EnergyWatch

The Journal of the Sustainable Energy Forum Inc.

Facilitating the use of energy for economic, environmental, and social sustainability

Published by: - The Sustainable Energy Forum Incorporated, PO Box 11-152, Wellington 6142
Email: -info@sef.org.nz Web: - www.sef.org.nz; and www.energywatch.org.nz

The Sustainable Energy Forum Inc. was registered as a charitable entity under the Charities Act 2005 on 30th June 2008. Its registration number is CC36438.

Issue 85 July 2022

editor: Steve Goldthorpe

ISSN 1173-5449 (print) ISSN 1179-4054 (online)

EDITORIAL

What is wrong with the Lake Onslow scheme?

A review in EnergyWatch 84 highlighted several fatal flaws with the Lake Onslow concept. It concluded that the NZ Battery Project should abandon the Lake Onslow project forthwith. However, the current NZ Battery project bulletin reports *"Cabinet confirmed a pumped hydro scheme at Lake Onslow appears technically feasible at this stage, although more work is needed."* There is much expert opinion in the electricity industry that also severely criticises the concept. Nevertheless, the Government's well-funded New Zealand Battery project retains the Lake Onslow concept as its flagship project and is spending the lion's share of its funding on geotechnical investigations in Otago to study the feasibility of the infeasible. A year has already been lost in addressing the real problems in the NZ electricity industry.

10 problems with the Lake Onslow concept

- The trivial rate of return on investment, if any, would be unattractive to investors.
- The scale of energy storage in Lake Onslow would be 7 times the scale of energy storage needed to accommodate a dry-quarter event.
- Leakage and evaporation of stored water would make Lake Onslow much less efficient when used for long-term energy storage.
- There is no "lower lake" as in a normal pumped storage system.
- The location of Lake Onslow is remote from the demand centres for electricity.
- Flooding of Lake Onslow would necessitate re-routing of the Roxburgh to Dunedin (TMH) 220 kV electricity transmission line.
- The economics of pumped storage depends on frequent cycling not long-term storage.
- The moorland terrain would require a 1.5 km long dam to be built.
- The Lake Onslow wetlands would be destroyed by large changes in the water level.
- The low rainfall in the Central Otago area is unsuited to a large-scale hydro scheme.

Lake Onslow, was originally created in 1890 by damming the Teviot river, which drained Dismal Swamp. It was raised by 5 metres in 1982.

In this issue of EnergyWatch these fatal flaws in the Lake Onslow pumped storage concept are discussed further and quantified. The year-by-year analysis of the dry year issue presented in EW84 is reworked here on a quarterly basis.

Many alternative energy storage concepts for New Zealand have been explored. The use of a stockpile of processed wood fuel at Huntly for security of supply was proposed in EW84.

The NZ Battery project bulletin also reports that the storage alternatives to Lake Onslow have been reduced to three non-hydro options *"flexible geothermal, hydrogen and biofuels"* with no further details. Geothermal is poorly suited to load-following. Storing energy as hydrogen is nonsensical compared with grid-scale batteries.

Perhaps a torrefied wood stockpile at Huntly may yet become the NZ Battery at the end of the day. Financing that New Zealand battery solution might be with a Security of Supply Service levy.

In this issue Stephan Heubeck reviews the potential role of flywheels to store energy in small scale applications. New battery technologies are becoming increasingly competitive and practical for ever larger applications as their chemistries evolve. So they are taking over the flywheel role.

There are plans in Taranaki for a second natural gas storage facility to complement the gas storage facility at Ahuroa. But reliance on fossil fuel as the traditional energy store, albeit natural gas instead of coal, runs counter to the principle of preparing New Zealand for a zero-carbon future, and gas is a depleting resource.

Another issue with natural gas infrastructure is the potential for methane losses and their lack of accountability in the emission trading scheme. I include a cautionary tale of a 240-tonne avoidable methane release in Taranaki in January this year.

Alternatives to electricity transmission for getting surplus energy from South Island to North Island have been sought, but hydrogen and ammonia are dismissed as energy carriers for that duty.

Switching from a petrol hybrid to an Electric Vehicle will reduce CO_2 emissions. In EW84 the cost of that switch was estimated to be an expensive \$800 per tonne of CO_2 emission avoided. Now that petrol costs \$3/litre instead of \$2/litre the emissions reduction cost is reassessed.

A long-standing theme of SEF discussions is that the competitive electricity market is not fit for purpose. An alternative philosophical approach to meeting New Zealand's needs is suggested.

As usual, this issue of EnergyWatch wraps up with the comparative chart of oil and gold prices that Neil Mander has maintained since 2004.

And that's it from me.

This is my last issue of EnergyWatch. After editing 29 issues of EnergyWatch over the last 12 years, the time has come for me to retire from the role of EW editor. I will formally resign as editor at the virtual SEF AGM on 28th July. So far, there is nobody waiting in the wings to take on the EnergyWatch challenge, but the door is open.

That raises the wider question of the future of SEF as an institution. From its proud ground-breaking beginnings in the 1980's, has SEF now run its course with a job well done? There are now other organisations leading the struggle against corporate business-as-usual and entrenched institutionalised apathy in more focussed ways.

I have been convenor of SEF for 12 years. I have been very pleased to lead the forum with wide ranging discussions from fossilised climate scepticism to deep-green environmentalism. But I am conscious that we tend to be preaching to the converted and ignored by the movers and shakers.

Can the SEF baton now be passed on to younger enthusiasts who see the on-going need for a champion of sustainable energy in Aotearoa. The future of SEF will be a principal agenda item at the upcoming virtual AGM on Thursday 28th July at 7.00.p.m. on Zoom.

See you there.

Steve Goldthorpe, editor

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Ten fatal flaws with the Lake Onslow concept

1. Rate of return on investment

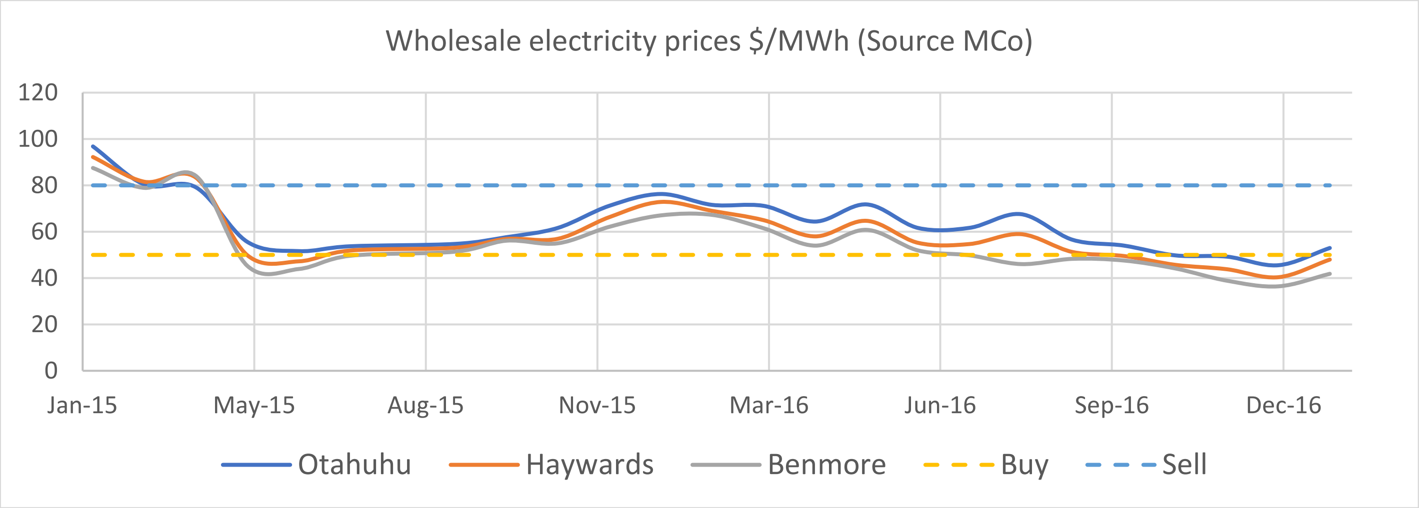
Electricity generation plant in New Zealand is all owned and operated by companies in a competitive electricity market. Investing $4 billion in the Lake Onslow Scheme by any of those companies would require a business model showing that there was scope for income to be earned from the buying and selling of electricity to provide a reasonable rate of return on that investment.

The figure below shows an illustrative example of wholesale electricity prices over a 2 year period. This data suggests that electricity might be purchased in the winter for about $50/MWh. At a round trip pumped storage efficiency of 70%, the stored energy would need to be sold for at least $80/MWh to generate earnings. The chart below shows that the wholesale price reached that level only for a short period, and not every year.

If 5 TWh of electricity were bought to fill lake Onslow at $50/MWh that would cost $250 million. If once every 2 years that water can be used to generate 3.5 TWh of electricity worth $80/MWh, then it would yield $280 million, i.e. a net biannual profit of $30 million, or $15 million earnings per year. On a $4 billion investment that would be a rate of return of **0.375%**.

Furthermore, a large purchase of electricity in the winter would raise the lower wholesale price and additional generation during a shortage would lower the upper wholesale price. Thus the implementation of the Onslow project would reduce the range of wholesale electricity prices and would likely eliminate any net earnings from the proposed Onslow pumped storage scheme.

This basic economic assessment does not present a viable business case to justify a $4 billion investment.



2. Scale of energy storage

The quarterly analysis "Quantifying the 'dry-year' issue in NZ" (on pages 8 and 9) determines that, in the last decade, the maximum quantity of abnormal generation required to resolve an infrequent hydro shortage situation called a "dry-year" is about 500 GWh in a dry quarter, which corresponds to 235 MW of full-time generation for 3 months. Therefore, the scale of energy delivery from Lake Onslow would be 7 times the scale of energy storage needed to accommodate a dry-quarter event. The worst case would be two adjacent dry-quarters.

3. Leakage and evaporation

70% round trip efficiency for pumped storage is the best that can be expected for a night-day pumped storage scheme. The aim of the Lake Onslow scheme is to store energy for at least 6 months and maybe for a few years.

In EW84, stored water losses were estimated as 2.5 m^3/s (3.2 mm/day) by evaporation and 0.8 m^3/s by migration of groundwater, i.e. 107 million m^3 of losses per year. The large generation head of 600 metres, would give a minimum loss of 175 GWh/year of potential energy, that is 4.2% of the stored potential energy each year. The losses due to groundwater flows could be much greater.

4. No lower lake

There is no "lower lake" as in a normal pumped storage system. Instead, water would be pumped in and out of the Clutha river below the Roxburgh dam. The average water flow in the Clutha river through the Clyde and Roxburgh power stations is about 600 cumecs[1], and about 1000 cumecs at full rated capacity.

The planned generation capacity of the Onslow scheme is 1000 MW, which is 3 times the capacity of Roxburgh and more than twice the capacity of Clyde. At 600 metres head the discharge from the Onslow scheme into the Clutha River would be 200 cumecs.

However, at 1000 MW, it would take 6 months for the Onslow scheme to deliver all the stored energy, so a greater capacity might be needed.

Alternatively, the use of Lake Roxburgh as the lower lake for pumped hydro has been suggested. That would reduce the hydro head, increase friction losses, and increase tunnelling costs.

5. Remote location

In central Otago the location of Lake Onslow is remote from the demand centres for electricity in North Island. When there is a shortage of electricity the transmission losses would make the Onslow scheme less attractive than Huntly power station as a back-up generator.

6. Moving Transmission line

Flooding of Lake Onslow would necessitate re-routing of the Roxburgh to Dunedin (Three Mile Hill) 220 kV electricity transmission line, which can be seen in the picture on page 1.

7. Storage cycle frequency

The economics of pumped storage works well in situations where there is a large base load capacity generating excess electricity at night which needs to be stored until the next day. Hence each day a conventional pumped hydro scheme can earn revenue by purchasing electricity at a low night-time tariff and selling most of it back at the high peak daytime tariff. Such frequent cycling works well. The long-term energy storage and use cycle proposed for the Onslow scheme does not make economic sense.

8. Dam length

The rolling moorland terrain, as shown in the picture on Page 1, is not well suited to impounding a reservoir. Raising the water level of Lake Onslow from 700 metres to 760 metres above sea level would require a 1.5 km long dam to be built. That is three times longer than the Clyde dam and 2/3 of the length of the giant Three Gorges Dam on the Yangtze River in China.

This picture of the Cochiti earth dam in New Mexico gives an indication of the type of dam that would be required to impound Lake Onslow.

9. Wetland disturbance

The Lake Onslow wetlands would be destroyed by the flooding of Lake Onslow. Large periodic changes in water level are incompatible with wetland ecosystems. It has been suggested that the existing soil and vegetation ground cover might need to be excavated and removed down to bedrock before flooding the Lake Onslow area.

10. Low rainfall

Central Otago is a low rainfall area unsuited to a large hydro scheme. Pumped hydro schemes typically have a base throughput of rain-fed hydro-generation to provide spinning-reserve for the pumped hydro system. That feature would be absent from the Lake Onslow scheme.

Steve Goldthorpe

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[1] Clyde 2100 GWh/yr from 50 metres head and Roxburgh 1650 GWh/year from 37 m head.

Quantifying the "dry year" issue in NZ

In EW84 a basic analysis was presented, which suggested that the scale of the so called "dry year" issue could be resolved by creating a levy-funded Security of Supply Service separate from the electricity market. That service would provide 1,100 GWh of stand-by generation to be used under specific conditions to offset the infrequent shortages in hydro generation.

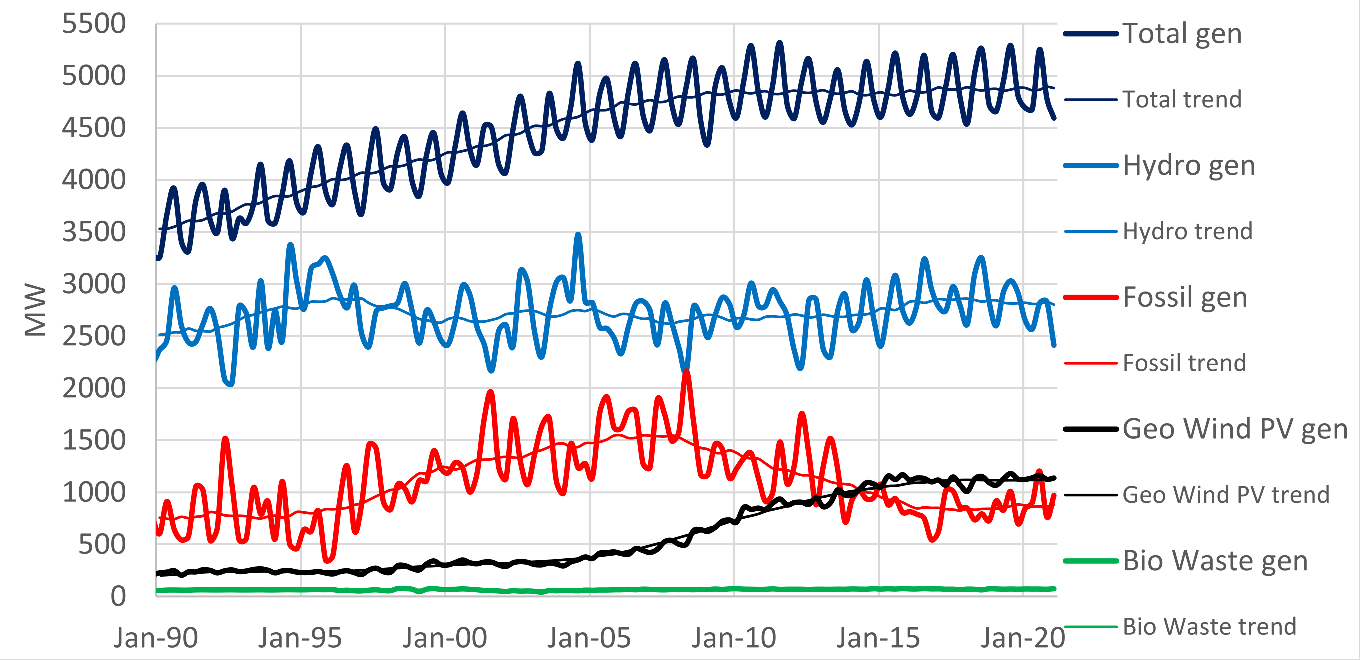
A criticism of that analysis is that the year-by-year approach taken was too broad and did not take account of the seasonal variability of both electricity demand and hydro generation.

The following analysis revisits the question by examining quarterly electricity generation data for the last 30 years to distinguish between the normal variability that the electricity supply system needs to accommodate and the abnormal variability that is better dealt with by a separate Security of Supply Service.

Figure 1 presents quarterly electricity generation data from 1990 to 2020 derived from MBIE's Data Tables for Electricity for 4 grouped sources; hydro, fossil, Geothermal/Wind/PV and bioenergy/waste as the energy sources.

The GWh per quarter data are presented as average megawatts (MW) using 2190 hours per quarter. This conversion relates actual electricity generation to equipment capacity.

Figure 1 Actual quarterly electricity generation in NZ[2]



The bark blue total generation plot shows the regular summer to winter oscillation in electricity demand in NZ. The electricity demand increased by one third from 1990 to 2010 but then remained constant over the last decade.

The blue hydro generation plot shows a seasonal variability overlaid with year-on-year variability. The hydro generation supply has remained fairly constant over the last 30 years, reducing from about 70% of total NZ electricity demand in 1990 to about 60% since 2005.

The black plot of Geothermal/Wind/PV shows an increase by a factor of five over the last 30 years. The green line shows bioenergy/waste is minor.

The red plot of fossil shows the discretionary electricity generation from coal, oil or gas to balance the demands of the NZ electricity market.

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[2] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics/

Figure 2 separates the predictable seasonal variability of electricity generation from the unpredictable variability in both supply and demand. This is achieved by plotting by source the 5-year running averages for the March, June, September, and December quarters.

The dotted plot at the bottom of Figure 2 shows the unpredictable component of fossil generation, that occurs in response to shortages of hydro supply and other upsets. This is determined as the difference between the actual quarterly fossil generation and the 5-year running quarterly averages.

This dotted plot shows the required excess fossil generation that occurred in response to shortages and quantifies the "dry year" issue in NZ.

Figure 2 5-year running averages for the same quarter

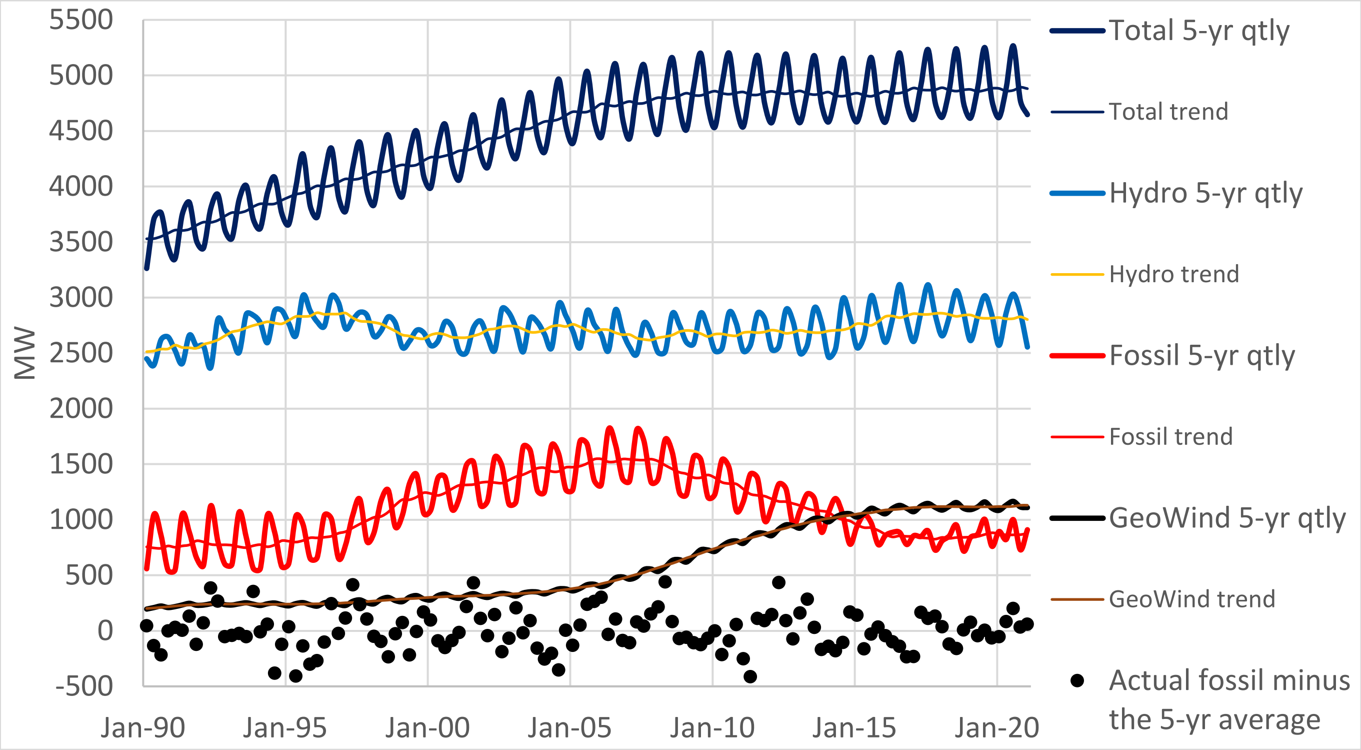


Figure 2 shows that since 2014 the predictable range of hydro generation has widened to +658 to -553 GWh/quarter (i.e. +300 to -250 MW), which is within the NZ working range of 1000 to 3000 GWh storage (5400 MW capacity).

The consequential fossil generation, plotted in red as a 5-year quarterly average, shows the predictable maximum fossil generation was +760 GWh/quarter (347 MW) above average in the 1990s, but has reduced to a maximum of 400 GWh/quarter (183 MW) over the last decade.

The black dotted plot shows that the unpredictable requirement for fossil generation was no greater than 931 GWh (425 MW) in any quarter since 1990, with more than 800 GWh (365 MW) extra required the June quarters of 1992, 1997, 2008 and 2012 and September 2001. Since 2014 the average autumn-winter supplementary fossil generation requirement has been less than 515 GWh per quarter, which corresponds to 235 MW of full-time generation.

In EW84 it was suggested that a Security of Supply Service might be created by converting Huntly power station into a standby generator using torrefied wood as stored fuel. In that earlier annual analysis, it was concluded "*that operating two of the 250 MW units at Huntly flat out for three months would provide enough electricity (1100 GWh) to meet the hydro-shortfall in a year when hydro output is below normal range*"

The present analysis of quarterly data suggests that only one 250 MW unit of Huntly power station maybe sufficient to provide the future Security of Supply Service required to accommodate the unpredictability of hydro generation. *Steve Goldthorpe*

A Security of Supply Service

New Zealand is fortunate in having a large hydroelectricity generation endowment, which provides most of the electricity supply and provides renewable load following capability that cannot be provided by wind, geothermal or solar generation. That security of supply might be enhanced by a pumped storage scheme based on Tekapo/Pukaki, as detailed in EW81.

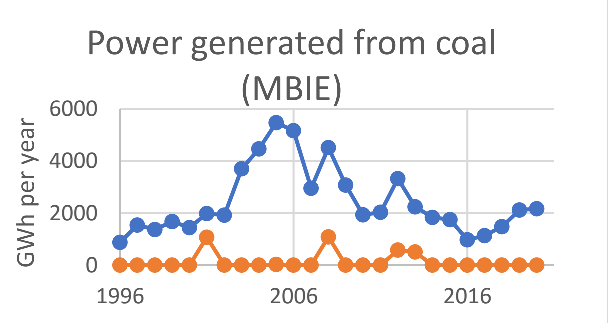
Historically, that hydroelectric load-following capability has been supplemented by Huntly power station and large gas fired power plants burning fossil fuels.

A substantial load-following capability is essential to ensure security of supply service (SSS) to keep the lights on.

Of course, the CO_2 emission question also needs to be addressed. That could be achieved by transitioning Huntly to a wood-derived fuel.

CO_2 emissions from Huntly PS

During the 25 years from 1996 to 2020, coal-fired generation produced 61,000 GWh of electricity from coal as shown by the blue line on the figure below. That coal burn resulted in the emission of 60 million tonnes of CO_2 over those 25 years.



The three low-rainfall years of 2001, 2008 and 2012/13 required in total 3,200 GWh of additional generation to address the “dry-year” issue, (see pages 5/6), and as shown by the orange line on the chart above. If Huntly power station had been operated purely in SSS mode for that period it would have been used only three times, i.e., run 24/7 for three months on two 250 MW units to supplement hydro. The consequent CO_2 emissions would have been 95% lower.

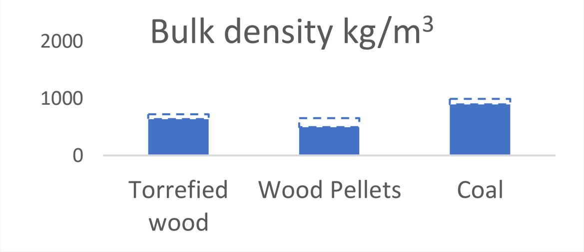
The boilers in Huntly power station are multi-fuel; they can burn coal or natural gas. Natural gas has 60% of the CO_2 emissions of coal. Therefore, an alternative fuel source for operation in SSS mode could be natural gas. SSS mode would require a strategic store of 11 PJ of natural gas for each dry-year event and the ability to access that gas at twice the gas extraction rate of the Ahuroa gas storage facility in Taranaki. Expansion of gas storage in Taranaki is planned.

However, in this SSS scenario, annual leakage of 1.3% of that stored methane could eliminate the greenhouse gas advantage of burning natural gas instead of coal.

Burning wood derived fuel at Huntly

Greenhouse gas emissions from burning fossil fuel in Huntly power station in SSS mode could be eliminated by developing the capability to burn wood-derived fuel in the boilers.

The torrefaction process involves heating wood anaerobically to about 250-300°C to drive off volatiles, which are used as process fuel. The pelletised fuel product has a calorific value of 22.5 GJ/tonne, which is like sub-bituminous coal, but it has a lower bulk density.



An 11 PJ store of torrefied wood fuel would require 20 enclosed silos 25 metres diameter and 75 metres high to protect it from the weather. The risk of spontaneous combustion of the stored processed fuel, might require nitrogen flooding.

The conversion of Huntly power station to SSS mode would require the levy-funded insurance principle of “They also serve who only stand and wait”. This use of the existing asset of Huntly power station would be much cheaper than ~$4 billion for Lake Onslow.

Steve Goldthorpe

Flywheels – more spin than energy storage

by Stephan Heubeck

The energy transition requires a large number of different energy storage systems to realize energy efficiency potentials and to manage the move away from fossil fuels. Flywheels are some of the oldest energy storage devices known in the engineering profession. They appear attractive for a wide range of automotive, rail, grid and off-grid electrical and hybrid energy storage applications. However, like some other technologies, they simply fail to deliver when removed from their very narrow niche of adequate application.

Vehicle Energy Storage

Many flywheel concepts have been proposed for vehicle energy storage and regenerative braking (hybrid) applications. The German blogsite “The Eco Solutions”[3] lists over 50 pilot, demonstrator and pre-commercial flywheel concepts for vehicle applications, developed and built since the 1950s. Surprisingly, while some of these concepts were developed by backyard inventors and start-ups, the majority of project proponents listed are either well known engineering giants (including Mitsubishi, Lockheed, Rockwell, MAN Nutzfahrzeuge, General Electric, GM, Volkswagen, Jaguar Cars, Volvo, etc.) or some of the world’s best research organisations (including TU Graz, Fraunhofer Institute, University of Texas Austin, ETH Zuerich, WTZ Rosslau, John Hopkins University, etc.). With all these technical and financial resources behind the flywheel concept, why haven’t we seen more of them applied in real world vehicles?

It’s simply because flywheels made of common materials like steel and constructed with established engineering techniques like mechanical bearings and mechanical power off-take, are actually not great energy storage devices. For example, with the often-quoted Swiss MFO Gyrobuses in the 1950’s, the 1.5 tonne steel flywheel rotating at up to 3,000 rpm could store a net 5kWh, giving the Gyrobuses a range of a mere 6km between charging stations. Of course, modern materials and engineering techniques allow flywheels to spin faster and store more energy, but at the expense of moving away from a simple concept. Flywheels constructed from carbon fibre, Kevlar or high-performance ceramics, rotating in vacuum chambers on magnetic bearings or in a controlled gas atmosphere on gas films can store several times more energy per unit mass than traditional flywheels, but are the exact opposite of a cheap and easy engineering solution. Furthermore, rotating at 30,000 or 50,000 rpm, it is very difficult to couple high performance flywheels mechanically, which is why most concepts are connected electrically into the vehicle power train, meaning that a whole raft of electric components like inverters, load controllers, electrical safety devices, etc. are required to use the simple concept of the flywheel in a vehicle. These electric components are becoming ever more powerful and cheaper, but primarily because the flywheel’s direct competitor for vehicle propulsion and hybrid solutions - battery technology - is advancing very fast. Flywheel proponents often argue that no other technology can make available larger amounts of power in shorter periods of times for vehicle propulsion. While this will certainly be a selling point at Silverstone, Daytona or on the Nuerburg Ring, the future of sustainable propulsion for everyday vehicles is certainly not dependent on vast and short power bursts, especially since advanced batteries and supercapacitors will increasingly be able to take care of power peaks and troughs for purely electric and hybrid vehicle systems.

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[3] www.apex-portal.com/ecosolutions/analysederexergie/speichern_schwung_nahverkehr.php

So, is there at least a niche for flywheels in vehicle applications? The Flybus consortium, comprised of design bureau Ricardo PLC, bus manufacturer Optare PLC, Torotrak and Allison Transmission Inc, provides a credible concept with their retrofit regenerative braking flywheel unit[4]. The carbon fibre flywheel, rotating at up to 60,000 rpm, is mechanically coupled via a variable drive system and clutch to the bus transmission. Excess energy from vehicle deceleration is preferentially stored in the flywheel, rather than converted to heat at the brake pads, and returned to the gear box during acceleration. With this mechanical hybrid configuration, buses working in frequent start/stop operation are supposed to achieve up to 20% overall fuel savings. Sadly, all available information about the Flybus system is about a decade old, indicating that this flywheel concept was also not a technical or commercial success. Its biggest advantage would of course have been the ability to retrofit existing vehicles. Going forward, the application scope for this technology is diminishing as hybrid and electric propulsion concepts based on battery technology are increasingly used in the bus sector. In 2020, 39% of global bus sales were already electric buses[5].

Grid Energy Storage

A handful of companies offer flywheel systems for grid and micro-grid electricity "storage", among them Beacon Power[6] (USA) offering systems based on 100kW carbon fibre units rotating at 16,000 rpm and Stornetic[7] (Germany), who offer 3.6kWh carbon fibre units rotating at 45,000 rpm with an output capacity of either 22 or 80 kW(peak). Both manufacturers rotate their flywheels inside vacuum cylinders, on magnetic bearings, and package individual units in shipping containers or concrete bunkers, to achieve system capacities of 20MW and more. However, both manufacturers (and others in the industry) have to be accused of hyping their technology if they brand it as (primarily) energy storage technology. The flywheel systems are very useful within an electricity network or micro-grid for providing frequency control, voltage control, reactive power management and other power quality parameters at reasonable scale for moderate cost and effort. But while the systems cycle stability and longevity is high, low energy storage capacity is the weak point. With a capacity rating of up to 80kW, the 3.6kWh Stornetic units will be inappropriate and not interesting for prosumers or small businesses trying to utilise distributed generation and increase electricity self-consumption as they require at least 12h (day/night) storage capacity, but preferably 2 to 4 days storage capacity. This leaves only network operators as potential users for the flywheel technology, and similar to the situation with electric buses, the window for application in this sector may be closing quite rapidly as well. If 100% renewable generation by 2050 is the goal for every electricity network around the world, some countries, like New Zealand, will be faced with comparatively few challenges in the area of power quality, as the hydro and geothermal stations spaced relatively evenly throughout the country will still be able to provide the majority of power quality services. This will be a much larger issue in countries where a large percentage of generation will be provided by (distributed) PV etc. However, such networks will also have a large need for inter-day and inter-week energy storage in the form of batteries, pumped hydro, etc. as well as a need for demand side management.

Cleverly organised, these system elements will also be able to provide the power quality services, envisaged to be provided by flywheels, at no or very little additional cost.

In summary, we may quite likely not witness the great breakthrough of flywheel technology in the future, because the best future for flywheel technology may already have passed.

Stephan Heubeck

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[4] www.youtube.com/watch?v=LC0pHkstuF8

[5] https://about.bnef.com/electric-vehicle-outlook/

[6] https://beaconpower.com/

[7] STORNETIC – battery-free energy storage and grid solutions | ETC (enritec.com)

No GHG accountability in the gas industry

Submission to the Ministry for the Environment and the Climate Change Commission concerning the determination of default national and field-specific natural gas emission factors

Introduction

The revision of the emission factors for NZ natural gas needs to be substantially more extensive than is proposed. The current natural gas emission factor protocols are seriously flawed and are not fit for purpose.

The purpose of NZ Greenhouse Gas Emission Trading Scheme is to put a price on emissions so that the entity producing the emissions is incentivised to modify their procedures to reduce or eliminate their Greenhouse Gas emissions.

Gas production stations create methane and CO_2 emissions from venting, leaks, flaring and own use of natural gas. The current inclusion of these emissions in the determination of a composite emission factor for their gas product, passes on ETS financial liability for those emissions to their customers. This protocol therefore fails to provide any economic incentive on the operator in the gas supply industry to take steps to reduce their emissions.

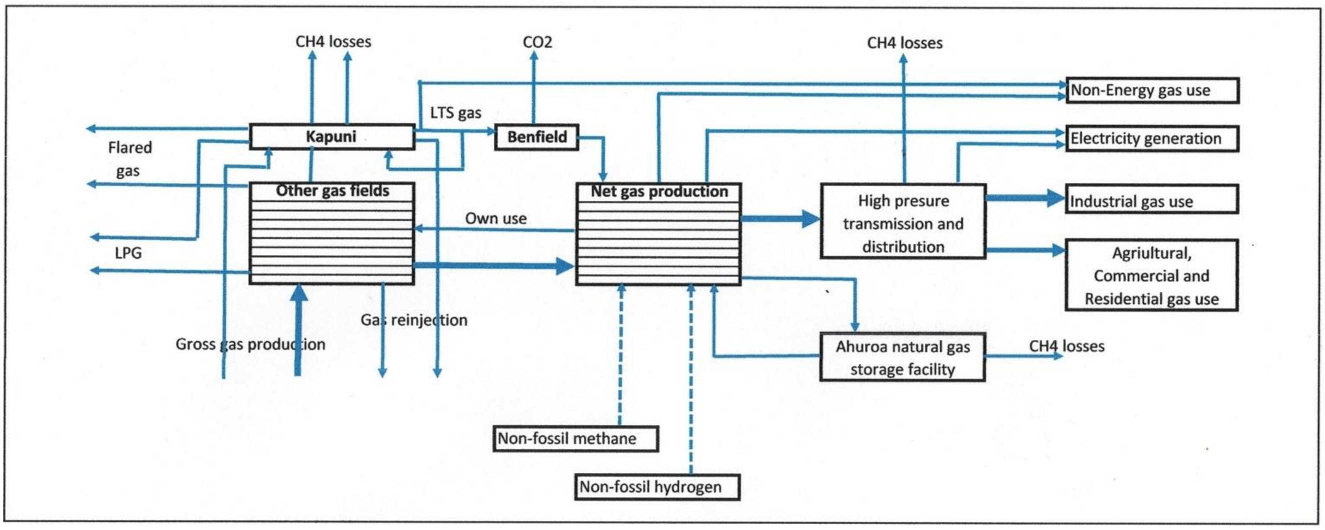
Loss of gas during transmission and distribution is not accounted for in the NZ ETS protocols. The absence of a mechanism to account for methane emissions from gas reticulation losses resulted in the unabated release to the atmosphere of 240 tonnes of CH_4 during a Maui pipeline maintenance activity by First Gas on 29th January 2022, which could have mostly been avoided.

The purpose of the National average natural gas emission factor is to quantify the CO_2 emission factor for burning reticulated natural gas that is provided by over 20 different sources in Taranaki. At present the National average emission factor is calculated as the weighted average of the gross production of natural gas from each field. The gross production of natural gas from gas fields includes :

- natural gas liquids that are separated and sold as LPG;
- natural gas reinjected for operational reasons.
- CO_2 stripped from Kapuni gas and vented.
- natural gas that is supplied to the producers of methanol, urea and hydrogen in Taranaki.
- other supplies of natural gas from production stations to industrial customers in Taranaki.
- venting/leaks from gas production facilities.
- venting/leaks from gas storage at Ahuroa.
- venting/leaks from gas reticulation services.

These sources of Greenhouse Gas emissions should be accurately accounted for under the ETS as a liability for the entities responsible for any consequent emissions of CO_2 or methane. The national average natural gas emission factor should then be the weighted average of the CO_2 emission factors for the net gas products contributed to the reticulated natural gas supply.

This diagram illustrates the New Zealand natural gas production arrangements.



Gas production station emissions

The Climate Change (Stationary Energy and Industrial Processes) (SEIP) Regulations 2009[8] requires natural gas producers to record the mass and energy content of natural gas that is sold, used on site, or flared, and the mass vented. In addition, gas analysis data is required to enable the consequent CO_2 and methane emissions to be calculated for each class of natural gas.

The SEIP regulations require the total gas sales, gas exported and direct gas sales to industrial (Opt-in) customers to be reported, but not the quantity of gas delivered into the gas reticulation system, which must be inferred by difference. That critical piece of information should be explicitly required in the natural gas production stations' reports.

Regulation 17, Clause 4 of the SEIP requires the total emissions figure from each field to be calculated from the net gas delivered to the gas reticulation grid (i.e., total natural gas sold less gas exported and less gas sold directly to customers) plus own use of gas, flaring of gas and venting of gas. That emission is the basis for determining the emission factor for the gas field.

Regulation 17 needs to be revised so that the emissions from own use, flaring and venting of gas from the gas production stations are explicitly calculated as separate values, which are the basis of a requirement on gas producers to submit the corresponding ETS units. That will then provide them with an economic incentive to reduce those emissions, in line with the purpose of the ETS.

Regulation 17 also needs to be revised to explicitly determine the mass and energy content of gas contributed to the reticulation network so that the emissions from burning that gas by downstream customers, i.e. the corresponding weighted average national emission factor, can be calculated.

In the case of the Kapuni gas field, which contains 43% CO_2, some gas is delivered to industrial operators in Taranaki with that high CO_2 content. That gas is known as LTS gas because it comes from the Low Temperature Separator after any reinjection of gas or separation of LPG. For those supplies of a high CO_2 gas to local industrial consumers, a CO_2 emission factor based on the composition of LTS gas is needed. LTS gas is not contributed to the gas reticulation network.

Some Kapuni gas is sent to a CO_2 separation plant, which uses the Benfield process to reduce the CO_2 content of Kapuni gas down to a few percent so that it can be contributed to the gas reticulation network. A second CO_2 emission factor for Kapuni gas is needed based on the lower CO_2 emission factor of the stripped Kapuni gas contributed to the gas reticulation network.

The Benfield process produces a by-product of CO_2, which is mostly vented to the atmosphere. The SEIP regulations should require explicit reporting of any CO_2 emissions from CO_2 removal processes so that an ETS liability can be determined for the process operators to provide an economic incentive for reducing, eliminating or sequestering that emission.

Carbon capture and storage (CCS) concepts have been widely studied and demonstrated internationally. The cost of CCS processes is generally greater per tonne of CO_2 emission avoided than current CO_2 emission trading prices. So, it is cheaper for operators to pay for their emission than to install a CCS process. Those studies of CCS processes have shown that the cost of the CO_2 separation element is the bulk the cost and the CO_2 storage element is a small part of the overall cost of CCS.

In the case of the Kapuni Benfield plant the CO_2 separation element is paid for as part of the cost of producing the low CO_2 gas. Therefore, the cost of a CCS scheme would be much lower than is typically assessed. If commercial liability for CO_2 emission were to be directly attributed to the Kapuni Benfield process operator, then it would provide an economic incentive to consider compressing and storing the separated CO_2 with consequent avoidance of its release to the atmosphere. Depleted natural gas fields could provide potential storage locations for CO_2.

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[8] As at 1 Jan 2022 – last revised 16 June 2017

Natural gas reticulation

The SEIP regulation do not provide a protocol for the reporting or calculating deliberate or accidental discharges of natural gas to atmosphere from gas reticulation activities. Therefore, the avoidance of methane emissions from natural gas reticulation relies only on commercial drivers to avoid loss of product and safety imperatives to avoid gas explosions.

On 28th January 2022, First Gas, the operators of the Maui gas pipeline, carried out maintenance work on the Maui pipeline involving the venting of the gas from a 20 km section of the pipeline amounting to a release to air of 240 tonnes of methane as natural gas in North Taranaki. Since First Gas only provides gas transmission services to the owners of the natural gas, the $100,000[9] commercial loss of product was not their loss but was absorbed by the gas market.

The only driver of First Gas' decision making was to reduce the risk of a major gas explosion occurring. Luckily, a gas explosion did not occur.

Had First Gas been liable for their deliberate methane emissions under the ETS then that liability would have been $450,000[10] in emission units. Being exposed to that high cost may have incentivised First Gas to choose a low emission, albeit more expensive, option involving pumping that natural gas into the downstream natural gas transmission pipeline for delivery to customers.

This event illustrates the regrettable failure of the current ETS arrangements to reduce emissions.

National average emission factor for reticulated natural gas

The national average natural gas emission factor of 55.73 tonnes CO_2e/TJ in 2021 is the same as the weighted average of emission factors based on the **gross** gas production in 2021 from all the gas fields. The gross gas production values include LPG that is separated, natural gas that is reinjected, gas that is flared, and the excess CO_2 in Kapuni gas. None of those categories of gas should be included in the determination of the national average emission factor for gas that is reticulated to customers.

If the **net** gas production figures were to be used as the basis for the weighted average natural gas emission factor, then the national average value would be 54.14 tonnes of CO_2e/TJ. However, that would still not be an accurate assessment of the average emission factor for reticulated gas because the gas quantities would include direct gas supplies to industry in Taranaki and own use of gas in the production stations, which are not delivered to the national gas reticulation system. Also, the individual field emission factors include methane venting and losses at the production stations.

The national average natural gas emission factor should be based on an assessment of the actual gas quantity delivered to the reticulation network and the CO_2 and methane emissions that would arise directly from the combustion of that gas. Emissions that result from activities upstream, of the delivery of reticulated gas to customers should all be assessed and attributed to the companies carrying out those activities.

Conclusion

The prime purpose of the Emissions Trading Scheme is to incentivise environmentally beneficial changes in behaviour, not just to raise tax.

To this end, liability for emissions of Greenhouse Gas should fall on the entities responsible for producing those emissions. A consequence of requiring companies involved in the production, storage, reticulation and distribution of natural gas to pay for their CO_2 and methane emissions may increase the wholesale price of natural gas, but that would make that cost penalty of methane and CO_2 emissions explicit rather than being hidden in a compound emission factor as at present.

Submitted to MfE and
Climate Change Commission
on 8th May 2022 by
Steve Goldthorpe

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[9] At a wholesale natural gas price of 2.25 cents per kWh

[10] At an ETS price of $75/tonne CO_2e and a global warming potential of 25

How transportable is hydrogen?

There is interest in converting surplus electricity in South Island into hydrogen as an energy carrier. But how transportable is hydrogen?

An Air Products truck delivering LH2 to the space shuttle Atlantis

The practical net calorific value of hydrogen is 33.3 kWh/kg, but as a transportable fuel it must be held at very high pressure and low temperature as LH2 (liquid hydrogen). LH2 containment systems hold 2 kWh/kg. =[11] - 6% fuel, 94% tank.

A 14 Wheeler truck with a 20 tonne payload would carry 40 MWh (144 GJ) of LH2 energy,

The truck might use 45 litres of diesel (1.7 GJ) per 100 km, or 50 GJ per return trip from Invercargill to Hamilton. If hydrogen were to be used instead of diesel in the truck engine, then 35% of the payload would be consumed in transporting energy as LH2 from a source in South Island to a terminal in North Island. Electricity transmission for the same energy relocation duty would have much lower losses.

Green Ammonia - but not an energy carrier

A novel process for direct production of ammonia by an electrochemical process is being researched in Australia.[12] One of the inventors, Professor MacFarlane said "You don't need a huge chemical engineering setup. They can be as small as a thick iPad, and that could make a small amount of ammonia continuously to run a commercial greenhouse or hydroponics setup, for example. It means that the distributed production of fertilisers becomes possible because the ammonia manufacturing unit is so small and simply constructed." The paper describing this research notes a faradaic efficiency of 69%.[13] for producing ammonia from hydrogen and nitrogen.

Energy efficiency is the product of faradaic efficiency and voltage efficiency. If voltage efficiency of the new ammonia process and the efficiency of converting renewable electricity to hydrogen are both about 60% then the overall energy efficiency of converting renewable electricity to ammonia might be about 25%.

However, bulk production of ammonia at 25% efficiency as an energy carrier from a remote stranded electricity source, such as Tiwai Point, would deliver much less of the electrical energy than hydrogen at 60% conversion efficiency as an energy carrier from such a location.

A 40 ft trailer hauling anhydrous ammonia at 20 atmospheres pressure could carry about 540 GJ of energy[14]. In this case about 10% of the energy payload might be consumed by the truck.

Ammonia Road tanker

Again, electricity transmission lines, even with 20% transmission loss, would provide a much better energy carrier to get stranded electrical energy from South Island to North Island.

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[11] Hydrogen Basics - Storage (ucf.edu)

[12] Australian scientists say discovery could render ammonia from fossil fuels obsolete | RenewEconomy

[13] Nitrogen reduction to ammonia at high efficiency and rates based on a phosphonium proton shuttle (science.org)

[14] Ammonia as a Hydrogen Carrier | ammoniaman

Cost of CO_2 reduction by switching from hybrid to EV

In EW84, a comparison was made of the lifetime costs and CO_2 emissions of hybrid, plug-in hybrid (PHEV) and fully battery electric (BEV) cars of the same model. That analysis found that the cost of reducing vehicle CO_2 emissions by switching from a hybrid to a PHEV or EV was about $800/tonne of CO_2 emission avoided.

That analysis was based on the Kia Niro model. The embedded emission in materials is assumed to be reflected in the vehicle purchase price.

The cost of petrol is now $3/litres compared with $2/litre used in the earlier study, so the comparison is revisited. In EW84 the PHEV option was found to be an intermediate stage of vehicle electrification with little climate benefit or penalty. So that option is ignored.

Hybrid vs EV	2021	2022
Petrol - $/litre	2	3
Electricity – c/kWh	25	25
Hybrid price	$40,000	$40,000
EV price (excl.rebate)	$78,000	$81,000
Lifetime cost Hybrid	$70,400	$95,600
Lifetime cost EV	$92,210	$95,210
CO_2 difference - tonnes	28.7	28.7
$/tonne CO_2 avoided	761	-13

The recent increase in petrol prices has made the switch to EVs economic. However, an EV Road User Charge of $50/1000km would make the cost of switching an expensive $640/tonne CO_2.

Grid electricity is a service not a product

There is widespread recognition that the existing competitive market mechanism, which treats electricity as a product, like a can of beans, is not fit for the purpose of transitioning NZ to fully renewable electricity. It relies on fossil generation to set a time-dependent price of the product, which is then paid to all producers.

The single buyer concept, in which a centralised agency would pay generators' actual costs and charge average time-dependent prices to consumers, would be a good start. That would reduce excess profit taking and market gaming. But that would still result in volatility of the electricity price because the electricity market is required to generate as much electricity as the consumers demand all the time.

The electricity consumer is used to being able to draw electricity from the grid at any time, limited only by what they can afford. That level of service is expensive to sustain.

In New Zealand there used to be a lower level of service via ripple switches that would cut off supply to water heating circuits at peak times. Those systems have largely fallen into disuse. Technology has moved on from the ripple switch to provide better ways to communicate in real time between the supplier and the consumer. Also, resettable trip switches now replace fuses in domestic use. So, there are new opportunities to provide different levels of service.

If the service provision was cut back to a minimum supply at peak times and a maximum at off-peak times, then plans could be offered to provide the required levels of security service. For homes with PV panels with a battery and an EV, rather than having an oversized installation to provide an independent security of supply service, a low-level battery charging capability from the grid would provide a more economic service.

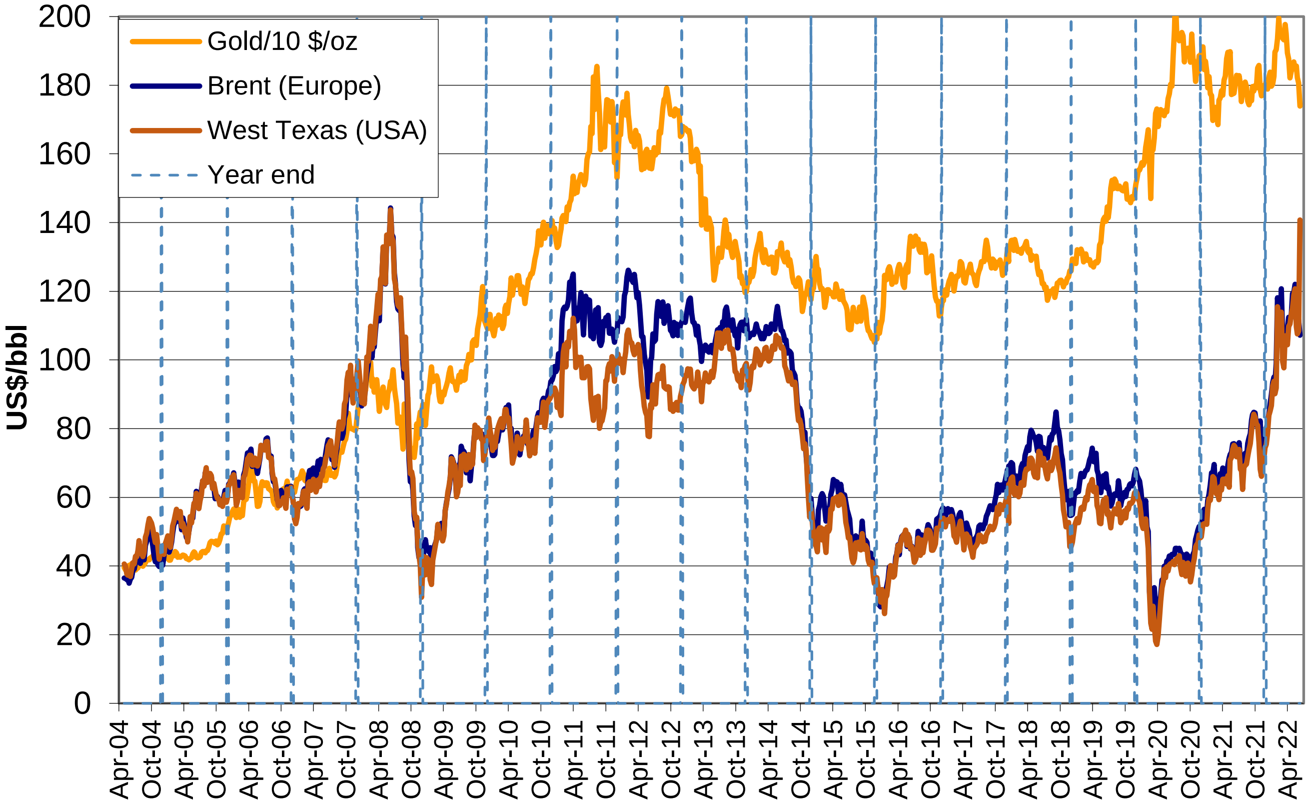
A few occasions of tripping out of the off-peak circuit breaker at the start of the customers' peak period, would soon educate the frugal consumer on how to live within their chosen level of service.

Multiple levels of service provision would require grid electricity retailers to compete on standing charge and energy supply combinations.

If the same principle of providing contracted time-dependent electricity supply limits is also widely adopted in commercial and industrial settings, then the problems of catering for peak loads by the electricity supply industry might be largely eliminated.

Steve Goldthorpe

Neil's Oil Price Chart



This historical chart of oil prices compared with the reference price of gold shows the influence of various geopolitical influences on oil price over the years. The doubling of oil price over the last 12 month explains the increase in transport fuel prices that we have witnessed in New Zealand. However, the chart shows that much of that increase predates the disruption caused by Russia's invasion of Ukraine. The rate of oil price increase mirrors what happened in 2007/2008, which was followed by the Global Financial Crisis. Can history repeat itself?

SEF AGM

The Annual General Meeting of The Sustainable Energy Forum of Aotearoa will be held via Zoom on

Thursday 28th July 2022 at 7.00 p.m.

Meeting ID: 835 3165 1057 Passcode: SEFAGM
The Zoom link will be notified on SEFnews on Monday 25th July or by request to convenor@SEF.org.nz

Agenda

Welcome, apologies, minutes of previous AGM, matters arising

Convenors report and Treasurers report

Discussion of motion "**That The Sustainable Energy Forum of Aotearoa should be wound up.**"

Appointment of the SEF executive committee and the SEF convenor.

The AGM will be followed by a panel discussion with

Alastair Barnett, Stephan Heubeck, Prof Ralph Sims discussing

The potential contribution of pumped storage to New Zealand's energy future

and other matters raised in this issue of EnergyWatch.

Join our sustainable energy news & discussion group

SEF membership currently provides a copy of our periodic EnergyWatch magazine. In addition, many members find the SEFNZ email news and discussion facility an easy way to keep up to date with news as it happens and the views of members. The discussion by the group of sustainable energy commentators who respond to the SEFNZ email service offers an interesting perspective.

The SEFNZ service provider has been changed from YahooGroups (SEFnews) to SEFNZ.Groups.io. Non-members are invited to join the SEFNZ email news service for a trial. To do this send a blank email to: SEF+subscribe@SEFNZ.groups.io. To help us stop spammers, non-members need to supply a name and contact details, and a brief statement of their interest and/or involvement in sustainable energy issues, before their trial is approved.

SEFNZ emails can be received "individually" (as they are sent) or as a daily summary (grouped into one email per day). Emails can be switched on and off, or read via a website, which is a handy option for travelling Kiwis. Groups.io saves all our text emails for later reference, and there is a search function so that you can review the emails stored since the changeover. For further details contact the administrator <office@sef.org.nz> to help set up your profile.

EnergyWatch

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Publication is now periodic, and EnergyWatch is posted on the SEF website (www.energywatch.org.nz) as a PDF file, shortly after individual distribution to SEF members.

Contributions Welcomed

Readers are invited to submit material for consideration for publication.

Contributions can be either as Letters to the Editor or short articles addressing any energy-related matter (and especially on any topics which have recently been covered in EnergyWatch or SEFnews).

Material can be sent to the SEF Office, PO Box 11-152, Wellington 6142, or by email to editor@sef.org.nz, or by contacting the editor, Steve Goldthorpe, 309/9 Queen St, Warkworth 0910

SEF membership

Memberships are for twelve months and include EnergyWatch.

Membership rates are:

Low income/student	$30
Individual	$50
Overseas	$60
Library	$65
Corporate	$250

Mail the form here, with your payment or order, to The Sustainable Energy Forum Inc., P O Box 11-152, Wellington 6142. Bank transfers, with your name, can be sent to the SEF account at 03-1538-0008754-00, with a confirming email to office@sef.org.nz.

A receipt will be sent on request.

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