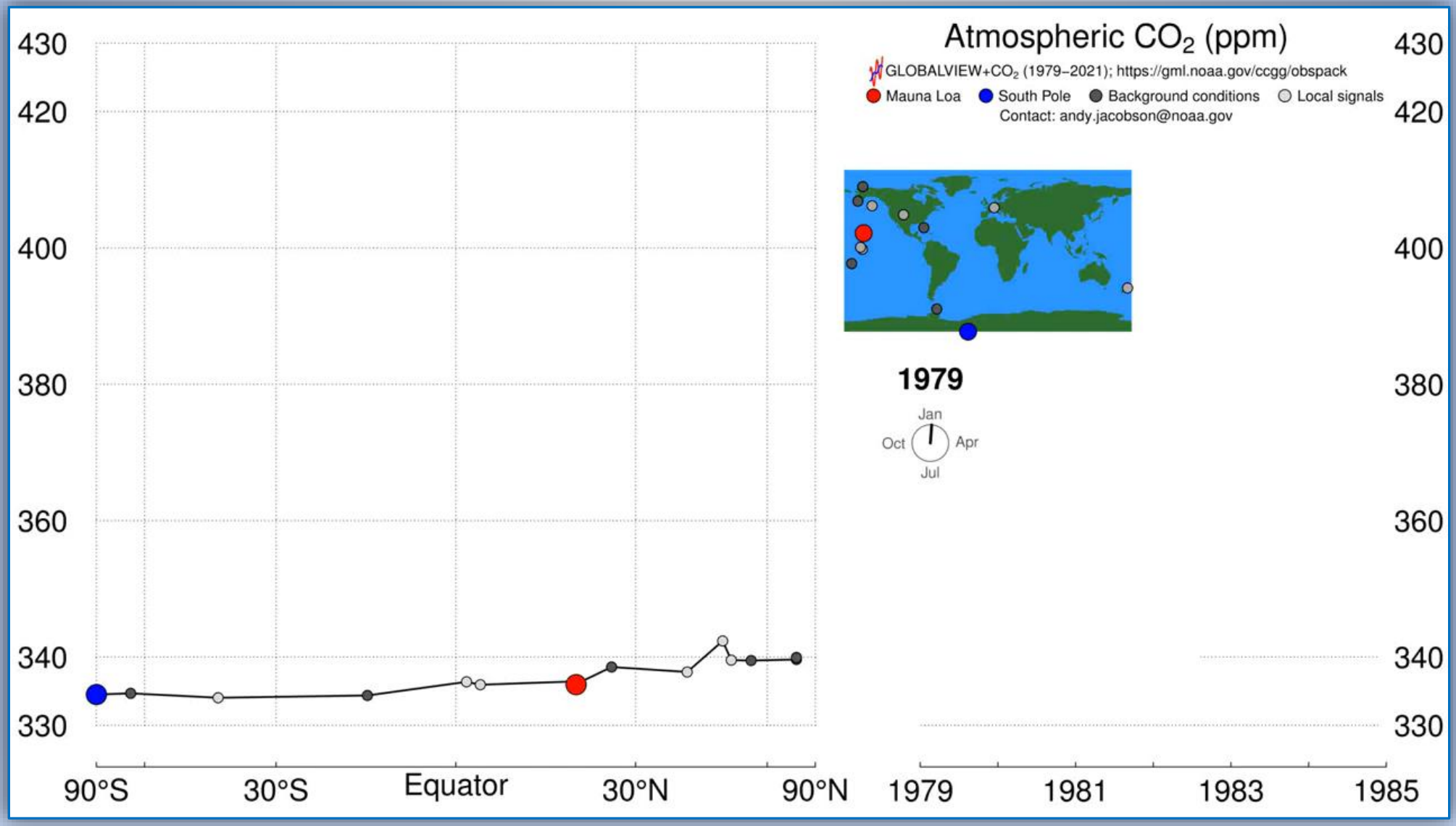
The Climate and Energy Crisis

Climate change has arrived and it's going to get worse, and how much worse depends on the decisions that we make this decade especially, this year and today.

Energy use is inextricably linked with climate outcomes.

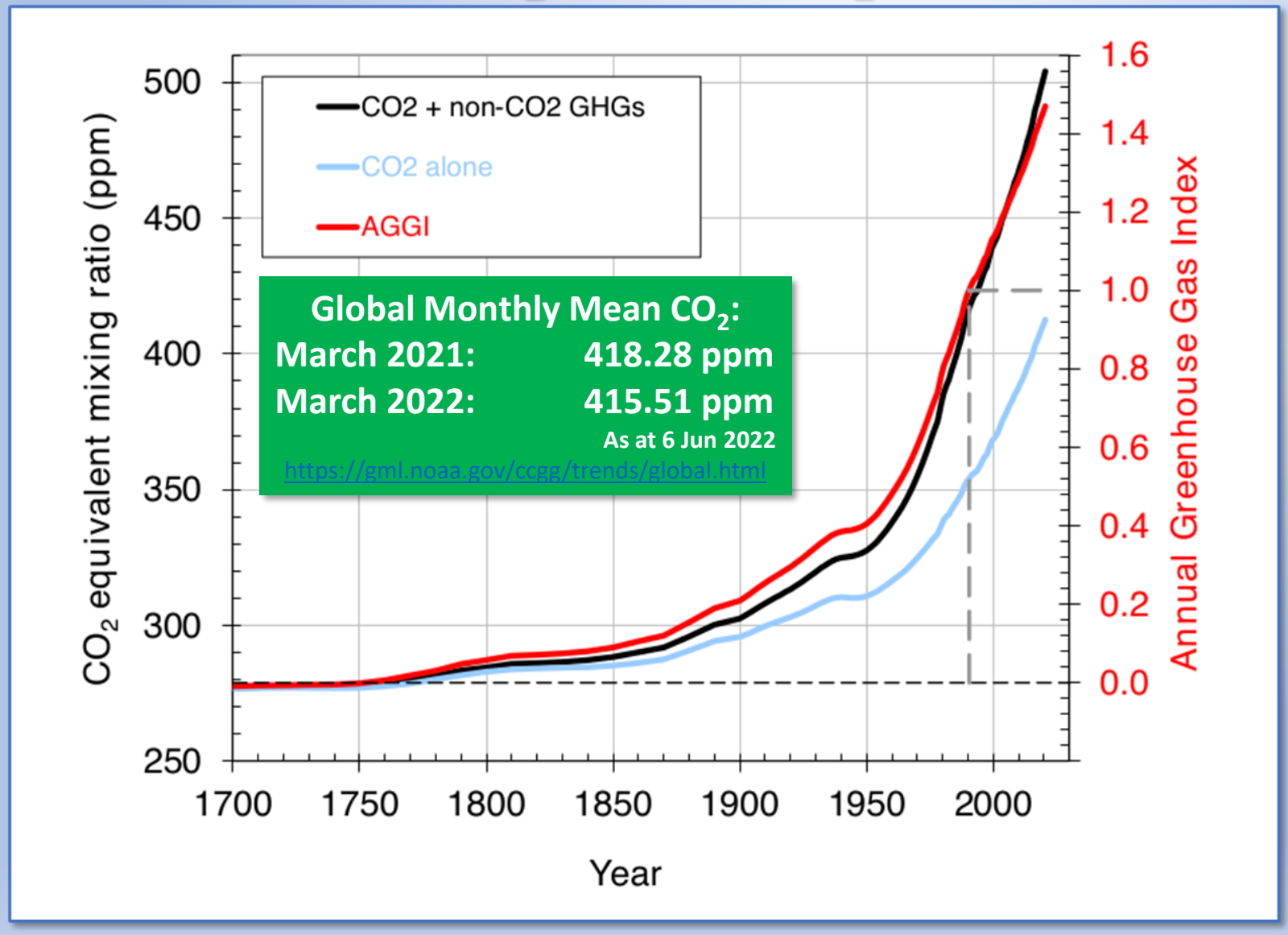
Compiled by Geoff Miell – 08 July 2022

Atmospheric CO_2 concentrations in the last 800,000 years



YouTube video **Carbon dioxide pumphandle – 2021**, published by CarbonTracker on 19 Oct 2021, https://www.youtube.com/watch?v=Mr84tEbCQSg

Global mean CO_2 + non-CO_2 greenhouse gases, and AGGI



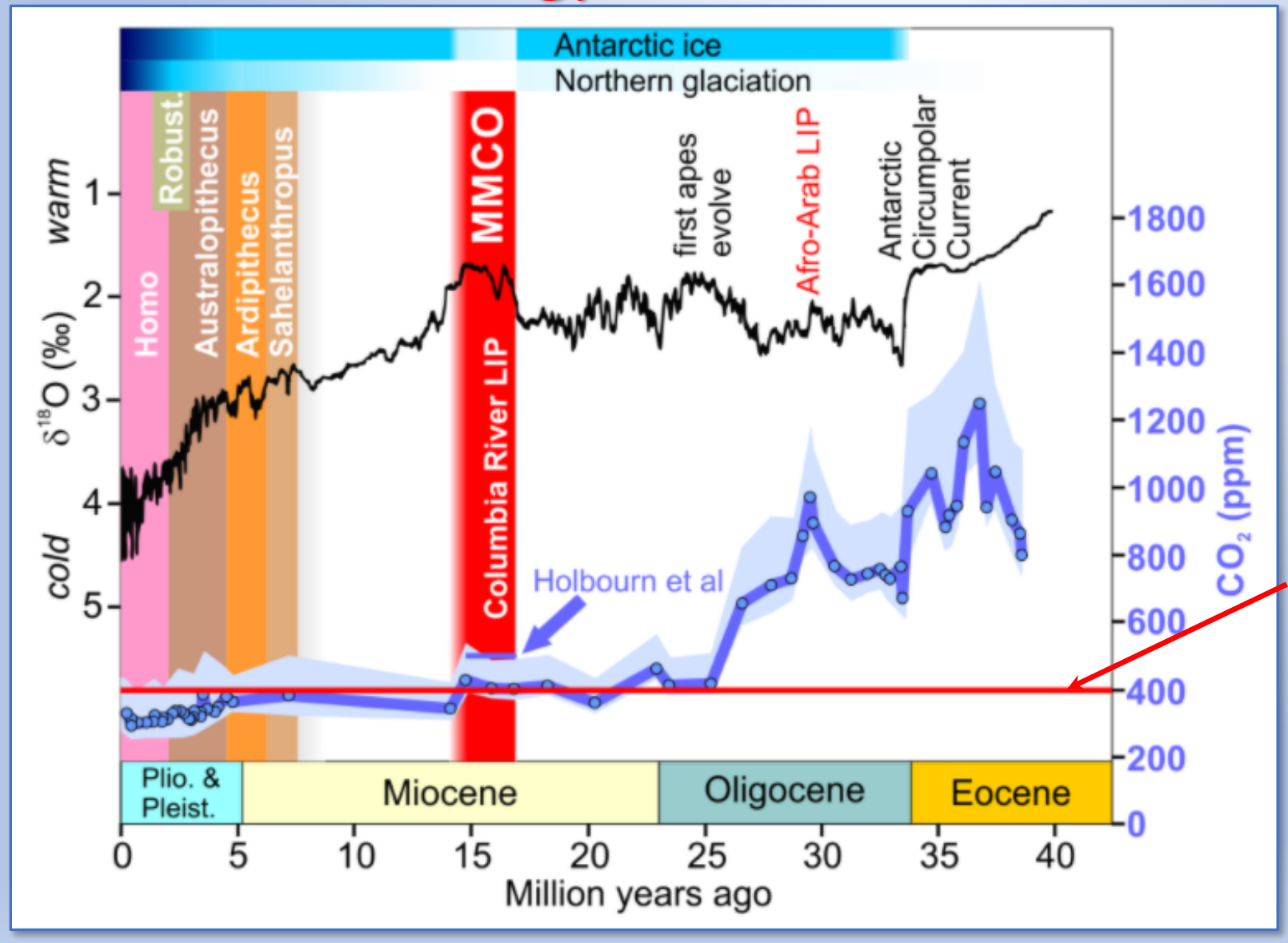
In terms of CO_2 equivalents, the atmosphere in 2021 contained 508 ppm, of which 415 is CO_2 alone. The rest comes from other greenhouse gases.

The NOAA Annual Greenhouse Gas Index (AGGI) in 2021 was 1.49, which means that we've turned up the warming influence from greenhouse gases by 49% since 1990.

It took ~240 years for the AGGI to go from 0 to 1, i.e., to reach 100%, and 31 years for it to increase by another 49%.

https://gml.noaa.gov/aggi/

Paleoclimatology: lessons from Earth's climate history



This is a graph showing CO_2 levels for the last 40 million years over genus-level human evolution and other key events. $\delta^{18}O$ is a proxy for both temperature and ice volume. From genetic data, the ape-human split was circa 7 million years ago.

As the Earth System has clearly crossed the 400ppm threshold in modern atmospheric CO_2, we have now entered climate territory not encountered for millions of years.

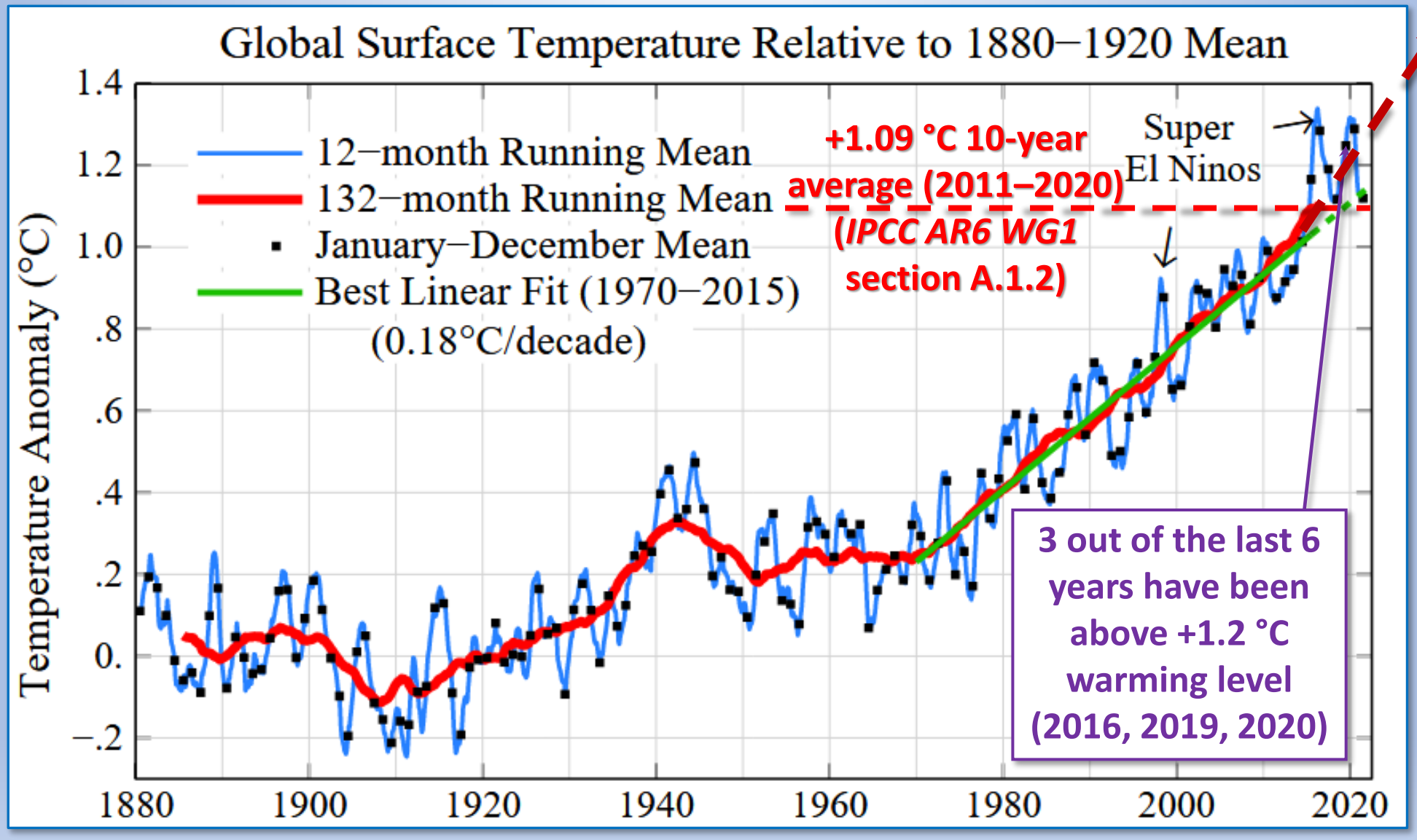
"**Robust.**" = Robust Australopithecus/ Paranthropus

"**LIP**" = Large Igneous Province

"**MMCO**" = Mid Miocene Climate Optimum

https://skepticalscience.com/print.php?n=2845

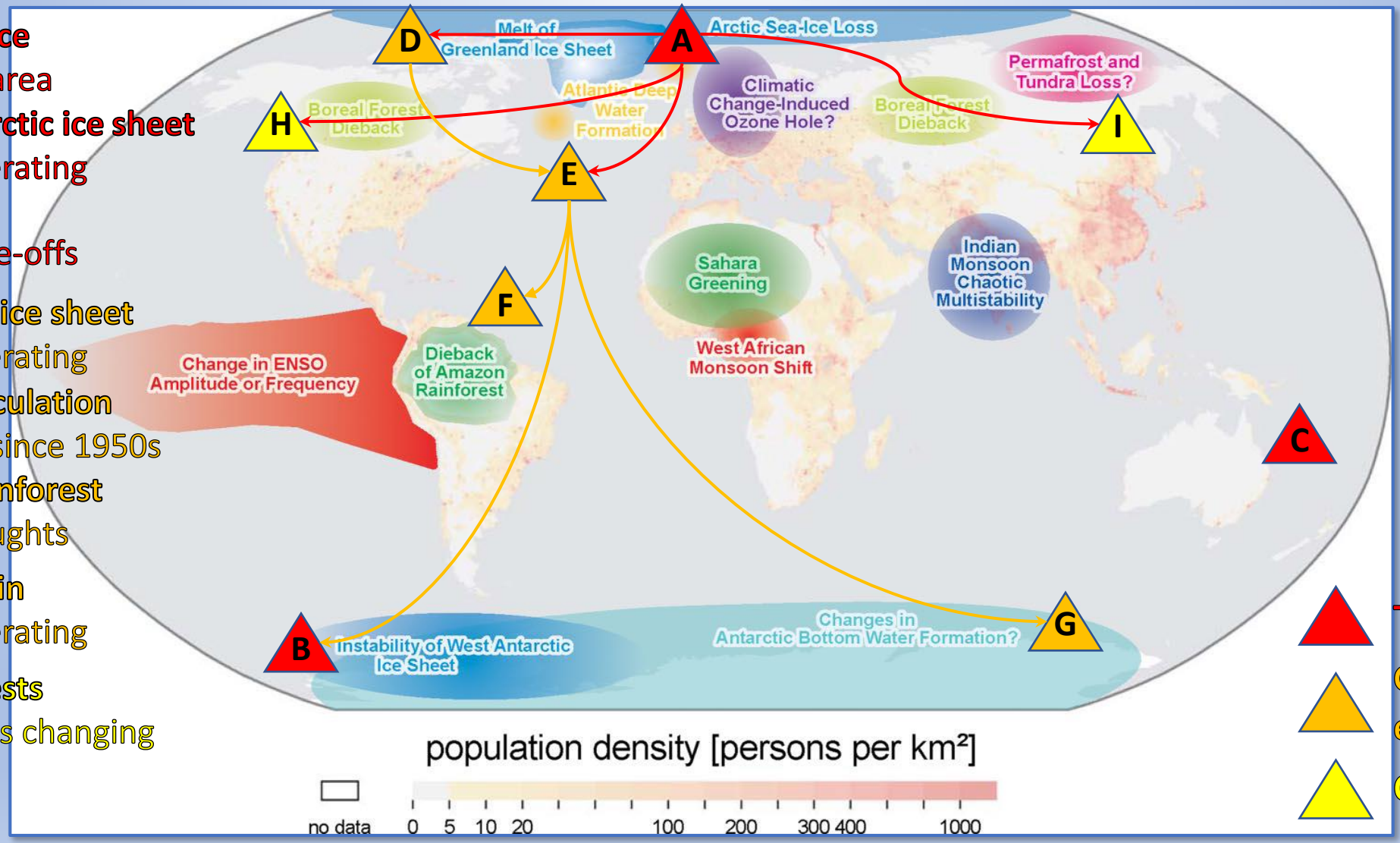
Global mean surface temperatures relative to 1880–1920



Temperature Update: Global Temperature in 2021, by James Hansen, Makiko Sato & Reto Ruedy, 13 Jan 2022, http://www.columbia.edu/~jeh1/mailings/2022/Temperature2021.13January2022.pdf

Climate tipping points

A. Arctic sea ice
Reduction in area
B. West Antarctic ice sheet
Ice loss accelerating
C. Coral reefs
Large-scale die-offs
D. Greenland ice sheet
Ice loss accelerating
E. Atlantic circulation
In slowdown since 1950s
F. Amazon rainforest
Frequent droughts
G. Wilkes Basin
Ice loss accelerating
H. Boreal forests
Fires and pests changing
I. Permafrost
Thawing



https://www.pnas.org/content/pnas/105/6/1786/F1.medium.gif; and https://www.youtube.com/watch?v=LJqmw_dXo-0 from time interval **0:20:47** to **0:22:55**

Climate model projections – ScenarioMIP of CMIP6

Time (calendar year best estimate and 5–95% probability range in square brackets) at which warming levels (relative to 1850–1900 era) are reached per various trajectory scenarios (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5). **NA** = not reached at that warming level by year 2100.

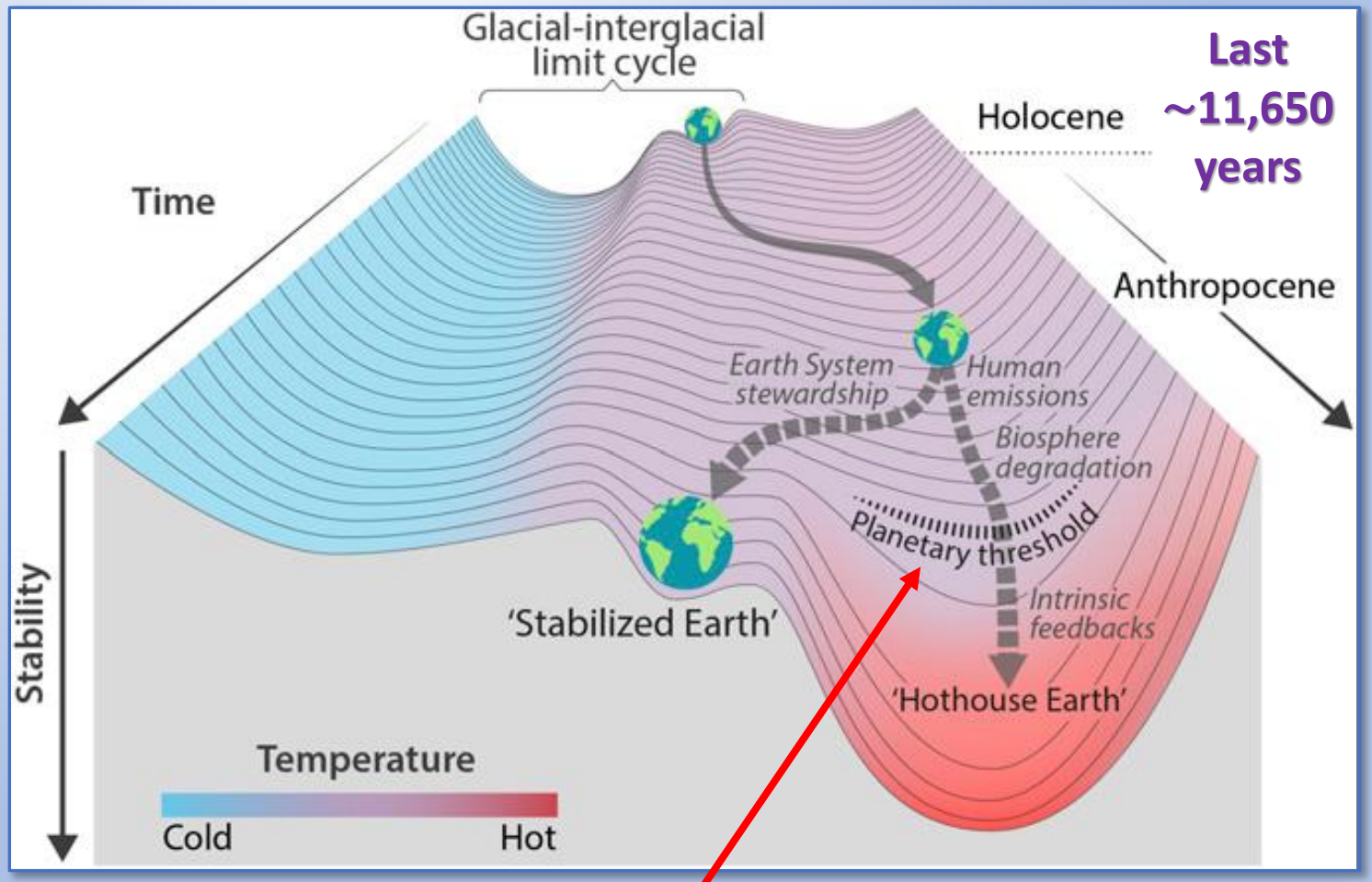
Warming Level	Trajectory SSP1–1.9	Trajectory SSP1–2.6	Trajectory SSP2–4.5	Trajectory SSP3–7.0	Trajectory SSP5–8.5
+1.5 °C Unsafe	**2029** [2021–NA]	**2028** [2020–NA]	**2028** [2020–2047]	**2028** [2020–2045]	**2026** [2020–2040]
+2.0 °C Very dangerous	**NA** [2036–NA]	**2064** [2032–NA]	**2046** [2032–2082]	**2043** [2031–2064]	**2039** [2030–2055]
+3.0 °C Catastrophic	**NA** [NA–NA]	**NA** [NA–NA]	**2094** [2058–NA]	**2069** [2052–NA]	**2060** [2048–2083]
+4.0 °C Society Collapse	**NA** [NA–NA]	**NA** [NA–NA]	**NA** [NA–NA]	**2091** [2071–NA]	**2078** [2062–NA]
+5.0 °C	**NA** [NA–NA]	**NA** [NA–NA]	**NA** [NA–NA]	**NA** [NA–NA]	**2094** [2075–NA]

Earth System Dynamics, 12, 253–293, 2021, by Claudia Tebaldi *et. al.*, 1 Mar 2021, from Table 1 in: https://doi.org/10.5194/esd-12-253-2021

Business-as-usual

Self-reinforcing feedbacks may lead to “Hothouse Earth”

Stability landscape showing the pathway of the Earth System out of the Holocene and thus, out of the glacial–interglacial limit cycle to its present position in the hotter Anthropocene. The fork in the road is shown here as the two divergent pathways of the Earth System in the future (broken arrows). Currently, the Earth System is on a Hothouse Earth pathway driven by human emissions of greenhouse gases and biosphere degradation toward a planetary threshold at ~2 °C, beyond which the system follows an essentially irreversible pathway driven by intrinsic biogeophysical feedbacks.



PNAS, vol 115, no. 33, 8252–8259, **Trajectories of the Earth System in the Anthropocene**, by Will Steffen *et. al.*, 6 Aug 2018, https://doi.org/10.1073/pnas.1810141115

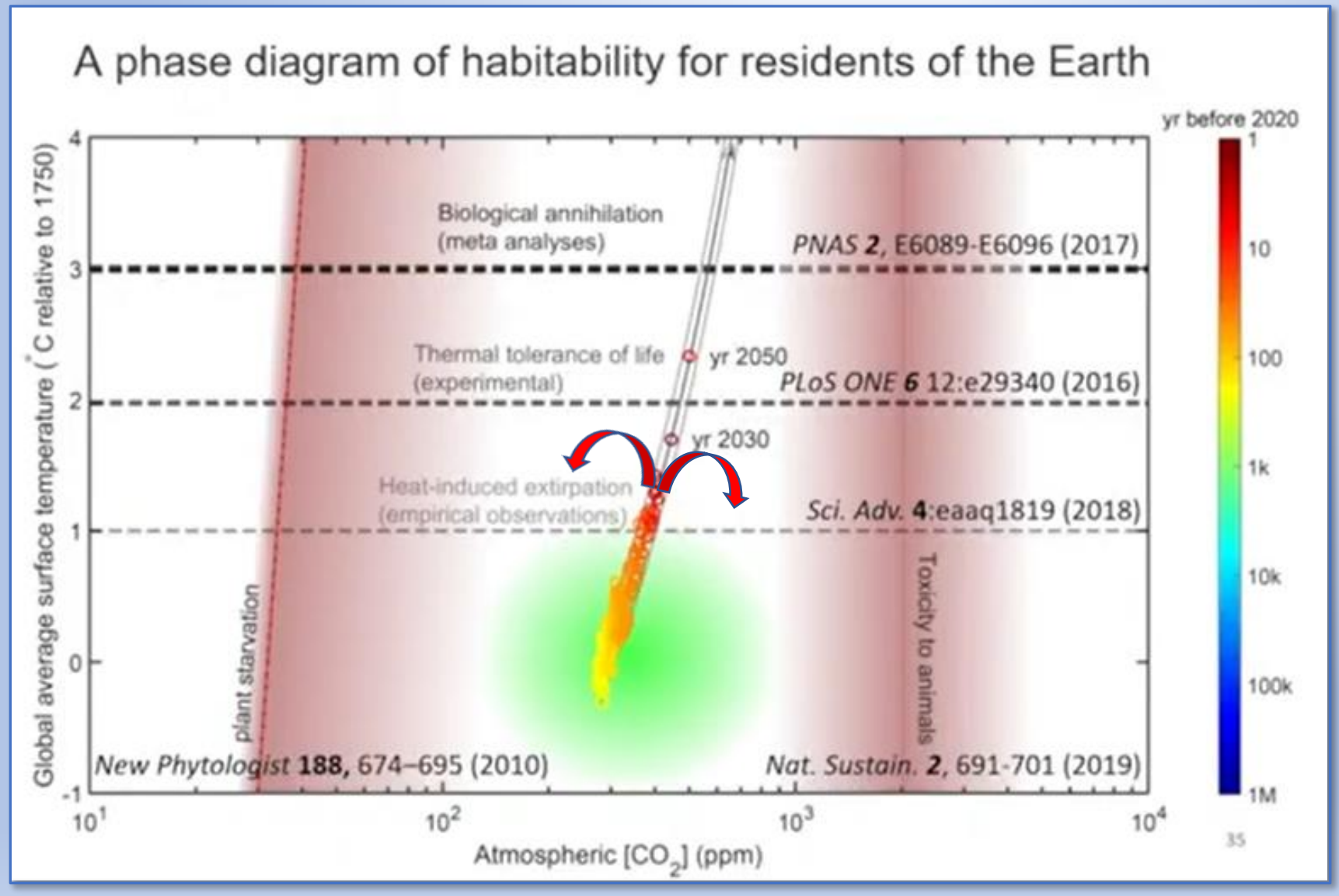
If the threshold is crossed, the resulting trajectory would likely cause serious irreversible disruptions to ecosystems, society, and economies.

Global food security risks rise rapidly from +1.5–2 °C warming

- The increasingly inter-connected global food system is becoming more vulnerable to production shocks owing to increasing global mean temperatures and more frequent climate extremes.
- Risks of simultaneous crop failure do increase disproportionately between 1.5 and 2 °C, so **surpassing the 1.5 °C threshold will represent a threat to global food security.**
- **For maize, risks of multiple breadbasket failures increase the most, from 6% to 40% at 1.5 to 54% at 2 °C warming.**
- **In relative terms, the highest simultaneous climate risk increase between the two warming scenarios was found for wheat (40%), followed by maize (35%) and soybean (23%).**

Agricultural Systems, Vol 175, Oct 2019, **Increasing risks of multiple breadbasket failure under 1.5 and 2 °C global warming**, Franziska Gaupp *et. al.*, https://doi.org/10.1016/j.agsy.2019.05.010

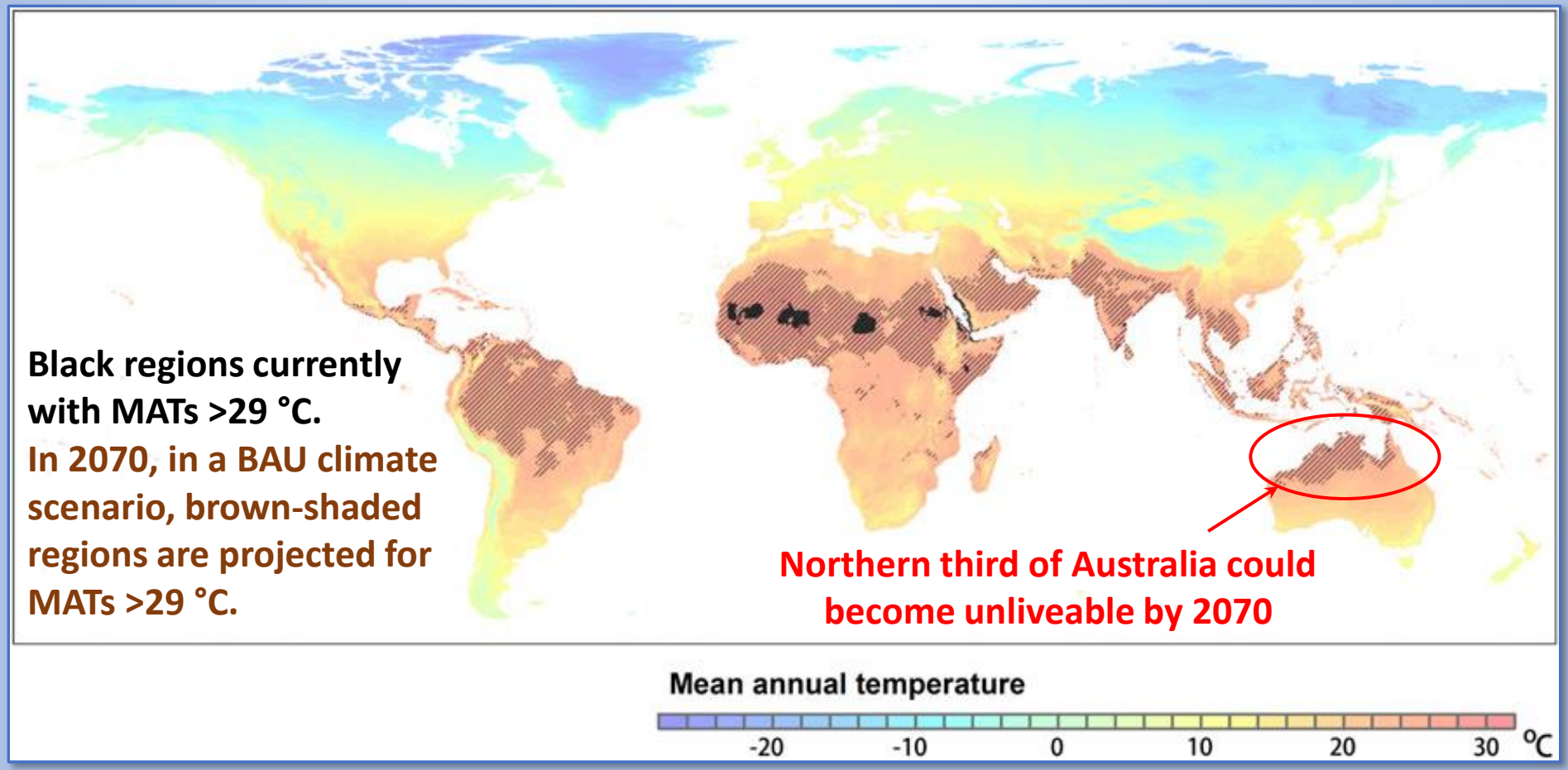
Temperature & CO_2 level phase diagram of habitability



- **Rising global mean surface air temperatures will kill plants and animals long before atmospheric CO_2 levels become toxic.**
- **We need to find urgent mobility in the negative direction on the temperature axis to avoid biological annihilation.**
- **There is plenty of buffer along the CO_2 axis.**

https://www.youtube.com/watch?v=fwvPJnPP9KI

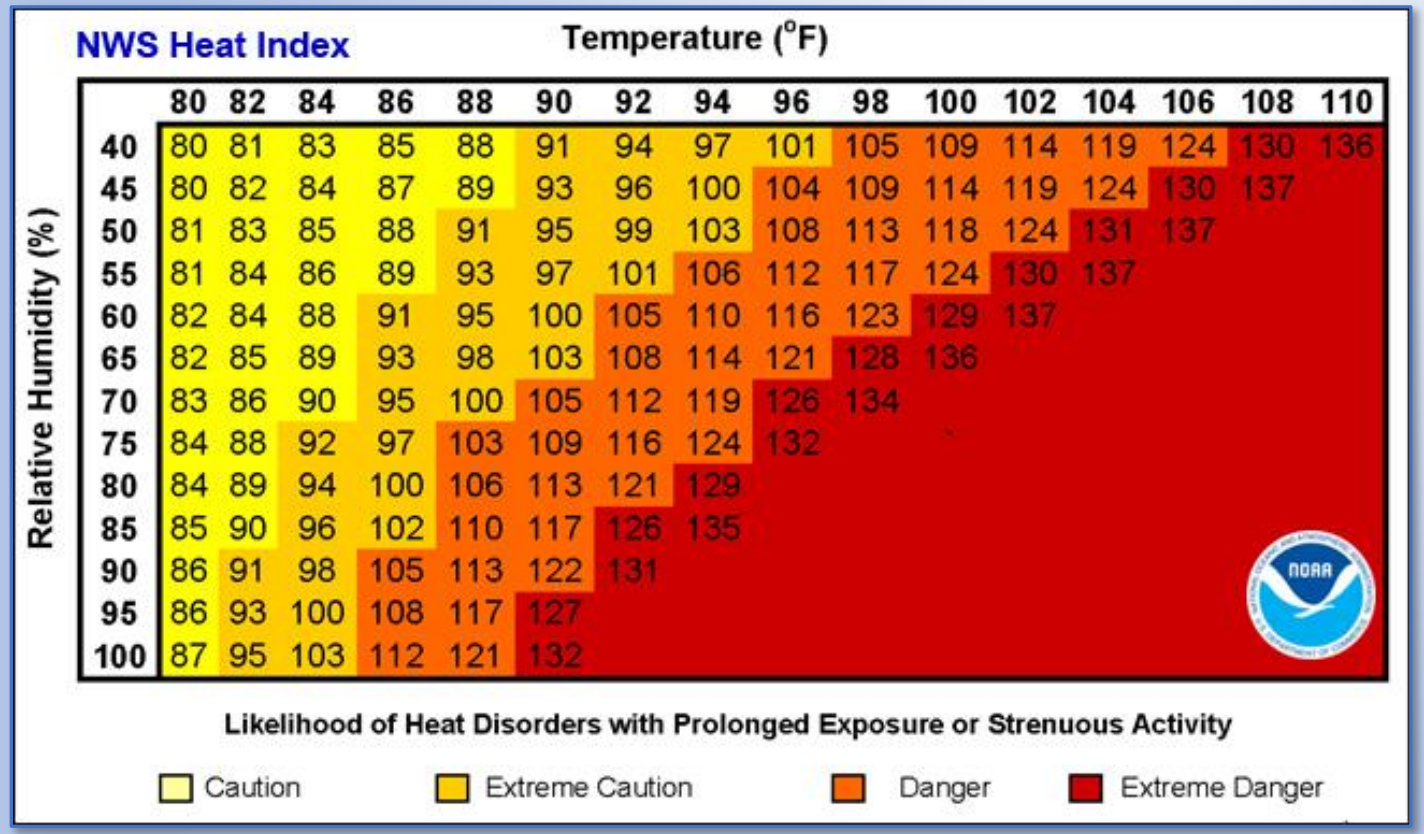
Future of the human climate niche – BAU scenario



PNAS, **Future of the human climate niche**, by Chi Xu *et. al.*, 4 May 2020, https://www.pnas.org/content/117/21/11350#F3

Expansion of extremely hot regions in a business-as-usual (BAU) climate scenario. In the current climate, mean annual temperatures (MATs) >29 °C are restricted to the small dark areas in the Sahara region. In 2070, such conditions are projected to occur throughout the shaded area following the RCP8.5 scenario. Absent migration, that area would be home to 3.5 billion people in 2070 following the SSP3 scenario of demographic development. Background colors represent the current MATs.

Heat index: a measure of temperature & humidity



Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

- The heat index, also known as the apparent temperature, is what the temperature feels like to the human body when relative humidity is combined with the air temperature.
- The heat index values in the chart opposite are for shady locations. If you are exposed to direct sunlight, the heat index value can be increased by up to 15 °F (8.3 °C).
- As shown in the table below left, heat indices meeting or exceeding 103 °F (39.4 °C) can lead to dangerous heat disorders with prolonged exposure and/or physical activity in the heat.

https://www.weather.gov/ama/heatindex

Consequences of warming at different temperatures (#1)

1.1–1.2 °C warming above the pre-industrial epoch – CURRENT:

- 47% of local extinctions reported across the globe during last century can be attributed to climate change.
- Millions of people are now displaced annually because of weather/climate disasters.
- Peak heatwaves that occurred only once per 30 years in pre-industrial times in Australia, can now be expected every 5 years.
- Most years in Australia are now warmer than almost any year in the 20th century.
- Some NSW forests are near, or have already crossed, local tipping points that would irretrievably alter those ecosystems.
- Agricultural areas in NSW now experience runoff reduced by 15%, on average.
- The frequency of very warm days in Australia has increased approximately fivefold compared to the period 1960-1989.
- Black Summer wildfires occur in Australia in 2019-20. Similar fires happen in California in 2020 and 2021.
- Temperatures reach 38 °C above the Arctic Circle in 2020, and reach 50 °C in Canada in 2021.

Consequences of warming at different temperatures (#2)

1.5 °C warming above the pre-industrial epoch – INEVITABLE & likely before 2035:

- Peak heatwaves that occurred only once per 30 years in pre-industrial times in Australia, can be expected every 2.7 years.
- 6% of insects, 8% of plants, and 4% of vertebrates lose over half of their climatically-determined geographic living area.
- What used to be Australia's hottest year on record (2019) is now an average year.
- NSW has 2 – 4 more heatwave days per year than it currently experiences.

Source: Table 1 in the **Expert Report to the NSW IPC on the Greenhouse Gas and Climate Implications of the Narrabri Underground Mine Stage 3 Extension**, by Dr Penny Sackett, 23 Feb 2022, https://www.ipcn.nsw.gov.au/resources/pac/media/files/pac/projects/2021/12/narrabri-underground-mine-stage-3-extension-project-ssd-10269/public-submissions/submissions-on-behalf-of-lock-the-gate-alliance/220225-penny-sackett_redacted.pdf

Consequences of warming at different temperatures (#3)

2.0 °C warming above the pre-industrial epoch – possible before 2050:

- 13% of the Earth's surface undergoes complete ecosystem transformations.
- 99% of the world's coral reefs, including the Great Barrier Reef, are eliminated.
- The number of insects, plants and vertebrates losing over half of their habitat doubles compared to losses at 1.5 °C.
- Moderate risk of large-scale singular events leading to climatic tipping points.
- The world's most vulnerable people experience compounding crisis upon crisis.
- In Australia, considerably higher risk of impacts compared to 1.5°C with regard to:
    a) Water stress and drought,
    b) Shifts in biomes in major ecosystems, including rainforests,
    c) Changes in ecosystems related to the production of food,
    d) Deteriorating air quality,
    e) Declines in coastal tourism,
    f) Loss of coral reefs, sea grass and mangroves,
    g) Disruption of marine food webs, loss of fin fish, and ecology of marine species,
    h) Heat related mortality and morbidity, and
    i) Ozone-related mortality.
- Black Summer-like weather conditions are four times more common than in 1900.
- Sydney and Melbourne experience summer temperatures of 50+ °C.

Consequences of warming at different temperatures (#4)

3.0–4.0 °C warming above the pre-industrial epoch – possible before 2100:

- Most of the world's ecosystems are heavily damaged or destroyed.
- Extreme weather events are far more severe and frequent than today.
- Large areas of the world become uninhabitable, causing migration and conflict.
- Aggregated global impacts significantly damage the entire global economy.
- Peak heatwaves that occurred only once per 30 years in pre-industrial times in Australia expected annually.
- Megafires to occur in southeast Australia irrespective of whether drought occurs simultaneously.
- Many locations in Australia become uninhabitable due to water shortages.
- Many Australian properties and businesses are uninsurable. Severe impacts to both flora and fauna cause many of Australia's ecological systems to become unrecognisable.
- Sea level rise transforms Australia's coastal regions, putting the health and wellbeing of many people at severe risk.
- NSW has one to two more heatwave weeks per year than it currently experiences.
- Agricultural areas in NSW experience runoff reduced by 45-60%.
- Moderately high risk that a cascade of tipping points in the climate system drives the Earth system into a 'Hothouse Earth' state not seen for millions of years, irrespective of humanity's late attempts to reduce emissions.

Climate reality check

- **There is NO CARBON BUDGET REMAINING for a safe climate for humanity.**
- **Three stages are required to mitigate the climate emergency:**
  i. **Deep and rapid decarbonization of civilisation ASAP – no more new fossil fuel developments AND a rapid phase-out of utilization of existing fossil fuel infrastructure;**
  ii. **'Negative emissions' or atmospheric carbon drawdown to safely get CO_2 levels back to well below 350 ppm; and**
  iii. **Maintain arctic summer sea ice cover.**
- ***"What we, humanity, do in the next 4 to 5 years will determine the future of humanity for the next few thousand years"*** **– Sir David King, Founder and Chair of the Centre for Climate Repair, University of Cambridge**

https://vimeo.com/527806796

- ***"If we don't solve the climate crisis, we can forget about the rest."*** **– Professor H.J. Schellnhuber, atmospheric physicist, climatologist and founding director of the Potsdam Institute for Climate Impact Research**

https://horizon-magazine.eu/article/i-would-people-panic-top-scientist-unveils-equation-showing-world-climate-emergency.html

‘The Paris Agreement’

- The Paris Agreement is a **legally binding international treaty on climate change**. It was adopted by 196 Parties at COP 21 in Paris, **on 12 December 2015 and entered into force on 4 November 2016**.
- Its goal is to **limit global warming** to well below 2, **preferably to 1.5 degrees Celsius**, compared to pre-industrial levels.
- To achieve this long-term temperature goal, **countries aim to reach global peaking of greenhouse gas emissions as soon as possible** to achieve a climate neutral world by mid-century.
- The Paris Agreement is **a landmark** in the multilateral climate change process because, for the first time, a binding agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects.
- Implementation of the Paris Agreement requires **economic and social transformation**, based on the best available science. The Paris Agreement works on a **5- year cycle** of increasingly ambitious climate action carried out by countries. By 2020, countries submit their plans for climate action known as **nationally determined contributions (NDCs).**

https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

- **Australia became a signatory to the Paris Agreement on 22 Apr 2016.**
- **Australia’s updated NDC includes: “*We will reduce greenhouse gas emissions by 43% below 2005 levels by 2030, which is a 15 percentage point increase on Australia’s previous 2030 target.*”**

https://www.industry.gov.au/news/australia-submits-new-emissions-target-to-unfccc

Key fossil fuel producers – What Australia does matters

Coal Producer, in 2021	*Exajoules*	*% global share*
World	**167.58**	**100.0**
1. China	85.15	50.8
2. Indonesia	15.15	9.0
3. India	13.47	8.0
4. Australia	**12.43**	**7.4**
5. USA	11.65	7.0
6. Russian Federation	9.14	5.5
7. South Africa	5.55	3.3
8. Kazakhstan	2.09	1.2
9. Poland	1.76	1.1
10. Germany	1.15	0.7

Gas Producer, in 2021	*Exajoules*	*% global share*
World	**145.33**	**100.0**
1. USA	33.63	23.1
2. Russian Federation	25.26	17.4
3. Iran	9.24	6.4
4. China	7.53	5.2
5. Qatar	6.37	4.4
6. Canada	6.20	4.3
7. Australia	**5.30**	**3.6**
8. Saudi Arabia	4.22	2.9
9. Norway	4.12	2.8
10. Algeria	3.63	2.5

https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

Australia is the world's largest metallurgical coal exporter, & second largest thermal coal exporter.

Australia is the world's largest LNG exporter.

Whether emissions from fossil fuels extracted by Australia occurs here or elsewhere, we all consequently share them in the one atmosphere.

The rush to mine more coal in NSW is accelerating

- **The coal industry is currently proposing more new coal mines and mine extensions in NSW.**
- **The rush to mine coal in NSW is accelerating, not slowing, as proponents scramble for approvals before an inevitable downturn in the market driven by climate action and cheap renewables.**
- **Governments and the coal industry expect further coal extraction developments to continue, but NSW production peaked in 2014 and the boom is not coming back.**
- **The case for new coal mines is undermined by increasing international climate ambition and continuing declines in the price of renewable energy. World demand for coal is likely to fall, not rise, over the life of the new mines being proposed (and mostly approved).**
- **While proponents of each new coal project make optimistic claims about how their project will deliver a significant increase in coal exports, royalty revenues, and employment, this cannot be true with flat or falling world coal demand, no plans to expand the volume of exports from the Port of Newcastle, and no likelihood of new coal-fired power stations being built in NSW.**
- **Building new coal mines when existing coal mines are under-utilized increases disruptions to the existing workforce and imposes additional external costs on other Hunter Valley and Western Coalfield region landowners and communities.**

One Step Forward, Two Steps Back: New coal mines in the Hunter Valley, Mar 2021, https://australiainstitute.org.au/wp-content/uploads/2021/03/P1029-New-coal-in-NSW-Web.pdf

New and extensions of existing coal projects in NSW (#1)

Coal Project Name	Local Government Area	Status	Max. Production (*Mt/y ROM*)	Extraction Permit to
Ashton South East Open Cut – Mod 1	Singleton Shire	L&EC Approved 27 Aug 2018	3.6	?
Maxwell Underground Coal Mine	Muswellbrook Shire	IPCN Approved 22 Dec 2020	8.0	30 Jun 2047
Spur Hill Underground Coal	Muswellbrook Shire	Prepare EIS	8.0	+25 years
Dartbrook – Mod 7 – Bord & Pillar Mining and Extension	Muswellbrook Shire	IPCN Approved 9 Aug 2019	1.5	5 Dec 2022
Glendell Continued Operations	Singleton Shire	IPCN Assessment	10.0	2044
Mangoola Coal Continued Operations	Muswellbrook Shire	IPCN Approved 26 Apr 2021	13.5	31 Dec 2030
Mt Pleasant Optimisation	Muswellbrook Shire	IPCN Assessment	21.0	22 Dec 2048
Mount Owen Continued Operations – Mod 5	Singleton Shire	DPIE Approved 15 Jan 2021	10.0	31 Dec 2037
United Wambo Open Cut Coal Mine	Singleton Shire	IPCN Approved 29 Aug 2019	10.0	31 Aug 2042

New and extensions of existing coal projects in NSW (#2)

Coal Project Name	Local Government Area	Status	Max. Production (*Mt/y ROM*)	Extraction Permit to
Bulga Optimisation Project – Mod 3	Singleton Shire	DPIE Approved 17 Jul 2020	12.2 *	31 Dec 2039
Bulga Underground – Mod 7	Singleton Shire	DPIE Approved 17 Jul 2020	14.0 *	23 Feb 2031
Liddell Coal Mine – Mod 7 – Minor Amendments to Rehab & Boundary	Muswellbrook & Singleton Shires	IPCN Approved 12 Feb 2019	8.0	31 Dec 2028
Stratford Extension Project – Mod 2	Mid Coast Council	DPIE Approved 13 Jan 2020	2.6	31 Dec 2025
Vickery Mine Extension	Narrabri & Gunnedah Shires	IPCN Approved 12 Aug 2020	10.0	+25 years 12 Aug 2045
Wallarah 2 Coal Mine	Central Coast & Lake Macquarie Councils	IPCN Approved 16 Jan 2018	5.0	16 Jan 2046
Dendrobium Extension	Wollongong City Council, Wollondilly & Wingecarribee Shires	IPCN Refused 5 Feb 2021 **NSW Gov declares it a SSI**	5.2	31 Dec 2048
Hume Coal	Wingecarribee Shire	IPCN Refused 31 Aug 2021	3.5	+23 years

New and extensions of existing coal projects in NSW (#3)

Coal Project Name	Local Government Area	Status	Max. Production (*Mt/y ROM*)	Extraction Permit to
Tahmoor South Coal	Wollondilly & Wingecarribee Shires	IPCN Approved 23 Apr 2021	3.0 (1st stage) 4.0 (2nd stage)	31 Dec 2033
Bylong Coal	Mid-Western Regional Council	IPCN Refused 18 Sep 2019; L&EC Upheld 18 Dec 2020; Appeal Refused 25 Aug 2021; **High Court Leave Refused 9 Feb 2022**	6.5	+25 years
Angus Place West	Lithgow City Council	Prepare EIS	2.0	31 Dec 2042
Chain Valley Extension Project – Mod 4 – Increase Boundary & Workforce	Central Coast & Lake Macquarie City Councils	DPIE Approved 5 Aug 2021	2.1	31 Dec 2027
Narrabri Underground Mine Stage 3 Extension	Narrabri Shire	IPCN Approved 1 Apr 2022	11.0	31 Dec 2044
Wilpinjong Extension	Mid-Western Regional	IPCN Approved 24 Apr 2017	16.0	31 Dec 2033

NSW coal-fired generator unit expected closure year

Site Name	DUID	Expected Closure Year	Closure Date	Capacity (*MW*)
Liddell	LD03	**Unit Closed**	**2022 Apr 01**	420 +
Liddell	LD04	**2023**	**2023 Apr 01**	420 +
Liddell	LD01	**2023**	**2023 Apr 01**	420 +
Liddell	LD02	**2023**	**2023 Apr 01**	420 +
Eraring	ER01	**2025**	**2025 Aug 19**	720
Eraring	ER02	**2025**	**2025 Aug 19**	720
Eraring	ER03	**2025**	**2025 Aug 19**	720
Eraring	ER04	**2025**	**2025 Aug 19**	720
Vales Point B	VP5	2029		660
Vales Point B	VP6	2029		660
Bayswater	BW01	2033		660
Bayswater	BW02	2033		660
Bayswater	BW03	2033		660
Bayswater	BW04	2033		660
Mt Piper	MP1	2040		730 *
Mt Piper	MP2	2040		730 ^

What's next?

+ LD01 through LD04 de-rated from 500 MW each to 420 MW.
* MP1 upgraded from 700 MW to 730 MW late-2020.
^ MP2 upgraded from 700 MW to 730 MW Mar – May 2022.
DUID = Dispatchable Unit Identifier.
https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information

Queensland coal-fired generator unit expected closure year

Site Name	DUID	Expected Closure Year	Current Age	Capacity (MW)
Callide B	CALL_B_1	2028	24 years	350
Callide B	CALL_B_2	2028	24 years	350
Gladstone	GSTONE1	2035	46 years	280
Gladstone	GSTONE2	2035	46 years	280
Gladstone	GSTONE3	2035	46 years	280
Gladstone	GSTONE4	2035	46 years	280
Gladstone	GSTONE5	2035	46 years	280
Gladstone	GSTONE6	2035	46 years	280
Tarong	TARONG#1	2036	38 years	350
Tarong	TARONG#2	2036	37 years	350
Tarong	TARONG#3	2037	36 years	350
Tarong	TARONG#4	2037	35 years	350
Kogan Creek	KPP_1	2042	15 years	750
Stanwell	STAN-1	2043	29 years	365
Stanwell	STAN-2	2044	28 years	365
Stanwell	STAN-3	2045	27 years	365
Stanwell	STAN-4	2046	26 years	365

Additional generator units:

- **Callide C** (2x 460 MW) closure date not yet determined;
- **Millerran** (2x 440 MW) expected closure in 2051.

Victorian coal-fired generator unit expected closure year

Site Name	DUID	Expected Closure Year	Current Age	Capacity (MW)
Yallourn W	YWPS1	**2028**	**49 years**	360
Yallourn W	YWPS2	**2028**	**47 years**	360
Yallourn W	YWPS3	**2028**	**41 years**	380
Yallourn W	YWPS4	**2028**	**40 years**	380
Loy Yang A	LYA1	2045	38 years	560
Loy Yang A	LYA2	2045	38 years	530
Loy Yang A	LYA3	2045	35 years	560
Loy Yang A	LYA4	2045	35 years	560
Loy Yang B	LOYYB1	2047	29 years	535
Loy Yang B	LOYYB2	2047	26 years	535

The design life for coal-fired generator units is typically 40 to 50 years.

As with any aging asset, operating reliability declines, and maintenance costs increase. The Australia Institute's *Gas & Coal Watch* has labelled Yallourn W as the least reliable coal-fired power plant in Australia by breakdowns per unit of capacity, while Loy Yang A Unit 2 was the worst performing unit.

The economics of coal-fired generators are simply not well-suited to a system with lots of solar and wind-powered electricity.

NEM coal-fired generator unit outages on 1 June 2022

Per WattClarity's Generator Outages widget:

- **Of the 22 coal units still operational in Queensland, with an aggregate maximum capacity of 8,577 MW, there was 2,388 MW unavailable for supply, or about 27.8%.**
- **Of the 15 coal units still operational in NSW, with an aggregate maximum capacity of 10,240 MW, there was 3,205 MW unavailable for supply, or about 31.3%.**
- **Of the 10 coal units still operational in Victoria, with an aggregate maximum capacity of 5,095 MW, there was 1,187 MW unavailable for supply, or about 23.3%.**

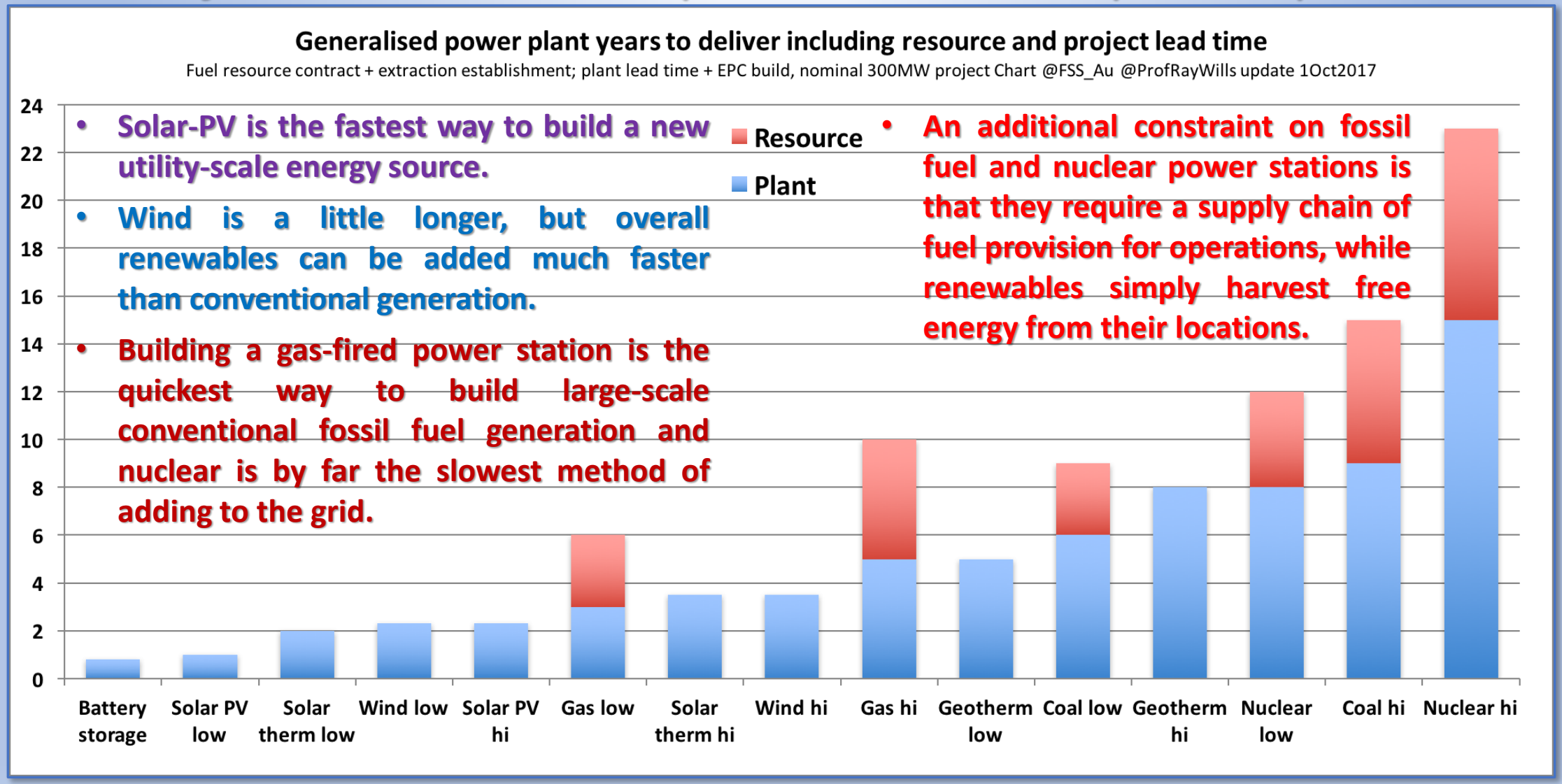
Morning price volatility on Thursday 2nd June 2022, https://wattclarity.com.au/articles/2022/06/02june-morning-price-volatility/

It seems Australia's remaining coal-fired generator units are demonstrating increasingly poor reliability in a time of need.

The AEMO issued a market notice on June 7 calling on generators to submit updates about their fuel stockpiles, or water storages, and what options they had to replenish them if stores were depleted.

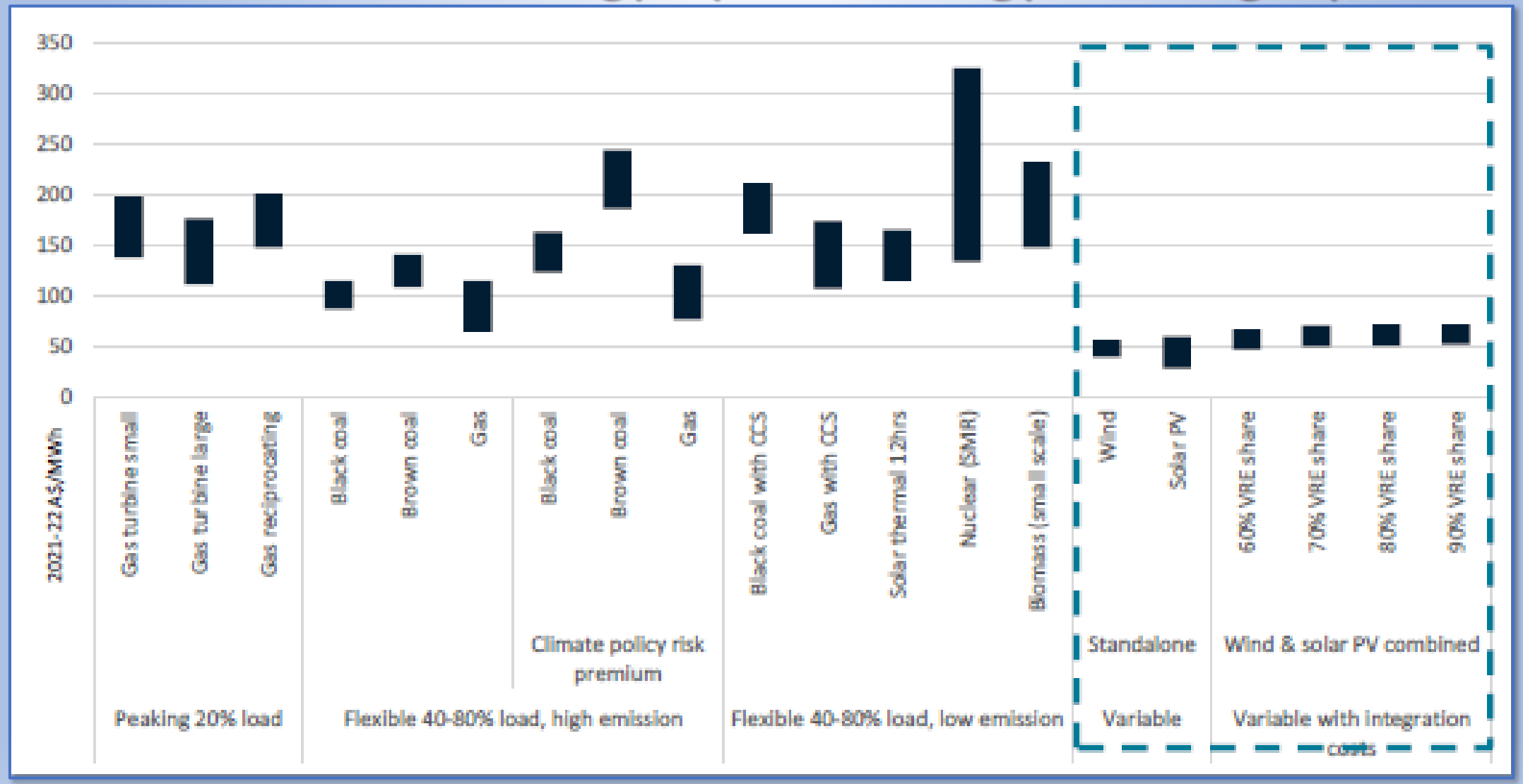
https://reneweconomy.com.au/have-you-got-enough-coal-and-gas-aemo-frets-about-winter-fossil-fuel-supplies/

Project lead times required to deliver power plants



https://twitter.com/ProfRayWills/status/983720784672604161/photo/1

Levelized Cost of Energy by technology & category, 2030

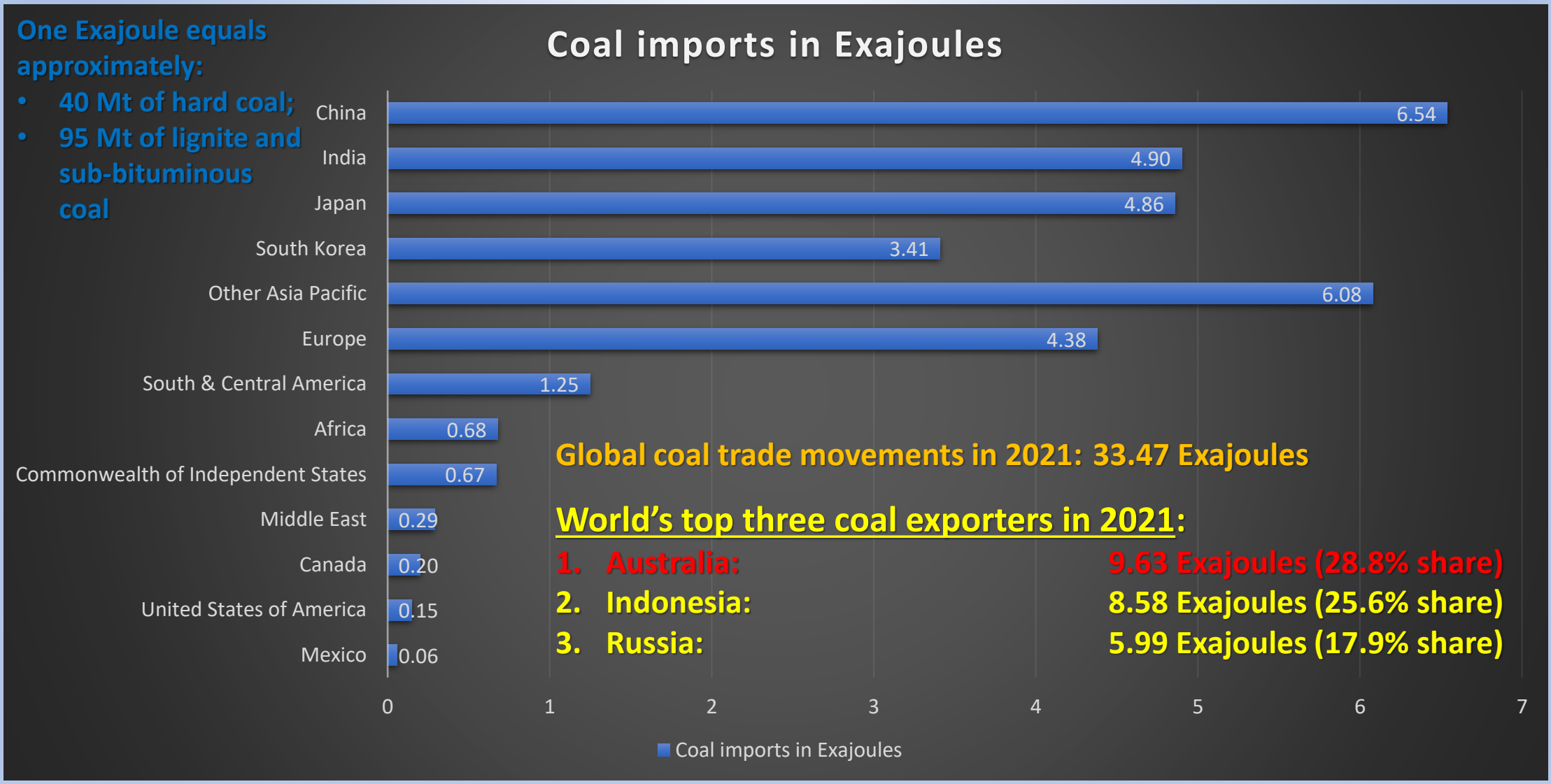


GenCost 2021-22: Consultation draft, https://publications.csiro.au/publications/publication/PIcsiro:EP2021-3374

Coal trade movements worldwide in 2021

One Exajoule equals approximately:

- **40 Mt of hard coal;**
- **95 Mt of lignite and sub-bituminous coal**



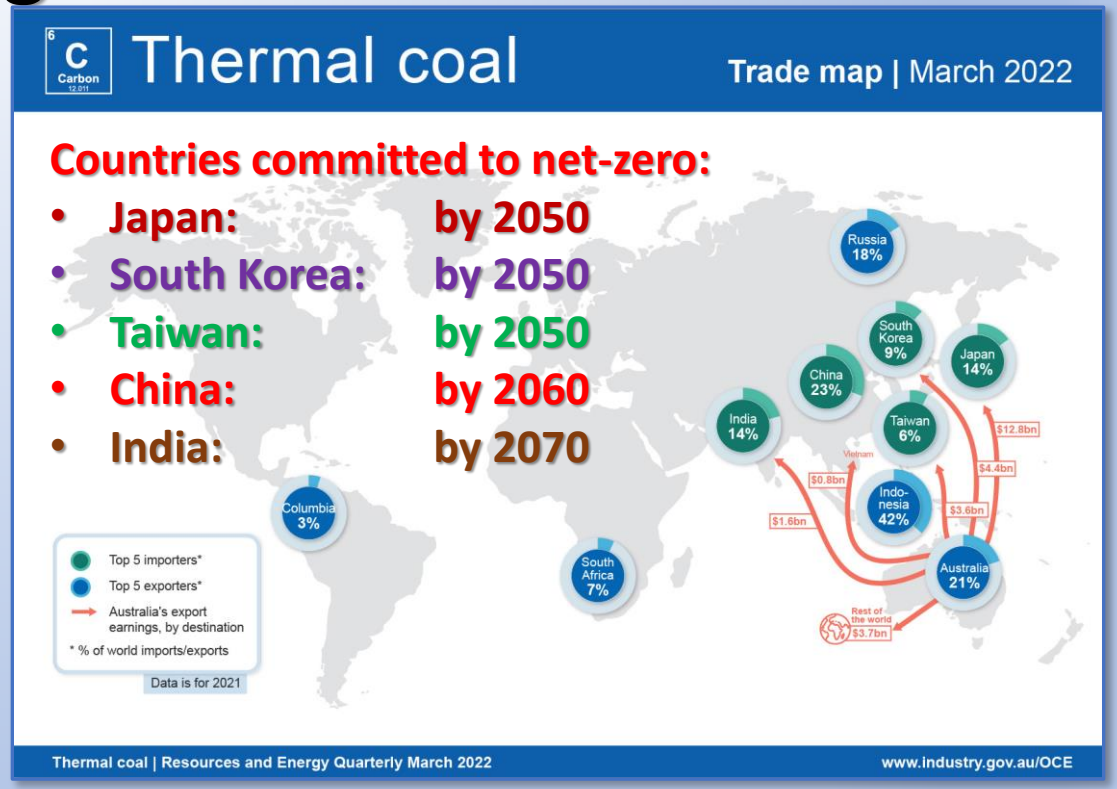
Global coal trade movements in 2021: 33.47 Exajoules

World's top three coal exporters in 2021:

1. **Australia: 9.63 Exajoules (28.8% share)**
2. **Indonesia: 8.58 Exajoules (25.6% share)**
3. **Russia: 5.99 Exajoules (17.9% share)**

BP Statistical Review of World Energy 2022, Jun 2022

Australia and global metallurgical & thermal coal markets



Australian metallurgical coal exports to:

- India: $11.5 billion
- Japan: $7.5 billion
- South Korea: $4.9 billion
- Taiwan: $2.2 billion
- Rest of the World: $9.3 billion

Australian thermal coal exports to:

- Japan: $12.8 billion
- South Korea: $4.4 billion
- Taiwan: $3.6 billion
- India: $1.6 billion
- Vietnam: $0.8 billion
- Rest of the World: $3.7 billion

Seaborne coal market set to decline

- **Chinese decarbonisation and energy security policy stand to reduce coal imports.**
- **Chinese investment in domestic transport infrastructure will push out overseas thermal coal imports.**
- **Seaborne coking coal imports to China will fall with growing supply from Mongolia.**
- **ANU climate change economist Professor Frank Jotzo said recently:**

  "Our findings illustrate how energy security concerns, a fracturing global security and trade landscape, combined with climate action are putting the squeeze on coal - not in the distant future but imminently."

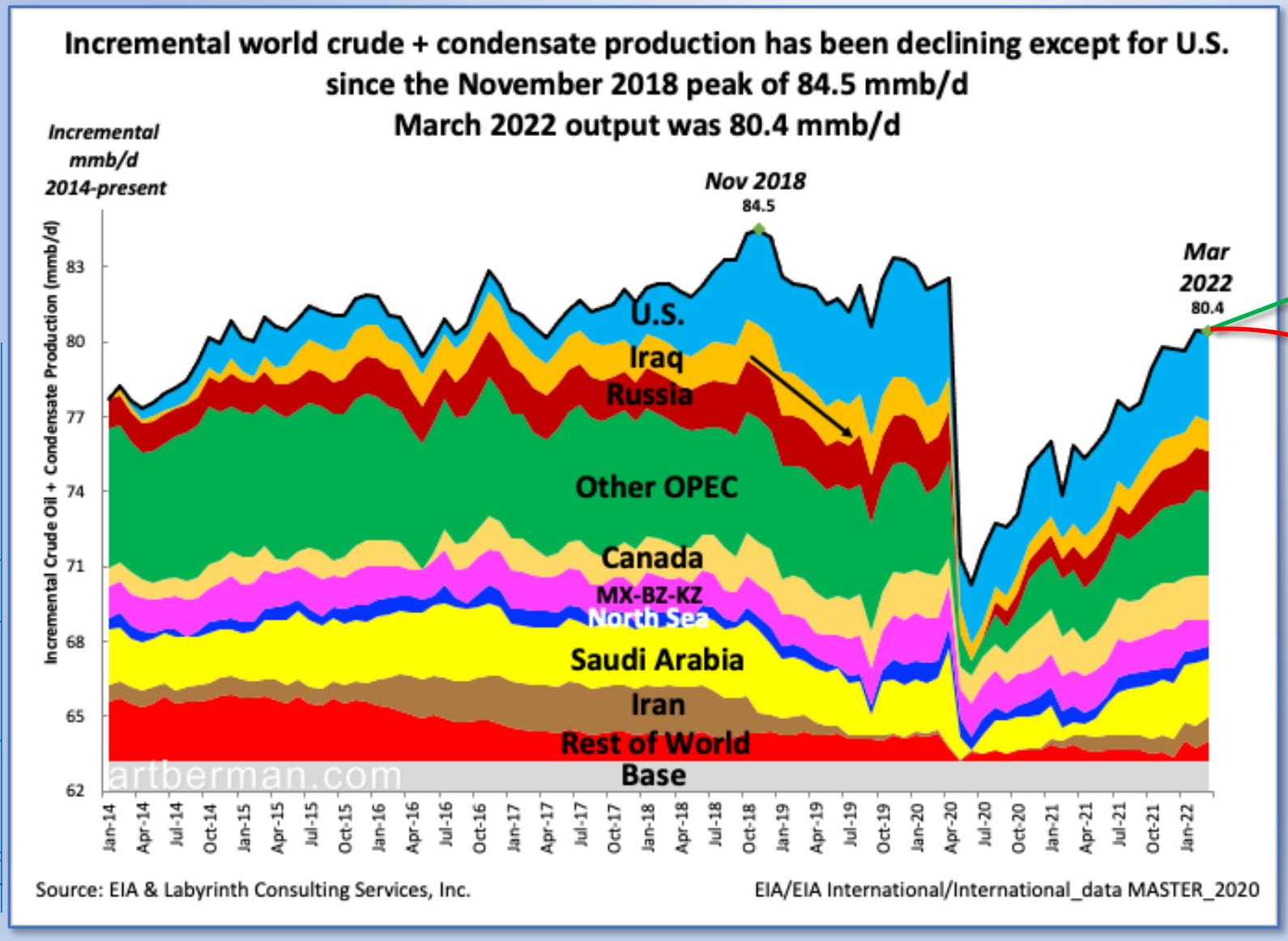
  "Our findings should be of high concern to the coal industry and to Australian governments. Coal will be on the way down. We need to foster alternative economic futures. Australia's resource and energy industries have every opportunity to prosper in a low-emissions world."

https://www.anu.edu.au/news/all-news/bleak-outlook-for-australian-coal-exports-to-china

The Oil Crisis

Accumulating data indicates the era of cheap and abundant crude oil & petroleum fuels has ended forever

World oil production growth mainly from US since 2010



https://twitter.com/aeberman12/status/1515373090779316225

"If capex stays stable at current levels, global oil supply will likely roll over around 2024 and then decline sharply thereafter."

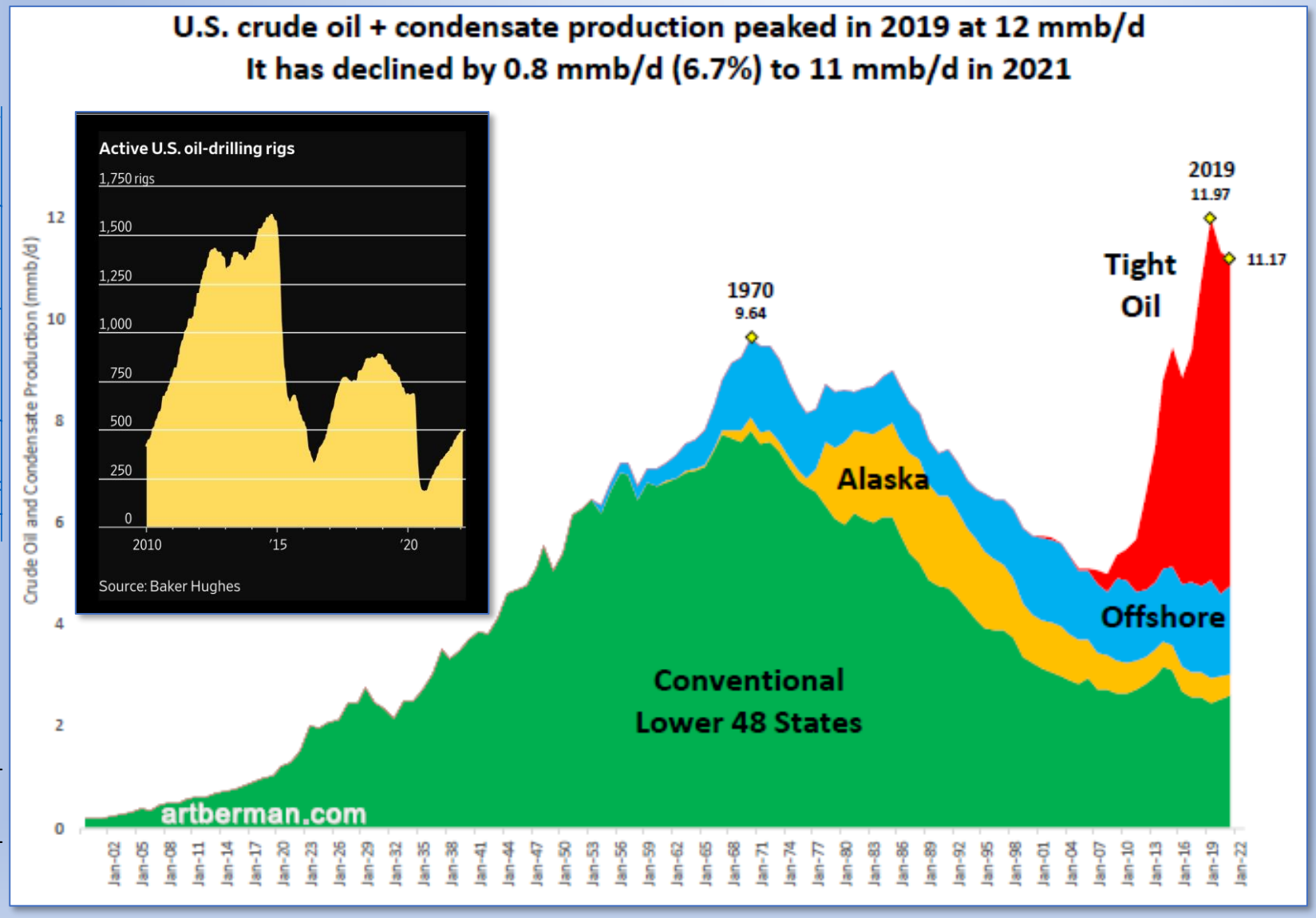
Oil & Gas Journal, 29 Oct 2021, **Morgan Stanley: Global oil supply likely to peak earlier than demand**

Where to next?

"Twelve months ago, few people listened when we predicted an energy crisis was imminent. Now, our models suggest that we could be entering a new period in the history of oil – a period without any excess global pumping capability. The ramifications could be huge."

Goehring & Rozencwajg blog post, 19 Nov 2021, **Running Out of Spare Capacity**

Since 2008, nearly all US oil supply growth from 'tight' oil



Source: **When Will Energy Prices Come Down? Maybe Never Warns Industry Expert | Art Berman,** Slides: https://www.artberman.com/wp-content/uploads/2022/01/WEALTHION-JAN-17-2022.pdf, Video podcast published on 19 Jan 2022: https://www.youtube.com/watch?v=vyxddYfXaQk

"…if demand keeps going up, where's the supply going to come from? And the answer is: We don't know, we just don't know. And the market knows that, and that's why prices are high." - US geologist Art Berman

Shale Reality Check 2021: Drilling into the U.S. Government's Optimistic Forecasts for Shale Gas & Tight Oil Production Through 2050, by Earth scientist David Hughes, finds the EIA's latest projections for shale oil and gas output and its long-term outlook is highly optimistic, overstating drillable acreage, assumes wells can be packed closer than the industry finds wise, and seems oblivious to diminishing returns.

https://shalebubble.org/

Global oil production and top 5 oil producing countries

x1,000 barrels/day average	2018	2019	2020	2021
World	**94,874**	**94,916**	**88,494**	**89,877 (100%)**
1. United States	15,310	17,114	16,458	16,585 (18.5%)
2. Saudi Arabia	12,261	11,832	11,039	10,954 (12.2%)
3. Russian Federation	11,562	11,679	10,667	10,944 (12.2%)
4. Canada	5,244	5,372	5,130	5,429 (6.0%)
5. Iraq	4,632	4,779	4,114	4,102 (4.6%)

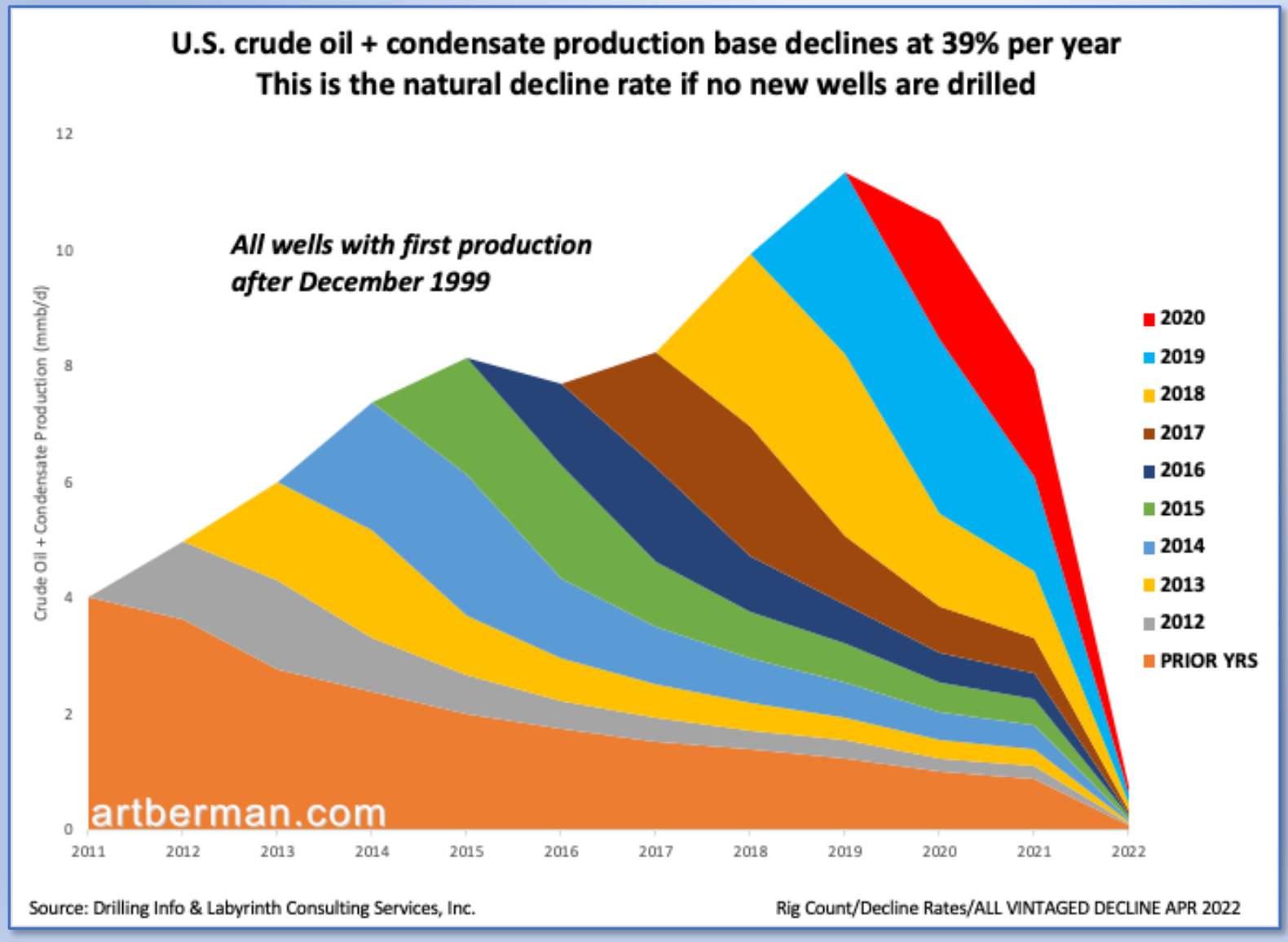
Includes crude oil, shale oil, tar sands, condensates (lease condensate or gas condensates that require further refining) and NGLs (natural gas liquids – ethane, LPG and naphtha separated from the production of natural gas).

Excludes liquid fuels from other sources such as biofuels and synthetic derivatives of coal and natural gas. This also excludes liquid fuel adjustment factors such as refinery processing gain. Excludes oil shales/kerogen extracted in solid form.

Statistical Review of World Energy 2022 | 71st edition, BP, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2022.pdf

These five countries listed above represent more than half of total global oil production

US crude + condensate production base decline at 39%

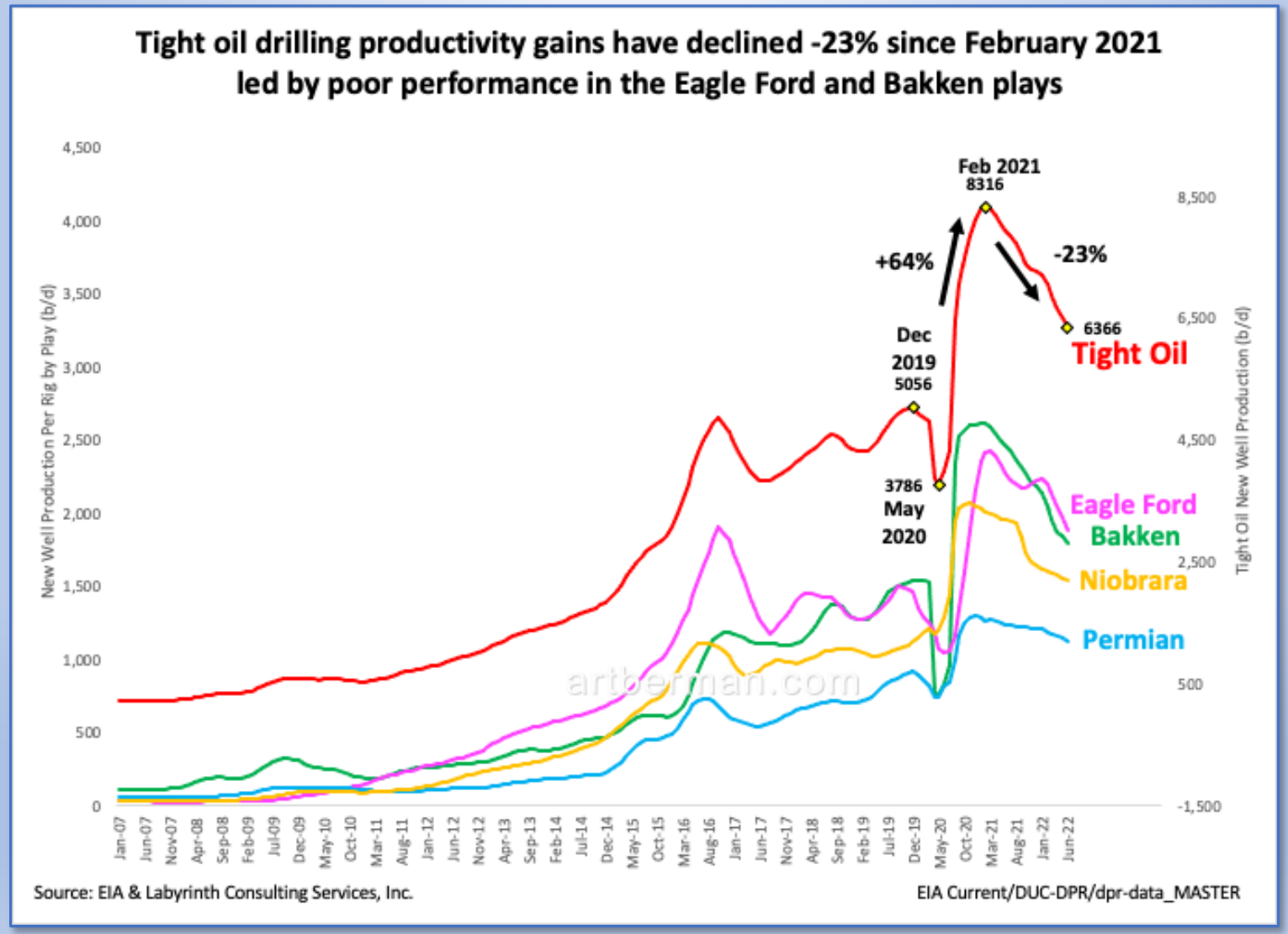


"The U.S. is a mature exploration and development province for oil and gas. New technologies of large scale, multistage, hydraulic fracturing of horizontal wells have allowed previously inaccessible shale gas and tight oil to reverse the long-standing decline of U.S. oil and gas production. This production growth is important and has provided some breathing room. Nevertheless, the projections by pundits and some government agencies that these technologies can provide endless growth heralding a new era of "energy independence," in which the U.S. will become a substantial net exporter of energy, are entirely unwarranted based on the fundamentals."

Drill, baby, drill: Can unconventional fuels usher in a new era of energy abundance? by J. David Hughes, Feb 2013

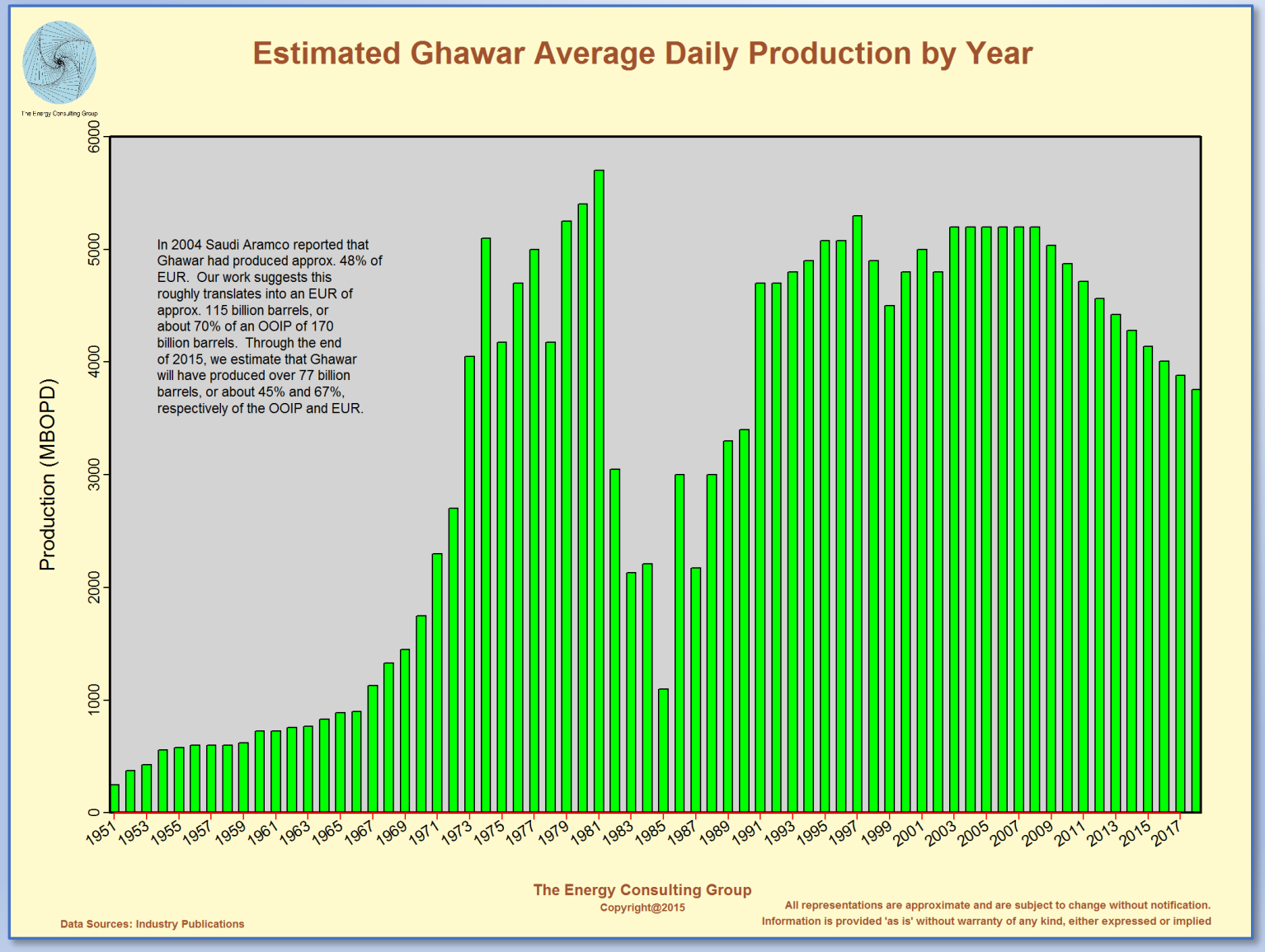
https://twitter.com/aeberman12/status/1516549141220007941

US tight oil drilling productivity declined since Feb 2021



https://twitter.com/aeberman12/status/1526937838905921536

Ghawar: world's largest oil producing field passed peak



http://energy-cg.com/OPEC/SaudiArabia/OPEC_SaudiArabia_Ghawar.html

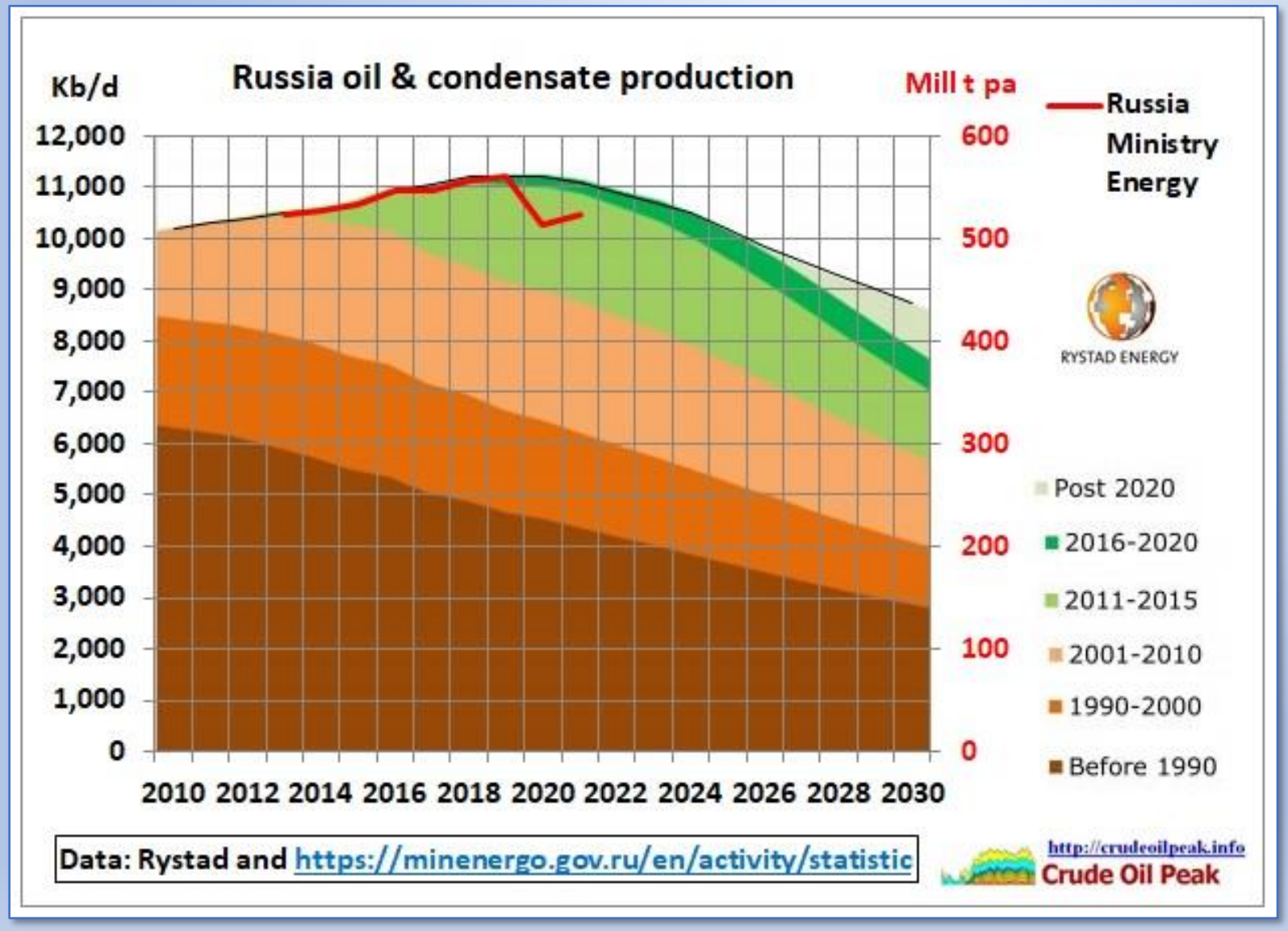
"With demand running higher than expectations and non-OPEC+ supply disappointing, all eyes are on OPEC+.

…

As of March 2022, nearly every OPEC+ country was producing below their allotted quota – something we never recall seeing. The core OPEC-10 countries produced nearly 1 m b/d less than allowed, effectively leaving $3 bn in revenue on the table in March alone while the remaining member countries missed their quota by 700,000 b/d. There is no logical explanation for why this should happen consistently, as it has, other than the member countries have been unable to increase production."

https://blog.gorozen.com/blog/running-out-of-spare-oil-capacity

Russian Federation may have passed peak oil production

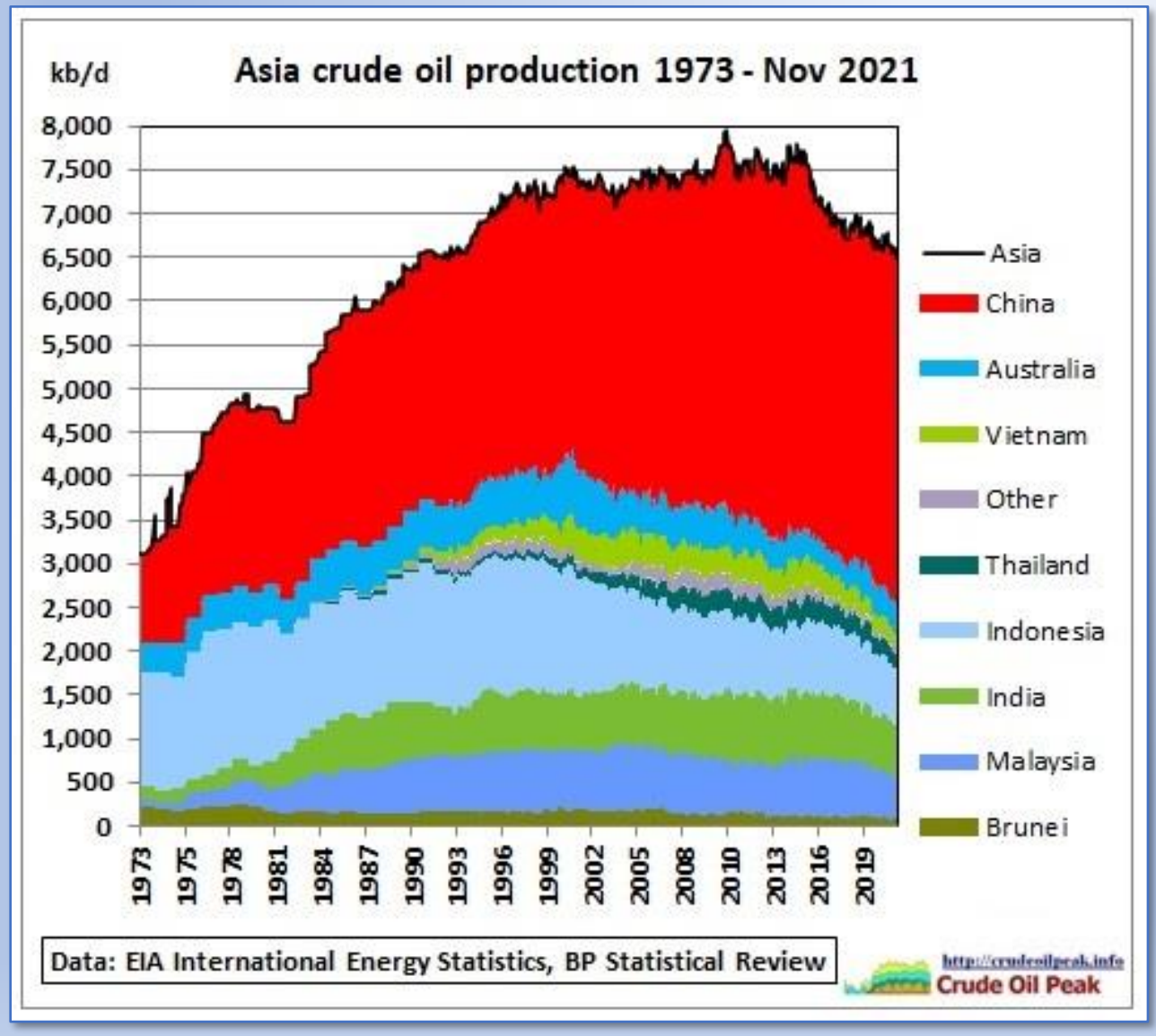


In the last full year before the pandemic, the Russian Federation produced 560 million tons of oil + condensate — equivalent to 11.3 million barrels per day.

Russian oil production may never recover to pre-coronavirus levels, according to the country's Energy Ministry strategy document, cited by Kommersant.

https://crudeoilpeak.info/russian-oil-production-update-nov-2021

Asia-Pacific region has passed peak oil production



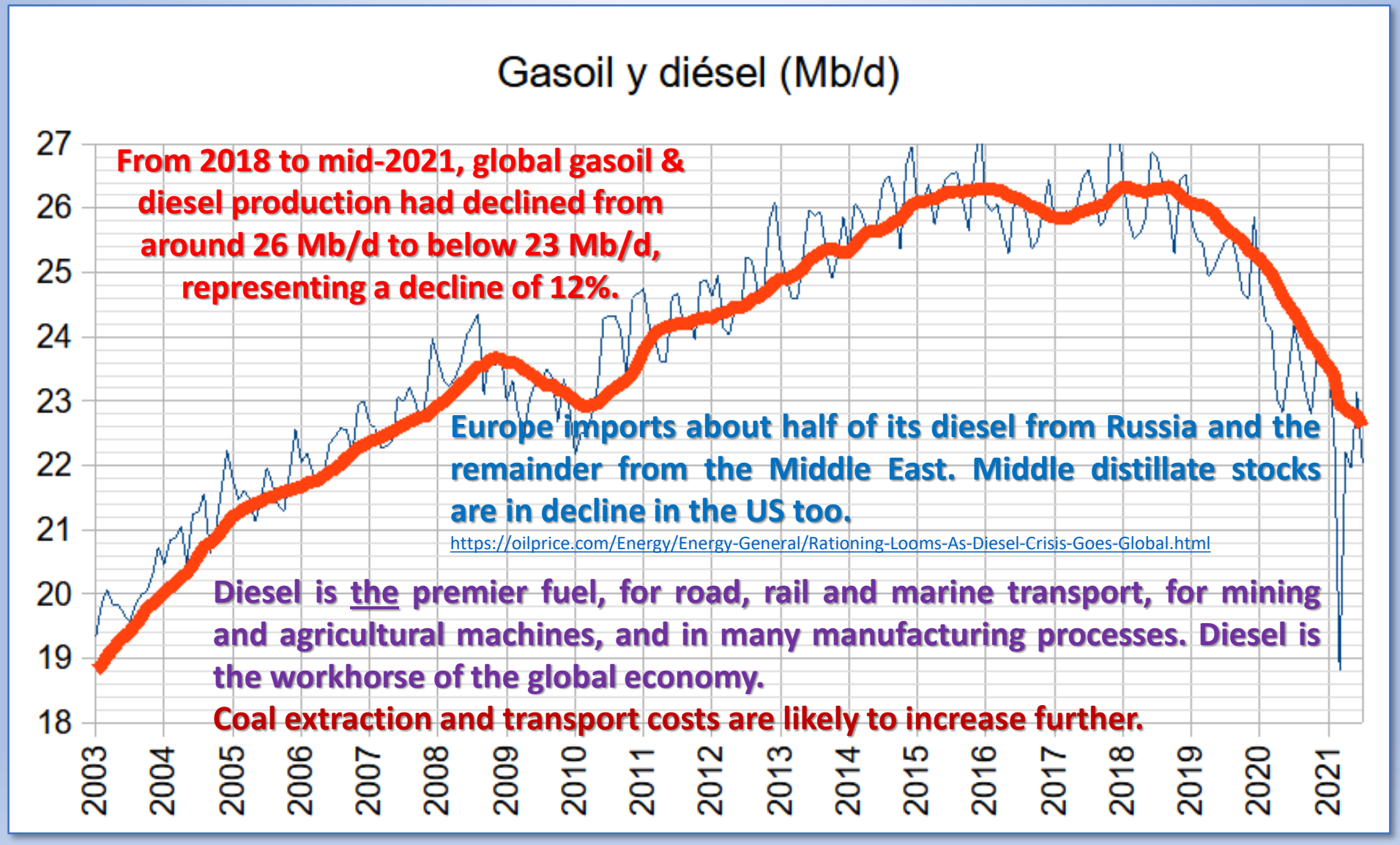
China dominates Asia-Pacific region crude oil production. For the rest of the Asia-Pacific region, crude oil production peaked in 2000, and has since declined by around 40%.

Year(s) of peak oil production:

- **Indonesia: 1977–1991**
- **Australia: 2000**
- **Malaysia: 2004**
- **Vietnam: 2004**
- **India: 2011**
- **China: 2015**
- **Thailand: 2016**

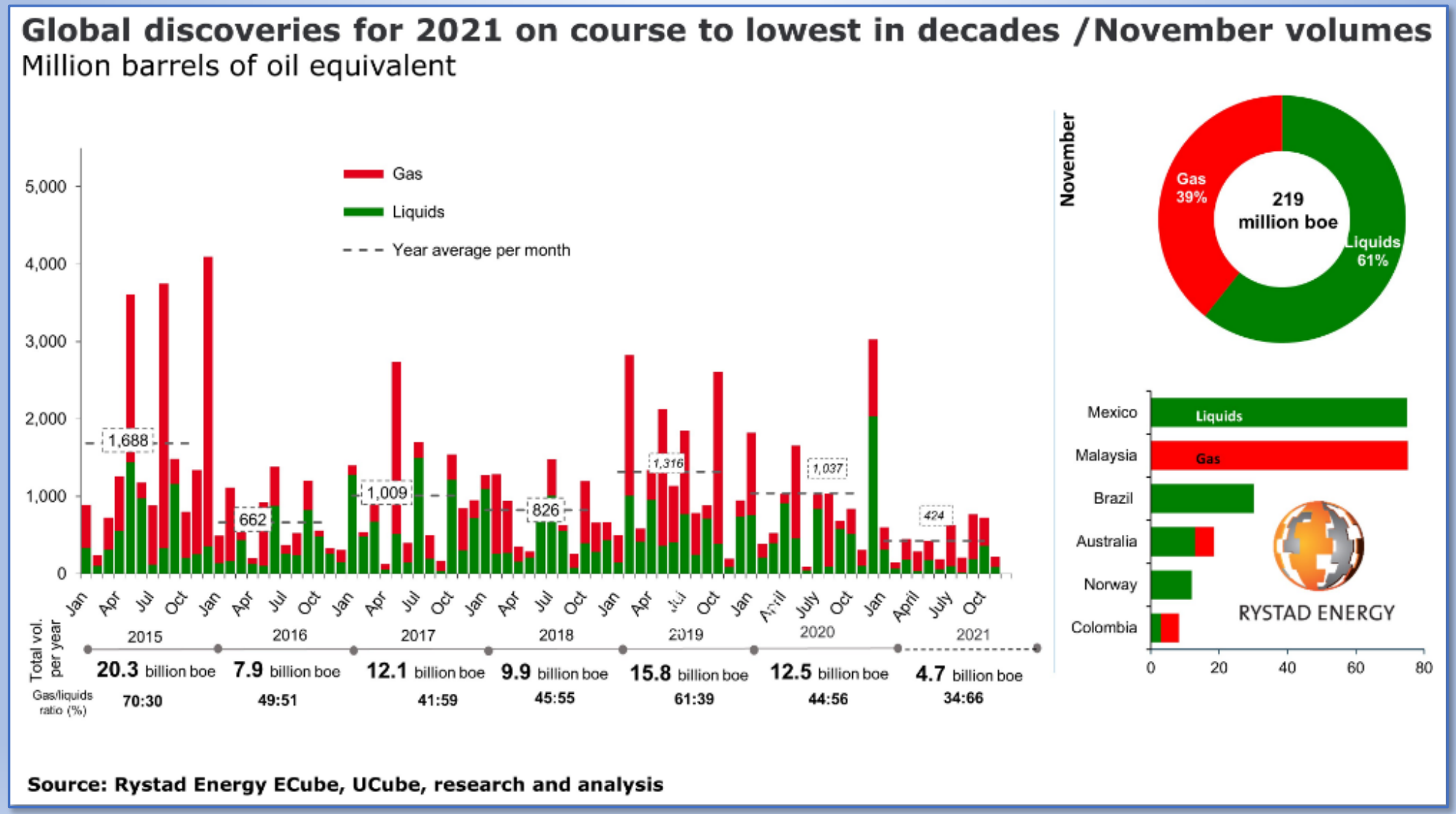
https://crudeoilpeak.info/asia-peak-oil-update-nov-2021

Global diesel fuel production is now declining



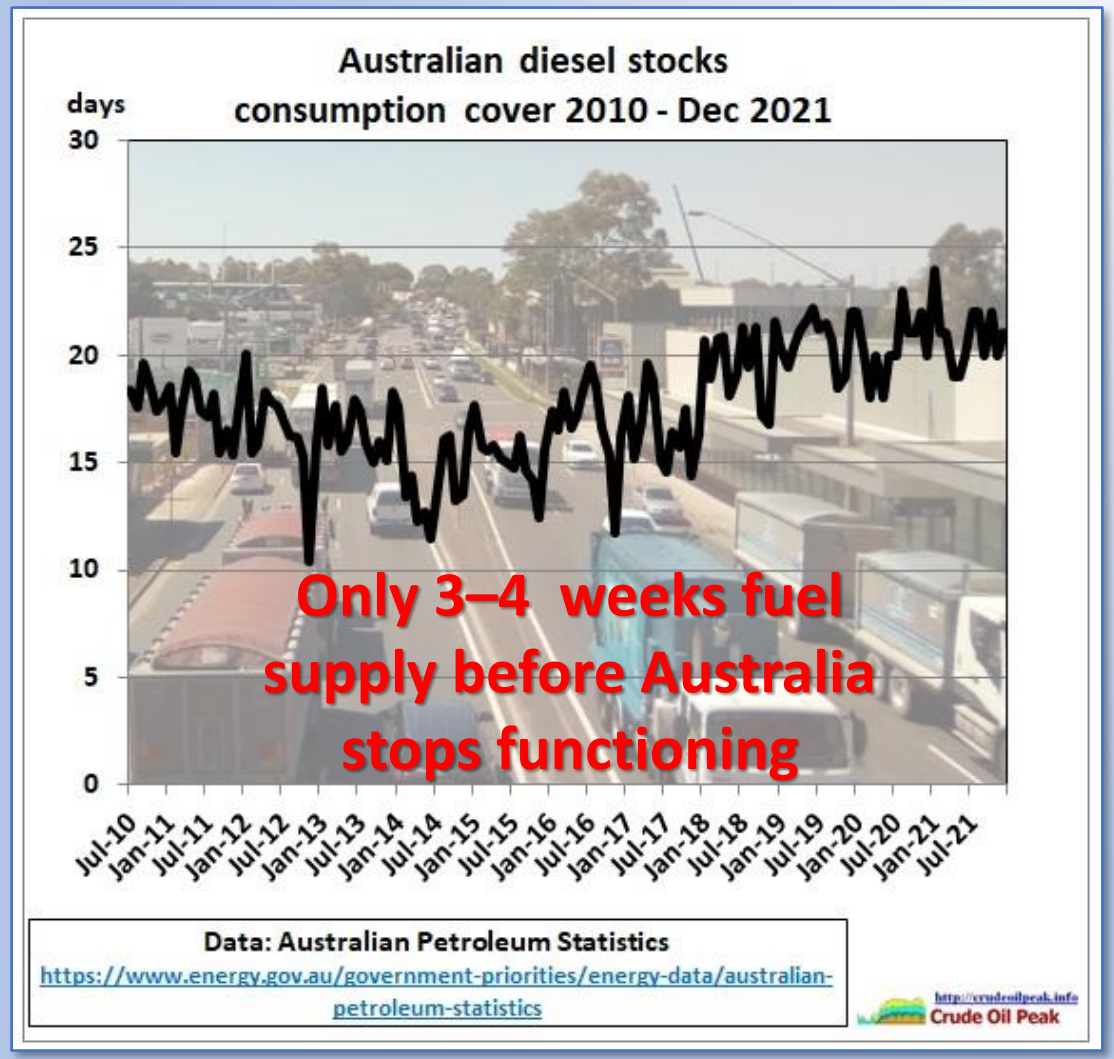
The diesel peak: 2021 edition., *The Oil Crash*, 19 Nov 2021, https://crashoil.blogspot.com/2021/11/el-pico-del-diesel-edicion-de-2021.html

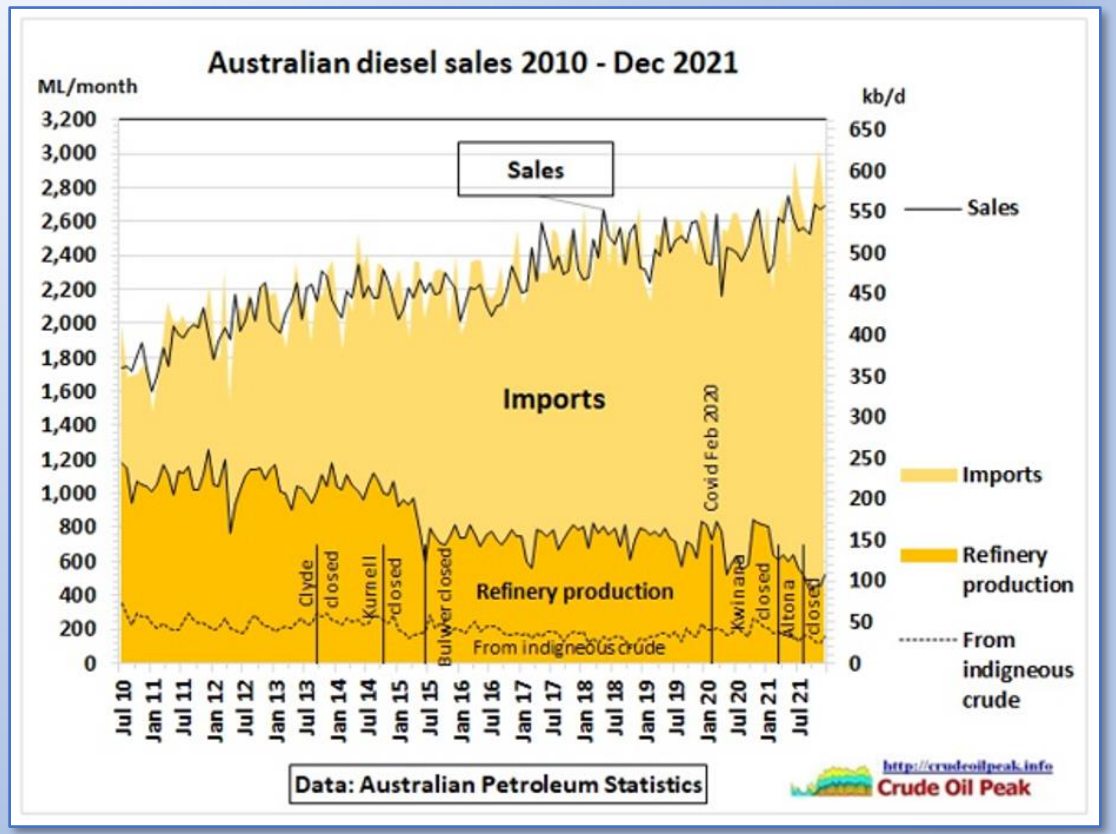
Global oil & gas discoveries lowest level in decades



https://www.rystadenergy.com/newsevents/news/press-releases/2021-global-oil-and-gas-discoveries-projected-to-sink-to-lowest-level-in-75-years2/

Australian diesel fuel in-country stocks & supplies

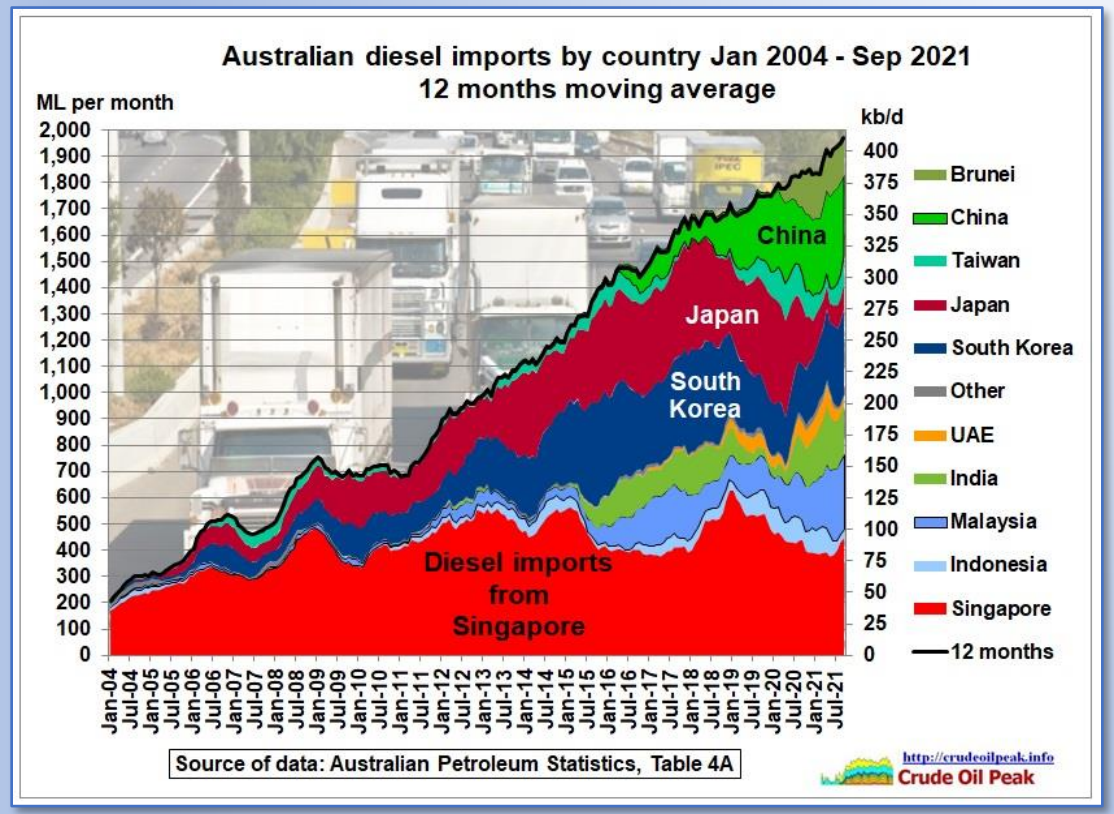


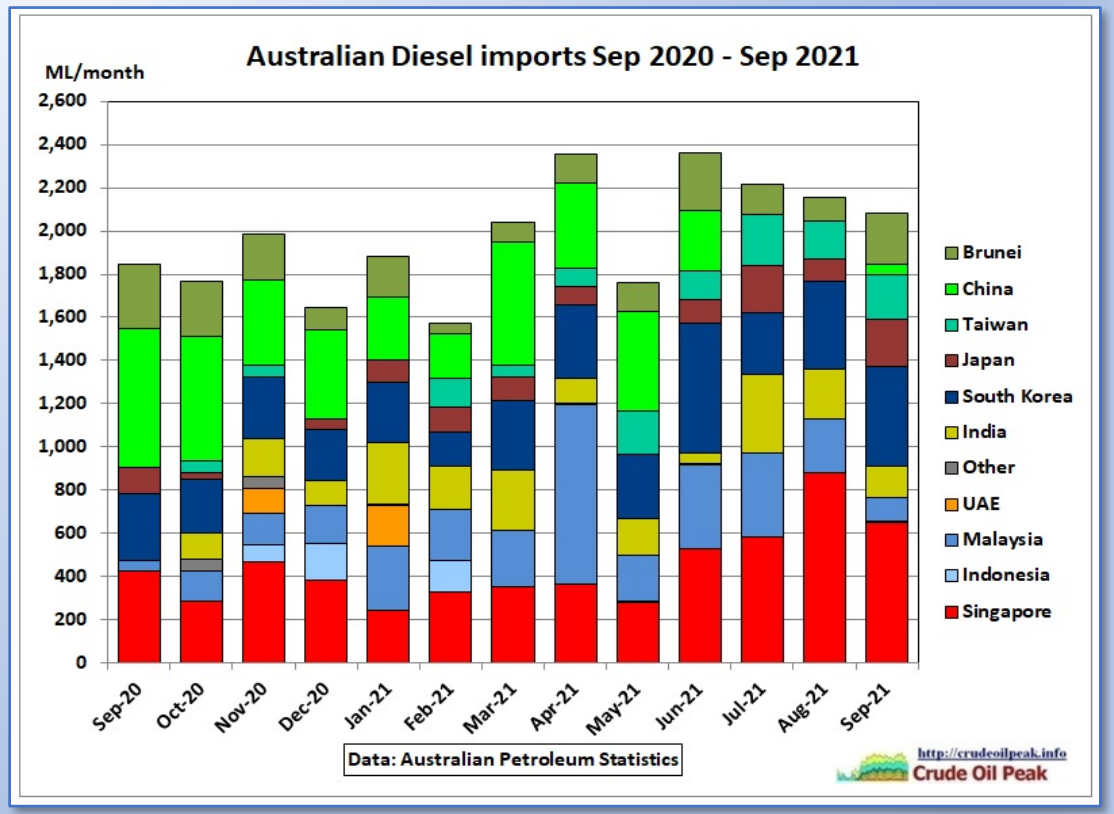


Note that indigenous crude is blended with imported crude at the ratio of around 1:3. Indigenous crude does not mean that this diesel can be refined from only indigenous crude.

Source: **Australian oil stocks consumption cover**, by Matt on 22 Mar 2022, https://crudeoilpeak.info/australian-oil-stocks-consumption-cover

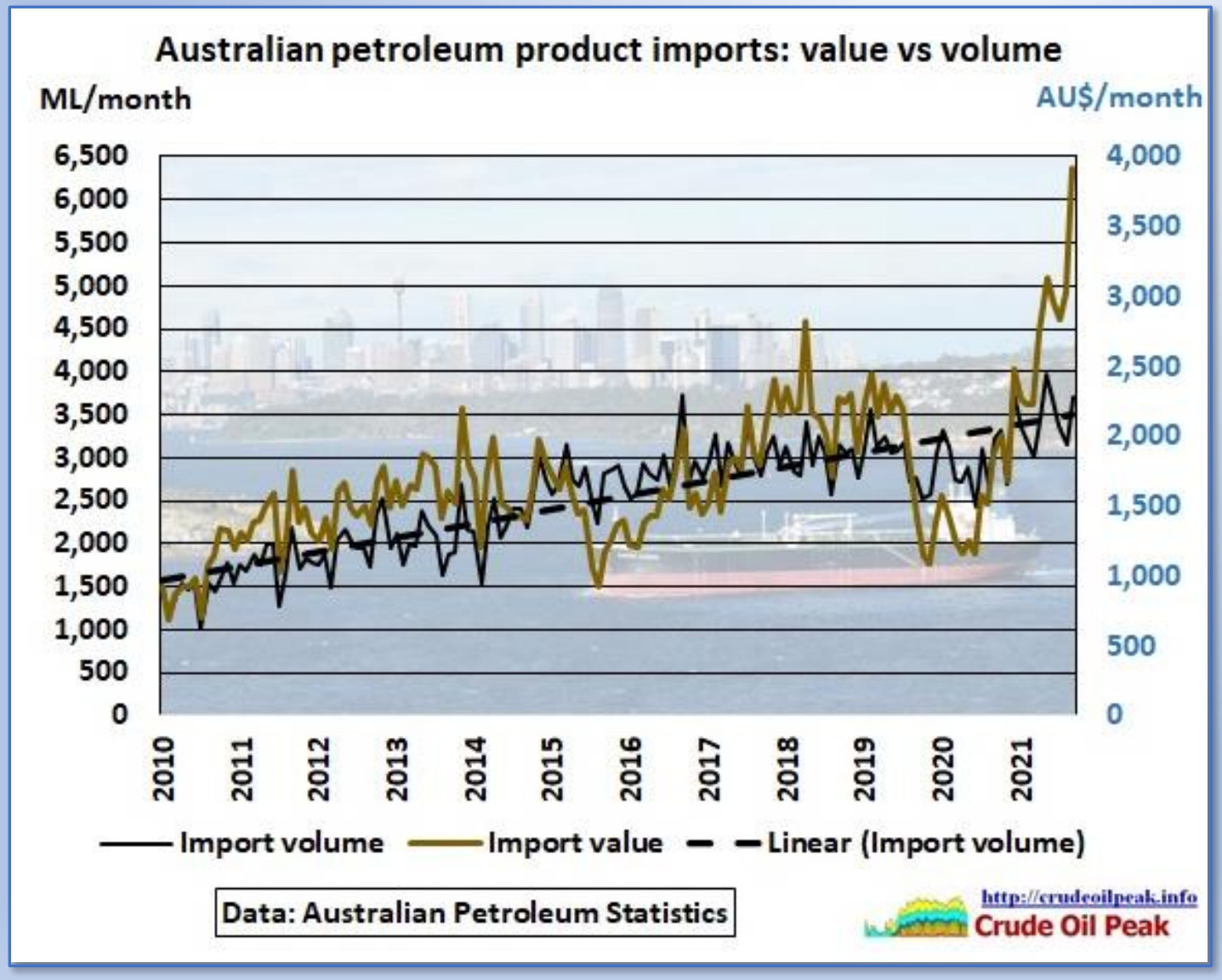
Australian diesel fuel import dependencies





The closure of Australian refineries has caused increasing fuel imports, mostly from neighbouring Asian countries, in varying volumes from month-to-month. This circumstance exposes Australia to commercial constraints and geopolitical changes in these oil markets. Oil production in Asia is in decline, which means more crude oil imports, mainly from the Middle East. Therefore, there are multiple layers of vulnerabilities over which Australia has little control. Australia should rapidly reduce its petroleum dependency to improve energy security. Source: **Australian fuel import dependencies Sep 2021 Data**, by Matt on 10 Dec 2021, https://crudeoilpeak.info/australian-fuel-import-dependencies-sep-2021-data

Australia's fuel import bill is rising rapidly

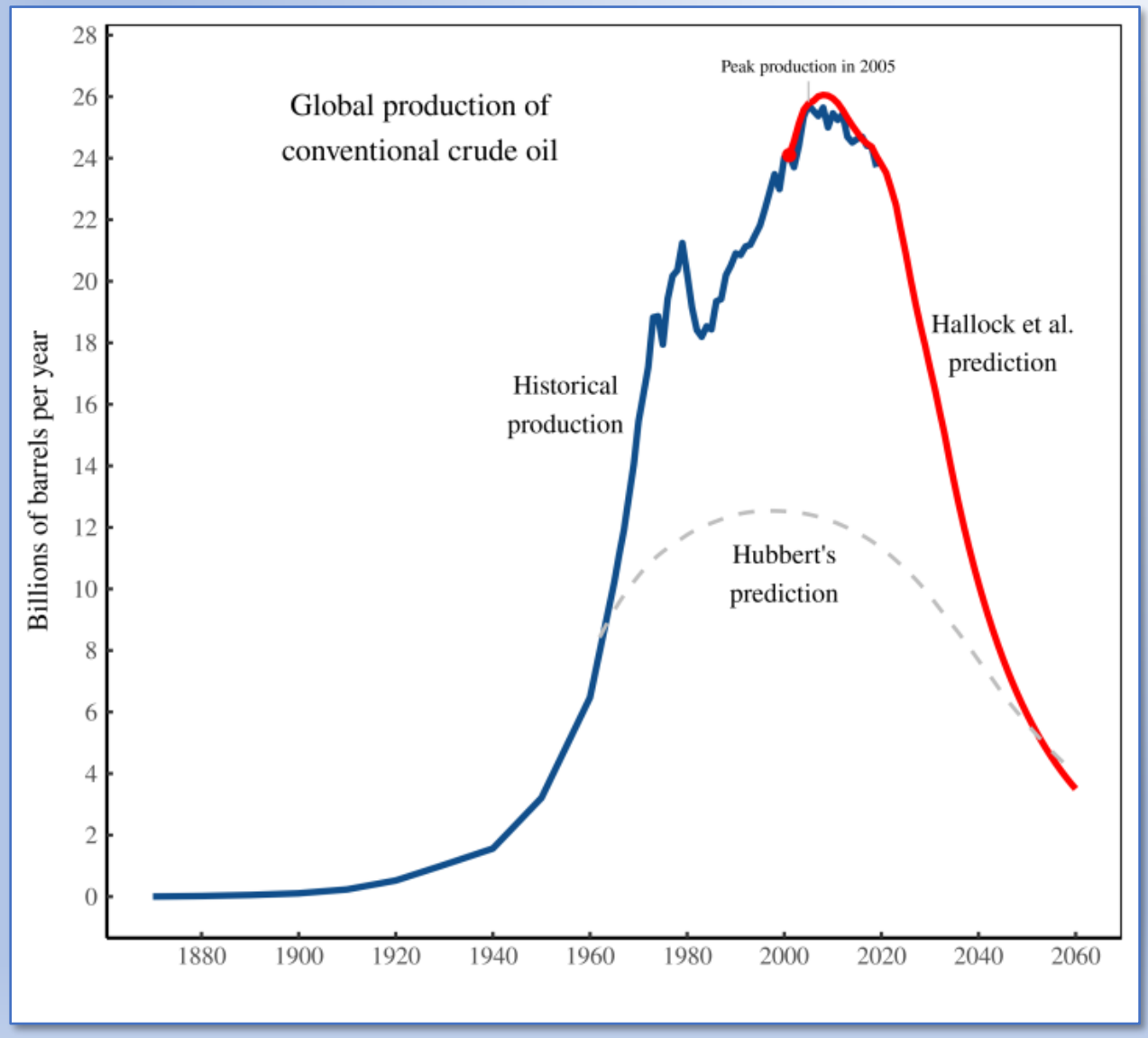


In March 2022, Australia's petroleum product imports had reached almost AU$4 billion per month, an increase of 70% compared with December 2019.

https://crudeoilpeak.info/australian-fuel-import-bill-going-sky-high

Australia needs to reduce its thirst for transport fuels. No new projects should be started which increase fuel consumption.

Global ‘peak oil’ never went away



Comparison of historical global production of conventional crude oil with projections by M. King Hubbert and John Hallock *et. al.*

If the Hallock model is correct, we’re on the precipice of an oil-production collapse. By 2040, the model predicts that we’ll be back to 1960-levels of oil production.

Peak Oil Never Went Away, by Blair Fix, 16 Nov 2020, https://economicsfromthetopdown.com/2020/11/16/peak-oil-never-went-away/

“We should not cling to crude down to the last drop – we should leave oil before it leaves us. That means new approaches must be found soon.” – **Fatih Birol**, IEA, 2 Mar 2008

There is only one planet we have to live on

– There is no planet B!

The Blue Marble, The Earth seen from Apollo 17 on 7 Dec 1972, NASA/Apollo 17 crew