IN THE MATTER	of the Resource Management Act 1991 (**RMA**)
AND	
IN THE MATTER	of the Freshwater Planning Instrument Parts of the Proposed Otago Regional Policy Statement 2021

STATEMENT OF EVIDENCE OF
Mr. Nathan Rajiv Surendran for Wise Response Inc

26 June 2023

Introduction and Expertise

1. My name is Nathan Rajiv Surendran.
2. I am a Professional Engineer, Chartered 2009 in Mechanical Building Services, with a special interest and expertise in energy systems and energy resource depletion
3. I have broad experience of energy analysis and modelling in the built environment, using dynamic systems models.
4. My primary focus in the last decade or so has been education regarding energy literacy via tertiary teaching, researching and incorporating a broad range of subjects at NCEA Level 5/6/7 for engineers and environmental managers, including perspectives from ecology, professional practice, various aspects of law and ethics, plus neoclassical, ecological and biophysical economic analysis.

Code of Conduct

5. I have read the Environment Court Code of Conduct for expert witnesses and agree to comply with it.
6. I confirm that the topics and opinions addressed in this statement are within my area of expertise except where I state that I have relied on the evidence of other persons. I have not omitted to consider materials or facts known to me that might alter or detract from the opinions I have expressed.

Scope of Evidence

7. I have been asked to cover the following issues
   - the current status of energy and resource supply/trends globally
   - the extent to which NZ is currently dependent on these and any risks implied
   - the relationship between these, emissions and the economy
   - any opportunities to buffer ourselves to any risks implied by the energy and resource situation that have relevance to landuse and freshwater
   - the urgency of any such buffering actions if they are to be effective

Industrial society relies on cheap plentiful oil supply for its continued function

8. With respect to energy flows supporting our global industrial society, oil supply, and specifically diesel, can be considered the master resource. Nothing that we count as GDP activity supporting material standards of living and the wellbeing that provides, happens without these energy inputs.

9. The scale of the energetic benefit that these energy flows give us is generally totally underappreciated. Consider these facts:

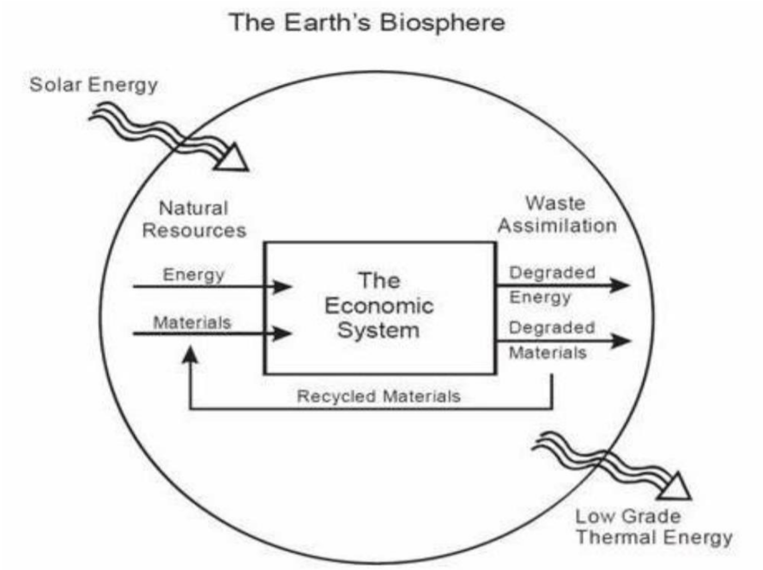
    - An average human working all day generates around 0.6kWh of useful energy output.
    - One barrel of oil contains about 1,700 kWh of fossilised and geologically processed solar energy.
    - Therefore, one barrel of oil, contains about 10.5 years of human labour.
    - After conversion losses, we actually get around 4.5 years of useful energy as work done.[1]
    - That barrel of oil currently costs around $100USD.
    - If we were to pay for that energy output as human labour, each barrel of oil would be worth 4.5y x $50,000 NZD = $225,000 NZD
    - We currently use around 100 million barrels of oil per day globally.
    - New Zealand currently uses around 130,000 barrels of oil per day.
    - That is, the oil energy used in NZ does for us: 4.5y/b x 130,000b = 585,000 years of human labour equivalent work **per day**.
    - As E.O. Wilson observed: “We have Paleolithic Emotions, Medieval Institutions, and God-Like Technology”

A ‘net energy lens’

10. There are a number of facts that combine to form a ‘net energy lens’ that we can use to aide strategic decision making around energy:

[1] Section 4 of this book outlines a biophysical energy perspective: https://bit.ly/RBREAD

11. The global economy is fundamentally an energy system, where energy inputs are transformed into goods and services.



12. Net energy (as defined by the school of thought referred to as biophysical economics[2]) is the energy output from an energy resource, minus the energy input needed to extract, process and distribute that resource. This concept and its implications are a fundamental omission from conventional (neoclassical or 'orthodox') economic analysis.
13. It is this net energy that is the surplus that drives all other economic activity outside of the energy sector[3].
14. If we include energy's contribution to economic output into our economic analyses, we see the much greater than generally accepted impact of energy disruptions on economic output. This is due to orthodox economics looking at energy's contribution to economic activity as related to its percentage of GDP expenditure, rather than taking a physical reality approach which understand that energy and material throughput ***is*** GDP[4]. A 10% drop in liquid fuel supply is close to a 10% drop in economic output, because diesel to a large extent is the industrial economy.
15. But the more impactful issue with energy systems as a whole appears to be that the surplus energy left, net of the energy it takes to sustain

---

[2] https://biophyseco.org/biophysical-economics/what-is-biophysical-economics/
[3] bit.ly/SEE_Summ
[4] https://bit.ly/3UcekFF and https://www.resilience.org/stories/2017-05-11/breaking-new-ground-economic-theory/

the current energy sector is declining rapidly, and particularly so for oil resources.

16. As we deplete the most easily accessible and highest quality energy resources (such as oil), we are left with lower quality and harder-to-extract energy resources that require more energy input to extract and process, (Figure 1) resulting in a decline in the net energy available to society[5]:

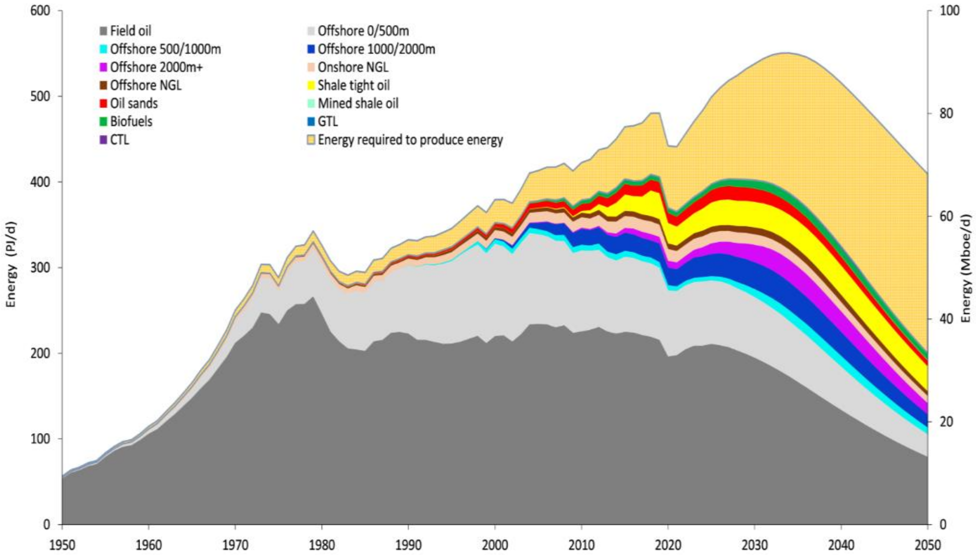


Figure 1: Low-carbon energy transition: A net-energy perspective

17. A decline in net energy means that there is less net energy available for economic growth, which inevitably leads to a squeeze on economic activity outside of the energy sector. A net energy decline is leading to increased competition for remaining energy resources, increased energy price volatility, and logistics, commodity and goods price inflation, plus a squeeze in discretionary spending. Charles Hall uses a 'Cheese Slicer' metaphor for the global economy to help illustrate this point which I have included the following 3 snapshots for (Figure 2).

18. Financial strategies that have worked in the past to obscure this issue are losing their power for a variety of reasons. *"The major issue is that money, by itself, cannot operate the economy, because we cannot eat money. Any model of the economy must include energy and other resources. In a finite world, these resources tend to deplete. Also,*

[5] https://www.sciencedirect.com/science/article/abs/pii/S0306261921011673?via%3Dihub

human population tends to grow. At some point, not enough goods and services are produced for the growing population."[6]

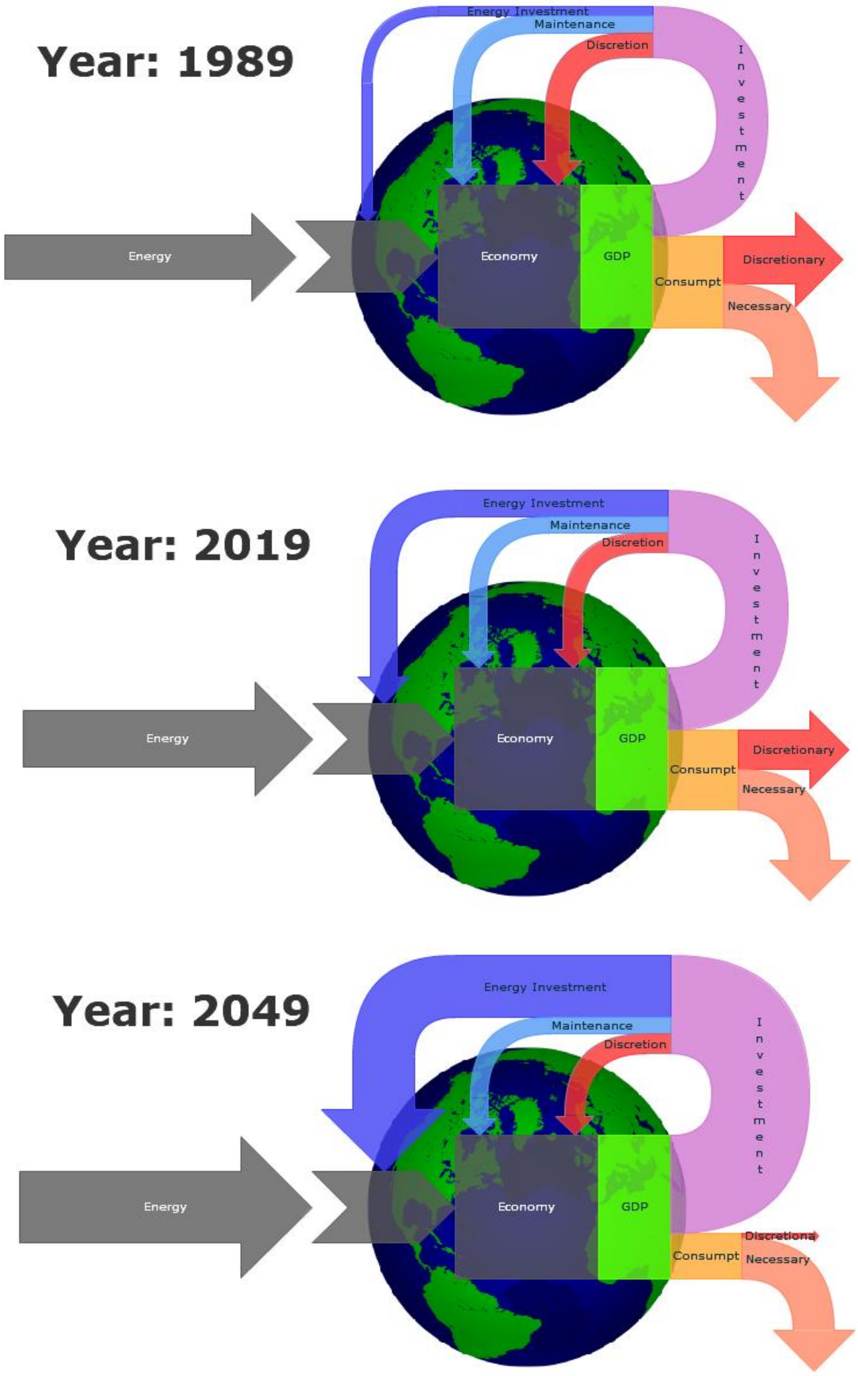


Figure 2: Changing proportions of energy available to service society

---

6 https://ourfiniteworld.com/2022/10/18/why-financial-approaches-wont-fix-the-worlds-economic-problems-this-time/

19. It is increasing clear from the data that we are at the point now where this is leading to what has been termed the 'age of energy disruptions'[7] (Figure 3).

20. Build out of renewable energy systems at a scale that would meet something like our current energy use, requires vast quantities of energy and materials[8], and both are limiting factors on global ambitions towards a renewable energy transition. We have to discuss the trade-offs[9] in terms of what we are going to do without, as gross liquid fuels supply will contract and not increase[10]. All of current energy production is spoken for in existing economic activity.

21. The proposed transition to lower EROI renewables makes the net energy available significantly worse[11]. Simplistically, the question becomes: "Do we make do with significantly reduced global movements of fuel and food so that we can move minerals and machines around to build out renewable energy infrastructure instead?"

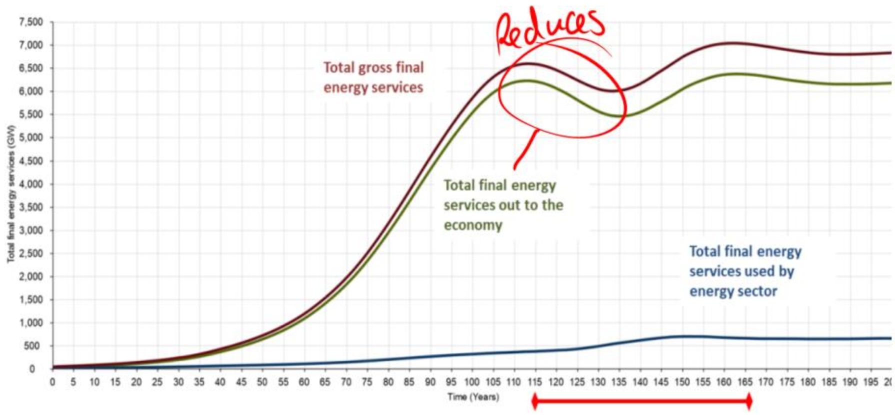


Figure 3: Total final energy services

Implications for New Zealand

22. Fuel supply decline and associated disruptions will drive military conflict over refined products that New Zealand isn't capable of directly

---

7 https://bit.ly/aedbiphec
8 https://bit.ly/enecma
9 https://bit.ly/3rlmv5S
10 Production from existing fields drops by 18 mb/d over this period, leaving a large gap in 2030 that needs to be filled by new sources of supply. https://www.iea.org/reports/world-energy-outlook-2022/outlook-for-liquid-fuels#abstract
11 https://doi.org/10.1016/j.ecolecon.2018.04.004

competing for. It is also creating a shift in geopolitical and economic power towards those countries that have more energy resources or better energy management strategies. We are at the end of some very long supply chains that are very vulnerable to disruption[12] particularly with the closure of Marsden Point refinery.

23. Historically, the growth of the global economy has been tightly coupled to increases in net energy, decoupling has proved a mythical beast[13] and should not be relied upon, and there are no substitutes that can provide the same level of energy return on energy investment as fossil fuels[14].

24. Worse still, and adding urgency to whatever we can accomplish in the near term, intuitively there is a point somewhere in the future, where net energy decline means oil supply will be an energetic zero-sum game[15], and therefore the oil supply and refining system performance decline will lead to a financial collapse[16], probably before the energetic cutoff point described in this diagram:

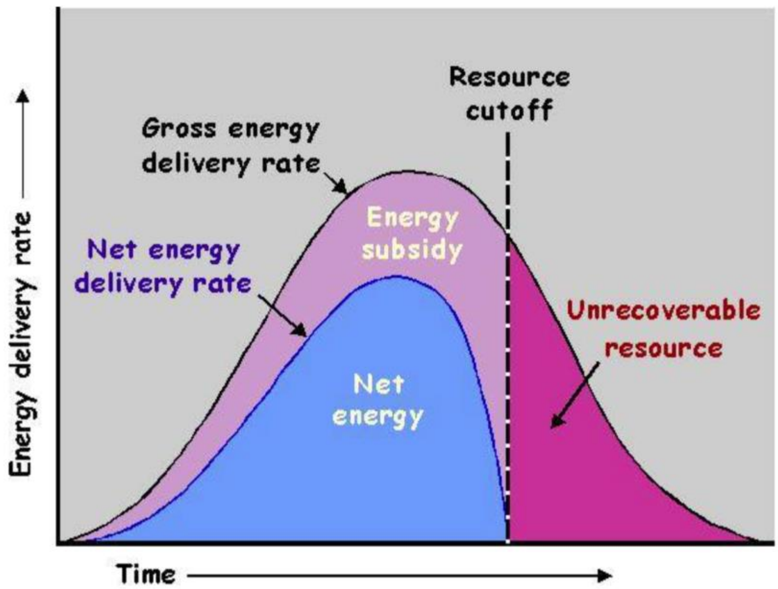


Figure 4: Comparing gross energy with net energy

12 https://bit.ly/3K4k6DY
13 https://bit.ly/3UojG0r
14 http://stanford.io/1yifujq
15 bit.ly/oilocenedfk
16 bit.ly/trdoff

25. Addressing net energy decline requires a fundamental shift in the way we think about and manage our economy, including drastic reduction in total energy consumption, as we have not been able to develop alternative energy sources that can provide a similar level of energy return on investment as fossil fuels.

Economic implications

26. Using a net energy lens, it is clear that we are rapidly running out of time before a decline-induced crisis, probably in our financial system, narrows our available options to a much smaller set of realistic possibilities.

27. Tim Garrett's research[17] has shown that there is a direct link between energy consumption and economic activity.

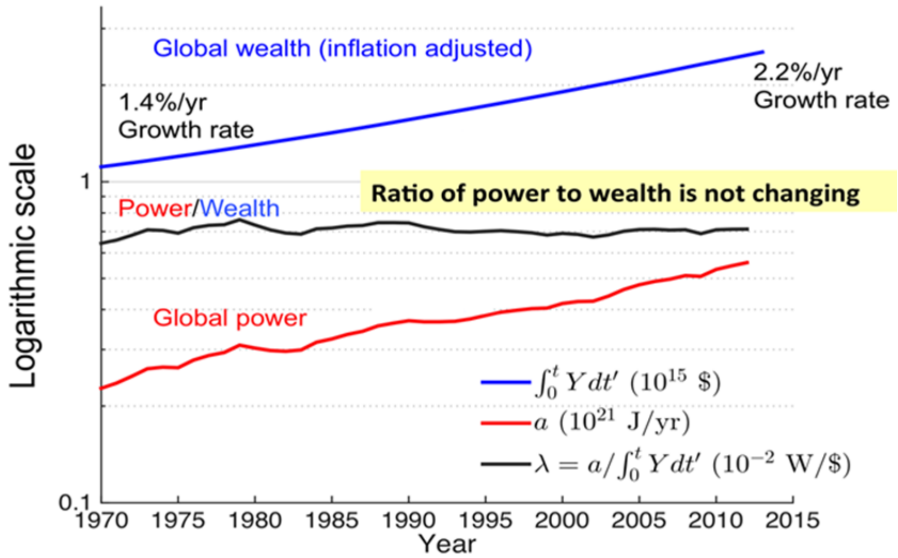


Figure 5: Garrett's constant: showing the relationship between physics and economics/power and wealth

28. *"In the case of the constant of proportionality that relates civilization's economic wealth to its rate of energy consumption, it tells us not just where we are today, but it dramatically simplifies and constrains long-term estimates of where the global economy is headed. The constant ties economics to physics, so with physics, more robust economic forecasts become possible.*

17 https://www.inscc.utah.edu/~tgarrett/economics.html

29. *"The most easily appreciated implication of the constant value is that sustaining the GDP will require that we constantly grow global power production capacity; or, sustaining long-run global GDP growth will require constantly accelerating growth of global power capacity, i.e., that the rate of increase must itself increase.*

30. *"The question of growing wealth shifts from the traditional approach of looking to economic policy to one that is largely a matter of assessing the geological availability of fossil reserves: will we uncover new reserves faster than we deplete them or switch to renewables? If we can't, what then? And if we can, what does growing fossil fuel consumption imply for our climate?*[17]*"*

31. In other words, our economy requires energy to function, and as the net energy available declines, so too will our economic output.

32. The fact of an over-leveraged, fiat money based, economic and financial system that is showing signs of increasing embrittlement as the headwinds of climate impacts, geopolitics and logistics challenges, (alongside the net energy decline I am highlighting), continue to bear down, and cannot be ignored.

33. Were the above analysis to prove incorrect, and the energy and material resources required somehow magically appear, it should be clear that they wouldn't be there then to support another generation of renewables on a similar global scale again in 20-40 years when this generation's machines reach the end of their life. In this context, intergenerational equity considerations demand that we give our children the 'optionality' by not consuming all available resources at this point.

Conclusions

34. This assessment means that we will not be able to continue to rely on economic growth and consumption-based lifestyles, nor, in fact, the continuation of industrial society in anything like its current form in the medium term (5-25 years). We must grapple urgently with how to adapt to live within the declining net energy of our energy system.

35. This will require adopting far less energy intense systems (ie plan for an energy budget of perhaps 20% of current rate of throughput by 2050),

conserving resources (as we won't have the energy supply to continue and expand industrial extraction at the scale we've seen), and a radical simplification of our economic arrangements needs to be planned for if we are to avoid a calamity.

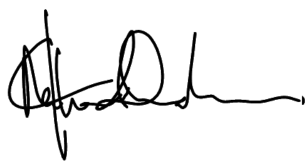
36. Common objections to this line of reasoning, such as technology will save us (a faith not reason-based appeal), or we can decouple resource and energy demand from growth are factually flawed, and must not be considered seriously in this context.

37. It is essentially a binary choice: retaining weak and poorly directed policy, and awaiting the inevitable, uncontrolled collapse in national GDP, living standards, public health and so forth. Or, adopting clear-sighted responses now, to drive the necessary change before it is too late.

38. The graphs I presented at the first hearing and oral submission, incorporated above, make it clear that time is now of the essence both from the environmental perspective and the biophysical energy and resource perspective.

39. To address these issues, activity must be framed within these energy and atmospheric limits. Because a high proportion of our emissions are due to the burning of fossil fuels, cutting them back and moving toward renewable energy will simultaneously reduce our vulnerability to the Net Energy trend.

Dated this 27th day of June, 2023



____

Nathan Rajiv Surendran