Sharing Communication Network Resources for a User-Controlled Electrical Energy Consumption

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The Problem

- Growing electrical demands followed by constantly growing supplies led to troubled electrical services manifested by technical and economic deficiencies and undesirable environmental impacts.
Figure 1: Energy demand and prices in Queensland as broadcasted by the Australian Energy Market Operator (AEMO) (2009).
Technical and economic difficulties:

- Congestions at peak demands
- High investment in infrastructure (gen. transm. and distr.)
- Detrimental environmental impact
- Compromised quality (e.g. voltage fluctuations)
- High-priced energy
- Low energy cost at low-demands
- Power stations operate at the limits of economic viability
• Electricity consumers according to EUAA (2005) also pay a significant price costs for building sufficient electricity generation and networks to meet the short peaks.

• More than 5% of the network infrastructure is only used for 0.2% of the time

• This under-utilised capital investment in the network is paid for by all consumers.
Solution

• The paper is describing a demand side response dynamic scheme to handle peak and low demand situations.

• The intelligent technique is based on sharing communication network resources on the internet to achieve controlled electrical energy consumption.

• Dynamic Smart Grid environment.

• Deliberate and timely user’s decision for electrical connection.
• **The user** is enabled to withdraw electrical energy in a conscious, responsible and cost-effective manner.

• **The supplier**, on the other side, is handing the quantity of the supplied electrical energy to a particular user at a time following specific transacted information.

• This implies the development and implementation of a dynamic **intelligent** energy management system.
Present situation

- The traditional user-supplier rapport is whenever demand occurs it is expected to be **fulfilled** by the **supplier** at the expected time and quality.

- Electrical **generators** are operating in isolation from the **users**.

- **Generators** are investing in equipment they don’t know whether they will be able to sell their product.
• Electrical users are consuming electricity in isolation from supplier’s situations.

• Users are buying a product they don’t know of quality or price.

• No communication, no information, no transparency between end-users and generators.
Figure 2 Fluctuation of electricity prices in Queensland, data extracted from the Australian Energy Market Operator AEMO (2009).
Figure 3 Fluctuation of electricity demand and prices in Queensland, data extracted from the Australian Energy Market Operator AEMO (2009).
Permanently growing electrical demand has changed those historical conditions.

• Today, the old scheme is causing big troubles.

• Technical, economic, social and environmental difficulties arose out of the conventional scheme.

• Users are suffering high electricity prices and compromised quality.
• Suppliers are suffering tough operating and economic conditions at high risks and pressing competition.

• The environment is suffering pollutants of over-sized machinery and infrastructure operating at 19th century very low efficiencies.
The basic concept of markets as mentioned by the Energy Users Association of Australia EUAA report (2005) pp23, is:

• That buyers (customers) should be able to make a choice of not purchasing if, for example, the price is too high.

• In order to do that, they must be able to see the price and make a judgement on the value of foregoing the purchase at that time.
• This does not mean they go without, but they may advance or **delay the usage**.
Figure 4  Electricity demand in Queensland in 2008, data extracted from the Australian Energy Market Operator AEMO (2009).
• **Table 1** Idle Power Plant Capacity in the USA according to Huber (2008)

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Percent of U.S. Capacity (Total: 1 TW)</th>
<th>Percent of Electricity Generated (Total: 4,000 TWh)</th>
<th>Idle Capacity (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Coal</td>
<td>30</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>40</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>Petroleum</td>
<td>6</td>
<td>2</td>
<td>85</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7</td>
<td>60&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Other Renewables</td>
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<td>2</td>
<td>55&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>ALL</td>
<td>100</td>
<td>100</td>
<td>55</td>
</tr>
</tbody>
</table>

<sup>a</sup> Limited by weather-related supplies of water and wind.

Source: Energy Information Administration<sup>19</sup>
Demand Side Response DSR

- Demand side response (DSR) can be defined as the changes in electricity usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time.

- Demand side response provides means for users to reduce the power consumption and save energy.
Further on, it maximizes utilizing the present capacity of the distribution system **infrastructure**, reducing or eliminating the need for building new lines and expanding the system.
Plant Capacity Factor

• The plant capacity factor (PCF) or the so also called utilization factor of a power plant is, by definition:

• The relation between the yearly electrical energy generated by a plant and the electrical energy generated in case the plant operates at its rated power for a full time of a year i.e. 8760 h/year.
Example:

Power plant rated capacity 100 MW

• If working 24 h/day (24x365=8760 hour/year)
  \[(PCF) = \frac{100 \times 8760}{100 \times 8760} = 1\]  e.g. coal power plants

  Low-operation cost power plants work for 8760 hour/year

• If working 8 h/day (8x365= 2920 hour/year)
  \[(PCF) = \frac{100 \times 2920}{100 \times 8760} = 0.33\]  e.g. solar or wind plants

  High-operation cost plants work only limited time / year to cover peak demands
Effect of the PCF on Energy Cost

The PCF has a direct influence on the energy cost (the fixed charge method):

\[ c_E = c_{tr} \frac{FCR}{(T_o \cdot PCF)} + c_{op} \]  

\[ (1) \]

- \( c_E \) cost of energy generated
- \( c_{tr} \) cost of the installed power
- FCR fixed charge rate of the capital, normally 15…18% a year
- \( T_o \) =8760 hours per year
- PCF plant capacity factor
- \( c_{op} \) operation and maintenance cost of the plant
Example:

\[ c_E = c_{tr} \frac{FCR}{(T_o \cdot PCF)} + c_{op} \] (1)

\[ c_{tr} = $1000/kW, \ FCR=0.16\%, \ T_o=8760, \ c_{op}=$0.05/kWh \]

Case 1) \textbf{PCF} = 1 \quad \text{e.g. coal power stations}

\[ c_E = 1000 \times \frac{0.16}{8760} + 0.02 = 0.038 \ \$/kWh = 38 \ \$/MWh \]

Case 2) \textbf{PCF} = 0.33 \quad \text{e.g. solar or wind power stations}

\[ c_E = 1000 \times \frac{0.16}{8760 \times 0.33} + 0.02 = 0.176 \ \$/kWh = 176 \ \$/MWh \]
The scheme

- **Figure 5** Outlines this scheme, where electricity users are enabled to switch (control) their electric demand according to continuous and **simultaneous** information communicated by the **Australian Energy Market Operator (AEMO)** (2009) on market conditions.

- The customer is then being helped undertaking **information-based decisions** for whether they maintain withdrawing electricity, reduce consumption or totally cut-off their connection to the supplier at certain times a day.
• Computer-controlled switches are used to switch on and off loads at user premises to maintain acceptable energy prices.
Figure 5 Electricity users are enabled to computer control switches to avoid peak demands.
Figure 6: Electricity demand curtailed beyond pre-set programmed computer software control switches to avoid peak demands (control)
• The presented scheme allows electricity users to make use of continuous and simultaneous information communicated to them by the Australian Energy Market Operator AEMO (2009) on the internet about electricity market conditions helping undertaking information-based decisions.

• The smart-grid technology will make use of the internet and modern communication systems to minimize the use of energy at times of peak demand.
Figure 7 Electricity demand curtailed in Queensland not to exceed $55/MW.
The scheme is offering the following benefits:

- creating transparent users-suppliers conditions
- better use of electrical energy resources
- reduced energy prices
- improved economics of power stations and el. Infrastructure
- diversified energy sources
- increased use of renewable energy
- reduction of environmental polluting emissions
Conclusions

• This scheme attempts to reduce the energy price volatility by decreasing peak demand, increasing grid reliability, reducing energy cost, and optimizing energy consumption.

• The scheme allows electricity end-users to “smooth” significant peaks by curtailing or shifting demand, thus avoiding or delaying investments in new infrastructure.
The scheme provides additional capacity more quickly and efficiently than new supply.

Flexibility lowers the likelihood and consequences of forced outages.

Reducing significant peaks averts the need to use the most costly-to-run power plants, driving production costs and prices down for all electricity purchasers.
• The scheme is avoiding large capital expenditures achieving savings.

• Enabling consumers to attend electricity prices allows them to reduce and optimize their energy consumption and realize electricity saving.

• The scheme will make use of the internet and modern communication systems reflecting so the benefit of the user and supplier.
Thank You for your Attention!