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NEW ENERGY FINANCE

CASE STUDY

Economics of residential demand response in Japan

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The four smart community projects[1] funded by the Japanese government, in collaboration with the private sector, included various residential demand response schemes. These demonstration experiments conducted from FY2011-FY2015 have shown peak reduction levels of 10% to 20% by relying on a combination of technologies eg, Home Energy Management Systems (HEMS) as well as time-of-use (TOU) or critical-peak pricing (CPP) for residential electricity users. Based on these preliminary results, researchers led by Kyoto University's Professor Ida, have conducted cost-benefit simulations to evaluate the impact of expansion of residential demand response (DR) across all of Japan (excluding Okinawa). The goal of the study was to evaluate the cost and benefits of residential demand response based on universal adoption of HEMS, as proposed by Japan's Cabinet Secretariat in 2012[1].

METHODOLOGY

In their analysis, the researchers considered demand profile of the residential segment across Japan using FY2012 data. The aggregate peak demand associated with the residential load in the analysis is 46.8GW (53.59m households).

For the simulations, the base residential electricity retail rate was assumed to be JPY 25/KWh ($0.21[2]/kWh), the same as the average Japanese residential rate in FY2012. Four residential demand response retail rates were simulated: a TOU tariff with the peak-time tariff set at JPY 45/kWh along with three CPP tariffs with the peak-demand price set at JPY 65/kWh, JPY 85/kWh and JPY 105/kWh. Under the CPP conditions, 15 days per year are simulated as DR events whereby the peak-demand during the highest three-hour peak period is reduced. Under the TOU condition, 50 days per year are simulated as a DR event. In the case of CPP retail tariffs, all residential units are assumed to be equipped with HEMS, enabled for receiving demand response notifications from the community energy management system (CEMS). The CEMS referred to by the Kyoto University research team functions as a demand response automation server (DRAS). Residential customers responses to the DR events were modelled based on actual results observed in the four smart community projects. For further details please refer to reference 3.

The analysis considered a 40-year lifetime period based on the average life of thermal generators (Reference 4). For the simulations, assumptions in Table 1 were used. While current initial HEMS costs are around $429, the researchers used $43 based on feedback from manufacturers who project lower prices once mass-adoption takes place.

Table 1. System cost assumptions

Assumption	HEMS	CEMS
Capex ($)	43	231k
Annual labour cost ($)	-	214k
Annual O&M cost ($)	-	92k
Replacement cycle	Every 10 years	Server replaced every five years
Total quantity for simulation	53.59m	107 (assuming one system per 500k households)

Source: Kyoto University Research Team

Figure 1 shows the annualised costs associated with the system assumptions in Table 1. Using these costs, the researchers, have calculated the short-term benefits (lower peak demand hence lower electricity bill) as well as long-term benefits – cost savings associated with deferral of building new power plants as well as lower O&M costs for existing power plants – for each DR retail menu.

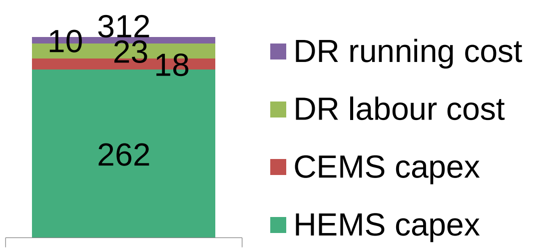

Figure 1: Annualised costs (million $/year)
Source: Kyoto University Research Team

[1] While the election in September 2012 resulted in a change of government, subsequent documentation under the new government, for example the Ministry of Economy Trade and Industry's budget announcement for a large-scale HEMS project, still includes a 2030 universal HEMS target.

[2] Exchange rate used is JPY 116.6/USD

ANALYSIS RESULTS

The impact of each DR retail menu on demand reduction is shown in Figure 2. As expected the CPP menu with the highest price (CPP-105) has the most impact on demand reduction.

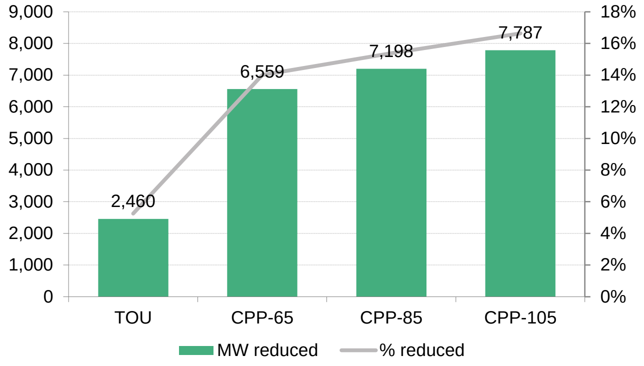

Figure 2: Peak demand reduction by each DR retail menu (left axis: MW, right axis: %)
Source: Kyoto University Research Team

In the TOU retail simulation – which did not rely on availability of HEMS – annualised benefits were estimated at $160m per year based on avoided capex of $110m per year, $35m per year of reduced social costs and $15m per year of reduced O&M expenditure. Comparing the annual benefits of each DR menu (Figure 3) with the annualised costs (Figure 1), shows that all the CPP tariffs have benefits outweighing their annual cost. CPP of JPY 65/kWh has annualised benefits exceeding costs by 31%, CPP of JPY 85/kWh has annualised benefits exceeding costs by 53% and CPP of JPY 105/KWh has annualised benefits exceeding costs by 76%. Using these results, the researchers have back-calculated what would be the HEMS break-even cost (keeping all other assumptions the same). For CPP of JPY 65/kWh, the resulting HEMS unit break

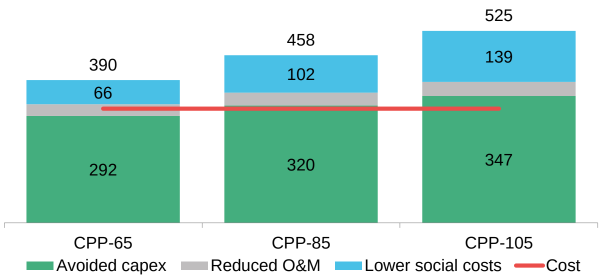

Figure 3: Annualised benefits of each DR retail menu compared to cost (Million $/year)
Source: Kyoto University Research Team

even cost is JPY 6,751 ($58), for CPP of JPY 85/kWh it would be JPY 8,049($69), and for CPP of JPY 105/kWh, the break-even cost would be JPY 9,324($80).

FINAL THOUGHTS

This study has shown that residential DR based on critical peak pricing can be cost-effective provided HEMS prices are significantly reduced. Specifically, if regulators are willing to set relatively high critical peak prices, then HEMS prices as high as $80 would still break-even. If the cost of HEMS technology is reduced to below $50, then even at lower CPP rates, the economics would be attractive.

REFERENCES

1. Green Policy Outline , Japan Cabinet Secretariat, November 2012
2. Large-scale HEMS demonstration experiment announcement, Ministry of Trade, Economy and Industry FY2015 budget announcement.
3. The Persistence of Moral Suasion and Economic Incentives: Field Experimental Evidence from Energy Demand, NBER Working Paper No. 20910.
4. Electricity generation cost sub-committee, convened by Ministry of Trade, Economy and Industry, May 2015.

BLOOMBER NEW ENERGY FINANCE'S VIEW

The results of this study demonstrate the benefits of deploying HEMS combined with critical peak pricing. While the cost of technology deployment may seem prohibitive, many developed markets like Japan are well underway to universal HEMS-enabled smart meter deployment, while in Europe we expect 187m smart electricity meters, capable of TOU and CPP, to be installed by 2020. In short, the technology challenge will likely be solved over time. The remaining challenges – as the researchers have discussed in Reference 3 – will be consumer acceptance and adaptation. In markets were TOU/CPP tariffs have already been introduced eg, Ontario, regulators have had to deal with consumer backlash and thus far, implementation of high CPP rates has been politically challenging. Furthermore results from studies around the world (Figure 4) on home energy management tools have shown that the energy reduction benefits can widely vary, with larger studies showing lower benefits. Further, consumer education as well as ongoing engagement will be necessary to ensure long-lasting benefits.

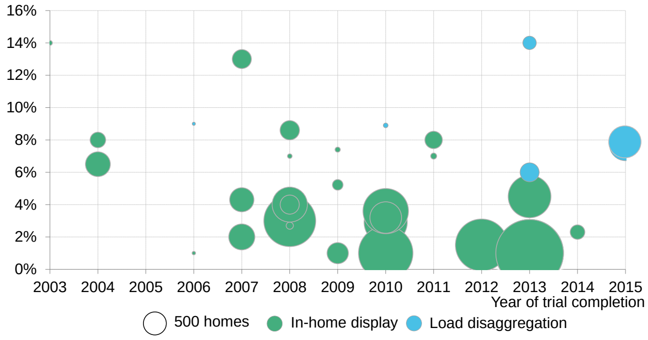

Figure 4. Energy reduction attributed to feedback from home energy management tools
Source: Bloomberg New Energy Finance

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