GETTING TO zero

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Center for Sustainable Landscapes | Pittsburgh, PA *Photo: Paul G. Wiegman*

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Getting to Zero: Grid Integrated Buildings

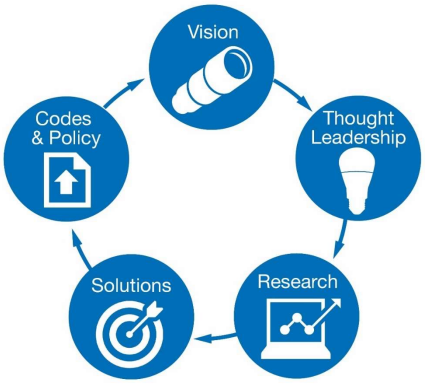
April 29, 2021

2

Efficiency delivered.

NBI is responding to increasing urgency to reduce carbon emissions and increased demand for improved energy performance of new and existing buildings.

NBI's Theory of Market Change:



Our Program Areas

(1) Building & Program Innovation

(2) Zero Energy Leadership & Market Development

(3) Advancing Codes & Policy

3

Frick Environmental Center | Pittsburgh, PA *Photo: Ed Massey*

Today's panel:

Alexi Miller
Associate Technical Director
New Buildings Institute

Rushil Desai
Senior Building Analyst
Elemental Engineering

Rois Langer
Senior Research Engineer
National Renewable Energy Lab

Victor Olgyay
Principal
RMI

4

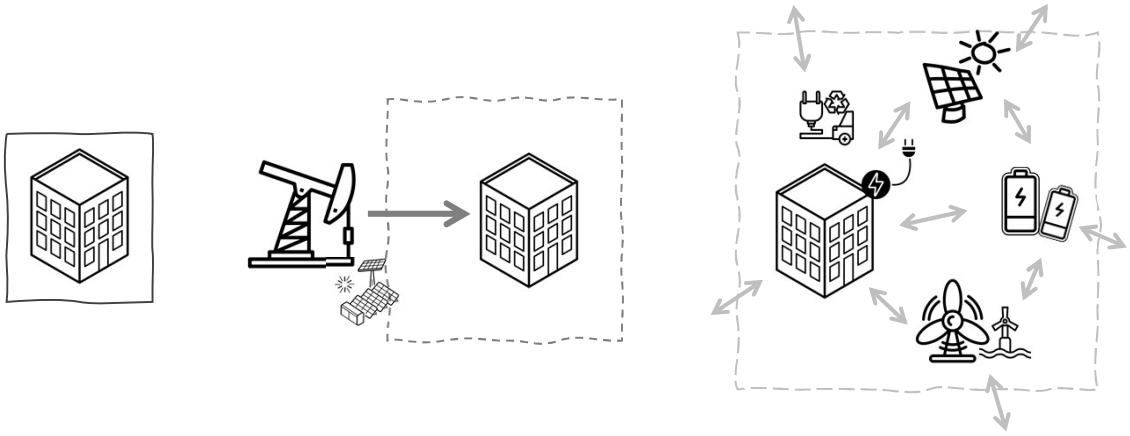
INTEGRAL | ELEMENTA

rushil desai

buildings in the context of an evolving grid

5

Grid-integrated buildings - what and why



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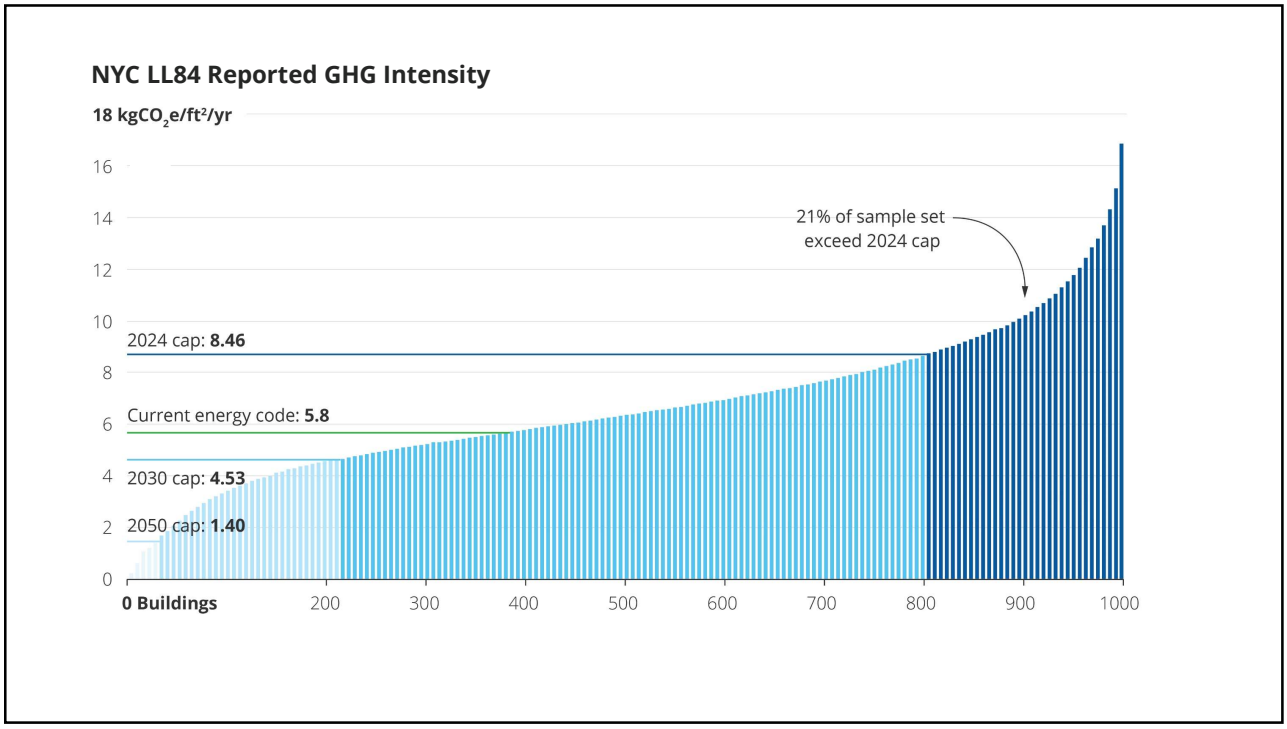
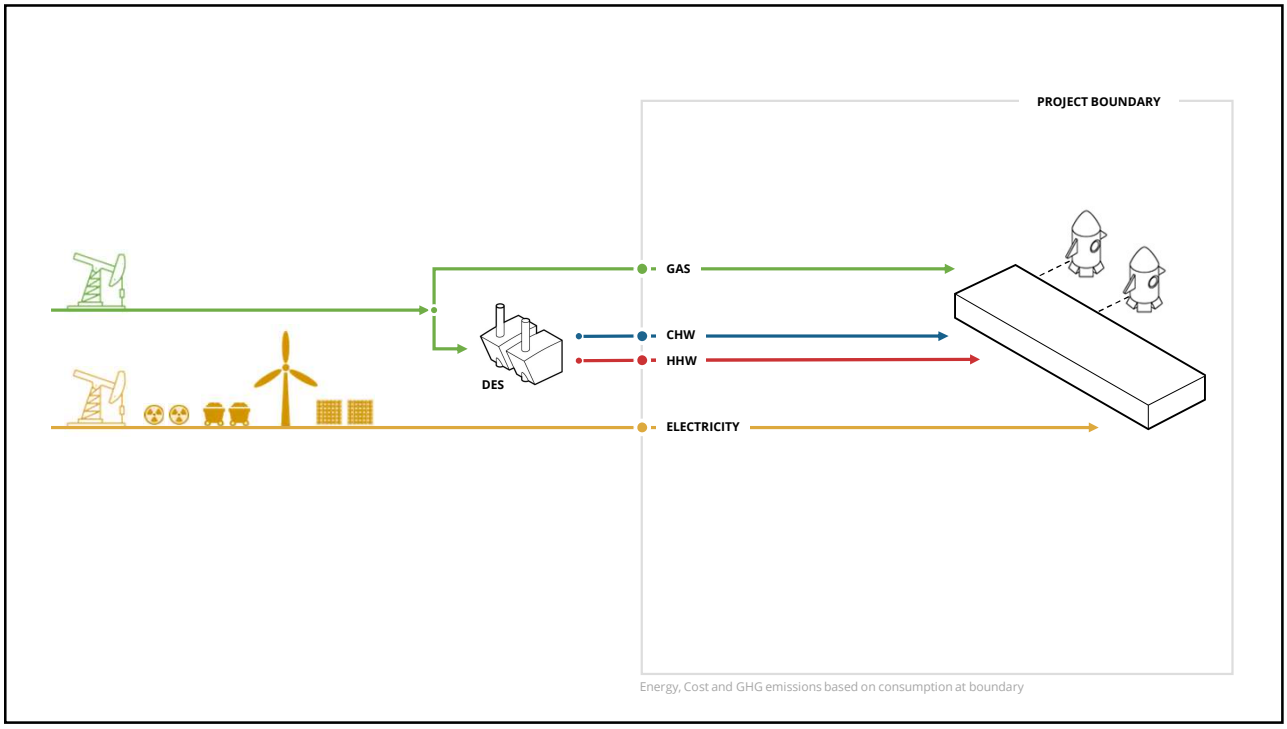

NYC LL84 Reported GHG Intensity
18 kgCO2e/ft²/yr
16
14
12
10
8
6
4
2
0
21% of sample set exceed 2024 cap
2024 cap: 8.46
Current energy code: 5.8
2030 cap: 4.53
2050 cap: 1.40
0 Buildings
200
300
400
500
600
700
800
900
1000

8

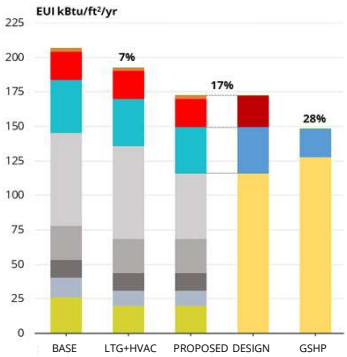
9


PROJECT BOUNDARY
GAS
CHW
HHW
ELECTRICITY
DES
Energy, Cost and GHG emissions based on consumption at boundary

10

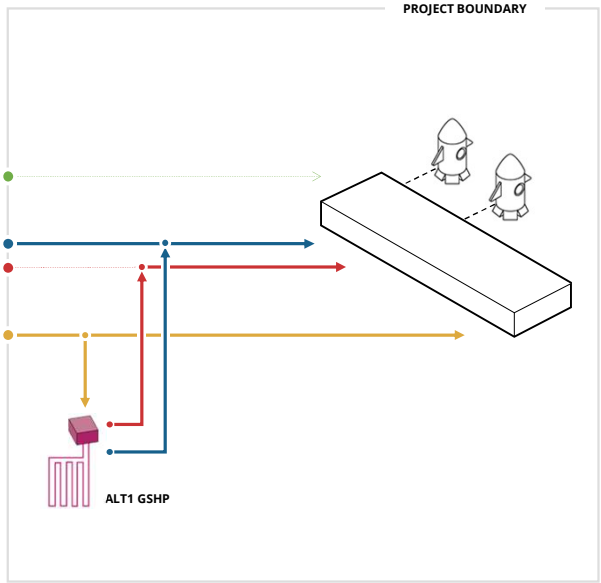
Partial Fuel Switching

Designing a system to completely switch away from central steam while still served by central chilled water



Utility Types
- Natural Gas
- DES Hot Water
- DES Chilled Water
- Grid Electricity

Energy End-Uses
- Building DHW
- Building Heating
- Building Cooling
- Process Equipment
- Building Receptacles
- Vert + Horiz Transport
- Fans + Pumps
- Int + Ext Lights

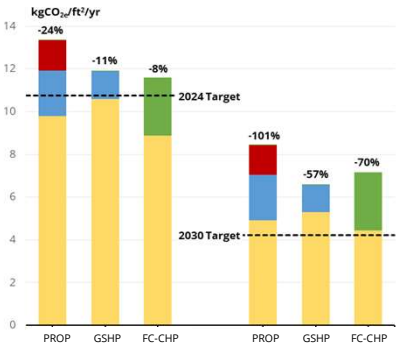


Energy, Cost and GHG emissions based on consumption at boundary

11

Onsite Co-Generation

Assessing the GHG impact of onsite Fuel Cell based combined cooling and power in 2024 and 2030



Utility Types
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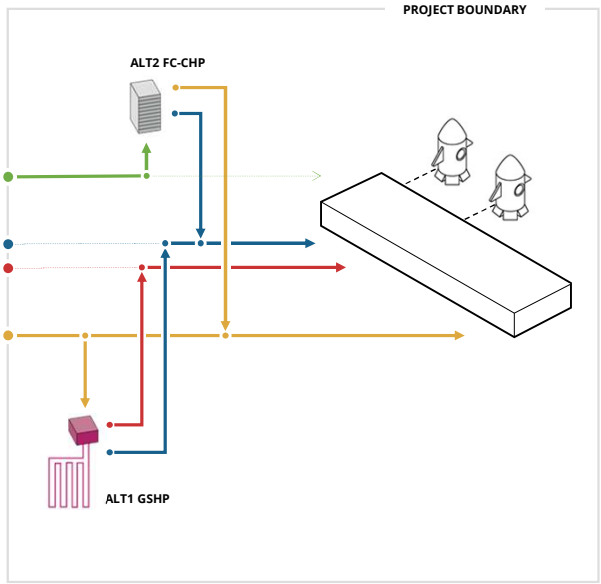
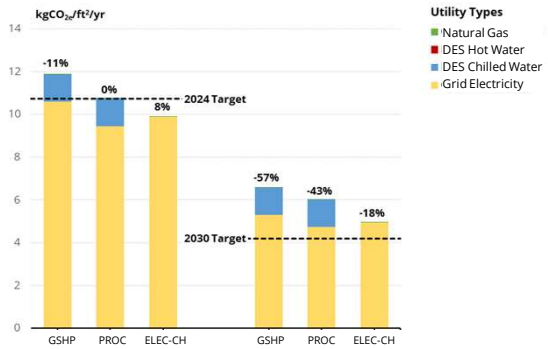


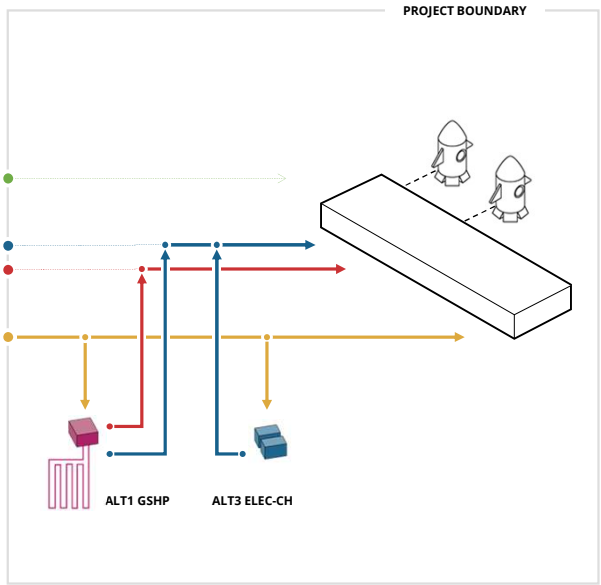
Energy, Cost and GHG emissions based on consumption at boundary

12

All-Electric Plant

Switching away completely from central utilities through an onsite all-electric chilled and hot water plant



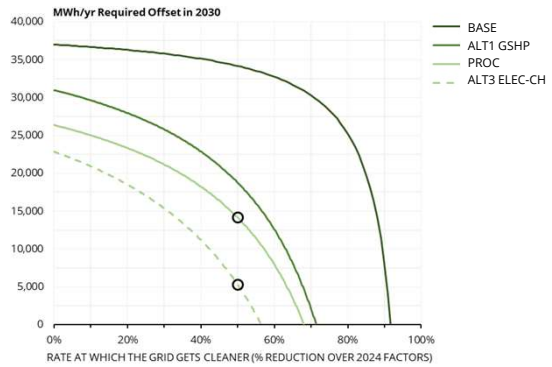


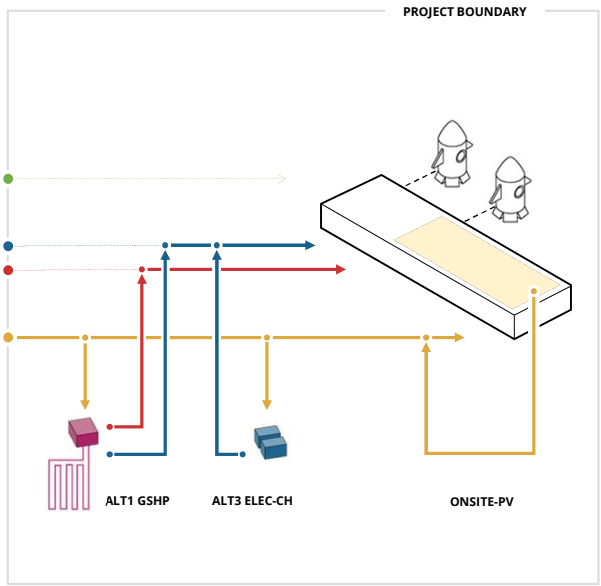
Energy, Cost and GHG emissions based on consumption at boundary

13

Prioritization Plan

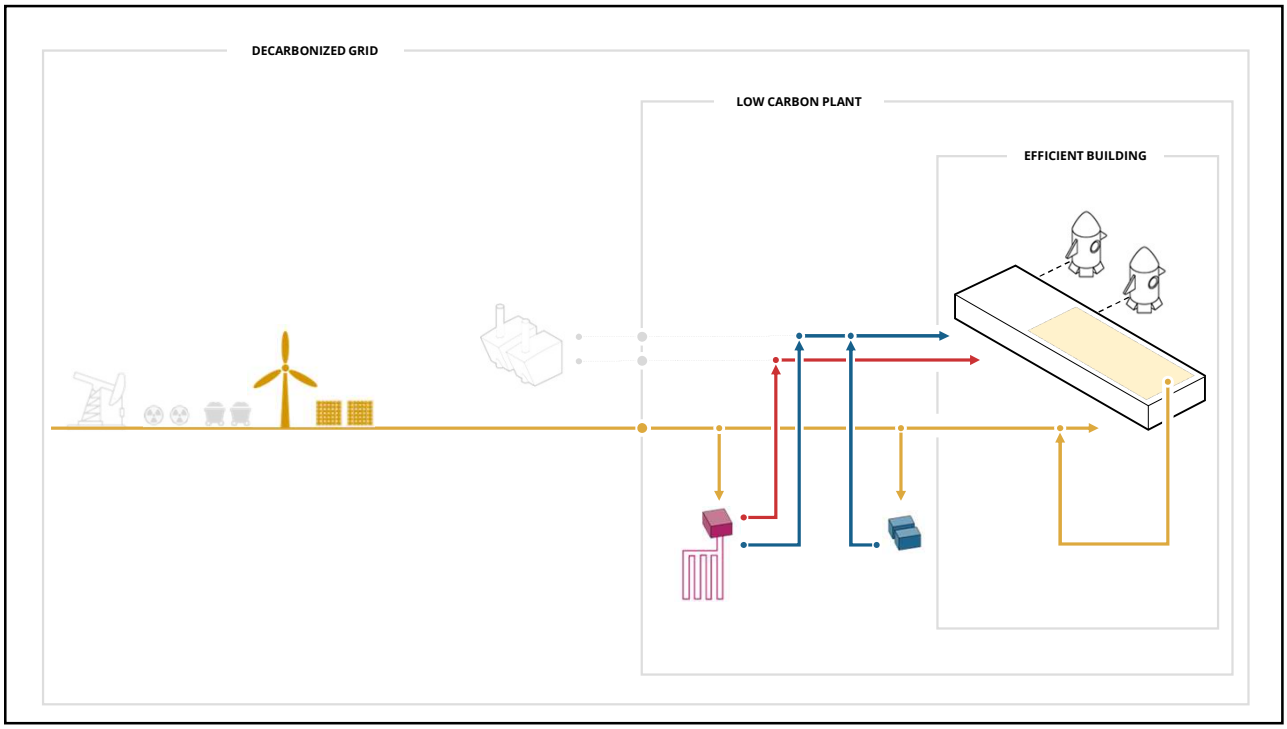
Estimating the range of magnitude of required offsets based on the rate at which the grid gets cleaner





Energy, Cost and GHG emissions based on consumption at boundary

14



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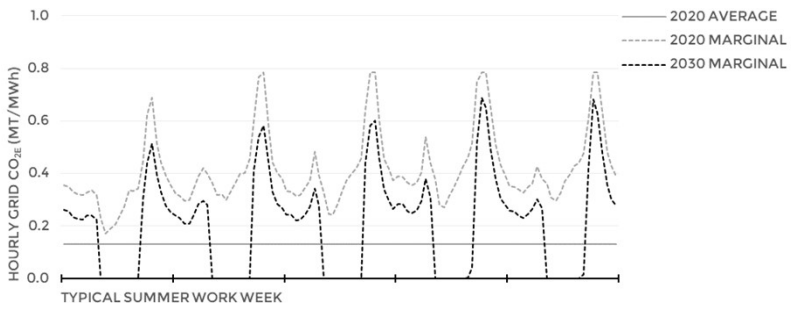
Future marginal emissions

The true GHGI of a building is affected by the magnitude as well as the hours of grid electricity draw



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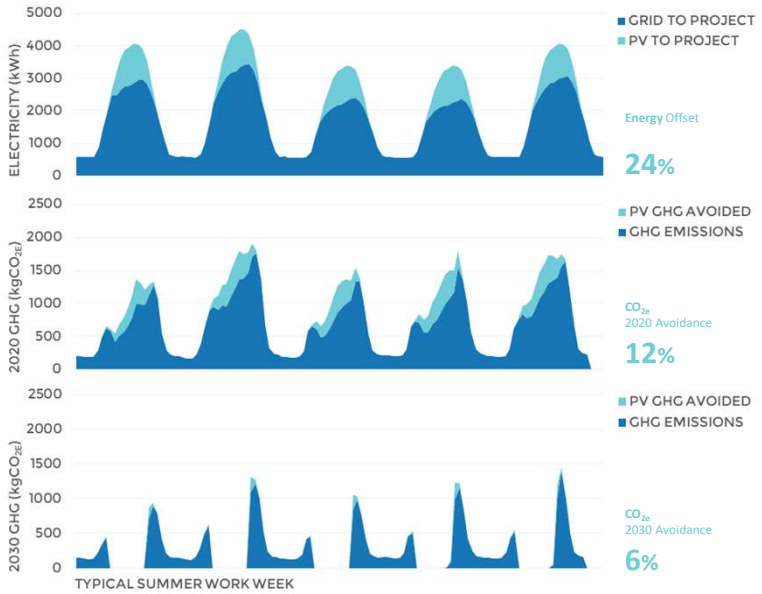
Generation is not enough

As the future grid gets cleaner, the significance of renewable energy generation will drop considerably



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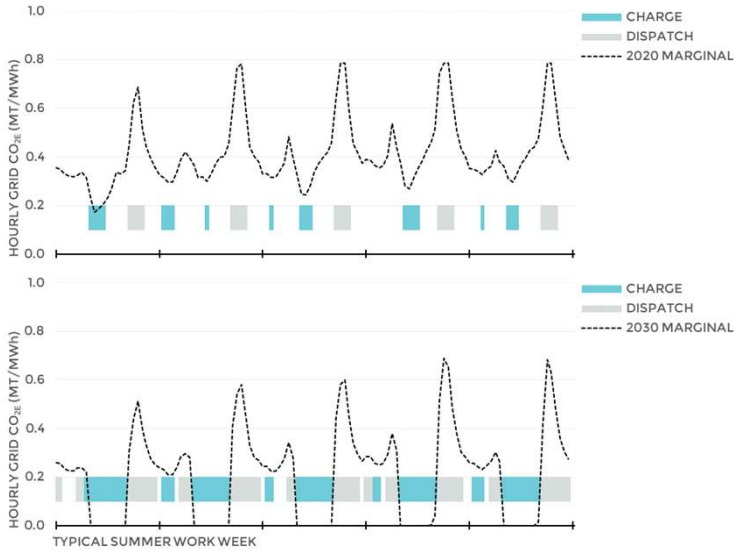
Automated dispatch logic

Look ahead at demand, emissions and signal a battery bank to charge and discharge optimally



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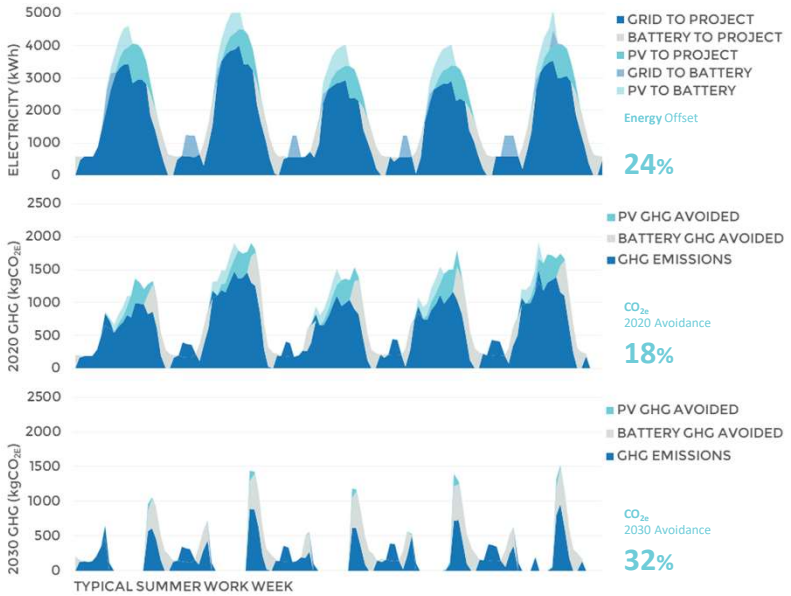
Shifting the load curve

By charging during low emissions hours and dispatching during high grid emission intensity hours



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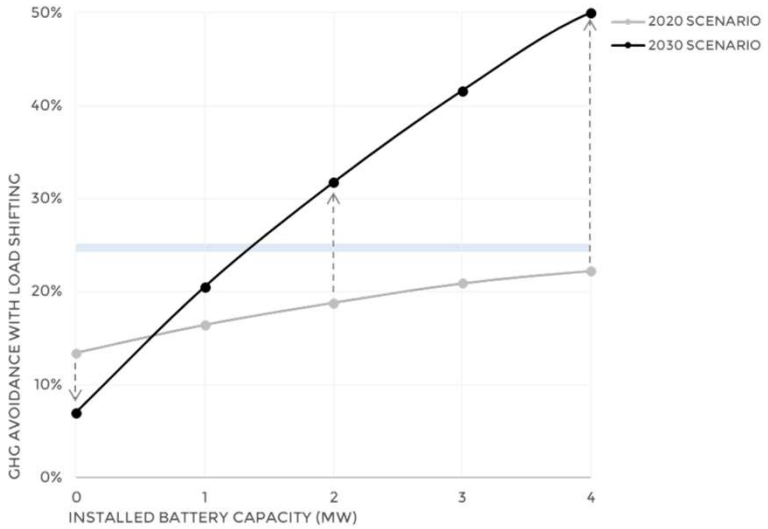
Avoided Emissions

The same renewable energy offset can avoid anywhere from 6% to 48% GHG as the grid gets cleaner



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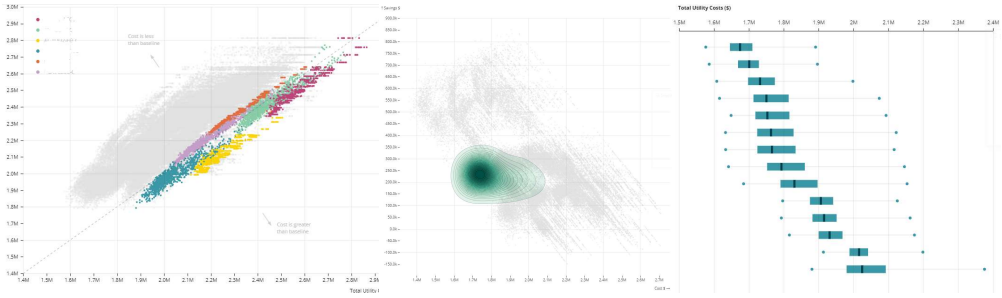
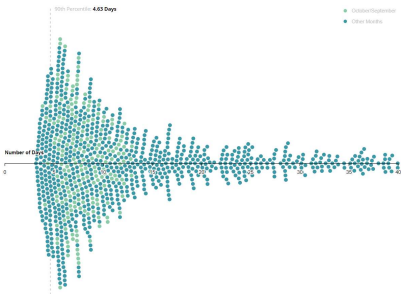
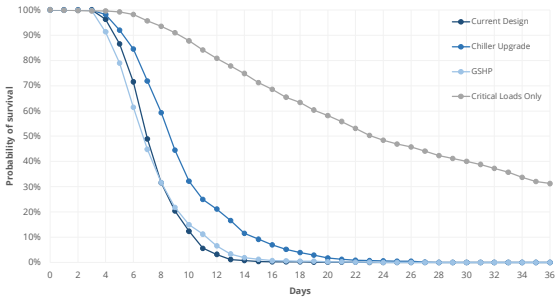
Rate structure optimization



Resilience





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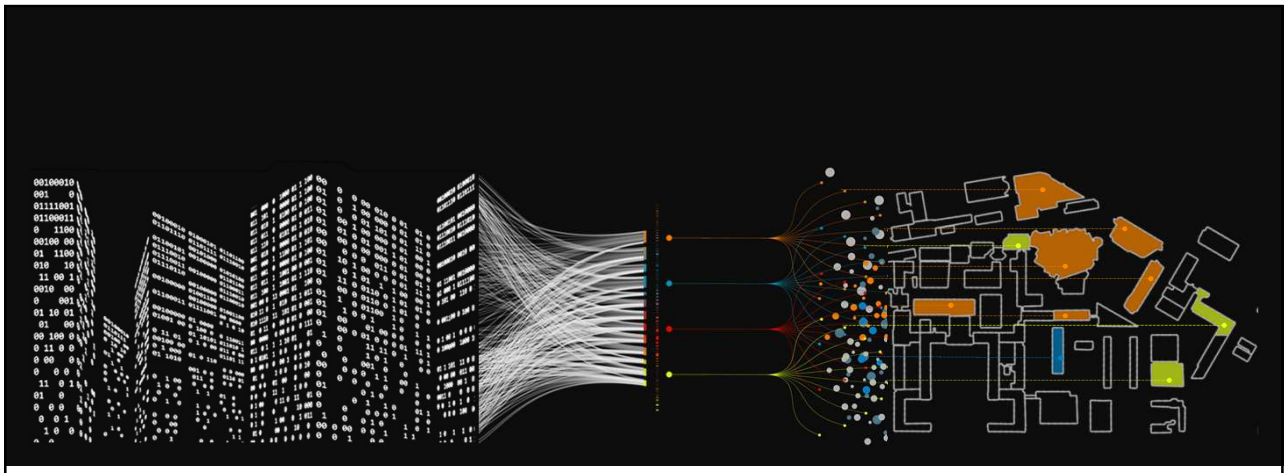

Rushil Desai
Senior Building Performance Analyst | Design Analytics
rdesai@elementaengineering.com

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The Value of GEB

Rois Langner
NREL

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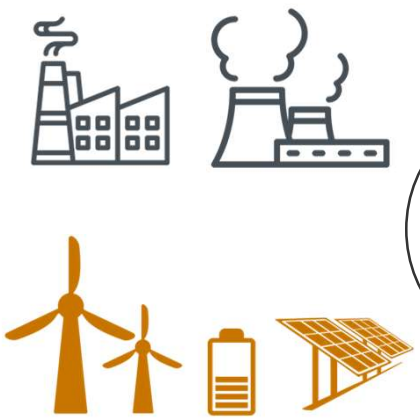
GEB is about enabling buildings to provide **flexibility** in energy use and grid operations



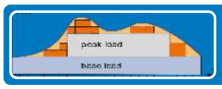
Supply

~75% of electricity generation is used in buildings

Demand

Potential Benefits of Flexible Building Loads

✓ Energy affordability



✓ Improved reliability & resiliency

✓ Reduced grid congestion

✓ Enhanced services

✓ Environmental benefits

✓ Customer choice

Key Characteristics of GEBs

A GEB is an energy-efficient building that uses smart technologies and on-site DERs to provide demand flexibility while co-optimizing for energy cost, grid services, and occupant needs and preferences, in a continuous and integrated way.

EFFICIENT

Persistent low energy use minimizes demand on grid resources and infrastructure

CONNECTED

Two-way communication with flexible technologies, the grid, and occupants

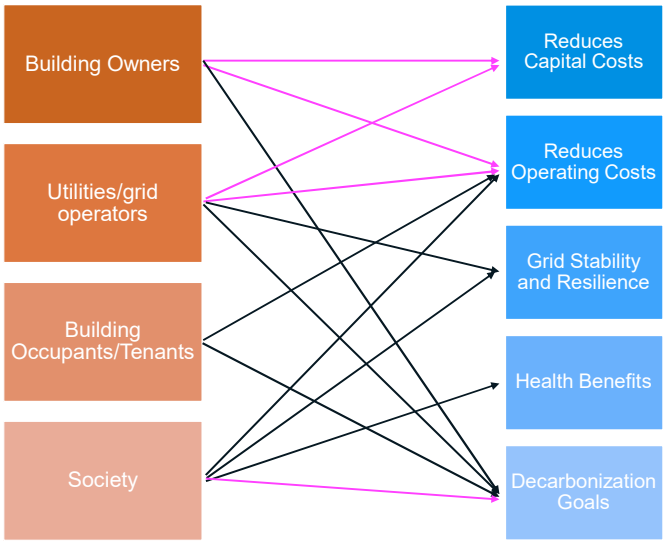
SMART

Analytics supported by sensors and controls co-optimize efficiency, flexibility, and occupant preferences

FLEXIBLE

Flexible loads and distributed generation/storage can be used to reduce, shift, or modulate energy use

Multiple Stakeholders, Multiple Sources of Value



Today's conversation:

1. Economic value to owners and grid stakeholders
2. Carbon value to society

The Value Potential for GEB in GSA's Portfolio

Direct Benefits to GSA	Grid and Societal Value	Indirect Value to GSA
• $50 MM in annual cost savings • $206MM in NPV • Project-level payback under 4 years • Futureproof: Accommodates future rate structure changes and helps manage costs	• Reduce grid-level T&D and generation costs up to $70MM/yr • These savings ultimately benefit the government and taxpayers • Future grid economic models will value savings (e.g. NWA's)	• Demonstrates federal and real estate industry leadership • Enables deeper savings in ESPCs and UESCs • Better building control can improve comfort, health, and productivity • CO2 savings

Assumes GEBs are applied across the GSA portfolio of owned office buildings; Based on bundle of measures modeled by RMI.

RMI ENERGY. TRANSFORMED.

Cost Effective GEB Measures & Strategies

Measures

Cost-effective in almost every location	Cost-effective in some locations

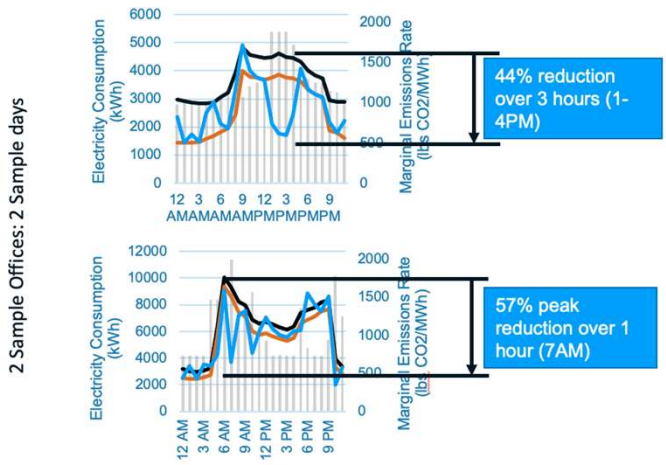
• **LED lighting upgrades,** including tube retrofits, fixture retrofits
• **Staging to reduce peak demand:**
  • Laptop battery charging
  • AHU fans
  • Electric resistance heaters (all-electric only)
• **Space temperature setback to reduce peak demand**
	• **Advanced lighting controls,** which enable peak shaving and DR
	• **Electric Battery storage**
	• **Solar PV** energy generation
	• **A solar + storage "bundle"** – bundling enhances the value beyond investing in solar and storage individually

GEBs measures have high net present value and short paybacks.

Strategies

1. The best returns are in locations with high demand charges, time of use rates, and seasonal variation.
2. Consistent demand management and peak shaving delivers greater value than demand response in most scenarios.

Carbon Value: Demand flexibility can cut building demand by 30-50%, reducing the need for peaker plants



- 80% of grid peak demand is driven by buildings[1]
- By shifting load strategically at peak hours can reduce or eliminate the need for dirty and expensive peaker plants

Source:
1. SEPA Webinar 2019

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Significant cost and health benefits by avoiding peaker plants.

- **Low efficacy**: Avoid $268 Million annually[1] in capacity payments that support the peaker plants which run < 10% of the time
- **Disproportionately expensive**: Peakers can cost up to 1,300% more than other typical sources[2]

- **Heavy Polluters:** Despite limited run-times, peaker plants contribute significantly to local air pollution with localized pollutants (i.e. Nox , SO2, PM2.5). While running, peakers can account for more than 1/3 of daily power plant NOx emissions[3]

- **Low-income and communities of color**: disproportionately bear the brunt of peaker plant health concerns. In these high impacted areas, rates are 4x higher for ozone-attributable asthma admissions[3]

Sources:
1. [Strategen for NY-BEST] NYC's Aging Power Plants: Risks, Replacement Options, and the Role of Energy Storage, 2017
2. [NYSERDA] Monthly Average Price of Residential Electricity, 2020
3. [Governor's Office of NY] Adoption of Regulations to Improve Air Quality, 2019

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On the horizon…

1. RMI, NREL, DOE and GSA are applying a similar GEB Value Analysis methodology on 2 BBA commercial portfolios (big box retail and multifamily) …stay tuned for results
2. GSA GEB RFI – piloting GEB controls solutions in public and private projects.
3. RMI working with NYSERDA to explore the carbon value of demand flexibility, implications on LL97.
4. GridOptimal Buildings Initiative – Released metrics and best practices from pilot projects
5. Forthcoming DOE Connected Communities projects

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GEB Field Studies

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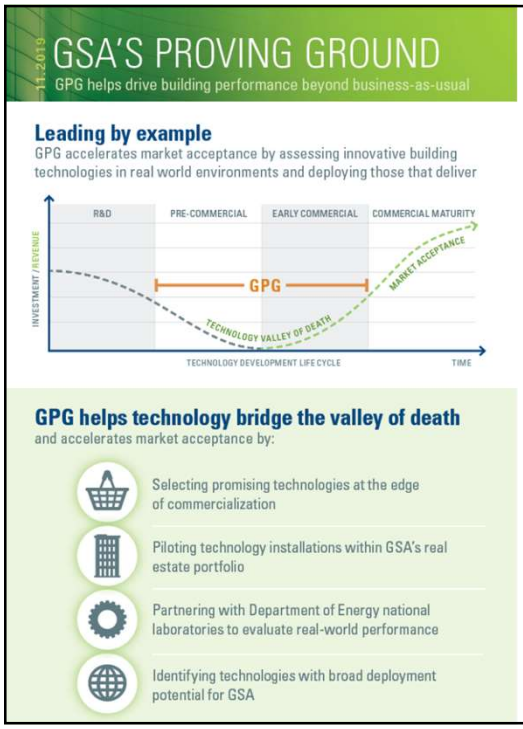
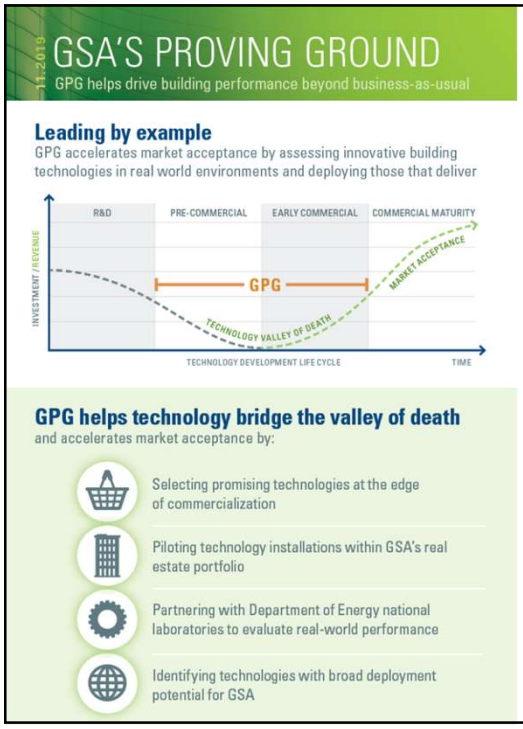


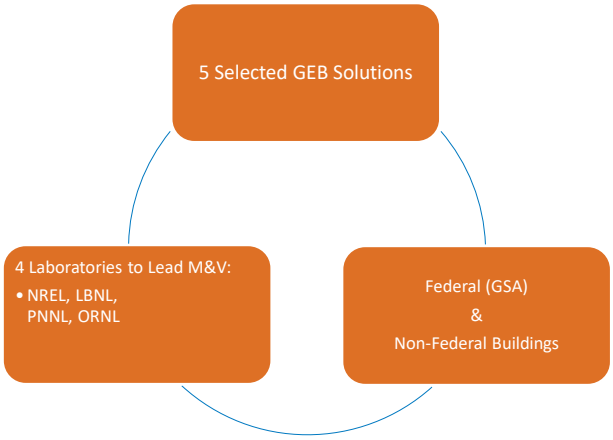
GSA Proving Ground DOE High Impact Technology Catalyst

2019 Request for Information:

- GEB solutions that cost-effectively provide building load flexibility
- Load flexibility modes (at least 3):
  - Energy efficiency
  - Load shed
  - Load shift
  - Modulation
- Integrate multiple building systems, beyond HVAC & lighting
- Aggregate data and dynamically manage and coordinate loads



GSA Proving Ground DOE High Impact Technology Catalyst



Key Objectives for GEB M&V

- Key objectives for evaluating GEB solutions:
  - Capability to enable energy efficiency & load flexibility – continuously & in response to DR events
  - Costs
  - Building owner and utility benefits
  - Integration and building service impact
- Highly complex solutions
  - Control of multiple building systems
  - Multiple load flexibility modes
  - Climate zone implications
  - Differences in building operational mission

Important to coordinate language, metrics, and M&V approach to enable as much consistency as possible across projects

Icons from www.flaticon.com

Metrics for Demand Flexibility

Energy Efficiency
- Energy savings: kWh/yr, % savings

Load Shed & Shift
- Monthly peak demand reduction: kW and %
- Monthly demand charge reduction
- Summer and winter average peak kW and charge reduction
- Demand shed per event: average kW
- Average demand increase/decrease over shift days summer/winter: kW, %

Load Modulation
- Upper and lower demand bounds for kW increase and decrease

Carbon Reduction
- Annual CO2 equivalent per year

Costs
- Capital costs
- Cost savings

Project Outcomes

1. Public facing reports and presentations
2. Calculating key success metrics – quantitative and qualitative
3. Capturing lessons learned and best practices from each field study

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Thank You

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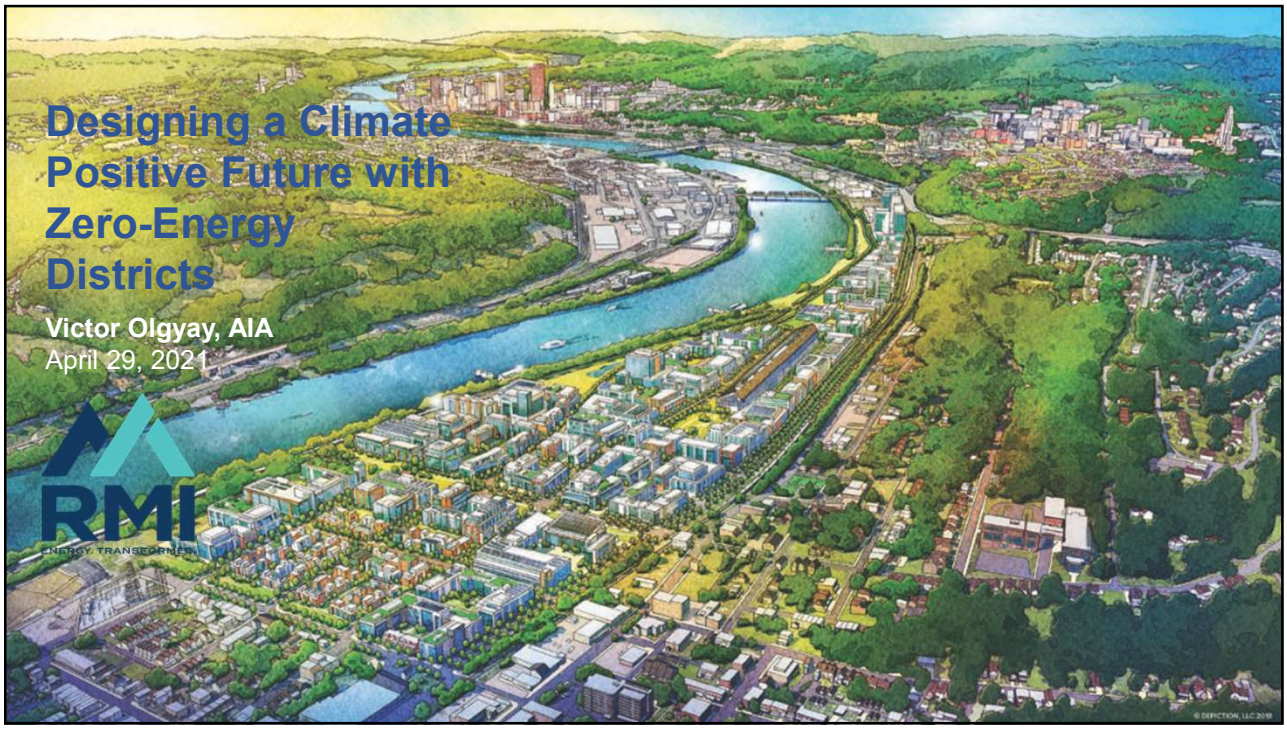
Designing a Climate Positive Future with Zero-Energy Districts
Victor Olgyay, AIA
April 29, 2021
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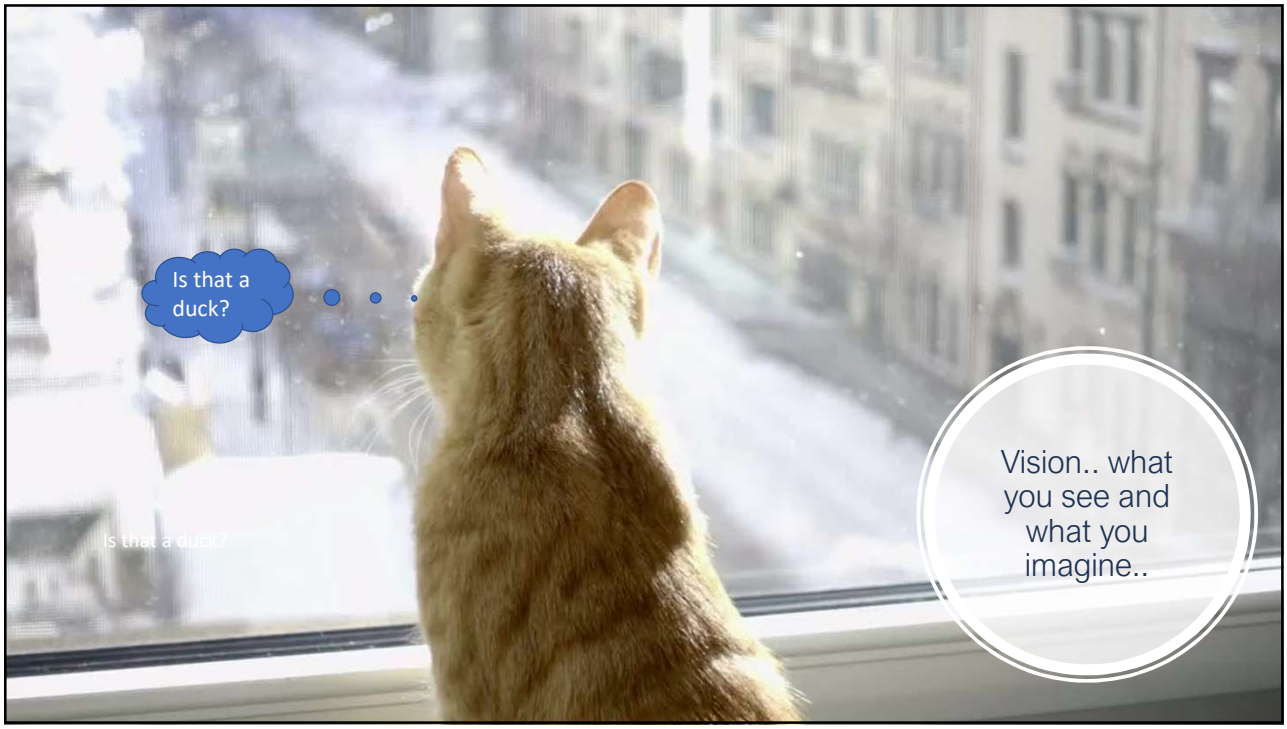
Is that a duck?
Is that a duck?
Vision.. what you see and what you imagine..

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"Eventually everything connects - people, ideas, objects. The quality of the connections is the key to quality per se."
— Ray and Charles Eames

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But we are still on "Version 1.0" of understanding building connections

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The "Duck Curve": Design generation and demand to fit load profiles

Duck Sitting in Water

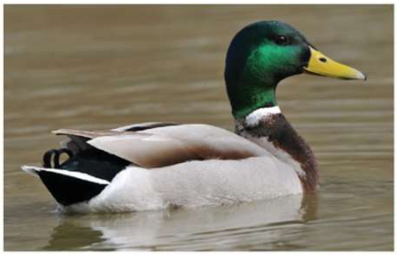
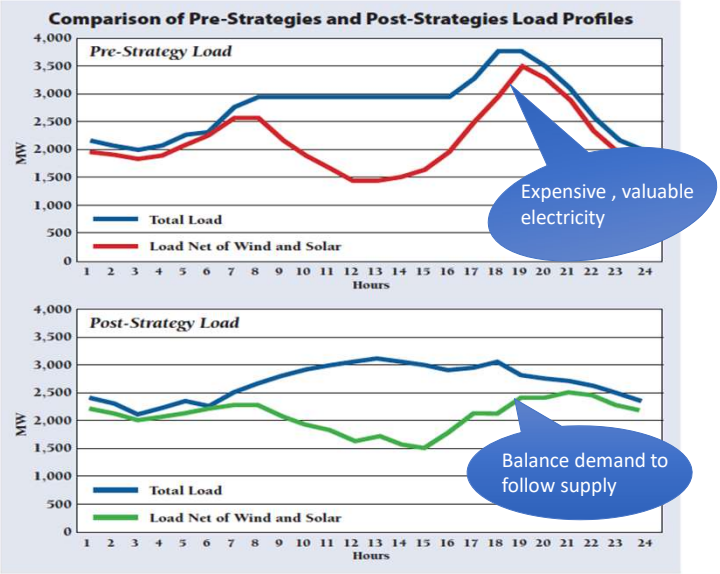


Figure 3
Duck in Flight



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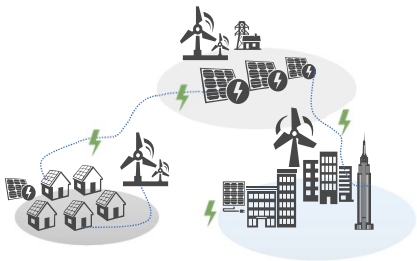
With grid integration, buildings can deliver significant value across stakeholder groups



Source of income to building owners

- Reduced operating cost, increased asset value
- Profit to building owner through selling electricity and associated grid services

Helps the grid run more smoothly

- Assist with load shaping by providing storage, demand flexibility
- Add diversity and resilience to grid by providing "spinning reserves" and frequency regulation
- Reduce capacity, transmission and distribution infrastructure costs and upgrades

Reduces energy costs and pollution for owners, utilities, and the general public

- Essential for the transition to a renewable powered system and ultimately decarbonization
- Demonstrates industry leadership
- Improves control and occupant comfort in buildings

Buildings: Grid services are one of many value propositions of buildings, try using an integrated design approach

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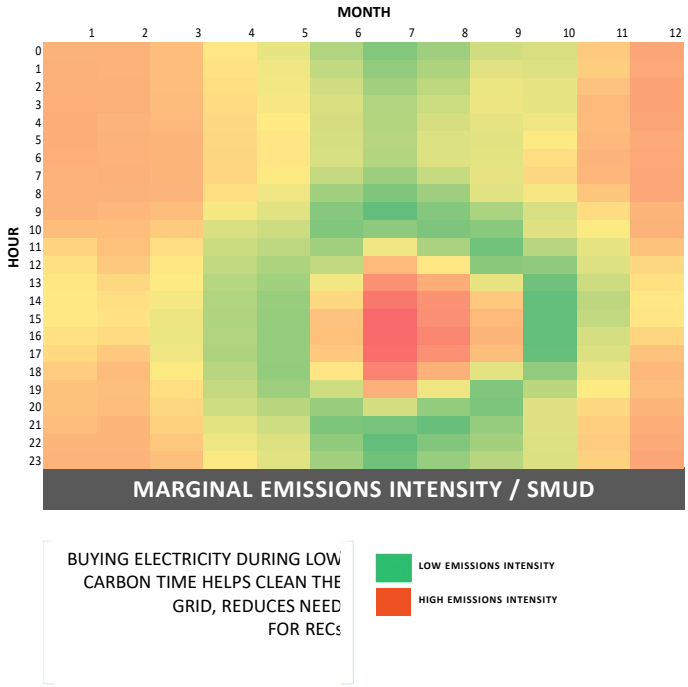
Pollute less by operating buildings strategically

Our buildings can influence the carbon emissions intensity of the electricity grid.

With grid integration we can use operational strategies to optimize both carbon & cost benefits today



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Connected Communities

- **Are Grid-interactive and efficient**
  - The capability to shed, shift, or modulate energy use in response to grid signals.
- **Connect Buildings and Grid Services**
  - Accessed with multiple technologies: building load flexibility, renewable energy generation, and energy storage.
- **Use Multi-building optimization**
  - Employ diversity and strategies to optimize energy use and dispatch of distributed energy resources to increase the benefits beyond that of a building-by-building approach.
- **Employ Shared systems**
  - Geographically contiguous connected communities can incorporate physically connected shared systems such as district thermal plants, community solar, or energy storage installations across multiple facilities,
- **Coordinate with Central Control systems**
  - Connected communities accomplish this through a controls platform enabling grid-interactivity at the multi-building scale.

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Basalt Vista Affordable Housing

A Net zero, all-electric community

- Led by Habitat for Humanity, this development has 27 families with all-electric, energy- efficient homes, **no gas**
- Simple design,
- High efficiency
- Hybrid electric water heaters
- Heat recovery ventilators
- Cold climate heat pumps
- Sealed conditioned crawlspaces
- Rooftop PV
- Battery storage
- EV chargers

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Holy Cross Energy, the local electric utility co-op, is working to reach its goal of 70% carbon-free energy by the year 2030. Basalt Vista a sophisticated communication and control device called a "coordinator" that interfaces between the house and the utility's dispatch center.

The batteries store power from the solar panels; supply power to the house; store power drawn from the grid; and they supply power to the grid. All those functions are managed by the coordinator, which is also able to control other "distributed energy resources" in the house—the heat pumps, the heat pump water heater, and the electric vehicle charger

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Providing meaningful amounts of grid services

A solar microgrid in conjunction with a one megawatt/ two MWh lithium-ion battery system. This 100-building district is connected to the local electric grid and provides services including solar to grid integration, ramp control, grid peak demand reduction, and frequency regulation. These valuable grid support services also strengthen grid resilience through backup power and ensures the community is supplied by abundant clean energy. In this district Xcel Energy was able to avoid the capital cost of building an electrical substation because of the grid support provided by the energy storage system.

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Microgrid Powered by Clean, Resilient, Renewable Energy

A 1.6 MW solar PV system at the 61st and Peña rail station, and another 259 kW of solar PV on Panasonic's rooftop, help power Peña Station NEXT with renewable energy. This system and a large on-site battery system owned and operated by Xcel Energy form a microgrid that strengthens energy resilience and ensures the community is supplied by clean energy.

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Hazelwood Green

A Brownfield Site with a Forward-Leaning Vision

- **Location: Pittsburgh, PA**
- 180 acre former steel mill site
- 6M gross ft^2 of building floor area
- 60% residential, 30% office, 10% other
- Deregulated electricity market

- **Problem Statement**
- Site owners have a net-zero energy ambition
- Must be financially sound for developers, building owners, and tenants
- First-cost premium may threaten project viability
- Market advised that net zero energy was unachievable

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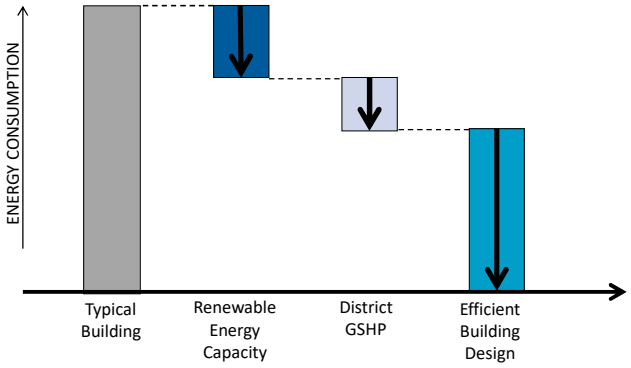
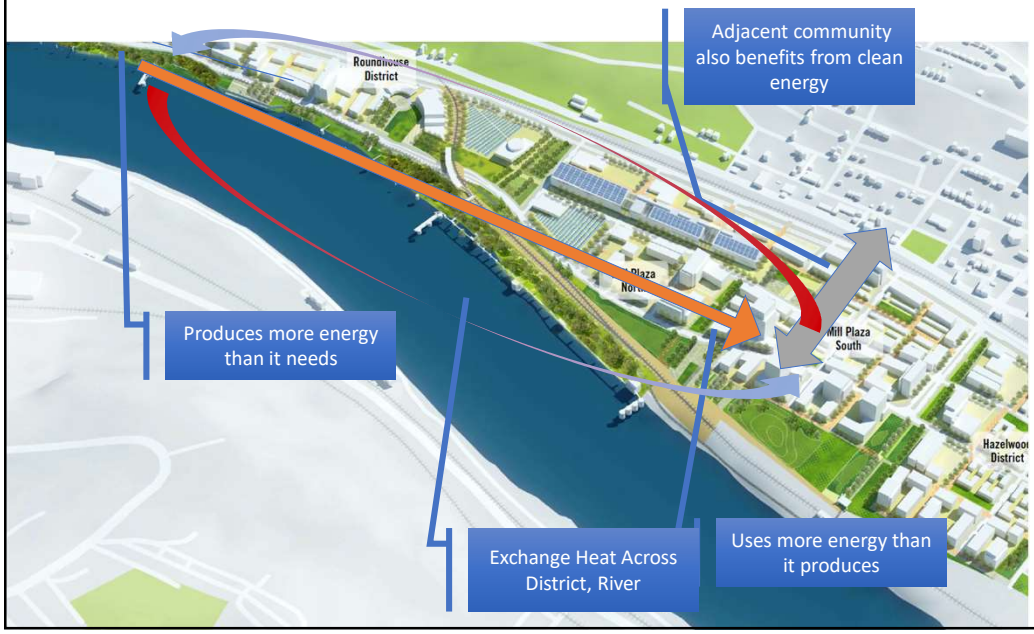
The pathway to zero for Hazelwood Green includes on-site renewables, district scale GSHP, and efficient building design



54

District scale provides greater opportunity to share energy



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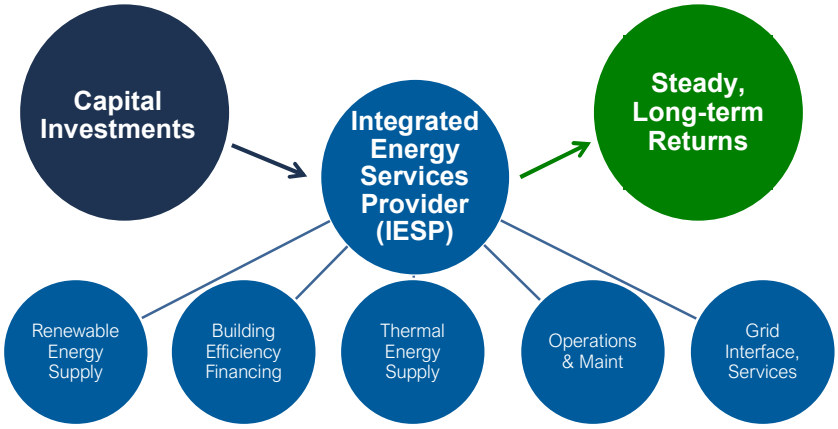
The Integrated Energy Services Provider (IESP) aligns incentives while driving a greater investment opportunity



The integrated energy services provider (IESP) aggregates site energy services while ensuring that net-zero energy is financially attractive to vertical developers and tenants while collecting a steady, long-term return .

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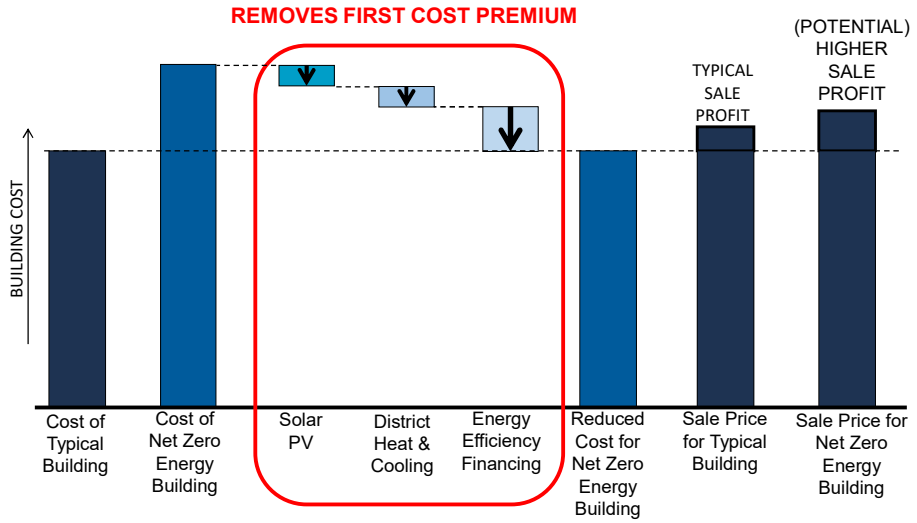
IESP shifts up front costs from individual building to central entity



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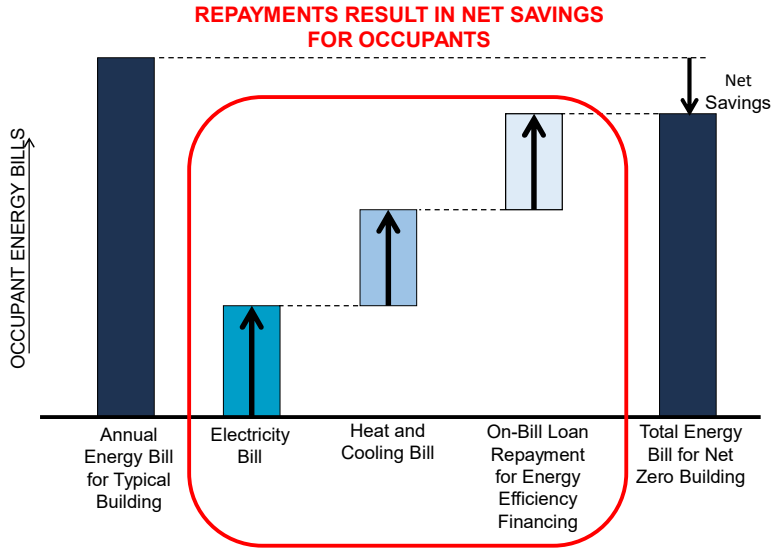
IESP revenues are delivered through the occupant energy bills



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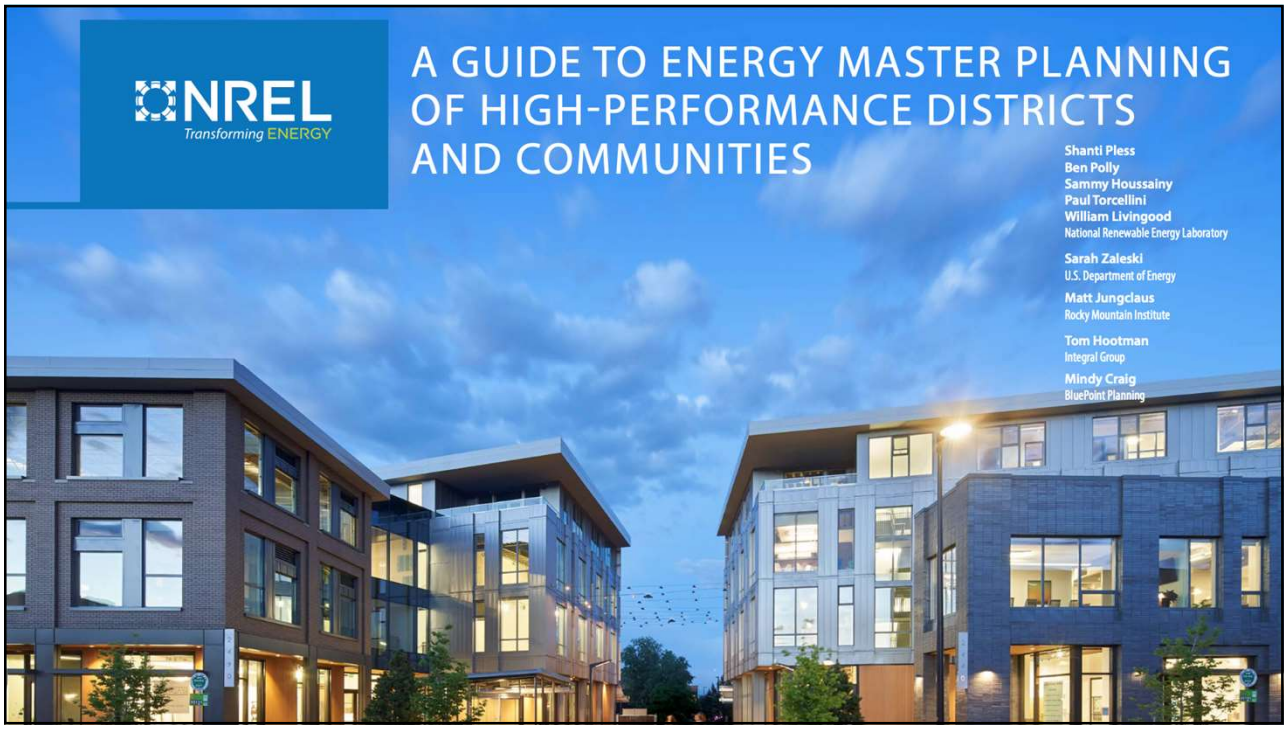
NREL
Transforming ENERGY
A GUIDE TO ENERGY MASTER PLANNING OF HIGH-PERFORMANCE DISTRICTS AND COMMUNITIES
Shanti Pless
Ben Polly
Sammy Houssainy
Paul Torcellini
William Livingood
National Renewable Energy Laboratory
Sarah Zaleski
U.S. Department of Energy
Matt Jungclaus
Rocky Mountain Institute
Tom Hootman
Integral Group
Mindy Craig
BluePoint Planning

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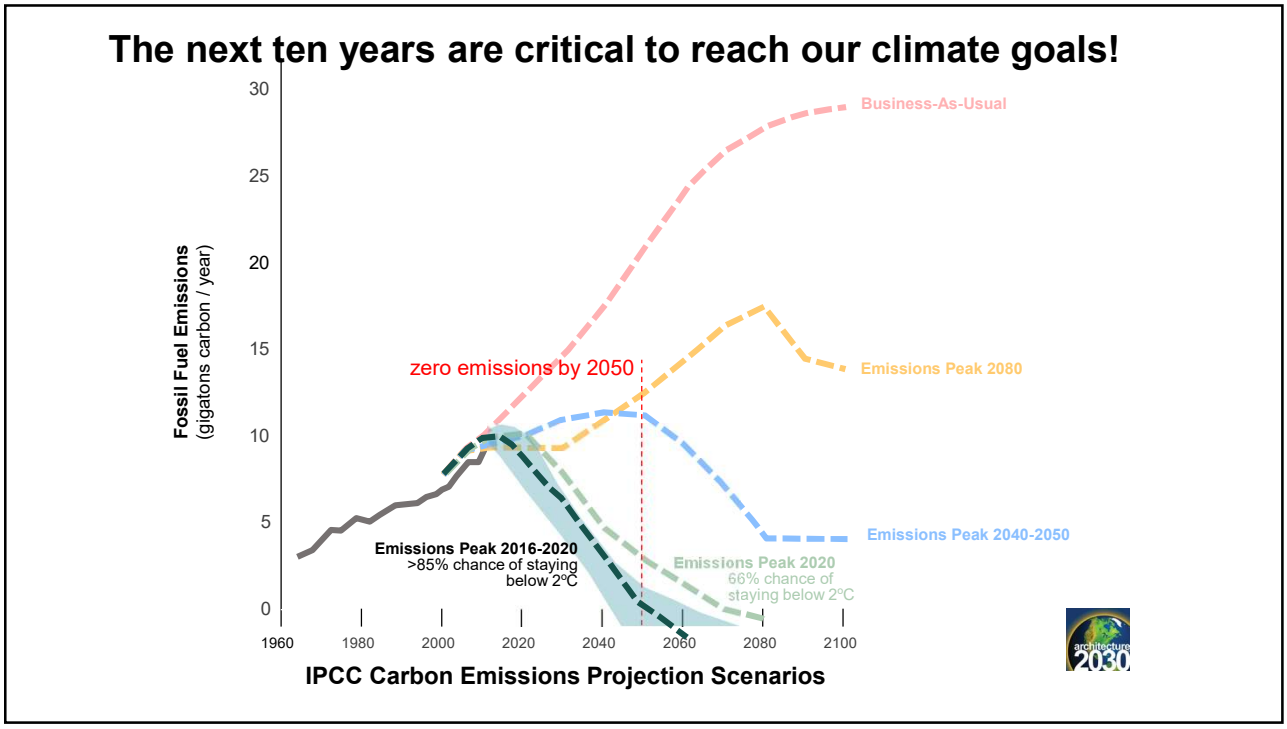
The next ten years are critical to reach our climate goals!
Fossil Fuel Emissions
(gigatons carbon / year)
30
25
20
15
10
5
0
1960
1980
2000
2020
2040
2060
2080
2100
Business-As-Usual
zero emissions by 2050
Emissions Peak 2080
Emissions Peak 2040-2050
Emissions Peak 2016-2020
>85% chance of staying below 2ºC
Emissions Peak 2020
66% chance of staying below 2ºC
IPCC Carbon Emissions Projection Scenarios
architecture 2030

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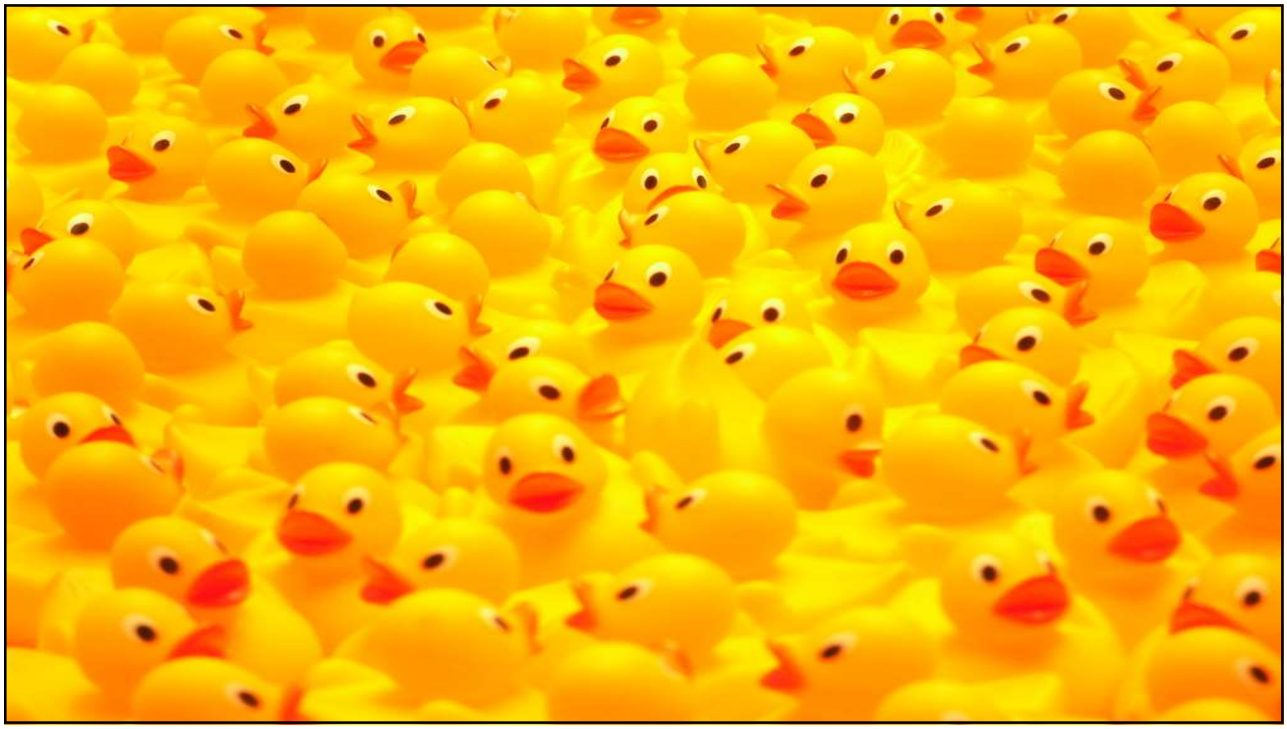

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Resources for designing Net Zero Districts:

Innovation Opportunities in Grid-Interactive Efficient Buildings
https://rmi.org/insight/value-potential-for-grid-interactive-efficient-buildings-in-the-gsa-portfolio-a-cost-benefit-analysis/

Guide: Best Practices for Achieving Zero Over Time for Building Portfolios
https://rmi.org/insight/zero-over-time-for-building-portfolios/

An Integrative Business Model for Net-Zero Districts
https://rmi.org/wp-content/uploads/2017/03/Insight-brief_Net-zero-energy8_2.pdf

Designing a Climate-Positive Future with Zero-Energy Districts
https://rmi.org/designing-a-climate-positive-future-with-zero-energy-districts/

Connected Communities: A Better Way of Building
https://rmi.org/connected-communities-a-better-way-of-building/

"Connected Communities: A Multi-Building Energy Management Approach"
https://www.nrel.gov/docs/fy20osti/75528.pdf

Thank You

Maybe we can help more ducks to fly?

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GridOptimal Buildings LEED Pilot Credit

Overview – April 29, 2021

GRIDOPTIMAL™
BUILDINGS INITIATIVE

https://newbuildings.org/gridoptimal/

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GRIDOPTIMAL™ BUILDINGS INITIATIVE

newbuildings.org/gridoptimal

- Main Focus: *new building-grid interaction metrics*
  - Metrics published (blog, white paper)
  - LEED Credit: GridOptimal Buildings Pilot Alternative Compliance Path published & available
- Current Work: *deployment*
  - Utility program criteria
  - Design guidance
  - Code and policy frameworks

A Joint Initiative Of:

nbi new buildings institute

Supporting Members:

Southern California Edison, PG&E Pacific Gas and Electric Company, SMUD, Austin Energy, Efficiency Vermont, EnergyTrust of Oregon

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GridOptimal Metrics: at the core of it all

GridOptimal Metric	What it Measures
Grid Peak Contribution	Degree to which building demand contributes to load on the grid during system peak hours
Onsite Renewable Utilization Efficiency	Building's consumption of renewable energy generated onsite (not exporting to grid) over a year
Grid Carbon Alignment	Degree to which the building demand contributes to upstream (grid) carbon emissions over a year
Energy Efficiency vs. Baseline	Percent better than code (annual total energy use)
Short-Term Demand Flexibility	Building's ability to reduce demand (shed) for 1 hour
Long-Term Demand Flexibility	Building's ability to reduce demand (shed) for 4 hours
Dispatchable Flexibility	Building's ability to automatically reduce demand (shed) for 15 minutes, controlled by utility/ third party
Resiliency	Building ability to island from grid and/or provide energy for critical loads for 4-24 hours; motor soft start capability to help grid restart after outage

https://newbuildings.org/wp-content/uploads/2020/11/NewMetricsForEvaluatingBuildingGridIntegration.pdf

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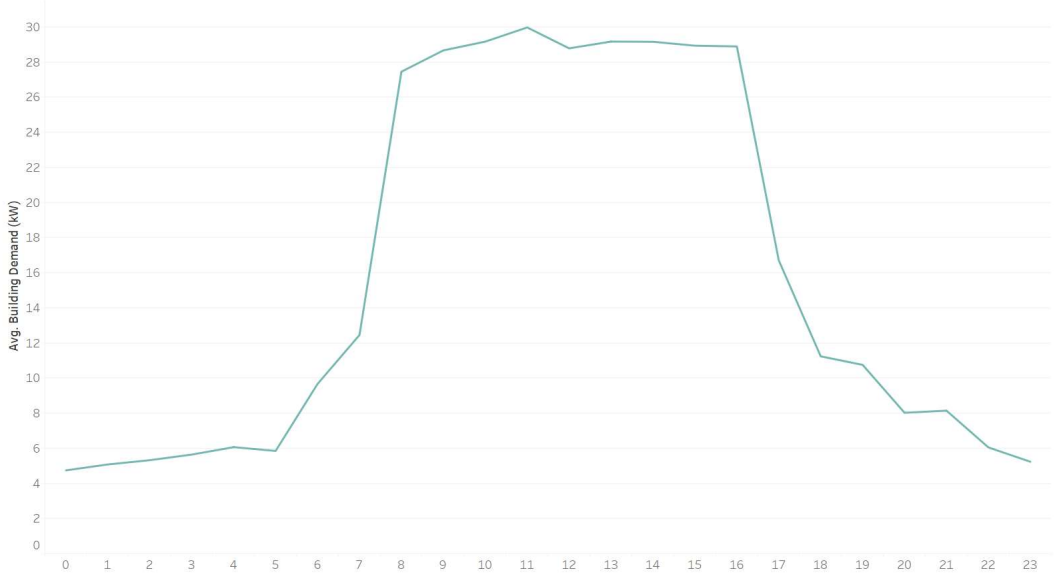
GridOptimal Metrics: Load Shape Metrics



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GridOptimal Metrics: Load Shape Metrics

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Energy Efficiency vs. Baseline	Percent better than code (annual total energy use)

These metrics evaluate the *building's load shape (demand profile)*

- Grid load (MW): bulk system peak shaving
- Grid emissions factors: GHG savings
- Renewable self-consumption: distribution congestion

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GridOptimal Metrics: Capability Metrics




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GridOptimal Metrics: Capability Metrics

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These metrics evaluate the *building's capabilities/assets*

- Demand Flexibility (load shed): how much of building's peak can it shed
  - Duration & controllability considerations (short/long/dispatchable)
- Resiliency: both sides of the meter
  - Islanding capability
  - Buildings supporting grid black starts w/ motor soft start

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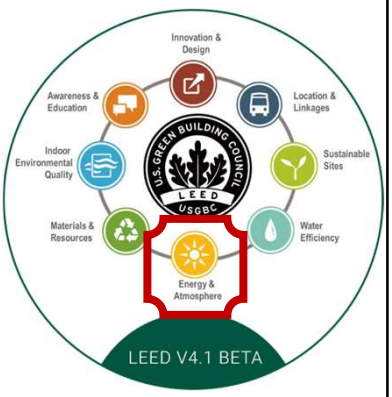
GridOptimal Buildings LEED Credit



- 3 options for project teams
  - 1 point: Calculate and report
    - do no worse baseline -> design (or explain)
  - 2 points (+1 ID avail.): Across-the-board improvements
    - Minimal score improvements in 3 categories (or 6 categories for +1 ID point)
  - 2 points (+1 ID avail.): Focused area improvements
    - Moderate score improvement in 1 category
    - (or higher for +1 ID point)

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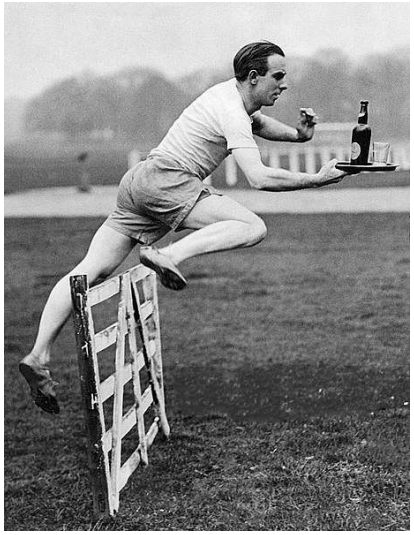
GridOptimal Utility Program Criteria



- Define *Credit Thresholds* for each metric
  - Improvement from baseline to proposed
  - Vary by Building Type, New/Retrofit, …
- Building the dataset needed for utilities to compare measures/strategies
  - GridOptimal metric scores
  - Conventional energy efficiency savings
  - Conventional DR / peak kW savings

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Grid Context Varies by Region & Over Time

- **Solar Heavy**, ex. California: PV produces more energy during summer and mid-day.
- **Wind Heavy**, ex. Midwest and Texas: onshore wind often stronger at night; can be variable over short term.
- **Hydro Heavy**, ex. Pacific Northwest: high hydro generation during the spring and early summer months as snow melts; system flexibility over short term.
- **Fossil Fuel Heavy**, ex. Rust Belt, Southeast: Emissions are typically highest during grid system peak demand hours (inefficient gas peakers) but are often also high during off-peak hours (coal base load).

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Climate Context Contributes to Grid Conditions

- **Summer Peaking:** Peak system load occurs in summer afternoon
  - Nearly all regions have a significant summer peak – some more than others
  - Focus on cooling system performance, thermal envelope upgrades, afternoon shading, internal load reductions, precooling
- **Winter Peaking:** Peak during cold winter morning, mid-day, or evening hours
  - Reduce energy usage in winter peak hours: thermal envelope upgrades, heating system performance, preheating strategies
- **Dual-peaking:** Peak system load in summer and again in winter
  - Consider both summer and winter strategies – ex., thermal energy storage tanks for precooling on summer afternoons *and* preheating on winter mornings/days
  - Some regions are summer-peaking today but may become dual-peaking as electrification of building heating systems accelerates

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Resiliency on Both Sides of the Meter

Puerto Rico, 9/22/17 (NBC)

Grid Integration Features in Buildings Support Resiliency Goals

- Independent power sources (PV) may allow grid-independent operation (islanding)
- Passive features support building habitability during no-power operation
- Staged start up capabilities can support faster grid recovery after outages
- On-site energy storage can provide emergency support for communities (communication, refrigeration, etc.)

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Our Long-Term Vision

- **Transform the built environment for tomorrow's grid**
- Support development of integrated utility programs
  - Holistic efficiency *and* demand response programs
  - Incentives: new metrics & a fresh framework
- Design guidance and tools for designers
- Program, Rating System, Market, and Policy Deployments

Buildings can be
grid decarbonization enablers

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GRIDOPTIMAL™
BUILDINGS INITIATIVE

Now welcoming pilot buildings + program participants – join us!
https://newbuildings.org/gridoptimal/

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Q and A

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Save the Date!
GETTING TO zero FORUM 2021
October 27-29, 2021
New York City
Join building and energy industry leaders at the premier global event dedicated to defining a low-energy, low-carbon future for the built environment.
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NYSERDA
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Access case studies, research, guidance, models and more
The Getting to Zero Resource Hub is an open-source collection of over 300 zero energy and zero carbon resources across six different topic areas:
Design & Development
Embodied Carbon
Codes & Policy
Local Governments Toolkit
Residential
Schools
gettingtozeroforum.org/resource-hub
GETTING TO zero
nbi new buildings institute
The Getting to Zero Resource Hub was developed and delivered by New Buildings Institute with ongoing support from our sponsors and partners.

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Thank you!

You will receive an email tomorrow with links to the on-demand recording and a PDF of the slides.

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