EnergyWatch

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EDITORIAL

Get Electricity Sorted!

A compelling talk to the Engineers for Social Responsibility (ESR) by Dr Geoff Bertram (pictured), followed by his emphatic letter to the NZ Herald, reminded us of the increasingly urgent need for the next Government to take steps to reform the NZ electricity industry.

Unfortunately, the choice that we face at the upcoming election only offers alternative styles of pursuing Business As Usual. Dr Bertram notes "...elections are reduced to mere beauty contests". Voters must make a Hobson's choice between kind expectations and encouragement by Labour or uncompromising regulations and enforcement by National. Neither main political party exhibits an appetite to initiate radical change.

But there is hope. A $30 million Green the Grid programme has been established, which provides an opportunity to explore options for reforming the electricity system in New Zealand to be fit for the purpose of keeping the lights on for the next 30 years, while assisting CO_2 emission reduction imperatives.

SEF has written to Government ministers proposing that the terms of reference for the Green the Grid programme should include a wide-ranging comparative technical and economic assessment of practical options for addressing complex energy supply and demand issues, including dry years. Local energy sources, including solar and biomass options, as well as energy efficiency must complement remote electricity generation.

Furthermore, the SEF letter requests that the next Government should address the injustices arising from the complex legislative framework that locks in gross overpayment for New Zealand's electricity supply. Rational electricity pricing is an important first step.

Most of NZ's bulk electricity supply is produced at low cost but is paid for as if it were high cost generation. This anti-competitive arrangement delivers vast profits to the power plant owners, which are 1/3 the NZ Government and 2/3 private corporations. Competition is limited to the retailing of over-priced electricity.

What's my number ?

When we moved, I had a credit with Contact Energy from their SmoothPay scheme. So, I kept my account with Contact to use that credit. I am charged 20.8 c/unit +30 c/day +EA levy +GST by Contact. After 12 months I did the "What's my number?" exercise with real data. PowerSwitch gave me 12 options and said I could save $162 per year. However, the Contact Energy number was calculated at 23.3 c/unit +GST. It was $99 more than I had actually paid. Only the offers with a one-off switching bonus were less than my real bill. I am staying with Contact Energy for now.

This issue of EnergyWatch includes the SEF letter to ministers, which included a copy of Dr Bertram's recent letter to the Dominion Post. He is a Senior Associate of the Victoria University Institute for Governance and Policy Studies. Dr Bertram recently presented to ESR his views on changes needed to the NZ electricity market.

A similar appeal was made in the NZ Herald by Peter Whitmore, executive member of ESR under the title *Fixing our Dysfunctional Electricity Market*. That article is also reproduced here.

The electricity industry moguls are now pressing for abolition of 2004 legislation requiring them to offer a low fixed tariff to domestic consumers. That would be reinforcement of what Dr Bertram calls *The Iron Cage of the Law*.

I have written a short allegorical tale about potato farmers, which mirrors the electricity industry. It explores how a change in Government thinking could lead to *Dismantling the Iron Cage*. Enjoy!

When the Tiwai Point aluminium smelter is closed next year there would be stranded electricity in the Lower South Island. Transpower is dealing with that problem by expanding the capacity up to Central South Island to 1000 MW.

The conceptual Lake Onslow pumped-hydro scheme would add another 1000 MW of dry-year generation in the Lower South Island, overloading the upgraded transmission capacity. The Lower South Island transmission issues are addressed.

Combined with the ecological impact of a great increase in the size of Lake Onslow, the downsides of this project keep stacking up. The project is promoted as replacing the coal fired Huntly power station for addressing the dry-year problem (see *Where to for Huntly Power Station* in EW 82). I estimate that strategy could cost a huge $1000 per tonne of CO_2 emission avoided.

Pumped storage is a useful technology for daily balancing of electricity supply and demand (see *A case for pumped storage in NZ* in EW 81) but over-simplistic ideas, like pumping water into the Otago hills for use one year in four, gives the technology of pumped storge a bad name.

Behind the immediacy of dealing with Covid-19, sits the urgency of addressing the Climate Change problem and reducing New Zealand's emissions.

Electrification of the transport sector would potentially reduce New Zealand's CO_2 emissions. However, that contribution should not be overestimated. It requires a well-designed flexible electricity supply system that can adapt to changes in transport energy demand modes, between road, rail, air and coastal shipping.

EnergyWatch 81 presented some views on the first hesitant steps by New Zealand into the electric vehicle age. In this issue Frank Pool gives his views on opportunities and barriers for the growth of EV use in NZ. He concludes that it is limited and could fail under Business-As-Usual.

Long overdue upgrading of the New Zealand rail network is now in progress. The shifting of freight from road to rail makes a big step towards CO_2 emission reduction. A further step is made by using electricity rather than diesel to power trains. The status of electrification of the NZ rail network is noted in Kerry Wood's review of rail.

The SEF AGM in July had two guest speakers on the prospects for hydrogen and transport systems.

This issue wraps up as usual with the long-term oil price chart. It appears that rampant Covid-19 in the USA may be the latest oil price depressant.

Steve Goldthorpe, Editor of EnergyWatch

CONTENTS

SEF Letter to Ministers

The following letter was sent on August 28th to the Government ministers: - David Parker, James Shaw, Megan Woods and Kris Faafoi.

Dear Ministers,

The Government's $30 million "Green the Grid" study must address not only the full range of potential solutions to NZ's dry-year problem, but also the entrenched malaise of the electricity market. This study provides an opportunity to address the wider issues of technical, institutional, and legislative barriers to achieving a fully renewable electricity system for the benefit of all.

The electricity corporates are thriving within their neoliberal 'iron cage' of laws, policies and regulations (see letter by Geoff Bertram, attached).

Their narrative of "100% renewable electricity" grows their profits and assets. Their pricing is predatory on energy efficiency and local energy supply and would grow even more extreme with the planned repeal of the Low Fixed Charges regulation.

Instead we need a suite of local energy options that cooperate instead of competing with bulk electricity supply. Local distribution companies should promote and even dispatch local energy to maximise the efficiency of use of the combined bulk and local energy resources.

New energy scenarios need to be commissioned that escape the 'iron cage', to minimise carbon emissions and environmental costs instead of maximising profits and asset values. The scenarios must maximise technical efficiency - instead of solely "economic-efficiency".

Household energy efficiency cuts winter peaks and energy demands. Biomass energy stores itself until needed, so NZ should use electricity when it is cheap and biomass when electricity is scarce. Pumped storage (Tekapo-Pukaki and not just Lake Onslow) and other supply-side measures need to be compared to the full range of local energy efficiency and supply options.

The analysis must address the climate emergency, and focus on financial, environmental, and social impacts. The Climate Change Commission, Ministry for the Environment, and EECA all need to play a prominent role in setting the terms of reference and overseeing this study.

The Terms of Reference and study oversight must also critically be set in consultation with environmental and climate interests and iwi, unlike those of the Electricity Price Review.

Based on the above scenario analysis, we will certainly need energy policies and legal changes that overcome today's massive barriers to local and community energy development [1]

The first step is to not make matters worse: do not repeal the Low Fixed Charges Regulations. The second step is to redefine the electricity market to include services that complement bulk electricity generation.[2]

We look forward to discussing this proposal with you at the earliest opportunity.

Steve Goldthorpe, SEF Convenor

A copy of Dr Geoff Bertram's letter titled ***Iron Cage of the Law*** *(see page 4), published in the Dominion Post page 14 on 25th August, was attached to the SEF letter to ministers. Formal acknowledgements advised that the issues raised fall under the portfolio responsibilities of Hon Dr Megan Woods, Minister of Energy and Resources, her office will lead the response, which will be reported in EW84.*

[1] https://www.sciencedirect.com/science/article/pii/S2210422420300162

[2] see sections 210-213 of https://comcom.govt.nz/__data/assets/pdf_file/0025/66535/comcom-egblfinaldetermination.pdf

Iron Cage of the Law

(Letter to the editor - Dominion Post 25th August 2020)

This could indeed be a good time for New Zealand to step out from under the shadow of neoliberalism, as several big names said in "NZ's next economic revolution" Dominion Post (Aug 22). But no political party proposed to overturn the looming edifice of statute law that casts the shadow.
The Commerce Act 1986 stripped our common law protections against monopoly.
The State-Owned Enterprises Act 1986 turned providers of essential services into profit-focused predators.
The State Sector Act 1988 degraded the public service.
The Employment Contracts Act 1992 smashed unions and opened the path to low wages and inequality.
The Public Finance Act and Fiscal Responsibility Act locked fiscal policy and policy thinking into a cramped austerity box.
The Ministry of Works and Development Abolition Act 1988 left public works dependent on opportunistic private contractors.
The Electricity Industry Reform Act 1998 has left us an unproductive Frankenstein monster with its knee firmly on the throat of our poorest households.
Alternative options abound, but while the iron cage of neoliberal legislation holds our politics prisoner, elections are reduced to mere beauty contests. A pity.

Geoff Bertram, Karori

Fixing our Dysfunctional Electricity Market

By Peter Whitmore, Executive member of Engineers for Social Responsibility

Published in NZ Herald 21st August 2020

Energy Minister, Megan Woods' recent announcement, that the government will seriously investigate pumped hydro for electricity generation, could be a major step in moving towards a 100% renewably powered electricity system. It provides a way of generating electricity, without the use of fossil fuels, when other power sources are not able to meet the demand. Water is pumped up into dams when surplus power is available, then used to generate electricity when needed. The dams effectively become giant batteries, which can store power for months, or even years if required.

Pumped hydro could be a strong contributor to a dependable renewably powered electricity supply, but will take significant time and expenditure to achieve. There are other ways of reducing our reliance on fossil fuels for electricity generation that are far simpler, faster and cheaper to implement. These involve changing the way our electricity market operates.

Currently, electricity providers submit regular bids to have their power fed into the grid. The highest bid that is accepted to meet the market demand for a given half hour period sets the price that all the other contributing generators receive.

At present, the Huntly power station, which runs on coal and natural gas, is often that highest bidding generator contributing to our North Island power supply. The other companies feeding into the grid welcome this because they all receive the same price for their electricity as Huntly, which pushes up their profits. There is even some evidence that one or more of them have taken steps such as deliberately spilling water over their hydro dams so as to keep Huntly in the market.

The outcome of this is that development of renewable power sources is strongly suppressed, despite the fact that it is often a lower cost

generating option than using fossil fuels, and despite our urgent need to move in this direction. Also, consumers end up paying more for their power than they would if charges were based on actual generation costs.

Two things need to happen to sort out this dysfunctional market and allow us to start rapidly reducing our use of fossil fuels for producing electricity.

First, we need to follow the example first set by the German government in 1991 and change our wholesale electricity market so that it gives precedence to electricity generated from renewable resources. This will give a very clear message to producers that renewable generation must be our path forward. But on its own this change will not be sufficient.

Second, we need to move to a regulated electricity market, that is properly monitored and controlled, where providers present bids that reflect the real cost of their generation, and this is what they receive when their bids are accepted. They will then be able to increase their profits by producing more renewably generated electricity rather than by holding back on this to keep Huntly in the mix.

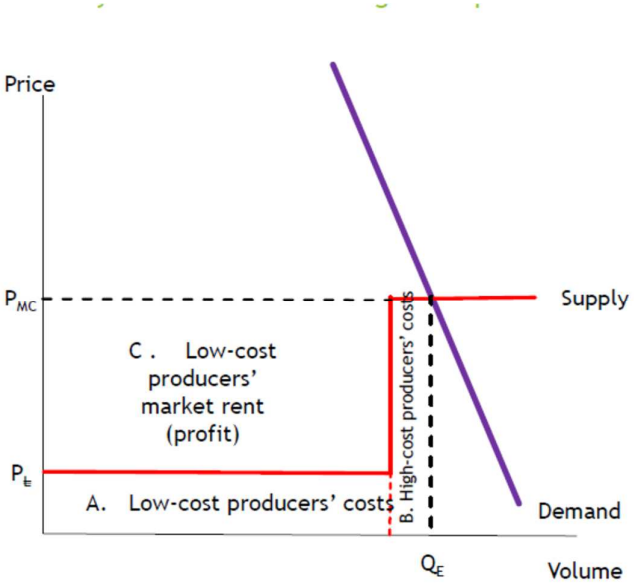
What would happen if we made these changes? There would almost certainly be a rapid increase in the development of renewably powered generating plants, creating many new jobs and business opportunities while reducing our reliance on fossil fuels. For example, there are currently around 10 consented but unbuilt windfarms in New Zealand, including one in the hills behind Huntly that could potentially generate up to half the electricity that the Huntly power station can.

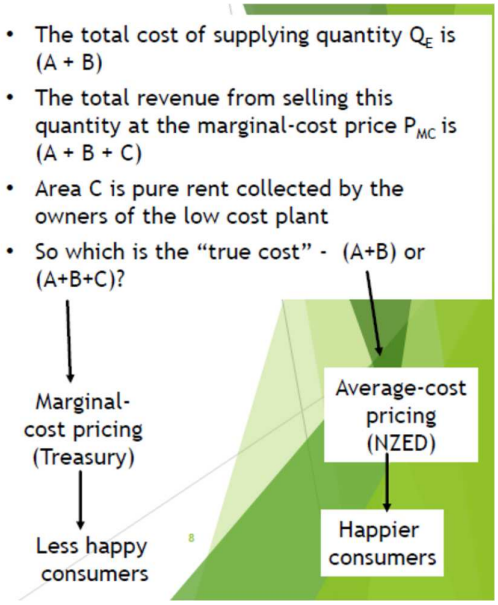
New Zealand also has other renewable options that could be developed. For example, a major tidal powered station was planned for the Kaipara Harbour, north of Auckland, but the project was abandoned in 2013 because of uncertainties about the electricity market. We could expect to see projects like this come to life again. Increased use of solar also has great potential.

Another strong plus for bringing in these changes is that they can be expected to immediately reduce electricity prices.

We are told by scientists and others that, in order to protect the planet and to ensure that the earth remains a viable living place for humanity, we need to very rapidly reduce our emissions from the burning of fossil fuels to essentially zero. Fixing our dysfunctional electricity market is one of the steps we urgently need to take to achieve this.

Peter Whitmore, ESR





Graphic and notes by Dr Geoff Bertram

Dismantling the Iron Cage

Three NZ farmers went to the market with bags of potatoes. They were happy to sell them for $2 per bag. That price would cover their costs and keep them in the business of growing potatoes forever. Another farmer also went to the market with bags of potatoes that cost him $5 per bag to produce in a hydroponic system. The peasants were hungry. They needed all the available potatoes.

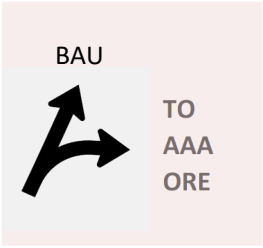
The town council told the low-cost producers that if they wanted stalls in the town marketplace, they must charge $5 per bag for potatoes. They felt uncomfortable about the arrangement, but they complied and pocketed the $3 per bag profit.

After a while, they got used to the extra income and no longer felt embarrassed driving home from the market in their shiny new SUVs, passing the peasants taking their potatoes home on their bicycles.

This status quo continued because the three farmers agreed to limit their potato production to three quarters of the needs of the people so that the high cost producer stayed in business.

The town council was pleased with the high level of gross domestic product and protected it by passing a law to ban the peasants from growing potatoes. They kept the peasants happy by letting them choose from 12 different colours for bags that they must buy to carry their potatoes home.

The market became the smartest place in town with grand shops replacing simple stalls. To keep it safe, the town council built an iron cage around the marketplace. The council then planned to charge the peasants $2 a day for a permit to enter the iron cage to buy their potatoes. The peasants became unhappy and started complaining.



The mayor was re-elected but was troubled by the unrest. When the mayor was on the road to Bau one day a mist came down. The figure of an old man emerged beside a sign to a disused mine that had triple A grade ore.

The sage gave the mayor an envelope[3], wished him good fortune and disappeared into the mist.

The mayor was excited. He had heard that the resource could provide a catalyst to turn potatoes into hyperogen. That would give the peasants work to do and would make his town peaceful and thriving again. He hoped the envelope would contain the recipe. He rushed to the town hall.

When the mayor opened the envelope, to his surprise, he just found a picture of the sign with the straight-ahead route now saying Business As Usual and the right turn spelling AOTEAROA. Underneath was a list of actions required to take Aotearoa in a new direction, away from BAU. The list was long. It included: -

- Firstly, the potato pricing regime must be changed so that all the farmers get a fair price for their crops and no more.
- The requirement to put potatoes in coloured bags must be dropped. The peasants can carry potatoes home in their bicycle baskets.
- The peasants must be free to grow their own potatoes. Few of them will be bothered, so potato fields in villages must be allowed.
- The costly potatoes are grown in greenhouses, protected from changes in wind and rainfall. However, their ventilation has a mysterious environmental impact that the peasants call The Greenhouse Effect. So those facilities must be taken over by the town council and only used in the event of a potato famine.

The mayor implemented the changes[4].

The iron cage was redundant and was dismantled.

The farmers adapted to the fair price arrangements and continued to prosper because they became more productive.

The hydroponic potato greenhouse was mothballed by the council and very rarely used.

The peasants were happy and well fed.

The mayor was re-elected again.

And they all lived happily ever after.

Steve Goldthorpe

[3] WWW.ESR.ORG.NZ – see Members Papers - Dr Bertram.

[4] This is where the rubber meets the road

Lower South Island generation

About half of the South Island hydro electricity generation capacity is located south of Cromwell, comprising the Manapouri power station (850 MW), the major power stations on the Clutha river; Clyde (432 MW) and Roxburgh (320 MW), several smaller hydro stations (total 128 MW) on tributaries to the Clutha river and White Hill wind farm (60 MW). If the average load factor of these power stations is 56% then they would on in combination average generate about 1000MW continuously. Over half of the electricity generated by these stations (principally by Manapouri) is currently consumed by the Tiwai Point aluminium smelter (570 MW operating 24/7).

The figure below shows the electricity transmission network in the Lower South Island. After meeting the other demands for electricity in Southland and Otago, the balance of electricity is exported to the Central South Island through two transmission lines. A double circuit 220 kV AC line runs 150 km from Roxburgh to Twizel and a single circuit 220 kV AC line runs 340 km from Roxburgh to Islington (Christchurch). The transmission capacity of a 220 kV circuit depends on various factors. Thermal losses, which are proportional to the square of the current carried, might ultimately limit transmission to about 400 MW per circuit. However, a technical constraint on transmission capacity (Surge Impedance Loading) could potentially limit capacity to about 400 MW for the three circuits[5].

Closure of Tiwai Point

The announcement by Rio Tinto that the Tiwai Point aluminium smelter will close next year means that an additional 570 MW of hydroelectricity will be released onto the Lower South Island grid. When added to the surplus power that is currently transmitted north, the existing transmission lines will be inadequate to deliver that power north.

Lower South Island Electricity Transmission Network[6]

[5] http://www.ksebea.in/wp-content/uploads/2015/09/SIL.pdf

[6] https://www.transpower.co.nz/sites/default/files/bulk-upload/documents/Substation%20Locator%20map.pdf

"Transpower general manager of grid development John Clarke said the company would continue to work on projects that could speed up the delivery of surplus renewable electricity northward. This is a priority for the organisation and work is already underway with the decision last week to complete the Clutha Upper-Waitaki Lines Project at a cost of around $100 million."[7]

The Clutha-Upper Waitaki Lines Project entails:-

- Duplexing of the Roxburgh–Livingstone section of the Roxburgh–Islington 220 kV line;
- Thermal upgrade of the Cromwell–Twizel section of the Roxburgh–Twizel 220 kV line.

This work is scheduled to be completed by May 2022 or sooner. It would increase the transmission capacity north from the Lower South Island to about 1000 MW.[8] However, additional work on the grid costing about $450 million and taking several years would be needed to efficiently distribute the surplus power across the whole country. There could be a push back from the generators against integration of this surplus low cost power into the NZ market, because it could obviate the established need for high-cost power generation, which sustains the high marginal price and excess profits for generators.

The Lake Onslow Scheme

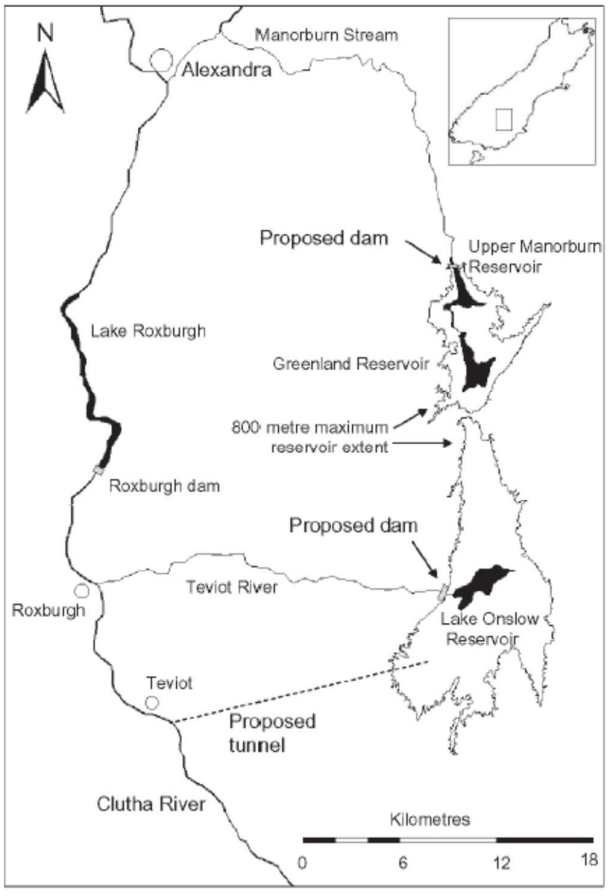
Over the last century the Teviot River has been dammed and the water used for mining operations, irrigation, and the production of hydroelectricity. Lake Onslow at the head of the river was created in 1890. The current hydro capacity of the Teviot River scheme is 14.5 MW.

The figure opposite shows the principles of Lake Onslow scheme, as envisaged by Prof. W E Beardsley in 2006. The scheme would involve building a large dam at the Teviot River outlet to raise the maximum water level of Lake Onslow from 680 m to 800m. The area flooded by the expanded Lake Onslow would increase about 20-fold with major ecological consequences.

The project would include the drilling of a 15 km long tunnel to take water up and down from a small lower lake beside the Clutha river.

If the Lake Onslow scheme were to be used for short-term pumped storage it could ease the transmission constraint by accommodating the short-term supply and demand variability in the Lower South Island after the aluminium smelter closes. However, transmission line upgrades would be a quicker and much cheaper means of addressing that problem than the Lake Onslow scheme costing $4 billion and taking about 7 years to build.

The Lake Onslow scheme is promoted as a solution to the dry year problem, by being able to generate 1000 MW from stored water for a few months. If that contingency were to be needed it would also require the northbound transmission capacity to be doubled.



[7] https://www.rnz.co.nz/news/business/420885/tiwai-point-smelter-closure-what-happens-to-the-electricity-sector - Radio NZ 9th July 2020

[8] https://www.transpower.co.nz/clutha-upper-waitaki-lines-project

A low-cost study would find that building a new hydro scheme as a national-scale carbon-free back-up generator would be much more expensive than refurbishing Huntly power station just for its design job of providing dry-year security of supply.

I estimate about $1,000 per tonne of CO_2 emission avoided to replace the existing coal power plant with a new zero-carbon hydro scheme for use 1 year in 4. There are much cheaper ways to address the Climate Change problem.

While the Lake Onslow proposal is obviously a lemon, the concept of pumped storage may have valid application in New Zealand. For example, The Tekapo/Pukaiki scheme in Central South Island (as described in EW 81), which is above the Lower South Island transmission constraint was constructed to be ready for pumped storage.

Steve Goldthorpe

A new era for KiwiRail?

A review by Kerry Wood

The history of NZ rail involved several changes of ownership such that the remaining KiwiRail inheritance has been asset-stripped.

Today, the North Auckland Line has had very little maintenance for 50 years and would soon have to be upgraded or abandoned. Upgrading to modern dimensions and axle-loads is proceeding with big benefits for the whole region. A rail link to Northport, beside the Marsden point refinery, will bring extra benefits, and could even replace Ports of Auckland.

Large ports, used by large container ships, prefer rail. Unlike road trucks, railway wagons arrive at a known time and in a known order. This means that the container handling system can be programmed to stack the containers in the best order for loading a large container ship. Large ships are taking over, as they are more economic.

In 2019 the Government published "The Draft New Zealand Rail Plan". Asset stripping was not mentioned but a crucial new approach appeared. KiwiRail was to be funded through the National Land Transport Fund, in the same way as other land transport. This raises the possibility of rational comparisons between funding a new highway or improved rail services.

The 2019 study gives the total economic value of rail to the New Zealand economy as $1.5 billion a year. Most of the benefits are reduced road congestion, the remainder are road safety, road maintenance and reduced emissions. Every tonne-km of freight switched from road to rail reduces carbon emissions by two thirds if diesel-hauled, or much better with electric traction.

It is going to be a long job: a key priority is given as: *Restore resilience and reliability to freight and tourism rail assets as a platform for growth.*

The biggest effects will be in the Auckland-Hamilton-Tauranga 'golden triangle.' That is where the traffic is heaviest and the benefits of electrification greatest. The Auckland end is already electrified through the urban area and is very likely to be extended to Hamilton and on to Tauranga. This will allow heavier trains and greater track capacity.

Once Auckland-Hamilton electrification is done, 25 kVAC electric locos will be able to run right through from Auckland to Palmerston North. The North Island Main Trunk (NIMT), where the grades are toughest, was electrified in 1982. The final 140-odd kilometres to Wellington is trickier. The existing 1500 VDC passenger trains will have to be either converted or scrapped.

The Wellington-Auckland passenger service takes about 11 hours, but faster services for freight would also make passenger trains faster. If an overnight sleeper-train were put on, could it reduce passenger trips by air? *Kerry Wood*

https://www.kiwirail.co.nz/assets/Uploads/documents/Annual-reports/2019/b563b44217/KiwiRail-Integrated-Report-2019-FINAL.pdf

https://www.transport.govt.nz/assets/Import/Uploads/Rail/The-Draft-NZ-Rail-Plan-December-19.pdf

ICE > Hybrid > PHEV > EV - Likely Evolution

By Frank Pool

One of the more popular and most vigorously debated topics in SEF News has been the evolution now underway of light duty vehicles (cars, light vans, crossovers, SUVs, utes/pickups) from internal combustion engines (ICEs) power to full electric vehicles (EVs). This summary article offers an overview of some of the key factors on how this evolution from conventional ICEs to full EVs is likely to play out from 2020 to 2025, and then to 2030.

ICE Current Status Overview

ICE vehicles have been manufactured at massive scale for over a hundred years (since the 1908 Model T Ford), with steady and overall amazing improvements in reliability, power, safety, fuel economy, affordability, durability, and reduced maintenance costs. 80.6 million ICE 4-wheeled new vehicles were sold in 2018 in a ferociously competitive and very dynamic global marketplace. The Volkswagen, Toyota and Renault-Nissan-Mitsubishi Groups each sold ~10 million vehicles in 2019. Honda are the largest ICE manufacturer at 23 million engines per year, used in Honda motorcycles, cars, outboards, portable generators, lawnmowers etc.

A huge range of new and second-hand imported ICE vehicles are available in NZ. The lowest-priced NZ-new ICE vehicles (with 3-year 100,000 km warranties) are the petrol Suzuki Celerio at 4.7 litres per 100 km for a 5-door hatch at \$16K+ORC[9], and the Great Wall 1-tonne payload diesel 9 litres per 100 km utes (pickups) from \$18K+ORC for a bare chassis 2WD and \$23K+ORC in 4WD with tray versions.

The best ICE vehicles will now run for 30 years and 300,000-500,000 km with just routine engine and transmission maintenance of an engine oil plus oil filter change per year or per 10,000 km for as little as \$80. A replacement \$150-\$250 lead-acid battery is needed every say 3-5 years. Transmission oil changes, new spark plugs and a valve clearance check every 10 years or 100,000 km can cost as little as \$300.

Petrol and diesel pump prices include a carbon charge of \$33 per tonne CO_2 (i.e. 7.6 cents per litre of petrol or 8.6c per litre of diesel). And even a \$100 per tonne CO_2 carbon charge would have less impact on fuel prices than variations in the USD/NZD exchange rates. An ICE can be refuelled in 3 minutes and gives a 500-1000 km range. The fuel can sit in the vehicle tank for months or years without significantly degrading.

Advances in Hybrid Technology

A further 10-25% fuel economy gain can be expected from well-proven commercially available hybrid technologies, which will be the default option in the next generation of ICE vehicles in Europe and Japan from 2025 to 2030.

Hybrids use a small on-board battery for an electric drive in parallel or series with the ICE drive. The electric motor acts as a generator during braking to recover energy. The hybrid battery can also facilitate starting the ICE engine on a cold morning – half the cars in Mongolia are hybrids as they will start outside at -40°C.

NZ-available 4-wheeled vehicle fuel economy is now as low as 3.7 litres per 100 km (WLTP[10]) from the latest NZ\$28K 2020 Toyota Yaris hybrid 5-door hatch with its 40% thermal efficiency 14:1 compression ratio engine. Honda is moving its entire Europe vehicle range to hybrids by 2022. The new 2020 Honda Jazz hybrid is already the sole model Jazz sold in the UK. The fuel

[9] ORC = On Road Costs

[10] WTLP = the UN ECE coordinated more realistic World harmonised Light duty vehicle Test Protocol for combined city, suburban, highway and motorway driving

economy of larger new family sized Toyota Prius and Corolla Hybrids and Honda Jazz and Insight (the latest Civic Hybrid) hybrid sedans and hatchbacks is around 4.5 litres per 100 km on the WLTP combined cycle. Similar fuel economy is available from Hyundai, Kia and Suzuki hybrids.

Similar 4.5 litres per 100 km fuel economy is available from numerous small European diesel vehicles. However, the single Road User Charge (RUC) rate for all vehicles <3500kg actually makes small diesel engine cars more expensive to run than small petrol cars. So ICE vehicles under around 1500kg usually only use petrol engines. The NZ break-even fuel cost point for petrol and diesel engines is around 9 litres per 100 km.

The most fuel-efficient petrol engines already available in cars and small AWDs, 4WDs, Crossovers, and SUVs are already at 40% (diesel engine) levels of thermal efficiency with compression ratios of up to 14:1 and some with combined spark and compression ignition. The most fuel efficient AWD vehicles (smarter and lighter 4WDs) fuel economy levels are now only 5% to 10% more than their 2WD base models.

All Formula 1 (F1) racing cars have used petrol hybrid-electric engines since 2014, with thermal efficiencies now exceeding 50%. F1 cars have 20kg hybrid batteries giving 120kW of free electric boost power that is harvested from braking and waste exhaust heat downstream of the turbocharger. Current F1 engines show that a further 25% fuel economy gains in ICEs is already proven technology from Mercedes, Ferrari, Renault (with Nissan and Mitsubishi) and Honda (and now via Honda to General Motors).

PHEV – a transitional technology

The logical extension of hybrid technology is the Plug-in Hybrid Electric Vehicle (PHEV) where the size of the high voltage battery is increased, and the battery can be charged when parked overnight. The weight of the bigger battery plus the ICE engine makes current PHEVs heavy and expensive. Their electric-only range is ~50 km.

The Prius Prime and Mitsubishi Outlander (pictured) in NZ, and Honda Clarity in the US, are already commercially available PHEVs, using different technical approaches.

EV Current Status Overview

EVs were developed more than a century ago, alongside ICE vehicles. Limited lead acid battery energy capacity and life meant that EVs languished until the NiMH and then the current Lithium Ion (Li-ion) batteries became available.

The two EVs sold in large numbers to date are the compact hatchback Nissan Leaf (1500kg, sold from 2011) and the Tesla Model-3 fastback sedan (1600-1850kg, sold from late 2017), each have sold around 500,000 vehicles to mid-2020. The time taken to charge Leaf or Model 3 batteries from 10% to 90% is around 6 hours from a 230V 3-phase AC charger. Faster DC charging (under an hour at 100-250kW) is also an option but at a higher electricity supply cost and with reduced EV battery life. Current EV batteries are expected to last from 8-12 years before they give major range reductions. There are currently limited (if any) vehicle supplier battery replacement options.

Electricity use is around 15 kWh per 100 km for both the Nissan Leaf and Tesla Model 3. The range on the WLTP combined cycle is 380-600 km for the Model 3, depending on battery size.

The new price in NZ for a Leaf is $62K+ORC and the Tesla Model 3 price is around $76K-$105K. However, hundreds of ex-Japan Leafs are for sale at any time for $10K to $20K in NZ. The lowest cost new EV currently available in NZ is the $50K MG ZS model with a 260 km WLTP range. VW now has a large focus on EVs after its “diesel gate” emissions cheating debacle. The VW EV iD3 sedan and the iD4 SUV in 2WD and 4WD

versions are likely to be priced at Leaf and Tesla levels respectively.

A Forward-Looking Overview

The first real mass-produced and affordable petrol 4-wheeler was the Model T Ford that was introduced in 1908. 1 million had been sold by December 1914. 16.5 million had been sold at the end of production in 1927. So, EVs are at a similar uptake level to the Ford Model T ICE at the start of WW1. The current EV development path includes the luxury and aspirational sedan segment (Tesla, Jaguar, Porsche, etc.) the most common 5-door hatchback segment (Nissan Leaf, Chevy Bolt, VW iD3 etc.) and the small-medium Crossover/SUV segment (Tesla Model Y and VW iD4 etc.)

In the next 5 years, Li-ion battery energy density is expected to increase from 0.25 to 0.4 kWh per kg, battery life to grow from 8-12 years to say 12-16 years, and battery costs to reduce from US$135 to US$80-US$100 per kWh. Vehicle weight is likely to decrease by 10% from lighter batteries, and EV costs and hence retail prices could decrease by say 20% from increased scale and from lower battery costs. So, $40K hatchback EVs with about 350 km range can be expected in NZ by 2025, as battery cost/weight gains are partly expected to go to larger EV batteries, as has happened with the Leaf's evolution since 2011.

There is a huge development of EVs underway in China and India, which is largely unrecognised in the West. These are mainly 2, 3 and 4-wheeler low-priced small city-oriented electric vehicles. China is the key EV market with hundreds of new firms developing and selling a wide range of EVs. So Chinese and Indian brands may be the source of NZ's affordable future mass market and urban-oriented EVs, not Europe, USA, Japan or Korea.

Meantime, hybrid petrol-electric vehicles have been sold by Toyota (1997) and Honda (1999). Hybrids (15 million sold to date) now account for 2/3 of new Toyota sales in the UK (Yaris, Prius, Corolla, Camry, RAV4) and will almost certainly continue increasing in Europe and Japan as well. Honda's dual electric motor i-MMD hybrid system with no gearbox (see picture) as used in its latest Jazz, Insight (Civic), Accord and CRVs is tailor made for a PHEV future with just a bigger battery and a charging port being needed.

Summary

ICEs are already well past the 1980-1990 technology 8.5 litres per 100 km Corollas that over-enthusiastic EV promotors use as their baseline "straw man" ICE to produce the widely quoted falsehood *"the cost of charging an EV is equivalent to paying 30c per litre for petrol"*. In addition to outdated ICE data, they use expensive dealer-provided servicing costs, unrealistically low electricity use and unrealistic 15 cent per kWh night rate tariffs. A more realistic comparison gives $1 per litre. (See EW81)

EVs currently pay no tax towards road maintenance. Petrol and diesel vehicles do, via fuel tax or RUC. With EVs currently having an 8-12 year effective battery life, slow charging and reduced range, significant numbers of new and second-hand import ICEs (albeit many being ex-Japan hybrids) are likely to be sold to 2030 in NZ.

ICE vehicle technology will not stand still. Improved fuel economy of 25-50% is likely by 2025-2030, from higher efficiency engines, reduced weight from greater use of high strength steel bodies, greater use of CVT, DCT and 6-9 speed automatic transmissions. In contrast, EV energy/electricity use per kilometre is only expected to improve around 10%, mainly from reduced battery weight. Hybrid vehicle sales

could grow to be the dominant ICEs sold in NZ with the right Government promotion and particularly including for second-hand imports from Japan. PHEVs could be a popular half-way option between standard hybrids and full EVs.

The priority actions (in order of cost effectiveness and impact) available to reduce NZ's light vehicle CO_2 emissions are: -

- make a <1500kg lower RUC band for light (European) diesel vehicles for rural use and for those generally making long trips;
- require all vehicle fuel economy labelling to be translated to the more realistic WTLP figures instead of current fuel economy figures that give particularly misleading hybrid and/or underpowered vehicle fuel economy figures;
- publicise independent realistic initial and operating cost comparisons rather than hype.

From the above summary, my estimates as to what the relative proportions of light vehicle sales for combined NZ-new and used imports are : -

	2025	2025	2030	2030
	BAU	Goal	BAU	Goal
Petrol ICE	75%	30%	50%	10%
Diesel ICE	10%	20%	10%	10%
Petrol hybrid	5%	20%	20%	40%
PHEV	2%	10%	10%	20%
EV	3%	10%	10%	20%

The Goal estimates above are what might be achieved with suitable sensible enhanced Government actions to change legislation to mandate WLTP fuel economy use, changing RUCs to give a new <1500kg category for both diesels and EVs, and government funded promotion that gives a balanced approach to all improved fuel economy/GHG reduction vehicle types. It is not sensible to just promote EVs while ignoring hybrids and PHEVs in favour of shifting all transport sector energy demand to electricity to satisfy the electricity industry's Think-Big fantasy of doubling electricity demand in NZ.

N.B. The above estimates relate to vehicles entering the NZ fleet. If the average vehicle life is 20 years, then the NZ light vehicle fleet distribution would lag these trends by 10 years.

In reality, I think that what will happen is that the road transport electrification hopes of the electricity generator/retailer cartel, EECA and one-eyed environmentalists will not materialise, because

- Honda et al will continue to ignore the NZ market for their best energy efficient vehicles.
- To maximise the sale price, a future National-ACT government would be very tempted to sell off the government generator/retailers without reducing their monopolistic market power, so retail electricity prices would rise.
- Without reform of RUCs for <1500kg vehicles, EVs would be charged the current <3500kg RUC rate of 7.2 cents per km causing any EV economic advantage to evaporate.

Hence, EVs could be killed off like CNG and LPG vehicles were when supports were withdrawn. In any case, there is no way that EVs will use up the surplus Tiwai Point electricity.

Frank Pool

Frank Pool is a Fellow of Engineers NZ. Frank has worked professionally on EE/RE GHG mitigation projects and program design, implementation, and evaluation in 51 countries for the NZ government, the Asian Development Bank, the UN, EU, APEC and bilateral donors.

Postscript to EW 81

EnergyWatch 81 (www.energywatch.org.nz) focussed on real-world use of an EV in New Zealand under the title EVs - *Good - but not that good.* It reported anecdotal stories of EV use, with articles including *Fast charging is not that fast* and *Cheap to run, but not that cheap.* We sold our 2016 Nissan Leaf to our son and his partner in suburban Wellington over a year ago. They love it. They charge it from a PV system. It transports our new granddaughter safely and can be loaned to her grandparents when they visit. 😊 *Editor*

SEF AGM Presentations

Energy efficiency engineer Glen Baxter spoke to

Is there a role for hydrogen in our future energy system?

Glen's talk followed on from EW82, which had highlighted some of the downsides with the hydrogen economy. Glen presented hydrogen energy applications in terms of hydrogen storage in Horton spheres that could each contain about 6TJ of energy in liquid hydrogen at 20° Kelvin.

10 metre diameter Horton spheres storing extremely cold liquid hydrogen

Glen identified several potential applications for energy storage or supply in terms of the number of Horton spheres of hydrogen that would be required.

He identified two scenarios in which hydrogen may provide an alternative energy supply route to low usage electricity transmission: -

- Grid upgrades for industrial process heat vs. locally stored hydrogen
- Rail electrification vs. hydrogen trains for low usage lines

An international perspective on hydrogen

Hydrogen will be a catalyst for deeply decarbonizing the oil and gas value chain. But it won't begin to scale as an energy carrier until the mid-2030s, according to our latest forecast for the world's energy mix. The transformation to decarbonized and green gases only really gets going in the 2040s.

DNV GL 2020 Energy Transition Outlook

Heidi O Callahan presented views on

Rail in NZ as the spine of a full network

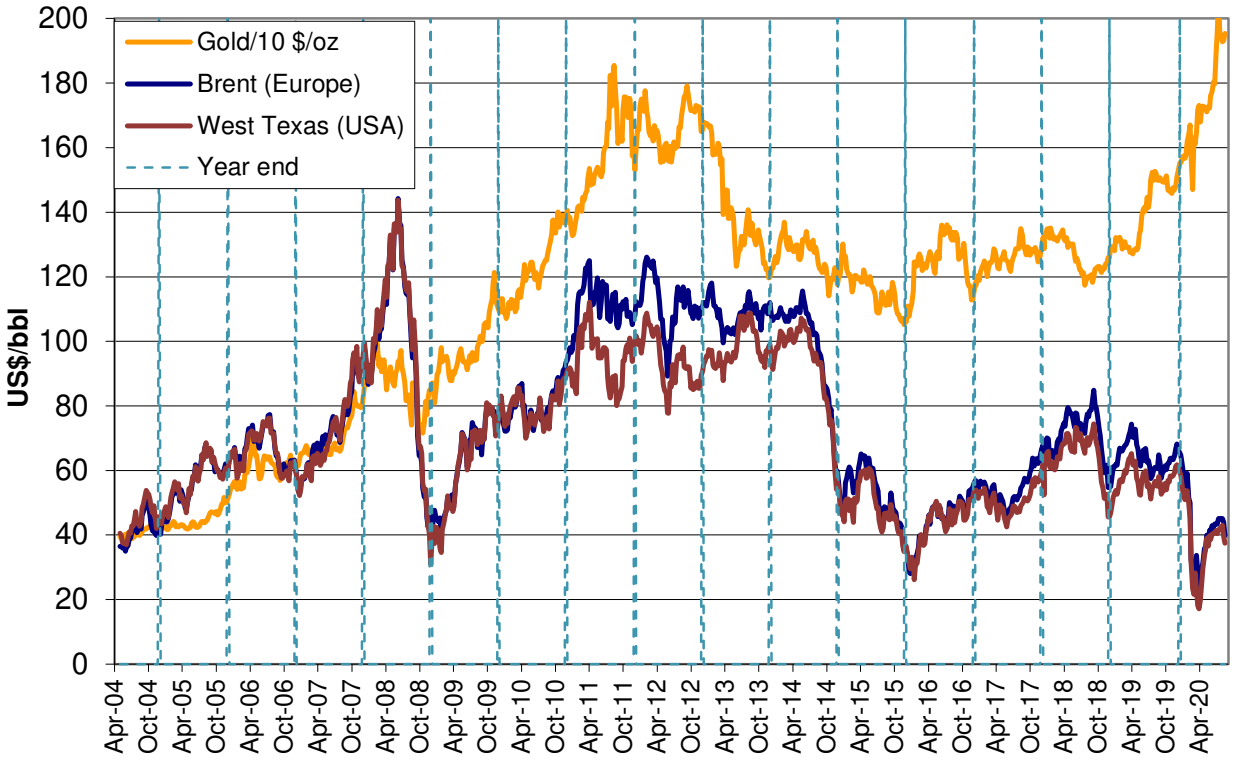
Heidi's presentation focussed on the vision of a multi-mode transport network anchored on an upgraded rail network based on the Intercity Rail plan, as shown below.

Green Party Intercity Rail plan 2020

Heidi discussed integration of bus services, including timetabling and ticketing. That concept was extended to include walking and cycling approaches to stops and stations.

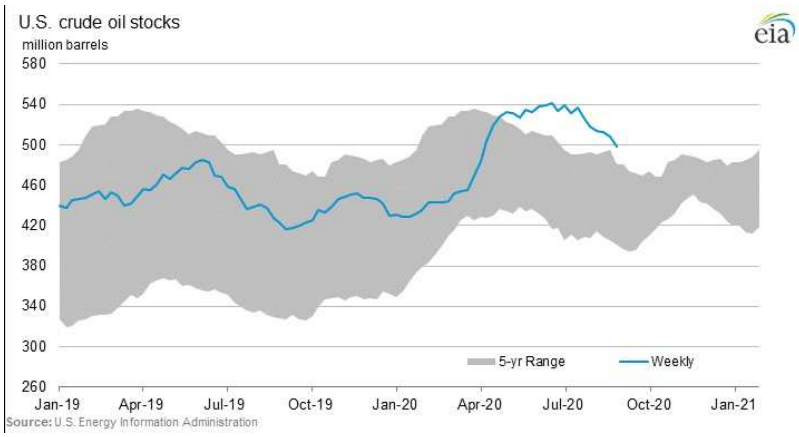
A series of recent posts on transport issues by Heidi O Callahan and Paul Callister include: *The Tourism Taskforce; Night train; Gathering Momentum by Gathering Data; Regional Access* and *A National Public Transport Network.*

These posts and other can be found at https://www.greaterauckland.org.nz/wp-content/uploads/2020/09/Greater-Auckland-articles-by-Heidi-OCallahan-and-Paul-Callister-on-establishing-a-National-Public-Transport-Network.pdf

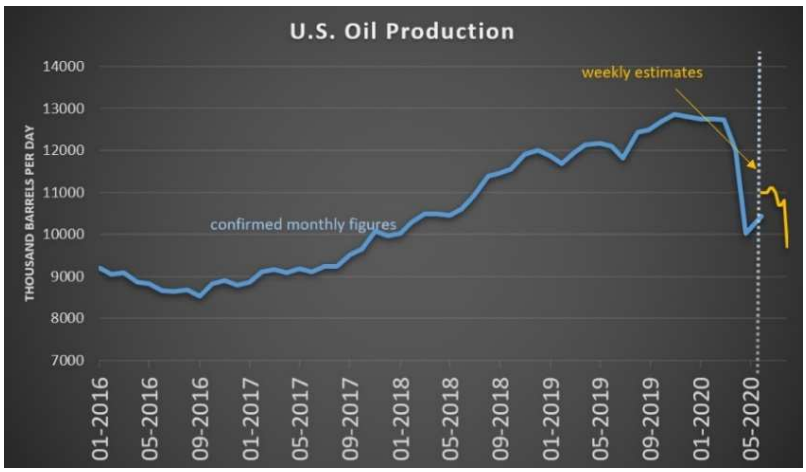


Neil's Oil Price Chart

This above chart shown that the gold price has increased by 20% over the last 5 months of global chaos. which partly masks the doubling of oil price recently, falling back to under $40 per barrel this week.



However, the storage chart here from Oil Price.com shows that US crude stocks have increased outside the expected range, which will act to limit oil prices. The production chart here from Oil Price.com shows that since the beginning of 2020 the production of oil in the USA has reduced from 12.5 million barrels per day to 10.5 million barrels per day, which should bolster the West Texas oil price.



The increase in crude oil stocks combined with the reduction in production indicates a large reduction in US demand for oil products, which is presumably due to the rampant Covid-19 outbreak in the USA. Hopefully, that reduction in US demand, combined with reduced air travel and global recession would be reflected in a slowdown in rate of increase of global CO_2, but that effect is not yet evident at Mauna Loa. *Ed.*

Join our sustainable energy news & discussion group

SEF Membership currently provides a copy of our periodic Energy Watch 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.

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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.

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Memberships are for twelve months and include EnergyWatch.

Membership rates are:

Low income/student	$30
Individual	$50
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Library	$65
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