CIGRE WG C6.09. Item 5
Available Knowledge on Demand Elasticity Price Impact

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Index

1. Introduction.

There are few studies which provide a rigorous analysis of the determinants of elasticity demand. Reliable estimates of the price and income elasticity of demand are important pieces of information in formulating public policies, in our case related to Demand Response. Several sources in the European Union, Australia, United States and Canada (consultings, research laboratories, market regulators, utilities,...) have been consulted before to preparing this report, but all the sources agree with the following idea: "the price reform is a major component of electricity market reform". In this way, pricing policies and the knowledge of available elasticity in each customer segment is an essential driver for Demand-Side Response Initiatives (DSRI).
A simple example shows the usefulness of demand elasticity: over $215 million per year in estimated cost savings from 1GW of Price Responsive Demand were reported in New England (USA). In this way there is a need to explore customer response and thus improve pilot projects. Also, it is necessary to connect retail and wholesale markets to promote the price-responsive demand while reducing the potential to exercise market power.

1.1. What does elasticity mean?

In the technical and sociological reports related to customer elasticity, several kinds of "elasticity" appear, but they do not refer exactly to the same concept. For example, some reports deal with price elasticity, others with elasticity of substitution and another group analyzes long-term price elasticity. Briefly (see terminology section) it can be defined:

a) *(Own) price elasticity:* the percentage of change in demand as a result of a percentage of change in the price (the elasticity should be a negative number).

b) *Elasticity of substitution*: is a measure of the percentage of change in the ratio of the peak to peak-off demand as a result of a percentage of change in the ratio of the peak to the off-peak price.

c) *Long-term price elasticity:* is the annual energy consumption response to an average change in energy price. This concept should not be confused with a demand response to high instantaneous energy prices.

And it is interesting to consider two further considerations:

- The price elasticity of demand is non-linear.
- The responsiveness to price changes is not symmetrical.

The majority of studies in this area report that the customer demand for electricity is price inelastic both in the short and in the long term, but a lot of them are based on false hypothesis.

1.2. Categorization of demand response programs.

Demand-Side Response Initiatives and Programs are classified according to the customer motivation method and the criteria with which load response events (reduction in some cases) are triggered [1]. This item 5 is focused on "price-response" (see table I).

		Motivation	
		Load Response	Price Response
Trigger criteria	Reliability	Direct Load Control Curtailable Load Interruptible Load	Critical Peak Pricing Demand Bidding
	Economic	Direct Load Control Curtailable Load	Time-of-Use Critical Peak Pricing Demand Bidding Real-Time Pricing

Item 5

Table I. Classification Criteria for Demand Response Programs and Initiatives.

Figure 5.1. shows the results of a USA national survey on Demand-Side Response programs for Industrial and Commercial loads compiled by the Rocky Mountain Institute (USA) according to the classification criteria stated in table I [1]. Load Response programs are slightly more common than price response programs. This lack of balance is even more significant in the European Union.

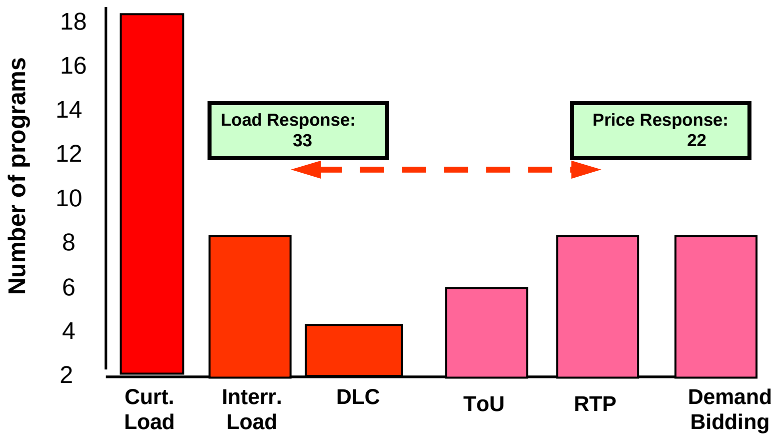

Figure 5.1. Demand-Side Industrial and Commercial programs survey (source [1]).

In order to participate in some of these programs, customers must know how and when they will reduce their load and which loads are the most suitable to reduce or change demand. Figure 5.2. shows the targeted end-use loads and the percentage of facilities that employ them for Demand Response. The source in this case is Ernest Orlando Berkeley National Laboratory (California, USA) [2].

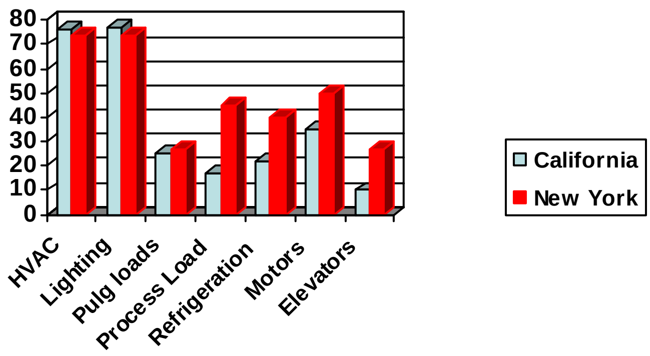

Figure 5.2. Customer End-Use targets in percent. Country: USA (source [2]).

1.3. Chronology of Price-Response programs.

Price-Response programs started in France in the sixties and came to the USA in the early eighties. These programs have been introduced in response to a range of regulatory and market conditions.

From the mid to late 80's, Real-Time Price (RTP) pilot programs have been developed to test its viability and potential impact as a novel Demand-Side Management strategy. Inducing demand response in the peak-period was not the primary goal for many price (real-time) programs. On the contrary, the objective of the utilities was to build satisfaction and improve loyalty among ***large customers.***

Due to this idea, most utilities have undertaken a few activities to help customers improve their price-response potential because it was not too relevant. The initial estimations of elasticity in this period were reported by Electric Power Research Institute (EPRI, USA). EPRI estimates price elasticities (elasticity of substitution) by ToU tariffs (1975-81) in -0.14.

The same idea (the utilities did not help customer thriving for their potential response) can be shown through an example: the significance of customer segments in these first programs. For example, only 3 out of 43 RTP programs in the USA had more than 100 non-residential participants, or over 500MW enrolled in 2003. Participation in RTP programs is dominated by large customer segments: industrial and institutional.

In the practice, only a small subset of the largest industrial and commercial customers (demand higher than 1MW) has apparently a demand elasticity high enough to justify participation because RTP programs only expose some customers segments to the volatility of cost in energy markets. Besides, quantitative and precise information on participants' price responsiveness (elasticity) is "relatively sparse" in reports for the following reasons:

- First: Usually, price response of customers had not been evaluated by RTP managers because many programs were motivated primarily for other purposes than load response. Therefore, utilities had little reason to devote resources to measure and quantify customers' price response.
- Second: A minority of RTP programs evaluated results, but few of those have made their way into the public domain.

These facts assume a considerable lack of data to evaluate elasticity, but this does not mean an absence of customer elasticity.

1.4. Current retail market conditions.

The market conditions are not the most advantageous to promote price response:

- Few retail customers are exposed to wholesale price volatility. For example, in California less than 3000 participants were involved in the Statewide Pricing Pilot (SPP) project [3] from 2003 to 2006. About 300 small and medium commercial and industrial outlets were involved too.

- Few retail customers are motivated to reduce load at times of high wholesale prices because Retail Rates do not reflect energy costs (Wholesale Prices are *disconnected* in real-time from retail-prices).

- Then, few customers are motivated to install the technology to automatically respond to changing prices. This technology grows costs, but what are the benefits? Tariffs must offer an attractive risk-reward proposition compared to protection within the standard fixed-price rate.

Customers should have the *option* (the right) of managing their energy costs through reducing load at times of high wholesale prices. In exchange, their electricity bill must decrease, i.e. providing a quantifiable and plausible benefit tothis response. Besides this can also provide capacity or ancillary services.

2. Customer Price-Response.

2.1. Can customer demand respond to prices? The response of large customers.

First tests of elasticity in New Electricity Markets were reported by Georgia Power [4]. In those pilot projects, large industrial and commercial customers participated in both load response and price response initiatives.

The response of large industrial customers seems easier because energy prices affect industrial benefits. This hypothesis is specially true for large and intensive energy demand segments, suchas: Aluminum Industry, Glass Industry, Metal-Casting Industry, Steel Industry, … [5]. Customers were tested by Georgia Power in 2003 to evaluate the response and elasticity in short term (hour-ahead) and medium term (day-ahead). Figure 5.3. shows, in a logartimic scale, day-ahead flexibility for the average industrial customer (where Q is demand, P ia the price, and Qg, Pg are reference or base levels). Elasticities range from -0.04 to -0.13.

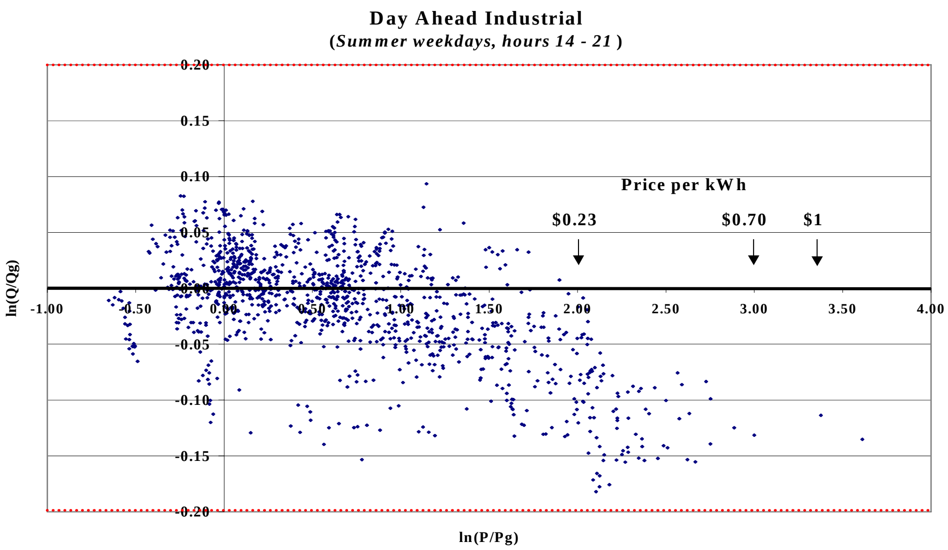

Figure 5.3. Medium-term industrial elasticity in Georgia, USA (source [4]).

Figure 5.4. shows hour-ahead (short-term) elasticity for the average industrial customer. Elasticity ranges from -0.2 (moderate price levels, red line in the figure) to -0.28 where prices are of $1/kWh or more.

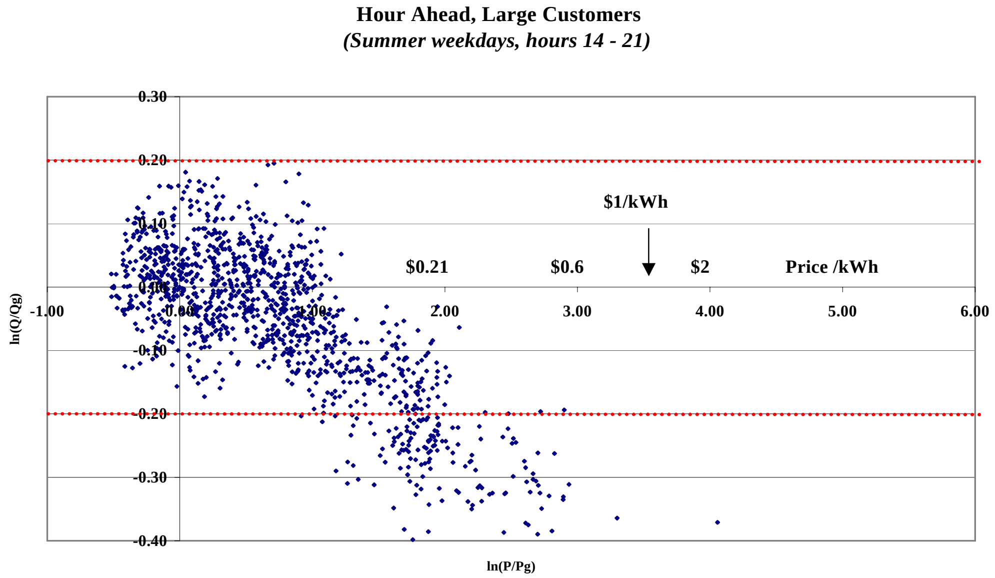

Figure 5.4. Short-term industrial elasticity in Georgia, USA (source Georgia Power[4]).

The response of large commercial customers was also evaluated. In this case, the pilot experience showed that many facility owners and managers are rightly concerned about the comfort of their building occupants during a DR event. For example, this fact explains why figure 5.5. shows a surprising positive elasticity. The growing in prices is due to the higher temperatures (in summer) and therefore more energy is needed for HVAC loads. But this positive elasticity changes to a "normal" negative one when the price spikes appear: customers react against price growth and price drives the reduction in demand (i.e. some loss of comfort is allowed to face to high price-levels)

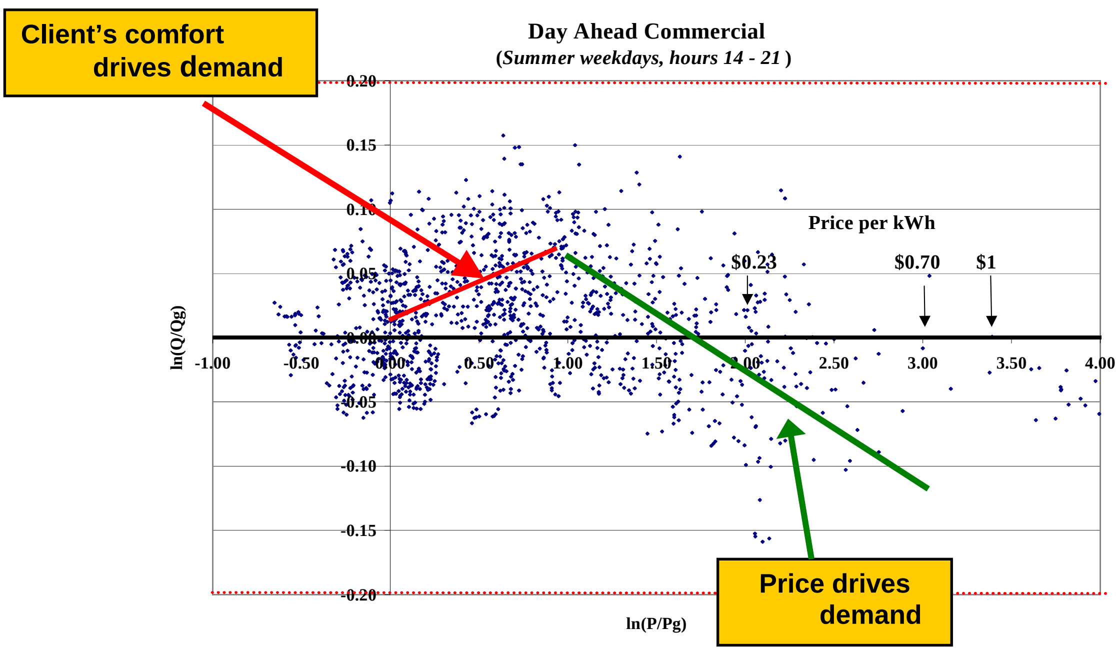

Figure 5.5. Medium-term (day-ahead) commercial elasticity in Georgia, USA (source [4]).

Conclusions from this report and others devoted to pilot experiences with large customers are that demand elasticity *"is considerably greater in the short time than in medium term"* ... and *"response is not available residential customers"*, but why not?

2.2. Small and Medium customers can also respond to prices.

Small and medium electricity customers contribute about 50% of utilities demand in developed countries. Besides, barriers and problems are higher for small customer segments. For example:

a) Prices: Without basic price information customers do not have any reason to make investments or change energy patterns. Therefore, customers *do not have well-developed price-response capabilities* (education is a barrier but also a driver for pilot DSRI experinces).
b) Tariffs: Small customers do not understand the electricity rates (nor the market rules and procedures).
c) Technology: Electrical power systems and customers require available technologies and procedures that often are not present in Demand-Side. They are too expensive, and the rewards are quite low to promote these technologies.

3. Demand Response and elasticity in California.

Fortunately, there are some experiences with small and medium customers in liberalized markets that allow the study of demand response and its elasticity which California (USA) is a very active market. Table II shows some price-driven programs: interruptible, price driven, CPP... A great part of these programs are focused on medium and large users, but the largest amount of data for elasticity studies are based on these initiatives both for the small and medium users.

Table II. Demand-Side Response Initiatives in California, USA.

Program – utility	Incentives/ Penalties	Eligibility	Requirements
Base Interruptible Power (BPI)– SCE	Yes / Yes	Demand > 200kW	Interval meter/ phone line
Demand Bidding Program (DBP)-SCE	Yes / NO	Demand > 200kW	Interval meter/ Web based
Critical Peak Pricing (CPP)- SCE	Yes / NO	Demand > 200 or 500 kW	Interval meter (free)
Optional Bidding Mandatory Curtailment- (OBMC) – SCE	Avoid rotating outages/ Yes (6$/kWh)	Any size of demand	Interval meter
Base Interruptible Program (BIP)- SDG&E	Yes / Yes	Reduction > 100kW	Interval meter/ communications
Demand Bidding Program (DBP)- SDG&E	Yes / NO	Demand > 20kW	Interval meter (free)
Scheduled EZ20/20- PG&E	Yes /NO	Any size of demand	Reduction > 20% of demand

3.1. California Statewide Pricing Pilot Project.

The Statewide Pricing Pilot (SPP) project comprises a wide list of pricing concepts from the well-known Time of Use (ToU) tariff to Critical Peal Pricing-Variable, an interesting concept near a real-time tariff [6], [7]. SPP tested the following concepts for small and medium users:

- **ToU:** traditional two-part Time-of-Use rate. The peak period is from 2pm to 7pm and rates vary seasonally.
- **Critical Peak Pricing-Fixed (CPP-F):** it is basically an improvement of the ToU rate, but reflecting wholesale price changes. The CPP-F is 350 over 365 days a year as the standard ToU, but the remaining ones have a much higher price during the peak period (referred to in the project as CPP days). The timing of the peak period is unknown (starting from 1pm to 6pm) and the notification to the customer is day-ahead only.
- **Critical Peak Pricing-Variable (CPP-V)**: is a ToU rate 350 over 365 days a year. The remaining 15 days have a much higher price during the peak period (days referred to as CPP days). The difference between CPP-F and CPP-V is that in the last case the notification can be as short as 4 hours ahead (peak period varies in length from 1 to 5 hours).
- **Tier Inverter Tariff**: is the standard tariff, but quite complex for a customer and the economic advantages for the user are not clearly fixed [8].

SPP iniciative also provided estimates of the impact of ToU and CPP rates:

- <u>ToU:</u> statewide reduction in peak period demand of around 6% in 2003. In 2004 the rate of impact was 0%, i.e. the customer failed to sustain their demand response behavior in consecutive years.
- <u>CPP-V (residential):</u> there were two groups of residential customers:
  - Track A (Central Air Conditioners): two tiers of customers have some kind of enabling technology (for example, through an automated control system).
  - Track C: 100% of Central Air Conditioners with smart thermostats.
- <u>CPP-V (commercial):</u> there were two groups for small and medium commercial customers:
  - LT20: demand < 20kW
  - GT20: 20kW < demand < 200kW

Enabled technology was offered free to customer joining the projects, but surprisingly not every one will take this option. An specific initiative was promoted in 2005-07 to evaluate the possibility of automated response (see paragraph 3.4.1)

3.2. Residential Time of Use and Critical Peak Pricing (CPP) rates.

Time of Use pricing programs are based on a stepped rate structure that includes a peak rate (from 2 to 7 pm on workdays) and an off-peak rate (all other hours, including weekends). Critical Peak Pricing is similar but, sometimes, a shoulder-peak rate (for predetermined blocks of time, usually from 2 to 7pm called critical days) is set by the utility. Obviously, the rate of critical days needs to be high enough to induce customer response. Figure 5.6. compares the cost of ToU vs. CPP-Variable tariff.

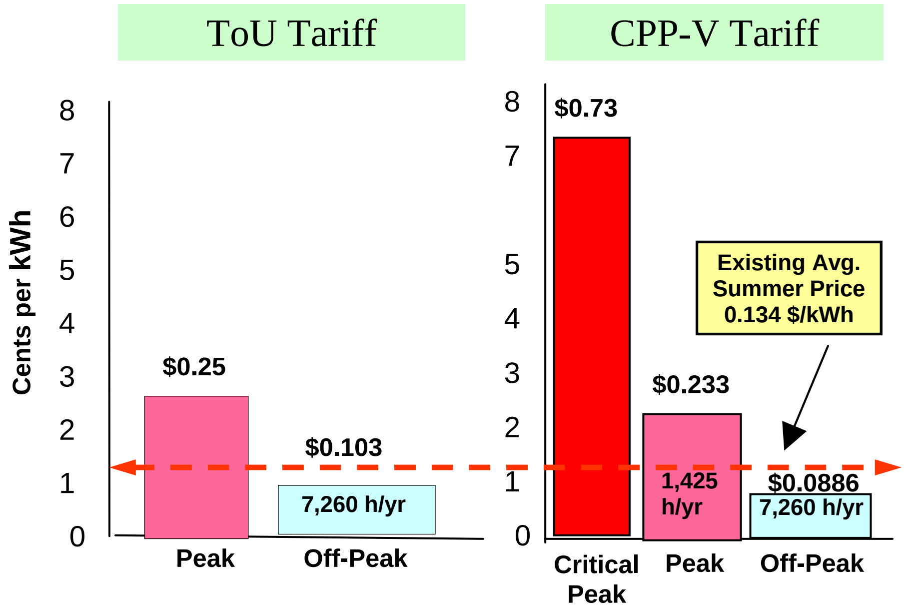

Figure 5.6. CPP & ToU High Options (California, USA).

Figure 5.7. shows the percentage of critical pricing hours in CPP-V in comparison with peak hours and valley hours. It must be taken into account that 75 hours a year is the maximum period to call a peak event and this represents 1% of time.

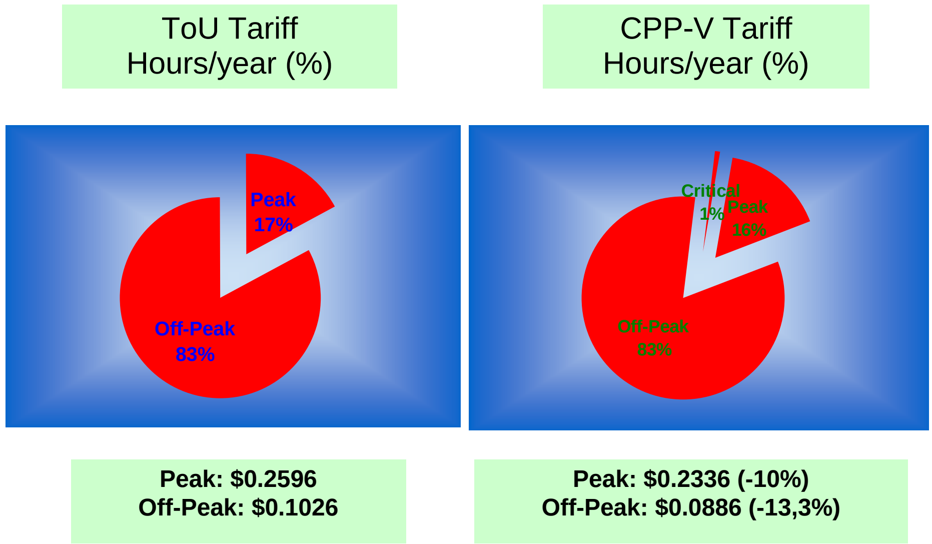

Figure 5.7 Time-Price distribution of ToU and CPP-V.

3.3. Commercial and Small Business ToU and CPP rates.

For small commercial and business customers, the CPP tariff is quite similar to that of residential users. Standard peak-prices in CPP are lower than in ToU, but however, the peak-critical prices (75 h/yr) are considerably higher. The California SPP pilot considers two CPP tariffs: one for customers with a power demand lower than 20kW (group or segment LT20) and the other one for customers with demand between 20 and 200kW (group or segment GT20). Figure 5.8. and 5.9. show the price structure for both segments in 2005.

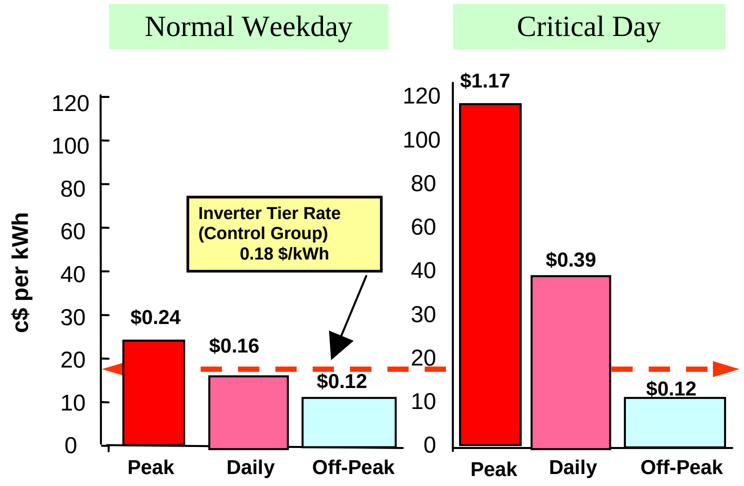

Figure 5.8. CPP & ToU High Options for LT20 customer (CA, USA).

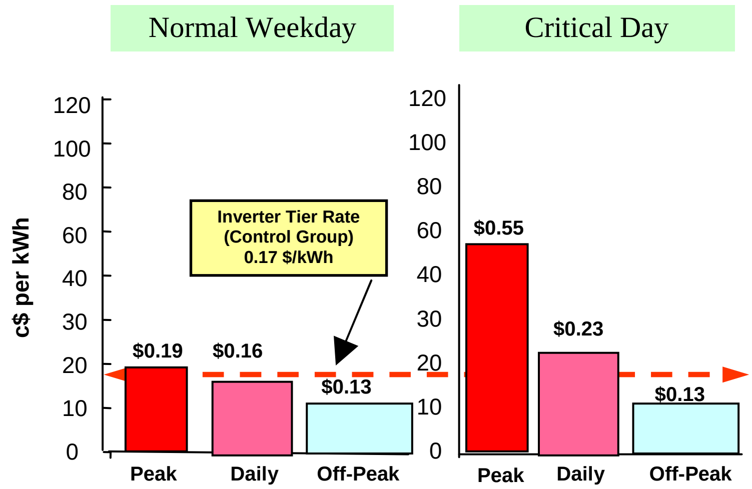

Figure 5.9. CPP & ToU High Options for GT20 customer (CA, USA).

It is important to consider when analyzing results that some critical-price events can be in consecutive days because this could modify the customer response and consequently elasticity. Twelve critical events were logged in 2004 and eleven in 2005. 24 percent of events were called in stand-alone days while the rest corresponds to multi-day critical events. Table III shows the statistics (days, duration, sequence,...) for these events during 2004 and 2005.

Table III. Characteristics of critical events days. Period 2004-05 (CA, USA)

Year	Month	Day	Start time	End Time	Duration	Day sequence
2004	July-Sept.	12 in 3 months	From 1pm	To 6pm	2 to 5h	1 to 3 days
2005	July	12th	2pm	4pm	2h	1
		13th	2pm	4pm	2h	2
		14th	1pm	6pm	4h	3
		21st	1pm	6pm	4h	1
	August	26th	2pm	4pm	2h	1
	Sept.	6th	2pm	4pm	2h	1
		7th	2pm	4pm		2
		23th	1pm	3pm		1
		27th	2pm	4pm		1
		28th	2pm	4pm		2
		29th	2pm	4pm		3

4. Results of Several Initiatives.

This paragraph gathers the results of Demand Response Initiatives explained in item IV and V of these reports. Data about demand, energy and bill impacts, together with the customer`s opinion about the acceptance of "real-time" tariffs and finally customer elasticity is presented.

4.1. Economical and technical results of CCP tariffs in California.

The most important result obtained in California with residential, commercial and small business (low and medium electricity demand) segments is that there is a customer response in small demand segments and this response held steady throughout consecutive-day events. Let us analyze each specific segment:

a) Residential segment:

- CPP-Fixed reduces the peak period on critical-peak days by more than 14%.
- Impacts held steady for two years (2003-04). The customer response is reliable.
- Impacts held steady throughout consecutive-day events: from 1 to 3 days (see table II of this section).

b) Small commercial segment LT20 (demand less than 20kW):

- CPP-Variable reduces the peak demand on critical days between 6% and 9%.
- Impacts held again steady throughout consecutive-day events.

c) Medium commercial segment (demand between 20kW and 200kW):

- CPP-Variable reduces the peak demand on critical-peak days between 8% and 10%.
- Impacts held steady throughout consecutive-day events (1 to 3 days).

Reports devoted to the analysis of this initiative [6] conclude that automation in the response is recommended over manual strategies to improve program participation. A simple premise of customer response supports this assert: manual load reduction or change requires that the customer be on-site during a load reduction event, and this premise could be a serious drawback to response. Figure 5.10. shows the catalyzing effect of enabling technology (automated controls) in demand response. The enhancement in response is clearly significant in all the segments and tariffs. For example, the peak load reduction in CPP-V tariff with enabling technology is three times higher (in percent) that CPP-F.

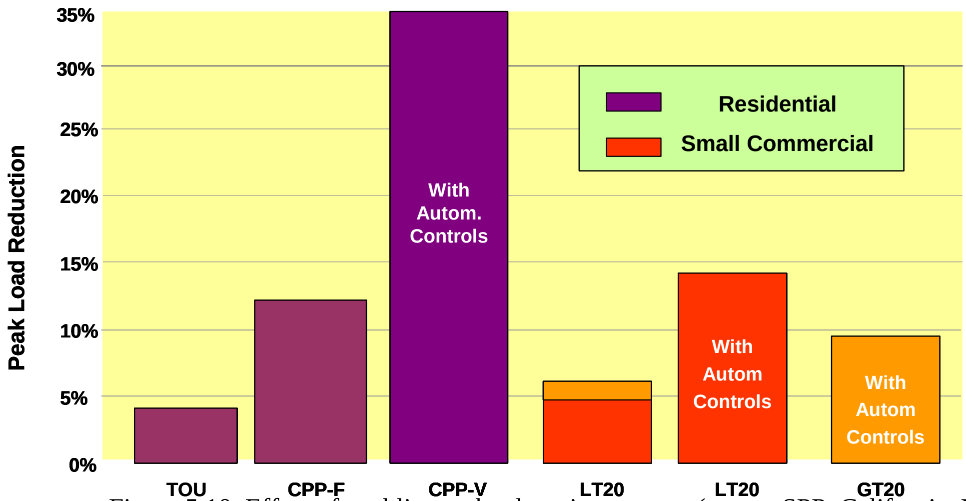

Figure 5.10. Effect of enabling technology in response (source SPP, California, USA).

An important drawback for customer response is that savings are relatively low (for example, less than $5/month in residential customer segments of SDG&E utility, or up to $45/month in commercial segments [9]) and therefore more incentives and technology are needed: participation in more products or markets (for instance ancillary services), involvement in sustainability, research in customer response and the optimization of this response. Table IV presents customer bill impacts for residential, commercial and industrial segments (small and medium users).

Table IV. Economic impacts in customer bills (customer with bill savings).

Customer Segment	**Residential**		**Small Commercial & Industrial (LT <20kW, GT > 20kW)**			
Tariff	**ToU**	**CPP-F**	**ToU LT20**	**CPP-V LT20**	**ToU GT20**	**CPP-V GT20**
Participants *with bill savings*	65.7%	74.1%	58.1%	61.0%	57.6%	67.9%
(*) Average Monthly Savings	4.0%	6.2%	12.1%	**12,1%**	8,7%	11.4%
(*) Average Monthly Savings	$3.15	$4.89	$26.45	**$46.83**	$176.39	$184.59

Several conclusions can be presented from this table and other reports [9]. CPP tariffs were more effectives than ToU: a greater extent of customers achieve bill reductions. The average savings are greater (up to 50%) than ToU options. Finally, the average savings are more encouraging (about twice for some customers).

An important concern to promote demand response and elasticity is customer acceptance of these tariffs:

- 70% of customers enjoyed remaining in their CPP tariffs.
- 60% to 70% of customers (residential and commercial) involved in these pilot projects thought that these tariffs should be offered to all customers.
- Customers associated dynamic rates with saving money and conservation.
- Very few participants did not respond to critical peak events, the majority of customers reacted by shifting or reducing load demand.
- Responsiveness varied with customer characteristics (end-uses), saturation, income and college education (up to 3:1).

4.2. Elasticities of small and medium customers in SPP pilot project (California).

Previously to the start of the SPP pilot project in California, Ernest Orlando Lawrence Berkeley National Laboratory (Goldman, 2005 [10]) and FERC in 2006 (Federal Energy Regulatory Commission, [11]), reported some data about the value of the elasticity of substitution analyzed in some large customer segments (RTP Tariff in Niagara Mohawk Power Corporation). These segments are high demand customers, but some insights appear about commercial and retail segments (the objective of some SPP initiatives). Figure 5.11. shows some results of this interesting report.

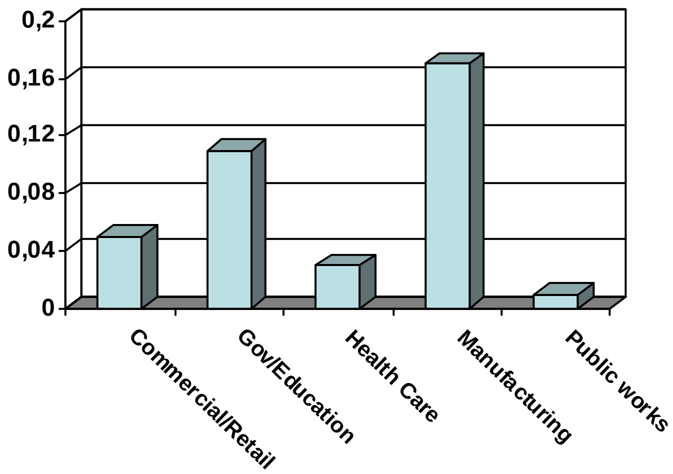

Figure 5.11. Variation of elasticity of substitution by customer segments (sources [10]&[11]).

4.3. The role of enabling technology in the elasticity of demand response. The California CPP example.

Elasticity of response needs advanced structures but also technology to respond to change in prices. Elasticity fails without the incentive of prices or the unavailability of fast or adequate responses. In this way automation should be a technological drivel for DSRI. A pararell pilot project is being developped with CPP tariffs.

4.3.1. The Automated-Critical Peak Pricing in California (Auto-CPP).

The Auto-CPP program was designed to evaluate the feasibility of deploying control systems that allow customer to participate in CPP with an automated response. Lawrence Berkeley (LBNL) and Pacific Gas & Electric [20] recruited 24 sites in California (including office buildings, retail stores, schools, museums, laboratory buildings, ...) in the summers of 2005 and 2006 (a large-scale program for summer 2007 was planned). Eah facility worked with LBNL to select and implement strategies for demand response and developed automation system designs based on existing internet resources, interval meters, and building control systems: Energy management control systems (EMCS), energy information systems (EIS) or similar end-use device with a contact relay. The communication system allowed to receive day-ahead or day-at-hand signal (125 events were reported and evaluated).

The CPP period lasts from May 1^{st} to October 30^{th}, and each participant received CPP notification to initiate demand response events. In this way each customer automatically shed predetermined electric loads; actually two levels of DR, one for moderate and another for high energy price periods. Control of cooling components, air distribution (ventilation) and lighting control were the usual DR strategies.

The average demand reduction was 14% on the whole-facility load based on a three-hour peak price period and a peak demand reduction of 1,2 MW (summer 2006). The result of the test was succesful: full automation is technically feasible and increases value to CPP customer, but this project need further development to improve:

- Peak demand saving evaluation methods: new dynamics models baed on knowledge of weather data, HVAC systems and controls, for peak demand saving estimates for short durations.
- The necessary communication of the concepts of DSRI.

- Accurate "Baseline models": to estimate the demand savings when a CPP event appears. Now, CPP baseline is the average hourly load shape of the three highest demand days in the last 10 work days excluding holidays.
- Develop new DR control strategies: based on dynamics models and with he help of the customer to avoid complaints.

With respect to the cost of automation, it was estimated to be $3000 to $5000 for each site. And this cost appear to be viable according to economic results of the project [20].

4.3.2. Evaluation of response with and without enabling technology

Figure 5.12. compares the response of small commercial customers (LT20 segment) with and without "enabling technology". For this segment a complete lack of response appears when technology is unavailable (red colums). The reduction in demand (%) in peak periods (critical peak days) falls as price increases since it becomes more difficult to decrease or change demand.

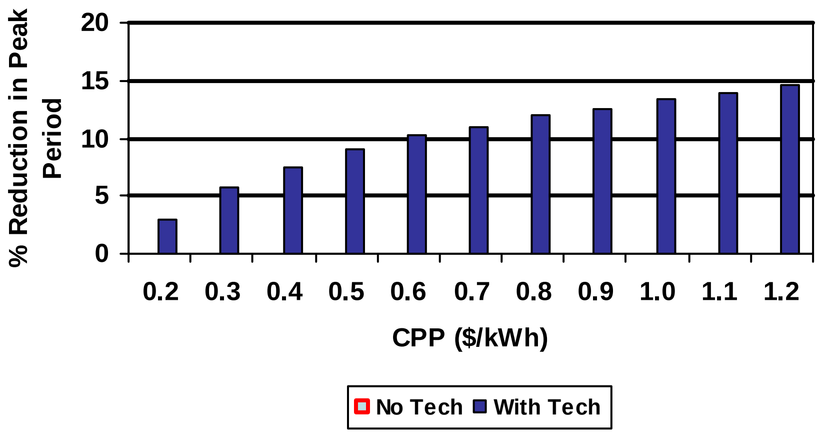

Figure 5.12. Reduction of LT20 segment (small commercial) on critical days. Average SPP price $0.97/kWh.

For customers with a higher demand (GT20), there is a significant response in absence of enabling technology. As seen in LT20 response, the percentage of decrease in peak periods falls as price increases, but this segment GT20 exhibits better elasticity than LT20 segment. Figure 5.13. shows some of the results of the SPP experience in California.

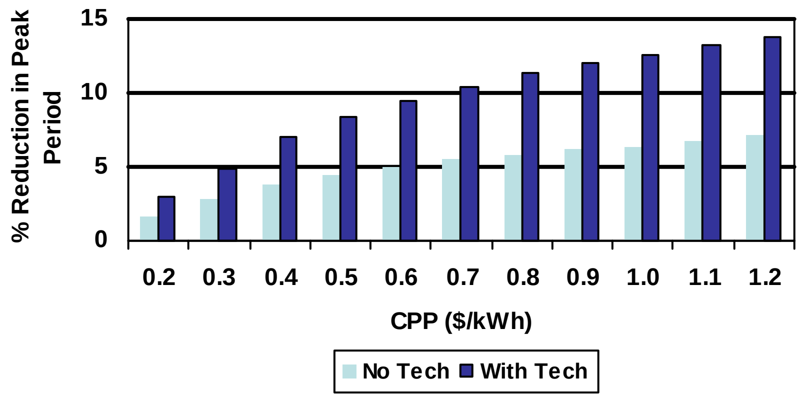

Figure 5.12. Reduction of GT20 segment (medium commercial) on critical days. Average SPP price $0.59/kWh.

4.4. Some examples in Europe: elasticity in Norway and Sweden.

Some elasticity is reported from European studies [12] and Ph. D. Thesis [13]. These papers conclude that in Norway and Sweden short-term price-response is still limited, as the purchase curve is nearly vertical at higher prices. For example, figure 5.13. shows Nord Pool spot results on February 6th 2003. Obviously, demand exhibits a limited capacity.

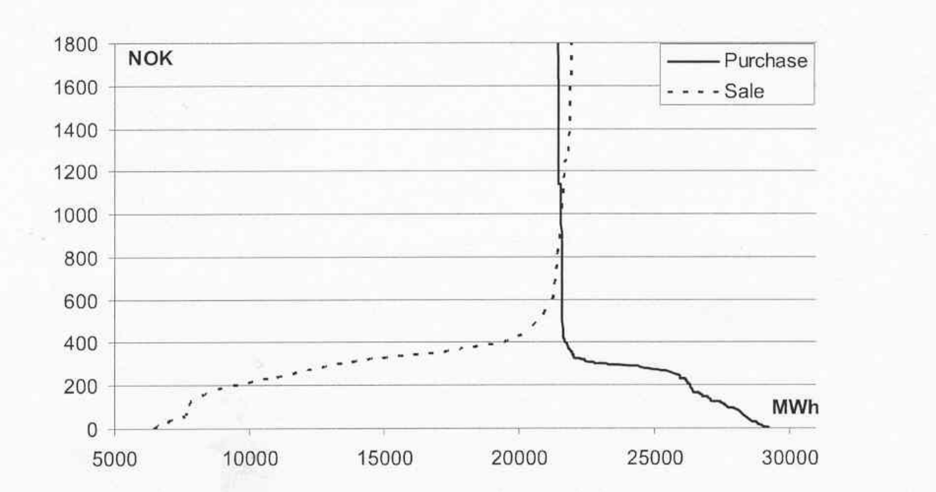

Figure 5.13. Results of Nord Pool Spot Market (02/06/2003 from 18h to 19h).

Hansen and Bye [12] estimated a low short-term demand elasticity in Norway in the range of -0.015 and even smaller in Sweden. Nevertheless, some authors argue that elasticity may be higher if measurement and monitoring requirements were lowered (to improve elasticity the minimum energy level was reduced by 75% in 2005, to achieve a higher elasticity).

For example, a recent work [13] in 2007 states that:

- Low elasticity may be a consequence of a reduced consumption within contracts tied to the spot price (the same conclusion was stated by LBNL in California). For instance, only a 0.2% of supply contracts in the energy-intensive industry (pulp and paper industry) reflected spot prices. In mining and other manufacturing industries the percentage grows to 2.6% (notice that these industrial sectors represent 46% of industrial demand). In the other side, trade, restaurants, public administration, health and social, services reach 70% of contracts tied to spot prices, but they represent only 10% of demand.
- The main part of the Norwegian consumption nowadays has no incentives to be short-term responsive, therefore demand appears as inelastic.

Some old experiences with ToU tariffs in Norway (1984&87, 374 households) reported an elasticity of substitution which ranges from 0.13 (winter) to 0.24 (spring).

4.5. Another example in the European Union: elasticity through French "tempo tariff".

Another European example is the "tempo tariff" in France. Aubin [15] studied the effect of "tempo" prices (Eléctricité de France EdF, France) in customers. As stated in CIGRE-item IV, "tempo" in a six rate real-time tariff. It divides the year into three types of days and each day into two periods. The number of days and price of each type is known in advance (22 are red days, 43 white and 300 blue days, see figure 5.14.), and the type of any particular day is announced at the end of the preceding day (with a signal lamp). The pilot project started between 1989 and 1992, involving 800 customers. The success of this pilot produced the generalization of the tariff gradually since 1995: 300.000 residential and 100.000 small businesses.

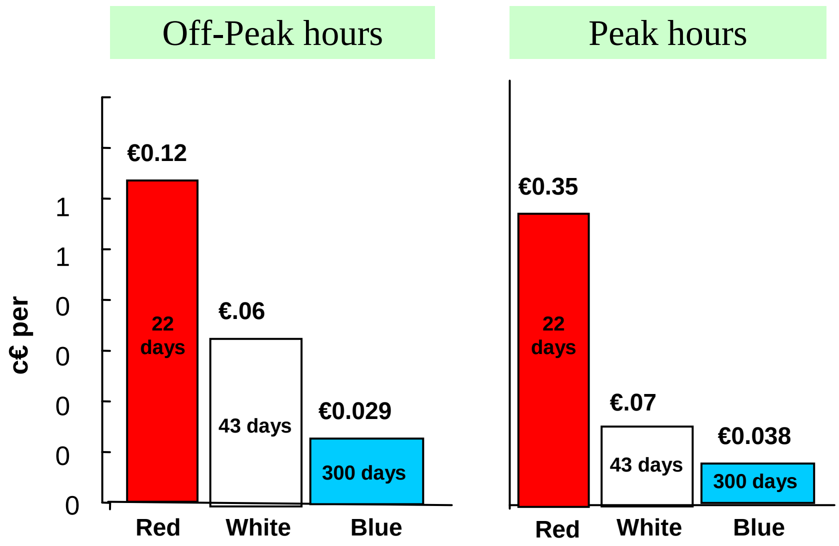

Figure 5.14. Tempo Tariff by EdF (France, EU).

The conclusions of this research are that RTP tariff improves the welfare of the majority of customers participating in the experiment and achieves significant demand reductions:

- 45% in red days
- 15% in white days

The report also concludes that the peak price elasticity is about -0.79 and an off-peak elasticity reaches -0.28.

4.6. Residential elasticity in Switzerland.

Another example is Swiss demand for electricity. Maximo Filippini published several works in the nineties [14] in scientific reviews on economics. Other authors (Spierer and Dennertein) stated conclusions very similar to Filippini results.

He used aggregate data at a city level for 40 Swiss cities over the period from 1987 to 2000. Main conclusions of these authors (perhaps valid from a macro-economic perspective, but not very accurate from any technical point of view: level of aggregated demand, too many customer segments, a study without tariffs tied to production costs,...), are the following:

- Price Elasticity (long-term) was estimated to be:

- Filippini: -0.30
- Spierer: -0.50 (data from 1960-64); Denerlein: -0.70

- I.e., a price inelastic demand.
- "There is a little room for discouraging residential consumption using prices increases".
- "Household income affects electricity demand". - "A pricing policy, ToU, can be an effective instrument for achieving conservation".

4.7. The case of Australia.

In the case of Australia some references about demand elasticity can be found [16]. This report estimates long and short-term elasticities according to the following models:

$$\ln EC = \alpha_0 + \alpha_1 * \ln Yt + \alpha_2 * \ln EP + \alpha_3 * \ln GP + \alpha_4 * \ln TM + \varepsilon$$

$$\ln EC = \alpha_0 + \alpha_1 * \ln Yt + \alpha_2 * \ln RP + \alpha_4 * \ln TM + \varepsilon$$

Where:
EC is the per capita residential consumption.
Y: real per capita income.
EP: residential electricity price.
RP: real price of the electricity.
GP: natural gas price.
and TM is the temperature.

Data used for this study is annual time series for the period 1969-2000 (obviously, a great percentage of data used corresponds to regulated markets). The results shows long-term own price elasticity about -0.541 and long-term own price elasticity about -0.263.

National Electric Market Management Company (NEMMCO, Australia) has several reports about load forecasting and demand [17], and some of these reports deal with elasticity, but focused on long-term price elasticity by sector (table V) and jurisdiction (table VI).

Table V. NEMMCO report (2006). Elasticity by customer sector.

Sector/Customer segment	Elasticity (%/%)
Residential	-0.25
Commercial	-0.35
Industrial	-0.38

Table VI. NEMMCO report (2006). Elasticity by jurisdiction.)

Region	Range	Mean
Queensland	-0.14 to -0.44	-0.29
New S. Wales	-0.22 to -0.52	-0.37
Victoria	-0.23 to -0.53	-0.38
S. Australia	-0.17 to -0.47	-0.32
Whole of NEM	-0.20 to -0.50	-0.35

Other results for the Australian case are analyzed in works by Akmal in 2001 (long-term price elasticity: -0.95) and Saddler in 1984 (long-term" price elasticity: -0.56).

4.8. Some results in Japan.

To conclude this revision of the scarce data available on customer elasticity, it is necessary to present and emphasize the interest for elasticity in Japan. Specifically, a ToU experience studied by Matsukawa in 2001 [18] and 2004 [19]. Matsukawa found peak elasticities from -0.70 to -0.77; and off-peak elasticities from -0.51 to -0.72.

5. Conclusions.

To sum up, several ideas arise from the bibliography on demand elasticity and the experiences carried throughout the world:

- HVAC and thermal loads are a key driver for demand response.
- High demand customers have more load to shift.
- Small customers react to price (education, understanding of tariffs and technology drivers are critical to improve response).
- CPP tariffs did not have a measurable effect on annual energy use (people increase the use during off-peak periods).
- Impacts (CPP) persisted across years and especially across multi-day critical events.
- Demand Response to price is alive but is not prospering as well as it could be.

The most important conclusion is that a lot of work needs to be carried out in the research and measurement of elasticity through the development of DSR initiatives.

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