General Introduction to Energy Transition

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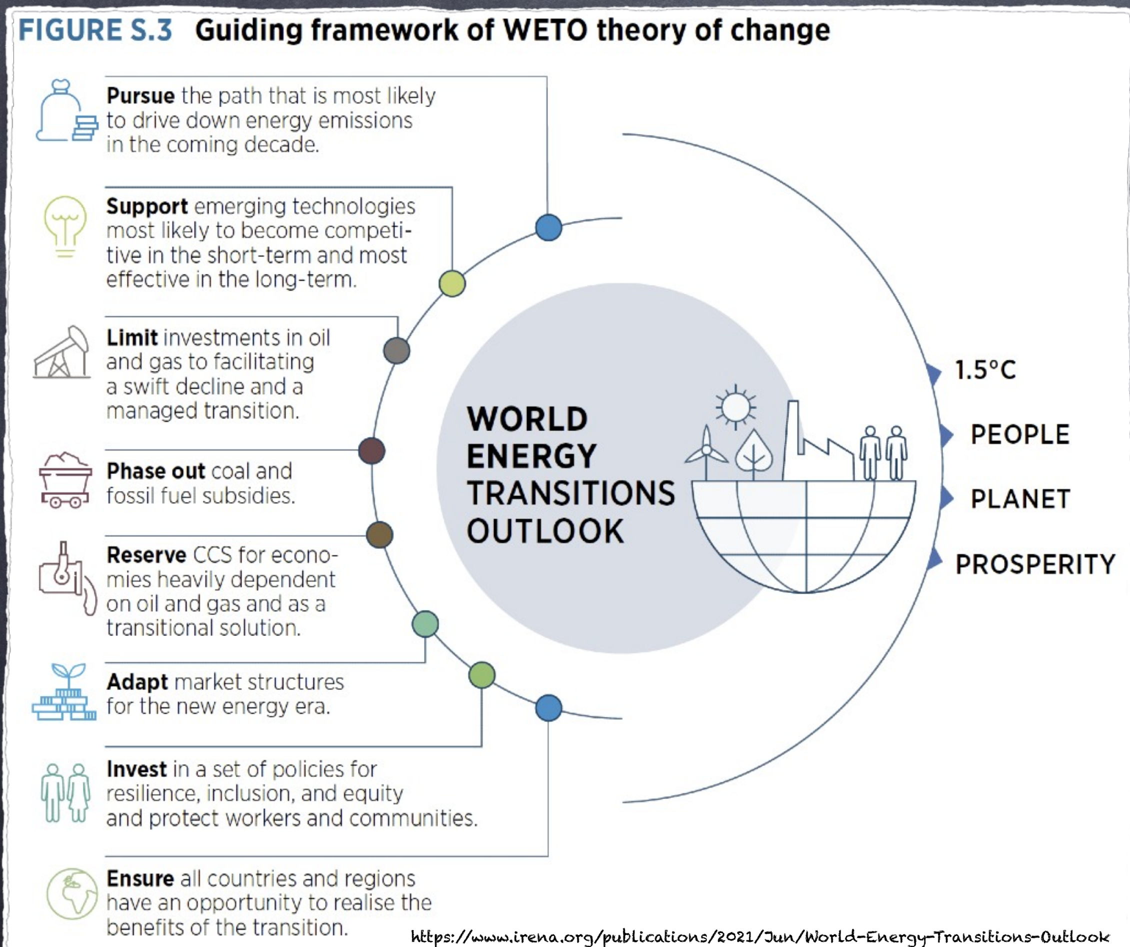
What is the Energy Transition?



The World Energy Transitions Outlook (WETO) outlines a pathway for the world to achieve the Paris Agreement goals and halt the pace of climate change by transforming the global energy landscape. They present options to limit global temperature rise to 1.5°C and bring CO_2 emissions to net zero by 2050, offering high-level insights on technology choices, investment needs, policy framework and the socio-economic impacts of achieving a sustainable, resilient and inclusive energy future.

What is the Energy Transition?

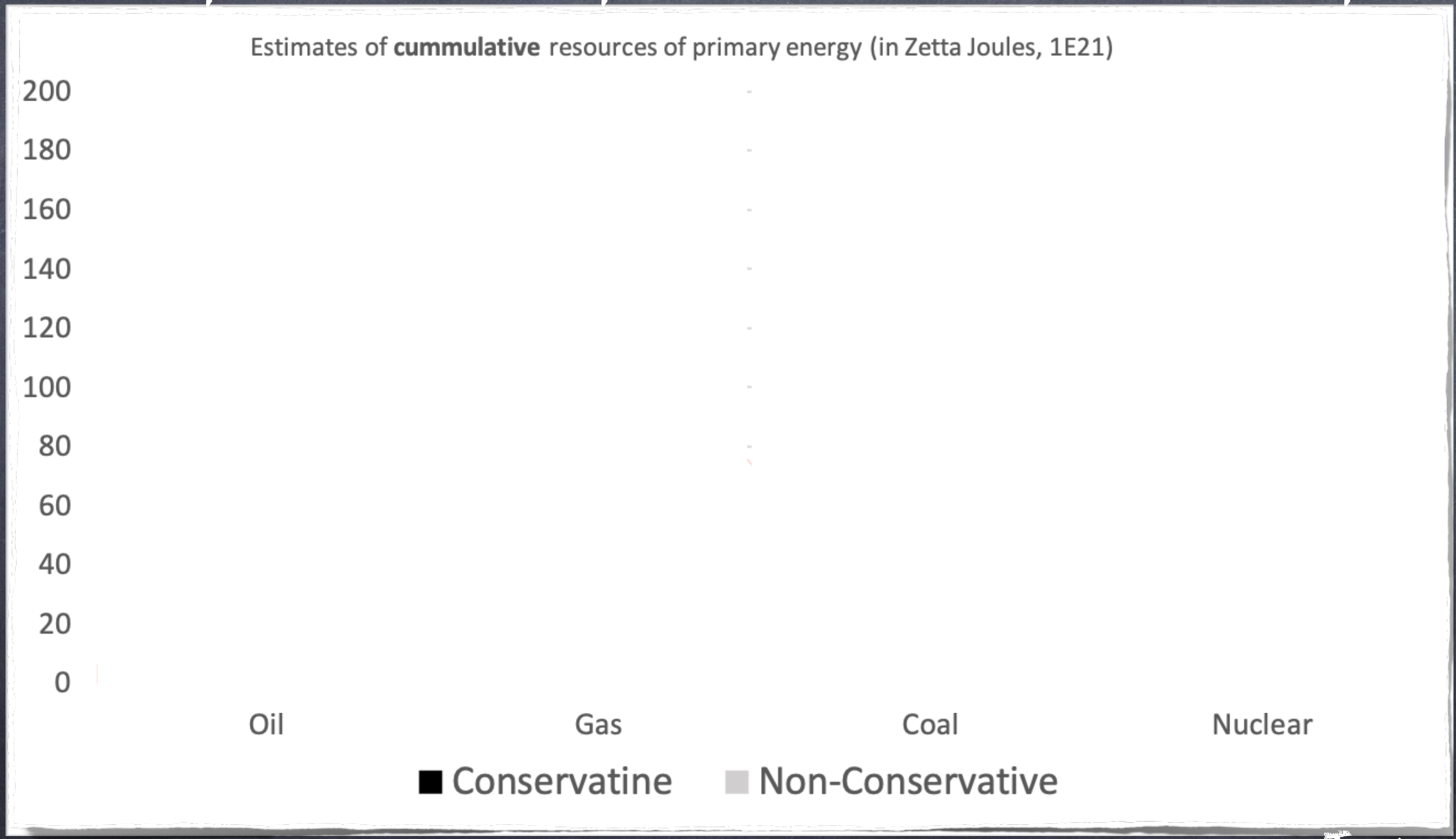
Six components of the energy transition strategy

https://www.irena.org/publications/2021/Jun/World-Energy-Transitions-Outlook

But...

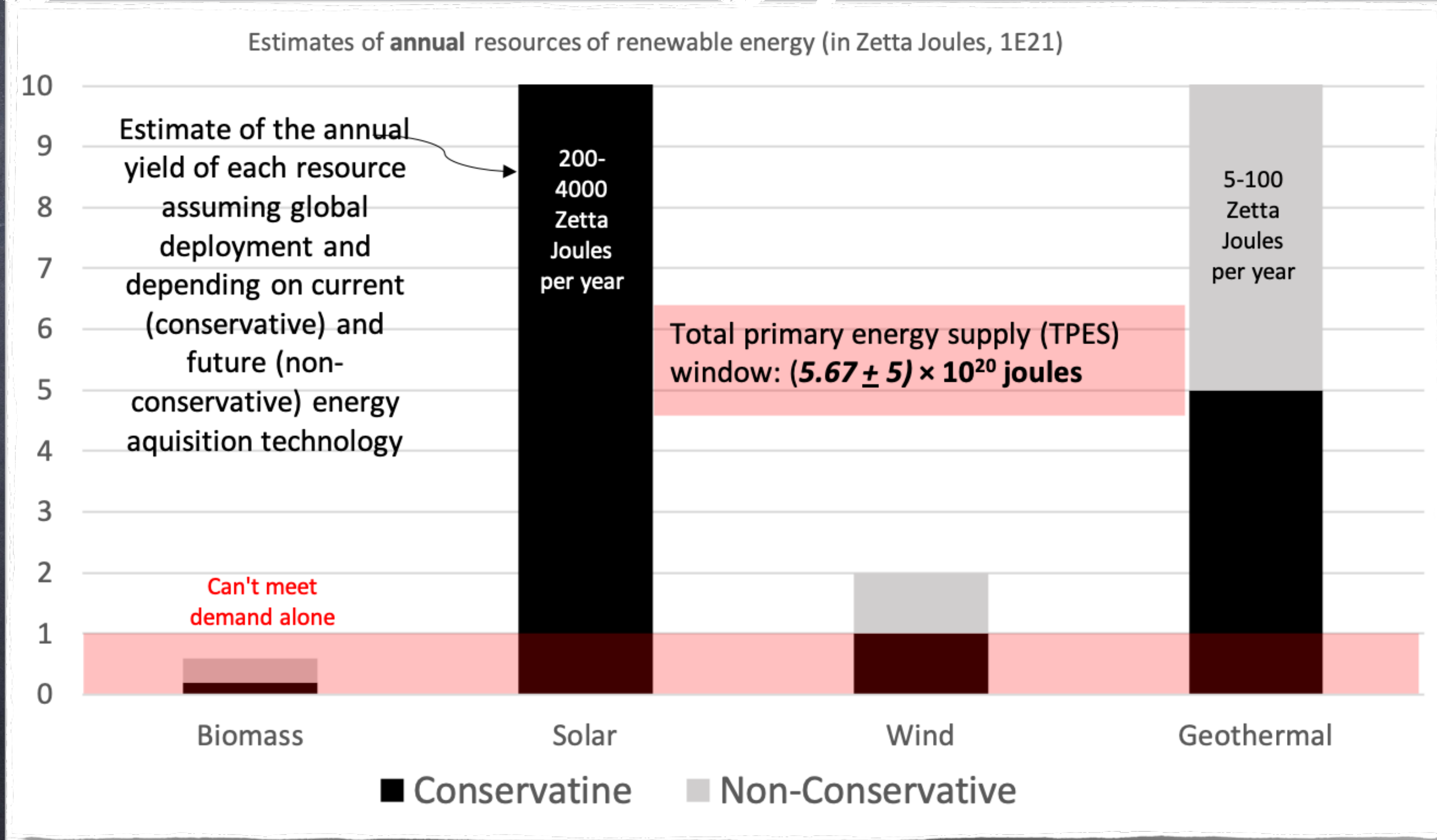
Energy transition goes far beyond CO2 emissions!!!

How many years of supply do fossil fuel have left?



Turner (2008, 2012)

Can renewables cover the global energy demand?



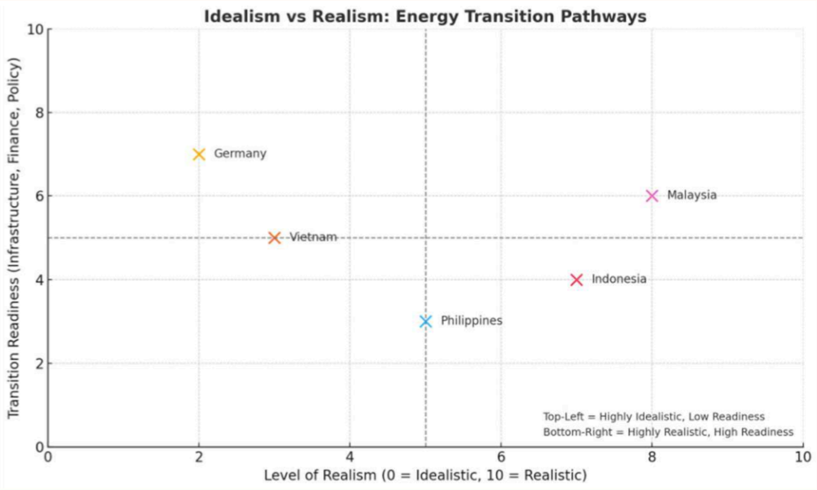
Turner (2008, 2012)

Energy Transition Plans vs. Reality

Idealistic and Realistic

Germany: Set aggressive coal and nuclear exit deadlines, now facing industrial decline and high-power prices.

Vietnam: Rapidly installed 17 GW of solar within two years but curtailed significant generation due to grid constraints.



Malaysia: Gradually expanding its solar fleet while enhancing grid codes, carbon pricing readiness, and financial instruments to scale investments sustainably.

Indonesia: Plans to reach net zero by 2060, with a pragmatic blend of renewables, CCS, hydrogen, and continued fossil use in the near term.

Y-axis (Transition Readiness):

- Low (0–4): Poor grid, limited private sector engagement, unclear policy frameworks.
- High (7–10): Strong infrastructure, clear financing mechanisms, mature governance.

X-axis (Realism Level):

- Far left (0–3): Highly idealistic, fast-transition goals without full infrastructure or financing.
- Center (4–6): Balanced or mixed strategy — ambitious but grounded on real capabilities.
- Far right (7–10): Very realistic, phased approaches based on available finance, technology, and social acceptance.

https://aperc.or.jp/file/2025/6/30/S2_1_Dr._Nuki_Agya_Utama.pdf

Energy Transition Plans vs. Reality

Contrasting Energy Transition Approaches

Idealistic Approach (Germany, Vietnam)

Very rapid transition speed with aggressive fossil fuel shutdowns

Infrastructure development often lagging behind ambitious targets

Heavy public spending, sometimes with private investment lag

Risks include grid instability and energy price shocks

Realistic Approach (Indonesia, Malaysia)

Gradual, phased transition aligned with actual capabilities

Managed decline of fossil fuels with partial retention (e.g., with CCS)

Blended finance focus, public-private partnerships, international support

Slower gains but more stable progress

https://aperc.or.jp/file/2025/6/30/S2_1_Dr._Nuki_Agya_Utama.pdf

Why the hell is this guy here, in a Geomechanics conference?

The role of Geomechanics in the Energy Transition

Energy transition goes far beyond CO2 emissions

- It needs to have a component of traditional fossil fuel during the transition (especially nuclear)
- It includes developing renewables (Geothermal, Wind, Solar) to cover the energy budget required
- It needs to be accompanied by Energy, Waste, Carbon and Hydrogen Storage

Why Geomechanics?

- The main challenge for shallow geothermal is the long-term performance of the system under coupled THM effects
- The main challenge for offshore wind energy is large pile installation design and their long-term cyclic behavior
- The main challenge for radioactive waste disposal design is the very long-term response of the storage site to coupled THM effects
- The main challenge for H2 and CO2 storage design is the very long-term response of the storage site to coupled cross-scale THMC effects
- The main challenge in deep geothermal design is fluid circulation through impermeable formations and the very long-term response of the reservoir to coupled THMC effects

Why Geomechanics?

Skills required:

- Deploying large structures, including cross-scale effects and modeling for the long-term, needs scaling
- Taking into account cyclic and coupled effects, needs tight non-linear models
- System design and installation, requires uncertainty quantification and minimization

'. . . and we can save 700 lira by not taking soil tests.'

(Courtesy of Engineering Testing Laboratory, Phoenix, Arizona)

Enjoy the 2025 ALERT School!