Michigan Public Service Commission

Time Value of Energy Savings in Michigan

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Thanks To:
  Michigan PSC
Consumers Energy Staff
  DTE Staff

&

Rick Morgan

For Your Assistance and Patience
Study Approach

- Document time-varying energy (TVE) and demand impacts of five measures in Michigan
  - Exit sign (flat load shape)
  - Residential lighting
  - Residential water heating
  - Residential central air conditioning
  - Commercial lighting

- Use publicly available avoided costs and a combination of hourly avoided energy cost and coincidence factors (CF) derived from:
  - DSMore hourly load shapes and CFs derived from DSMore
  - DSMore hourly load shapes with CFs derived from Michigan Energy Measures Database (MEMD)
  - Hourly load shapes from metered data from the Pacific Northwest (PNW) or building simulation modeling

- Compare Michigan TVE results to four locations in prior study
General Methodology

- Average Consumers Energy and DTE Energy system load shapes from 2014-2016 used to represent Michigan hourly load shape to determine system “peak”

- DSMore hourly energy load shapes and 15 year forecast of hourly avoided energy cost used to calculate value of energy (kWh) savings

- Coincidence factors (CF) from Michigan Energy Measures Database and avoided generation capacity, transmission and distribution deferrals, and ancillary services used to calculate capacity (kW) value of energy savings

- Hourly load shapes from Pacific Northwest metering research used to derive energy and capacity value for three end uses: residential lighting, residential water heating and commercial lighting

- Building America simulation model hourly load shapes used to derive energy and capacity value for residential air conditioning
Input: Annual System Load Shapes

Percentage of peak month load varying by location:
- Pacific Northwest
- California
- Massachusetts
- Georgia
- CE/DTE

Graph showing load percentages from Jan to Dec.
Input: CE/DTE Typical Summer Day System Load Shape and DSMore End-Use Load Shapes

![Graph showing load shapes for different types of loads: Michigan CE/DTE, ResLight, ResCAC & ResDHW, CommLight, Exit Sign.]
Input: CE/DTE Typical Winter Day System Load Shape and DSMore End-Use Load Shapes

Percent of Peak Hour Load

Michigan CE/DTE  ResLight  ResDHW  CommLight  Exit Sign
## Inputs: Avoided Cost

<table>
<thead>
<tr>
<th>Input Assumption</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Discount Rate*</td>
<td>3.88%</td>
</tr>
<tr>
<td>Expected Measure Life</td>
<td>15 years</td>
</tr>
<tr>
<td>Annual Savings (Normalized for all measures)</td>
<td>1000 kWh/yr. (1 MWh)</td>
</tr>
<tr>
<td>System Losses</td>
<td>7.08%</td>
</tr>
<tr>
<td>Levelized Avoided Energy Cost</td>
<td>Varies by load shape</td>
</tr>
<tr>
<td>Levelized Avoided Capacity Cost (2016$)</td>
<td>$71.50 /kW-yr.</td>
</tr>
<tr>
<td>Levelized Avoided Transmission and Distribution Cost (2016$)</td>
<td>$80 /kW-yr.</td>
</tr>
<tr>
<td>Levelized Avoided Ancillary Service Cost (2016$)</td>
<td>$3.34 /kW-yr.</td>
</tr>
<tr>
<td>Avoided CO₂ Cost</td>
<td>$0</td>
</tr>
<tr>
<td>Avoided Renewable Portfolio Standard Cost</td>
<td>$0</td>
</tr>
<tr>
<td>Avoided Demand Reduction Induced Price Effect (DRIPE)</td>
<td>$0</td>
</tr>
<tr>
<td>Avoided Risk</td>
<td>$0</td>
</tr>
</tbody>
</table>
## Inputs: Coincident Peak Capacity Reduction

<table>
<thead>
<tr>
<th>End Use</th>
<th>Coincidence Factor</th>
<th>Maximum Non-Coincident Demand (MW)</th>
<th>Coincident Peak Load Reduction (MW/MWh)</th>
<th>Coincidence Factor</th>
<th>Maximum Non-Coincident Demand (MW)</th>
<th>Coincident Peak Load Reduction (MW/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Lighting</td>
<td>0.10</td>
<td>0.98</td>
<td>0.098</td>
<td>0.25</td>
<td>0.31</td>
<td>0.08</td>
</tr>
<tr>
<td>Residential Water Heating</td>
<td>0.71</td>
<td>0.25</td>
<td>0.178</td>
<td>0.21</td>
<td>0.40</td>
<td>0.08</td>
</tr>
<tr>
<td>Exit Sign (Flat)</td>
<td>1.00</td>
<td>0.12</td>
<td>0.122</td>
<td>1.00</td>
<td>0.12</td>
<td>0.12</td>
</tr>
</tbody>
</table>
# Inputs: Coincident Peak Capacity Reduction

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</thead>
<tbody>
<tr>
<td>Residential Central Air Conditioning</td>
<td>0.72</td>
<td>0.75</td>
<td>0.543</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential Central Air Conditioning - Lansing</td>
<td></td>
<td></td>
<td></td>
<td>0.49</td>
<td>7.28</td>
<td>3.59</td>
</tr>
<tr>
<td>Residential Central Air Conditioning - Detroit</td>
<td>0.53</td>
<td>4.41</td>
<td>2.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential Central Air Conditioning - RBSA</td>
<td>0.36</td>
<td>2.29</td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Residential Central Air Conditioning - ELCAP</td>
<td>0.48</td>
<td>2.91</td>
<td>1.40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial Office Lighting</td>
<td>0.49</td>
<td>0.37</td>
<td>0.180</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial Office Lighting - CEC</td>
<td></td>
<td></td>
<td></td>
<td>0.76</td>
<td>0.29</td>
<td>0.22</td>
</tr>
<tr>
<td>Commercial Office Lighting - ELCAP</td>
<td>0.52</td>
<td>0.28</td>
<td>0.14</td>
<td></td>
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*Residential CAC for Lansing and Detroit derived from Building America building simulations
## Inputs: Coincident Peak Capacity Reduction

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<thead>
<tr>
<th>End Use (Source of data, if applicable)</th>
<th>Coincidence Factor</th>
<th>Maximum Non-Coincident Demand (MW)</th>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>0.10</td>
<td>0.98</td>
<td>0.10</td>
<td>Michigan Energy Measures Database</td>
</tr>
<tr>
<td>Lighting (RBSA)</td>
<td>0.25</td>
<td>0.31</td>
<td>0.08</td>
<td>Metered or Simulated Load Shapes</td>
</tr>
<tr>
<td>Water Heating</td>
<td>0.71</td>
<td>0.25</td>
<td>0.18</td>
<td>Michigan Energy Measures Database</td>
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DSMore Typical Summer Day Load Shapes Compared to Metered Residential Water Heating End-Use Load Shapes

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Percent of Peak Hour Load

CE/DTE Summer Day System Peak Hour

Difference in Peak Impact

Metered-PNW  DSMore
DSMore Typical Summer Day Load Shapes Compared to Metered Residential Lighting End-Use Load Shapes

CE/DTE Summer Day System Peak Hour

Difference in Peak Impact

Metered-PNW  DSMore
DSMore Typical Summer Day Load Shapes Compared to Metered Commercial Lighting End-Use Load Shapes

Difference in Peak Impact

CE/DTE Summer Day System Peak Hour

Percent of Peak Hour Load

Metered-PNW  DSMore
DSMore Typical Summer Day Load Shapes Compared to Simulated Residential Central AC End-Use Load Shapes
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. 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.
Results: Total Value
DSMore Load Shapes and MEMD Coincidence Factors

Note: Avoided Transmission cost also include avoided cost of distribution
Results: Total Value
Metered Load Shapes and Coincidence Factors

Levelized Total Utility System Value (2016$/MWh)

- Energy
- Reserves/Ancillary Services
- Risk
- CO2
- Avoided RPS
- DRIPE
- Generating Capacity
- Transmission
- Distribution

Note: Avoided Transmission cost also include avoided cost of distribution
Why Accurate Load Shapes Matter

Example: When DSMore and Metered Commercial End-Use Load Shapes Agree, Both Produce Equivalent Values for Annual Energy Savings

- Levelized Value of Annual Energy Savings Using Metered Load Shape = $62/MWh
- Levelized Value of Annual Energy Savings Using DSMore Load Shape = $61/MWh
Why Accurate Load Shapes Matter
When DSMore and Metered Load Shapes Residential Lighting Disagree, They Produce Significantly Different Values for Annual Energy Savings

- DSMore Load Shape
  - Levelized Value of Annual Energy Savings = $75/MWh

- Metered Load Shape
  - Levelized Value of Annual Energy Savings = $56/MWh
Why Accurate Load Shapes Matter
When DSMore and Metered Load Shapes Residential Air Conditioning Disagree, They Produce Significantly Different Values for Annual Energy Savings

DSMore Load Shape Levelized Value of Annual Energy Savings = $108/MWh

Metered Load Shape Levelized Value of Annual Energy Savings = $127/MWh
Why Accurate Load Shapes Matter
Example: Valuing Residential Lighting Annual Energy Savings

Levelized Total Utility System Value (2016$/MWh)

- Distribution
- Transmission
- Generating Capacity
- DRIPE
- Avoided RPS
- CO2
- Risk
- Reserves/Ancillary Services
- Energy

Non-Metered Load Shapes May Overstate Energy Value

DSMore w/MEMD CF vs. Metered
Why Accurate Load Shapes Matter

Example - Valuing Residential Central AC Capacity Savings

Simulated load shape overstates peak demand impact due to lack of “diversity”

Levelized Total Utility System Value (2016$/MWh)

- Distribution
- Transmission
- Generating Capacity
- DRIPE
- Avoided RPS
- CO2
- Risk
- Reserves/Ancillary Services
- Energy
Conclusions (1)

- Overall, the ratio of the total utility system value of energy savings to their energy-related value in Michigan aligns with other states with similar system load shapes.

- End-use load shape research that is specific to Michigan would enable more accurate analysis of the time-varying value of efficiency.

- Until such time that statistically representative, metered data on end-use load shapes in Michigan are available, data from regions with similar energy consumption characteristics should be considered for adoption (e.g., we used Pacific Northwest end-use load shapes in our analysis because they are based on metered data and are very similar to the end-use load shapes for some measures from the Electric Power Research Institute (EPRI) End Use Load Shape Library that are applicable to Michigan).
Use of current DSMore load shapes to determine both energy and peak savings may overstate the value of residential water heating savings and understate the value of residential air-conditioning savings.

Lack of statistically representative metered end-use load shape data for Michigan limits the ability to confidently characterize the time-varying value of energy efficiency savings, especially for weather-sensitive measures such as residential air-conditioning.

Investigating alternative data sources for the analysis, we found that substitution of simulated end-use load shapes may not accurately represent the hourly distribution of energy use unless the data reflects diversity of occupant behavior.
Conclusions (3)

- Investigation of all value streams for energy efficiency in Michigan will help avoid undervaluing this resource. For the purpose of this analysis, we assumed that there is no value for DRIPE or avoided fuel price risk, air emissions, and RPS compliance costs.

- Prior analysis by Berkeley Lab (Mims et al. 2017) found that in states where avoided cost includes a value for the risk mitigation benefits of energy efficiency, the total value of savings increased by 3-5 percent, depending on load shape. Including DRIPE also increased the value of savings by about 5 percent. For those jurisdictions which include a value for reduced carbon dioxide emissions, the total value of energy savings increased significantly — 6-13 percent in California, 13-28 percent in Massachusetts, and 32-52 percent in the Pacific Northwest.

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