LEED Demand Response Credit: A Plan for Research towards Implementation

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DISCLAIMER

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ABSTRACT: Buildings represent a large portion of the electric system consuming over 70% of electricity and approximately third of the electric peak is due to the commercial sector. We introduce the need and methods for commercial building sector involvement in demand response (DR). We summarize the new Demand Response Partnership Program, whose goal is to facilitate the adoption of variety of timescales of DR in LEED certified buildings. We describe the program's research goals, methodology and preliminary results from socializing the new USGBC LEED DR credit with the building industry stakeholders, including architects, engineers, consultants, contractors, and building owners and managers**.** Finally, we share the proposed credit language.

(Keywords: automated demand response, LEED DR credit.)

INTRODUCTION

In early 2000s, the blackouts in California and the northeast, and terrorist threats nationwide caused new concerns about reliable supplies of affordable energy. In New York and California, blackouts caused billions of dollars of losses to businesses and individuals [1] [2]. While reliable power is an important goal, economic factors and market issues are key constraints in electricity systems. Recent improvements in developing and demonstrating demand response (DR) in electricity markets address these challenges. In early 2010, the adoption and deployment of renewable portfolio standards in 29 states in the US increased the focus on the need for flexible demand-side resources to address four major challenges related to renewable generation penetration:1) over generation during low-load hours; 2) steep and unpredictable ramps; 3) forecast errors associated with renewable generation; and 4) intra-hour variability of these resources [3]. Two primary goals of DR are to ensure electric supply reliability and improve price response to allow end-use consumers to see and respond to dynamic electricity prices.

Buildings are a large portion of the electric system consuming over 70% of electricity [4]. They also account for a large portion of summer peak demand. Understanding the magnitude and distribution of peak demand in the U.S. is crucial to developing goals and strategies to reduce it.

One obstacle to assessing the opportunity for commercial buildings peak load reductions is that there is limited information on the contribution of commercial buildings to electric system peak loads. Two national sources of peak load data are the Energy Information Administration's (EIA) Commercial Buildings Energy Consumption Survey (CBECS) and National Energy Modelling System (NEMS). CBECS is a national survey of energy-related building characteristics, and energy consumption, and expenditures data for commercial buildings. The 1995 CBECS data included a unique survey of electric peak demand data. Subsequent CBECS surveys did not include peak demand data. Median peak demand intensity in the entire commercial sector was 5.4 W/ft^2, with office buildings at 6 W/ft^2. Two-thirds of the buildings were summer peaking.

The second source of electric peak demand data, NEMS, is the primary midterm forecasting tool of the EIA. NEMS consists of a group of simulation modules that represent all major energy supply, demand, and conversion sectors of the U.S. economy, as well as general domestic macroeconomic conditions and world oil markets. The commercial sector in the Commercial Demand Module of NEMS considers business establishments that are not engaged in industrial or transportation activities as commercial building. Its floor space module uses the CBECS floor space as its base with future year floor space forecasted with new construction trends. Lawrence Berkeley National Laboratory (LBNL) researchers extracted three years of peak demand data (1999, 2003 and 2005) in all sectors within the thirteen regions in the United States from one run that represents the AEO2005 Reference Case.

Table 1: Comparison of CBECS and NEMS based estimates of commercial sector electric peak demand [5].

	1995 (GW)	2003 (GW)
CBECS Estimation 1	**273**	**333**
CBECS Estimation 2	**317**	**387**
NEMS Coincident Peak	**291**	**328**
NEMS Non-coincident Peak	**317**	**349**

Current participation in DR programs does not nearly touch the potential. Enrolments (which entail a commitment to curtail) are not well understood. There is also an inevitable difference between commitments and actual curtailment. The potential to provide peak load reductions reliably with automated DR is largely unexplored. For example, California's investor-owned utilities, San Diego Gas & Electric, Southern California Edison and Pacific Gas & Electric reported automated demand response (AutoDR) in their peak-time DR programs comprised just 3%, 11% and 6% of their respective DR portfolios in 2011 [6, 7, 8].

The USGBC's LEED credit for DR is a confirmation of DR's growing role in demand-side management activities and commercial buildings' integration with the electricity grid to identify and develop flexible loads. DR integration with energy efficiency will reduce the cost to enable DR, increase societal benefits and provide utility bill savings to commercial buildings. OpenADR, which is a standard developed for AutoDR, maximizes the value of DR to commercial buildings by facilitating participation in various timescales of DR.

Additional research is needed to evaluate the technical and economic potential of DR resources. This research will inform the refinement of programs, such as U.S. Green Building Council's LEED Program's DR credit, to meet the needs of building owners, operators, occupants and contractors.

In the remainder of this paper first we introduce how DR fits with demand-side management activities, DR methods and levels of automation. We highlight OpenADR as a standard for commercial buildings to communicate with the electric grid operators. We then outline the DR Partnership Program, its research objectives and methodology. Finally, we summarize the preliminary findings from socializing the concept with various stakeholders who are customers of a large electric utility in California.

DEMAND RESPONSE AND COMMERCIAL BUILDINGS

Electricity demand varies constantly throughout the year. At times of low demand, only the lowest marginal cost plants operate, while at peak times, most available power plants run to meet demand. Electricity providers and their customers are concerned with peak demand because of the financial and environmental challenges of providing growing electric system capacity. The value of DR is summarized by the Peak Load Management Alliance [9] as having impact on the reliability of the electricity system; reducing costs associated with generation, transmission and distribution; creating efficient markets; reducing suppliers' and customers' price risks; and reducing environmental impact by reducing or delaying new power plant developments.

In addition to avoiding investments in new generation resources, DR can provide immediate environmental benefits. Where emissions per unit of electricity generated (i.e., marginal emissions rates) are greater at peak than off peak times, DR can shift electricity demand to times of the day with lower marginal emissions rates [10].

The demand-side management (DSM) framework presented in Figure 1 provides continuous energy management concepts for shaping electric loads in buildings, including energy efficiency (for steady state load optimization), peak load management (for daily operations); and demand response (DR) (day-ahead, day-of, and fast-acting) [11]. In this section, we present the DSM framework from a buildings perspective concentrating on energy management and control system (EMCS)-based options. In this paper, load and demand are used interchangeably.

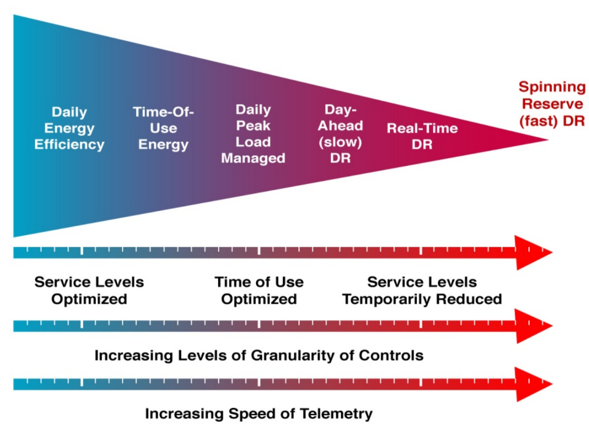

Figure 1: Timescales of Demand Response

• *Energy Efficiency:* Energy efficiency can lower energy use to provide the same level of service. Driven by conservation goals, plus the desire for environmental protection and utility bill savings, energy efficiency measures permanently reduce peak load by reducing overall consumption. In buildings this is typically done by installing energy efficient equipment or improving operations to reduce energy waste.

• *Daily Peak Load Management:* The advance of metering technology has made it possible to differentiate electricity usage patterns of buildings. Peak load management is motivated by high charges for peak demand and time-of-use rates. Typical peak load management methods include demand limiting and demand shifting. *Demand limiting* refers to shedding loads when pre-determined peak demand limits are about to be exceeded. Loads are restored when the demand is sufficiently reduced. This is typically done to flatten the load shape when the pre-determined peak is the monthly peak demand. *Demand shifting* is shifting the loads from peak times to off-peak periods. Figure 1 displays the typical demand profile of a commercial building employing these methods.

• *Demand Response:* DR refers to the modification of customer electricity usage at times of peak usage in order to help address system reliability, reflect market conditions and pricing, and support infrastructure optimization or deferral. DR programs may include dynamic pricing and tariffs, price-responsive demand bidding, contractually obligated and voluntary curtailment, and direct load control or equipment cycling. DR methods such as demand limiting and shifting can be utilized when the economics and reliability issues are predicted and communicated to each site in advance. *Demand shedding* is dynamic temporary reduction, or curtailment of peak load when dispatched and refers to strategies that can be possibly implemented within a shorter period of response times

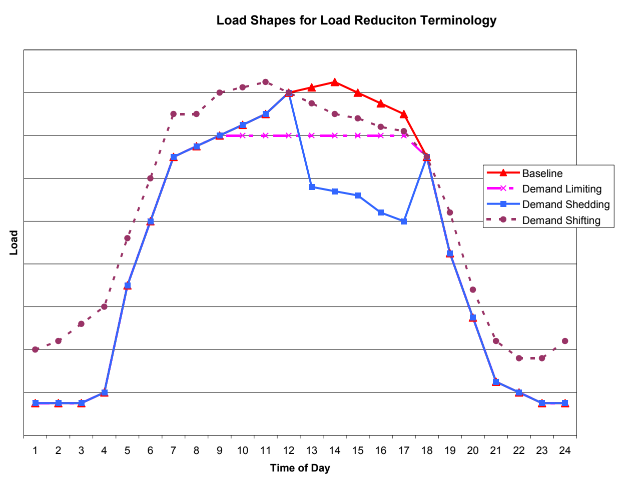

Figure 2: Illustrative Demand Profile of Various Demand Response Methods

Nearly half of all U.S. states are implementing or piloting technology for load management. Load Management is defined by the EIA as any activity other than Direct Load Control and Interruptible Load that limits or shifts peak load from on-peak to off-peak time periods. It includes technologies that primarily shift all or part of a load from one time-of-day to another and secondarily may have an impact on energy consumption. Examples of system loads subject to load management include space heating and water heating storage systems, cool storage systems, and load limiting devices in energy management systems.

Levels of automation in DR can be defined as follows:

• *Manual Demand Response* involves a labor-intensive approach such as turning off unwanted lights or equipment.

• *Semi-Automated Response* involves the use of controls for DR, with a person initiating a pre-programmed DR strategy.

• *Fully-Automated Demand Response* does not involve human intervention, but is initiated at a facility through receipt of an external communications signal.

EMCS in commercial buildings can be utilized in two ways to ensure DR participation: automating DR events and corresponding DR control strategies; and integrating new technologies and intelligently processing energy related data to optimize electricity use.

For fully automated-DR, commercial buildings can benefit from OpenADR, which is an information exchange model developed as a formal standard through the Smart Grid Standards process led by the National Institute of Standards and Technology (NIST). OpenADR was initially developed by the Demand Response Research Center at Lawrence Berkeley National Laboratory [12], who donated it to a NIST-designated standards development organization known as Organization for Advancement of Structured Information Standards (OASIS). OASIS published a series of standards for expressing electricity prices and DR signals. OpenADR 2.0 is derived from the OASIS standards ant equipment is currently being certified by an industry led alliance called the OpenADR Alliance[1]. One primary goal of OpenADR is to reduce the cost and improve the performance of DR by embedding the software in common control systems. All of the major control companies are building this capability into controls for commercial buildings.

OBJECTIVES OF THE RESEARCH

The US Green Building Council (USGBC), Skipping Stone, Schneider Electric, the Demand Response Research Center (DRRC) at Lawrence Berkeley National Laboratory (LBNL), and the California investor owned utilities worked to introduce a pilot demand response (DR) credit, 8: Demand Response, into the LEED rating system. This credit [13] was created in an effort to increase participation in demand response programs that reduce peak energy generation and make distribution systems more efficient, while reducing environmental impacts.

To deploy, evaluate and further develop this LEED DR credit, the Demand Response Partnership Program (DRPP), made up of the original team that developed the LEED DR credit as well as utility, environmental non-profit and industry partners was developed. The DRPP

[1] http://www.openadr.org

engages the commercial building and energy industries to educate, promote and drive participation in existing demand response programs, while undertaking a robust research agenda focused on market adoption, grid reliability and environmental impact assessment through improved energy management.

The objectives of the research are twofold. From customers' perspective, the DRPP will evaluate the:

1) process of achieving the credit;
2) cost effectiveness of the credit;
3) performance of the buildings; and
4) peak loads of commercial buildings.

From utilities' perspective, the DRPP will evaluate the:

1) impact of the DR credit on participation in DR and associated customer acceptance;
2) process and how it fits with their internal processes.

This project brings together a large population of building owners (i.e., USGBC members) and technical assistance from LBNL, Environmental Defense Fund (EDF), and Skipping Stone to consider three areas of inquiry:

- Consumer Perspectives: DRPP examines consumer energy use behavior and participation in DR using the USGBC membership base. We will examine participation in LEED for DR programs, including identification of barriers to participation, customer awareness, technology utilization, and customer financials;
- Energy Performance: DRPP plans data gathering and analysis to evaluate the performance of and to inform the design of LEED for DR programs using building load data, weather data, and existing building models; and
- Valuation and Cost-Effectiveness: DRPP develops DR estimation tools, including establishing baselines, peak load benchmarking of buildings, quantifying environmental benefits, and customer financial analysis that, for example, compare the cost of obtaining LEED DR certification against payments and avoided energy costs from DR participation.

Our findings will provide lessons from building DR program participation while exploring non-participation, since both types of buildings are present in the USGBC membership base.

EDF will provide technical expertise in quantifying environmental benefits of DR resources, in particular those benefits that pertain to operating modes of DR participation and consequences for grid-based emissions. Environmental opportunities included avoided costs of building new larger scale generation resources, improved ability to integrate large quantities of renewable resources into the generation mix, and avoided pollution (and cost) impacts of operating the dirtiest (and most expensive) peaker power plants.

While the environmental opportunities are significant, DRPP will consider the potential risks and costs of DR. For example, DR participants that turn to on-site diesel generators might undermine air quality during reliability events. Similarly, but on a larger scale, programs that shift load from peak generation using relatively clean natural gas to coal-fired base load generation may increase greenhouse gas pollution and degrade local and regional air quality. In addition to air quality, there may be DR implications for water consumption and water quality impacts from cooling at power plants.

In addition to evaluating our design hypothesis for building DR participation and associated environmental benefits partnering with USGBC members, we will explore the implications of our findings for the sale of DR in electricity and ancillary energy services markets.

METHODOLOGY

The research methodology has three key elements: data gathering, infrastructure development for data sharing and storing, and data analysis. The completion of all key elements is anticipated to require at least two years, with the first year focused on data gathering, infrastructure development and preliminary data analysis.

The data gathering effort will include the following:

- Surveys to monitor and evaluate the LEED DR credit deployment process;
- Electric load data from existing buildings;
- Weather data;
- Mechanical and electrical drawings and building models that may be used for energy analysis; and
- Cost of DR enablement including labor and technology. (For example, we plan to calculate the labor cost of enabling each DR event in manual DR programs.)

The surveys are the key to refining the language of the LEED DR credit. They will be designed to collect and evaluate the following information:

- Non participant surveys to determine barriers and reasons for not participating;
- Participant program selection surveys to compare and contrast different DR programs and various value propositions;
- Customer awareness surveys to determine market awareness and perceptions;
- Technology utilization to assess technologies and usability of existing systems; and
- Critical experience and feedback from building owners in LEED DR.

The surveys will be designed carefully to increase participant response, and to increase the speed and accuracy of analysis.

Electric load data in large commercial buildings with interval meters are usually captured in 5- to 15-minute intervals. These data are stored by the utility and are sometimes made available to sites over a utility information system. Therefore, there are two paths to receiving these data: 1) the building site gives access to their portal of the utility information system; or 2) the utility provides data via access to their utility information system or via one-off data requests from their customers. The ideal for this study would be to give the researchers access to the utility information system and add sites as they agree to be a part of the project through a formal agreement that is acceptable to the utility, site and the research team.

In addition to the electric load data, the research team will collect weather data (e.g., wet bulb, dry bulb, cooling degree days, etc.). Some utilities already collect these data and use them to deliver certain analytic tools for their customers. In cases where the data are not available through the utility information system, the research team will be using closest NOAA weather station data.

For new construction, all related mechanical and electrical drawings will be collected. In cases where there is a building energy simulation model, the research team will use the model to determine DR participation potential.

In order to collect, organize and share data, a database will be established. The database will have access privileges for various people depending on their role, e.g. if they are entering the data or analyzing the data, part of the partnership or public.

Analytical tools will use the database to support the following analyses:

- DR estimation methods for new and existing buildings;
- Developing baseline methods that are representative of building loads;
- Benchmarking peak load and demand response against other buildings and also past performance;
- Customer economics (e.g., cost of implementation, benefits of participation, and payback horizons);
- Multi-year DR performance analysis including shed variability and baseline error calculations;
- Environmental benefits assessment including greenhouse gas emissions impact of the DR participation; and
- Reliability impact assessment and readiness for energy markets.

PRELIMINARY RESULTS

LBNL socialized the pilot credit with building industry stakeholders, including architects, engineers, consultants, contractors, and building owners and managers through calls and meetings within one utility's territory. Discussions were held with over 15 stakeholders from the broader buildings industry when the LEED DR credit was first released, finding a large amount of support for the inclusion of DR strategies within the LEED rating systems. Although stakeholders were generally supportive of the credit, it was suggested that there is some room for improvement based on the pilot credit language. The following is a summary of feedback received:

- **LEED points offer additional incentives for adoption of DR**. Stakeholders of the building community felt that, currently, there is not much appetite to push the widespread adoption of DR, and different incentives are required to get owners and operators interested and engaged. Stakeholders also noted that rewards for participating in DR programs have diminished significantly, thus offering LEED credits would give participation more value.
- **Energy efficiency performance is not considered in load-shed requirements.** Buildings already achieving a high level of energy efficiency must apply a disproportionately large amount of effort to reduce load when compared to equal buildings with lesser energy performance. When dealing with large buildings that require 10% load shed due to sheer size, this problem presents a difficult obstacle to adoption.
- **Load-shed thresholds may be too high for small to medium commercial buildings**. Often there are simple, small-scale, DR strategies that may help reduce overall environmental impact but may not necessarily reach the targets set by USGBC. Stakeholders from the building community have suggested interest in access to such recognition.
- **LEED points offered are not equitable for the cost and effort required**. Many stakeholders have voiced concerns that the LEED DR credit requirements for action plan development, staff training, financial analysis, and testing are disproportionately onerous when compared to points offered by other LEED credits. Interviewees suggested that such effort and costs will likely be a deterrent to adoption of the LEED DR credit.
- **DR strategy development must be started early in the design process.** When started late in the design process, DR is difficult and costly to implement. The burden of designing such strategies and technologies is also not typically included in consultants' original fees, and is thus considered an add-on service.

CONCLUSION

In this paper, we introduce the need and methods for commercial building sectors involvement in DR and describe the research goals, methodology and preliminary results from socializing the new LEED DR credit with the building industry stakeholders, including architects, engineers, consultants, contractors, and building owners and managers**.** DRPP will continue to work with its partners to test and refine the pilot credit. It is expected to publish its results in 2013.

The value of DR and participation by commercial buildings varies regionally within the nation. DRPP will be limited to conducting research in regions where they have innovative partners. There are remaining research needs to better understand the diversity of DR programs and customer value around the U.S., and to lower the cost of grid integration for commercial buildings. Significant federal leadership is needed to understand and develop value to the commercial buildings sector around the country.

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