Resource Efficient Electrification/Decarbonization:

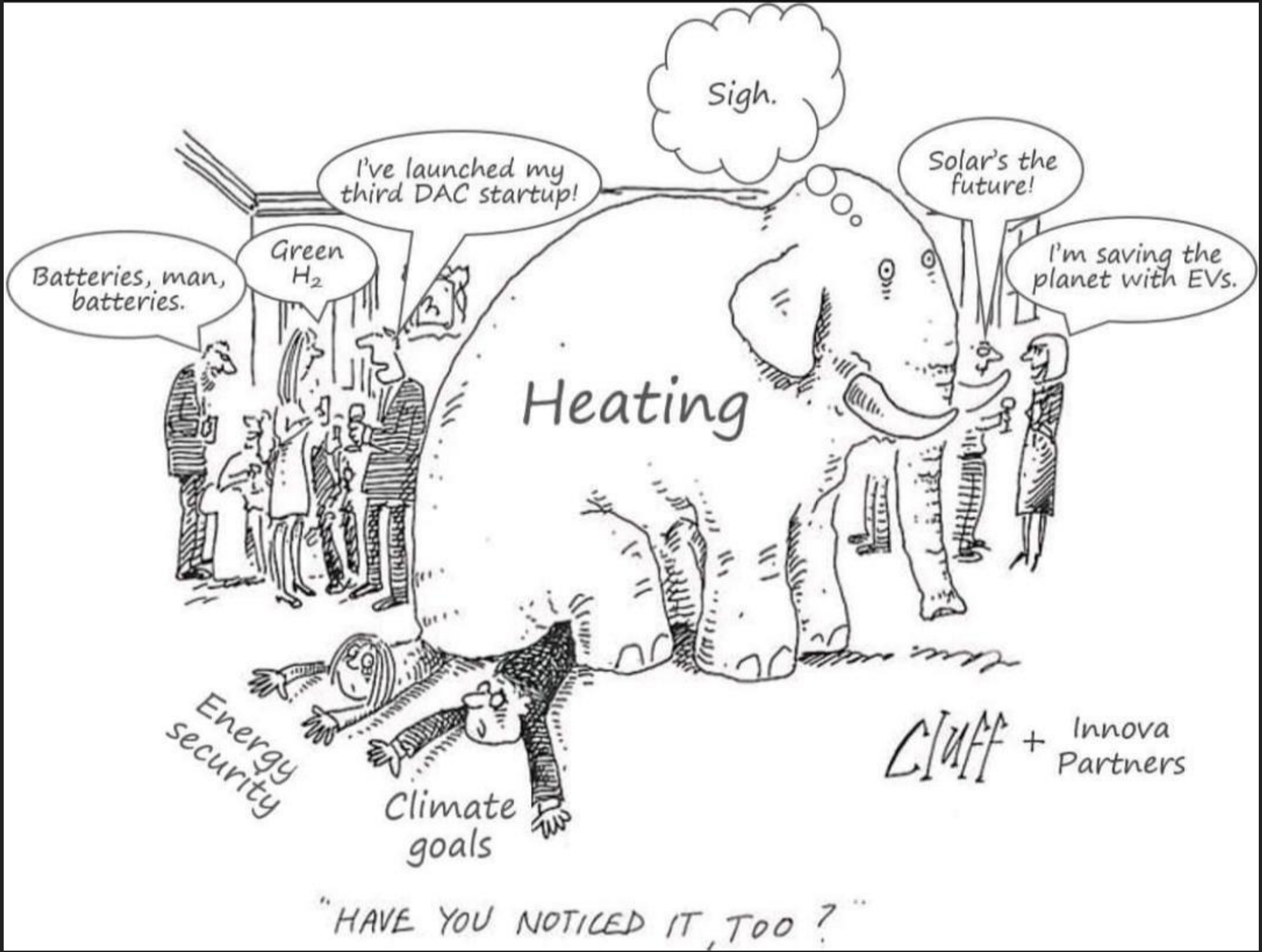
Creating an approach to building decarbonization at scale while minimizing grid impacts

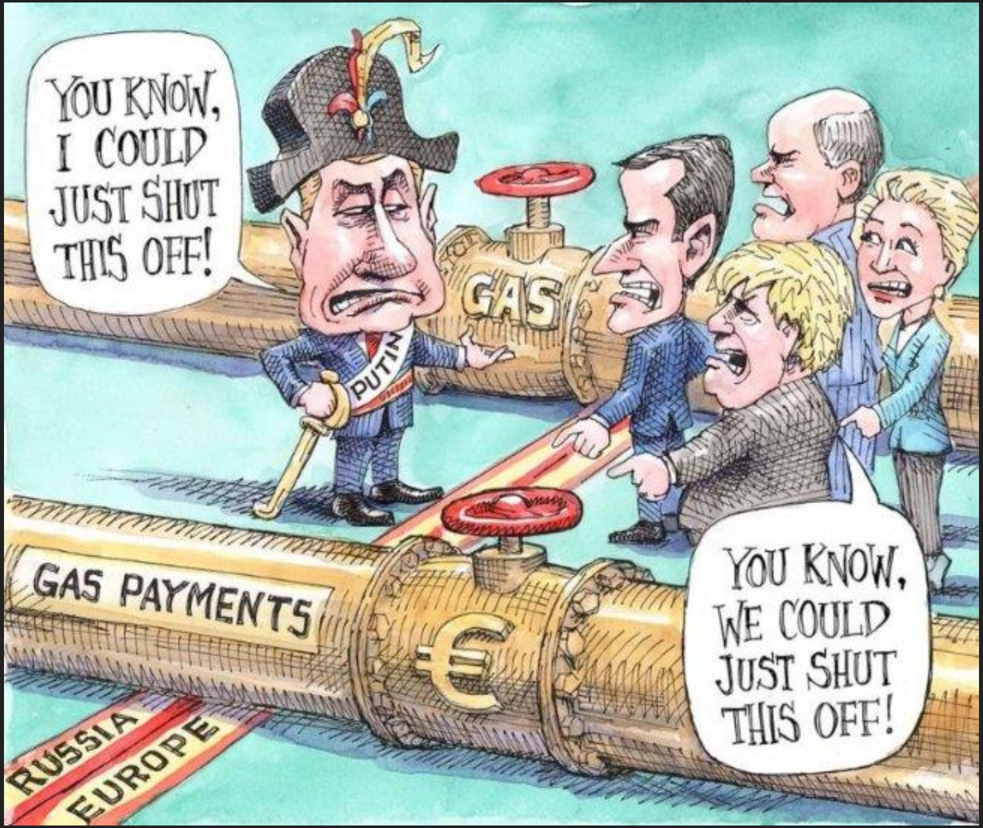
Mark Kleinginna | mark@emergentgroup.com
Jared Rodriguez | jared@emergentgroup.com

@Westford Symposium #24

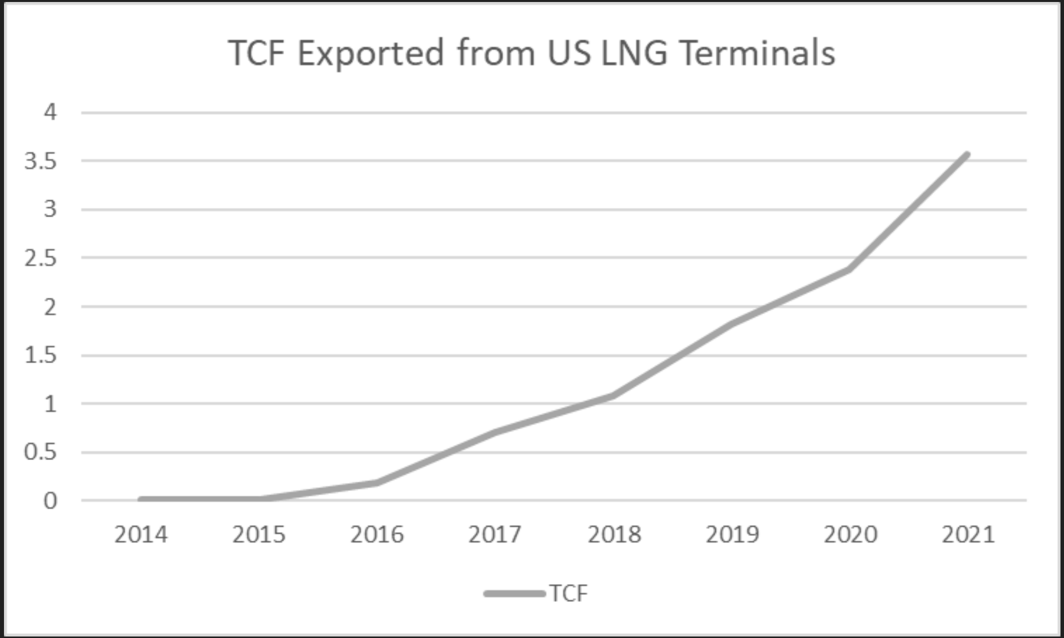
Outline

1. Intro/Welcome
2. Heat is the elephant in the room
3. Putin: gas is a global commodity
4. To decarbonize, we need to eliminate natural gas combustion inside buildings
5. ASHPs during low temps: ASHPs alone can't get us there
6. In a high-electrification scenario, low carbon heat networks are electric capacity
7. Inside-out: Resource Efficient Decarbonization
8. Outside-in: Thermal Energy Network development and frameworks
9. NYS TEN Law
10. Utility Role
11. Private Role


Sigh.
I've launched my third DAC startup!
Solar's the future!
Green H_2
Batteries, man, batteries.
I'm saving the planet with EVs.
Heating
Energy security
Climate goals
Cluff + Innova Partners
"HAVE YOU NOTICED IT, TOO?"


YOU KNOW, I COULD JUST SHUT THIS OFF!
PUTIN
GAS
GAS PAYMENTS
€
YOU KNOW, WE COULD JUST SHUT THIS OFF!
RUSSIA
EUROPE

NG is not a North American Commodity Anymore



Local and State Policy Landscape: New York

- New York State Climate Leadership and Community Protection Act (CLCPA)
- Mandated Grid Decarbonization by 2040
- Economy-wide decarbonization by 2050
- New York City Climate Mobilization Act (NYC Local Law 97)
- CO_2 Emissions caps for buildings (80% reduction x 2050)
- Gas Ban for New Construction (NYC, State pending)
- Gas Transition Planning: Leak Prone Pipe, Moratoriums, Non-Pipe Alternatives; Thermal Utility Legislation

Emissions Limits (Tonnes CO2e/SF) by Occupancy/Use Group (example)

Occupancy Group	2024-29	2030-34	2035-49	2050
R-2 (inc. multifamily)	0.00675	0.00407	0.002735	0.0014
B (inc. office)	0.00846	0.00453	0.002965	0.0014
R-1 (inc. hotel)	0.00987	0.00526	0.00333	0.0014

Fine = $268/Tonne of CO2e over the building wide cap.

Emissions Coefficients (Tonnes CO2e/kBTU) by Energy Source

Energy Source	2024-29	2030-34	2035-49	2050
Grid Electric (per kWh)	0.000288692	TBD	TBD	TBD
Natural Gas	0.00005311	TBD	TBD	TBD
#2 Fuel Oil	0.00007241	TBD	TBD	TBD
#4 Fuel Oil	0.00007529	TBD	TBD	TBD
District Steam*	0.00004493	TBD	TBD	TBD
Other	TBD	TBD	TBD	TBD

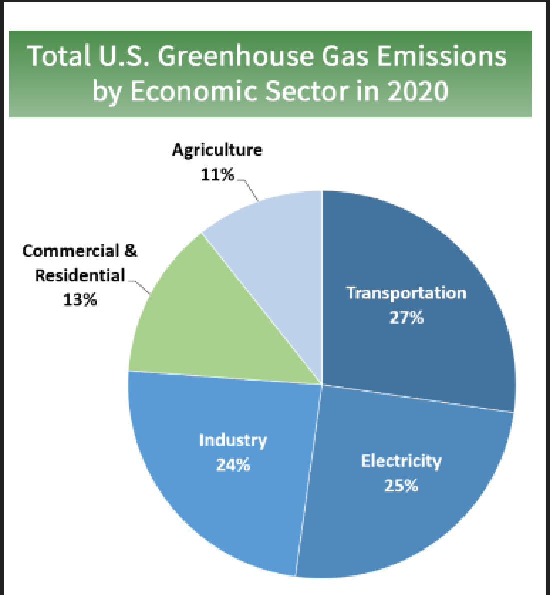
*Con Edison roadmap to carbon neutral steam, system expansion with hydronic loops.

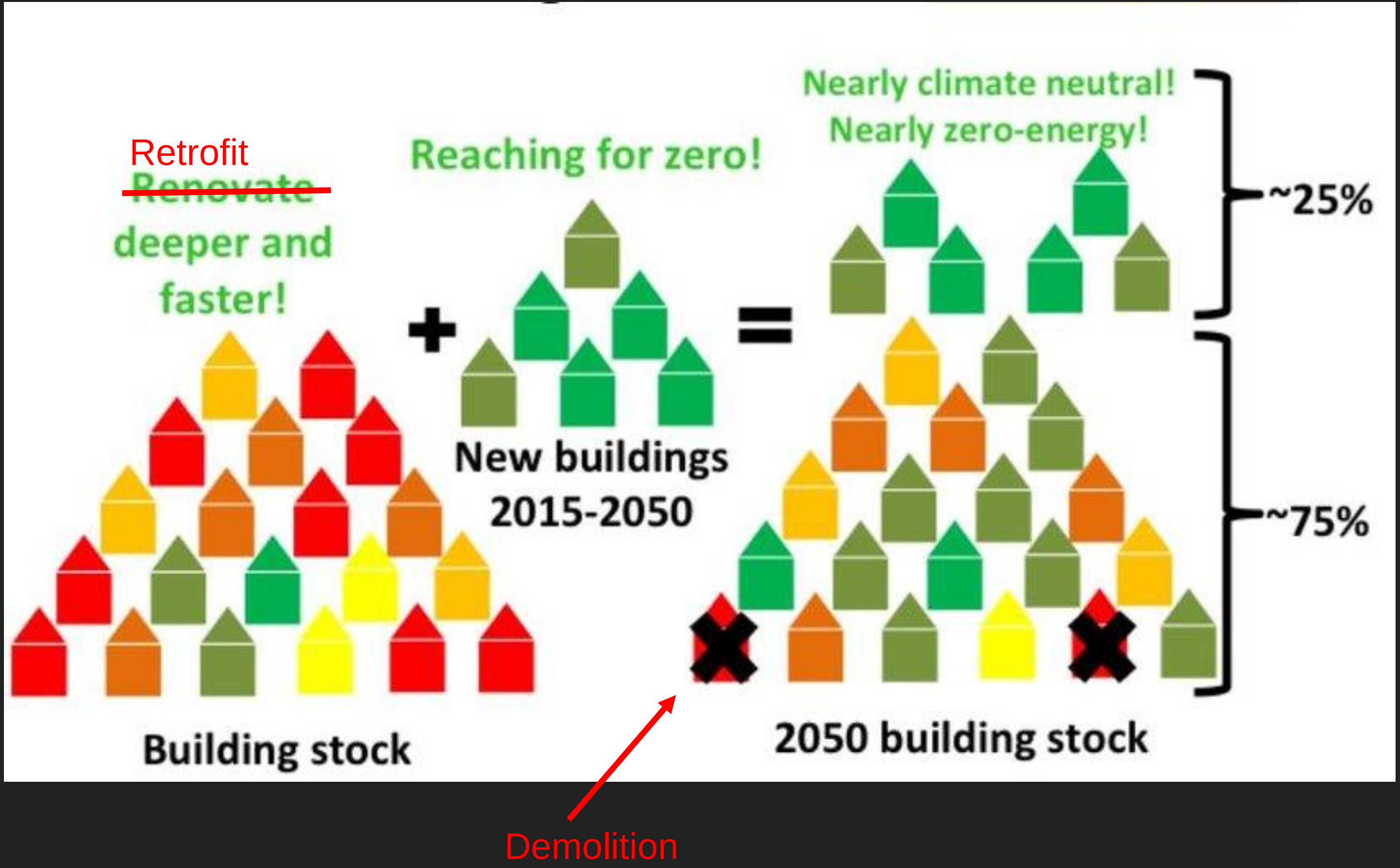
Problem Statement

The commercial and residential built environment is responsible for 13% of all carbon emissions in the US.

Of this 13%, emissions from natural gas consumption represent 79% of the direct fossil fuel CO2 emissions from the residential and commercial sectors in 2020. This was over 600 million metric tons of CO2 in 2020 according to the EPA.

Eliminating fossil fuels from buildings requires overcoming difficult economics for electrification of heating systems, and . . .



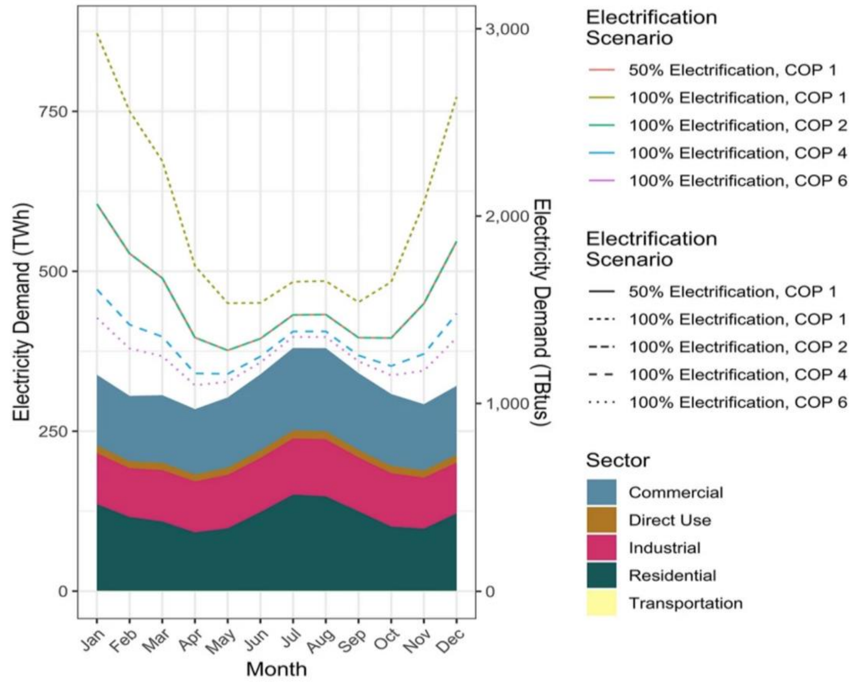


Retrofit
~~Renovate~~
deeper and
faster!
Reaching for zero!
Nearly climate neutral!
Nearly zero-energy!
~25%
~75%
New buildings
2015-2050
Building stock
2050 building stock
Demolition

To achieve decarbonization by 2050, we must begin to eliminate fossil fuel fired heating in existing buildings now.

ASHPs during low temps: ASHPs alone can't get us there

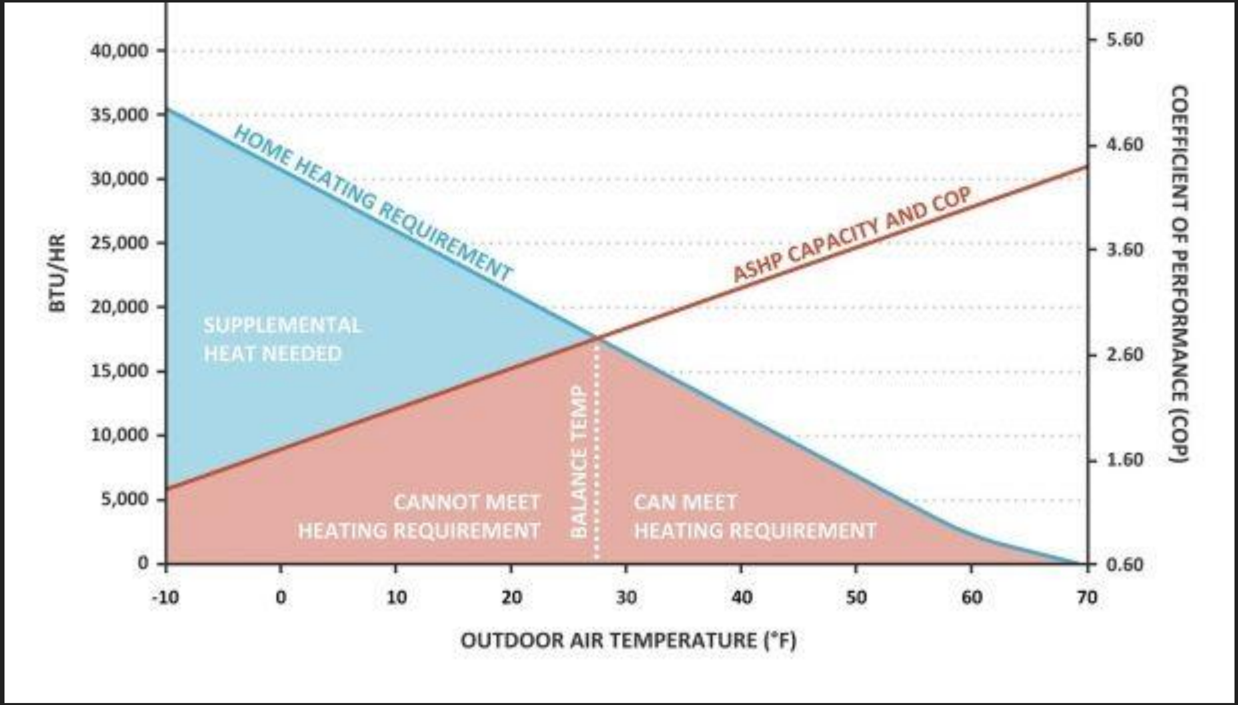
This is not demand



Current monthly total electricity demand by sector from March 2010 to February 2020, and projected changes to total building energy demand under different building electrification scenarios using technology with varying COPs. Solid area represents current demand, different electrification scenarios are represented using both color and line style.

ASHPs during low temps: ASHPs alone can't get us there

This IS demand



The manufacturer (and the activists) will not [typically or fully] reveal when and at what temperature resistance heat turns on (COP = 1.0).

In a high-electrification scenario, high performance buildings and low carbon heat networks act as electric capacity.

- Unmitigated air source heat pumps would drive up peak winter month electric consumption by almost 50%
- Unmitigated, low COP ASHPs would at least cause winter peaks to be triple the summer electric peak (increase of 300%)
- When we increase the COP to 6 through the utilization of a thermal network, we create a peak that is only 20% higher than current summer peaks in a full electrification scenario
- This greater efficiency allows for much lower cost decarbonization as the thermal network acts like electric capacity
- ASHP’s are a [good/big] piece of the decarb puzzle, but they are not suitably efficient at meeting peak heating at scale.

Inside-out: Resource Efficient Decarbonization and Pitfalls of too simple “Beneficial Electrification”

What could go wrong? /s

- Have heat pumps everywhere but operate independently;
- Replace fossil fuel kBTUs with electrons but maintain single use pathway through the building, ie. 1:1 swapouts (ignoring storage, heat recovery, EE, network effects);
- Do everything all at once to show the biggest possible financial burden (ignoring business cycles, tenant disruption, opportunity to leverage necessary investment);
- Optimize around “simple payback” only (ignores marginal cost differences, BAU cost and cost of inaction or total Net Present Cost of options);
- Fail to integrate other requirements, e.g. envelope requirements, gas safety rules, etc.;
- Fail to optimize for remaining useful life and ignore stranded asset risk at both the building and delivery system level;
- Use unrealistic assumptions about utility and offset costs.

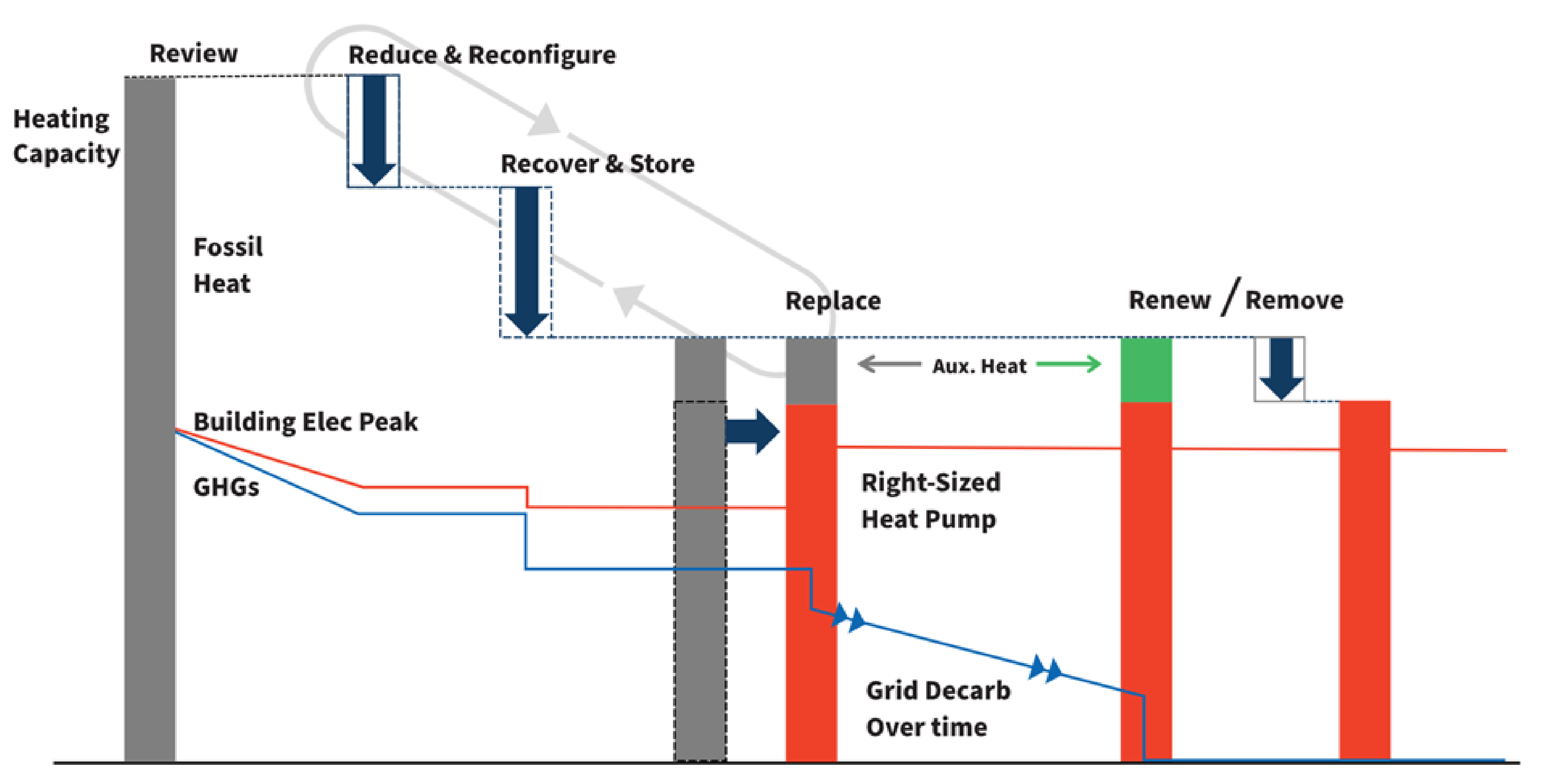
Enable Decarbonization. . .
Inside Buildings.
Thermal Dispatch Modeling and a technology agnostic approach

- Provide Decarbonization Pathways including
  - Energy Efficiency
  - Demand Reduction
  - Thermal Storage
  - Thermal Energy Network Connections
  - Fossil Fuel Phase-out
- Develop a Thermal Dispatch Model which allows for a technology agnostic approach to rank decarbonization pathways for a building, a campus, a neighborhood, a large urban system, or an entire city.

Inside-out: Resource Efficient Decarbonization

- Current Thinking: “Electrify Everything as soon as possible!!!”
- Evolved thinking: Do Deep Decarbonization by:
  - Drastically reducing or eliminating combustion;
  - Increasing efficiency at low design temperatures;
  - Remaining resilient during extreme weather;
  - Utilizing solutions that are demand conscious and energy grid-interactive
  - Reducing thermal waste by capturing and recycling as many on-site or nearby thermal flows as possible;
  - Incorporating realistic and flexible implementation strategies by optimizing and scheduling phase-in of low carbon retrofits competing with business-as-usual;
  - Developing and maintaining transparency to all stakeholders
  - Integrating a variety of heat pump and storage technologies in a heat source/cost optimized thermal dispatch

Resource Efficient Decarbonization (RED): an incremental methodology and integrated design process combined with strategic capital planning creates a path towards carbon neutral buildings.



1. Condition Assessment has two distinct parts

Tech Baseline:

Engineering considerations, constraints and opportunities

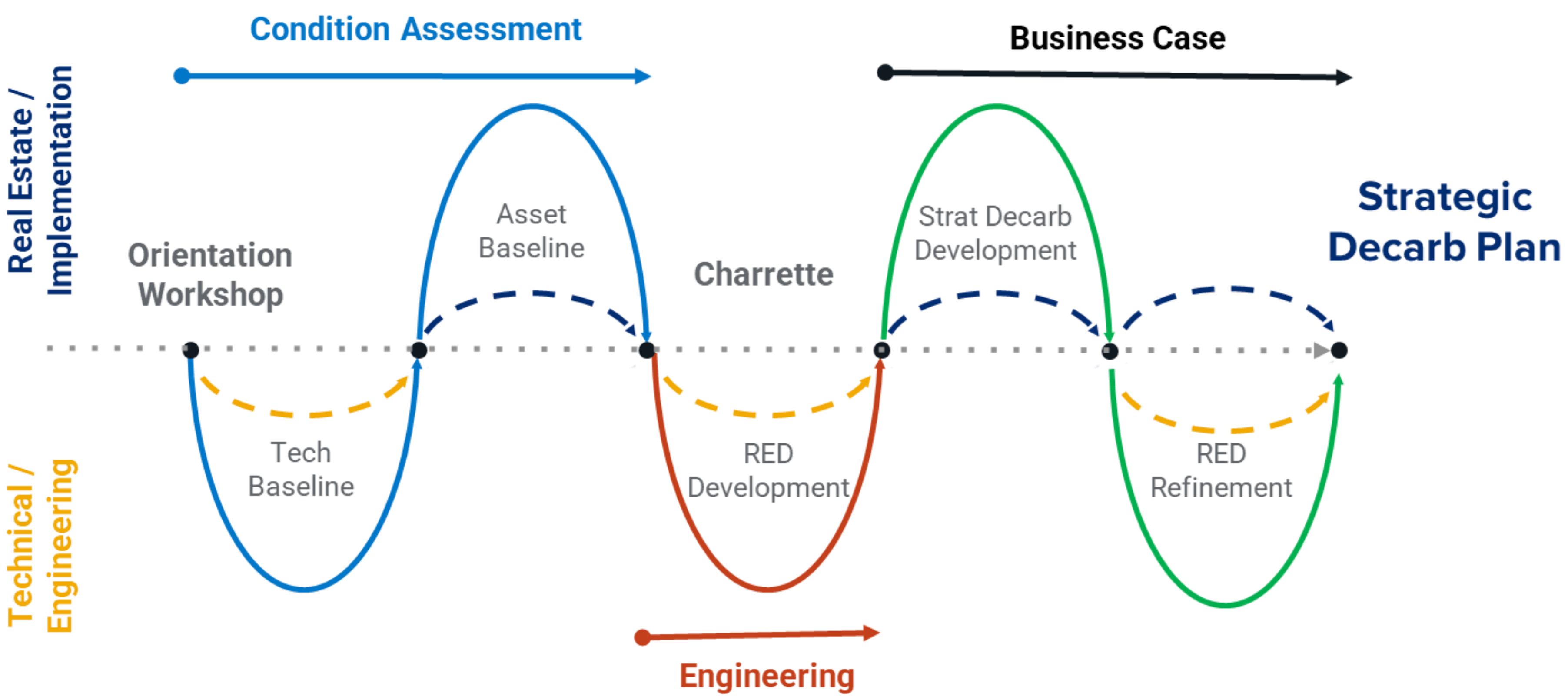
Equipment and performance audit info that will be operationalized to achieve decarbonization

- Replacement costs
- ECMs
- Budget constraints
- Stranding Assets

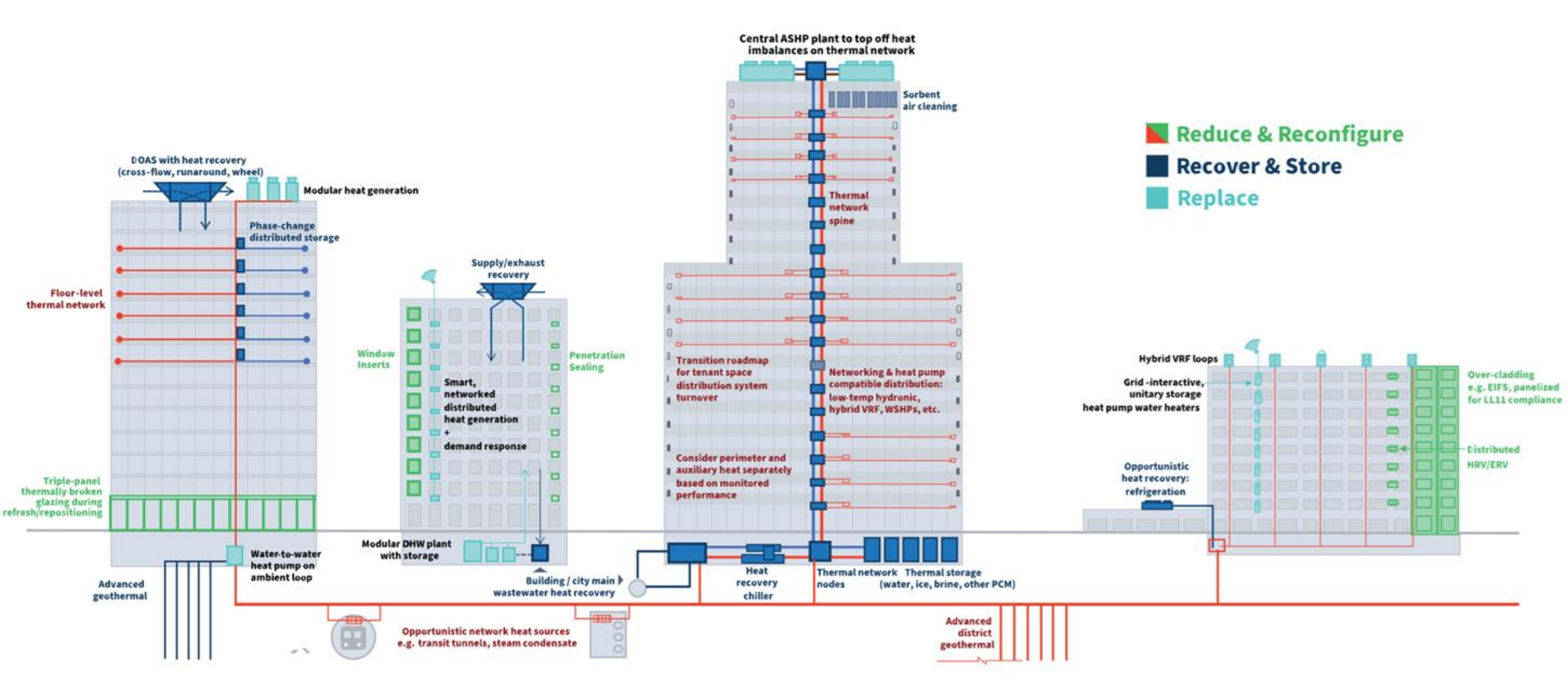
Asset Baseline :

Real estate and capital markets considerations, obligations, constraints and opportunities

Pro Forma info that will be leveraged to justify Strategic Decarb Plan


Condition Assessment
Business Case
Real Estate / Implementation
Asset Baseline
Strat Decarb Development
Strategic Decarb Plan
Orientation Workshop
Charrette
Tech Baseline
RED Development
RED Refinement
Technical / Engineering
Engineering

Resource Efficient Decarbonization (RED): an incremental methodology and integrated design process combined with strategic capital planning creates a path towards carbon neutral buildings.

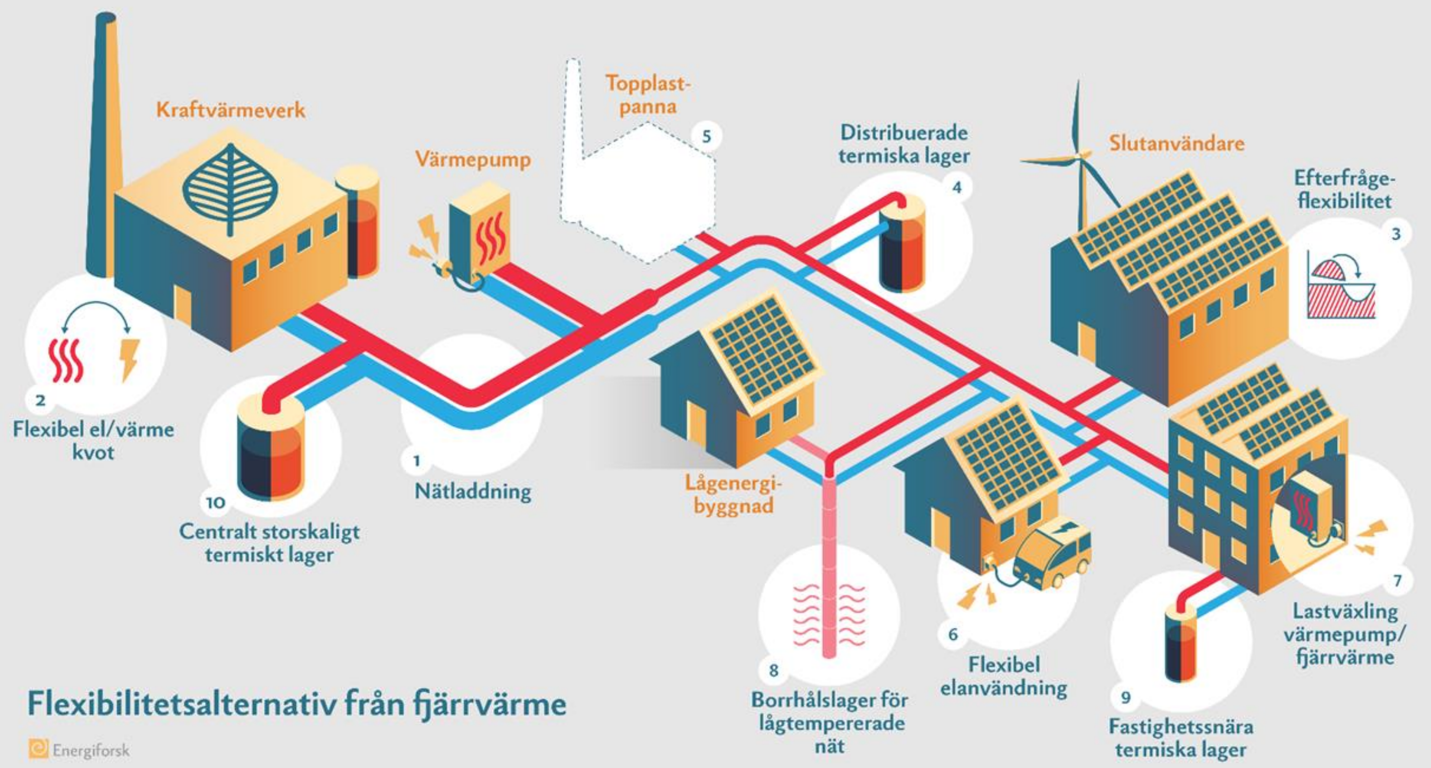


Enabling Decarbonization. . .
Outside Buildings.
Develop thermal energy networks as public private partnerships to phase out fossil fuels for heat.

- Build a community-based coalition and infrastructure development fund by partnering with agencies, utilities, local business, community organizations
- Work with municipal partners to authorize the construction of thermal energy networks
- Finance, engineer, procure and construct thermal energy networks while acquiring customers who seek affordable, secure, non-volatile, clean heat
- Share equity with the Coalition through innovative approaches

Thermal Energy Networks

- Fossil fuel heating will be replaced with electric heat pumps over the next three decades due to decarbonization requirements and economics
- Air source electric heat pumps become remarkably inefficient at temperatures below 35 degrees F and having enough capacity for design day is unaffordable
- Average temperature is increasing, but so are extreme high and low temperatures
- By using water source heat pumps and thermal storage, heating becomes much more efficient (5-6X even at very low temperatures)
- Thermal Energy Networks utilize a heat transfer fluid (usually water) to carry heat to and away from heating and cooling nodes (aka buildings and industry)
- Thermal Energy Networks also allow for the efficient trading of heat energy between sources and sinks enabling recovery of waste heat
- Network heating and cooling sources traditionally include energy from combustion, geothermal, waste heat, storage facilities, latent heat and beyond. Networks are technology agnostic.
- Locally produced heat is secure and price stable.



Kraftvärmeverk
Värmepump
Topplast-
panna
5
Distribuerade
termiska lager
4
Slutanvändare
Efterfråge-
flexibilitet
3
2
Flexibel el/värme
kvot
10
Centralt storskaligt
termiskt lager
1
Nätladdning
Lågenergi-
byggnad
8
Borrhålslager för
lågtempererade
nät
6
Flexibel
elanvändning
9
Fastighetssnära
termiska lager
7
Lastväxling
värmepump/
fjärrvärme
Flexibilitetsalternativ från fjärrvärme
Energiforsk

image credit: U.S. Dept. of Energy, Geothermal Technology Office

Coalition Members May Include

- State and Local Regulators
- Policymakers and Other Officials
- Other Governmental Bodies (City, County, State)
- Economic and Industrial Development Agencies and Organizations
- Public and Private Regulated Utilities
- Activist or Community Based Organizations
- Solution Providers and Manufacturers
- Trade Unions
- Trade Organizations

Next Steps

1. **Engage Thermal Development Team**
2. **Identify Coalition Members, Structure and Form the Coalition**
3. **Develop a Thermal Access Agreement and Authorize the Coalition to Perform**
4. Identify thermal supply sources and supply deals
5. Identify and Secure a Project Pipeline through Customer Acquisition
6. Identify and Procure EPC, Maintenance and Billing Partners
7. Finance and Construct Thermal Nodes and Connections
8. Identify and Secure Partners for conveyance if applicable