Bridges to Nowhere

A review of misunderstood, out-of-context and invalid analysis concepts undermining renewable energy and GHG emission reduction progress around the globe

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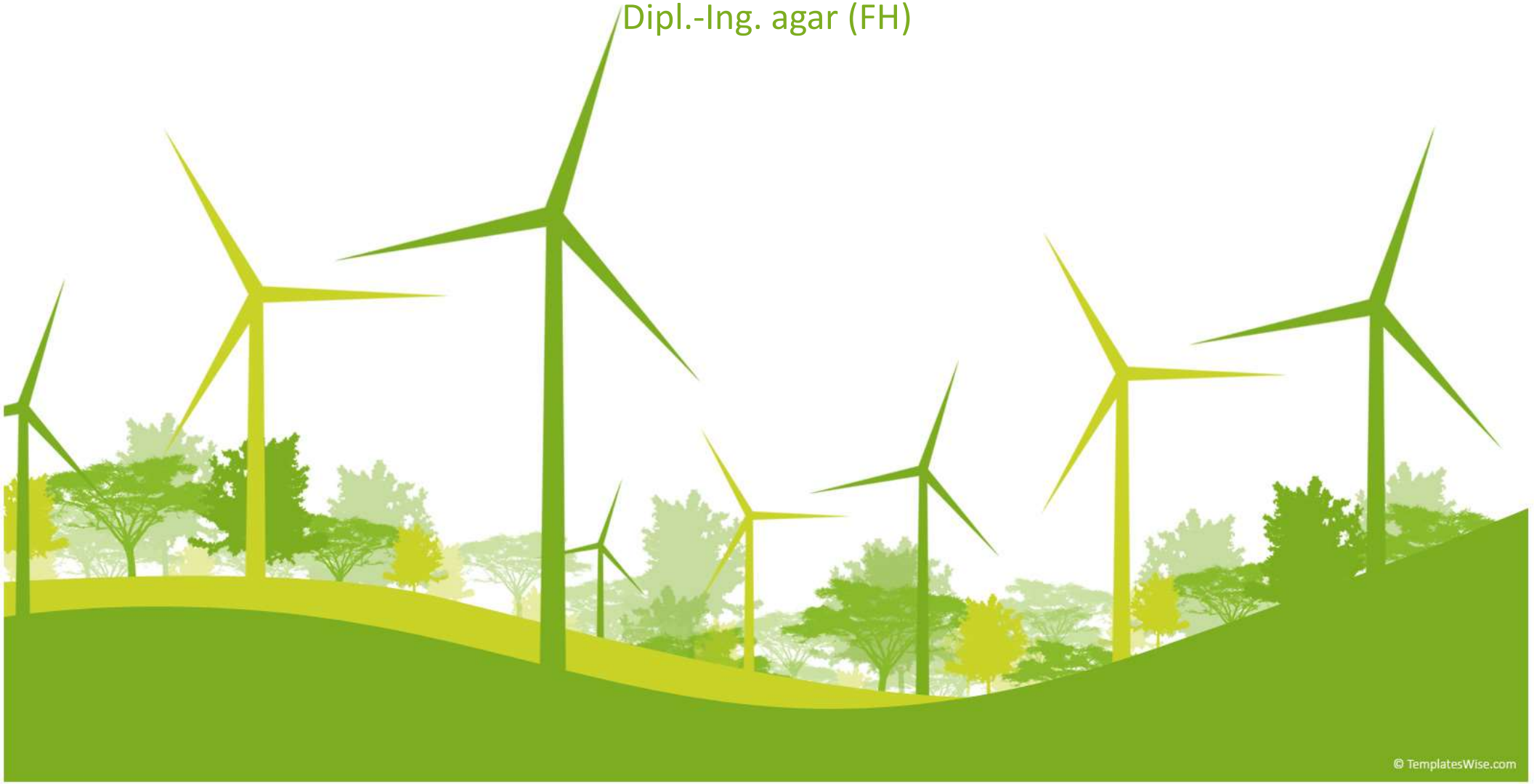
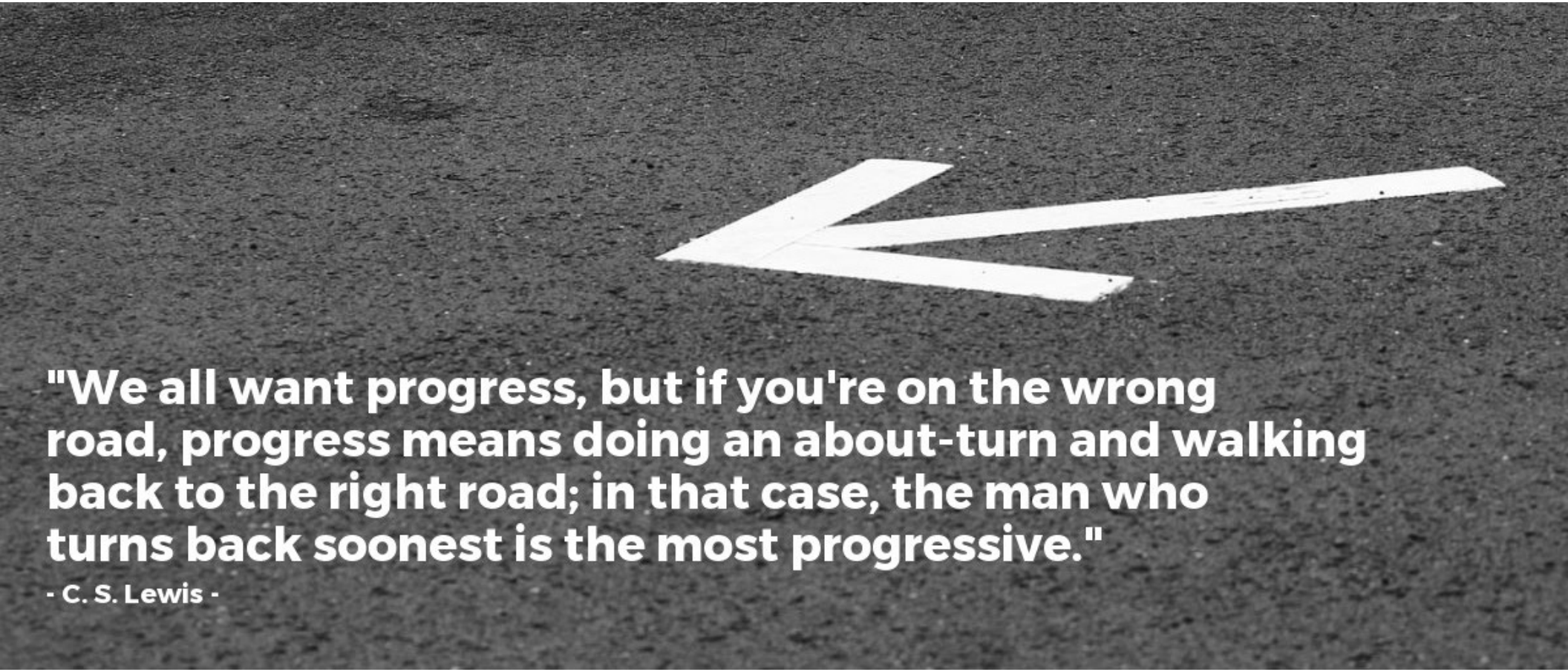


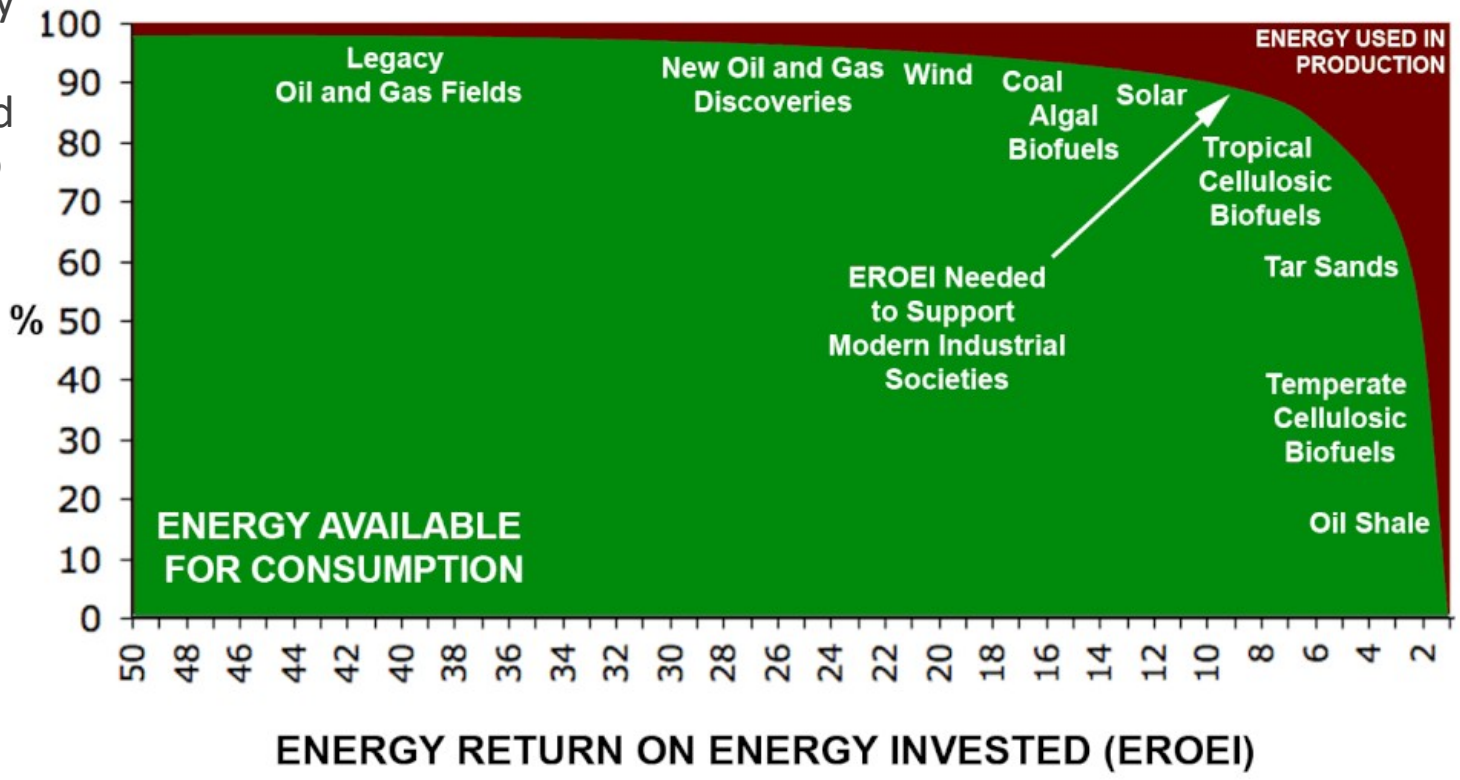
Bridges to Nowhere



ERoEI (Energy Returned on Energy Invested)

- An academic concept from the study of ecology (predator-prey, trophic levels) applied to the sector of energy technology (C. Hall, V. Smil et al.).
- Studied and worked on by many energy transition writers and influencers (R. Heinberg, N. Hagens, D. Murphy, E. Mearns, G. Tverberg, et al.)
- ERoEI is simply the ratio of energy gathered to the amount of energy used to gather the energy (energy invested): **ERoEI = energy gathered / energy invested**
- Previous consensus:
  - Low hanging fruit principle: ERoEI legacy oil > ERoEI new oil.
  - ERoEI >5 to 7 required for modern society to function.
  - "New" and "Green" energy sources have much worse ERoEI than old fossil technologies.

Source: https://commons.wikimedia.org/wiki/File:Net_energy_cliff.gif



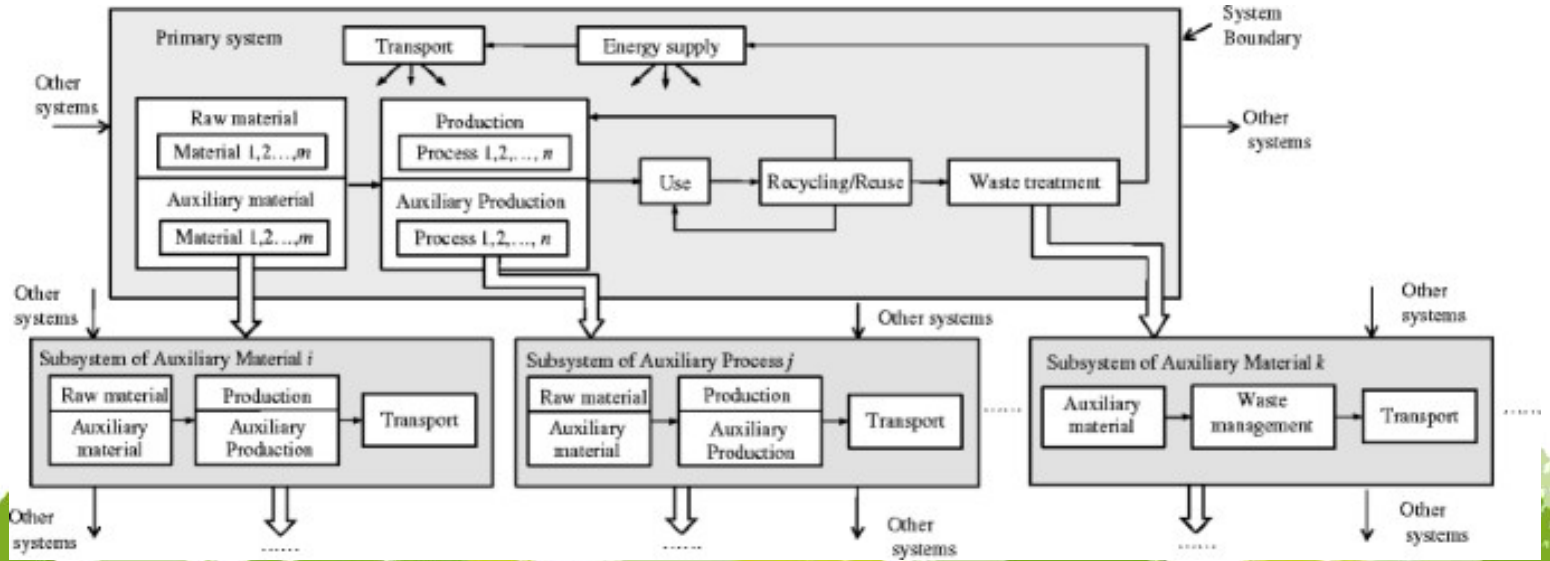
ERoEI (Energy Returned on Energy Invested)

Several shortcomings of the ERoEI method are widely accepted, including:

- Boundary issues: particularly around co-products, dual use, end of life recycling (very similar to the Achilles heel of LCA GHG accounting methods).
- Invested Energy (EI) can/should/must be limited to fossil energy only (EI_f):
  - It's pointless adding solar/air drying energy to a biomass scheme.
  - It's pointless adding solar energy (evaporation) to a hydro scheme.
  - What about hydro electricity for wind turbine manufacture (Y?,N?, in fossil fuel equivalents?).

    → as set of "Russian Dolls" of boundary issues.

Source: T. Li et al. (2013)



EROEI (Energy Returned on Energy Invested)

Overlooked Problem 1: The Denominator – Numerator Issue.

Example:

A NZ wood fuel scheme replaces 1PJ/y industrial steam boiler coal use with forestry waste biomass:

- Transport distances are far.
- Lots of processing and double handling.
- $EROEI_f$ is **10 to 1**.
- Nearly all input energy is diesel.
- Scheme replaces 44,000t/y coal, with
- 62,500t/y wood fuel.
- Scheme saves (gross) 95,000tCO_{2e}/y.
- Scheme consumes 2,200t diesel/y.
- Diesel emissions are 7,000tCO_{2e}/y.
- "Net" emission saving: 88,000tCO_{2e}/y.
- *Have the coal mining and mine gas emissions been netted in?*

Source: www.stuff.co.nz

EROEI (Energy Returned on Energy Invested)

Overlooked Problem 1: The Denominator – Numerator Issue.

Example:

The wood fuel scheme could install an on-site facility to convert a part of the forestry biomass to green diesel, eliminating almost all fossil (external) energy inputs:

- New $EROEI_f$ is **100 to 1**.
- The wood to diesel process is assumed to be 20% efficient.
- After diesel manufacture, the scheme can only supply 31,250t/y wood fuel, replacing
- 22,000t/y coal.
- New scheme GHG savings (gross) 47,500tCO_{2e}/y.
- Green diesel emissions are 0tCO_{2e}/y.
- "Net" emission saving: 47,500tCO_{2e}/y.
- Overall: NZ industry has 500,000GJ/y less (green) boiler fuel available.

Verdict: Improving $EROEI_f$ by shrinking the denominator is pointless!

Source: Licella Holdings Ltd.

EROEI (Energy Returned on Energy Invested)

Overlooked Problem 2: The Time Component.

Example:

Canadian canola-based biodiesel has a $EROEI_f$ of **50 to 1**, Canadian tar sands have a $EROEI_f$ of **2 to 1**.

Even excluding further environmental side effects and resource demands, biodiesel should by far outcompete tar sands on a strategic, economic (national level) and case specific financial level, based on $EROEI_f$ alone.

The problem is time:

- The 50 to 1 biodiesel $EROEI_f$ yield is delivered once per year.
- The 2 to 1 $EROEI_f$ yield from tar sand mining is available each day of the year AND every day.
- 50% of yesterday's 2 to 1 $EROEI_f$ gain can be invested today to yield another 2 to 1.
- Over 1 year the tar sands energy investment from 1st of January, yields 365 units vs. 50 from biodiesel, despite being vastly more inefficient!

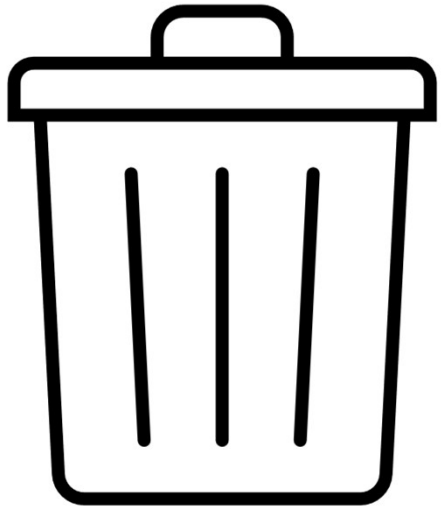
Source: www.reuters.com

Verdict: If $EROEI_f$ analysis can't qualify the time component it is pointless!

ERoEI (Energy Returned on Energy Invested)

What's the way forward for $EROEI_f$ analysis?

- Nate Hagens (2024): "ERoEI is a very cool idea, but operationally, not so useful"
- Luis de Sousa: "On the grand scheme of things: PV ERoEI estimates range from 30 down to 0.8. Before asking the IEA (or whomever) to start using ERoEI, the community producing these estimates must come down to a common, accepted methodology for its assessment. As it stands now, EROEI is not far from useless to energy policy."
- *Stephan Heubeck: "ERoEI analysis has fundamental flaws. Because or despite of this, the concept has repeatedly been weaponized against everything from wind energy to energy efficiency and PV to bioenergy. ERoEI analysis should be treated as a smoke and mirror argument until further notice and be kept well away from any energy policy discussion."*



Jevons Paradox

What is it?

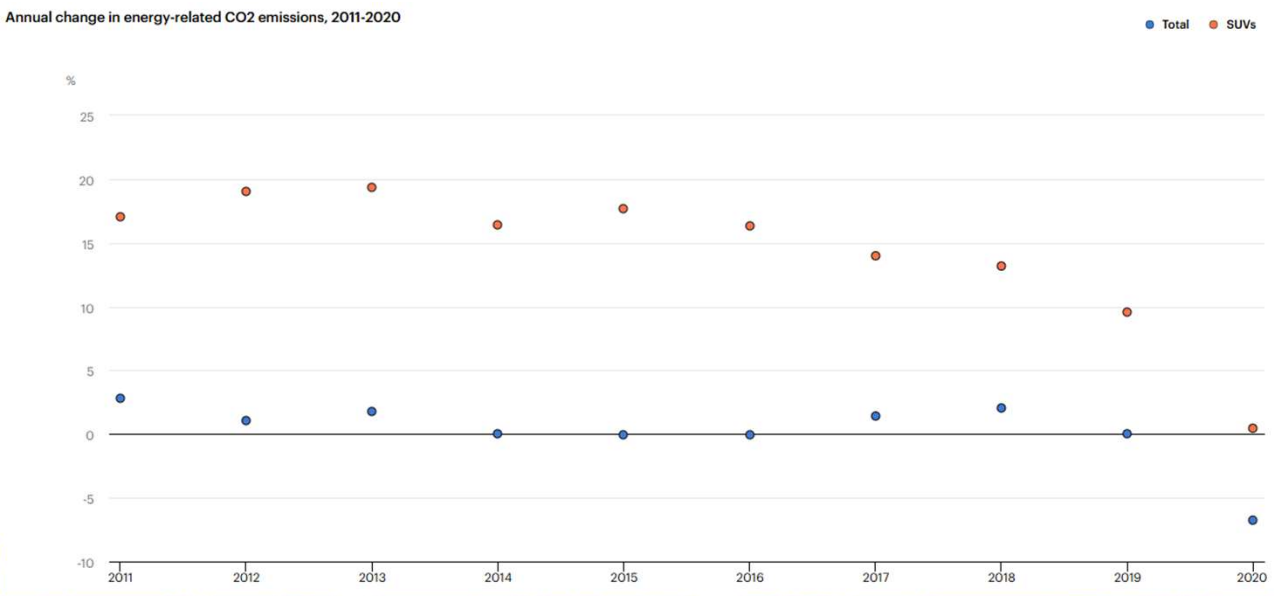
- Wikipedia: “In 1865, the English economist William Stanley Jevons observed that technological improvements that increased the efficiency of coal use led to the increased consumption of coal in a wide range of industries. He argued that, contrary to common intuition, technological progress could not be relied upon to reduce fuel consumption.”
- Academia and energy policy circles: “Net energy savings form energy efficiency measures may be smaller than anticipated due to rebound effects.”
- Popular press: “Energy efficiency measures lead to overall increased energy consumption.”

Source: https://en.wikipedia.org/wiki/Jevons_paradox#/media/File:PSM_V11_D660_William_Stanley_Jevons.jpg

Jevons Paradox

Issue 1: Jevons Paradox can hardly be a universal law, if it cannot be reversed.

- We lack empirical evidence that decreasing energy efficiency leads to overall reductions in energy consumption.
- To the contrary, we have empirical evidence that decreasing energy efficiency leads to overall increases in energy consumption.
- Example: The increasing share of less fuel-efficient SUV within the personal vehicle fleets of all OECD countries has let to SUV heavier (less fuel efficient, not more) transport being the only sector preventing total OECD GHG emissions form substantially falling between 2009 and 2020.
- An additional 300milliontCO_{2e}/y, should not have happened if Jevons Paradox would be reversable.



Source: (https://www.iea.org/commentaries/carbon-emissions-fell-across-all-sectors-in-2020-except-for-one-suvs

Jevons Paradox

Source: https://en.wikipedia.org/wiki/Justus_von_Liebig

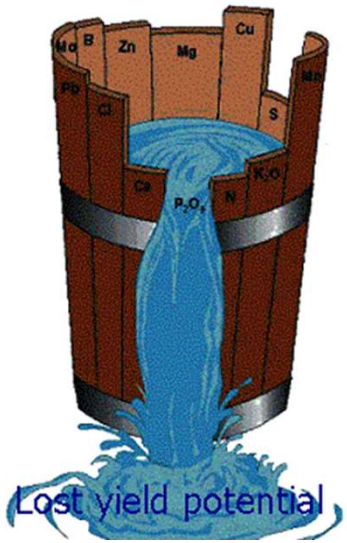
Issue 2: Jevons Paradox is not aligned with Liebig's law of the minimum.

- Like individual nutrients for plant growth (N,P,K, etc.), energy is only one of many in-put factors (labor, capital, physical space) in a consumption or production process.
- An overall increase in energy consumption based on more available energy from efficiency measures can only occur in situations where energy remains the first-limiting input factor in a production or consumption process.
- This situation would be rare in OECD countries, however, if this is the case even more energy efficiency would be the right cause of action!

Law of the Minimum – Liebig's Law

Justus von Liebig, generally credited as the "father of the fertilizer industry", formulated the law of the minimum: if one crop nutrient is missing or deficient, plant growth will be poor, even if the other elements are abundant.

Liebig likens the potential of a crop to a barrel with staves of unequal length. The capacity of this barrel is limited by the length of the shortest stave (in this case, phosphorus) and can only be increased by lengthening that stave. When that stave is lengthened, another one becomes the limiting factor.



Jevons Paradox

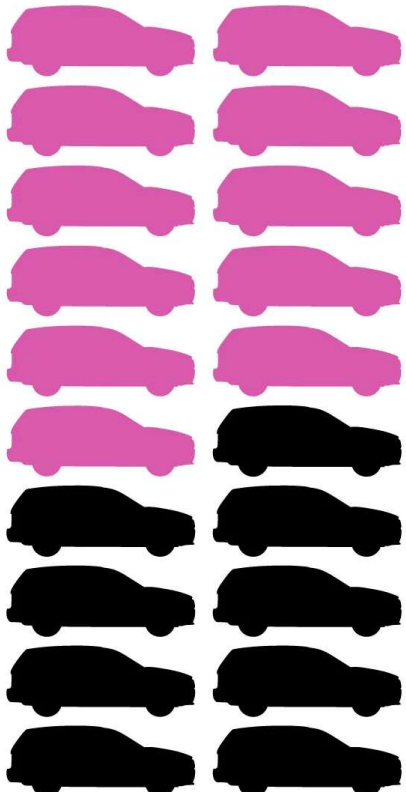
Summary: If Jevons Paradox is not reversable and not aligned with Liebig's law of the minimum, what is it?

- On the part of William Stanley Jevons, it was a confusion of correlation and causation. At the height of the industrial revolution, coal consumption was substantially increasing, irrespective of efficiency gains.
- Within academia and energy policy circles, Jevons Paradox is a red herring and distraction hindering very important energy (and resource) efficiency work.
- Within the popular press, Jevons Paradox is a weaponized smoke screen, aimed at preserving the status quo for the incumbency.

Inefficiency always counts against us!

55%

of new vehicle purchases in 2020 were SUVs



Source: https://interactives.stuff.co.nz/2021/09/heavy-traffic-nz-vehicle-weight/

The non-existent carbon pulse from bioenergy

No alternative energy option has been as severely, unfairly and unscientifically criticized in recent years as bioenergy. Inadequate criticism includes:

- The “food vs fuel argument” which is invalid in a world were 28% of all produced food goes to waste (FAO 2013), and cases of obesity outnumber hunger 2 to 1.
- Pimentel D. & Patzek T. (2005) - made-up facts and numbers (ERoEI).
- ”Indirect land use change” – made-up facts and numbers, no emperical evidence.

More recent criticisim of bioenergy has come in 2 flavours:

”Bioenergy can only be called a renewabel, GHG neutral energy source once the replanted trees have fully grown and re-absorbed all emitted CO_2”

”In a world close to climate tipping points, every bit of additional / unnecessary CO_2 in the atmosphere needs to be avoided, even if bioenergy is GHG neutral long-term”

Source: www.cngfuels.com

The non-existent carbon pulse from bioenergy

The criticism and worry about a ”carbon pulse” from bioenergy use falls short of a basic logic test:

Question: Why is bioenergy GHG neutral?

Answer: Not because regrowing plants can reabsorb the released CO_2 in the future, but because the biomass availabe, and usable for bioenergy applications today, will be converted into atmospheric CO_2 within a few short weeks / months (years) irrespective of bioenergy utilisation happening or not!

Addendum: This is irrespective of the biomass in question being a by-product, a purpose grown energy crop or an agricultural waste.

Source: Environment Canterbury

Source: Marlborough District Council

Source: NZ Herald

The non-existent carbon pulse from bioenergy

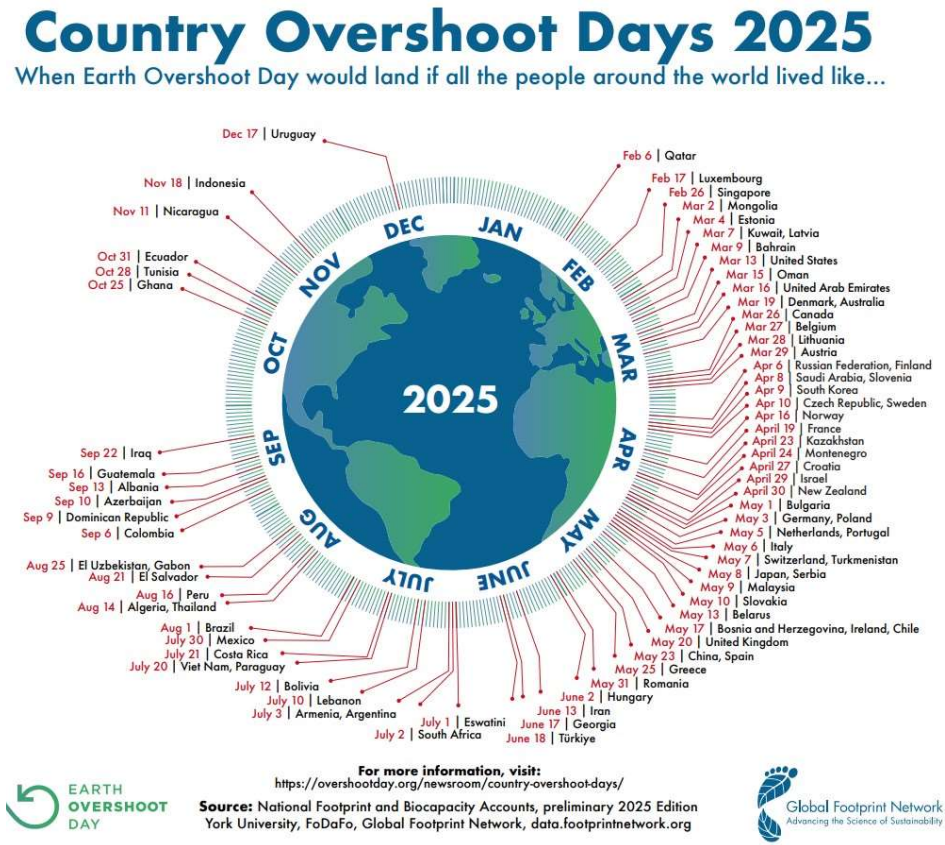
Bioenergy systems recycle carbon in a closed-loop between biomass and atmosphere. Short-lived accelerations or decellerations of parts of this cycle do not lead to additional ”carbon pulses” into the earths atmosphere, as the overall system remains in balance.

”Carbon pulses” from bioenergy systems are as unreal as an observer sliding down a hillside noticing the hill moving or the earth rotating, rather than his own descent.”

The elusive population question

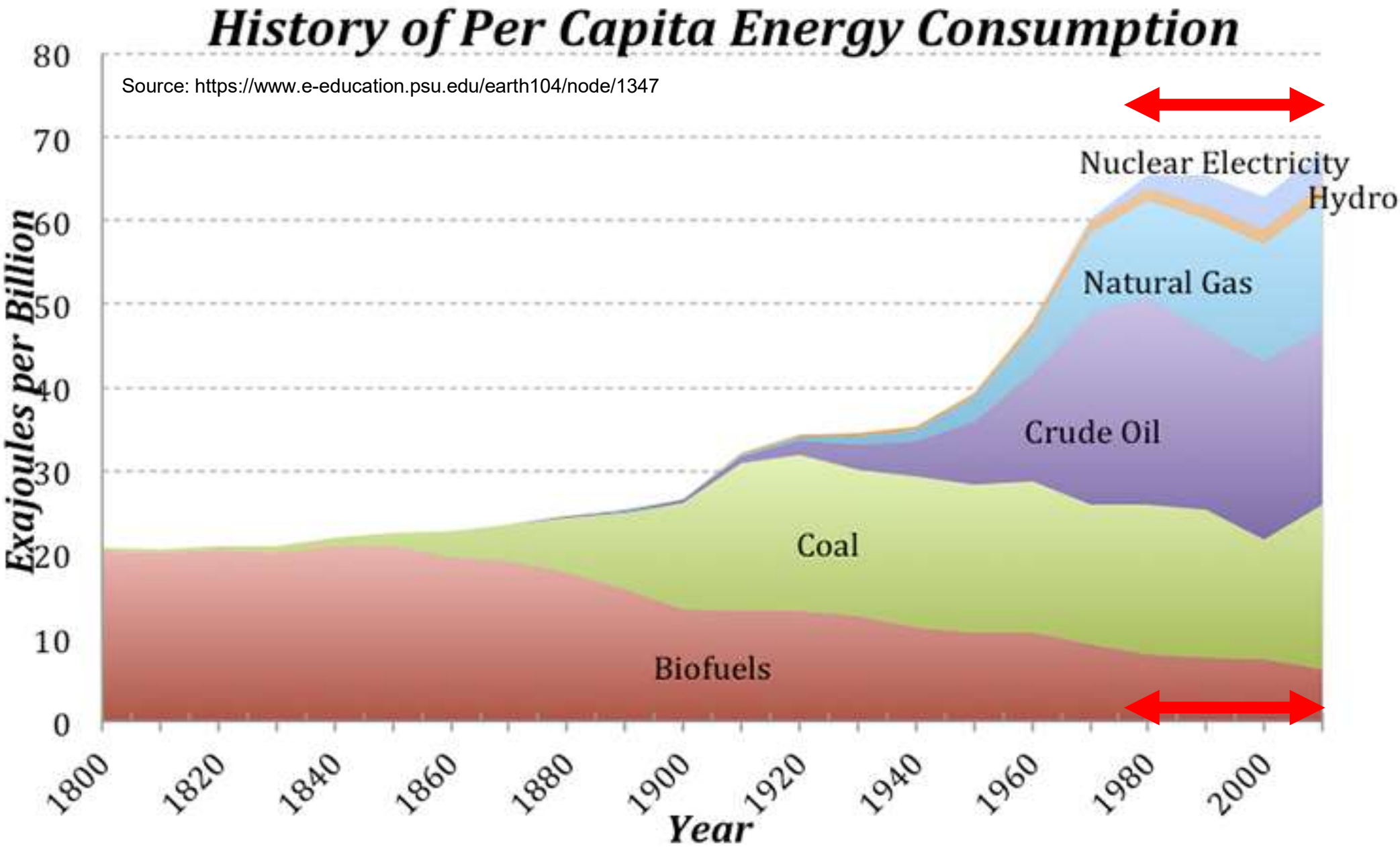
Many energy analysts exclude population size as a key variable from energy statistics, energy analysis or scenario modelling. The factor of population size is viewed as either unimportant, politically charged or taboo. Not only is this methodologically incorrect, but this also generates a whole raft of biased or inappropriate follow-on narratives, including:

- *Individual consumption levels, not population is the problem!*
- *Focus on the individual carbon footprint!*
- *If Westerner's would reduce their energy consumption to the per capita level of India / China / Mongolia there would be no GHG or energy problem.*
- *Prof. Serge Latouche: "For a sustainable future, per capita consumption in France needs to return to the level of the 1960's".*



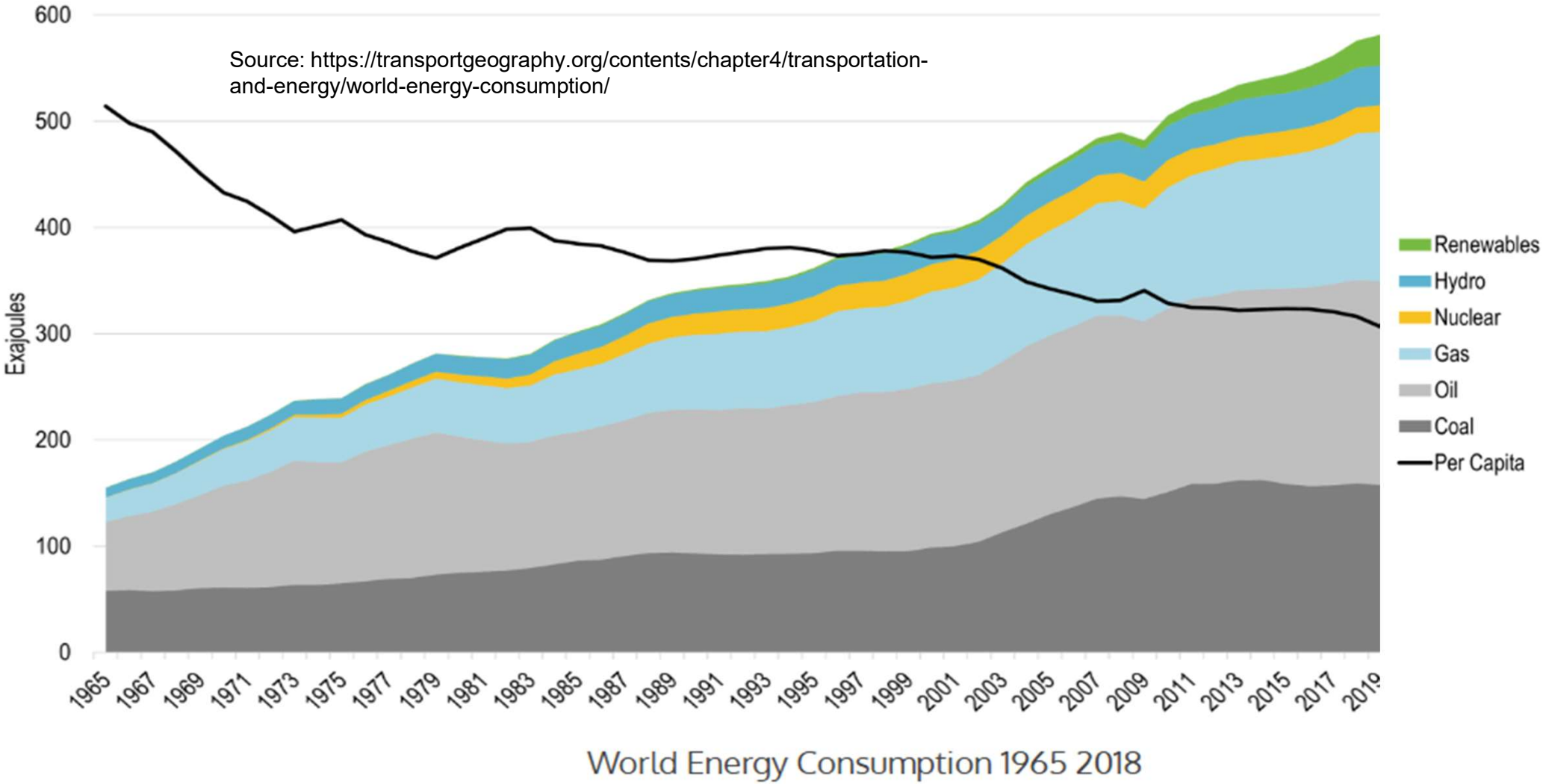
The elusive population question

Exhibit A: 45 years of quasi-stable per capita primary energy consumption 1975-2020!



The elusive population question

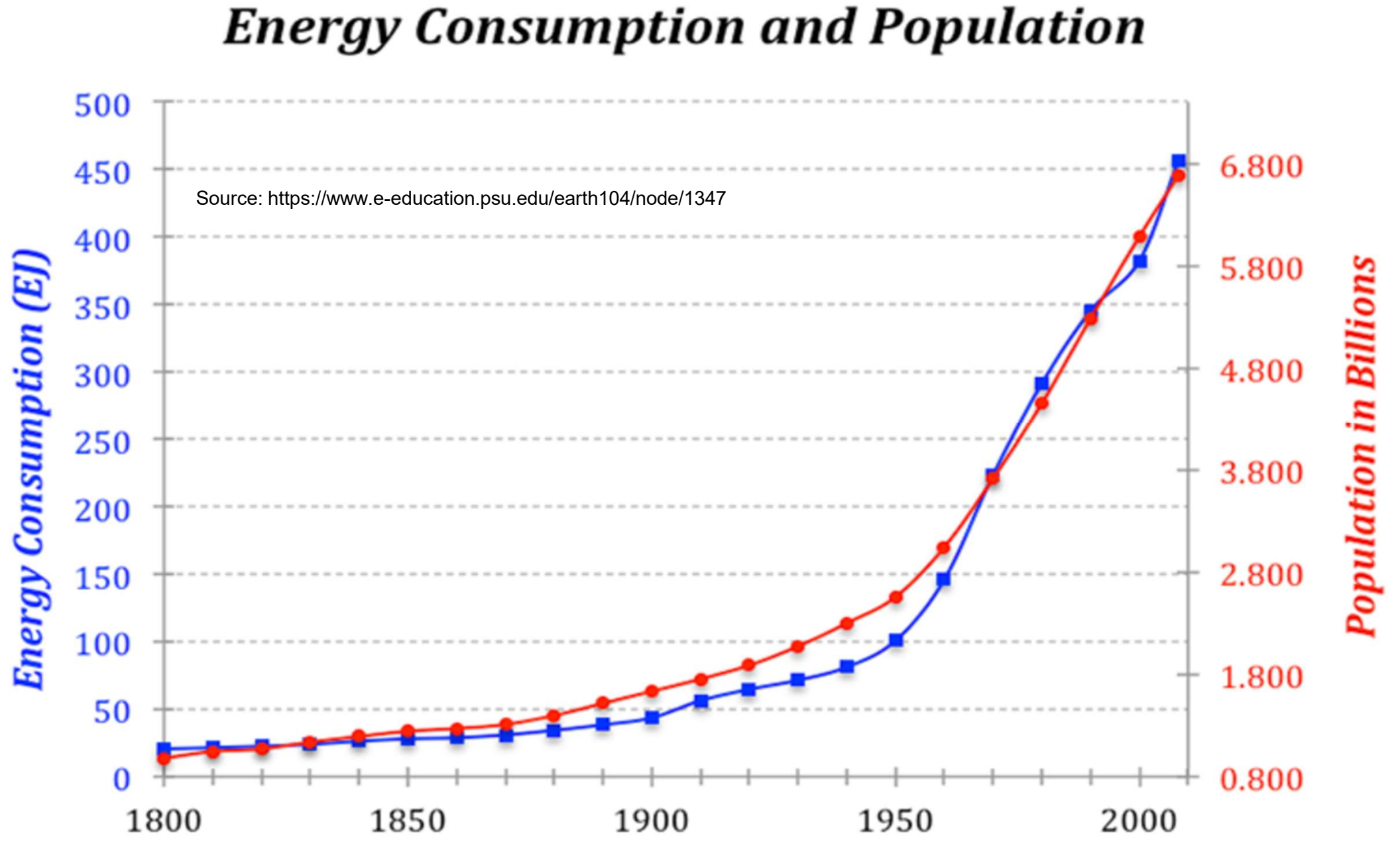
Exhibit B: Solely focusing on commodified energy resources, global per capita primary energy consumption has substantially declined from 1975-2020!



Source: BP Statistical Review of World Energy. Population data from Wo

The elusive population question

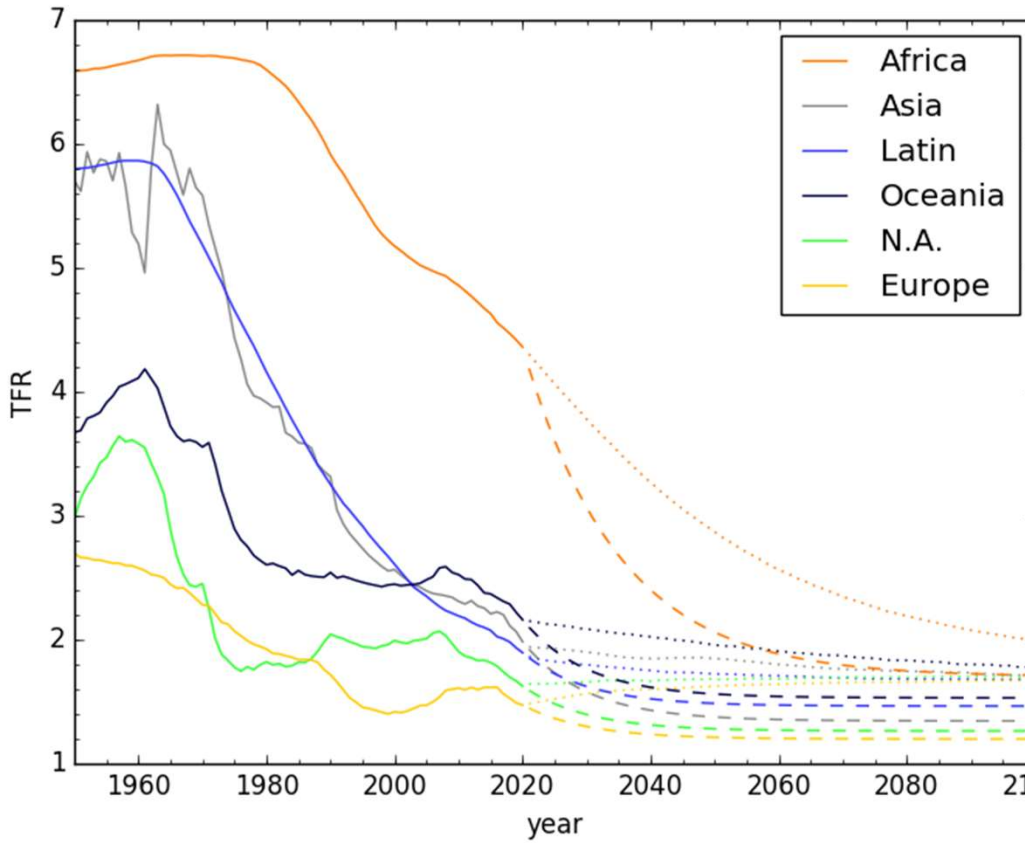
Exhibit C: Since the 1970's, global population growth has been the SOLE driver for increasing world energy consumption (and GHG emissions)!



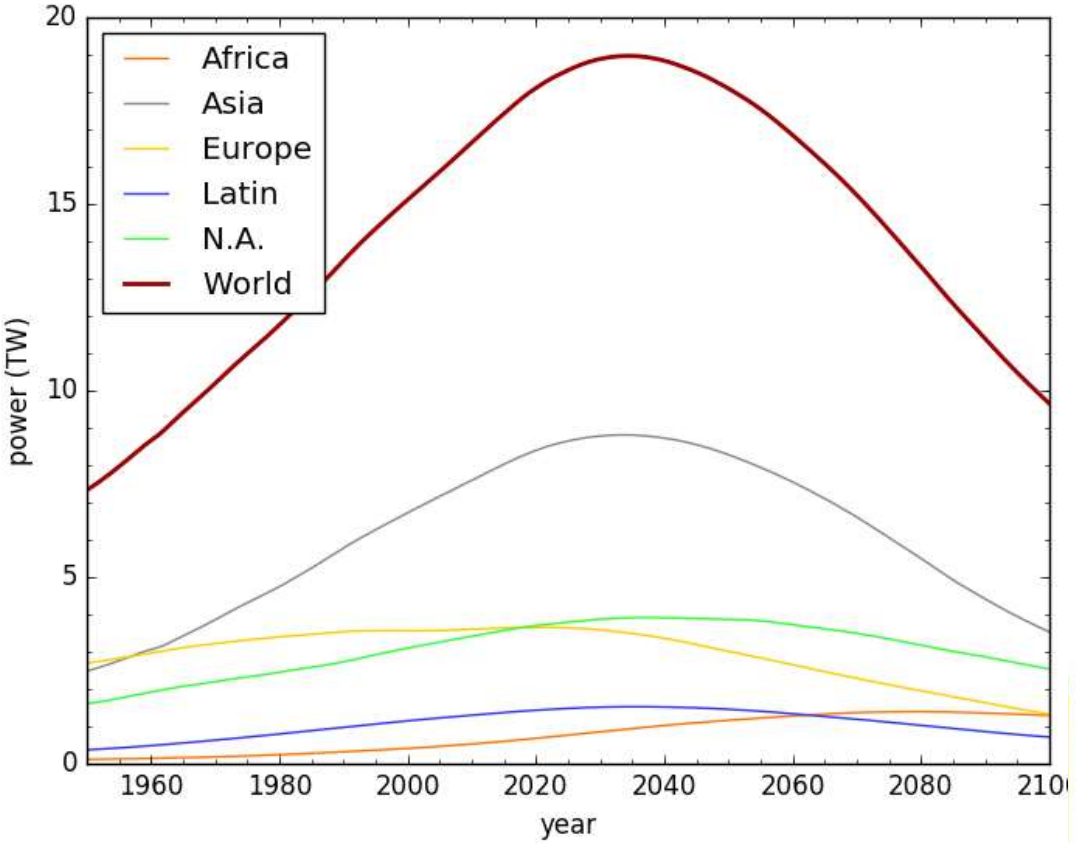
The elusive population question

- Population size is and remains a paramount factor for global and national energy use as well as scenario development.
- Declining fertility rates (TFR) all over the world might soon deliver population size driven reductions in energy use.
- The population question may continue to be ignored, not actively managed and not debated, but may still deliver a large positive contribution to global energy availability and GHG emission reduction efforts.

Declining global Total Fertility Rate (TFR) Source: Tom Murphy



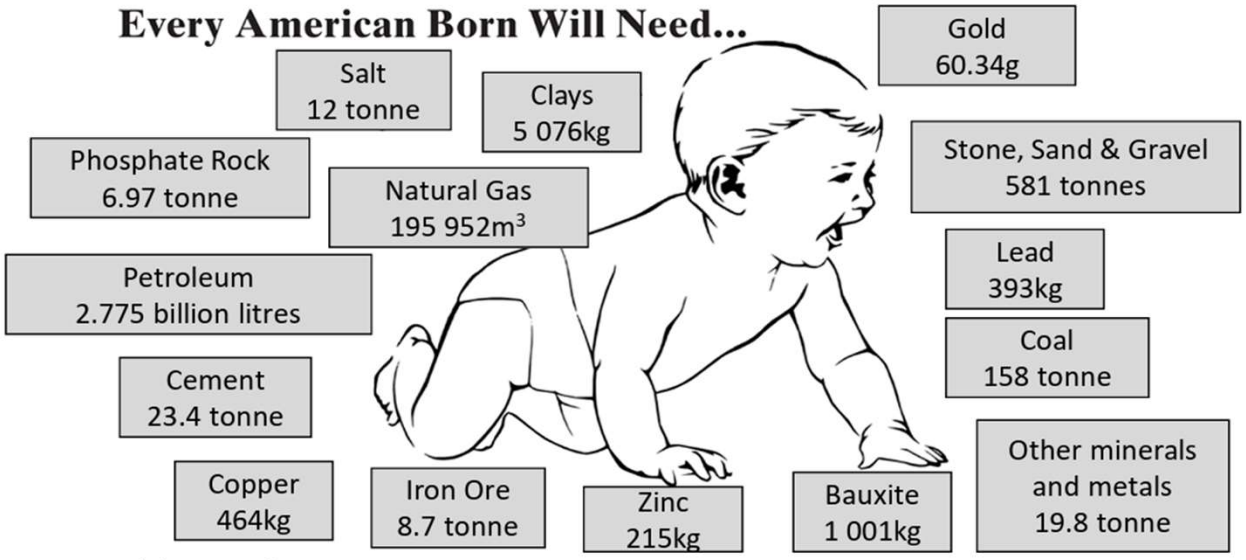
Shrinking global population reducing energy use Source: Tom Murphy



Bonus slide

- Per-capita energy consumption being flat for half a century, combined with the prospect for a declining global population is one part answer to the question of where all the minerals and resources for a green energy transition are going to come from. The green energy transition (possibly) will not have to supply and overall increasing energy demand, meaning an overall declining population could free-up additional resources.
- Second part answer: Fossil fuels (coal, oil, gas) themselves, represent globally one of the largest shares of extracted / mined resources. Reducing this enormous resource draw, frees up capacities for the build-up of green energy systems in terms of overall resources, but also labor, capital and required skills.

Approximately half of which is fossil fuel (coal, oil, gas), with the rest being primarily building materials. "Critical minerals" represent single digit %. Compared to potentially avoided mining through abandoning fossil fuels, even an increased demand remains within the error margins!



Total consumption over the lifetime:
1,37 million kilograms of minerals, metals and fuels

Author’s analysis

Why are the most progressive and radical sectors of the environmental movement so receptive for flawed analysis tools and inadequate arguments against renewable energy, energy efficiency and meaningful GHG emission reductions, which are often copied from the arsenals of fossil fuel lobbyists?

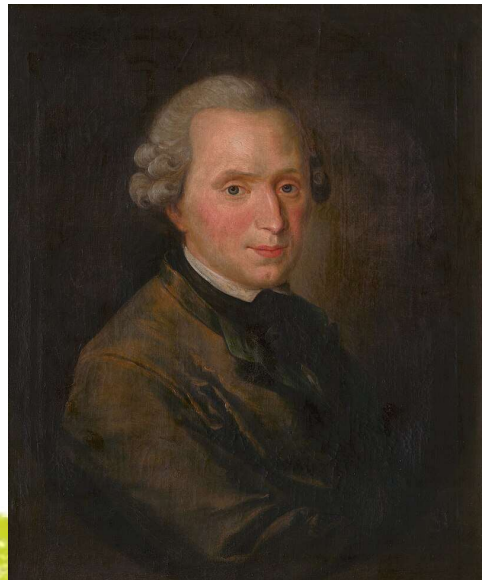
Source: www.imago-images.de

Author's analysis

Two schools of though appear to be in conflict:

- Sceptic viewpoint: Mankind has inflicted enormous damage on the earths eco- and life-support- systems, primarily through industrial means of production and consumption. The methods that have caused the problems are unfit solve them. Therefore, we need to adapt completely new social, production, economic and organizational systems to address the existing problems.
- Utilitarian viewpoint: Mankind has inflicted enormous damage on the earths eco- and life-support- systems, primarily through industrial means of production and consumption. We need to mobilize and apply counteraction on an industrial scale to prevent more harm from happening and un-do damage already caused.

Source: https://en.wikipedia.org/wiki/Diogenes



Source: https://en.wikipedia.org/wiki/Immanuel_Kant

Author's analysis

Why do the two schools of thought have to be in conflict at all?

Why can't we have:

- More public transport AND more EV's instead of ICE road transport?
- Less intensive land use AND more bioenergy?
- More walkable cities AND only PassiveHaus design for all newbuilds?
- More energy efficiency AND gas networks converted to renewable gases?
- Old-fashioned rail transport AND high-tech PV technology?
- More autonomous home generation AND updated bi-directional electricity grids?
- Less reliance on foreign oil AND more jobs in NZ's neglected rural areas?
- Harsher energy use regulation AND more innovative new green energy concepts?
- More altruistic renewable energy leadership AND higher taxes on fossil fuels?

A way forward

Golden Rule 1: Energy efficiency is paramount – all the time and everywhere!

EECA TE TARI TIAKI PŪNGAO
ENERGY EFFICIENCY & CONSERVATION AUTHORITY

Energy efficiency first

By enabling energy users to access and implement energy efficiency, we can unlock substantial economic and environmental benefits.

- IEA: “Energy efficiency is called the “first fuel” in clean energy transitions, as it provides some of the quickest and most cost-effective CO_2 mitigation options while lowering energy bills and strengthening energy security.”

A way forward

Golden Rule 1: Energy efficiency is paramount – all the time and everywhere!

Don't do "dumb stuff" against energy efficiency. New Zealand examples:

- Government plans for the introduction of petrol car road user charge (RUC 2027)
  - One cannot trust in the steering function of ETS price signals on petrol consumption, to then negate the very effect by compensating with a much larger flat tax for all road users (indirect subsidy for fuel inefficient vehicles).
  - The OECD (2023) notes: "Fuel taxes are an efficient means of making drivers pay the climate-related costs of the use of fossil-fuel powered vehicles. Governments should continue to impose them for as long as these vehicles are in use. Revisions to their levels should ensure that the drivers of these vehicles pay the full cost of their carbon emissions, and of their air and noise pollution."
- Abolishing the residential low-user fixed electricity line charge tariff
  - An incentive to encourage electricity waste among NZ households at a time of continued electricity crises.

A way forward

Golden Rule 2: Focus on fossil fuel CO_2 emissions!

Roughly ¾ of the GHG emission and energy supply security / resource problems we are faced with are due to fossil fuel combustion (coal, oil, fossil gas).

- Focus on these essentials.
- Negative side effects of alternative energy systems, including cement CO_2 or fugitive methane are not unimportant, but minor and/or transient by comparison.

Source: https://teara.govt.nz/en/photograph/25906/kapuni-gas-production-station

A way forward

Golden Rule 3: If green energy action is possible today – do it today!

We are running out of time:

- The future won't provide any magic solutions by itself.
- Consider inertia and lead times. Petroleum-powered airplanes ordered today will be delivered in 2035 and will still be part of the active fleet in 2065.
- There will always be another pandemic, economic crisis, war or other excuse for not taking serious and immediate action on alternative energy, energy efficiency and GHG emission reduction schemes.
- Don't allow false, invalid or flawed analysis tools and inadequate arguments to undermining or delay progress with renewable energy, energy efficiency and GHG emission reductions possible today, any further.

Source: www.standards.govt.nz

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