Assessing Demand Response (DR) Program Potential for the Seventh Power Plan

UPDATED FINAL REPORT

Prepared for:
Northwest Power and Conservation Council

Navigant Consulting, Inc.
One Market Street, Spear Street Tower
Suite 1200
San Francisco, CA 94105

415-399-2109
www.navigant.com

Reference No.: 175295

ORIGNIAL REPORT DATE: October 24, 2014
UPDATED REPORT DATE: January 19, 2015

NAVIGANT

Table of Contents

1. Summary[1]

1.1 Introduction

The Northwest Power and Conservation Council (NPCC) commissioned Navigant to conduct a preliminary assessment of Demand Response (DR) programs and potential that could ultimately form the basis for DR-related inputs to the upcoming Seventh Power Plan. This report outlines the process by which Navigant went about developing representative DR programs that could be considered, identifying the parameters that would be associated with the applicable DR programs, and identifying the market potential and cost associated with the DR programs. While the Western Electricity Coordinating Council (WECC) has developed estimates of DR potential that are representative for the entire WECC region, NPCC wanted this effort to be more tailored to the unique conditions that are present in the Northwest, which may not have been ideally captured from the broader WECC study.

1.2 Approach

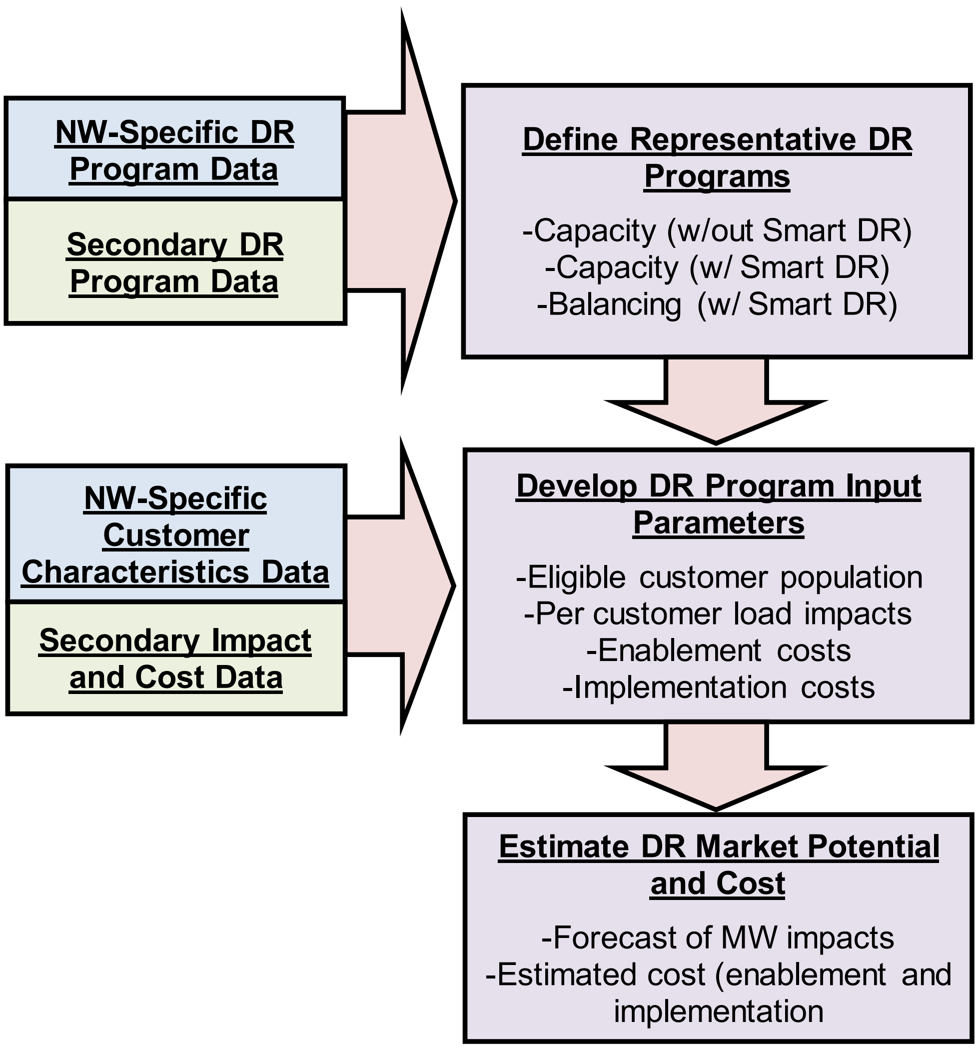
Figure 1 illustrates the approach that was taken to conduct this study. First, a series of Northwest-specific data sources were tapped. This included pulling together DR program plans and assessments from the regulated utilities in the Northwest. In addition, Navigant utilized information about DR programs and data gaps that was prepared by Navigant for BPA. This data source included a DR program literature review and results of interviews with several regional stakeholders, including NPCC staff. Second, Navigant utilized existing information about DR programs from non-Northwest sources including the WECC study referenced earlier as well as data and information about DR programs that Navigant has compiled as part of its ongoing DR program development and planning practice. This included DR program-related information from other utilities outside of the region.

Once the data were pulled together, the next step in the process was to define representative DR programs. Since NPCC is intending to model capacity-oriented programs for the 7th Power Plan, the initial focus of the DR programs was to meet capacity needs. Based on the review of DR program experience, it is apparent that DR for capacity purposes can be fulfilled in one of two ways. The first (and most common) is for customers to respond to capacity DR events using basic methods to reduce their loads (e.g., simple switches and manual approaches such as turning off lights and raising/lowering thermostats). The second is through the use of advanced or so-called *Smart DR* technologies. With the advancement of new technologies, we are beginning to see more applications of those technologies appear in DR programs. Examples include the use of programmable communicating thermostats (PCTs) for residential heating and cooling applications and automated demand response (AutoDR) measures tied into energy management control systems in commercial, industrial and agricultural facilities. In

[1] Note that this report is a revision to a report originally submitted to NPCC on October 24, 2014. This revision includes estimates of DR potential for summer and winter peak periods. In addition, the total DR potential is slightly adjusted relative to the original estimates to reflect corrections to some of the modeling computations.

addition, there is much interest in how DR can be used as a balancing resource for the growing renewable energy industry. To that end, the various DR programs identified in this exercise that could potentially accommodate balancing activities were assessed. While not all capacity DR customer segments or end-uses are ideally suited for balancing purposes, it is appropriate to consider a subset of the identified programs that could be considered for balancing purposes.

Figure 1. Assessment Methodology



The next step in the process was to develop DR program input parameters. These input parameters would identify the eligible customer populations for each program, the typical per customer load impacts that would be realized during various DR events, the costs to enable the customer's demand responsiveness in the event that they are deploying Smart DR technologies, and the costs to implement and operate the DR programs.

Based on the information obtained, the DR market potential and program cost was estimated through the development of an Excel-based potential tool. The tool produces results of the forecasted demand reduction impacts for the Northwest region (as a whole) and the associated yearly cost required to develop, implement and operate the various DR programs. The tool is included as an attachment to this report.

1.3 Overall Results

Table 1 summarizes the overall results of this DR market assessment. By 2030, the estimated DR impact associated with all capacity-based DR programs that utilize a combination of standard technologies and *Smart DR* technologies is 3,546 MWs in the winter and 3,208 MWs in the summer, at an approximate total cost of $239.8 million. This yields a unit cost of acquisition that ranges between $68 and $75 per kW-year. The cumulative load impact as a percentage of forecast peak demand for the Northwest is 8.8% relative to the winter peak and 8.2% relative to the summer peak.

By 2030, the estimated DR impact associated with renewable balancing programs that utilize *Smart DR* technologies is 275 MWs in the winter and 315 MWs in the summer at an approximate cost of $11.5 million. This yields a unit cost that ranges between $36 and $42 per kW-year. The cumulative load impact as a percentage of forecast peak demand for the Northwest is 0.7% relative to both the summer and winter peak.

Table 1. Summary Results

	Capacity (Base + *Smart DR*) Programs							
	2015		2020		2025		2030	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Total Load Impact (MW)	146	130	3,136	2,837	3,345	3,026	3,546	3,208
Total Load Impact (%)	0.43%	0.42%	8.65%	8.41%	8.75%	8.35%	8.78%	8.18%
Total Program Cost ($)	$ 35,615,367		$ 316,365,496		$ 227,417,673		$ 239,753,207	

	Balancing Programs							
	2015		2020		2025		2030	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Total Load Impact (MW)	1	1	243	278	259	297	275	315
Total Load Impact (%)	0.00%	0.00%	0.67%	0.72%	0.68%	0.72%	0.68%	0.70%
Total Program Cost ($)	$ 72,438		$ 16,636,820		$ 10,852,975		$ 11,465,038	

A few observations are offered about these results:

- The market potential steadily for both capacity and balancing programs are assumed to grow over a 5-year period from 2015 to 2020 as programs are ramped up, reaching a steady state of modest growth through 2030.
- The total program cost assumes the cost of technology enablement as new participants come onto the programs as well as the ongoing cost of program implementation. The enablement cost includes technology costs, installation costs, and customer incentives. The implementation cost

includes the costs of program administration, DR program management systems, and evaluation studies.

- The estimated cumulative DR market potential for capacity programs represents nearly 9% of winter peak load by 2030. This estimate is in line with estimates of other DR potential studies conducted both in the Northwest and other parts of the country.
- The DR potential and cost estimates for balancing programs are likely low, due to the limited data on program experience. Over time, more program experience will allow for more comprehensive analyses to be conducted for this DR program application.
- This DR market potential assessment was intended to establish a framework by which DR market potentials could be considered as NPCC develops modeling inputs to support DR-related forecasts for the Seventh Power Plan. While these preliminary estimates appear to be reasonable, a multitude of assumptions have gone into the analysis. NPCC would be well served by taking a more in-depth look at the backup assumptions and analysis contained in the attached spreadsheet tool.

2. Representative DR Programs

A total of three representative DR programs were developed for this assessment. The programs cover a broad range of DR options including Direct Load Control (DLC), Curtailable/Interruptible tariffs, and Load Aggregator approaches addressing all sectors and a variety of appropriate end-uses. DR programs and their associated input parameters were developed for the Northwest to address future capacity needs based on anticipated constraints on the grid as well as for load balancing purposes to address the growing amount of variable renewable energy in the Northwest. Table 2 presents a matrix of the three DR program options (as defined by the various customer segments), and their applicability for addressing capacity and balancing needs. Note that for capacity-based programs two deployment options are considered: one where more traditional or manual means of achieving load curtailments are utilized and the second where advanced or so-called *Smart DR* technologies are applied. For balancing services, all DR program scenarios also consider the use of *Smart DR* technologies since curtailment calls are more frequent with very short notification windows and thus are not conducive to using manual means for achieving the load curtailments.

Table 2. Representative DR Program

DR Program Type	Capacity		Balancing Services
	With Basic Technology	With Advanced Technology	
1. Residential DR	X	X	X
2. Commercial DR	X	X	X
3. Industrial/Agricultural DR	X	X	X

An overview of each program is provided in the sections that follow.

2.1 *Residential DR Programs*

2.1.1 Description

There are a variety of DR programs that could be targeted at residential customers. This includes Direct Load Control (DLC), Peak Time Rebates, and Dynamic Pricing. Of the three, the most common is DLC. DLC programs allow a utility to interrupt or cycle electrical equipment remotely during load peak times. DLC for air conditioning units is achieved through cycling units on-and-off or making thermostat adjustments throughout different times of the day. DLC has traditionally been used to turn on and off residential air conditioning compressors which typically make up 70% of the electrical load of a residential air conditioning system. [2]

[2] (LBNL Publication that looks at DR for WECC) http://drrc.lbl.gov/sites/all/files/lbnl-6417e.pdf

There are a number of on-going studies evaluating and developing communication and control mechanisms and infrastructures for direct load control of residential refrigerators for demand response, but it is assumed that this type of demand response program is currently not yet in place.[3]

2.1.2 Benchmark Review

There are several examples of utilities that use DLC for a variety of residential applications that target space cooling, space heating, and water heating. These examples highlight programs where conventional technologies are used mainly for capacity needs and examples of programs that utilize so-called *Smart DR* technologies for capacity and balancing needs.

Examples of utilities that offer residential DR programs using traditional switch-based technologies include:

- Avista
  - From 2007 to 2009, Avista conducted a residential DLC pilot in approximately 100 volunteer households. DLC devices were installed on heat pumps, water heaters, electric force-air furnaces and air conditioners to control operations during 10 scheduled events at peak times ranging from two to four hours. For a separate study pilot, Avista installed in-home display devices for a group of customers within the same communities. The aim of the study was to receive near-real time energy usage feedback from these customers.[4]
- Idaho Power
  - Idaho Power runs an air conditioner cycling program in which residential customers can sign up to install a control switch near their A/C units. This program enables A/C units to be cycled on-and-off on summer days when electricity demand is at its peak.[5]
- Puget Sound Energy (PSE)
  - From 2009 to 2011, PSE implemented a space and water heating DLC pilot.[6,7]

---

[3] (LBNL Publication that looks at DR for WECC) http://drrc.lbl.gov/sites/all/files/lbnl-6417e.pdf
[4] https://www.avistautilities.com/inside/resources/irp/electric/Documents/Avista_2013_Electric_IRP_Final.pdf
[5] https://www.idahopower.com/AboutUs/OurView/PreviousOurViews/demandResponse.cfm
[6] Comprehensive Assessment of Demand-Side Resource Potentials (2014-2033), (Cadmus Group)
[7] 2011 EM&V Report for the Puget Sound Energy Residential Demand Response Pilot Program (Navigant) http://pse.com/inyourcommunity/kitsap/Documents/BainbridgeIslandDemandResponseProject.pdf

- Central Electric Cooperative (CEC) [BPA pilot][8],[9]
  - CEC concluded a pilot that turned off water heaters from 5 a.m. to 9 a.m. daily, seven days a week. The pilot used DLC controls for water heaters, and gave homeowners the option to override the controls at any point in time.
- Alliant Energy
  - Alliant's runs the "Appliance Cycling Program", which allows customers to sign up for the installation of a radio-activated switch on central air conditioner at no cost. Alliant will turn on the radio signal to activate the switch and cycle the AC units if the demand for electricity hits a critical point. The program runs from May to September on weekdays and the dates vary in each state of coverage.[10]
- Florida Power and Light (FPL)
  - FPL runs an optional DLC program that allows residential customers to install a two-way communication system on their air conditioning, space heating, and water heating units, as well as swimming pool pumps.

Examples of residential programs that target *Smart* DR technology applications include:

- Avista
  - As part of the Northwest Regional Smart Grid Demonstration Project (SGDP), Avista installed a Smart Communicating Thermostats for enabled force-air electric furnaces, heat pumps, and central air-conditioning. The demand response events were not prescheduled, but these assets were directly controlled by the customer preferences at any time when the regional Transactive signal needs the curtailment.[11]
- City of Port Angeles (COPA) [BPA pilot]
  - COPA's pilot involves the purchasing and installation of DR equipment, including residential water controls, in-home displays with controllable home area network capabilities, and thermal storage devices for home heating.
- Emerald People's Utility District (EPUD) [BPA pilot]
  - EPUD's pilot involves the deployment of water heater control devices and programmable thermostats that use Cooper AMI systems.
- Koonetai Electric Cooperative (KEC) [BPA pilot]

---

[8] NWPPA Demand Response Update 2011.
[9] http://www.bpa.gov/EE/Technology/demand-response/Pages/residential_demand_response.aspx
[10] http://www.alliantenergy.com/SaveEnergyAndMoney/AdditionalWaysSave/ApplianceCycling/
[11] https://www.avistautilities.com/inside/resources/irp/electric/Documents/Avista_2013_Electric_IRP_Final.pdf

  - KEC implemented the "Peak Project" program, which provided homeowners with a programmable thermostat and water heater controls to curtail heating and cooling equipment at specific times of peak demand.
- Milton-Freewater City Light & Power
  - Milton-Freewater City Light & Power offers homeowners the option to install small signal-receiving units on their water heaters, central heating units, and air conditioners. Their current program allows all customers to replace their existing one-way load control units with two-way communication units at no cost. Customers participating in this program receive discounts on their electric bill.[12]
- Orcas Power & Light Cooperative (OPALCO) [BPA pilot]
  - OPALCO installed residential water heater DR controls in 410 homes in Orcas and San Juan Island, and is in the process of running DR events.

Examples of residential programs that target renewable balancing include:

- City of Port Angeles (COPA) and Emerald PUD (EPUD) [BPA Pilot]
  - Steffes Equipment Pilot - BPA is partnering with each utility to purchase and install Energy Thermal Storage (ETS) units that can store underutilized renewable or off peak electric energy for space and water heating. ETS systems store electric energy as heat in a well-insulated brick core. Built-in microprocessor-based control systems regulate the charging level and rate. Storage occurs as utilities signal the unit to charge with available renewable or off-peak energy, or in response to other needs of the grid, or when signaled based on built in time clocks, input from residential thermostats, or consumer control. Steffes equipment has the ability to take on "extra" storage during periods when excess energy is available (e.g., when the wind fleet ramps up rapidly) or to turn off when the power supply is limited (e.g., when the wind fleet connected to the BPA grid is suddenly becalmed).[13]
- Mason Country PUD No. 3 (PUD3) [BPA pilot]
  - PUD3 completed a pilot program in which homeowners received communication equipment that enabled water heaters to preferentially store energy generated from wind energy resources in the grid.
- Ecofys [BPA Pilot]
  - Ecofys, under contract to BPA, pilot tested energy storage opportunities at the residential and commercial sector levels. The residential pilots are in the service territories of Lower Valley Energy, Eugene Water and Electric Board, and Cowlitz PUD.

---

[12] http://www.mfcity.com/conservation#rems
[13] http://www.bpa.gov/EE/Technology/demand-response/Pages/residential_demand_response.aspx

The pilot includes thermal storage furnaces and space and water heater control devices from Steffes Corporation.

2.1.3 Expected DR Technologies / Measures

DLC programs for space cooling and water heating typically require installation of a receiver system to signal the interruption or cycling of equipment. Water heaters can either use a radio- or digital internet gateway- activated switch. Historically, DLC for cooling has relied on switches but increasingly utilities are utilizing more advanced programmable communicating thermostats (PCTs). DLC programs for space heating are also trending toward the use of PCTs. While still in pilot phases, there is increasing interest toward using certain types of DLC for load balancing purposes, particularly for water heating applications. The technology application for water heating DLC for balancing purposes is exclusively aimed toward internet gateway-activated switches.

2.1.4 Program Components

For the purposes of this assessment, we looked at three applications of residential DR, along with their associated end-use components:

- Residential DR (Capacity)-with basic enablement technology
  - Component A: Central A/C
  - Component B: Room A/C
  - Component C: Space Heating
  - Component D: Water Heating
- Residential DR (Capacity)-with advanced PCT (or equivalent) technology
  - Component A: Central A/C
  - Component B: Room A/C
  - Component C: Space Heating
  - Component D: Water Heating
- Residential DR (Balancing)-with advanced PCT (or equivalent) technology
  - Component A: Water Heating

2.2 Commercial DR Programs

2.2.1 Description

The types of DR programs that could be targeted to commercial customers are typically split into two categories based on customer size. The first is focused on small commercial facilities (typically with peak demands that are less than 50 kW). In this case, customers with cooling systems that can be controlled either through a conventional switch or through a PCT are targeted. Other end-uses such as space heating and water heating tend to not be ideally suited to the small commercial customer class, even in the Northwest. This is due to relatively small saturations or minimal per-customer impacts making such DR program efforts not worthwhile. The second category is focused on medium-sized commercial facilities (typically with peak demands that range from 50 kW to 200 kW). In these cases, customers with cooling systems that can be controlled with a conventional switch or through AutoDR systems are targeted. For large commercial customers (e.g., with peak demands greater than 200 kW), it is assumed that those customers would fall under an interruptible tariff or load aggregator program (addressed in the industrial/agricultural section).

Lighting applications for DR are also considered for medium commercial customers. In these cases, the customer is presumed to have some type of lighting control system that can easily be adapted to receive remote signals that initiate a DR event sequence.

2.2.2 Benchmark Review

There are several examples of utilities that use DLC for commercial applications mainly for space cooling. Based on relatively small end-use saturations in the Northwest, space heating and water heating applications were not deemed to be particularly relevant for the commercial sector. These examples highlight programs where conventional technologies are used mainly for capacity needs and examples of programs that utilize so-called *Smart DR* technologies for capacity and balancing needs.[14] Note that no examples were found for lighting-specific applications for DR programs; however, Navigant is aware that the California utilities have utilized AutoDR strategies specifically aimed at lighting applications.

Examples of utilities that offer commercial DR programs using traditional switch-based technologies include:

- PacifiCorp / Rocky Mountain Power
    - PacifiCorp's Rocky Mountain Power currently offers the Cool Keeper Program in Utah, which provides participating residential and qualifying small commercial customers with bill credits in exchange for curtailing their cooling loads during the high demand summer peak. The program is administered by Comverge on a pay-for-performance contract.
- Florida Power and Light (FPL)
    - FPL runs an optional DLC program for businesses that allows for cycling of air conditioning systems for short periods of time during times of high electricity demand. The program is achieved through the installation of a two-way automatic communication system to control air conditioning units.

[14] Comprehensive Assessment of Demand-Side Resource Potentials (2014-2033) (Cadmus)

- Xcel Energy
    - Xcel Energy offers customers the "Saver's Switch", a switch product that cycles air conditioning units during peak periods, typically between 2 p.m. and 7 p.m. on weekdays. Switches installed prior to 2004 use a 50% cycling strategy during the control period, while switches installed after 2004 use an adaptive algorithm that allows customers to achieve a 50% reduction in load based on different usage patterns throughout the day. As of December 31, 2012, about 96% of the 167,000 currently installed switches use the adaptive algorithm strategy. Customers may have their air conditioning controlled for up to four hours between either 2 p.m. to 6 p.m. or 3 p.m. to 7 p.m. on a control day.[15]

Examples of commercial programs that target *Smart* DR technology applications include:

- Seattle City Light (SCL) [BPA pilot]
    - SCL concluded a year-long DR pilot in 2010, in which they tested automated DR with pre-programmed control strategies in a local energy management control system. It involved dimming or turning off non-critical lights, changing zone temperature set points and turning off non-critical equipment. One of the project goals was to achieve savings in a way that did not significantly impact building tenants.[16]

2.2.3 Expected DR Technologies / Measures

Customers enrolled in direct load control programs for cooling require a switch installed on their cooling equipment (either a central air conditioner or heat pump), which cycles the units on an off during a program event. Utilities typically offer the participating customers the switches free of charge, or may offer a financial incentive to compensate them for the cost of the switch.

Technologies that fall into the *Smart DR* category would be aimed at PCTs for small commercial cooling applications and AutoDR for medium cooling. As mentioned earlier, advanced lighting controls are looked at for *Smart DR* and Balancing DR program options.

2.2.4 Program Components

For the purposes of this assessment, we looked at three applications of commercial DR, along with their associated market/end-use components:

- Commercial DR (Capacity)-with basic enablement technology
    - Component A: Cooling for small commercial

---

[15] 2014 Demand-Side Management Plan, Electric and Natural Gas. Xcel Energy, 2013. http://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/2014-CO-DSM-Plan.pdf

[16] http://www.bpa.gov/EE/Technology/demand-response/Pages/Commercial-and-Industrial.aspx

  - Component B: Cooling for medium commercial
- Commercial DR (Capacity)-with advanced or *Smart DR* technology
  - Component A: Cooling for small commercial (w/ PCT)
  - Component B: Cooling for medium commercial (w/ AutoDR)
  - Component C: Lighting controls
- Commercial DR (Balancing)-with advanced or *Smart DR* technology
  - Component A: Cooling for medium commercial (w/ AutoDR)
  - Component B: Lighting controls

2.3 Industrial/Agricultural DR Programs

2.3.1 Description

Industrial and agricultural DR programs have been in place for many years. For agricultural applications, the DR programs have focused exclusively on direct load control measures for water pumping and irrigation. For industrial, the DR program focus for many years has been on a passive tariff approach known as curtailable/interruptible. In more recent years, load aggregator approaches have become a preferable alternative to curtailment approaches as many utilities prefer to procure demand reductions to third-party entities like EnerNOC who are contractually obligated to deliver load reductions through customer aggregation approaches.

DR programs for direct load control of irrigation pumps may include a scheduled component, where customers subscribe in advance for specific days and number of hours their irrigation systems may be turned off, along with a dispatchable component, where irrigation pumps are controlled for a specific time period during each event.[17]

Under a curtailable/interruptible tariff options, eligible customers agree to reduce their demands by a specific amount or curtail their consumption to a pre-specified level. In return, they receive a fixed incentive payment in the form of capacity credits or reservation payments (typically expressed as $/kW-month or $/kW-year) and are paid to be on call even though actual load curtailments may not occur. The amount of the capacity payment typically varies with the load commitment level. In addition to the fixed capacity payment, participants receive a payment for energy reduction. Enrolled loads represent a firm resource and can be counted toward installed capacity requirements. Since load reductions must be of firm resource quality, curtailment is mandatory and penalties are assessed for under-performance or non-performance.

[17] Assessment of Long-Term System-Wide Potential for Demand-Side and Other Supplemental Resources, 2013-2032 Volume I. (Cadmus)

Load Aggregators (LAs) are customers or third-party contractors that combine a utility's customer loads and make them available for reductions or interruption. Fundamentally, LAs serve two primary functions in the markets in which they operate. First, by pooling together individual sites into a single portfolio, LAs are able to increase the reliability of demand response and ensure that the requirements set forth by utilities can be met. Second, this portfolio approach allows smaller customers below the minimum size threshold for direct market participation to provide demand response to the market and receive compensation for their efforts. Of course, LAs may also provide other associated services, such as identification of curtailable loads and installation of control equipment, but those characteristics will differ among the various LAs and the markets they operate in.

2.3.2 Benchmark Review

There are several examples of agricultural and industrial DR programs for capacity purposes where both basic and *Smart DR* technologies are utilized.

Examples of agricultural DR programs that use DLC approaches applied to irrigation pumping loads: [18]

- Idaho Power
  - Idaho Power offers the "Irrigation Peak Rewards Program" for the irrigation season (June 15 through August 15 for 2014). The Peak Rewards Program allows customers to receive a financial incentive in exchange for remotely turning off specific irrigation pumps a minimum of three times during the program season. The program is available to all Idaho Power agricultural irrigation customers with existing load control devices installed on their equipment, as well as existing participants classified as Large Service Locations.[19]
- PacifiCorp
  - PacifiCorp offers the Irrigation Load Control Program in Utah and Idaho. The Irrigation Load Control program was offered in 2013 to irrigation customers receiving electric service on Schedule 10, Irrigation and Soil Drainage Pumping Power Service. As of the 2013 program season, EnerNOC manages the irrigation load control program through a pay-for-performance structure, which allows enrolled participants to receive participation credit in exchange for curtailment of their electricity usage. Irrigation equipment is typically set up with a dispatchable two-way control system, which gives EnerNOC control over the irrigation loads. Participants are given a day-ahead

[18] Comprehensive Assessment of Demand-Side Resource Potentials (2014-2033). Puget Sound (Cadmus)
[19] https://www.idahopower.com/EnergyEfficiency/Residential/Programs/ACCoolCredit/default.cfm

notification in advance of control events and have the choice to opt-out of a limited number of dispatch events each season.[20]

- Bonneville Power Administration (BPA)
    - BPA signed a one-season demonstration agreement with United Electric Cooperative to evaluate the ability of the Southwest Irrigation District system to increase pumping during light load hours. The 2014 project kicked-off in early March and will conclude months later in November.[21]

Examples of utilities that offer load curtailment or interruptible tariff mechanisms for large industrial and commercial customers:

- Idaho Power
    - FlexPeak Management gives customers the flexibility to manage their business's peak demand and electricity usage. Through the "FlexPeak Management" program, commercial and industrial customers reduce their power usage during times of system peak demand. Customers who wish to participate are open to enroll through EnerNOC, a third-party developer and provider of energy solutions. The program enables participants to work directly with EnerNOC to identify the best ways their business can shift or reduce energy demand during days when the demand for electricity is at its highest.[22]
- Eugene Water & Electric Board (EWEB) [BPA Pilot]
    - EWEB's proposal goal is to demonstrate how pumping stations, coupled with storage, can be used for decreasing and increasing load. This program aims to show how a utility can leverage its SCADA system to dispatch DR resources, and to document what types of loads, including what characteristics are required for load-following resources. The proposed pilot program can be scaled to other Pumping Stations and Water Authorities in BPA's region, and prove how storage can be used by these C&I customers to provide value to the grid both locally and to BPA. More importantly the pilot will demonstrate whether loads can be used for addressing the intermittency of wind and these impacts on the grid, and how loads can be used to release the grid of overcapacity.[23]

---

[20] Utah Energy Efficiency and Peak Reduction Annual Report. Rocky Mountain Power (PacifiCorp), 2014 http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Demand_Side_Management/2014/2013-UT-Annual-Report-FINAL-Report-051614.pdf

[21] http://www.bpa.gov/EE/Technology/demand-response/Pages/Agricultural.aspx

[22] https://www.idahopower.com/energyefficiency/Business/Programs/FlexPeak/default.cfm

[23] http://www.bpa.gov/EE/Technology/demand-response/Pages/Commercial-and-Industrial.aspx

- MidAmerican Energy
    - The utility uses Itron's curtailment and consumer engagement solutions to help manage its DR programs.[24]
- Pacific Gas and Electric (PG&E)
    - PG&E offers the "Base Interruptible Program", which pays an incentive to reduce a facility's load to or below a level that is pre-selected by the customer. The program gives customers a 30 minute advance notice and pays between $8.00/kW to $9.00/kW per month incentive. Monthly incentive payments are received if no events are called, however, failure to reduce load down to or below the pre-selected level during an event will result in a charge of $6.00/kWh for any energy use above the pre-selected level.[25]
- Sacramento Municipal Utility District (SMUD)
    - Commercial customers can sign up for SMUD's "Voluntary Emergency Curtailment Program", in which the utility asks the customers to reduce their energy use by a pre-determined amount during an emergency energy shortage in the summer. Enrollment is voluntary, and participating customers get recognized through a public "thank you" by the utility's partner publications.[26]

Examples of industrial DR programs that target renewable balancing include:

- City of Port Angeles (COPA) [BPA Pilot]
    - BPA partnered with COPA to demonstrate the viability of using industrial process loads to balance the intermittency of renewable loads. The pilot was implemented by EnerNOC and involved a paper processing plant where the plant's loads were automatically ramped up and down to match the conditions on the grid.
- Ecofys [BPA Pilot]
    - Ecofys, under contract to BPA, pilot tested energy storage opportunities at the residential and commercial sector levels. The commercial pilot was implemented by EnerNOC and targeted commercial cold storage facilities at various locations in the Pacific Northwest.

2.3.3 Expected DR Technologies / Measures

Irrigation DLC requires the installation of a control switch on agricultural water pumps. In addition to installed devices, these types of programs typically require trained utility or third-party staff to interface with the customer systems or install additional equipment to accommodate the needs for the DR

---

[24] https://itron.com/na/newsAndEvents/Pages/Itron-Customers-Successfully-Implement-Demand-Response-Programs.aspx
[25] http://www.pge.com/en/mybusiness/save/energymanagement/bip/index.page
[26] https://www.smud.org/en/business/save-energy/energy-management-solutions/energy-curtailment.htm

program. In some instances, more advanced irrigation control systems are in place, which can easily be adapted to accommodate AutoDR systems that will allow for automated irrigation load control programs. AutoDR consists of fully automated signaling from the utility to provide automated connectivity to customer end-use control systems, devices and strategies. AutoDR does not require full automation on the customer end.[27] These programs typically require a higher level of trained expertise to interface with each different customer's system and ensure interoperability.

For industrial facilities, AutoDR systems would be deployed to ensure greater reliability of DR event performance. AutoDR systems would be essential for any of the balancing programs considered in this analysis.

2.3.4 Program Components

For the purposes of this assessment, we looked at three applications of industrial/agricultural DR, along with their associated market/end-use components:

- Industrial/Ag DR (Capacity)-with basic enablement technology
  - Component A: Agricultural pumping
  - Component B: Curtailable/interruptible tariffs
- Industrial/Ag DR (Capacity)-with advanced or *Smart DR* technology
  - Component A: Agricultural pumping (w/ AutoDR)
  - Component B: Curtailable/interruptible tariffs (w/ AutoDR)
  - Component C: Load aggregator contracts (w/ AutoDR)
  - Component D: Refrigerated warehouses (w/ AutoDR)
- Industrial/Ag DR (Balancing)-with advanced or *Smart DR* technology
  - Component A: Agricultural pumping (w/ AutoDR)
  - Component B: Curtailable/interruptible tariffs (w/ AutoDR)
  - Component C: Load aggregator contracts (w/ AutoDR)
  - Component D: Refrigerated warehouses (w/ AutoDR)

[27] OpenADR Alliance, http://www.openadr.org/faq#2

3. DR Program Results

3.1 Results for Capacity Programs with Basic Technology

Table 3 summarizes the results of the market potential for the capacity programs with either basic technology or no technology applications for each DR program component considered in the analysis. By 2030, the estimated DR market impact associated with capacity-based DR programs that utilize basic technologies is 1,467 MWs in the winter and 1,311 MWs in the summer. The bulk of the savings mainly come from three programs: residential space heating, residential water heating and curtailable/interruptible tariffs.

Table 3. DR Market Potential for Northwest Capacity Programs with Basic Technology

	Capacity - Base							
	2015		2020		2025		2030	
	Winter	Summmer	Winter	Summmer	Winter	Summmer	Winter	Summmer
Load Impact (MW)								
Residential								
a. Space Cooling - CAC Switch	0.00	7.71	0.00	99.60	0.00	106.33	0.00	112.66
b. Space Cooling - RAC Switch	0.00	0.35	0.00	4.48	0.00	4.78	0.00	5.07
c. Space Heating - Switch	21.09	0.00	272.35	0.00	290.72	0.00	308.03	0.00
d. Water Heating - Switch	21.86	21.86	470.42	470.42	502.16	502.16	532.06	532.06
Total	**42.96**	**29.92**	**742.77**	**574.51**	**792.89**	**613.27**	**840.09**	**649.79**
Commercial								
a. Space Cooling, Small - Switch	0.63	1.27	8.13	16.26	8.67	17.33	9.19	18.38
b. Space Cooling, Medium - Switch	1.69	3.39	21.77	43.54	23.21	46.42	24.62	49.23
Total	**2.33**	**4.65**	**29.90**	**59.80**	**31.88**	**63.76**	**33.81**	**67.61**
Agricultural / Industrial								
a. Irrigation Pumping - Switch	0.38	0.43	8.20	9.11	8.74	9.71	9.27	10.30
b. Curtailable/Interruptible Tariff	24.10	24.10	516.03	516.03	550.19	550.19	583.47	583.47
Total	**24.48**	**24.52**	**524.23**	**525.14**	**558.93**	**559.90**	**592.73**	**593.76**
GRAND TOTAL	**69.76**	**59.10**	**1,296.89**	**1,159.44**	**1,383.70**	**1,236.93**	**1,466.64**	**1,311.16**

Table 4 summarizes the associated cost for the same set of DR programs that make up the capacity scenario with basic technologies. The total cost of $28.1 million by 2030 yields an estimated 1,467 MWs of peak load reduction in the winter, at a unit cost of $19/kW-year. The largest contributor to the total cost comes from residential DR programs.

Table 4. DR Program Cost for Northwest Capacity Programs with Basic Technology

	Capacity - Base			
	2015	2020	2025	2030
	Estimated Program Cost ($)			
Residential				
Enablement Costs	$ 8,308,593	$ 23,243,572	$ 1,912,496	$ 1,771,710
Implementation Costs	$ 1,020,344	$ 16,937,063	$ 18,079,924	$ 19,156,419
Total Program Cost	**$ 9,328,937**	**$ 40,180,636**	**$ 19,992,420**	**$ 20,928,130**
Commercial				
Enablement Costs	$ 365,245	$ 752,013	$ 63,065	$ 58,009
Implementation Costs	$ 46,535	$ 597,969	$ 637,554	$ 676,111
Total Program Cost	**$ 411,781**	**$ 1,349,982**	**$ 700,618**	**$ 734,120**
Agricultural / Industrial				
Enablement Costs	$ 19,694	$ 421,774	$ 449,694	$ 476,890
Implementation Costs	$ 245,206	$ 5,251,401	$ 5,599,035	$ 5,937,646
Total Program Cost	**$ 264,900**	**$ 5,673,174**	**$ 6,048,729**	**$ 6,414,537**
GRAND TOTAL	**$ 10,005,618**	**$ 47,203,792**	**$ 26,741,767**	**$ 28,076,787**

3.2 Results for Capacity Programs with Advanced Technology

Table 5 summarizes the results of the market potential for the capacity programs with *Smart DR* technology applications for each DR program component considered in the analysis. By 2030, the estimated DR market impact associated with capacity-based DR programs that utilize *Smart DR* technologies is 2,079 MWs in the winter and 1,897 MWs in the summer. The bulk of the savings mainly come from two programs: residential space heating using PCT technologies and curtailable/interruptible programs that deploy AutoDR technologies.

Table 5. DR Market Potential for Northwest Capacity Programs with *Smart DR* Technology

	Capacity - *Smart*							
	2015		2020		2025		2030	
	Winter	Summmer	Winter	Summmer	Winter	Summmer	Winter	Summmer
	Load Impact (MW)							
	Residential							
a. Space Cooling - CAC PCT	0.00	7.71	0.00	232.41	0.00	248.09	0.00	262.86
b. Space Cooling - RAC PCT	0.00	3.47	0.00	104.58	0.00	111.64	0.00	118.29
c. Space Heating - PCT	21.09	0.00	635.48	0.00	678.36	0.00	718.75	0.00
d. Water Heating - WH Controls	2.43	2.43	52.27	52.27	55.80	55.80	59.12	59.12
Total	**23.52**	**13.62**	**687.75**	**389.26**	**734.15**	**415.53**	**777.87**	**440.27**
	Commercial							
a. Space Cooling, Small - PCT	0.32	0.63	9.48	18.96	10.11	20.22	10.72	21.44
b. Space Cooling, Medium - AutoDR	3.39	6.78	101.60	203.19	108.32	216.64	114.87	229.75
c. Lighting Controls - AutoDR	7.40	7.40	158.48	158.48	168.98	168.98	179.19	179.19
Total	**11.10**	**14.81**	**269.56**	**380.64**	**287.41**	**405.84**	**304.79**	**430.38**
	Agricultural / Industrial							
a. Irrigation Pumping - AutoDR	0.19	0.21	4.10	4.55	4.37	4.85	4.63	5.15
b. Curtailable/Interruptible - AutoDR	24.10	24.10	516.03	516.03	550.19	550.19	583.47	583.47
c. Load Aggregator - AutoDR	6.02	6.02	129.01	129.01	137.55	137.55	145.87	145.87
d. Refrigerated Warehouses - Controls	10.84	12.05	232.22	258.02	247.59	275.10	262.56	291.73
Total	**41.15**	**42.38**	**881.35**	**907.61**	**939.70**	**967.69**	**996.53**	**1,026.22**
GRAND TOTAL	**75.78**	**70.80**	**1,838.66**	**1,677.52**	**1,961.26**	**1,789.07**	**2,079.18**	**1,896.87**

Table 6 summarizes the associated cost for the same set of DR programs that make up the capacity scenario with *Smart DR* technologies. The total cost of $211.7 million by 2030 yields an estimated 2,079 MWs of peak load reduction in the winter, at a unit cost of $101.83/kW-year. The largest contributor to the total cost comes from enablement technologies associated with residential DR programs.

Table 6. DR Program Cost for Northwest Capacity Programs with *Smart DR* Technology

	Capacity - *Smart*			
	2015	2020	2025	2030
	Estimated Program Cost ($)			
	Residential			
Enablement Costs	$ 18,812,526	$ 195,473,786	$ 140,185,642	$ 147,770,900
Implementation Costs	$ 867,736	$ 25,618,560	$ 27,347,221	$ 28,975,499
Total Program Cost	**$ 19,680,263**	**$ 221,092,345**	**$ 167,532,863**	**$ 176,746,399**
	Commercial			
Enablement Costs	$ 3,744,040	$ 15,479,650	$ 1,298,138	$ 1,194,082
Implementation Costs	$ 296,194	$ 7,612,845	$ 8,116,803	$ 8,607,681
Total Program Cost	**$ 4,040,234**	**$ 23,092,495**	**$ 9,414,941**	**$ 9,801,764**
	Agricultural / Industrial			
Enablement Costs	$ 860,945	$ 2,954,372	$ 247,756	$ 227,897
Implementation Costs	$ 1,028,307	$ 22,022,492	$ 23,480,345	$ 24,900,361
Total Program Cost	**$ 1,889,252**	**$ 24,976,863**	**$ 23,728,101**	**$ 25,128,258**
GRAND TOTAL	**$ 25,609,749**	**$ 269,161,704**	**$ 200,675,906**	**$ 211,676,421**

3.3 *Results for Balancing Programs with Advanced Technology*

Table 7 summarizes the results of the market potential for the balancing programs for each DR program component considered in the analysis. Note that it is assumed that all balancing programs will deploy *Smart DR* technology applications. By 2030, the estimated DR market impact associated with balancing-based DR programs that utilize *Smart DR* technologies is 274 MWs in the winter and 315 MWs in the summer. The bulk of the savings mainly come from two programs: curtailable/interruptible programs and refrigerated warehouses. It is important to note that the DR potential and cost estimates for balancing programs are likely low, due to the limited data on program experience.

Table 7. DR Market Potential for Northwest Balancing Programs

	Balancing							
	2015		2020		2025		2030	
	Winter	Summmer	Winter	Summmer	Winter	Summmer	Winter	Summmer
Load Impact (MW)								
Residential								
a. Water Heating - WH Controls	0.03	0.03	12.94	12.94	13.81	13.81	14.63	14.63
Total	**0.03**	**0.03**	**12.94**	**12.94**	**13.81**	**13.81**	**14.63**	**14.63**
Commercial								
a. Space Cooling, Medium - AutoDR	0.03	0.05	0.00	30.17	0.00	32.17	0.00	34.12
b. Lighting Controls - AutoDR	0.05	0.05	23.53	23.53	25.09	25.09	26.61	26.61
Total	**0.08**	**0.11**	**23.53**	**53.71**	**25.09**	**57.26**	**26.61**	**60.73**
Agricultural / Industrial								
a. Irrigation Pumping - AutoDR	0.00	0.00	0.81	0.90	0.87	0.96	0.92	1.02
b. Curtailable/Interruptible - AutoDR	0.30	0.30	127.72	127.72	136.17	136.17	144.41	144.41
c. Load Aggregator - AutoDR	0.07	0.07	31.93	31.93	34.04	34.04	36.10	36.10
d. Refrigerated Warehouses - Controls	0.11	0.12	45.98	51.09	49.02	54.47	51.99	57.76
Total	**0.48**	**0.49**	**206.44**	**211.64**	**220.10**	**225.65**	**233.41**	**239.29**
GRAND TOTAL	**0.59**	**0.63**	**242.91**	**278.28**	**259.01**	**296.72**	**274.66**	**314.65**

Table 8 summarizes the associated cost for the same set of DR programs that make up the balancing scenario. The total cost of $11.5 million by 2030 yields an estimated 275 MWs of peak load reduction in the winter, at a unit cost of $41.82/kW-year. The largest contributor to the total cost comes from implementation-related activities associated with agricultural/industrial DR programs.

Table 8. DR Program Cost for Northwest Balancing Programs

	Balancing			
	2015	2020	2025	2030
	Estimated Program Cost ($)			
Residential				
Enablement Costs	$ 16,292	$ 2,016,363	$ 93,376	$ 86,503
Implementation Costs	$ 1,127	$ 485,119	$ 517,854	$ 548,687
Total Program Cost	**$ 17,419**	**$ 2,501,482**	**$ 611,230**	**$ 635,190**
Commercial				
Enablement Costs	$ 25,984	$ 3,794,296	$ 178,145	$ 163,865
Implementation Costs	$ 3,158	$ 1,611,273	$ 1,717,937	$ 1,821,832
Total Program Cost	**$ 29,142**	**$ 5,405,569**	**$ 1,896,082**	**$ 1,985,698**
Agricultural / Industrial				
Enablement Costs	$ 7,699	$ 943,835	$ 44,314	$ 40,762
Implementation Costs	$ 18,178	$ 7,785,934	$ 8,301,350	$ 8,803,389
Total Program Cost	**$ 25,877**	**$ 8,729,769**	**$ 8,345,664**	**$ 8,844,150**
GRAND TOTAL	**$ 72,438**	**$ 16,636,820**	**$ 10,852,975**	**$ 11,465,038**

3.4 Backup Assumptions and Analysis

This DR market potential assessment was intended to establish a framework by which DR market potentials could be considered as NPCC develops modeling inputs to support DR-related forecasts for the Seventh Power Plan. While these preliminary estimates appear to be reasonable, a multitude of assumptions have gone into the analysis. NPCC would be well served by taking a more in-depth look at the backup assumptions and analysis contained in the attached spreadsheet tool.[28] The tool was designed to serve as a framework that could be improved upon through further iterations.

The tool contains the following worksheet tabs:

- The first five tabs contain basic information about Northwest customer characteristics, including the number of customers, energy consumption, and forecasted peak demand. These data are mainly from backup data that supported the Sixth Power Plan.
- The next tab (Summary Table) contains the various summary results that are presented in the tables above.
- The seventh tab (Key Assumptions) contains many of the driving assumptions that comprise the estimated DR load impacts, program costs, and program participation levels.
- The next three tabs (shaded in light red) contain many of the sector-specific inputs and calculations that generate program-specific load impacts and costs for capacity-based DR programs that utilize basic DR enablement technologies.

[28] The spreadsheet tool is titled "NPCC_7thPowerPlan_DR_Programs_UPDATE_2015 01 16.xlsx"

- The next three tabs (shaded in blue) contain many of the sector-specific inputs and calculations that generate program-specific load impacts and costs for capacity-based DR programs that utilize *Smart DR* enablement technologies.
- The final three tabs (shaded in green) contain many of the sector-specific inputs and calculations that generate program-specific load impacts and costs for balancing-based DR programs.

Appendix A. Key Assumptions and Sources

This appendix lists the key assumptions and sources used for the "Key Assumptions" tab in the Excel-based DR potential tool created for this study.

Technology Costs

- Capacity – Base
  - Residential CAC DLC switches = $60 (cost of one-way switch)[29]
  - Residential Room AC DLC switches = $40 (assumes room AC switches are $20 cheaper than central AC switches due to smaller equipment size)
  - Commercial DLC switches = $100[30]
- Capacity - Smart
  - Residential PCTs = ($400/kW * load impact)[31]
  - Water Heater Controls = assumes same technology cost as residential PCTs.
  - Commercial PCTs = ($285.71/kW * load impact)[31]
  - Auto DR + Lighting Control System = ($138.50/kW * load impact)[31]
  - Auto DR + Energy Management System = ($138.50/kW * load impact)[31]
  - Auto DR for Curtailable/Interruptible Tariffs = average of costs for customers with and without a Building Management System (BMS). $2500 on CII side assumes that roughly 50% of customers have BMS and thus their device costs are around $500; the others need some sort of low-cost BMS or gateway plus points. Does not include labor costs associated with installation and integration.[32]
  - Auto DR for Load Aggregator = average of costs for customers with and without a Building Management System (BMS). $2500 on CII side assumes that roughly 50% of customers have BMS and thus their device costs are around $500; the others need some sort of low-cost BMS or gateway plus points. Does not include labor costs associated with installation and integration.
  - Refrigerated Warehouse Controls = $5000 (assumes half the cost of BPA's pilot hardware cost, $10,000[33])
- Balancing
  - Assumes same as "Capacity – Smart" technology costs

---

[29] Navigant Research, Demand Response for Residential Markets, RDR-12, 4Q 2012. Does not include labor costs associated with installation and integration.
[30] Navigant analysis conducted for Tucson Electric Power's mass market DLC program. Does not include costs associated with installation and integration.
[31] Navigant analysis conducted for BPA smart grid investment case, 2014.
[32] Navigant analysis conducted for LADWP DR strategy, 2013.
[33] Bonneville Power Administration Technology Innovation Project 220 - TI 220 Project Evaluation Report, 2012.

Installation Costs

- Capacity – Base
  - Residential DLC switches = ($80/kW * load impact) (Navigant experience-based estimate)
  - Commercial DLC switches = ($60/kW * load impact) (assumes downward trend in installation cost from residential, based on a larger load offset)
  - Industrial DLC switches = ($40/kW * load impact) (assumes downward trend in installation cost from commercial, based on a larger load offset)
- Capacity – Smart
  - Installation Cost for Residential PCTs = ($114.90/kW * load impact)[31]
  - Installation Cost for Water Heater Controls = assumes same installation cost as residential PCTs
  - Installation Cost for Commercial = ($82.07/kW * load impact)[31]
  - Installation Cost for Auto DR + Lighting Control System = ($96/kW * load impact)[31]
  - Installation Cost for Auto DR + Energy Management System = ($96/kW * load impact)[31]
  - Installation Cost for Curtailable/Interruptible Tariff = assumes 50% of the technology cost
  - Installation Cost for Refrigerated Warehouse Controls = assumes 50% of the technology cost
- Balancing
  - Same installation costs as "Capacity – Smart"

Implementation Cost

- Capacity – Base
  - Residential DR = $20/kW-yr (Navigant experience-based estimates)
  - Commercial and Industrial DR = $10/kW-yr (assumes a 50% derate from residential estimate, based on scale economies due to larger customers)
- Capacity – Smart
  - Residential DR = assumes an additional 25% to the implementation cost of residential "base" DR programs.
  - Commercial and Industrial DR = assumes double the implementation cost of commercial "base" DR programs.
  - Lighting controls = assumes the same implementation cost as other Commercial DR categories.
  - Load Aggregator = $50/kW-yr (Navigant experience-based estimates)
  - Refrigerated Warehouses = assumes the same implementation cost as Commercial and Industrial "Smart" DR programs
- Balancing
  - Assumes 50% increase from all "smart" DR programs

Load Impacts

- Capacity – Base
    - Residential Space Heating – DLC = (1.74 kW/customer)[34]
    - Residential Water Heating – DLC = (0.58 kW/customer)[34]
    - Residential Space Cooling – CAC DLC = (0.6 kW/customer)[32]
    - Residential Space Cooling – RAC DLC = (0.27 kW/customer)[32]
    - Commercial Space Cooling, Small – CAC DLC = (2.8 kW/customer)[32]
    - Commercial Space Cooling, Medium – CAC DLC = 15 kW/customer (Navigant experience-based estimate)
    - Agricultural Irrigation Pumping – DLC = 25 kW/customer (Navigant experience-based estimate)
    - Industrial Curtailable/Interruptible Tariffs = 500 kW/customer (Navigant experience-based estimate)
- Capacity – Smart
    - Assumes same load impacts as "Base" DR programs
    - Commercial Lighting Controls = 57 kw/customer[31]
    - Industrial Load Aggregator = 100 kw/customer (Navigant experience-based estimate)
    - Industrial Refrigerated Warehouses = 250 kw/customer (Navigant experience-based estimate)
- Balancing
    - Assumes same load impacts as "Smart" DR programs

Saturation

- Capacity – Base
    - Residential Space Heating – DLC = 33% (assumes 1/3 of homes in the Northwest are eligible for space heating DLC)
    - Residential Water Heating – DLC = 57%**Error! Bookmark not defined.** (calculated as the average of single-family and multiplex units water heat saturation results)
    - Residential Space Cooling – CAC DLC = 35%[35]
    - Residential Space Cooling – RAC DLC = 18% (assumes half the saturation rate of central AC)
    - Commercial Space Cooling, Small – CAC DLC = 35% (58% of cooling saturation[32] multiplied by an assumed 60% of commercial customers being in the small category)
    - Commercial Space Cooling, Medium – CAC DLC = 17% (assumes the 58% of cooling saturation from small commercial cooling and multiplies by an assumed 30% of commercial customers being in the medium category)

---

[34] Cadmus Group, Comprehensive Assessment of Demand-Side Resource Potentials (2014-2033), 2013.

[35] Based on 2009 FERC study saturation data. Federal Energy Regulatory Commission - A National Assessment of Demand Response Potential, 2009.

    - Agricultural Irrigation Pumping – DLC = 70% (Navigant experience-based estimate)
    - Industrial Curtailable/Interruptible Tariffs = 70% (Navigant experience-based estimate)
- Capacity – Smart
    - Same as "base" DR programs.
    - Commercial Lighting Controls = 25% (assumes 25% of all lighting systems have automatic controls)
    - Industrial Curtailable/Interruptible Tariffs = 35% (assumes 50% saturation levels of "base" industrial curtailable/interruptible tariffs program)
    - Industrial Load Aggregator = 18% (assumes 25% saturation of "base" industrial load aggregator program),
- Balancing
    - Assumes all "smart" DR programs can be enabled for balancing services.

<u>Participation</u>

- Capacity – Base
    - Residential DR programs = 25%
        - Other participation rates were estimated based on the residential participation rate.
    - Commercial DR programs = 15% (based on Navigant assumption that commercial customers are harder to reach and tend to exhibit smaller participation rates relative to residential).
    - Agricultural DR programs = 20% (based on Navigant assumption that agricultural customers have similar participation characteristics to residential customers).
    - Industrial DR programs = 25% (assumes the same participation rate as residential programs participation).
    - Refrigerated Warehouses = 20% (assumes to be comparable to agricultural customers in terms of participation).
- Capacity – Smart
    - Same as "base" DR programs.
- Balancing
    - Same as "base" DR programs.

<u>Load Impact Seasonality</u>

- Capacity – Base
    - Residential Space Heating – DLC
        - Winter = 100% (assumes the full load in the winter)
        - Summer = 0% (assumes no load in the summer)
    - Residential Water Heating – DLC
        - Winter = 100% (assumes the full load in the winter)
        - Summer = 100% (assumes the full load in the summer)

- Residential Space Cooling – CAC DLC
  - Winter = 0% (assumes no load in the winter)
  - Summer = 100% (assumes the full load in the summer)
- Residential Space Cooling – RAC DLC
  - Winter = 0% (assumes no load in the winter)
  - Summer = 100% (assumes the full load in the summer)
- Commercial Space Cooling, Small – CAC DLC
  - Winter = 50% (assumes commercial AC is still operational during the winter due to internal heat sources; assumes 50% of the summer load)
  - Summer = 100% (assumes the full load in the summer)
- Commercial Space Cooling, Medium – CAC DLC
  - Winter = 50% (assumes commercial AC is still operational during the winter due to internal heat sources; assumes 50% of the summer load)
  - Summer = 100% (assumes the full load in the summer)
- Commercial Lighting Controls
  - Winter = 100% (assumes the full load in the winter)
  - Summer = 100% (assumes the full load in the summer)
- Agricultural Irrigation Pumping – DLC
  - Winter = 90% (assumes there is more irrigation activity in the summer than winter months; assumes 10% less than the summer load)
  - Summer = 100% (assumes the full load in the summer)
- Industrial Curtailable / Interruptible Tariffs
  - Winter = 100% (assumes the full load in the winter)
  - Summer = 100% (assumes the full load in the summer)
- Industrial Load Aggregator
  - Winter = 100% (assumes the full load in the winter)
  - Summer = 100% (assumes the full load in the summer)
- Industrial Refrigerated Warehouses
  - Winter = 90% (assumes the load required in the winter is lower than in the summer due to a lower temperature differential; assumes 10% less than the summer load)
  - Summer = 100% (assumes the full load in the summer)

- Capacity – Smart
  - Same as "base" DR programs.
- Balancing
  - Same as "base" DR programs.