EnergyWatch

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EDITORIAL

Full circle back to square zero

New Zealand in the year 2023. Like in every other country around the world vast technical and financial resources should by now be deployed to facilitate a fundamental transformation of our energy sector to reduce GHG emissions. Civil society and academics should be discussing and implementing plans for richer and more sustainable living arrangements ranging from maximum energy efficiency everywhere to circular economy principles. New Zealand farmers should by now profit from premium prices realisable for low emission and low fossil fuel input agricultural products. New Zealand politicians, from local to national government, should be busy implementing better public transport and doubling down on New Zealand's emission reduction targets for Paris and beyond.

The reality of course couldn't be more different. Not only does NZ remain as dependent on fossil fuels as ever and totally off-track for meeting its binding and aspirational GHG emission targets for 2030 and 2050. The country also seems to have adopted a switch strategy, where every small step towards a sustainable energy future gets counter balanced by two monumental steps backwards. Yes, the increasing adoption of electric vehicles is positive, more and more homeowners and businesses committing money for new PV installations is a step in the right direction, councils finally focusing on better recycling options is long overdue and installing several dozen MW of biomass boiler capacity will reduce the GHG footprint of New Zealand's industry.

However, what good can all these small steps do, if at the same time elimination of the low user fixed line tariff kills off any incentive for household energy efficiency measures, enormous amounts of political and financial capital gets wasted on the unworkable, unnecessary and obsolete non-solution of Lake Onslow, which can't address any of the real fundamental electricity sector problems, an almost ready-to-go biofuels sales obligation gets cancelled without replacement at the last minute for no good reason at all, and an existing coastal shipping service is underutilized and eventually abandoned in favour of road transport, even during a severe truck driver shortage.

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Meanwhile, during the 2023 election campaign, most political parties speculate that they can increase their share of the vote by promising billions of dollars for new roads, abandon penalty payments for inefficient, fuel wasting vehicles, stop support for industrial energy efficiency measures and fuel switching, delay any action on agricultural GHG emissions by another decade, promote urban sprawl, and increase New Zealand's population, and consequently resource consumption, through immigration at unprecedented levels.

These developments speak of more than disregard and ignorance for energy and GHG emission issues. They clearly show that in the year during which cyclone Gabrielle caused unprecedented devastation, environmental topics have not only lost relevance, but it has become politically expedient to promote fossil fuel consumption and work actively against energy efficiency and GHG emission reductions.

Meanwhile, our own Professor Ralph Sims, with quite some justification and hard earned frustration, asks what future there can be for the IPCC, if after two dozen COP conferences and shelfs full of assessment reports and special reports, the key message to urgently and radically reduce fossil fuel consumption around the globe still remains the same - yet no country, industry or sector of civil society is taking adequate enough action, despite the dire consequences of business as usual practices being known all too well.

Mahatma Gandhi is credited with the quote: "First, they will ignore you, then they will laugh at you, then they will fight you, then you will win." Apparently, this paradigm of change does not apply to efforts around renewable energy, GHG emission reduction, green buildings, energy efficiency, sustainable transport, recycling and waste minimisation or general reductions in resource use in New Zealand. Such efforts have been fought hard by the fossil fuel industry and their collaborators in the political sphere right from the start. And following increased public awareness and discussion about 20 years ago, these topics are now largely ignored again if current media coverage or the 2023 NZ election campaign is used as an indicator. In the end of course, without a radical transformation of our energy system there will only be losers, and no one will have any reason to laugh about any aspect of our energy, resource and GHG emission predicament - even if trolls, astroturf activists and self-proclaimed climate sceptics are currently trying their very best to turn every online discussion, political meeting, or public campaign into a theatre of the absurd.

What then can the purpose and mission of SEF be in such a contradictory and treacherous situation? Logic dictates that it has to remain the same it has always been: continuing to assist with the first step in the right direction by providing a receptive forum for novel and left-field ideas and concepts in the energy space, utilizing the collective knowledge and experience of our members to identify ways of doing things better, and providing factual and scientifically rigorous critique of programs, policies and products that may or may not improve New Zealand's energy use patterns and GHG emission profile.

It may be frustrating for people who have engaged at this level for many decades that today, in 2023, we are still working around square one. However, to paraphrase another famous quote: "Even the most basic truth needs courageous people to talk about it", especially since topics around sustainable energy and GHG emission reductions are at risk of being pushed back to square zero.

In this spirt, we've packed Energy Watch 86, with articles about novel, interesting and unconventional energy topics, ranging from slow progress on building insulation to the big picture concept of degrowth, and from alternative shipping fuels to an overlooked capacity problem complicating the phase-out of gas use in the residential sector. We hope that readers will learn something about issues that may not have been on their, or anyone else's, radar, and hope that we encourage at least a few householders, businesspeople, or political decision makers to take the second step in the right direction, towards a brighter and better sustainable energy future.

Stephan Heubeck

Lead story: Renewable Gas Use and the Limits of Electricity Peak Capacity

Green gases are available and needed

Reducing fossil fuel consumption is hard, especially within those sectors of the New Zealand's energy landscape that are often absent from public discussion, expert scrutiny, and high-profile policy decisions. Natural gas (fossil methane) and LPG (liquified petroleum gas) consumption in NZ are two of those overlooked sectors. Considering that NZ lags far behind most other OECD countries with the utilisation of green gases, the recent increase in discussion around renewable substitutes for fossil gases is a very much welcome development.

New Zealand has the resources to develop a renewable gas sector over the next two decades, that can produce several dozen Petajoule per year (PJ/y) of renewable biogas, a fact repeatedly outlined by several industry assessments[1] and studies[2]. The main showstopper for NZ biogas projects is a lack of long-term take guarantees for green gases at stable prices, rather than the absolute cost of renewable gases, which are lower than many alternatives, including industrial heat electrification. Industrial heat use has always been the logical focus for biogas and other green gas use in NZ, for the simple reason that processes like glass recycling, production of building insulation material, or certain types of food processing have no practical alternative to the use of energy dense, gaseous hydrocarbons. And while all of New Zealand's hard to substitute industrial gas demands can be met with green gases, this transition would nevertheless be a multi-decade task, requiring billions of dollars of investment, and creating thousands of new green sector jobs.

Why focus on household gas use?

With these fundamentals, it was surprising to see the recent interest in renewable gases triggered by the 2021 Climate Change Commission (CCC) draft advice for consultation document[3], which recommended for NZ households that "no further natural gas connections to the grid, or bottled LPG connections occur after 2025". At a first glance it was difficult to understand why the CCC would suggest such draconian measures for the household sector. After all, other than many industrial applications, households have plenty of practical gas alternatives at their disposal – from proper house insulation to pellet fires and from induction cook tops to solar hot water. Wouldn't most of the fossil gas use in households simply disappear once increasing Emission Trading Scheme (ETS) charges make the already existing renewable alternatives more cost competitive? Was the CCC risking to overlook the undeniable need for, and complexities associated with, renewable gas use in industry by starting a sideshow discussion around household gas use?

Alas, not really, because behind the thin veil of simplicity around household gas use substitution lays an abyss – a chasm full of contradictions and complexities.

One contradiction to consider is, that despite massive efforts to reduce fossil fuel consumption in sectors such as electricity generation or transport, the NZ household and building sectors have actually increased their consumption of fossil fuels over the last decade. This increase of fossil fuel use was mainly in the form of natural gas and LPG, and the International Energy Agency (IEA) 2023 New Zealand Energy Policy Review[4] provides some astonishing data in this regard. Considering the combined energy consumption in residential (56%) and commercial (44%) buildings, NZ reached a fossil fuel low point in 2008, when 19% (20PJ out of a total of 105PJ) of building energy was derived from fossil fuels. By 2021 fossil fuel consumption in buildings had increased by 30% to 26PJ, out of a total of 118PJ, which was made up of 13PJ natural gas use and a similar amount of LPG use.

[1] https://www.biogas.org.nz/documents/biogas/BANZ-Biogas-Strategy-110224.pdf

[2] https://www.beca.com/getmedia/4294a6b9-3ed3-48ce-8997-a16729aff608/Biogas-and-Biomethane-in-NZ-Unlocking-New-Zealand-s-Renewable-Natural-Gas-Potential.pdf

[3] https://www.climatecommission.govt.nz/public/evidence/advice-report-DRAFT-1ST-FEB/ADVICE/CCC-ADVICE-TO-GOVT-31-JAN-2021-pdf.pdf (page 60).

[4] https://iea.blob.core.windows.net/assets/124ce0b0-b74e-4156-960b-bba1693ba13f/NewZealand2023.pdf (Figure 4.4., page 55)

Increasing fossil fuel use in private households

The IEA numbers mirror a worrying trend. According to industry association GasNZ[5] there are currently 272,000 residential natural gas connections in the country, and 300,000 homes and businesses use LPG. According to Statistics New Zealand[6] there were 1,865,300 households in NZ in March 2021, which indicates that ~ 15% of all households use natural gas and ~16% use LPG. These numbers are in line with the BRANZ study report 372 (2017)[7], indicating that 20% and 15% of NZ households are using flued and un-flued gas heaters for space heating, respectively. The same source also states that gas heating is more prevalent among owner-occupied and more affluent households, which tend to have an above average energy consumption. However, according to Master Plumbers, Gasfitters and Drainlayers chief executive Greg Wallace[8], more than 65% of consumers are currently choosing gas hot water systems for new homes and renovations, indicating that household fossil gas use is increasingly becoming a mass phenomenon.

Cost savings can explain part of the increase in fossil fuel consumption in New Zealand households. According to MBIE numbers[9], the 2021 average price for household electricity was NZ$ 81.56/GJ, while the average price for residential natural gas was NZ$ 40.02/GJ, giving a clear cost advantage to natural gas. To bridge this price discrepancy between largely renewable electricity and fossil natural gas with an GHG emission factor of $54kgCO_{2equi}/GJ$ with an ETS charge alone, would require the ETS cost to increase by more than $NZ\$770/tCO_{2equi}$ – a near impossibly high number.

Household gas phase out or cut – could NZ infrastructure cope?

The fact that household natural gas use will be hard to influence through GHG emission pricing alone, lends a lot of credibility to the CCC suggestion to mandate a household gas phase-out via a ban on new natural gas connections and LPG supply to new buildings from 2025 onwards. This would lead to a gradual phase-out of household gas use by 2050. However, there remains the question of how the elimination of household gas use would affect the remaining NZ energy supply system, particularly the electricity system. Since projections for 2050 are uncertain due to future technology and population developments, a simplistic, yet meaningful, estimate can be made by assuming an instant cut of natural gas and LPG supply to households based on 2021 data.

According to MBIE data[10], NZ households consumed 7.19PJ of natural gas and 3.78PJ of LPG in 2021, which is equivalent to 3,047,000MWh/y. Using a top-down analysis assuming that all households would substitute these gas volumes in 2021 directly with grid electricity, would result in an additional electricity demand equivalent to about 7% of New Zealand's total net electricity generation of 43,271,000MWh for 2021. This is a large, yet manageable, increase in electricity demand, that could easily be satisfied from new electricity generation capacity already consented.

However, the real problem with these 3,047,000MWh annually supplied form household use of fossil gas, is their very peaky consumption profile. Simplistically assuming that all household natural gas and LPG is consumed during 1,000h per year, equivalent to an average of about 3hours per day, would indicate, that substituting the 2021 household fossil gas use with grid electricity would increase New Zealand's peak electricity demand by ~ 3,000MW. This is an enormous number, representing 41% of New Zealand's all-time peak electricity demand of 7,250MW on the 9th of August 2021[11].

A bottom-up countercheck based on 572,000 NZ households currently using natural gas or LPG

[5] https://gasnz.org.nz/what-we-do

[6] https://www.stats.govt.nz/information-releases/dwelling-and-household-estimates-march-2021-quarter/

[7] https://d39d3mj7qio96p.cloudfront.net/media/documents/SR372_Warm_dry_healthy.pdf

[8] https://www.stuff.co.nz/business/131760598/gas-industry-floats-plan-for-switch-to-renewables

[9] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-publications-and-technical-papers/energy-in-new-zealand/

[10] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-publications-and-technical-papers/energy-in-new-zealand/

[11] https://tpow-corp-production.s3.ap-southeast-2.amazonaws.com/public/bulk-upload/documents/Market%20insight%20report%20-%20Winter%20Review%20-%2011%20Nov%202022.pdf?VersionId=QaQVHc8zmQ6_FpC_Ux7GOimodObF9Vt2

yields similarly high numbers. Information form equipment suppliers[12] [13] [14] and Consumer NZ[15] indicates, that typical gas heaters and flame effect fires sold in NZ have an output capacity of 5 to 10kW, while gas cook tops have a heat output of 1 to 2kW, with the output of gas Wok cooktops being as high as 4 to 5kW. Other than gas instant hot water heaters which can be replaced with a ripple control electric hot water cylinder, most of the gas space heating and gas cooking energy demand is peak relevant during New Zealand's usual electricity demand peak on winter evenings. The BRANZ study report 372 (2017) states that 90% of all heating appliances installed in main living areas are regularly in use during winter evenings, and numbers for the use of cooktops are likely to be similar. Assuming conservatively that 90% of NZ households using gas utilize 5kW for space heating and 1kw for cooking on winter evenings during peak demand hour, and that these households would directly replace their gas use with grid electricity, would result in an increase of peak electricity demand of 3,089MW.

Adding roughly 3,000MW additional peak demand to the existing NZ peak demand, results in a total peak electricity demand figure at the upper end of MBIE projections for 2050[16], which assume a bold and rapid uptake of electric vehicles and industrial heat electrification. This indicates that replacing the inflexible household gas consumption with electricity may require electricity infrastructure investments equal to or greater than the electrification of a large fraction of New Zealand's light vehicle fleet. The fact that a phase-out of household fossil gas use could be organized gradually until 2050 provides little relief for the problem of additional peak electricity demand. A gradual phase-out of household fossil gas use would add 111MW additional peak electricity demand every year until 2050. An additional 111MW would almost double the projected 2023 winter peak demand increase of 138MW, which transmission system operator Transpower already describes as a challenge demanding urgent cross-sector collaboration.

Locked in the peak capacity trap

Concerns about the capacity of electricity transmission and distribution infrastructure aside, all of the electricity generation capacity substituting fossil gas use in households during peak demand hour would be required during winter evenings, when solar generation is unavailable, wind generation cannot be guaranteed, and hydro and geothermal generation may already be strained. This indicates that the most likely sources for satisfying the additional peak demand would either be generation from biomass or fossil gas. If that is the case, it would be better to keep burning gas directly in households and avoid the transformation losses associated with electricity generation, transmission, and distribution, and save the investments for additional electricity generation capacity on top.

What does this hitherto overlooked issue of additional electricity peak demand through reduced household fossil gas consumption mean for a future-proof NZ energy strategy and renewable gas supply in Aotearoa? Firstly, that the CCC is right that NZ cannot afford to increase fossil gas use in the building sector any further, and a ban on any additional fossil gas use in new buildings or renovated buildings is warranted, since GHG emission pricing alone is unlikely to drive any desirable change. Secondly, that serious efforts must be made with building energy efficiency, to reduce the overall demand for space heating. Options that enable energy time of use flexibility, like ripple control electric hot water cylinders, also need to be supported.

However, for the existing and remaining household fossil gas use, the very peaky and inflexible nature of energy use for cooking and space heating during winter evening peak demand hours makes electrification of this energy demand very difficult and prohibitively expensive. The

[12] https://www.westinghouse.co.nz/cooking/cooktops/?page=1
[13] https://www.placemakers.co.nz/online/heating-catalogue
[14] https://www.belling.co.nz/en-nz/products/cooktops
[15] https://www.consumer.org.nz/articles/flued-gas-heaters?gclid=EAIaIQobChMI6JivjKDk_gIVjpNmAh0OWwKqEAAYBCAAEgKv2_D_BwE
[16] https://www.mbie.govt.nz/dmsdocument/5977-electricity-demand-and-generation-scenarios

swift and large-scale roll-out of biogas, and other green gas technologies, appears as the most sensible, most practical, and most cost-effective way forward for reducing fossil gas use in residential buildings.

New Zealand is already required to roll out biogas production and upgrading infrastructure to replace natural gas and reduce GHG emissions from industrial applications like glass recycling and food processing. Additionally supplying green gas volumes that could substitute current household fossil gas use would require to build an additional 30 to 40% of biogas and other renewable gas production capacity on top. However, given the moderately high retail price of residential natural gas (NZ$ 40.02/GJ in 2021) this will be financially possible. What NZ lacks is a sensible gas market framework and the right mix of biogas producers and long-term investment to achieve this goal.

One way forward

Overall, reducing GHG emission from the residential use of natural gas and LPG presents a real-world dilemma. On the one hand industrial gas demands are more deserving and a higher value use for the renewable gas volumes New Zealand can produce. On the other hand, the peak capacity constraints of our current and future electricity system would demand the on-going use of gas fuels in the residential sector, which would have to be substituted with renewable gases to reduce GHG emissions. Both, the industrial and the residential sector therefore call for a bolder, more aggressive, and faster uptake of biogas and other green gas technologies. One policy that could support this would be the introduction of a fixed price, variable volume green gas mandate in NZ. A green gas mandate would support the roll out of new biogas production and upgrading capacity with long term, fixed price off-take contracts into the natural gas network. The cost and benefits of green gas utilisation would be equally distributed over all natural gas users as a discount or surcharge by the gas system operator to the cost of managing and maintaining New Zealand's natural gas network. Considering that the last 13 years of only talking about GHG emission reductions have led to a 30% increase in fossil energy use in the NZ building sector, it is clearly indicated that it is high time to get active now with real policies and new economic tools.

Written by Stephan Heubeck

Methanol Marine Fuel

The news cycle has featured "fragile international logistics chains" quite frequently over the last 2 years. Despite this, most New Zealanders, and most people living in other OECD countries, would very likely still consider international shipping to be an issue "out of sight and out of mid". International shipping accommodates more than 90% of all physical international trade, and in New Zealand, effectively all consumer goods, apart from food and some building materials have found their way to the end user thanks to international shipping. Despite being very energy and GHG emission efficient, international shipping still accounted for 667 million tonnes of CO_2 emissions in 2021, or ~2% of total global energy GHG emissions[17]. Incrementally, international shipping tries to become more fuel and emission efficient, employing various strategies from individually larger ships, to better biofouling control, to wind-power assisted propulsion systems[18]. However, most experts agree that the big shift for low GHG emission shipping will have to come from renewable shipping fuels.

Regarding the question what type of renewable shipping fuel will dominate the future, an interesting discrepancy can be observed. Like many speakers at the NZ H22Zero hydrogen

[17] https://www.iea.org/energy-system/transport/international-shipping

[18] https://www.dnv.com/maritime/insights/topics/waps-wind-assisted-propulsion-systems/index.html

summit in Wellington in September 2023[19], a very long list of researchers, start-ups, venture capitalists, policy analysist and electricity sector players, see the ships of the future powered by liquified ammonia fuel or hydrogen, employing modified reciprocating engines or fuel cells. In addition to modifications to a ships power train, these fuels would also require the establishment of completely novel and rather complex cryogenic or pressurized fuel storage and distribution systems, which are associated with a long list of safety concerns. This would add additional costs to the already quite high costs projected for green hydrogen based marine fuels.

Despite, or because, of the many open questions around the future availability, and financial and technological viability of ammonia and/or hydrogen shipping fuels, the world's largest shipping company, A.P. Møller – Mærsk A/S, is taking a different, and arguably better, approach to renewable shipping fuels. To meet its company internal net zero emission 2040 target, Mærsk has ordered 24 green methanol vessels for delivery between 2024 and 2027, with the first one taken into service in September 2023. Furthermore, in 2022 Mærsk set up strategic partnerships with six companies[20] with the intent of sourcing at least 730,000 tonnes of green methanol per year by 2025, and recently announced that its parent company would directly invest in additional green methanol manufacturing capacity around the globe.

The advantages of green methanol as a shipping fuel are obvious: standard marine engines can be adopted to run on green methanol with relatively little effort, as a liquid methanol is relatively easy and safe to handle and store (compared to other green alternatives), and methanol manufacturing can be coupled with the widest possible range of green energy technologies. It is possible to convert green electrolysis hydrogen into methanol just as well as gasified biomass or green bio-methane from biomass fermentation. In addition, existing infrastructure, such as the natural gas network can be utilized, and with fossil natural gas as back-up, a gradual transition from fossil methanol to green methanol can be planned.

Why should New Zealand take note of this development?

Because NZ has currently 700,000t/y methanol manufacturing capacity sitting mothballed at Waitara Valley, which, with some effort, could be fuelled with some of the millions of tonnes of forestry residues continuing to cause environmental problems - from forest fire danger to clogged beaches - up and down the country. Rail transport of the required biomass to the processing site is possible, and with a dense gas pipeline network and electricity infrastructure in Taranaki, it would also be possible to provide additional and increasing volumes of green bio-methane and/or green hydrogen for green methanol manufacture. The existing skill base and existing methanol handling facilities at Port Taranaki could further assist the production, use and export of green methanol shipping fuel from New Zealand.

Making use of what's already there and joining forces with credible international players, like Mærsk, using proven technology, appears as a much safer and worthwhile plan for a low emission shipping fuel future, compared to continuing to speculate about future NZ hydrogen and/or ammonia capacities from as yet unidentified sources, produced and handled with as yet unavailable technology.

Written by Stephan Heubeck

[19] https://www.events.nzhydrogen.org/h2-2-zero-summit-2023/h2-2-zero-summit

[20] https://www.maersk.com/news/articles/2022/03/10/maersk-engages-in-strategic-partnerships-to-scale-green-methanol-production

Pumped Hydro – It's already built!

SEF Open Letter, 2nd of August 2023

This is an open letter from the Sustainable Energy Forum (SEF) Inc. to the Minister of Energy and Resources the Hon Dr Megan Woods, the Parliamentary Commissioner for the Environment Simon Upton, the Energy spokespersons of all parliamentary parties and representatives of the media.

The mission of SEF is to assist "Facilitating the use of energy for economic, environmental, and social sustainability". As such, we feel compelled to contribute vital information to the currently unfocused and unproductive discussion around the New Zealand Battery Lake Onslow project, and the proper application of pumped hydro technology within a future-proof New Zealand electricity system. The consensus among SEF members, many of which have decades of electrical, structural, environmental or civil engineering expertise, is that pumped hydro energy storage is a highly valuable and important technology for a sustainable New Zealand energy future, but that the current NZ Battery Project proposal for Lake Onslow is woefully inadequate, ill-targeted, and above all - obsolete. The project should therefore be abandoned sooner rather than later, as it is unfitting and too expensive to provide electricity back-up for generation shortfalls occurring on the decade scale. All other features expected from Lake Onslow, including buffer and back-up capacity for the integration of more intermittent renewable generation and price peak modulation ability, can alternatively be provided from New Zealand's already built, tested, but unused pump hydro scheme on the Pukaki-Tekapo canal.

History lesson: Pukaki-Tekapo pumped hydro

Early in 1977, the Power Division of the Ministry of Works completed construction of their Tekapo canal, joining Lakes Tekapo and Pukaki to form the core water reservoirs for the Upper Waitaki Power Development. However, there were concerns about introducing design flows of 120cumecs to the new canal, which could be expected to potentially cause significant channel damage. Would the compacted gravel bed withstand erosion? Could the untried 25km canal overflow somewhere and degrade or damage the billion-dollar investment? Would the new gates at the Tekapo A power station (Figure 1) control inflows reliably enough?

The solution proposed by a specialist systems engineer (Dr Alastair Barnett, seconded to power division) was to manage the planned canal commissioning programme in stages via a computational model of the canal. The first stages would be at half design steady flow (60cumecs) with later stages run at more challenging flows, culminating with the final test required by Ministry compliance rules: the surge resulting from sudden rejection of full design flow through the Tekapo B station downstream. Such severe conditions would arise only if all transmission of power from the station failed (for example, through the collapse of a transmission pylon). However rare, such a possible station trip event must not endanger the power stations and the connecting canal.

Figure 1: Calibration of new inflow control gate at Tekapo A on 1st of July 1977.

At each stage, model predictions of the outcome were compared with observed results. Only after the match between predicted outcomes and observed results was accepted by the design office, was authorisation given for the next stage to proceed. A schematic test programme prepared by Dr Barnett was issued as an appendix to "Tekapo B Power Project M.W.D. Commissioning Procedures H.D. 1154" dated April 1977. It schedules the on-site presence of 36 specialist staff over the four-month canal commissioning period, twelve of some one hundred staff-years spent on testing during the whole Upper Waitaki Power Development. Of Interest is the approval of the Chief Design Engineer, Bill Fookes, the architect of the Pukaki-Tekapo concept, who already envisaged a national battery in the Upper Waitaki over 45 years ago. An example of the model predictions, plotted below (Figure 2) shows the maximum safe reverse flow through the canal. Although such a flow would require the addition of pumps at Tekapo A and B, significant reverse flows occurred during reflection from suddenly closed gates during the final flow rejection test. Successful model prediction of these flows gives full confidence that this estimate of maximum flow capacity for pumped storage development is accurate.

Pumped hydro storage is already built!

What does all the work conducted in the Upper Waitaki in 1977 and before, mean for New Zealand's energy future today? It means that, if there is a scope or need for pumped hydro storage in New Zealand, it has already largely been built and tested on the Tekapo canal. All that is technically required to make use of this existing asset is to buy pumps and install them in their pre-built locations at Tekapo A and B power stations. This could be accomplished in less than two years at an estimated cost of less than NZ$100 million, and, assuming the completed pumped hydro scheme would be operated coordinated with other adjacent generation assets, could provide back-up, firming and energy storage capacity for several hundred MW of new and future wind or solar generation development. There are no technical barriers preventing the completion of the pumped hydro scheme at the Tekapo canal and the comparatively small financial outlay required, would make it one of the most cost-effective pumped hydro schemes realizable anywhere in the world. All it requires for New Zealand to utilize this unique pumped hydro opportunity, would be to reverse the ill-conceived 2011 ownership transfer of Tekapo A and B power stations. Furthermore, like any other energy storage concept in NZ, the Tekapo canal pumped hydro scheme cannot operate under the existing electricity spot market pricing system, which provides no revenue base, but an assured revenue reduction during the most profitable trading hours of the year, for the operators of this, or any other, electricity storage scheme. Just like for the realisation of Lake Onslow pumped hydro, a revenue base for a Tekapo canal pumped hydro scheme would require a compensation model outside the electricity spot market, or fundamental reform of this system. We encourage political decision makers and the New Zealand public to focus on overcoming these legal, market order and financial barriers, holding back all electricity storage concepts in Aotearoa, rather than to continue arguing about the disadvantages and problems of Lake Onslow. Once a sound basis for the operation of energy storage concepts is established, the Tekapo canal pumped hydro scheme would be able to provide capacity and services at extremely low cost and with minimal environmental impact.

Written by Dr Alastair Barnett and Stephan Heubeck

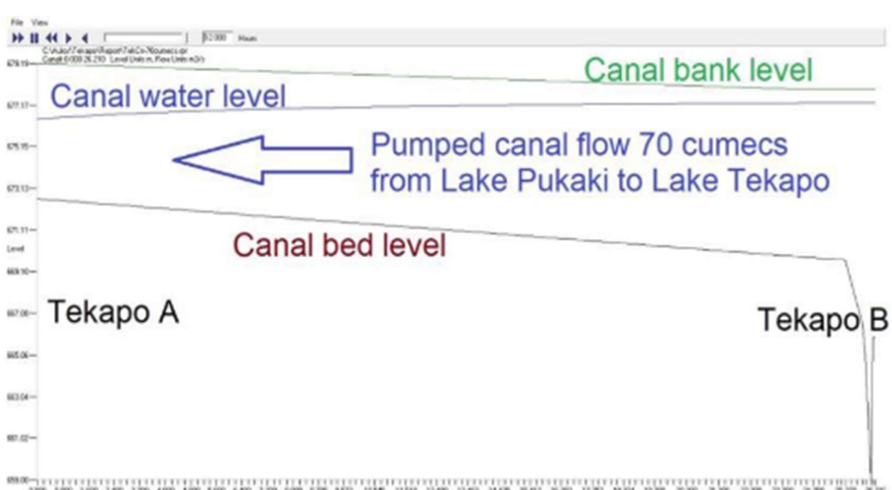

Figure 2: Model predictions of the maximum safe reverse flow through the Tekapo canal; prepared by Dr Barnett.

Belated NZ New House Insulation Increases

From November 2023 the insulation requirements for all new houses and relevant existing house retrofit work will significantly increase. This is 15 years since the last 2008 house insulation increase. The 2008 increases were in turn the first major changes for the 30 years since the first NZ-wide house insulation requirements in 1978. So how did this happen, what does it mean, and what is still needed in the future? Hopefully it will not be another 15 or 30 more years until the next serious update (2038 or 2053) as the NZ historical record might suggest?

No systematic requirements pre-1978

Until 1978, very few NZ houses were fully insulated. Both old and new houses had:

- single glazed windows with either simple low insulation wooden frames or, increasingly, no insulation but less draughty aluminium frames.
- No, or minimal, ceiling insulation.
- external walls with outer cladding to slow the rain down, building paper to mostly stop the rain, uninsulated vented wall cavities to deal with any residual moisture, and inner plasterboard linings to give a modicum of air tightness and give a surface to paint or paper.
- uninsulated suspended wooden floors. New houses increasingly had a concrete slab poured directly on the ground with no perimeter or under slab insulation.

In summary: old houses were very draughty, newer houses were less draughty. In any house serious heating was needed to make the one heated room even vaguely warm.

A high heat output whole house heating option in the South Island was oil fired central heating, and in the North Island an increasingly popular heating option was natural gas, although less than 5% of houses in either island had this level of warmth. Uncontrolled heat output night-storage electric heaters were also common. Plug-in electric heaters were limited to 10 Amps, hence 2.3kW, which was not enough to heat uninsulated drafty rooms. Low efficiency wood and coal open fires and modest efficiency closed burners were common, with 16 kW or even greater heat outputs, but with the side effect of major winter air pollution in many urban areas. Un-flued LPG heaters were also increasingly used, with their associated serious condensation/mould and health impacts.

Energy was very cheap, everyone who wanted one had a job, almost no one cared much about house heating, houses were just cold and draughty, and it was just taken for granted that houses used lots of energy for heating to get even just part of a house to be vaguely warm. A couple of South Island Councils had insulation requirements, but most houses were not required to, nor had any insulation.

The first NZ-wide insulation requirements: 1978 - 2000

In 1973/74 the first global oil crisis led to a fourfold increase in oil prices. The 1978/79 second global oil crisis led to a further threefold increase in oil prices. So crude oil prices increased from USD3-4/bbl to USD12/bbl and then to USD 39/bbl in just 6 years, leading to "carless days", reduced speed limits, and fuel stations being closed on most of weekends to reduce fuel demand. There were also electricity supply shortages. Alongside the 'Think Big' energy policies on the supply side, the Muldoon National government announced a requirement for all new houses to be insulated (primarily to save electricity) – made through a budget announcement. The result, in force from 1978 to 2007, was the longest "P" in NZ history. NZS4218P:1977 (NZ Standard 4218 (Provisional) set house insulation levels for 30 years (1978 to 2008). NZS4218P:1977 effectively specified:

- 75mm of bulk insulation (in effect, fiberglass batts) in the standard 100mm wall cavity timber framed walls for R1.5 walls - and effectively no insulation requirements for the then still common solid (e.g., 'Lockwood") wooden walls or concrete block walls in new houses.
- 100mm of insulation batts for R1.9 ceiling insulation levels.
- underfloor reflective foil draped over the floor joists for R0.9 floors.

- no insulation requirements for windows. Windows in new houses were almost all very high heat loss uninsulated aluminium framed and single glazed.

There were no climate zones. The same new house insulation levels that applied in subzero winter Central South Island Twizel were applied in the 'winterless North' around Kaitaia.

1st Upgrade of insulation requirements – 2001 - 2008 - 2022

Before 1990 building controls in NZ were a confusing mishmash of different Acts and local By-laws. Building controls were administered by a bewildering range of government departments and territorial authorities A new unifying Building Act was passed in 1991. It included Energy Efficiency as one of its eight themes for building regulation in NZ as the result of policy work led by the predecessor of EECA. No funding was allocated for developing a new approach and updated technical Standards. NZS4218P continued to be used.

EECA finally obtained a suitable budget - via a last-minute budget "new initiatives" funding addition - in 1993 for developing new building energy efficiency requirements. The work was then co-funded by EECA and BIA (the Building Industry Authority). Most of the housing work was undertaken by BRANZ and the Centre for Building Performance Research at VUW, on behalf of BIA (the responsible NZ Building Code (NZBC) agency). This established a new "performance-based" approach for NZBC Clause H1 Energy Efficiency. However, the updated energy efficiency 'deemed to comply' (Approved Solutions) requirements were what most people used.

The technical work was completed in 1996. But Max Bradford was the new Minister of Energy and wanted to kill any increase in house insulation levels following the 1996 general election – key officials quietly prevented this. It took 4 years and 4 days and five different Ministers of Internal Affairs (responsible for BIA) and a change to the Clark Labour government for the new house energy efficiency (insulation) requirements to come into force from 2001.

The 2001 requirements introduced three climatic zones and defined "houses" as buildings under 300 m^2. Buildings over 300m2 were deemed to be commercial scale buildings. In line with the then regulatory vogue, a "performance requirement" was set. But in practice the "Acceptable Solution" to Clause H1 (NZS4218P) was still what mattered until 2007/08. Ceiling and wall insulation levels were similar to the 1978-2000 levels for Zones 1 and 2 (the warmer North Island areas) but were increased for Zone 3 (the SI and NI Central Plateau).

On paper, underfloor insulation levels were increased by including the benefits of the foundation wall to R1.3 for all zones. But nothing actually changed in practice, except for pole houses. The commonly used floor constructions of uninsulated slab-on-ground concrete and draped aluminium foil under the joists of suspended wooden floors continued to be accepted under the new Clause H1 Acceptable Solution. The big changes in the 2001 requirements were that in Zone 3 (the SI and NI Central Plateau) ceiling insulation increased to R2.5. Wall insulation increased to R1.9 - that is, the full 100mm standard wall cavity was filled with bulk insulation e.g., fiberglass batts. Double glazed windows became common on new buildings in the SI, but on a voluntary basis.

As per Table 1 below, from 2007-2008 the next logical step since 1978 was finally taken. Basic double glazing (still with uninsulated aluminium frames allowed) R0.26 windows and skylights were effectively mandated for all new houses. Ceiling insulation increased to R2.9/3.3 (150mm of bulk insulation (e.g., Batts). Wall insulation levels remained unchanged.

Table 1: H1 Energy Efficiency Acceptable Solution H1/AS1 (4th Edition Amd4)

Effective 30 Sep 2008	Zone 1	Zone 2	Zone 3
Roof	2.9	2.9	3.3
Wall	1.9	1.9	2
Floor	1.3	1.3	1.3
Vertical glazing	0.26	0.26	0.26
Skylights	0.26	0.26	0.31

2nd Upgrade of Insulation Requirements – 2022/2023 (and beyond)

Significantly upgraded new house insulation requirements are now in the one-year process of being fully implemented from November 2023 (see Table 2 below). There are now six climate zones (see Figure 1 below), with some increases in insulation requirements between zones. The big changes are that ceiling, non-slab on ground floor, window and skylight minimum insulation levels have effectively doubled.

Ceiling insulation is now at the point of diminishing returns. Floors now require significant bulk insulation for suspended floors and perimeter insulation for slab on ground concrete floors. Windows and skylights now need to be Low E throughout NZ.

Issues Around the new 2022/2023 Insulation Requirements:

Walls - wall insulation has remained at a nominal R2.0 (nominal as thermal bridging through wall studs makes the real overall insulation levels lower) which is probably the technical limit for current bulk insulation approaches in a 100m thickness wall. To go to a more ambitious wall insulation level would require a change to say 150mm deep wall studs or ideally to staggered wall studs that do not go the full depth of the wall to reduce thermal bridging. This would add to building costs but would be balanced by reduced operating energy costs and warmer internal house temperatures.

Windows – vertical window insulation requirements of R0.46 – R0.5 can only be met with Low E (low emissivity) double glazing. Uninsulated aluminium frames are effectively outlawed. Thermally broken aluminium frames are able to be used with higher performance Low E double glazing. However, R0.9 advanced "warm edge" Low E double glazing is widely available from all major glazing suppliers. Coupled with uPVC (ultra-violet protected PVC) or suitable wooden window frames, double glazed windows with an overall R0.7 are now available in NZ. The question is whether a future government will be prepared to ban aluminium window frames – new buildings in similar climates to NZ such as in southern Europe use uPVC or wooden windows.

Skylights - the widely used international Velux skylights sold in NZ do not meet the new insulation requirements for Zones 3 – 6 for all their models. It is unclear if this is an oversight, or if Velux will not sell all their models in NZ, or if Velux will not sell some models in the colder parts of NZ.

Summer Overheating – increased insulation levels also mean that excess heat cannot get out of a house. New houses can have large areas of north-facing glazing, and no horizontal shading over such windows. Overheating is likely to be a major emerging energy efficiency issue – especially if the occupants' solution is to use their heat pumps in cooling mode.

Embodied Energy/Zero Net Carbon – in principle, the energy/carbon embodied in building materials can be optimised against the building's energy use over its life. However, this raises a whole new magnitude of complexity. The embodied energy/carbon depends on the exact source and specification of the materials involved. Addressing this in a simple and easy to understand and administer form will not be easy, although it forms part of the MBIE "Building for Climate Change programme"[21].

Future Backlash Against Growing Building Control Costs – the NZBC was supposed to lead to a bright and simpler lower cost buildings control future. Following the "leaky buildings" debacle, new building inspectors were hired and building documentation requirements and costs have grown and grown. A future backlash against the use of regulations and building controls, in particular to support any ambitious low-carbon greenhouse-gas visionary future, can be expected.

Written by Frank Pool

[21] https://www.mbie.govt.nz/building-and-energy/building/building-for-climate-change/

About the author: Frank Pool has been involved with building energy use and energy efficiency for over 4 decades. His Master's project was developing a dynamic version of a building thermal model. Frank then worked for 6 years as an Energy Research Fellow at Victoria University School of Architecture. From 1989-1991 Frank led the Cabinet development and approval process to include energy efficiency in the NZBC. From 1993-2001 Frank got the EECA budget and led the EECA side work that eventually led to the 2008 major insulation increases. Frank later designed the project that led to a doubling of new building insulation levels in Mongolia and has worked on building energy efficiency in Georgia, Kazakhstan, Rwanda, and Micronesia. Nigel Isaacs has provided very useful materials and inputs for this article. He led the relevant work at the Centre for Building Performance Research, VUW and at BRANZ. The work of numerous other people is also acknowledged in increasing building energy efficiency in NZ.

Figure 1: 2001 and 2023 NZ climate zones for building insulation requirements, plus table showing NZ population distribution in the 6 new zones. (Source: https://www.building.govt.nz/building-code-compliance/annual-building-code-updates/2021-building-code-update/).

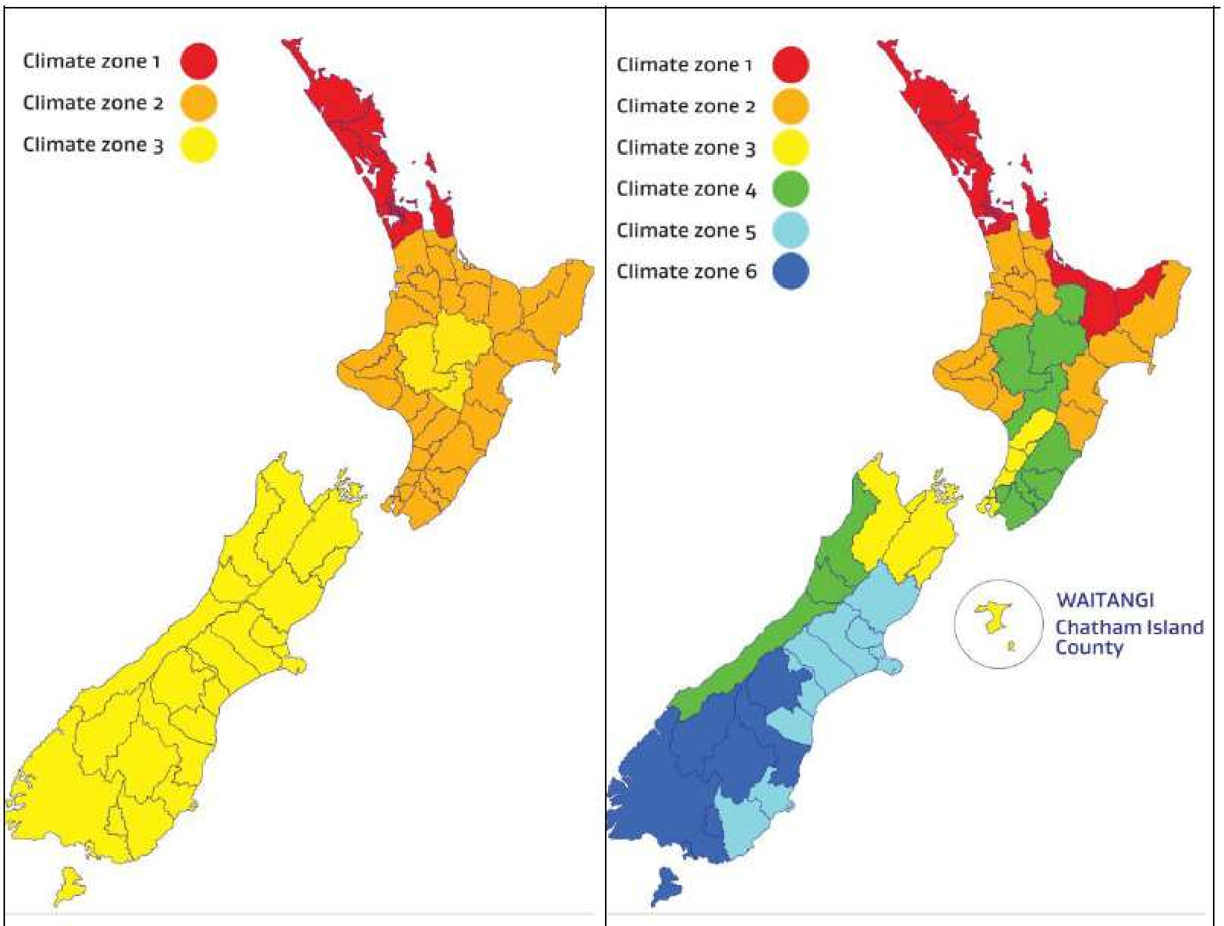

FIG 1.1: Existing & proposed climate zones for NZ
(a) Existing three climate zones in NZ
(b) Proposed six climate zones for New Zealand

Zone	Description	% Population
1	Northland, Auckland, Coromandel and Bay of Plenty	43%
2	Hamilton, East Coast and New Plymouth	16%
3	Manawatu, Horowhenua, Wellington, Nelson, Marlborough and the Chatham Islands	15%
4	Central Plateau, Wairarapa and the West Coast	6%
5	Canterbury and coastal Otago	16%
6	Inland Otago, Southland and Stewart Island	4%

Table 2: Energy Efficiency Acceptable Solution H1/AS1 (5th Ed.). Minimum construction R-values for building elements that do not contain embedded heating systems.

	Construction R-values (m²·K/W)(1)					
Effective 1 Nov 22	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6
Roof(2)	6.6	6.6	6.6	6.6	6.6	6.6
Wall	2	2	2	2	2	2
Floor Slab-onground	1.5	1.5	1.5	1.5	1.6	1.7
Floors other than slab-ongroun	2.5	2.5	2.5	2.8	3	3
Windows and doors(3)	0.46	0.46	0.46	0.46	0.5	0.5
Skylights	0.46	0.46	0.54	0.54	0.62	0.62

Notes: (1) Climate zone boundaries are shown in Appendix C. (2) In roofs with a roof space, where the insulation is installed over a horizontal ceiling, the roof R-value may be reduced to R3.3 for a distance of up to 500 mm from the outer edge of the ceiling perimeter where space restrictions do not allow the full thickness of insulation to be installed. (3) For building consent applications submitted before 2 November 2023, the minimum construction R-values for windows and doors in climate zones 1 and 2 are permitted to be reduced to R0.37 m²·K/W.

Degrowth

It is now 50 years since the publication of the landmark book "Limits to Growth" by the Club of Rome.

The concept of Degrowth is actively discussed at international and local levels, including at an international 3-day Beyond Growth conference hosted by the European Union[22] in Brussels in May 2023, where the President of the European Commission, von der Leyen, emphasised a vision for sustainable growth, and stated that "a growth model centred on fossil fuels is simply obsolete". While fossil fuels (FFs) - coal and later oil and natural gas - have been humanity's major source of energy over the past two centuries, 50% of all FFs ever burned have been consumed in just the past 30 years (as much as 90% since the early 1940s).

Degrowth is a planned and democratic reduction of unnecessary production in rich countries designed to bring the economy back into balance with the living world in a safe and equitable way and is now being widely discussed in international circles. Jason Hickel (author of "Less is More") also speaking to the European parliament said: "The question to consider therefore is not whether the crash will happen, but how to develop the skills, the will and the resources necessary to recapture the initiative and build the resilient sequel to our present society. It will be the decentralised, low impact human ecology which has always taken the human story forward from the closing down of civilisations: small scale community, closed-loop systems, and a strong culture".

The review "Through the Eye of a Needle"[23] presents data showing that plunging biodiversity and climate change, along with air/land/ocean pollution, deforestation, desertification, incipient resources scarcity, etc., are the inevitable consequences - indeed, parallel symptoms - of the same root phenomenon: the spectacular and continuing growth of the human enterprise on a finite planet.

"H. sapiens is in overshoot, exploiting ecosystems beyond their regenerative and assimilative capacities. Overshoot is possible only because of: (a) the short-term availability of prodigious stocks of both renewable (fish, forest, soil, etc.) and non-renewable (coal, oil, natural gas, etc.) forms of so-called "natural capital"; and (b) the enormous, but finite, natural waste assimilation and recycling processes of the ecosphere. However, a reckoning is at hand. In just a few decades of geometric population and economic growth, humans have

[22] https://www.beyond-growth-2023.eu/programme/

[23] https://www.mdpi.com/1996-1073/14/15/4508/htm

exploited to collapse natural capital stocks that took millennia to accumulate and have impeded natural life-support processes through excessive, often toxic, waste discharges. The human enterprise now uses the bio-productive and assimilative capacities of 1.75 Earth equivalents. In simple terms, the industrial world's ecological predicament is the result of too many people consuming too much and over-polluting the ecosphere."

Catherine Knight wrote in a Newsroom article:

"…there is a growing realisation that to make the transition to a low-carbon economy quickly enough to slow the accelerating effects of climate change and ecological breakdown, we must reduce our impact on the planet by consuming less, now. Isolated pockets of change, including the much-vaunted 'behaviour change' by the individual (which sits so comfortably within a neoliberal mindset) will not be enough. Only system-wide change will enable us to downscale our economy in time to have any chance of averting catastrophe. So, what does this mean? What can we do, practically? Aside from supporting any local initiatives that aim to build authentic resilience and connection in our communities, we need to urge our local councils to wake up to the reality of energy descent and urge them to explore alternative economic models that put human and ecological wellbeing at the centre. In Europe, city governments such as Amsterdam and Barcelona are doing just this, through their implementation of Kate Raworth's doughnut economics model. …"

According to Simon Michaux, Associate Professor at Geological survey of Finland, the current ecosystem has no concept of its dependency on minerals and does not consider long-term concepts like continuous growth in production against finite resources. He maintains that current renewable energy systems generally have a lower Energy Returned on Energy Invested ratios (ERoEI) than current fossil fuel-based systems and they may not be productive enough to replace fossil fuels. As such, they may not be the energy foundation for the next industrial era, but merely a steppingstone to some other kind of energy and economic system. To enable an easier transition, he recommends:

- Conduct a Maslow hierarchy of needs analysis loop in the context of industrial activity and capacity.
- Assess what is truly needed for society to function and work back from there.
- Develop engineering technology that can cope with variable power supply and power spikes (intermittency buffer then no longer needed).
- Plan for an economy where some industrial capability can periodically shutdown and startup without damage and a possible period of dormancy over winter.
- Develop an engineering decision-making system that can define whether an industrial outcome is logistically sensible or economically viable to a new set of constraints.
- Re-tool the existing power grid into a network of microgrids, that can transfer power between them and can still function if part of the grid is temporarily shut down. Each microgrid supports a vital industrial or social activity.
- Plan for a re-prioritization of industrial capacity.

Jennifer Wilkins describes the goal of degrowth as universal well-being, to be delivered through global and local provisioning systems that are distributive and regenerative. "This demands a reprioritisation of social values and behaviours toward sufficiency and sharing; it is driving development of innovative post-growth business models that focus on meeting needs and respect local biosphere boundaries, both scientific and cultural; it is guiding macroeconomic research on a coherent set of policy interventions that would balance green policies with protection of livelihoods; and it is agitating for reform of governance institutions and an increase in community agency through participative democracy. No-one is claiming that degrowth would be easy or non-disruptive or linear." Wilkins maintains that there is no evidence that conventional sustainability approaches will make enough of a difference in the precious time we have left to make choices before our climate, biodiversity and inequality crises could tip us (and all living beings) into universal catastrophe.

"We need high-income countries to scale down excess energy and material use; we need a rapid transition to renewables, and we need to shift to a post-capitalist economy that's focused on human well-being and ecological stability rather than on perpetual growth. Degrowth begins as a process of taking less. But in the end, it opens up whole vistas of possibility. It moves us from scarcity to abundance, from extraction to regeneration, from dominion to reciprocity, and from loneliness and separation to connect with the world that surrounds us. What we call "the economy" is our material relationship with each other and with the rest of the living world. What do we want this relationship to look like? Do we want it to be about domination and extraction? Or do we want it to be about reciprocity and care?"

The suggestion by some economists that our current economic system is equitably and sustainably provisioning for a widespread increase in people's capacity to thrive sits in stark contrast to the findings of the latest World Inequality Report. In New Zealand, Degrowth Aotearoa New Zealand (DANZ) (www.degrowth.nz) advocates a rationing scheme to replace the current Emissions Trading Schemes (ETS) as the only way forward, with a direct fossil fuel phase-out with adaptation through resource allocation and rationing. Deirdre Kent a board member of DANZ said that price-based schemes such as the ETS and carbon taxes simply can't reliably deliver the explicit reductions now required. "Prices high enough to change behaviour could risk excluding many from essential energy needs. Prices too low will be a waste of time. Only by tackling inputs rather than emissions will we achieve the required outcome with certainty".

A petition on the parliamentary website, calls for the investigation of a rationing scheme such as Tradable Energy Quotas (TEQs), which would set a weekly energy ration granted equally to everyone over the driving age. Kent said that total quotas would be collectively capped to meet our climate goals and will decline each year, ensuring a reduction in emissions. "TEQs would be deducted when purchasing petrol, diesel, coal and fossil fuel-generated electricity. It is equitable and involves everyone in the solution. People with money will still be able to pollute more by purchasing more quotas. But because TEQs will be decreasingly available over time, they will not be able to do this for long. Government and businesses would be bound by the TEQs system. A TEQ economy can direct quotas to facilities and activities that aid a just transition and will be useful in a low-carbon world. The scheme incentivises everyone to find creative solutions to lower emissions. The national TEQ price would be determined by national demand. Because of this it will be in everyone's interest to reduce our energy demand and to work together, encouraging our sense of common purpose. TEQs do not reduce emissions by increasing price - that is what ETS and Carbon Taxes do. TEQs control emissions directly by controlling the quantity of fossil fuels in the economy. It also makes measuring emissions easier - this can be easily calculated from the emissions equivalent of the annual TEQ amount".

The petition can be found on www.degrowth.nz and is also on the Parliamentary website[24].

Increased immigration and the possibility of climate refugees is controversial. With any net migration, TEQs would be diluted. However, this would be minor compared to the 8% annual decline in emissions needed to fulfil our commitment for 2030 if we start reductions today. However, it is vitally important that new entrants be assimilated into NZ into well-insulated solar houses and to connected communities with a full grasp of their citizenship obligations with respect to carbon footprints. The DANZ website contains blogs on a range of degrowth subjects, including the population issue[25].

Degrowth and TEQ's are evolving issues that require input from many sectors of society, particularly the currently marginalised ones. Faced with unprecedented challenges, humanity has no other choice but to engage with unconventional and novel ways of organizing itself if it wants to preserve any hope of a liveable world for the next century.

Written by Paul Bruce

[24] https://petitions.parliament.nz/15c9b925-a23e-4a38-879e-8f514ac0c147

[25] https://www.degrowth.nz/blog/population-the-touchy-topic-in-the-overshoot-discussion

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