User-Moderated Electrical Consumption In Eastern and Southern Australia – A Smart Grid Technique

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

The Problem

- The present situation of the electricity market in Queensland is based on a demand base-load operated at 4100 MW (in 2008).

- Peak loads between 7000 and 8000 MW are occurring at very low frequency below 10% a year.

- Short operating times per year are causing specifically high energy generation cost.

- Accordingly, limited operation time of the more expensive power plants covering those loads makes their operation even more expensive.
- Figure 1

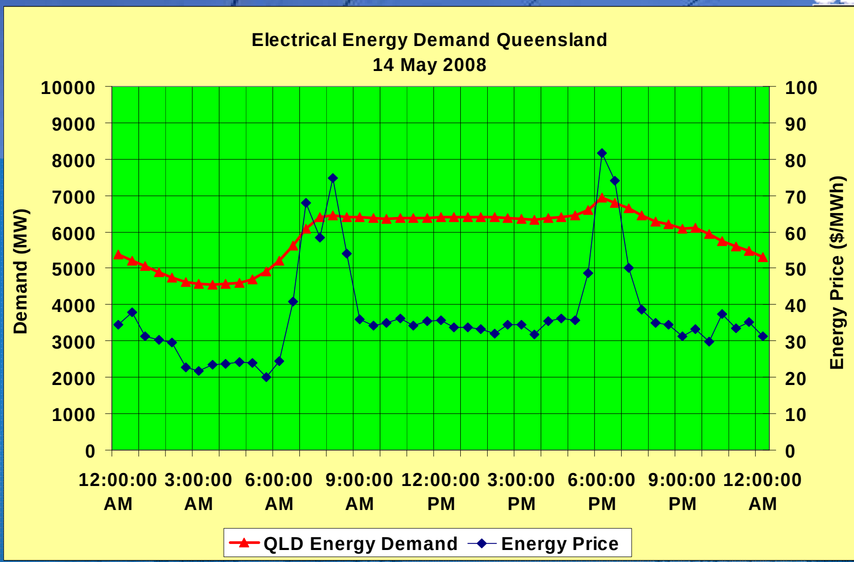


Figure 1 Energy demand and prices in Queensland, data extract of the Australian Energy Market Operator AEMO.

Hypotheses

- A dynamic smart grid technique applicable in a transparent electricity market in Eastern and Southern Australia, where the Australian Energy Market Operator (AEMO), is described.
- The technique is enabling end-users to be acting on controlling or curtailing own demand according to received information about market conditions on the internet
- .

Technical and economic difficulties:

- Congestions at peak demands
- High investment in infrastructure (generation, transmission and distribution)
- 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 R. S. Fraser (2005) Energy Users Association of Australia (EUAA) also pay a significant price costs for building sufficient electricity generation and networks to meet the short peaks.

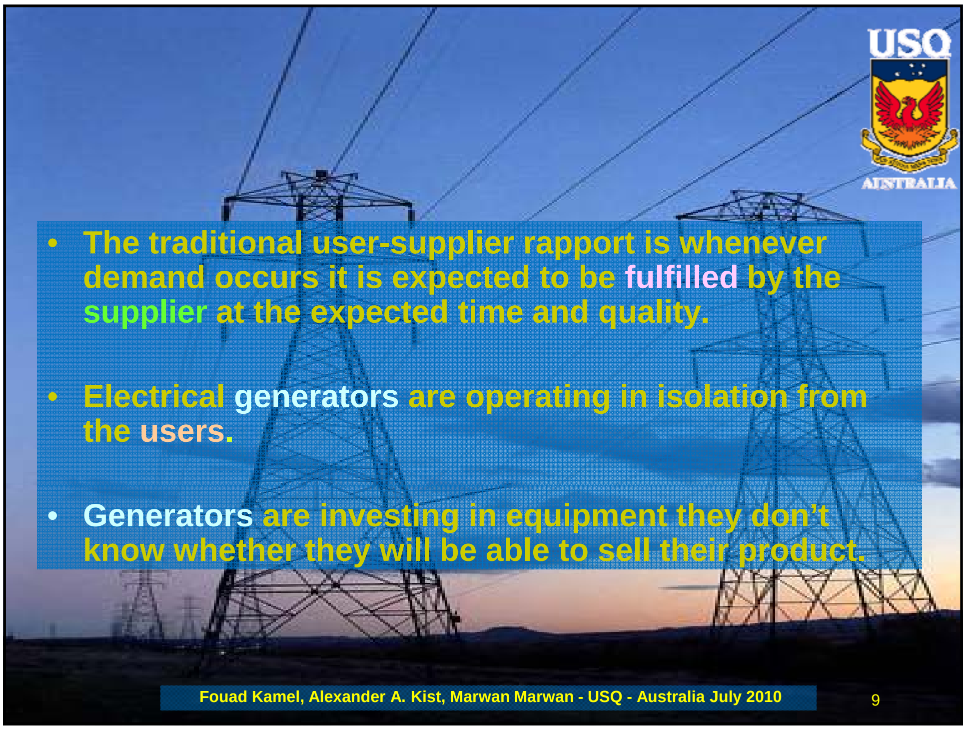
- More than 5% of the network infrastructure is only used for 0.2% of the time

- 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.
- This implies the development and implementation of a dynamic intelligent energy management system.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• 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.
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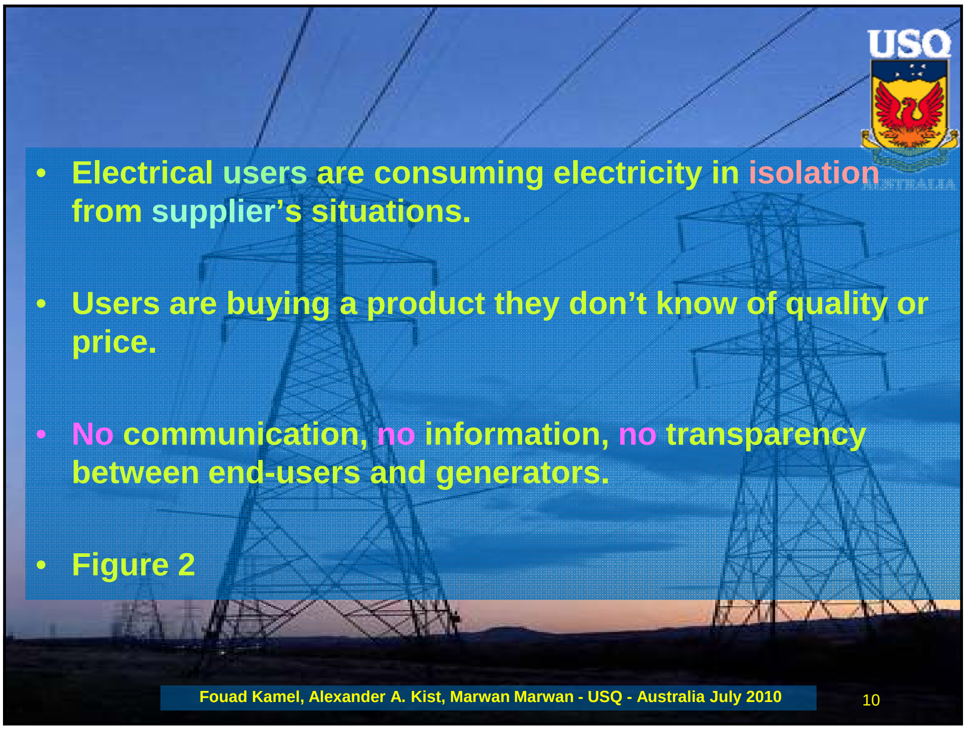
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• Electrical users are consuming electricity in isolation from supplier's situations.
• Users are buying a product they don't know of quality or price.
• No communication, no information, no transparency between end-users and generators.
• Figure 2
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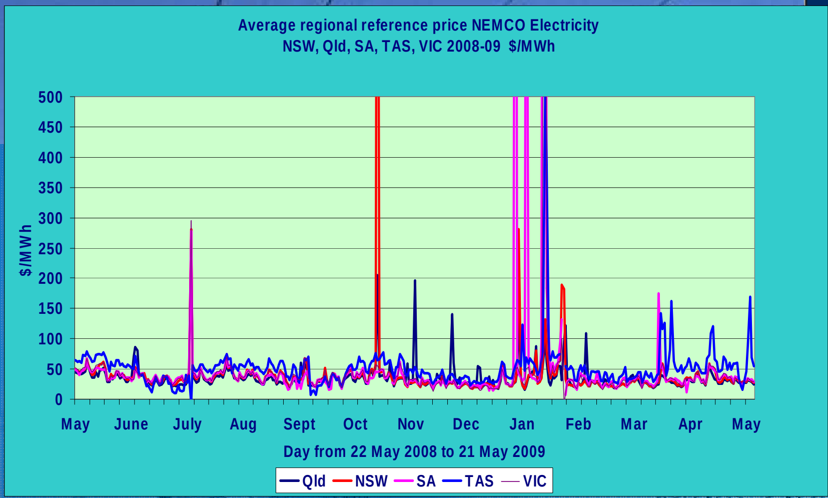


Figure 2 Fluctuation of electricity prices in Queensland, data extracted from the Australian Energy Market Operator AEMO (2009).

- 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.
- Figure 3

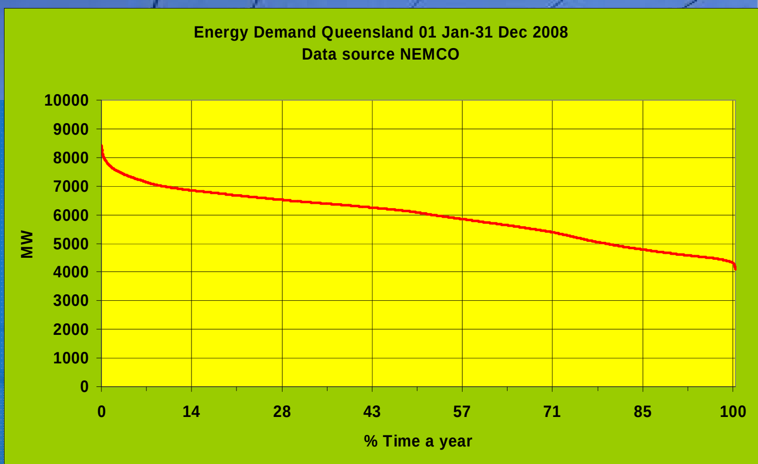
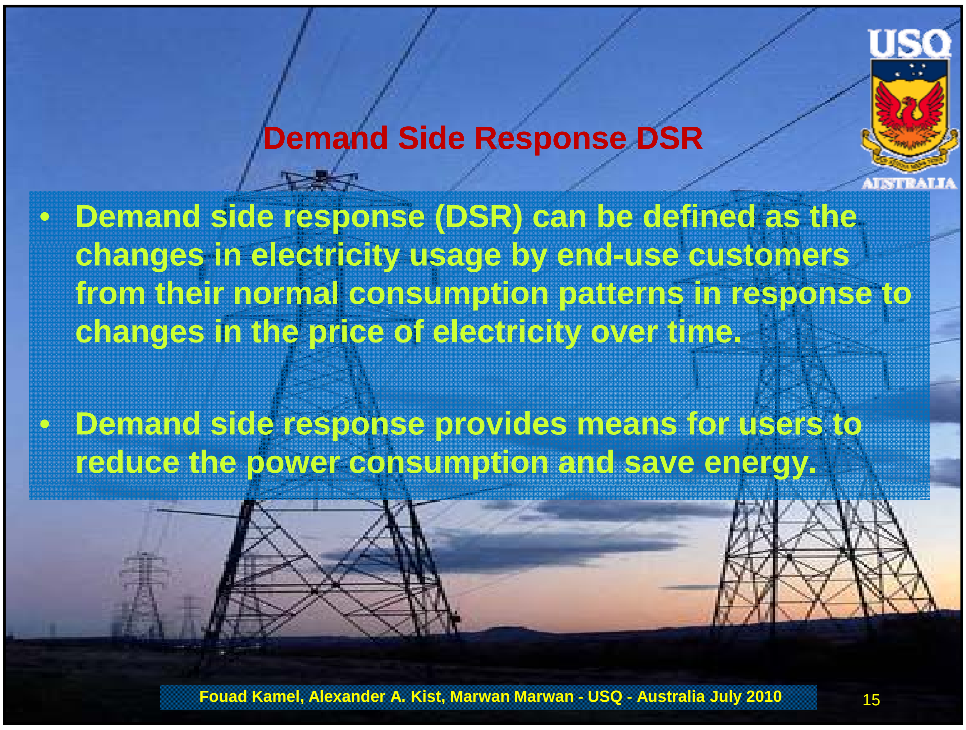


Figure 3 Electricity demand in Queensland in 2008, data extracted from the Australian Energy Market Operator AEMO (2009).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Demand Side Response DSR
• Demand side response (DSR) can be defined as the changes in electricity usage by end-use customers from 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.
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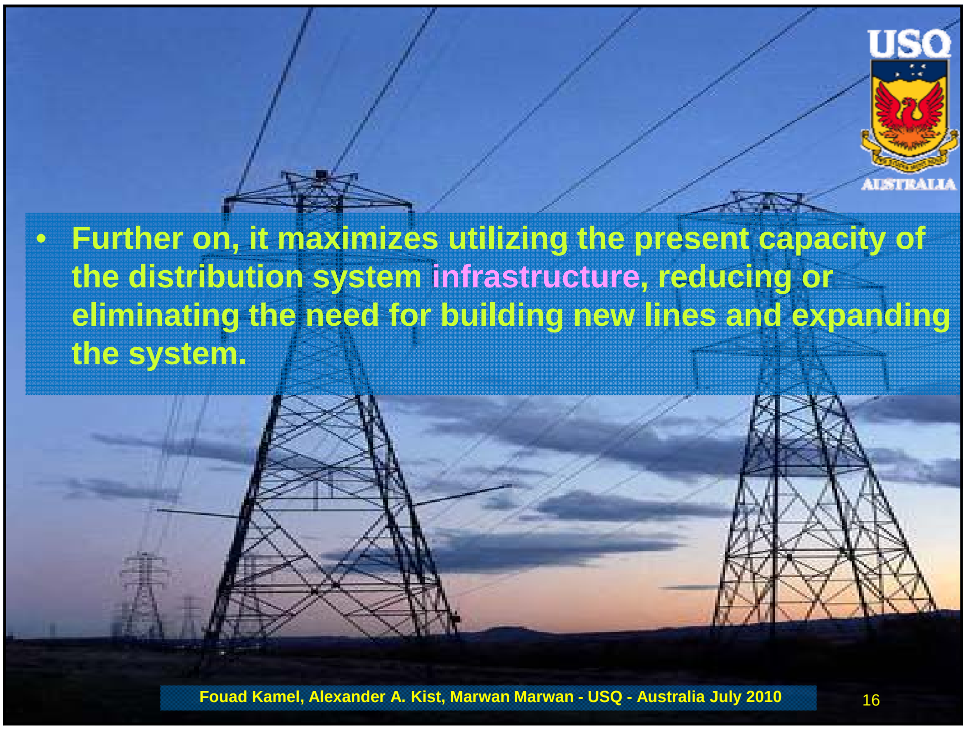
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• Further on, it maximizes utilizing the present capacity of the distribution system infrastructure, reducing or eliminating the need for building new lines and expanding the system.
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Plant Capacity 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 plants High-operation cost plants work only limited time / year to cover peak demands

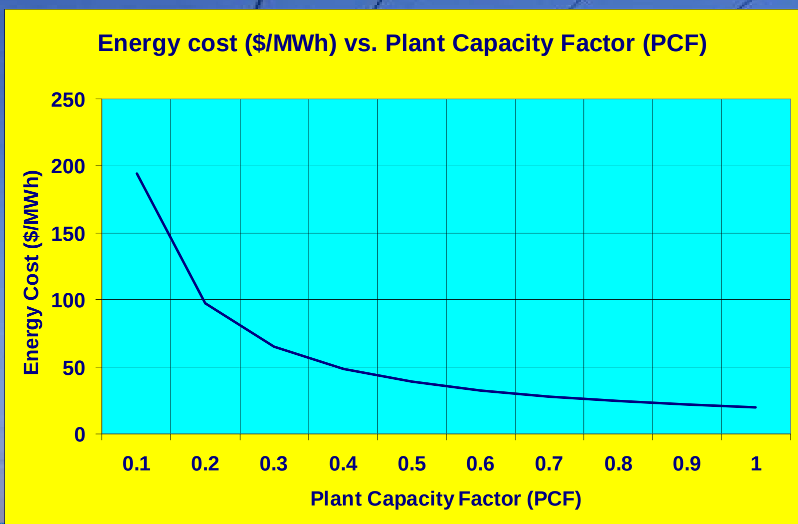
Effect of the PCF on Energy Cost

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

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

- 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

- Figure 4

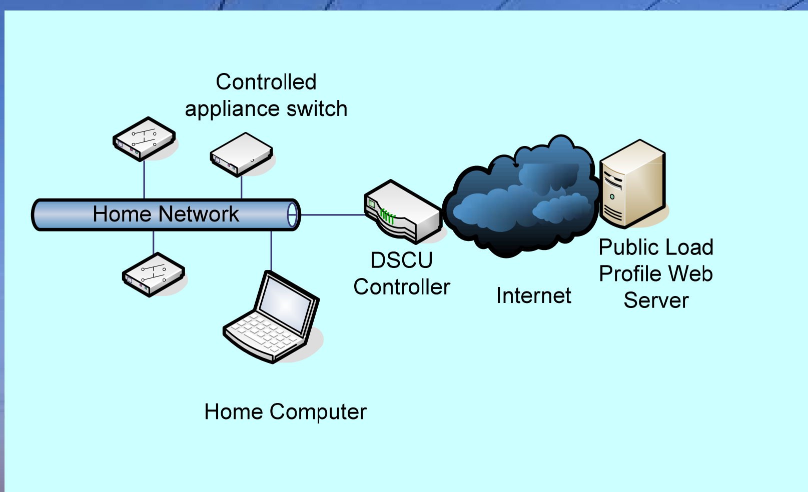


- Figure 4 Impact of the plant capacity factor on the cost of the produced energy.

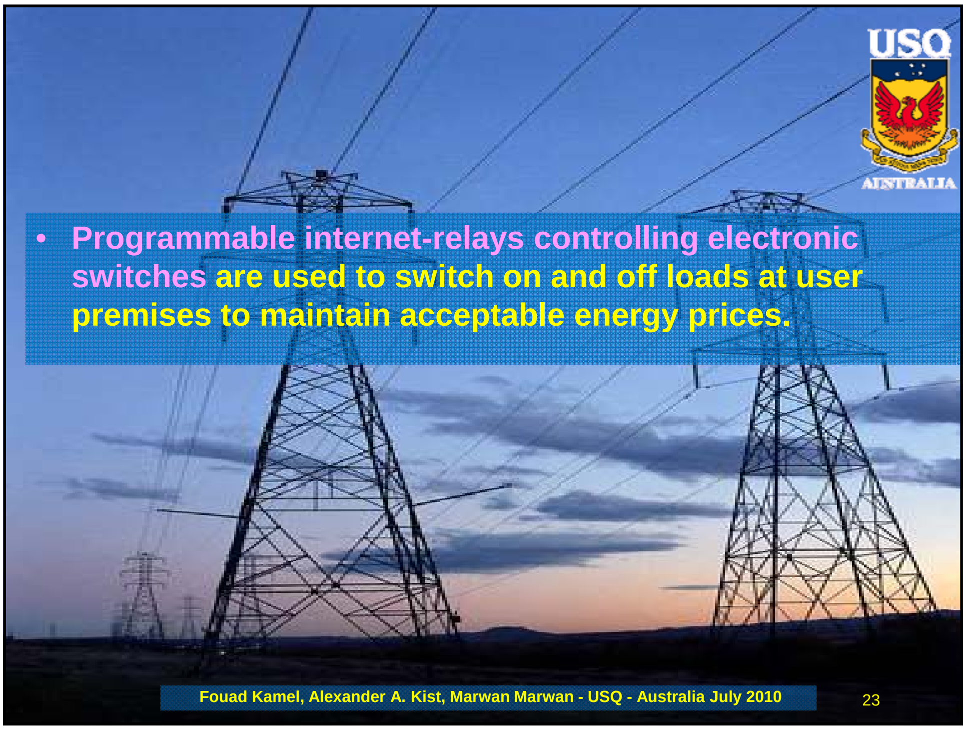
The scheme

- Figure 5 Outlines the scheme, where electricity users are enabled to switch (control) their electric demand according to 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.



- Figure 5 Controller Scenario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• Programmable internet-relays controlling electronic switches are used to switch on and off loads at user premises to maintain acceptable energy prices.
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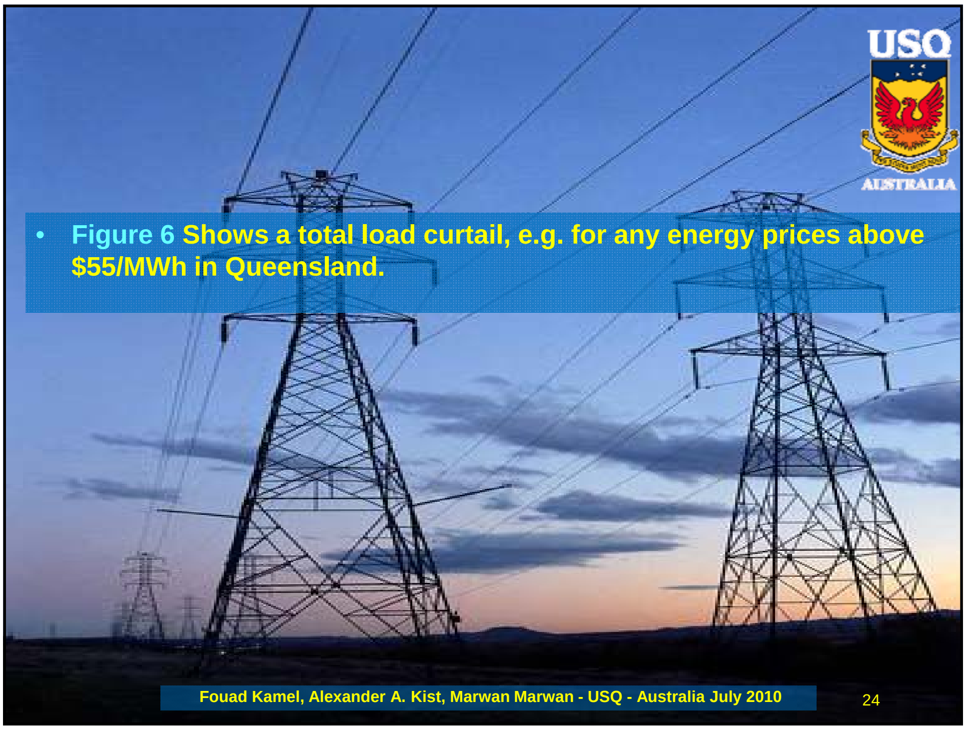
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• Figure 6 Shows a total load curtail, e.g. for any energy prices above $55/MWh in Queensland.
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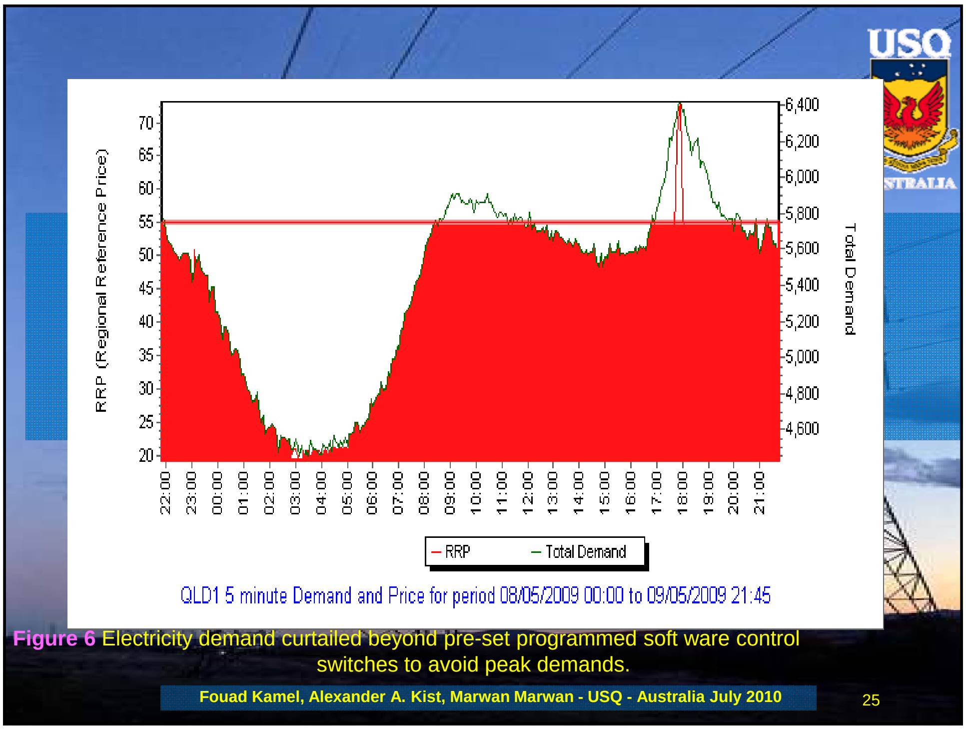
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RRP (Regional Reference Price)
70
65
60
55
50
45
40
35
30
25
20
6,400
6,200
6,000
5,800
5,600
5,400
5,200
5,000
4,800
4,600
Total Demand
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
RRP
Total Demand
QLD1 5 minute Demand and Price for period 08/05/2009 00:00 to 09/05/2009 21:45
Figure 6 Electricity demand curtailed beyond pre-set programmed soft ware control switches to avoid peak demands.
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Figure 7 Shows electricity demand curtailed in Queensland, e.g. not to exceed $55/MW.
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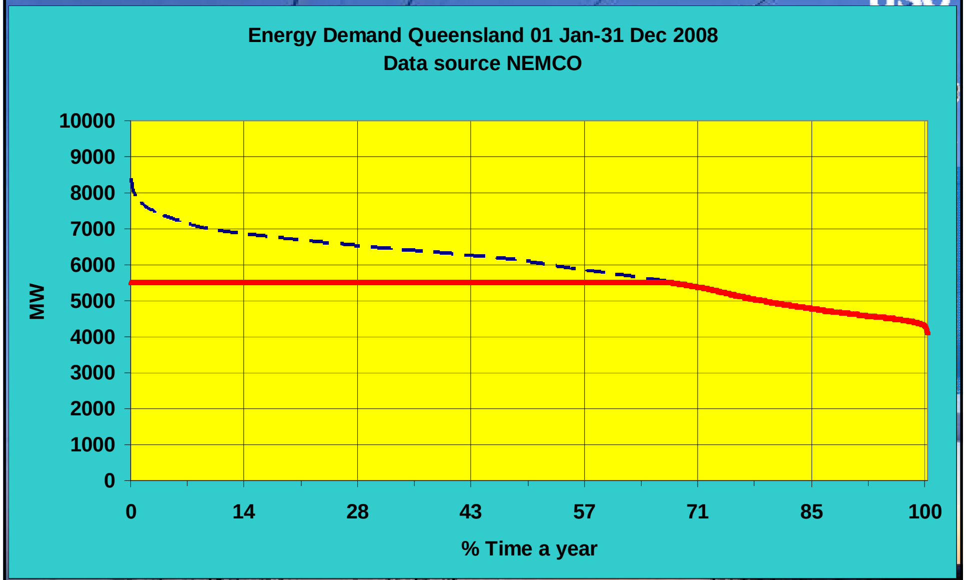
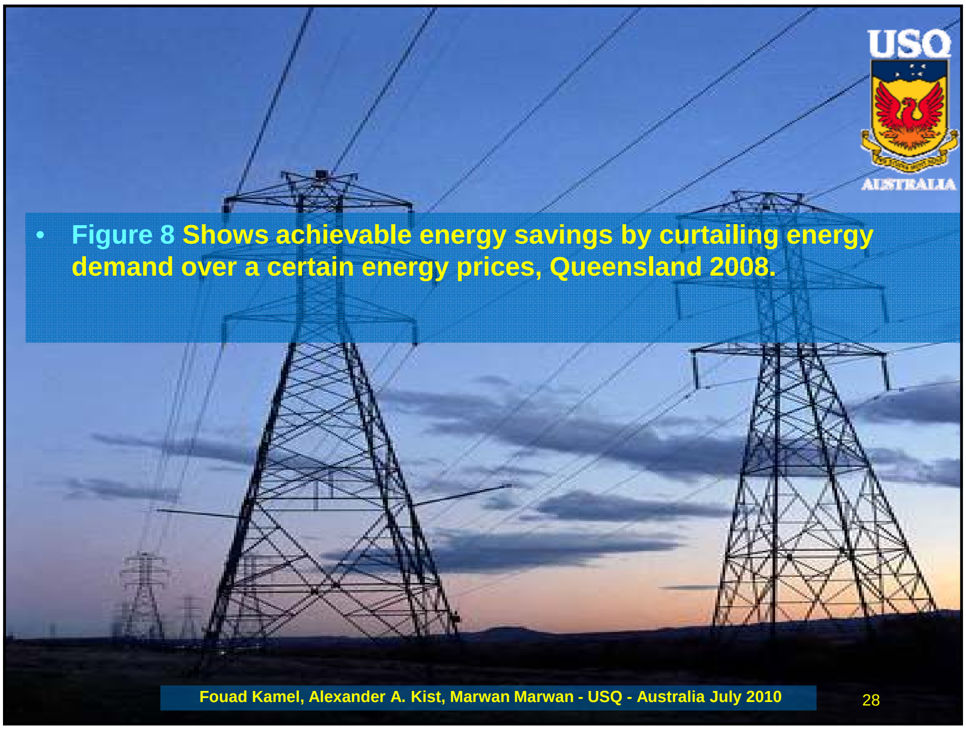
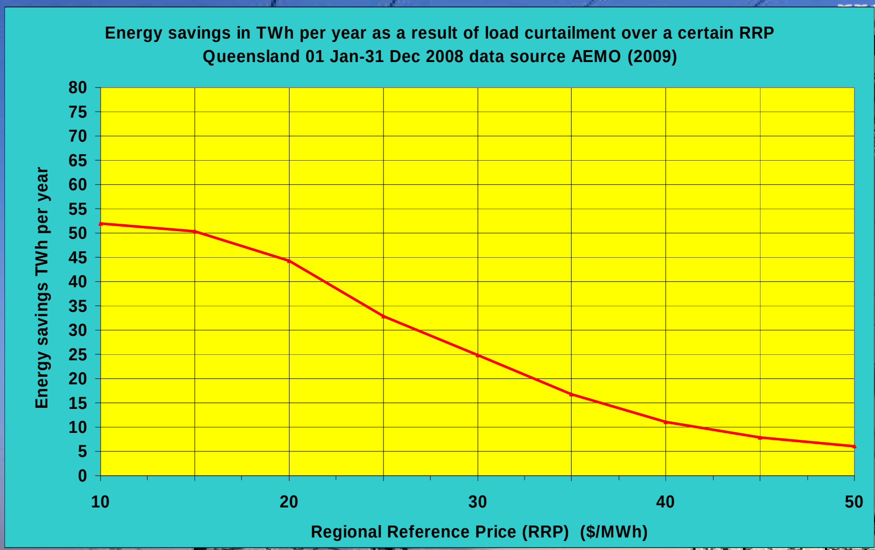


Figure 7 Electricity demand curtailed in Queensland not to exceed $55/MW.



- Figure 8 Shows achievable energy savings by curtailing energy demand over a certain energy prices, Queensland 2008.



- Figure 8 Achievable energy savings by curtailing energy demand over a certain energy prices, Queensland 2008.

- The scheme is able to remove 6.1 TWh/year from a total of 52.18 TWh/year if users are setting switches to curtail own loads at any regional reference (RR) prices above $50/MWh; this is a percentage of 11.7 % of the total demand, Figure 8.
- In case the user choose to curtail loads at $40/MWh, the savings will be 11.1 TWh/year; a percentage of 21.2%, and 24.8 TWh/year at a $30/MWh curtailment; a 47.5%.

- The scheme attempts to reduce the energy price volatility by decreasing peak demand and increasing grid reliability.
- 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 also 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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- Figure 9 Shows a possibility of energy demand shifting from peak to low-demand periods in Queensland to achieve a continuous balanced load. Total load shift 3.26 TWh/year in 2009.

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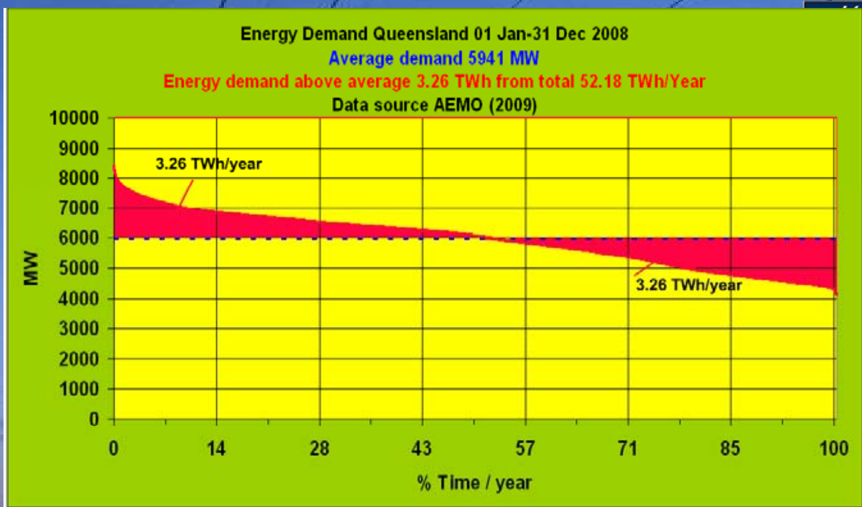
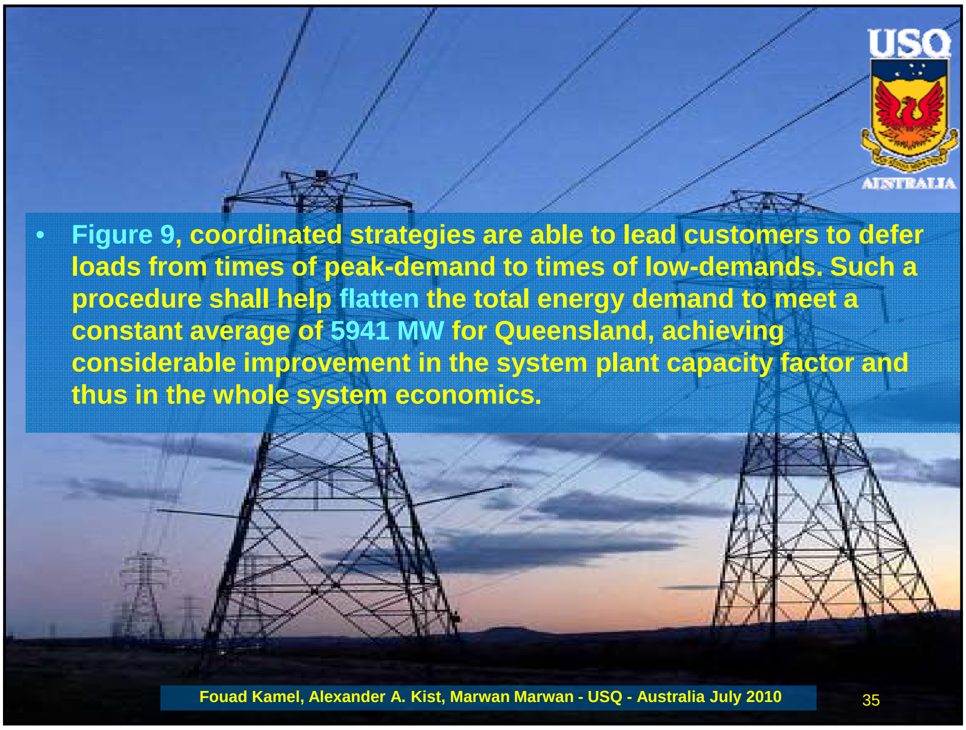


- Figure 9 Shows a possibility of energy demand shifting in Queensland to achieve a continuous balanced load. Total load shift 3.26 TWh/year in 2009.



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• Figure 9, coordinated strategies are able to lead customers to defer loads from times of peak-demand to times of low-demands. Such a procedure shall help flatten the total energy demand to meet a constant average of 5941 MW for Queensland, achieving considerable improvement in the system plant capacity factor and thus in the whole system economics.
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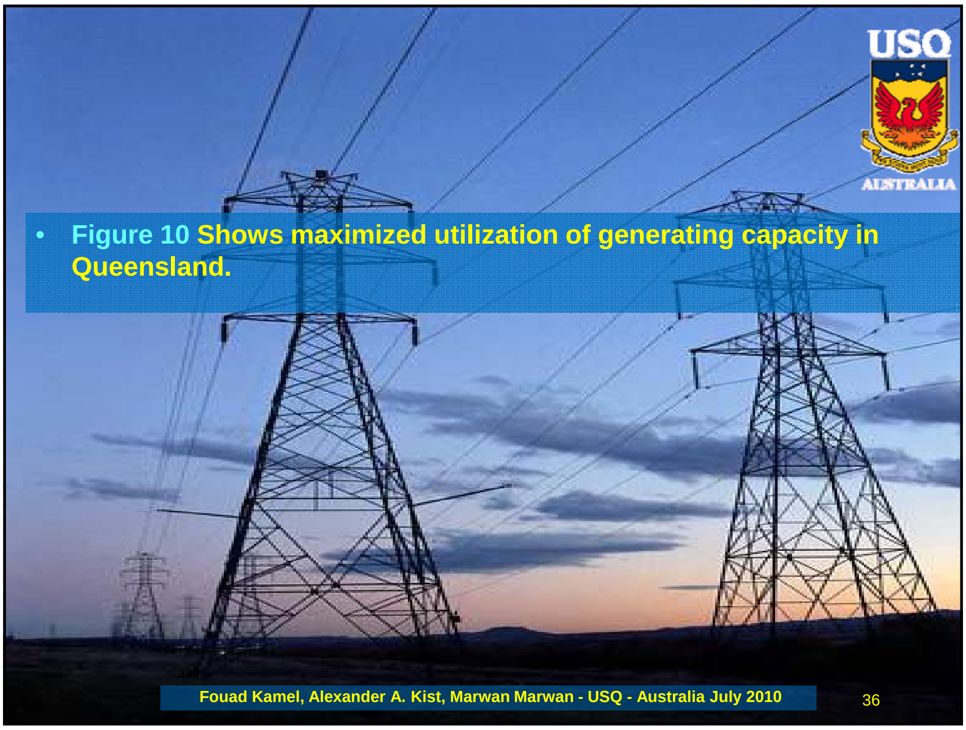

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• Figure 10 Shows maximized utilization of generating capacity in Queensland.
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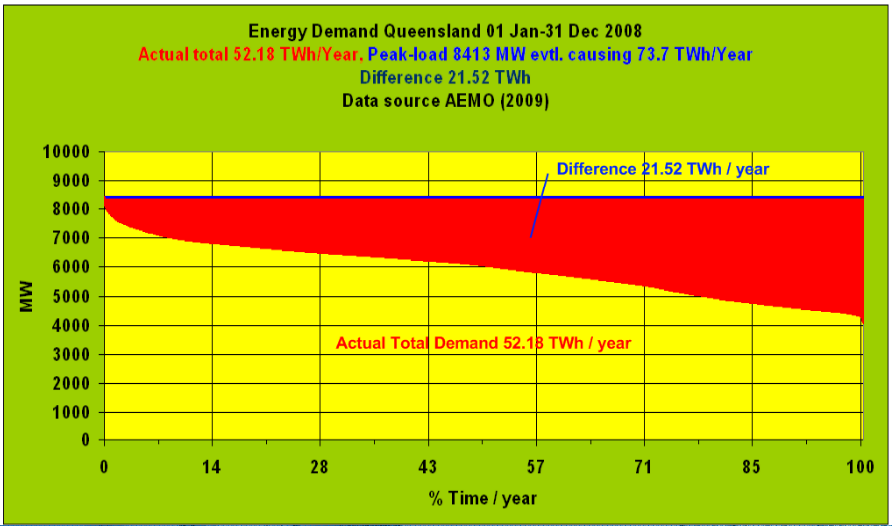

- Figure 10 Maximized utilization of generating capacity in Queensland.

- The scheme offers further the integration of the present electrical supply system to supply the transport sector for the use of charging hybrid vehicles at low-demand times (at night), Figure 10.
- The scheme offers the possibility to utilize 21.52 TWh/year of electrical capacity, mainly of peak-load power stations, otherwise not used.
- The procedure helps enhancing the utilization of present electrical power stations to approach a plant capacity factor close to the unity, achieving thus an optimal use of power plants.

- The scheme is offering the following benefits:
  - Making use of transparent users-suppliers conditions
  - Reduced energy cost
  - improved economics of power stations and electrical infrastructure
  - Reduced of environmental polluting emissions caused by the electricity sector

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 for new generation/distribution capacity achieving savings
- Enabling consumers to attend electricity prices allows them to reduce and optimize their energy consumption and realize economic savings
- The scheme is making use of the internet and modern communication systems reflecting so the benefit of the user and supplier

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