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IEA-DSM Task XXI: Standardisation of Energy Savings Calculations

Subtask II: Demand Response and Energy Savings Calculation

Summary Demand Response products M&V

3rd Expert's meeting

Madrid, 13th & 14th October 2010

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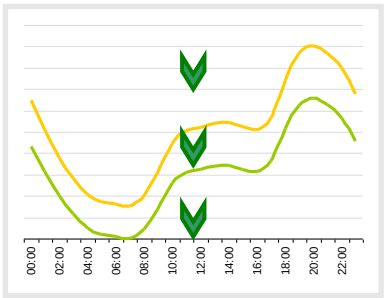
1. Demand Response

Introduction: interaction with energy efficiency

Subtask II objectives included “to develop a methodology to nominate and describe the Demand Response products”. This document aims to describe here the basic concepts related to Demand Response and what are the main issues related to M&V of DR products:

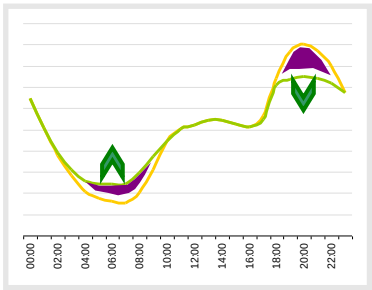
1

Demand reduction



2

Movement of demand from peak to off peak



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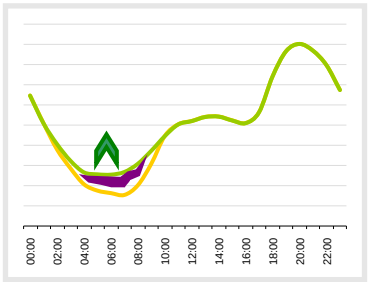
High demand on/off peak



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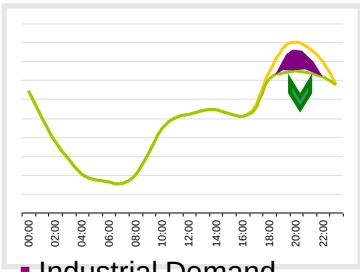
Demand reduction on the Electrical System peak hours



- Industrial Demand management: Interruption Service
- Automated management of electrical loads

Demand Response

Final consumers energy efficiency refers to using less energy to provide the same or improved level of service to the energy final energy consumer

Demand response entails customers changing their normal consumption patterns in response to changes, oriented to diminish energy consumption at critical periods aiming at improving energy efficiency of the whole electric system

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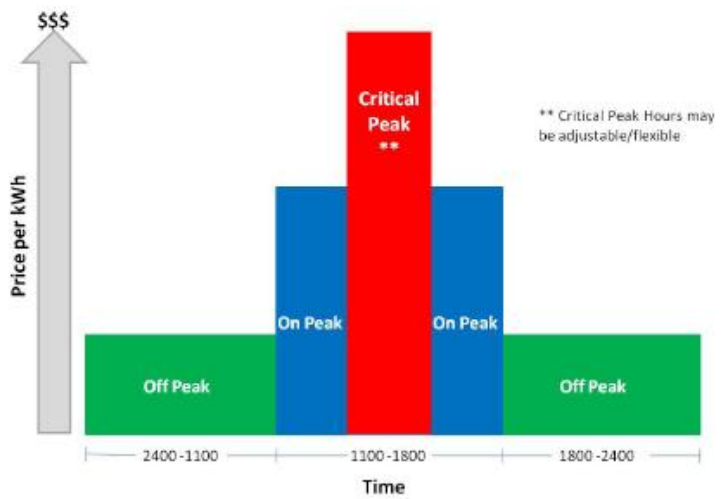
2. Demand Response products

Definition

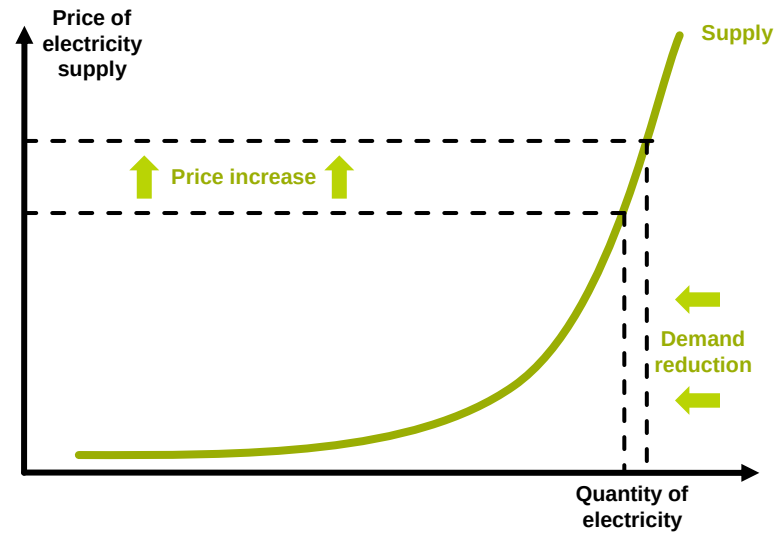
Demand response can be defined[1] as **changes in electric usage by end-use customers from their normal consumption patterns** in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at time of high wholesale market prices or when system reliability is jeopardized

Example of Time of use rates



Source: Demand Response Measurement & Verification

Impact of price reduction in electricity demand



Source: Benefits of Demand Response in Electricity Markets. US Department of Energy

The final goal of demand response products is to influence customers to reduce energy consumption in response to particular conditions within the electricity system

[1] U.S Department of Energy (DOE)
Source: Harry Vreuls, Experts meeting Task 21 April 29/30 March 2010

2. Demand Response products

Description of DR products

Some of the **most common** incentive-based and price-based DR products are:

Time-of-use (TOU) Rate	• A rate with different unit prices for usage during different blocks of time
Real Time Pricing (RTP):	• A retail rate in which the price for electricity typically fluctuates hourly reflecting changes in the wholesale price of electricity
Direct load control (DLC) and Automation	• Allows the utility some degree of control over certain equipment, for example switching-off non critical loads or modifying devices' parameters
Emergency demand response programs (ERDP):	• Customers receive incentive payments for load reductions when needed to ensure reliability
Interruptible / curtailable (I/C):	• Customers receive a discounted rate for agreeing to reduce load on request
Ancillary services market programs	• Customers receive payments from a grid operator for committing to restrict load when needed to support operation of the electric grid (i.e., auxiliary services)

DR products are oriented to change consumer's habits, either promoting their active participation or allowing the utility to control some of their energy consumption

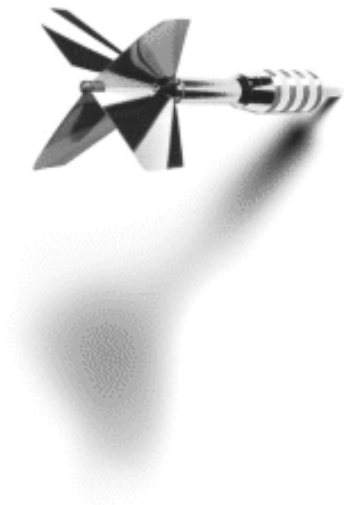
Source: Coordination of Energy Efficiency and Demand Response, A Resource Of The National Action Plan For Energy Efficiency. U.S. Department of Energy
Source: IEA-DSM Tasks

2. Demand Response products

Key factors to assess DR benefits

Quantifying the potential nation-wide benefits of demand response is a difficult undertaking requiring the following key information and assumptions:

- **Demand Response Options:** there are different types of time-varying rates and demand response programs currently offered, or potentially available
- **Customer Participation:** the likelihood that customers will choose to take part in the offered programs may differ considerably from one DR event to another, even for the same DR product
- **Customer Response:** it is necessary to document and quantify participants' current energy usage patterns, and also determine how participants adjust that usage in response to changes in prices or incentive payments
- **Financial Benefits:** methods to quantify the short- and long-term resource savings of load response under varying market structures must be developed
- **Other Benefits:** any additional benefits provided by demand response resources (e.g., improved reliability) should be also identified and somehow quantified
- **Costs:** costs associated with achieving demand response must me establish and valuated prior to the program



Source: Benefits of Demand Response in Electricity Markets. US department of Energy

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2. Demand response products
3. Measuring DR energy savings
4. Annex: Demand Response benefits

3. Measuring DR energy savings

Standards, protocols and practices for estimating DR benefits

Policymakers and industry participants are currently working to develop standardized tests applicable for the evaluation and cost-effectiveness screening of demand response resources:

- **Standard Practice Manual (SPM) tests:** some are **widely used** among state regulatory commissions and utilities in the US to evaluate and screen energy efficiency programs
- **Application:** a number of states and utilities **have also used these tests** for cost-effectiveness screening of load management programs

However, there is general consensus that a **more comprehensive evaluation framework is needed** to fully capture the benefits of demand response

Some of the challenges in developing standardized tests appropriate for demand response are revealed by comparing energy efficiency and demand response resources:

1 **Peak of demand estimation**	• More difficult to estimate the reduction of energy consumption on peaks rather global timeless energy reduction
2 **Program participation**	• There is still a high degree of uncertainty about participation in these programs
3 **Uncertainty**	• Uncertainties in estimating demand response impacts mean that demand response benefit and cost estimates are equally uncertain

Although there are some initial projects[1] about how to measure the DR impact, there is the need of specific standards to assess the impact of DR in the transport system

[1] US department of energy has conducted some research about DR evaluation and its relationship with Energy Efficiency within the national action plan for energy efficiency

3. Measuring DR energy savings

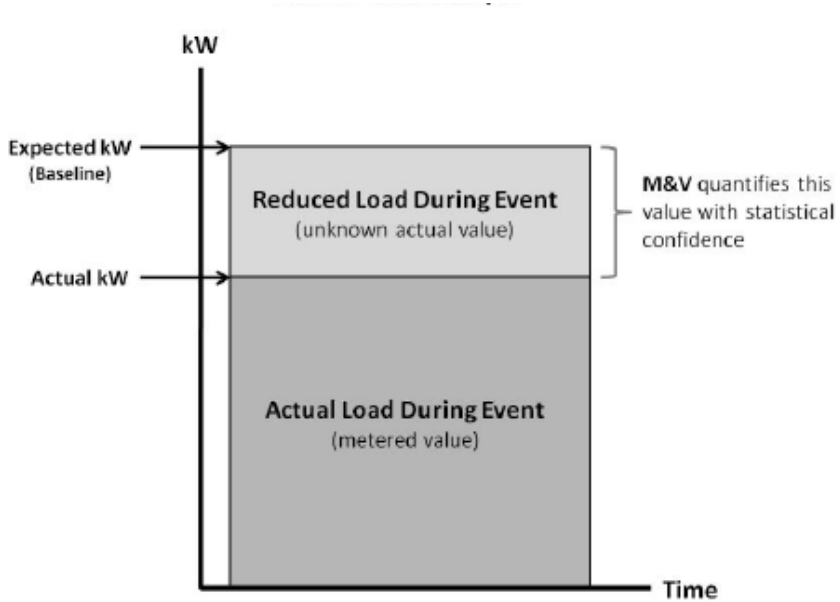
Basic concepts

As with any energy efficiency project, the key factors for Measurement & Verification (M&V) of DR products, baseline energy definition and actual load, depend on a lot of external factors and key issues that must be considered, including also a certain degree of uncertainty

- **Energy savings** can be defined as:

> Customer's Load Response = Baseline Usage – Actual Load

- **Actual load** is known and measured directly from interval meters
- **Key challenge is estimating the baseline:** estimating the electricity that would have been consumed by a Customer or Demand Resource in the absence of a Demand Response Event. Desirable features in a customer baseline calculation method should be:
  - Simple – easy to use, understand, calculate
  - Lack of bias – no systematic tendency to over or under-state reductions
  - Minimize opportunity for gaming
  - Ability to handle weather-sensitive customer loads fairly
  - With minimal cost of implementation



Source: Demand Response Measurement & Verification. Association of Edison Illumination Companies (AEIC)

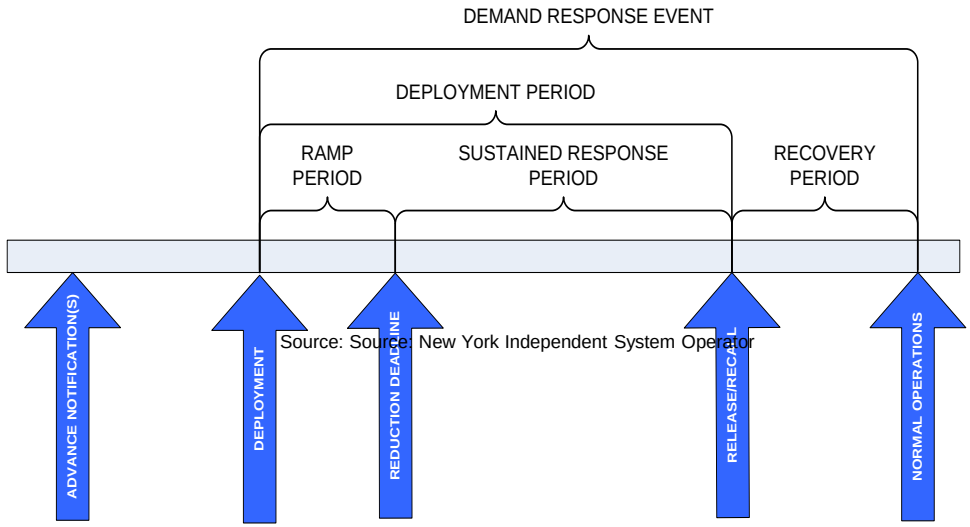
Source: Coordination of Energy Efficiency and Demand Response, A Resource Of The National Action Plan For Energy Efficiency. U.S. Department of Energy
Source: EVO

3. Measuring DR energy savings

Key considerations for baseline estimation

When producing **estimates of the change in energy use** resulting from a DR program over some historical period, some key issues must be considered for baseline estimation:

- **Time periods**: spillover impacts before and after the DR event
- **Uncertainty**: uncertanty can be controlled by selecting appropriate sample sizes, but it can not be eliminated completely
- **Output format**: impact estimates can be developed using a variety of methodologies.
- **Day types**: DR impacts will vary across event days based on a variety of factors, including variation in usage patterns, event characteristics , event participation, and other factors
- **Statistical measures**: the evaluation for event-based programs concerns the calculation and reporting of statistical measures designed to reveal the level of precision and presence of bias



Source: Source: New York Independent System Operator

The estimation, consideration or even omission of these key issues must be defined prior to establish the baseline energy and variables to be measured during the DR event

Source: Proposals for load impact estimation and cost effectiveness evaluation of southern California Edison company, san Diego gas & electric company, and Pacific gas and electric company

3. Measuring DR energy savings

Energy savings calculation: impact estimation

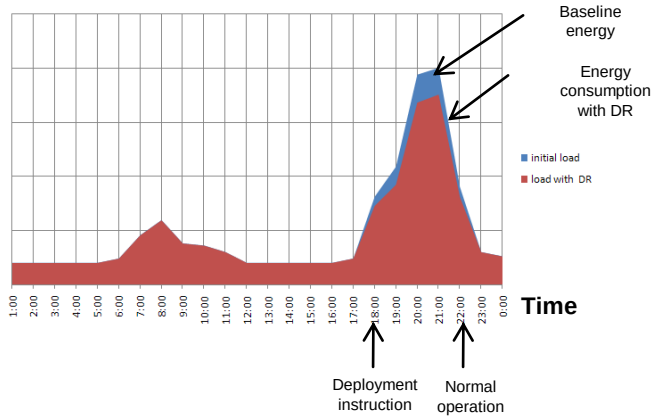
Energy savings achieved through DR can be estimated as the **difference between baseline energy and load energy measured** when demand is requested to be reduced[1]. There are two different ways to estimate these savings:

Approach within the Tasks XXI

A) Individual Measurement

Load reduction of a **single consumer** comparing its actual energy use during the DR event period with its load shape, and **translating this single impact to the net**

Individual electricity usage

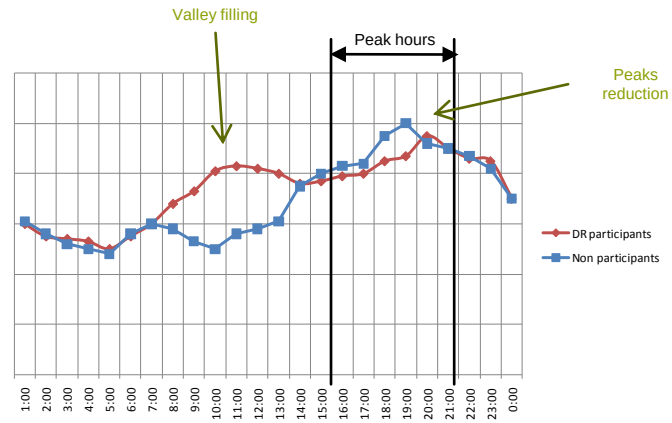


Time of use consideration to energy efficiency questionnaire

B) Mass Market Measurement

Aggregating all participating customers and **comparing the resultant load shapes** against similar non-participating customers

Market electricity usage



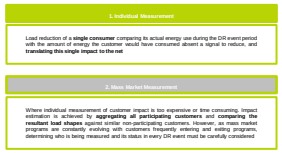
Specific DR questionnaire

1 which is referred to as a Demand Response event

Source: everis

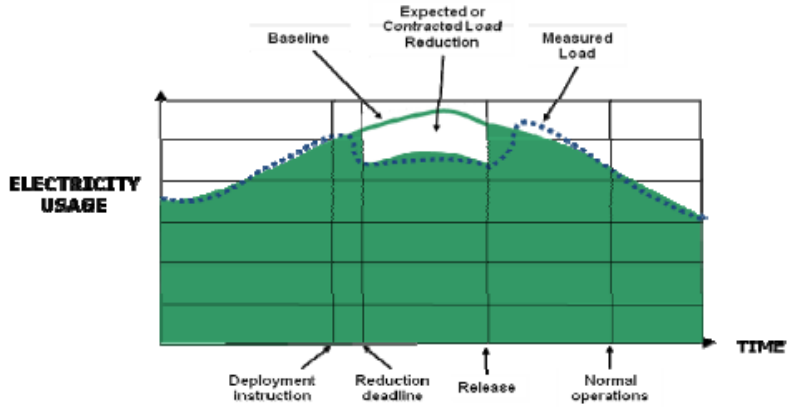
3. Measuring DR energy savings

A) Individual Measurement



For **individual measurement**, energy savings are estimated comparing **customer baseline energy (CBL) for each single participant with their real energy consumption.** Two common methodologies can be used for CBL energy calculation

- **Day matching:** taking a short historical time period and attempting to match what the usage for an event day would have been based on the usage during the historical period chosen. Different approaches can be considered: previous day, average daily, proxy day, etc.
- **Regression methods:** creating a model to represent the customer's load shape on an event day. The development of the baseline could be accomplished in two ways:
  - including only non-event day data for an individual customer
  - using a pooled data series that distinguishes between event and non-event days



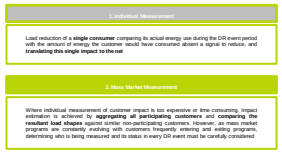
Source: Source: New York Independent System Operator

Baseline energy calculation is the a critical point for individual measurement. When this is too expensive or time consuming, mass market methodology becomes a better approach

Source: everis

3. Measuring DR energy savings

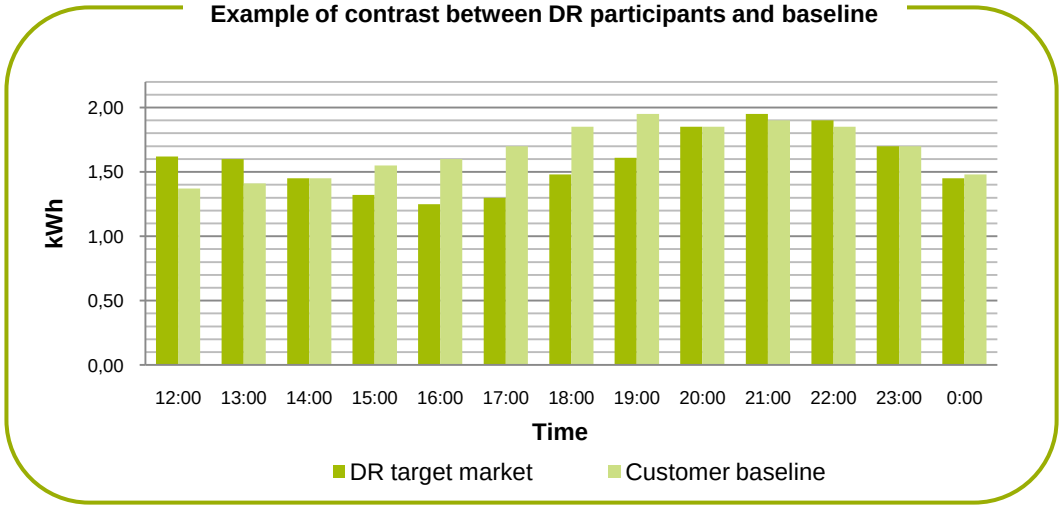
B) Mass market measurement



In **mass market measurement**, impact estimation is achieved by **aggregating all participating customers** and comparing the resultant load shapes against similar non-participating customers

- **Impact estimation:** a profile representing the customer baseline (CBL) is developed and compared to a profile that has been developed to represent all participating market customers (the “Actual Use”)

- **Mass market CBLs** are typically developed:
  a) Using a control group to develop a load shape for non-participating customers in the target market
  b) By developing a CBL via estimations based on the participant market’s response to DR events



Energy savings are estimated in the same way as individual measurement, that is comparing the energy load shape before and after the DR event

Source: everis

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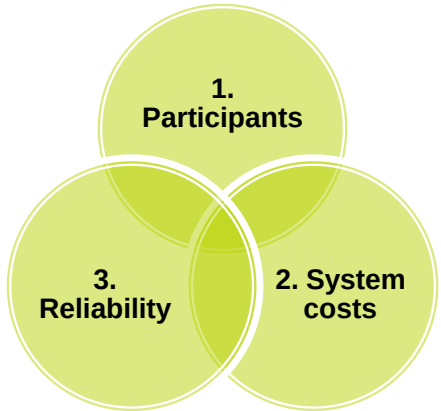
4. Annexes: Demand Response benefits

Additional benefits to DR

Additionally to energy savings, other benefits of demand response can be classified in terms of whether they accrue directly to participants or to some or all groups of electricity consumers:

1. **Participant bill savings:** electricity bill savings and incentive payments earned by customers that adjust load in response to current supply costs or other incentives
2. **Bills savings for other customers:** lower wholesale market prices that result from demand response translate into reduced supply costs to retailers and eventually make their way to almost all retail customers as bill savings.
3. **Reliability benefits:** reductions in the probability and consequences of forced outages that impose financial costs and inconvenience on customers



Demand response also provides other benefits that are not easily quantifiable or traceable, but can have a significant impact on electricity market operation, such as:

Power plants: less energy loads also avoid power plants to operate at maximum power, considering the amount of energy generated is bigger than the consumed due to losses in the transmission system

System security: system operators are provided with more flexible resources to meet contingencies

Market performance: demand response acts as a deterrent to the exercise of market power by generators

Improved choice: customers have more options for managing their electricity costs

Electrical distribution networks: buildings and equipment that use less energy impose smaller power loads

Environmental Impacts: for every unit of electricity not generated, the nation reduces its consumption of energy resources, air pollutant emissions, water use, and associated land uses.

Renewable energies: matching between renewable energy production and energy demanded becomes easier, switching load peaks to peaks of renewable generation and so increasing the percentage of renewable on the system

Source: Benefits of Demand Response in Electricity Markets. US department of Energy

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