Perspectives on transition & Net Zero scenarios

Context, complexities, contingencies, paradoxes & dilemmas

SA Roundtable for Energy Resources – 24 Oct 2023

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Disclaimer

This presentation represents my views and does not purport to represent the views of any others.

This presentation synthesises many of the author's ideas with materials many other sources. The presentation was not intended as a peer reviewed 'publication' and while I have attempted to include the main references and links to sources – there are too many to list in this format.

Please contact me if you want more information.

Perspectives on energy transition

- Context
- The scale and nature of transition – two worlds, dynamics in practice vs. in theory
- Lessons from recent events - or relearned – or maybe not
- Dissonance, confusion and confirmation bias
- Risk management

Energy & demand

5,727,000,000
(pop'n at time of Kyoto)

8,031,317,400
(pop'n end 2022)

9,750,000,000
(pop'n 2050)

65,810,000 pa
Annual additions +/- 1 x UK

~180,000 pd

Increasing decarbonisation scenarios →

	2019 (ref year, WEO 2021)	(2022) 2050 STEPS (2.6°C)	(2022) 2050 Pledges (2.1°C)	(2021) 2050 Sust Dev (1.6°C)	(2022) 2050 Net Zero (1.5°C)
Energy Supply(1) / EJ (Δ2019)	613.0	740.0 (+21%)	629 (+3%)	577.9 (-6%)	532.0 (-11%)
Gas Supply / EJ (%TES, Δ2019)	141.1 (23%)	174.0 (23%, +23%)	133.2 (20%. -6%)	85.2 (15%, -40%)	40.0(5) (11%, -57%)
% Fossil Energy	79% A persistent and stubborn fraction	62%	39%	29%	18%
% of energy which is electricity(2)	~30%	42%	56% (CCS)(3)	51% (CCS) (3)	72% (CCS+CDR) (3)
% of energy which is wind & solar	1.5% ~CAAGR 18% from 2010-2019!!	11%	21%	26%	34%
Energy supply / GJ pp pa (4)	80	76 (-4%)	65 (-13%)	59 (-26%)	55 (-31%)

(1) Note that the figures are energy "supply" not "consumption".
(2) Major increases in electrification in all scenarios
(3) Scenarios include CCS, 2022 NZE also includes CDR
(4) All scenarios assume significant rise in world GDP & pop'n (22%)
(5) Range across several other 'deep decarb' scenarios (BP, Shell, Total, IRENA, Equinor) is 40 – 90 + EJs {1100 – 2500 – *4000* bcm}

Sources: modified after IEA World Energy Outlook 2021&2022; world bank data; and, UQ CNG analyses.
NB: IEA 2050 pop'n est. < 9.75B

When supply is restricted/expensive?

This really happened – a ground truth

2,500,000,000

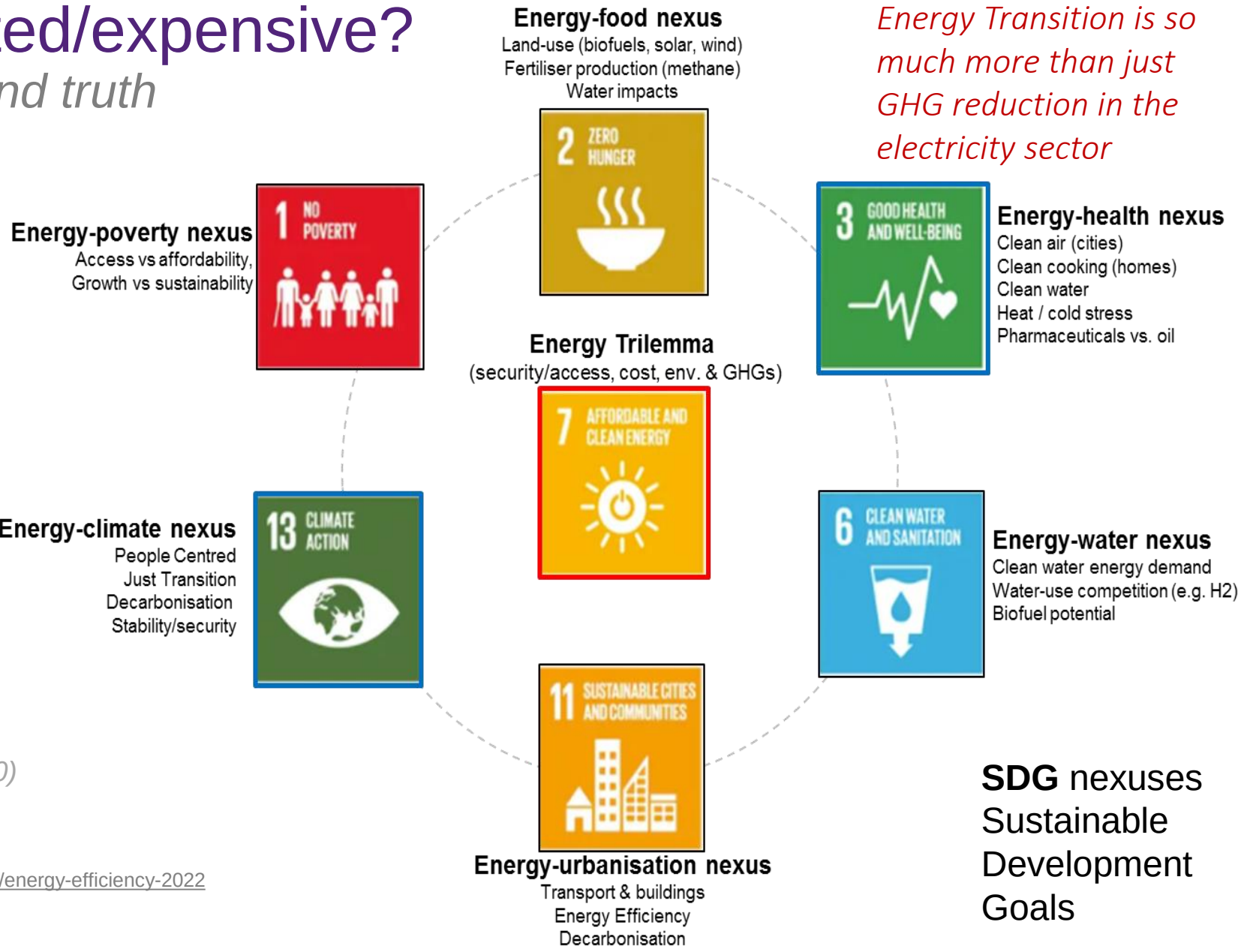
+ 100,000,000 (LPG->Wood etc.)

759,000,000

+ 75,000,000 (can't afford pwr)

+ 325,000,000 (Food Poverty)

660,000,000 *(S/S Africa 2030)*



Energy Transition is so much more than just GHG reduction in the electricity sector

SDG nexuses Sustainable Development Goals

Sources: worldbank.org,
IEA (2022), Energy Efficiency 2022, IEA, Paris https://www.iea.org/reports/energy-efficiency-2022
IEA, WEO 2021/22.
UN World Food Program 2023
https://sdgs.un.org/ and UQ CNG analyses)

Transition for me is not what it is for thee ... *Two worlds*

After... IEA-WEO-2021&22	Ref year GJ/pp pa	2021/22 Population		2050 Population[1] (% change)	2050 IEA[2] NZE GJ pp pa *(Fraction of current)*
Global	**80** (2019)	8,000,000,000		9,750,000,000 (+22%)	**55** *(70%)*
USA	**275**	332,000,000		458,000,000 (+38%)	*(20%)*
EU	**133**	447,000,000		500,000,000 (+12%)	*(40%)*
CHINA	**111**	1,412,000,000		1,320,000,000 (-7%)	*(50%)*
AFRICA	**26**	1,393,680,000		2,489,280,000 (+79%)	*(x 2.1)*
INDIA	**28**	1,393,000,000		1,660,000,000 (+19%)	*(x 2.0)*

Just to get to only1/5th of energy supply of USA today by 2050

(1) Pop'n estimates from World Back and www.statista.com/
(2) WEO 2022, IEA 2050 Estimate is ~9.62B

Which Net Zero pathway / scenario ?

- take your pick – here are several different ones

Deep decarbonization scenario	Approx. Peak[1]	2050 gas supply bcm pa	Decline pk-2050 CADR %[2]	CDR &/or CCS ?
2023 IEA NZE 2050	*2024*	*909*	*-5.3%*	*YES*
2022 IEA NZE 2050	*2025*	*1055*	*-5.0%*	*YES*
2021 IEA NZE 2050	*2025-30?*	*1570*	*-3.0%*	*YES*
2021/2 IEA SDS (~1.6)	2025	2230	-2.1%	YES
Equinor Bridges	2025	1197	-4.5%	YES
BP Net Zero (2022)	2025	1658	-3.3%	YES
Shell Sky 2050 (Energy Security)	2025	1728	-3.1%	YES
IRENA 1.5S 2021	2025	2200	-2.2%	YES
Rystad 1.5 (IGU23)	2022	936	-4.9%	YES
Rystad 1.6 (IGU23)	2030	1872	-4.0%	YES
IEA APS (2022)	***2025***	***2408***	***-1.8%***	***YES***

Conclusion:

Even in a deep decarbonising future ..

1. Decline in gas supply is **driven by demand reduction** (not supply restriction) to avoid SDG damaging prices

2. There's a **very wide range of demand** (hence supply) outcomes – risk management?

In 2050: 900 to 2200 bcm pa : avg 1550

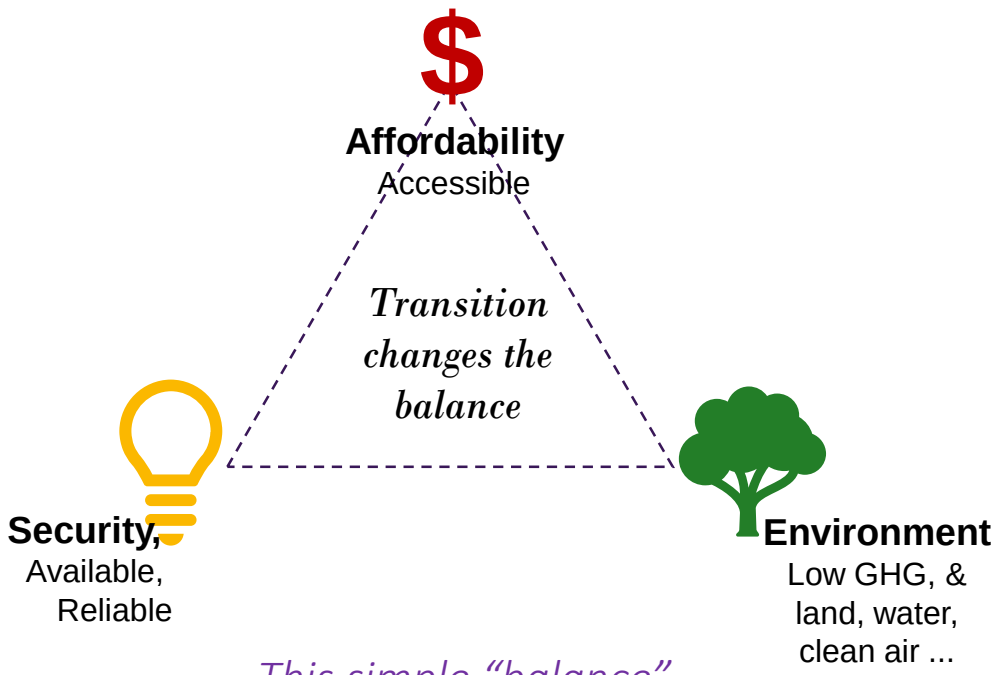
To 2050 – CADR 5% to 2% : typical 4%

Sources: Author analyses of scenarios from IEA, Equinor, BP, Shell and IGU/Rystad.
Note: 2022 supply est, 3,900 bcm
[1] Some peaks re-set to 2025 if before 2023; [2] CADR= compound annual decline rate - assumes constant rate compounding

Energy Trilemma – is not in practice what we imagine?

Lessons from shocks and choices ?

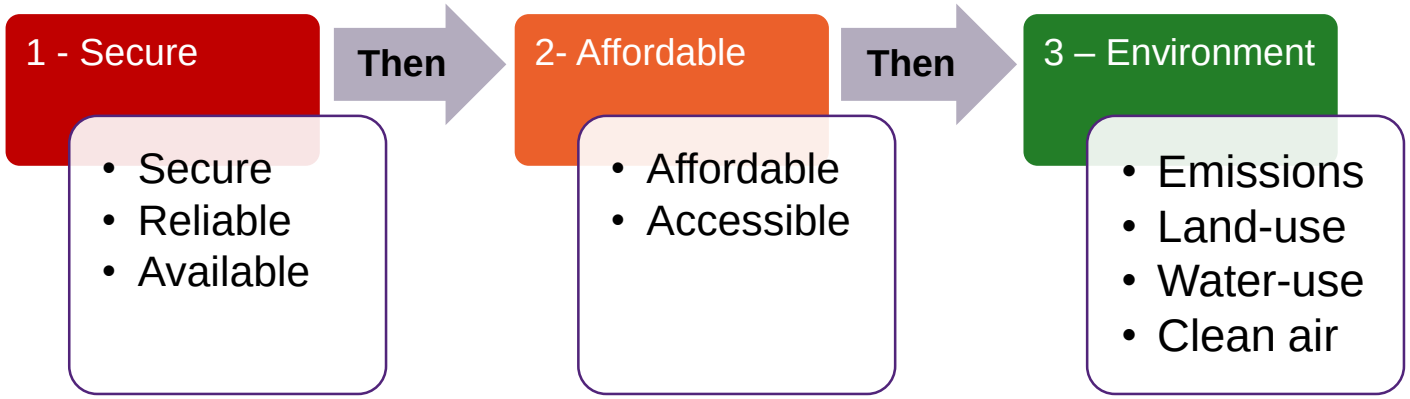
Energy Trilemma & the <u>Transition Pace Dilemma</u>



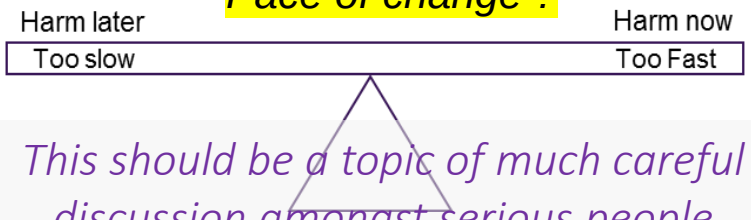
This simple "balance" conceptualisation is attractive, but limited at best

But is it really a 'balance'?

In recent response 'no' - a hierarchy of value-in-action



Appropriate / feasible Pace of change ?



This should be a topic of much careful discussion amongst serious people

Supply vs demand balance - lessons COVID & Russia ?

- **The poorest suffered most** - energy diverted to people / countries who can pay, energy & food prices rose
  - SDGs #1, #2, #3 & #7 poverty, hunger, health, energy access … E.g. Pakistan and Bangladesh had fuel shortages
- **Emissions rose** (even during low economic activity post-COVID – could have been worse)
  - SDG #13. The power sector reverted to coal, the poorest switched back from LPG to wood, dung etc. ...
- All countries **added measures for long term energy security** … (investment in VREs increasing and …)
  - *China to host ~1/3rd of worlds new coal mines & ~2/3rd of world's planned new coal power(iii)*
  - *Major plans(i) to expand, extend and up-rate nuclear power France, UK, Belgium, Netherlands, Korea, India, Iran, Egypt, China ....*
  - *UK, Norway, US – more oil and gas licensing (and, at last, more CO2 storage licensing)*
- **Bizarre things happened** *in extremis*
  - demolish wind farms for lignite mines, switch off nuclear, built >9 Mtpa of import LNG capacity in ~ 1 year – while India imported cheap oil (x14) from Russia and global coal power generation rose to record levels …
- **Nexuses (SDGs) <u>really</u> matter**: if you have only one dimension of value ("reduce CO_2") you will case harm today for the poorest, the OECD can outbid the developing world, food insecurity can increase .....

(i) https://world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx
(ii) About 100 power reactors with a total gross capacity of about 100,000 MWe are on order or planned, and over 300 more are proposed
(iii) Bloomberg 09/22 & 04/23

Supply vs demand balance - lessons COVID & Russia ?

- ***Sequencing & Pace.*** ***If you restrict supply before "better", alternatives are ready and deployed at scale, prices go up, somebody goes short and <u>the Trilemma unravels</u>*** *… (an odd sort of virtue)*
  - Other ethics emerge … EU-Africa Energy Partnership *invest in "sustainable infra". and "now give us your gas"*
  - Calls to "stop supply / exports" (to those who need it) – Marie Antoinette economics
- **The poorest suffered most** - energy diverted to people / countries who can pay, energy & food prices rose
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Dissonance & Confusion

– beware simple conclusions

"***No new fields***" *(isn't that what the IEA says?)*

Why do we need new fields when there are already *plenty of reserves available*?

This is not an unreasonable question.

There's an underlying, understandable and common ***fallacy of construction***.

And it's' not *quite* what the IEA said, *and* they've just modified it ...

"***No new fields***" *(isn't that what the IEA says?)*

Why do we need new fields when .... there is already the required, secure, assured flows of gas-energy to satisfy demand, affordably, with lowest emissions, when and where needed in a very uncertain demand future, where failure to supply has real consequences? – *Ans: because this just isn't so*!

This is the actual question – much more nuanced (*reserves are not assured rate*)

There was an underlying, understandable and common ***fallacy of construction***.

And it's' not *quite* what the IEA said, *and* they've just modified it ...

Demand and supply to be kept in balance (focus on gas)

I. Substitution is the main driver ... "*clean energy is the main factor behind a decline of fossil fuel demand*" *(iii)*

II. Gas supply flows must closely match a very uncertain demand (*SDG lessons*) – flexible surpluses will be needed

- Global gas supply (actually 'demand') decline in NZE 2023 is ~5.0% pa
- Global gas decline with no investment is ~10% pa - shortages would occur *(much higher % for unconv.)*
  - *"Sequencing the decline of fossil fuel supply investment and the increase in clean energy investment is vital if damaging price spikes or supply gluts are to be avoided*" & now OK for "*...already approved [O&G} projects"*(iii)

III. NZE is not a '*no new investment*' case – the key question for us is, where should that investment be?

- It *really* matters where the future gas flow comes from ... (security, diversification, reliability, emissions, costs, SDGs)
- *In NZE gas supply 2050* is also less diverse(i) c.f.*1970s oil crisis*

Middle East share	from 17% to 31%
?Australia (i)	from 3.6% up to ?? (** *major change from 2021 NZE – Russia – still under revision*)

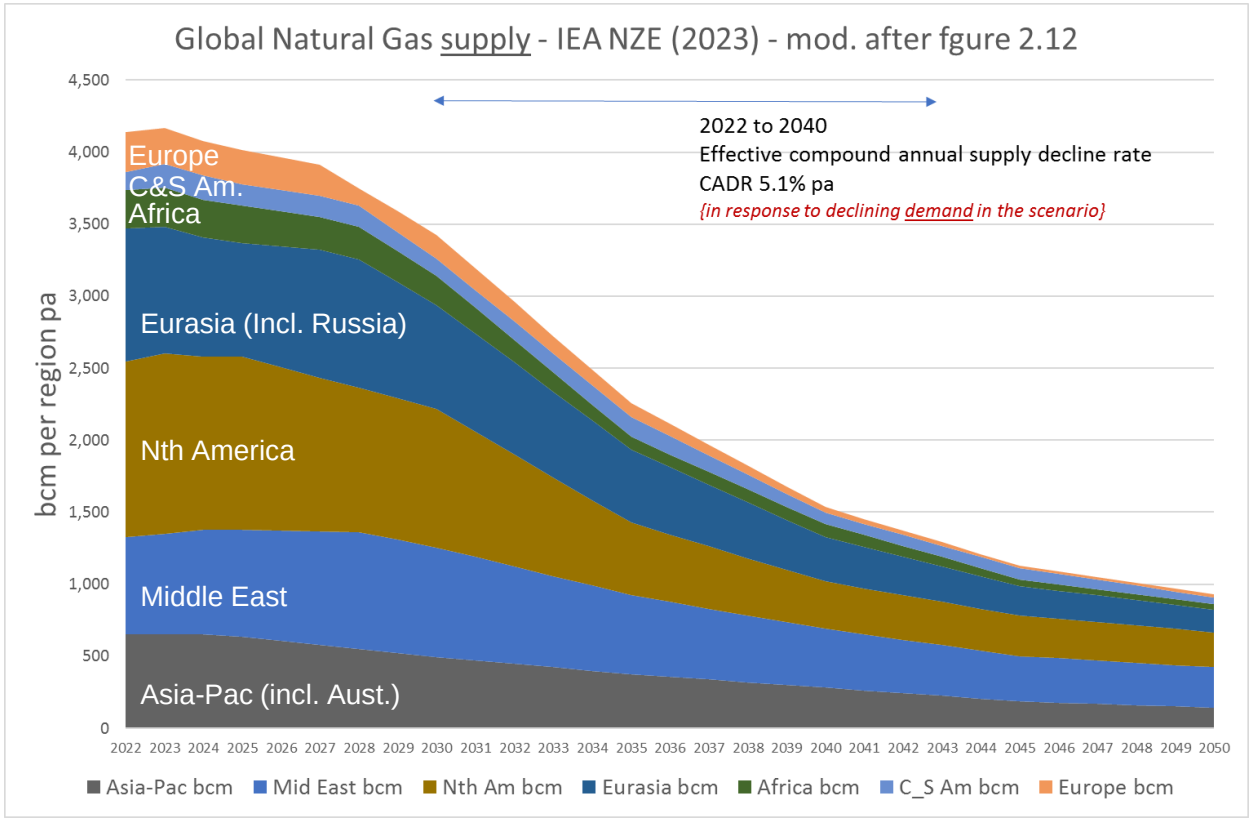
(est. 151 bcm in 2021 between 54 & 90 bcm(i) in 2050) ← *neither is logically consistent with 'no new fields'*

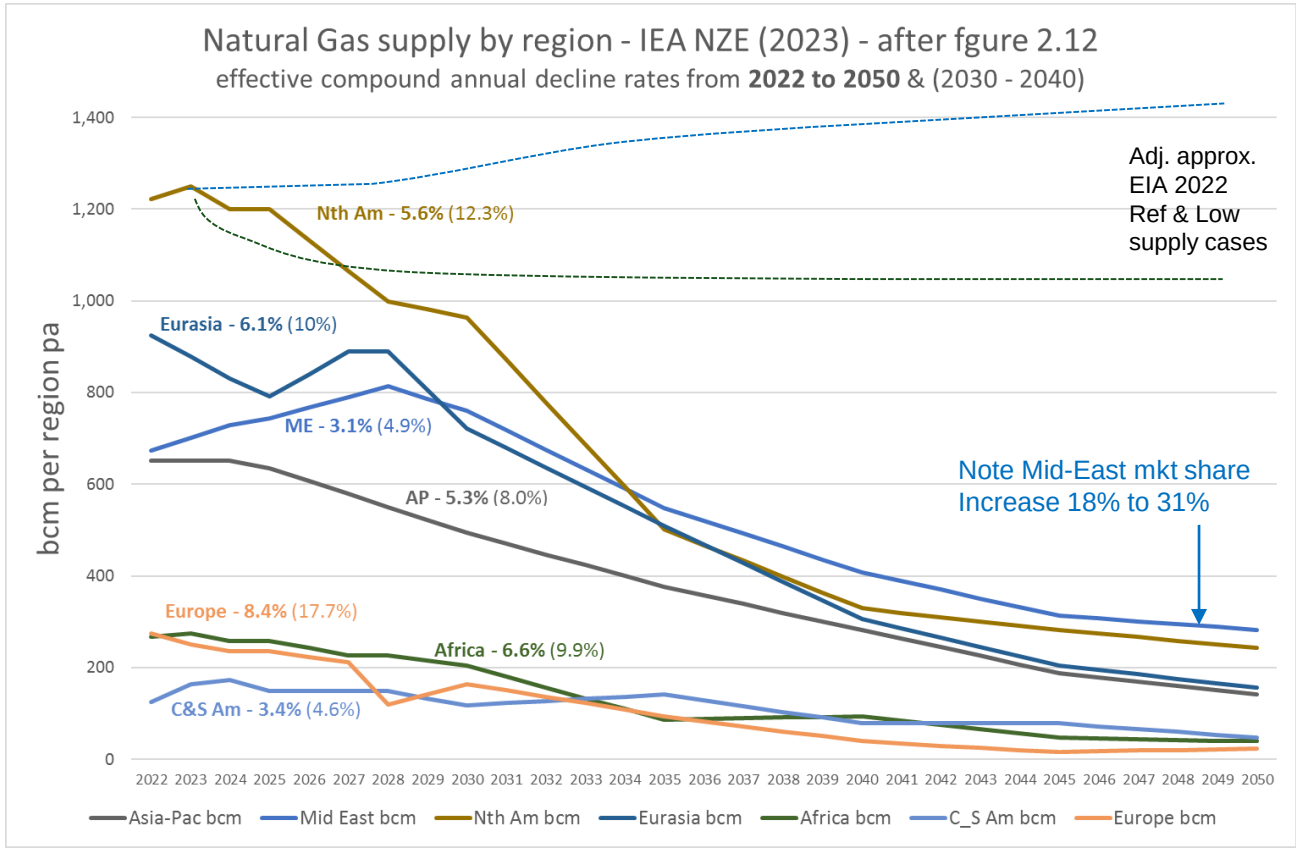
- *Oddly, if Australia increases market share (of a declining NZ demand) there'd be significant methane emissions reductions(ii) based on IEA Methane Tracker data vs. alternatives (Mid East, Eurasia, US)*

(i) Scaled and estimated by the author from published reports and data. *After*, modified from, the 2022 &2023, IEA NZE 2050 report (data sheet, supply trends & 2022 Figs 8.5 & 7.6 and 2023 Fig 2.12) .
(ii) Author analysis of IEA MT data suggests that Australia is on top 3 in terms of methane emissions intensity (kt CH4 per bcm production)
(iii) Updates from 2022 NZE included in 2023 NZE

IEA NZE 2050 (2023 update) decline rates vs. “no new fields” ?

Data extracted, modified[1] from IEA NZE 2050 (2023 update)





Sources: modified by author after fig 2.12 *in* Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach (2023 update) and US, EIA, 2022 data
www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach
[1]: these are approximate, not precise, IEA 2023 figures & EIA 2022 figures

Important: read all '*Net Zero Scenario*' as conditional ... IF/THEN's

Given	population, GDP growth and other SDG constraints ...
If	you want *this* scenario and its outcome ✓ Net Zero 2050
Then	*to be logically consistent* you must *(1)* want these <u>many</u> other things <u>all</u> to eventuate; *<u>and</u> also,* (2) believe that they can and will.
Then	energy demand would change in response and this would be the implication for energy supply ... solar/ wind/ gas/ nuclear etc etc.

The Simon & Garfunkel Effect & the net zero scenario *preference*

~(2022) 6-7% CO2e reduction pa (c.f. COVID), TES↓ 11%, Shares: FF from 80% to 18%, Gas from 23% to 11%

***Definition**: "Simon & Garfunkel Effect"* - when someone "*hears what he wants to hear and disregards the rest*"

Globally

By 2050		Much lower per capita energy use (esp. for us in OECD)
✓	*And*	1700% x Wind & solar (grids??)
?	*And*	250% x Modern bioenergy
?	*And*	190% x Hydroelectric
?	*And*	210% x Nuclear
?	*And*	9250% x CCUS energy supply (on 40 EJ & 335 GW_e installed)
?	*And*	**++electrification** [1] *rapid & massive expansion mining*[(i),(ii)]: [2] *new-energy supply chains*[(iii)]
	And	*technology that's not yet commercial ... and … and ... and*

Risk management

What is the energy-supply fall-back

if this does not all come to pass?

(i) More Copper to be produced by 2040 than in history; more Aluminium than in the last 150 years ...

(ii) *In* APS new mines by 2030 {Ni+60, Co+17, Li+50}: *in* SDS prod growth by 2040 {Ni x19;Co x21; Li x42 – NZE Larger)- *After* data in IEA Role of Critical Minerals in Clean Energy Transitions,(2022)

(iii) To avoid another energy diversification problem ... Currently 80% of PV is manufactured in 2 provinces of China, ... 95% of polysilicon, 77% of batteries, 70% of rare earths production ... And for gas a large concertation of market supply in the Mid East is "built-in" to the IEA NZE 2023 scenario

Supply of energy (resources) is demand driven ... and demand is *very* uncertain with many future risk factors

[1] <u>Satisfy demand</u>: Assure the rate of flow of energy to where its needed (protect the 'other' SDGs)

and

[2] Decarbonise *FF* supply & end use *asap*

while

[3] Developing and deploying "better" alternatives at <u>scale</u> – *also asap*

(secure, reliable, affordable, cleaner, functional equivalents)

and less energy per capita use (for us)
and far more renewables
and more energy storage
and a massive, rapid expansion of mining
and diversify new-energy supply chains
and deploy CCUS asap at scale
and reduce methane fugitives
and more modern biofuels
and more nuclear
and more hydroelectric dams
and better energy efficiency
and behaviour changes
and new business models
and ....

Transition and Net Zero ...

Scenarios are not forecasts or prescriptions

– *they're supposed to prepare and provoke the mind for strategic thinking*

"what if" and "what could be"

– *is this what really we're doing with them?*

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Domestic considerations (spares)

– volatility and domestic GPG demand

- think in terms of risk management: how to assure supply into a very volatile demand?

This work is from recent GENX system modelling work in progress at UQ Centre for Natural Gas

(Lane, Maurer and Garnett, 2022 & 2023)- contact a.garnett@uq.edu.au

Historic patterns are not representative of future demand ***volatility*** ...

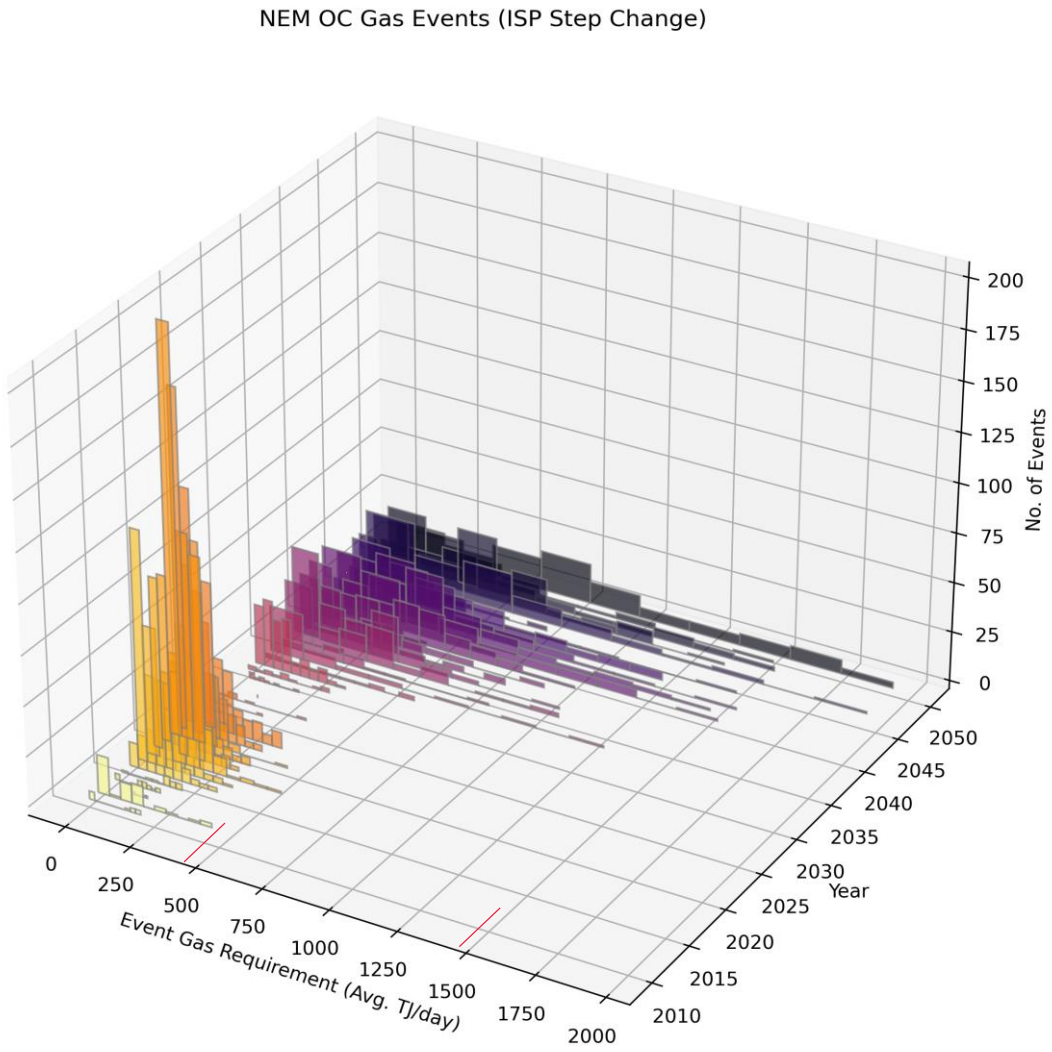
and future volatility is likely under-represented in models.

UQ CNG GENX modelling

- Yellow-orange – historic / actual data
- Purple – model data using ISP & equiv. weather data in GENX

Notes

- 2022 to 2030 *chart gap* is a modelling-display artefact
- Future modelled vs. historic gas demand (OCGT "on" events) substantially different
- ***Challenges***
  - Pipeline infrastructure sustained rate
  - Storage (size and intermittency)
  - > Business & market models
    - Power gen
    - Pipelines
    - Gas storage
    - Long term supply (production) assurance



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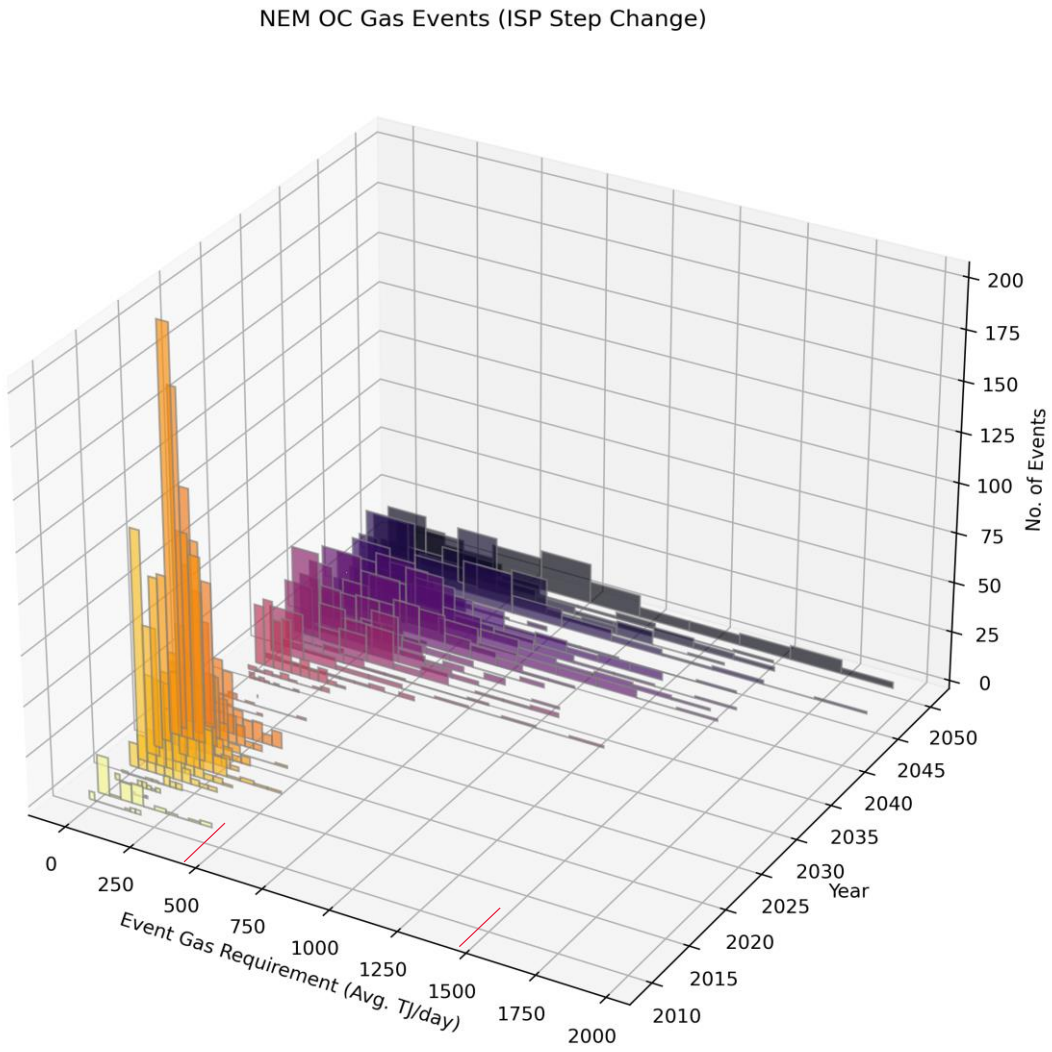
How do you support this extreme demand pattern?

Ans.

1. By having surplus created by an sustained export sector
2. By changing market model for gas storage & peakers (e.g. capacity mechanisms)
3. By more storage



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End

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