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Valuing Residential Appliances for 'Mass Market' Demand Response (DR) Ancillary Services

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What do We Mean by “Mass Market” DR?

- ▶ “Mass market” implies products in high volume production, widely used by residential/commercial users, and are *ubiquitously* equipped with low cost DR capability.
- ▶ Mass market residential/commercial DR products include:
 - HVAC thermostats (residential, unitary commercial)
 - Electric water heaters
 - Pool/spa pumps & electric pool/spa heaters
 - Grid-friendly appliances (clothes washers, clothes dryers, dishwashers, refrigerators, freezers)
 - Smart electronics (computers, entertainment, printers, etc.)
 - Other?

- ▶ Options for mass market DR product (e.g., appliances) introduction into the market can include:
 - Consumer-driven purchases
 - Appliances offer attractive features to consumers such as a ‘label’ and/or highly efficient.
 - Utility purchase and wide-scale deployment
 - Lease or provide at deep discount/ in selected/targeted feeders
 - Third party aggregator-purchase and deployment
 - Bulk purchase and/or lease with split incentives with consumers

What are “Ancillary Services”?

- ▶ Ancillary services are services necessary to support the transmission of electric power from seller to purchaser (customer).
- ▶ These services are provided by the Regional Transmission Organizations/Independent System Operators/Utilities within those their control areas to maintain *reliable operations* of the interconnected transmission system.
- ▶ Ancillary Services include:
 - Reactive power and voltage control
 - System protection (security)
 - Loss compensation
 - Load following (**Spinning Reserve**)*
 - Load balancing (**Regulation**)*

***A service that could be provided by the customer (end use) rather than by the generator**

- ▶ What is spinning reserve?
 - Power plants up & running, on standby to increase output within 10-min. in case of contingencies.
 - Consumes fuel; wear-and-tear on generators
 - Ties up expensive power plant capacity, > 5% of load
 - More needed with increased renewables due to intermittent nature.
- ▶ How would an appliance supply it?
 - Reduce load for ~10-20 min, must complete within 10-minutes
 - Same as load shifting or regulation
 - Examples (cost-effective): turn off dryer element, delay defrost, turn off A/C compressor.
- ▶ How much is it worth?
 - \$8/MWh – about ¼ cost of wholesale electricity; not currently high value unless high penetration of renewables.

- ▶ What is regulation?
 - Power plants continually adjust output minute-to-minute to exactly balance supply & demand, $\pm 1\%$ of load
 - Respond to 4-sec signals from grid operator
 - Switches from load-up to load-down on ~ 60 sec. intervals
 - No net energy shift, on average over hour
- ▶ How would an appliance supply it?
 - Interrupting a cycle (drying), then returning it to normal.
 - Interrupting a pool pump.
 - Increasing, then decreasing (or decreasing then increasing) water heater setpoint.
- ▶ How much is it worth?
 - $\sim \$30/\text{MWh}$ – about the cost of wholesale electricity; high value.

- ▶ But there remain several vexing issues including:
 - What are the (additional) costs of those appliances and are incentives required to move consumers to purchase? And if so, how much \$\$? Low marginal costs are critical.
 - Who provides those incentives? Are they a one-time payment?
 - If incentives are required and available, how/where are those distributed (Consumer? Manufacturer? Retailer? Aggregator?)
 - What are the 'energy' savings from the deployment of (smart) appliances that provide ancillary services?
 - Which appliances are most compatible and will have the greatest value for providing ancillary services and will customers 'over-ride' the ability of the appliance to respond to signals?
 - Need for robust and secure communications.
 - Need for appropriate tariff (regulatory action).

Estimated Value of Spinning Reserve from Residential DR

Appliance	Spinning Reserve								
	Annual Machine Energy Consumption (kWh/yr)	Avg. Market Price, Load-Weighted (\$/MW-hr)	Fraction of Load Available	Average Capacity Available (kW)	Wholesale Market Value		Equipment & Installation Cost (\$)	Net Earned Value (\$/15-yr)	Average Cost of Resource Provided (\$/MWh)
					(\$/yr)	(\$/15-yr)			
Dryer	967	\$9.08	100%	0.110	\$8.78	\$131.69	\$20.00	\$111.69	\$1.38
Clothes Washer	139	\$8.82	100%	0.016	\$1.23	\$18.42	\$20.00	-\$1.58	\$9.58
Dishwasher	156	\$9.53	100%	0.018	\$1.48	\$22.27	\$20.00	\$2.27	\$8.55
Freezer	423	\$7.97	100%	0.048	\$3.37	\$50.54	\$20.00	\$30.54	\$3.15
Refrigerator	450	\$8.08	100%	0.051	\$3.64	\$54.54	\$20.00	\$34.54	\$2.96
Water Heater	2814	\$8.77	100%	0.321	\$24.67	\$370.04	\$100.00	\$270.04	\$2.37
Air Conditioner	2822	\$4.24	100%	0.322	\$11.97	\$179.54	\$100.00	\$79.54	\$2.36

- ▶ Availability for spinning reserve assumed to be 100% of load.
- ▶ Marginal smart appliance, thermostat, and HW control costs are estimates.
- ▶ Engaging small loads requires very low costs
 - Note clothes washer and dishwasher are not competitive at \$20 marginal cost.
- ▶ Dryers, refrigerators, freezers, water heaters, AC best targets?

Estimated Value of Regulation from Residential DR

Appliance	Regulation								
	Annual Machine Energy Consumption (kWh/yr)	Avg. Market Price, Load-Weighted (\$/MW-hr)	Fraction of Load Available	Average Capacity Available (kW)	Wholesale Market Value		Equipment & Installation Cost (\$)	Net Earned Value (\$/15-yr)	Average Cost of Resource Provided (\$/MWh)
					(\$/yr)	(\$/15-yr)			
Dryer	967	\$30.56	25%	0.028	\$7.39	\$110.88	\$20.00	\$90.88	\$5.51
Clothes Washer	139	\$30.18	25%	0.004	\$1.05	\$15.75	\$20.00	-\$4.25	\$38.33
Dishwasher	156	\$31.37	25%	0.004	\$1.22	\$18.34	\$20.00	-\$1.66	\$34.22
Freezer	423	\$31.27	80%	0.039	\$10.58	\$158.72	\$20.00	\$138.72	\$3.94
Refrigerator	450	\$31.25	80%	0.041	\$11.25	\$168.73	\$20.00	\$148.73	\$3.70
Water Heater	2814	\$30.57	50%	0.161	\$43.01	\$645.19	\$100.00	\$545.19	\$4.74
Air Conditioner	2822	\$39.02	50%	0.161	\$55.05	\$825.77	\$100.00	\$725.77	\$4.72

- ▶ Fraction of load availability is variable.
- ▶ Marginal smart appliance, thermostat, and HW control costs are estimates
- ▶ Engaging small loads requires very low costs
 - Note clothes washer and dishwasher are not competitive at \$20 marginal cost.
- ▶ Dryers, refrigerators, freezers, water heaters, AC best targets?