CIGRE WG C6.09. Item 4
Demand-Side Response Initiatives

Reported by:

- Universidad Politécnica de Valencia, Spain
Instituto de Ingeniería Energética
(Institute for Energy Engineering, IIE-UPV)
- Universidad Politécnica de Cartagena, Spain
(E.T.S. de Ingeniería Industrial, ETSII-UPCT)

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1. Objectives

The objectives of this section are:

- The study of the current Demand-Side Response initiatives (DSRI) and the drivers behind them.
- The review of actual products for Demand-Side Response.
- To evaluate the advantages of DSR for the different actors.
- To examine state of the evaluation practices at present.

2. Background: state of the art in Demand-Side Response.

Limited DRSI exists in developed countries nowadays. From the nineties to the present the Demand-Side Response potential is continuously reducing. This is well explained when observing analyzed examples, for instance the existing USA DRSI potential from 1996 to 2004 (see figure 4.1.).

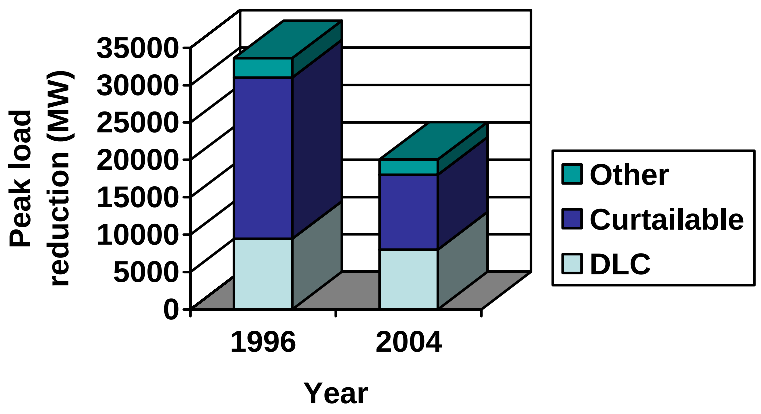

Figure 4.1. USA Demand Side Response potential. Source [1].

Fortunately, a number of recent initiatives renewed the interest by policy-makers, grid operators and utilities in strengthening DSR capability. Some drivers are necessary to promote DSR growth, such as:

- <u>Environmental drivers:</u> where the focus is on reducing overall energy and greenhouse gas emissions.
- <u>Network drivers:</u> based on solving network constraints by adding generating capacity or demand resources.
- <u>Economical drivers:</u> focused on achieving demand elasticity to reduce high pool energy prices.
- <u>Customer choice drivers:</u> the need to have some opportunities to trade energy in markets and, in this way, to manage and reduce electricity and energy costs.
- <u>Social benefit drivers:</u> efficiency in use and the operation of energy markets.
- <u>Enabling technologies drivers:</u> several initiatives show how technology significantly improves demand response.

Moreover, some barriers can became "drivers". For example, the lack of information about the meaning of DSR, appears as a serious barrier and explains some past failures amongst different DSM initiatives. Nowadays, information campaigns and specific software (for instance Dayzer, an user friendly detailed market analysis tool [2] devoted to customers) could change failure to success.

3. Options for Demand-Side Response: example of initiatives worldwide.

The most common options for DSRI are Tariff Options and Program Options. The firs class, Tariff Options (or "Price-Based" DSRI) provide customers with time-varying rates that reflect the value and cost for electricity in different time periods. Some examples of "Price-Based" options are: Time of Use (ToU), Real-Time Pricing (RTP) and Critical Peak Pricing (CPP).

The second class is Program Options or "incentive-based" response. These initiatives pay participants to reduce their loads at times requested by the program sponsor, triggered either by a grid problem or high electricity prices. Between these programs, we can find:

- Direct Load Control (DLC).
- Interruptible and Curtailable Load (I/C).
- Demand Bidding/Buyback programs.
- Emergency programs.
- Capacity Market programs.
- Ancillary Services Market programs.

Following table shows some examples of DSR initiatives around the world. A greater extent of programs in the table refers to USA past or present policies. The reason is based on the fact that USA market for DSR is amongst the most advanced in market operation with demand. Some interesting lessons have already been learned in these few years of competitive market operations.

Table I. Examples of DR programs and drivers around the world.

Program Example	Kind of DSR initiative	Drivers
Statewide Pricing Pilot Project-SPP (CA, USA) Tempo Tariff (EdF, France)	Tariff option	Technology Customer choice Economical
Real Time Pricing (>10 utilities in USA)	Tariff option	Customer choice Economical
Ontario Power Authority, Canada	Incentive Based (emergency)	Network Economical
Policy Act 2005 (EPACT, USA)	Evaluate DR benefits Subsides	Legislative Economical
Energy Efficiency Minnesota, USA	Subsides	Economical
Western Sydney Interruptible AC, Australia	DLC (residential)	Network Economical
Castle Hill Demand Management, Australia	Interruptible/DLC	Network

New England-ISO (USA)	Incentive Based (ancillary services)	Network Economical

3.1. California Statewide Pricing Pilot (SPP) Project.

The first example is the Critical Peak Pricing project in California. This option is offered to a sample of Residential, Commercial and Industrial electricity customers in Southern California Edison´s during 2004 and 2005. The characteristics of the customers are:

- Customer demand: < 200kW.
- Characteristics of control group:
    - Residential (several clusters amongst users, i.e. power, houses, climate,...).
    - Customer Segment "LT20": demand is less than 20kW.
    - Customer Segment "GT20": demand is between 20kW and 200kW.
- Critical Price period from 12am to 6pm:
    - From 2 to 5 hours long.
    - Several price changes were tested.

The conclusion of this pilot is that some elasticity is present in small and medium customers when price suffers some significant change. Information is an essential driver for customer response. A more detailed explanation about elasticity will be presented in item V report.

3.1.1. The role of enabling technologies.

In the same experience the role of enabling technologies (DSR driver) has been evaluated, specifically the impact of smart thermostats in the response during critical peak prices. In this experience [3], 220 residential and 235 small business customers were equipped with "smart thermostats". The conclusion was that a higher demand response is achieved when time varying pricing is combined with an enabling technology. For example, the average residential load reduction was 0,64kW (27% demand relief) and indeed 15% was reported for business users.

The effect of other enabling technologies such as smart meters or gateway systems is shown in figure 4.2. (sources [4], [15]).

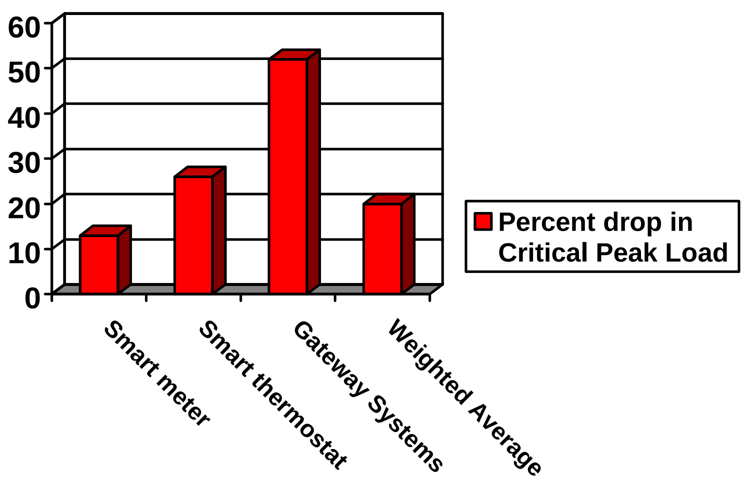

Figure 4.2. Influence of enabling technologies in DSR.

Unfortunately, there is a considerable lack of enabling technologies in all the customer segments in our countries. For example, the presence of advanced or smart meters in a lot of customer segments. A recent FERC survey (2005) is shown in table II.

Table II. The lack of technologies in customer segments (source FERC, USA).

Customer class	Advanced Metering (%)
Residential	6
Commercial	5
Industrial	5.7
Transportation	8.0
Other	2.6

The conditions in other technologies (Energy Management Systems, Automated Response devices, turning on on-site generators,...) are worse in a lot of cases. Therefore, customers require load (and on-site generator) control and communication systems that allow them to respond to the price signal. Technology is not cheap. There are not incentives to purchase technology (price or event signals) and, thus, low load response is achieved. For this reason and due to this fact, it is necessary to promote response drivers. Other experiences from Australia are reported in [15].

3.2. Real Time Pricing programs.

Another well-known initiative (program) is Real Time Pricing (RTP). The analysis of the USA situation is quite representative for this program. Approximately 70 utilities in the US offered an RTP program at some point over the past 25 years (1980-). In 2003, only 47 utilities were still offering an optional TRP program, being in several cases pilot projects. In 2007, only 12 utilities in States (Maryland, New Jersey, New York and Pennsylvania) with retail choice currently offer RTP as the default service for large customers. About 50% of these tariffs were expressly introduced for building customer satisfaction and loyalty, i.e. an opportunity to reduce and manage customer costs.

Another interesting concern is to know what customer segments are involved in these RTP programs. First, we can state that programs have attracted limited participation. Only three programs in 2003 (Georgia Power, TVA and Duke Power) had over 100 participants or more than 500MW of response capacity. These programs represent about 80% of 11GW of the total retail load enrolled in RTP programs (2003). A lot of programs are technically forbidden to small customers because they are limited to 1MW load. This is the reason why the participation in most RTP programs has been dominated by large industrial and institutional customers.

In the other side, quantitative information on price-responsiveness is relatively sparse. In some occasions, price response had not been formally evaluated (too few participants, too short duration,…). Likewise, as it has been stated in previous paragraphs, programs were motivated for purposes other than load response, and utilities had little reason (an economical one) to quantify price response.

Fortunately, results are available from some RTP programs [5] (eight program managers with more than 20 customer each one). The conclusions are as follows:

- Load reduction was in the average of 12-22% of participants' total load (maximum load available for response was about 33%).
- These reductions occurred across a wide range of hourly prices: from $0.12/kWh to $6.50/kWh".
- Customers responded with rather low-tech strategies such as: rescheduling of arc furnaces and steel mills, running on site generation, manually or by using existing control equipments.

There is not specific technology (driver) to improve demand response.

3.2.1. "Price-Based" programs in Europe: "Tempo tariff" by EdF

Tempo Tariff [6] is a ToU/RTP tariff. This program has been generalized since 1995 in France (notice France is perhaps the first country with well developed ToU tariffs for their residential customers). The number of customers involved in this tariff is about 400.000, mainly small and business customers.

There are four different versions in "Tempo-Tariff" according to the technology available in each customer segment:

- Standard: where an electronic meter is needed.
- Dual energy: applied to boilers that can be switched from an energy source to other (i.e. dual loads).
- Thermostat: the utility/aggregator is able to manage space heating and water heater loads.
- Comfort tempo: associated with an energy controller.

The results are very promising. They report on demand reductions from 45% in peak (red) days to 15% in valley (white) days. Accurate information and additional results will be presented in part V of this report.

3.3. Cross initiatives: Education programs.

Education is an important concern for utilities and demand aggregators to enable customer response capability. In this case, the barrier can become a driver for demand response. For example, there is a lack of RTP awareness among eligible customers and utilities may offer customers some education programs. RTP must offer an attractive risk-reward option compared to the standard fixed-price rate: RTP should provide a quantifiable benefit and the customer should be fully aware of the opportunity to financially hedge their exposure to price volatility (and purchase technology to respond to price).

Regulators, Aggregators and Utilities should provide technical assistance and programs to facilitate the adoption of DR enabling technologies. It is very important to take into account that traditional tariffs (the only and safe tariff that a customer usually knows) avoid well-developed price-response capabilities in a lot of customers.

Evaluation of price responsiveness and the role of on-site generation are required, being difficult to change the customer behavior.

3.4. Emergency Load Reduction Programs (ELRP).

The next kind of DSR programs aims at reducing energy during critical peak periods when the network is at risk. For example Load-Shedding is a primitive, extreme and well known alternative through utilities and ISO to reduce load when critical conditions suddenly appear in the power system, but the customer have not any possibility of response. So, these kinds of policies are excluded in this report.

In developed countries, several ISO (IESO) have advanced ELRP programs at present (for instance in USA: California, PJM, NYISO or NE-ISO). A very good example [7] of ERLP outside USA is the program being developed by Ontario-ISO. This initiative became available in June 2006 for distributors, aggregators and large individual industrial loads, including backup generators. The minimum demand reduction is 1MW (i.e. small customer should participate through a demand aggregator).

The objectives of Ontario-ISO are:

- To reduce energy use during critical peak periods.
- To avoid emergency energy purchases and voltage reductions.
- To expand the role of Demand Response in the management of Ontario's electricity system and market.

The ELRP program works day-ahead and day-at-hand. It is a voluntary program available to all participants including loads and organizations with emergency backup generators. The IESO (ISO) initiates the ERLP when an emergency process is forecasted. The parameters of this program are as follows:

- First step: notification to participants.
- Second step: voluntary submission of offers by participants and, if needed, activation of those offers.
- Third step: Payments. The user can receive standby (15$/MW) and verified reduction payments (up to 600$/MW).

Figures 4.3. and 4.4. show respectively the time schedule to submit offers and the payment for the customer (activation incomes) for Day-Ahead ERLP program in the Ontario System.

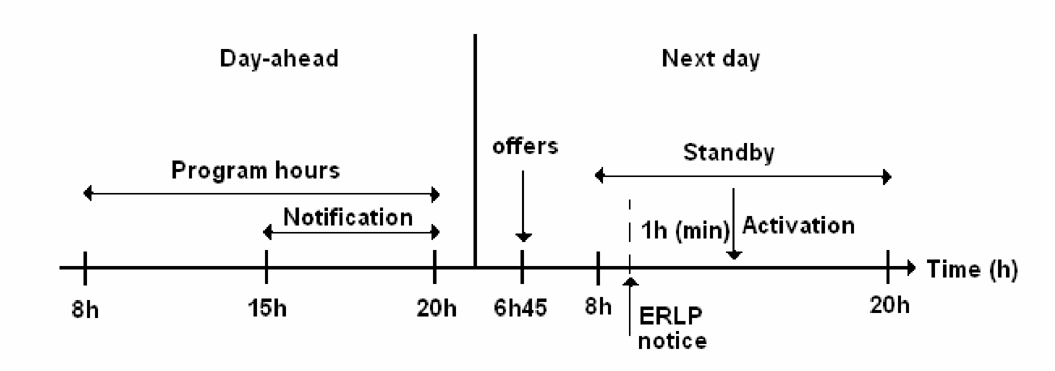

Figure 4.3. ERLP Day-Ahead Process Timeframes (Ontario ISO).

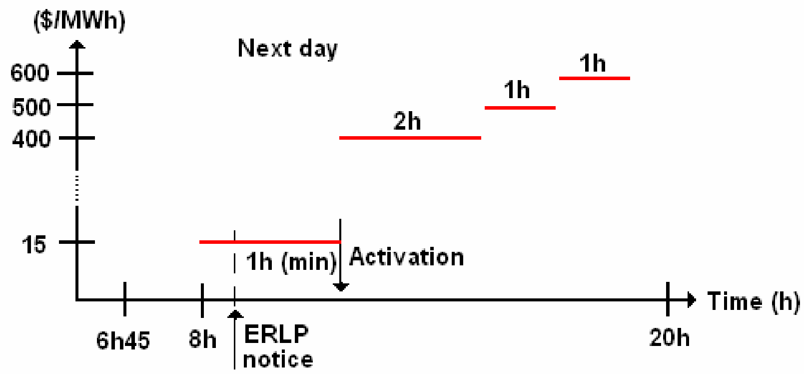

Figure 4.4. ERLP Day-Ahead Process Payments (Ontario ISO).

The day-at-hand alternative is very similar to the day-ahead program, but the notification period ends at 9h am in the event day, and the customer has less than two hours to notify offers to IESO. The minimum time period between ERLP notice and activation is the same in both programs: an hour.

3.5. Retail-Load provision of Ancillary Services (ISO New England, USA).

There are interesting opportunities for Demand-Side participation in Ancillary Services. For instance, the general thesis of ISO (in this example New England ISO) is that loads can be ideal suppliers of contingency reserves, specially for spinning reserve. There are two reasons (drivers):

- Technical (driver): the power reliability events are fast, infrequent and relatively short (< 1h).
- Economical (driver): the reduction in cost of conventional Supply-Side resources (generation plants involved in spinning reserve).

Unfortunately, Demand-Side resources face some barriers again:

- Legislative barriers (driver): to recognize and eliminate biases in contingence reserve (supply) rules due to the different characteristics of demand and supply resources.
- Education barriers (driver): to recognize and accommodate differences in resource capabilities (Supply vs. Demand).

It is necessary to consider in depth the technical relevance of loads as a contingency resource:

- Their fast (electrical) response and deployment via web, phone or PLC.
- Their geographical distribution around the power system.
- A better use of available generation sources.

Load is a geographically distributed resource through the power system, and this property is of the greatest interest for the power system operator. This distribution implies a more reliable resource from an statistical point of view, i.e. the failure of a significant percentage of the resource (some network failure, some customers who do not respond in the desired way,..) is possible but the failure of the 100% of the resource is also quite difficult (the possibility of failure of three or four generators is much more likely from a probability analysis). Moreover, the operator does not look for the overall load involved in the program: it only aims at a small percentage of load response.

Figure 4.5. shows the customer dropout rate in response when the time of curtailment growths. Obviously, as stated before, problems are not expected for small control periods.

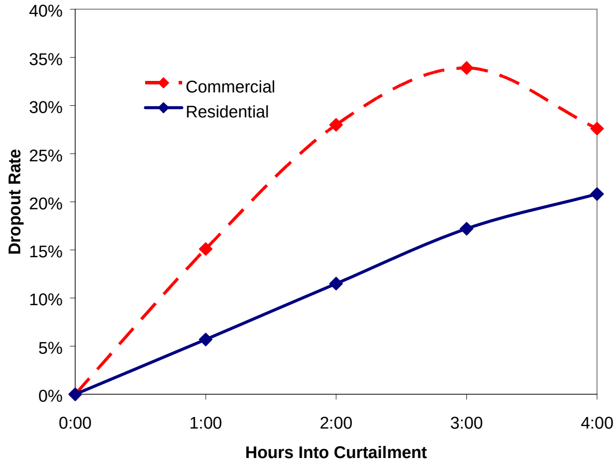

Figure 4.5. Load Dropout rate (source Oak Ridge National Laboratory, USA [8]).

Some research argues [8] that loads have a continuous availability curve (load is an aggregated resource, that is perhaps a hundred or more loads which are taken into account for response), while generators have a stepped characteristic (monitored responses of few generation units, where a failure implies a stepped curve of reliability). Figure 4.6. shows this idea.

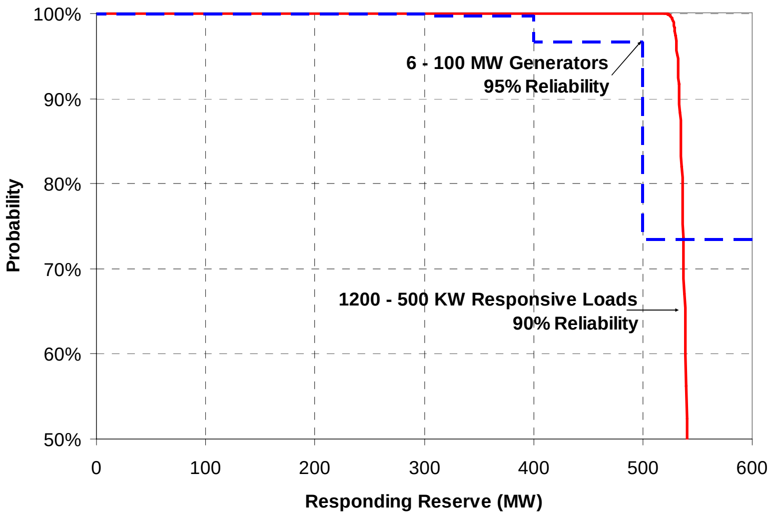

Figure 4.6. Availability curves for supply and demand resources.
(Source Oak Ridge Laboratory, USA [8])

Figures 4.5. and 4.6. clarify the previous assumption that demand and supply resources are quite different from several points of view. This is an advantage for Demand-Side resources. Statistical (demand) resources do not need an individual real-time monitoring such as in generation deterministic resources. This fact supposes that:

- Performance monitoring can be slower.
- Statistical load aggregation may not need any individual-real time monitoring such as in generation resources (redundancy may be better than operability).
- Communications requirements are asymmetric (Carrier Comfort Choice thermostat for small commercial customers [9]):
  - * System-to-load: broadcasting, paging,…
  - * Load-to-system: individual (web) or through an aggregator.

Indeed, the payment for reliability resources are an ideal complement for customers involved in price-option-energy DSR programs (cost-effectiveness of enabling technologies). The customer can provide spinning reserve while providing peak reduction. Besides it is easier to respond to shorter load interruptions due to several reasons:

- A less energy storage capacity (thermal, electrical) is needed (more potential loads and users).
- A less disruption of user comfort (interruption times are strongly correlated with loss of load service).

But other reasons arise in favor of load as a contingency resource:

- Social: a reduced need for generation and transmission levels.
- Economical: reduced ancillary prices for other customers.
- Environmental: exclude old pollutant power plants that go on when reliability problems appear in the power system.

In conclusion, the load response is easy, faster and reliable. The most suitable load characteristics are:

- Load with some kind of storage:
  - Industrial: Product, water, liquid or gas pumping.
  - Commercial: Thermal loads.
  - Residential: Thermal loads.
- Control: direct (supply) or secondary (thermostat).
- Low cost to shift load use when needed: precooling, preheating, shift work schedule,…

This resource is in size potentially large, but it requires further research to quantify this, as well as real work with “demand aggregators” of residential and small commercial customers load.

3.6. Interruptible Load (Direct Load Control).

Interruptible load initiatives (the oldest Demand-Side Management policy) are common in several markets, and not only in the United States (regulated and liberalized systems) but also in Europe and Oceania. We will expose two simple examples.

3.6.1. The STAR program, Ireland.

The STAR (Short Term Active Response) program is driven by ESB National Grid and started in the year 2004 [10]. The objective here is demand-supply balance when a drop in frequency is monitorized. The program is focused on 39 large electricity customers with about 55MW of automatic load response. The cost is not known but seems competitive when compared to alternative standby generation.

3.6.2. Network constraints: Castle Hill pilot project, Australia.

In the case of Australia, the Department of Energy, Utilities and Sustainability (DEUS, New South Wales) is developing some interesting pilot projects. Unfortunately, there is little information available with respect to their status and results. The problem there is not new and is usual amongst power systems in developed countries: the increasing AC load penetration in commercial centres and residential surroundings.

The program utilizes a number of policies:

- Interruptible loads.
- Existing standby generators (commercial segments).

- Upgrading of existing AC systems.
- Installation of efficient lighting.

The objective in Castle Hill is to achieve reductions from 0.5 to 1MWA in load per annum. The cost of the pilot project is over $300,000.

3.6.3 Smart appliances: frequency control

These appliances allow a dynamic demand control that could help smooth out some fluctuations in electricity demand. Usually these so called "intelligent" appliances are used to help frequency control. They provide and emergency load shedding when the frequency drops. Some of these ideas are presented in [16], and the "candidates" for demand control are time flexible appliances, i.e. loads that need electricity but are flexible as to when that energy is delivered (for example fridges in domestic clusters which are always available, relatively constants in load and with a reasonable storage time without disruption of service). These loads are fitted with a frequency sensitive control system, acting as a vast frequency-dependent load, but only when a drop in frequency is reported. In this case the load responds without the intervention of the customer.

3.7. Legislative programs.

3.7.1. Subsides to demand response.

Renewable energy is widely subsidized around the world. It is necessary to promote renewables, but the Demand-Side too. An example of subsides is Europe: in Spain one kWh generated through photovoltaic panels can achieve a value up to €0.4/kWh (about $0.55-0.6/kWh) with assured retributions in 20 years. The question is: Are Demand Resources and Initiatives (Energy Efficiency, Demand Response,...) less valuable options? Are not they interesting programs to promote efficiency and reliability from Demand-Side?
The response should be affirmative. In this way, some utilities promote subside programs, for example Minnesota Energy-Efficiency programs [11]. Table III shows some of these programs.

Table III. Some incentives to promote DSR and Efficiency (Minnesota, USA).

Policy/Program	Qualified if …	Subside
AC Units	SEER > 14 (standard 13)	$75 to 150
Commercial Lighting	Electronic Ballast Occupancy sensor	$10 $10
Wash machines	Energy Star	$50-100
Audits	Utility	70% less
Windows area update	U Factor < 0,35 Tested by NFRC, USA	$20/window

Energy Policy Act (EPAct) 2005 (USA) also promotes energy efficiency and conservation. Some incentive and tax credits are available for customers who upgrade thermostat technologies (smart technologies [9]) and install efficient central HVAC systems (the incentive can reach up to US$500).

3.7.2. The development of a comprehensive legislation.

In some developed countries there is a growing consensus: insufficient levels of demand response exist in their electric power systems. An important driver for DSR is to develop a comprehensive legislation in the energy sector. An example is the EPAct 2005 in the United States of America. From sections 1252 e&f where we can extract some concerns:

- "… is the policy of the US to encourage time-based pricing and other forms of Demand-Response, whereby electricity customers are provided with electricity price signals and the ability to benefit by responding to them".
- It further states that "… deployment of such technology and devices … shall be facilitated, and unnecessary barriers to DR participation in energy, capacity and ancillary services markets shall be eliminated".

This law requires US Department of Energy (DoE) to provide a report that "identifies and quantifies the national benefits of demand response and makes a recommendation….by January 2007". It was not possible to perform a complete recommendation yet. DoE was not able to provide recommendations to be implemented and does not have any practical impact (benefit evaluation).

As an alternative, DOE offered a report to the USA Congress (2006) pursuant section 1252 of the Energy Policy Act (2005). Some recommendations to encourage demand response are [12]:

- Fostering Price-Based Demand Response
- Improving Incentive-Based Demand Response
- Strengthening DR Analysis and Valuation
- Integrating Demand Response into Resource Planning
- Adopting Enabling Technologies
- Enhancing Federal Demand Response Actions

4. Evaluation of Demand Response Costs and Benefits.

Following paragraphs show an insight which will assess costs and benefits in achieving the evaluation of DSRI. Education, technology, social benefits,... are obviously important drivers, but customers and aggregators need some basic tools to evaluate the cost-effectiveness of a Demand-Side program. These tools must consider some of the following costs and benefits.

4.1. Evaluation of costs.

The evaluation of demand costs, both for the participant and system, must consider some of the items presented in table IV.

Table IV. Costs in DSR programs.

Type of cost		Cost
Participant costs	Initial costs	Technology investments (ex. Storage)
		Enabling technology investments
		Establishing response plan/strategies
	Event specific costs	Comfort/ lost business
		Rescheduling costs
		Generator fuel/maintenance costs
System costs	Initial costs	Metering/communication system upgrades
		Utility equipment or software costs
		Customer education
	Ongoing program costs	Program administration/management
		Marketing/recruitment
		Payments to participants
		Program evaluation
		Metering/communications (tariffs)

4.2. Evaluation of benefits.

In the same way, benefits can be evaluated taking into account some of the items proposed in table V.

Table V. Benefits in DSR programs.

Type of benefit	Recipient	Benefit	Examples
Direct	DSR Customers	Financial	Bill savings/incentive based DSR
		Reliability	Reduced exposure to forced outages
Collateral	Some or all customers	Market impact	Short-term: marginal costs/prices
			Long-term: capacity, price caps infrastructure upgrades
		Reliability	Reduced forced outages
Other	Some or all customers (ISO/RTO/ LSE)	Markets	Innovation in retail markets
		Choice	Desired degree of hedging
		Environment	Reducing peaking plants gen.
		Independence	Dependence on external supply

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