# Electricity Markets Research Institute

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## *Submission to the Inquiry into Energy Efficiency Improvements*

### Preface

This submission is based on an intimate knowledge of the Victorian Electricity Industry Restructuring, the close involvement with the establishment of the National Electricity Market (NEM), over 15 years experience in electricity cost modeling and pricing development, both under a regulated environment and in the new competitive market and a keen interest in the techno-economics of energy use in Australia. As the attached biography shows, the author has professional qualifications and over 30 years experience in both electrical and mechanical engineering aspects of electricity generation, distribution and end-use.

Electricity Markets Research Institute (EMRI) undertakes research with primary focus on:

- Public benefit aspects of competitive energy markets;
- Technical and market efficiency;
- Equity issues;
- Transition issues going from integrated utility in a monopoly market to competitive marketing.

A brief write-up of the work of EMRI and a short biography of the author are given in Attachment A.

### 1.0 Introduction

The Environment and Resources Committee of the Queensland Parliament is to be congratulated for the foresight in instituting this inquiry into energy efficiency, which they very rightly define as "*Energy efficiency, unlike energy conservation, aim to reduce energy consumption while at the same time maintaining or increasing the level or useful output of outcome delivered using less energy input*". Technology development is not frozen in time and countries like USA, UK, and New Zealand do not have a monopoly on technology development. New industry developments also create new opportunities for process / procedure / rules adaptation. While some of the new technologies mentioned in the submission may not yet be proven in operation, key component technologies have been proven in other industry applications. There is merit in considering them if they **inform the development options available to the Queensland energy industry in the next 5 to 10 years.**

This submission will be structured as follows:

A. Expand on the definition of energy efficiency and explore concepts like synergy, technical efficiency, economic efficiency, environmental efficiency, societal efficiency, time efficiency, full cycle assessment, factor productivity, etc.;
B. briefly discuss already established technologies / processors impinging on energy efficiency outcomes;
C. provide a simplified account of the brand new technologies that will further improve energy efficiency in the near future. More detailed account is given in the accompanying Confidential part of the submission;
D. briefly discuss new imperatives that will substantially alter future energy industry structure;
E. explore available energy efficient options for Queensland to
    1) achieve a sustainable energy future;
    2) reduce greenhouse gas emissions;
    3) reduce the need for investment in energy infrastructure;
    4) cut fuel costs, increase competitiveness and improve consumer welfare;
F. make recommendations.

## A.0 Energy Efficiency

According to the Wikipeda encyclopedia "*Efficient energy use, sometimes simply called **energy efficiency**, is using less energy to provide the same level of energy service*" but misses the rigor of the classical definition that provide for two more aspects of efficiency, viz where lesser input provides the same output, or the case where a lesser output results from a proportionately lower input. The vast array of energy units we have is testimony to the many forms of energy we have to deal with, eg. electrical energy, thermal energy, potential energy, solar energy, wind energy, nuclear energy, etc. etc. The definition of energy efficiency is applicable to each stage of energy transformation, not only to the final stage of energy end-use.

Energy raw material extraction can be considered a particular form of energy transformation, eg coal, oil or gas usually found underground are harvested and prepared for sale as energy raw materials. A Puritan would be concerned with amount of energy that has to be expended to make available one unit of energy embedded in coal, crude oil or gas. An Economist will say efficiency is also to do with factor productivity, the factors being those used in a production environment of which energy is only one factor. Economists use cost as the common denominator to combine the contribution from the different factors. An extension of this is 'least cost planning' and on such a yardstick coal power stations situated close to the coal mine are hard to beat.

We therefore have two concepts of efficiency. **Technological efficiency** occurs when it is not possible to increase output without increasing inputs. **Economic efficiency** occurs when the cost of producing a given output is as low as possible.

Up to now electricity from coal has been the least costly and so coal now account for around 70% of the world production of electricity. This is in spite of the fact that average 'energy efficiency' of existing coal power stations is less the 25% and average 'energy efficiency' of existing gas power stations is between 30% and 55%. Up to now there has been no assessment of the environmental impacts from using different energy raw materials and as yet there is no accurate measure of the cost of their environmental impact. Lacking consensus on various contributory factors for environmental degradation, the focus has turned to Greenhouse Gas (GHG) emissions - of which carbon dioxide is the biggest component. If this is the over-riding influence, we should be concentrating effort on **Environmental efficiency**, ie an efficiency measure specific to assessing GHG emission reductions.

Given the enormity of the task and time constraints involved in effective containment of Global Warming and capital constraints resulting from the Global Financial Crisis we have been through, any plans we may be formulating will need to also evaluate the **Capital Cost efficiency** and **Time efficiency** of candidate response options.

Wikipeda encyclopaedia traces the origin of the word 'synergy' as coming from the Greek words syn-ergos, meaning working together. It is a term used to describe a situation where the combined effect exceeds the sum of their individual effects. Synergy fits well with the notion of Total Factor Productivity, especially when assessments involve multiple objectives. By combining supply side energy efficiency with efficiency in energy use, we stand to achieve much more benefits than when we examine them separately, eg co-generation at the customer premises enables useful recovery of heat energy otherwise wasted, significantly improving the efficiency of the combined operation, not forgetting the savings in electricity transportation losses and deferred capital costs of associated infrastructure.

## B.0 Energy Situation in Australia and in Queensland

To appreciate the role of Energy Efficiency, it is important to have a good understanding of the broad energy scenario we are faced with. We need an appreciation of our energy resource endowments, our current levels of energy production and use, the breakdown of the different energy forms, the different energy uses, the GHG emissions position, the competitiveness of these different energy forms to provide our desired benefits:

- reduce greenhouse gas emissions
- achieve a sustainable energy future
- reduce the need for investment in energy infrastructure, cut fuel costs, increase competitiveness and improve consumer welfare

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The following summary data about Australian energy sources / industry breakdowns / energy consumption, etc are sourced from the latest ABARE publications on Australian Commodities and Australian Energy.

## B.1 Energy Resources in Australia

2 Australia's economic demonstrated resources, January 2007 a

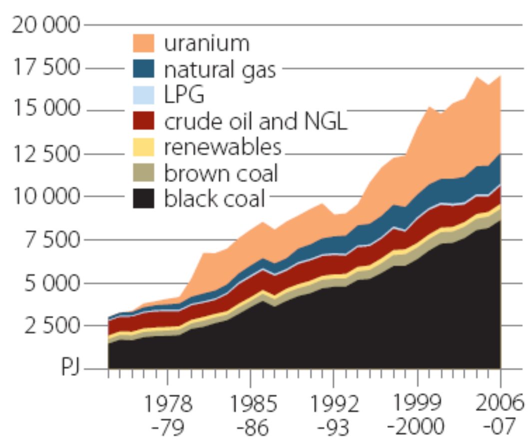
| | unit | Australia | share of World % | reserves to production b yrs | PJ |
|---|---|---|---|---|---|
| **Coal c** | | | | | |
| Black coal | Gt | 39 | 5.4 | >100 | 1 053 000 |
| Brown coal | Gt | 37 | 24.1 | >500 | 362 600 |
| **Petroleum** | | | | | |
| Oil | GL | 173 | 0.3 d | 8 | 6 401 |
| Condensate | GL | 258 | na | 36 | |
| LPG | GL | 214 | na | 45 | 5 671 |
| **Gas** | | | | | |
| Conventional gas | PJ | 98 264 | 1.4 | 57 | |
| Coal seam methane e | PJ | 12 833 | na | 101 | |
| Uranium f | kt | 1 163 | 38.0 | 138 | |

a Coal and Uranium as at January 2007, petroleum and gas as at January 2006. b 2007 rates of Australian production. c Recoverable resources. d Naturally occurring crude oil, condensate and LPG combined. Shares of total world EDR reserves for oil and natural gas sourced from BP Statistical Review. e Proved and probable reserves as at November 2008. f RAR recoverable at costs of less than US$80/kg U. *Sources:* Geoscience Australia 2008, *Australia's identified mineral resources 2007, Oil and gas resources of Australia 2005*; Energy Quest, EnergyQuarterly, November 2008.

A point worth noting is that 'economic demonstrated resources' depend on markets for that form of energy, infrastructure to get that energy to the market, prevailing prices, etc.

## B.2 Energy Production in Australia by source

Australian energy production




*Source*: ABARE, *Australian commodity statistics.*

## B.3 Energy Transformation in Australia by sector

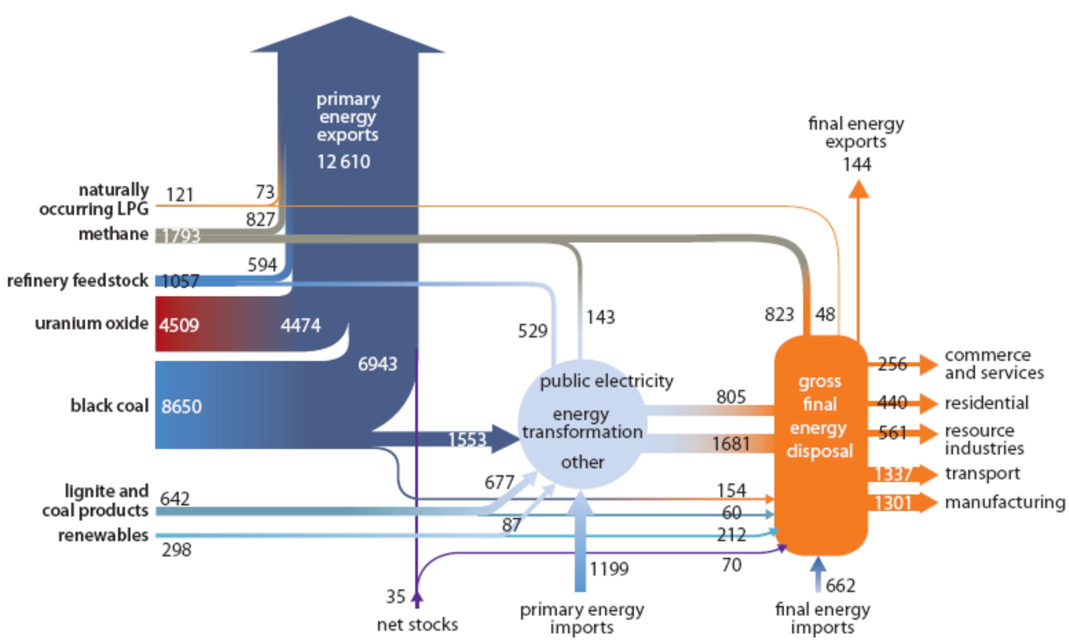
1 Energy related industries in Australia, 2006-07

| | industry value added A$b | gross fixed capital formation A$b | employment '000 |
|---|---|---|---|
| Coal mining | 16.4 | 5.4 | 26.5 |
| Oil and gas extraction | 22.4 | 6.5 | 10.2 |
| Petroleum refining and petroleum fuel manufacturing | 2.2 | 0.5 | 5.8 |
| Electricity supply | 14.6 | 8.5 | 43.9 |
| Gas supply a | 1.5 | 0.8 | 2.0 |
| Total | 57.1 | 21.7 | 88.4 |
| Australian economy | 961.9 | 238.5 | 10 436 |

a Gas distributed to end users.
*Sources*: Australian Bureau of Statistics, Mining operations, cat. no. 8415, Manufacturing Industry, cat. no. 8221, Electricity, Gas, Water and Waste Services Australia, cat. no. 8226, Australian System of National Accounts, cat. no. 5204, Australian Labour Market Statistics, cat. no. 6105.

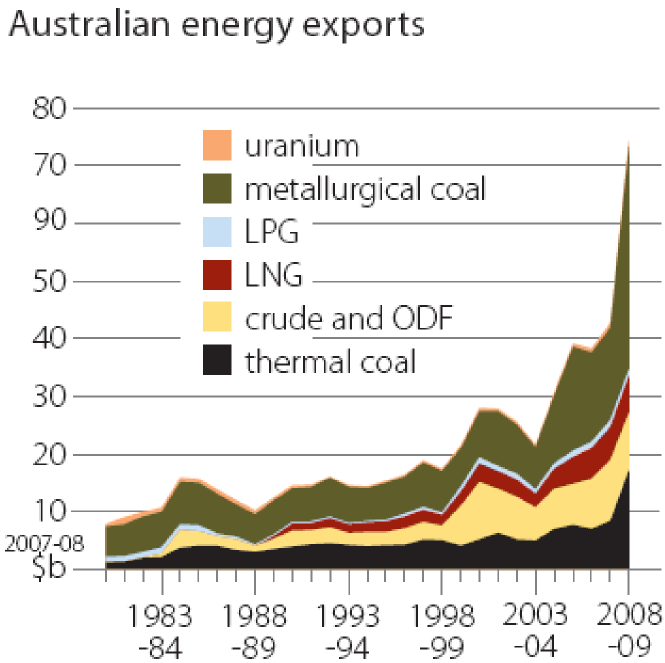
An important part of government policy would have to be concerned with how much of domestic cheap and clean energy sources are available to satisfy domestic demand and to provide competitive advantage to domestic industries /businesses. The lopsidedness of Australian energy flows is a stark reminder to energy policy planners.

Australian energy flows
units: petajoules




*Source*: ABARE, *Australian energy statistics*.

## B.4 Australian Energy Exports by source




*Source*: ABARE, *Australian commodity statistics, Australian commodities.*

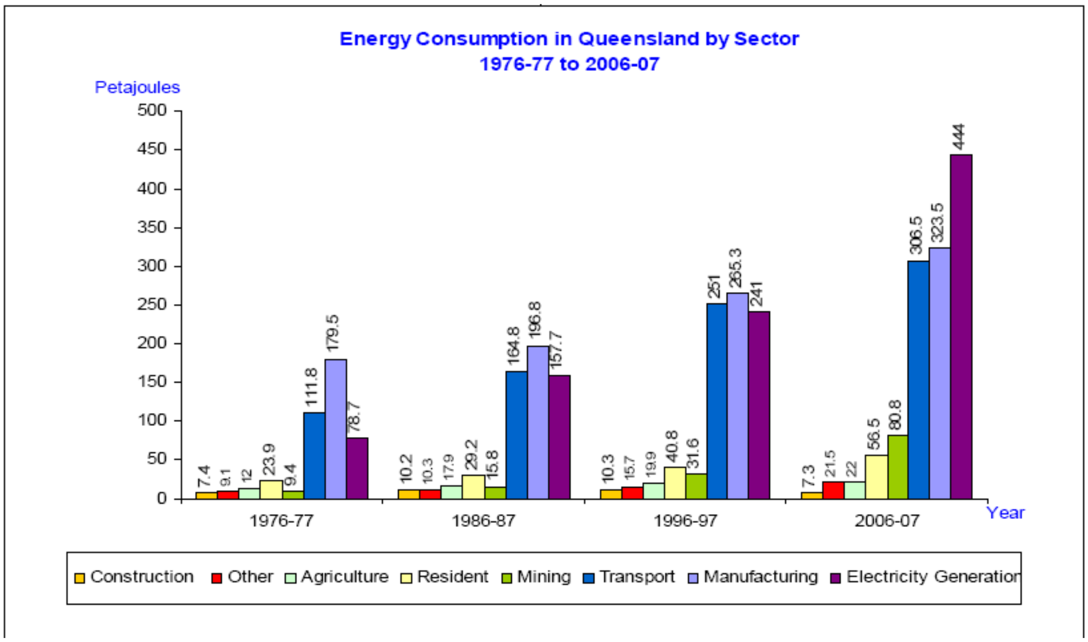
## B.5 Energy Use in Queensland

The following tables / graphs provide information on energy use in Queensland.

4 Gross energy consumption by state, by fuel, 2006-07

| | black coal PJ | brown coal PJ | renewables a PJ | petroleum products PJ | natural gas PJ | state share b % |
|---|---|---|---|---|---|---|
| New South Wales | 807 | 62 | 46 | 567 | 139 | 28 |
| Victoria | 0 | 675 | 27 | 447 | 261 | 24 |
| Queensland | 648 | 0 | 116 | 491 | 109 | 23 |
| Western Australia | 125 | 0 | 14 | 279 | 474 | 15 |
| South Australia | 70 | 0 | 9 | 112 | 115 | 5 |
| Tasmania | 15 | 0 | 44 | 41 | 13 | 2 |
| Northern Territory | 0 | 0 | 0 | 64 | 45 | 2 |
| Total | 1 664 | 737 | 285 | 2 001 | 1 157 | |
| Share of total | 28% | 13% | 5% | 34% | 20% | |

**a** State breakdown does not include wind, solar PV or biogas which are included in the total. **b** Excluding wind, solar PV and biogas.
*Source*: ABARE, *Australian energy statistics*.




The information contained in the above graph has been re-worked into a table that also indicate the average annual growth rates that span the four sets of data. We can see that electricity generation is the biggest component and has had the fastest growth between 1976-77 and 2006-07. Transport sector also has had substantial growth but manufacturing has still managed to keep second place after electricity generation.

| **Year**<br>Petajoules (*Annual average compound growth %*) | **1976-77** | **1986-87** | | **1996-97** | | **2006-07** | |
|---|---|---|---|---|---|---|---|
| Construction | 7.4 | 10.2 | *3.3* | 10.3 | *0.1* | 7.3 | *-3.4* |
| Other | 9.1 | 10.3 | *1.2* | 15.7 | *4.3* | 21.5 | *3.2* |
| Agriculture | 12 | 17.9 | *4.1* | 19.9 | *1.1* | 22 | *1.0* |
| Resident | 23.9 | 29.2 | *2.0* | 40.8 | *3.4* | 56.5 | *3.3* |
| Mining | 9.4 | 15.8 | *5.3* | 31.6 | *7.2* | 80.8 | *9.8* |
| Transport | 111.8 | 164.8 | *4.0* | 251 | *4.3* | 306.5 | *2.0* |
| Manufacturing | 179.5 | 196.8 | *0.9* | 265.3 | *3.0* | 323.5 | *2.0* |
| Electricity Generation | 78.7 | 157.7 | *7.2* | 241 | *4.3* | 444 | *6.3* |

## B.6 Greenhouse Gas emissions for Queensland

Greenhouse Gas emissions for Queensland has had significant impact because of changes in the Land Use, Land Use Change and Forestry sector.

The following graphs are sourced from the 2007 publication by the Dept Climate Change titled "**State and Territory Greenhouse Gas Inventories".** They show the composition of GHG Emissions in Queensland by sector and how GHG emissions in Queensland have grown over the period 1990 to 2007. We can see a strong growth in GHG Emissions mostly due to strong growth in the stationary energy sector.

Figure 6: Queensland – Emissions by Sector, 2007

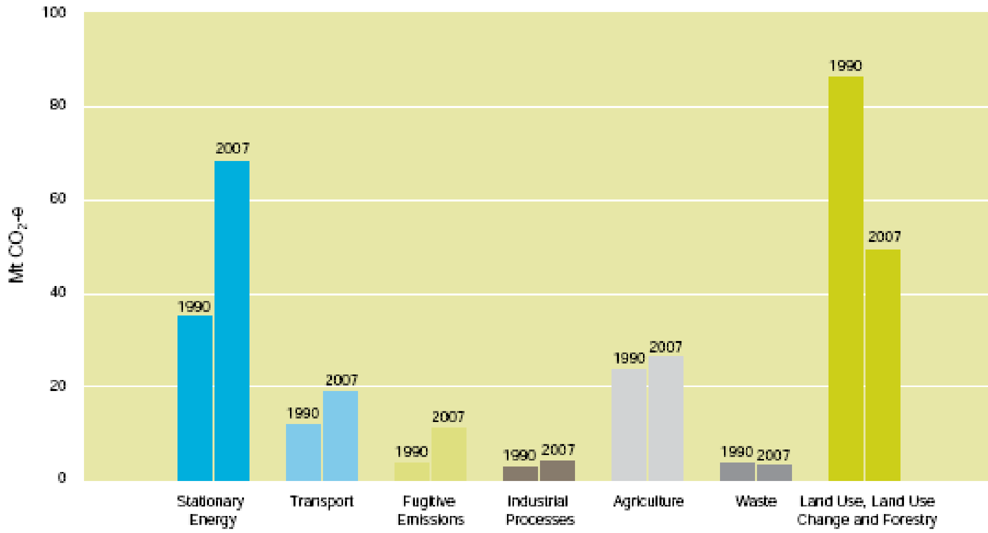
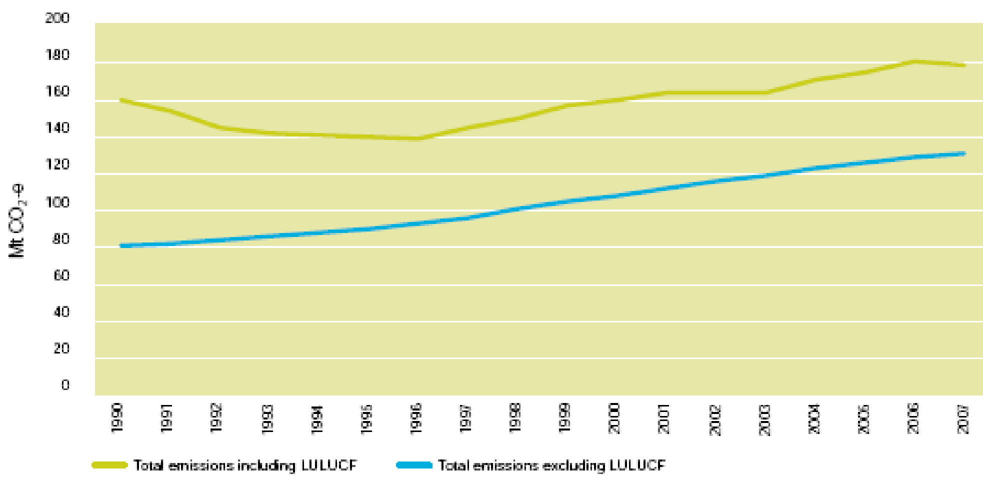



Figure 5: Queensland – Emissions, 1990-2007




Note: Time-series emissions have been smoothed using 3-year averaging.

## B.7 Energy Policy Priorities of the Queensland Government

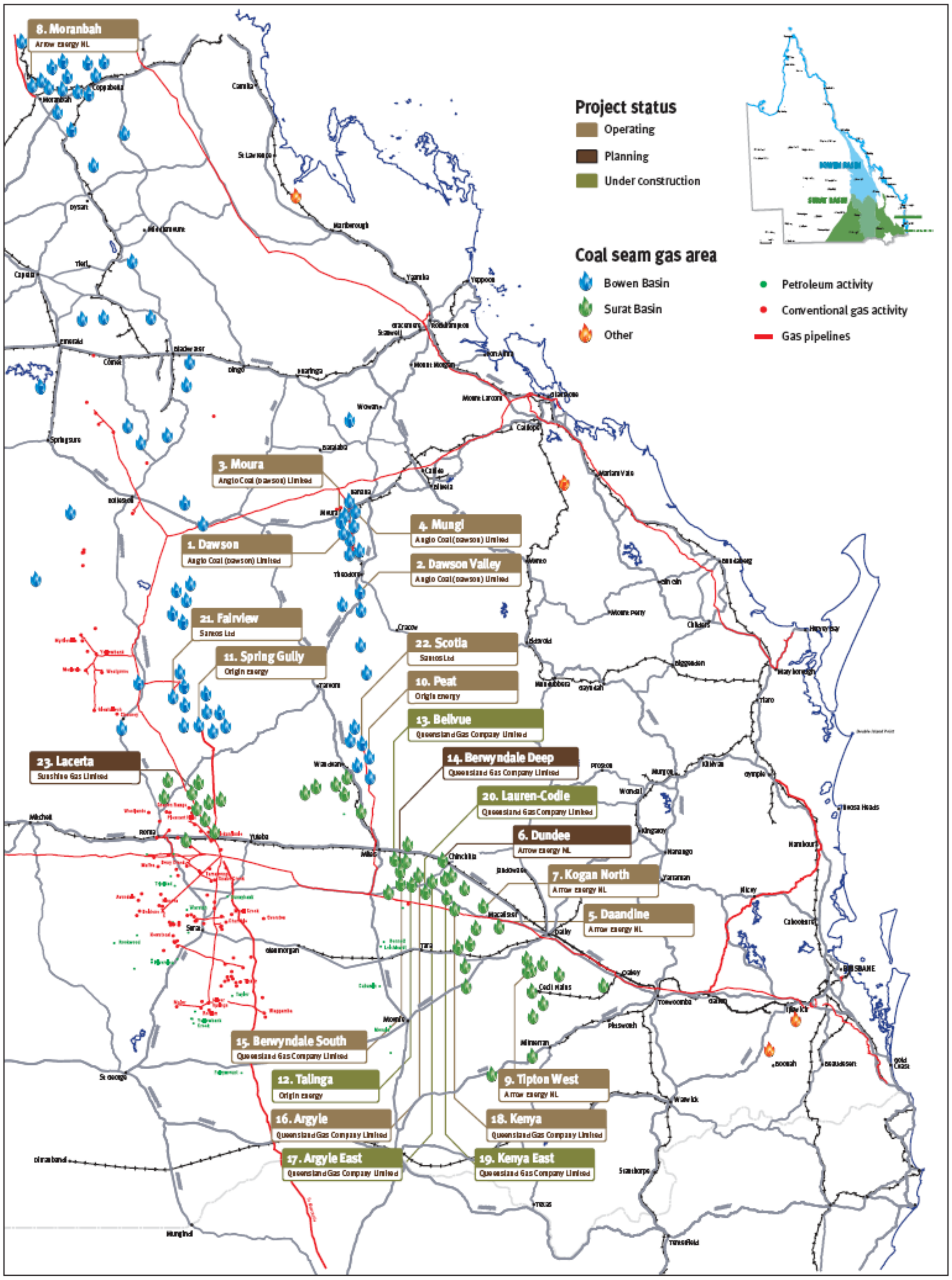
Queensland government has clearly articulated it's energy policy stance in the May 2000 paper "Queensland Energy Policy - A Cleaner Energy Strategy", where it is stated:
*"The supply of competitively priced gas and electricity to provincial cities is seen by the Queensland Government as an important element of its regional development strategy and fundamental to the Government's efforts in attracting industry and promoting value adding to the State's abundant natural resources".*

Queensland government emphasis on seeking a greater role for indigenous gas resources is praiseworthy and bodes well for the future energy requirements of all Queenslanders, both urban and rural:
"*Increased competition in the gas industry as a result of the availability of new supplies and interconnection of gas networks between the States is estimated to yield*

*$1 billion in economic benefits over 35 years, double the benefit that arises from creating a national electricity grid*".

This foresight in shifting the policy emphasis to gas is vindicated by the more recent assessment of Queensland's coal seam gas bonanza outlined in the **Queensland's coal seam gas overview - October 2008**, from which the map below has been extracted.

**Figure 1: Queensland coal seam gas – Ownership and locality map**



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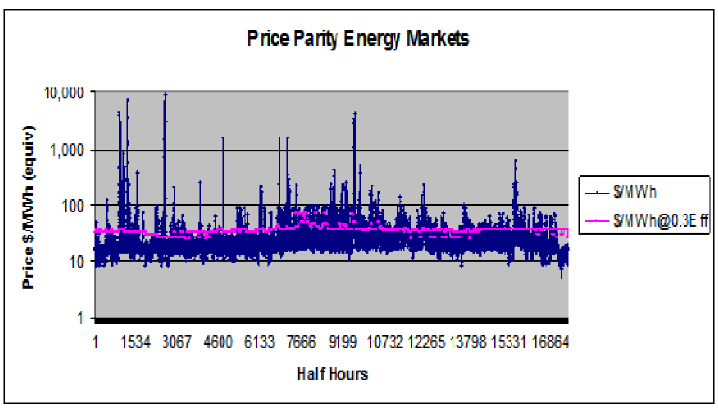
## C.0 New imperatives that will substantially alter energy industry structure in the near future include the following:

### C.1 Coal will lose its place as the lowest cost fuel for electricity generation

At present the difference in long run marginal cost between centralised coal power plant and combined cycle gas turbines (CCGT) is relatively small if a reasonably high utilisation factor is used for the gas turbine. Since a CCGT emits only about one third the GHG emissions from a coal power station, the coal power stations will lose their present cost advantage with the introduction of carbon trading.

Further, economy of scale from large power stations at remote locations cannot compare with improved conversion efficiencies of gas fired co-generation at the customer premises, more so if the premises already have a gas connection for other purposes.

The graph below superimposes the 2006 Victorian Region National Electricity Market half hour price for electricity on to the Victorian gas market price for 2006 converted to electricity at a conversion efficiency of 30% applicable to the gas engine driven generator. What we can see is that the fuel cost on the gas market for such a generator is less than the electricity cost in the NEM wholesale market for quite a number of half hours, while making a handsome return during the many half hours when the pool price was above $100/MWhr.




What if the generator conversion efficiency is improved by making it a co-generator, where exhaust heat from the engine is recovered for supplying the premises hot water requirement? A reasonable conversion efficiency then would be 85% and the same graph is reproduced below but with the increased efficiency.

Ureka, for most of the time gas generated electricity is now cheaper than off-peak period (bottom dips) pool prices mostly determined by coal power stations. If we can further increase efficiency, it is a bonus. A point many people miss is that 85%

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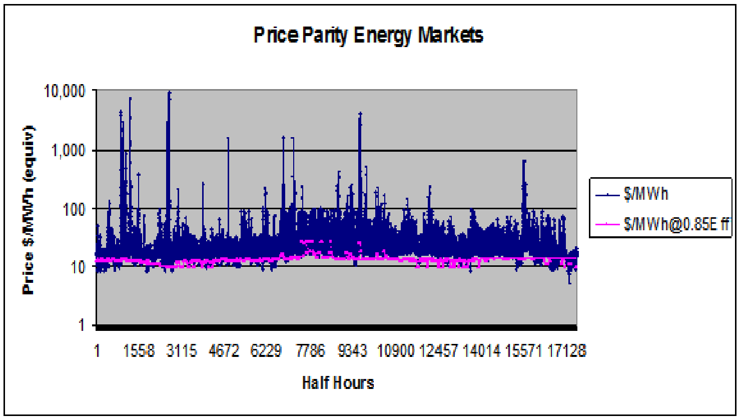



efficiency is for the whole co-generation system, but the opportunity impact is still 85% when you net-out useful heat which remains the same with or without the project. To illustrate the aspect of opportunity impact, say 200 units of gas was used. It will produce 200 x 0.40 units of electricity and 200 x 0.45 units of heat. So we end up with little more heat output (=90 units) than the gas only application of 100 units at 85% efficiency for the stand alone gas appliance which gives 85 units of heat, giving rise to the opportunity outcome of 80 units of electricity from the marginal use of 100 units of gas. Assuming the value in 'little more' heat units offsets the value in 'little less' electricity units.

### C.2 Gas will become the fuel of choice and availability of a gas connection will become the future Universal Supply Obligation for energy customers in temperate climates

The almost universal incidence of gas use for space and water heating in areas where reticulated gas supply is available is ample testimony to the cost efficiency of using gas for such purposes. Since space and water heating constitute around 70% of energy used in residential and small business premises in Australia, these customers have a substantial saving in energy costs.

Few people appreciate the fact that energy transport in the form of gas is far cheaper than in the form of electricity. An October 2005 report[1] by Vencorp entitled "25 year vision for Victoria's Energy Transmission Networks" substantiated this very clearly. In 2006-07 Victoria used more gas (252 PJ) than electricity (158 PJ).

| | GASNET'S GAS TRANSMISSION NETWORK | SP AUSNET'S ELECTRICITY TRANSMISSION NETWORK |
|---|---|---|
| Transmission asset value per PJ of energy delivered | $2.2 million/PJ | $8.9 million/PJ |
| Transmission asset augmentation costs to 2030 | $445 million | $1,505 million |

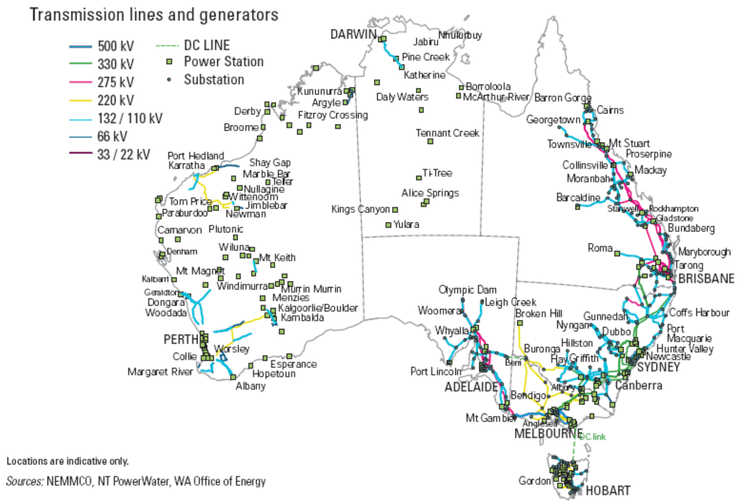
[1] **See http://www.vencorp.com.au/index.php?action=filemanager&pageID=7742&sectionID=7720&searchstring=vision+2030&search=search&search.x=43&search.y=9**

Victoria has high penetration of gas use, around 1.7 million supply connections compared to 2.4 million electricity connections (2007), which shows the gas transmission system in Victoria is very extensive. Actual customer dispersion is more a cost driver for the distribution system than for the transmission system. So the 3 to 1 ratio favouring **gas as a form of energy transport** is inherent in the energy form. As people familiar with electricity transmission systems would appreciate, gas transmission being mostly via underground pipelines, are more reliable than electricity transmission, as they are immune to bushfires, storms and lightning strikes, reactive power problems, no need for fault level controls, etc.

Comparing the existing gas transmission system in Australia with the map[2] of existing electricity power stations / transmission system, it is very evident that gas transmission is extremely vital for efficient development of Australia, both to improve living conditions for remote communities and to better utilize our natural resources, making possible increased value adding rather than be content with direct export of our mineral wealth.


Happily for remote areas in Queensland, the new found coal seam gas (methane) is facilitating setting up of remote area power stations, but it would be a great pity if the massive involvement of the global oil and gas companies and their inordinate rush to line up export facilities, were to deny gas resources needed to develop Australia, provide jobs for Australians and help reduce national GHG emissions without causing a heavy burden to Australian households. All governments have a duty to facilitate such essential services (gas) in the same vein as to provide roads and railways.

[2] Source: ABARE Energy in Australia 2009




As indicated by the current map of the existing gas transmission system in Australia, achieving a fully interconnected national gas grid is timely and becoming urgent. The expansion of the scope of the national electricity market and related planning / regulatory bodies to include gas as from 1 June 2009 is a good start.

## C.3 Gas supply and price will be driven by new forms of gas

For over a decade very substantial natural gas reserves in the North West corner of Australia has idled because of the distance from major markets and very substantial costs associated with developing LNG market / transport systems. Equally substantial coal seam methane resources have now been discovered[3] in Queensland and New South Wales, with good prospects of similar deposits being found in Victoria, South Australia, Northern Territory and Tasmania. In Australia and elsewhere, demonstration projects have established viability of producing synthesis gas by underground gasification of coal, able to access vast coal deposits too difficult to mine through traditional mining methods. In the next decade Australia would have much more relatively cheap gas than there is readily available coal, a fact recognised by major international O&G companies like Shell, ConocoPhillips, British Gas, Petronas, Mitsui, Gastar, Sojitz, etc.

## C.4 Compressed natural gas / methane will replace petroleum products like petrol, diesel and LPG currently being used for transport vehicles

Latest available regional count was taken in 2008[4] (given below), showing a phenomenal growth in worldwide natural gas vehicle numbers over the last three years.

| Region | Refueling | 2005 | 2006 | 2007 |
|---|---|---|---|---|

[3] Santos estimate 250+ Tcf in Eastern Australia compared to 200 Tcf in the NW shelf, see: http://www.santos.com.au/Archive/library/Santos%20Roadshow%20Mar%202009%20A5_ASX_cover.pdf

[4] http://www.iangv.org/tools-resources/statistics.html

| | 2008 NGV Count | Stations | | | |
|---|---|---|---|---|---|
| ASIA | 4,380,412 | 5,925 | 1,167,761 | 1,823,993 | 2,795,476 |
| EUROPE | 1,109,796 | 3,052 | 600,926 | 760,934 | 877,722 |
| NTH AMERICA | 125,177 | 1,204 | 113,542 | 105,177 | 115,177 |
| STH AMERICA | 3,784,664 | 4,220 | 2,649,325 | 3,003,575 | 3,521,136 |
| AFRICA | 101,326 | 126 | 64,155 | 76,003 | 84,994 |
| **WORLDWIDE** | **9,501,375** | **14,527** | **4,595,709** | **5,769,682** | **7,394,505** |
| Percent growth on previous year | 28.5% | | 17.1% | 25.5% | 28.2% |

Honda had their commercial release of the Civic GX - their natural gas car, in the USA six years ago and since then it has been named the 'greenest vehicle' sold in the US by the American Council for an Energy Efficient Economy (ACEEE) – beating all gasoline vehicles, including all the gasoline hybrids.

**Australia price comparison for energy product export / import ($/GJ)**

| | Exports | | Imports | |
|---|---|---|---|---|
| | 2006-07 | 2007-08 | 2006-07 | 2007-08 |
| Crude oil | 14.7 | 18.5 | 14.9 | 18.5 |
| Automotive gasoline | 18.8 | 21.9 | 19.9 | **23.8** |
| Diesel fuel | 18.1 | 21.8 | 17.7 | **22.8** |
| Liquefied petroleum gas (LPG) | 15.3 | 19.0 | 14.5 | **18.8** |
| Liquefied natural gas (LNG) | 6.3 | **7.3** | | |

Data source: http://www.abareconomics.com/interactive/08ams_dec/excel/ams_tables.xls

Australia is blessed with abundant sources of energy. Our immense reserves of coal are able to give us vast quantities of clean energy – coal seam gas or methane. The scramble by major global energy companies to lock in control of these vast reserves speaks volumes. The table above is extracted from Australian Mineral Statistics report produced by ABARE, but converted to a common denominator, the price of energy in dollars per Giga Joule ($/GJ).

Australia imports automotive gasoline and diesel at around three times the price of export LNG (easily substitutable for petrol and diesel). LPG price is substantially more than twice LNG price.

Full cycle GHG emissions for common transport fuels are given in the Table[5] below and it shows a benefit of about 15.5% for heavy duty vehicles (11.5% for light duty vehicles) when converting from petrol or diesel to natural gas:

| | **Energy content (GJ/kL)** | **Full fuel cycle emission factor kg CO2-e/GJ** |
|---|---|---|
| Automotive gasoline (petrol) | 34.2 | 77.2 |
| Automotive diesel oil (diesel) | 38.6 | 77.6 |
| LPG | 26.2 | 69.3 |
| | **GJ/m$^3$G** | **kg CO2-e/GJ** |

[5] http://www.environment.gov.au/atmosphere/ozone/publications/pubs/cold-hard-facts.xls

| | | |
|---|---|---|
| Natural gas [b] (LDV [c]) | 0.0395 | 68.6 |
| Natural gas [b] (HDV [c]) | 0.0395 | 65.2 |

b. The emission factors for natural gas engines are indicative only. From AGO experience with the Alternative Fuels Conversion Programme, the AGO has discovered that many natural gas engines, whether dual fuel or dedicated, emit significant amounts of unburnt fuel to the atmosphere. This level of methane is dependent on a range of factors and varies from system to system. An accurate emissions factor therefore requires measurement of at least CO2 and CH4 for each engine type.
c. LDV stands for Light Duty Vehicles, e.g. forklifts, and HDV stands for Heavy Duty Vehicles, e.g. buses.

A study by California-based TIAX LLC[6] has confirmed a 21% reduction in greenhouse gas (GHG) emissions in LNG trucks featuring a Westport ISX G engine and LNG fuel system based on a 10 year, 400,000 mile well-to-wheel (WTW) scenario. Under this scenario, a typical Westport LNG-equipped natural gas truck operating at the San Pedro Bay ports in California will realize reductions of 21 tonnes of GHG emissions per year compared to an equivalent diesel truck and includes upstream emission factors as well.

A June 2008 CSIRO report[7] also has pointed to a greater role for gas in the Australian transport sector:

*"In this context, domestic natural gas use in transport and other sectors may still demand a significant and potentially growing share of total Australian gas production, particularly in road freight. Modelling indicated as much as an **additional 200PJ per annum** of natural gas could be required for the Australian transport sector by 2020 relative to the approximate 900PJ currently used in manufacturing processes and electricity generation. Current use of natural gas in Australian transport is **less than 2PJ**".*

Courtsey FuelMaker

For the USA market, FuelMaker has introduced Phill[8] - the world's first appliance that lets you refuel your Natural Gas Vehicle indoors or outdoors from your household natural gas line as shown in the picture below. In Australia close to 50% of premises having an electricity connection also have a gas connection. Most major towns have gas lines. Setting up a gas filling facilities is much easier than setting up facilities for LPG.

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[6] http://www.westport.com/pdf/GHG_and_Criteria_Pollutant_Emissions_Estimator.pdf
[7] See **Fuel for thought - The future of transport fuels: challenges and opportunities** @ http://www.csiro.au/files/files/plm4.pdf
[8] See www.myphill.com

The many energy regulators, experts and consultants advising the federal and state governments is doing a disservice to Australia and Australians by not advising relevant decision makers that natural gas for transport vehicles needs to be fast tracked with immediate effect.

There is close synergy effects between energy efficient technologies mentioned above and use of gas as fuel for transport vehicles. Both benefit from improved gas transmission and distribution network development, leading to almost universal gas connections to residential and business premises. In addition to that, gas engine development work and component availability will help both purposes, as well as the increased emphasis on skills development, standards formulation and service capability. Size of gas cogeneration equipment depends on the host facility and there is need for engine sizes that go from small to very large engines that would be equivalent to the size of rail engines.

**C.5 Rapid growth in co-generation and heat pumps** will lead to reduced dependence on centralised coal / gas power stations, reducing stress on power systems and reducing need for power system augmentation;

### C.5.1 Heat Pumps

- Heat pumps with high coefficient of performance (COP 3 to 6) can pluck heat from ambient air equivalent to 3 to 6 times the energy input to the heat pump;
- The compressor – the core of a heat pump, has significantly improved in performance with the introduction of scroll type impellers and use of carbon dioxide as the refrigerant;
- Heat pumps improve utilisation of low level heat and cold from ambient air, significantly increasing effectiveness of solar / ground thermal applications. European Parliament legislative resolution passed on 17 December 2008 recognises for the first time aerothermal and hydrothermal energy **as sources of renewable energy under EU law**;
- There is synergy effect of combining heat pumps with solar / ground thermal applications, avoiding significant deterioration of heat pump efficiency at extreme temperatures (hot or cold) that would occur otherwise. This then reduces the big drain on mains energy supplies. For example, on very hot summer afternoons the heat pump air-conditioners have to work harder since their efficiency drops with increased ambient temperature. Unfortunately, this is the very time when the energy delivery capacity of the power system also gets de-rated because higher ambient temperatures reduce the cooling available to operating power lines and electrical plant. This triggers plant tripping when they reach thermal limits for safe operation;

### C.5.2 Co-generation

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- Co-generation increases efficiency of energy conversion (85% compared to 30% when displacing the lowest efficient generator) to be substantially higher than in any big conventional or new technology power station;
- Large scale co-generation by end users (distributed generation) reduces pressure on already strained transmission and distribution systems, saving on power systems augmentation costs and eliminating power line and transformation losses (8% – 15%);
- By incorporating load buffering eg thermal storage capacity, opportunity is created for electricity output from co-generation to derive best financial returns taking account of peak periods in network loading / electricity market operations;

### C.6 Global Warming and Carbon Trading will have huge impact on the electricity industry and challenge the growth capacity of the gas industry

As shown in table[9] below, stationary energy and transport account for around 65% of GHG emissions in Australia, with around 50% being due to stationary energy.

| | Emissions Mt CO2-e | | Percent of total emissions | Percent change in emissions |
|---|---|---|---|---|
| | **1990** | **2006** | **2006** | **1990 - 06** |
| Energy | 286.4 | 400.9 | 69.6% | 40.00% |
| **Stationary Energy** | **195.1** | **287.4** | **49.9%** | **47.30%** |
| **Transport** | **62.1** | **79.1** | **13.7%** | **27.40%** |
| Fugitive Emissions | 29.2 | 34.5 | 6.0% | 18.10% |
| Industrial Processes | 24.1 | 28.4 | 4.9% | 17.70% |
| Agriculture | 86.8 | 90.1 | 15.6% | 3.80% |
| Waste | 18.8 | 16.6 | 2.9% | -11.40% |
| Land Use Change(a) | 131.5 | 62.9 | 10.9% | -52.20% |
| Forestry (b) | 0 | -23 | NA | NA |
| **Australia's Net Emissions** | **547.7** | **576** | 100.0% | **5.20%** |

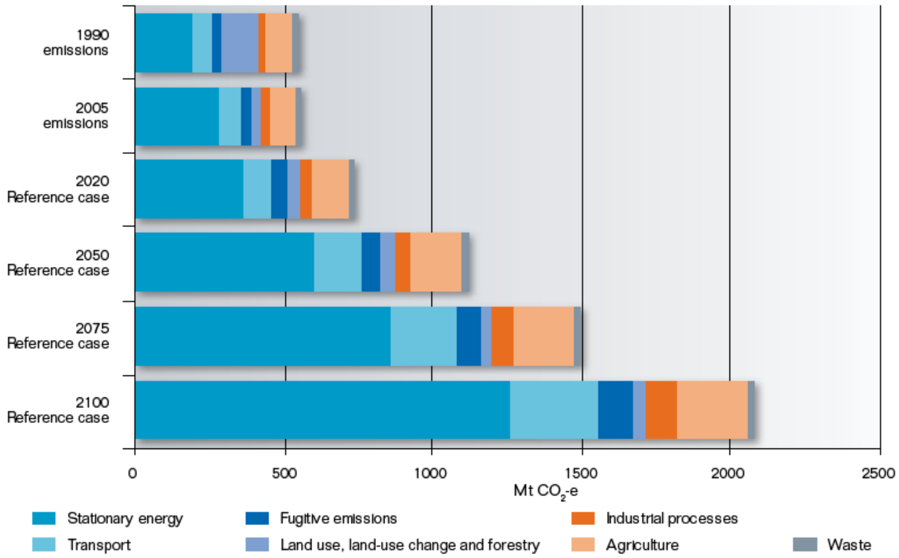
A more worrying fact is the extremely high growth in emission between 1990 and 2006. For stationary energy the emissions increase was 47.3% and for transport it was
27.4%. It is worth noting that close to 40% of stationary energy use[10] is consumed by the residential and commercial sectors, and is predominantly energy used for building services.

The graph below is taken from the Garnaut Climate Change Review Draft Report of July 2008, show that Reference Case projections up to 2100 also indicate very significant growth in emissions from stationary energy and the transport sectors. The proposed new technologies described previously are well suited to arrest such growth.

**Greenhouse gas emissions by sector: 1990, 2005 and reference case scenarios**

[9] Source: Australias Greenhouse Gas Emissions fact sheet 5 - Dec08
See: http://www.climatechange.gov.au/whitepaper/factsheets/pubs/005-australias-greenhouse-gas-emissions.doc

[10] **Source:** Australia's National Greenhouse Gas Inventory - 1990, 1995 and 1999, End Use Allocation of Emissions. Report to the Australian Greenhouse Office by George Wilkenfeld & Associates Pty Ltd and Energy Strategies, 2003




A key outcome of the successful implementation of the proposed paradigm shift is the very substantial **reduction in GHG emissions** with no ifs and buts, the extent and timing of benefit flows depending on industry and governments efforts to facilitate speedy technology adoption / diffusion. Renewable energy sources like wind and solar photovoltaic are intermittent and so can only replace marginal generation which is mostly natural gas. Energy Arbiter™ replaces base load generation[11] which is mostly brown or black coal. Electricity from a gas turbine power station give GHG emission reductions of 66% (brown coal case) and 50% (black coal case) respectively. On top of this, generation at the customer premises will give a 15% reduction due to savings on station use of energy and transmission / distribution line losses. Further, as co-generation increases conversion efficiency from 55% for a combined cycle gas turbine to around 85% (after heat recovery & allowing for internal combustion engine losses), there is a further 30% efficiency benefit. Resulting net GHG emission reduction are around 80% (of brown coal case[12]) and 70% (of black coal case[13]). By generating own electricity requirements and exporting excess amounts of electricity, the net reduction in GHG emissions will vary between **62%** (generate only sufficient electricity to cover own use) to **117%** (co-generating electricity to fully cover own heat requirement will give a substantial net export of electricity reducing more GHG emissions). Such substantial and definite reduction in GHG emissions is a far better outcome than pursuing an elusive promise of 'Clean Coal FutureGen plant' at significantly higher cost.

Assessing certainty of outcome extends to evaluating prospects of technology uptake and diffusion. Given the economic life of premises space and water heating units are

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[11] As Energy Arbiter™ includes heat storage capacity like in a refrigerator, normal operation is in the form of cyclic bursts. The aggregate of a large number of such activity (diversity factor) gives a fairly steady generation output (equivalent to base load plant), spread though out the 24/365 cycle, except for occasional peaks coinciding with pool price excursions – very desirable as it happens mostly during periods of energy / supply capacity shortage.

[12] Derived from 1 minus the emissions ratio, the E ratio being equal to (1-66/100) x (1-15/100) x (1-30/100)

[13] Derived from 1 minus the emissions ratio, the E ratio being equal to (1-50/100) x (1-15/100) x (1-30/100)

between 10 and 15 years, and taking into consideration the substantial financial benefit from the new technology package, with good marketing the technology package will be adopted by almost all customers having a gas connection - well within 20 years, ie before 2030.

### C.7.1 Electricity pool market design still evolving

The Victorian Power Exchange (expanded to become the National Electricity Market) closely replicated the original compulsory gross pool market model developed in the United Kingdom, which itself was based on the then existing economic despatch model. The reasoning was that fixed costs were already ‘sunk’ and as such economic efficiency lay in reducing short run marginal cost. It took for granted the theory of ‘economy of scale’ according to which electricity from centralised large power stations provided the lowest per unit cost. As discussed under the sections on Heat Pumps and Co-generation, physical laws are immutable and must be considered first before applying economic theory. Use of these two technologies in association with the new bridging technologies described in Section D below, now enable the same gas presently used for water and space heating in many homes to provide also for their electricity requirements. This is a clear demonstration of the dichotomy between ‘economy of scale’ and opportunity for increased energy efficiency through synergy.

### C.7.2 Challenge ahead for electricity generation sector

Energy Supply Association of Australia estimates[14] capital expenditure in the generation sector over the next 5 years is between $17-19 billion. The current value of energy supply industry assets is estimated at over $120 billion. The industry is worried that there will be a value loss between $ 2 billion and $ 10 billion in the first decade following the introduction of the Carbon Pollution Reduction Scheme (CPRS).

### C.7.3 Challenge ahead for energy networks

According to Parsons Brinckerhoff Report[15] to ENA, “highest risks (from climate change) arises from bushfire, tropical cyclones and a change in the mix of generation. Lesser risks arise from floods, droughts and an increase in peak demand”. “The cost to energy networks from climate change is estimated to be $2.5 billion over the next 5 years. The largest proportion of this cost arises from the requirement to augment networks to accommodate the increased use of air-conditioning”. “A high level of investment is required to meaningfully reduce electrical losses. It is estimated that capital expenditure of about $1.2bn would be required to reduce electrical losses by 10%.”

**C.7.4 Future energy retailers** will evolve to become energy service companies, more closely servicing customer energy requirements rather than the present predominant form of commodity trader. A good example of such a transformation under way is Osaka Gas[16]:

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[14] ESAA submission on Exposure Draft of the Carbon Pollution Reduction Scheme legislation – 17 April 2009. See http://www.esaa.com.au/images/stories/policy_submissions/20090417cprsbills.pdf
[15] Energy network infrastructure and the climate change challenge – Feb 2009, see: http://www.ena.asn.au/udocs/PB-Report-and-Note.pdf
[16] See http://www.osakagas.co.jp/htmle/corporate.pdf

- Started business operations more than 100 years ago in 1905
- Serving 6.8 million natural gas customers in the Kansai Region (27% Japan gas market share in sales volume)
- Managing 57,800km of transmission & distribution pipelines. Still expanding pipeline networks
- Imports 7 million tons of LNG annually (approximately 5% of world traded volume)
- Participation in upstream projects in Australia, Indonesia, Oman and Norway; and holds interest in LNG carriers
- Developing power business as 2nd core business. Osaka Gas formed a power marketing company "ENNET" with Tokyo Gas and NTT. ENNET is the largest independent power marketer in Japan.
- 1, 390 MW cogeneration systems installed at 2, 210 locations in Kansai region
- Installed capacity of gas-fired air conditioners total 3.23 million RT

Local companies like Origin and AGL have followed similar models, but of late seem to favour alignment with 'centralised power generation' model rather than the deeper involvement with 'customer energy applications' model.

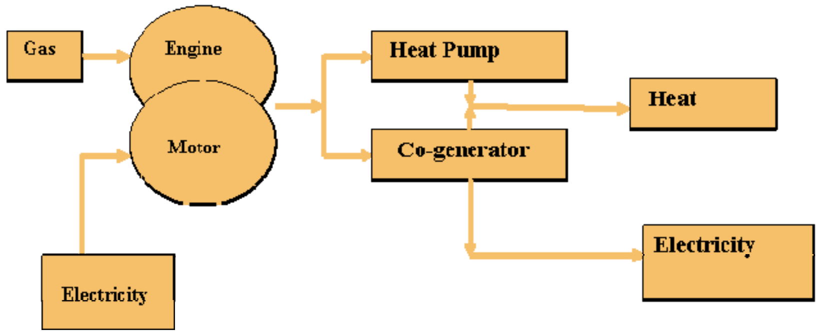
## D.0 New technology developments not considered before:

- Opportunity Power ™ a new technology package[17] that combines
    - a new type of dynamic real-time retail energy contract that contain provisions to limit pool price exposure risk but able to access financial gains from price excursions in the pool market;
    - provision to add further incentive payments from retailer, network operator, electricity market operator, or demand response aggregator;
    - provision for incentive payments to be location / region specific;
    - a fully automated demand response system covering key loads installed at the premises, in communication with smart meter installed at the premises, able to access pool price and price forecast information, able to disconnect or reconnect loads on occurrence of specified conditions;
    - conditions for disconnecting or reconnecting loads dependent on type of load being served and customer attributed value of using that load;
    - the diligent operation of which enables substantial financial gain with minimal exposure to pool price risk;

- Energy Arbiter™ a new[18] type of automated co-generator plant that enable key customer loads (eg HVAC, water pumping, compressor operations, etc) to arbitrage between energy sources, between electricity import / export and between energy efficient technologies (co-generation and heat-pumps in the case of building systems). The key component being a gas fuelled engine, whose local production / assembly will benefit from availability of components / suppliers resulting from recently announced local production of electric hybrid cars (Toyota

[17] Covered by Australian Patent No 748800, patent granted in NZ, pending in USA, Canada & Europe
[18] Covered by Australian Patent No 2004907153, patent pending USA, Canada, Europe, Japan, China, India & NZ

has recently announced[19] the global first commercial production of natural gas – electric hybrid cars).




Hydronic heating systems - widely used in Europe, are employed facilitating the combining of water and space heating applications. Including an intermediate thermal storage facility enables optimum technical, operational and financial outcomes. The system is further optimised by use of a supplementary solar or ground thermal facility to improve heat pump operations, specially under extreme hot or cold ambient conditions.

- Within the last decade there has been a progression of combustion engine developments such as substantial improvement in diesel engine performance eg. Cummins Inc demonstrated[20] in May 2005 an ISX heavy-duty truck engine with an increased Brake Thermal Efficiency (BTE) of 45 percent while simultaneously reducing emissions as well. Launch of electric - petrol (and diesel) hybrids is already being outperformed by the Honda Civic GX running on natural gas and very recently Toyota has announced the [21] the global first commercial production of electric - natural gas hybrid cars. These developments bode well for the performance improvement of small gas engines suitable for distributed co-generation.

## E.0 Specific comments on achieving stated benefits from Energy Efficiency

As the current submission seeks to achieve greater benefits by expanding the scope of energy efficiency, there is little merit in following the narrow area ear-marked for public comment. In other words a narrow definition of Energy Efficiency is itself a barrier / impediment to energy efficiency enhancement. Further, the government's role is not confined to making information on energy efficiency improvements more accessible, but must be involved in the complete process to ensure energy efficiency improvement is realized across the whole state.

[19] http://www.themotorreport.com.au/12702/toyota-unveils-cng-camry-hybrid-concept/
[20] See "Cummins demonstrates technology road map for high-efficiency engine with U.S. Department of Energy" at http://www.cummins.com/cmi/content.jsp?dataId=2282&anchorId=453&menuIndex=none&feed=1&siteId=1&overviewId=15&menuId=4&langId=1033&
[21] http://www.themotorreport.com.au/12702/toyota-unveils-cng-camry-hybrid-concept/

They say a picture is worth a thousand words. In the following discussion I will be looking hard at the three facets of Energy, viz Energy Resources; Energy Transformation, and Energy Use.

**Energy**

Energy Resources

Energy Transformation

Energy Use

The discussion on Energy Efficiency can also be conveniently sub-dived into an examination of Energy Efficiency as applies to each of these facets. Such an examination would be assisted by examining the sub-heading within each of these facets as indicated in the following picture.

**Energy Efficiency**

**Energy Resource Extraction**
Coal
Oil & Gas
Biomass
Hydro, Wind, Solar

**Energy Transformation**
Technical
Economic
Environmental
Societal
Resource Allocation

**Energy Use**
Technical
Economic
Societal
Resource Allocation

To help the Committee to prepare a fruitful and practical report, there is merit to focus the ensuing discussion on outcomes. I have therefore taken the 'benefits of Energy Efficiency Improvements' enumerated in the Discussion Paper prepared on behalf of the Committee, as the main headings for my comments, taking them in the order most suited to plan the deliver of desired outcomes, viz.

- achieving a sustainable energy future

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- reducing greenhouse gas emissions
- reduce the need for investment in energy infrastructure
- cut fuel costs, increase competitiveness and improve consumer welfare

As efficient energy markets and where markets are not appropriate efficient regulation, play a crucial role in delivering efficient outcomes. The ensuing discussion will cover efficiency issues in both energy markets and energy regulatory regimes.

Modern living involve so much of electrical and electronic conveniences / gadgetry, that we tend to take supply of electricity for granted. High level of supply reliability is to be expected. The data provided by the Energy Supply Association of Australia[22] is very sobering:

Average electricity supply reliability in 2006-07:

- the average time each customer was without supply in the year was 281.66 minutes
- the number of interruptions per customer was 2.28
- the average number of minutes per interruption was 123.37

The ensuing discussion will explore efficiency implications in delivering a more reliable electricity supply.

### E.1 Achieving A Sustainable Energy Future

In Section B.1 Energy Resources in Australia we saw that Australia had **39 GT** (equivalent to 1 053 000 PJ) of economic demonstrated black coal resources sufficient to cover over **100 years** of current production. Much of this black coal is in New South Wales and next largest source being Queensland. Two things we need to keep in mind. First, to book coal resources there has to be a market for them, which can be domestic or export. The second thing is that we are looking at current production, where Queensland is producing very large quantities of metallurgical and thermal coals for export. As the diagram Australian Energy Flows in section B3 show, of the 8 650 PJ of black coal produced in Australia, 6 943 PJ of coal were destined for export (~80%). As the diagram Australian Energy Exports in section B4 show, Australia earned close to $ 55 billion from these exports (less profits repatriated by foreign owners of these resource rights / companies). With pick up in world economic growth, there is increasing demand for coal exports. Significant growth in black coal exports will add to Australian export earnings, but will reduce Australia's black coal sustainability from current estimate of 100 years.

Australia has 37 GT of economic demonstrated brown coal resources sufficient to cover over 5**00 years** of current production, most of in located in Victoria. This translates to around 360 000 PJ – around one third of the energy contained in Australia's economic demonstrated black coal resources. There is no export market for brown coal, and future economics of black coal use is very uncertain. If they prove un-economic under the new circumstances, the economic demonstrated brown coal resources may have to be reviewed to zero, with nil contribution to Australia's energy sustainability.

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[22] See http://www.esaa.com.au/index.php?option=com_content&task=view&id=230&Itemid=178

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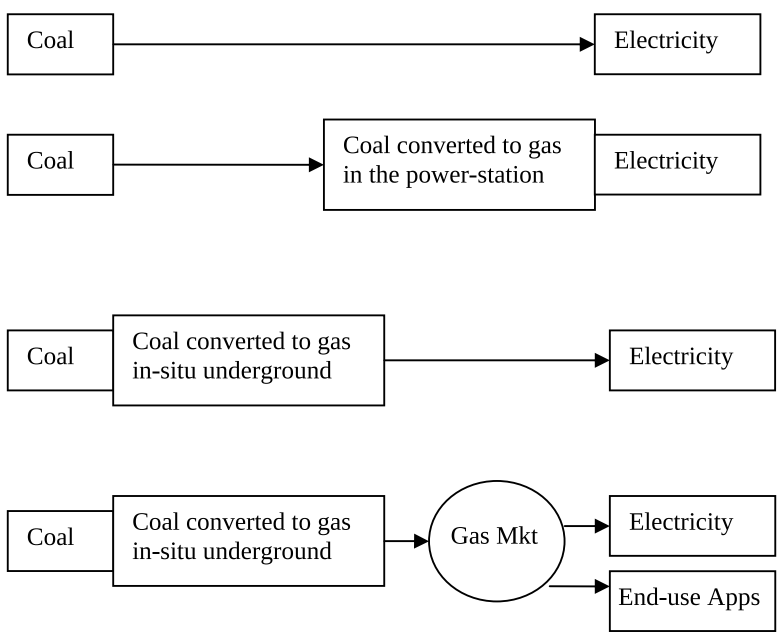
The diagram Australian Energy Flows in section B3 show domestic production of petroleum refinery feedstock was 1 057 PJ of which 594 PJ were exported. Domestic production of LPG was 121 PJ of which 73 PJ were exported. In that year Australia imported 1 646 PJ of petroleum products (feedstock 984.9 PJ, LPG etc, 19.2 PJ and refined products 642.3 PJ). Net domestic availability of all petroleum products was around 2 000 PJ, which means Australia's self sufficiency was little over 50%. Unfortunately for Australia, our petroleum exports were mostly lower priced items compared to our petroleum import - much of it being higher priced items like refined products, resulting in a petroleum import bill of $ 17 billion compared to petroleum export earning of $ 10.5 billion.

The diagram **Australian Energy Flows** in section B3 show domestic production of gas (methane) was 1 793 PJ of which 827 PJ were exported. In Section **B.1 Energy Resources in Australia** we saw that Australia had **98 264 PJ** of economic demonstrated conventional gas resources sufficient to cover over **57 years** of current production and a further **12 833 PJ** of economic demonstrated coal seam methane (CSM) gas resources sufficient to cover over **101 years** of current production. In the recent past we have seen significant increase in the commitment to increase gas production, both conventional and CSM. Due to the fact that a large proportion of the needed investment comes from foreign parties wanting tied gas export commitments, Australia's gas self sufficiency ratio is bound to come down.




As explained in the earlier discussion under section **C.3 Gas supply and price will be driven by new forms of gas**, CSM will very significantly change the energy sustainability picture in Australia and more so in Queensland. The 39 GT (equivalent to 1 053 000 PJ) of economic demonstrated black coal resources in Australia is dwarfed by the amount of coal now being proven to exist deeper down. These deep lying coal resources are beginning to be accessed by new technologies from a simple case of de-watering and gas extraction, to more complicated processes of deep down

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in-situ partial coal combustion using controlled amounts of oxygen and water / steam, so as to give a mixture of hydrogen and carbon non-oxide.

Given time, 2 050 PJ of coal used for electricity generation can be totally replaced by gas (including CSM). It is worth re-visiting section **C.1 Coal will lose its place as the lowest cost fuel for electricity generation**, to re-cap the recent technological and commercial developments that now tip the balance in favour of gas.

Further, as discussed in section **C.4 Compressed natural gas / methane will replace petroleum products like petrol, diesel and LPG currently being used for transport vehicles,** the bulk of the 1 337 PJ used in the Transport sector could also be sourced from gas – remembering that liquefied natural gas is exported at around one third the price of imported transport fuels such as diesel or petrol. To satisfy most requirements in the use gas for transport within Australia, there would be no need for gas liquefaction - maybe only needing extra compression over and above compression requirements for gas transmission.

**Australia & Queensland gross energy consumption by fuel, 2006-07**

| | black coal PJ | brown coal PJ | renew-ables *a* PJ | petroleum products PJ | natural gas PJ | state share *b* % |
|---|---|---|---|---|---|---|
| Queensland | 648 | 0 | 116 | 491 | 109 | 23 |
| Share of total | 47% | | 8% | 35% | 8% | |
| | | | | | | |
| Total Australia | 1 664 | 737 | 285 | 2 001 | 1 157 | |
| Share of total | 28% | 13% | 5% | 34% | 20% | |

**Notes** *a* State breakdown does not include wind, solar PV or biogas which are included in the total. *b* Excluding wind, solar PV and biogas.
**Source**: ABARE, Australian energy statistics.

The above table on Gross energy consumption by fuel, 2006-07, we see that in Queensland coal and petroleum account for 1 139 PJ, over 80% of gross energy consumption. Section **B.7 Energy Policy Priorities of the Queensland Government**, mentioned the Queensland Governments strong commitment to expanding use of gas in Queensland and with the success already locked-in by Queensland's CSM industry as illustrated by the contained Queensland Coal Seam Methane Gas - Ownership and Locality Map, Queensland is well set to give the lead to Australia's progressive change over to a gas dominated economy.

This change over from a coal and petroleum dominated economy to a gas based economy will happen eventually, but can be expedited by proper planning and appropriate government incentives. The establishment of the National Energy Market and the newly constituted Australian Energy Market Operator with responsibility for promoting efficient investment in and operation of Australia's electricity and gas services for the long-term interests of consumers – with respect to price, quality, safety, reliability and security of energy supply, bodes well for the future.

Given that economic reserves can be booked only if there is a viable market price for the gas, it is in Queensland government and the Queensland gas industry's interest to do the following:

a) make an all out effort to promote an appreciation of the potential for gas resources and provide incentives for investment in gas transmission / distribution pipelines to move gas from well head to market place;
b) make an all out effort to promote an appreciation of the potential for using gas in transport and encourage by providing incentives for development / demonstration projects for using gas in cars, buses, trucks / lorries and in rail road applications;
c) make an all out effort to promote an appreciation of the potential for using gas for electricity generation, giving government subsidies to initiate the conversion of coal power stations to operate partly or fully on gas;
d) make an all out effort to promote an appreciation of the potential for using gas for direct end-use to by use of appropriately sized gas engines instead of / or in combination with electric motors, giving incentives for early diffusion of such technologies.

As the following table taken from the Productivity Commission May 2008 submission to the Garnaut Review show, electricity from renewable resources like wind and photovoltaic cells are cost significantly more than electricity from traditional sources like coal and gas, with gas have a significant advantage due to it's lower GHG emissions.

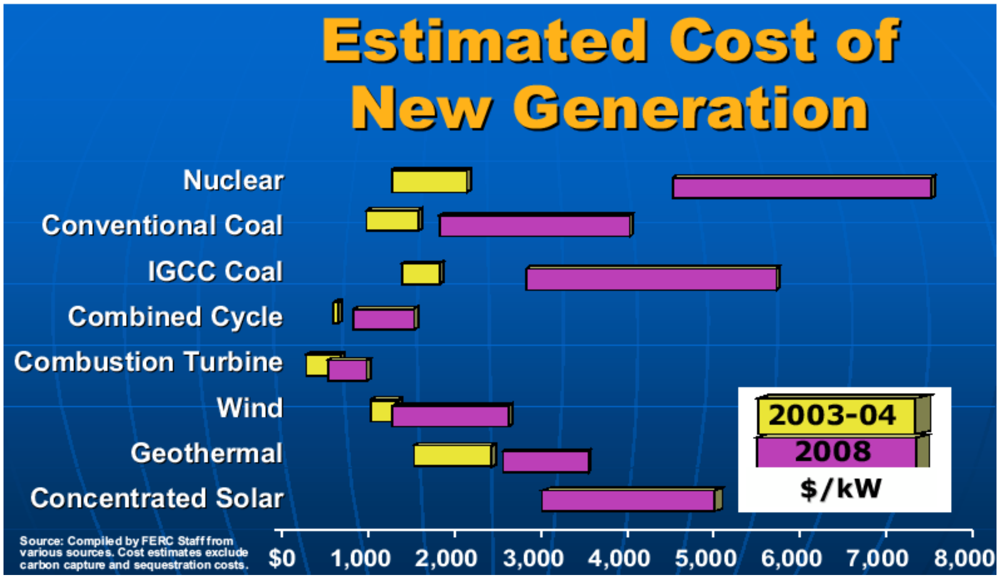
Table A.1 **Indicative costs and emissions for electricity generation**
Projections for 2010

| *Technology* | *Cost per unit of electricity generated* | *Greenhouse gas emissions* |
|---|---|---|
| | \$/MWh in 2010 | kg $CO_2$ per MWh |
| Supercritical black coal | 30–35 | 780–820 |
| Supercritical brown coal | 36–40 | 1000–1100 |
| Natural gas combined cycle | 35–45 | 430 |
| Wind | 55–80 | – |
| Bagasse[a,b] | 30–100 | – |
| Small hydro[a] | 50–70 | – |
| Solar hot water[c] | 80–100 | – |
| Photovoltaic | 250–400 | – |

[a] Limited resources available. [b] One component of broader biomass energy. Short and Dickson (2003) estimate that other forms of biomass are likely to cost between \$20 and \$130 per MWh in 2010. [c] As solar hot water does not create electricity, costs are based on electricity savings. – Nil or rounded to zero.

*Source*: Department of the Prime Minister and Cabinet (2004).

Of late there has been renewed calls for Australia to embark on electricity generation from nuclear fuel, citing Australia's large resource base of nuclear raw materials. From the graphs reproduced in sections **B.2 Energy Production in Australia by source** and **B.4 Australian Energy Exports by source, w**e see that the energy content of our Uranium raw material exports are very considerable but the export income we receive for them amounts to a negligible amount. Lacking the expertise and experience with both nuclear fuel processing and building / operating nuclear




**Estimates of the cost of new electricity generation (FERC June 2008)**

power stations, Australia is not well placed to embark on such ventures. Given that very few new nuclear facilities have been built in western countries and the paucity of cost data regarding such ventures, the proponents for nuclear energy have tended to rely on readily available data that is now outdated. The contrast between the new data and the old data is clearly illustrated by the above graph produced by the staff of the United States of America Federal Energy Regulatory Commission around June 2008. What is very clear is the huge blow-out in the estimated costs per unit of capacity of nuclear power stations, going from around US $ 2,000 per kW to around US $ 6,000 per kW. The cost escalation seems to be the least for gas turbines.

### E.2 Reducing Greenhouse Gas Emissions

As shown in the graph of Queensland Emission by Sector for 2007 contained in section **B.6 Greenhouse Gas emissions for Queensland,** the largest and fastest growing emitter is Stationary Energy sector.

In section **C.6 Global Warming and Carbon Trading will have huge impact on the electricity industry and challenge the growth capacity of the gas industry,** a graph reproduced from the Garnaut Climate Change Review Draft Report of July 2008, showed that Reference Case projections up to 2100 indicate very significant growth in emissions from stationary energy and the transport sectors. In that discussion there was also mention that electricity generated from a gas turbine power station give GHG emission reductions of 66% (versus brown coal case) and 50% (versus black coal case) respectively. On top of this, generation at the customer premises will give a 15% reduction due to savings on station use of energy and transmission / distribution line losses. Further, as co-generation increases conversion efficiency from 55% for a combined cycle gas turbine to around 85% (after heat recovery & allowing for internal combustion engine losses), there is a further 30% efficiency benefit. Resulting net GHG emission reduction are around 80% (of brown coal case) and 70% (of black coal case).

Renewable energy sources like wind and solar photovoltaic are intermittent and so can only replace marginal generation which is mostly natural gas having lower GHG emissions. On the other hand, Energy Arbiter™ replaces base load generation which is mostly brown or black coal. Since it involves co-generation at the customer's premises, net GHG emission reduction achievable is around 80% (replacing electricity from brown coal) and 70% (replacing electricity from black coal). What this demonstrates is that although Energy Arbiter™ does not reduce GHG emissions to zero, because unit cost of electricity using the Energy Arbiter™ is lower than cost of electricity from renewable energy sources like wind and solar photovoltaic, it is much more efficient at reducing global GHG emissions than such renewable energy sources.

The next largest and fastest growing GHG emitter in Queensland is the transport sector. Developments to gas engines discussed in Section **C.4 Compressed natural gas / methane will replace petroleum products like petrol, diesel and LPG currently being used for transport vehicles**, already more than 20% reduction in GHG emissions is possible with fuel switch to gas.

Above mentioned developments by themselves would not be sufficient to achieve the more challenging but needed GHG reduction targets of 50% by 2030 or 80% by 2050. Leading Australian researchers like Dr Beverley Henry are convinced that agroforestry and reforestation are the best option for providing carbon offsets[23]. They say soil carbon sequestration also holds potential, but more research is needed to gauge the impact of management practices on long-term changes in soil carbon,

## E.3 Reduce The Need For Investment In Energy Infrastructure

### E.3.1 Need for extra new investment

Given federal and state governments commitments to reduce GHG emissions, systems employed for this purpose can be considered as part of the Energy Infrastructure. As discussed in the previous chapter, new technologies like Energy Arbiter™ which incorporate co-generation, heat-pumps, distributed generations, use of gas engines instead of electrical machines in appropriate end-use applications, etc., will reduce the total investment needed for reducing global / national / state GHG emissions compared to using alternate means eg renewable resources like wind and solar photovoltaic.

In section **C.7.2 Challenge ahead for electricity generation sector**, it was noted that the Energy Supply Association of Australia estimates capital expenditure needed in the generation sector over the next 5 years to be between $17-19 billion. In section
**C.7.3 Challenge ahead for energy networks**, an ENA was quoted as saying , "The cost to energy networks from climate change is estimated to be $2.5 billion over the

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[23] See http://business.theage.com.au/business/forests-best-option-for-providing-carbon-offsets-20080427-28ve.html

next 5 years. The largest proportion of this cost arises from the requirement to augment networks to accommodate the increased use of air-conditioning". "A high level of investment is required to meaningfully reduce electrical losses. It is estimated that capital expenditure of about $1.2bn would be required to reduce electrical losses by 10%." Both these items of capital expenditure can be very significantly reduced by using the technologies mentioned previously, enabling further reductions in delivered electricity costs compared to the case if such technologies were not widely used.

As wind generation and large scale solar power stations would mostly be situated far from current electrical load centres, effected transmission networks need significant new investment to connect up such remote power stations. Such extra investment is not needed if such generation requirement was instead satisfied by use of previously mentioned technologies.

### E.3.1 Investment for augmenting transmission and distribution networks

Transmission and distribution networks are accepted as natural monopolies, in that having duplicate systems would be uneconomic. Both network systems must be able to satisfy peak demand that may eventuate only a few hours in the year. Because the networks are mostly power lines strung above ground, there are many influences that can cause a disruption to the safe supply of electricity. Influences include trees, branches or flying debris, etc, making contact with live conductors, conductors making contact with each other under windy / storm conditions with or without external intervention, lightning striking the lines causing damage or tripping of the line, bush fires, excessive ambient heat and / or line overloading making it unsafe to continue transfer of electrical power, line or component failure, etc., etc. To enable a reasonable level of supply reliability, most power transmission and many distribution systems have a target level of redundancy, so that if one line was to fail for any reason, supply can be maintained with the use of the remaining lines. Building high levels of redundancy is very expensive, so a balance is struck between containing costs and targets set for supply reliability.

It is now widely accepted that it is more efficient to involve customer participation (also called demand side participation or DSP) in demand management rather than only depend on network investment to maintain / improve supply reliability. Australian Energy Market Commission has an insightful definition of demand-side participation (DSP) in the NEM "ability of consumers to make decisions regarding the quantity and timing of their energy consumption which reflects their value of the supply and delivery of electricity." A common form of DSP is the use of time-varying pricing rates (also called time-of-use or TOU rates) giving the customer a financial incentive to avoid electricity consumption during peak periods by having a reasonable price differential between peak rates and off-peak rates. A variation on this was critical-peak pricing (CPP) that resembles a TOU rate on most days but on stipulated dates (eg 12 summer days and three winter days), it charges much higher prices during peak periods. These high-priced days were called on a day-ahead or day-of basis, to enable the network to better manage unexpected changes in weather or in power system conditions.

A major draw back in critical-peak pricing is that the utility has no way to know what is the price that will provide just sufficient response to clear a specific congestion situation. Another draw back is that there is usually an upfront commitment fee which may or may not be effectively utilized.

The airline industry, a highly capital intensive industry like the electricity networks, has been very successful with using reverse auctions to increase yield. Reverse auctions are auctions where the bidder is the seller and not the buyer. The bid reflects how much the buyer is being asked to pay. The airline knows that certain percentage of customers do not turn up to fly as stipulated in the ticket, so they regularly overbook according to their best forecast of passenger numbers that will turn up. Occasionally there are more passengers than there are seats. So the auction starts with the airline offering an increasing sum of money until sufficient number of passengers volunteer to cancel their booking for that flight. Unscrupulous airline operators have been firmly reminded by regulators that the model is valid only if there is voluntary cancellation.

### E.3.2 Efficient regulation must emulate and allow competition where possible

The whole intent of regulation is to set conditions that will align private company motivations with intended socially efficient outcomes, without which or with lax enforcement of conditions to that effect, the private company will concentrate on achieving it's main objective, ie make profit. We must remember the distribution network is a monopoly service, meaning up to now the customer had no other option to get electricity. If the network had two options, one to pay the DSP a fair price and increase social welfare and the other not pay the DSP - ignoring social welfare benefits (as there is no mechanism to enforce it) so that it can make more profit, no prize is needed to work out what option the DSP would choose.

The notion that the networks are regulated on the basis of a 'price cap' is a furphy. What the regulators actually do is start with the regulated asset base, determine the allowed rate of return and with the network nominated capital depreciation rate - to work out the capital charge on the business (largest component by far). The allowed operating expenses and the allowed capital expenditure are added to the capital charge to arrive at the revenue cap from which comes the price cap. We are talking of a capital intensive industry with asset lives extending to around 50 years, the capital invested in the business is very high. As the regulator allows the company to set the depreciation rate (on the mistaken belief the company will not take out too much as it will reduce future returns) the company is happily taking out lots of money and at the same time trying to make it up by substantially increasing the capital expenditure budget. To break this vicious cycle, it will be necessary to make it possible for the customer to substitute customer's own facilities to serve the same distribution outcomes, instead of being tied forever to a monopoly gold plated money maker. No wonder the network businesses had plenty of interested buyers whenever they came up for sale, in spite of the seemingly incongruous notion of a regulated asset base – which formed the basis for the regulated returns that were allowed under the Code.

The Opportunity Power ™ technology package described above provides a two part capability, first a facility for the customer to access the full benefit of the pool price excursions. This is by using a specified energy quantity – price schedule broken down to half hours corresponding too pool settlement periods plus exposure to the pool price for any energy variance including export to the grid. The retailer servicing the customer is benefiting because the troublesome volume risk has been eliminated and any response by the customer that contributes to pool price being reduced (through reduced aggregate demand) would lessen the impact of the retailer's residual pool price exposure. Able to access the high pool price excursions with minimum pool price risk exposure is a major draw for the customer.

The second part of the package provides a single platform for a reverse auction process by any one or more of the following parties:

- the network operator faced with a network congestion, and / or
- NEMMCO faced with a market shortfall or faced with a need for constrained dispatch, and / or
- the retailer who is under hedged or exposed to volume variance due to extreme events.

Two comments are offered to improve the benefits we can draw from this exercise:

First, if all attempts to improve complicated processes concentrate only on one item at a time, we will have optimal sub-sets but for ever we will be left with **sub-optimal complete systems**. As mentioned previously substantial technology progress in energy efficiency is now available, very substantial energy price changes are projected as a result of impending carbon trading scheme, and very substantial investments are envisaged both by generation and network companies, that some cognizance of their combined effects are badly needed;

Second, in the current circumstances defining DSP only in relation to "energy consumption" is equivalent to doing only half the job entrusted. As shown in the previous chapters, **distributed co-generation from gas** is expected to be cheaper than electricity from even coal power stations, so DSP must cover customer choice of: whether to use electricity form the grid, whether not to use electricity from the grid and whether to export electricity to the grid.

### E.3.3 Transmission and Distribution Networks are different

Power system comprises both the transmission and distribution networks, starting from generator dispatch connection point to the customer delivery connection point. The interface between the two networks is the intermediate connection point usually at the lower voltage bus bars of the transmission grid power station. The management of the reliability and security of the transmission power grid is the responsibility of the National Electricity Market Management Company (NEMCO), while reliability and security of the distribution system is the responsibility of distribution network owner / operators.

The transmission owner is responsible for preparing load forecasts in consultation with NEMMCO, with distribution network owners connected to relevant part of the transmission system and customers / generators connected directly to relevant part of the transmission system; for network augmentation and maintenance; and for operation of the network under NEMMCO instructions. The transmission owner is also responsible to inform NEMMCO of the safe operating conditions for the transmission plant and equipment, and to provide a forward plan for maintenance that require plant and equipment disconnection. The approach was different for the Victorian Transmission System as a whole, in that there was separation of ownership and network augmentation planning. VenCorp was entrusted the role of network planning and initiating capital works projects, which was then subjected to open tender on a Build & Own basis. This 'split role' model was widely accepted as being superior to the traditional owner / manager model for other transmission entities.

NEMMCO has many resources to manage the reliability and security of the transmission power grid. First option is that there is a market clearing demand and supply every 5 minutes. NEMMCO has the power to 'Direct' a market participant to take a particular course of action aimed at resolving a current or pending shortfall in capacity or reserves. The part of NEMMCO's work that is specific to network security is the maintenance of reserve capacities to meet contingencies. As market manager, NEMMCO does this by specifying reserve requirements and keeping the market informed through a series of cascading notices. First there are the market forecasts which include:

- Statement of Opportunities – a 10 year forecast of demand for electricity, capacity of existing and committed generating plant, inter-regional transmission capabilities, and advice on the impact of technical limits on sections of the network, forecasts of ancillary service requirements, minimum reserve levels, and economic and operational data. Also incorporates an Annual National Transmission Statement to provide an integrated estimate of the current state and potential future development of major national transmission flow paths;

- Projected Assessment of System Adequacy (PASA):
  - MT PASA for 2 years updated by 2:00 pm every Tuesday
  - ST PASA for 7 days updated 2 hourly from 4:00 am

- Pre-dispatch Forecast: estimate of price and demand forecast for the next trading day

Then there are ad hoc Reserve Notices drawing attention to forecast lack of future reserves graded according to level of expected reserve shortfall. And if matters are still not resolved NEMMCO has the option of using the Reserve Trader provision and / or the Power of Direction.

It is unfortunate that the Distribution Networks almost always attempt to rectify network capacity shortfalls with:

- increased investment in hardware part of the network, including voltage support and switching, at high cost and time;
- increase metering, communication and control / switching facilities to better use existing assets, which process (also called Smart Grid) is still more expensive.

The distribution system invariably contain parts that are serviced by single spur lines with no provision for back-up switching like in a ring-main system.

Opportunity PowerTM and Energy ArbiterTM will turn things around, to give the CustomerGrid – where customers will directly contribute to investment in new generation facilities, help manage power system demand, contribute to resolving power system constraints and take an active part in the control of energy market outcomes. Detailed economic analysis is not needed to work out that CustomerGrid is a far superior solution than Smart Grid, and provides superior multiple benefits like improved overall energy efficiency, reduced greenhouse gas emissions, reduced line losses, increased reliability for customer and to the power grid, reduced investment requirements, more transparency, improved energy market outcomes – the list goes on and on.

### E.3.4 Tasmanian innovation can improve Distribution Network performance

In the 2003 Distribution Price Determination the Tasmanian Energy Regulator[24] agreed to a performance enhancement offer from Aurora, that involved portable generation to be owned by the distribution business and used in emergencies at remote locations and to facilitate planned maintenance. The Regulator's conclusions and how he incorporated expected outcome into performance targets, are very relevant to the question of facilitating DSP in the NEM

**Enhanced Services Options Revised Estimates April 2003**

| Project | Total Cost $m | SAIDI minutes avoided | $ per SAIDI minute avoided |
|---|---|---|---|
| Portable generation | 0.75 | 13.00 | 57 000 |

*"As discussed in Chapter 3, each of the performance improvement options appear to represent good value for money for customers in that the capital cost of implementation in terms of cost per minute SAIDI avoided, are $114 000 (portable generation), $125 000 (feeder protection upgrade) and $215 000 (remote controls). Annual costs for these programs increase to total $400 000 by 2006, representing costs of about $10 000 per minute avoided SAIDI if the programs deliver the performance improvement forecast by Aurora."*

*"The outcomes of the customer value study, as described in the report, are that customers, on average, would appear to be prepared to accept an increase in annual bills of about 2.5 per cent for a reduction in outages of 20 per cent. This may be quantified as a customer aggregate willingness to pay of about $250 000 per minute reduction in SAIDI (assuming that customers ascribe a value to time without supply in the same scale as they value the loss of supply). This conclusion should be treated cautiously, as it is expected that the performance improvements will be delivered primarily in areas that currently experience poor performance and the majority of the customer base would be contributing to significant performance improvements for relatively few customers. The question of a customer's willingness to pay for another customer's improvement in performance was not posed in the customer value study. Nevertheless, on the basis that the proposed performance improvements are generally considered to be equitable, this value is a guide to the benefit from*

[24] See: http://www.energyregulator.tas.gov.au/domino/otter.nsf/LookupFiles/R_ElectPriceInvest_FinalReport.pdf/$file/R_ElectPriceInvest_FinalReport.pdf

*performance improvements. Hence it appears that customers' willingness to pay is many times the costs of the improvements."*

*"The full reduction for the enhanced cases has not been used since it was deemed inappropriate to penalise Aurora for not achieving the full benefit of the enhanced scenarios. The Regulator decided that Aurora should be expected to achieve 50 per cent of the projected improvement from the protection upgrades, 100 per cent of the improvement from the remote switching and 100 per cent from the introduction of portable generators."*

What this exercise demonstrated was that dispersed small scale generation is valuable to the distribution network and can improve network performance significantly. Although the Regulator accepted the Aurora proposal to invest in portable generators on the basis it provided the customers, value for money, he raised a very valid question. "*The question of a customer's willingness to pay for another customer's improvement in performance was not posed in the customer value study*". There is also the market research finding that customers perceive receiving a dollar payment as being better than saving a dollar on their bill.

Looking at this exercise in the light of technology package for distributed co-generation from gas as described above, if the customers were able to provide the electricity when needed by the distribution network, the network would not have to incur capital expenditure on equipment that had very low utilisation, the operating cost of the mobile generator is saved, and also very significant in the current global warming scenario, there would be significantly less GHG emissions. The Regulators question would be redundant since customers would be responding to their own choice of intervention price if there was a reverse auction as proposed in the technology package. Considering the extremely low utilisation factor and the cost of diesel fuel for the generator, the opportunity cost to Aurora could well be over $ 1 per KWh, which many a co-generation customer would find very attractive. Yet this is only one tenth the value of lost load ($10, 000 per MWh or $ 10 per KWh) used for capital investment justification, which then needs to be translated to a realistic marginal incentive (bonus / penalty) by the regulator.

This is consistent with the need for a transparent regulatory control mechanism for ensuring security / reliability of the distribution network.

### E.3.5 Distribution Network Regulation must provide for explicit security / reliability management processes

In the late 1980s EPRI had a project to develop the parameters for Priority Service Methods (PRISM). The concept was that by offering customers the choice of different "qualities" of electricity at different prices, the value of electricity service may be increased to all customers. In practice utilities had little capacity to increase the level of reliability to particular customers, but had more leeway to reward customers to surrender their right to the 'common' level of reliability by means of curtailment rates / incentives.

Network charges in rural areas are a larger part of the electricity bill due to the longer lines needed to service them. As their augmentation is partly based on the value those customers place on reliability, the design level of reliability is low in rural areas. Also regulators tend to set a lower level of reliability when mandating minimum service standards for such areas. Often cost of supply studies that show large cross-subsidies to rural areas fail to correctly reflect this variation in service reliability levels.

Networks are not the sole contributor to the cost of reliability in electricity supply. The NEM is based on a 0.002% level of reliability in the supply of electricity to the wholesale market. This standard of reliability is very far removed from the level of supply reliability available in rural areas, or even available to small business / residential customers embedded in the urban distribution network. To these customers it makes no economic sense to pay for an extremely high level of reliability for wholesale market energy that cannot be delivered at comparable levels of supply reliability. One way to overcome this anomaly is to expedite introducing facilities for demand side response that provide means to sell back undervalued components like reliability, as provided via the combined technology package described above.

Power system reliability generally refers to generation and transmission systems (because of NEM), and is a measure of the ability of the system to supply energy to meet the load. But most of the load is embedded in the distribution system yet there is scant attention to managing supply reliability in the distribution system. In general, Regulators have been snug in concentrating on performance measures such as:

SAIDI - System Average Interruption Duration Index
SAIFI - System Average Interruption Frequency Index
CAIDI - Customer Average Interruption Duration Index
MAIFI - Momentary Average Interruption Frequency Index

Calling these ‘reliability measures’ is like keeping count of air craft collusions, which in reliability studies parlance is counting the ‘collateral damage’. In air craft reliability studies the critical event is when the **aircraft collusion envelopes overlap** due to loss of control of aircraft energy. This critical event is termed a ‘**near misses**” and is considered to have occurred when two or more aircraft are within a defined horizontal (1Nm) and vertical (500 feet) limits without being aware of each other’s presence.

From transmission reliability studies we know that the ‘critical event’ (loss of control point) is when interfering object penetrates the conductor flashover envelope. This covers movement of conductors relative to each other, line sag due to high currents and / or high ambient temperatures, compounded by the effect of line sway in high winds, etc. etc. Transmission owners / managers are supposed to inform the system operator (NEMMCO) of safe operating conditions of their plant and equipment including updates if ambient conditions change. NEMMCO uses such information on a deterministic manner to arrive at requirements for secure operation and the required reserve levels to meet credible contingencies. Changes to previously published conditions are provided as updates to market participants.

A rare instance of a regulator taking cognizance of a true measure for reliability control (a near miss situation rather than consequences of poor reliability) was Performance Reports by the Tasmanian Energy Regulator. These reports include performance of distribution feeders classified as 'firm' but which had continued in service in a 'non-firm' condition, gives the number of times this happened and the aggregate time this condition continued. Given the large investments involved and the peaky nature of electricity demand (extreme hot or cold weather conditions) it is not uncommon to find many distribution systems go 'non-firm' on extreme weather days. According to the 2008 Reliability Review Report[25] by the RNPP of the Office of the Tasmanian Economic Regulator, Aurora had 7 zone substations and 62 HV feeders exceeding their firm capacity. The Tasmanian Economic Regulator is to be commended for publishing such information on a regular basis, something that should be made mandatory by all state regulatory bodies / AER.

A proper reliability system for distribution networks must, like in the case of NEMMCO, publish information on network constraints specially shortfalls in secure capacity of respective lines and times they are occurring or are forecast to occur – the distribution system version of Projected Assessment of Distribution System Adequacy (PADSA) Report. This public document (updated on a regular basis) should also indicate a minimum (base) payment the Distribution company will undertake to pay for energy from embedded generation exported to the relevant distribution grid area within respective shortfall intervals. The distribution company must also stipulate the maximum amount it will bid through a reverse auction to clear that deficiency in that period. This is the crucial point (network regulation simulating market outcomes) where regulators can verify the validity of customer value imputed by the Distributor when justifying capacity augmentation. Given that spur lines are by definition not secure, the report for spur lines should contain information on the 'safe working load' (SWL) for the line and actual maximum load for the last 3 years. Such data will provide guidance on the potential for exceeding SWL of the line and other plant elements, specially under very hot ambient conditions (when multiple hazards converge, eg. high ambient temperatures reducing cooling effect, high customer loads due to air conditioners and the combination of high ambient temperature conditions and high loads increasing the sag of network line spans).

### E.4 Cut Fuel Costs, Increase Competitiveness And Improve Consumer Welfare

As discussed in section **C.1 Coal will lose its place as the lowest cost fuel for electricity generation** fuel switching from coal to gas for electricity generation where co-generation is now appropriate will significantly reduce fuel costs and as discussed in section **C.4 Compressed natural gas / methane will replace petroleum products like petrol, diesel and LPG currently being used for transport vehicles** fuel switching from petroleum products to gas for transport requirements will significantly reduce fuel costs, once CSM support systems are fully developed. Indications are that Queensland will lead this changeover, thereby wrestling the 'lowest fuel cost in Australia' crown worn by Victoria from the early days of La

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[25] See: http://www.energyregulator.tas.gov.au/domino/otter.nsf/LookupFiles/Reliability_Review_2008_Final_Report_March_2009.pdf/$file/Reliability_Review_2008_Final_Report_March_2009.pdf

Trobe valley brown coal exploitation and gas being sourced from the Bass Straits reserves.

Considering the high costs and technology uncertainty faced by ‘clean coal’ projects to capture and safely store carbon dioxide, future fuel cost advantage of CSM is a safe assumption.

### E.4.1 Key to maximising allocative efficiency

***Allocative efficiency***[26]*: Maximising allocative efficiency involves allocating resources to their highest-valued use given existing technology at a given point in time. When prices are efficient, resources tend to be directed to those who value them most (as expressed by their willingness to pay for them). The concept of allocative efficiency places an emphasis on the choices made by decision-makers in response to the prices they confront; if prices do not accurately reflect costs, then the choices made by individuals may lead to an inefficient allocation of resources. In the NEM, for example, spot market pricing signals are highly relevant to the delivery of allocative efficiency at times of very low generation reserve levels. In such situations (typically accompanied by increased spot prices and/or supply curtailment)* ***allocative efficiency is enhanced if market arrangements facilitate voluntary load curtailment by customers, in response to diminishing reserve levels and rising spot prices.*** *Where voluntary responses to supply shortages are facilitated, the available (reduced) supply will continue to be consumed by those who value consumption the most.*

In the late 1980s EPRI had a project to develop the parameters for Priority Service Methods (PRISM). The concept was that by offering customers the choice of different “qualities” of electricity at different prices, the value of electricity service may be increased to all customers. In practice utilities had little option to increase the level of reliability to particular customers, but had more leeway to reward customers to surrender their right to the ‘common’ level of reliability by means of ‘curtailment rates’ / incentives.

Outage cost (also called Value of Lost Load or VoLL) studies have established that an outage with prior notice creates less problems to customers than unannounced interruptions. It has also been shown that different customers place different values on supply outages. Figure 6 gives the customer class average values for lost load, which are taken from a study done by Monash University[27] for the Victorian Power Exchange and later extended to cover other states as well. These studies formed the early basis for setting the pool price cap in Victoria and in the NEM (pool) as well.

Also around the time VoLL studies were being conducted by Monash University, the Electricity Supply Association of Australia (ESAA) constituted an expert working group to develop a Guide for Reliability Assessment in Network Planning. The

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[26] Assessing the efficiency impact of proposed changes to market arrangements – Guideline By NEMMCO (27August 2002)
[27] Value of Lost Load – Study for Victorian Power Exchange by Dr M. E. Khan, Monash University Aug 1997

Guide[28] provided typical values for demand and energy costs of interruption that was somewhat close to the findings from the Monash study.

**Estimates of Value of Lost Load for different customer classes**

| Customer Grouping | Monash Study (Victoria) | ESAA Guideline (Medium case) | |
|---|---|---|---|
| | | Demand Component | Energy Compt |
| | ($/kWh) | ($/kW) | ($/kWh) |
| Residential | 0.7404138 | 0 | 6 |
| Commercial | 75.958978 | 1 | 20 |
| Agricultural | 96.198087 | | |
| Industrial & major user | 11.193920 | 2 | 8 |
| Central Business District | | 6 | 20 |

The Monash study involved a stratified customer survey with responses from over 1,100 residential customers and over 2,000 business customers. The survey responses were matched with actual customer billing data to derive weightings. Results of similar studies[29] done in the USA, UK and Canada seem to be closer to the Monash study results than the ESAA figures.

A point worth noting is that the Monash study indicates that residential customers place a very low value on lost load compared to all other classes, being one hundredth of the value placed by commercial customers. The average aggregate value of lost load derived by the Monash study was 28.9 $/kWh, which was comparable with the values obtained by Kariuki and Allan in their 1995 study[30] of customer outages costs in the UK. There is a major problem in using aggregate values to drive investment for reliability improvement, as most business customers value reliability more than the average aggregate value that sets the delivered level of reliability (so are dissatisfied with the outcomes) while on the other hand most residential customers place much less value on the delivered level of reliability, so end-up paying more than they ought to.

The inference we can draw from the above is that seeking load shedding from only large customers (they are easier to manage because few customer can give large load reductions) on the basis of transaction time and cost , is misplaced as it will be counter to the main objective of improving allocative efficiency. With the new technology package, we are able to overcome the transaction cost / time / verification constraints so that DSP from large customers is no longer the preferred option. The advantage is further reinforced by the capability for reverse auctions, which means that the process goes step by step until the required level of load reduction is obtained. This process may be too difficult for big customers but is easily accommodated by a large number of small customers, the process considerably helped by the diversity inherent in very large numbers of small customers.

[28] Guidelines for Reliability Assessment Planning – ESAA 1997

[29] See also Customer Demand for Service Reliability – A synthesis of the outage cost literature (EPRI paper) September 1989

[30] Evaluation of reliability worth and value of lost load by K K Kariuki and R N Allan in IEE Proc – Gener. Transm. Distrib Vol 143 No 2 March 1996

## E.4.2 DSP and the Wholesale Market

To appreciate the potential for improving market outcomes offered by DSP in general and DSP using the technology package described previously, the comments will first re-iterate the features of the technology package that provide it a comparative advantage in interacting with the pool type energy market; then go on to look at the objectives of electricity industry restructuring and the principles governing pool market design. The last part of the commentary is concerned with options possible for making a contribution to improved market outcomes and any changes to the rules that might be desirable.

### E.4.2.1 Features that interact with the pool type energy market

The cornerstone of the technology package described above is its ability to operate in a pool type energy market. The package uses a derivative to gain exposure to pool price excursions with protection for a contracted level of consumption. There is no negotiation needed since the customer can provide a staggered response according to threshold triggers for shedding different loads or exporting different levels of energy, as the prices offered escalate in the reverse auction process. The package has a common platform to accommodate price premiums offered by the network, by NEMMCO, or any other party and the response is time stamped because of the included smart meter. Because it includes an ‘always on’ communication system linked to the computer based control system, the response time is well within the 5 minute dispatch period.

Retail customer using the technology package will have smart metering and always on communications. The metering database can easily tag these customers, so that their meter readings can be accessed easily. The package involves computer control of package facilities and provides very fast response, well within the 5 minute market rebalancing / dispatch pricing solution. The unique customer meter code incorporating zonal codes can be used to channel price premium offers only to customers in particular zones. Accommodating an internet poll enabled database of 5 minute meter readings is also possible. The in-premises generator is connected to the mains supply via an inverter, as such it has inherent capacity to also export reactive power into the mains power system.

Following demand side participation options are made possible:
- reduce load in steps according to pool market price exceeding price threshold for that set of loads;
- price premiums on offer from the distribution / transmission network operators increase the impact price enabling earlier crossing of threshold values for load shedding;
- price premiums can also be from NEMMCO or a load response aggregator;
- in addition to load reduction, generator operation can provide electricity export to the mains power system;
- because the mains connection is via an inverter, KVAr export is also possible with appropriate incentives.

### E.4.2.2 Objectives and principles governing electricity market design.

The objectives of the electricity industry restructuring as enunciated in the Electricity Act 1996 and the Market design principles incorporated in National Electricity Rules are reproduced below to set-up a frame of reference for the ensuing discussion..

Electricity Act 1996
**Sect: 3 Objects**
The objects of this Act are—
(a) to promote **efficiency** and competition in the electricity supply industry; and
(b) to promote the establishment and maintenance of a safe and **efficient** system of electricity generation, transmission, distribution and supply; and
(c) to establish and enforce proper standards of safety, **reliability** and quality in the electricity supply industry; and
(d) to establish and enforce proper safety and technical standards for electrical installations; and
(e) to **protect the interests of consumers of electricity**.

National Electricity Rules
***Section 3.1.4 Market design principles***
*(a) This Chapter is intended to give effect to the following market design principles:*
*(1)* ***minimisation of NEMMCO decision-making*** *to allow Market Participants the greatest amount of commercial freedom to decide how they will operate in the market;*
*(2)* ***maximum level of market transparency*** *in the interests of achieving a very high degree of* ***market efficiency****;*
*(3) avoidance of any special treatment in respect of* ***different technologies*** *used by Market Participants;*
*(4) consistency between central dispatch and pricing;*
*(5)* ***equal access to the market*** *for existing and prospective Market Participants;*
*(6) ancillary services should, to the extent that it is efficient, be acquired through* ***competitive market*** *arrangements and as far as practicable* ***determined on a dynamic basis****. Where dynamic determination is not practicable, competitive commercial contracts between NEMMCO and service providers should be used in preference to bilaterally negotiated arrangements;*

We see that the primary objective of electricity industry restructuring was to promote efficiency in the electricity supply industry. The objective statement identifies the intended beneficiaries "to protect the interests of consumers of electricity". There would be no disagreement if one was to say - that any industry exists to serve the customer, but some times the industry is so big that dominant suppliers fail to appreciate how vulnerable they are if they were to disconnect from the customer - General Motors now facing bankruptcy is a good example.

Electricity pool market was established in the current form as it was considered at the time of it's institution, that a fully open two way market with both demand and supply bids was not feasible with the available technology and time. So the current form of the market was accepted as the next most efficient way to provide a safe and secure supply of electricity to customers. There is no dispute that an efficient market must provide equal opportunity for both buyers and sellers. As discussed earlier, retail

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customers can provide demand side response and since the wholesale market is linked in real-time to customer consumption of electricity, that very fast response on the part of the customer – now possible with the described technology package, can have an impact on the next market rebalancing at the end of the current dispatch period. The dynamic nature of this interaction is evident from the fact that it is not only the kilowatts of energy that is involved. First, when the market is facing a shortfall because of excessive demand, the line losses are also very high - given that line losses are a square of the current flowing. Second, as systems controllers are well aware, to push kilowatts through heavily loaded power lines, the reactive power losses are also very high, sometimes more than the kilowatts delivered. Accordingly, the kilowatt shed by the customer is more valuable than the kilowatt sent out from the power station.

Under normal operating conditions the Ancillary Services market is almost inconspicuous but at times of severe supply shortage, price in the Ancillary Services market also can go up to VoLL - meaning the market is failing it's function (to clear). Given we now have a mechanism for NEMMCO to add a price premium so as to incentivise more customer demand side response, it is suggested that the appropriate method should be for NEMMCO to open the Ancillary Services market (where possible) to customer participation. This NEMMCO can do by offering the same price as is offered to Ancillary Service providers as a price premium to enabled customers. Such a step is necessary to ensure that there is balance in the opportunities available to the supply and demand sides, which is an essential condition for an efficient market. It is well accepted that reverse auctions are more efficient (for capacity utilization in capital intensive industries) compared to competitive tenders, adding further increase in efficiency from use of the new technology package.

The National Electricity Rules is abundantly clear - that competitive commercial contracts for Ancillary Services is second best with dynamic determination as the preferred option, and competitive commercial contracts are to be used only if dynamic determination is not practicable. As explained above, with the new technology package, dynamic determination is practicable – maybe it will take some time for sufficient facilities to be installed but eventually it will provide a much better outcome to the customers and to market operations. Before industry restructuring, generators were loaded in a manner so that each generator could perform regulation services. That way large number of generating plants were able to respond instantaneously to a power system disturbance, which response was significantly better than having only a few generating plant trying hard to ramp-up output to meet capacity shortfalls due to a trip of a major generating plant or transmission line. Now dynamic response at the customer end can substitute for the lost dynamic response at the generator end. Since generators bidding into the Ancillary Market cannot serve the energy market at the same time, their capacity utilization is quite low. On the other hand the dynamic response by the customer using the new technology package is using a multimode plant, so the capacity utilization of that plant is much better and the energy conversion efficiency of the plant is also better than at a central power station. Thus overall efficiency is now better.

**E.4.2.3 Options for contributing to improved market outcomes**

The draft report is absolutely right in saying that DSP must include pool price benefits. The beauty of the proposed technology package is that in many cases where the distribution network requires network reserve capacity support, the pool price may be high enough to trigger sufficient customer response which will re-instate network reserve capacity. If the network wants more response, the network operator can add a price premium. The customer is already benefiting from the high pool price and with the extra premium will step up the response level. So effectively the outlay needed by the network may be small if it coincides with high prices in the pool market. If the network congestion / loss of reserve happens when the pool price is low, then an attractive enough premium needs to be offered in a step process made possible with reverse auctions. This also applies to 'out of merit generation dispatch' situations when a zone is impacted by constrained network access. If sufficient DSP was able to overcome the network constraint there is no need for out of merit generation dispatch.

The Longford gas plant failure illustrated the frustration the State Governments have when market procedures do not allow customers to self-disconnect at a high enough buy-back price, which very many customers will be willing to undertake (those with generation facilities can export part of the output or the full amount) for a payment, if it is organized in rotation. In the days of the SECV, there was always more than adequate customer response to advertisements in the newspapers and local radio - to say that problems in the Valley is threatening electricity supplies and appealing for customers to reduce their electricity consumption. That way SECV avoided the need for rolling blackouts over a period of almost a decade.

Customers equipped with the technology package can provide NEMMCO the following services:

- Frequency Control Ancillary Services;
- Network Control Ancillary Services;
- Introducing dynamic determination to Reserve Trader via reverse auctions would enable NEMMCO to restore adequate reserve levels within the 30 minutes period following a contingency event;
- Substitute for rolling blackouts, by offering premiums going up to VOLL, selectively target customers in affected areas, in rotation until underlying major contingency is resolved.

It is important that the market has a mechanism for ***competitive market*** *arrangements (equal opportunity extending to customers as well)* ***determined on a dynamic basis*** to avoid involuntary load shedding, since involuntary load shedding would be a mark of **market failure**.

## F Conclusions / Recommendations

I have been reliably informed that the Queensland government is very keen to improve energy efficiency and deploy clean energy. Some of their recent undertakings, like the measures to encourage use of gas in electricity generation, the establishment of the Office of Clean Energy, range of demand management initiatives being progressed in conjunction with Energex and Ergon Energy, are all very commendable.

I have tried to provide your committee a broad picture of the inner workings of the energy industry, the levers of change as it were. Not knowing to what depth you intend to take the inquiry, and considering the different jurisdictions involved in some of the aspects covered in my submission, it would not be appropriate for me to make specific recommendations. I am confident we both share the dream to see Queensland take the lead in setting the tone for the new energy reform process. The very considerable work already accomplished in the field of coal seam gas extraction and underground coal to gas conversions place Queensland in an enviable position. To obtain an efficient outcome as the culmination of this work, it must deliver maximum possible benefits to Queensland, to Queenslanders, to Queensland businesses, and to Australia. Benefits to potential investors is of course negotiable but benefits to the rest of the world must only be a secondary consideration. As I said before in section **E.1 Achieving A Sustainable Energy Future**, to achieve this efficient outcome it is necessary to:

- make an all out effort to promote an appreciation of the potential for gas resources and provide incentives for investment in gas transmission / distribution pipelines to move gas from well head to market place;
- make an all out effort to promote an appreciation of the potential for using gas in transport and encourage by providing incentives for development / demonstration projects for using gas in cars, buses, trucks / lorries and in rail road applications;
- make an all out effort to promote an appreciation of the potential for using gas for electricity generation, giving government subsidies to initiate the conversion of coal power stations to operate partly or fully on gas;
- make an all out effort to promote an appreciation of the potential for using gas for direct end-use to by use of appropriately sized gas engines instead of / or in combination with electric motors, giving incentives for early diffusion of such technologies.

Thank you for this opportunity to provide comment. I would be happy to provide further explanation / clarification on any of the matters mentioned above. My contact details are provided at the bottom of the page.

**Lasantha Perera,** MIET, MIMechE, FIE (Sri Lanka), CEng
BSc, DipEE, MSc Technological Economics (Stirling)

Electricity Markets Research Institute

**Attachment A**

Electricity Markets Research Institute (EMRI) undertakes research with primary focus on:

- Public benefit aspects of competitive electricity markets:
- Technical and market efficiency,
- Equity issues,
- Transition issues going from integrated utility in a monopoly market to competitive marketing.

Other research & consultancy work cover:

- demand side response in the context of the electricity pool market;
- retail pricing and value studies;
- distributed generation;
- network and ancillary services pricing.

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## Biography of Lasantha Perera, Director - National Electricity Markets Research Institute

September 2001 to January 2004, was Assistant Director at the Office of the Tasmanian Energy Regulator responsible for setting up the Performance Monitoring and Reporting section and providing technical advise to the Regulator. Also provided technical and secretarial support to the Reliability and Network Planning Panel responsible for setting standards for the Tasmanian power system and making recommendations to the Regulator on network investment proposals

Until July 1999, was Manager Pooling with Eastern Energy Ltd. Played a significant part in the deliberations of various bodies connected with the setting up of the National Electricity Market, including membership in the Dispatch and Pricing Reference Group. Was a founding member of the National Retailers Forum and have made many submissions to NEMMCO, NECA and the ACCC on different facets of the National Electricity Market.

Was inducted into Eastern Energy at its inception in 1994 and as Manager Pricing and Forecasting set up their Pricing and Forecasting section, participated actively in the trade sale process and managed the contestable customer pricing process.

As Pricing Analysis Manager with SECV spent seven years working on pricing development, cost of supply studies and the development of industry cost models, and defining price paths to reduce cross-subsidies. Was an active participant in the Victorian Electricity Supply Industry Restructuring process involving industry codes, Tariff Order and network pricing.

Has a MSc in Technological Economics from the University of Stirling in Scotland, is a Chartered Engineer from both the Electrical and Mechanical Institutes in the UK. Has over 35 years experience as an engineer / techno-economist, with work experience covering electricity generation, distribution, contracting, engineering jobbing, co-generation plant maintenance and R&D into renewable energy sources.