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

Fouad Kamel
Faculty of Engineering & Surveying
Electrical, Electronic & Computer Engineering
University of Southern Queensland, Toowoomba, Queensland
e-mail: kamel@usq.edu.au

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.

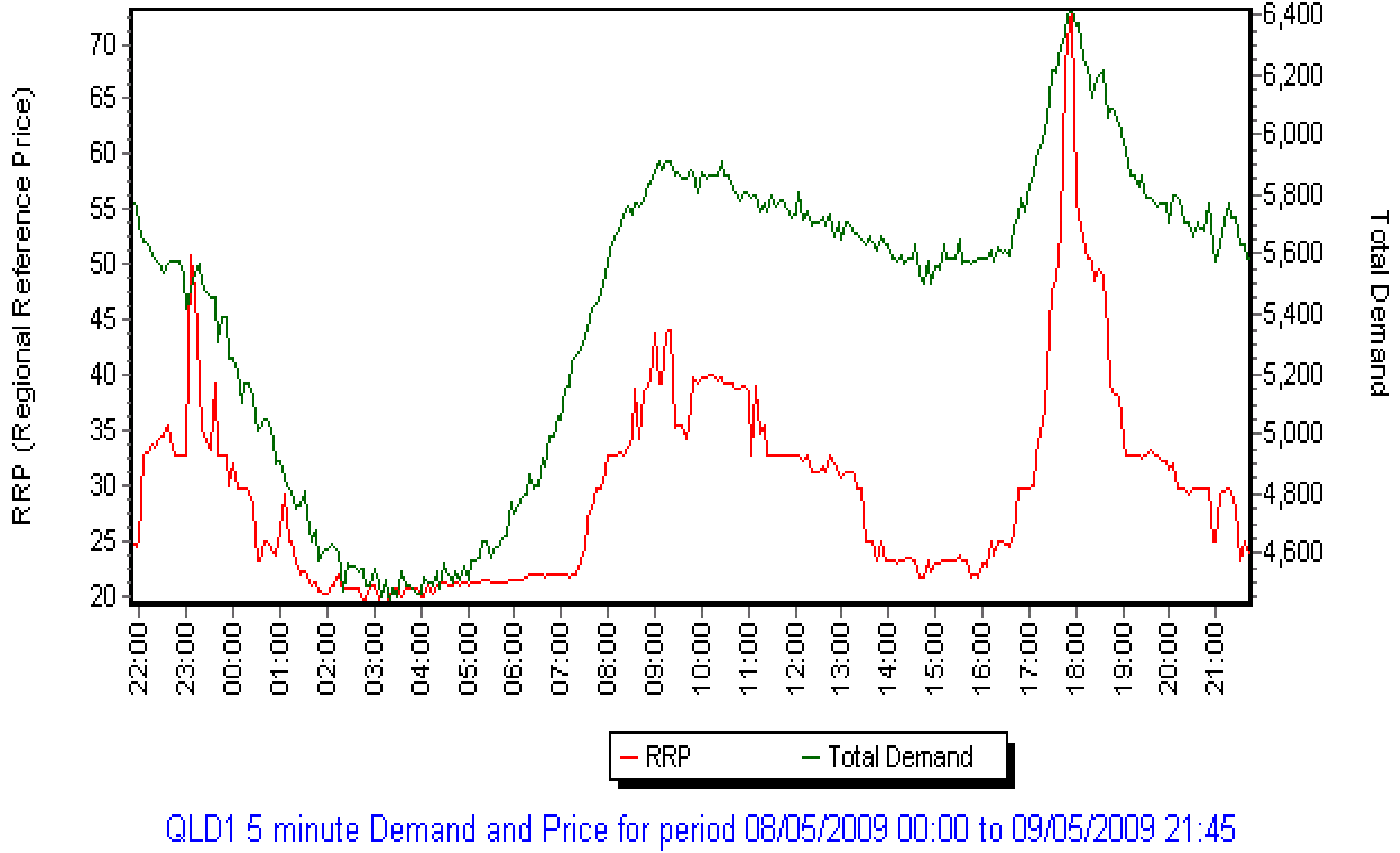

Figure 1 Energy demand and prices in Queensland as broadcasted by the Australian Energy Market Operator AEMO (2009).

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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.

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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.

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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.

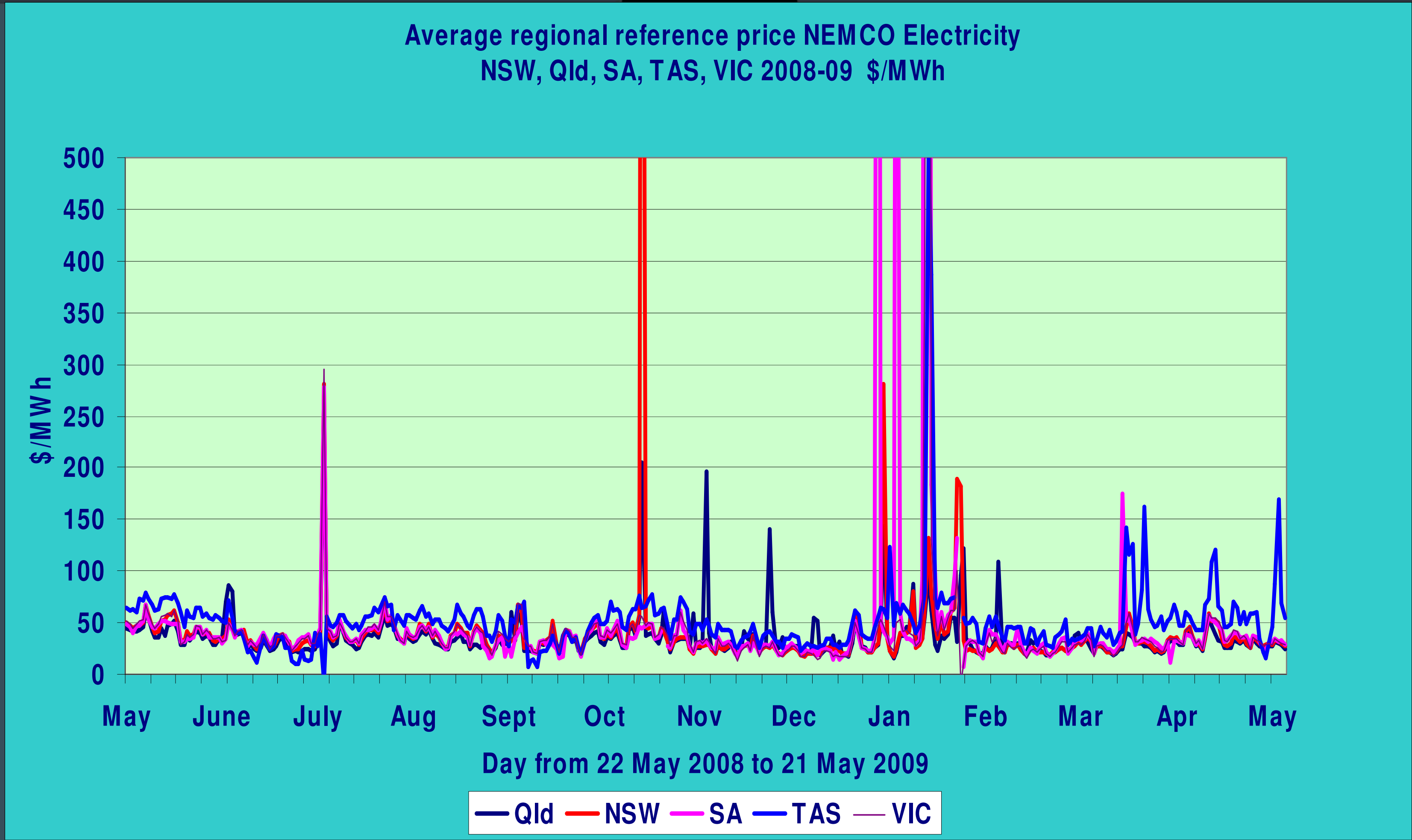

Figure 2 Fluctuation of electricity prices in Queensland, data extracted from the Australian Energy Market Operator AEMO (2009).

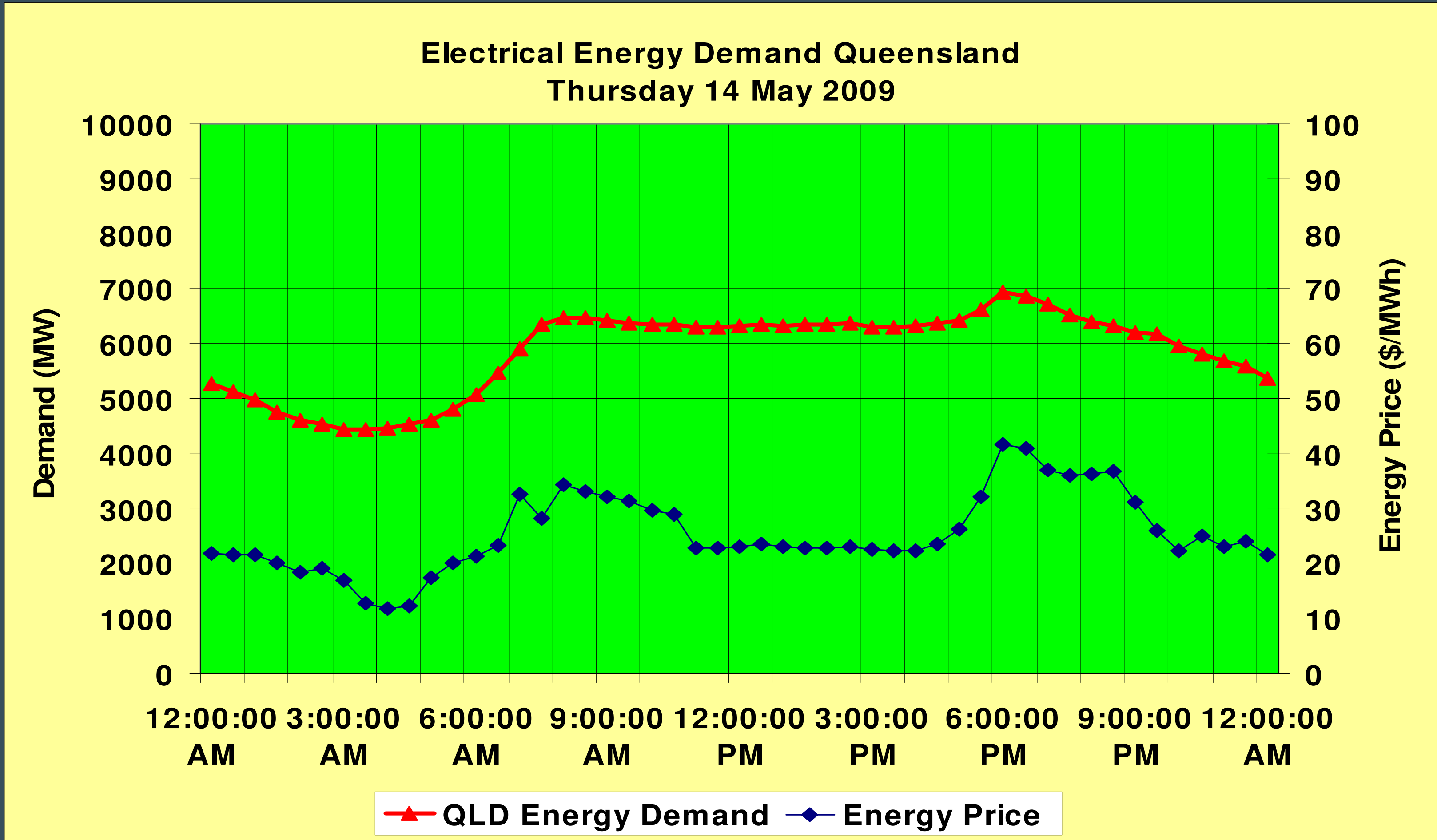

Figure 3 Fluctuation of electricity demand and prices in Queensland, data extracted from the Australian Energy Market Operator AEMO (2009).

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.

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- 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 19^{th} century very low efficiencies.

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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**.

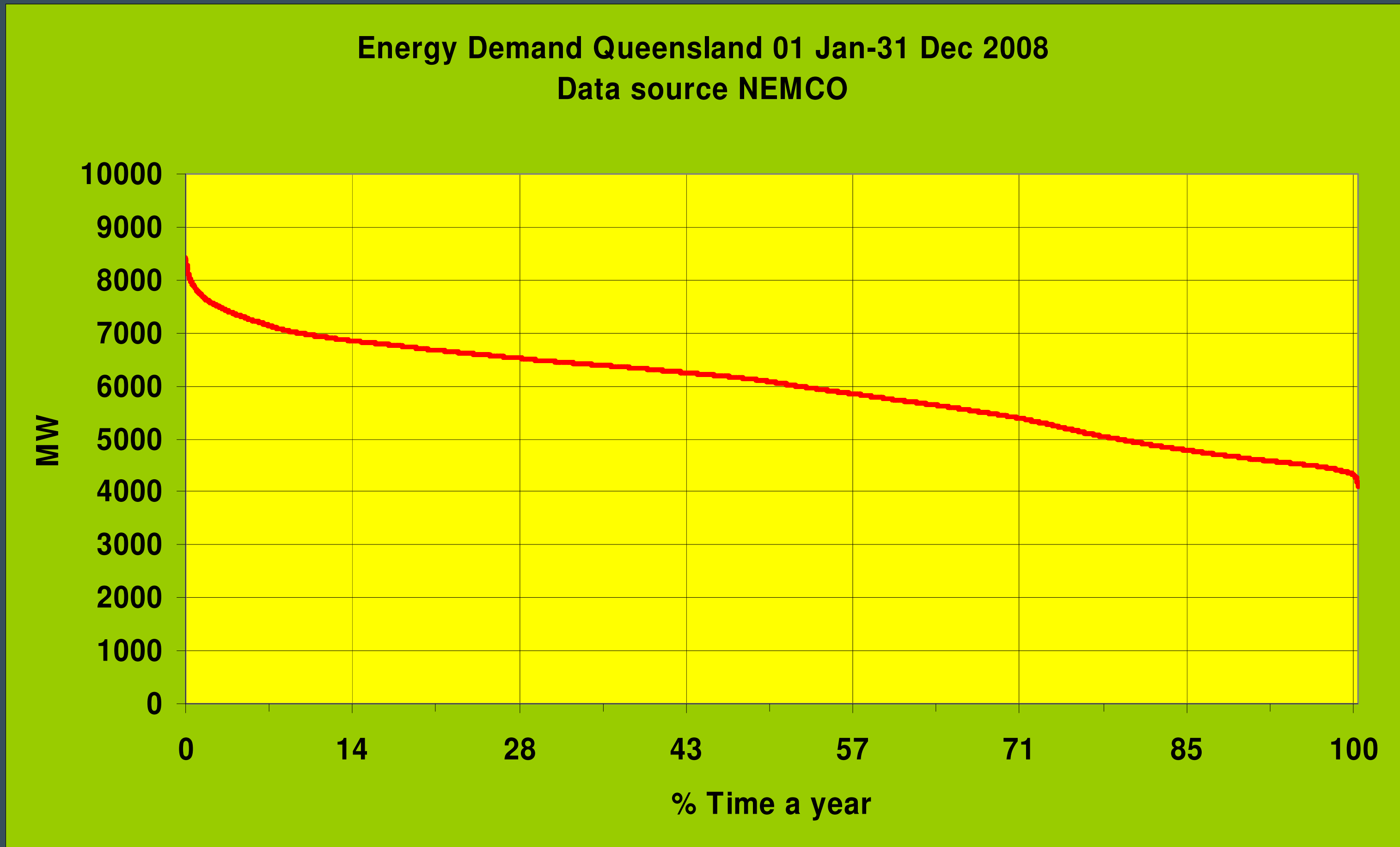

Figure 4 Electricity demand in Queensland in 2008, data extracted from the Australian Energy Market Operator AEMO (2009).

- **Table 1** Idle Power Plant Capacity in the USA according to Huber (2008)

Idle Power Plant Capacity (2006)

Fuel	Percent of U.S. Capacity (Total: 1 TW)	Percent of Electricity Generated (Total: 4,000 TWh)	Idle Capacity (percent)
Nuclear	10	20	10
Coal	30	50	25
Natural Gas	40	20	80
Petroleum	6	2	85
Hydroelectric	10[a]	7	60[a]
Other Renewables	2[a]	2	55[a]
ALL	**100**	**100**	**55**

[a] Limited by weather-related supplies of water and wind.

Source: Energy Information Administration[19]

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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 **infrastructur**e, reducing or eliminating the need for building new lines and expanding the system.

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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) = 100 x 8760 /100 x 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) = 100 x 2920 / 100 x 8760 = **0.33 e.g. solar or wind** plan

  High-operation cost plants work only limited time / year to cover **peak demands**

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Effect of the PCF on Energy Cost

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

$$c_E = c_{tr}\ FCR / (T_o\ PCF) + c_{op} \qquad (1)$$

- 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:

$$c_E = c_{tr}\ FCR / (T_o\ \mathbf{PCF}) + c_{op} \qquad (1)$$

c_{tr}= \$1000/kW, FCR=0.16%, To=8760, cop=\$0.05/kWh

Case 1) **PCF** = 1 e.g. **coal power stations**

c_E =1000x 0.16/(8760x1)+0.02 = 0.038 \$/kWh = 38 \$/MWh

Case 2) **PCF** = 0.33 e.g. **solar or wind power stations**

c_E =1000x 0.16/(8760x0.33)+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.

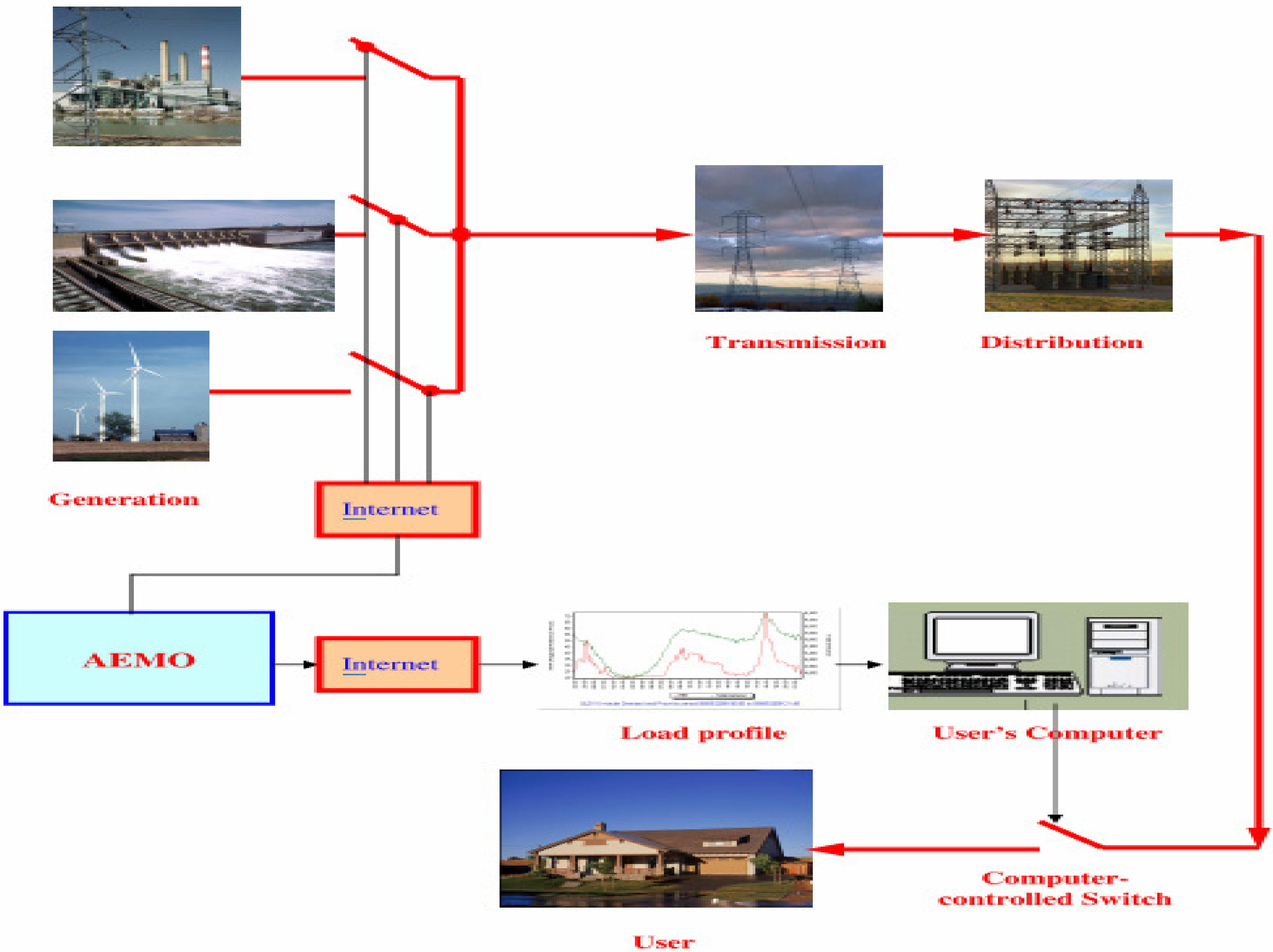

Figure 5 Electricity users are enabled to computer control switches to avoid peak demands

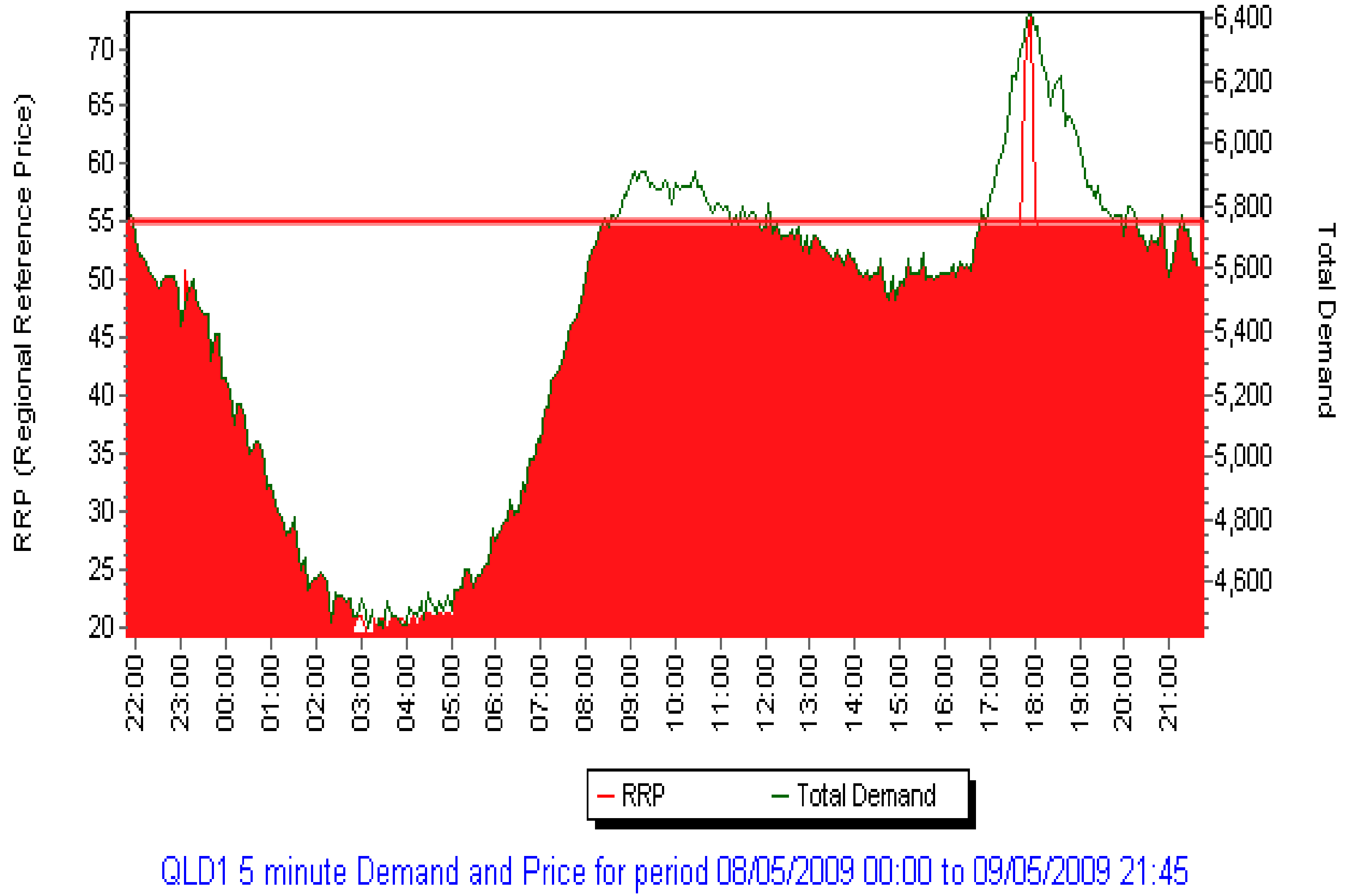

Figure 6 Electricity demand curtailed beyond pre-set programmed computer soft ware control switches to avoid peak demands (control)

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- 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.

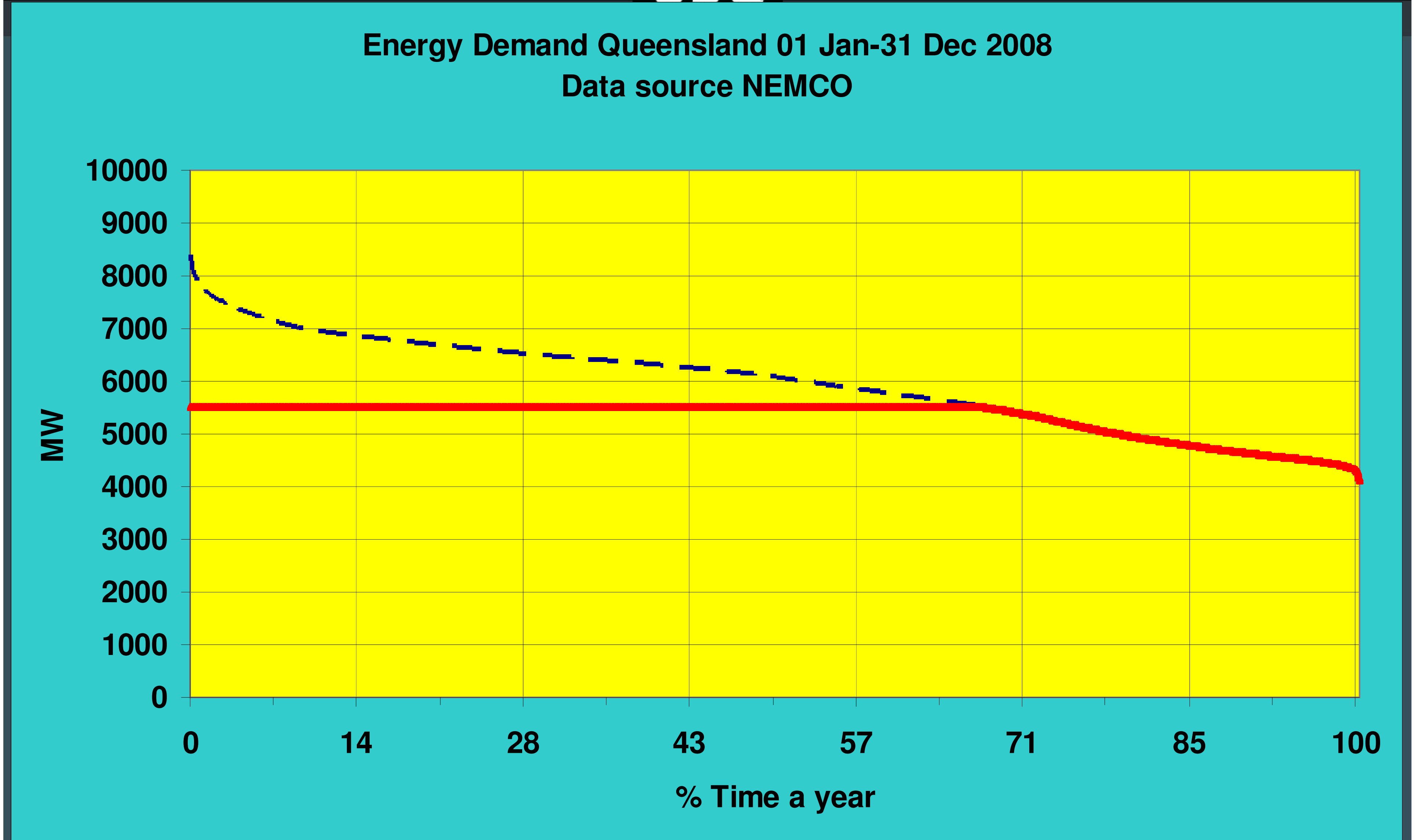

Figure 7 Electricity demand curtailed in Queensland not to exceed $55/MW.

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- 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**

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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.

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- 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.

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Thank You

for your

Attention!