Crude Awakening!

Fast rising seas threaten seaborne oil & energy security

Spotlight: Japan & South Korea

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- **Rapid sea level rise (SLR) threatens seaborne crude & energy security** as global oil trade is very reliant on maritime trade routes. Tankers which ship oil around the world make up almost 30% of the global shipping fleet and shipping emissions. **64% of oil produced globally, moved by these ships, can be disrupted as key import/export ports are impacted by rising seas.**
- **SLR = existential threat to oil trade: 12 of the world's Top 15 tanker terminals will be impacted at just 1m of SLR, disrupting top global exporters & importers of oil.** Maritime infrastructure like ports & bunkering facilities are coastal & largely low-lying making them vulnerable to SLR. We stress tested the Top 15 ports that are essential to global oil trade to various SLR levels; the results were shocking: 12 are impacted by 1m; another 2 are hit by 2m of SLR.
- **Beware! SLR is accelerating due to 1) rapid ice loss from Greenland & Antarctica; 2) thermal expansion from hotter oceans.** Observations in the past 20 years show losses from both ice sheets running well ahead of earlier projections causing concerns that IPCC SLR projections are too low. Many ice sheet scientists never thought they would see this level of melt in their lifetimes & now warn that: **ice is already in the danger zone at 1.5ºC, & 2ºC is too hot for ice. The only option is to stay <1.5ºC or risk unleashing 2-3m SLR.**
- **Timing matters! For 1.5ºC, fossil fuel cuts must be made by 2030; coal has peaked but oil emissions are only plateauing 2030-2050.** Oil output is still rising by 5.8mn b/d for 2023-2028, meanwhile drastic coal cuts means that after 2040, oil's carbon emissions will exceed those of coal. By 2050, this gap is 6.5GtCO_2 – similar to the GHG emissions of the US & Australia. This last hurrah in oil led by the Americas could end up shooting the sector in the foot.
- **Asia is especially vulnerable with much of its oil delivered by sea:** Top 5 importers of crude oil account for 60% of global crude oil imports – 4 of these are from Asia – China, India, South Korea & Japan. We focused on **most-at-risk Japan & South Korea + they may warrant sovereign risk re-ratings:**
  - Oil is the key fuel source of primary energy: Japan (39%) & South Korea (36%).
  - Almost 100% reliant on oil imports by sea = very vulnerable to SLR.
  - 1m SLR threatens Japan's energy security: 3 ports of key suppliers (78% crude imports) + 5 receiving ports (68% of refining capacity) impacted.
  - 1m SLR threatens South Korea's energy security: 6 ports of key suppliers (70% crude imports) + 4 key receiving ports (100% refining capacity) impacted.
  - Yet both countries are behind on transition with implementation gaps that are 7.5-9x that of China's; EV adoption rates are also abysmal, plus large shares of Top 10 exports are skewed towards oil-related sectors.
- **Crude awakening! YTD March warming of 1.58ºC = accelerated SLR risks = time to rethink energy security & examine port resilience.** We worry that adaptation plans in place are not sufficient to address fast rising seas. Governments, asset owners, banks & other stakeholders from port operators, shipowners, downstream oil players & users must prioritise SLR assessments, port resilience & oil transition; outcomes will dictate who survives the impacts.
- **Asia is the region most vulnerable to SLR = Asia must lead global oil transition.** Asia's position as the prime importer, refiner & producer of petrochemicals to global leadership in bunkering, maritime services, ship owning & building means it can deliver catalytic & transformative resilience in the energy sector. The infrastructure risks highlighted in this report offer unique investment opportunities. The rapid rate of ice loss today means there's no time to waste **– so take action with our 5 opportunities to lead in transition & adaptation.**

Why we are writing this…

We are worried. Our oceans are now warming much faster than ever before. Glaciers and ice sheets are also seeing "unimaginable" losses as global heating accelerates. These are worrying as thermal expansion from warming oceans, and ice sheet losses are key drivers of sea level rise.

As it is, sea levels are rising at unprecedented rates. Indeed, with year-to-date (YTD) March 2024 warming at 1.58°C, sizeable SLR of 6-9m has already been locked-in. But if we manage to keep warming to 1.5°C, we will only see up to 0.55m by 2100; however, at 2°C of warming, this level could double. Further warming brings exponential sea level increases – alarmingly, current annual CO_2 emissions growth tracks the very worst-case scenario – this means 2m to 5m of SLR cannot be ruled out by 2100 and 2150.

Clearly this will be disastrous – swathes of coastlines will be redrawn, coastal cities and rural populations uprooted. SLR impacts are pervasive – rising seas is not just a threat but a threat multiplier and if we are not careful, we could end up shooting ourselves in the foot. One such sector doing this is the oil sector – its last hurrah to pump more oil before 2030 (the last-stop date by which we must deliver a ~24GtCO_2e emissions cut to stay within 1.5°C) could well trigger ice tipping points. Passing these will unleash unstoppable multi-metre SLR which will not only sink key oil ports and disrupt global oil trade but also swamp coastal refineries & petrochemical facilities – many of these facilities, as this report shows, will be impacted by just 1m of SLR.

We are writing this report because we are all in for a crude awakening – continued oil expansion and insufficient emission cuts in the near term could not just sink the oil industry but all our futures. We have 6 years left until 2030 to deliver deep emission cuts and since SLR threatens our coastal capitals and hubs, it's time we take a deeper dive into Asia's energy security vis-à-vis rising seas. Ironically, oil, a key component of energy security could end up threatening energy security of multiple countries across Asia, in particular Japan and South Korea as this report shows.

With sizeable energy security exposure, it's time to rethink oil – far from providing energy security, our oil habit could sink all our futures. Once triggered, we cannot "undo" rising seas, so we must start talking about the implications of this "crude catastrophe" now. In sounding the alarm, we hope this report can help bring fresh perspectives on oil transition and draw critical attention to catalyse actions from the governments of oil importing and exporting countries, oil/port/tanker asset owners, the financial sector, NGOs and academia to provide strategies and solutions to wean us off this deadly habit.

António Guterres
The UN Secretary-General
UN Security Council Debate on "Sea-level Rise: Implications for International Peace and Security", February 2023
"Mega-cities on every continent will face serious impacts including Lagos, Maputo, Bangkok, Dhaka, Jakarta, Mumbai, Shanghai, Copenhagen, London, Los Angeles, New York, Buenos Aires and Santiago. The danger is especially acute for nearly 900 million people who live in coastal zones at low elevations — that's one out of ten people on earth. Some coastlines have already seen triple the average rate of sea-level rise."

Pam Pearson
Director & Founder of the International Cryosphere Climate Initiative (ICCI)
Director of the Ambition on Melting Ice (AMI) Secretariat
In conversation with CWR, November 2023
"Based on what we have seen in the past 20 years, loss from both ice sheets is running well ahead of earlier projections. Many ice sheet scientists never thought they would see this level of melt in their lifetimes … drawing from Earth's past, there have been periods when sea levels rose between 3-4 meters per century (the last time, about 14,500 years ago) … But the really serious issue is that those past rapid increases in sea levels were taking place in a world that was not warming nearly as fast as ours today."

"We really need to dial back emissions this decade, before 2030. If we do not, then bringing down CO_2 levels and temperatures close to 1.5°C becomes impossible; and for each tenth of a degree we go higher, the changes become more and more irreversible."

CWR Accelerated Threat Series

The **"Accelerated Threat Series"** launched in 2024, is our response to the increasing challenges due to rapid global warming. Today, compounded by El Niño, temperatures are rising at an alarming rate – annual warming shot up from 1.15°C for 2022 to 1.45°C in 2023. Then, an abnormally warm start to 2024 pushed YTD warming in January to 1.52°C. Since then, warming for the 12-month rolling period has only risen – 1.56°C by YTD February and 1.58°C by YTD March 2024. Although we will head back into a "cooler" La Niña period (when the world is on average cooler than it should be) in around 3-4 years' time, it is worth noting in the last La Niña, we still had many temperature peaks.

Sadly, accelerated global warming only exacerbates water scarcity – carbon causes climate change but water is how we will largely feel it. Already, we are reeling from the impacts – floods, droughts, rising water scarcity and so on. Seas are also rising faster than expected due to unprecedented warming of our oceans causing thermal expansion as well as rapid ice sheet losses from our polar regions. All these only serve to accelerate physical risks which have material implications for governments, asset owners and the financial sector.

Our first report in the **Accelerated Threat Series** focused on freshwater challenges posed by the ICT sector – it explored how AI & climate risks amplify existing water risks faced by thirsty data centres. This time, we turn to saltwater challenges posed by the fossil fuel sector, specifically oil. Although this report only focuses on oil, it does not mean that other fossil fuel types and/ fossil fuel power generation do not face coastal threats – they do. Depending on funding, we hope to cover these in the future so watch this space!

Finally, it is important to note that this series of reports are meant to be briefs to raise awareness and discourse around accelerating risks so that we can design adequate responses. As a result, in these reports we have not included assessments of the adequacy of adaptation in place nor planned, if any.

China ICT running dry?

The rise of AI & climate risks amplify existing water risks faced by thirsty data centres

April 2024

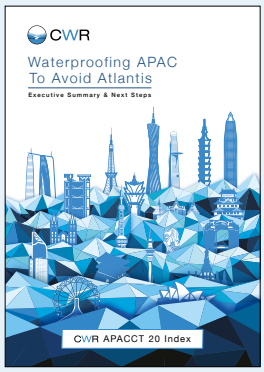
The new report revealed that 4.3mn data centre racks in China consume around 1.3bn m^3 today but can rise to >3bn m^3 by 2030. For perspective, ~1.3bn m^3 is 1.9x the water use for households & services in Tianjin, a city of 13.7mn people... but with data centre growth plus AI, this could explode to more than 500mn people!

Clearly, this doesn't bode well for China ICT because even without generative AI, the exposure to water risks is high – almost half of China's data centre racks are located in water scarce regions, which are as dry as the Middle East.

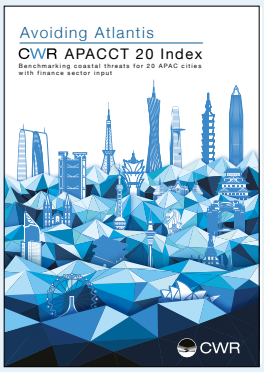
Generative AI and chatbots could see water use surge by a shocking 20x – putting pressure on already stressed water resources. Besides rising competition for water, the report shows sizeable threats from multiple types of water risks from rising scarcity & water stress, floods, droughts, coastal threats as well as increasing regulatory risks. Check out the 5 to-dos to waterproof your portfolios & assets.

Recommended reading on coastal threats…

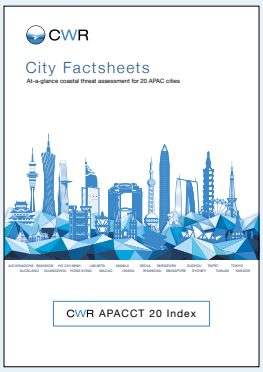
CWR APACCT 20 Index
CWR Survival Guide to Avoiding Atlantis



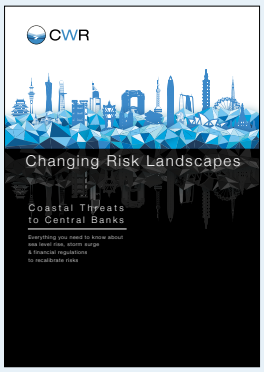
Waterproofing APAC To Avoid Atlantis
Executive Summary & Next Steps



Avoiding Atlantis: CWR APACCT 20 Index
Benchmarking coastal threats for 20 APAC cities with finance sector input



The CWR APACCT 20 Index City Factsheets
At-a-glance coastal threat assessment for 20 APAC cities



Changing Risk Landscapes: Coastal Threats To Central Banks
Everything you need to know about sea level rise, storm surge & financial regulations to recalibrate risks

Sovereigns at Risk – APAC Capital Threats
Re-ratings warranted as city capitals & GDP are materially exposed to coastal threats

Contents

Abbreviations & Definitions

AMI	Ambition on Melting Ice
APAC	Asia Pacific
BNEF	Bloomberg New Energy Finance
CCUS	Carbon capture, utilisation & storage
CO_2	Carbon dioxide
EU / EU27	European Union excluding the UK
EV	Electric Vehicles
G7	Canada, France, EU, Germany, Italy, Japan, UK, & USA
G20	Argentina, Australia, Brazil, Canada, China, EU, France, Germany, India, Indonesia, Italy, Japan, Mexico, Republic of South Korea, Russia, Saudi Arabia, South Africa, Türkiye, UK, & USA
GDP	Gross Domestic Product
GHG	Greenhouse gas
ICCI	International Cryosphere Climate Initiative
IEA	International Energy Agency
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
IPCC AR6	Intergovernmental Panel on Climate Change Sixth Assessment Report
IPCC AR6 WG1	Intergovernmental Panel on Climate Change Sixth Assessment Report Working Group 1
IPCC AR6 WG2	Intergovernmental Panel on Climate Change Sixth Assessment Report Working Group 2
IPCC AR6 WG3	Intergovernmental Panel on Climate Change Sixth Assessment Report Working Group 3
OEC	Observatory of Economic Complexity
OPEC	Organization of the Petroleum Exporting Countries – Algeria, Angola, Congo, Equatorial Guinea, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Saudi Arabia, UAE & Venezuela. *Note: Angola left OPEC on 1 January 2024, but all figures related to OPEC in this report includes it.*
OPEC+	OPEC+ Azerbaijan, Bahrain, Brunei, Kazakhstan, Oman, Malaysia, Mexico, Russia, South Sudan, Sudan
SLR	Sea Level Rise
SSP	Shared Socioeconomic Pathway
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
WMO	World Meteorological Organization

SLR impact

For the purposes of this report, an oil terminal is considered flooded if any of its port facilities, including berths, pipelines, storage & so on, are lower than the projected SLR. For boundaries of such facilities, we have used data from Verschuur et al. (2022) *"Multi-hazard risk to global port infrastructure and resulting trade and logistics losses"*, published in Communications Earth & Environment. However, unlike the paper, which uses an underlying map of JAXA AW3D30 DEM model, we have instead for this report utilised NASA SRTM 30m-grid map as the underlying elevation map for stress tests. We have done this to ensure consistency and comparability across all previous CWR reports highlighting coastal threat risks.

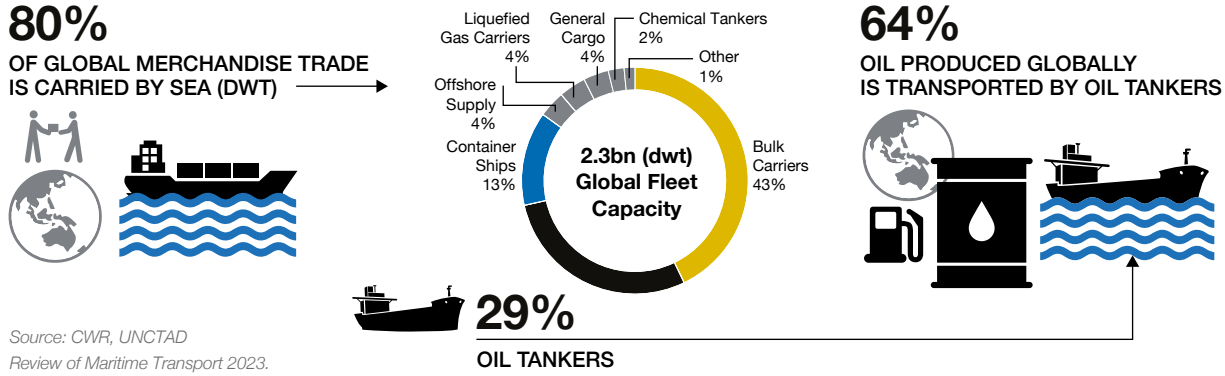
It is important to note that local astronomical high tides are not considered in the SRTM which means that impacts will be worse than results shown in this report. Therefore, we recommend that all stakeholders utilise local maximum/ astronomical tides to conduct SLR stress tests. Also, where available, local elevation DTM or LIDAR maps should be used for stress testing; the higher the granularity (e.g. 5m-grid) the better.

Units:

bn	Billion	mn	Million
b/d	Barrels per day	$MtCO_2$	Million metric tonnes of CO_2
dwt	Deadweight tonnage	$MtCO_2e$	Million metric tonnes of CO_2 equivalent
$GtCO_2$	Gigatonnes of CO_2	NM	Nautical miles
$GtCO_2e$	Gigatonnes of CO_2 equivalent	trn	Trillion
GT	Gross tons	TJ	Terajoule
GW	Gigawatt	TW	Terawatt
kWh	Kilowatt hour	y-o-y	Year-on-year
m	Metre	YTD	Year-to-date

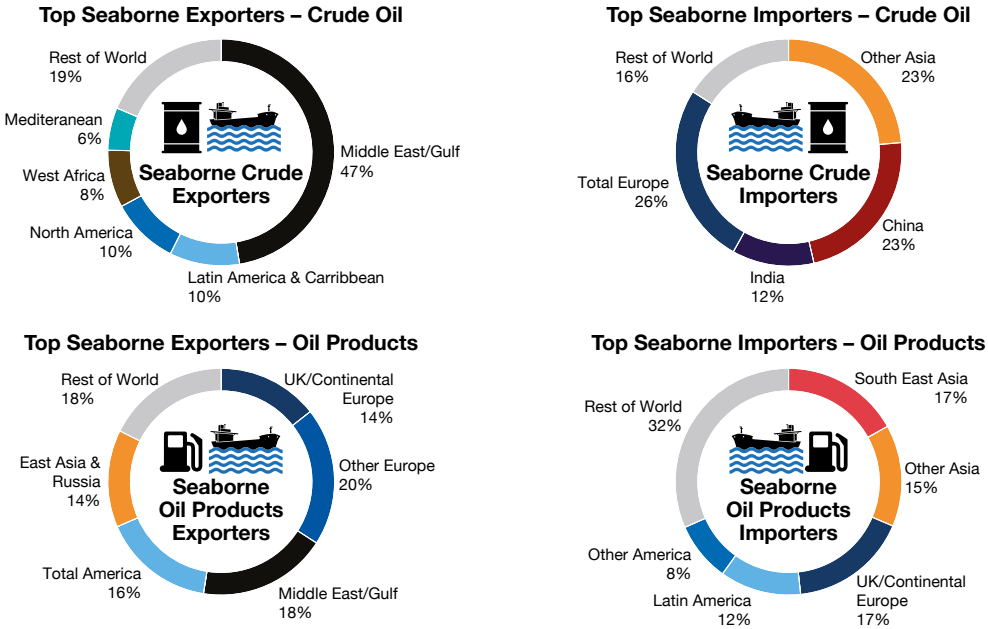
Global oil – can't flow without ships but ports will be hit by rising seas…

- **High reliance! 64% of oil produced globally is moved by oil tankers which make up almost 30% of global fleet capacity.** Sea routes are an important conduit of global trade. The UNCTAD estimates that over 80% of the volume of global merchandise trade is carried by sea.[1] In January 2023, global maritime trade was transported on board 105,493 vessels of 100 gross tons (GT) and above – oil tankers, bulk carriers, and container ships account for 85% of total capacity as per the middle chart below.[2] Oil is a key component – with a total capacity of over 651mn dwt, oil tankers make up almost 30% of the global world fleet capacity in 2023.[2] These tankers shift vast amounts of oil – almost two-thirds of oil produced globally is moved by ships.[3]



Source: CWR, UNCTAD Review of Maritime Transport 2023.

- **Asian seaborne crude is one of the highest crude oil trading blocks in the world, accounting for 58% of global seaborne crude import volumes.** The charts below show that while the Middle East/Gulf is the largest exporter of seaborne crude accounting for 47% of global export volumes, Asia is the largest importer of seaborne crude.[2] As of 2022, Asia accounted for 58% of global seaborne crude import volumes – China has the largest share at 23%, followed by India at 12%; while Japan & South Korea, also top importers of oil, make up a large share of Other Asia.[2] Asia also accounts for 31% of global seaborne oil product import volumes.[2] **This large seaborne crude trade block makes both Asia & the Middle East very vulnerable rising seas.**



Source: CWR, UNCTAD Review of Maritime Transport 2023.

- **Accelerated warming = accelerated SLR which threatens seaborne crude trade & energy security.** Maritime infrastructure such as ports and bunkering facilities are coastal and likely located in low-lying areas making them vulnerable to sea level rise (SLR). The map on the following page provides an at-a-glance overview of the seaborne oil trade between key ports of top oil producing/ exporting countries as well as the top oil consuming/importing countries. Clearly, **if key ports are not resilient to rising seas, then key maritime oil trade routes will be disrupted – port insecurity is energy insecurity. We are especially worried as polar ice has been melting much faster & much sooner than expected** – see box below. **We therefore stress tested the Top 15 ports that are essential to global oil trade to various levels of SLR.**

- **The results of our stress tests were alarming:**
  - **12 of the Top 15 global oil tanker terminals are vulnerable to 1m of SLR; with a further 2 terminals underwater at 2m of SLR.** The graphic on the following page shows the Top 15 oil tanker terminals ranked by the total number of port callings according to Clarkson Research for 2023.[4] Of the Top 15, 5 ports are in the Middle East, 2 in the US, 3 in China and one each in Singapore, the Netherlands, South Korea, Malta & Russia. We analysed these 15 tanker terminals for SLR impacts and found that 12 of the Top 15 tanker terminals will be impacted at just 1m of SLR and a further 2 terminals are impacted at 2m of SLR – only Malta Freeport is not impacted at either 2m or 3m of SLR. Please refer to the next page for the list of terminals impacted. For the definition of impact, see **"Abbreviations & Definitions"**.
  - **Results could be worse due to support infrastructure exposure, tides & higher granularity.** It's important to note here that we did not stress test surrounding support infrastructure such as roads and so on – this may well increase the vulnerability of these oil ports. Also, only average tide was accounted for; local maximum/astronomical high tide wasn't factored in, so impacts could be worse. Finally, as more granular (e.g. 5m-grid) local elevation maps were not available across all locations globally, for comparability purposes we used the NASA SRTM with 30m-grid resolution as the underlying elevation map to carry out the stress tests.[5]
  - **Both export and import oil terminals are impacted.** It is clear from the graphic on the next page that seaborne oil trade can be impacted on both the export and import side as export/import terminals are vulnerable to SLR. These Top 15 ports serve some of the largest exporters and importers of crude oil – 6 of these serve 4 of the Top 10 exporters of crude: Saudi Arabia, Russia, US, UAE which together comprise 42% of global crude exports; whereas 7 of these serve 4 of the Top 10 importers: China, US, South Korea and the Netherlands which together absorb 45% of global crude imports.[6]
  - **Of the Top 15 Tanker Terminals we analysed, all 5 based in Asia are impacted at 1m of SLR** – Singapore, Ningbo-Zhoushan, Shanghai, Gwangyang & Dalian. If this list was expanded to the Top 20, then the two Malaysian ports of Tanjung Pelepas (#16) and Pengerang (#19) as well as India's port of Sikka (#18) would be included.[4] The Top 20 Tanker Terminals account for 27% of the total port calls of 188,603 in 2023, whereas the 8 Asian ports account for 13%.[4] Although this report does not focus on India, the key transit ports of Singapore and Malaysia nor the exporting oil ports of the Middle East, they are clearly not immune – more on this later in **"Other climate chokepoints – Straits of Malacca, the Middle East & Panama"**.

- **We worry that port adaptation may lag fast-evolving "unthinkable" ice melt observed today that could unleash rapid SLR sooner than we think.** While some of these oil ports have coastal threat adaptation plans in place, we worry that they may no longer be adequate due to accelerated warming and the "unthinkable" rapid ice melt we are observing today. Plus, the fact that we have breached 1.5°C in 2024 is alarming.[7] Although there are deep uncertainties in ice dynamics, scientists are *"virtually certain"* that seas will rise, and that this rise is irreversible. And what's certain from our analysis shown in the graphic on the next page is that **rising seas will pose clear and present danger to commercial trade as well as energy security risks for major Asian economies.** What's also becoming clearer is that seas will rise faster with accelerated global warming – please see the box below.

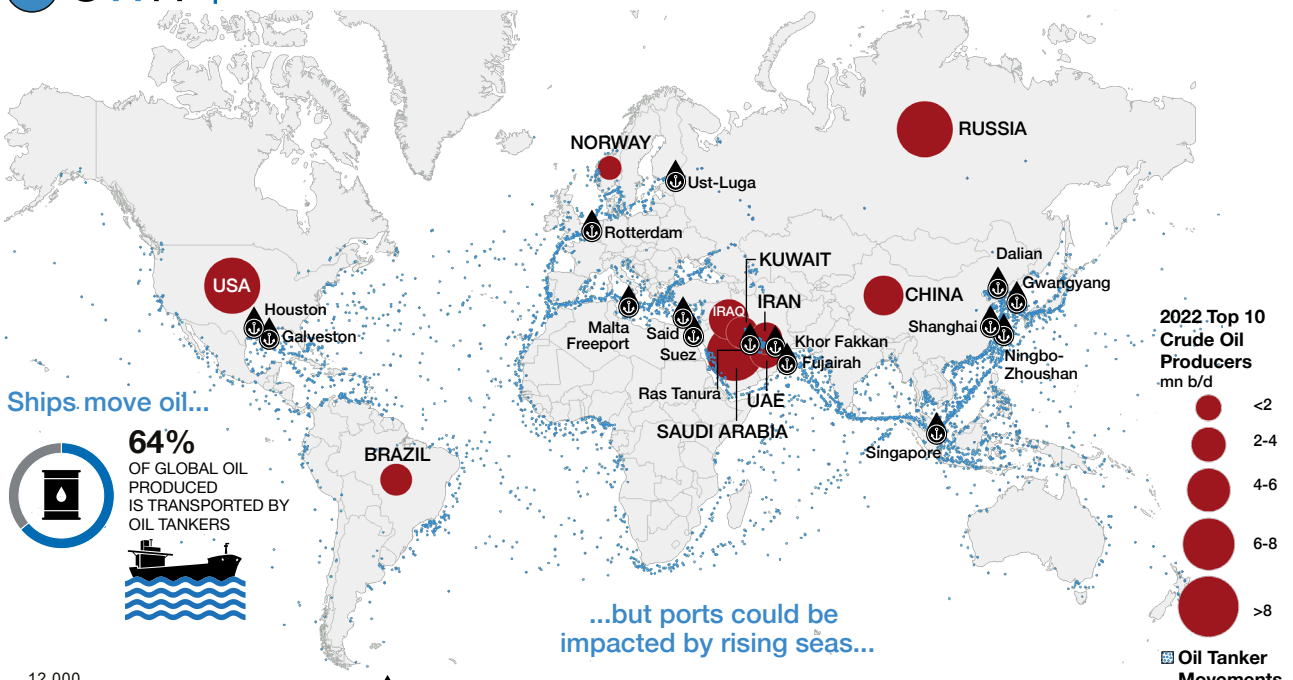
"Unthinkable" rapid polar ice melt today means that 2-3m of SLR "cannot be ruled out" by 2100! The IPCC warned in 2021 that *"Approaching 2-5m by 2100 and 2150 cannot be ruled out due to deep uncertainty in ice sheet processes".* Now, cryosphere scientists say that ice sheet losses from both Greenland & Antarctica *"is running well ahead of earlier projections".* The latest "State of the Cryosphere 2023" notes that **2ºC is too hot for ice and that 1.5ºC is the only option**, yet YTD warming breached 1.5°C in January 2024 putting ice in the *"danger zone"*.

Unfortunately, we are set to warm more as emissions are still growing – key countries are not on track to meet their pledges plus escalating wars & tense global geopolitics only serves to fracture global unity required to tackle the climate crisis. Worse still, the UN's "Emissions Gap Report 2023" notes that current policies track a 3°C path while delivering on all unconditional & conditional pledges by 2030 will only lower this estimate to 2.5°C. Clearly, this is not good enough for ice – if accelerated warming of land as well as ocean temperatures persists through to 2030, these will accelerate SLR. We would well see rapid SLR in the coming 3 decades, which means we cannot rule out multi-metre SLR of 2-3m by 2100. For more on rising seas please see:

- **2ºC is too hot for ice! 1.5ºC is the only option – or face rapid ice melt & SLR**
- **Facing reality! Accelerated warming – the real base case & SLR projections**

Source: CWR; IPCC Climate Change 2021: The Physical Science Basis; CWR interview "2°C Too Hot for Ice & Rising Seas – A Conversation with ICCI Director Pearson" (21 November 2023); ICCI State of the Cryosphere 2023 – Two Degrees Is Too High; WMO; UNEP Emissions Gap Report 2023.

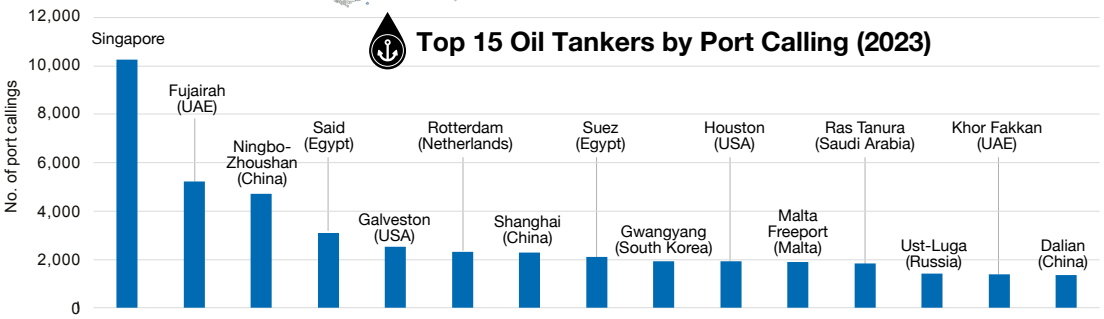
CWR | AT-A-GLANCE GLOBAL OIL FLOWS VULNERABLE TO RISING SEAS

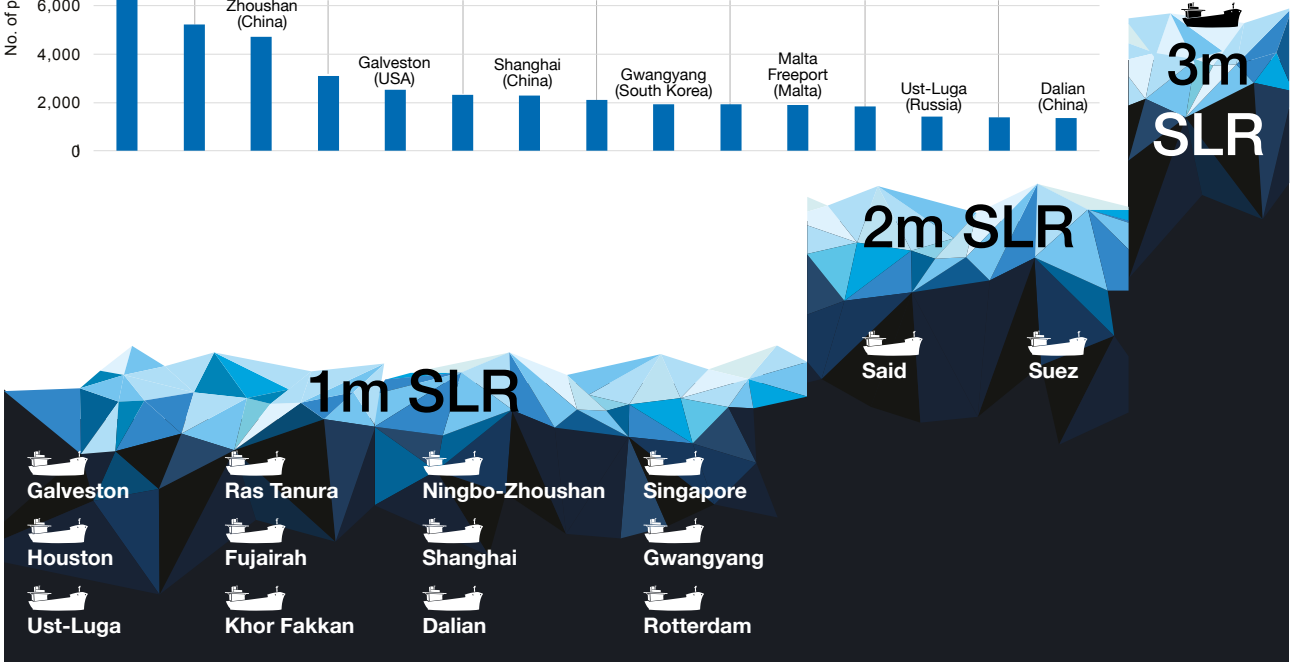


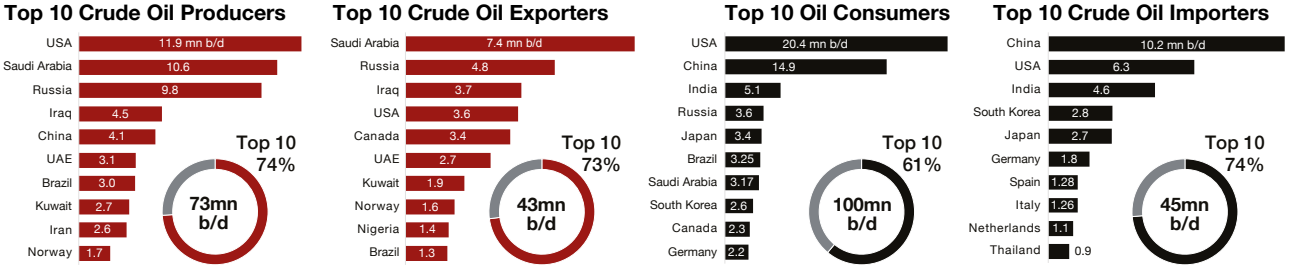
Ships move oil...

64% OF GLOBAL OIL PRODUCED IS TRANSPORTED BY OIL TANKERS

...but ports could be impacted by rising seas...







Note: There was no available data for top 10 crude oil consumers. Therefore, this report used the top 10 oil consumers, which includes crude oils, refineries and other oil products, for analysis.

Source: CWR; Clarksons Research 2023; OPEC Annual Statistical Bulletin 2023; NASA SRTM 30m; Verschuur et al. (2023) "Multi-hazard risk to global port infrastructure and resulting trade and logistics losses", Communications Earth & Environment.

2 °C is too hot for ice! 1.5ºC is the only option – or face rapid ice melt & SLR…

Too fast, too soon! Vanishing ice & rising seas will redraw coastlines = existential threats to coastal populations & global trade unless adapted. Accelerated global warming means that ice in our polar regions is melting too fast and too soon. If such unprecedented ice loss continues, it will unleash devastating SLR. Not only will this be existential for small island states but cities from London, New York to Shanghai will also be significantly impacted. Rising seas can sink our futures; it is not just a threat but a threat multiplier. Worryingly, faster and higher SLR can outpace existing adaptation efforts, disrupt global trade and trigger mass migration and systemic shocks across financial systems. **We are simply not ready for the impacts as warming has significantly outpaced adaptation efforts so far – we have breached 1.5ºC of warming some 70 years sooner than the Paris target year of 2100.**

2ºC is too hot for ice! Already at 1.5°C, ice is in the danger zone. Previously, we thought that as long as we kept global warming below 2°C, that ice would be "safe". But that's not the case anymore. It turns out that top cryosphere scientists are warning that 2°C is too hot for ice and that even reaching 1.5°C will put ice in the danger zone. **Leading global scientists and policymakers were so worried that they formed a new group at COP27 – the AMI (Ambition on Melting Ice) to sound the alarm on the scale & speed of melting ice and permafrost thaw.** Pam Pearson, the Founder & Director of the International Cryosphere Climate Initiative (ICCI) as well as the Director of the AMI Secretariat, does not mince words: *"based on what we have seen in the past 20 years, loss from both ice sheets is running well ahead of earlier projections".* How fast it is melting is scary, Pearson said that *"many ice sheet scientists never thought they would see this level of melt in their lifetimes".* If you want a dose of ice cold facts, read our interview with her – it is terrifying – click on the image below.

We cannot overshoot 1.5°C, sea level rise is irreversible; at today's temperatures, we've already locked in 6-9m of SLR – it's not a matter of 'if' but 'when'. According to the report "IPCC Climate Change 2021: The Physical Science Basis", even if we stopped emitting, *"it is virtually certain that global mean sea level will continue to rise over the 21st century".* Indeed, the IPCC notes that many changes due to past and future greenhouse gas emissions are irreversible for centuries to millennia, especially changes in the ocean, ice sheets and global sea level. In fact, at today's temperatures, we have likely locked in 6-9m of SLR; even more worrying is that seas were 20m+ higher the last time the world experienced CO_2 levels of today. So, it's not a matter of 'if' but 'when' this will happen – and 'when' depends on how fast we are warming. Here, it is worth noting that **SLR does not rise in a linear manner; abrupt jumps in SLR can occur due to abrupt ice melt. The only way to slow down the melt is to cut emissions** – this is why it is important to cut fossil fuels now not later – this decade rather than the next as *"we cannot negotiate with ice"*. As Pearson warned: *"Thinking we can turn back the clock in 2040 or 2050 or 2060 without causing extensive global loss and damage is a fantasy; and we need to face physical reality"*

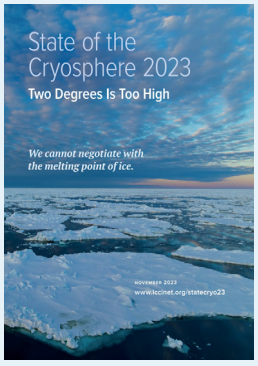
Ocean warming & thermal expansion are key drivers of SLR – new record highs in 2023 & 2024 for global sea temperatures are alarming. Our oceans have been warming; warmer water expands (thermal expansion) as well as accelerates polar ice caps and glacier melt – all these make sea levels rise faster. Indeed, thermal expansion alone contributed to 50% of SLR between 1971 and 2018 whereas ice sheet and glacier ice losses accounted for 42%, making it the largest single contributor to rising seas. Unfortunately, our oceans are now warming much faster than expected. The WMO's 2023 data showed that our global ocean has warmed faster over the past century than at any time in the past 11,000 years. Notably, Florida's ocean temperature soared to >38°C, which is similar to a "hot tub" in 2023. Sadly, ocean temperatures have now been warming at unprecedented levels for the last 12 months to March 2024. This rapid rate of warming is worrying as our oceans help cool land temperatures by absorbing around 90% of the land heat. As we are still emitting, land temperatures will continue to rise and ocean warming will continue. However, warmer oceans mean that its ability to act as a heat shield has lessened. As a result, both land and ocean temperatures may well rise faster from now on – all this will further accelerate thermal expansion and marine ice sheet melt resulting in faster SLR.

It's important to face the stark reality of ice sheet losses and the SLR it could unleash – see **"Facing reality! Accelerated warming – the real base case & SLR projections". Staying within 1.5°C to slow this down is only possible with serious emission cuts before 2030. With 6.5 more years left to take action, it's time we make an "eyes-wide open" assessment of SLR threats before we inadvertently shoot ourselves in the foot!** For more see **"Ice tipping points & runaway SLR – window to act closes by 2030".**

Source: CWR article "Too Fast, Too Soon – Vanishing Ice & Rising Seas" (21 November 2023); CWR interview "2°C Too Hot For Ice & Rising Seas – A Conversation with ICCI Director Pearson" (21 November 2023); IPCC AR6 WG1 (2021); WMO "Global Sea-Level Rise & Implications" (2023); Guardian article "Florida ocean records 'unprecedented' temperatures similar to a hot tub" (26 July 2023);Copernicus; NOAA Climate.gov.

Recommended Reading

Futureproofing APAC Banks & Savings
Stress test right today, avoid hard landing from rising seas

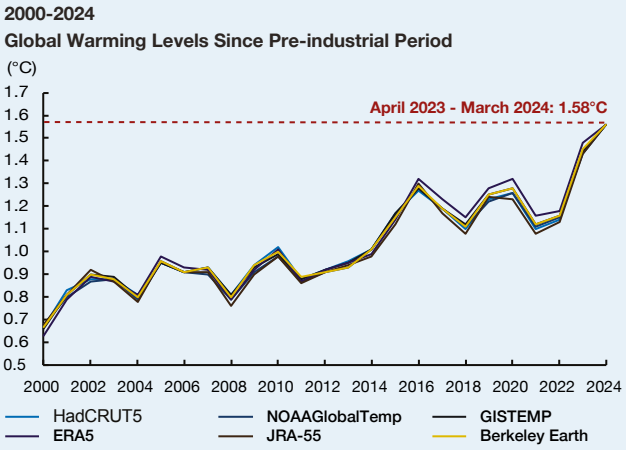


State of the Cryosphere 2023
Two Degrees Is Too High

Facing reality! Accelerated warming – the real base case & SLR projections...

We breached 1.5ºC of warming in 2024. The global mean temperature in 2023 ended up being 1.45ºC warmer than the pre-industrial period, making it the hottest year ever. Then, an abnormally hot January in 2024 pushed us to 1.52°C for the rolling 12-month period, surpassing the Paris Agreement target of 1.5°C. Warmer temperatures persisted throughout February 2024 and monthly warming soared to 1.77°C with highs of 2°C over four consecutive days.

Continued warming raised year-to-date global temperatures for March 2024 to 1.58°C. It's worth noting that warming was only at 1.15°C above pre-industrial levels for 2022 and 1.12°C for 2021. **So warming is not inching but accelerating due to our inability to rein in growing emissions; with El Niño, expect 2024 to be even hotter** – this is clear from the chart on the right



Source: CWR, The Meteorological Office (Met Office), Copernicus.

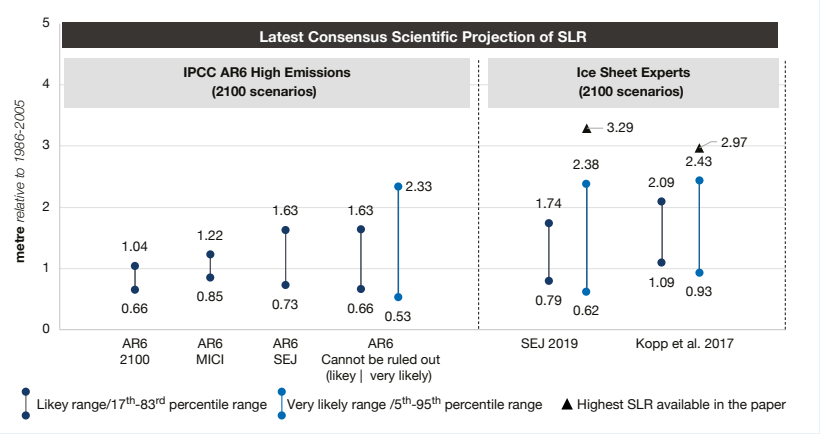
Emissions are still going up, not down – IPCC's SSP3 or 3.6°C of warming by 2100 is likely our base case and not worst-case scenario. Global GHG emissions increased 1.2% from 2021 to 2022 to reach a new record of 57.4GtCO_2e. According to the UN's "Emissions Gap Report 2023", current policies track a 3°C path while delivering on all unconditional & conditional pledges by 2030 will only lower this estimate to 2.5°C. Sadly, the report also noted that key countries are not on track to meet their pledges. With wars escalating and continuing tense global geopolitics, the current base case we are arguably tracking is the IPCC's SSP3-7.0 *"Regional Rivalry Scenario – A Rocky Road"* (SSP3). Under SSP3, the best estimate for warming by 2081-2100 is 3.6°C.

Accelerated warming signals that we may well be tracking IPCC's SSP5 or 4.4°C of warming. Worryingly, while the G7 calls for a reduction in coal in Asia, it is continuing to invest in fossil fuels. According to analyses by Oil Change International, between 2020 and 2022 the G7 provided US$78bn in public finance for fossil fuel projects – this was 2.6x their support for clean energy. Indeed, according to the IEA, the Americas will be the biggest incremental supplier of oil to global markets with additional exports of 4.1mn b/d from 2023-2028. Given the explosion in fossil fuels, could we be tracking SSP5-8.5 "Fossil-fueled Development – Taking the Highway" (SSP5)? If so, this means we will see warming of 4.4°C by 2081-2100. While some may argue that this scenario of doubling carbon emissions by 2050 is unlikely, we cannot ignore the reality that ice sheets are much more sensitive to warming than expected plus the fact that **actual y-o-y growth in CO_2 levels indicates that we are tracking 4-5ºC by 2100.**

Under SSP5, or the current warming path, the upper end of IPCC's SLR projections range from 1.04m to 2-3m by 2100; but rapid ice melt could point to 3m+ by 2100. The IPCC AR6 released in 2021 noted that *"Approaching 2-5m by 2100 and 2150 cannot be ruled out due to deep uncertainty in ice sheet processes"*. Even then, ice sheet experts warned of multi-metre SLR as per the chart below. Unfortunately, rapid ice losses observed today are running ahead of earlier projections plus new research shows that **Antarctica is warming with 20-50% more intensity than estimates from climate models in the AR6 reports. This means that the IPCC AR6 may have significantly underestimated Antarctic warming,** ice loss and projected SLR. Given this, it pays to face reality and adjust levels for stress testing and adaptation planning to the "real base case".

Source: CWR article "Soaring High Or Scorched Earth? 5 Trends For The Year Of The Dragon" (22 February 2024); WMO; The Meteorological Office (Met Office); Copernicus; IPCC AR5 WG1 (2021); IPCC AR6 WG2 (2022); Carbon Brief guest post "Ice cores reveal Antarctica is warming twice as fast as global average" (13 September 2023).

CWR | THE REAL BASE CASE – SLR PROJECTIONS AT THE CURRENT WARMING PATH



Source: CWR; IPCC AR6 Report (2021); Bamber et al. (2019) "Ice sheet contributions to future sea-level rise from structured expert judgement", PNAS; Kopp et al. (2017) "Evolving Understanding of Antarctic Ice-Sheet Physics and Ambiguity in Probabilistic Sea-Level Projections." Earth's Future; Infographic © China Water Risk 2024, all rights reserved.

Current policies path of 3°C = rapid SLR in ~30years' time & 3m by 2100 …

DeConto et al. (2021)
"The Paris Climate Agreement and future sea-level rise from Antarctica", Nature.
"…scenarios more consistent with current policies (allowing 3°C of warming) give an abrupt jump in the pace of Antarctic ice loss after around 2060…"

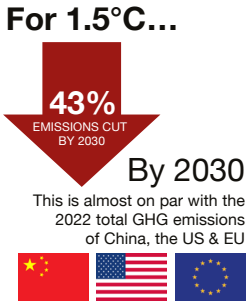
International Cryosphere Climate Initiative
"State of the Cryosphere 2023 – Two Degrees Is Too High"
"Once 3°C is passed, ice loss from Greenland & West Antarctica may become extremely rapid. Together with extensive ice loss from parts of East Antarctica …
…3m might be passed early in the 2100s, wiping out entire low lying nations and coastlines…"

Vicious cycle! 5 Reasons why the inability to peak oil by 2030 will unleash rapid SLR…

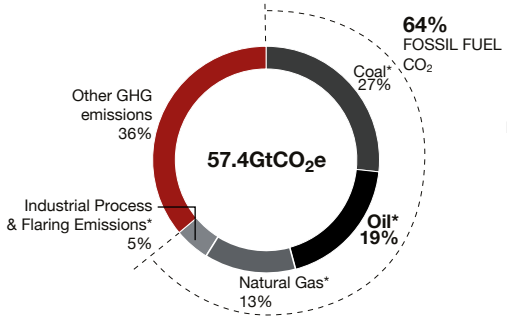
- **Emissions cuts of 43% by 2030 are needed to stay below 1.5ºC – the "safe zone" for ice.** According to the IPCC AR6 WG3: **"Climate Change 2022: Mitigation of Climate Change"**, limiting warming to 1.5°C (with over 50% likelihood by 2100) with no or limited overshoot by 2100 is only possible if GHG emissions are cut by 43% by 2030 relative to 2019 levels;[8] this was reiterated in the 2023 Nationally Determined Contributions Synthesis Report released in November 2023.[9] For perspective, a 43% emissions cut is almost on par with the combined 2022 GHG emissions of China, the US and the EU – **this sizeable cut of around 24GtCO$_2$e is impossible without fast tracking fossil fuel transition as fossil fuel carbon emissions of 36.7GtCO$_2$, account for almost two-thirds (64%) of total global 2022 GHG emissions** per the middle chart below.[10,11,12]

- **Oil is a key component – oil's carbon emissions are at least 11GtCO$_2$ or 19% of total global GHG emissions from fuel combustion** compared to coal which accounts for 27% and natural gas which has a 13% share.[11] Moreover, there are industrial process & flaring emissions across fossil types of 3GTCO$_2$ (5%). **If fossil fuels were a country, oil would rank as the 3rd largest emitter globally below China (1st) and coal (2nd)** as per the chart below right.[11,12] However, do note that fossil fuel emissions in the charts below are carbon emissions only;[11] methane emissions related to fossil fuel extraction are excluded, so fossil fuel GHG emissions will be higher.[8] Although coal emissions are currently significantly greater than oil emissions, coal has already peaked, while oil is still growing…

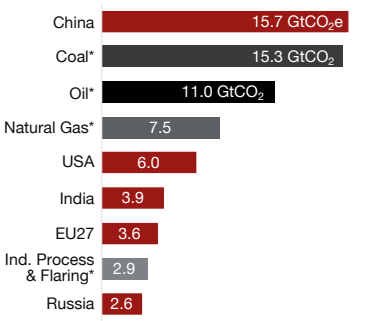
43% Cut in CO$_2$ by 2030 for 1.5ºC



Fossil Fuel Share of Global GHG Emissions



If Fossil Fuels Were a Country…



**carbon emissions only, the rest are GHG emissions*
Source: CWR, UN Emissions Gap Report 2023, IEA World Energy Outlook 2023 & JRC & IEA GHG Emissions of all world countries 2023.

- **We are running out of time to "slow down" ice melt & SLR – there's less than 6 years left to deliver aggressive emission cuts to stay below 1.5ºC.** Timing matters – we need cuts sooner rather than later to avoid unleashing rapid SLR. To stay below ice's "safe zone" of 1.5ºC with little or no overshoot, not only must we deliver 1) a 43% emissions cut from 2019 levels by 2030 but also 2) up these cuts to 60% from 2019 levels by 2035.[8] As we have less than 6 years to deliver the first set of sizeable cuts, the window to act is closing. If we fail to do so, we will risk triggering tipping points and rapid SLR – we cover this later in **"Ice tipping points & runaway SLR – window to act closes by 2030"**.

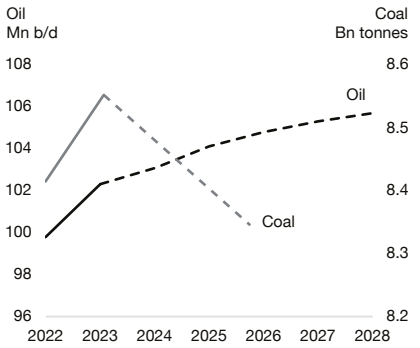
- **The inability to peak oil before 2030 and lower oil emissions dramatically by 2030/2050 will unleash rapid SLR.** Clearly, the current glacial pace of oil transition does not bode well for ice and we fear that oil expansion through to 2028 as well as insignificant cuts in oil emissions through to 2050 will could tip this delicate balance, especially when we have already breached warming of 1.5ºC today. Here are 5 reasons why we are worried:

    1. Oil demand is still growing by 5.9mn b/d from 2023 to 2028; after 2040, oil emissions will exceed that of coal;
    2. Energy supply financing – fossil fuel spending still outpaces clean energy; oil receives over 50% of this;
    3. Fossil fuel subsidies sky-rocketed 3x since the Paris Agreement to US$1.53trn in 2022; oil benefits with the largest share;
    4. With 76% of emissions, the G20 can lead fossil fuel transition – China delivers on coal but US lags on oil; and
    5. Shipping, essential to oil trade, is 3% of global GHG emissions & rising – tankers are the key cause.

1. Oil demand is still growing by 5.9mn b/d for 2022-2028; after 2040, oil emissions will exceed that of coal

- **Unlike coal which has peaked, oil demand is still growing by 5.9mn b/d to 2028, possibly peaking by 2030.** While the IEA expects world coal demand to peak in 2023 at 8.5bn tonnes, falling by some 192mn tonnes by 2026, it notes that global oil demand will continue to rise from 99.8mn b/d in 2022 by 5.9mn b/d to 105.7mn b/d in 2028 as per the chart on the right.[13,14] As it is, oil is set to hit 103.1mn b/d in 2024, up by 3.3mn barrels 2022-2024. Since 2028 is the last year of the IEA's oil production forecast, it is unclear if oil would peak by 2030.

Oil vs. Coal – Demand by 2030



Source: CWR, IEA Oil 2023 Analysis and forecast to 2028 and Coal 2023 Analysis and forecast to 2026.

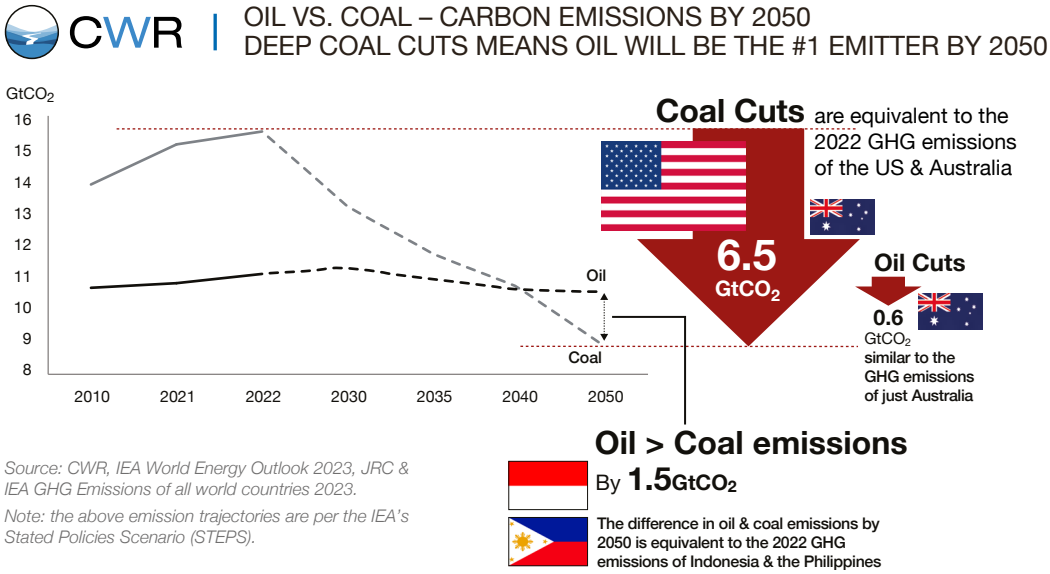
- **However, the IEA expects oil's carbon emissions to peak in 2030 & plateau to 2050 compared to coal's drastic cuts.** The IEA's emissions forecasts do point to a peaking of oil emissions in 2030, but instead of a dramatic fall in emissions like coal, oil emissions dip slightly, somewhat plateauing through to 2050.[11] Meanwhile, coal emissions fall significantly after peaking much earlier in 2022 as per the graphic below:

Pick the right scenario:

Here, we have used the IEA's Stated Policies Scenario (STEPS) instead of its Announced Pledges Scenario (APS) as it is more reflective of the current policies pathway as well as actual near-term oil expansion.

APS includes all major national announcements as of the end of August 2023 even if they have not been legislated or updated in the NDCs.

As we are not even tracking the NDC pledges, we are of the view that APS reflects wishful thinking … under APS, both coal & oil emissions peak in 2022 falling by 12.4GtCO$_2$ and 6.1GtCO$_2$ respectively by 2050.



Source: CWR, IEA World Energy Outlook 2023, JRC & IEA GHG Emissions of all world countries 2023.

Note: the above emission trajectories are per the IEA's Stated Policies Scenario (STEPS).

Key points to note from the above graphic are:

- **By 2030 – oil carbon emissions are expected to rise 2% by 192MtCO$_2$ from 2022 levels** (this amount is just shy of the combined 2022 GHG emissions of Singapore, Hong Kong, Laos & Cambodia) whereas **coal emissions are slated to fall by a sizeable 2.3GtCO$_2$** or 15% (equivalent to the 2022 GHG emissions of Japan (1.2GtCO$_2$e), South Korea (726MtCO$_2$e) and the UK (427MtCO$_2$e)).[11,12]
- **By 2050 – oil carbon emissions only fall by 5% or 585MtCO$_2$ from 2022 levels** (slightly more than Australia's 2022 GHG emissions of 571MtCO$_2$e) compared to **coal emissions which fall drastically by 42% removing 6.5GtCO$_2$** (equivalent to the annual GHG emissions of the US of 6GtCO$_2$e as well as Australia).[11,12]
- **After 2040, oil will overtake coal to become the #1 fossil fuel emitter** and by 2050 oil emissions will be greater than that of coal's by 1.5GtCO$_2$.[11] This difference in emissions is significant – it is equivalent to the combined 2022 GHG emissions of Indonesia (1.2GtCO$_2$e) and the Philippines (265MtCO$_2$e).[12]
- **Although coal carbon emissions cuts are much more aggressive than oil, it will likely not be enough by 2030.** Emission cuts from coal by 2030 will only amount to 2.3GtCO$_2$ – we need a 43% emission cuts or around 24GtCO$_2$e.[8] This will likely not be enough to hold back ice melt and rapid SLR especially when oil emissions are still rising at the same time. We will risk triggering tipping points and rapid SLR – see **"Ice tipping points & runaway SLR – window to act closes by 2030"** on the next page.

Ice tipping points & runaway SLR – window to act closes by 2030...

We've underestimated the rate of ice melt & SLR! Multi-metre SLR may be a reality by 2100. Previously, we thought Antarctica will not melt and contribute materially to SLR within this century; we were wrong. The harsh truth is that we've underestimated polar climate impacts. Scientists now find that irrespective of efforts to limit emissions, the melting of the West Antarctic ice shelf over the 21st century is *"unavoidable"* due to committed rapid ocean warming (3x faster). This ice shelf is holding back the precarious Thwaites Glacier, the collapse of which could result in around 0.6m of SLR; whereas the West Antarctic Ice Sheet holds 3-4m of SLR. Over in Greenland, scientists now say that warming of 1.7-2.3°C above pre-industrial levels will trigger abrupt Greenland ice-sheet loss; the Greenland ice-sheet holds 7m of SLR. Alarmingly, we've breached 2°C of warming for four consecutive days in February 2024. 2-3m of SLR by 2100 warned by the IPCC could well be a reality – **multi-metre SLR has happened before – sea levels did rise 3-4m per century some 14,500 years ago.**

REALITY CHECK

The last time we were 0.5°C-1°C warmer than pre-industrial levels, it was during the Last Interglacial Period when SLR was 6-9m higher than it was today.

TIPPING POINTS

Glacier melt and associated SLR will be locked-in when we reach various temperature tipping points. We are likely to have already locked in 8m of SLR at today's temperatures but when that will occur depends on whether we can keep temperatures below 1.5°C. At the current rate of warming, we could risk triggering multi-meter SLR sooner...

1.7-2.7°C

GREENLAND ICE SHEET

Breaching this threshold will trigger abrupt Greenland Ice Sheet loss, locking in at least 2-3m to 7m of SLR. The month of February 2024 already warmed by 1.77°C above the pre-industrial period and temperatures stayed above 2°C for 4 consecutive days.

3-4m SLR

WEST ANTARCTICA ICE SHEET

Rapid ocean warming – at around 3x the historical rate – is likely committed to 2100 causing widespread acceleration of ice-shelf melt. New 2023 research now finds the melting of the entire West Antarctica Ice Shelf "unavoidable" by 2100. Separately, other 2023 research shows Antarctica to be warming with 20-50% more intensity compared to the estimates provided by the climate models in the IPCC AR6 reports raising concerns that projected SLR levels were too low.

0.6m SLR

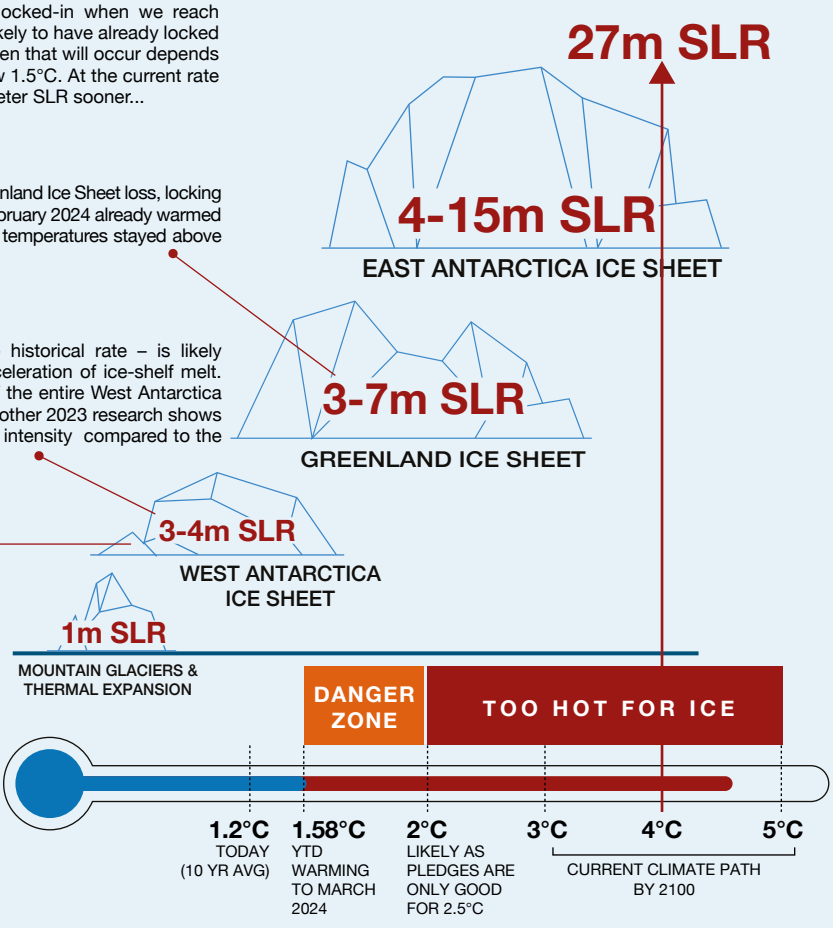
THWAITES "DOOMSDAY" GLACIER

Thwaites is one of the most vulnerable ice masses in West Antarctica. It is dubbed the Doomsday Glacier due to its ability to cause widespread coastal destruction – the collapse of Thwaites Glacier could result in around 0.6m of SLR.

Now, ice scientists warn that the Thwaites Ice Shelf which stabilises and holds back the Thwaites Glacier from flowing into the ocean could break apart by 2026. This could destabilise the whole West Antarctica Ice Sheet.

REALITY CHECK

The last time we were 2°C-4°C warmer than pre-industrial levels, it was during the Pliocene when SLR was as high as 25m+.



Other feedback loops. If we cross a tipping point in our climate, vicious cycles/feedback loops take over and we become irreversibly set (i.e. locked-in) for an uninhabitable planet. Here are two other important feedback loops:

1. **Ice-albedo effect – We are already experiencing ice-albedo at levels that far exceed record lows** – in 2023, the maximum extent of sea ice surrounding Antarctica during winter reached "mind-blowing" low levels at less than 17mn km^2; this was 1.75mn km^2 below the 1981 to 2010 average. For perspective, the area of sea ice loss of 1.75mn km^2 is more than half the land area of India. Losing a white surface area half the size of India not only means that less energy is reflected but the darker sea waters now exposed to sunlight will absorb more heat from the atmosphere, further accelerating ice melt in the polar regions. This is also happening in the Arctic – even at the low emissions scenario, the Arctic will be free of sea ice in September in the next few decades.
2. **Permafrost thaw – We face significant challenges with GHG emissions from Arctic permafrost thaw, which have not been fully included in the carbon budget.** As our world warms, permafrost (frozen ground) in polar and tundra regions begin to melt, releasing methane, one of the most potent greenhouse gases. This in turn heats the world even more, releasing more methane. We expected permafrost thaw to happen sometime in the future but it is happening now. Even at warming of 1.1-1.2°C, the ICCI 2022 State of Cryosphere Report warned that we have locked-in annual GHG emissions from permafrost thaw by 2100 that are equivalent to Japan's annual GHG emission today.

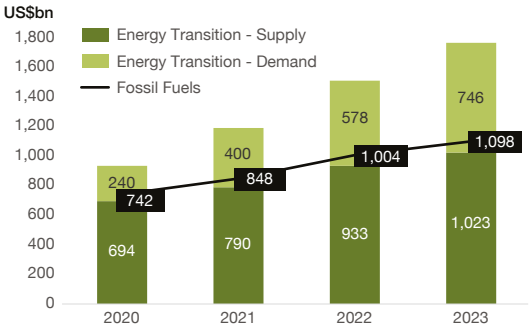
Source: CWR; CWR report "Waterproofing APAC to Avoid Atlantis" (2020); Naughten et al. (2023), Nature Climate Change; Bochow et al. (2023), Nature; Copernicus; Carbon Brief guest post "Ice cores reveal Antarctica is warming twice as fast as global average" (13 September 2023); Pettit et al. (2021). "Collapse of Thwaites Eastern Ice Shelf by intersecting fractures" presented in AGU Fall Meeting 2021; National Snow & Ice Data Centre; ICCI State of Cryosphere 2022.

2. Energy supply financing – fossil fuel spending still outpaces clean energy; oil receives over 50% of this

- **Clean energy investments have grown but so have fossil fuel investments since COVID.** Total clean energy investments in 2023 ranged from US$1.74trn (IEA) to US$1.77trn (BNEF) – this includes end-user energy efficiency, network improvements and so on.[15,16]

  However, if we just look at energy supply, BNEF conceded that **clean fuel supply investments still trail fossil fuel supply investments by US$75bn in 2023 and that this lag of US$75bn has been *"broadly consistent since COVID"*** – please see the chart on the right drawn from BNEF's Energy Transition Investment Trends 2024.[16]

Energy Supply Investments
Clean Energy Spending Lags Fossil Fuels

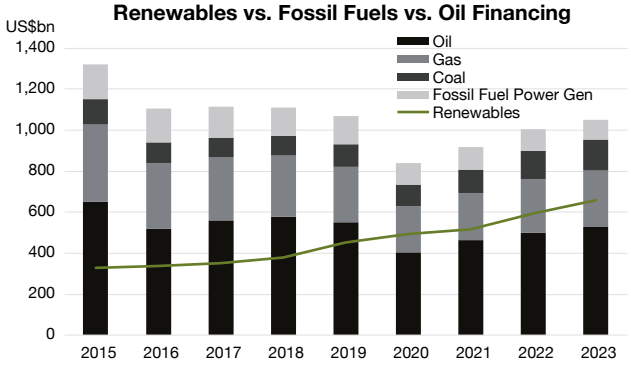


Source: CWR, BNEF's Energy Transition Investment Trends 2024.

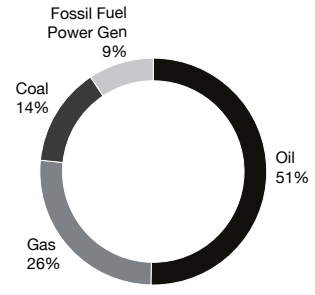
- **Investments in renewables outpaced oil investments since 2020 as oil spending fell but since COVID, oil investment growth has kept a pace of renewable expansion.** It is clear from the chart below left that renewable investments have doubled since the Paris Agreement from US$331bn in 2015 to US$659bn in 2023.[15] Meanwhile, fossil fuel investments were actually falling from 2015 until 2020, after which this trend was reversed – spending in oil, gas & coal rose post COVID; only investments in fossil fuel power generation continued falling through the entire period. More money poured into oil year-on-year for the last three years – even for 2023, total oil investment (ex-powergen) rose from US$501bn in 2022 to US$529bn in 2023. This increase of 5.6% or US$28bn is just shy of the GDP of Cambodia of US$29.5bn[17] – if this amount was invested in renewables, it could have built around 95 Tianjiao Green Energy Solar Parks which could have provided >47GW of solar annually; the construction cost of Tianjiao Green Energy Solar Park was around US$295mn.[18] Instead, **it will go towards new oil projects which will only lock-in carbon emissions negating hard-earned emission cut gains from renewables** – see box below on Willow Alaska.

- **Oil still accounts for at least 50% of fossil fuel financing in 2023.** It is clear from the chart below right that oil is still the key driver of fossil fuel investments. Indeed, oil financing is significantly larger (25%) than investments in coal and natural gas combined for 2023 – this trend is also consistent in the past.[11] It is worth noting here that the total IEA fossil fuel financing figure of US$1.05trn in the charts below also differs from BNEF's of US$1.1trn – this is likely due to different classification/including of financing.[15,16] However, it is important to note that both amounts do not include subsidies – a deeper look into subsidies reveal even more worrying trends...

Renewables vs. Fossil Fuels vs. Oil Financing



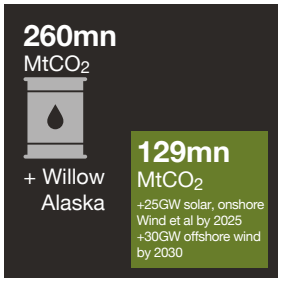
Oil is >50% Fossil Fuel Financing



Source: CWR, IEA World Energy Investment 2023.

Beware! Carbon bombs like Willow Alaska approved in 2023 can negate renewable gains. Even in 2023, as global warming soared to 1.45°C for the whole year, President Biden was still approving new "carbon bomb" projects like Willow, Alaska. This new controversial project with peak capacity of 180,000 b/d is estimated to add a total of 576mn barrels of oil over its production life of 30 years.

Besides damage to the fragile ecosystem, burning this oil will produce over 260mn $MtCO_2$ – equivalent to the annual output of nearly one-third of US coal power plants. Worse still, a CAP analysis notes that Willow's emissions would more than negate the estimated 129mn $MtCO_2$ avoided by reaching Biden's renewable energy goals on public lands and waters. This is not the only upstream start up – for more please see **"Dirty money – oil investments, subsidies & expansion vs. clean energy spending"**.

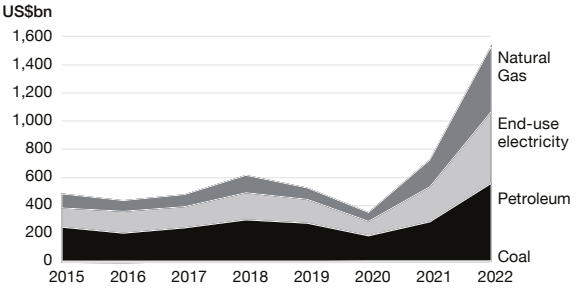


Source: CWR; WM; Washington Post article "Republicans champion Alaska drilling project that poses major climate test for Biden" (February 16, 2022); CAP article "The Biden Administration's Easiest Climate Win Is Waiting in the Arctic" (March 3, 2023); The White House "FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs" (March 239, 2021).

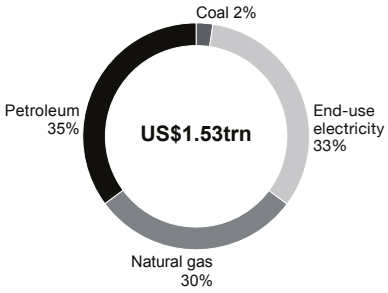
3. Fossil fuel subsidies sky-rocketed 3x since the Paris Agreement to US$1.53trn in 2022; oil benefits with the largest share

- **Fossil fuel subsidies sky-rocketed 3x since the Paris Agreement in 2015 to US$1.53trn in 2022.** Besides persistent direct oil financing, there are also fossil fuel subsidies which amounted to a whopping US$1.53trn in 2022 according to the Fossil Fuel Subsidy Tracker.[19] The chart below shows fossil fuel subsidies movements since Paris by fuel type:

Global Fossil Fuel Subsidies 2015-2022



2022 Subsidies by Fossil Fuel



Source: CWR, FossilFuelSubsidyTracker.org, 2022.

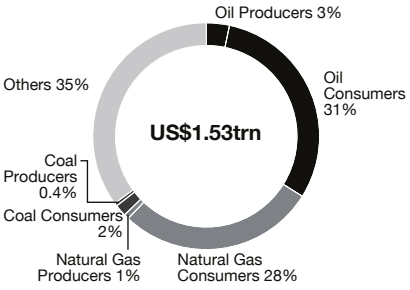
Key points of note from the charts above are:

  - **Petroleum, natural gas & end-use electricity subsidies have sky-rocketed since 2020 reversing previous downward trends.** Since COVID and the Russia-Ukraine conflict, subsidies have increased at an alarming rate. End-use fossil fuel electricity subsidies have grown the most, followed by natural gas and oil. Recent year-on-year subsidies growth across all fossil fuel types have helped edge emissions higher for 2022. If subsidies growth persists, they signal continued emissions growth from fossil fuels to 2030. **Albeit also increasing, coal has the smallest slice of subsidies.**
  - **But all fossil fuels are not equal – oil has the largest share of subsidies (35%) at US$537bn.** Oil receives the most subsidies with US$537bn going towards petroleum subsidies. As of 2022, petroleum subsidies make up the largest share (35%), while coal subsidies account for a mere 2% or US$36bn.[19]
  - **Petroleum subsidies tripled since COVID.** Note that Petroleum subsidies did fall to a low of US$178bn in 2020 but it has since tripled in just 2 years to US$537bn in 2022.[19] **Shockingly, 2022 petroleum subsidies alone are almost as much as renewable financing of US$659bn in 2023.**[15] For more perspectives on financing, see infographic on the next page.

- **Fossil fuel subsidies are consumer focused except for oil where US$52bn is also going to producers.** A deeper look at the type of fossil fuel subsidy revealed that most subsidies were consumer focused. It is clear from the chart on the right that oil has the largest share consumer focused subsidies.

  Note that oil also has sizeable subsidies for producers compared to that for coal or natural gas – it is the only fossil fuel to have double-digit billion-dollar subsidies for producers of US$52bn.[19]

2022 Fossil Fuel Subsidies by Type



Source: CWR, FossilFuelSubsidyTracker.org, 2022.

- **Including subsidies, fossil fuel investments amount to US$2.6trn – this dwarfs total clean energy spending of over US$1.7trn.** Assuming that fossil fuel subsidies have not gone down in 2023, if we add the 2022 fossil fuel subsidies of US$1.53trn to the 2023 fossil fuel financing of US$1.05trn per the IEA, the estimated total annual spending on fossil fuels for 2023 will be a staggering US$2.58trn.[15,19] This is clearly much greater than clean energy investments so far of US$1.74-1.77trn.[15,16] Albeit not directly comparable as we haven't included renewable subsidies (which are hard to find), we can be sure that annual renewable subsidies are not in the region of trillions of dollars like fossil fuel subsidies. For an at-a-glance overview of such spending, please see "**Dirty money – oil investments, subsidies & expansion vs. clean energy spending**". This amount of fossil fuel funding certainly does not bode well for polar ice sheets and SLR as previously discussed in "**2ºC is too hot for ice! 1.5ºC is the only option – or face rapid ice melt & SLR**".

Dirty money – oil investments, subsidies & expansion vs. clean energy spending...

CWR | AT-A-GLANCE FOSSIL FUEL VS. CLEAN ENERGY INVESTMENTS

US$2.58trn
FOSSIL FUEL SPENDING

- **US$529bn** OIL INVESTMENTS
- **US$537bn** OIL SUBSIDIES
- **US$98bn** FOSSIL FUEL POWERGEN INVESTMENTS
- **US$502bn** END USER SUBSIDIES
- **US$276bn** NATURAL GAS INVESTMENTS
- **US$456bn** NATURAL GAS SUBSIDIES
- US$148bn + US$36bn COAL INVESTMENTS & SUBSIDIES

US$1.77trn
CLEAN ENERGY SPENDING

- **US$1,023bn** ENERGY TRANSITION SUPPLY
- **US$746bn** ENERGY TRANSITION DEMAND

Of which **US$1.37trn** is from …

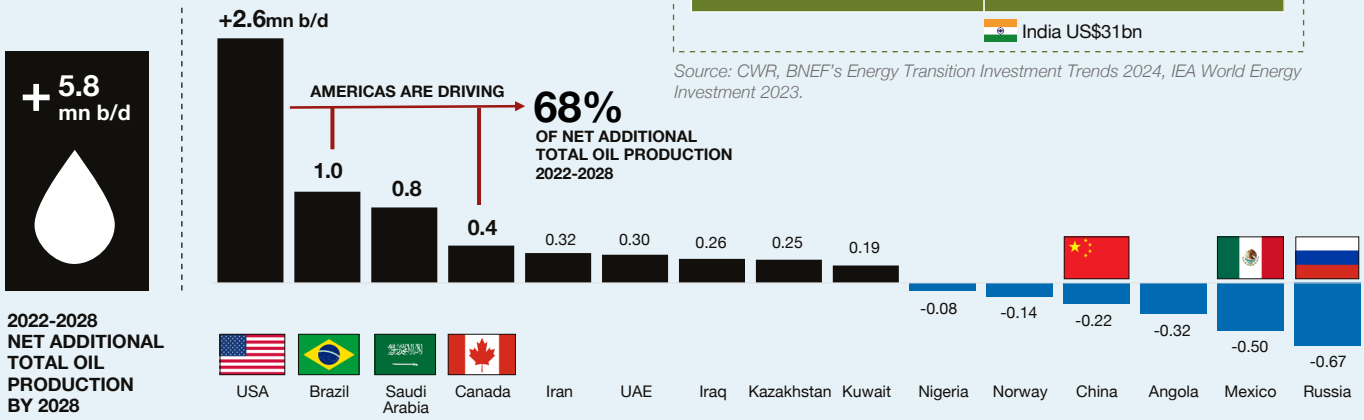
- CHINA **US$676bn**
- EU-27 **US$361bn**
- USA **US$303bn**
- India US$31bn

Source: CWR, BNEF's Energy Transition Investment Trends 2024, IEA World Energy Investment 2023.

CWR

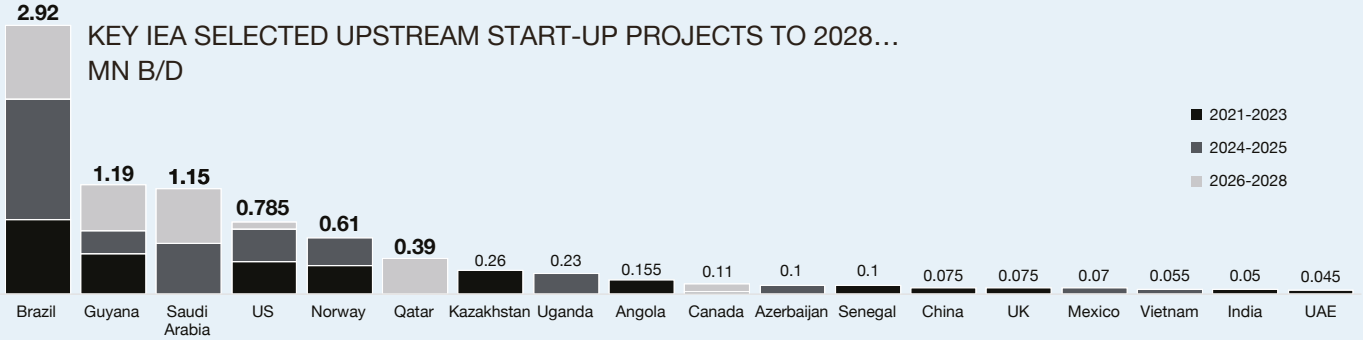
WHO'S PUMPING MORE OIL?

2022-2028 OIL MOVEMENTS FOR THE TOP 15 OIL PRODUCING COUNTRIES



Note: For Iran, UAE, Iraq, Kazakhstan & Kuwait & Nigeria forecasts are for crude oil only; the rest are total oil movements.
Source: CWR, IEA, Oil 2023 - Analysis and forecasts to 2028.

KEY IEA SELECTED UPSTREAM START-UP PROJECTS TO 2028…
MN B/D

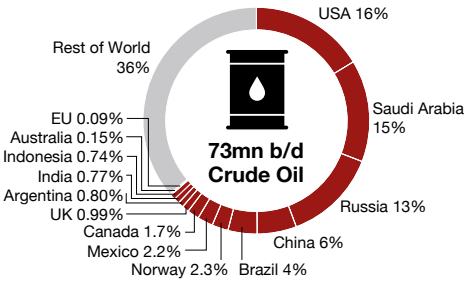


Source: IEA Oil 2023 Analysis and forecast to 2028.

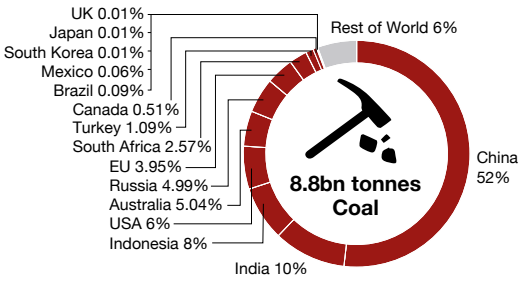
4. With 76% of emissions, the G20 can lead fossil fuel transition – China delivers on coal but US lags on oil

- **The G20 is 76% of global GHG emissions and can lead in aggressive emission cuts.** The UN Emissions Gap Report released around last year's COP28 called for the G20 to lead the way in fast tracking transition because collectively, the G20 currently accounts for 76% of 2022 global GHG emissions.[10] This is not surprising as the G20 accounts for 64% of 2022 global crude oil production of 73mn b/d and a massive 94% of 2022 global coal production of 8.8bn tonnes as per the charts below.[6, 20]

G20 Oil – the US, Saudi Arabia, Russia, China & Brazil drive >50% of global crude oil production



G20 Coal – China, India & Indonesia drive 70% of global coal production



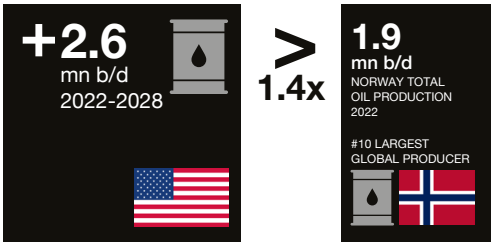
Source: CWR, OPEC Annual Statistical Bulletin 2023, Energy Institute Statistical Review of World Energy 2023.

Key points of note from the charts above are:

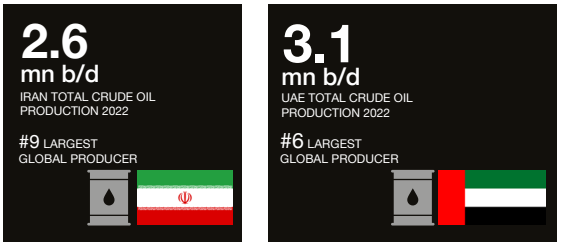
- **G20 coal production is dominated by China & India which have been aggressively investing in energy transition.** China & India together account for 62% of global coal production.[20] Despite being developing nations plus the fact that coal remains their key source of energy, they have reined in coal demand growth with aggressive transition investments:
  - **Indeed, China, with 52% of global coal & 6% of global crude oil production, has been the driving force of energy transition investments.** China accounted for 38% of global total energy transition investment in 2023.[16] As per the graphic on the previous page, it is still the clear leader in 2023 spending US$676bn on energy transition – this was greater than the energy transition spend of the EU27 (US$361bn) & the US (US$303bn) combined.[16] According to the IEA, continued renewable investments may even allow China to peak coal consumption in 2023.[14] Also, China's on track to add over 2TW of renewables in 2023-2028 – this is 3x the additional capacity of the last five years.[21]
  - **India is also amongst BNEF's Top 10 energy transition financing countries with spending of US$31bn.**[16] The country aims to triple global renewable capacity from 130GW today to 450GW by 2030.[22]
- **G20 oil crude production – the US, Saudi Arabia, Russia, China, Brazil drive 54% of global production.** Global crude oil production is less concentrated in the G20 countries than coal. That said, the US (16%), Saudi Arabia (15%) and Russia (13%) have sizeable shares compared to China & Brazil – together these 3 account for 44% of global crude oil produced. As it was difficult to find consistent set of crude oil forecasts by country, we turned to IEA's total oil forecasts to gauge the near term moves by the Top 5 G20 oil producers:[13]
  - **IEA forecasts China & Russia to cut total oil production but US, Saudi Arabia & Brazil to up production for the next 6 years (2022-2028).** As per the graphic on the previous page which shows the 2022-2028 oil movements for the Top 15 oil producing countries, it is easy to see who is pumping more oil and who's not. The US add the most at 2.6mn b/d, followed by Brazil at 1mn b/d, while Saudi Arabia rises by 0.8mn b/d. However, China and Russia's oil production fall by 0.2mn b/d and 0.7mn b/d respectively. Other G20 countries worth mentioning are Canada and Mexico – while Mexico cuts production by 0.5mn b/d, Canada adds 0.4mn b/d.
  - **Non-OPEC+ members drive growth – the Americas will be the biggest incremental supplier of oil to global markets.** To match demand of 5.9mn b/d, the IEA forecasts an increase in production of 5.8mn b/d to reach supply of 105.7mn b/d by 2028. Of the 5.8mn b/d, the US alone will provide 45%; together with Brazil and Canada, they will drive 68% of this increase. The Middle East will account for just over 40%; Saudi Arabia alone is projected to account for 14% of the increase of 5.8mn b/d. Worth noting is Guyana, although not included in the chart on the previous page as it is not one of the Top 15 oil producers, it will increase production by 0.9mn b/d from 2022-2028.

- **+2.6mn b/d of oil production of the US from 2022 to 2028 = adding the production of 1.4x Norway or another Iran.** The US's additional capacity is significant – for perspective, the additional 2.6mn b/d of total oil production by 2028 is 1.4x greater than the total oil production of Norway of 1.9mn b/d, the #10 largest producer of crude oil in the world. This amount is similar to the 2022 crude oil production of Iran.

US additional oil production 2022-2028
= 1.4x Norway's production



= comparable to Iran & UAE crude oil production



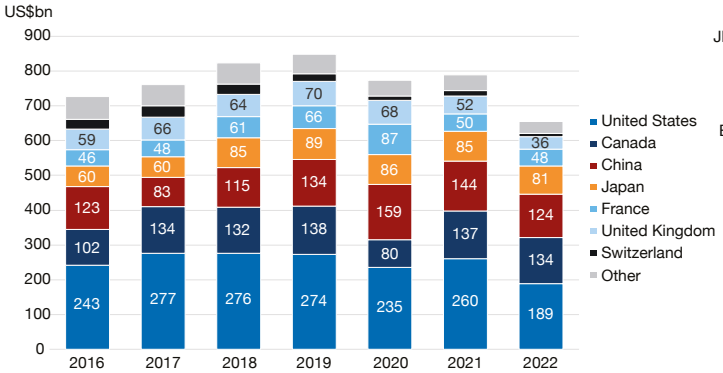
Source: CWR, IEA Oil 2023 - Analysis and forecasts to 2028, OPEC Annual Statistical Bulletin 2023.

- **The last hurrah in oil led by the Americas = dangerous for ice.** Given the above, the IEA expects the Americas, as the biggest incremental supplier of oil to global markets to up its exports by 4.1mn b/d by 2028. Even more worrying is the region's oil expansion drive in upstream project start-ups. It is clear from the chart on the previous page showing the IEA's selected upstream project start-ups, that future supply is primarily driven by Guyana, Brazil and the US. **So, while China, the 2nd largest consumer of oil can always do more, the US as the largest producer and consumer of oil as well as the largest incremental supplier in global oil production can do much more.[6]**

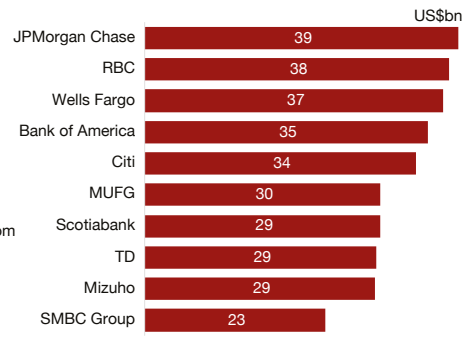
- **The support of oil by the US & Canada is echoed by the analyses by Banking on Chaos which reviewed the fossil fuel financing of the Top 60 global banks.** According to their data,[23] 8 US headquartered banks have consistently provided the largest share of fossil fuel financing since 2016 as per the chart below left. The 13 Chinese banks follow suit but in 2022, the 5 Canadian banks overtook China to be the 2nd largest provider of fossil fuel financing amongst the Top 60 banks. Note that the 3 Japanese banks are generally at 4th place while the UK and France fight for a space in the Top 5.

  Interestingly, when it comes down to financing from individual banks – see chart below right, it is dominated by 4 US banks, followed by 3 Canadian banks and all of the 3 Japanese banks ranking #6 (MUFG), #9 (Mizuho) and #10 (SMBC Group). The fact that these 3 Japanese banks are still financing fossil fuels plus the fact that Japanese financing for fossil fuel has held steady since the Paris Agreement is worrying, especially when Japan's energy security is very vulnerable to climate impacts – we cover the exposure later in **"Spotlight Japan & South Korea"**.

2016-2022 Top 60 Banks Fossil Fuel Financing by Bank HQ



Fossil Fuel Financing – Top 10 Banks



Source: CWR, Banking on Climate Chaos 2023 report.

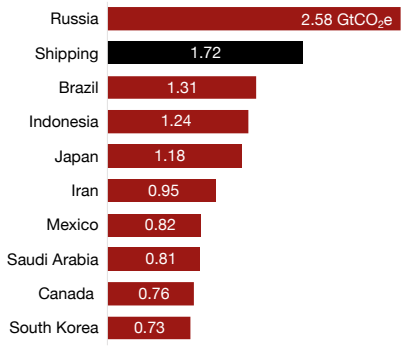
Starting & financing new projects is short-sighted as this will only lock-in near term emissions and fast track warming, bringing about rapid SLR which will not only permanently submerge low-lying tanker terminals and severely disrupt the oil trade but redraw the coastlines of non-OPEC+ and OPEC+ countries.

The clock is ticking, the action window to keep within 1.5°C of warming is narrowing – oil producers must deliver emission cuts, not gains, by 2030 or risk triggering more tipping points & accelerated SLR. There is no negotiating with ice – once triggered SLR is unstoppable, only an Ice Age will reverse it – as can be seen from the previous page **"Ice tipping points & runaway SLR – window to act closes by 2030"**, the numbers are scary. The impacts are equally scary – please see the next section.

5. Shipping, essential to oil trade, is 3% of global GHG emissions & rising – tankers are the key cause

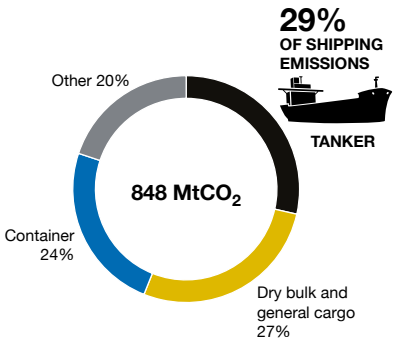
- **Shipping emissions have risen to 3% of global emissions in 2023 & are expected to continue to rise – tankers account for the largest share at 29%.** According to UNCTAD, the shipping industry's GHG emissions have increased by 20% over the last decade to account for 3% of global GHG emissions; and without action, shipping emissions could be 130% of their 2008 levels by 2050.[2] Tankers are a key cause – it is clear from the right pie chart below that they have the largest carbon emissions among the different ship types, accounting for 29% of shipping emissions.
- **Tanker emissions growth is greater than other carrier types.** In addition, as can be seen from the lower left chart below, tanker emissions' growth trajectory is far greater than that of dry bulk & general cargo as well as container ships. Indeed, since the pandemic, seaborne oil trade surged 6% in 2022 and for 2023, strong demand from China and India buoyed seaborne crude oil trade volumes despite OPEC cuts.
- **Emissions are expected to stay high as shipments of oil cargo also travelled longer distances in 2023 than any other year on record** as conflicts in the Middle East & Russia continue. Rising tanker emissions was also due to changes in direction of trade flows and distances travelled due to rising demand for crude & refined oil products in Asia as well as the rising exports of refined oil products from Asia. Going forward, tanker emissions are expected to rise as average distances travelled are projected to grow further from 4,350 nautical miles (NM) in 2022 to 4,577NM in 2023 and 4,654NM in 2024.[2]

Shipping GHG Emissions
If Shipping Were a Country...



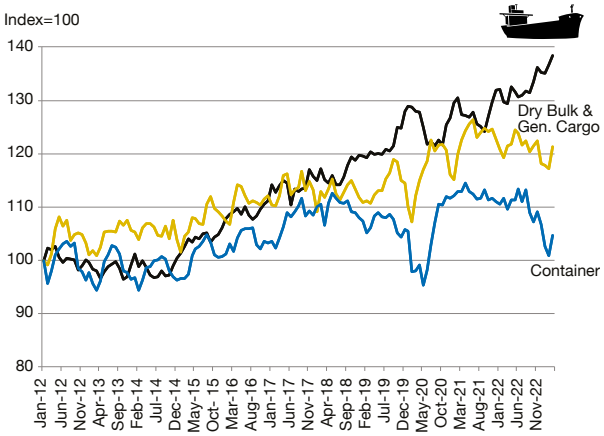
Source: CWR, IEA World Energy Outlook 2023 & JRC & IEA GHG Emissions of all world countries 2023, UNTCAD Review of Maritime Transport 2023.

Shipping Carbon Emissions
by Type 2023...

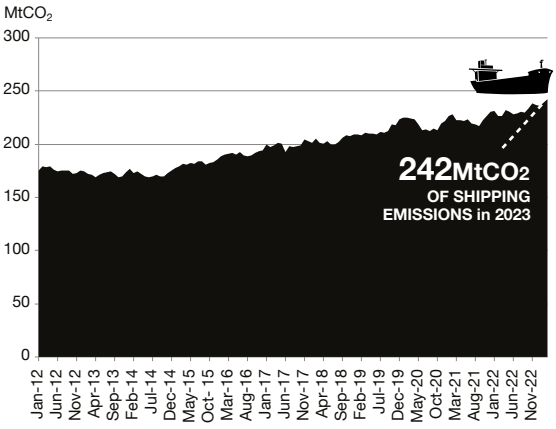


Source: CWR, UNCTAD Review of Maritime Transport 2023.

Tankers
Fastest Growing Carbon Emissions since 2012...

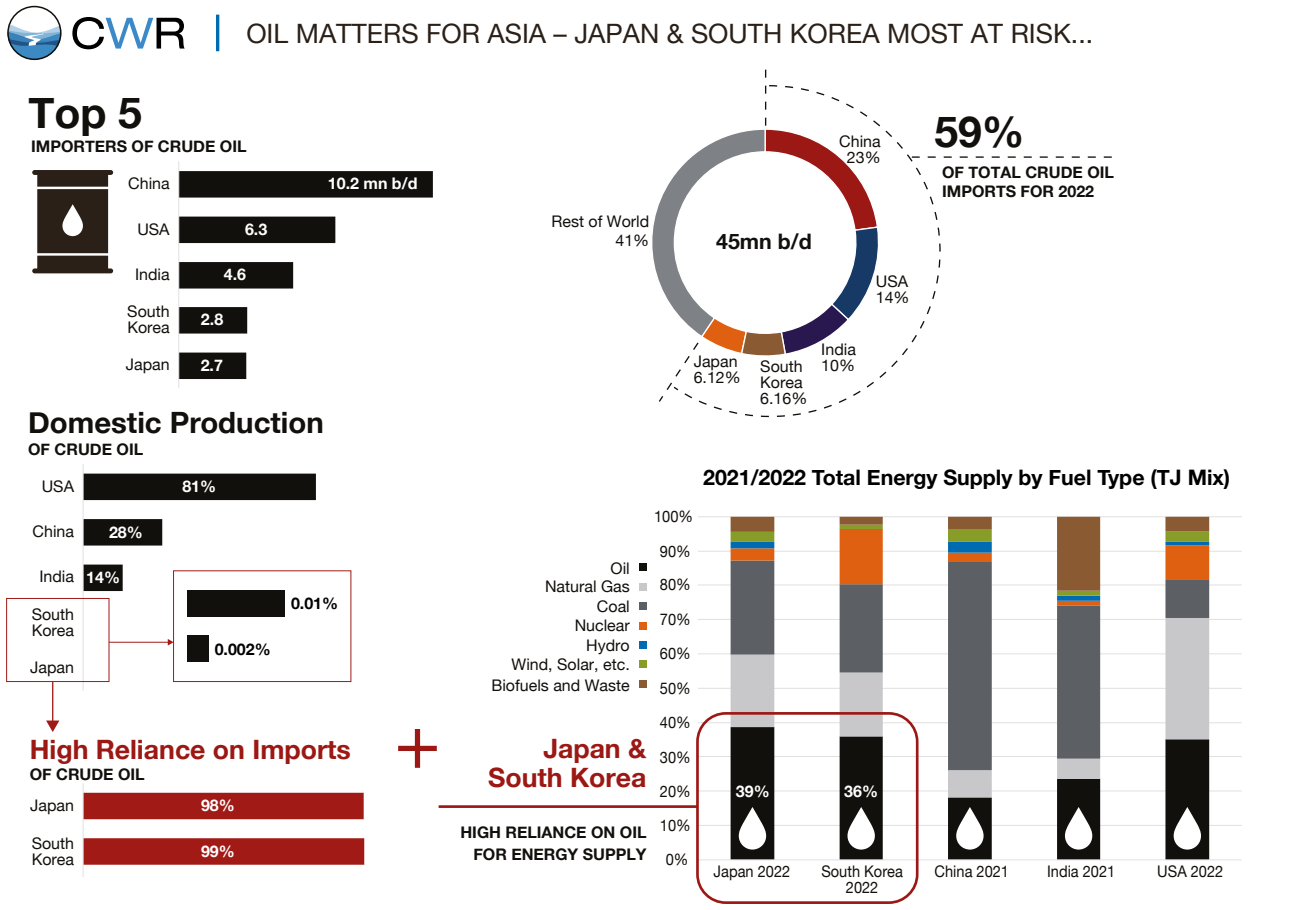


Carbon Emissions Growth 2012-2023
Tankers Going Up & Up...



Source: CWR, UNCTAD Review of Maritime Transport 2023.

Asia disrupted! SLR threatens energy security – spotlight Japan & South Korea...



Note: The domestic crude oil production data for China & India are for 2021; the rest are for 2022.
Source: CWR, OPEC Annual Statistical Bulletin 2023, IEA Energy System web data for respective countries 2021 & 2022.

- **Top 5 importers of crude oil account for 60% of global crude oil imports – 4 of these are from Asia – China, India, South Korea and Japan.** The graphic above shows that China is by far the largest importer of oil – importing 1.6x that of the US and 2.2x that of India, coming in 4th place is South Korea with Japan rounding up the 5th place. Together these Top 5 importers account for almost 60% of global crude oil imports; even without the US, Asia dominates, **the 4 Asian countries account for 45% of global crude oil imports.**[6]
- **Reliance on crude oil imports for energy security is high for Japan & South Korea.** As per the graphic above, it is clear that the US is the least reliant on imports with sizeable domestic production of oil and while both China and India have some domestic production amounting to 28% and 14% respectively, South Korea and Japan have hardly any. This means that **South Korea and Japan are almost 100% reliant on oil imports.**[6,24]
- **Oil is the key energy fuel source for both Japan & South Korea.** South Korea and Japan's high dependency on oil imports is even more pronounced when we look at sources of total energy supply. As illustrated in the bottom right chart in the graphic above – **oil provides the largest share of energy supply for both Japan and South Korea respectively at 39% and 36%** – these shares are even higher than the US's (35%). China and India on the other hand is more reliant on coal, which they largely produce domestically. **So while domestic coal production offers China and India buffer, Japan and South Korea's energy security are tied to the import of oil.**[24]
- **This led us to conduct deeper analyses on just Japan and South Korea instead of China and India.** Also, India and China are aggressively investing in renewables and EVs putting them both on track to meet their Paris Agreement pledges whereas Japan and South Korea are not – this means that Japan and South Korea could be shooting themselves in the foot as their inability to cut emissions will accelerate SLR which will increase their vulnerability to seaborne crude, threatening their energy security. **However, this does not mean that China and India are not impacted** – it is clear from our analysis of the Top 15 Tanker Terminals that the 3 key importing oil ports of Ningbo-Zhoushan, Shanghai & Dalian are vulnerable to 1m of SLR. **Certainly, as key drivers of oil demand growth, both China & India can do more to rein in oil production & demand** – please see box below.

China & India drive both renewables & oil growth. China & India have been the drivers of global renewables expansion adding 2.3TW of the 3.7TW between 2023 and 2028. However, they are also large oil guzzlers – after the US, China is the 2nd largest consumer of oil globally at 14.9mn b/d in 2022 followed by India at 5.1mn b/d.

China has been a key driver of oil demand growth but according to the IEA, **China's demand growth slows markedly from 2024 onwards due to its explosive adoption of electric vehicles driving global oil demand growth to "shrivel" from 2.4mn b/d in 2023 to just 400,000b/d by 2028.** Indeed, the IEA notes that China will account for more than half of the projected 155mn EVs to be sold by 2028 which will displace 2.3mn b/d of incremental gasoline use and 640,000b/d of diesel demand. The IEA also states that China's aggressive EV adoption means that **China's oil demand growth will slow, and India will overtake China as the key driver of oil demand growth by 2027.**

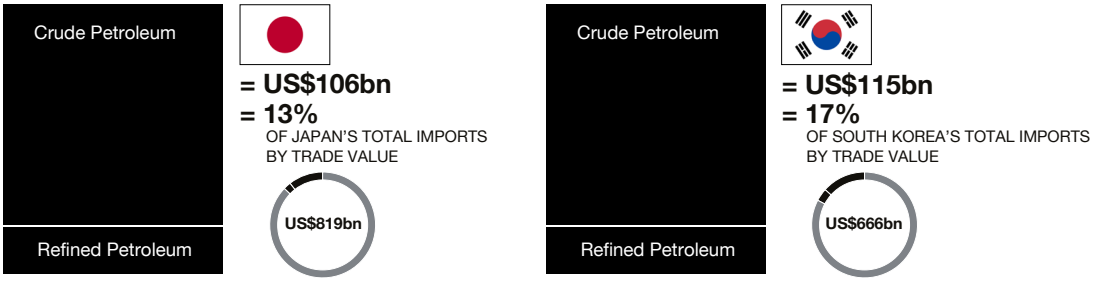
According to Bloomberg, China's EV sales as a share of new cars are at 24% well above the US of 8%. It is also way ahead of South Korea and Japan (which despite being reliant on car exports) are far behind. More on this in below in **"Spotlight Japan & South Korea"**.

Source: CWR; IEA – Renewables 2023 Analysis and forecast to 2028; OPEC Annual Statistical Bulletin 2023; IEA – Oil 2023 Analysis and forecast to 2028; Bloomberg "Electric Cars Pass the Tipping Point to Mass Adoption in 31 Countries" (28 March 2024) & Bloomberg Green – The most surprising EV laggards (April 2024).

Crude awakening to rising seas – spotlight Japan & South Korea

- **Oil is Japan & South Korea's largest energy source & No.1 import by trade value.** As per the graphic above, oil is the largest energy source for both South Korea and Japan but without any material indigenous supplies of natural energy resources, most of their energy requirements must be imported. In 2022 the aggregate value of fossil fuels imported by Japan and South Korea amounted to US$106bn and US$115bn respectively.[25] Of this, oil petroleum crude made up the largest block for both countries – US$87bn for Japan and US$89bn for South Korea. **Indeed, crude oil was the No.1 import by trade value for both countries.** Together, crude and refined petroleum comprise 32% and 38% of the Top 10 imports of both countries respectively or 13% and 17% of total import value respectively. Interestingly, despite the fact that Japan's GDP is 2.5x that of South Korea's, crude & refined petroleum imports for South Korea is 8% more than Japan's.

Crude Oil & Refined Petroleum Imports – Japan vs. South Korea



Source: CWR, OEC database.

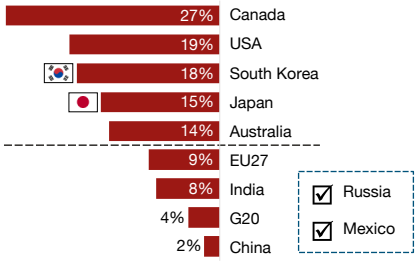
- **Both Japan & South Korea are very vulnerable to seaborne crude imports.** To gauge the vulnerability to seaborne crude, for each country, we analysed the SLR impacts to key export ports which account for 70% or more of their respective crude imports. In addition, we also analysed key oil receiving ports for each country – which have almost 70% or more of each country's national refining capacity. The results are alarming:
    - **Japan's energy security is highly exposed to rapid ice loss & SLR as ALL 8 key ports analysed are impacted by 1m of SLR.** Because it is an island country with no international oil pipeline, all imports of crude and other oil products arrive by sea on tankers. The 3 key oil ports of its key suppliers Saudi Arabia and UAE – Ras Tanura, Fujairah and Khor Fakkan – are impacted by 1m of SLR. These 2 countries provide Japan with 78% of its total crude imports. In addition, all 5 of Japan's key oil receiving ports – Chiba, Aichi-Yokkaichi, Osaka, Mizushima and Yokohama-Kawasaki are also impacted by 1m of SLR. These 5 have 68% of Japan's refinery capacity – for details, please see our at-a-glance factsheet **"Japan – Crude awakening to rising seas"**.
    - **South Korea's energy security is highly exposed to rapid ice loss & SLR as ALL 10 key ports analysed are impacted by 1m of SLR.** Although South Korea is not an island nation, its division with North Korea means that it is a de-facto island state. Like Japan, it also has no international oil pipeline which means all imports of crude and other oil products arrive by sea on tankers. The 6 key oil ports of its key suppliers Saudi Arabia, the US, Kuwait and the UAE – Ras Tanura, Galveston, Houston, Al-Ahamadi, Fujairah and Khor Fakkan – are impacted by 1m of SLR. These 4 countries supply South Korea with 70% of its total crude imports. In addition, all 4 of South Korea's key oil receiving ports – Ulsan-Onsan, Daesan, Gwanyang-Yeosu and Incheon – are also impacted by 1m of SLR. These 4 account for 100% of national refinery capacity – for details, please see our at-a-glance factsheet **"South Korea – Crude awakening to rising seas"**.

- **Impacts could be worse.** We have only assessed the minimum number of ports to illustrate Japan and South Korea's precarious position – the exposure could be worse if other crude/oil export/import ports were also assessed. Again, for consistency, we have used the NASA SRTM 30m maps which only includes average tides. Impacts may be worse if more granular elevation maps were used and local astronomical high tides factored in.

- **Yet, neither Japan nor South Korea are on track to meet its 2030 pledges.** According to the UNEP Emissions Gap Report 2023, Japan has a 15% implementation gap between current policies & NDC pledges by 2030, compared to 2015 levels; South Korea's is worse at 18%.[10]

  This means that among other G20 countries which have not met their pledges, South Korea and Japan are among the Top 5 worst performers: Canada is the worst performer with an implementation gap of 27% followed by the US at 19%, then South Korea, Japan and Australia coming in at 14% – see chart on the right.

Not Meeting Paris Agreement Pledges
Top 5 Laggards' Implementation Gaps

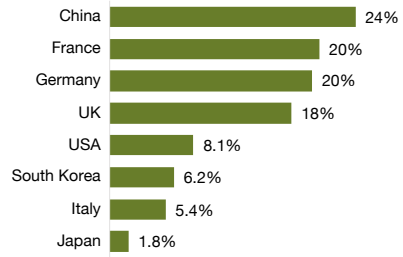


Source: CWR, UNEP Emissions Gap Report 2023.

- **EV adoption is also abysmal = indicates no intention of fast tracking oil transition.** According to Bloomberg, 31 countries have already surpassed the EV tipping point to mass adoption – the threshold is when 5% of new car sales are EVs. While South Korea has just passed this threshold at 6.2%, Japan lags abysmally at a mere 1.8%.[26,27] They are clearly behind other car manufacturing countries of China, US, Germany, UK, France & Italy – see chart on the right.

  Given Japan & South Korea's vulnerability to coastal threats, it is surprising that the uptake is so low. Faster adoption of EVs and renewables can help mitigate their exposure to fossil fuel stranding by rising seas; stockpiling oil is not a sustainable option.

EV Adoption – South Korea & Japan Lag
EV share of new car sales



Note: EV adoption is based on new car sales in 2023Q4 except for Japan & South Korea which reflect the entirety of 2023.
Source: CWR, Bloomberg.

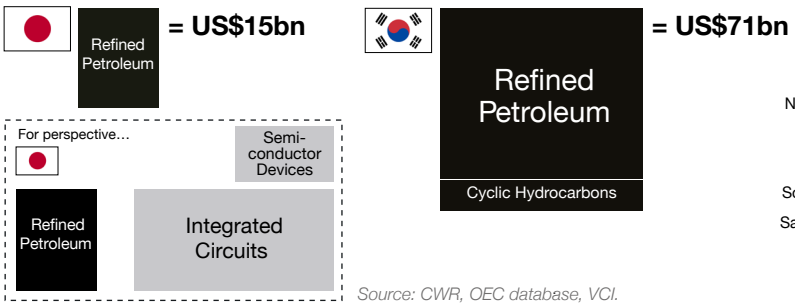
Given their vulnerability to SLR, both Japan & South Korea are evidently shooting themselves in the foot with respect to energy security by not meeting their Paris Agreement pledges nor fast tracking oil transition. There are also repercussions for their economies…

- **Knock-on effects on the economy as exports are also affected; exposure is significant = sovereign risk re-rating if adaptation measures are not taken.**

  - **South Korea & Japan are sizeable players in refined petroleum, petrochemicals & other derivatives; South Korea more so than Japan.** Both Japan & South Korea export refined petroleum – the amounts are large enough for it to feature among their Top 10 exports by trade value. However, South Korea is a much bigger player. Despite its lack of domestic energy resources, South Korea is home to some of the largest and most advanced oil refineries in the world, and it exports a significant amount of refined fuel for transportation use.[28] SK Energy is the largest marketer of petroleum products, followed by GS Caltex, S-Oil, and Hyundai Oilbank. These companies have historically focused on refining, but some companies have increasingly emphasized crude oil extraction projects in other countries.[28]

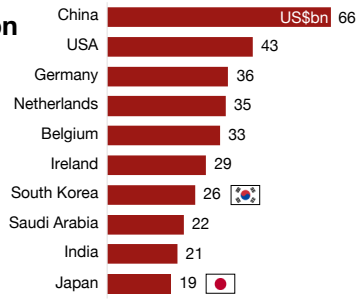
    South Korea's #2 export by trade value is refined petroleum worth US$61bn – this is 4.2x that of Japan's refined petroleum exports worth US$15bn ranking #5 by export trade value. In addition, for South Korea, cyclic hydrocarbons worth US$10bn also make it into the Top 10 exports. For perspective, Japan's exports of semiconductor devices and integrated circuits are only worth US$10bn and US$37bn respectively. In addition to these, Japan and South Korea rank amongst the Top 10 Petrochemical Exporters – South Korea ranks higher at #7 with Japan rounding up the #10 slot.[29]

Refined Petroleum & Cyclic Hydrocarbons Exports
Japan vs. South Korea

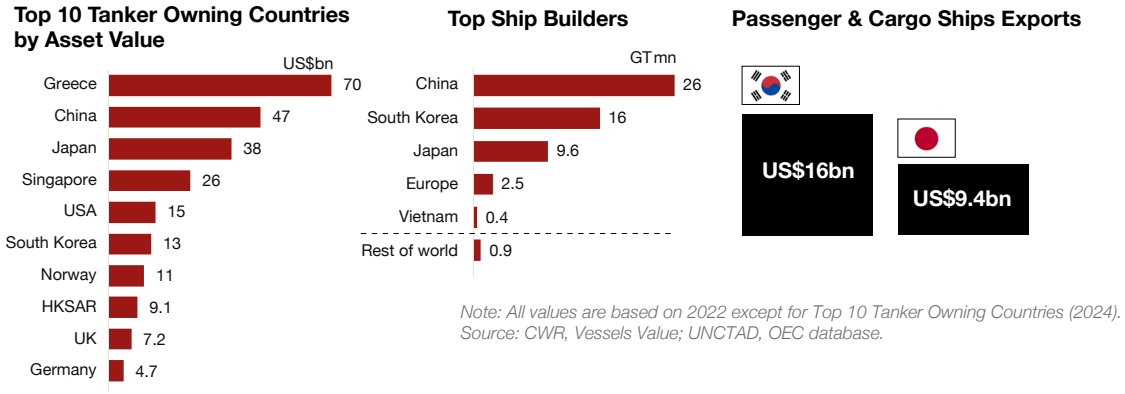


Source: CWR, OEC database, VCI.

Top 10 Exporting Countries
Petrochemical & Derivatives



- **Cars, other vehicles & vehicle parts also feature heavily in their Top 10 exports by trade value.** This is not surprising as Honda, Toyota, Hyundai and Kia are global household names. For Japan, cars are the No.1 export by trade value; other related sectors also rank in the Top 10 – vehicle parts (#4), construction vehicles (#6) and trucks (#9). Together these amount to US$143bn or 20% of Japan's total exports by trade value. These are likely still mostly oil reliant as well, given Japan's abysmal EV adoption rate. Clearly, these exports will be affected if global oil transition is fast tracked. South Korea is similarly exposed while cars (#3) and motor vehicles parts (#5) make up a smaller amount of US$72bn, this is still a sizeable share of 10% of South Korea's total exports by trade value. Like Japan, these will also be affected if oil transition was accelerated as they are likely still oil reliant – South Korea's EV sales, although better than Japan's, are still only at 6.2% of new cars sold.[27]
- **Japan & South Korea are major shipping players – tanker ownership, ship building & exports.** As can be seen from the chart below left, Japan & South Korea are among the Top 10 Tanker owning countries by asset value. Japan's tanker fleet is worth US$38bn whereas South Korea's US$13bn – clearly this will be at risk if the oil trade was disrupted.[30] Moreover, both countries are key ship building nations ranking behind China to make up the Top 3 ship building countries in the world – South Korea is #2 and Japan #3 – see the middle chart below. This ship building prowess means that passenger & cargo ships also feature among their top exports – for Japan, this came in at #11 (US$9.4bn), falling short of the Top 10 exports by trade value whereas for South Korea, passenger & cargo ships exports were worth US$16bn made it the #6 largest export by trade value.[2]



Note: All values are based on 2022 except for Top 10 Tanker Owning Countries (2024).
Source: CWR, Vessels Value; UNCTAD, OEC database.

- **High exposure = strong argument for sovereign credit re-rating if transition not on track.** Previously, our analysis of the coastal threat exposure of 20 major APAC cities showed that sovereign risk re-rating was warranted as city capitals and GDP are materially exposed to coastal threats. [31] We'd placed Japan, Taiwan, Hong Kong and Macao on our watchlist. However, with the additional layer of energy security, it is clear that risk exposure to rising seas are upped. The concentrated impact on global oil trade and energy security from rising seas will create a significant and permanent overhang that warrants a recalibration of tail risks – not only for the entire oil & oil-related industries but also the sovereign credit of Japan & South Korea. Beyond oil impacts discussed above, both countries have sizeable coastal populations clustered in large coastal cities – 69% of Japan's population live in 19 large coastal cities of over 300,000 residents whereas 40% of South Korea's population live in just 8 large coastal cities. Worse still, the size of the overhang and exposure is directly related to the industry/ country's ability to fast track transition.

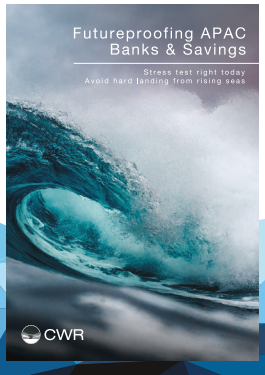
  In addition, our analysis of the loan books of major Japanese and South Korean banks' exposure to SLR risks show exposure sizeable enough to trigger financial collapse.[32] Given the existential nature of the risks and accelerated warming we must start prioritising transformative and holistic approaches to oil transition – more on this in the next section …

For more on sovereign risk impact please read **"Sovereigns at Risk: APAC Capital Threats – Re-ratings warranted as city capitals & GDP are materially exposed to coastal threats"**.

And for more on exposure of major South Korean and Japanese Banks please see **"Futureproofing APAC Banks & Savings: Stress test right today, avoid hard landing from rising seas"**.

Sovereigns at Risk: APAC Capital Threats

Re-ratings warranted as city capitals & GDP are materially exposed to coastal threats



Futureproofing APAC Banks & Savings

Stress test right today, avoid hard landing from rising seas

JAPAN

- With oil as the key energy source and high reliance on crude oil imports, Japan's energy security is highly exposed to rapid ice loss & SLR, yet Japan is not on track to meet its 2030 carbon pledges.
- 2 suppliers – Saudi Arabia & UAE account for 78% of crude oil imports, yet their key oil ports are impacted by 1m of SLR. In addition, 5 of Japan's key crude oil receiving ports which have 68% of national refinery capacity are also impacted by 1m of SLR.
- Japanese exports are also affected. Besides refined petroleum, exports are skewed towards cars & other vehicles, all of which are still oil reliant; Japan's EV sales are at 1.8% of new cars sold.

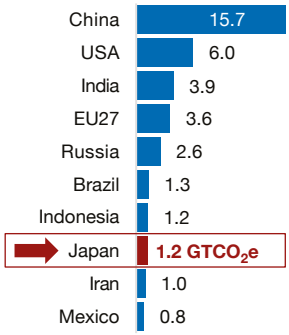
Pledged Net Zero by 2050

☑ Targets: 46% reduction in GHG emissions by 2030 from 2013 levels and to reach net zero emissions by 2050.

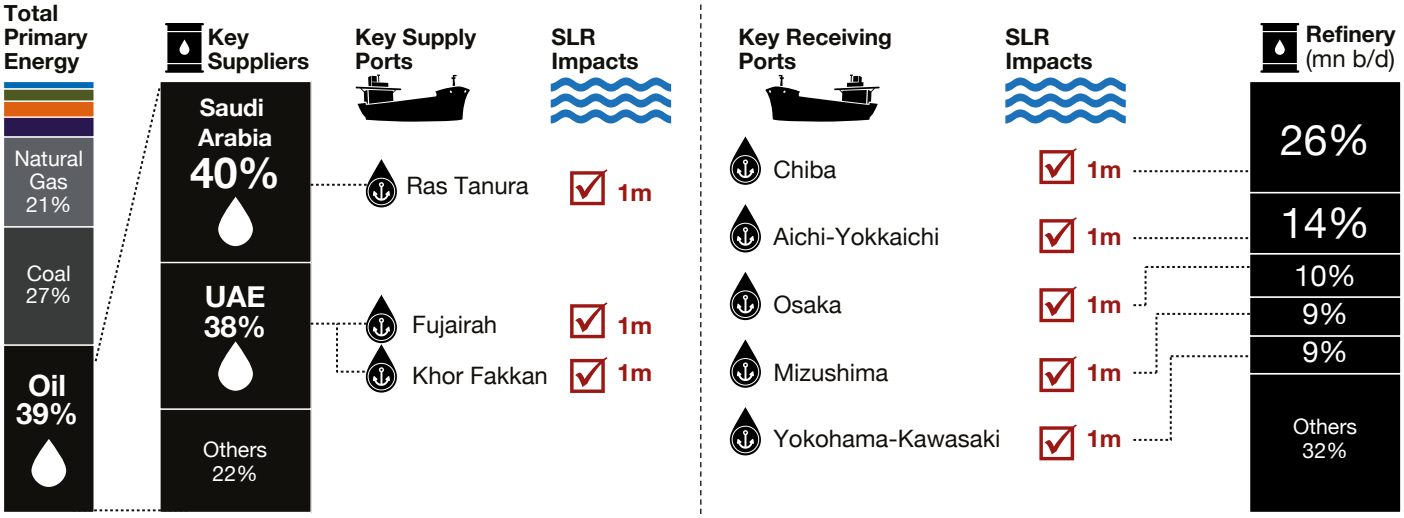
Not on Track to Meet Targets

☒ UNEP Emissions Gap Report 2023: Japan has a 15% implementation gap between current policies & NDC pledges by 2030, compared to 2015 levels.

GHG Emissions

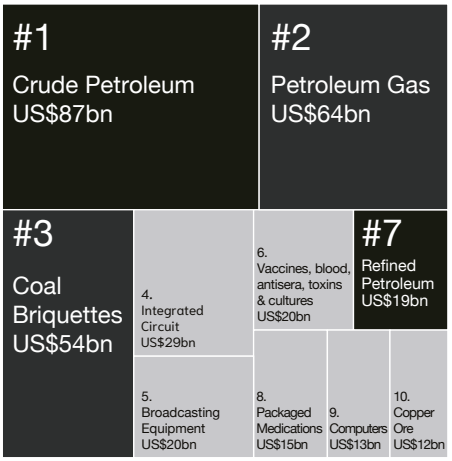


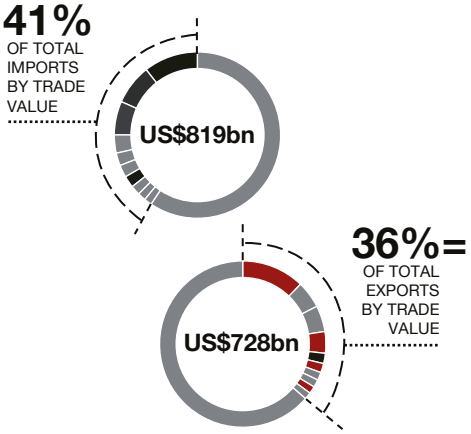
Key Supply & Receiving Ports are vulnerable to SLR…



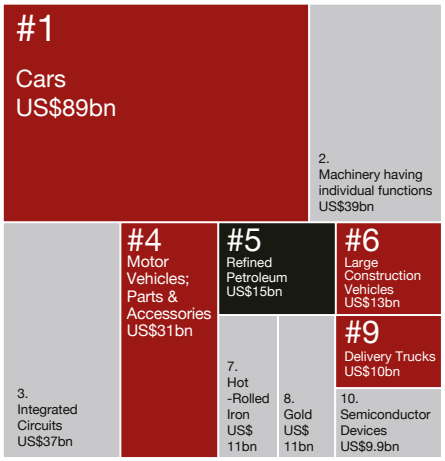
Key impacts on the economy…

Top 10 Imports



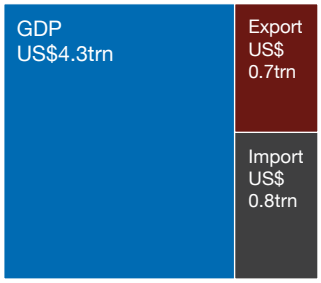


Top 10 Exports

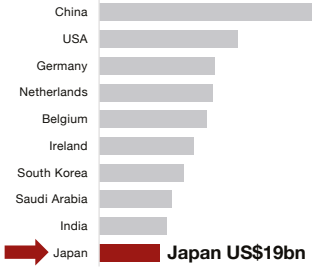


#11 Passenger & Cargo Ships, US$9.4bn

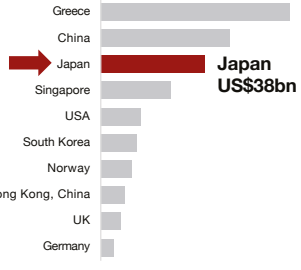
GDP vs. Import & Export



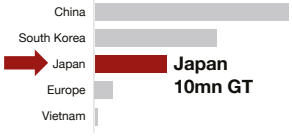
Top 10 Petrochemical & Derivatives Exporters



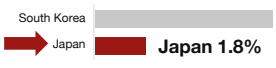
Top 10 Oil Tanker Owners



Top 5 Ship Builders



EV Share of New Car Sales



Note: All statistics are based on 2022, except for oil tanker owners (2024) & EV Share of New Car Sales (2023).
Source: CWR; UNEP Emissions Gap Report 2023; UNFCC; JRC/ IEA Report "GHG Emissions of all world countries 2023"; IEA various Japan reports; NASA SRTM 30m-Grid; Verschuur et al. (2023) "Multi-hazard risk to global port infrastructure and resulting trade and logistics losses", Communications Earth & Environment; OEC database; World Bank; VCI 2022; Vessels Value 2024; UNCTAD Report "Review of Maritime Transport 2023"; Bloomberg Green – The most surprising EV laggards (April 2024).

SOUTH KOREA

- With oil as the key energy source and high reliance on crude oil imports, South Korea's energy security is highly exposed to rapid ice loss & SLR, yet it is not on track to meet its 2030 carbon pledges.
- 4 suppliers – Saudi Arabia, USA, Kuwait & UAE account for 70% of crude oil imports, yet their key oil ports are impacted by 1m of SLR. In addition, 4 of South Korea's key crude oil receiving ports which have 100% of national refinery capacity are also impacted by 1m of SLR.
- South Korean exports are also affected. Besides refined petroleum, exports are skewed towards cars & other vehicles, all of which are oil reliant. South Korea's EV sales are at 6.2% of new cars sold.

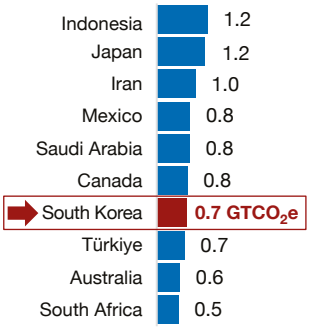
Pledged Net Zero by 2050

☑ Targets: 40% reduction in GHG emissions by 2030 from 2018 levels and to reach net zero emissions by 2050.

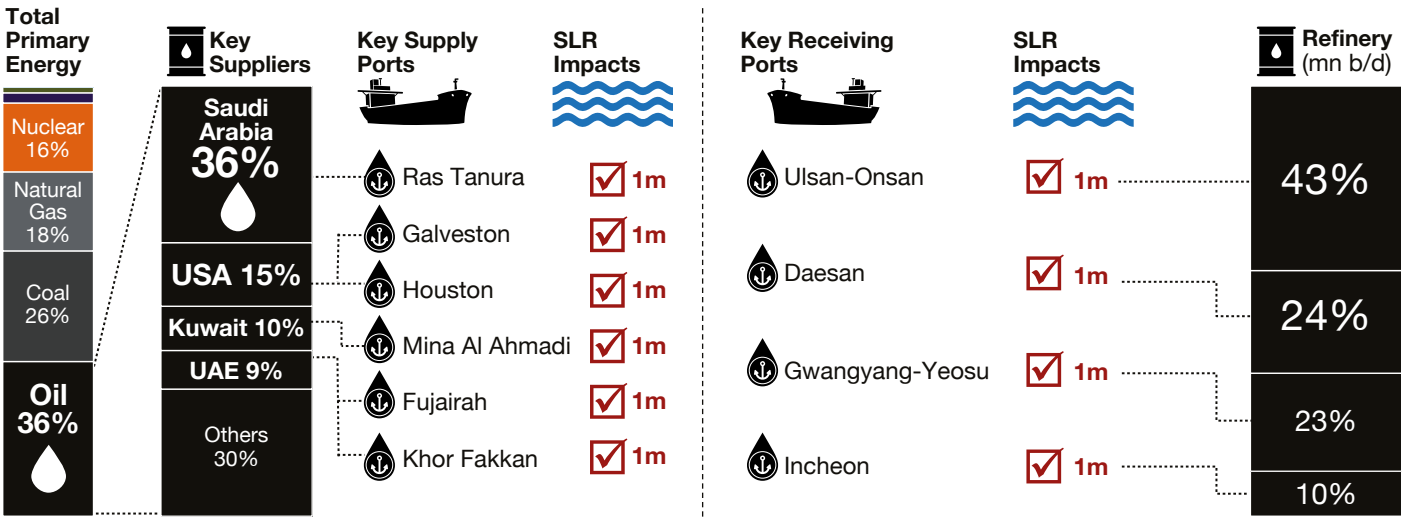
Not on Track to Meet Targets

☒ UNEP Emissions Gap Report 2023: South Korea has a 18% implementation gap between current policies & NDC pledges by 2030, compared to 2015 levels.

GHG Emissions



Key Supply & Receiving Ports are vulnerable to SLR…



Key impacts on the economy…

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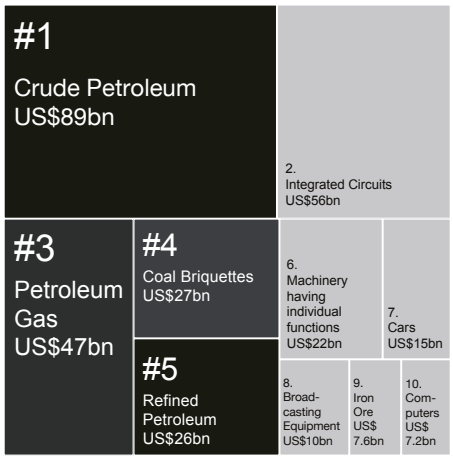
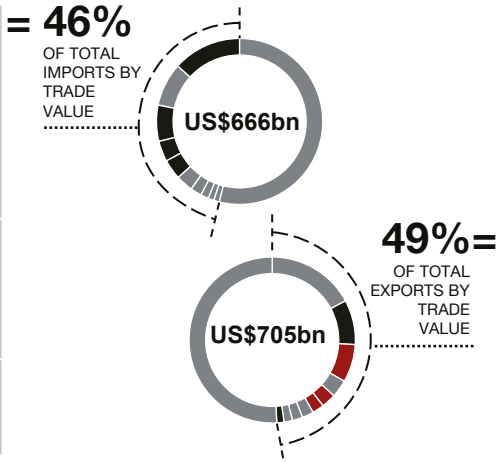
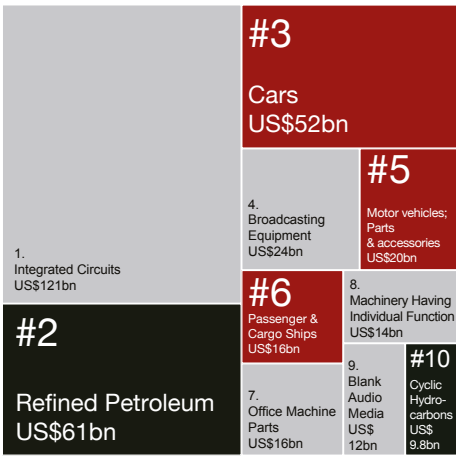
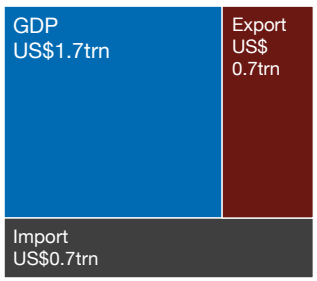




Top 10 Exports



GDP vs. Import & Export



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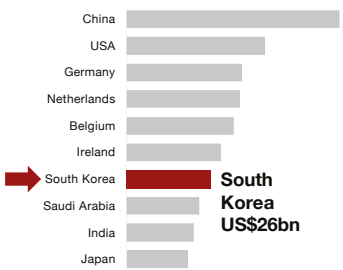
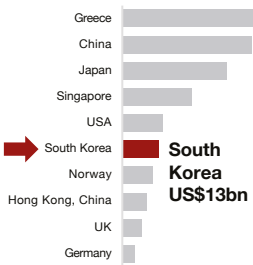
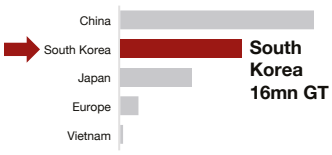


Top 10 Oil Tanker Owners



Top 5 Ship Builders



EV Share of New Car Sales

Note: All statistics are based on 2022, except for refinery capacity (2019), Top 10 Oil Tanker Owners (2024) & EV Share of New Car Sales (2024).
Source: CWR; UNEP Emissions Gap Report 2023; UNFCC; JRC/ IEA Report "GHG Emissions of all world countries 2023"; IEA various South Korea reports; NASA SRTM 30m-Grid; Verschuur et al. (2023) "Multi-hazard risk to global port infrastructure and resulting trade and logistics losses", Communications Earth & Environment; OEC database; World Bank; VCI 2022; Vessels Value 2024; UNCTAD Report "Review of Maritime Transport 2023"; Bloomberg Green – The most surprising EV laggards (April 2024).

Other climate chokepoints – Straits of Malacca, the Middle East & Panama...

The Straits of Malacca, a crucial maritime chokepoint, is home to the world's top tanker terminals, including 3 of the Top 20 Tanker Terminals – Singapore (#1) and Malaysia's Tanjung Pelepas (#16) and Pengerang (#19). While we did not assess the 2 Malaysian ports for this report, Singapore is clearly vulnerable and acting to build resilience to rising seas – see below. However, since the Straits of Malacca accounts for around a third of global shipping transits, **we recommend SLR stress tests to be performed on all key ports serving this route.**

- **Our analysis shows that top bunkering hub Singapore will be hit at 1m of SLR.** As per the infographic showcasing the SLR impacts of the Top 15 Tanker Terminals, Singapore will be impacted at 1m of SLR. Clearly this is a problem as Singapore is the world's No.1 bunkering hub as well as oil transit hub with double the port calls of Fujairah, the 2nd busiest port by callings. The Port of Singapore is also the world's busiest transshipment port (with more than 30mn TEUs passing through every year) and plays a pivotal role in global shipping and trade, connecting over 200 shipping lines to more than 600 ports worldwide. Indeed, the maritime industry is estimated to account for around 7% of Singapore's GDP.
- **Good news! Singapore government is actively adapting to rising seas.** The Meteorological Service of Singapore in 2020 stated that seas have risen by 0.14m since pre-1970 levels and projects a further increase of ~0.2m by 2050 and 1m by 2100. However, in case of multi-metre SLR, critical infrastructure like the Tuas mega port is constructed with an allowance of over 5m above mean SLR as a precautionary measure. The Singapore government is currently conducting feasibility studies on protecting four key vulnerable sites to SLR – Jurong Island, where significant oil assets are clustered, is one of the key sites studied for coastal protection. **What's not clear is whether such studies are carried out on other vulnerable oil sites like Pulau Sebarok/ Bukom as these islands are managed by private companies such as Royal Vopak & Shell.**

Middle East to fast track the rethink of the oil economy & transition? As the world's oil export hub, their economies & coastal capitals are vulnerable to SLR. All 4 Middle Eastern ports assessed in this report are impacted by 1m of SLR – they are Ras Tanura in Saudi Arabia; Fujairah & Khor Fakkan in the UAE; and Mina Al Ahmadi in Kuwait. This is worrying as the 3 countries rank amongst the Top 10 producers & exporters of crude oil accounting for 22% of global crude production & 28% of global crude exports. Although we didn't assess all oil ports in these countries, the fact that their key ports are impacted causes concern. Sadly, the inability to fast track oil transition will only accelerate SLR which in turn could strand these countries' oil assets unless adaptation is put in place. **Beyond, the oil ports, key cities of these three countries such as Jeddah, Dammam, Al Jubail, Dubai, Abu Dhabi and Kuwait City are all coastal and vulnerable to rising seas.** So although the region has made a good start with the hosting of COP last year on oil transition, they may have to step up the speed to save their coastlines.

Moreover, trading partners such as Japan & South Korea will also be affected. **So rising seas will not only sink the Middle East's oil economies & coastal cities but countries/ regions which rely on their oil exports. Asia is especially exposed as the majority of the 3 countries' crude oil exports are headed there.** We therefore recommend all countries reliant on Middle East crude oil exports to conduct in-depth SLR stress tests. Other climate impacts that can disrupt trade should also not be ignored …

Suez Canal disruptions – war, extreme weather & SLR. It's all over the news now – vessels are diverting from the Suez Canal due to Ansar Allah attacks on Israel-bound ships in the Red Sea. According to the UNCTAD, this has affected 42% of maritime traffic; warships and aircrafts have thus been deployed to counter these attacks.

- **War = more emissions = accelerated ice loss & SLR:** As highlighted previously, regional conflicts will likely only keep the world on the path of SSP3 and accelerated warming. According to the Guardian, just the first two months of the Israel-Gaza war alone produced the annual emissions equivalent to more than 20 climate-vulnerable nations. And that doesn't consider the embodied carbon that comes with rebuilding infrastructure post-war which adds to more emissions. Also, according to the Ground Report, for every 100 nautical miles flown by a US F-35 fighter jet, it emits the equivalent emissions of an average UK petrol car in a year. All these emissions do not bode well for SLR. **The 2 Egyptian ports we analysed – Said & Suez – are impacted at 2m of SLR, so accelerating warming is bad news.** Besides SLR, there's also extreme weather…
- **Extreme hot windstorms blew the Ever Given off course in 2021 disrupting US$10bn of trade per day.** Wedged between the narrow waterway, one of the largest container ships blocked the canal for 6 days, stranding ~US$10bn worth of trade per day. In addition to stronger winds, could the Suez like the Panama Canal be affected by a drought? Clearly, trade is disrupted and can be costly when both canals are choked. Plus, lengthier detours only mean more emissions, further increasing the vulnerability of these chokepoints. As we are writing this, Dubai was just hit with extreme rains which caused widespread flooding; the current infrastructure is simply not designed to cope with our new climate realities.

Panama Canal traffic was also cut by more than a third earlier this year due to a severe drought. This canal which shifts ~US$270bn of cargo per annum has been facing a drought for almost a year. The drought forced traffic to cut by more than a third this year. Late last year, large oil tankers were prohibited from using the waterway altogether. Now, ships that want to transit the waterway have to wait in line for several days; some are even paying millions of dollars to jump the line. This will delay shipments of oil from US ports of Houston and Galveston to Asia.

Source: CWR; Maritime Port Authority of Singapore; Meteorological Service Singapore; Ministry of Sustainability and the Environment "Engagement on New Coastal Protection Legislation" (4 March 2024); JTC Corporation website "Who's on Jurong Island?"; OPEC Annual Statistical Bulletin Report 2023; CWR article "War & Climate Change: Suez & Panama Canals' Trade At Risk" (22 February 2024).

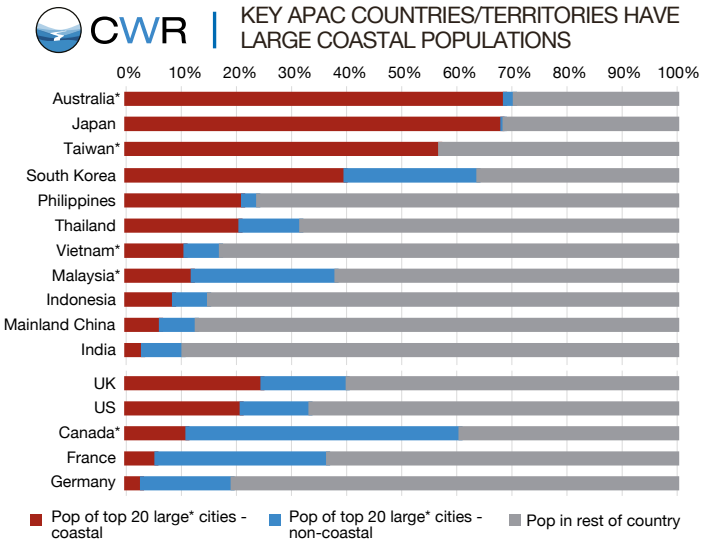
Asia to drive change - 5 opportunities to lead in transition & adaptation

- **Crude Awakening! Instead of helping to ensure energy security, oil now threatens it – especially if we are unable to deliver significant oil emission cuts by 2030-2035.** The analyses in this report clearly show significant disruptions to the oil sector from SLR if we are unable to stay within 1.5°C of warming. To do this, we will need heavy lifting from the fossil fuel sector to deliver a 43% cut in emissions by 2030 from 2019 levels, which will have to be upped to 60% by 2035.[8] Yet, oil production is still growing to 2028 and IEA STEPS forecasts oil emissions to rise to 2030, falling modestly by 5% for 2022-2050. Coal however, delivers cuts of 42% for the same period. Albeit not fast enough, coal transition is far ahead of oil transition. As the IEA notes, although industry investment in giant projects has slowed sharply (ultimately pointing towards transition), the financing of smaller, short-cycle projects persists.[13] While **such expansions have shorter payback periods to avert stranded assets amid increasing ESG pressures & climate policies, as this report shows, this last hurrah in oil expansion could sink all our futures.**
- **Asia must act! Beyond severely disrupting energy security, SLR will pose existential threats to Asia's coastal cities & populations.** Rising seas will redraw swathes of coastlines posing existential threats across Asian nations. Amongst all the continents, Asia is particularly vulnerable as its pivotal role in global trade has meant that many of Asia's capitals and economic hubs are located along the coast. According to the Ocean Policy Research Institute, over 200m people in APAC could be at risk from just 1m of SLR.[33] In addition, a Verisk Maplecroft study revealed that 11 out of 15 cities which are most at risk from flooding due to SLR are located in Asia.[34] This is not surprising given the concentration of significant shares of national populations in large coastal cities – see box below on **"Asia is most region vulnerable to SLR – APAC has more top cities that are coastal than EU & US"**. As per the chart below, given the relatively smaller SLR exposure, it is not surprising why SLR is not a hot topic in the "West"; however, in APAC, SLR must be prioritised.
- **Multiple key roles in global seaborne oil trade = unique opportunities for Asia to lead catalytic & transformative resilience in the energy sector.** Asia plays critical roles in the global oil trade: it is the largest importer of crude & other oil products; it has the largest share of global refining & petrochemical capacity; and it is a global leader in bunkering, maritime services, ship owning and ship building. These strategic positions offer Asia unique opportunities to bring about catalytic and transformative resilience in the energy sector even though most of Asia is still developing. Developed Asia such as Japan, South Korea and Singapore which are particularly exposed to this "crude awakening" have no excuses not to act and must lead the way; China and India, as Asia's 2 largest economies, must also play their parts. Together these 5 countries can and must bring about innovations and infrastructure shifts to fast track transition; plus at the same time, they must protect and adapt critical infrastructure to "virtually certain" and "irreversible" SLR.
- **Given the rapid pace of melting ice and accelerated warming, there is no time to waste – we are racing against time and we are losing, the time to act is now.** We set out 5 opportunities where Asia can lead in both transition and adaptation in the following pages …

Asia is most vulnerable region to SLR – APAC has more top cities that are coastal than EU & US. Assuming that cities with large populations generate the highest GDP for a country/ territory, we examined the top 20 large cities of various countries. Large cities are defined as those with populations of 300,000+. We find that APAC has a significant proportion of its population located along the coast compared to other regions.

As shown in the chart on the right, coastal cities amongst the top 20 large cities account for almost 70% of Australia's and Japan's total population, and 57% of Taiwan's. In comparison, this share is only 25% for the UK, 21% for the US and as low as 5% for France, plus 3% for Germany.

The higher the number of large coastal cities = the higher the GDP at risk. If a large number of a country's/territory's top cities are located in coastal areas, a greater share of its GDP is at risk to coastal threats. For example, out of Australia's 11 large cities, 10 are coastal; for Japan 19 of its top 20 large cities are coastal; for Taiwan all of its 8 large cities are coastal; and for South Korea 8 of its top 20 large cities are coastal.



Note: Large cities are defined as those with populations of over 300,000. Countries/territories with (*) have less than 20 cities with more than 300,000 people.

This is worrying as our previous analysis showed that adaptation plans in some of these APAC cities are not sufficient to address accelerated SLR & coastal threats. This assessment of adaptation adequacy should be revisited, especially vis-à-vis rising SLR risks, as unpreparedness by key coastal cities for such accelerating chronic risks could warrant sovereign credit re-ratings.

Source: The above including the chart is extracted from CWR report "Sovereigns at Risk: APAC Capital Threats – Re-ratings warranted as city capitals & GDP are materially exposed to coastal threats" (2020).

Here are 5 opportunities where Asia can lead in both transition and adaptation:

1. **Asia can lead! With the biggest block of crude oil imports & refined petroleum, it can influence oil production & lead transition.** Asia's own oil production is falling but with its dominance in oil imports, it can also influence oil expansion which is primarily led by the Americas. The top global importers China, India, South Korea & Japan can play key roles, especially since China and India are driving global demand growth.

Our spotlight on Japan and South Korea shows that ironically, oil may no longer help ensure energy security but instead continued usage and expansion could end up threatening energy security. Given that oil is their primary energy source and nearly 100% is seaborne imports, accelerating oil transition to slow down fast rising seas should be a priority for Japan & South Korea. Weaning off oil to ensure energy security is especially urgent as both their key suppliers and receiving ports are low-lying. Moreover, significant amounts of their population are clustered in large coastal cities as per the chart in the box above.

With 12 of the Top 15 Tanker Terminals vulnerable to just SLR of 1m, no country is immune from SLR shocks, especially when many of these low-lying terminals serve major oil producers of the world such as the US and the Middle East. So although China and India can rely on domestic coal production for their primary energy supply, they should also move to fast track oil transition. **Do not be tempted to open up/invest in new oil projects for the sake of energy security as these could well deliver the opposite by triggering runaway ice melt & SLR.**

✓ **DO: Have a cohesive transition & adaptation strategy.** The fact that 1m of SLR poses clear existential threats to Japan and South Korea's energy security signals that they have neither conducted extensive stress testing nor developed cohesive strategies as both countries are lagging in transition by not meeting their national pledges. If none of these key emitting developed countries like the US, UK, Canada, Japan, South Korea, Australia and the EU27 are on track for transition,[10] we will head for more warming which means multi-metre SLR is likely to happen sooner than later.

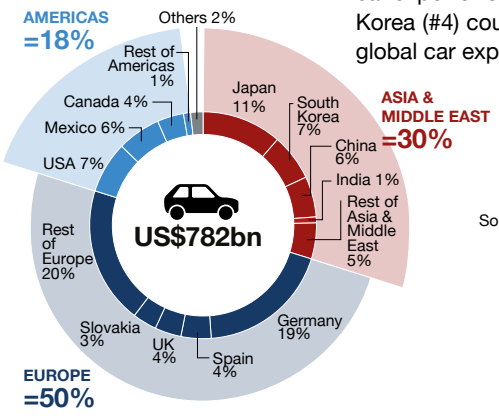
It is therefore vital to have cohesive transition strategies – we should be delivering on our targets to cut emissions to stay within 1.5°C but preparing for 4°C as this is what actual CO_2 emissions growth is tracking. More on stress testing /adaptation later.

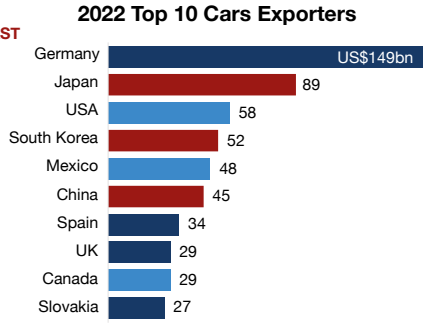
✓ **DO: Wean off oil for energy security & fast track transition to slow down SLR & ensure energy security – shift emission scenarios from IEA STEPS to APS.** Ice is already in the danger zone with warming having breached 1.5°C this year. Because 1.7°C will trigger the accelerated melting of the West Antarctica Ice Sheet (3-4m of SLR) and the Greenland Ice Sheet (3m-7m of SLR), it is critical that we deliver rapid and deep emission cuts.

IEA's Stated Policies Scenario (STEPS) will only deliver 6.5GtCO_2 and 0.6GtCO_2 from coal and oil respectively by 2050. This is clearly insufficient, but under IEA's Announced Policies Scenario (APS), emission cuts are significantly increased to 12.4GtCO_2 and 6.1GtCO_2 respectively by 2050. Although this may be wishful thinking, we should hold oil majors and countries to their announcements to deliver these cuts which will slow down rising seas. Here, Asia can & must lead; immediate action can be taken to:

✓ **DO: Up EV adoption & rethink the auto sector** – with disappointingly low adaptation rates, Japan & South Korea can definitely up their EV strategies but they should also rethink their auto sector strategies as our analysis showed significant export exposure related to the auto sector. Together, Japan & South Korea comprise 18% of global car exports, almost on par with the top car exporter Germany. Given their position in the Top 10 Car Exporters, both Japan (#2) & South Korea (#4) could have led global EV transition; instead, it took China (#6) with a 5.8% share of global car exports to shake up the global EV race.

Cars: Total Export Trade Value by Country (2022)





Source: CWR, OEC database.

The chart on the far left shows clear European influence (50% of global exports) which begs the question – why aren't we all already transitioned to EV given Europe's push for all things green? Perhaps it's because of their dominance in refined oil… more on this later.

Regardless, Japan's & South Korea's car exports are worth US$141bn – that's quite a hit if these are not transitioned to EVs.

✓ **DO: Step up investments in renewables** – Japan & South Korea together account for 1.9GtCO_2e of GHG emissions – this is just over half of the emissions of EU27, yet their investments in renewables/clean transition investments lagged the EU27's of US$361bn for 2023 – Japan ranked #8 out of BNEF's "Top 10 economies for 2023 Energy Transition Investment" spending US$32bn, just ahead of India's US$31bn whereas Germany (#3) spent US$95bn.[16] South Korea didn't even rank in the Top 10 and it's worth noting that Germany's 2022 GHG emission were 1.5x Japan's.

But, it's not just Japan & South Korea which must act to slow down SLR, other countries that are also vulnerable to rising seas must also take action.

✓ **DO: Plan & implement carbon capture, utilisation & storage (CCUS) strategies where possible, as soon as possible** Currently, CCUS only accounts for a small share of emissions reduction – in 2022 total CO_2 captured from fossil fuel & industrial processes as well as bioenergy amounted to a mere 45MtCO_2 as per the IEA's updated 2023 *"Net Zero Roadmap: A Global Pathway to Keep the 1.5°C Goal in Reach"*.[35] However, the IEA remains optimistic – it notes that *"if announced CO_2 capture capacity is realised"* plus *"the current growth trend continues"* global capacity could reach just over 1GtCO_2 by 2030 and over 6GtCO_2 by 2050.

IEA forecasts two-thirds of total CO_2 capture to come from emerging markets and developing economies so it's time that Asia steps up its game in this space. This will help us get closer to the IEA's APS numbers and give us a fighting chance to stay within 1.5°C. How much emission cuts/ avoided emissions we can deliver will dictate the amount of adaptation we will need to do, bringing us to the next action…

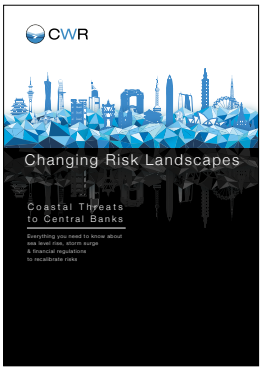
2. **Asia must adapt ports as heavy reliance on seaborne crude imports = energy security is tied to port resilience to SLR.** It is clear from this report that oil ports are extremely vulnerable to 1m of SLR and that nations must act to build resilience against rising seas to ensure energy security. But beyond oil and energy security, the economic impact of unprepared ports could be devastating – almost two-thirds of total goods discharged were received by Asian ports[36] and some are already taking action to adapt these – see box below.

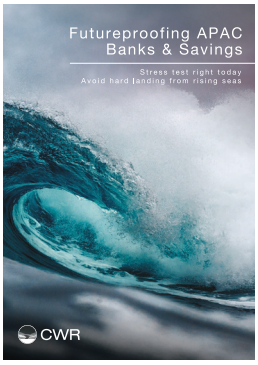
! **Mismatched climate strategies = negative feedback loop; we worry that fast rising seas may have outpaced port adaptation action.** Prioritising carbon over physical risks leads to a false sense of security as assessing one set of risks but not the other will provide an incomplete picture of the risk landscape. Because of this, wrong investment decisions are being made that will add to risks and perpetuate bad decisions – stakeholders will continue invest in oil expansion/delay transition which will escalate SLR risks. At the same time, because we cannot "see" the full extent risks, capital will also continue flowing to vulnerable locations, further compounding SLR risk exposure. This negative feedback loop will continue until chronic SLR risks are assessed and proper risk evaluations made. This is exactly what's happening to Japan & South Korea – their inability to "see" SLR risks has resulted in a more complacent stance towards decarbonising. This also leads to worry that adaptation action to secure coastlines, in particular ports may not be adequate or transformative enough to cope with fast evolving risks.

! **Sovereign risk re-ratings could be warranted if ports are not safe.** This is especially true for South Korea and Japan where energy security is tied to port security. Besides oil, all other fossil fuels such coal and natural gas are also imported – it is thus imperative to ensure ports survive rising seas. Given this, unpreparedness for rising climate risks could literally sink these economies. **We did not conduct a comprehensive assessment of port adaptation.**

✓ **DO: Stress test national energy assets against coastal threats & DO be realistic about SLR projections.** Given accelerating risks, we recommend stress testing critical infrastructure for SLR and other imminent coastal threats such as increasing frequency and intensity of typhoons. It is imperative to have a realistic understanding of the threats ahead so that port resilience can be planned accordingly so do be realistic about SLR projections. In this case, do stress test against the "cannot be ruled" out scenarios as per the IPCC and do use the correct timelines. If you would like more details in how to stress test right for SLR, see our 70+ page report: **"Futureproofing APAC Banks & Savings: Stress test right today, avoid hard landing from rising seas"** released in November 2022.[32]

All Asian countries reliant on seaborne oil should carry out a realistic SLR threat assessment to gauge the extent of energy security exposure. **However, SLR assessments should also be carried out for all relevant ports of key suppliers.** These should also be carried out by port operators, ship owners/ builders, energy traders and other marine service providers.





✓ **DO: Use more granular data for stress testing and don't forget to factor in tides & subsidence.** Don't forget to also stress test support infrastructure such as roads/rail links to the port. Also, remember that seas do not rise uniformly and SLR differs from location-to-location so use local SLR data where available. It is also worth noting that seas do not rise in a straight line and that abrupt jumps in SLR can occur especially if we start triggering rapid ice-sheet melt. This is important when scheduling the timing of progressive SLR adaptation implementation as part of the larger transformative adaptation plan.

Also, do note that we've only stress tested for SLR. In addition, high tides, storm surges from typhoons and subsidence must also be considered. These all also vary by location. For more on how to build scenarios to include these please see CWR's report **"Changing Risk Landscapes: Coastal Threats to Central Banks"** published in 2020.[37]

✓ **DO: Plan & implement transformative rather than incremental adaptation.** Given accelerated warming, rapid ice melt and the increasing probability of multi-metre SLR, the IPCC recommends transformative rather than incremental adaptation to protect cities/critical infrastructure. To effect transformative adaptation, governments should use multi-metre "low-regret" SLR levels to plan adaptation – this allows flexibility in adaptation as projects can be carried out in phases that can be ramped up should SLR escalate. Yet, not all governments are doing this – see box below.

Read up on this in **"Transformative adaptation: 5 tips summarized from the IPCC"** in our banks report **"Futureproofing APAC Banks & Savings: Stress test right today, avoid hard landing from rising seas"**.[32] How much adaptation to implement and when will depend on the progress of global and national decarbonisation as well as the sectors' (oil/port/shipping) own transition achievements. Given that many ports have yet to adopt net zero strategies, plus they must not fail, it is safe to say that ports should plan for the worst. Clearly, if the port is also lagging in decarbonizing, then do also implement net zero strategies – more on this below.

When drawing up transformative adaptation plans, rather than focusing solely on port adaptation, consider adapting surrounding critical infrastructure links as well bunkering. Weighing the cost benefit outcomes of these may result in expanding oil bunkering to cleaner fuels as part of the port's net zero strategy – more on this below.

Finally, it is not good enough to ensure that Asia's importing ports are safe but that your key suppliers are also adapting their ports to adequate levels so **DO: engage with key oil suppliers with regards to their port adaptation measures.**

For avoidance of doubt, a defence of coastlines to protect energy security is NOT a defence of the fossil fuel industry; it is a smart move to ensure trade & near-term energy resilience. For medium-to-long term energy security, it is best to wean off fossil fuels as expanding emissions could sink all our futures.

! **Asia's ports are most at risk globally!** A 2023 Oxford University study analysed 1,340 ports to multi climate hazards found that Asia faced the largest port-specific risk. Locations of high trade risk was concentrated in cyclone-prone areas of East Asia, where hazard-induced port downtime disrupts large trade flows – a total of 27 ports faced trade risks worth US$0.5bn+ per year in ports like Kaohsiung (Taiwan), Ningbo (mainland China), and Busan (South Korea).

US$30.9bn to US$49.4bn to adapt 53 of Asia Pacific's largest ports to 1.6 to 2.3m of SLR. Adapting these ports is expensive – a report by HSBC and ARE showed that depending on the scenario, costs could range from around US$30.9bn to US$49.4bn to adapt 53 of Asia Pacific's largest ports to changing climate conditions of 1.6m to 2.3m of SLR – clearly costs will be more if levels were increased. The report concluded that it will be considerably cheaper to build ports with greater height initially than to elevate them later. The report also flagged insurance issues – it noted that Typhoon Meranthi caused US$32mn in damage when it hit the port of Kaohsiung and while ports/operators may be able to pass these costs to insurers for now, as more incidents occur, these extreme weather events will raise premiums. **Eventually insurers will likely deny cover for ports that are not adequately adapted for coastal threats ahead.**

Another adaptation study highlighted in a 2020 UNCTAD Conference showed that depending on SLR and storm surge scenarios, potentially between ~JPY15-80trn of property could be affected in Tokyo and Kanagawa affecting approximately ~3-17% of Japan's GDP. The cost of raising levees and land areas to mitigate this would cost over JPY123bn for Tokyo and JPY263bn yen for Kanagawa – this is only the cost of materials, NOT cost of rebuilding all the buildings.

Japan & South Korean governments are acting: Currently, Tokyo Bay, which is home to Japan's 6 major ports (Tokyo, Yokohama, Kawasaki, Chiba, Yokosuka, and Kisarazu) is protected by a "tidal barrier line" which is 5-8m higher than sea level at low tide. This tidal barrier line is made up of 15 floodgates, 21 flood embankments and around 60km of continuous seawall. Plans to enhance the coastal defence of Tokyo Port was mentioned in the "Tokyo Resilience Project" released in 2022 – sea wall height in 2100 will be up to 1.4m higher than the current plan. As for South Korea, it announced that in its revised 4th Port Master Plan (2021-2030) that ~US$580mn will be injected into reinforcing peripheral protective facilities, including breakwaters and shore banks, as well as maintenance of disaster prevention facilities such as protective walls and disaster prevention hills at 13 state-managed ports to cope with *"increasingly severe abnormal weather conditions including SLR & stronger typhoons"*. **Adaptation is indeed a costly exercise; it is far cheaper and better to mitigate by investing in fast tracking transition today.**

Source: Verschuur et al. (2023); ARE & HSBC (2018) Climate Costs for Asia Specific Ports; 2020 UNCTAD Conference Presentation by Miguel Esteban; Tokyo Metropolitan Government (2022); Ministry of Oceans and Fisheries of South Korea (2024).

✓ **DO: Have a net zero port strategy.** Ports are key in facilitating emission cuts and transition. With efficient management, ports offer easy-win opportunities for reducing emissions. According to Det Norske Veritas, an international accredited registrar and classification society, ports can deliver up to 15% of GHG emission savings required by 2050 by leveraging energy-efficient technologies like blockchain, machine learning, AI, and digital twin systems.[38] However, ports can go beyond that and achieve net zero emissions.

A prime example of such progress is the Smart Tianjin Port located in northern China, which is the world's first smart zero carbon port. This port is powered entirely by renewable energy from on-site wind and solar power, with a total capacity of 42.55MW. Moreover, it incorporates advanced technologies such as intelligent twins, autonomous driving, 5G, and Internet of Things, resulting in a 17% reduction in energy consumption, a 30% cost reduction, and a 60% decrease in on-site staff.[39]

The efficiency gains achieved by these advancements not only enable ports to achieve net-zero emissions but also contribute to a more streamlined and sustainable shipping process. For example, the improvements in port operation efficiency can result in reduced vessel waiting times – shorter waiting times for ships means reduced idling and decreased fuel consumption, leading to significant reductions in vessel emissions.

Moreover, enhanced port efficiency means that the port can handle a higher volume of ships without compromising sustainability goals, increasing its competitive edge among other ports. This will not only benefit the port's own emissions profile but also supports the overall reduction of carbon emissions in the shipping industry. However, it is imperative that these digital advancements are powered by renewable energy to ensure that Internet, Communication and Telecommunication emissions will not also balloon.[40]

While planning a net-zero strategy, the port should also lean into the opportunities or "green corridors" or "zero emissions shipping routes" – part of this is the provision of clean fuel bunkering services bringing us to the next point...

✓ **DO: Facilitate clean fuel transition for shipping.** Since the signing of the Clydebank Declaration at COP26, there has been a strong commitment to establish *"green shipping corridors"*, which aims at facilitating zero-emissions shipping routes between two ports and driving the decarbonization of the maritime sector.[2] In this transition, ports play a vital role in offering bunkering options for vessels running on low or zero carbon fuels. Of course, to be a fully green corridor, participation ports should also be net zero.

According to UNCTAD, achieving 100% carbon-neutral fuels by 2050 will require significant annual investments ranging from US$28bn to US$90bn.[2] These investments will be necessary to scale up fuel production, distribution, and bunkering infrastructure. Given that Asia has an extensive network of ports, dominates in refining & petrochemicals, and is the largest ships owner, the cost of inaction in this region would far outweigh the required investments, particularly as many of Asia's ports are already at risk with just 1m of SLR.

To ensure survivability from rising seas, it is therefore crucial for the port industry and multilateral institutions to prioritise investments in sustainable port facilities, clean energy marine hubs and green shipping corridors. Close collaboration among stakeholders will also ensure a sufficient supply of low-carbon alternative fuels – these efforts align with guidelines to reduce emissions recently issued by the International Marine Organization (IMO)[41] – see box below.

! **The 2023 IMO Strategy on Reduction of GHG Emissions from Ships updated in July 2023,** should give the industry a boost to decarbonise faster. The 2023 IMO GHG Strategy represents a framework for Member States, and sets out the future vision for international shipping and levels of ambition to reduce GHG emissions and guiding principles:

1. Ship carbon intensity to decline through further improvement of the energy efficiency for new ships: to review with the aim of strengthening the energy efficiency design requirements for ships;
2. Carbon intensity of international shipping to decline: to reduce CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, compared to 2008;
3. Uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources to increase: to represent at least 5% striving for 10% of the energy used by international shipping by 2030; and
4. GHG emissions from international shipping to reach net zero: as soon as possible and to reach net-zero GHG emissions by or around 2050.

Source: 2023 IMO Strategy on Reduction of GHG Emissions from Ships (July 2023).

3. **Asia is the dominant producer of refined oil products + petrochemicals = rethink these exports + fast track shift to producing new shipping fuels.** As energy transition progresses, winds of change are already prevalent for these industries but we are of the view that change should be faster. Indeed, several converging trends provide support to fuel catalytic change – underlying this is spare capacity in both refining and petrochemical production in Asia and looming peak in transportation fuel consumption thanks to the adoption of EVs will require refiners to manage down their assets.[13] China, India, Japan & South Korea will no doubt be impacted, but China, with the largest global share of refining installed capacity, will feel it the most. However, this easing-off is offset by a burgeoning petrochemical demand which will also need to be reined in. That said, there is some good news. Capacity expansion will outpace growth in end-user demand so there will **unlikely be further appetite to finance new capacity in either petrochemicals or refining projects globally, putting Asia in the driving seat to rethink these.**

Petrochemicals make up 15% of oil demand in 2022 + still booming, sucking up the 2nd largest amount of oil after transport.[11] The IEA notes that petrochemical demand is on a booming trajectory – its share of oil demand is expected to expand to 17% by 2028.[13] According to the IEA, petrochemicals are the largest driver of oil demand growth – ahead of trucks, aviation and shipping. Indeed, chemical feedstocks will account for an additional 2.3mn b/d between 2022-2028 – this is ~40% of total oil demand growth for the period.[13] Here again, Asia can take the lead in reining in growth as China dominates global production as well as the expansion of petrochemicals; plus the others also rank in the Top 10 Exporting Countries of Petrochemicals & Derivatives – South Korea (#7), India (#9) and Japan (#10).

Refining and petrochemicals assets are also very vulnerable to SLR = provides impetus for governments/asset owners to rethink policies towards these sectors. Refiners and petrochemical facilities are often clustered located near seaports as this provides convenient access for the transportation of crude oil as well as other chemical feedstocks. It is convenient not just for the import of these raw materials but also for the exports of refined / petrochemical products. Such concentration of assets = high clustered risk exposure to SLR & other coastal threats adding urgency to the need to build resilience against rising seas for these assets.

DO: Assess SLR exposure of refining & petrochemical assets. These threats may happen sooner than you think and some areas have already started – for example, Houston which learned the hard way in 2017 when Hurricane Harvey temporarily knocked out a quarter of refining capacity of the US – see box below.

Adaptation action such as raising plants, storage or building sea walls are expensive and such costs must be weighed against the profitability and sustainability of these industries. Given that fossil fuel transition must occur to keep the planet habitable by humans, is it wise to spend hundreds of millions if not billions of dollars protecting refineries and petrochemical plants or is the money better spent on transitioning these sectors and building new clean fuel production and bunkering facilities? After all, fall in overall demand for transport fuel is already causing refining over-capacity. **Cost benefit analysis of adapting oil assets for SLR may well point to strategic expansion that lean into rather than go against oil transition.**

DO: Lean into the transition – governments should build holistic polices that benefit industries where Asia already dominates globally to get the most upside. Governments should build strategies that leverage Asia's dominance to ramp up change. Such policies will have to balance energy security, jobs, geopolitics, adaptation of critical coastal infrastructure/ cities/ rural populations to SLR impacts as well as deliver sizeable emission cuts sooner rather than later to avoid runaway ice melt and slow down rising seas.

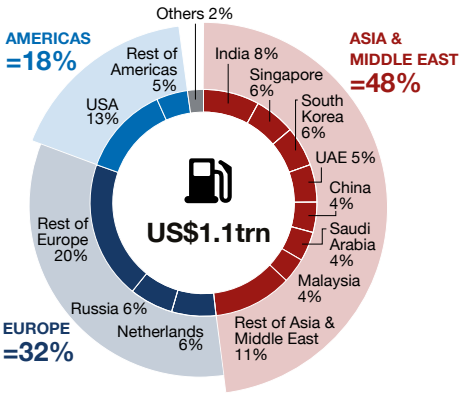
Policies set in Asia can certainly influence global fuel markets – we have seen this with China's rapid EV uptake. But countries should not miss out on the opportunity to rethink the strategic importance of the refining & petrochemical industries … after all, they may not provide but instead threaten medium to long term energy, food and economic security by exacerbating climate change. Cohesive strategies should also include the shipping industry where Asia also plays a key role – more on this later. Asset owners should keep in view these potential shifts in national strategies.

Coastal adaptation to protect refineries in Gulf of Mexico where 15% of US crude oil production & over 47% of US refining capacity are concentrated. The region is however prone to hurricanes. In 2005, refineries in the path of hurricanes Katrina and Rita, accounting for 29% of US refining capacity, were shut down at the peak of disruptions. Two of the three pipelines and three-quarters of platforms in the Gulf were in the direct paths of these two category five storms. In 2017, hurricane Harvey swamped Houston and temporarily knocked out a quarter of the national refining capacity affecting gasoline prices nationwide. In 2018, following these pervasive disruptions, major US oil and gas companies asked the government to take measures against bigger and more intense future storms as well as higher tides expected from climate change. One project stands out: an ambitious US$12bn proposal to build a nearly 60-mile "spine" of concrete seawalls, earthen barriers, floating gates and steel levees on the Texas Gulf Coast. Like other oceanfront projects, this one would protect homes, delicate ecosystems, and vital infrastructure, but it also has another priority — to shield some of the crown jewels of the petroleum industry in the US.

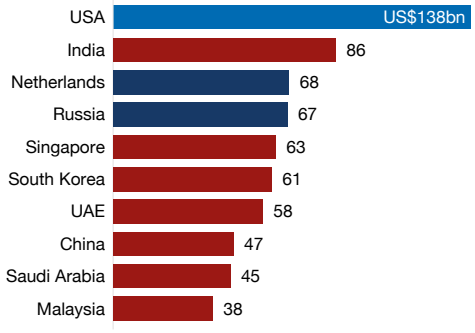
Source: EIA Gulf of Mexico Fact Sheet (21 June 2023); American Petroleum Institute article "How is the Natural Gas and Oil Industry Preparing?"; Reuters "Texas refineries begin restart after hit from Harvey" (3 September 2017); The Energy Mix "Texas Fossils Seek Federal Funds to Protect Their Operations from Climate Change" (26 August 2028).

DO: Manage refinery step down as EV adoption speeds up. Transition momentum for land transportation is clear with pick up in EVs but for shipping and aviation transition lags. Here, with almost half of the global share of refined petroleum exports by trade value, Asia & the Middle East have a clear role to play – see charts below. Among the Top 10 Refined Petroleum Exporters by trade value, India, Singapore, South Korea, China and Malaysia must act – all their major oil ports (except India which we did not map) are low lying. Europe with 32% of global refined petroleum exports must also do some heavy lifting to transition out their refineries if they are do seriously up EV adoption rates. Interestingly key oil terminals of all the Top 10 ex-India are impacted by 1m of SLR. We did not map India as their ports did not rank in the Clarkson Research's Top 20 tanker terminals.

Refined Petroleum: Total Export Trade Value by Country (2022)



Top 10 Refined Petroleum Exporters



Source: CWR, OEC database.

DO: Expedite scale-up of cleaner shipping fuels. Given the above exposure perhaps it is time for refiners to pivot to cleaner shipping fuels. Indeed, there has been positive movement from the shipping industry – in 2023, the IMO adopted the "2023 IMO Strategy on Reduction of GHG Emissions" which aims to peak GHG emissions from international shipping as soon as possible and to reach net-zero GHG emissions by or around 2050.[41] As a result, the IEA expects marine bunker demand to be tempered by IMO efficiency standards – world bunker fuel consumption will rise by 300,000 b/d by 2028 reaching 4.5mn b/d but without this, demand will be 4.9mn b/d. **The IMO push as well as the imminent threat of stranded assets, provide clear support for the clean shipping fuels market and expansion. It's time to pivot.**

DO: Draw up a petrochemicals transition plan & introduce policies to cap petrochemical production. While most countries and banks have transition plans drawn up for steel, aluminium, as well as cement, plastics & other oil synthetics have flown under the radar. Instead of just tackling plastics as a pollution and waste issue, surely it is also time to cut production? After all, endless fast fashion is not just dirty but also very thirsty and is a large contributor to climate change. Already the demand for plastics has outpaced that of all other bulk materials such as steel, aluminium, and cement – demand has nearly doubled since 2000. At this rate, it looks like we won't be able to fast track oil transition unless we **start introducing policies to transition petrochemicals or make better choices about the products we're buying and materials they are made of** – see box below.

In 2022, petrochemicals are estimated to have emitted 5.6GtCO_2e of emissions – this is almost as much as the annual emissions of the US in 2022 of 6GtCO_2e.[42] Given the sizeable and growing emissions could trigger runaway ice melt & SLR, **it is time to draw up a petrochemicals transition plan. This will also add momentum to the circular economy movement related to plastics and textile fabrics plus cut waste and curtail ocean pollution.**

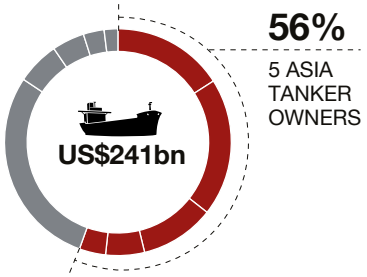
Beyond energy – cosmetics, athleisure, plastics et al, While we typically know that oil is used as fuel for transport – cars, buses, trucks, ships, and planes, and to make plastic – bottles, containers, utensils, packaging and so on, many of us don't realise that oil is also used in textiles, cosmetics, furniture, pharmaceuticals, electronic appliances, computers, engine parts, adhesives, paint, detergent, fertilizer, construction and the list goes on. According to Petrochemical Europe, petrochemicals are in 95% of all manufactured goods.

For example, 70% of clothes manufactured in 2021 were from synthetic fibres (chemicals derived from petrochemicals) – accounting for ~1.4% of global oil production, more oil than Spain used in that year. According to This Is Unfolded, a sustainable clothing company, today the average wardrobe contains 379L of oil. That's enough oil to fill more than 8 fuel tanks of an average car or make ~5,700 plastic bags!

*Source: The above is an extract from the article **"Ending Oil By Making Smarter Choices"** by Sophie Lam published in December 2023 on CWR website*
Read the full article here:
https://chinawaterrisk.org/resources/analysis-reviews/ending-oil-by-making-smarter-choices/

4. Asia dominates global oil tanker ownership = influence transition to a new "green fleet". 5 Asian countries/territories own 56% of global tankers by asset values – they are China (20%), Japan (16%), Singapore (11%), South Korea (6%) and Hong Kong (4%). Shipowners play a key role in the fuel transition as they are one of the key drivers in the shipping industry's value chain. They are responsible for making commercial and investment decisions related to ships, including determining when to order new capacity and choosing the type of engines and fuels to be used. Asia's dominance means that they have the power to influence the transition of the existing carbon intensive fleet to a new "green fleet".

Top 10 Oil Tanker Owners



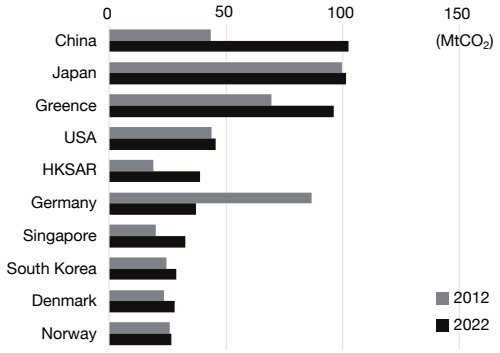
Source: CWR, Vessels Value (2024).

Fuel transition in shipping is still in its "infancy" as 98.8% of the global fleet is still using conventional fuel according to the UNCTAD.[2] Currently, tankers account for 29% of shipping emissions, which is the largest share among all other types of ships. As large asset owners of the tanker fleet, Asia can certainly influence fleet transition and should as **Asia will have the most to lose if it doesn't** – beyond tankers, Asia also dominates overall ship ownership – more below. This places it in an even more commanding position to take lead in the global shipping transition which is ever more important global shipping emissions have already risen to 3% of global GHG emissions today… and without action, shipping emissions could be 130% of their 2008 levels by 2050.

Asian ship owning countries are driving an increase in emissions. It is evident from the chart on the right that Asia dominates in overall shipping emissions by ship owning countries. China and Japan are neck-to-neck in the lead with just over 100MtCO$_2$ each.

Key points of interest are 1) Japan's emissions have stayed high over a decade; 2) China's emissions have more than doubled; and 3) increases in emissions in the last decade for Hong Kong, Singapore and South Korea are also significant. It is therefore important for Asia to lead this shipping transition.

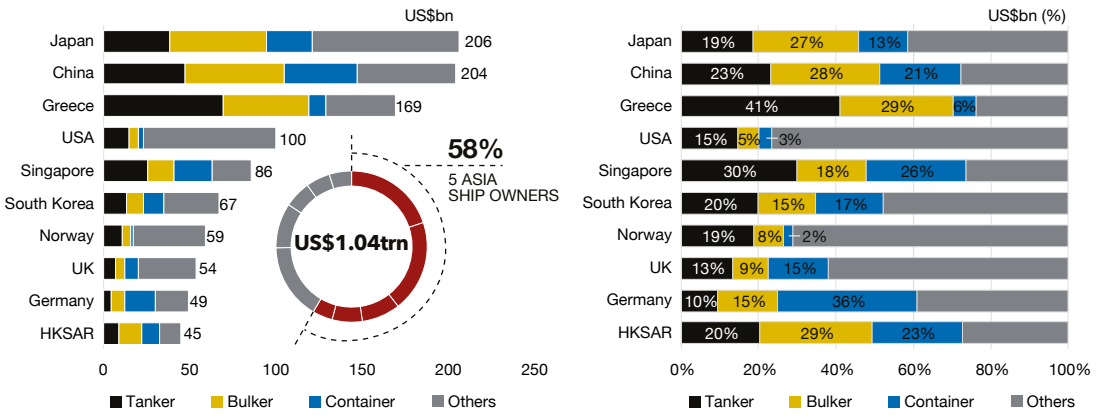
Asia Dominates Shipping CO_2 Emissions…



Source: CWR, UNCTAD Review of Maritime Transport 2023.

Besides oil tankers, Asia also owns a lot of other ships – US$608bn worth in total = lots to lose = must lead transition. Looking at all ship types, 5 of the Top 10 Ship-owning Nations are Asian – they are Japan, Mainland China, Singapore, South Korea, & the Hong Kong.[30] Together, the value of ships they own amount to US$608bn – clearly there is a lot to lose if ports are submerged by SLR which these ships are accelerating if unless they are running on clean fuels. Therefore, not only does Asia needs to step up its oil port adaptation, but Asian shipowners must also transform their fleet – given that they own a sizeable share of global shipping – they must collaborate to drive deep change in global shipping and make net zero shipping a reality.

Top 10 Ship Owners – All Ship Types



Source: CWR, Vessels Value (2024).

✓ **DO: Proactively green your fleet & lean into rising green shipping corridors.** The good news is that the global fleet is ageing – the UNCTAD notes that at the start of 2023, commercial ships had an average age of 22.2 years.[2] This presents a favourable opportunity to renew ageing fleets and transition to greener options, as stipulated by the IMO's 2023 revised GHG strategy as discussed above.[41]

However, as greening the fuel chain is beyond shipowners, **it is crucial to engage with other stakeholders to provide clean fuel bunkering especially when decarbonization shipping by 2050 will require large investments.** UNCTAD reports that an additional US$8-28 billion will be required annually to decarbonize ships by 2050, but as mentioned above, even more substantial investments, ranging from U$28-90bn annually, will be needed to develop infrastructure for 100% carbon-neutral fuels by 2050.[2,43] The rise of green shipping corridors will be inevitable – don't miss the opportunity to shape these – proactively engage.

✓ **DO: Introduce policies & regulations to stimulate demand for alternative fuels, green tech & green fleets.** The government and port authorities need to intervene at the policy and regulatory level to encourage the industry to invest. Currently, shipowners face a conundrum – they must decide whether to renew the fleet now while lacking clarity about future alternative fuel bunkering, green technology options and the regulatory regime. Governments therefore play a key role in offering clear guidance and assistance to shipowners to facilitate the adoption of all these green measures in the shipping industry, while also encouraging industry investments.

Such guidance is especially vital now as uncertainty in shipping due to the Red Sea crisis has not only extended NM sailed, but also sucked up excess shipping capacity and delayed the scrapping of ships.

✓ **DO: Take active positions on future green fuel decisions; don't just leave this to governments or the ports.** According to the IEA, while half of low-emission fuel use in 2030 is in the form of biofuels, which can be used in existing vessels, technological development and associated policy support will be required to enable the use of other fuels, particularly ammonia and hydrogen to reduce dependency on oil-based fuels in international shipping.[44] However, due to uncertainties around the availability of lowemissions fuels, many shipowners have begun to build or retrofit their fleets to include multiple-fuel vessels (such as vessels that can run on diesel and methanol).

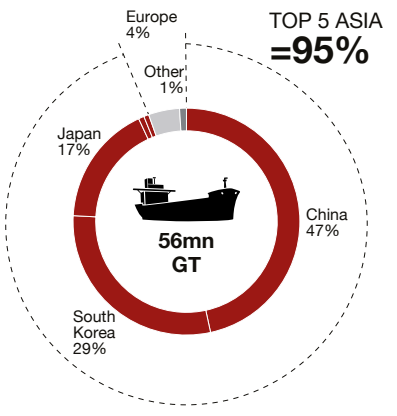
According to UNCTAD, LNG is currently the most popular alternative fuels in global active fleet and orderbook.[2] But LNG is still a fossil fuel and faces problems such as methane slip and 'well-to-tank' emissions, even though it may have a lower carbon footprint than heavy fuel oils. Given fast rising seas, perhaps it is time to step up decarbonisation with green ammonia? Indeed, some ship builders are already exploring this – more on this in the next point.

While it is easy to adopt a "wait and see" approach to ascertain which fuel gains market share, the shipping industry may not have the luxury of time to leave it to the markets. **With fast rising seas, the maritime industry can no longer afford to put this on the back burner, but instead must take a proactive stance towards shaping the development of the industry's fuel of the future – especially since Asia can influence ship building.**

5. **Asia ship building prowess = opportunities to transform shipping & leap ahead with clean fuels.** As per the chart on the right, 5 Asian countries account for 95% of global ship building capacity of 56mn GT – they are China (47%), South Korea (29%) Japan (17%), Vietnam (0.8%) and the Philippines (0.7%). Indeed, South Korea's and Japan's ship building prowess mean that passenger & cargo ships also feature among their top exports worth US$16bn and US$9.4bn respectively.

This concentration in Asia presents an opportunity for the continent to lead in greening the shipping value chain … after all, all these countries have large swathes of coastlines vulnerable to rising seas.

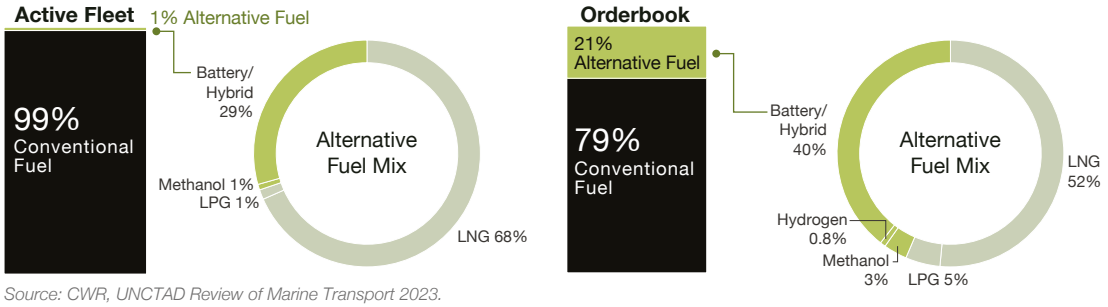
Asia Leads Global Ship Building Capacity



Source: CWR, UNTCAD Review of Maritime Transport 2023.

Orderbook reveals no clear direction as to which fuel to focus on. Although ship builders are natural drivers in steering decarbonization, they face multiple layers of challenges that impede their ability to be leaders in this space. The UNCTAD notes that these challenges include uncertainties regarding the types of ships that will be ordered, built, and retrofitted, as well as the availability of fuels and engines that can align with the goals of ship owners, operators, and regulations.[45] Besides LNG, which is cleaner but still a fossil fuel, the orderbook is fragmented making it difficult for ship builders to lock into one type of fuel. However, there is good news – the alternative fuel share of the orderbook has a larger share of new vessels (21%) than the active fleet (1.2%).

2022 Alternative Fuel Uptake by Number of Vessels – Active Fleet vs. Orderbook



Source: CWR, UNCTAD Review of Marine Transport 2023.

DO: Proactively explore new ship designs & tech to accommodate clean fuels & work through safety & operational protocols. It's evident that the shipping sector must transition so those who grab the first-mover advantage will benefit. According to the IEA,[44] Japan, China and South Korea are already leading in designing and building ammonia-ready vessels, as well as on bunking protocols and infrastructure – see box below.

DO: Facilitate consensus and guidance on alternative clean fuels. It is imperative to get governments involved and build a consensus on this front. Ship builders should engage with multiple stakeholders from governments, ports, service providers, ship owners and so on but governments must provide guidance.

Given the critical role shipping plays with regards to energy security & trade, perhaps it is time to draw up a holistic green shipping plan that incorporates all upstream players – the concentration of these in Asia gives the region a unique opportunity to transform global shipping. **In particular, China, Japan, South Korea & Singapore should work closely together to upscale clean shipping fuels – this will not only help secure existing maritime trade routes but also extend their leadership in international shipping.** Indeed, collaboration is already afoot – for a few examples please see the box below.

As this section shows, Asia can and must take the lead; the financial sector too must do some heavy lifting – see **"5 to-do's for the financial sector"** on the next page. If Asia does not unite to resolve and shape its energy security and shipping futures, decisions made by others will result in its coastlines being redrawn and economies thrown into havoc. Time is of the essence – there is 6 years left to deliver significant emission cuts, let's make the most of this time to stay afloat!

To ammonia or not to ammonia? A quick glance at the orderbook and active fleet shows (charts above) the dominance of LNG as the alternative fuel. But ammonia, can be more attractive as it has zero carbon content when produced from renewable sources.

The UNCTAD also notes that this will not require capturing carbon emissions, which can increase the final cost of e-methanol. Indeed, a 2024 study from the University of Oxford found that green ammonia, which is similar to very low sulphur fuels, could be a viable technological solution to decarbonize 60% of global shipping when offered at just 10 regional fuel ports.

Nonetheless, the UNCTAD warned that the safety and availability issues of green ammonia remain important barriers that need to be overcome before it can be used at scale. The study also underlined that investments up to US$2trn are required to build new infrastructure, with a large share of this in developing countries. Here, green finance is key to support the transition to either green hydrogen and/or green ammonia production in these countries.

Indeed, collaboration on ship building and bunkering is already afoot. For example, China Class Society issued 2022 Guidelines for Ships Using Ammonia Fuel and in 2023, awarded Singapore's SDTR an Approval in Principal certificate for the world's first Ammonia Dual Fuel Kamsarmax Bulk Carrier, a joint development project with Shanghai Merchant Ship Design & Research Institute. Japan's Sumitomo Corporation is exploring Ammonia Ship-to-Ship bunkering in Singapore as part of the multi-stakeholder Sabre Project. Over in South Korea, 6 large organisations got together to form the 'Green Ammonia Marine Transport and Bunkering Consortium' in May 2021 and the Korea Registry has since been issuing Approval in Principal certificates to build green ammonia-fuelled ships as well as supporting the development of ammonia bunkering.

Source: IRENA, 2021; UNCTAD Review of Maritime Transport 2023; Verschuur et al. (2024) "Optimal fuel supply of green ammonia to decarbonise global shipping", Environmental Research: Infrastructure and Sustainability; Media files from SDTR Marine, Sumitomo Corporation & The Korean Register.

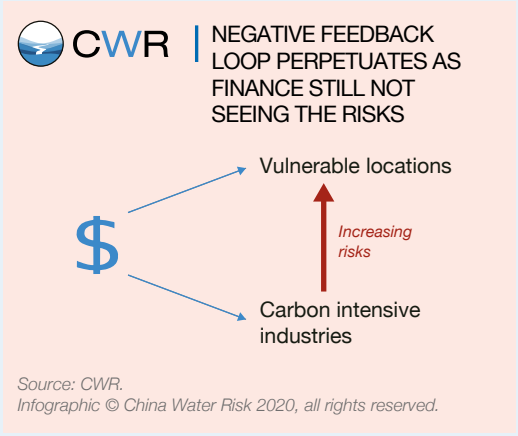
5 to-do's for the financial sector…

Clear material implications for finance – the financial sector, from banks to investors and insurers must rethink oil and other fossil fuels as they may no longer provide but threaten energy security. The energy sector is clearly at risk from the disruptions that the oil supply chain faces due to rising seas to the extent that oil may no longer play a key role in energy security. Therefore, the financial sector, from banks to investors and insurers must rethink oil and other fossil fuels in this context. If not, continued flows to the oil sector to support its expansion will accelerate rising seas that will trigger systemic shocks across the financial sector. As discussed previously, fossil fuel financing still makes up a big part of lending and investing – indeed, fossil fuel financing from just 60 banks has totalled US$600-800bn annually since 2016. Such support for near-term expansion will not stop but delay transition and increase risks – the financial sector will ultimately end up shooting itself in the foot, like the oil sector.

Avoiding this will require a holistic re-think of the oil sector from finance – get started with 5 to-do's below:

1. **Assess risks to loan book and portfolio from SLR risks to oil sector.** Physical climate risks are locational, so they must be mapped and assessed – CWR's 2022 report **"Futureproofing APAC Banks & Savings: Stress test right today to avoid hard landing from rising seas"** provides an in-depth 3-Step Guide to Stress Test Right for SLR Risks that details how to 1) use the right timeline, 2) use the "low-regret" scenario; and 3) assess what governments are or are not doing on adaptation to build resilience against rising and compounding coastal threats. This can help the sector start understanding and assessing the SLR risks facing the oil sector – armed with this assessment finance can then engage and allocate capital better – see below.
2. **Engage with the entire oil supply chain to ensure risks are being assessed and planned for.** It's not just crude oil suppliers that are at risk and have to be engaged, finance must also engage with refiners, transporters and other downstream users that rely on the oil chain. As part of the engagement, do ascertain if different players have a net zero goal and how they expect to achieve this, because a goal without a plan is futile. In addition, engagement must also include whether physical climate risks are being assessed, whether they're being assessed to the right levels, and what the adaptation plans are, if any.
3. **Reallocate portfolios & make better allocation decisions to reduce future losses & avoid the negative feedback loop.** Given that the world is currently heading towards accelerating risks due to rising temperatures, finance must not lend or invest in projects/corporates that will further increase warming as this will increase climate risks & exposure to SLR which impact all future business located in vulnerable locations as illustrated in the diagram on the right.

   This negative feedback loop will perpetuate until risks are assessed. So in addition, investments in projects/corporates that are not assessing physical risks nor adapting should also be avoided as they will be vulnerable to risks.



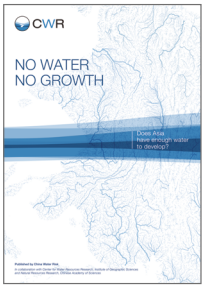
Source: CWR.

4. **Look for opportunities that will support the transition as well as adaptation.** With the need to fast track transition, finance should support innovative solutions that can help such as CCUS, smart ports, and development of clean fuels (ships & bunkering). Some of these technologies already exist but require further investment or expansion to reach critical scale so that they are more cost effective. The oil supply chain will also have to adapt for climate impacts, but adaptation financing currently lags transition. However, as insurers will not bear the risk in the long-term, adaptation finance must kick in to ensure resilience.
5. **Don't forget shipping – transporters of oil will be at risk & must be prioritised.** Shipping is seen as a hard to abate sector due to multiple challenges along the supply chain including costs. However, ships are essential to global trade and have a symbiotic relationship with oil – it is essential for the sector as 64% of oil produced globally is moved by ships, and the oil tanker fleet accounts for about 30% of global fleet capacity. Considering fast rising seas, it is thus imperative for finance to rethink the role of shipping and adjust net zero strategies for the shipping sector

For more on financing flows to oil, please see **"Vicious cycle! 5 Reasons why the inability to peak oil before 2030 will unleash rapid SLR"** and **"Dirty money – oil investments, subsidies & expansion vs. clean energy spending"**.

CWR

Over a decade of unpacking & valuing interlinked waternomic risks in the water-enrgy-climate nexus ...



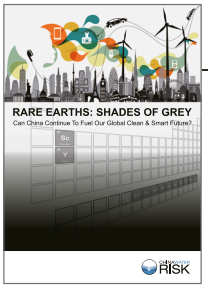
No Water No Growth – Does Asia have enough water to develop?
CWR with CAS-IGSNRR, 2018

Notably:
- Cited by IPCC AR6 WG2: "Climate Change 2022: Impacts, Adaptation & Vulnerability"
- Led to a waternomics chapter in a 2021 Nature Springer book: 'Water Security Under Climate Change" launched by Scotland's Minister of Net Zero ahead of COP26 in Glasgow

Rare Earths: Shades Of Grey Can China continue to fuel our clean and smart future?
CWR, 2016 (EN/中文)

Institutional investor highlighted CWR's report in the 2016 PRI in persons meeting

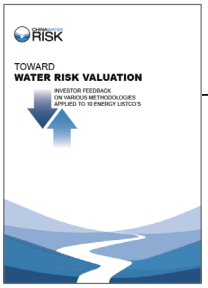
The PRI tabled rare earths as an emerging risk along with cybersecurity and antibiotics

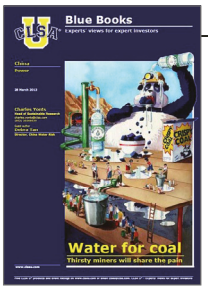


Toward Water Risk Valuation: Investor Feedback on Various Methodologies Applied to 10 Energy ListCo's
CWR, 2016 (EN/中文)

Methodologies included in:
- 1st ever book on "Environmental Risk Analysis by Financial Institutions" by Dr Ma Jun (Chinese only)
- Palgrave MacMillan 2021 Textbook: *"Water Risk and Its Impact on the Financial Markets and Society"*

The report is "Recommended Reading" in the 2021 CDSB (now IFRS) Framework: *"Application guidance for water-related disclosures"*

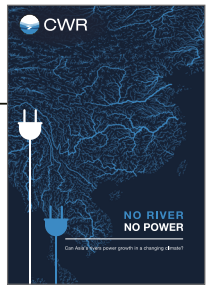




Water for Coal – Thirsty miners will feel the pain
CWR for CLSA U, 2013

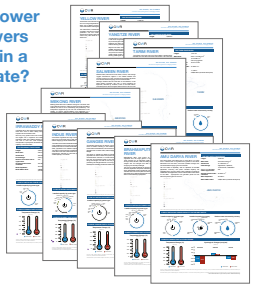
Unpacking water risks in the power sector in sell side research (institutional investors only)

No water, no power Does China have enough power to fuel expansion?
CWR for HSBC, 2012

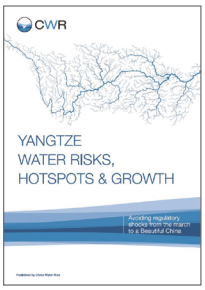


No River, No Power - Can Asia's rivers power growth in a changing climate?
CWR, 2023

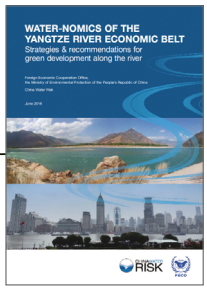
Includes at-a-glance stats in 10 River Briefs



Yangtze Water Risks, Hotspots & Growth – Avoiding regulatory shocks from the march to a Beautiful China
CWR, 2019



长江经济带水资源水环境指标评估及对策
Journal of Beijing Normal University (Natural Science), 2019
(Chinese only)

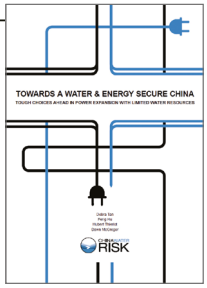


Water-nomics of the Yangtze River Economic Belt
CWR with MEP-FECO, 2016 (EN/中文)

Findings were:
- Distributed internally as "red-heading" communication to central & provincial government bodies & environmental authorities of China
- Published in national academic journal "Environmental Protection" (Issue 15, 2016), one of the most influential environmental journals in China

Water Use in China's Power Sector: Impact of Renewables & Cooling Technologies to 2030
CWR & IRENA, 2016 (EN / 中文)

Findings were presented by IRENA in:
- Clean Energy Ministerial (CEM) 7 Preparatory Meeting in Beijing in March 2016
- The 12th Council of the International Renewable Agency



Towards A Water & Energy Secure China – Tough choices ahead in power expansion with limited water
CWR, 2015

Unpacking water risks for different power types - coal, hydro, nuclear & renewables (open source)

Water Risk Analysis & Recommendations for Water Resource Management in Ningxia
WRI with CWR, 2015 (EN/中文)

Provincial case study on water use permit trading between the power sector & agriculture

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WATER MATTERS

DECISIONS TODAY FOR WATER TOMORROW

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About

China Water Risk (CWR): CWR is a non-profit think tank that aims to create a world where water and climate risks are embedded in business & finance. Since its launch in 2011, it has worked from its Hong Kong base to engage with global business and investment communities in understanding and managing various types of water and climate risks in China and across Asia. CWR's collaborative reports with financial institutions, IGOs, scientists as well as government related bodies have been considered ground-breaking and instrumental in understanding Asia's water challenges. They have helped inform better decision-making today for a water secure tomorrow. Join the conversation at **www.chinawaterrisk.org**

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