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Summary Report on Canadian Residential Demand Response and Ancillary Service Market Opportunities

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BACKGROUND

The introduction of the smart grid, particularly two-way communications between operators and loads, is opening up new resources for demand response (DR) with a wide range of capabilities and applications. Among the benefits that this new DR can bring are improved power system asset utilization, optimized generator operation, and increased reliability and security. The residential sector, constituting a third of Canada's electricity consumption, is a relatively untapped resource that can contribute to this DR potential. Varying by province, this potential is contingent on the sector's load size and composition.

Of the aforementioned benefits, contributions to reliability and security by DR may be easily realized and monetized through the provision of ancillary services (ASs). ASs are resources employed to support the transmission of energy throughout the bulk electric grid. Most ASs are used to facilitate balance between supply and demand, either routinely or in emergencies, and have traditionally been acquired from conventional bulk generators. With the smart grid, DR-enabled loads may also be able to supply ASs; already, loads from the commercial and industrial sectors have been deployed on a limited basis for this purpose. DR from the residential sector is an additional resource for ASs, and conversely ASs are a source of value for its DR resources.

OBJECTIVES AND METHODS

This report first appraises the existing AS market across Canada, focusing on those that are both commonly utilized by system operators and can be served from DR resources. These include ASs that are routinely deployed (regulation and load following reserves) and those activated during contingencies (spinning, non-spinning, and replacement/supplemental reserves). Each AS is defined, their method of procurement identified, and market size and value assessed.

Second, this report looks at Canada's residential sector, which is characterized by a large number of small but simple loads that will, as the smart grid develops, become economically and technically feasible to employ as DR resources capable of complex tasks (such as contributing to the aforementioned ASs). It identifies, by end-use, which of these loads will have the most DR potential from technical and accessibility perspectives. As part of this assessment, an evaluation of the potential available from each province is highlighted. While these two appraisals, of AS and residential DR potential, stand well on their own – ASs can be served by more than one resource (e.g., storage) and DR can serve more than one purpose – this report goes further by appraising the technical and economic potential of each residential load end-use as a purveyor of DR for AS applications.

ANCILLARY SERVICE MARKET ASSESSMENT

AS reserve requirements are set by each province to meet reliability requirements (a function of prior performance and asset mix and configuration); these have been estimated, for each province, in Fig. 1. Commensurate with total electric loads, QC and ON have the largest market for ASs followed by BC and AB.

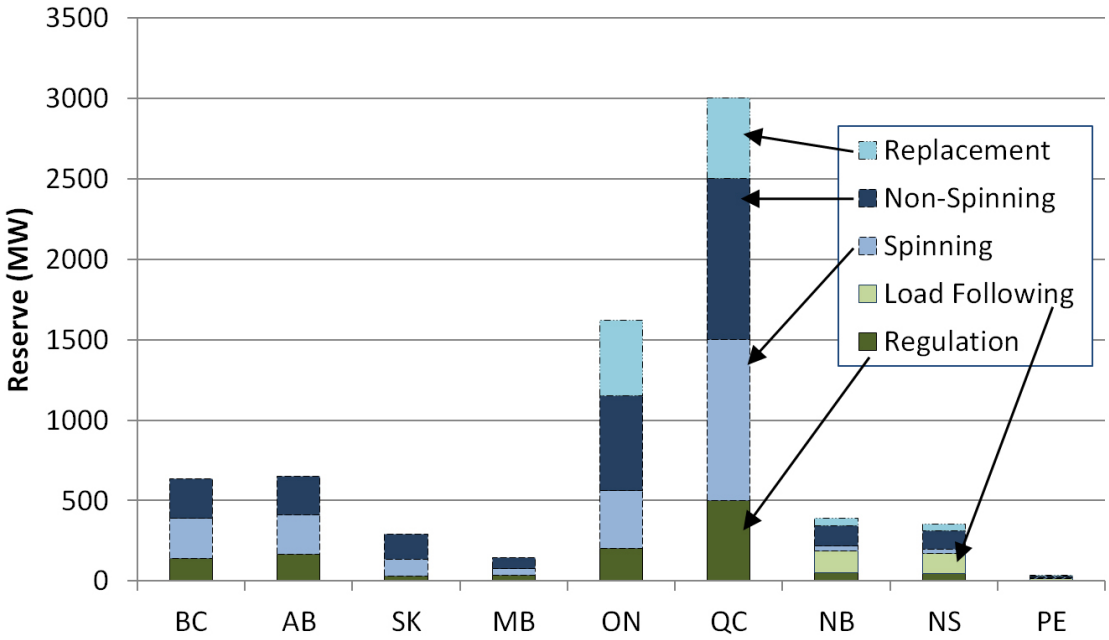

Figure 1: Estimated AS reserve requirements

Years 2012 or 2014 estimates of AS rates are given in Table 1. They reflect either market costs (for AB or ON) or tariffs associated with connected vertically integrated utility's transmission network. (Data on QC was unavailable.) There are significant variations by province, both by costs and rank (by most valued).

Table 1: Procurement costs of reserves

	BC	AB	SK	MB	ON	QC	NB/PE*	NS
Regulation ($/MWh)	6.4	11	14	5.1	>24	n/a	2.0	8.5
Load following ($/MWh)	-	-	-	-	-	-	1.8	12
Spinning ($/MWh)	6.2	13	9.7	5.1	7.3	n/a	8.7	11
Non-spinning ($/MWh)	6.3	12	9.7	3.1	6.2	n/a	4.5	5.5
Replacement ($/MWh)	-	-	-	-	1.3	-	15	13

*Estimated assuming that NB/PE transmission users have the same obligations as NS users

Taking AS market size and rates, approximations can be made of the annual market value of each, by province; these are given in Fig. 2. The two deregulated provinces (AB and ON) also have ASs with the highest market value.

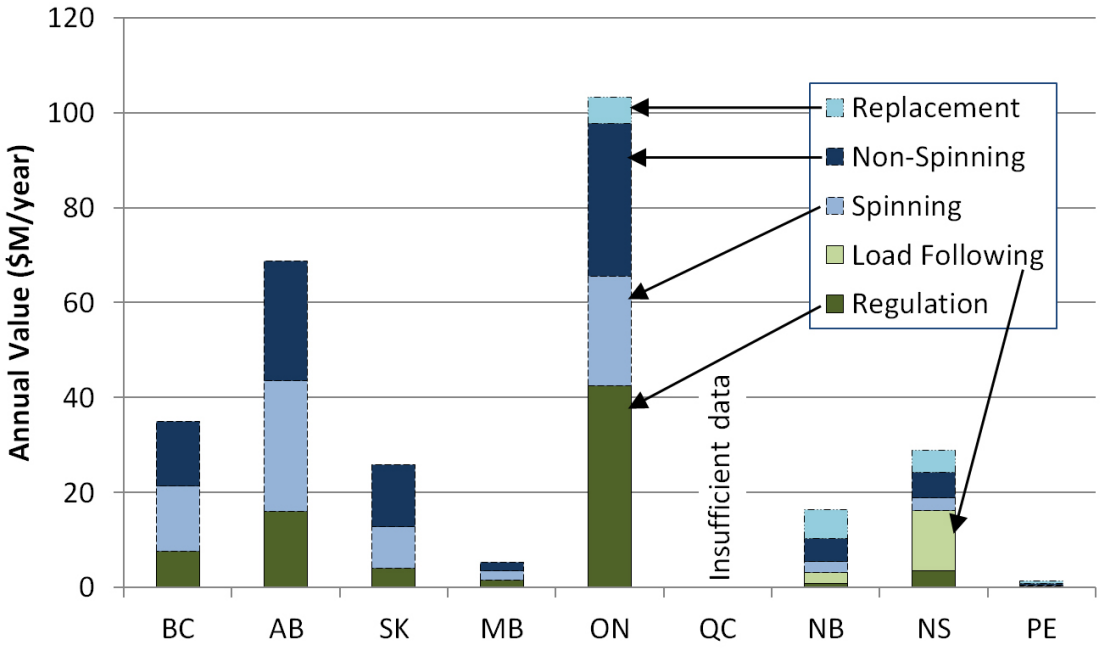

Figure 2: Annual value of reserve services

RESIDENTIAL DEMAND RESPONSE ASSESSMENT

NRCan classifies residential electric loads into five major end-use categories: space heating, space cooling, water heating, lighting, and appliances. The technical competency of each end-use to supply DR, generally, and DR for ASs, specifically, varies. Adding the stipulation that user comfort must be maintained during DR deployment, appliance and lighting categories were found to be poor candidates for the DR. The other end-uses were found to be more amiable for general DR deployment, with each's potential as an AS resources given in Table 2, ranked low (–), moderate (↗), or high (↑).

Table 2: End-use DR technical competencies to supply reserve Ass

Reserve	Space Heating	Space Cooling	Water Heating
Regulation	↗	↗	↗
Load Following	↗	↗	↗
Spinning	↑	–	↑
Non-spinning	↑	–	↑
Replacement	↑	–	↑

The DR resource potential of end-use loads, by province, can be gauged by measuring penetration by magnitude or as a function of power system demand. Table 3 below shows peak electric space and water heating loads and thermal storage capacity. The numbers of homes with central AC units are also given. By magnitude, the highest potential resides in the largest provinces (ON and QC).

Table 3: Electric end-use load attributes

		BC	AB	SK	MB	ON	QC	NB	NS	PE	NL	Total
Space Heating	Peak Load (GW)	3.6	0.58	0.25	1.2	6.1	13	1.1	0.68	0.02	0.93	27
	Thermal Storage Capacity (GWh)	7.2	1.2	4.9	2.4	12	25	2.2	1.4	0.05	1.9	58
Space Cooling	No. Homes with Central AC (k)	198	221	194	271	3110	524	52	18.0	0.5	4.8	4593
Water Heating	Peak Load (GW)	0.73	0.12	0.08	0.27	1.3	3.6	3.3	2.3	0.01	0.23	12
	Thermal Storage Capacity (GWh)	2.8	0.46	0.30	1.0	5.2	14	1.3	0.91	0.05	0.88	27

DR potential by province, as a function of grid demands, requires compiling other indicators such as max load as a % of system peak load, demand as a % of system demand, and storage capacity as a % of system average hourly demand. By these indicators, QC, NB, and NL appear to have the most space heating resource potential, followed by BC, MB, ON, and NS.

POTENTIAL OF RESIDENTIAL DEMAND RESPONSE TO SUPPLY ANCILLARY SERVICES

There are numerous revenue streams available to residential DR through the several benefits they offer; however, this work focuses just on those it can get through ASs. In Table 4, their overall potential, as evaluated by weighing DR technical potential with the size and value of the AS market in each province, is ranked as low (–), moderate (↗), or high (↑). Where a dot (·) appears, not enough information was available on AS cost to make a determination.

Table 4: Overall end-use DR potential to serve reserve Ass

	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Space Heating										
Regulation	↗	–	–	↗	↑	·	–	↗	–	·
Load Following	–	–	–	–	–	–	–	↑	–	·
Spinning	↗	–	–	↗	↗	·	↑	↑	–	·
Non-Spinning	↗	–	–	↗	↗	·	↗	↗	–	·
Replacement	–	–	–	–	–	·	↑	↑	–	·
Space Cooling										
Regulation	–	–	–	↗	↗	–	–	–	–	–
Load Following	–	–	–	–	–	–	–	–	–	–
Spinning	–	–	–	–	–	–	–	–	–	–
Non-Spinning	–	–	–	–	–	–	–	–	–	–
Replacement	–	–	–	–	–	–	–	–	–	–
Water Heating										
Regulation	↗	–	–	↗	↑	·	–	↗	–	·
Load Following	–	–	–	–	–	–	–	↑	–	·
Spinning	↗	–	–	↗	↗	·	↑	↑	↑	·
Non-Spinning	↗	–	–	↗	↗	·	↗	↗	↗	·
Replacement	–	–	–	–	–	·	↑	↑	↑	·

Table 5 shows the potential monetary value of utilizing a home's space heating system as a DR resource to the various contingency reserves 15% and 20% of the year. (These numbers assume a single detached or semi-detached heating requirement of 5 kW.)

Table 5: Annual value, per home, of space heating DR contributions to contingency reserves

Load Availability	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Spinning Reserve ($/home/year)										
15%	41	85	64	33	48	-	57	75	57	-
20%	54	114	85	45	64	-	76	100	76	-
Non-Spinning Reserve ($/home/year)										
15%	41	79	64	21	41	-	30	36	30	-
20%	55	105	85	28	54	-	39	48	39	-
Replacement Reserve ($/home/year)										
15%	-	-	-	-	9	-	101	84	101	-
20%	-	-	-	-	12	-	135	112	135	-

Similarly, Table 6 shows the potential income per electric water heater if it was applied as a DR resource for contingency reserves. Two values are given for each reserve: the first represents baseload, i.e., that a minimum of 5% are available to be turned OFF (that would otherwise be ON) at all hours; the second represents intermediate-load, i.e., that a minimum of 15% of electric water heaters are available to be turned OFF 65% of the time. These values are considerably less than that for space heating, reflecting their lower energy consumption.

Table 6: Annual value of electric water heater DR contributions to contingency reserves

Sheddable Loads	Load Avail.	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Spinning Reserve ($/EWH/year)											
5%	100%	10	20	15	8	12	-	14	18	14	-
15%	65%	19	40	30	16	23	-	27	35	27	-
Non-Spinning Reserve ($/EWH/year)											
5%	100%	10	19	15	5	10	-	7	9	7	-
15%	65%	19	37	30	10	19	-	14	17	14	-
Replacement Reserve ($/EWH/year)											
5%	100%	-	-	-	-	2	-	24	20	24	-
15%	65%	-	-	-	-	4	-	47	39	47	-

CONCLUSIONS

Embracing smart grid-enabled residential end-use loads as demand response (DR) resources enables their participation in the grid as value-added products (rather than as just uncontrollable loads). Their value as DR resources include increased asset utilization and capital investment deferment, improved system security and reliability, and increased energy optimization. Serving ancillary services (ASs, particularly reserves), as explored in this paper, are just one of many possible contributions they can make to improving system security and reliability. Together, DR opportunities can change the way utilities and operators view and interact with residential loads.

It was shown that there is substantial DR potential in residential space heating, space cooling, and electric water heating loads; this DR can be applied not just to the aforementioned ASs, but also to gain other benefits as well. The collective potential of residential DR across Canada from space and water heating end-uses alone was estimated to be 39 GW/85 GWh, the size of Québec's winter peak demand for 2 hours.

All provinces but AB and SK have proportionally significant contributions to this potential.

There exists a substantial, but varying, market for ASs across the country that residential loads with the right technical capabilities could serve. Such DR loads would be able to capitalize on the value of ASs as one of many revenue streams it could participate in; in this regard, the most potential proportionally (by size) was found to lie in NB and NS with moderate opportunities in BC, MB, and ON. (The potential in QC was not evaluated.)

FULL REPORT

Steven Wong, Canadian Residential Demand Response and Ancillary Service Market Opportunities, CanmetENERGY, Varennes Research Centre, Natural Resources Canada, Report No. 2015-022 (RP-TEC), April 2015, 57 pages.