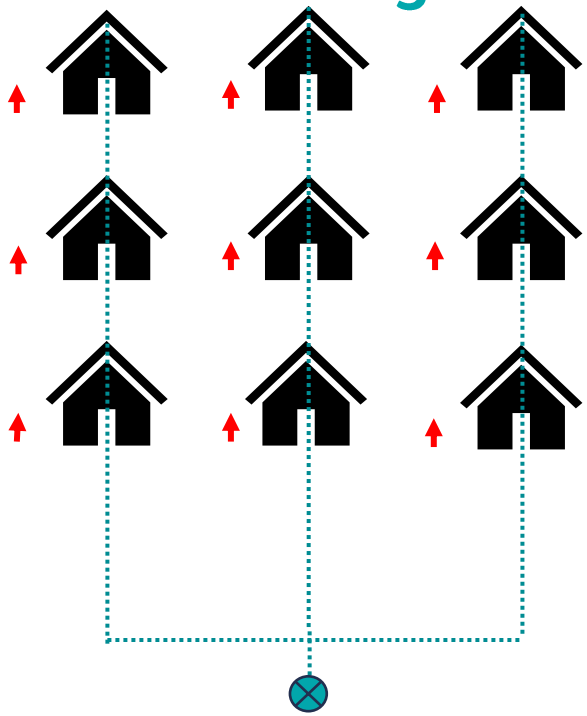
Passive Building + Typical Centralized Grid



Sum of coincident peaks

Peak per building = 2
Grid peak = 9 x 2 = 18

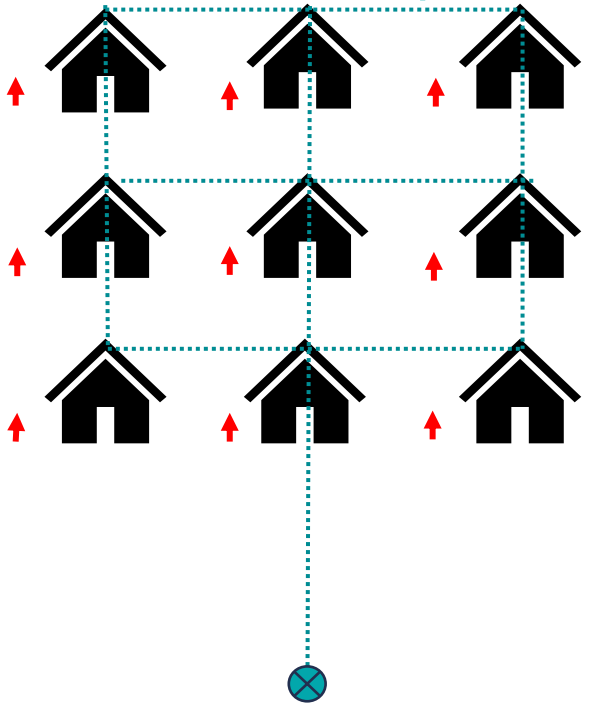
Passive Building + Typical Centralized Grid + GEB Load Shifting or Shedding



Sum of coincident peaks

Peak per building = 1
Grid peak = 9 x 1 = 9

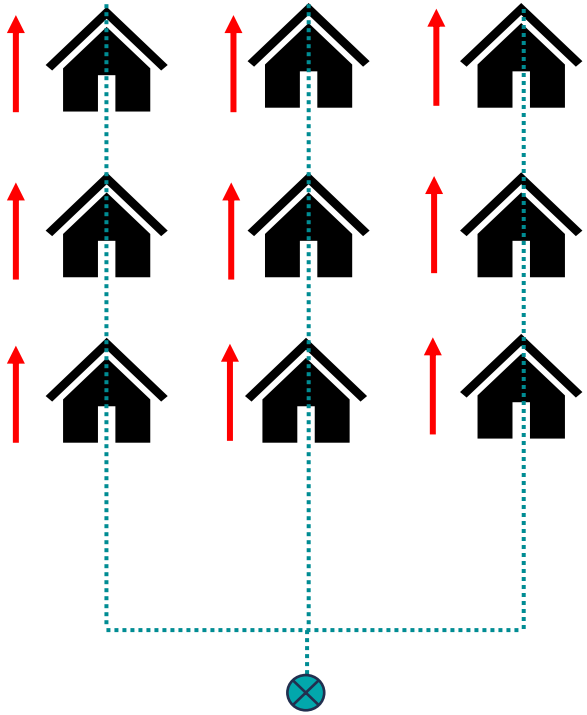
Passive Building + Microgrid Control + GEB Load Shifting or Shedding



Sum of coincident peaks

Peak per building = 1
Grid peak = 3 x 1 = 3

Baseline Building +
Typical Centralized Grid

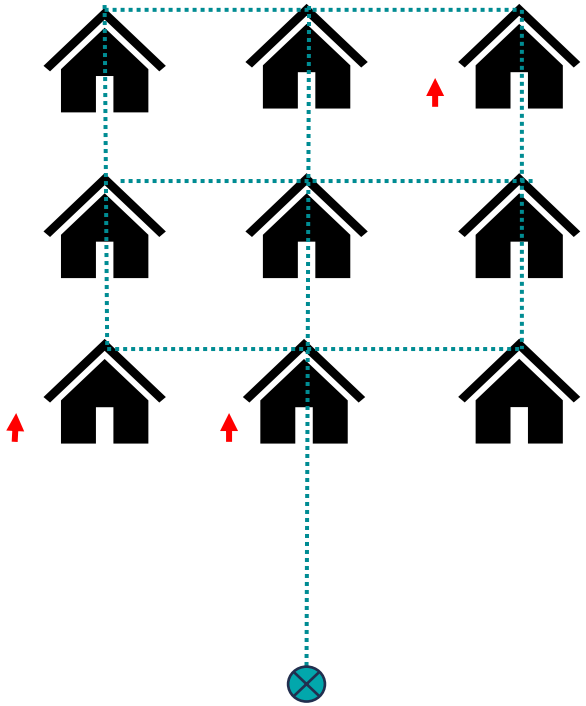


Sum of coincident peaks

Peak per building = 4

Grid peak = 9🏠 x 4 = 36

Passive Building +
Microgrid Control +
GEB Load Shifting or Shedding



Sum of coincident peaks

Peak per building = 1

Grid peak = 3🏠 x 3 = 3

Optimization at Each Level

Passive Building = Optimizing deign to significantly reduce Building Loads

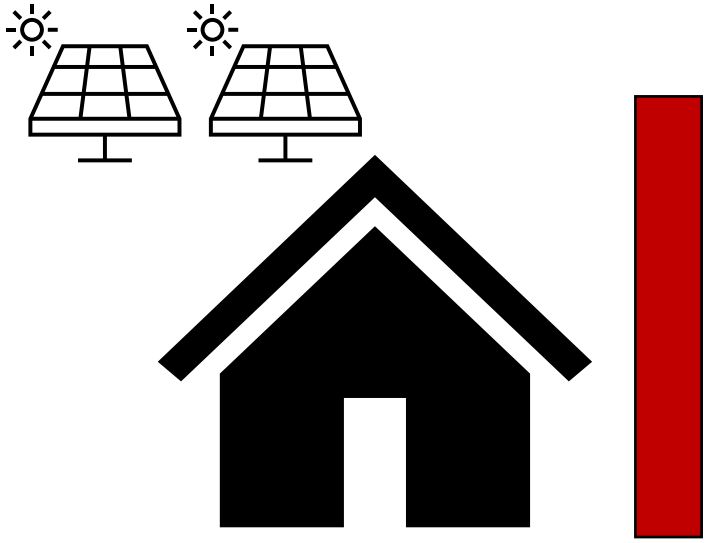
Reducing demand (and renewable supply required to meet it)

Grid-Interactive Efficient Building (GEB) = Optimizing operation of remaining building loads, maybe generation and supply

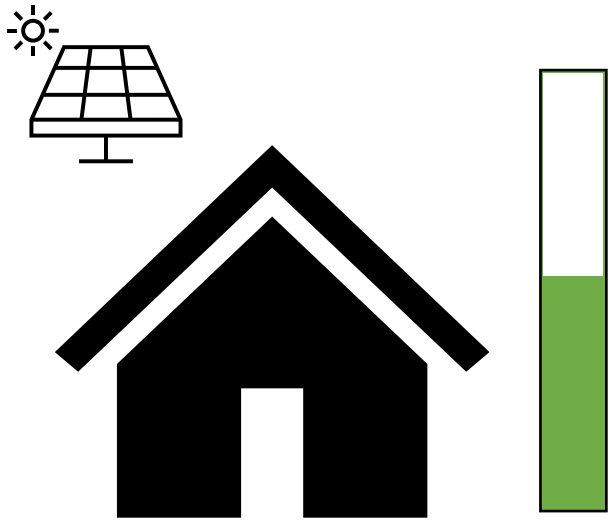
Enabling demand to align with supply

Microgrid = Optimizing generation, storage, and a group of operational building loads

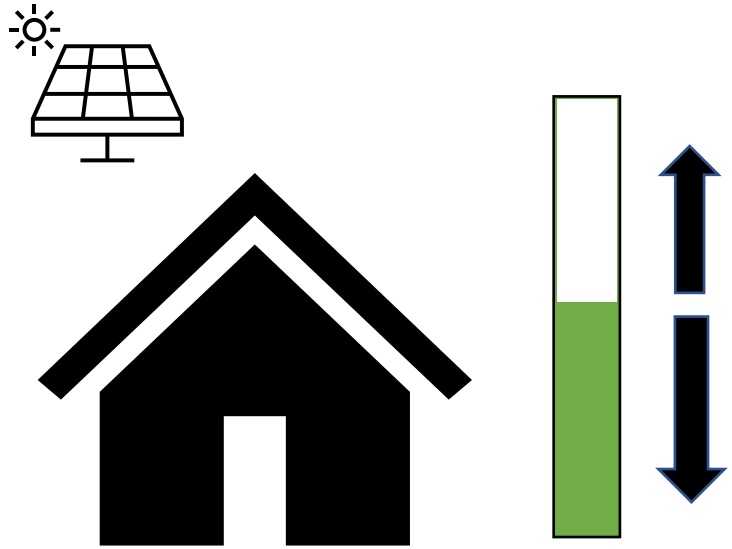
Optimizing supply and demand to maximize use of infrastructure & minimize emissions.



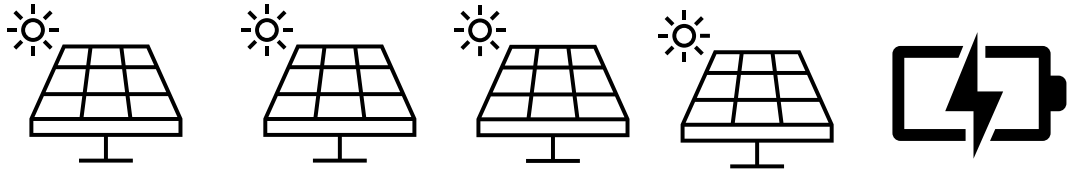
Baseline



Phius ZERO

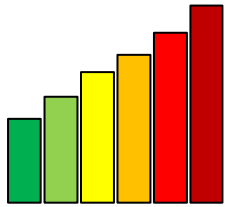


Phius ZERO + Grid-Interactive Building (GEB)

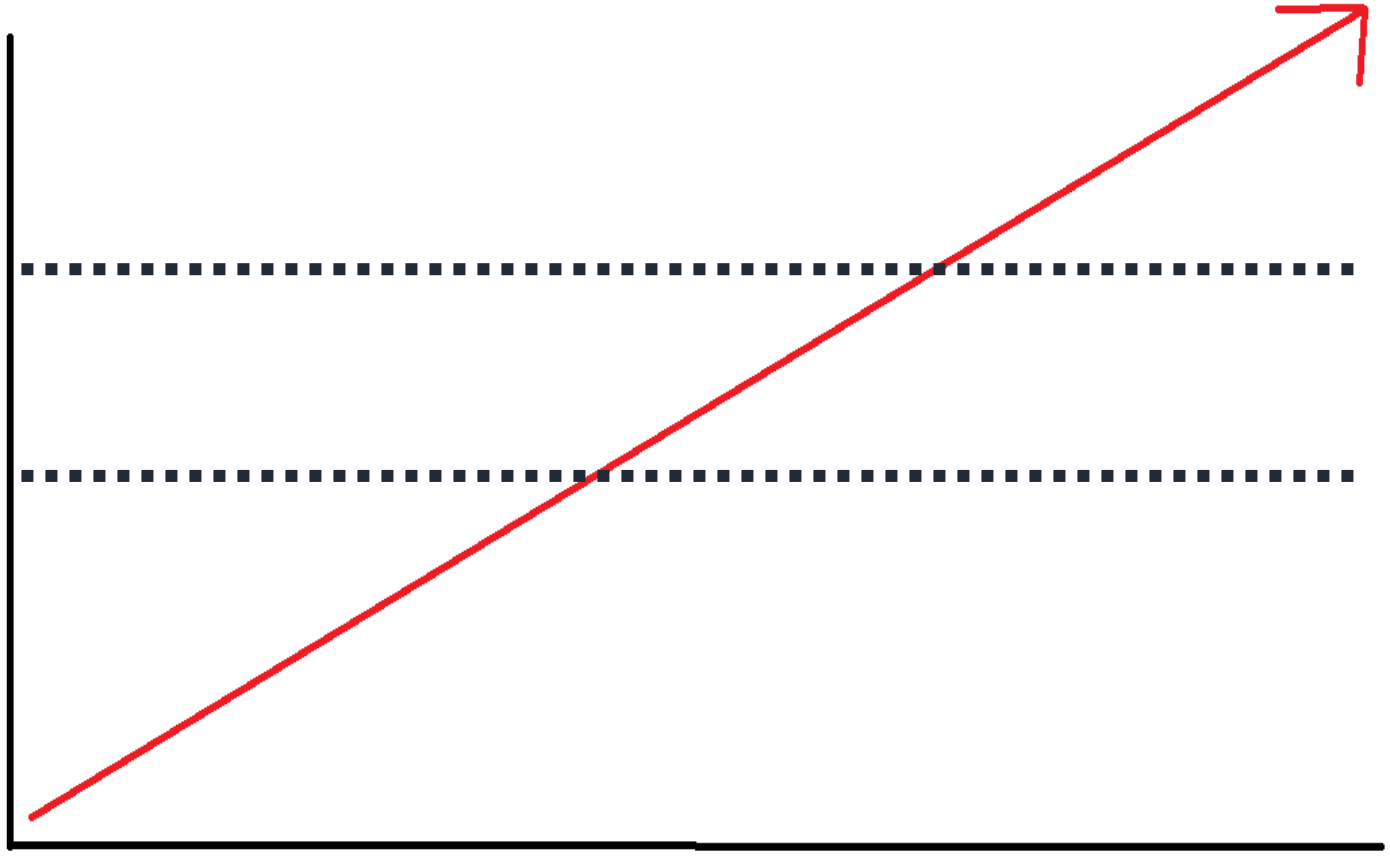


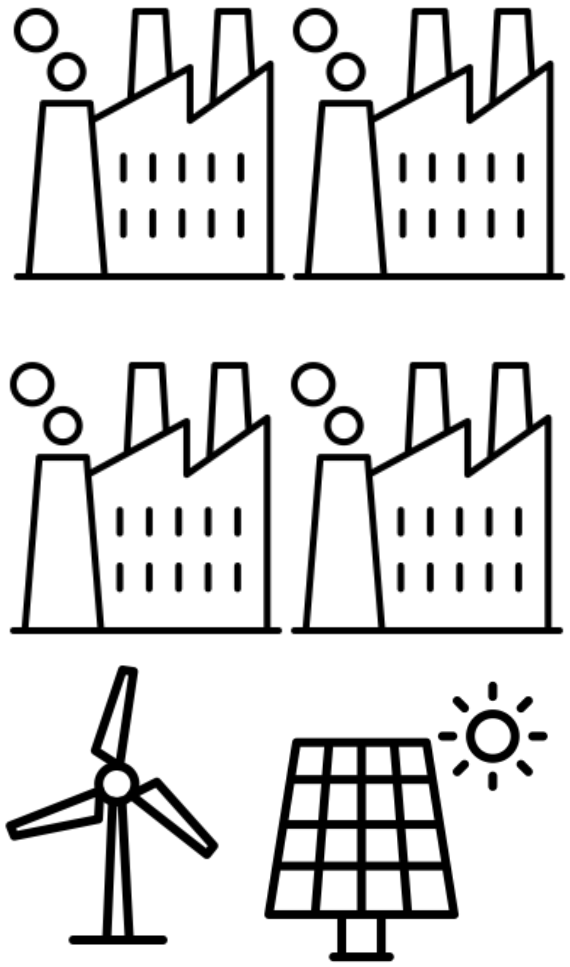
PhiusGEB Microgrid Community

Business as Usual

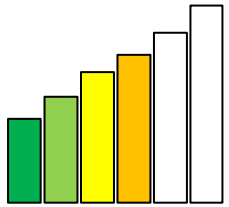


Electricity Demand (Grid Load)

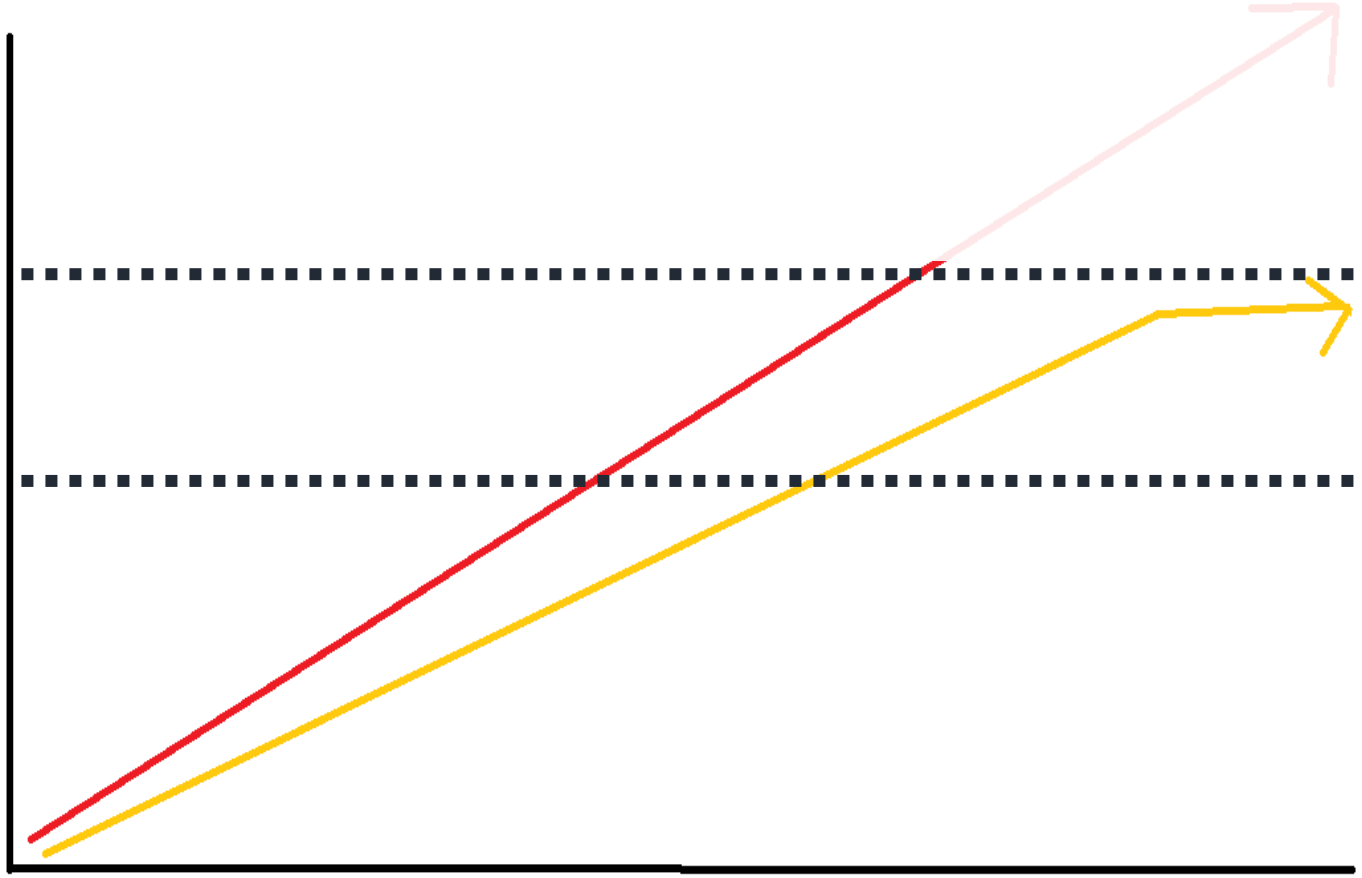


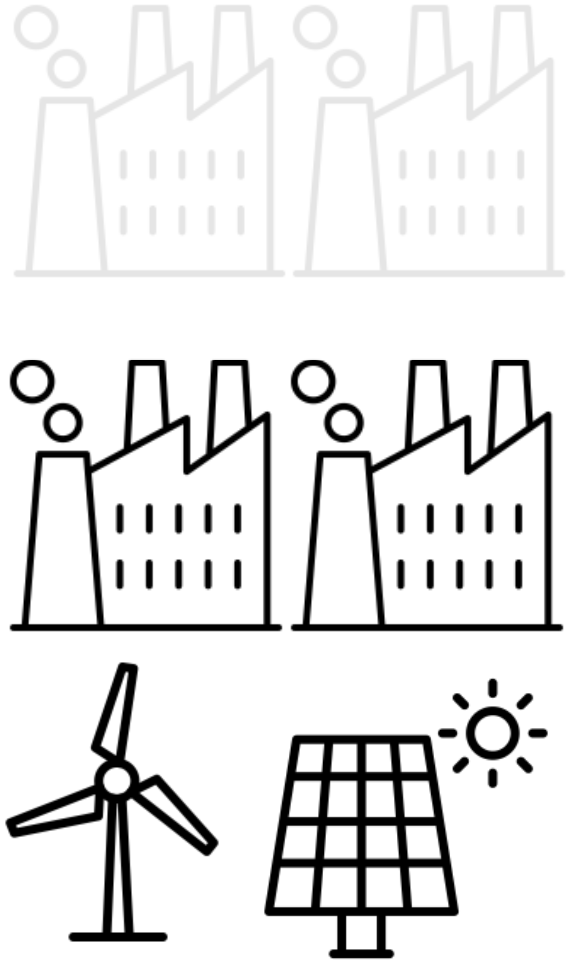


Passive Building

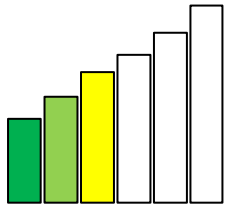


Electricity Demand (Grid Load)

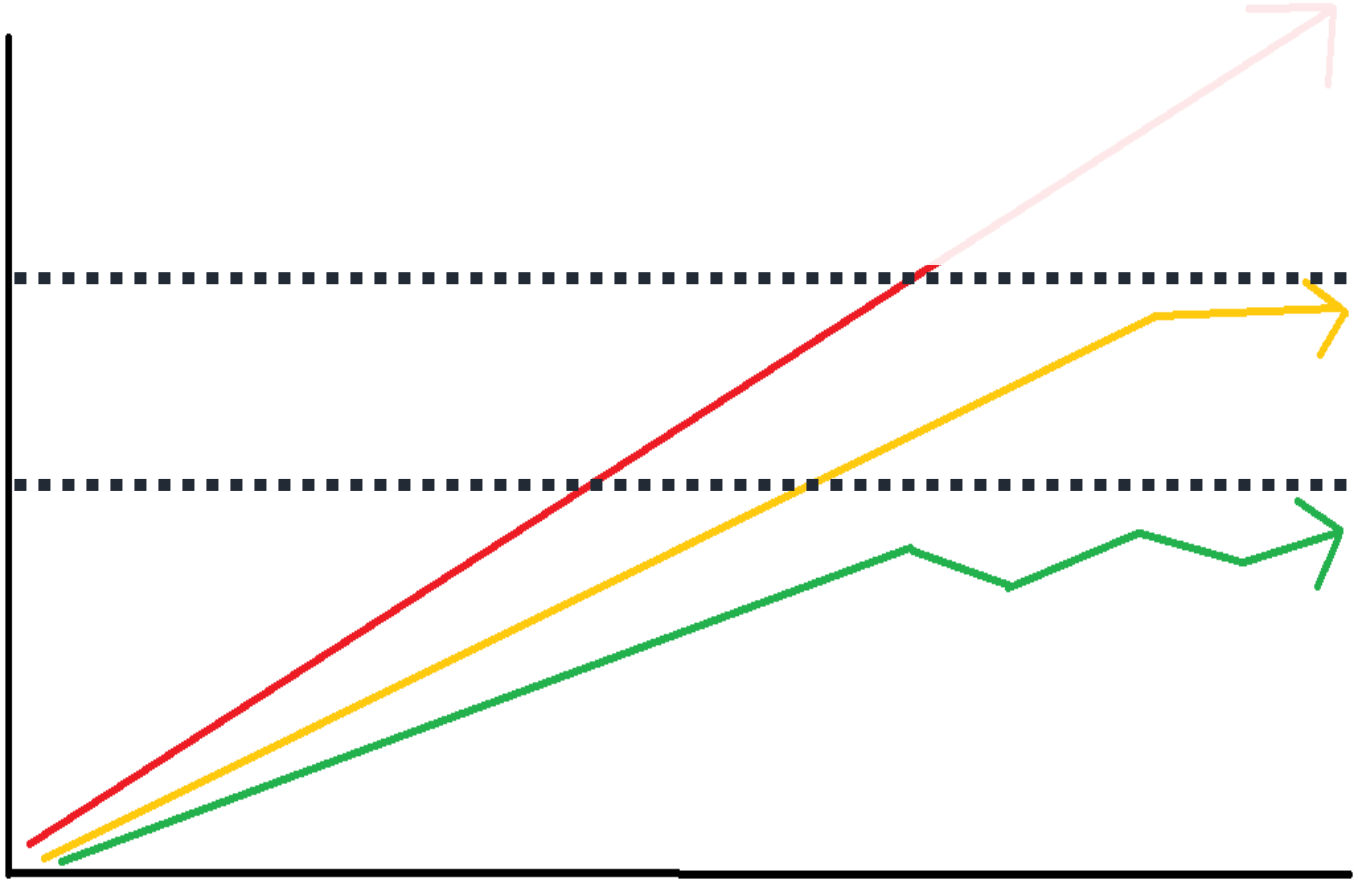


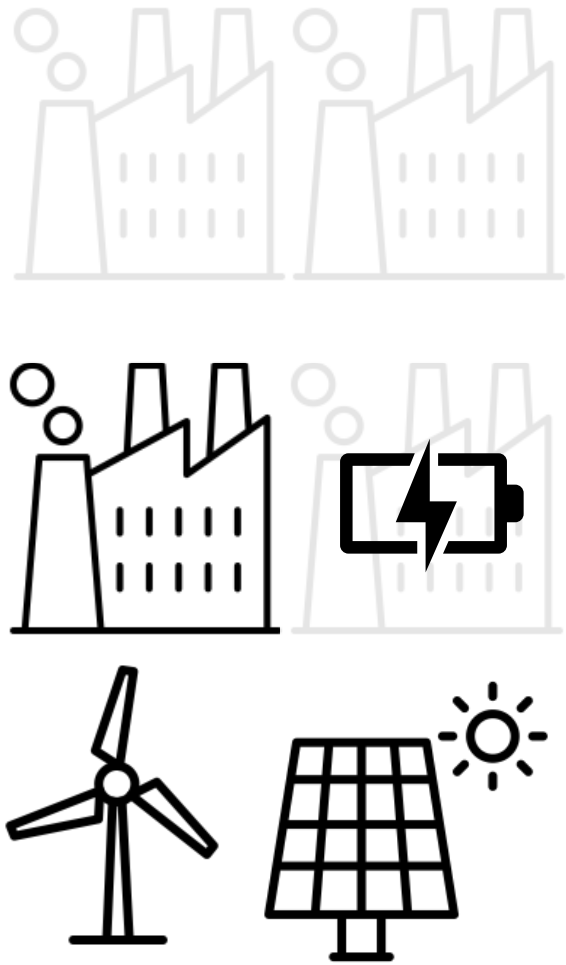


Passive Building + GEB

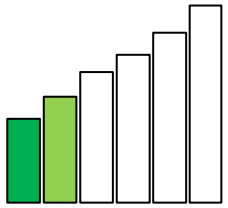


Electricity Demand (Grid Load)

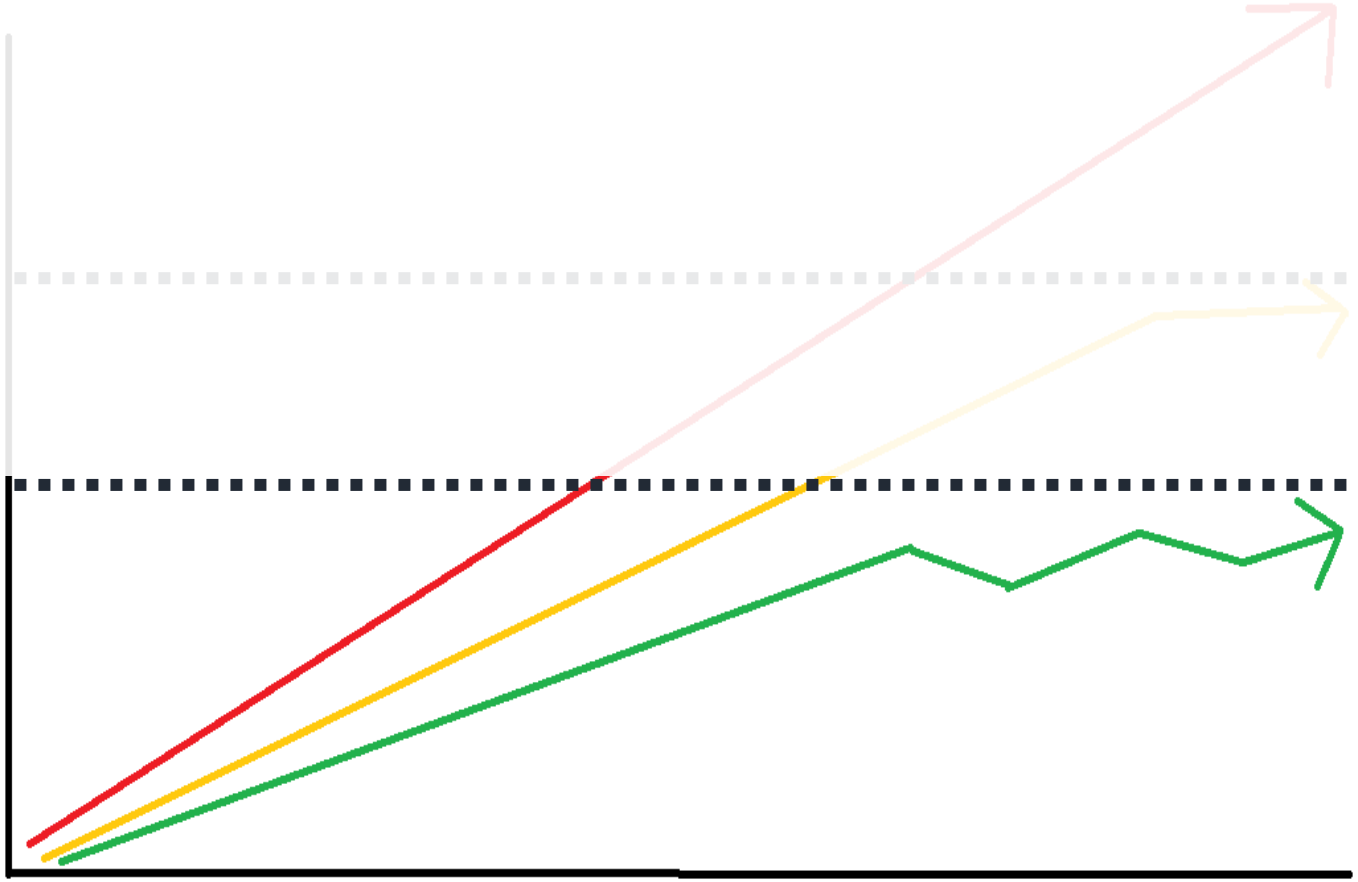


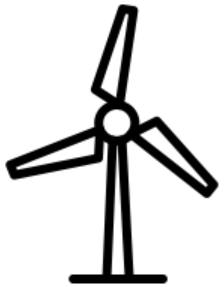


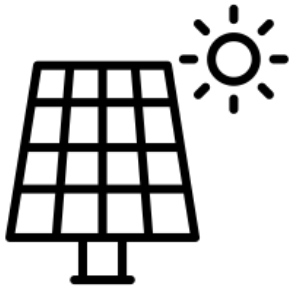
Passive Building + GEB + Microgrid Manager



Electricity Demand (Grid Load)







Future AIA UpJohn Grant Research

Topic: **Synergies between Ultra-Low-Energy Buildings, Microgrids, and Direct Current**

Prototype City-Block Microgrid in Milwaukee, WI

Variables:

Microgrid Design Priority – Resilience vs. Financial

Building Performance Level (all electrified) – Existing Buildings, 2021 IECC, Phius 2021

Completion: **June 2023**

Synergies to study/quantify:

1. Thermal storage/load shifting
2. Load shedding
3. Peak Loads
4. Total generation capacity cost (renewables + storage)
5. Critical loads

Thanks!
Questions?

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