Greenhouse Gas Reductions from Demand Response: Impacts in Three U.S. Markets

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Abstract

The U.S. Environmental Protection Agency (EPA) released a draft of the Clean Power Plan (CPP) in 2014 to cut carbon dioxide (CO_2) emissions from power plants. The EPA did not address demand response (DR) in the draft CPP. This paper summarizes analysis, conducted prior to the final CPP, showing that DR can reduce CO_2 emissions and thus merits consideration in state compliance plans.

The analysis includes modeling of direct emission reductions from DR, a qualitative review of indirect emission reduction potential from DR, and a literature review. The modeling effort examines pathways by which DR can reduce emissions, including:

- **Two direct emission reduction pathways:** DR reduces peak load and DR provides ancillary services
- **Two indirect emission reduction pathways:** DR contributes to increased levels of renewable penetration and DR impacts the economics of power plants such that the system fuel mix changes

Results show that DR can directly reduce CO_2 emissions by more than one percent through peak load reductions and the provision of ancillary services, and that it can indirectly reduce CO_2 emissions by more than one percent through accelerating changes in the fuel mix and increasing renewables penetration. This emission reduction potential is significant when compared to the EPA's targets—32 percent below 2005 levels by 2030 for the power sector. The analysis demonstrates that DR is able to provide valuable CO_2 emission reductions and should be a strategic part of implementation of the CPP. Following comments submitted on the draft, the final CPP included DR as a compliance strategy.

Introduction

On June 2, 2014, the U.S. Environmental Protection Agency (EPA) released a draft of the Clean Power Plan (CPP), a proposal to regulate carbon dioxide (CO_2) emissions from existing fossil fuel power plants under Section 111(d) of the Clean Air Act (U.S. EPA 2015). The EPA did not directly include demand response (DR) in the draft CPP, either as a building block in their calculations of state goals or as a potential CO_2 emission reduction strategy for states to employ in their implementation plans. DR is defined as "changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized" (Federal Energy Regulatory Commission 2016). Many North American electric utilities and system operators use DR programs as resource options for balancing supply and demand and for lowering wholesale prices. The potential peak reduction in the United States from DR in 2013 was 27 gigawatts (GW) (Federal Energy Regulatory Commission 2015).

Analysis described in the following sections shows that DR can reduce CO_2 emissions and merits consideration by the EPA for inclusion in the final CPP.

Background on the CPP

The CPP has two main parts: calculation of emission rate targets and direction for states to implement plans to meet those targets. The EPA used building blocks to calculate emission rate targets, but the CPP does not propose to require or limit states to using those building blocks for implementation. The EPA's targets are designed for 2030 and will reduce carbon pollution from the power sector by 32 percent below 2005 levels (U.S. EPA 2015).

The proposed targets represent the EPA's assumption of the level of emission reductions that can be achieved by cost-effective programs and policies using its Best System of Emissions Reduction (BSER) methodology. In the draft CPP, the EPA defined BSER as a combination of four building blocks:

1. Improvements to the efficiency of carbon-intense, fossil fuel power plants
2. Substitution of carbon-intense generation with less carbon-intense generation (e.g., replacing coal generation with gas)
3. Substitution of carbon-intense generation with low- or zero-carbon generation (e.g., replacing coal generation with nuclear and/or renewables)
4. Reduction of the total amount of generation required through demand-side energy efficiency programs

The CPP allows compliance mechanisms to include cap-and-trade programs and multistate implementation plans, making way for the expansion of existing regional trading schemes like the regional and state programs in the Northeast and California as well as the potential addition of new trading schemes.

Purpose of this Study

The objective of this effort was to demonstrate that DR can help achieve meaningful emission reductions that will help reach CO_2 targets. This study describes the potential for emission reductions; forecasting actual emission reductions that would result in a given case is beyond the scope of this study. This analysis was intended to show that the CO_2 reduction potential of DR merited consideration by the EPA for inclusion in the final CPP.

Methodology

The study examined literature relating DR to emission reductions and considered direct emission reductions resulting from DR as well as indirect reductions resulting from DR's role in supporting renewables and impacting the economics of plant operations and fuel use. Direct emission reductions can result from peak load reductions and through providing ancillary services, specifically synchronized reserve and regulation. Navigant modeled direct emission reductions for three markets: the PJM Interconnection (PJM), the Midcontinent Independent System Operator (MISO), and the Electric Reliability Council of Texas (ERCOT). Navigant developed analysis cases using different assumptions for DR penetration. Each case compared the overall system emissions from the null case with those from differing levels of DR penetration. For emission reductions from peak load reduction, Navigant calculated the emissions from the expected marginal energy unit during super peak load hours to estimate the reductions due to DR. For reductions from ancillary services, the model dispatched the system against the energy and ancillary services requirements and compared the changes in CO_2 emissions from system operations. This study also provides a qualitative overview of the potential for indirect emission reductions from DR.

Peak Load Reduction Model. This model, shown in Figure 1, was developed for the three markets to demonstrate CO_2 reductions from peak load reduction provided by DR. Emission rate and total emission data is from the EPA's modeling of compliance year 2030 under the CPP. The number of hours and number of megawatts (MW) called are based on data from the individual markets, while the emission rate for diesel backup generation is from a study by the University of California, Riverside (Davis 2004).

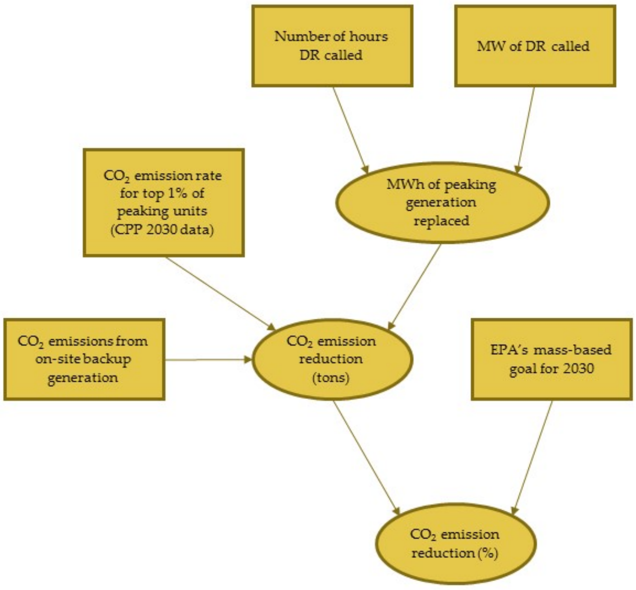

Figure 1. Peak Load Reduction Model

Ancillary Services Model. This model, illustrated in Figure 2**Error! Reference source not found.**, was developed for the three markets to demonstrate CO_2 reductions from ancillary services provided by DR. The ancillary services requirements and minimum generation assumptions are from actual industry data from the three markets in 2012. The heat rate penalty assumptions are Navigant's assumptions based on internal data, and the average heat rate by plant type is from the EPA's modeling of compliance year 2030 under the CPP.

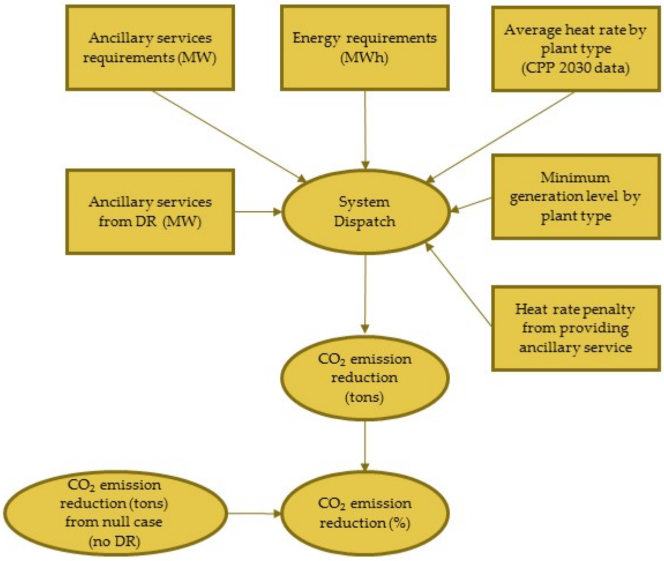

Figure 2. Ancillary Services Model

Literature Review

Navigant conducted a review of literature pertaining to DR and CO_2 emission reductions. Methods included Internet searches, professional referrals, and inquiries with the Lawrence Berkeley National Laboratory's Demand Response Research Center and the Association of Demand Response and Smart Grid. This review uncovered studies that relate to the subject matter.

The Pacific Northwest National Laboratory released a report (Pacific Northwest National Laboratory 2010) that articulates nine mechanisms by which the smart grid can reduce energy use and carbon impacts associated with electricity generation and delivery. It states:

> *"Demand response itself can reduce energy consumption because controlling an end-use to lower peak load demand shifts the load to other times, or in some cases actually eliminates some consumption. . . . The smart grid can provide reductions in primary energy and CO_2 emissions by shifting peak load to more efficient lower emission base and intermediate generation resources. . . . the California "Shift & Save" quantifies the reduced CO_2 emissions at between 10 and 20 percent."*

The Texas Clean Energy Coalition commissioned a study in 2014 (Brattle Group 2014) that modeled existing DR programs in ERCOT and new program scenarios. The report states:

> *"The combined effects of higher gas prices, lower load growth, enhanced DR and CHP installations lower CO_2 emissions about 4 percent by 2032 versus the Phase II Reference Case, or 143 million metric tons. This is the equivalent of closing one 600 MW coal plant for 30 years."*

There are several studies that explore the indirect effect that DR can have on emissions by helping to integrate intermittent renewable energy like solar and wind power onto the grid. The North American Electric Reliability Corporation (NERC) recently released analysis of the CPP (NERC 2014) that states:

> *"A large penetration of Variable Energy Resources (VER) will also require maintaining a sufficient amount of reactive support and ramping capability. More frequent ramping needed to provide this capability could increase cycling on conventional generation. This could contribute to increased maintenance hours or higher forced outage rates, potentially increasing operating reserve requirements."*

The literature review indicates that DR can play a meaningful role in reducing CO_2 emissions and should be included in the menu of demand-side options for emission reduction.

Overview of DR in PJM, ERCOT, and MISO Markets

This section provides an overview of the three markets analyzed in this project. Wholesale market areas were chosen for this analysis due to the availability of data. The results of this analysis are translatable to vertically integrated utilities because the ways in which DR influences emissions are similar regardless of whether that DR is called upon by a market or by a utility.

DR in the PJM Market

This section presents an overview of DR in PJM and a discussion of ancillary services in this market.

DR in PJM. The implementation of PJM's capacity market, the Reliability Pricing Model (RPM), in 2007 facilitated significant growth in demand-side participation in the market. DR can bid into the energy market, curtail for emergency conditions, or provide both services. The majority of DR's revenues comes from capacity payments because they are generally used for emergency curtailment during periods of extrememly high load. Figure 3 indicates historical and forecasted DR and energy effciency capability by year as it participates in the capacity market. After years of steady increases, DR participation has decreased in the past two auctions due to recent caps on limited and extended summer DR and mandates that DR providers give increased assurance they will be able to deliver the demand reductions promised in their offers. About 12 GW of DR cleared the RPM in the 2017/2018 auction.

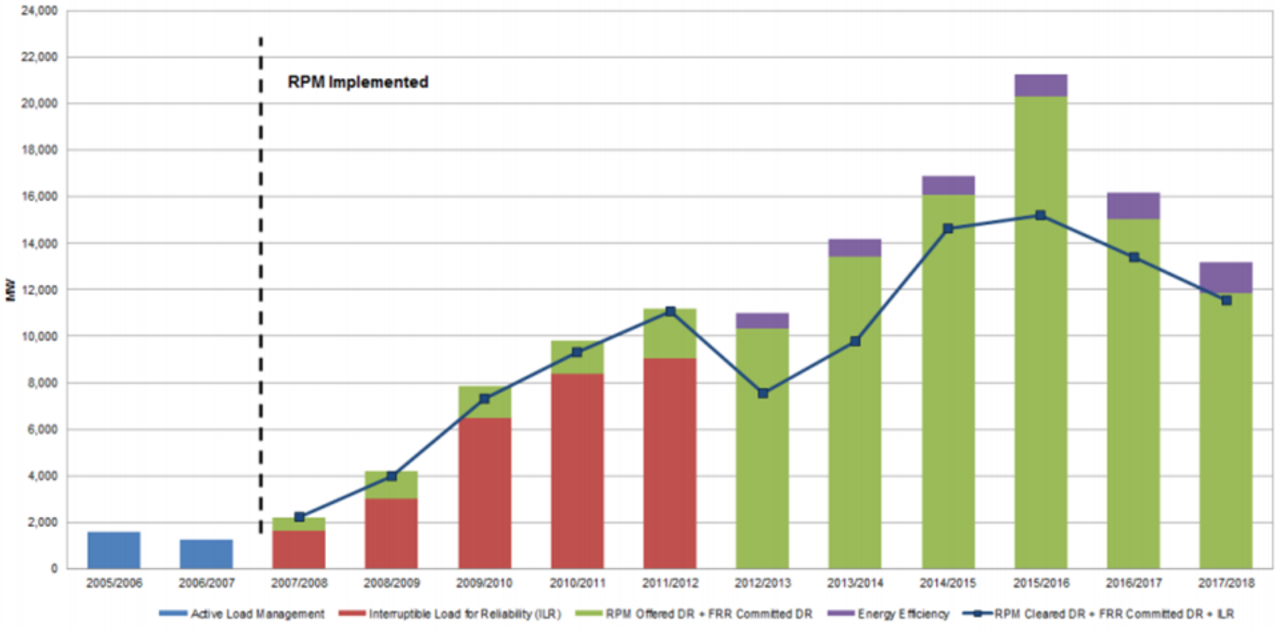

Figure 3. Demand-Side Participation in PJM Capacity Market (PJM 2013)

PJM also operates an Economic Load Response Program (ELRP), which allows commercial and industrial (C&I) customers to voluntarily reduce load during times when their bid exceeds the locational energy market price at that time. There are no penalties for non-compliance and payments are made for each megawatt-hour (MWh) that is curtailed. From the implementation of the RPM in 2007 until 2011, the capacity payments were the dominant source of income for DR resources, so payments through the ELRP declined substantially. After the implementation of Federal Energy Regulatory Commission (FERC) Order No. 745 in April 2012, which requires that demand-side resources be paid for the full locational marginal price (LMP), ELRP participation rates increased significantly, as shown in Table 1.

Table 1. PJM ELRP Resources

	2011	2012	2013
Registered Resources on Peak Load Day (MW)	2,042	2,302	2,375
Total Energy Savings (MWh)	16,782	141,568	127,045

Ancillary Services in PJM. Ancillary services support the reliable operation of the electric grid. PJM currently provides regulation, synchronized reserve, and non-synchronized reserve (operating reserves) through markets.

Regulation reserve is a service that allows the system operator to adjust participating generation to accommodate short-term differences in system loads and resources. As demand increases or decreases from moment to moment, generation or DR resources are ramped up and down automatically, keeping the grid in balance. DR is limited to providing 25 percent of regulation; DR provided approximately one percent of regulation in PJM in 2013. Also in 2013, coal units provided only 15.5 percent of regulation, a decline from the 30 percent of regulation they provided in 2012.

Originally limited to synchronized reserves, PJM's primary reserve market now includes reserves that are not synchronized. To provide synchronized reserve, a generator must be synchronized to the system and capable of providing output within 10 minutes. DR resources can also provide synchronized reserve. In 2012, PJM's primary reserve requirement was 150 percent of the footprint's largest contingency (2,063 MW), and 1,375 MW of that requirement was required to be synchronized. Non-synchronized primary reserves, such as hydro and combustion turbines (CTs), are those that could deliver energy within 10 minutes from a shutdown state. DR is a significant part of the synchronized reserve market in PJM but is limited to providing 33 percent of synchronized reserves; DR provided approximately 17 percent in 2013.

DR in the MISO Market

This section discusses the role of DR in MISO including a discussion on ancillary services.

DR in MISO. DR programs in MISO can be categorized as follows: Behind-The-Meter Generation (BTMG), Load Modifying Resources (LMRs), Emergency Demand Response (EDR), and Demand Response as a Resource (DRR). BTMG consists of emergency generation and other physical capacity that can be turned on during a power shortage. This generation is located either in the distribution system or on customer sites; it is, therefore, measured as a reduction in load. LMRs are physical loads that can be curtailed in an emergency, such as reduced consumption at an industrial site or reductions in lighting and air conditioning. Both of these programs are administered by load-serving entities (LSEs), and MISO does not directly control them. EDR consists of BTMG and LMRs but differs from the other programs in that MISO has direct control to curtail these loads during declared NERC emergency events. However, by definition, EDR is not price-responsive, does not set energy prices, and does not participate directly in the MISO energy markets.

Economic DRR is the only type of DR program that can participate in the energy market, not only during emergencies but also at any time when energy prices exceed the marginal value of the consumer's electricity consumption. A summary of resources enrolled in MISO DR programs from 2011-2013 can be found in Table 2. MISO resources enrolled in DR programs have been fairly constant in recent years, although there was a substantial increase in enrolled LMRs in 2013.

Table 2. MISO DR Program Resources (MW)

DR Type	2011	2012	2013	% of 2013 Peak
BTMG	3,001	2,969	3,411	4%
LMR	2,898	2,882	5,045	5%
EDR	930	902	894	1%
DRR	547	443	447	0%
Total	**7,376**	**7,196**	**9,797**	**10%**

For resource adequacy, all DR resources are treated as comparable to generation resources in their ability to meet planning reserve margins in the Resource Adequacy Construct. DR increases in

MISO are likely, as MISO has initiated significant efforts to reduce barriers to integrating DR resources into existing markets. MISO has developed a conceptual design for enabling LMRs and BTMG to set prices when called. As DR resource quantities grow, they are expected to be deployed more frequently to satisfy peak loads and to respond to system contingencies.

Ancillary Services in MISO. MISO began its ancillary services market in January 2009. MISO currently provides regulation, spinning, and supplemental reserves (non-spinning reserves). To provide spinning reserve, a generator must be synchronized to the system and capable of providing output within 10 minutes. To provide supplemental reserve, a generator must also be able to provide output with 10 minutes, but the resource can be offline.

DR that participates in MISO's DRR program is characterized as either a Type I or Type II resource. Type I resources are capable of supplying a fixed, pre-specified quantity of energy or contingency reserve through physical load interruption. Conversely, Type II resources are capable of supplying varying levels of energy or operating reserves on a five-minute basis, such as through controllable load or BTMG. Currently, Type II resources can offer all ancillary services products, whereas Type I units are prohibited from providing regulation.

DR in the ERCOT Market

This section describes the role that DR currently plays in the ERCOT market.

DR in ERCOT. ERCOT has approximately 1,200 MW of load resources (mostly large industrial consumers) that bid into the day-ahead market and can be curtailed at times of high prices and in emergencies. Additionally, it has approximately 700 MW in emergency interruptible load (from C&I customers) that is shed to prevent blackouts (ERCOT 2014*)*.

Ancillary Services in ERCOT. ERCOT currently operates day-ahead and balancing ancillary service markets for up regulation (reg-up) and down regulation (reg-down) (frequency regulation), responsive reserves (spinning reserves), and non-spinning reserves (30-minute reserves).

Regulation reserves are used to balance demand and supply dynamically in real time. To provide reg-up, generators are given a higher set point and asked to increase power output from that point in real time. For generators providing reg-down, the situation is reversed: they lower power output in real time. Responsive reserve must be able to replace lost generation within 15 seconds. Non-spinning reserves must be able to deploy within 30 minutes of being called. ERCOT allows qualified load resources to participate in the responsive reserves and non-spinning reserves ancillary services markets. Those providing responsive reserves must have high set under frequency relay equipment that enables them to be automatically tripped when the frequency falls below 59.7 hertz (Hz), which will typically occur only a few times per year. Deployments of non-spinning reserves occur much more frequently. To date, load resources have shown a clear preference for providing responsive reserve service; load resources are limited to providing no more than half of responsive reserves in ERCOT.

DR Pathways for Reducing Emissions

Navigant's modeling indicates that DR has the potential to directly reduce overall sector CO_2 emissions by more than one percent annually through peak load reduction and the provision of ancillary services. Indirect emission reductions from supporting the expansion of renewable resources and changing the fuel mix used in generation have the potential to be larger. These results are described below.

Direct Emission Reductions

Navigant quantitatively assessed two direct emission reduction pathways:

1. When DR reduces peak load
2. When DR provides ancillary services

DR Providing Peak Load Reduction. DR has a direct impact on CO_2 emissions when it provides peak load reduction. The impact was assessed by displacing natural gas CTs that are in service to provide peaking capacity on high load days. For peak load reduction, Navigant modeled direct emission reductions from varying levels of DR penetration. The following cases were run:

- Variations of DR penetration based on the number of hours DR is called using the total MW of DR in each market.[1] The values varied from 10 to 100 hours called. No backup generation assumed.
- Variations of DR penetration based on the amount of MW of DR that is called (with an assumption that DR was called for 50 hours annually). No backup generation assumed.
- The two above cases were run assuming 25 percent of DR used for peak load reduction also used onsite diesel backup generation.

For the peak load reduction cases, it was assumed that none of the peak load reduction is shifted to another timeframe.[2] In all cases, the displaced generation was assumed to be the average of the highest one percent of natural gas-fired CT capacity in the region in regards to total variable costs.

The potential for annual emissions reductions from DR from peak load reduction, based on the CPP targets for 2030, is on the order of 0.05 percent to 0.35 percent, with the variance caused by the number of MWh of DR that are called within the year. As expected, the emission reduction is higher when more MWh of DR are called in a year. Also, as expected, emission reduction is lower when DR is backed up by onsite diesel generators. Navigant's findings can be found in Table 3 and Table 4.

1 Values pulled from the latest versions of the PJM, MISO, and ERCOT State of the Market Reports. The values are 9,360 MW for PJM, 9,355 MW for MISO, and 850 MW for ERCOT.

2 This assumption regarding load shifting simplifies the calculations. Navigant reviewed literature addressing the degree to which load reduction provided by DR is shifted to other periods. Based on this review, load shifting was determined not to be a significant factor in the emissions calculation. Note that peak load reductions account for a smaller reduction in energy than the use of DR to provide ancillary services year round. Also, a recent study of direct load control found little snapback or pre-cooling: PECO. 2013. *Final Annual Report for the Pennsylvania Public Utility Commission for the Period June 2012 through May 2013 Program Year 4 for Pennsylvania Act 129 of 2008 Energy Efficiency and Conservation Plan.* Another study showed no load shifting during winter DR events: Lawrence Berkeley National Laboratory. 2012. *Field Demonstration of Automated Demand Response for Both Winter and Summer Events in Large Buildings in the Pacific Northwest*. Other resources reviewed include NV Energy. 2014. "Demand Response Program, Program Year 2013, Final Evaluation Report"; Ontario Power Authority. 2013. "2012 Impact Evaluation of Ontario Power Authority's Commercial & Industrial Demand Response Programs"; Alcoa. 2011. *Dynamic Demand Response- A New Paradigm*; and Lawrence Berkeley National Laboratory. 2010. *Coordination of Energy Efficiency and Demand Response*.

Table 3. Direct Emission Reductions from Peak Load Reduction: No Backup Generation Cases

Hours Called	ERCOT	PJM	MISO		Total MW Called	ERCOT	PJM	MISO
10	0.01%	0.03%	0.04%		10%	0.00%	0.01%	0.02%
20	0.01%	0.05%	0.07%		20%	0.01%	0.03%	0.04%
30	0.02%	0.08%	0.11%		30%	0.01%	0.04%	0.06%
40	0.03%	0.11%	0.15%		40%	0.01%	0.05%	0.07%
50	0.03%	0.13%	0.19%		50%	0.02%	0.07%	0.09%
60	0.04%	0.16%	0.22%		60%	0.02%	0.08%	0.11%
70	0.04%	0.19%	0.26%		70%	0.02%	0.09%	0.13%
80	0.05%	0.21%	0.30%		80%	0.03%	0.11%	0.15%
90	0.06%	0.24%	0.33%		90%	0.03%	0.12%	0.17%
100	0.06%	0.27%	0.37%		100%	0.03%	0.13%	0.19%

Table 4. Direct Emission Reductions from Peak Load Reduction: 25 Percent Backup Generation Cases

Hours Called	ERCOT	PJM	MISO		Total MW Called	ERCOT	PJM	MISO
10	0.01%	0.02%	0.03%		10%	0.00%	0.01%	0.02%
20	0.01%	0.04%	0.06%		20%	0.01%	0.02%	0.03%
30	0.02%	0.06%	0.09%		30%	0.01%	0.03%	0.05%
40	0.02%	0.09%	0.12%		40%	0.01%	0.04%	0.06%
50	0.03%	0.11%	0.15%		50%	0.02%	0.05%	0.08%
60	0.03%	0.13%	0.18%		60%	0.02%	0.06%	0.09%
70	0.04%	0.15%	0.21%		70%	0.02%	0.07%	0.11%
80	0.04%	0.17%	0.24%		80%	0.02%	0.09%	0.12%
90	0.05%	0.19%	0.27%		90%	0.02%	0.10%	0.14%
100	0.05%	0.21%	0.30%		100%	0.03%	0.11%	0.15%

DR Providing Ancillary Services. Ancillary services provided by fossil generation result in some units operating at lower capacity levels in order to provide operating reserve and regulation services. Plants run less efficiently when turned down, thus emitting more CO_2. DR-provided ancillary services can reduce CO_2 emissions due to more efficient dispatch of generation units. For example, if a 500 MW coal plant bids 200 MW into the reserves market, it then takes a heat rate penalty for operating at 300 MW instead of 500 MW. The EPA demonstrated in their calculations for the first building block in the CPP that small changes in the heat rates of coal plants can have a significant impact on CO_2 emissions.

For ancillary services, Navigant modeled direct emission reductions from varying levels of DR penetration for four time classifications: summer on-peak, summer off-peak, winter on-peak, and winter off-peak.[3] In addition, Navigant ran the following cases:

3 The DR penetration levels are based on observations in the PJM market. The 25 percent reduction represents a conservative estimate of DR currently active in PJM, 33 percent is representative of penetration rates under current rules, and 50 percent is a plausible high case.

1. Variations on the heat rate impacts of turning plants down
2. High load
3. Low cost of coal

Navigant estimates that DR providing ancillary services can reduce CO_2 emissions by 0.3 to 0.8 percent annually. As seen in the High Heat rate, High Load, and Low Coal Cost cases, DR providing ancillary services can reduce CO_2 emissions by a greater amount for an individual hour in which these assumptions are present. Higher loads tend to result in higher CO_2 reductions, as less efficient gas units are on the margin and there are larger heat rate penalties for operating below full load. In ERCOT, increasing load beyond the summer peak average leads to reductions in CO_2 in excess of two percent in individual hours. This results from less coal generation in the region; therefore, the reductions in CO_2 are driven by using more efficient natural gas combined cycles for generation rather than CTs. This effect is not present in MISO and PJM, as there is still significant coal. DR has an even greater potential for emission reductions in cases with low net load (net of renewables penetration). There may be situations where renewables need to be curtailed such that sufficient fossil fuel generation is available to provide ancillary services. In these circumstances, DR can instead provide the ancillary services, thereby preventing the curtailment of renewable resources. The CO_2 emission reductions in such a scenario could be 10 percent or more.

Additionally, curtailment is often caused by transmission constraints, and DR's ability to be sited close to load makes it less likely to be affected by such constraints when providing ancillary services.

Table 5. Direct Emission Reductions from Ancillary Services by Case in PJM

PJM	Summer, Peak	Summer, Offpeak	Winter, Peak	Winter, Offpeak	High Heat Rate Impacts	High Load	Low Coal Cost	Weighted Annual Average
Load (MW)	107,853	83,912	93,993	81,403	107,853	130,000	107,853	95,959
Additional Renewable Gen (MW)	-	-	-	-	-	-	-	-
Reserve Requirement (MW)	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375
Up Regulation Requirement (MW)	979	979	979	979	979	979	979	979
Down Regulation Requirement (MW)	979	979	979	979	979	979	979	979
% CO_2 Reduction – 0% A/S from DR	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
% CO_2 Reduction – 25% A/S from DR	-0.3%	-0.3%	-0.3%	-0.3%	-0.4%	-0.3%	-0.1%	-0.3%
% CO_2 Reduction – 33% A/S from DR	-0.4%	-0.3%	-0.4%	-0.4%	-0.5%	-0.3%	-0.2%	-0.4%
% CO_2 Reduction – 50% A/S from DR	-0.6%	-0.5%	-0.6%	-0.6%	-0.8%	-0.5%	-0.2%	-0.6%

Table 6. Direct Emission Reductions from Ancillary Services by Case in MISO

MISO	Summer, Peak	Summer, Offpeak	Winter, Peak	Winter, Offpeak	High Heat Rate Impacts	High Load	Low Coal Cost	Weighted Annual Average
Load (MW)	69,391	55,358	64,190	55,757	69,391	85,000	69,391	63,563
Additional Renewable Gen (MW)	-	-	-	-	-	-	-	-
Reserve Requirement (MW)	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Up Regulation Requirement (MW)	569	569	569	569	569	569	569	569
Down Regulation Requirement (MW)	569	569	569	569	569	569	569	569
% CO_2 Reduction – 0% A/S from DR	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
% CO_2 Reduction – 25% A/S from DR	-0.4%	-0.4%	-0.4%	-0.4%	-0.5%	-0.3%	0.4%	-0.4%
% CO_2 Reduction – 33% A/S from DR	-0.5%	-0.5%	-0.5%	-0.5%	-0.6%	-0.3%	0.4%	-0.5%
% CO_2 Reduction – 50% A/S from DR	-0.8%	-0.8%	-0.8%	-0.8%	-0.9%	-0.4%	0.4%	-0.8%

Table 7. Direct Emission Reductions from Ancillary Services by Case in ERCOT

ERCOT	Summer, Peak	Summer, Offpeak	Winter, Peak	Winter, Offpeak	High Heat Rate Impacts	High Load	Low Coal Cost	Weighted Annual Average
Load (MW)	52,901	39,630	37,126	31,419	52,901	60,000	52,901	43,454
Additional Renewable Gen (MW)	-	-	-	-	-	-	-	-
Reserve Requirement (MW)	4,200	4,200	4,200	4,200	4,200	4,200	4,200	4,200
Up Regulation Requirement (MW)	503	503	503	503	503	503	503	503
Down Regulation Requirement (MW)	402	402	402	402	402	402	402	402
% CO_2 Reduction – 0% A/S from DR	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
% CO_2 Reduction – 25% A/S from DR	-0.4%	-0.3%	-0.2%	-0.2%	-0.6%	-1.5%	-0.4%	-0.3%
% CO_2 Reduction – 33% A/S from DR	-0.5%	-0.4%	-0.3%	-0.2%	-0.9%	-1.9%	-0.5%	-0.4%
% CO_2 Reduction – 50% A/S from DR	-0.8%	-0.6%	-0.4%	-0.4%	-1.3%	-2.4%	-0.8%	-0.6%

Indirect Emissions from Demand Response

DR can indirectly influence CO_2 emissions through two pathways:

1. Changes in fuel mix
2. Renewables integration

Changes in Fuel Mix. There are a number of factors driving the current wave of retirement of inefficient fossil fuel plants, including competition in the energy market with cheap natural gas that is primarily driven by the shale revolution and increased costs to comply with other environmental regulations. DR can provide year-round ancillary services and is expected to provide more regulation services over the CPP compliance period due to increased renewables penetration and advancements in technology for controlling loads. As a result, DR is one of the drivers that can lead to lower capacity factors for inefficient fossil fuel units, thus leading to their retirement.[4] PJM noted this trend in a recent transmission expansion plan.[5]

The CO_2 emission reductions from fossil fuel plants that have already retired, have announced that they will retire, and that will likely retire before 2030 are substantial. PJM calculates that the removal of CO_2 emissions from coal units that have announced their retirement reduced overall emissions from units covered by the CPP by 12 percent, or from 442 million short tons to 392 million short tons, using 2012 emissions.[6] These emission reductions in PJM play a major role in helping states meet their proposed interim (2020-2029) goals under the CPP.

DR also allows fossil fuel units that plan to retire to do so earlier. DR provides stopgap capacity until replacement capacity can be built and reduces the amount of replacement capacity needed.[7] For instance, in PJM, Navigant estimates that increases in DR would allow PJM to decrease the capacity of reliability must-run (RMR) units.[8]

The potential for indirect CO_2 emission reductions from fossil fuel retirements attributable to DR is viewed as larger than the direct emission reductions modeled through peak load reduction and ancillary services. DR is a contributing factor to plant retirement decisions that have large impacts on emissions. While a precise estimate of the MW of retirements attributable to DR is difficult to derive, the size of the impact and the role that DR plays in the economics of plant operating decisions indicate that DR can help achieve significant emission reductions.

Renewables Integration. DR plays a role in the development and integration of renewable resources that can reduce CO_2 emissions. Larger amounts of renewables on the grid increase the need for ancillary services due to the intermittent nature of solar and wind generation.[9] DR is a low-cost way to meet the increased demand for ancillary services. This makes increased levels of renewable penetration more economic, which results in lower levels of CO_2 emissions.

As discussed above, DR providing ancillary services reduces the need to curtail renewable generation in favor of fossil fuel generation because DR provides ancillary services without adding additional generation to the grid. Therefore, DR allows a greater portion of load to be met by renewable generation.

Additionally, DR can be procured quickly and in small amounts. Renewables are added to the grid in small increments and over periods of time. DR can be procured as needed to support

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4 FirstEnergy in Docket EL14-55 on May 23, 2014 states that "continued use of demand response in capacity auctions is likely to prevent generation units owned by FirstEnergy to clear in PJM's auctions, resulting in potentially millions of dollars in lost revenues," and that the FERC's decision "will impact not only rates, but commercial decisions whether to close or build new generation resources." http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14219331

5 PJM, *2012 Regional Transmission Expansion Plan*: http://www.pjm.com/documents/reports/rtep-documents/2012-rtep.aspx

6 PJM's presentation *EPA's Clean Power Plan Proposal: Review of PJM Analyses Preliminary Results*, presented to the Members Committee on November 17, 2014: http://www.pjm.com/~/media/committees-groups/committees/mc/20141117-webinar/20141117-item-03-carbon-rule-analysis-presentation.ashx

7 See Sierra Club's comments to the New Jersey Board of Public Utilities on Docket EO11050309, July 12, 2011: http://nj.gov/bpu/pdf/energy/Sierra%20Reply%20Comments.pdf

8 PJM currently has three plants categorized as RMR for a total of 870 MW of coal-fired capacity.

9 Several studies discuss this, including the National Renewable Energy Laboratory's *The Western Wind and Solar Integration Study Phase* 2, September 2013: http://www.nrel.gov/docs/fy13osti/55588.pdf ; PJM's *Renewable Integration Study Task Report: Review of Industry Practice and Experience in the Integration of Wind and Solar Generation*, November 2012: http://pjm.com/~/media/committees-groups/task-forces/irtf/postings/pris-task3b-best-practices-from-other-markets-final-report.ashx; and NERC's Special Report. *Ancillary Service and Balancing Authority Area Solutions to Integrate Variable Generation*, March 2011: http://www.nerc.com/files/IVGTF2-3.pdf

renewables as they are added to the grid, without the lead time needed to plan and build a fossil plant. In this way, DR helps smooth the "lumpiness" of capacity additions that occurs as renewables are integrated onto the grid.

Considerations for the CPP

This study demonstrated that DR can be an important part of a strategy to reduce CO_2 emissions and should be included in emission reduction strategies and plans. Navigant estimated that DR could directly reduce CO_2 emissions by more than one percent (up to 0.35 percent from peak load reduction and up to 0.8 percent from ancillary services) and that its overall role in the economics of fuel mix and plant operations will result in reduced CO_2 emissions by a larger amount—i.e., potentially an additional one percent. Direct emission reductions occur when DR reduces peak load and provides ancillary services. Indirect emission reductions occur when DR contributes to fossil fuel retirements and increased levels of renewable penetration. While the potential reduction is not enough to meet the required target reductions, this emission reduction potential is significant when compared to the EPA's targets—reducing CO_2 emissions from fossil fuel power plants by 32 percent below 2005 levels (U.S. EPA 2015). DR can play a role in the development and integration of renewable resources, a key building block in the CPP. While the EPA did not directly include DR in the proposed CPP, this analysis demonstrates that DR provides valuable CO_2 emission reductions and thus should be a strategic part of implementing the CPP. Following comments on the proposed CPP based on this analysis, the EPA did include DR as a strategy in the final CPP (U.S. EPA 2015).

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