Best of the Forum Webinar

Decarbonization Technologies
What We Have, What We Need

October 29, 2020

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.
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:

Today’s panelists:

Clay Nesler  
Vice President  
Global Energy and Sustainability  
JCI

Shanti Pless  
Senior Energy Efficiency Research Engineer  
NREL

Richard Young  
Director of Education  
The Food Service Technology Center

Ram Narayanamurthy  
Technical Executive  
Decarbonization of Buildings and Communities  
EPRI
The 13th edition of the Energy Efficiency Indicator Study surveyed 400 energy and facility management executives across the U.S.

<table>
<thead>
<tr>
<th>Survey respondents</th>
<th>Commercial</th>
<th>37%</th>
<th>C-Level</th>
<th>21%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Institutional</td>
<td>25%</td>
<td>Vice President/Director</td>
<td>31%</td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>25%</td>
<td>Manager</td>
<td>46%</td>
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<tr>
<td></td>
<td>Other</td>
<td>13%</td>
<td>Other</td>
<td>2%</td>
</tr>
</tbody>
</table>

Survey respondents meet one of the following criteria:
- Review or monitor the amount of energy used by organization’s facilities
- Propose or approve energy efficiency or smart building initiatives
- Have budget management or investment responsibility for organization’s facilities
Organizations that expect to increase energy efficiency investments over the next 12 months

Energy focused educational programs, HVAC, and building controls are expected to be the biggest investments in the next year

- Energy focused behavior or educational programs: 68%
- Heating, ventilation, air conditioning improvement: 67%
- Building controls improvements: 67%
- Electric energy storage: 59%
- Fire / life safety improvements: 57%
- Integration of fire/ life safety systems: 52%
- Building systems integration: 50%
- Demand response / management: 50%
Organizations planning to achieve or have achieved green building certifications

- 83% have achieved
- 86% plan to achieve
- 83% have achieved or plan to achieve

Organizations ‘extremely’ or ‘very’ likely to achieve a net zero facility in the next ten years

- 57%
- 67%
- 59%
- 70%
## Investment difference between organizations planning to achieve net zero versus not

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand response / management</td>
<td>17%</td>
</tr>
<tr>
<td>Distributed energy resource integration</td>
<td>15%</td>
</tr>
<tr>
<td>Thermal energy storage</td>
<td>14%</td>
</tr>
<tr>
<td>Lighting system integration</td>
<td>10%</td>
</tr>
<tr>
<td>Non-renewable distributed energy generation</td>
<td>9%</td>
</tr>
<tr>
<td>Mobile occupant interfaces</td>
<td>8%</td>
</tr>
<tr>
<td>Controls</td>
<td>5%</td>
</tr>
<tr>
<td>HVAC</td>
<td>4%</td>
</tr>
<tr>
<td>Lighting</td>
<td>3%</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>3%</td>
</tr>
</tbody>
</table>

## Organizations extremely or very likely to have one or more facilities that can operate off the grid in the next 10 years

- **61%**
- **64%**
- **61%**
Organizations that replaced fossil-fuel heating with heat pumps in the previous 12 months

Occupant health and resiliency are driving investments in 2020

Percentage of organizations reporting improving occupant health and wellness as an ‘extremely’ or ‘very’ important driver of investment

81% said increasing the flexibility of facilities to quickly respond to a variety of emergency conditions (e.g., pandemic, natural disaster) was extremely or very important as a driver of investment.
In response to COVID, facility managers are investing in upgrades

Energy use has not decreased in 2020 in proportion with significantly reduced building occupancy
What is the future of the Building Energy Efficiency Industry in the era of cheap grid-scale baseload renewables?

Shanti Pless, NREL Commercial Buildings Energy Efficiency Researcher

10/11/2019
New study reaches a stunning conclusion about the cost of solar and wind energy

Building new renewables is now cheaper than just running old coal and nuclear plants.

“A widely-used yearly benchmarking study — the Levelized Cost of Energy Analysis (LCOE) from the financial firm Lazard Ltd. — reached this stunning conclusion: In many regions “the full-lifecycle costs of building and operating renewables-based projects have dropped below the operating costs alone of conventional generation technologies such as coal or nuclear.”

https://thinkprogress.org/solar-wind-keep-getting-cheaper-33c38350fb95

Los Angeles seeks record setting solar power price under 2¢/kWh

The city’s municipal utility is readying a 25-year power purchase agreement for 400 MWac of solar power at 1.997¢/kWh along with electricity from 200 MW / 800 MWh of energy storage at a 1.3¢/kWh adder, for an aggregate price of 3.297¢/kWh.

JUNE 28, 2019 JOHN WEAVER

PV Costs Continue to Fall...

Figure ES-1. NREL PV system cost benchmark summary (inflation adjusted), 2010–2018
https://www.nrel.gov/docs/fy19osti/72399.pdf

$1.81

• $0.0181/kWh
• Median bid of 100 open source project bids received in Q4 2017 in Xcel Colorado for over 4000 MW of new wind projects
  • demonstrates that these low bids weren’t one-off outliers, but rather indicative of real industry costs.
  • For projects to be put in place over the next 5 years
  • 1.1 cents/kWh lowest bid..

2018 updated costs

Xcel Energy’s 120-day report to Colorado regulators includes an additional 1.1 GW of wind at 1.1-1.8¢/kWh. Solar power bids have come in at 2.2-2.7¢/kWh, and solar+storage at 3.0-3.2 c/kWh


• move Colorado from 28% renewables as of 2017, to 53% by 2026.
Building Energy Efficiency in the era of cheap renewable baseload

- Will classic utility efficiency programs investments go down?
  - ~$7 Billion/year in 2016
  - $0.046/kWh saved average cost for efficiency programs
- Saving energy during hours of high renewables on the grid will not be a benefit...
- Saving energy during peak fossil hours and peak congestion hours will still be of high value
  - "kWh savings anytime, anyplace" will be become "kWh savings at the right time, in the right place"
- Demand Flexibility and GEBs
- Zero Energy to enhance on-site resiliency
100% Renewables – Google’s Corporate Commitment
The Internet is 24x7. Carbon-free energy should be too.

https://www.blog.google/outreach-initiatives/sustainability/internet-24x7-carbon-free-energy-should-be-too/

100% Renewables, 100% of the time

• Met 100% offsite in 2017 with aggressive datacenter efficiency, large scale off-site PV and Wind PPAs and local utility direct purchasing programs
• 100% Renewable, 100% of the time is the next goal

“Ultimately, we aspire to source carbon-free energy for our operations in all places, at all times.”
Every hour of electricity use at Netherlands data center

Overall in 2017, 69% of this data center's electricity use was matched on an hourly basis with carbon-free sources.

*This heat map assumes that our Netherlands data center's hourly electric load was constant throughout the year (based on January 2017 values). In reality, the data center experienced load growth. We suppress that growth here in order to accentuate the impact that a solar farm can have on carbon-free energy matching. The 69% carbon-free match reported above does reflect the data center's actual load growth.

Every hour of electricity use at North Carolina data center

Overall in 2017, 67% of this data center's electricity use was matched on an hourly basis with carbon-free sources.

*FIG. 7*

This data center's midday electricity use is matched with regional solar energy, making its carbon-free profile highest during those hours.
Thanks for the Time and your Questions

• Shanti Pless – NREL Buildings Research
• Shanti.pless@nrel.gov
**EPRI Mission and Membership**

- Not-for-profit research organization working on public benefits research on electricity issues
- 450+ participants in more than 30 countries with international members comprising 25% of research funding
- EPRI members generate approximately 90% of the electricity in the US

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**Building decarbonization pathways**

**The case for hybrid pathways**

- How can we preserve customer functionality?
- How do you provide resilience?
- How do you decarbonize affordability?
- How do you preserve future optionality?
Research trajectory towards zero carbon communities

2014 Fontana, CA

2019 Irvine, CA

2017 Clovis, CA

Energy related GHG emissions for a new home (using hourly source emissions from 2018)
- Mixed Fuel
- All Electric

Understanding behavioral load shapes + ZNE/electrification in LIMF communities

Decarbonization portfolio in affordable housing communities

Understand ZNE + Electrification in infill settings (LINC)

All Electric Zero Carbon new construction affordable housing

Heat Pump retrofits in existing multifamily housing

Mixed fuel + renewable retrofits

Electrification ZNE retrofit in 50-yr old community
Archetypes for Smart, low carbon communities

- Electrified ZNE communities (Irvine & Clovis, CA)
- Smart Thermostat Evaluation Collaborative (17 utilities, 10000 connected devices)
- University Hospital Campus San Diego, CA
- Microgrids serving 62 home communities
  - Birmingham, AL & Willowbrook, CA
- Affordable Housing Retrofit Solar + Weatherization + Electrification Fresno, CA
- Zero Net Energy Farm Morris, MN
- All Electric ZNE, mixed use affordable housing Fresno, CA
- Utility Territory
- New Construction – SF & MF
- Agricultural & Industrial
- Mixed Use Affordable Housing
- Community Microgrids
- Community scale Retrofits
- University Campus
- Smart, Sustainable Communities
- Zero Net Energy Farm

State of electrification of existing buildings

- Panel Upgrade
- Supply Chain markup
- First hour draw
- Cold blow
- Closet size
- Cold blow
- Strip heat
- Direct Buried Cable
- Transformer upgrade
- Refrigerant GHG
- Transformer upgrade
- Asbestos mitigation
- 240 V
- Drain line
- Secondary replacement

Gas as WH fuel source

- Considerations:
  - Customer acceptance & resilience
  - Electric grid integration
  - Customer cost
Heat Pumps: Working on the Supply Chain

What if…..

Every air conditioner sold starting today is a heat pump?

- Barriers:
  - A long supply chain between manufacturer and installer restricting availability and increasing cost
  - Understanding sizing calculations for heating
  - Panel Upgrade, wiring and electrical costs
Results from heating electrification (35 homes)

Deep efficiency critical to reducing customer energy burden
- 15 SEER, 8.2 HSPF heat pumps
- Roof insulation
- Window replacements

<table>
<thead>
<tr>
<th>Building Total Energy Use</th>
<th>Summer (June 1st to Aug 31&lt;sup&gt;st&lt;/sup&gt;)</th>
<th>Winter (Nov 1&lt;sup&gt;st&lt;/sup&gt; to Feb 28&lt;sup&gt;st&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-retrofit period (total kWh consumption)</td>
<td>32870.88</td>
<td>24993.52</td>
</tr>
<tr>
<td>Post-retrofit period (total kWh consumption)</td>
<td>25096.65</td>
<td>31993.26</td>
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<tr>
<td>Savings (or delta)</td>
<td>7774.23 kWh</td>
<td>-6999.74 kWh</td>
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</table>

Measured impact of electrification - gas savings
- Gas analysis shows combined impact of efficiency and electrification
- 70% reduction in carbon intensity, split between heat pumps and gas efficiency
HP retrofit solutions for wall heaters

120V heat pumps avoid electrical upgrade costs with small energy increase

Key Take-aways from heating electrification

- Heat pump retrofit can be cost neutral to straight air conditioner replacement
  - But variability in channel pricing for heat pumps – Zero to $4000/unit additional
  - Avoid backup resistance through better sizing and pre-cooling/heating
- Capture significant carbon savings at much lower cost than HPWH

<table>
<thead>
<tr>
<th>Tons</th>
<th>SEER</th>
<th>Cost</th>
<th>Location</th>
<th>Source</th>
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<tbody>
<tr>
<td>2</td>
<td>14</td>
<td>$3,714</td>
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<td>$7,865</td>
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<td>16</td>
<td>$8,005</td>
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<td>4</td>
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<td>$10,490</td>
<td>Eastern Nebraska</td>
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<td>3</td>
<td>21.7</td>
<td>$11,071</td>
<td>Fresno, CA</td>
<td>Field Data</td>
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Decarbonization Strategies for Water Heating

- Efficiency
- Renewables
- Electrification

- Multifamily water heating is more complicated - technology plays a part, but...
- Application design and guidance play a much more significant role
Upgrading multifamily water heating

- Heat Pump water heater cost adder to replace 40gal gas WH was ~$12000/apartment

<table>
<thead>
<tr>
<th>Line Item (per apartment unit)</th>
<th>Net cost adder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment cost</td>
<td>&lt;$100</td>
</tr>
<tr>
<td>Closet construction/ outdoor location protection</td>
<td>~$2000</td>
</tr>
<tr>
<td>Panel upgrade</td>
<td>~$1500</td>
</tr>
<tr>
<td>240 V wiring to location</td>
<td>~$1800</td>
</tr>
<tr>
<td>SCE distribution upgrade (Meter, Xformer &amp; secondaries)</td>
<td>~$7000</td>
</tr>
</tbody>
</table>

Electric WH market a carbon beachhead for HPWH market

- Carbon benefits from efficiency (i.e., converting electric to heat pump water heaters) greater than carbon benefits from electrification even in a low emission grid
Retrofit approaches and technologies

Consider hybrid approaches that do not require full electrification today

Grid impacts of electrification
Aggregate customer resources for flexibility in a decarbonized environment

As the peak shifts to later and narrows, aggregation platforms can help peak load management.

High potential for flexibility: Smart Thermostats and EVs

Smart Thermostats are low cost, high impact for flexibility in heating and cooling. EV charging management could be critical to addressing evening load peaks.
Summarizing.....

- Consider the customer..... What is important?
  - First Cost, Reliability and resilience
- Target heat pump replacements where air conditioners exist – easier, cost effective and products exist than one-one HPWH
- Develop and implement 110V products to both reduce cost and increase resilience
- Get more transparency on cost/ bulk purchasing
- Electrify in an appropriate manner, could leave gas backup (dual fuel HP) to avoid grid upgrades and provide customer resilience

Together...Shaping the Future of Electricity
USING ENERGY EFFICIENCY TO DECARBONIZE KITCHENS

October 29th, 2020

Richard Young
Director
ryoung@frontierenergy.com

California Energy Wise  CAEnergyWise.com

The Food Service Technology Center

fishnick.com
CO₂ = 37.3 metric tons/year

Fuel Cost = $11,812/year
CO\(_2\) = 25.7 metric tons/year

Fuel Cost = $7,877/year

Savings vs Base = 11.6 tons and $3,935
Fast, Small, Flexible, and Energy Efficient: Kitchen of the Future

Hybrid “Kitchen of the Future” Cookline

CO₂ = 13 metric tons/year

Fuel Cost = $4,079/year

Savings vs Base = 24.3 tons and $7,733
All-Electric “Kitchen of the Future” Cookline

$\text{CO}_2 = 5.2 \text{ metric tons/year}$

$\text{Fuel Cost} = $9,356/\text{year}$

$\text{Savings vs Base} = 32.1 \text{ tons and } $2,456$

Big Picture Comparison: Cost vs $\text{CO}_2$

$\text{Fuel Cost}/\text{Year}\quad 0\quad 5\quad 10\quad 15\quad 20\quad 25\quad 30\quad 35\quad 40\quad 45\quad 50$

$\text{Metric Tons of CO}_2\quad 0\quad 5\quad 10\quad 15\quad 20\quad 25\quad 30\quad 35\quad 40\quad 45\quad 50$

$\text{Base Efficiency}\quad $11,812\quad $7,877\quad $4,079\quad $9,356$

$\text{High Efficiency}\quad $11,812\quad $7,877\quad $4,079\quad $9,356$

$\text{Hybrid KOF}\quad $11,812\quad $7,877\quad $4,079\quad $9,356$

$\text{Electric KOF}\quad $11,812\quad $7,877\quad $4,079\quad $9,356$

$1.00/\text{therm}, 0.17/\text{kWh}, 206 \text{ lb CO}_2/\text{MWh (PGE 2018)}$
Reality #1:
Full Electrification is not currently economically feasible for many commercial kitchens.

Significant economic, policy, and grid-system changes are needed to create effective electrification.

Reality #2:
Significant decarbonization is achievable immediately by upgrading to energy-efficient gas equipment.
The Electric Challenge:

Electric appliances can cost significantly more to operate so, we need to “design smart” in order to achieve decarbonization.

Even Countertop Equipment Must Be Efficient

![Efficiency Comparison Chart]

www.fishnick.com/cecplug
We Must Install Demand Controlled Kitchen Ventilation

Successful use of HPWH will require a change in plumbing design, decentralized water heating, and heat recovery dish machines.

Bonus: There is lots of waste heat in a commercial kitchen!
What We Have:
Lots of equipment choices and
The Food Service Technology Center

What We Need:
1. More equipment testing – “data for design”
2. Hands-on education and industry outreach
3. Policy Solutions that consider the operators

Fethree.com

Richard Young
ryoung@frontierenergy.com
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
Join us for another webinar

December 3, 2020
Getting to Zero in Affordable Multifamily

Find links to register for these sessions at newbuildings.org/event/

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