

Waikato Affordable Energy Webinar Series

June-November 2026



**Wellbeing
Waikato**
TOIORA O WAIKATO

Research.
Knowledge.
Storytelling.

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Wellbeing Waikato



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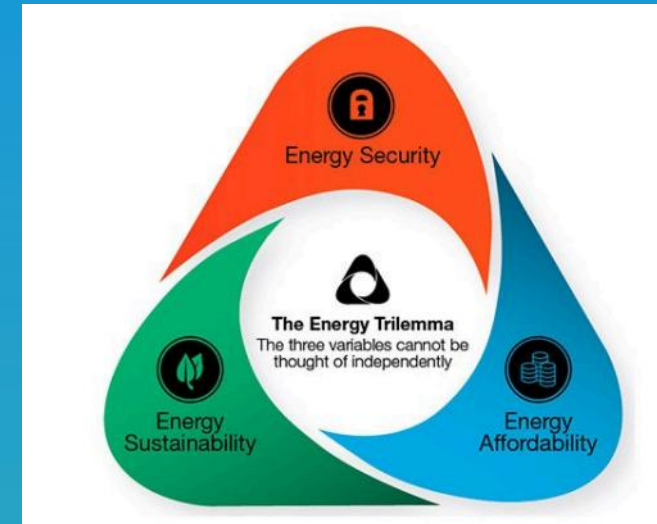
Independent Charitable Trust focused on:

- Regional intelligence about what's most important to households and whanau
- Identifying emerging opportunities and risks early
- Surfacing underlying drivers, not just symptoms
- Convening government, iwi, councils, community organisations and the private sector around decision-useful insights.



Energy systems need to be:

- Affordable
- Reliable
- Sustainable



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4 Big Questions

1. How does the electricity system actually work—and why is it designed this way?
2. What drives power prices, and how could they be made more affordable?
3. How does energy affordability affect household and community wellbeing?
4. What would a better system look like—and how do we get there?



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10 June



24 June



8 July



15 July



22 July



5 August



19 August



26 August



2 September



16 September



23 September



30 September



Energy in NZ - A Biophysical Lens



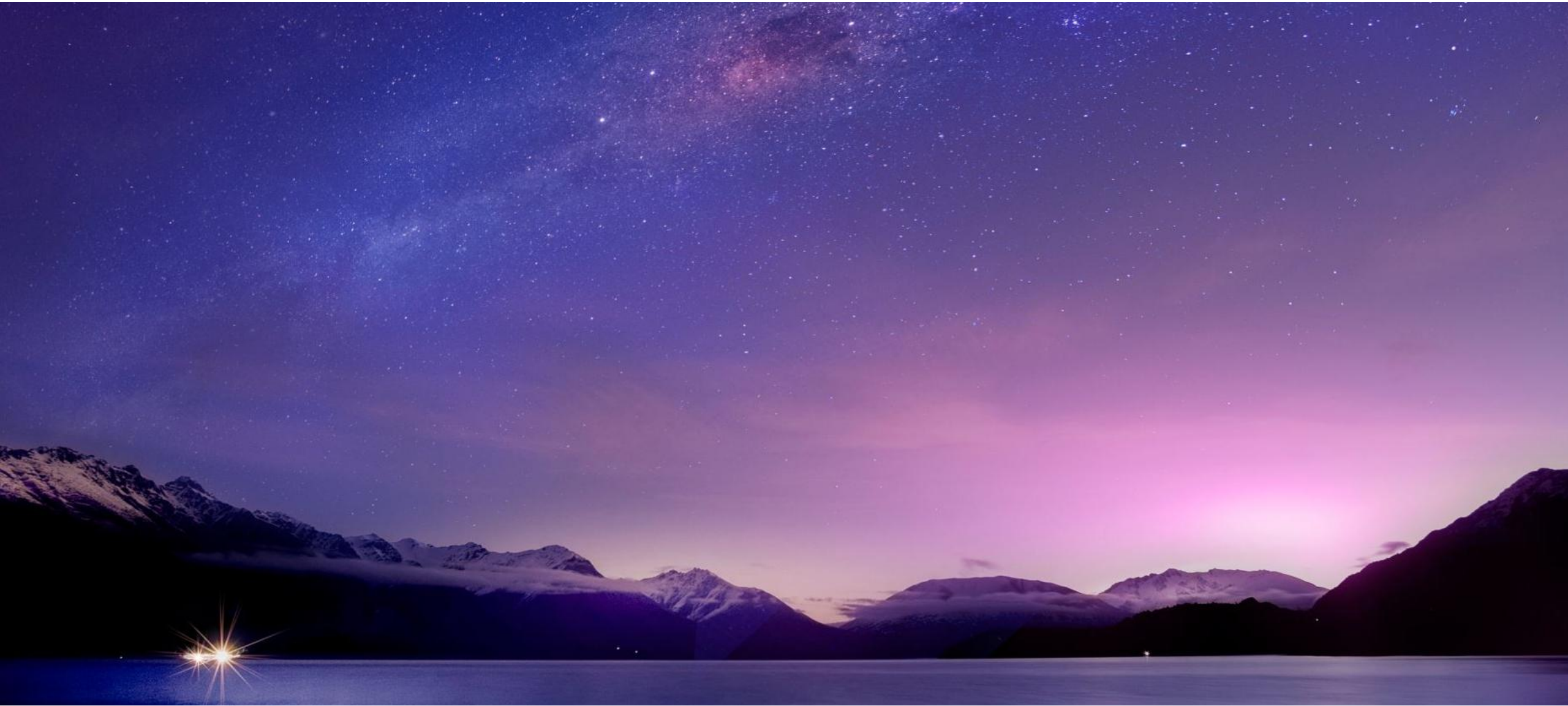
Larry Blair

Energy Consultant and Literacy Advocate



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ENERGY IN NZ - A BIOPHYSICAL LENS

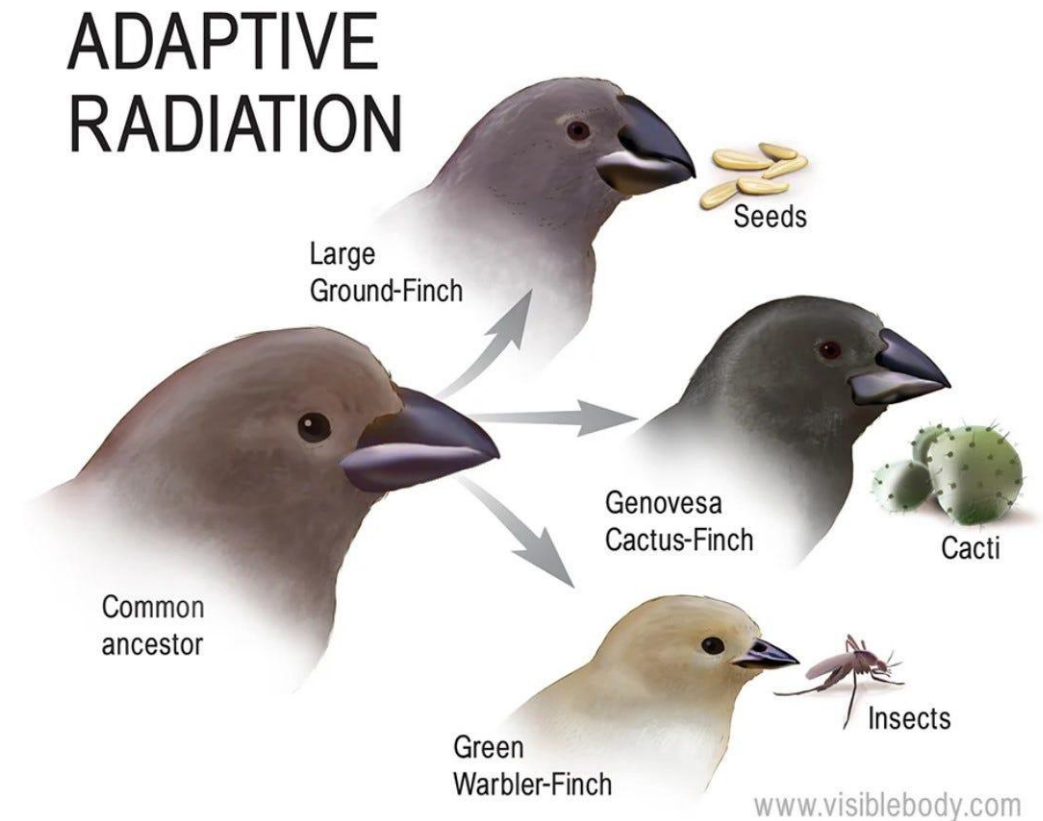


The world we live in is not the result of some
conscious design.

Humanity is instead being carried along by the
innate forces of biology and physics.

THE BIOLOGY OF LIFE

- Biology forms the foundation of all relationships to energy.
- The biological objective of any species is to project its genome forward in time.
- Evolutionary strategies select for fitness.
- Fitness in the context of evolution is defined as maximum energy throughput (power), otherwise known as the “**Maximum Power Principle**”.
- Biological systems self organise to optimise an energy gradient (niche).
- Evolution is in essence oriented towards energy.



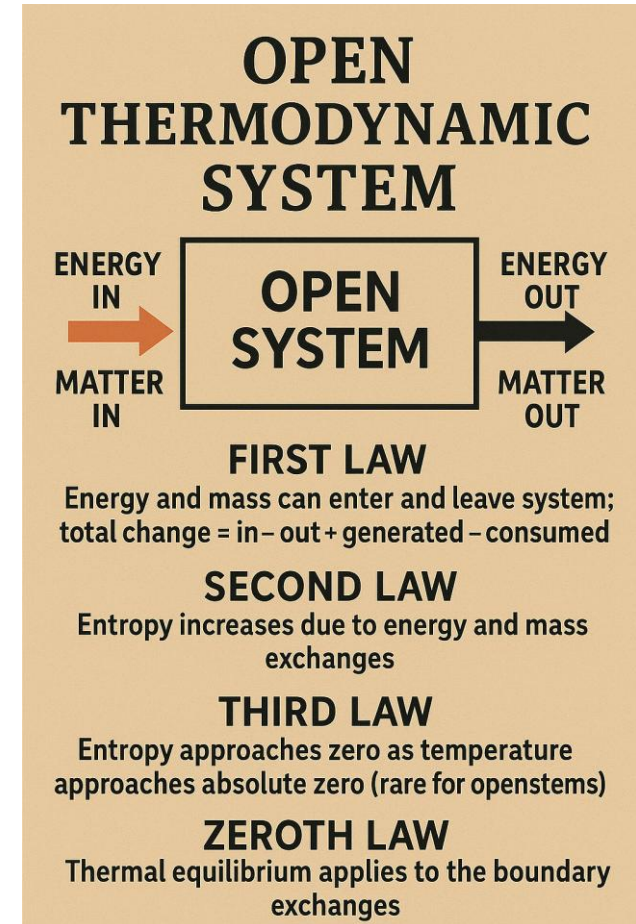
“The maximum accumulation of energy allows maximum reproductive output which is, after all, what natural selection is based on.” - Charles Hall

Humanity functions in the same way although in the modern context we call our niches “markets”.

We self organise to identify a niche (new market) and maximise the energy (flows of money) within the niche to out complete others also trying to capture the niche.

THE PHYSICS OF LIFE

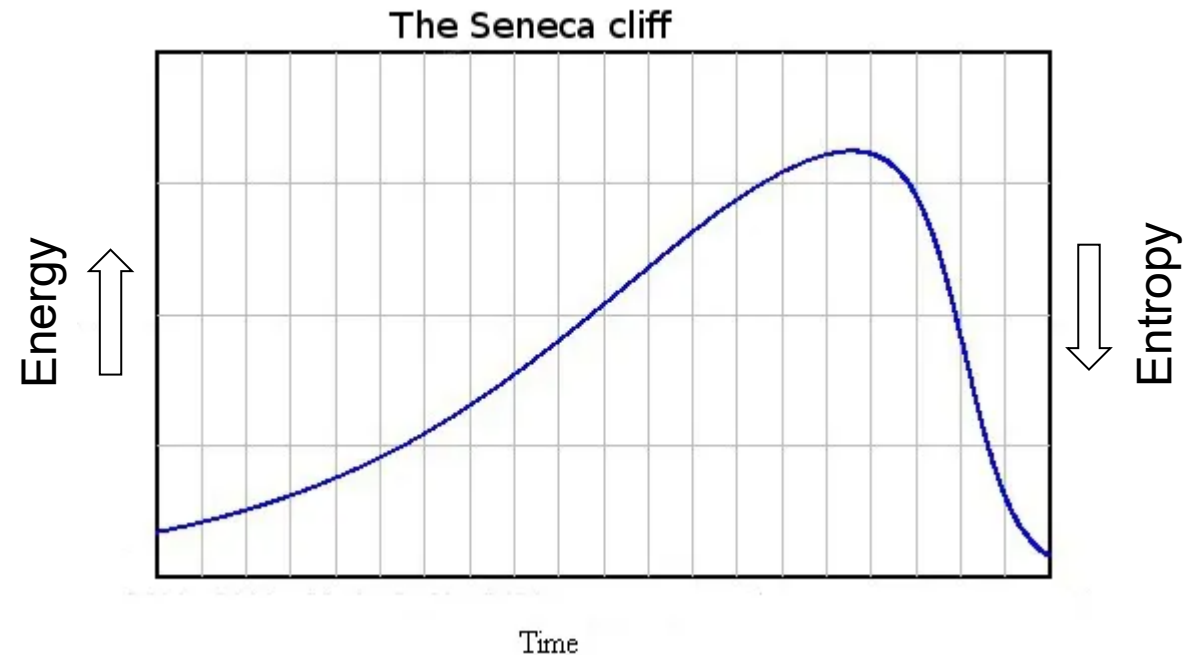
- Thermodynamics describes energy, heat, and work, and how they interact in physical and biological systems.
- It explains how energy moves and changes form, governing everything from engines, air conditioning units, to stars, and biological processes.
- We all understand that if we get something out of the freezer it defrosts, or if we kick a ball it will eventually stop, or that as time goes on things need more maintenance. Observations that are all a function of thermodynamics.
- We deplete the available energy gradients in accordance with the laws of thermodynamics.
- We take low entropy energy, apply it to matter to produce a product and high entropy waste.



Remember from high school that energy cannot be destroyed it can only be transformed? That's what we are talking about here.

THE INTEGRATION OF BIOLOGY AND PHYSICS

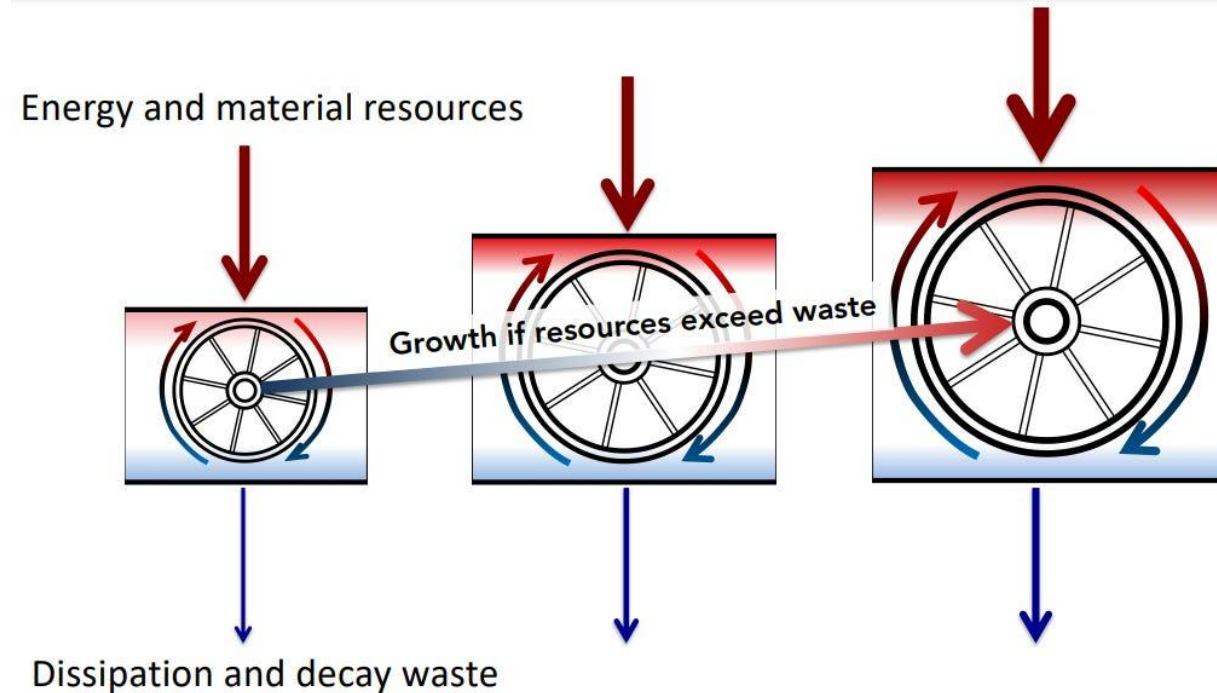
- We have a biological imperative to grow.
- Growth requires the processing of increasing amounts of energy and matter to produce both surplus and waste.
- As we grow entropy (disorder) accumulates in the system.
- As entropy accumulates more energy is required to maintain the surplus necessary to grow.
- When there is insufficient energy to both **maintain** and to **grow** entropy becomes the dominant factor in the system leading to a loss of complexity.



“Fortune is of sluggish growth, but ruin is rapid” – Lucius Anneaus Seneca 4BC – 65AD

LOTKA'S WHEEL

- As a system grows it takes increasingly more energy and materials to maintain.
- Lotka represented this as the wheel getting bigger and spinning faster. This increases the entropy of the system (how fast the energy dissipates). Therefore, growth is only possible if the positive rate of change of energy and materials entering the system, exceeds the positive rate of change of energy and materials required to maintain the system.
- As soon as the energy flows become negative the system collapses (the wheel stops spinning).



Alfred Lotka - 1922

ENERGY CONTEXTUALISED

What is energy?

Energy is the capacity to perform work.

Why does it matter?

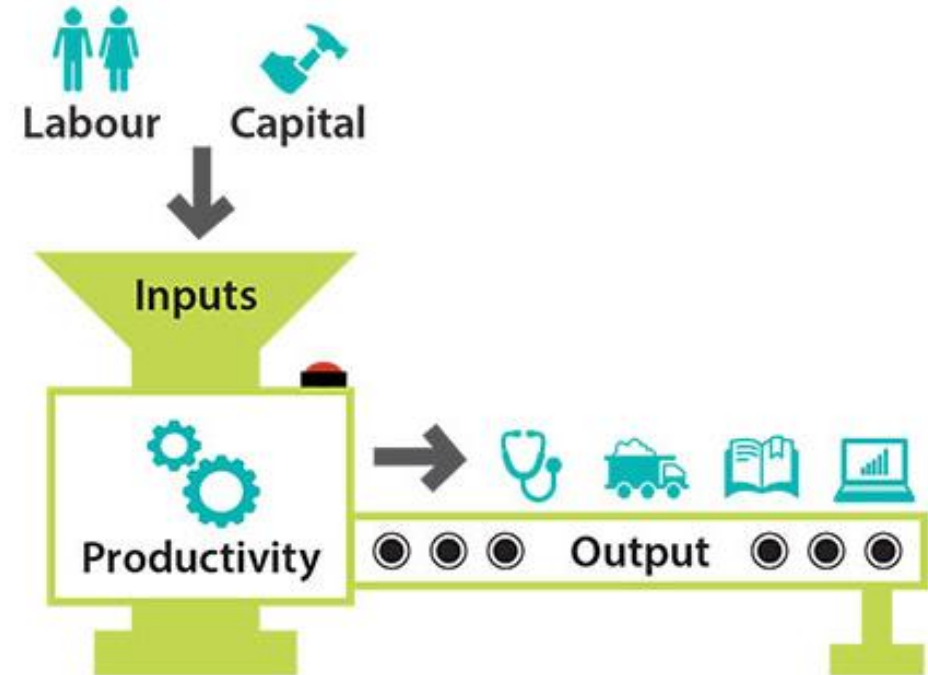
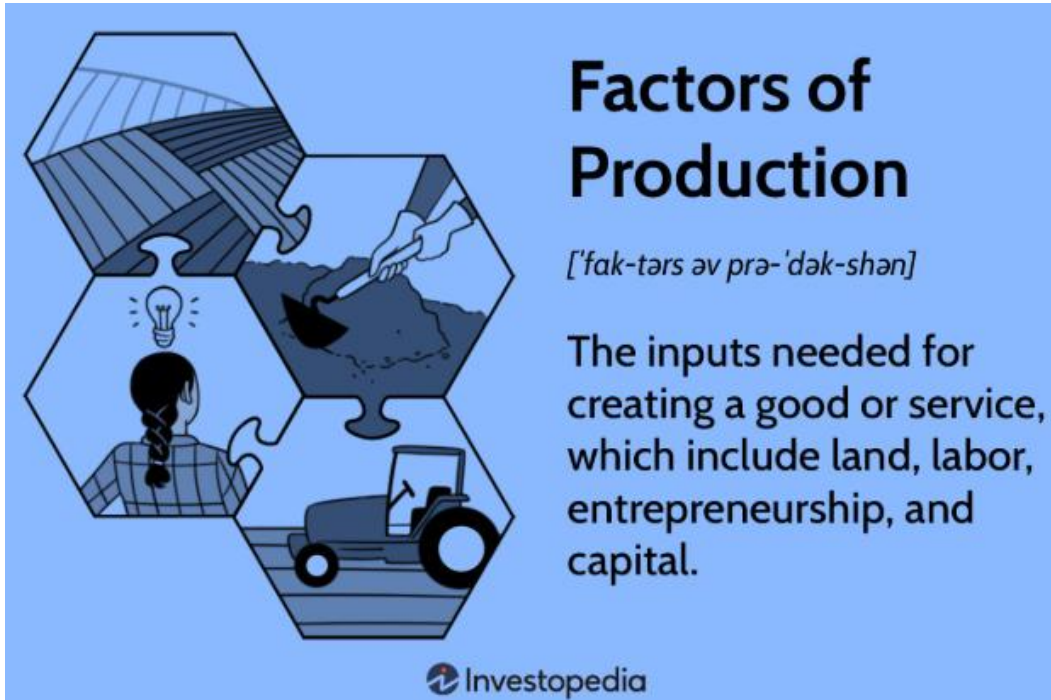
Energy allows humans to create and maintain highly ordered states that would otherwise be impossible.
“Energy enables us to create states of improbability in the natural environment – John Constable”

What is the purpose of an energy system?

To provide a **NET SURPLUS** of useful energy that supports the complexity of modern civilisation.

Everything we value - food, shelter, healthcare, education, technology, and economic prosperity is ultimately a claim on net energy surplus.

NEO-CLASSICAL ECONOMICS



$$Y(t) = A(t) \times L(t)^{1-\alpha} \times K(t)^{\alpha}$$

THE ECONOMY WITH A BIOPHYSICAL LENS

Production = Energy applied to matter.

In this context money is a claim on energy.

Debt is a claim on future energy (future production)

COBB DOUGLAS – CORRECTED FOR ENERGY

$$Y = (L \times E_L \times e_L) \times (K \times E_K \times e_K)$$

Diagram illustrating the Cobb-Douglas equation corrected for energy, with arrows pointing from the variables to their definitions:

- Y : Production (GDP)
- L : Labor
- E_L : Energy applied to labor
- e_L : Efficiency of energy conversion
- K : Capital
- E_K : Energy applied to capital
- e_K : Efficiency of energy conversion

“Wealth is proportional to the rate of energy consumption, and the global economy behaves as a heat engine that converts energy into work and waste heat.”

“The growth of civilization is a thermodynamic process, consuming energy and dissipating waste heat; economic production is inseparable from energy consumption.”

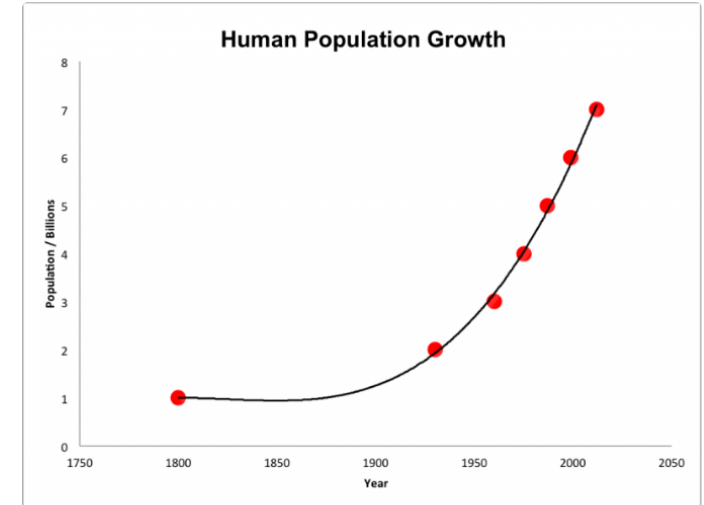
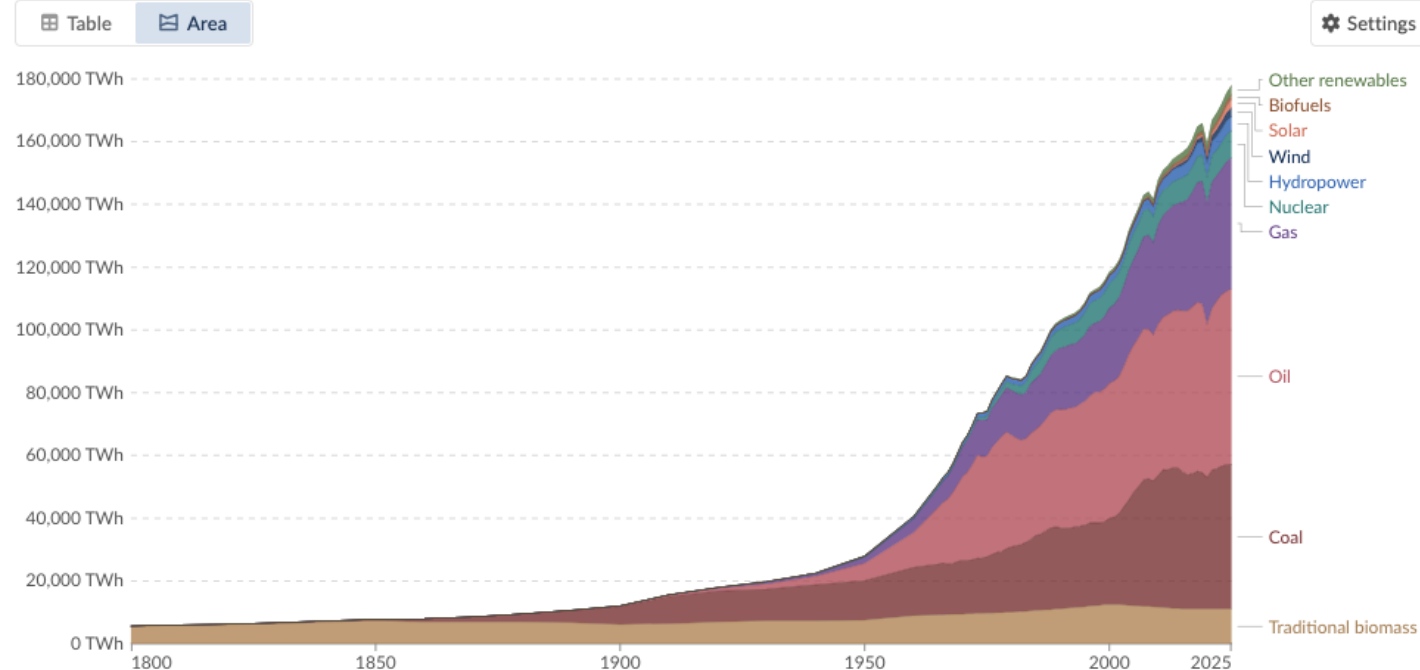
Dr Tim Garrett – Atmospheric Physicist Utah State University

ENERGY VS GROWTH

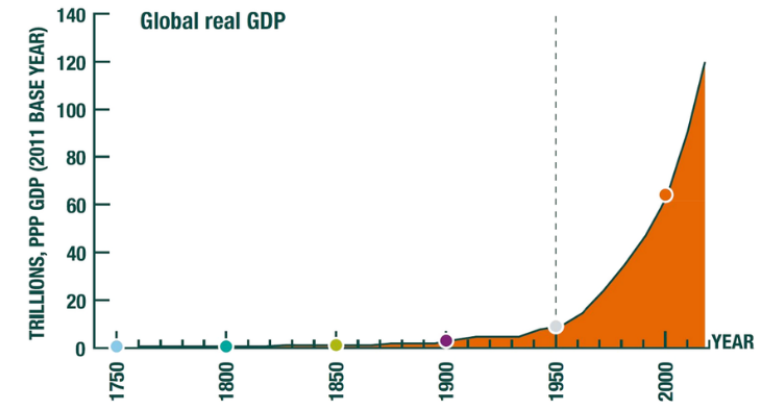
- There has never been a transition, only addition.
- Global population and GDP have an almost 1:1 correlation, but lagging, the discovery and subsequent depletion of an energy gradient.
- First comes the energy then comes the growth.

Global primary energy use by source

Measured in terawatt-hours of total energy supply.



Human population growth from 1800 to 2000, via Wikimedia Commons.



Global Real GDP since 1750 CE. Source: Our World in Data based on World Bank and Maddison Project Database, version 2018. Bolt et al. (2018), "Rebasing 'Maddison': new income comparisons and the shape of long-run economic development", Maddison Project Working paper 10

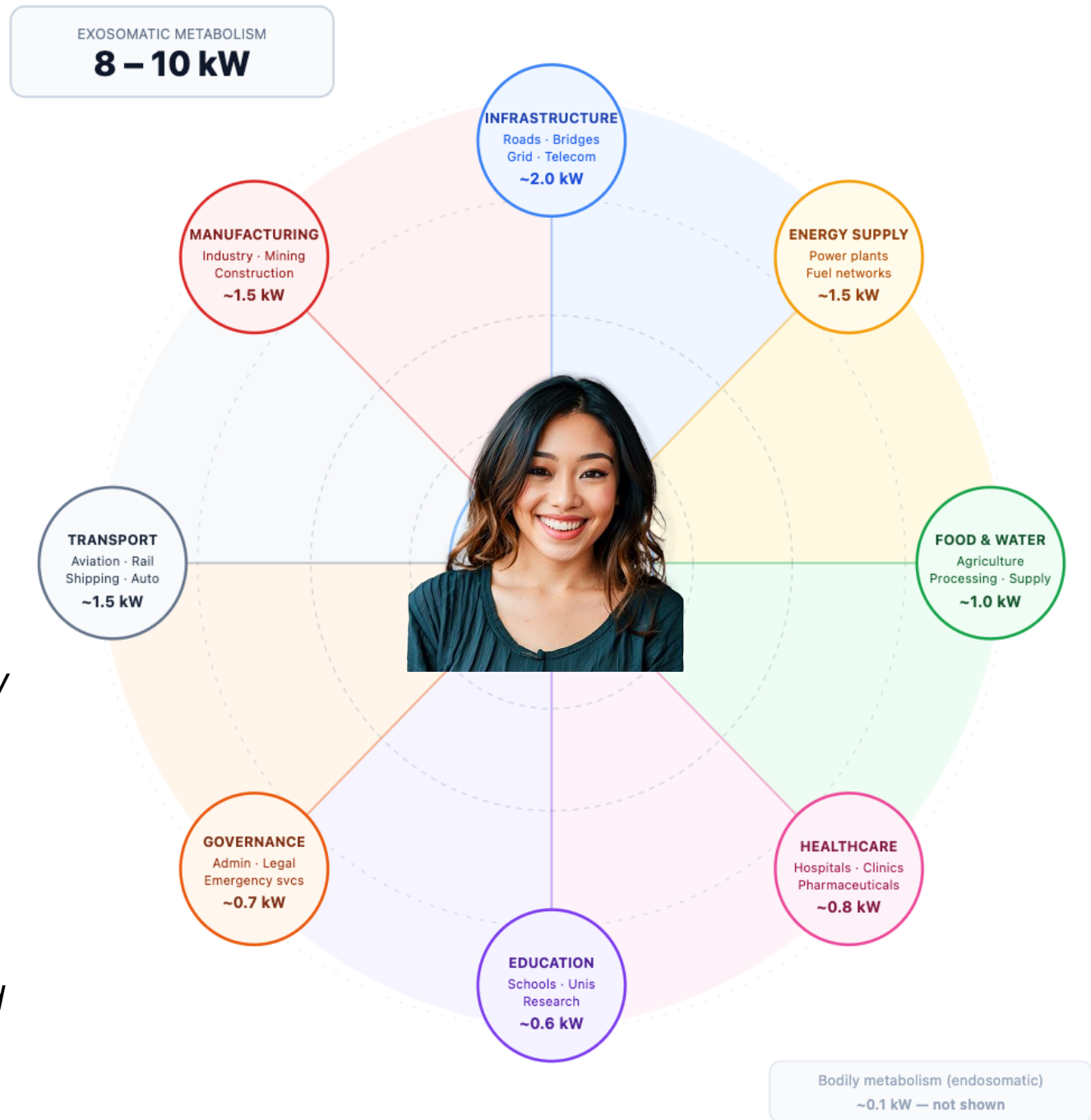
OUR INDIVIDUAL ENERGY METABOLISM

A moderately active person has an endogenous (internal) energy metabolism of 150-250W

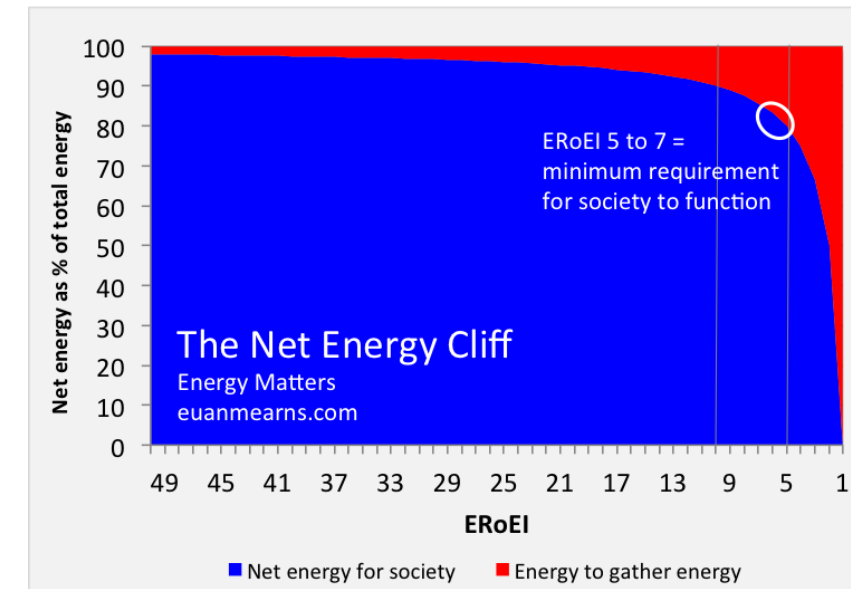
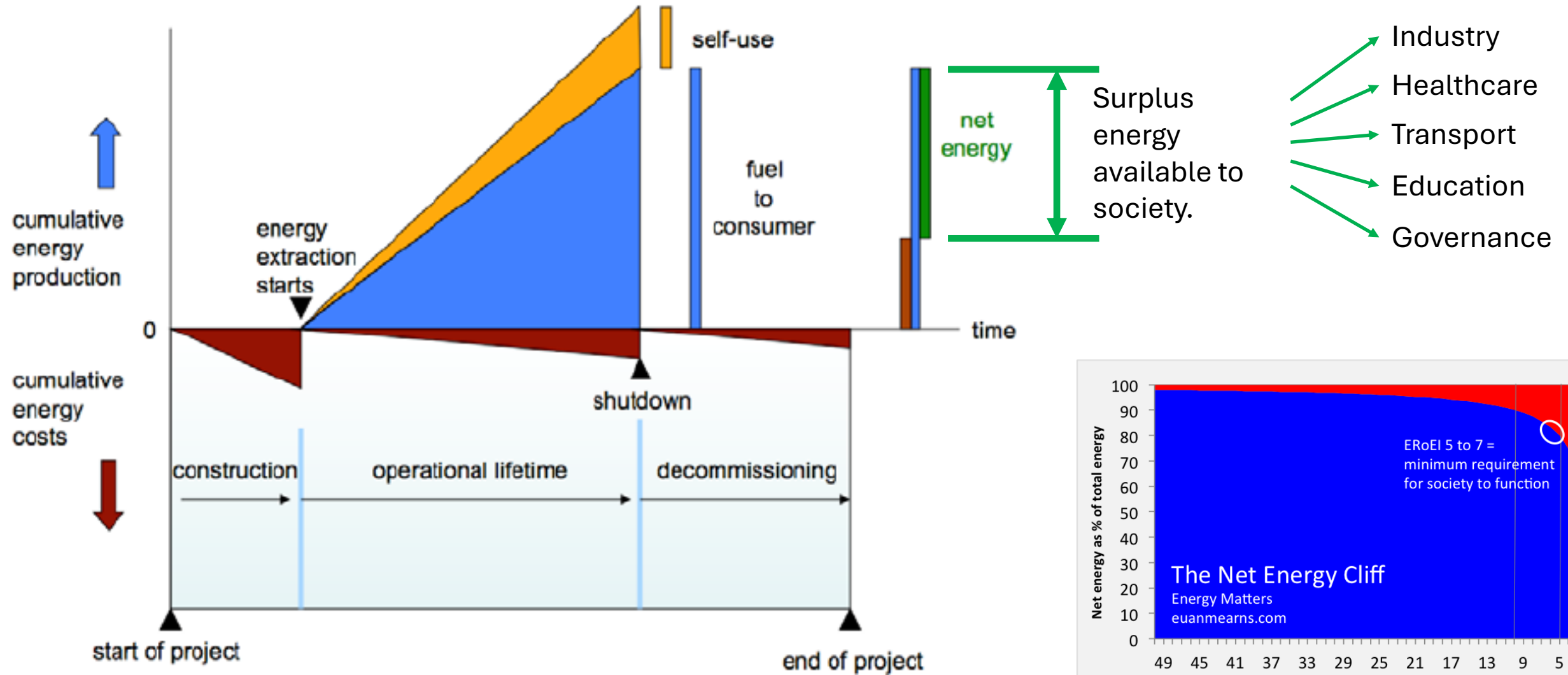
Our exogenous (external) energy metabolism is 8-10kW

This is ~40 times what our bodies need to function.

Our exogenous metabolism is the energy required to maintain societal complexity and our modern standard of living.



NET ENERGY SURPLUS – WHAT SOCIETY RUNS ON



EROI & SOCIETY

The second law of thermodynamics dictates that society needs both the energy to maintain and the energy to grow. This necessitates increasing the amount of surplus energy available. Surplus energy funds the complexity, services, and quality of life that define advanced societies. If too much of society's effort goes into just getting more energy, there's not enough left over for everything else leading to social, economic, and technological contraction.

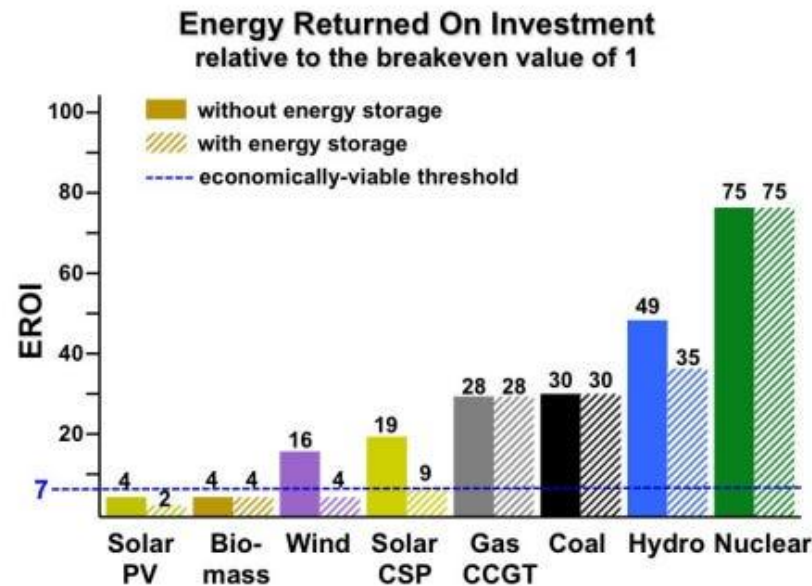
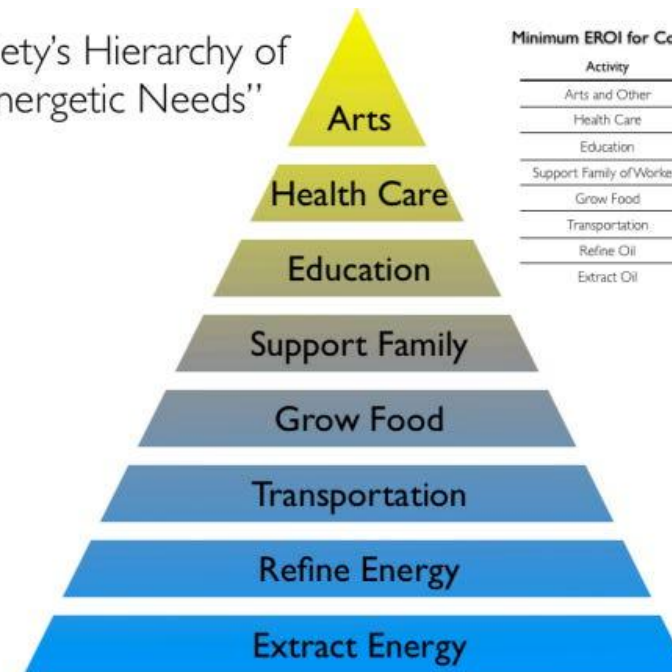


Figure 6: EROI ratios for different energy sources. (Source: Conca, J., 2015. EROI - A Tool to Predict the Best Energy Mix. <URL=<http://www.forbes.com/sites/jamesconca/2015/02/11/eroi-a-tool-to-predict-the-best-energy-mix/>>)

Society's Hierarchy of "Energetic Needs"



Minimum EROI for Conventional Sweet Crude Oil

Activity	Minimum EROI Required
Arts and Other	14 : 1
Health Care	12 : 1
Education	9 or 10 : 1
Support Family of Workers	7 or 8 : 1
Grow Food	5 : 1
Transportation	3 : 1
Refine Oil	1.2 : 1
Extract Oil	1.1 : 1

Figure 5: "Pyramid of Energetic Needs" representing the minimum EROI required for conventional oil, at the well-head, to be able to perform various energetic task required for civilization. The blue values are published values; the yellow values are increasingly speculative (figure adapted from Lambert and Lambert, in preparation [3]).

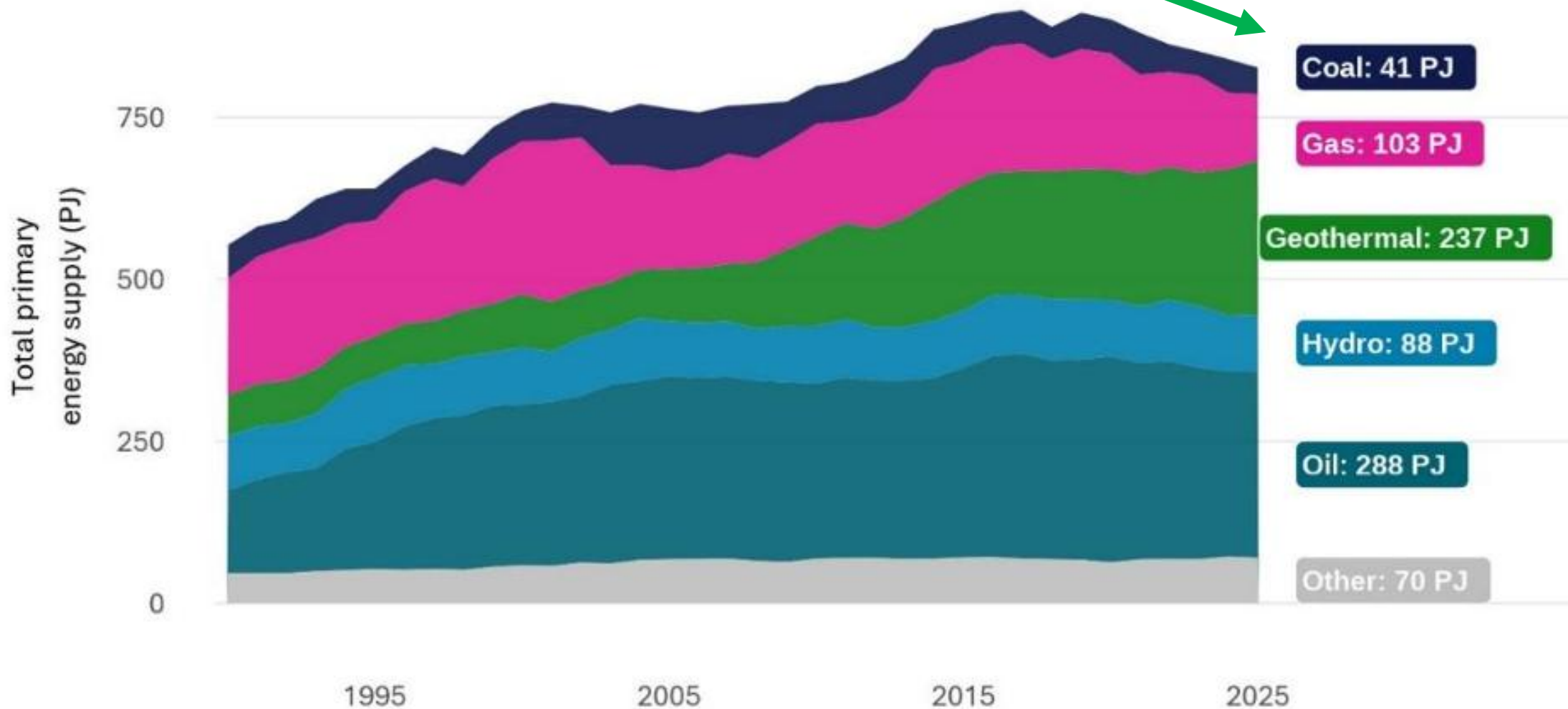
NEW ZEALAND IN 2026

WHERE DO WE STAND?

WHERE ARE WE HEADING?

TOTAL PRIMARY ENERGY – 2025 YEAR END

The energy available to the economy is falling



Lost in transition: The businesses trapped by New Zealand's energy crisis

9:23 am on 11 December 2025

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 **Kirsty Johnston**, Investigative journalist
kirstyjohnston@rnz.co.nz



Heinz Wattie's proposes closure of three manufacturing facilities, impacting 350 jobs

5:03 pm on 11 March 2026

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What went wrong in the New Zealand electricity market and why it will get worse before it gets better



By **Thomas Coughlan**

Political Editor · NZ Herald · 2 Oct, 2024 05:00 AM · 11 mins to read

LOSING COMPLEXITY

Report tips Methanex will close NZ operation next year, gas production plummets

 **Tom Pullar-Strecker** | The Post

March 12, 2026

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BUSINESS

Kapuni fertiliser plant may temporarily shut due to gas supply concerns

9:14 pm on 7 August 2025

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Susan Edmunds, Money Correspondent
susan.edmunds@rnz.co.nz

BUSINESS

McCain to close Hastings vegetable processing plant by January 2027

4:17 pm on 24 March 2026

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New Energy Minister Simon Watts warned of risk of outages, business closures in challenging sector



By **Jamie Ensor**

Political reporter · NZ Herald · 17 Mar, 2025 04:24 PM · 7 mins to read

NEW ZEALAND / BUSINESS

Hundreds of jobs lost as Winstone shuts mills

5:14 pm on 10 September 2024

Share this

Watts warned about deindustrialisation due to gas supply dwindling



LIQUID FUELS



PER CAPITA OIL USE

*In 2024 New Zealand consumed approx. 7.4 million tonnes of oil products.
This loosely translates to around 55 million barrels of oil.*

- LPG 60 litres
- Petrol 548 litres
- Diesel 730 litres
- Fuel oil 32 litres
- Aviation fuel 348 litres
- Other oil products 64 litres



In total the average New Zealander consumes 1780 litres of oil derived products, or a bit over 10 barrels of oil annually – the equivalent to 45 years of manual labour.

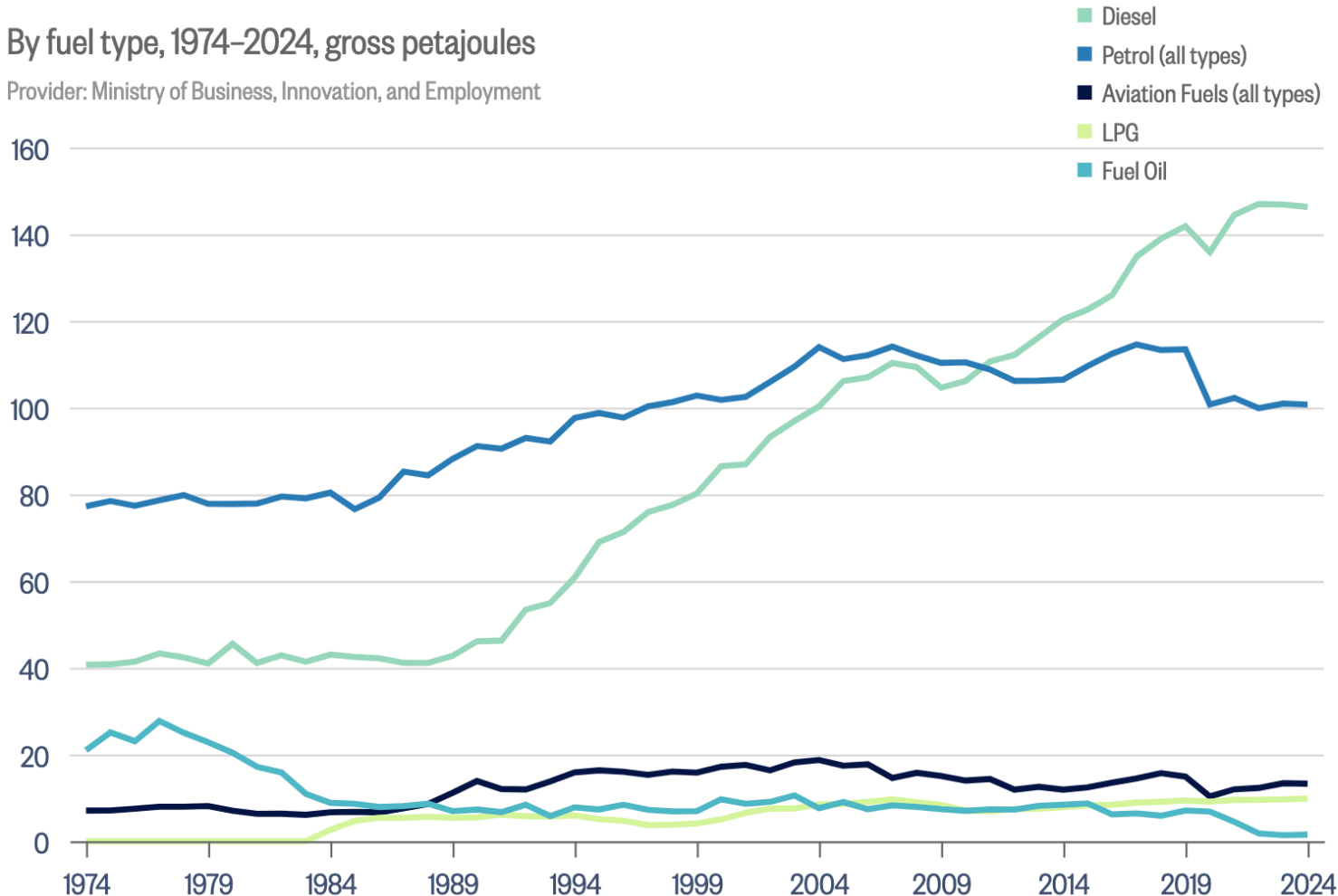
LIQUID FUEL USE

Consumption of oil in New Zealand

By fuel type, 1974–2024, gross petajoules

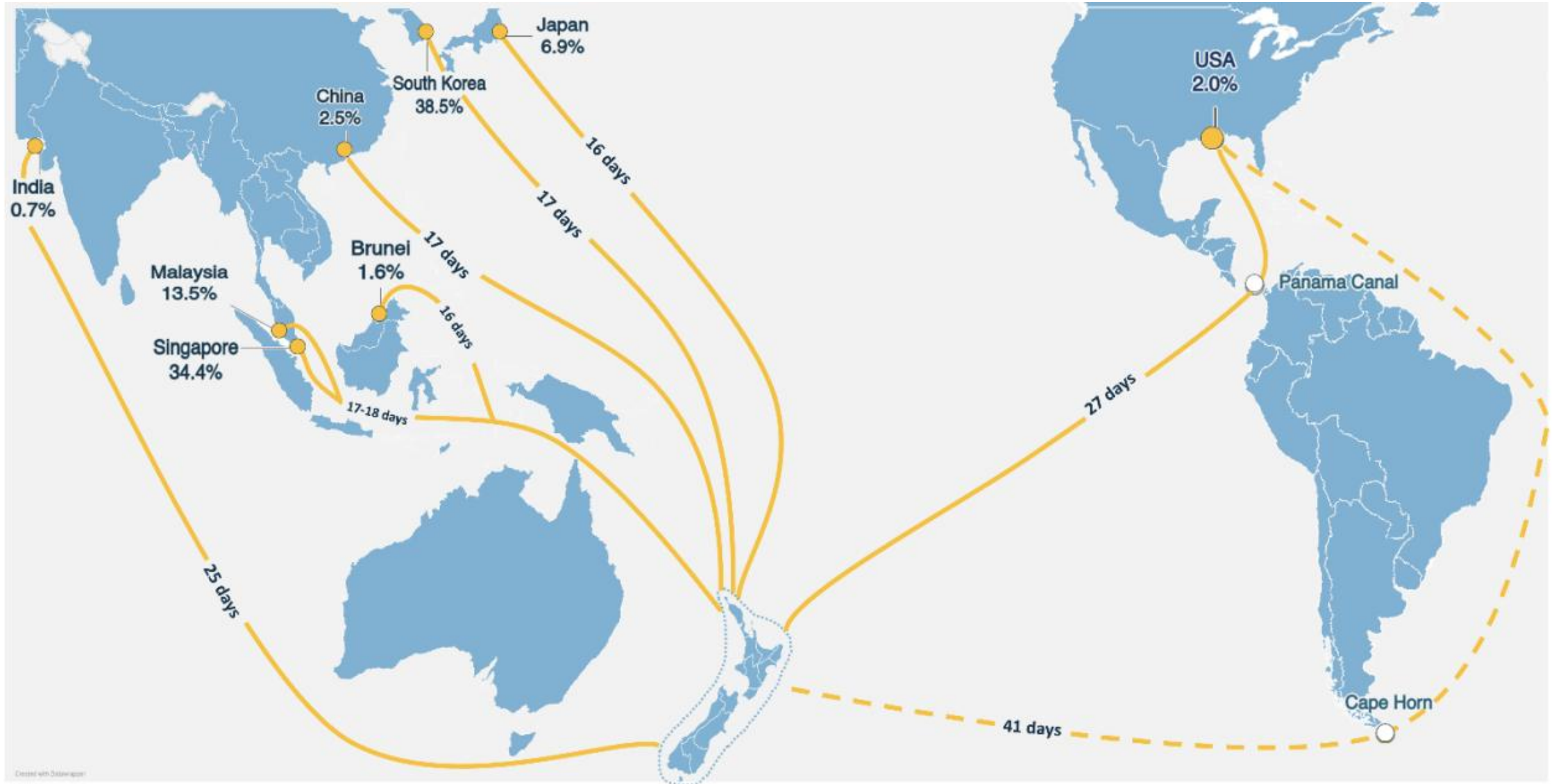
Provider: Ministry of Business, Innovation, and Employment

figure.nz

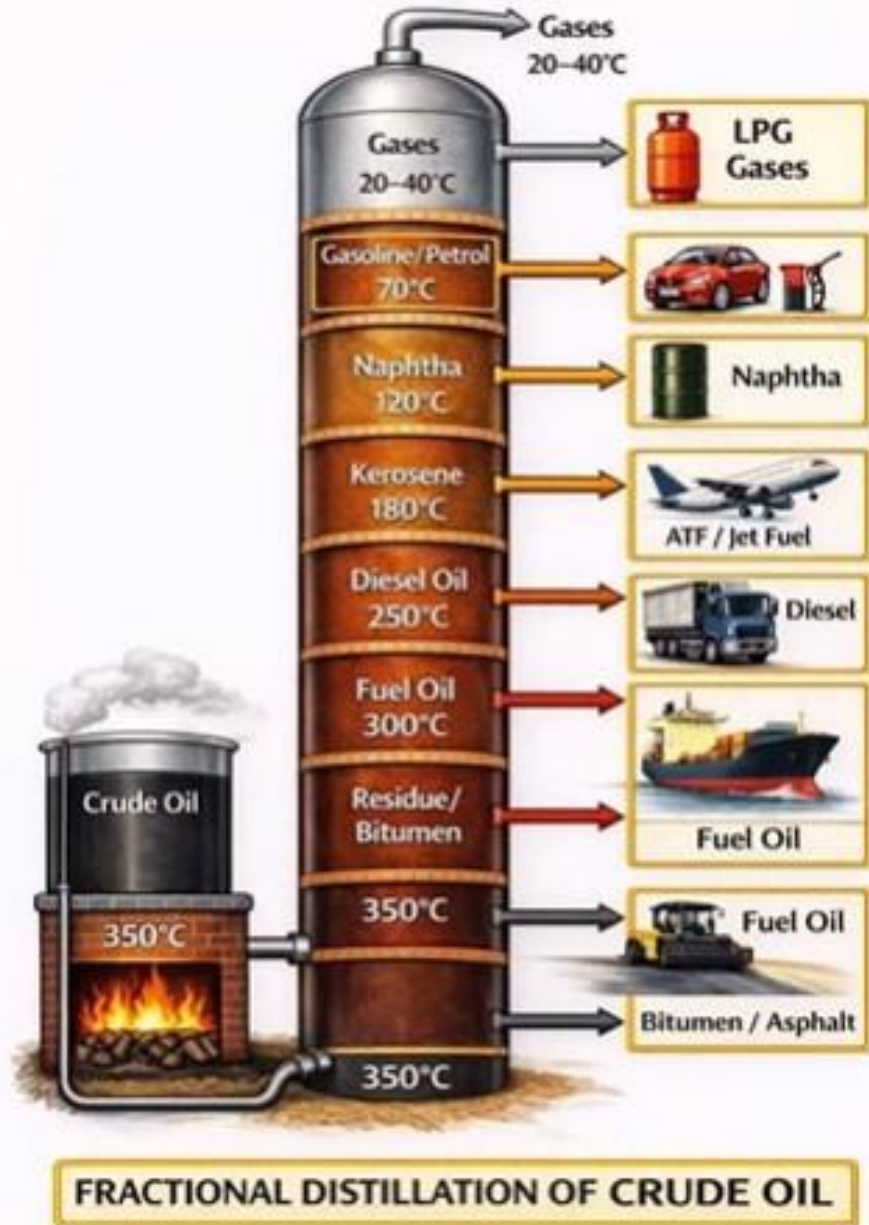


- All fuels are 100% imported. Primarily from Asia.
- Diesel fuels New Zealand's economy.
- Demand has flattened over the past few years which is indicative of the absence of economic growth in real terms.

LIQUID FUEL SUPPLY CHAIN



OIL & GAS TECHNICAL TRAINING



DISTILLATION

Crude oil is not a single substance. It is a complex mixture of:

- light gases
- gasoline-range hydrocarbons
- diesel-range molecules
- heavy oils
- waxes
- asphaltic compounds
- The refinery separates these into “fractions”.

Different hydrocarbons boil at different temperatures.

Smaller molecules:

- boil first
- are lighter
- more volatile

Larger molecules:

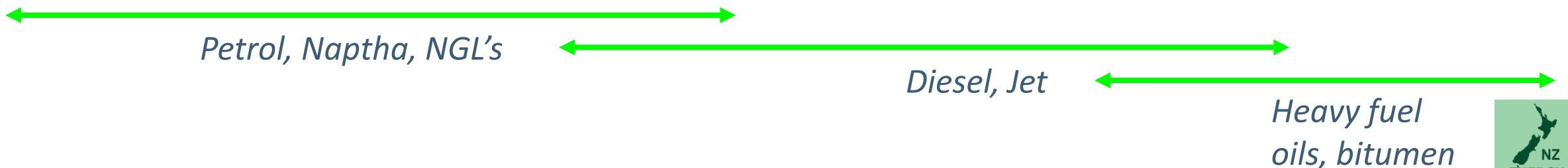
- boil at higher temperatures
- are heavier
- more viscous

NOT ALL OIL IS CREATED EQUAL

API gravity and sulphur content determine what a barrel of crude is worth and what it can produce

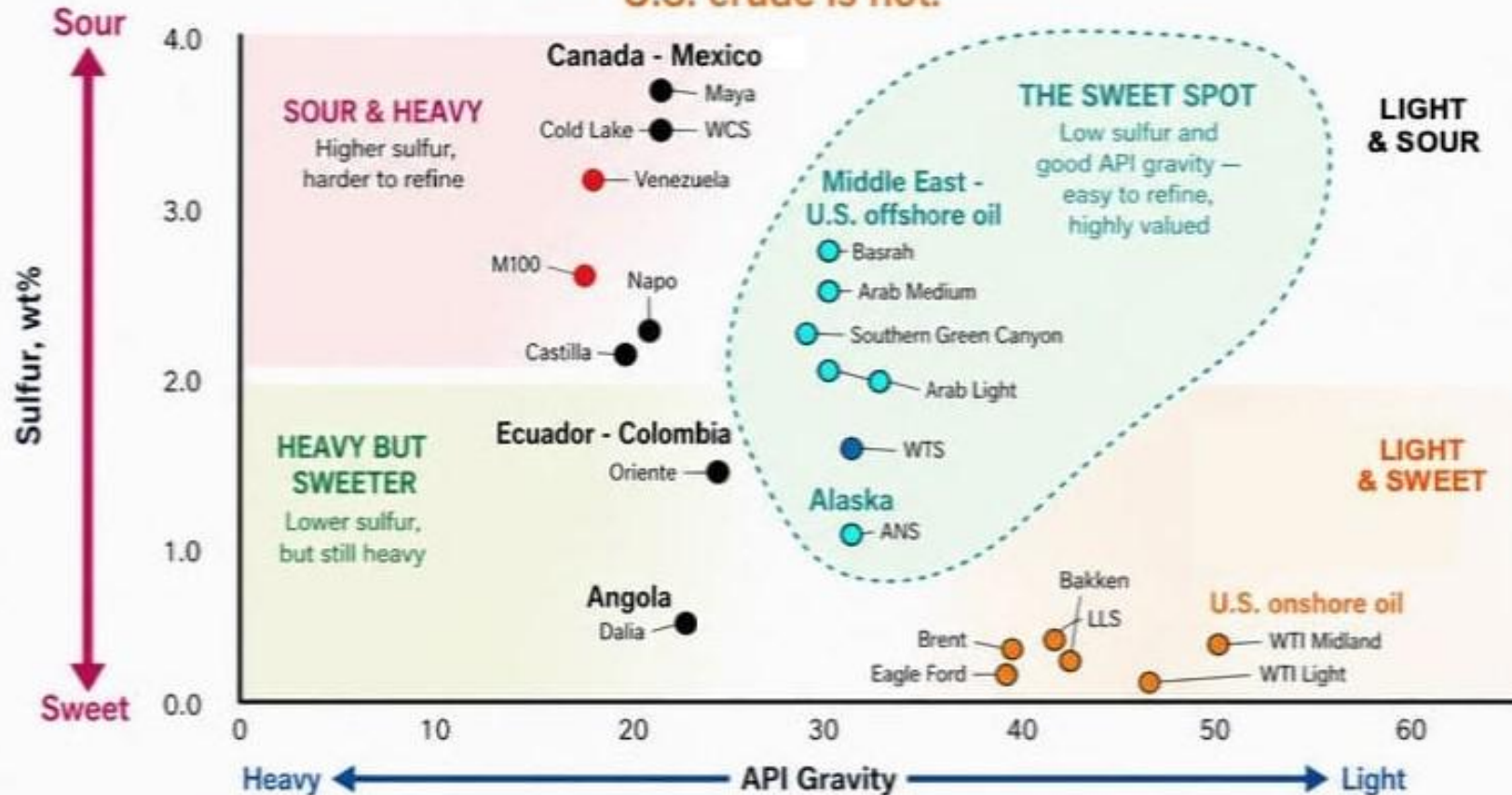
Extra Light / Condensate	Light Sweet	Medium Sour	Heavy / Extra Heavy
API Gravity >50° API	API Gravity 35–50° API	API Gravity 25–35° API	API Gravity <25° API
Sulphur Very low	Sulphur < 0.5%	Sulphur 0.5–2%	Sulphur > 2%
Example <i>Eagle Ford condensate, NGL</i>	Example <i>WTI, Brent, Taranaki crude</i>	Example <i>Arab Medium, Iranian Heavy</i>	Example <i>Venezuelan, Canadian bitumen</i>

Higher API = lighter, easier to refine · Lower sulphur = 'sweet', cheaper to process · Middle East = medium sour



Not All Oil Is The Same

Middle Eastern oil sits in the “sweet spot” —
U.S. crude is not.



Higher sulfur (sour) = more emissions and refining cost

Sweet spot = low sulfur + good API = easier, cleaner, more valuable

Out of sweet spot = more refining effort, lower margins

4

The Global System Runs on the Right Oil—Not Just More Oil

Different crudes. Different results. One economy that depends on diesel.

THREE VERY DIFFERENT CRUDES

U.S. SHALE OIL
Light, sweet
High API, low sulfur
→ Gasoline-heavy

MIDDLE EAST OIL
Medium, sweet
Optimal balance
→ Diesel + Jet Fuel

CANADA / VENEZUELA OIL
Heavy, sour
Low API, high sulfur
→ Diesel-rich but complex



WHAT THE WORLD NEEDS

FUEL GAS / LPG



GASOLINE



JET FUEL



DIESEL & DISTILLATES
(The Engine of the Economy)



RESIDUAL FUEL / BUNKER FUEL



ASPHALT / ROAD OIL



THE REALITY



Too much light oil means too much gasoline, not enough diesel.



The sweet spot delivers balanced, efficient yields.



Heavy crude delivers diesel — but needs more complex refining.

ENERGY MARKETS DON'T RUN ON BARRELS.
THEY RUN ON THE RIGHT BARRELS.

YIELDS BY REGION

Middle east crudes are particularly well suited to producing middle distillates of diesel and jet fuel both in terms of yield and economics.



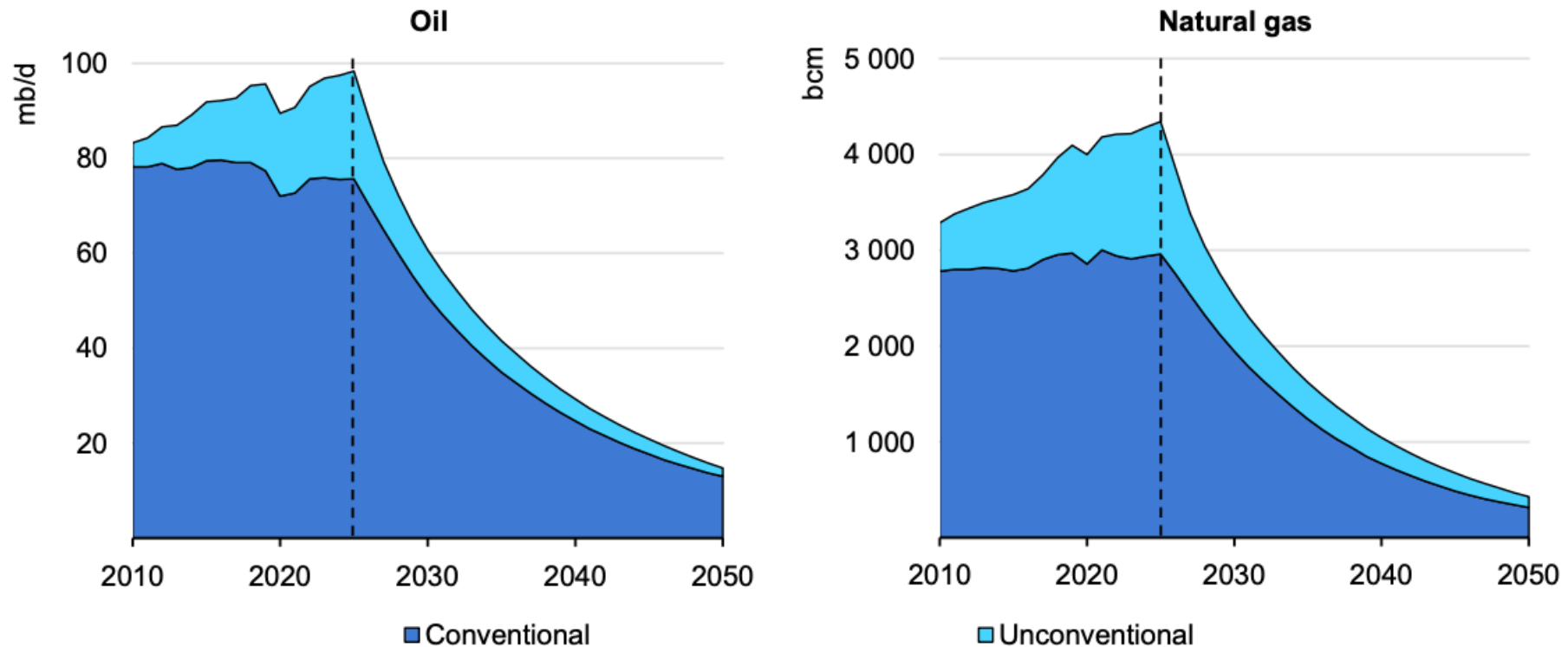
THE CURRENT SITUATION

- Multiple problems:
 - Crude oil flows severely disrupted.
 - Global refining capacity significantly reduced due to damage in the Middle East & Russia.
 - Shipping costs have exploded from VLCC rates of ~\$50K / day pre war to \$1.2M/ day currently.
 - Matching crude grades to refinery specs is difficult and logistically expensive.
 - Global reserve stocks are at record low levels.
- Since the start of this conflict NZ has been spending an average of ~\$50M / week more on fuel, equal to our red meat export earnings. This is a key reason to increase electrification of transport in particular.
- Key take away – The EROI of oil is falling. It is providing less net energy surplus to the global society.

GLOBAL DEPLETION

IEA global oil & gas natural decline rate predictions.

Figure 37 Global oil and gas production with natural declines rates from 2025



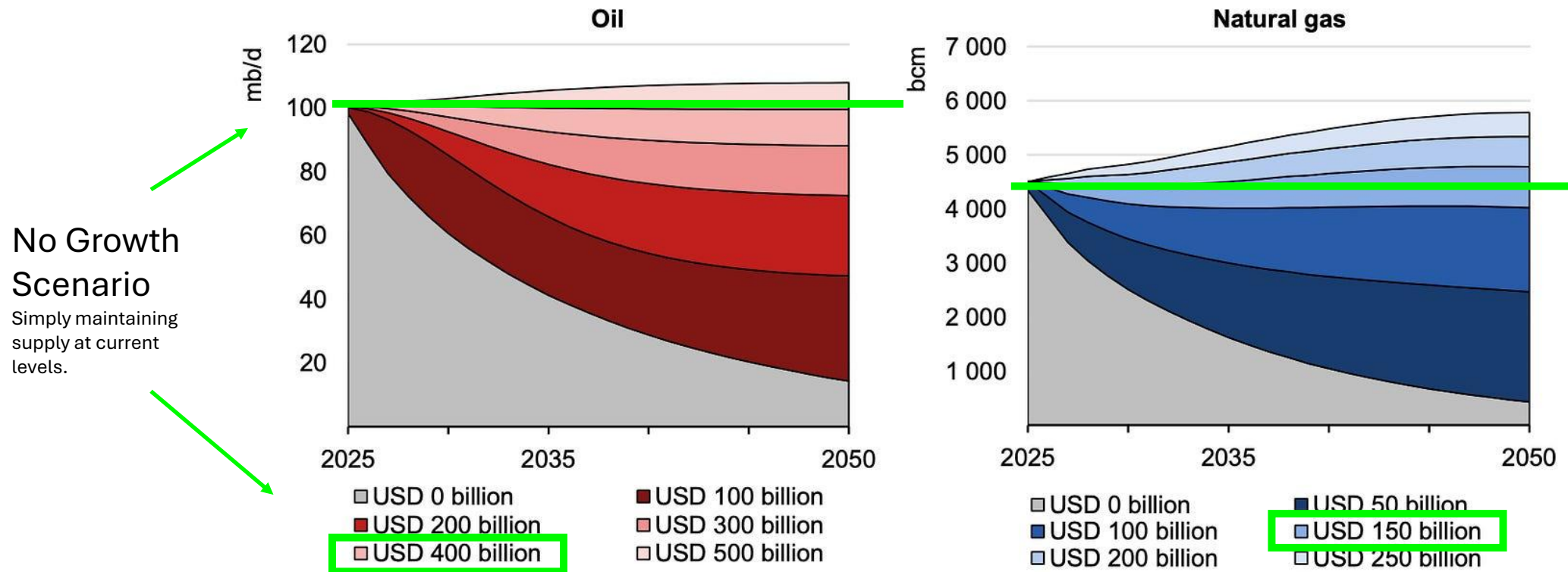
IEA. CC BY 4.0.

Note: Natural decline rates begin from the end of 2025.

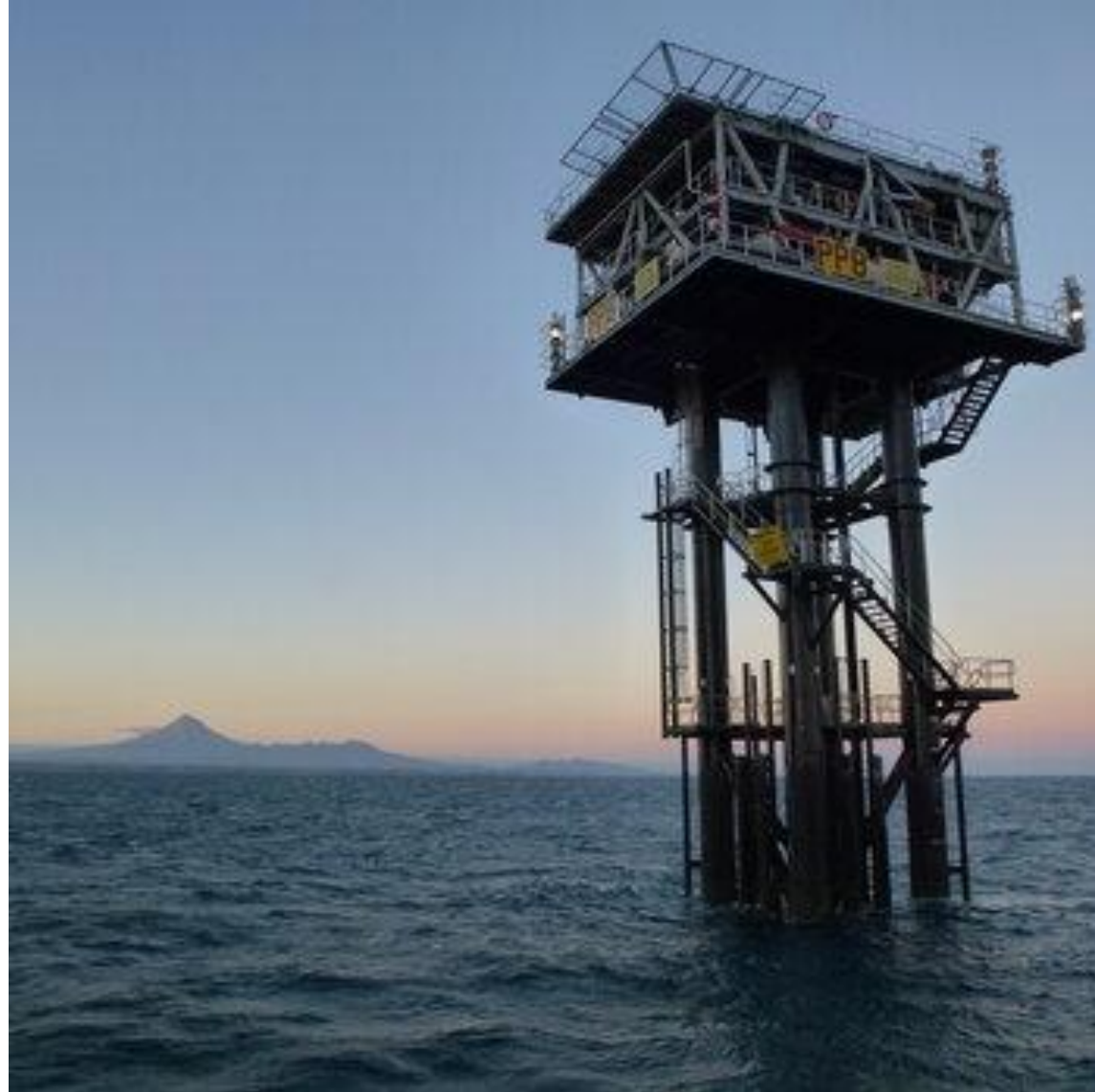
GLOBAL DEPLETION

IEA supply predictions relative to investment levels.

Figure 43 Global oil and natural gas production at varied average annual upstream investment levels to 2050



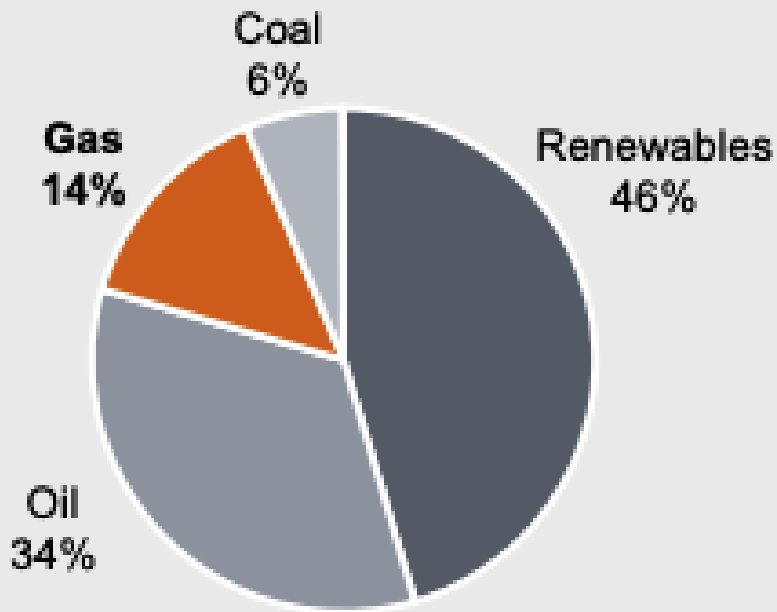
NATURAL GAS SUPPLY



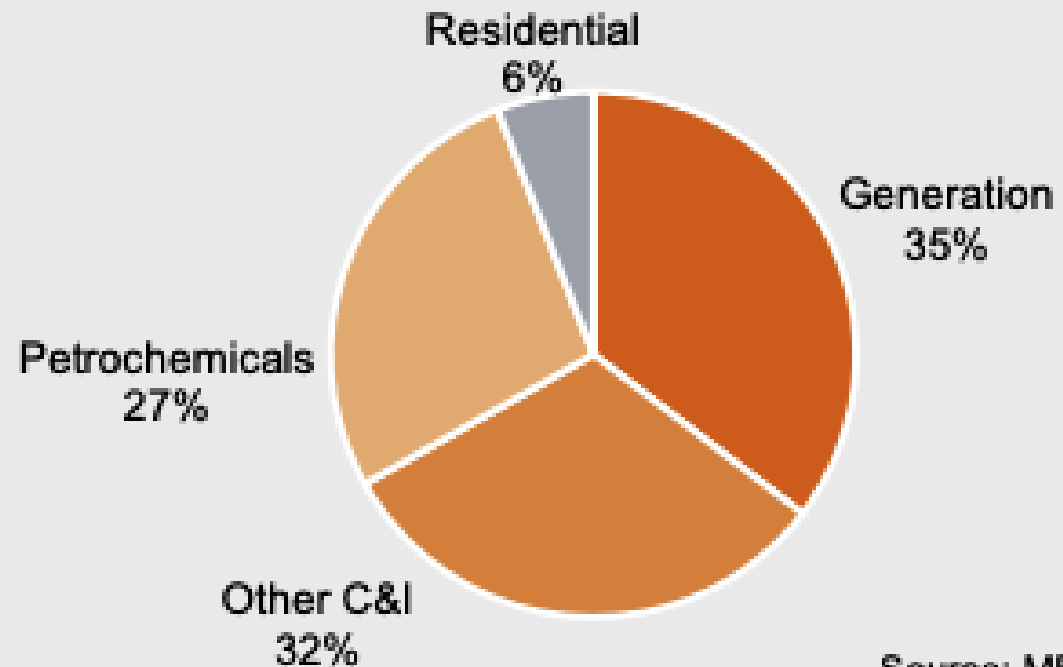
NATURAL GAS SUPPLY

Gas is New Zealand's third largest source of primary energy and is vital for industry and electricity generation

New Zealand Sources of Energy (2024)

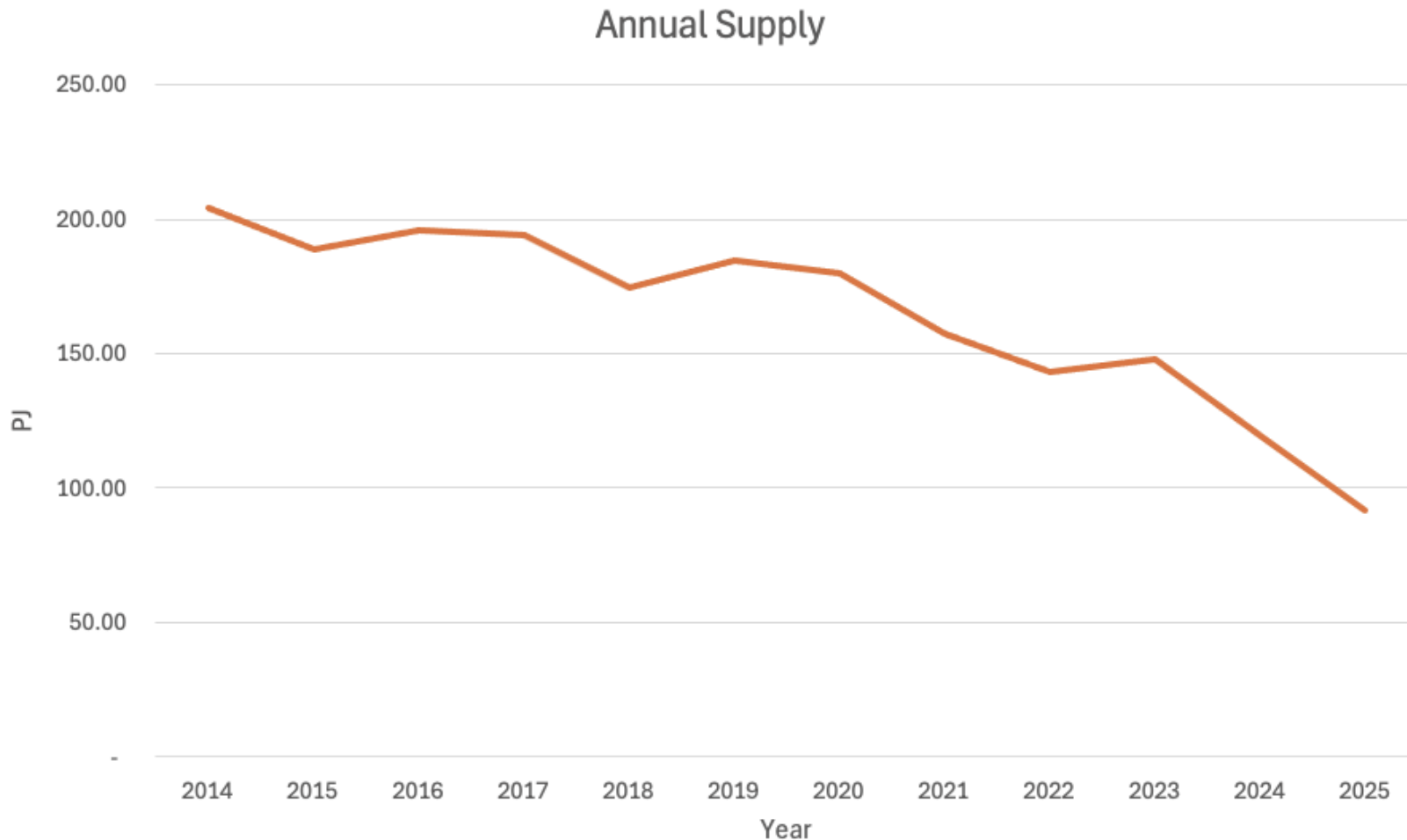


Gas Use by Consumer Segment (2024)



Source: MBIE

NATURAL GAS SUPPLY



- Total production in 2025 was 91.8PJ (GIS open access pipeline data).
- We have less than half the natural gas supply we had available 10 years ago.
- This has led to both high electricity prices and extensive industrial curtailment.
- Supply can not meet demand.
- 1PJ is the energy in all forms required to supply ~30,000 NZ homes.
- This is why we are talking about an LNG facility in New Plymouth

NATURAL GAS USE

\$76 Billion

~ 18,000 Industrial & Commercial Businesses

- ~~Methanol production~~ — Methanex
- **Fertiliser production** — Urea at Ballance
- **Food processing** — dairy, red meat, horticulture
- **Electricity generation and cogeneration.**
- **Wood, pulp, paper, and printing Commercial and institutional users** — schools, hospitals, rest homes, commercial buildings

~**280,000 Households** — smaller share for space and water heating

Estimated direct, indirect & induced contribution to NZ GDP annually (20%).

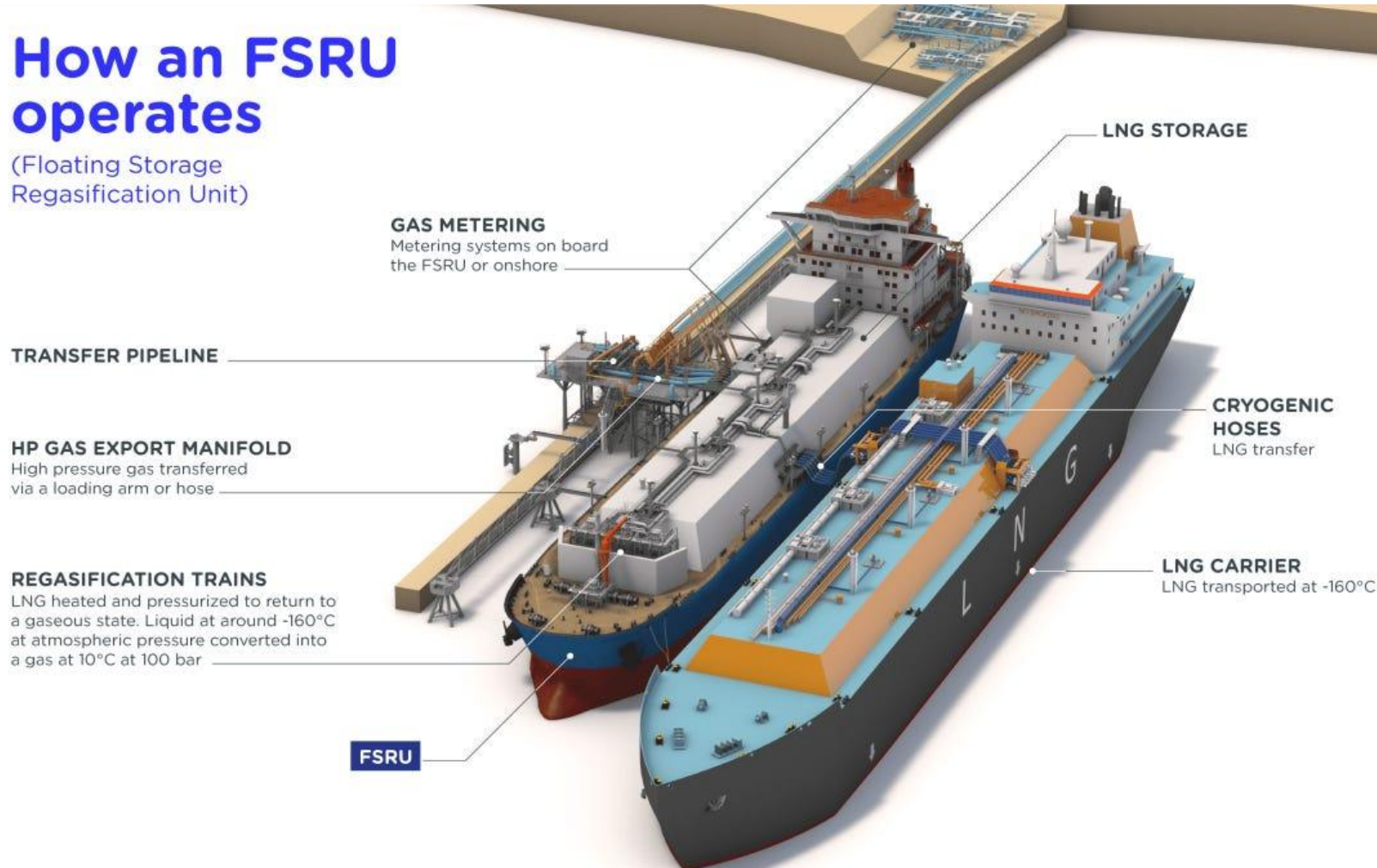


"More than 40% of businesses surveyed say transitioning to alternative fuels is not commercially viable within the next five years, with a further 20% uncertain. Even with a phase-out period of 15 years, only 75% of all respondents were confident of being able to transition."

LNG ???

How an FSRU operates

(Floating Storage Regasification Unit)

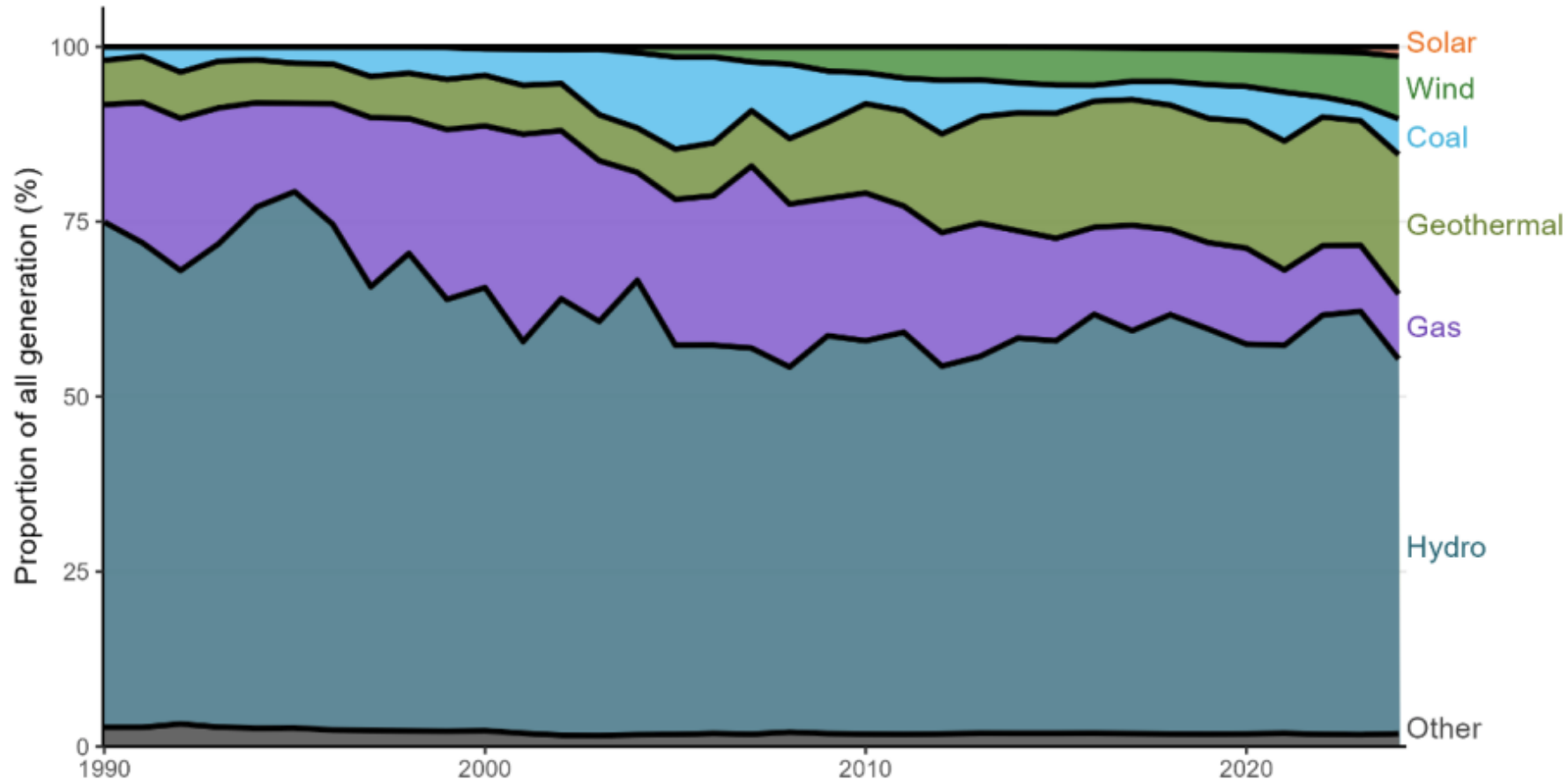


- A potential solution to our domestic natural gas depletion issue.
- Importing natural gas in the form of cryogenically chilled liquid methane.
- Forward contract prices for 2028 are forecast to be around $\$10 / \text{GJ}$ which would land LNG here for $\sim \$25 / \text{GJ}$.
- **Negatives** - Price volatility, import dependency, balance of trade, technical challenges, lock in risk.
- **Positives** – Short lead time to deliver, essentially plug and play, gives $\sim 18,000$ commercial and industrial gas users a life line and a bridge.
- This is a duress position.

ELECTRICITY SYSTEM



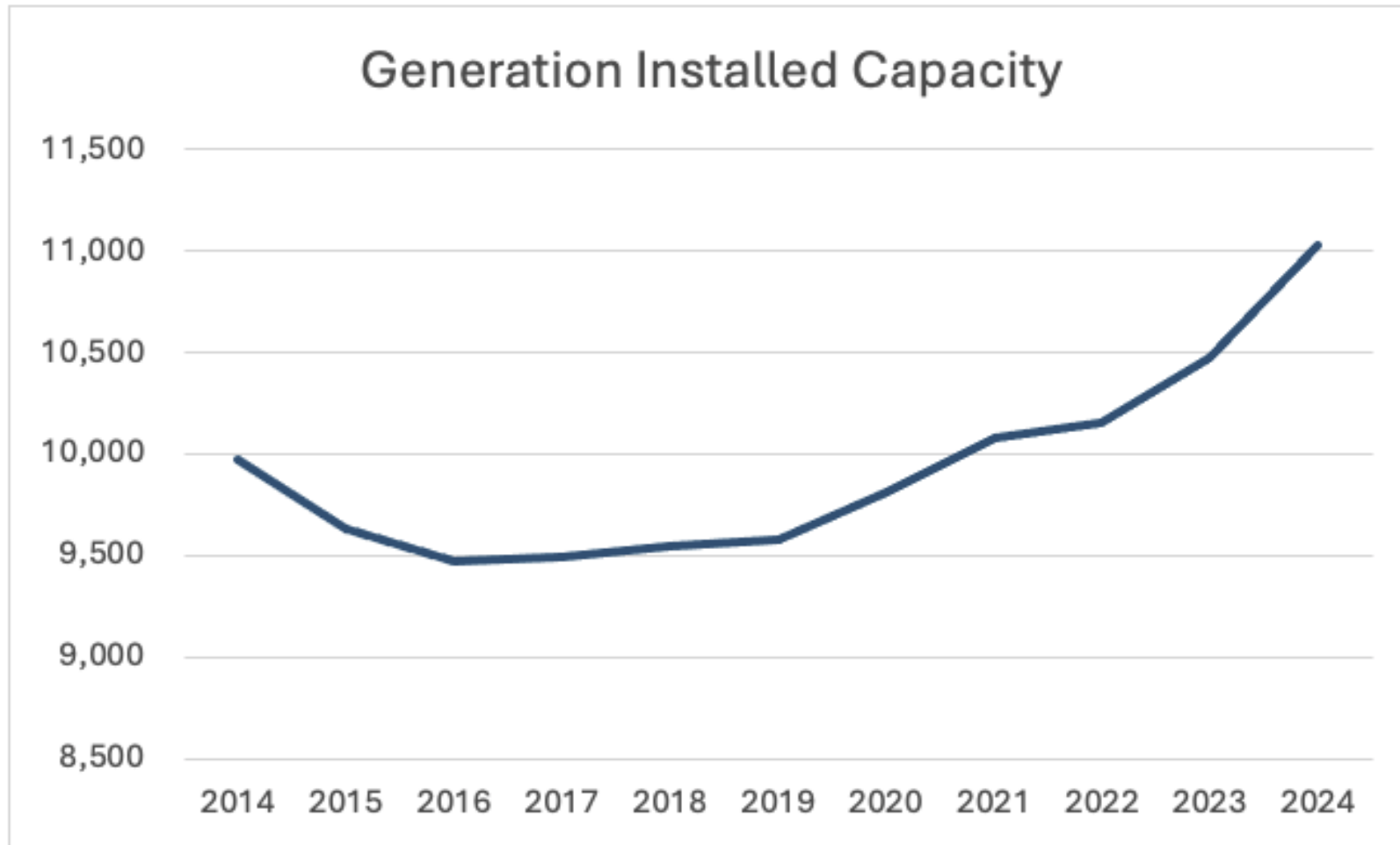
ELECTRICITY GENERATION BY TYPE



- 1990 – 2024 data.
- Strong growth of geothermal and wind.
- Gas has declined significantly.

Figure 5. The proportion of total electricity generation from each fuel type, by year.

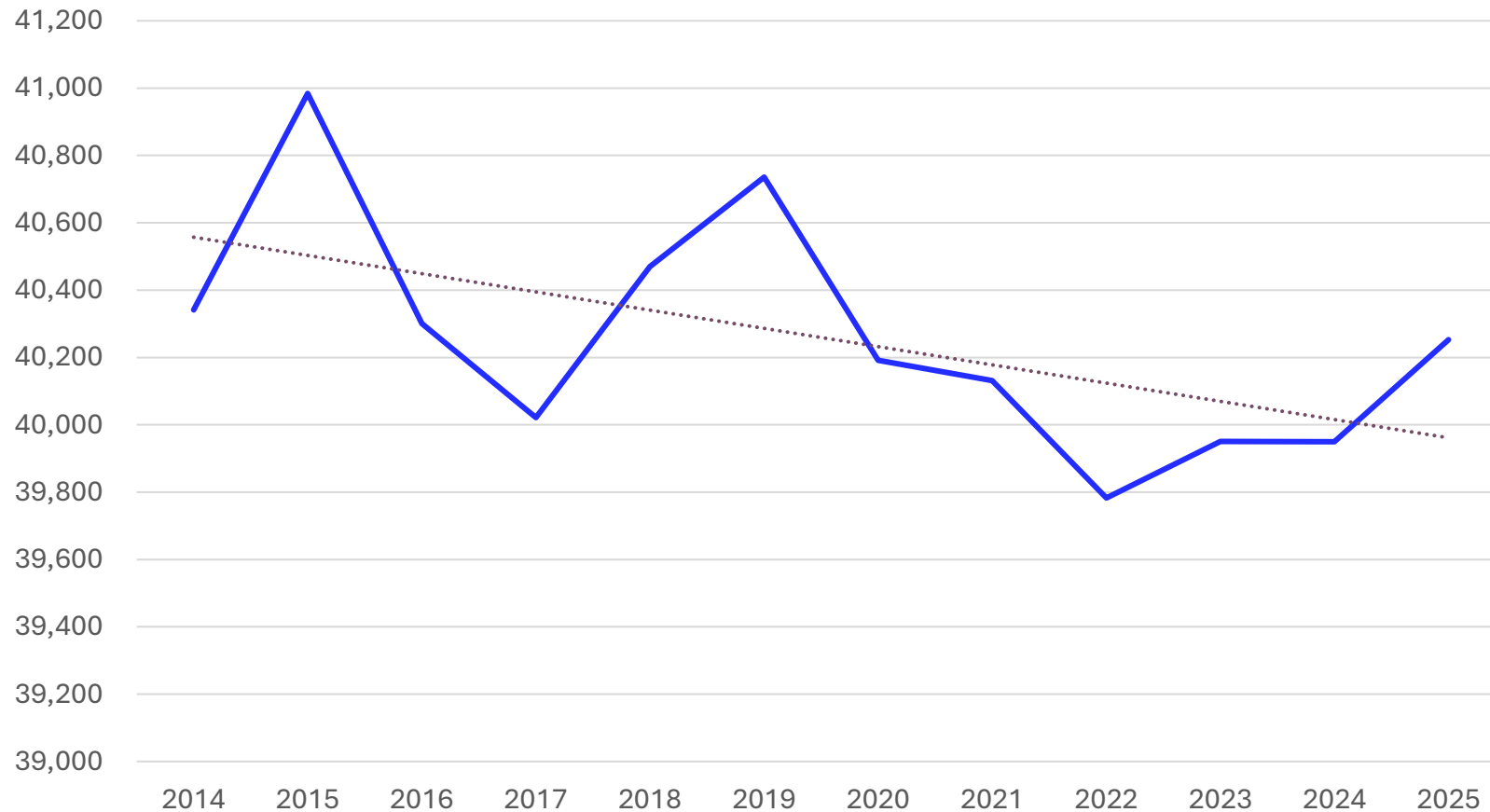
ELECTRICITY GENERATION



- Installed capacity has increased by 10.6% in the past decade.
- New generation has come primarily in the form of geothermal, solar and wind.

ELECTRICITY CONSUMPTION

NZ Electricity Consumption (GWh)



- We are consuming less electricity than a decade ago.
- This is not due to a lack of demand – its due to a lack of economic supply.
- There is an estimated 900 – 1000 GWh of behind the meter solar generation included here.

ELECTRICITY USE

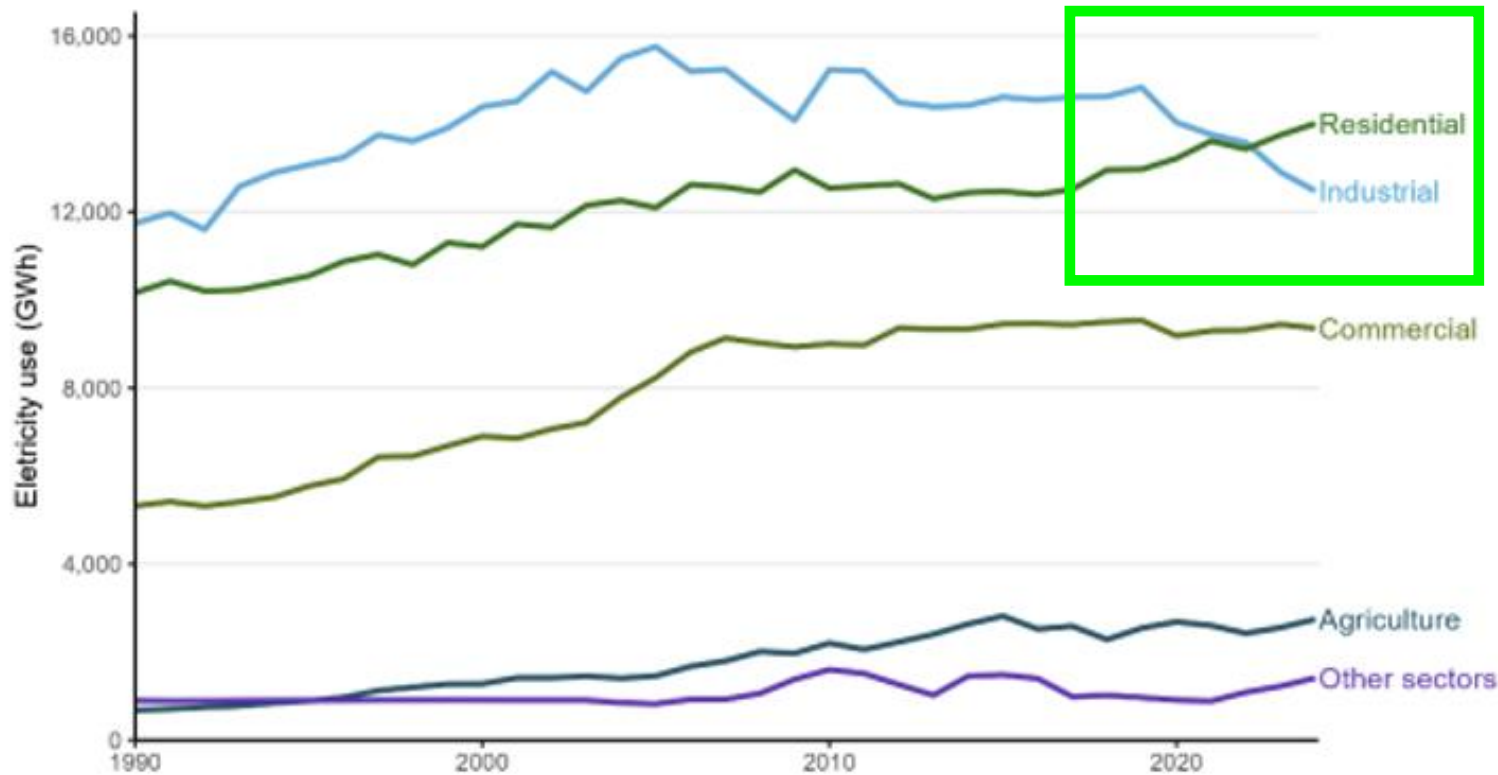
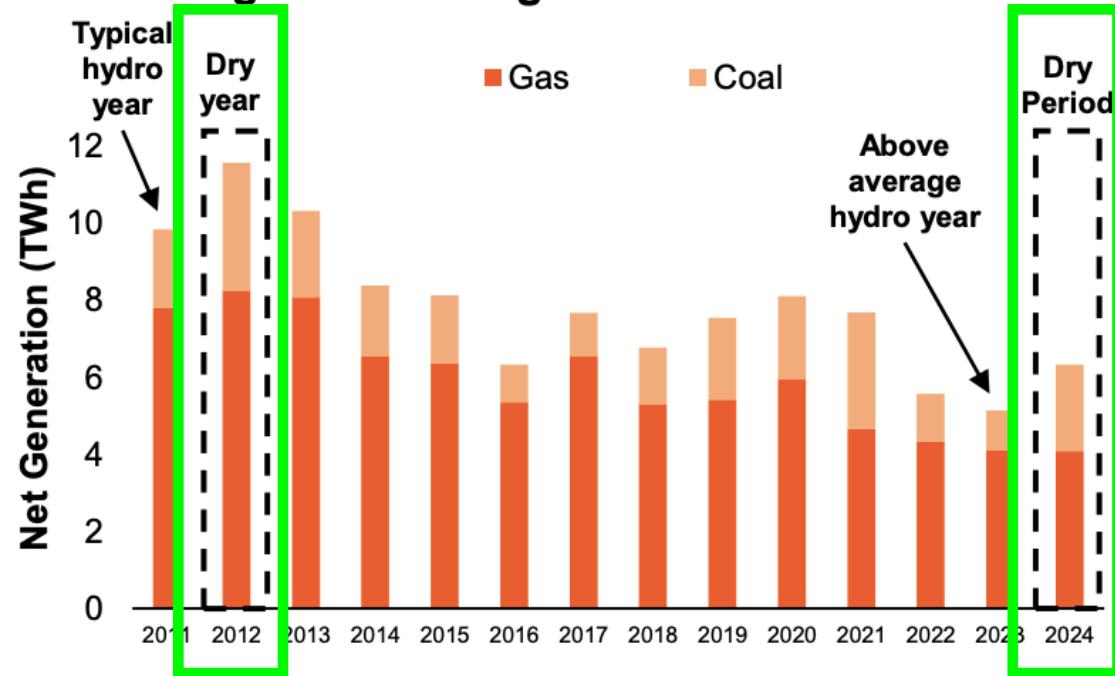


Figure 9. Electricity consumption by sector, by year. "Other sectors" includes transport, unallocated onsite generation, and unallocated demand.

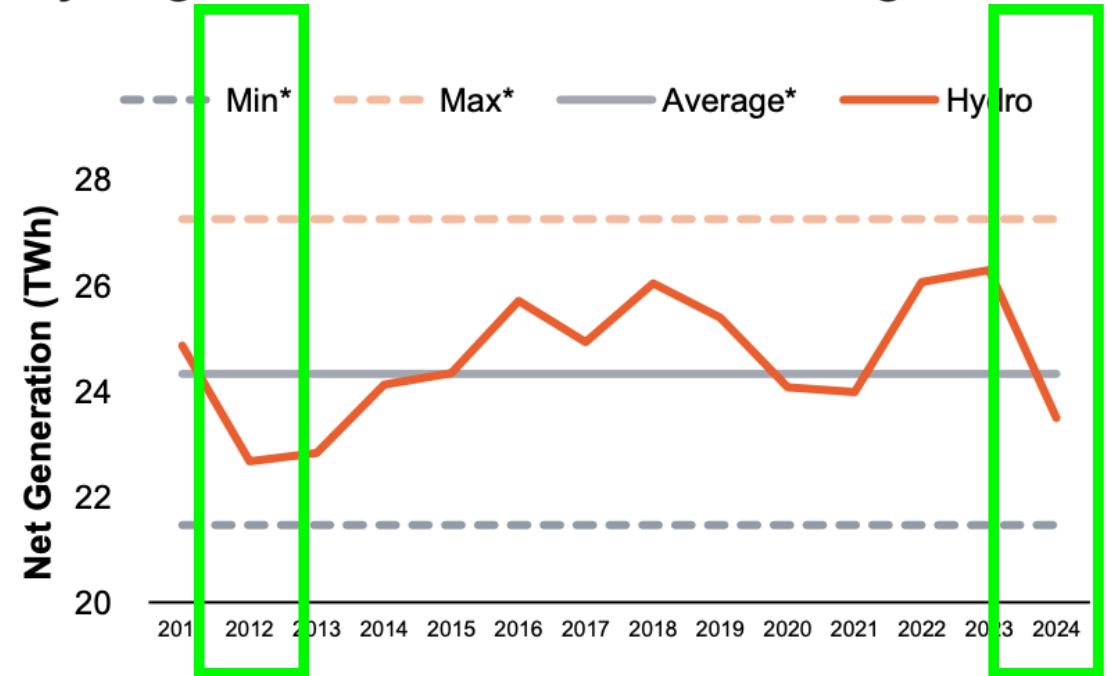
- For the first time since records began residential electricity use exceeds industrial.
- Industrial electricity usage is not dropping due to efficiency it is driven by curtailment and business closures.

GAS & COAL DRY YEAR GENERATION SUPPORT

Historical gas and coal generation



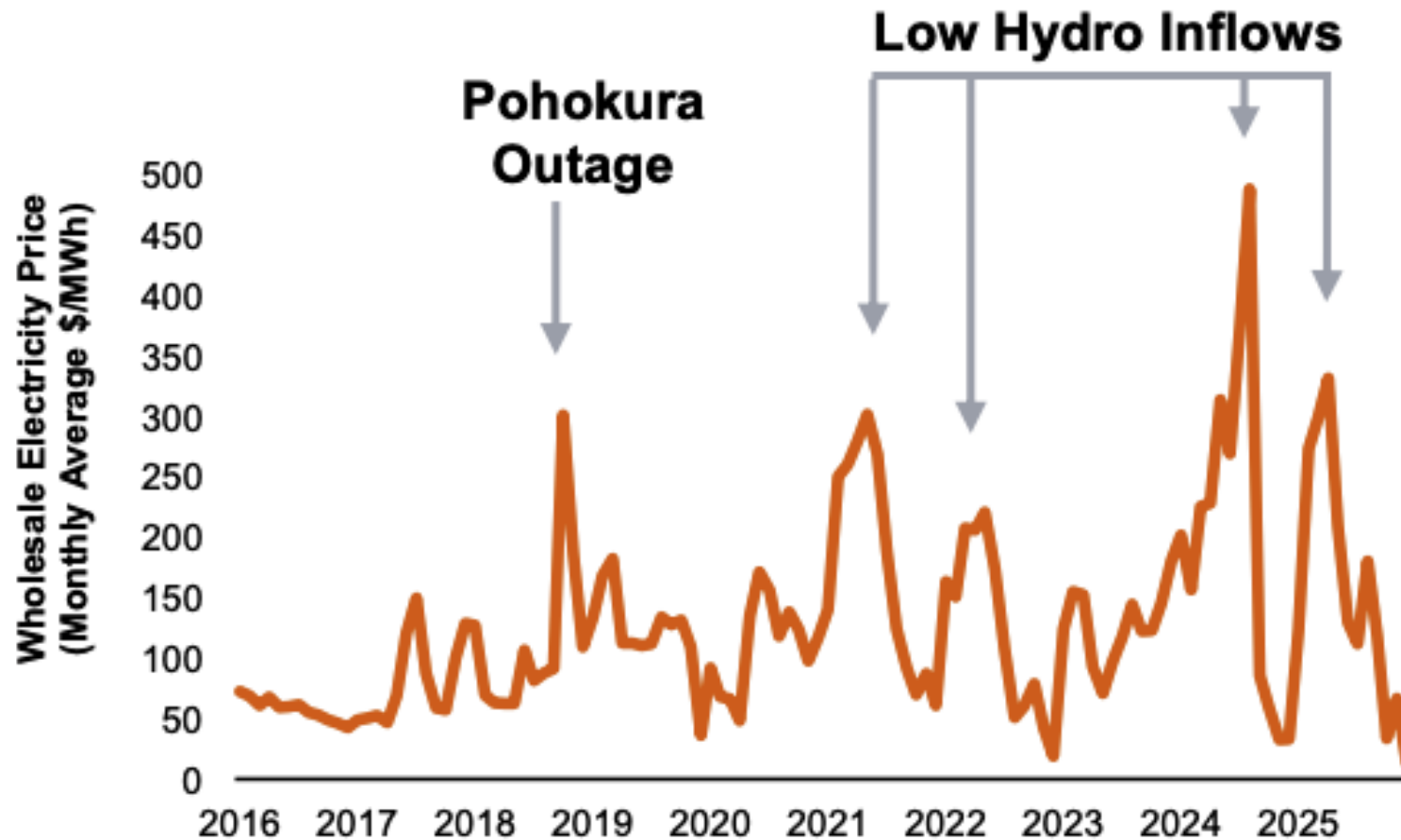
Hydro generation versus historical average



- Gas and coal use tracks hydro inflows almost perfectly.
- Increasing hydro storage is possible but lowers the utilisation of Huntly even further.

PRICE VOLATILITY

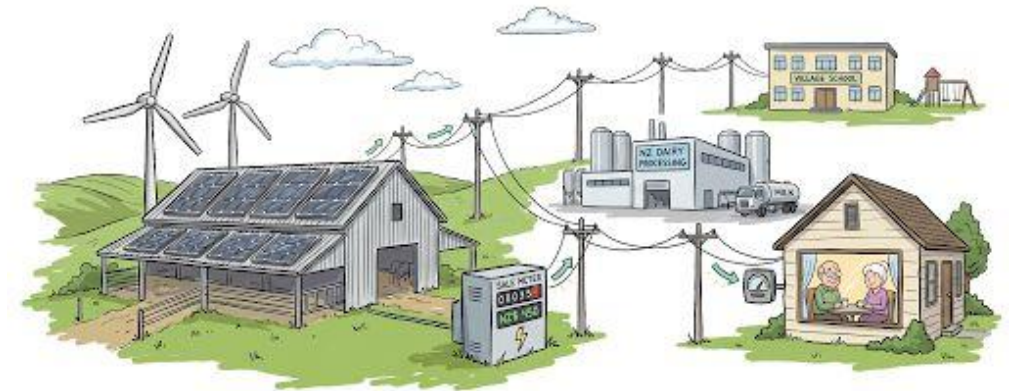
Electricity prices during supply constraints



- In the absence of cheap gas firming the NZ electricity market is becoming increasingly weather dependent and as a result increasingly volatile.
- This is very difficult for businesses to manage when selecting power purchase agreements on a fixed or floating basis.
- Larger users that select fixed options very often have to accept demand management provisions.

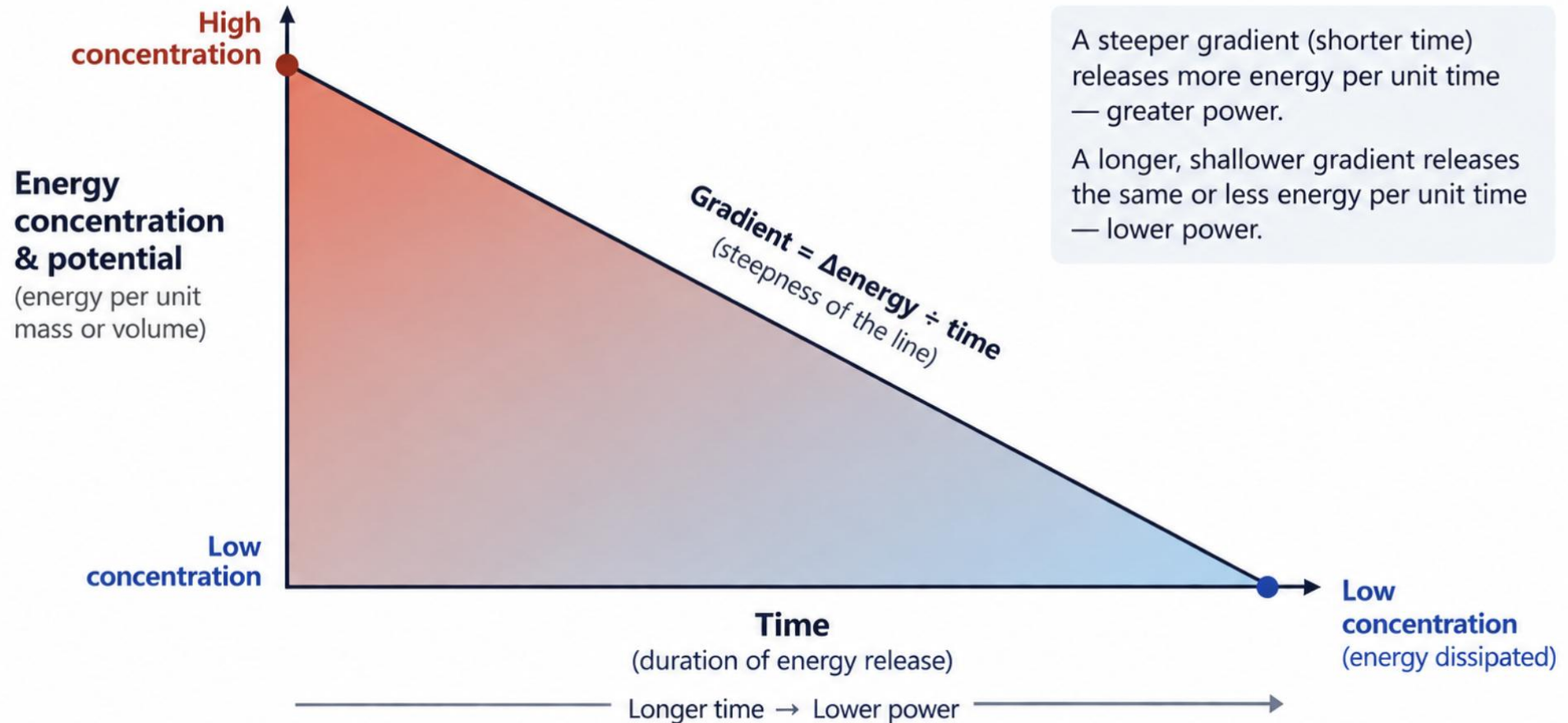
BENEFITS OF ELECTRIFYING NEW ZEALAND

- Improved energy security.
- Less dependence on imported fuels.
- Improved energy efficiency
- Lower emissions.
- Improved balance of trade.



Energy Gradient

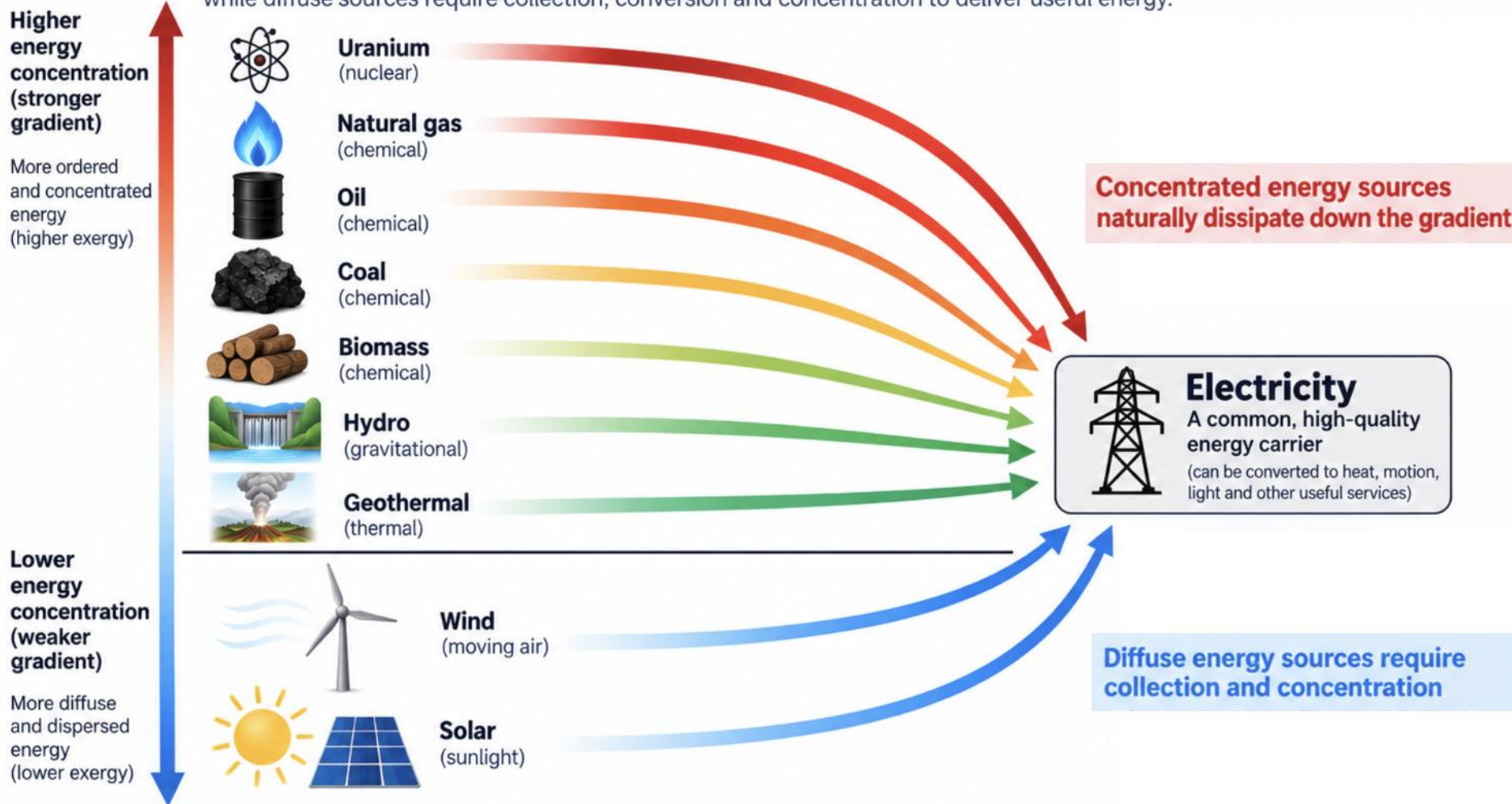
Energy flows from higher to lower potential. The steeper the gradient, the greater the power.



The same amount of energy released over a longer time delivers lower power.

Different Energy Sources, Same Electricity Output

Energy flows from higher to lower concentration. Concentrated energy sources naturally dissipate down the gradient, while diffuse sources require collection, conversion and concentration to deliver useful energy.



**LOW ENERGY
DENSITY
=
HIGH
RESOURCE
INTENSITY**

NZ ELECTRIFICATION – TWO KEY CHALLENGES

FULL SYSTEM COST OF ENERGY

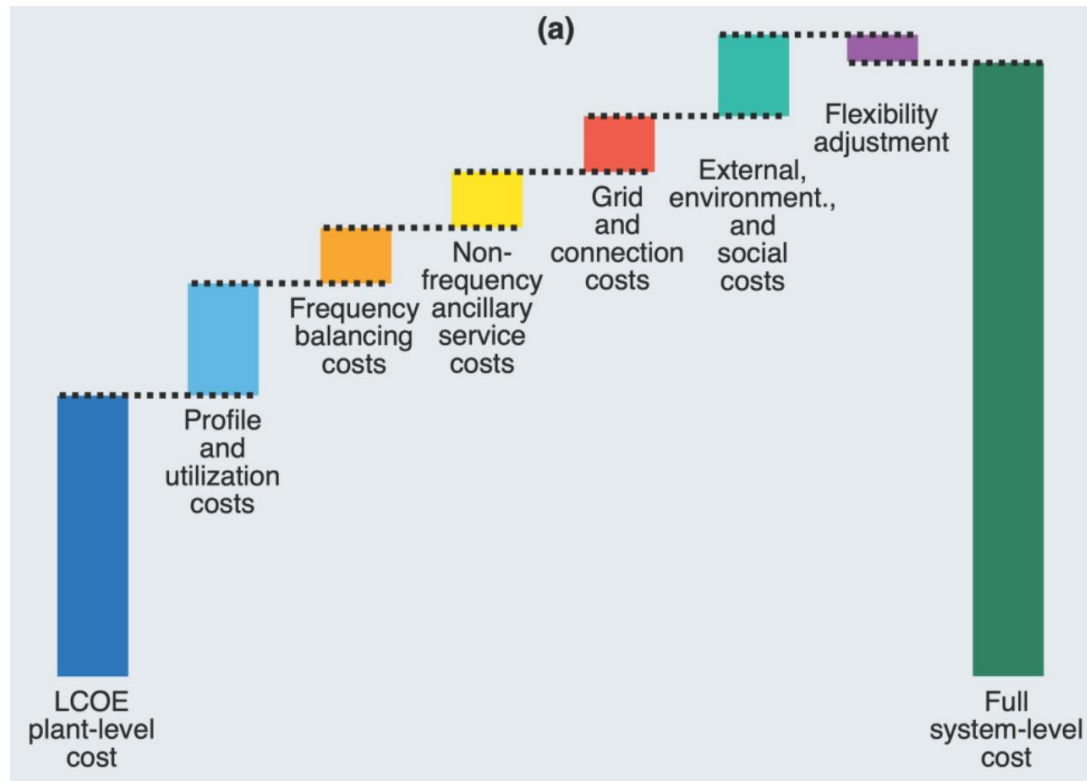


SUPPLY CHAINS

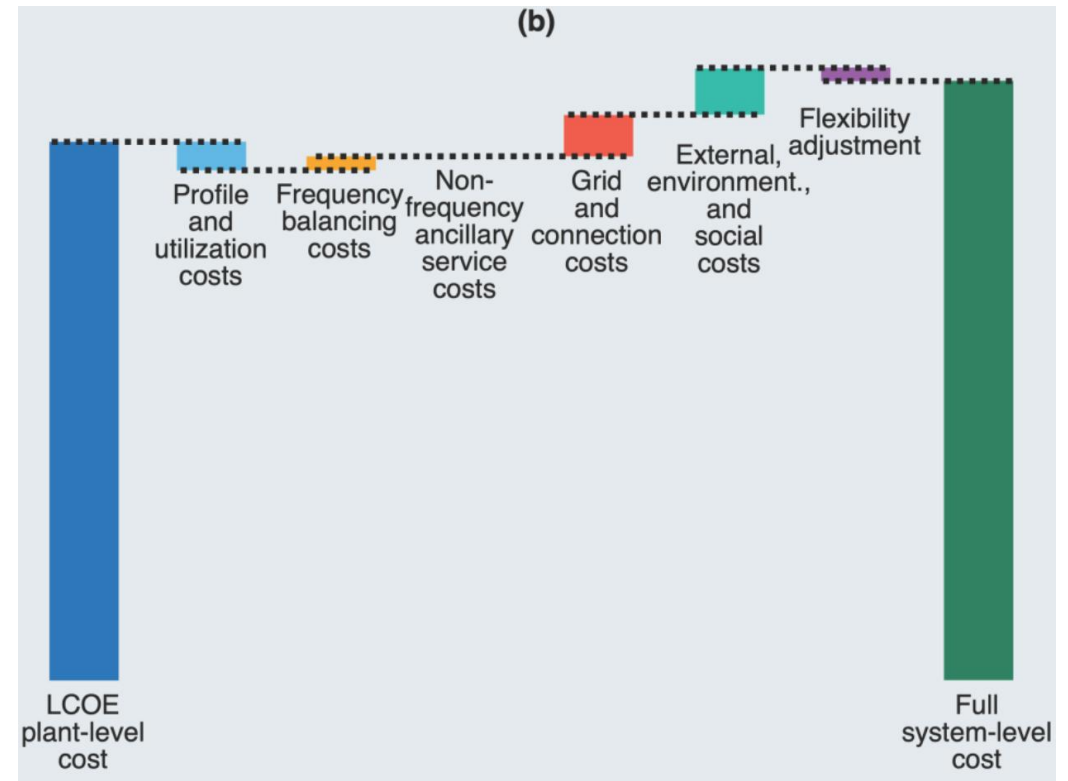


LCOE (LEVELISED COST OF ELECTRICITY) VS FSCOE (FULL SYSTEM COST OF ELECTRICITY)

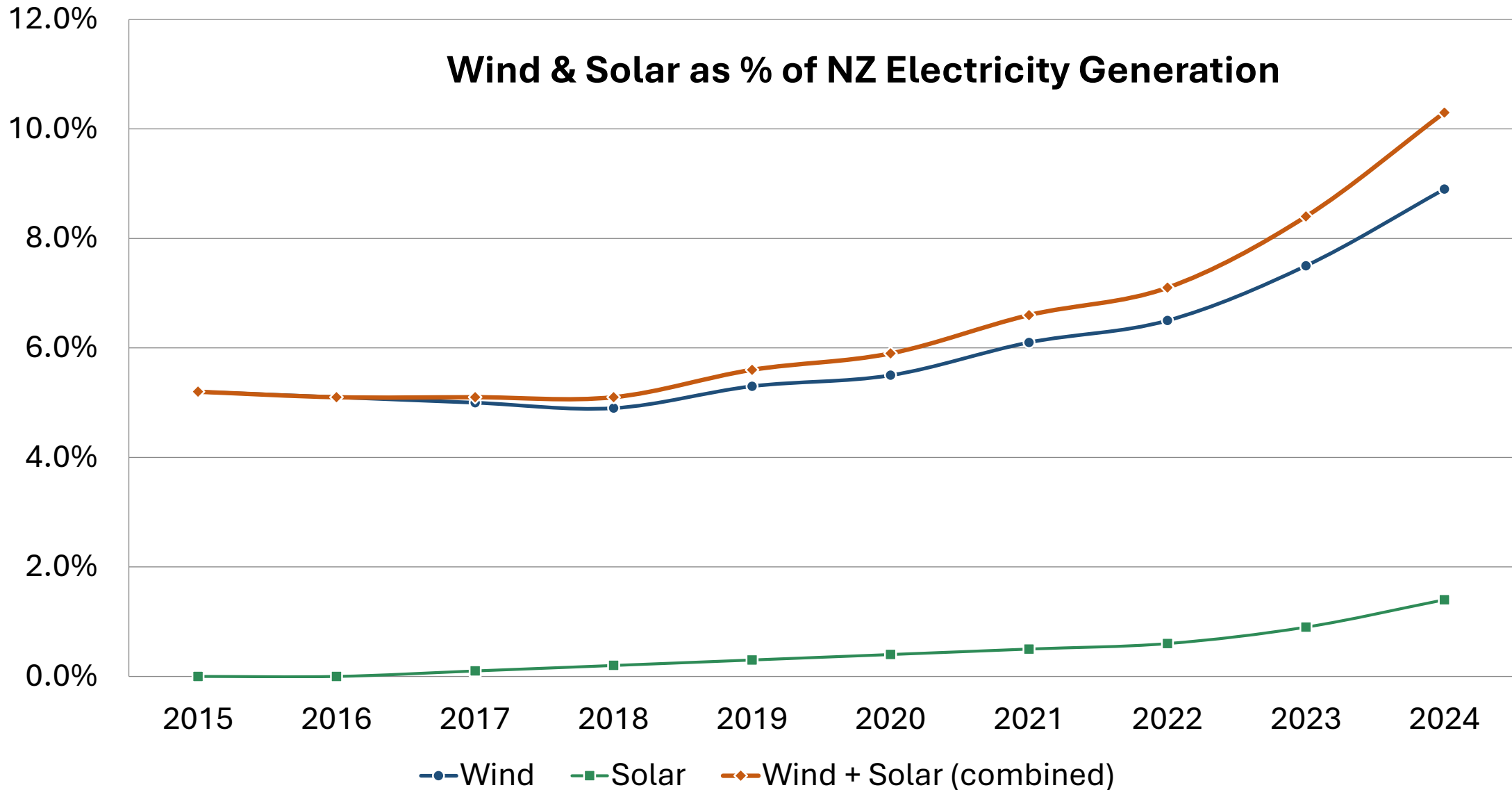
Wind & solar have a low levelised cost of electricity (LCOE) because the fuel is free, but the full system cost of electricity (FSCOE) is much higher due to the additions to the system necessary to integrate variability and deliver a reliable energy supply.



Dispatchable or firm generation has a higher LCOE typically due to fuel costs, but the cost to integrate this electricity into the system is lower as it requires less network services. Meaning that additions of firm and dispatchable generation have less impact on the FSCOE.

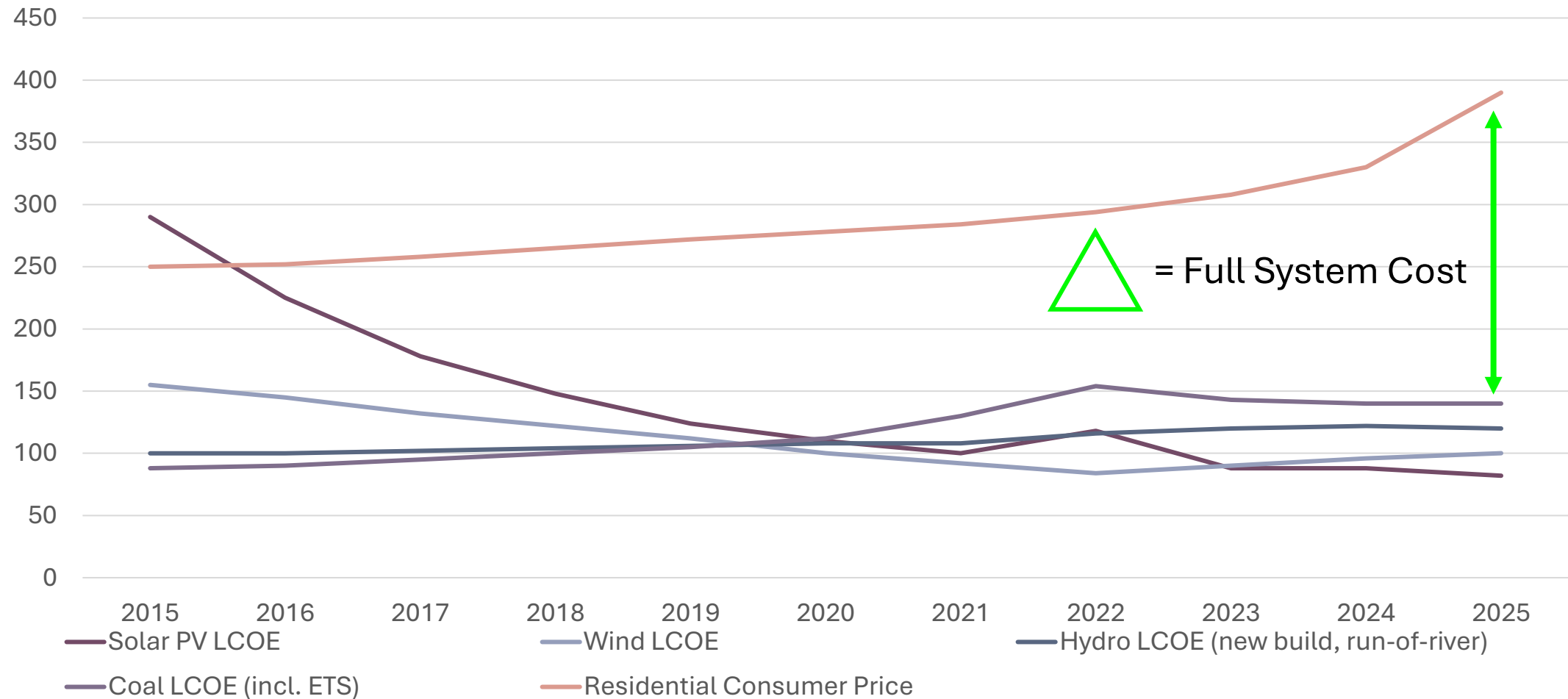


INTERMITTENT & VARIABLE GENERATION %



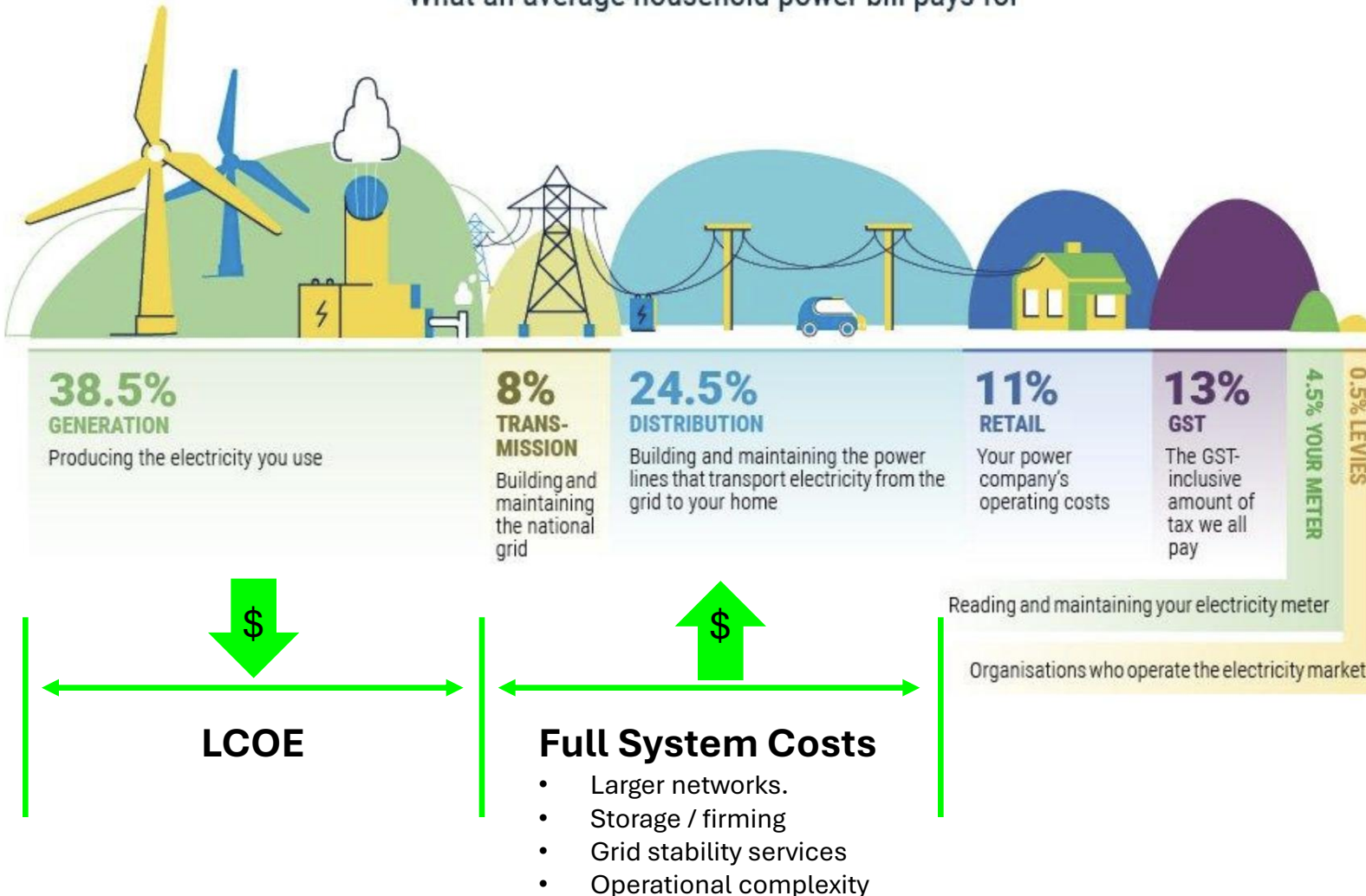
FULL SYSTEM COSTS

NZ Electricity: Generation LCOE vs Consumer Price (NZD/MWh, nominal)



FULL SYSTEM COSTS

What an average household power bill pays for

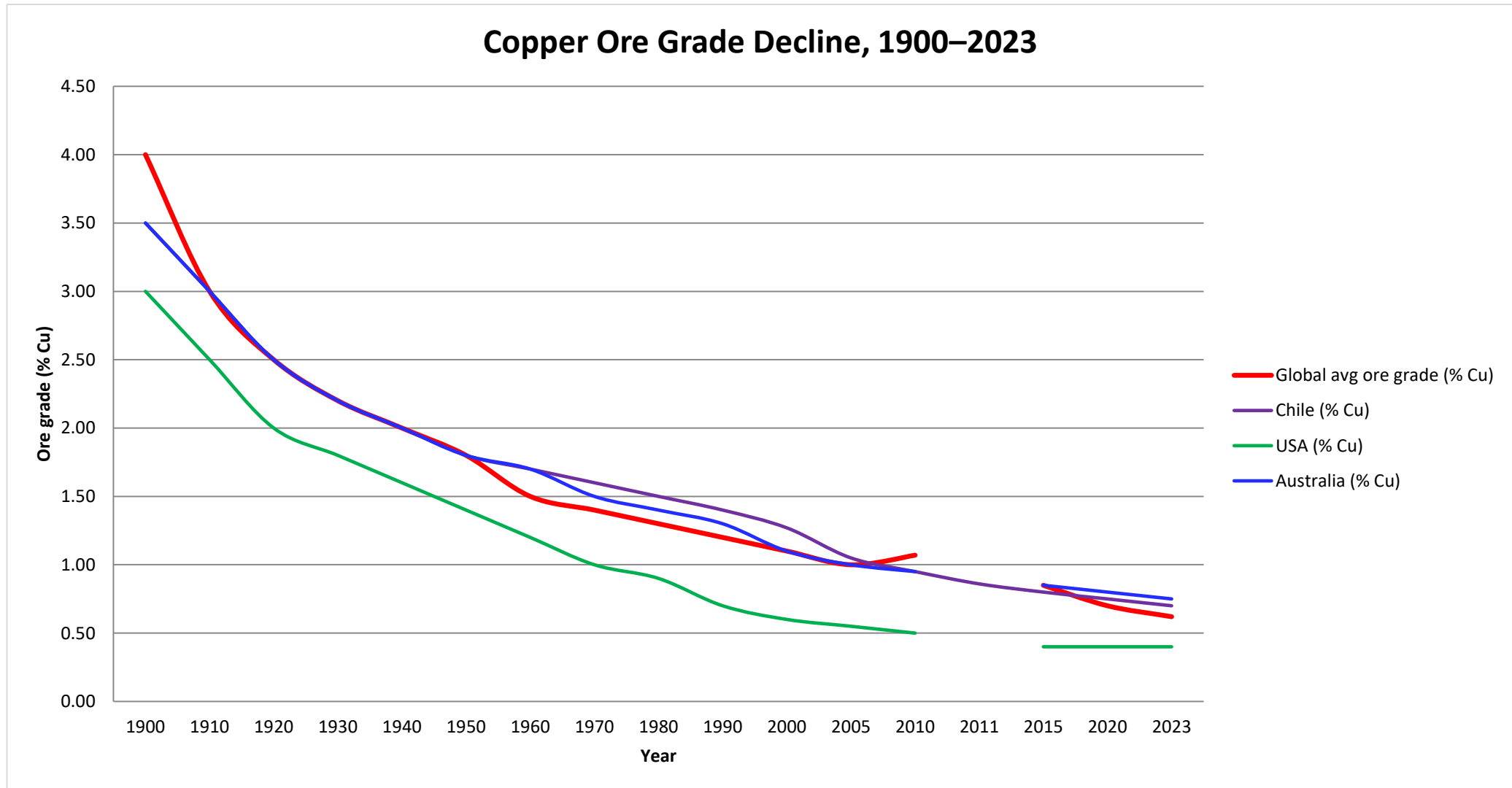


- As intermittency and variability increase as a % of the grid system costs rise as system complexity increases.
- This pattern is not unique to New Zealand and is one of the key challenges for the energy transition
- Key take away – system costs can quickly erode the net energy surplus the system provides

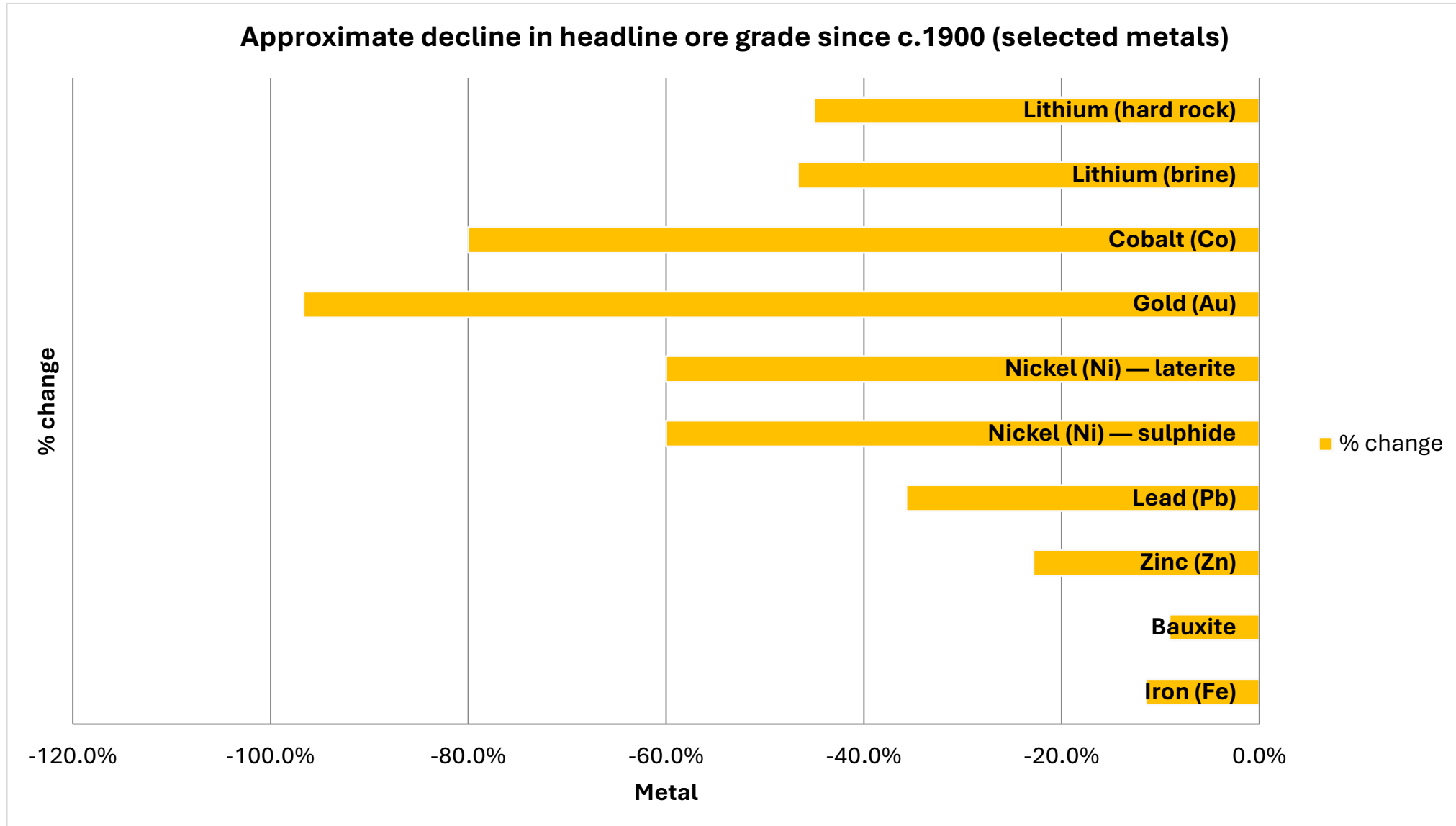


SUPPLY CHAIN – MINING GRADES

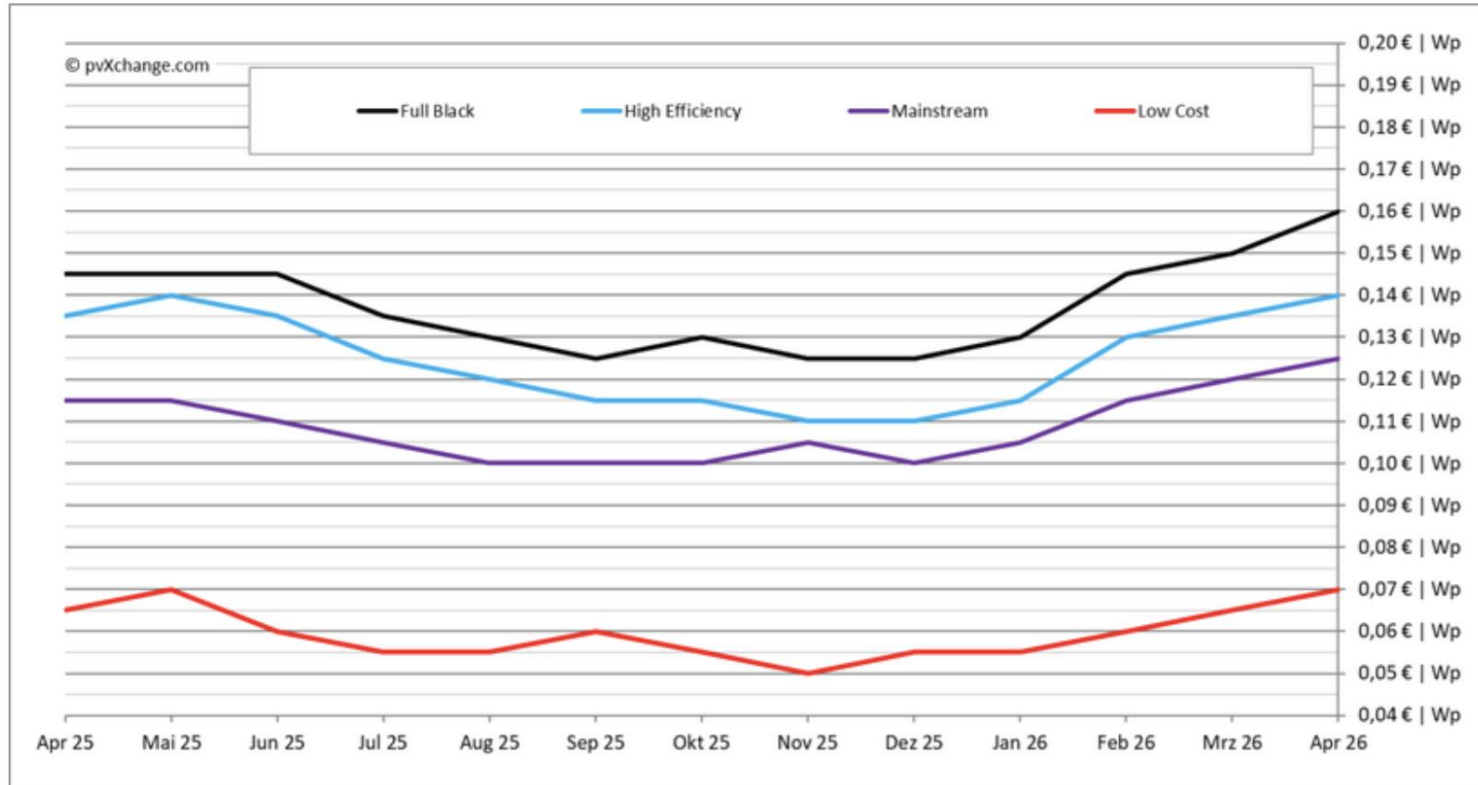
COPPER ORE GRADES



OTHER METALS - % YIELD PER TONNE OF ORE



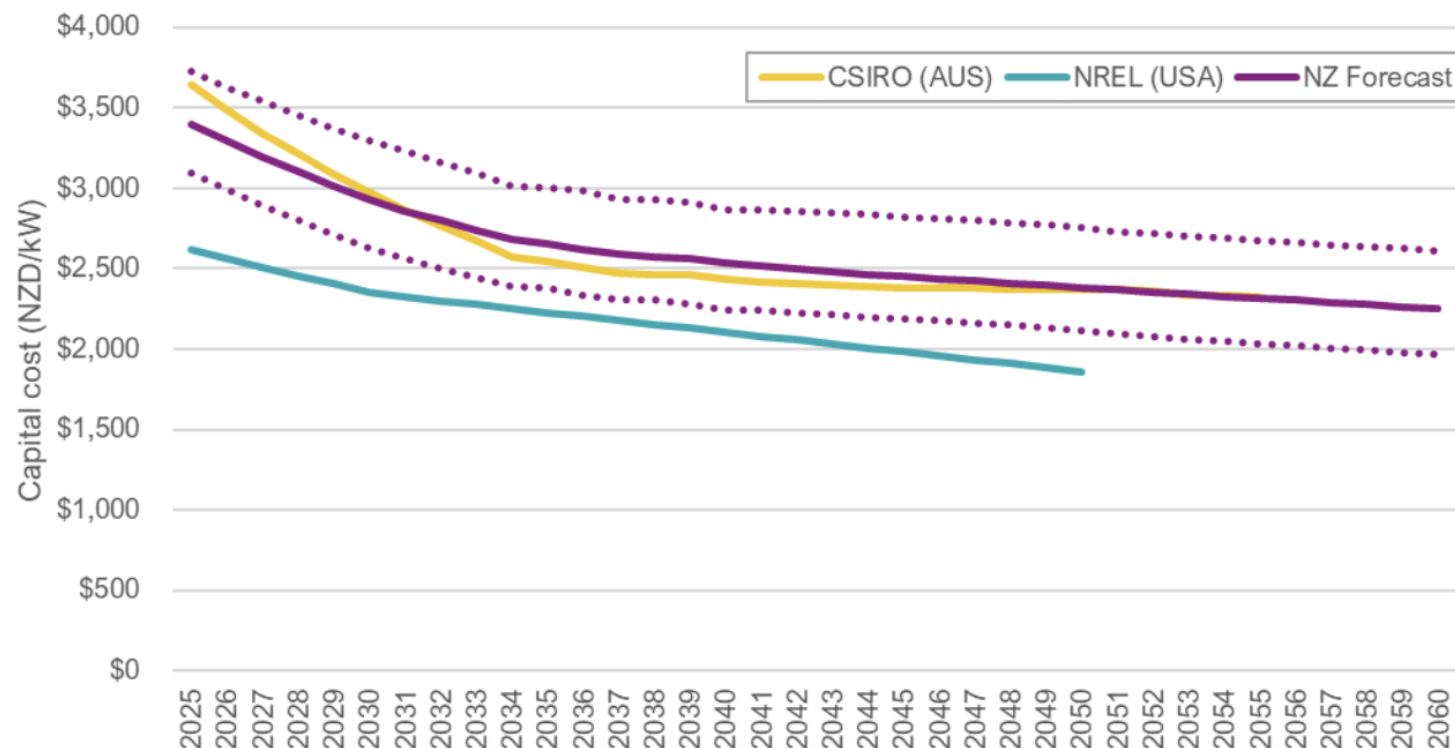
SOLAR PV MODULE PRICES



- Solar panel prices have started to rise as a result of the removal of Chinese export tax credits and higher material costs. Particularly silver.

NZ WIND PROJECT COST PROJECTIONS

Transpower 2025 Generation Stack Report – Concept Consulting



“Even adjusting for inflation, the cost of wind projects has **increased in the past five years, contrary to expectations.**

The “cost for 2025 wind in 2025” is roughly **50% higher** than its “cost for 2025 wind in 2021 projections”.

Partly this is due to disruptions caused by Covid-19 but also includes higher turbine costs due to increased warranty costs and an apparent reduction in price competition between major suppliers.

We consider the recent cost increases to be an anomaly and that prices will return to a learning rate driven trend.

My thoughts - Wind turbines may continue to improve technologically, but that does not necessarily imply that future wind farms become cheaper. Mine ore grades, diesel crack spreads, interest rates and the costs of producing steel, copper, and concrete will increasingly offset the traditional benefits of manufacturing learning curves.

IN SUMMARY

- We have accumulated enormous societal complexity – complex systems are typically only stable when they are growing.
- Our energy metabolism is a function of needing both the energy to maintain accumulated complexity and a small surplus with which to grow.
- Oil and gas are key components of NZ's energy system both systems are providing us with much less net energy to society – this manifests as a loss of capacity to perform work – jobs go and things get more expensive.
- Electrification is our key response to this situation – this however comes with fundamental challenges:
 - Low energy density.
 - High resource intensity.
 - High system complexity.
 - The ability to provide sufficient net energy surplus to maintain societal complexity remains an open question?

POTENTIAL SOLUTIONS

Short Term

- Conventional geothermal expansion.
- Increased run of the river hydro expansion.
- Small pumped hydro storage schemes to supplement solar generation.
- Domestic solar and battery systems.
- On farm and on warehouse solar.
- Market reform - single buyer market.
- LNG to give a transition lifeline to 18,000 C&I gas users.
- Transport electrification.

Long Term

- Nuclear baseload generation.



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Q&A



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4 November

Martin Atkins, UoW Ahuora Centre for Smart Energy Systems

11 November

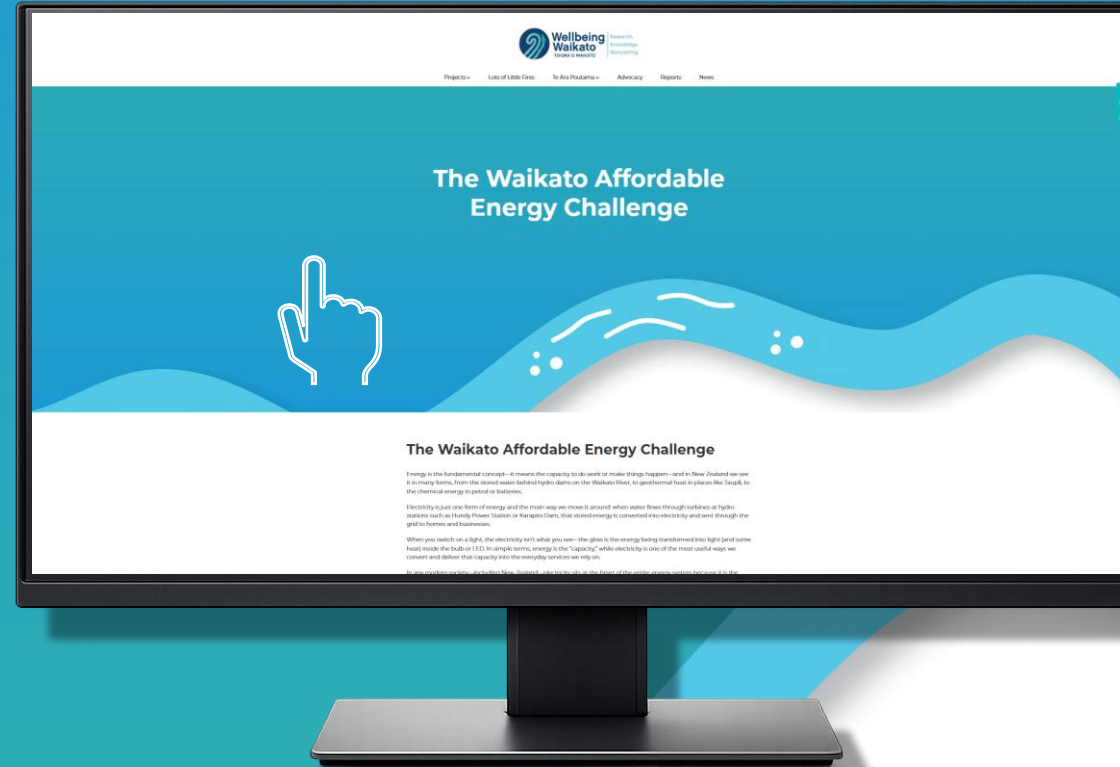
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