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Demand-side Response towards Optimizing Energy and Infrastructure Usages in the Electricity Supply Market – Smart Grid Tools

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Abstract

The presented scheme allows electricity users to make use of the continuous and simultaneous information communicated on the internet by the Australian Energy Market Operator enabling them to be acting on controlling, deferring or curtailing own demand by using computer-controlled switches.

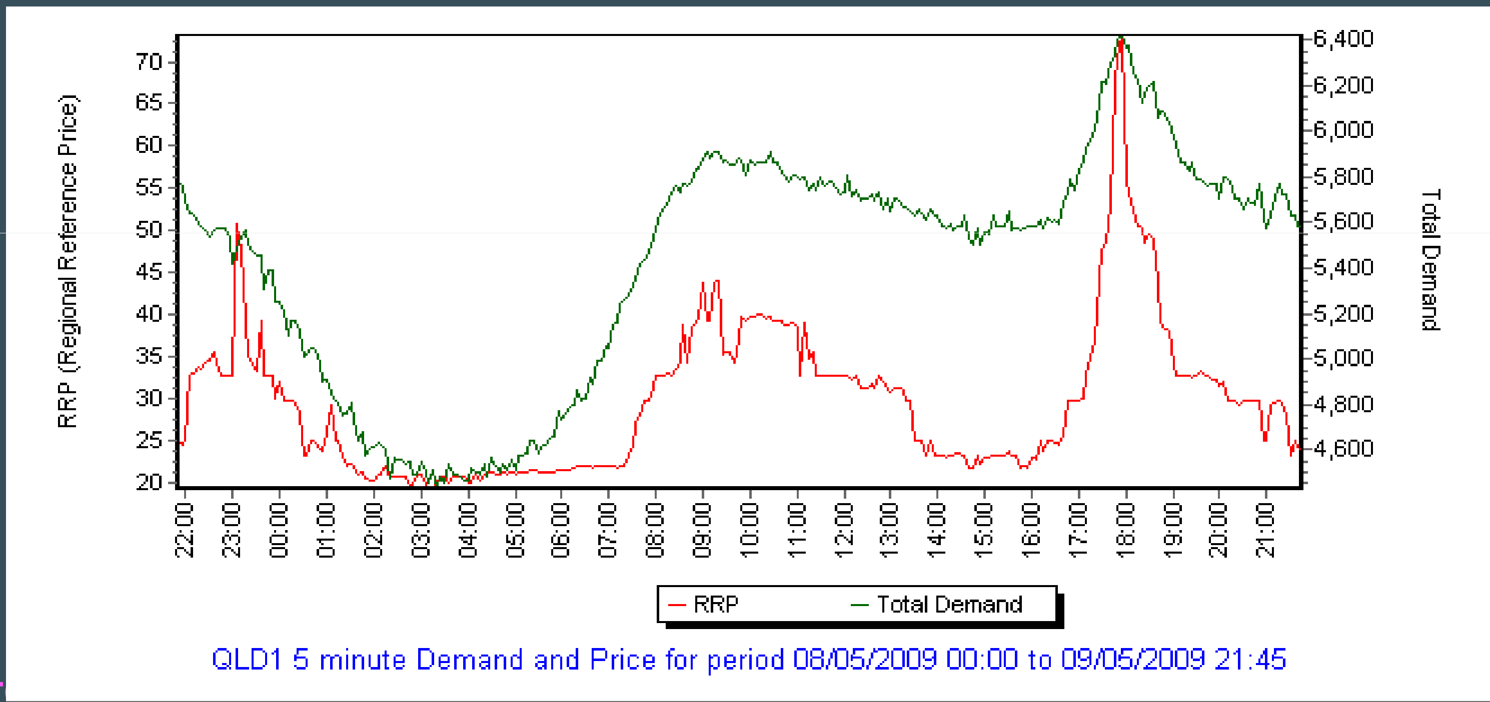
This technique is applicable in Eastern and Southern Australia where the electricity market is managed by the Australian Energy Market Operator.

The scheme enables users to be averting peak demands by deferring loads to low demand/price times.

The scheme is inherently restricted to take effect only in frame of tariff regimes made to encourage and reward conscious users being proactively participating in holistic energy management strategies. .

Introduction

- **Figure 1** depicts an example of an actual energy demand and prices situation regularly broadcasted on the internet by the AEMO, 2009.
- The **price curve** is closely following the **demand curve**.
- **Electricity prices** are typically at their lowest level **at night** during times of low demand (off-peak).



Figur

in Queensland on 5th May 2009;

source: The Australian Energy Market Operator AEMO, 2009

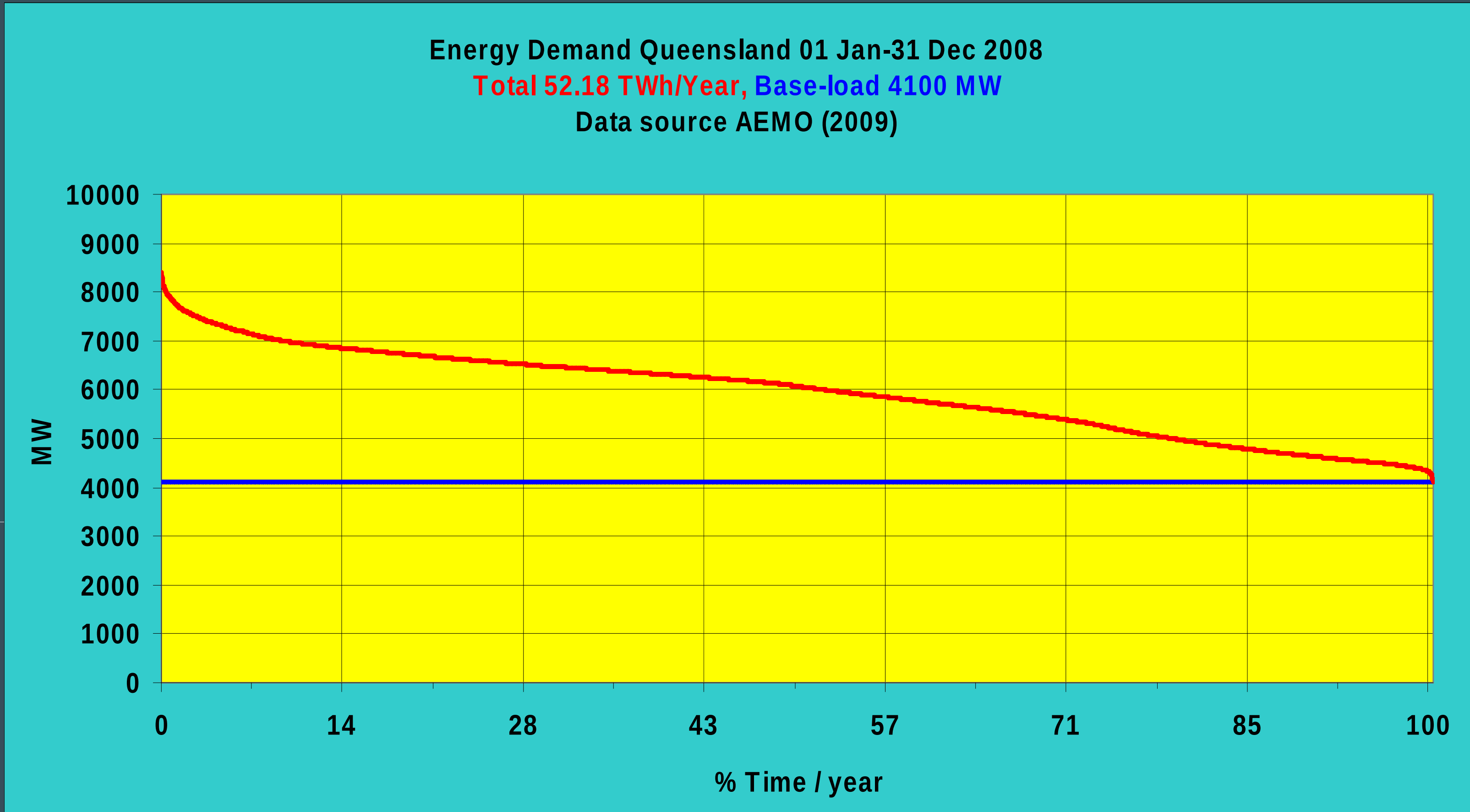


Figure 2 Occurrence of electrical energy demand Queensland during 2008.
Peak demand **8413 MW**, base-load **4100 MW,** average **5941 MW**
Total electrical energy supplied **52.18 TWh**
Energy supplied above base load **21.52 TWh**
Data extracted from the Australian Energy Market Operator AEMO, 2009.

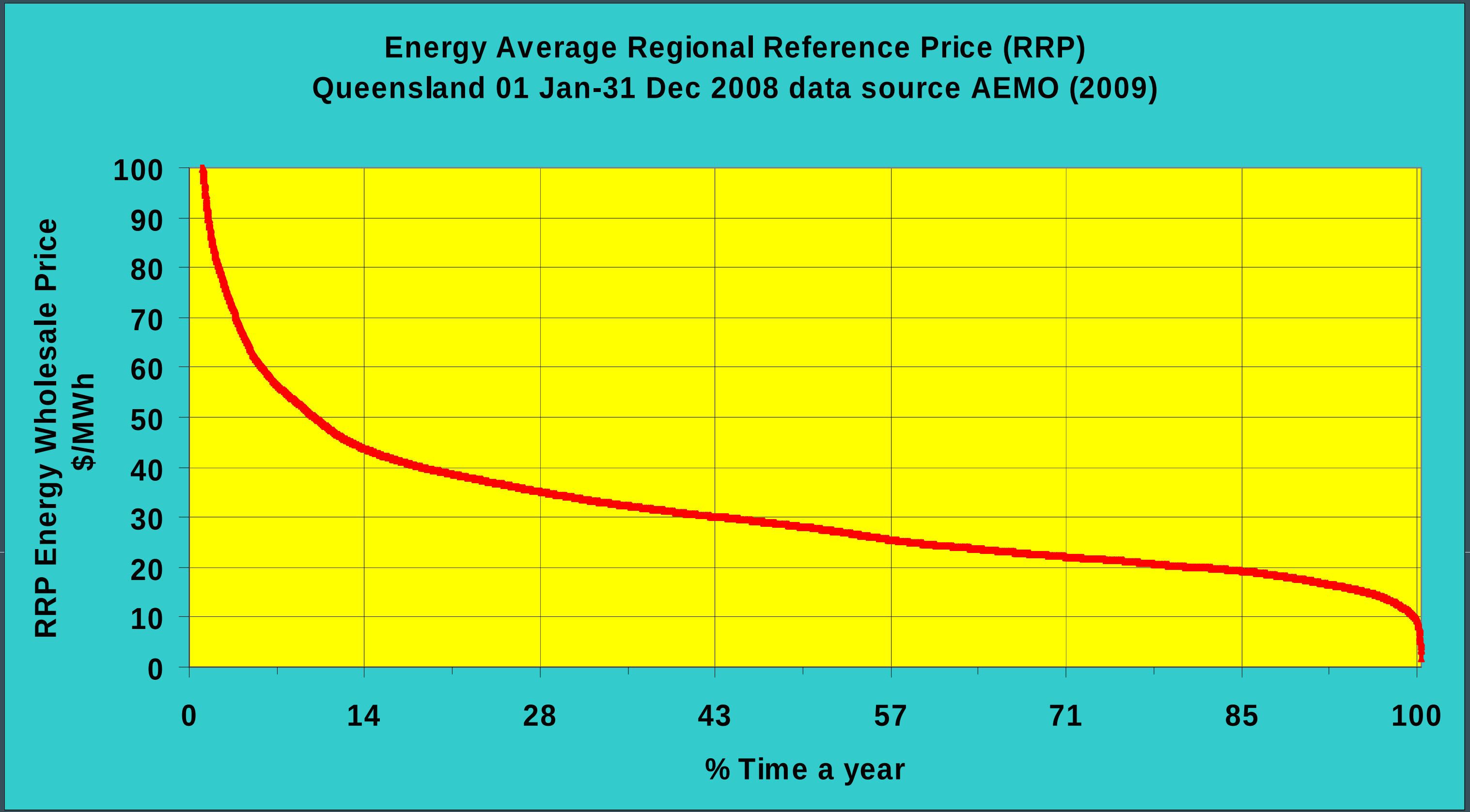


Figure 3 Occurrence of the regional reference wholesale price RRP in Queensland during the year 2008.

Prices around AUD $20/MWh are occurring at frequencies of about 80 %, while prices of over $50/MWh have occurrences of less than 10 %.

Data extracted from the Australian Energy Market Operator AEMO, 2009.

Energy cost and Plant Capacity Factor

Plant capacity factor **(PCF)** of a power plant is, by definition, the proportion between the actual electrical energy generated yearly by the plant and the electrical energy, which would be generated in case the plant is operated at its rated power for a full year time (8760 hours).

PCF has a direct influence on the **energy cost** as can be deduced from the following equations of the fixed charge method:

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

c_E	cost of energy generation,
c_{tr}	cost of installed power,
FCR	fixed charge rate of the capital, normally 15…18 % a year and
T_o	8760 the hours per year,
PCF	plant capacity factor and
c_{op}	the operation and maintenance cost of the plant.

For plants operating 24 hour/day, 7 days a week, i.e. 8760 hour/year PCF is a unity, which produces the least possible energy cost and best economic conditions.

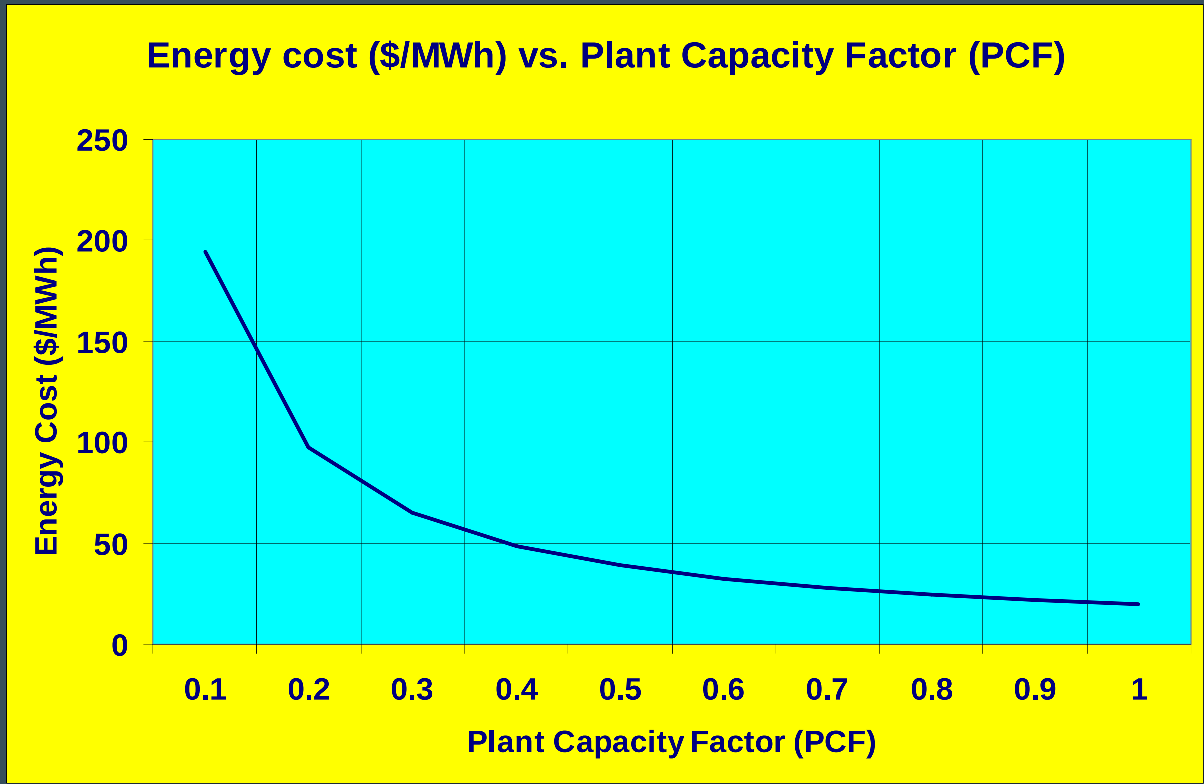


Figure 3 shows the impact of the plant capacity factor on the cost of the generated electricity. The calculation is made on the basis of the cost of the installed power c_{tr} = $1000/kW, capital fixed charge rate FCR = 0.17 and the operation and maintenance cost of the plant c_{op} = $0.02/kWh.

It is evident that a power plant operated at low plant capacity factor e.g. PCF = 0.1 (this is 2.4 hour/day) will be producing energy at a cost $150/MWh, while the same plant operated continuously for 24 hour it will be producing energy at a cost of $25/MWh.

Methodology

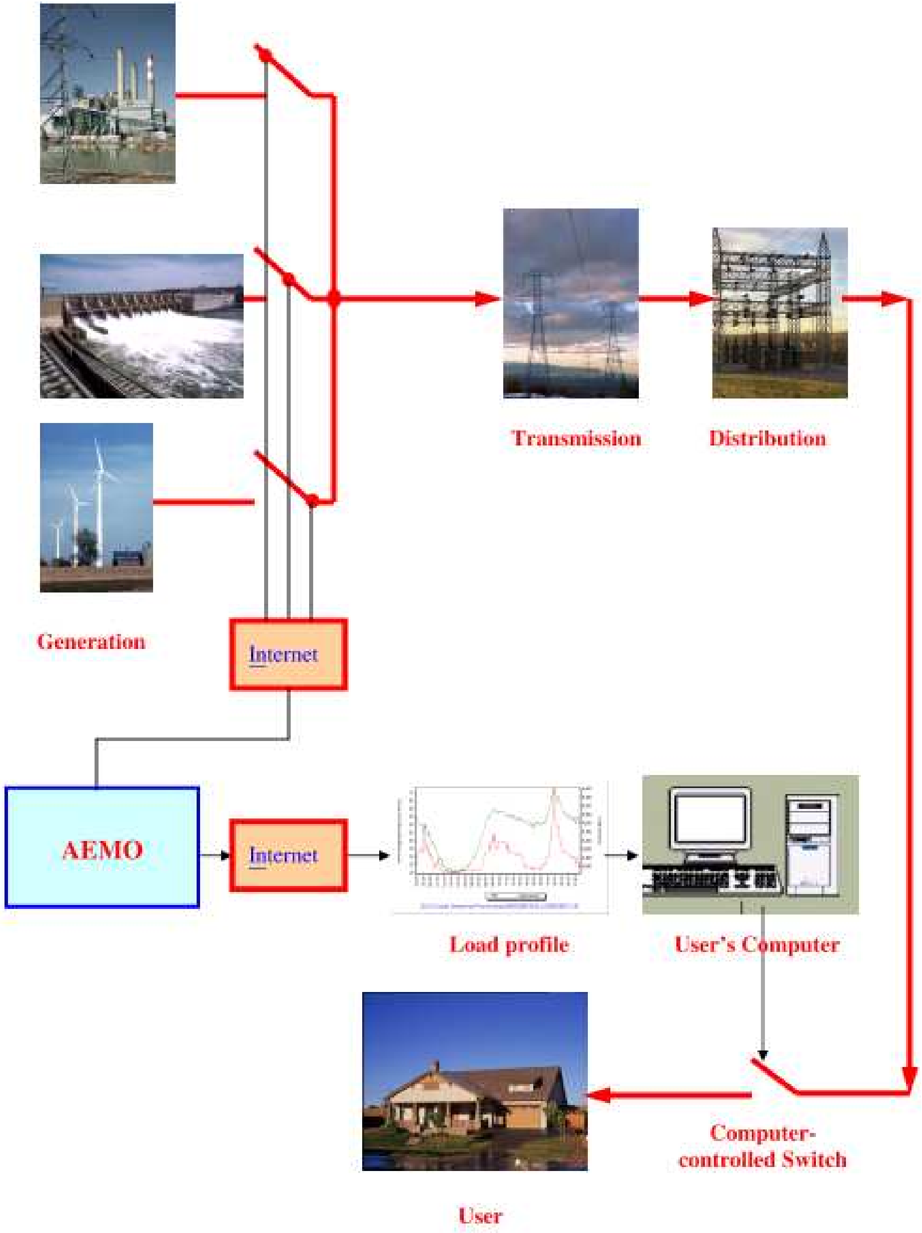
In the scheme electricity users are enabled to control their own electric demand responsive to continuous and simultaneous information publicly communicated by the Australian Energy Market Operator AEMO, 2009 on the internet.

Adjustable softwares and computer-controlled switches on user's premises are used to automatically switch on/off loads to satisfy user conditions.

Customers are then being helped undertaking information-based decisions for whether to maintain withdrawing electricity, reduce consumption or totally cut-off their connection to the supplier at certain times, energy demand or price.

Outlines of this scheme are depicted in **Figure 5**.

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



Results and discussion

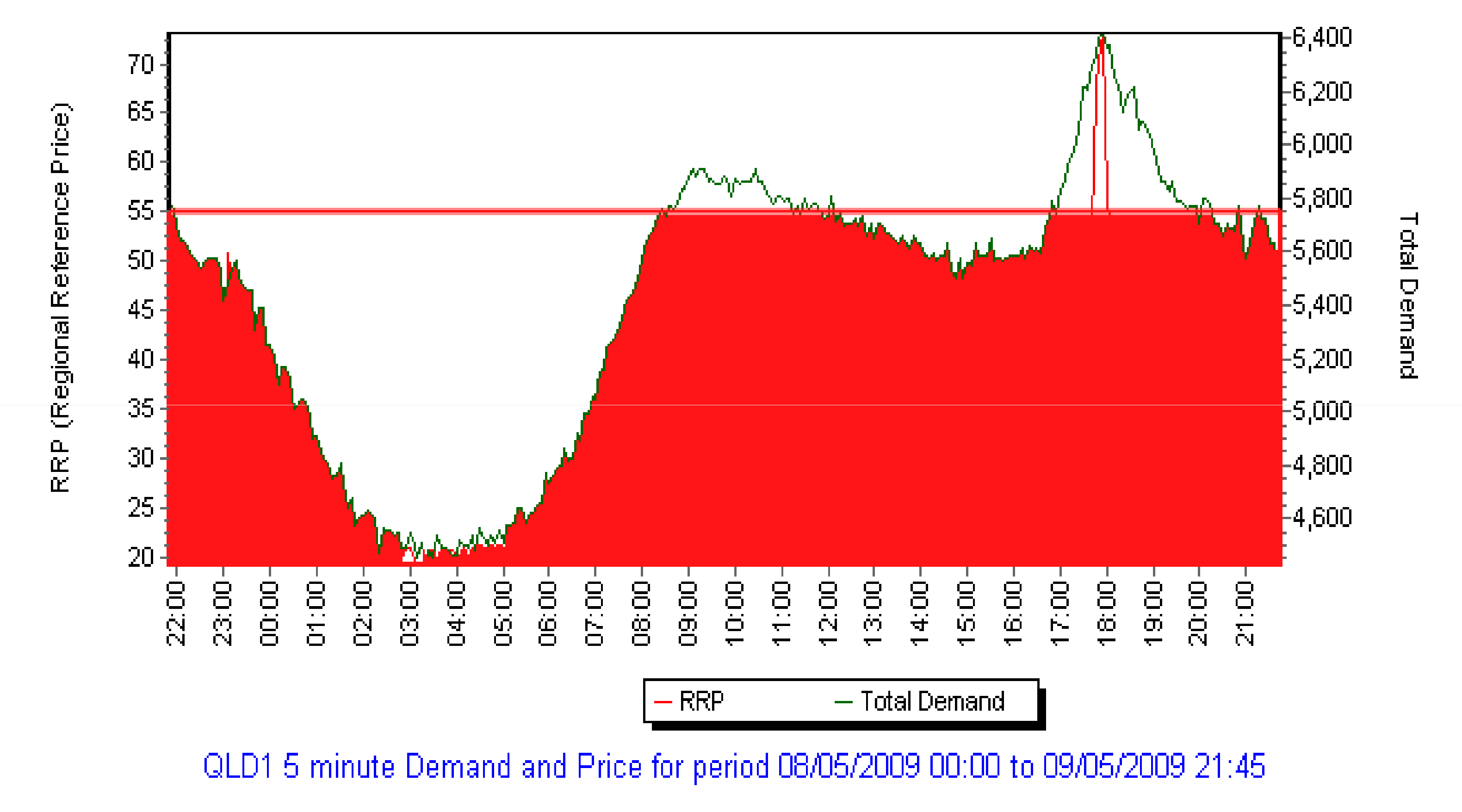


Figure 6 shows customers fully curtailing energy withdrawals at any energy price above $55/MWh as example.

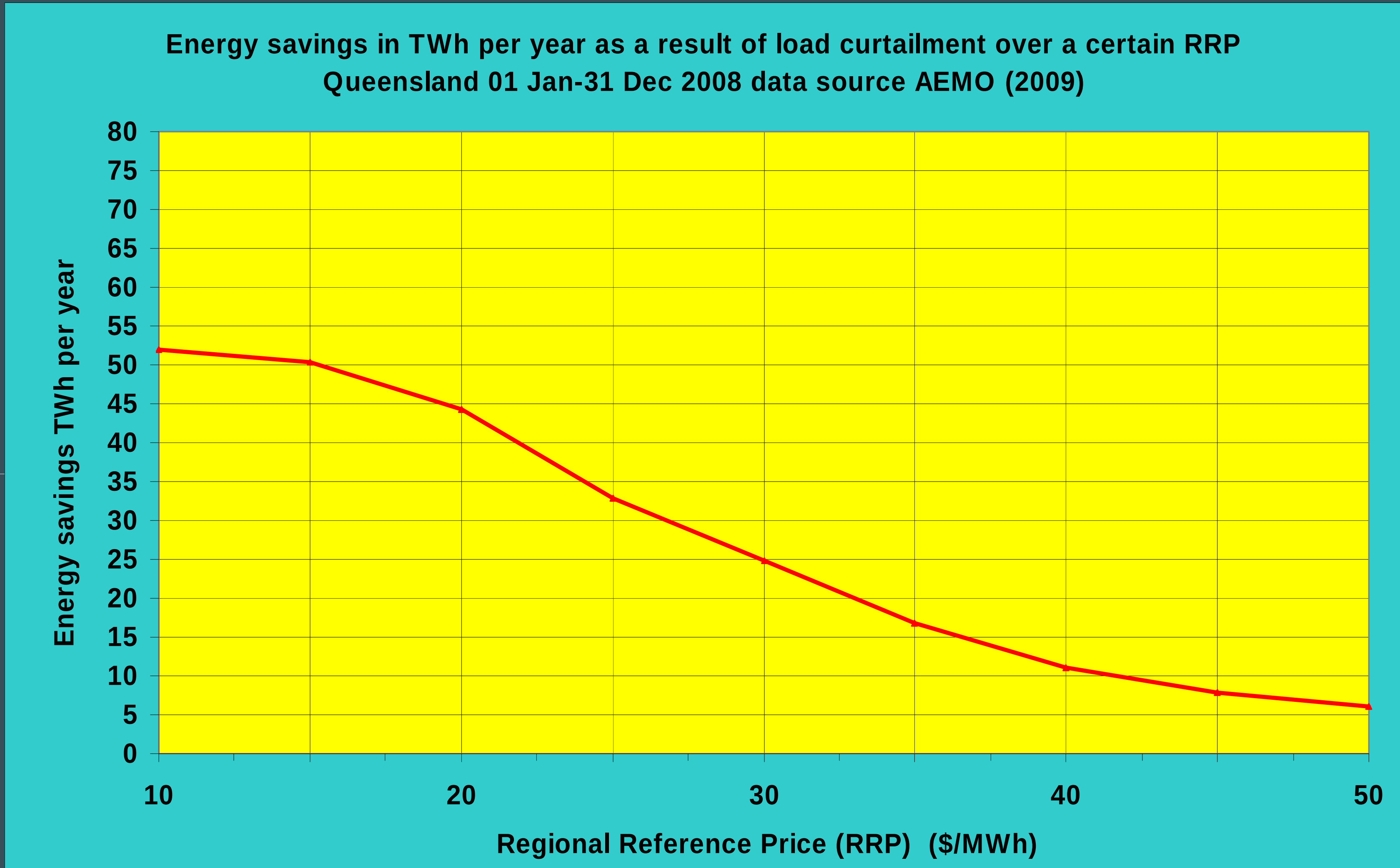


Figure 7 shows achievable energy savings by curtailing energy demand over a certain energy prices, Queensland 2008.

Energy demand in Queensland 2008
Total 52.18 TWh/year

Curtail energy price $/MWh	Energy demand removal TWh/year	Savings %
50	6.1	11.7
40	11.1	21.2
30	24.8	47.5

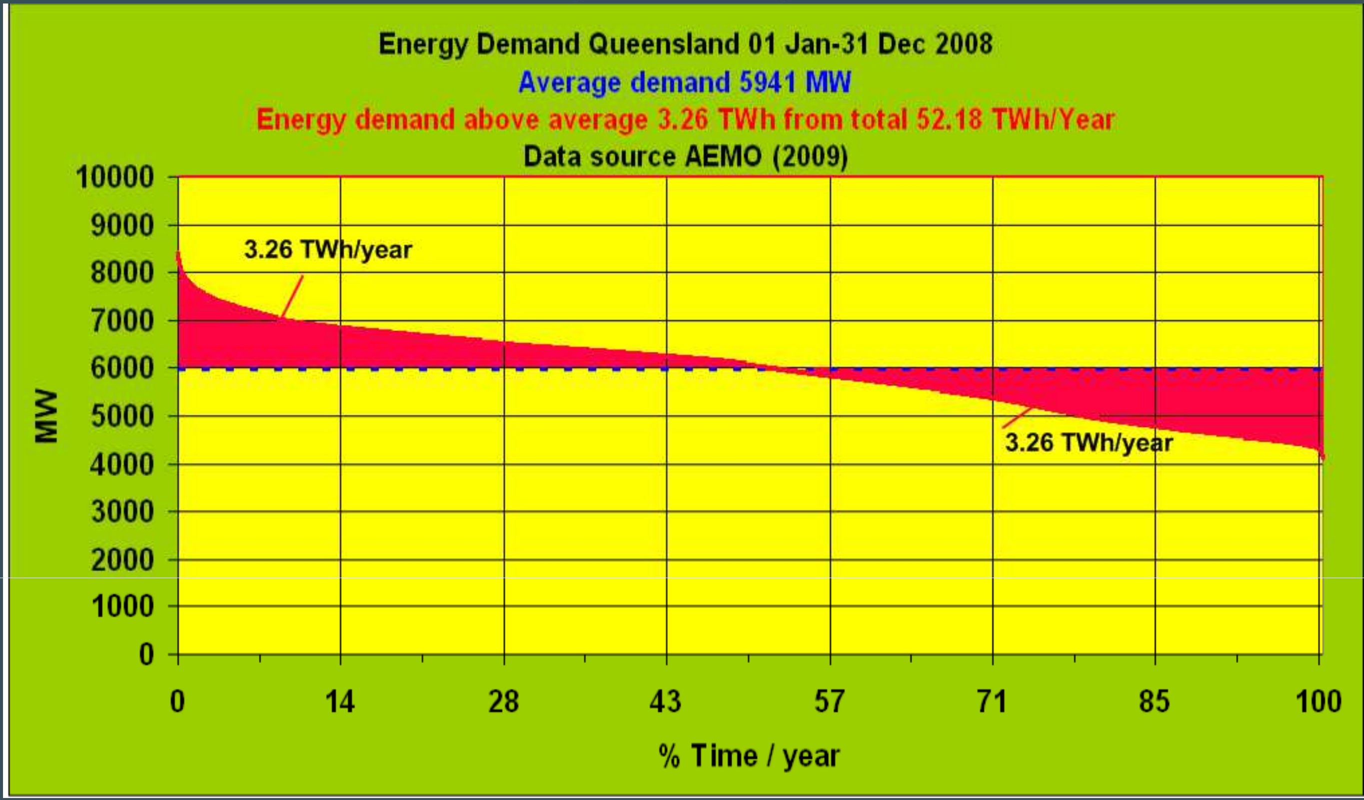


Figure 8

- Coordinated actions are enabling 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.
- In such a procedure the scheme enables deferring 3.26 TWh/year from peak to low demand times.

Energy consumption in Australia by industry

	1974-75 PJ	1979-80 PJ	1989-90 PJ	1999-00 PJ	2006-07 PJ
Agriculture	39	47	55	72	92
Mining	65	81	160	273	457
Manufacturing	928	965	1 067	1 192	1 369
Electricity generation	540	743	1 066	1 427	1 695
Construction	29	38	41	29	26
Transport	701	825	1 012	1 267	1 359
Commercial a	87	104	151	219	252
Residential	246	262	322	392	442
Other b	59	66	69	77	78
Total	2 695	3 131	3 944	4 946	5 770

a Includes ANZSIC Divisions F, G, H, J, K, L, M, N, O, P, Q and the water, sewerage and drainage industries. **b** Includes consumption of lubricants and greases, bitumen and solvents, as well as energy consumption in the gas production and distribution industries.

Source: ABARE, *Australian energy statistics.*

Figure 9 Energy consumption in Australia, source: RET, 2009

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).

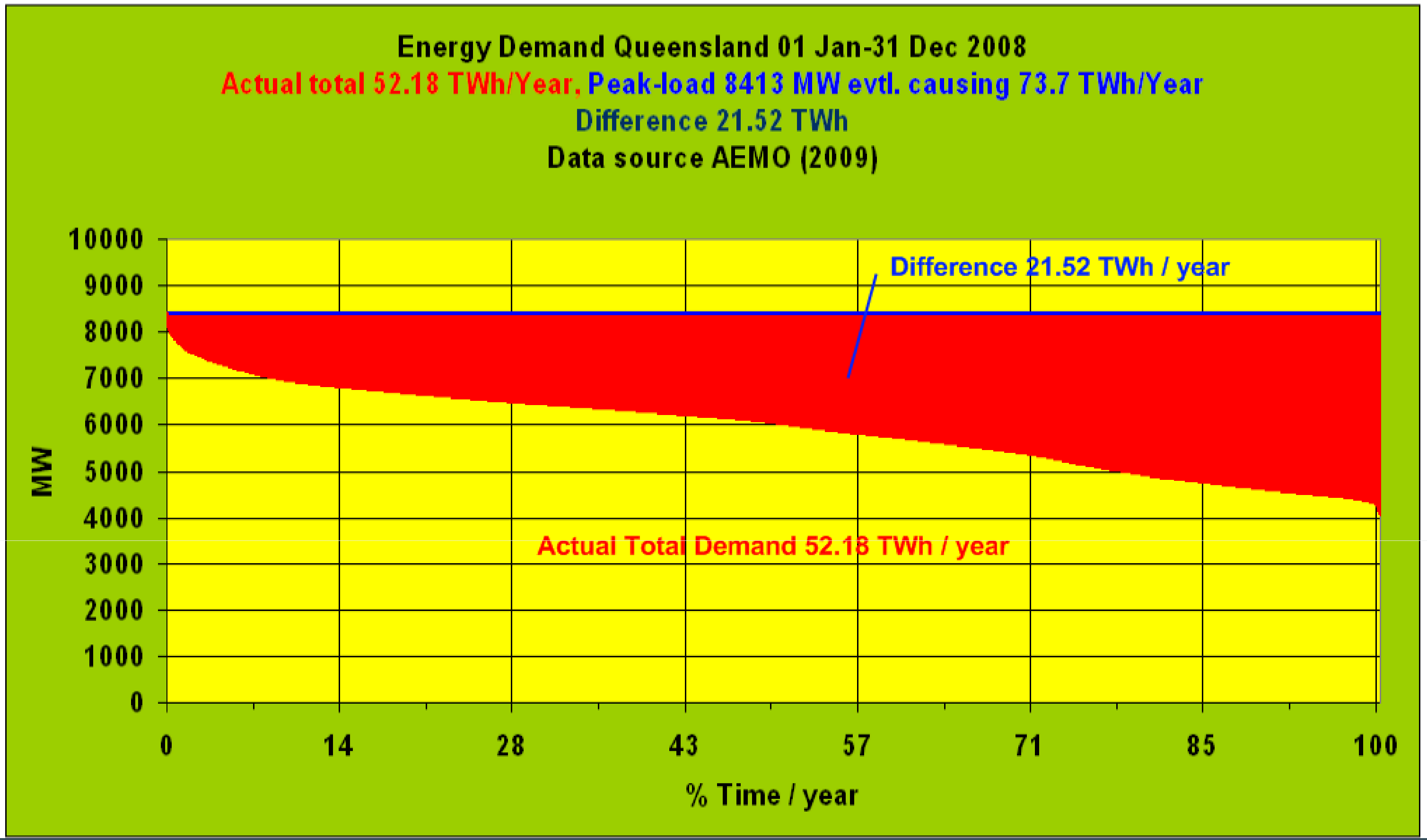


Figure 10 depicts the possibility to utilize 21.52 TWh/year of electrical capacity, mainly of peak-load power stations, otherwise not used. The procedure helps enhancing the utilization of present electrical power stations to approach a plant capacity factor close to the unity, achieving thus an optimal use of power plants.

Conclusions

- The study introduces the use of computer-controlled switches to control peak electrical demand curtailing or shifting loads to different times of a day when the demand is less strained.
- Providing consumers, on the internet, with the information needed to control own electricity demand allows them to be consciously and proactively reducing and optimizing their energy consumption.
- The scheme is helping achieving:
  - improved electrical supply services,
  - reduced energy cost
  - Removing price volatility,
  - enhanced grid reliability,
  - optimized energy consumption,
  - reduced additional electrical capacity
  - improved utilization of the existing infrastructure.
- Referring to the fact that actual load-price curves are presently being publicly accessible on the AEMO website the scheme is today readily applicable.

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