In the Nick of Time: Aiming for Efficiency’s Highest Value

David Nemtzow, U.S. Department of Energy
Natalie Mims Frick and Lisa Schwartz, Berkeley Lab
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Webinar housekeeping items

- We’re recording the webinar and will post it on our website.
- Because of the large number of participants, everyone is in listen mode only.
- **Please use the chat box** to send us your questions and comments any time during the webinar.
- Moderated Q&A will follow, with speakers responding to questions typed in the chat box.
- The recording and webinar slides will be posted at [https://emp.lbl.gov/projects/time-value-efficiency](https://emp.lbl.gov/projects/time-value-efficiency)
Today’s speakers

- **David Nemtzow** is the director of the Building Technologies Office of the Department of Energy’s Office of Energy Efficiency and Renewable Energy. David brings to US DOE more than three decades of experience in the field, including running the large state government energy, utilities and water department in New South Wales, Australia; leading the Alliance to Save Energy, a prominent bipartisan nonprofit energy efficiency association; he had a utility and DER consulting practice; and frequently speaks and publishes in the field.

- **Natalie Mims Frick** is an Energy Efficiency Program Manager in the Electricity Markets and Policy Group at Lawrence Berkeley National Laboratory. Natalie conducts research and manages projects on energy efficiency technical assistance, policy, program design, implementation and evaluation.
Presentation outline

- What is time-sensitive value of energy efficiency and why do we care?
- Overview of prior time-sensitive value of energy efficiency research by LBNL
- *Time-Sensitive Value of Efficiency: Use Cases in Electricity Sector Planning and Programs*
- Conclusions
- Q&A
What is time-sensitive value of energy efficiency?

Time-sensitive value of energy efficiency (TSV-EE) considers *when* energy efficiency occurs and the *economic value* of the energy or demand savings to the electricity system at that time.

Sources: Navigant MA Baseline Load Shape Study, LBNL analysis using ISO-NE 2018 LMP data
ERCOT: Monday, July 23, 2018

ERCOT daily peak was 72,994 MW (4-5 pm)

ERCOT Hub Average Settlement Price peaked at $2061.56/MWh (4-5 pm)

The most valuable savings occur between 4-5 pm

Source: ERCOT system, ERCOT price, Texas air-conditioning load shape
ERCOT: Monday, 12/10/2018

ERCOT Hub Average Settlement Price peaked at $117.99/MWh (7-8 am)

ERCOT daily peak was 51,934 MW (8-9 am)

The most valuable savings occur between 7-8 am

Source: ERCOT system, ERCOT price, Pacific Northwest heat pump load shape
Motivation for using time-sensitive value of efficiency

- Increased interest in how efficiency can provide value to the electricity system as it changes due to increased adoption of DERs & smart/connected equipment, technology cost reductions, and generation retirements emerge.

- Determining the time-sensitive value of efficiency will help utilities and governmental decision makers craft efficiency plans and programs that better target efficiency activities to where they are most valuable...thus helping cost-effectively implement a reliable, low-cost electricity system, integrate renewables, etc.
DOE’s Grid-interactive Efficient Building initiative

For more information see: https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings
Interactions with building occupants

- Interoperable, integrated systems
- Continuously optimized operation for maximum comfort and efficiency
- Grid-responsive

Outdoor Conditions

Lighting Controls

HVAC EMS

Occupant Preferences

Utility

Sensor/Occupant Inputs

Control Signal

Utility Communication

Applicable to Other Technologies, e.g.:

- HVAC EMS
- Lighting Controls
- Outdoor Conditions
- Occupant Preferences
- Utility
Demand flexibility provided by Grid-interactive Efficient Buildings

**Efficiency**
- Power Demand vs. Hour of the Day

**Load Shed**
- Power Demand vs. Hour of the Day

**Load Shift**
- Power Demand vs. Hour of the Day

**Modulate**
- Power Demand vs. Sub-Seconds to Seconds
<table>
<thead>
<tr>
<th><strong>VALUATION</strong></th>
<th><strong>TECHNOLOGY OPTIONS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>How do <em>time &amp; the interaction of flexibility options</em> impact value?</td>
<td>Which end use technologies provide solutions to specific grid needs?</td>
</tr>
<tr>
<td>Identify values to stakeholders, quantification of national value.</td>
<td>Prioritize technologies / solutions based on grid services.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>OPTIMIZATION</strong></th>
<th><strong>VALIDATION</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>How to maintain or improve services while optimizing for flexibility?</td>
<td>Do technologies <em>perform as predicted</em> and meet grid &amp; occupant needs?</td>
</tr>
<tr>
<td>Solutions that meet grid operator &amp; building occupant needs.</td>
<td>Verification of technologies / strategies, increasing confidence in the value of energy flexibility.</td>
</tr>
</tbody>
</table>
Overview of prior time-sensitive value of energy efficiency research by LBNL
Recent time-sensitive value of efficiency publications by LBNL

**Time-varying value of electric energy efficiency**

**Authors:**
Natalie Mims, Tom Eckman, and Charles Goldman

**Energy Analysis and Environmental Impacts Division**
**Lawrence Berkeley National Laboratory**
**Electricity Markets and Policy Group**

**June 2017 technical report** supported by DOE’s Office of Energy Efficiency and Renewable Energy - Building Technologies Office

**April 2018 technical brief** supported by DOE’s Office of Electricity – Transmission Permitting and Technical Assistance
The 2017 and 2018 studies used the same approach to calculate TSV-EE

- Provide background for the studies by summarizing existing analyses that quantify benefits of electric efficiency measures and programs during peak demand and high electricity prices.
- Use publicly available avoided costs and end-use load shapes from state or regional sources.
- Document time-varying energy and demand impacts of 5 measures in 5 locations:

<table>
<thead>
<tr>
<th>Measures</th>
<th>State/Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit sign (flat load shape)</td>
<td>Pacific Northwest</td>
</tr>
<tr>
<td>Commercial lighting</td>
<td>California</td>
</tr>
<tr>
<td>Residential lighting</td>
<td>Massachusetts</td>
</tr>
<tr>
<td>Residential water heater</td>
<td>Georgia</td>
</tr>
<tr>
<td>Residential air conditioning</td>
<td>Michigan</td>
</tr>
</tbody>
</table>
Annual system load shapes

*CE/DTE is Consumers Energy and DTE Energy, utilities in Michigan
Pacific Northwest time-sensitive value by load shape
Results: Total utility system value of savings compared to only their energy value

Notes: The flat load shape is an exit sign. Energy value includes: energy, risk, carbon dioxide emissions, avoided RPS and DRIPE, as applicable if reported. Total time-varying value includes all energy values and capacity, transmission, distribution and spinning reserves. Ratios are calculated by dividing total time-varying values by energy-only values.
Time-Sensitive Value of Efficiency:
Use Cases in Electricity Sector Planning and Programs

Natalie Mims Frick and Lisa Schwartz

November 2019
NEW Berkeley Lab TSV-EE study

- **Time-Sensitive Value of Efficiency: Use Cases in Electricity Sector Planning and Programs**
- Study identifies 5 use cases that consider the time-sensitive value of efficiency

- Energy efficiency planning
- Distribution planning
- Resource planning
- Rate design
- State activities
Benefit-cost analysis: CPUC Avoided Cost Model

California Avoided Cost Calculator Output for Climate Zone 4 (hot and dry)
2019 and 2024

The stacked bar charts are comprised of components of publicly available avoided costs in California. This chart was made by E3 for the California Public Utilities Commission.
Energy efficiency program planning: Xcel Energy

- Reduced lighting power density: cost and carbon savings exist today and in future.
- Electric reheat coils: cost savings improve in future.
- Electric solar water heat storage: carbon increases today and in future.

Source: Chris Baker, Willdan
### Select Incentives for Oncor 2019 Commercial Standard Offer Program

<table>
<thead>
<tr>
<th>Description</th>
<th>Measure Life</th>
<th>$/kW for On Peak Demand Reduction</th>
<th>$/kWh for Annual Energy Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Cooled Chiller</td>
<td>25</td>
<td>$387.81</td>
<td>$0.125</td>
</tr>
<tr>
<td>LED</td>
<td>15</td>
<td>$209.21</td>
<td>$0.057</td>
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<tr>
<td>Energy Star Commercial Dishwasher</td>
<td>11</td>
<td>$193.11</td>
<td>$0.054</td>
</tr>
<tr>
<td>Hot Food Holding Cabinet</td>
<td>12</td>
<td>$164.21</td>
<td>$0.041</td>
</tr>
<tr>
<td>Zero Energy Doors for Refrigerated Cases</td>
<td>12</td>
<td>$123.16</td>
<td>$0.025</td>
</tr>
<tr>
<td>Lodging Guest Room Occupancy Sensors</td>
<td>10</td>
<td>$86.51</td>
<td>$0.022</td>
</tr>
<tr>
<td>Refrigeration Evaporator Fan Controls</td>
<td>16</td>
<td>$49.57</td>
<td>$0.010</td>
</tr>
<tr>
<td>Vending Machine Controls</td>
<td>5</td>
<td>$20.64</td>
<td>$0.021</td>
</tr>
<tr>
<td>Pre-Rinse Spray Valves (Food Service)</td>
<td>5</td>
<td>$12.38</td>
<td>$0.004</td>
</tr>
</tbody>
</table>

**TSV-EE Application:** Several utilities in Texas, including Oncor, provide energy efficiency program incentives for both energy and peak demand savings. Peak demand reductions are calculated for each utility using methodologies described in the statewide technical reference manual.
Non-wires alternatives: Pacific Power and Energy Trust of Oregon

- Energy Trust of Oregon and PacifiCorp partnered to implement a time and location-specific energy efficiency pilot.
- With a goal to develop and implement a learning pilot focused on bringing additional value to the grid through the quick deployment of existing energy efficiency resources.

<table>
<thead>
<tr>
<th>Sector</th>
<th>End Use</th>
<th>Annual kWh</th>
<th>Summer kW</th>
<th>Winter kW</th>
<th>Measures</th>
<th>Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>HVAC</td>
<td>99,071</td>
<td>7.2</td>
<td>16.9</td>
<td>49</td>
<td>$37,281</td>
</tr>
<tr>
<td>Residential</td>
<td>Water Heating</td>
<td>32,959</td>
<td>3.3</td>
<td>6.0</td>
<td>223</td>
<td>$1,336</td>
</tr>
<tr>
<td>Residential</td>
<td>Lighting</td>
<td>9,636</td>
<td>1.1</td>
<td>1.3</td>
<td>102</td>
<td>$3,317</td>
</tr>
<tr>
<td>Residential</td>
<td>Miscellaneous</td>
<td>468,822</td>
<td>78.2</td>
<td>62.4</td>
<td>12</td>
<td>$3,878</td>
</tr>
<tr>
<td>Commercial</td>
<td>HVAC</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>Commercial</td>
<td>Water Heating</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>Commercial</td>
<td>Lighting</td>
<td>2,984,616</td>
<td>404.9</td>
<td>409.2</td>
<td>91</td>
<td>$508,261</td>
</tr>
<tr>
<td>Commercial</td>
<td>Cooking</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
<td>$0</td>
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<tr>
<td>Commercial</td>
<td>Refrigeration</td>
<td>1,259,439</td>
<td>272.5</td>
<td>127.8</td>
<td>15</td>
<td>$297,706</td>
</tr>
<tr>
<td>Commercial</td>
<td>Miscellaneous</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>Industrial</td>
<td>Miscellaneous</td>
<td>1,597,389</td>
<td>179.4</td>
<td>199.1</td>
<td>23</td>
<td>$96,736</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Miscellaneous</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td><strong>All</strong></td>
<td><strong>All</strong></td>
<td><strong>6,451,932</strong></td>
<td><strong>946.6</strong></td>
<td><strong>822.8</strong></td>
<td><strong>515</strong></td>
<td><strong>$948,515</strong></td>
</tr>
</tbody>
</table>

Note: Results are preliminary and need to be verified.

Source: Angela Long, PacifiCorp
TSV-EE Methodology:
PacifiCorp creates energy efficiency cost curves using annual hourly (8,760) load shapes, which are inputs to the IRP capacity expansion model with all other resources. Allowing efficiency to compete with all other resources creates a reliable portfolio at least cost.
Capacity markets: ISO-NE

ISO-NE Forward Capacity Auction (FCA) 11-13; Total Capacity Acquired

<table>
<thead>
<tr>
<th></th>
<th>All Other Capacity</th>
<th>Energy Efficiency Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCA #11 (2017)</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>FCA #12 (2018)</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>FCA #13 (2019)</td>
<td>9%</td>
<td></td>
</tr>
</tbody>
</table>

Source: FCA #11, FCA #12, FCA #13

On-Peak Resources Performance Hours

- June
- July
- August
- December
- January
Rate design

- Utilities have implemented time-based rates to integrate resources such as solar, electric vehicles, storage and demand response.
- Utilities have not typically considered the time-sensitive value of efficiency in rate design.
- Rate design may have a critical impact on DER adoption.
- TSV-EE could help identify when efficiency is more or less valuable during designated rate periods, and use it to inform their procurement strategy or improve value proposition to customers.
- Examples of residential rates that can be used to improve the value proposition of efficiency:
  - Default time-of-use rate in California
  - Default time-of-use rate in Minnesota
  - Time-of-use rate in Arizona
  - Real-time-pricing in Illinois
- Non-residential customers typically have more time-based rate options, but most do not have a tariff that sends prices signals to encourage load shaping or shifting.
  - Most non-residential rate design includes a demand charge
  - Demand charge is typically for customer non-coincident peak (customer’s highest consumption — e.g., any 15-minute period in a billing cycle — not utility system peak)
  - Time-varying value of efficiency could provide insights to customers on how to reduce demand charge and bill
Most electricity system related state and local government activities could benefit from TSV-EE.

Examples of state and local government activities that employ TSV-EE are:

- Several states require peak demand reduction in energy efficiency resource standards (Colorado, Illinois, Ohio and Texas).

- Six states provide an opportunity for utilities to earn a financial incentive for achieving peak demand savings targets (Hawaii, Massachusetts, Michigan, New York, Rhode Island and Vermont).

- California uses time-dependent value in its building energy code (Title 24).
Conclusions
Conclusions

- Determining the time-sensitive value of efficiency will help utilities and state and local decision-makers craft efficiency plans and programs.
- Each of the 5 use cases showcase several examples of how the time-sensitive value of efficiency can be used for more effective planning or programs.
- There is a growing number of examples of states and utilities using the time-sensitive value of efficiency to refine or improve their planning and programs.
- States and utilities can start using the time-sensitive value of efficiency by considering it in any of the use cases discussed.
  - The data granularity that is required for the time-sensitive value of efficiency will depend on the purpose.
Select LBNL Resources

- **Time and locational sensitive value of efficiency**
  - Time-Sensitive Value of Efficiency: Use Cases in Electricity Sector Planning and Programs
  - Time-varying value of electric energy efficiency (2017)
  - Time-varying value of energy efficiency in Michigan (2018)
  - No Time to Lose: Recent research on the time-sensitive value of efficiency (webinar)

- **End-Use Load Profiles for the U.S. Building Stock**
  - Building Technologies Office (BTO) funded project that is a multi-lab collaboration to create end-use load profiles representing all major end uses, building types, and climate regions in the U.S. building stock.
  - End-Use Load Profiles of the U.S. Building Stock: Market Needs, Use Cases and Data Gaps
  - End-Use Load Profile Inventory

- **Electricity Markets and Policy** energy efficiency research
  - Locational Value of Distributed Energy Resources (forthcoming)
  - Peak Demand Impacts from Electricity Efficiency Programs
  - Energy Efficiency in Electricity Resource Planning (forthcoming)
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