Opportunities for Mass Market Demand Response to Provide Ancillary Services

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with contributions from
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What do We Mean by “Mass Market” DR?

“Mass market” suggests mass distribution of demand response (DR) devices with a “one-size fits all” character

Mass distribution could be

- Consumer-driven purchases, with or without utility/grid subsidy
- Wide-scale deployment with utility purchase and installation
- Something in between
- Suggests opportunities for market transformation activities

“One-size fits all” implies residential & small/medium commercial loads such as

- Thermostats (residential, unitary commercial)
- Elec. water heaters (or load controllers)
- Pool/spa pumps & elec. heaters (or load controllers)
- Smart appliances (clothes washers, dryers, dishwashers, refrigerators, freezers)
- Smart electronics? (computers, entertainment, printers, etc.)
- Other?
Mass Market DR-based Ancillary Services – Current Baseline

- Many utility programs, pilots, demos of DR focused on peak loads/prices, not ancillary services
- A few notable demos of ancillary services
  - RLTech freq.-responsive refrigerators in UK (n=300/3000?)
  - PG&E/LBNL – spinning reserves, Res. AC (n=250)
  - SCE/LBNL/ORNL – spinning reserves, Res. AC (n=2000)
  - Ecofys (BPA/NW utilities) – regulation for wind integration
    - Water heaters (n=90), thermal storage furnaces (n=7), refrigeration warehouses (n=5), commercial thermostats (n=?)
  - PJM/Steffes – regulation, Res. water heater (n=1)
  - GridWise Olympic Peninsula (BPA/NW utilities) – autonomous, under-freq. load shedding dryers & water heaters (n=50 ea.)
  - NW Smart Grid Demo (ARRA) – numerous technologies
  - PJM – regulation, PHEVs (3)
  - Analysis/PNNL: PHEVs could supply all additional ancillary services for integration of 30% wind in Pacific NW
Technical Issues

Spinning reserve & up regulation (decreasing loads)
- Similar to traditional demand response (relatively well understood)
  - Curtailing all or part of load
  - Slowing appliance processes
  - Requires short-cycle protection for refrigerant cycles (AC, refrigerators, freezers, heat pumps)

Down regulation (increasing loads)
- Difficulty is designing control strategies to increase loads
- Returning curtailed loads or slowed processes
- Shifting cycles coincident with reg. signal can be accomplished by shifting thermostat setpoints
  - Only works on avg. in populations, not individual loads
- Desire to mimic droop characteristic of generator governor controls
  - More/faster frequency deviation = more response
**Value of Spinning Reserve from Residential DR**

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<tbody>
<tr>
<td>Dryer</td>
<td>967</td>
<td>$9.08</td>
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<td>0.110</td>
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<td>0.048</td>
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<td>$8.77</td>
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<td>$179.54</td>
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<td>$79.54</td>
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</table>

- Availability for spinning reserve assumed to be 100% of load
- Marginal smart appliance, thermostat, and HW control costs are for illustration
- Engaging small loads requires very low costs
  - Note clothes washer & dishwasher are not competitive at $20 cost
- Dryers, refrigerators, freezers, HW, AC better targets
# Five Characteristic Load Types re. Regulation

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Control Strategy</th>
<th>Resource Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periodic, low duty-cycle: refrigerator*, freezer*</td>
<td>shift cycles coincident with reg. signal</td>
<td>80% (?)</td>
</tr>
<tr>
<td>Periodic, high duty-cycle: AC*, heat*, HVAC*</td>
<td>shift cycles + some curtailment</td>
<td>50% (?)</td>
</tr>
<tr>
<td>Continuous service: CW, dryer, DW</td>
<td>slow rate of service, modulate</td>
<td>25% (?)</td>
</tr>
<tr>
<td>Thermal storage: HW - no mixing valve</td>
<td>slow rate of service, modulate</td>
<td>50% (?)</td>
</tr>
<tr>
<td>Thermal storage: HW - with mixing valve</td>
<td>also allows overheating</td>
<td>100% (?)</td>
</tr>
</tbody>
</table>

* Includes small medium commercial: offices, retail, grocery, warehouses
## Value of Regulation from Residential DR

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</thead>
<tbody>
<tr>
<td>Dryer</td>
<td>967</td>
<td>$30.56</td>
<td>25%</td>
<td>0.028</td>
<td>$7.39</td>
<td>$110.88</td>
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<tr>
<td>Clothes Washer</td>
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<td>$30.18</td>
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<tr>
<td>Dishwasher</td>
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<td>$31.37</td>
<td>25%</td>
<td>0.004</td>
<td>$1.22</td>
<td>$18.34</td>
<td>$20.00</td>
<td>-$1.66</td>
<td>$34.22</td>
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<tr>
<td>Freezer</td>
<td>423</td>
<td>$31.27</td>
<td>80%</td>
<td>0.039</td>
<td>$10.58</td>
<td>$158.72</td>
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<tr>
<td>Refrigerator</td>
<td>450</td>
<td>$31.25</td>
<td>80%</td>
<td>0.041</td>
<td>$11.25</td>
<td>$168.73</td>
<td>$20.00</td>
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<td>$3.70</td>
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<tr>
<td>Water Heater</td>
<td>2814</td>
<td>$30.57</td>
<td>50%</td>
<td>0.161</td>
<td>$43.01</td>
<td>$645.19</td>
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<td>$545.19</td>
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<tr>
<td>Air Conditioner</td>
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<td>$39.02</td>
<td>50%</td>
<td>0.161</td>
<td>$55.05</td>
<td>$825.77</td>
<td>$100.00</td>
<td>$725.77</td>
<td>$4.72</td>
</tr>
</tbody>
</table>

- Availability for regulation assumed (see previous page)
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- Dryers, refrigerators, freezers, HW, AC better targets (?)
End-Use Load Shapes (Summer Weekdays)

- Metered end-use loads shapes (ELCAP)
- Scaled to current appliance standards & U.S. avg. AC, elec. heat & HW loads
- Appliances as a group are always available (unlike AC, heating)
Potential for Spinning Reserve from Res. DR

Summer
- Ref + Frz + Dry: 5% - 10%
- with HW: 9% - 19%
- with AC: 63% - 82%

Swing Season
- Ref + Frz + Dry: 13% - 22%
- with HW: 24% - 40%
Potential for Regulation from Res. DR (Fraction Of Res. Class Load)

Summer
- Ref + Frz + Dry: 3% - 8%
- with HW: 5% - 10%
- with AC: 34% - 42%

Swing Season
- Ref + Frz + Dry: 8% - 13%
- with HW: 14% - 20%
Regulatory Barriers

- Requirement for 4-sec SCADA connection could be (is?) show-stopper for mass market
- Possible from RTO to aggregator, not to loads
- Market rules may have to be adapted
- Balancing area consolidation could enable autonomous approaches: frequency deviation = ACE
- Low total need for regulation (~1%)
  - Will increase with renewables
  - Suggests limited market, potential for price collapse if DR offers plentiful resource into a buyer’s market
Barriers – Infrastructure Requirements

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Communications

- High speed 1-way (broadcast) – NIST BnP DEWG proposing FM radio
- 2-way (supports M&V)
- Autonomous: low cost, low latency

AMI – required (except for one-time payment approaches)

- Rate of availability of AMI may limit rate of deployment, delay ramp-up by manufacturers
- Advanced 2G meters being announced
  - M&V could be accomplished with high-speed meter reads
  - Could integrate signal & load coincidence in meter to compute incentive (to deal with bandwidth issues)
Operational and Market-Rule Barriers

Spinning Reserve
- Duration matters (opposite of power plants)
- Loads acts fast, but hard to sustain
  - Does this mean power plant reserve capacity is not displaced, just hours of operation?
- Some RTOs require load switches: no thermostat/population approaches

Regulation
- Some concern about operator knowledge of resource limits
  - Forecasting the resource availability
  - How long until response declines?
  - What rate is the rate of decline?
- Possibility of unstable control strategies
Barriers – Incentives to Customers/Manufacturers

► How is a customer rewarded?
  - 1-time payment (e.g., on purchasing/enabling smart appliance
  - Incentives for response (requires ratemaking + AMI)
    - Regulation: requires real-time prices or response rebates/credits
    - Spinning reserve: could also involve CPP*-like approaches

► How is manufacturer incentivized?
  - Low marginal costs for smart appliances
  - AHAM petition for Energy Start credit
    - Important near term signal to jump start market
    - May not insufficient in long term

* CPP: critical peak pricing