# Electrons, Rocks, and Brains

## Canada's power in the new geopolitical order

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CENTRE FOR NET-ZERO INDUSTRIAL POLICY
LE CENTRE DE POLITIQUE INDUSTRIELLE POUR LA CARBONEUTRALITÉ

The Transition Accelerator
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**The Transition Accelerator** is a pan-Canadian organization that works with others to identify and advance viable pathways to a net-zero, prosperous and competitive Canada in 2050. Learn more at transitionaccelerator.ca.

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# Introduction

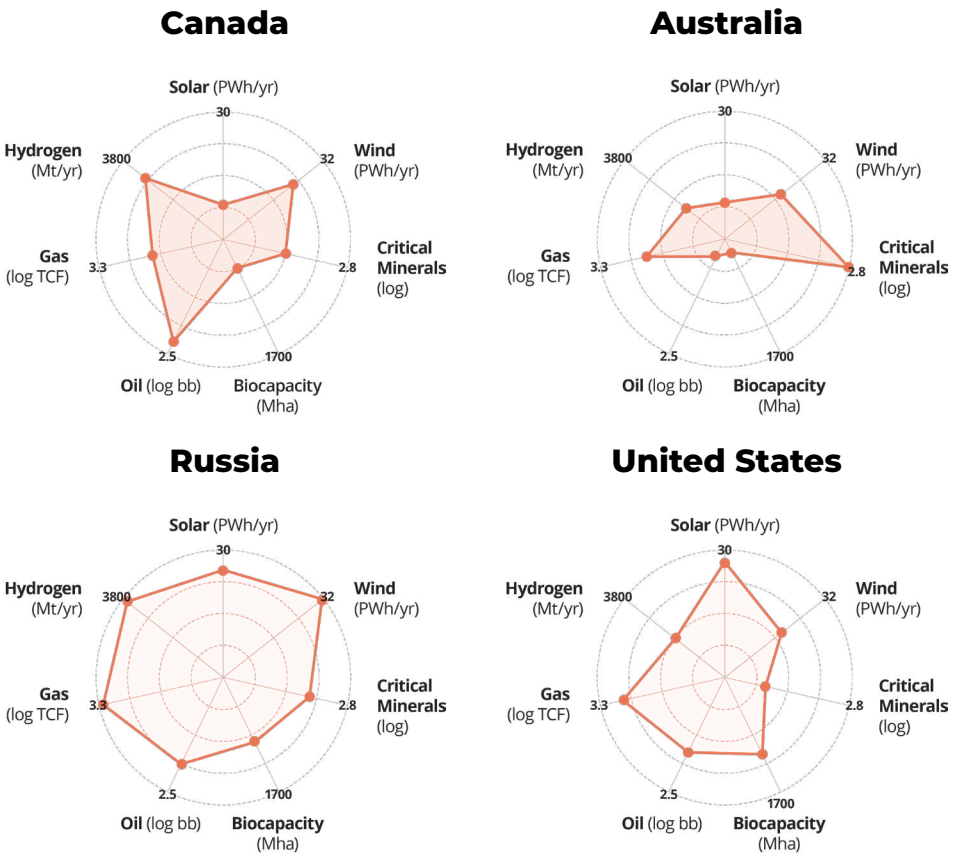



**Figure 1. Radar plots assessing Canada's new energy resource base relative to three other countries**

Canada takes its position in the global geopolitical order for granted. But the global energy transition is transforming geopolitics and the foundations of national power. The old geopolitical order was based on oil. Canada prospered under this order, but there is a risk that it will lose its position in the new energy world. This brief presents findings from an original study of energy and other resources conducted by the Centre for Net-Zero Industrial Policy to show Canada's potential in the new energy economy. It places Canada's position in comparative perspective, assessing its potential geopolitical role. The data show that Canada has the potential to lead, but in order to matter geopolitically, Canada must:

- Develop a strategy to harness its national resources for the maximum benefit of all Canadians.

- Identify where Canada's comparative advantage in the new world lies by following the smart money with government support.
- Cultivate advanced production and innovation capabilities ("the brains") in the processing of materials for net-zero supply chains.
- Align procurement, diplomacy, trade, and public policy across ministries and programs to support national asset development.

Canada often takes its place in the global geopolitical order for granted. It is a G7 nation, a close friend of the United States, and a leading exporter of oil and gas. The foundations of its security and prosperity seem strong and secure. However, the ongoing shifts in the global energy system create downside risk for the Canadian economy, with strong knock-on effects for its global position.

A new competitive dynamic between China, the US, and the EU is fueling investment in renewables, batteries, hydrogen, and critical minerals. These countries are seeking to achieve three goals: decarbonization, security, and economic development. Industrial policy offers a way to achieve all three at once.

In the twentieth century, geopolitics centered on securing supplies of oil and gas. Today's geopolitics is built around the production of clean energy and the processing of raw materials into advanced chemicals and materials. The countries that matter in this new world will build clean power and manufacturing capabilities on top of strong endowments of water, wind, sun, critical minerals, and knowledge.

Consider the case of Morocco: Morocco is not an important player in the current geopolitical order as it is not a leading provider of fossil fuels or critical minerals. But it is leveraging its world class solar and wind resources, its proximity to Europe, and its stable investment environment into hydrogen and battery manufacturing plays.[1] The case demonstrates how the geopolitical shift will redistribute power, creating winners and losers.

What will Canada's position in this new order be? This brief presents the results from an original analysis conducted by the Centre for Net-Zero Industrial Policy. Our analysis quantifies a country's potential to contribute to the new energy order along seven critical indicators: solar, wind, hydrogen, critical minerals, biocapacity, gas, and oil. Canada has a strong position in all seven, meaning that

it has the potential to be a key geopolitical player in the coming order, provided the associated value-add and net-zero supply chains can secure lasting cost advantages relative to competing countries.

However, development of Canada's resource sector for net-zero supply chains has been slow. Canada's net-zero industrial policy has focused on the battery supply chain. While Ontario and Québec, with federal support, have secured landmark investments in the battery supply chain, the task now is to build horizontally into other sectors and vertically into the upstream supply chain.

The battery investments have taught all levels of Canadian government, including Premier Ford's Conservatives, that low-carbon power is essential to future prosperity. As one project developer has said, "No green power, no project."[2] Canada has a rich endowment of clean energy, but it will need to build more green power fast if it is to meet skyrocketing demand for electric vehicles and heat pumps while adding manufacturing power.

Beyond manufacturing, Canada needs a concerted effort to build advanced capabilities ('the brains') in the mining and forestry sectors to ensure these have a strong position in the new global order. But this cannot be achieved solely through extraction. It is the midstream of these supply chains, where minerals are transformed into materials and fibres are combined into products, that truly matters. Activating the resource sector means combining Canada's expertise in resource development with knowledge and technologies in innovation hubs for hydrogen, minerals, and bioeconomy products. To make good on its promise, Canada needs a national resource strategy that seeks to position it as a key player in the new geopolitical order.

# Energy and World Order

Energy politics is the foundation of world order: the states, institutions, rules, and flows that shape global security and economic dynamics are built on the production, distribution, and consumption of energy.[3]

Since 1939, the world order has been premised on oil and gas.[4] Critical diplomatic initiatives and macroeconomic events are best seen through the lens of oil. After the Second World War, the United States worked to secure friendly regimes in the Middle East not because it needed oil, it was an oil exporter after all, but to ensure that its allies in Europe would remain independent of Russian oil.

Today the task is different. The US and its allies are dependent on clean energy supply chains dominated by China. China's strength in solar, wind, battery, and critical minerals supply chains is a strategic liability for the West. History teaches us that the US will work hard to ensure that its key allies do not remain dependent on resources and energy from China and Russia.

Canada can remain relevant in the new geopolitical order by providing the broad-based energy resources that will be needed. As the Canada-Germany Hydrogen Alliance demonstrates, Canada's resources are a key part of the EU's plan to wean itself from dependence on Russian oil. While Europe made it through the winter of 2022-23 without Russian gas, the pinch is just starting to be felt in increased energy prices and their effect on German manufacturing competitiveness.[5] Liquified natural gas (LNG), cannot solve the problem because it costs at least twice the price of Russian gas. There is more work to do to build an energy order that does not depend on Russian gas or Chinese minerals. Canada can support this objective by providing the clean power, minerals, and technologies that its allies need.

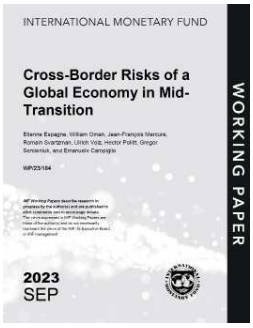
# The New Geopolitics

Countries that can play an outsized role in new forms of energy will experience an increase in relative importance. New countries, like Morocco, are emerging as hubs for Chinese investment. Chinese companies have invested US$20 billion in Morocco's clean energy and battery manufacturing capability because of its proximity to markets and its favorable status as a US Free Trade Agreement country. Morocco is one of a series of countries including Australia, Indonesia, and Vietnam that are poised to be "middle powers" in the new order. If Canada is to matter and retain its position as a middle power, it must play a role as a source of critical resources and capabilities for the energy transition.

In the current world order, energy is primarily transported via fossil fuels. Ensuring secure access to sources of these fossil fuels has been the predominant factor in international geopolitics. In the new energy economy, a wider variety of production modes and carriers will matter. Renewables will dominate new sources of energy, with biomass supporting. Hydrogen and ammonia will be key carriers. Critical minerals will be needed for the batteries, transmission lines, turbines, and solar panels needed to produce and carry energy in the form of electrons. Depending on market dynamics, oil risks becoming a downside liability, starting late in the next decade, but gas will remain a part of the energy order, especially when paired with CCUS.

The transformation in global economy will have profound effects on patterns and flow of international trade in both energy and other goods. This in turn will have substantial impacts on the balance of payments and exchange rates, of many importing and exporting economies. As a small, open economy, Canada's basis of power and prosperity, currently dominated by its role as a major fossil fuel producer, is under threat. Canada faces considerable risks to its exports, balance of payments, and growth prospects.

Canada has substantial oil and gas reserves, but the country's role in international export markets faces considerable uncertainties during the energy transition, given its relatively high costs compared to most OPEC countries. Recent analysis published by the IMF estimates that Canada's trade balance could decline by 2-3 percent of GDP up to 2050, as fossil fuel exports decline (see figure).[6] Among G20 countries, only Russia, Saudi Arabia and South Africa are expected to be even worse affected in this analysis. Furthermore, as the transition progresses, fossil fuel markets are likely to experience ongoing price volatility driven by the repeated occurrence of supply constraints in renewable energy supply chains.




**Source:** Cross-Border Risks of a Global Economy in Mid-Transition (Working Paper)
IMF, September 2023

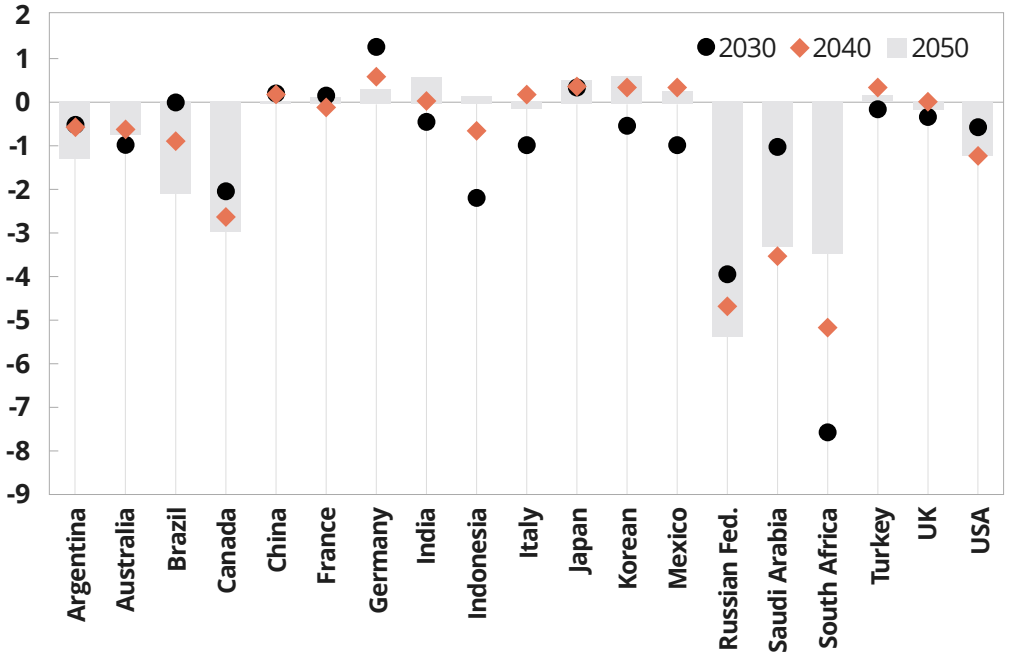



Figure 2. Trade balance change relative to baseline GDP (%).

To have a chance of maintaining its position and prosperity, there is a need to adjust its trajectory. Pressures on Canada's overall competitiveness and balance of payments could be alleviated by pursuing new export possibilities, particularly in hydrogen, critical minerals, and the bioeconomy.

Canada has promising opportunities to transform its position in the new geopolitical landscape created by the energy transition. Canada has several strategic advantages in the new geopolitical order emerging, based on its resources and energy profile. As major trading partners and strategic allies seek to decarbonize, Canada's minerals, renewable energy, and bioresources means the country will have opportunities in several value chains with trading partners in North America, East Asia, and Europe.

Compared to other competing countries, Canada is exceptionally well-placed with its resource endowment, which will allow it to transition from being an oil and gas exporter to a renewable and cleantech exporter. To achieve this requires federal and provincial governments to develop a proactive industrial strategy to develop its natural resource and manufacturing base.

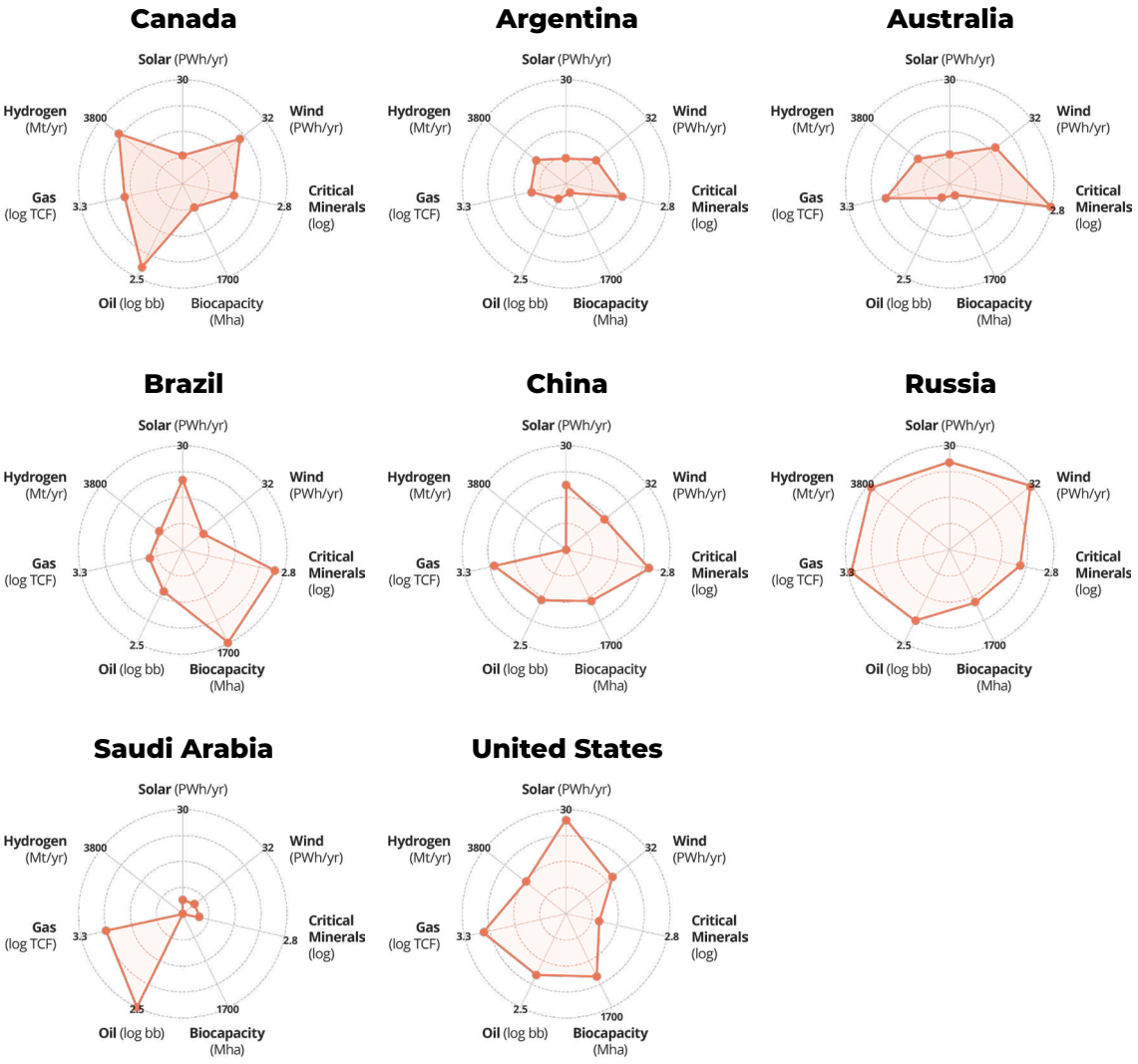



Figure 3. Radar plots assessing the new energy resource base in eight leading countries.

Figure 2 presents original radar plots developed by the Centre for Net-Zero Industrial Policy, based on published and internationally comparable datasets. The charts show different resource profiles, highlighting the strengths and weaknesses of a range of countries that constitute important energy and resource players. These are the main options for European and East Asian countries who will remain dependent on foreign energy and resource sources. The chart includes the two dominant energy resources, oil and gas, and a number of key resources in the energy transition. The methodology is explained in more detail in the Annex.

As the plots show, the resource superpowers in this order will be the US, China, and Russia. With large land masses, each of these countries possesses significant solar and wind resources. That renewable potential, when combined with freshwater resources in the US and Russia, creates hydrogen potential. China, although lacking freshwater, may be able to develop its hydrogen potential using desalination. However, the country is unlikely to become a net exporter.

Canada has the potential to be a leader in the second rank of countries: a group including Australia, Brazil, Argentina and India that have large land masses and therefore the resources to contribute in net-zero world. Canada's potential for solar energy is comparable to both Australia and Argentina, though exceeded by Brazil and other countries, either with sunnier latitudes (US, China) or more land area (Russia).

However, Canada's potential as a major wind power producer exceeds that of Argentina, Australia and Brazil. Together with its water resources, the wind provides the basis for having the largest green hydrogen production potential (exceeded globally only by Russia). These advantages in new energy sources are even more promising for Canada than the basic numbers show, given that Canada already occupies a leading position in terms of the low carbon intensity of its grid. An expanded clean grid provides the comparative advantage for processing and manufacturing of materials and products of the net-zero supply chains, such as metals and materials for batteries, as well as biobased products.

Canada's relative position in reserves of critical minerals is more modest, but still promising, given the scale of supply increases necessary to support electrification, including the EV sector, but also other uses. The market for key energy transition minerals has doubled over the past five years, reaching US$320 billion in 2022, and even stronger growth is projected for the future.[7] Canada is already a leading mining country. Exploration activity is strong in some minerals, such as lithium and nickel.[8] Here, Canada's relative geographical proximity to the US and especially Europe, provides an additional advantage.

Regarding biocapacity, Canada has a large land mass but lower biological productivity than Brazil, China, and the United States. In some respects, this is a resource indicator for which population also matters, as biocapacity is also needed to meet domestic food and other consumption needs. At 214 million, Brazil's population is more than five times that of Canada, meaning that Canada's biocapacity per capita is roughly comparable (and certainly exceeds that of the US). So Canada may have export plays equivalent to other large countries in biobased products such as sustainable aviation fuel and value-added forestry products, including mass timber and others.

Many insights emerge in examining these charts. It is clear, for example, that despite its sub-tropical location and exposure to solar radiation, Saudi Arabia's prospects as a renewable energy power are severely limited by its smaller geographic size and lack of water. Also lacking meaningful mineral reserves or biocapacity, the Kingdom will have a strong incentive to rely for as long as possible on its fossil fuels, which are fortuitously, relatively inexpensive to exploit. The contrast with Canada, as a leading fossil fuel country that can also deliver resources for the energy transition, is stark.

# Conclusion: Knowledge and strategy are necessary to unlock rocks and electrons

Canada is very well-positioned, given its natural endowments, to prosper during the energy transition. To do so, however, requires a proactive vision and strategy to develop its new sectors of competitiveness in hydrogen, critical minerals, and biobased resources. Canada does need more investments. But most importantly, what it needs is a simple, powerful process to identify and leverage national strengths: [9]

- Take stock of national resource potential in the seven areas outlined here, and identify where global supply will be constrained.
- Compare Canada's 2050 potential to current projects, investment trends, and policy directions.
- Create a strategy to maximize the benefit and advantages of national resource development for Canadians. For example, the forestry industry has

proposed a national bioeconomy strategy that would identify best uses of wood fibre within a plan to create manufacturing value-added across forest supply chains.[10]

- Identify and develop knowledge-based capabilities in these new sectors. Canada needs "brains" to bring together its resource economy with innovative technology (including intellectual property) in dynamic, export-oriented clusters.[11] The challenge is to ensure that as much of the innovative stages of these supply chains take root and flourish, enhancing both value-add and strategic autonomy.

- Align procurement, diplomacy, trade, and public policy in a multi-level collaboration that brings together indigenous communities, provincial governments, and federal agencies.

The key actions are not that complicated, and national and provincial governments are currently doing many of these, though not in a coordinated or high priority fashion. What is encouraging is that Canada has done this in the past. The country's success as an oil and gas producer rests on concentrated and coordinated efforts of governments and industry to develop the technologies and know-how to economically exploit its oil sands resources. Similarly, the success of Canada's automotive cluster—the second largest export earner—is also based on a deliberate strategy and array of policies that ensured the sector's growth and successful integration into consolidating US supply chains.[12]

The policy processes and the specific mix of different measures—innovation policies, public investment, financial incentives, trade measures, etc. —must, however, necessarily be different now than those that advanced the fossil fuel sector or the automotive cluster. The global economy and the conditions for ensuring competitive success continue to evolve and change. To ensure success, policymakers and others must learn from the past, both successes and failures, including the experiences of peer countries.

The potential is clear. The challenge for Canada and its capacities for strategic economic policymaking is considerable. The energy transition represents the largest transformation of industries yet envisaged. The sheer scope for creative destruction and reconfiguration of supply chains, and the associated investment flows, is hard to grasp. How Canada confronts this challenge will have a major impact on the prosperity of the country and its diverse regional economies. Equally important, this transition will affect the country's position and autonomy in the new geopolitical order emerging over the coming 10-20 years.

# Annex: Methodology

This research measured seven resource-based variables at country level to provide an indication of relative potential geo-political power in the energy isolating these from other factors influencing power, such as military capacity, industrial capacities, population, etc. The seven selected variables are; solar production potential, wind production potential, hydrogen production potential, critical minerals reserves, biocapacity, oil reserves, and gas reserves.

Note that hydrogen differs from the other six resources by being an energy carrier as contrasted with a resource input. The analysis includes green hydrogen, but excludes blue hydrogen, given a likely preference for emissions-free hydrogen from major importing countries.

Data sources and calculations are described below for each of the indicators used.

Solar potential is taken from the World Bank SolarGIS dataset, using the Level 1 indicator for potential utility-scale PV generation.[13] This Level 1 indicator excludes areas which are assessed as not being practical for utility-scale PV development, due to physical or technical land-use constraints. Various alternative indicators, including from this publication or others, were considered. A more detailed analysis could consider an index based on a range of different indicators, using alternative assumptions concerning land use and technological feasibility. A comparison was made and one indicator was chosen for ease of interpretation, also aiming for one that avoided boundary-condition assumptions.

Wind potential is measured based on data provided by Tonelli et al. (2023), who estimate the maximum capacity in TWh's/yr a country can produce from onshore wind or PV solar resources if all eligible available land is used for solar or wind.[14] The analysis assumed the use of 100% of all land considered suitable for wind, excluding forested land, agricultural land, and urban land;  10% of forested land was deemed eligible for wind power generation, and 70% of agricultural land was deemed suitable. No urban land was considered suitable for wind.

Hydrogen production potential was estimated using a mean of total production based on solar or wind resources, taking the availability of power or water as

a limiting factor. Estimates of solar and wind potential were used to determine potential hydrogen production, subtracting for national power demand.[15] An electrolyser efficiency of 50 kWh per kg hydrogen produced was assumed. Water requirements were assumed to be 32 kg per kg hydrogen for PV solar-based production and 22 kg per kg hydrogen for wind-based production.[16] Water availability was calculated as total available water minus water consumption.[17]

The potential for increasing available water through desalination has not been included in the original analysis. This could increase green hydrogen production for a number of countries with coastal waters and potentail renewable generation

For both wind and solar production options, potential hydrogen production was based on the limiting factor, either electricity or water. The mean of the two resulting hydrogen production estimates from solar and wind production respectively was the final estimate used. Note that negative withdrawals of water beyond national availability resulted in a negative hydrogen score for some countries, in which case a value of zero was assigned.

An appropriate indicator of a country's critical minerals potential could not be found in existing literature. An indicator was calculated based on national reserves for seven minerals (cobalt, copper, lithium, nickel, manganese, phosphate, and bauxite) from USGS data.[18] For each mineral, national reserves were calculated as a proportion of the largest national reserve globally for each mineral. The mean of these seven proportional values was then calculated, and a logarithmic scale was used.

National biocapacity is based on the dataset from Global Footprint Initiative at York University.[19] This is based on an estimate of biological productivity, measured in a standardized hectare value. For the current analysis, a sum of biocapacity from cropland, forest land, and grazing land was calculated.

Oil and gas reserves were taken from the US Energy Information Administration.[20] A logarithmic scale is used.

# Endnotes

1 https://www.netzeropolicylab.com/s/GP01-Morocco-vf.pdf

2 https://www.bloomberg.com/news/articles/2023-10-09/swedish-industrialists-explore-6-billioncanada-steel-project

3 Yergin, Daniel. *The New Map: Energy, Climate and the Clash of Nations*. Penguin Press, 2021; Thompson, Helen. *Disorder: Hard times in the 21st century.* Oxford University Press, 2022.

4 Colgan, Jeff D. *Partial hegemony: Oil politics and international order*. Oxford University Press, 2021; Vitalis, Robert. *Oilcraft: the myths of scarcity and security that haunt US energy policy.* Stanford University Press, 2020; Kelanic, Rosemary A. *Black gold and blackmail: Oil and great power politics.* Cornell University Press, 2020.

5 https://www.ft.com/content/7ed06bf8-fe60-4127-b5fe-c8181a0ec8cb

6 https://www.imf.org/en/Publications/WP/Issues/2023/09/08/Cross-Border-Risks-of-a-Global-Economyin-Mid-Transition-538950

7 https://www.iea.org/reports/critical-minerals-market-review-2023

8 https://www.iea.org/reports/critical-minerals-market-review-2023

9 See, Allan and Eaton, *Critical Next Steps to Ensure Canada's Competitiveness.* 2023. https://netzeroindustrialpolicy.ca/reports/critical-next-steps-to-ensure-canadas-future-competitiveness

10 https://www.fpac.ca/reports/canadas-bioeconomy-strategy-leveraging-our-strengths-for-a-sustainable-future

11 Cimoli, Mario, Giovanni Dosi, and Joseph E. Stiglitz. 2009. "The Political Economy of Capabilities Accumulation: The Past and Future of Policies for Industrial Development." *In Industrial Policy and Development: The Political Economy of Capabilities Accumulation*, edited by Mario Cimoli, Giovanni Dosi, and Joseph E. Stiglitz, 0. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199235261.003.0001

12 Harris, Richard G. 2015. *Trade, Industrial Policy, and International Competition,* Second Edition · Books · 49th Shelf. McGill-Queen's University Press. https://49thshelf.com/Books/T/Trade-Industrial-Policy-and-International-Competition-Second-Edition3

13 World Bank. *Global Photovoltaic Power Potential by Country*. 2020. https://documents1.worldbank.org/curated/en/466331592817725242/pdf/Global-Photovoltaic-Power-Potential-by-Country.pdf

14 Tonelli, D., Rosa, L., Gabrielli, P., Caldeira, K., Parente, A., & Contino, F. (2023). "Global land and water limits to electrolytic hydrogen production using wind and solar resources." *Nature Communications*, (1), 5532. https://doi.org/10.1038/s41467-023-41107-x

15 National power demand was also provided by Tonelli et al., which was also the source for both wind and solar potential. (2023).

16 Blanco, H. (2021). "Hydrogen Production in 2050: How much water will 74EJ need?" Retrieved from: https://energypost.eu/hydrogen-production-in-2050-how-much-water-will-74ej-need/

17 Using data from Tonelli et al. (2023).

18 USGS. (2021). "Mineral Commodity Summaries." Retrieved From: https://www.usgs.gov/centers/national-minerals-information-center/mineral-commodity-summaries

19 Global Footprint Network. (2022). Compare Countries. Retrieved From: https://data.footprintnetwork.org/?_ga=2.131142797.343727173.1695998929-1528741181.1695238799#/compareCountries?type=BCtot&cn=all&yr=2022

20 EIA. (2023). "Petroleum and other liquids." Retrieved From: https://www.eia.gov/international/data/world/petroleum-and-other-liquids/annual-crude-and-lease-condensate-reserves; EIA. (2023). "Natural gas." Retrieved From: https://www.eia.gov/international/data/world/natural-gas/dry-natural-gasreserves