New Zealand Sustainable Energy Supplies

the practicality thereof

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The juggernaut of Global Warming and Climate Change has attained so much momentum that, if the Hauraki Gulf froze over tomorrow, it would give the juggernaut only the smallest of wobbles. There are just too many reputations at stake, both scientific and political, for the world to be permitted to survive a catastrophe.

When all is said and done, talk outweighs action by millions to one. This paper attempts to look at some of the effects if talk does somehow become action in New Zealand.

The Government of New Zealand has declared that 90% of electricity generation will be from renewable resources. Hydro, wind, solar, and geothermal have been declared acceptable, plus a private offering of tidal power. (Speech by Minister D. Parker, 16 April, 2008.)

Hydro power

According to the Department of Statistics, hydro generation runs between 50% and 65% of total demand, somewhat less than the 70 – 80% sometimes stated in the press. The supply of hydro power is heavily dependent upon rainfall and the 50% times are in dry years, one of which appears to be heading for us right now.

The main supply of hydro power is the South Island. However, the Cook Strait cable systems are in disarray, with one system damaged and an older system shut down because of age. It is unlikely that the damaged system will come on-line this winter because they are still arguing over who will pay the several millions of dollars for repairs. Insurers have agreed to cover the older systems to partial capacity for the winter, but risks of failure are still there. The North can get possibly 700 MW from the Southern hydro stations. Huntly coal provides 1000 MW, but the Greenery hates it.

With the main electricity demand in the North and the main hydro supply in the South, meeting demand from renewable hydro power is reliant upon rain and the capacity of the Cook Strait cable systems.

Wind power

This appears to be the flavour of the times. However, as a yachtsman, I have found that the wind is unreliable as to strength. Sometimes, it actually stops!

One of the main suppliers of wind turbines is Vestas, in Denmark, and their published performance figures are instructive. They are sales brochure figures, by the way, so may need to be adjusted a bit for real life.

It takes 14.5 km/h of wind to get the machine to produce anything at all. This can be considered the equivalent of the petrol required to make your car idle. More power is needed to actually move the car.

Maximum power is generated at 55 km/h wind, which is defined in the Beaufort scale as "near gale".

At 65 km/h, you shut down because the blades will fall off or get otherwise damaged. There is a spectacular entry on You Tube at http://www.youtube.com/watch?v=7nSB1SdVHqQ where a Vestas turbine suffered brake failure in strong wind. The repair gang decided that the turbine speed already made it too dangerous to climb the tower and try to apply the brake again. Instead, they filmed the failure. The blades literally exploded off the hub, but not all at the same time, and the imbalance toppled the entire 70-metre tower.

At half a gale, about one-third capacity will be generated.

Why not half capacity for half wind speed? The laws of physics do not allow it, despite the wailings of politicians.

At present, using the windiest spots for their windfarms, the power generated in New Zealand is about 45% of installed capacity, i.e., for every 100 MW of wind turbines, we get, on average, 45 MW of electricity. This will inevitably reduce as less windy spots have to be developed.

The world average for wind power is about 22% capacity, but in Germany it is down to 18%. This poor result is because of the Greenery laws in Germany. Anyone who can get the finance can put up a renewable energy supply and the power company has to buy the electricity generated at top marginal rates (not one third of the domestic rate, as in New Zealand). If you drive across Germany, as I have recently done, you will see wind turbines in the oddest of places, mostly doing nothing because the wind is too light or from the wrong direction.

How many wind turbines do we need, and where will we put them for best generation?

Solar power

Auckland is alleged to receive some 2000 hours of sunlight per annum.

There are 8760 hours per year (except leap year, when there is another 24 hours). Thus, we could generate solar power for 22.8% of the time. How much individual installations could generate depends, of course, on how many solar panels can be put on the roof.

Solar panels generate at full output only when the sun is shining directly upon them. However, the sun traverses across the sky during the day, so, unless you spend up large for a rotating system, the usual fixed system will not generate at anywhere near its rated output. There have been many complaints about solar hot water heaters not performing—usually, it turns out, because of roof angles not being at optimum for the available sun.

If you install a big solar array, the Government, in a fit of generosity, has agreed to buy your excess generation for one third of the price that they charge you to buy electricity from the State-Owned Enterprises such as Genesis. See the numbers below!

Geothermal power

At first sight, this appears to be a permanent renewable resource, but I personally disagree.

Some people may remember that the inhabitants of Rotorua were made to shut off their bores because of the steamfield losing pressure and concerns that the Pohutu geyser might fail to properly display for the tourists. Steam turbines require steam at a steady pressure to perform and, as the pressure drops, so does the output. The Wairakei station has, for a long time now, had their high-pressure turbines disconnected because there is not enough pressure left to run them. The station runs just its intermediate and low pressure turbines.

The underground steam is not inexhaustible. What happens is that water from rainfall a distance away makes its way through cracks and fissures in the underground rocks, all the time being heated by the earth's heat welling up from the core. Geothermal is inexhaustible only if the rate of drawoff of steam is not above the rate at which water can seep through the rock cracks.

This seepage cycle takes time, usually years, so the effect of a couple of successive dry years may not be felt in the geothermal station until much later. At Ohaaki, the condensate is re-injected into bores in the steamfield in the hope that it will again be turned into steam, so that there is a recycling system operating. It has not yet been operating for a long time, so the real effect of re-injection has yet to be proved.

Incidentally, there are a couple of nasties that are emitted with geothermal steam, but which don't get mentioned by those pushing for renewable resources. Carbon dioxide and hydrogen sulphide are the main ones—hydrogen sulphide gives acid rain!

Tidal power

Tides are completely predictable, so why isn't everyone making tidal power generation stations? The big drawback is that tides do stop flowing four times a day, which means that, for 8 to 10 hours a day, the same amount of power has to be generated by other means, so why build two sets of generation?

We ought to bear this and some other things in mind when considering the skullduggery being perpetrated upon us by the Powers Who Think They Be and their associated spin-doctors.

The Second Law of Thermodynamics

This is the law of physics that says that there is no free lunch. Many people, from top scientists to cranks, have tried to figure out a way around the law, but it seems to be as immutable as gravity.

Everything is a compromise, and every step in an energy chain will result in the loss of some of that energy. This is the direct effect of the Second Law of Thermodynamics.

To take an example: the modern high-efficiency transformers are about 97.5% efficient, which means that they lose about 2.5% of the power that goes into them. Stepping up from generation voltage to transmission voltage loses 2.5% minimum. Stepping down at the receiving substation costs 2.5% of what was left, then the area substation, and street transformer, each taking their 2.5%. Your house receives, at very best, 90% of what left the generator. However, we haven't included the line losses yet, and a thing called power factor, so, at best, you get, in real life, about 80% of what is generated in your name—and that assumes that all transformers are of the latest efficient design, which, in the real world, is just not so.

That means that, for every 100 MW of windmill capacity installed at present (i.e. 45% capacity factor), only 38%, on average, will be of use in the most modern of distribution systems. Older systems will have less to use.

The Law of Conservation of Energy

There is a law of physics which is just as immutable as the second law of thermodynamics which says that energy can neither be created nor destroyed, only changed into another form.

Taking wind power again, as long as energy is taken from the wind, it will slow the wind down. When there are only relatively few turbines extracting energy, there will be no noticeable drop in wind speed. However, it is reported that some of the huge windfarms take so much energy from the wind that the ecology of the area is transformed.

Considering tidal power (and hydro, for that matter), the available power in the water depends upon the mass flow rate (kg/sec, tonnes/hour, etc.) which in turn depends upon head (or pressure drop) between the dam water level and the turbine outlet. In a tidal system, the head depends upon the difference between the water levels inside and outside the barrage, dam or whatever else is chosen to hold the machines.

The French La Rance system has a tidal range of some 10 metres (I know—I have had to anchor a yacht in the nearby harbour. The Kaipara, where New Zealand's tidal power station is proposed, has a tidal range of about 2 metres. The same amount of water will give us, at the very best, 20% of the French power.

Because energy has been taken from the water, there is also the possibility that there will not be enough energy left to carry away the sand and silt normally found in estuaries. This has been found to occur in some hydro systems as well, where the downstream river silts up after the hydro station comes on line.

Again a dreaded compromise—how much siltation are we prepared to put up with?

In the February newsletter of IPENZ, the proponents of tidal power gave the Kaipara numbers as averaging 0.75W per turbine for 15 hours per day. The proposal is for 200 turbines.

Number of houses to be supplied

This subject is a real delight for spin doctors and other apologists, but is totally useless as a measure of the effectiveness of any power installation.

Bear in mind that, according to the Department of Statistics, the average household uses 35 kWh per day.

Also, at least 15% and probably more likely 20% of generation is lost by inefficiencies under the second law of thermodynamics.

Therefore, in order to supply 35kWh required by the average household, 43.75 kWh must be generated.

According to the spinners, the 200 MW wind turbine capacity to be installed in Otago will supply 100,000 homes.

Assuming that we do in fact get the 45% capacity factor thus far achieved, we are left with:

$200{,}000\text{kW} \times 0.45 = 90{,}000\text{kW}$ on average generally available.

$90{,}000 \times 0.8 = 72{,}000\text{kW}$ after transmission losses.

$72{,}000 \div 100{,}000 = 0.72\text{kW}$ per household. (A new electric kettle, by the way, consumes 2.4kW.)

$0.72\text{kW} \times 24 \text{ hours} = 17.28\text{kWh}$ per day.

This, you will see, is a bit short of the 35 kWh per day, and is unlikely to be reached even with the new requirements for insulation, etc. and that assumes modern distribution equipment.

The Kaipara scheme is even more optimistic. They are claiming to be able to supply 260,000 homes.

$200 \text{ machines} \times 0.72\text{MW} \times 15\text{hrs / day}$

$= 2{,}160{,}000\text{kWh / day}$

Over 260,000 homes = 8.3 kWh per day.

The average home might need a bit more than that.

Money money money

As mentioned above, in a fit of largesse, Her Majesty's New Zealand Government has seen fit to offer to buy back your excess solar power generation for one third of the price that they charge for selling it.

The Government has also estimated the cost of a 2 kW solar panel array to be between $37,000 and $47,000. I trust this estimate as much as I trust any other Government financial estimate and would budget a good $55,000. However, let us be nice and use $50,000 as the base estimate.

This will not be a rotating panel system, so we have to reduce the output to allow for the sun not always being perpendicular to the panel. Allow an efficiency of 80%. This number I arrived at by experimentation. I have a solar panel on my boat to keep the battery charged, and measured the current generated as I turned the panel across an arc representing the sun's traverse.

$2\text{kW} \times 0.8 \times 2000 \text{ hours} = 3200\text{kWh}$ per year that your solar panels can generate.

If you use all of it yourself, you will save $3200\text{kWh} \times \$0.2042/\text{kWh}$ (from Genesis Energy's latest price sheet) = $653.

Simple payback time $= 50{,}000 \div 653 = 76.5 \text{years}$.

Lost interest at 8% less tax $= 50{,}000 \times 0.08 \times 0.67$

$= \$2680\text{pa}$ assuming 33% tax.

However, the system will last only 30 years according to the Government, so you will have to allow a sinking fund to replace the system over 30 years. At 3% inflation, the cost will rise to about $120,000 over 30 years, so you will have to put aside $4000 p.a.

Each year, in order to save yourself $653, you have lost out on $2680, AND you have to put aside $4000 towards the replacement of the solar system. Personally, that doesn't strike me as a particularly good deal.

It gets even worse if you happen to have an empty house during the day because both parents work and the kids are in school. It is during the day that solar power is generated, and you will not be home to use all of it. For an example, assume that you use half, and the other half is sold back to the Government at 5.7 cents per kWh. According to the Government website, that is the present buy-back price.

On 1500 kWh, you will save 0.2042 $/kWh = $306 p.a.

On the other 1500 kWh, Government largesse pays you $1500 \times 0.057\ \$/\text{kWh} = \$85.50$ p.a.

Total saving plus income = $391.50 p.a.

You have just lost another $653 – $391.50=$261.50 p.a.!

How many windmills ?

The Government has declared that 90% of New Zealand's electricity is to be generated by renewable means. The rush is on for wind power.

For the purposes of demonstration, let us assume that our final capacity factor is above the world average, living as we do in the roaring forties. Say we average 33%, which is near enough mid-point between world average and our present best sites.

The Government Statistician says that we now average about 55% of our 40,000 GWh p.a. from renewables, leaving 35% to be found, presumably by wind. That 35% is 14,000 gigawatt-hours.

On a 24-hours a day basis, that is 14,000/8760 hr/yr = 1.6 GW. By way of comparison, the Huntly coal-fired power station is flat-out at 1.0 GW.

Installed wind turbine capacity required at 33% capacity factor = 4850 MW.

The favourite size at present seems to be the 2 MW units, so we need a minimum of 2425 units, assuming, of course, that the Cook Strait link is fully functional.

But the wind doesn't always blow, so a secure back-up plant is necessary, which means we still need thermal plants!

The lawyers specialising in Resource Management Act squabbles will never be out of work!

The Electric Car

People will recall that our Leader is pushing for electric cars as a pollutant reducer, to be recharged overnight from renewable resources. This matter is further pursued in the Government Discussion Paper on Sustainable Transport dated 10 December, 2007. It needs some consideration, especially as windmills may be needed.

In 1999, the D.o.E. in the U.S. ran trials on several electric vehicles. Indeed, some companies even today are still running their own development trials. For example, consider the electrified Dodge Caravan. It is a vehicle about the size of a Honda Odessy people mover, but, because of the weight of batteries, has a load-carrying capacity of 430 kg, only slightly above the Corolla estate.

Range at a steady 70 km/hr on a flat road with no wind was 170 km.

Range under real-life conditions per the American Standard was 120 km.

Time to charge was 6 hours drawing 60 amperes from 240 volts single phase.

The standard size of 3-pin plug in New Zealand is 10 amperes, so you would have to rewire your house.

60 amps at 240 volts = 14.4 kw.

Because of transmission losses, each charger would require the generation of 18 kW.

There are reported to be just over 3 million cars in New Zealand. Suppose that 10% were persuaded to go electric: say 300,000.

Generating capacity required

$$= 300{,}000 \times 18\text{kW}$$
$$= 5400\text{MW}$$

Multiplying this out at 6 hours per night for 365 nights per year, those cars would need 30% of all the electricity generated in New Zealand over a whole year!

Assuming that the hydro stations supply the rest of the electricity demand overnight:

$$5400\,\text{MW}$$
$$= \left(\left(5400 \div 2\right) \times 3\right)\text{windmills}$$
$$= 8100\ \text{machines}$$

That will be an interesting Resource Management Act debate, especially when added to the 2425 machines required to meet the extra 35% renewables demand. 10,525 windmills!

I have chosen the Dodge Caravan example because its carrying capacity is similar to one of the favourite New Zealand vehicles. Battery weight for any sort of useful range is a big penalty.

Another vehicle worth considering is the spiritual successor to the Deux Cheveau, the Citroen Berlingo/Peugeot Partner which is now on the market in Europe with petrol, diesel or electric propulsion. As far as I can discover, it is the only commercially- available practical electric vehicle from a major manufacturer. It can be a small panel van or a 4-seater estate car, with a payload of 500 kg (half ton, in old language) and freight volume of 3 cubic metres. The practical range is claimed by Citroen to be 70 to 100 km, depending upon driving conditions, and charging time is said by Citroen to be 9 hours via a standard household plug. The data came from the British Citroen website, where the domestic plug is 13 amperes.

The smaller battery capacity and longer charging time allow for a reduction in power generation to 3.75 kW per vehicle.

Over 300,000 vehicles, this equates to 1.125 Huntly coal stations running flat out every night, or two Benmore hydros wide open every night with the Cook Strait power link in full operation, just to recharge 10% of our vehicles. Replacing Huntly coal with windmills would require only 1500 units assuming 33% capacity factor. Citroen Berlingo recharging would therefore need $1500 \times 1.125 = 1690$ windmills.

However, N.I.W.A., New Zealand's experts on weather and atmosphere, state on their website that they would like to see 60% of New Zealand vehicles electrically powered by 2040. As NIWA is a Government department, is this a sneaky way of promulgating Government policy without really bringing it to the notice of the public? The discussion paper mentioned above aims, by the year 2015, to have "electric vehicles widely used", and "80% of the vehicle fleet either electrically propelled or using 10% bio-fuel". A subsequent speech by Minister D. Parker on 2 April 2008 retains the percentages, but extends the time to allow for generating capcity to be built up.

If sufficient families were prepared to down-size to a Berlingo, we would need only $6 \times 1690 = 10{,}140$ windmills to recharge our cars. Or 6.75 Huntly coal stations, or 12 Benmore hydros. Then what happens to the Cook Strait link?

This all assumes an average windspeed of half a gale, and sufficient back-up generation when windspeeds are below that!

The Holden Combo van seen around here occasionally is very similar to the Berlingo, maybe even a badge-engineered version.

Apropos of nothing in particular—what is the Government definition of "off peak" time?

A cautionary tale

There is a strong feeling of diesel-hatred abroad, but let us have a look at a couple of facts.

In any engine relying upon internal combustion, the efficiency of the engine (the ratio of how much energy you get out compared with the energy content of the fuel) depends largely upon the difference in gas temperature between the start of the power stroke and the exhaust. The bigger that difference, the more efficient the engine.

Diesel engines are much more efficient than petrol engines because they run at higher temperatures. They use about 40% less fuel for a given power! This translates into 40% less carbon dioxide.

BUT nitrogen oxides, which give rise to smog and from there to respiratory problems in the populace, are greater from diesel engines because NOx increase markedly with combustion temperature. Petrol engines do produce NOx, but at much lower levels.

Now you have a choice: petrol and lots of carbon dioxide, or diesel and lots on NOx. To quote the North-of-Englanders: "You don't get owt for nowt."

Final comment

I have tried, in this brief overview, to indicate that we are being subject to a lot of propaganda and woolly political thinking. Renewable power resources do exist, but they are not entirely as benign and easy to harness as the politicians would have us believe.

We have to foot the bill, so it behoves us all to make sure that we thoroughly investigate all options and the best proportions of each before we let the spin-doctors get away with it. A knowledgeable public is a pain in the backside to politicians, but the pain will be all ours if we just sit back in happy ignorance.