DRAFT STATE SUSTAINABILITY STRATEGY
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INTRODUCTION

The draft State Sustainability Strategy (SSS) covers an extensive range of issues and topics. Pressure from other commitments prevents me from comment on most. I will concentrate on energy issues and petroleum with a focus on transport.. However, this subject is pivotal to all other sustainability issues. Practically every activity in this State has a heavy dependence on transport fuelled by petroleum products. Hydrocarbons are also the source of a wide range of petrochemicals from fertilisers, plastics, synthetic fibres and pesticides, to name a few.

Modern agriculture generally, and especially as practised in Australia, has been described as *'a way of using land to convert petroleum into food'.*

There is now a growing acceptance among informed people that world production of *cheap* oil will reach a peak and begin decline in about 10 years. Even major oil companies are now publicly admitting this. Woodside Energy and the Australian Petroleum Producers and Exploration Association a year ago warned that Australia's oil self-sufficiency is declining rapidly, saying the issues arising were far more important than reform of the electric power industry. They saw transport as most at risk and considered that this country needed to make a shift to natural gas-based transport fuels, as well as giving priority to public transport infrastructure and transport demand management They urged the Australian Government to prepare a National Energy Strategy covering all energy issues.

So the issue of oil *vulnerability as* discussed in the Draft SSS is a central issue, if not the most important one. The threat of an invasion of Iraq and its possible consequences only sharpens its importance. The three accompanying papers outlined below are an integral part of my submission.

These oil vulnerability issues are discussed at length in my accompanying paper, ***Natural Gas: "Magic Pudding" or Depleting Resource*****,** as is the adequacy of Australian natural gas to meet substantial transport uses given the agenda for petrochemical and LNG projects in the Carnarvon Basin. This Basin contains over half of Australia's discovered natural gas. The discussion is in the context of an overview of world oil supply trends. Aspects affecting food supply, population and political instability in the Middle East and other issues are discussed as well.

My main discussion in this submission will be on *energy quality issues and the relation between energy and economics.* Energy drives everything – no energy, then no economic or any other activity. That applies to the energy industry too. We have to use energy to extract energy from natural resources and to convert it into useable forms, and to deliver it to locations where it is to be used. It is the net energy yield that we use, the *difference* between gross energy output and the direct and indirect energy inputs embodied in goods and services needed to make these energy transformations. There are other aspects to energy quality as well. For example, aeroplanes are powered by petroleum products. We are unlikely to see coal powered ones.

Differences in energy quality can summed up in the statement; '*all fuels are equal but some are more equal than others',* to paraphrase George Orwell.

It is not possible to compare and assess the economic effectiveness of alternative fuels in different uses without taking into account these basic physical characteristics of the different sources of energy, to be able to sort the wheat from the chaff. Prices alone are not sufficient.

An introduction to Ecological Economics, the relations between energy quality and economics are discussed in some detail in my accompanying paper; *Energy Quality and Economic Effectiveness.* At the end there is a discussion comparing quantitatively the various transport fuels from an energy quality perspective. I conclude, as have many others, that there are *no alternative fuels that can replace petroleum products* as we have known them for the last century. I would recommend that you read this paper first.

Finally, I discuss hydrogen as an alternative transport fuel and conclude that its physical characteristics as a gas and as the lightest of all the elements preclude its use as a transport fuel, or for any use as an energy source where it must be transported much beyond its point of manufacture.

The basic physics are in the accompanying paper; *The Future of the Hydrogen Economy: Bright or Bleak* by Baldur Eelason and Ulf Bossel.

This is of crucial importance given the emphasis placed on hydrogen as an alternative transport fuel around the world and in the draft SSS.

It highlights the utmost importance of addressing systematically issues of energy quality and economic effectiveness when considering sustainability.

OVERVIEW

The significant contribution that the draft SSS makes to the global sustainability debate is its emphasis on the necessity for an *integrated approach to* economic, social and environmental development. These are not to be regarded in isolation one from the other as mostly happens now. There is much debate on what sustainability means. To see sustainability as some end-point, a nirvana to be reached, is to view a *dynamic* world from a *static* viewpoint. Sustainability is a journey in a dynamic evolving world. We will find out what sustainability is by actively exploring and pursuing sustainability agendas. The debate will always be with us, a never-ending journey.

Competition Policy is a pivotal agenda of governments in Australia, and to a considerable degree of business. Competition Policy legislation and its application has raised the values of the market place, economics, to be supreme above all other values. The legislation does make provision for consideration of environmental and social values, but only as subordinate to competition values which dominate. This relationship has been even more apparent in the implementation of the legislation.

The Competition Policy approach is in direct conflict with an *integrated* approach to economic, social and environmental issues where the latter two carry an importance at least equal to economics. But even this is inadequate. Ultimately the integrated approach to these three issues must be seen as subordinate to the larger global environment. Human life is embedded in the environment, not the other way round. This viewpoint must surely emerge sooner rather than later on the sustainability journey. Some reference to the incomplete character of the integrated approach is warranted in the SSS, foreshadowing its future development.

There does not seem to be any reference in the draft SSS recommendations to this conflict with Competition Policy. Such a reference is necessary, even if it is just to note that the conflict exists and that a debate is needed on the issues involved.

The SSS will be an incomplete document without a constructive critique of Gross Domestic Product (GDP) as a prominent economic statistic that has become wrongly identified with general human welfare. Business and governments seek to maintain high growth in GDP.

Gross domestic product (GDP) during a given period is the total *monetary value* of all the goods and services produced in a nation without deductions for depreciation or other business expenses, minus the net payments on foreign investments. It is in effect the sum of all monetary transactions in a given period regardless of the consequences of those transactions, positive or negative. It has come to be regarded as a de facto measure of welfare, but was never originally designed for that purpose. Its critics say this use of GDP is seriously deficient as it does not account for the benefits from the extensive unpaid community activity (about half of all labour), and gives no regard as to whether the goods and services included add to or detract from welfare, nor lead to environmental degradation. For example, the dollar costs of fighting, cleaning up and restoration after recent bushfires in Australia adds to GDP.

Alternative indices have been proposed to accommodate these deficiencies. The Australia Institute (1997) has attempted to do this with its General Progress Indicator. (See www.gpionline.net). For Australia GDP has steadily risen since 1950. The GPI also rose from 1950 to 1975, though slightly below GDP. However, since 1975 GPI has not increased and for periods has actually declined. There is a growing gap between GDP and GPI. Sustainability must take on board the deficiencies in using GDP as a measure of welfare.

Equally important is to identify the deficiencies and components of GDP that detract from welfare that provide a basis for initiating programs for positive and beneficial change to promote sustainability. In particular, where adapting to declining oil availability is concerned, people will have to make some sacrifices and significant changes to lifestyles. To focus initially on those facets of GDP that detract from welfare in its broadest sense should encourage people to commence the sustainability journey.

These issues are worthy of inclusion in the SSS.

SECTORS DEPENDENT ON PETROLEUM

Transport

Over 60 per cent of Australia's oil consumption is used by transport – some 160 million barrels per year. About three quarters of transport fuel is used by vehicles on roads, followed by aviation, then by rail. The whole economic structure, as well as present day social interaction and leisure activities are heavily dependent on powered transport. Responding to oil vulnerability and the shift to alternative transport fuels therefore must be considered as the major driver of the sustainability agenda in virtually all its sectors. A brief assessment of the ranking of transport fuels from an energy quality perspective is given below.

Over two-thirds of Australian food production is exported – a higher percentage in W.A. This adds to the transport dependence of our agriculture and links it to the world scene. Major destinations for grain production are the Middle East oil producing countries whose population growth has outstripped their agricultural output by wide and growing margins.

Mineral production and its marketing are transport dependent industries. Tourism is an energy intensive industry totally dependent on transport fuelled by petroleum products.

Commercial aviation is the transport mode most at risk to petroleum product supply disruption. It does not receive the attention it deserves in the draft SSS.

Agriculture

Cereal cropping in Western Australia has a heavy and growing dependence on direct and indirect energy inputs, principally petroleum products. The principal *indirect* energy inputs are embodied in machinery, herbicides, water supply and fertilisers. Much water is pumped for irrigation. Transport on and off the farm is significant and indispensable.

In 1996 approximately 560,000 tonnes of superphosphate and 250,000 tonnes of nitrogen fertiliser were used in W.A., nearly all in the wheatbelt.

Lime addition is now needed to counter soil acidification arising from use of these fertilisers, and to a lesser extent from the growing of leguminous crops. Without lime addition present agricultural production will be reduced and heavy metals mobilised into the ground water system. In 1996/97 300,000 ha were treated with 332.000 tonnes of lime increasing to 586,000 ha and 653,000 tonnes in 1998/99. This is should increase to 1,000.000 tonnes per year within a decade. In 1997/98 lime was supplied by 33 commercial coastal lime operations from Port Gregory to Esperance (Gazey 2000). Diesel power is used to mine the lime, transport it to farms and to spread it on the land. *Use of farm fertilisers is transport intensive*. Most lime is used on farms close to coastal lime pits. Long-term lime mining on this scale will devastate coastal limestone coastal environments.

This massive energy intensive fertiliser input imposed on Australia's infertile and fragile soils to sustain present food production practices is not sustainable. Some say soil acidification is just as big an issue as dryland salinity in Australia.

Mechanisation of agricultural production *using petroleum products* has enormously increased labour productivity on the land, principally in Canada, USA and Australia, leading to depopulation of rural communities and the decline of rural industries, businesses and services. In Western Australia this has reached the stage where social life in many rural communities is collapsing. Despite having annual production budgets well over $500,000 per year many wheatbelt farmers or their families are forced to take second jobs to be able to survive- where such jobs are available.

There has been a corresponding growth of cities made possible mainly by these applications of petroleum products to agriculture and transport.

It is becoming widely recognised that present agricultural practices in Australia, and especially Western Australia, are unsustainable given the mainly dry climate, infertile soils and massive salinisation of land and water arising from land clearing. *Less well recognised is that petroleum products more than any other factor are allowing us to impose for a limited time these foreign agricultural practices on an alien environment*.

Re-inventing more sustainable agriculture and rural communities in Australia will take time – decades. The use of petroleum products will be indispensable to achieve this transition. *This task must have first call on our remaining petroleum products.*

This problem is not unique to Australia – with variations, it is a global one.

This agenda for rural revitalisation and its intimate connection with oil vulnerablity and alternative fuel scenarios is perhaps *the central issue for the State Sustainability Strategy* because of its intimate connection with the sustainable future of our cities and towns as well.

There cannot be healthy cities and towns without healthy and vibrant rural communities.

Minerals and Mining

Australia is the world's largest exporter of coal, iron ore, alumina and mineral sands. Western Australia is the countries largest exporter of the last three, and also of LNG. Australia also mines and exports significant other minerals such as gold, nickel, copper, zinc, lead, tantalum and others. Asia is the principal destination of these minerals.

The mining operations and associated processing plants are capital intensive (therefore with a high embodied energy content) and often very energy intensive in their operation, e.g. alumna from bauxite, nickel. For most of the lesser minerals exploration is becoming more challenging as deposits with surface expressions diminish and ever more technically sophisticated methods are needed over longer time frames at higher cost. Most mining is in remote locations far from urban centres. The capital and energy investment per direct permanent job is extremely high.

Nearly all mining operations use diesel power extensively on-site to excavate the ores and move over-burden. There is a significant transport component moving raw and/or processed minerals to ports for export, mostly by diesel powered rail. Most overseas mineral transport is by diesel powered ship.

It is the application of high quality energy such as petroleum products and electricity to mining and mineral processing over the last century that has significantly reduced the real cost of mineral products. More recently natural gas is playing a similar role in Western Australia.

Tourism

Tourism has become a significant component of Australian life and economy. Millions of Australians tour inside Australia and overseas while millions more overseas visitors come to Australia. Tourists are a substantial component of aviation passengers and of road transport. Cheap petroleum products have made this possible, both in fuelling the transport modes and reducing travel costs, and indirectly by making possible high enough incomes for a sufficiently large number of people so that they can afford to travel. It is an energy intensive industry.

Cities and towns
The draft SSS has extensive discussion on issues in which transport issues and car dependence play an important part. However, much of the SSS discussion is based on the internal transport and service needs of urban areas. Not enough attention is paid to their *absolute* dependence on *external* transport and service needs without which no city could survive.

Public water supply and wastewater
I have a particular sympathy for this one, having spent my working life in the water utility industry in Western Australia.

Nearly 90 per cent of the states population receives piped water from the Water Corporation. Perhaps 70-75 per cent are connected to public sewers. It is a capital intensive industry and most of its assets can have very long lives – often over 100 years for pipelines and dams. About 85 per cent of all public water supply and wastewater in Western Australia is pumped, often more than once. The Water Corporation is Western Power's second biggest customer. Private pumping for industry and irrigation is additional.

The present trend is for the industry to become more energy intensive. The possibility of sea water desalination is on the agenda. Yet the Water Corporation's forward planning for new works to cater for growth decades ahead assumes that present low cost energy supply will continue to be available in increasing quantity virtually to the end of the century. New pumped water and wastewater systems are on planning horizons decades ahead and with lives beyond this century.

The draft SSS does not mention these issues. The final SSS recommendations need to address them as a HIGH PRIORITY. The very viability of existing hydraulic infrastructure is at stake, let alone future additions. A starting off point would be to evaluate the direct and indirect energy inputs to all the goods and services used by the water utility industry and the trends of these.

Water is a renewable resource. But the systems that mobilise it for human use are based substantially on non-renewable resources.

Transport and energy quality
The discussion below is a modified abstract from my accompanying paper *Energy Quality and Economic Effectiveness.*

We discussed very briefly above the concept of the energy cost of extracting energy from nature and transforming it into forms useful to humans. The energy cost of these extraction and transformation processes includes both direct inputs and indirect inputs embodied in the goods and services used. One measure of the energy quality of a fuel is energy profit ratio (EPR), the gross energy obtained divided by these direct and indirect energy inputs. He higher the ratio the more economically effective the fuel. An EPR of less than one means more energy is consumed than is produced, there is a net energy LOSS.

$$\text{EPR} = \frac{\text{Energy output}}{\text{Energy inputs}}$$

There are other aspects to energy quality as well in addition to EPR, discussed in my accompanying paper.

Figure 1 below compares important quality characteristics of some transport fuels. Their EPR's are listed on the vertical axis and the fuels are *ranked* on the horizontal axis according to other quality characteristics, as discussed below. The EPR data is mostly for the USA and taken from Cleveland et al (1984), also shown in Gever et al (1991, p.70) and Hall et al (1986, p.48).

There are over 30,000 producing oil fields in the world. However, 120 giant fields (mostly those holding over 500 million barrels or 80 GL on discovery) produce nearly half the world's oil. Of these 14 produce 20 per cent and FOUR produce 11 per cent. These fields have long lives, produce the cheapest oil and generally have the highest EPR (Simmons 2002). The EPR is generally highest in the middle years of their life. Most of these fields are ageing and few are now being discovered.

What *Figure 1* shows is the unique role that oil from giant oil fields has played, ranked well above all alternatives. But their best years are now mainly in the past.

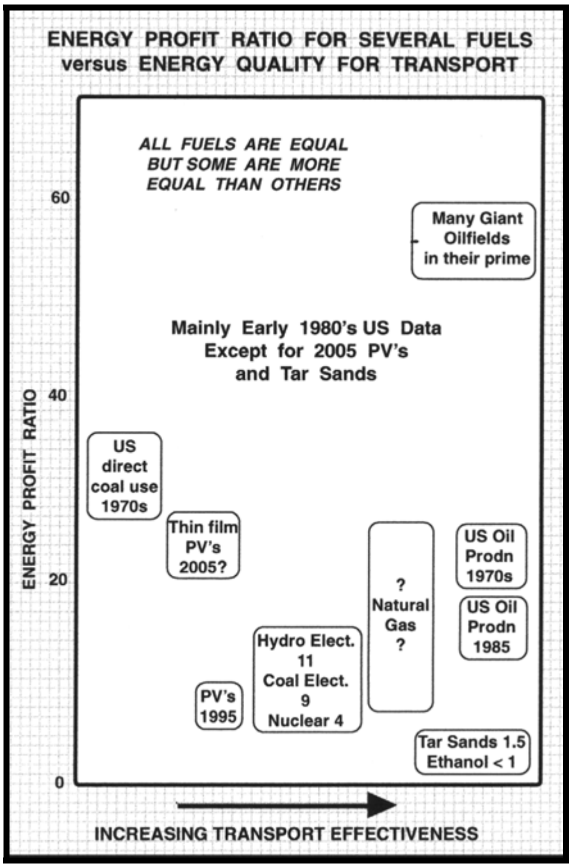

Figure ***1***

Liquid fuels are listed on the right because they are the most convenient and adaptable transport fuels and the technology for their use is well developed. *Natural gas* is to the left of liquids because it is more difficult to store and transport than oil, but it can be used in existing internal combustion engines and the basics of a distribution system exist. EPR's for natural gas have not been published to my knowledge. Natural gas is the only fuel immediately able to substitute for petroleum products in land and sea transport.

Oil from Canadian tar sands has an EPR of 1.5 (Youngquist 1999). Massive mining operations and energy intensive processing is required. *Large-scale* biofuel production (such as ethanol and biodiesel), according to studies embracing several countries by Giampietro, Uligiati and Pimentel (1997), *"is not an alternative to the current use of oil and is not even an advisable option to cover a significant fraction of it."* Using the net energy approach and including both direct and indirect inputs as outlined above, they found that the energy inputs exceeded the output – there was a net energy LOSS. Also the area of land required to grow the crops made serious and unacceptable in-roads on land needed for food production, along with major environmental problems.

Electricity is perhaps the most effective energy form for transport. Unfortunately it has to be manufactured from other fuels with attendant energy losses that attenuate EPR's, and it cannot be economically stored. Four litres of petrol has the same energy content as a one tonne lead acid battery, the reason why battery operated cars have never gained a large market (Youngquist 1999a). However, electric assisted bicycles are already viable – you do not need power to transport a heavy vehicle and battery. Electric power is therefore to the left of natural gas.

Photovoltaics for electricity have the additional disadvantage of only generating electricity while the sun is shining. The EPR expectations of researchers for thin film silicon technology have to be realised before photovoltaics could be a serious contender for a role in transport, say for electrolysis of water for hydrogen – see below. Nearly all the energy input for photovoltaics occurs in the initial construction of the facilities, an energy call on existing commercial energy supply. This requirement limits the rate at which this technology can be introduced. The call on existing high quality energy supply is at the expense of existing uses.

The EPR for nuclear energy is for the early 1980s in the USA. It is based on the original very electric power intensive gaseous diffusion process for uranium enrichment, now superseded by the less energy intensive centrifugal process. However, the EPR does not include the energy cost of decommissioning nuclear plants and the disposal of nuclear wastes – unknown costs much of which will occur AFTER the plants are decommissioned. It is difficult when assessing the economic merits of nuclear power to disentangle the power industry from its connections with the nuclear weapons issue – indeed that is not possible.

Finally, direct use of coal as a fuel for transport has the real disadvantage of it being a solid and dirty fuel.

Hydrogen is not shown on Figure 1. It is being widely promoted as a transport fuel in conjunction with fuel cells to generate electricity. But hydrogen has to be manufactured using some other fuels or energy sources. Hydrogen is an energy *carrier,* like electricity, not an energy source. The fuel cell technology is still under development. At least two energy transformation processes are involved to ultimately obtain electricity, with their attendant energy losses and embodied energies incorporated in the processes involved. However, there are many possible primary energy sources that can be used to manufacture hydrogen, one reason for it being favoured as a potential fuel for transport and other uses.

But hydrogen is a gas and is the lightest of all the elements. Even compressed, its energy per unit volume is very low compared to all liquid and gaseous alternatives so that the storage and transport costs of hydrogen are very high by comparison. Likewise the proportion of its energy content needed for these tasks is also very high.. These issues are discussed in detail in the accompanying paper. *The Future of the Hydrogen Economy: Bright or Bleak.* The essence of the paper's conclusions comparing hydrogen to natural gas are:

- For an equal energy content the size of a hydrogen pressure vessel storage vessel must be four to five times larger than the corresponding natural gas one.
- A similar relationship exists for transport by pipeline.
- Existing gas pipelines are not suitable for hydrogen because of diffusion losses and incompatibility of pipeline materials and equipment in the presence of hydrogen.
- The proportion of the energy content of these fuels needed to compress them, both for storage tanks and pipeline transport, is four to five times higher for hydrogen than for natural gas.
- For delivery by 40-tonne road tankers, 21 road tankers are needed to deliver hydrogen equivalent to one tanker of gasoline.

The authors conclude that hydrogen, whether as a gas or liquefied, has no future as a transport fuel to replace petroleum, or for any use requiring even moderate transport from the manufacturing location.

One option is to manufacture methanol, a volatile liquid, which can be used directly in some fuel cells to generate electricity. It does not have the transport and storage problems of hydrogen, but is not as good as natural gas. Methanol can be manufactured from natural gas and from biomass. But natural gas is also a limited non-renewable resource and the biomass route has the same limitations as does ethanol and biodiesel.

CONCLUSION

The net energy yield approach, combined with a systematic evaluation of the physical properties of alternative fuels from an energy perspective, must be at the centre of evaluation of fuels to replace petroleum products.

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