Handbook of Energy Transitions

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Geopolitics of the Energy Transition

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3 Geopolitics of the Energy Transition

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CONTENTS

3.1 INTRODUCTION

For more than a century, oil and gas have been critical components of international relations. Since Winston Churchill, in his capacity as the First Lord of the Admiralty, pushed the British Navy to move from coal to oil—a fuel that allows greater speed, greater radius of action, and at-sea refueling—at the cost of external dependence, the control over hydrocarbons has become a matter of national security (Yergin 1992). In parallel, after the Second World War, oil seduced global capital with the promise of a higher energy density and a lower need for unionized manpower (Mitchell 2011) and paved the way for an age of mass consumption (Pirani 2018), becoming essential to industrialized nations' economic development and social reproduction (Di Muzio 2015). This gave rise to important geopolitical developments—out of which the most evident has been the strategic relevance of oil provinces such as the Persian Gulf to large powers' economies and military might. The energy transition—implying a gradual, but ultimately massive reduction in the global consumption of fossil fuels and a qualitative change toward decarbonized forms of energy—is expected to bring about a structural change in many socio-technical foundations of our civilization (Bridge et al. 2018), including the way in which power and influence are allocated and exerted on the international stage.

In this respect, different aspects raise the attention of scholars and policy communities. First, a reduction in the role of fossil fuels in the global economy, although slow and geographically uneven, is expected to alter the strategic balance between importers, exporters, and transit countries. Second, a rise in renewable energy will make most countries able to source energy domestically, blurring the boundaries between energy exporters and importers, and giving rise to new energy actors and new patterns of international interdependencies (Scholten et al. 2020). At the same time, while change in geographical and socio-technical features of energy systems affects international relations, it also takes place in an international system in flux. Concepts such as the rise of China, the neorevisionism

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of emerging and regional powers, or a sense of "westlessness" (Kennedy 2020) and decline of the liberal international order—summarized by some as a "return of geopolitics" (Mead 2014)—interrogate expectations on the pace and patterns of the energy transition and call the geopolitical analysis of the transition to take into consideration shifts in the surrounding political context.

To dissect this complex puzzle, this chapter—based on a dominant review element—will first offer an understanding of what does it mean to look at energy systems through geopolitical lenses. Then, it will explore the geography of geopolitical "winners" and "losers" emerging from a declining importance of fossil fuels. Section 3.4 discusses which emerging interdependencies are expected to rise with the energy transition, figuring out their geopolitical dimension. Section 3.5 will then reflect on the evolving quality of energy geopolitics, focusing on shifting balances in technological mastery, before proceeding to the conclusions.

3.2 FRAMING ENERGY IN GEOPOLITICAL TERMS

Some definitional clarification is necessary with respect to what does it mean to think at the energy transition through geopolitical lenses. Geopolitics is referred to as a descriptive approach to the international relations, looking at inter-state patterns of amity and enmity through the prism of a dynamic interaction between power and geographical features that are supposed to be fixed—such as geographical positions, natural borders, demography, resource endowments (Dodds 2007). The geopolitics of energy looks, in particular, at how the geographical and technical features of energy systems contribute to shaping patterns of inter-state relations (Scholten 2018; Högselius 2019). Despite the abundance of historical, descriptive accounts on the interplay between energy and geopolitics, international politics, and security (Yergin 1992; Brown 1999; Yergin 2020), systematic attempts to conceptualize such an interplay are scarce. According to Van de Graaf and Sovacool (2020), looking at energy in geopolitical terms means to consider energy resources as "a currency of power, a strategic tool in foreign policy, and a source of conflict." To this extent, the focus is placed on three main notions associated to energy that are geopolitically relevant: inter-state relations of dependence, geoeconomic statecraft, and resource conflicts.

Few states are entirely independent as for energy and energy systems. Oil and gas, in particular, are the subject of a dense international trade. In geopolitical terms, dependence on foreign resources is typically associated to vulnerability (Mearsheimer 2001; Krasner 1978). As hydrocarbons are essential to the economy and to mechanized warfare, energy dependence is ultimately a matter of national security. Nevertheless, states establish relations of energy dependence because of the uneven distribution of energy resources, economic opportunities—in case imported fuels are cheaper than domestically sourced energy—or environmental concerns—in case importing fuels helps preserve the domestic environment. In some cases, they can even establish dependence for geopolitical reasons, i.e. to expand their influence over exporters. To counter the risks associated to dependence, importing states adopt energy security policies (Deese 1979; APERC 2007; Chester 2010; Ang et al. 2015; Cherp and Jewell 2014) such as fuel switch to domestic supply, diversification of importing routes, demand reduction, or energy diplomacy (Verrastro and Ladislaw 2017). Depending on different strategies to contain the risks associated to dependence, relations between importers and suppliers, or among importers, can evolve in cooperative or antagonistic manners.

Notably, energy dependence affects importers as much as exporters, giving rise to an interdependence. While symmetric interdependence can be expected—especially under liberal institutionalist assumptions—to give rise to peaceful relations and the buildup of institutions to manage it and prevent its politicization, when interdependence grows asymmetrical it can be used by actors as a source of power (Keohane and Nye 2001; Blackwill and Harris 2016; Szabo 2015), bringing about opportunities of geoeconomic instrumentalization of energy by states or non-state actors such as regions, international organizations, or terrorist organizations and rebel groups (Van de Graaf and Sovacool 2020). Different declinations of energy statecraft include the manipulation of flows, infrastructures or system-building, prices, discourses (Högselius 2019), the rent associated to energy exports, and the instrumentalization of large import markets. The *control of energy flows* affords geostrategic centrality to actors holding it. Actors such as producers or terrorist organizations can leverage on the threat of interrupting flows, as much as a large military power can achieve influence and establish relations of dependence by protecting flows in critical chokepoints (Yergin 1992; Glaser and Kelanic 2016; Krane and Medlock 2018). Similarly, the control of *infrastructure or system-building* can be instrumentalized to entrench involved countries into long-term interdependencies or marginalize adversaries, excluding them from certain energy routes (Jentleson 1986; Little 1990; Kemp 2000; Rashid 2002; Sziklai et al. 2020; Gustafson 2020). *Price manipulation* became a less viable tool of energy statecraft after the restructuring of global physical and financial markets that followed the '70s oil crisis. However, the practice of politically motivated discounts on hydrocarbons is still present (Colgan and Van de Graaf 2017). More recent tendencies based on critical geopolitics (Dodds 2007; Power and Campbell 2010) address how energy is politicized through *discursive practices* (Kratochvíl and Tichý 2013; Kuzemko 2014a, b). Very often, disputes that originate on legal or technical grounds are presented in political terms, and inter-state pipeline projects crossing contested regions become symbols in the context of political rivalries (Baev and Øverland 2010; Meierding 2020). Another—perhaps more indirect and possibly disputed—form of fossil energy statecraft relates to a foreign policy-motivated use of the *oversea investment of oil rent*. Oil money can be re-invested by petrostates in foreign assets in more or less transparent ways and with different degrees of political implications, i.e. supporting the influence of corrupt networks aimed at promoting a petrostate's interests in other countries (Shaxson 2008). A final declination of fossil energy statecraft refers to importing countries. Large importers can instrumentalize their *energy demand* to establish influence over third countries, and keep producers locked into bilateral relations and outside the influence of rival powers.

A third notion of interest for the geopolitics of energy is the "resource conflicts." These can stem from asymmetric distribution and global scarcity of resources so that actors perceive them as something worth fighting for (Klare 2007; Månsson 2015; Klare 2016); in other circumstances, resource conflicts could be expected to take place where the environmental impact of extractive activities causes the eruption of violence involving local communities (Watts 2016). The fact that conflicts appear to be frequent in resource-rich regions has nourished popular geopolitical imaginary, and for this reason, the idea of resource conflicts is frequently played in political narratives. Indeed, these events are rare (Meierding 2020), no less because the prospect of conquering access to oil rarely offsets the costs of initiating a conflict. For this reason, great powers are more used to recur to anticipatory strategies (Kelanic 2020) such as operating to keep energy in friendly hands and denying access to enemies (Van de Graaf and Sovacool 2020) rather than utilizing military means to achieve direct control of resources. Conflict frequency in oil-rich regions was explained by Colgan (2013) through the notion of "petro-aggression"—notably, the tendency of revolutionary petrostates to rely upon their resources to support the regional revisionism of revolutionary leaders. However, regardless of whether energy can originate conflicts or not, access to oil is fundamental to warring parties for its centrality to mechanized warfare, so that oil can play a critical role in orienting military tactics during non-resource conflicts and even contribute to deciding the fate of some of them (Yergin 1992).

All these declinations of energy geopolitics have been analyzed and associated for decades to global and regional energy systems dominated by fossil fuels, and their application to clean energy resources and technologies is not exempt from criticism (Øverland 2019). Indeed, it is a difficult task to balance the risk of geopolitical reductionism and conceptual overstretches. Nevertheless, they constitute a useful reference framework to understand the magnitude of the geopolitical change the energy transition is bringing. This is the objective of the remainder of this chapter.

3.3 THE (SLOW) DEMISE OF FOSSIL FUELS

Attaining the objectives of the Paris Agreement implies a significant reduction in the consumption of fossil fuels in the course of the XIX century, as well as the "unburnability" of vast amounts of known fossil fuel reserves (Van de Graaf 2018). Reversing traditional assumptions about peak oil supply—according to which the world would have moved toward a structural trend of declining production and a "race to what's left" driven by growing scarcity (Klare 2012)—the climate agenda helped introduce the notion of "peak demand," according to which carbon constraints and structurally declining demand would move the world toward a "geopolitics of too much oil" (Verbruggen and Van de Graaf 2015).

In this context, indicators focusing on geopolitical gains and losses from the energy transition uniformly reveal that the main losses would affect fuel exporters, which would find themselves holding "stranded geopolitical assets" (Øverland et al. 2019; Smith Stegen 2018). As the distribution of the oil rent is central to the social contract of exporters of hydrocarbons (Eisenstadt 1973; Beblawi 1987; Gelb 1988; Noreng 2005; Krane 2019; Bradshaw et al. 2019), the loss in oil revenues associated to the global energy transition is expected to compromise authoritarian petrostates' output legitimacy (Goldthau and Westphal 2019) and trigger processes of reform and/or domestic instability (O'Sullivan et al. 2017; Tagliapietra 2017, 2019; IRENA Global Commission 2019; Krane 2019; Bradshaw et al. 2019), which can, in some cases, affect regional security. Besides compromising neo-patrimonial petrostates' model of buying consensus through patronage and strategic allocation of the oil rent, a decline in oil demand would hit oil suppliers also on ideational grounds, as the possession of natural resources is often discursively constructed by petrostates' elites as elements of great power status, i.e. in Russia (Sakwa 2017), post-colonial identity or sovereignty, i.e. in Algeria, Mexico, and Venezuela (Entelis 1999; Colgan 2013), or generous social models, i.e. in Norway (Austvik 2019).

However, not all oil suppliers are made equal. Their exposure to energy transition can vary in function of many variables. Vulnerability can be, for instance, being understood as directly related to the weight of the public sector on total employment, as a measure of oil's importance for domestic political legitimacy; the level of export dependence on fossil fuels, as a measure of oil's importance to keep the economy afloat; and costs of extraction—as low-cost producers are likely to continue supplying a shrinking demand during the transition. Considering these aspects, geography of vulnerability would reveal a deep exposure in Angola, Nigeria, Libya, Venezuela, and Turkmenistan, while the UAE, Australia, and Mexico seem to be the best equipped for the transition. Different studies on petrostates' vulnerability may use further indicators, generally reaching similar results in terms of nations' grouping (IRENA Global Commission 2019; Carbon Tracker Initiative 2020).

Confronting a critical situation and the prospect of a weakened external and internal position, fossil fuel exporters are expected to undertake strategies to reduce their vulnerability to the energy transition, which may constitute, therefore, a further factor of differentiation among petrostates in terms of stability and geopolitical alignments in the age of the transition.

A frequently discussed short-term coping strategy is a push to extract oil at the quickest possible pace. If oil left in the ground is no longer perceived as a financially safe asset, producers may see an incentive to extract as much oil as possible (Van de Graaf and Verbuggen 2015), calculating that resources that can go stranded are less valuable than oil sold underprice (Van de Graaf 2018). Such a "cash in" approach would be especially rational among high-cost producers and producers presenting high fiscal break-evens—notably the oil price required to balance state budgets—as they are those that would be eventually squeezed out of the market in a low prices environment (Goldthau and Westphal 2019). Yet, this is not a strategy without risks. It may imply the acceleration of the transition toward a structurally low oil prices environment. Risks may provide incentives for an opposite strategy, such as engaging in some form of multilateral—formal or informal—energy governance to manage a process of structural fossil fuel decline. The Organization of Petroleum Exporting Countries plus (OPEC+) scheme, emerged in 2016 to coordinate OPEC supply policy with the policy of Russia and other non-OPEC producers, and the US' lobbying toward OPEC to cut production in the wake of the 2020 price collapse, constitute signals in this direction. On the other hand, oil suppliers may undertake aggressive military and geoeconomic action to deny rivals' production capacity (Van de Graaf 2018). The civil war in Libya took the country's production off the global markets in a context where warring parties are influenced by several petrostates' interests. The US sanctions limited, to different extent, supply or supply prospects in Venezuela, Iran, and even Russia. Iran has made a permanent threat to Saudi oil facilities and Gulf shipping lanes a key feature of its foreign policy toolbox. Under a carbon constrain, these tendencies may consolidate and aggravate, coexisting with or replacing cooperative attempts to manage the oil decline.

A second coping strategy, currently taking place among several petrostates and arguably valid in the short-to-medium term, is the energy re-specialization and export re-orientation of fossil fuels producers. Some petrostates seem willing to expand downstream in the energy-intensive sectors. Especially Gulf countries are well-placed to hedge the decline of hydrocarbons with a rise in petrochemical production.[1] For petrostates wishing to maximize their resources' value in the transition phase, control over refining means also to enhance demand security in times of potentially tougher competition. In recent years, petrostates' national oil companies (NOCs) such as Aramco, ADNOC, or Rosneft expanded their control over refining and distribution assets in emerging economies (Øverland 2015; Braekhus and Øverland 2007). In parallel, crude oil and gas export capacities expanded eastwards based on the assumption that emerging Asian economies may ensure at least a certain level of demand security during the transition[2] (Griffiths 2019). A major geopolitical implication would be an expanded Chinese influence over exporters such as Russia and the Gulf countries, which would consolidate these countries' "detachment" from the historical west (Sakwa 2017) in a phase where US-Saudi, US-Russia, and EU-Russia political relations are under strain. At the same time, it remains an open geopolitical question whether this may ultimately imply that emerging Asian economies could grow more involved in the Gulf security issues.

Finally, petrostates may attempt to diversify their economies. The capacity to undergo such a change, however, is unevenly distributed. The UAE is usually portrayed as a success story. In two decades, oil went from accounting for almost the whole UAE GDP to 40%, while non-oil exports rose in the last decade from 13% of total exports to almost 60%. This evolution—largely leveraged, however, on oil money—took place without major social and political unrest, while the country's foreign policy grew over time increasingly ambitious and assertive (Krane 2019; Yergin 2020). Saudi Arabia engaged in an even more ambitious path of diversification, as Crown Prince Mohamed bin Salman's Vision 2030 plan conflates economic diversification with plans of major socio-economic transformation aimed at changing the neo-patrimonial nature of the state (Bradshaw et al. 2019). These petrostates show unparalleled advantages in their quest for diversification—notably, a combination of large financial availabilities and relatively stable governments. As for many other large oil producers, the journey has not even started. Notably, fragile petrostates (i.e. in Iraq, Nigeria, Libya, or South Sudan), or petrostates promoting revolutionary or externally revisionist policies, (i.e. Iran, Venezuela, or Russia) lag behind in their political commitment to diversification.

As the demise of fossil fuels is expected to weaken exporters, it is also well expected to benefit large importers, whose dependence on oil volumes or prices constrains policy options and affects

[2] In 2019, Saudi Aramco merged with Saudi petrochemical giant SABIC, expanding its refining assets to 50 countries and doubling its refining capacity (Todd 2019).

[3] In 2014, Russia and China signed a $400 bn, 30-year gas deal to be supplied to China by way of the new Power of Siberia pipeline, financed by China for $400 bn. The deal makes China the second largest recipient of Russian gas after Germany. In addition, Chinese CNPC participate to Novatek's Yamal LNG project, providing critical financing to complete a complex project in an age of sanctions that cut off Novatek's access to western finance (Yergin 2020). In 2017, Russian oil company Rosneft expanded its downstream presence in India through the acquisition of Indian refiner Essar Oil (Rosneft 2017). Similarly, Saudi Aramco took over 17% of Korean refiner Hyundai Oilbank (Todd 2019).

economic performance. However, the picture is ambiguous with "winners" as well. The US is generally seen as a geopolitical "winner" in the energy transition, due to the role that oil dependence has played in constraining Washington's foreign policy options and enabling adversaries such as the USSR/Russia, post-revolutionary Iran, Saddam Hussein's Iraq, Gaddafi's Libya, or the Bolivarian Venezuela. However, for the US—a large fossil fuel producer itself—the oil should not just be considered as a geopolitical constraint, but also as a geopolitical asset. As much as coal was central in building up the British hegemony, the history of US hegemony is deeply intertwined with the emergence of the global oil order (Yergin 1992). The role of the US Navy in patrolling critical chokepoints, prominently emerged with the "Carter doctrine," can be considered an international public good whose provision—in line with the basic tenets of the hegemonic stability theory (Gilpin 1987; Keohane 1984)—has been playing as an integral part of the US hegemony on the international system (Glaser and Kelanic 2016) by establishing a strategic dependence of both allies and rivals—such as Europe, Japan, the Gulf Monarchies, or more recently China—on Washington (Högselius 2019). Oil has also played a central role in the US' dominance of the global financial architecture. The dollar-denomination of oil transactions contributes to the primacy of the dollar as an international reserve currency, facilitating the enforcement of an ever more defining instrument of US geoeconomic statecraft such as the application of extraterritorial sanctions. Yet, things change. The energy transition, spurring an era of newfound fossil fuel abundance and redefinition of energy security, conveniently occurs in a time when the US leaders are undergoing a process of reflection on the costs and benefits of certain aspects of its hegemonic engagement (Mead 2014; Ikenberry 2018). To this extent, it remains an open question whether the demise of the oil order will coincide with the emergence of a more multipolar international system, where a more mixed, decentralized, and deglobalized energy system will require less engagement from a global hegemon (Sivaram and Saha 2018).

In contrast, Europeans unambiguously find themselves in the camp of the geopolitical "winners" of the transition. Dependence on fossil fuel imports turned out to be a chapter of tension between the buildup of EU actorness in external energy relations and member states' commercial priorities. Nowhere has this proved more evident than in the case of energy relations with Russia, where understandings of energy security and Russia's reliability as a supplier diverge among the EU member states (Schmidt-Felzmann 2011; Sharples 2013; Haukkala 2015; Krickovic 2015; Thaler 2020; Gustafson 2020), complicating the emergence of a coherent EU external actorness instead of facilitating it (Herranz Surralles 2015). To this extent, the process of decarbonization could be expected to remove a divisive element in the crafting of unified external actorness toward fuel suppliers, and potentially an obstacle to the improvement of their relations with the EU. Similarly, risks associated to vanishing European influence on exporters of fossil fuels as a result of the energy transition should not be overestimated. In a distinctive exercise of normative, transformative geopolitics, the EU has sought to leverage on its energy relations to expand its regulatory frameworks beyond its borders (Lavenex and Schimmelfennig 2009). However, except for those fuel suppliers or transit countries embedded in a highly institutionalized relation with Europe—i.e. Norway or Ukraine—the majority of hydrocarbon suppliers to Europe and transit countries have not moved in the regulatory or political direction desired by the EU (Aalto and Korkmaz Temel 2014; Thaler 2020; Darbouche 2010). To this extent, bilateral energy relations appear to be a poor predictor of the EU's ability to shape outcomes in supplier countries, especially if insulated from other factors.

Large Asian importers are also likely to geopolitically benefit from a reduced centrality of fossil fuels in their economy. China is the biggest consumer of oil flowing out of the Persian Gulf through the Strait of Hormuz, making the country dependent on flow security that can only be provided by its systemic rival, the US. Half of the oil shipped by tankers passes through the South China Sea—one of the most contentious geopolitical hotspots in the world (Holslag 2015)—fueling not only China but also South Korea and Japan. To this extent, oil dependence is for China and other Asian powers a factor of major strategic fragility. As the three of them are now committed to carbon neutrality plans for 2050–2060, their geopolitical position is expected to be stronger.

Yet, such a map of winning and losing sides—limited, in its exemplifying purposes, to few geopolitical actors—in the geopolitics of fossil fuel decline requires some nuance. A transition should not necessarily be seen as a quick adjustment from a steady-state to another. According to the IEA Sustainable Development Scenario, oil supply is expected to still amount to 3000 Mt in 2040, while natural gas supply is expected to amount to 2800 Mtoe (IEA 2020). As coal is expected to be phased out more urgently than oil and gas, especially emerging economies are expected to raise their consumption of natural gas in the near future. This means that in all likelihood the phase-out of fossil fuels will take the form of a protracted process, lasting decades, with elements of non-linearity. A generalized, gradual decline of fossil fuels may imply a temporary re-concentration of fossil fuel supply in low-cost production provinces, such as Russia and the Gulf, as global demand decline would drive a reduction in prices (Van de Graaf 2018; O'Sullivan et al. 2017; Goldthau and Westphal 2019).

3.4 GEOPOLITICS OF RENEWABLE ENERGY

The geopolitical dimension of renewable energy is currently the most explored aspect of the geopolitics of the energy transition (Vakulchuk et al. 2020; Scholten et al. 2020; Øverland 2019; O'Sullivan et al. 2017; Criekemans 2018). Many forms of renewable energy—such as wind, solar, geothermal, and tidal waves—show characteristics that are fundamentally different from those of hydrocarbons in geographical and socio-technical terms (Paltsev 2016). First, renewable energy is, by definition, not scarce. Second, renewable resources are not geographically concentrated, although some areas can produce renewable energy at lower costs than others. This would ideally imply a lower density of inter-state energy dependence, interdependence, and therefore less geopolitical contention around issues such as access to resources (O'Sullivan et al. 2017; Paltsev 2016; Criekemans 2018). Yet, while a renewable energy sources (RES)-based energy system is allegedly less internationally connected—and eventually less contested—than the fossil fuel-based one, cross-border interdependencies will not necessarily be over. This section will identify inter-state interdependencies associated to decarbonizing and decarbonized energy systems, exploring their geopolitical dimension.

3.4.1 Geopolitics of Electrification

Electricity is going to become a dominant carrier of renewable energy, so that the attention of geopolitics is likely to shift toward the availability and control of electricity infrastructures, storage capacity, and cross-border interconnections (Casier 2015; O'Sullivan et al. 2017). In addition, a decarbonized energy mix requires the replacement of fossil fuels with electricity in many components of final energy consumption, from mobility to residential and industrial heating. Deep decarbonization scenarios are ultimately electrification scenarios.

In contrast to oil and gas, electricity is an efficient energy carrier only if traded across relatively short distances. As such, a switch toward electricity as a carrier of choice is likely to produce a *deglobalization* of energy trading. Unless technological breakthroughs happen with utility-scale storage or fuel cells, electricity's centers of production will need proximity to centers of consumption. Scholten and Bosman (2016) identify a "continental" or regional scenario, where inter-state integration continues between producers, consumers, and transit countries through high-voltage power lines within a regional dimension. Such a scenario is more likely in regions that already show a high level of economic and regulatory integration, such as Europe, where the integration of power grids was initiated well before the massive penetration of renewable energy technology, with early attempts dating back to the immediate post-war period. In the meantime, several regional high-voltage direct current (HVDC) projects are emerging. The Sun Cable project aims at providing Australian renewable electricity to the ASEAN power grid. In other contexts, however, the direct current—implying one-way trade—raised geopolitical concerns. It is, for instance, the case of China's State Grid plans to provide renewable electricity from Xinjiang to Central Asia or even Europe (Högselius 2019), or the Desertec Industrial Initiative (DII) promising to provide electricity from the sunny Sahara Desert to Europe (Lilliestam and Ellenbeck 2016). In theory, inter-state HVDC raises the same geoeconomic implications of inter-state trading of fossil fuels—especially gas—in terms of manipulation of flows, infrastructure (Smith Stegen 2018) and discourses in politically charged environments. As such, a "regional scenario" is less likely to emerge in regions characterized by inter-state tensions. Wherever geopolitical framings of energy security take precedence over commercial framings or efficiency considerations, states may profit from the distributed nature of renewable energy to pursue energy self-sufficiency instead of cross-border integration, adopting a "westphalian" approach to energy systems (Aalto 2008). While case studies are generally rare, Escribano (2018) looked at Spain-Morocco RES cooperation, arguing that fossil fuel-related concepts such as the quest for "energy independence" or "RES mercantilism" continue to affect inter-state energy relations, acting as a barrier to strategic opportunities. A third electrification scenario would be a "neomedieval" one (Aalto 2008), where security is ensured neither by cross-border interconnection or national self-sufficiency, but instead by a decentralized model of self-sufficient communities. Such a scenario is geopolitically relevant as for the possibility it raises for sub-national entities to assert more autonomy from central governments. Powerful sub-national entities with ambitious decarbonization agendas such as California operate their own energy diplomacy, i.e. by autonomously establishing carbon markets and linking them with those of foreign entities. On the other hand, decentralization can also coexist with certain levels of nationalization/regionalization of the grid, ideally providing system resilience to possible attacks (Øverland 2019) – especially in light of the growing cybersecurity threats implied by the growing digitalization of electricity systems (O'Sullivan et al. 2017; Hielscher and Sovacool 2018).

3.4.2 Hydrogen Geopolitics

Electricity is not the only possible energy carrier under deep decarbonization scenarios. Especially in recent years and in some contexts such as Europe and Japan, the potential role of hydrogen in the energy transition has been gaining traction, so that optimistic forecasts foresee hydrogen to serve up to one-quarter of the world's energy needs by mid-century (Bloomberg NEF 2020). Hydrogen offers the possibility to store and transport renewable electricity over long distances in liquid or gaseous form via ships or pipelines, potentially giving rise to transnational connectivity. With its large availability of wind and hydro power, large network of transmission infrastructure, gas reserves, and natural sites for storage, Norway shows the ideal profile for a supplier of hydrogen to the industrial clusters of north-western European countries. Similarly, North African countries, Chile, the Gulf countries or Australia could generate renewable hydrogen at the lowest cost and make the most of abundant gas export infrastructure (De Blasio and Pflugmann 2020), potentially becoming large suppliers for the Asian markets (Van de Graaf et al. 2020). Similar considerations could be made about Russia, although an expansion of the energy partnership beyond natural gas may remain exposed to the political vagaries of Russia's relations with the transatlantic community, not to mention the poor Russian record with renewable energy deployment (Khrushcheva and Maltby 2016).

In contrast to fossil fuel importers, hydrogen importers could retain the choice of procuring hydrogen domestically, although potentially at higher costs. Such a possibility reduces the room for geoeconomic statecraft by hydrogen producers. In all cases, questions remain unanswered with respect to the likely uptake and spread of hydrogen technologies. Hydrogen would remain in many sectors in direct competition with other green technologies that could be currently deployed at lower cost with less complex logistics (i.e. in the residential and transport sectors). This would make it a much less pervasive carrier for energy systems—and ultimately economies and societies—than hydrocarbons. Such a lower pervasivity, or even niche utilization, points in the direction of a relatively low geopolitical relevance.

3.4.3 A Race for Critical Materials?

Geopolitical re-articulations driven by the expansion of renewable energy also revolve around the role of raw materials that are critical to the decarbonization of energy systems (Bazilian 2018; O'Sullivan et al. 2017; Månberger and Johansson 2019; Kalantzakos 2020; Smith Stegen 2015; 2018). Materials like lithium, copper, nickel, cobalt, graphite, indium, platinum group metals, and rare earth elements (REE) such as neodymium, dysprosium, and yttrium are essential components for renewable energy hardware such as solar panels and wind turbines, batteries, fuel cells, and electrolyzers. The level of concentration in critical materials extraction and processing is remarkable. In the case of cobalt, the Democratic Republic of Congo (DRC) accounts for more than 50% of production and slightly less than half the world's reserves. Lithium production is concentrated in Australia and Chile, with a prominent role of Argentina and China. The production of natural graphite and REE is currently concentrated in China, mostly due to unparalleled processing capabilities—with a prominent role of Mozambique and Brazil for the former, and the US and Australia for the latter. All in all, out of many metals and metalloids critical for renewable energy, only copper, tellurium, and silicon show a geographical concentration that is less accentuated than oil (Månberger and Johansson 2019). Such a concentration implies some shift with geostrategic centralities. Latin America, China, and Sub-Saharan Africa would achieve strategic importance, while the Middle East and North Africa are largely out of the picture—potentially as both suppliers and customers. On the other hand, the EU and Japan—likely large buyers—continue to be confronted with external dependency, while Russia would confirm its role as an exporter of raw materials. Around such a concentration, three main factors of geopolitical risk emerge. The potential for a confrontational race among major manufacturing powers for the access to critical raw materials, the manipulation of flows and systems, and the fragility of some critical raw materials (CRM) exporters (Pitron 2018; Gulley et al. 2018; Kalantzakos 2020; Church and Crawford 2020).

Rivalry for access among the three largest CRMs consumers—the US, China, and the EU—could emerge especially for access to lithium, for which external dependence accounts for 50% for the US, 75% for China, and 100% for Europe (Gulley et al. 2018). Especially China moved assertively, given the large processing capacity and its leadership in battery production, in trying to acquire production assets abroad. With respect to bilateral competition, China and Europe are heavily dependent on cobalt imports, while Europe and the US depend on REE imports. However, in this latter case, common over-dependence caused cooperation between the two importers rather than competition. Notably, Washington and Brussels aligned their action to contrast Chinese REE export restrictions, bringing the dispute to the WTO. In 2016, the EU undertook legal action against China before the WTO over Chinese restrictions on the export of raw materials such as graphite, cobalt, copper, lead, chromium, magnesia, talcum, tantalum, tin, antimony, and indium (European Commission 2016) following similar legal actions in 2012 and 2014.

As for the risks associated to the instrumentalization of interdependence, concerns have mounted since 2010 among the US foreign policy and security bureaucracies with respect to potential coercive use by China of its quasi-monopolistic position in the REE extraction (US Department of State 2010), on the occasion of an export embargo that China imposed on Japan following an incident concerning the disputed Senkaku/Diayou islands. Australia had already blocked a Chinese attempt to take over Australian REE assets (Kalantzakos 2020). To be sure, Chinese activism on this front cannot be reduced to merely strategic considerations. Instead, one needs to consider China's quest for primacy in finite products—hence the need to secure access to raw materials for an increasingly sophisticated industrial-technological complex (Freeman 2018). This should not be surprising, considering that REE markets accounted in 2010 for 1.3 bn USD value, against 4,800 bn USD of end-use industries (Smith Stegen 2015).

The third factor of geopolitical risk concerns the potential for a "resource curse"—notably, the paradox where countries rich in raw materials are particularly exposed to intra-state violence, authoritarianism, and economic backwardness (Ross 1999). Månsson (2015) notices that despite a lower propensity of RES to provide incentives to conflicts to secure control, increased competition for land possession may trigger conflictual dynamics involving non-state actors—depending on specific technologies and the implementation of sustainability side policies. Månberger and Johansson (2019) suggest that risks remain country-specific. Some exporters show a very diversified economy, where raw materials supercycles or downturns are unlikely to heavily affect political or macroeconomic stability. It is, for instance, the case with China or the US. The second group of countries—such as Russia or Australia—export CRM as well as hydrocarbons. Due to the foreseeable contraction in the trade of hydrocarbons and the relatively smaller CRMs trade volume, it is predictable that in aggregate terms this second group will become less dependent on raw materials—and therefore less exposed to the resource curse. Major distortions may however be expected in the present and future CRMs exporters with small economies and an already dominant mining sector such as Chile, Cuba, or the DRC (World Bank 2020). These contexts risk a growing exposure to the fluctuation of CRMs' prices, which may amplify political or economic instability that were already latent or present (Church and Crawford 2020).

However, risks connected to the concentration could be easily overestimated in a context where China's domination of supply chains is conducive to a securitization (Buzan et al. 1997) of CRMs access in western discursive practices. Indeed, there are important factors that mitigate CRMs' geopolitical sensibility, especially with respect to fossil fuels. *First*, clean technologies need different CRMs and are frequently in competition with each other. Greater electrical interconnectivity would imply greater demand for copper while mitigating the need for storage - and with it the demand for lithium and cobalt for batteries or PMG for fuel cells. Greater use of hydrogen in electric mobility would increase the demand for PMG, but mitigate the demand for lithium. The shift toward wind turbines of ever-larger capacity involves a shift from neodymium to yttrium.[3] Other materials such as aluminum, zinc, or selenium would still be employed in a large number of non-energy sectors, implying that the demand for wind turbines or solar panels could be offset by fewer uses of the raw materials needed in other sectors. *Secondly*, it is appropriate to relativize the notions of scarcity and concentration for many of the elements necessary for the transition (Øverland 2019). The production of REE underwent a de-concentration over the last 10 years, so that the Chinese market share dropped from 97% to 64%. Lithium also seems to show no major risks in terms of depletion. The projections concern only reserves currently being exploited, while the available resources seem much more abundant. In the long term, any shortage in conventional sites would favor the development of alternative mining technologies.[4] *Thirdly*, in contrast to fossil fuels, CRMs do not need to flow daily to importers. They have a flexible logistics and low storage costs, which act as important factors mitigating flow manipulation risks. *Fourthly*, in the medium and long terms—intervals in which the results of technological innovation take over—opportunities arise from recycling, efficiency, and substitutability of CRMs. These interventions reduce both the CRMs' environmental and geopolitical criticalities. While advanced economies have for a long time looked at CRMs through the lenses of trade policy principles and instruments—i.e. pushing for open global supply chains and attacking export restrictions—the new geopolitical environment is shifting toward import-substitution policies (European Commission 2020). In the light of the cases examined, it is concluded that environmental and geostrategic risks can mainly affect in short term, and the role of politics and technological development remains essential in their mitigation.

[4] Neodymium is employed for magnets in turbines below 10 MW of capacity, while yttrium is necessary for superconductors in turbines above 10 MW.

[5] An example is lithium's extraction from sea water. Already now the prices of lithium carbonate, at $ 12–15,000/t, are approaching the $ 16,000/t needed to make marine extraction profitable, capable of expanding current reserves from 15,000 to 2 mn tons (Greim et al. 2020).

3.4.4 Hydro, Nuclear, and Biomass

By concentrating on the geopolitical implications of renewable energy, one should not neglect the role of more traditional low-carbon sources—which currently provide most of the carbon-free energy and are often found in competition with each other (Paltsev 2016). Based on these sources, some states such as Brazil, France, Sweden, or Norway already rely upon a relatively decarbonized energy mix. One of the major difficulties in assessing the geopolitics of the transition is factoring in the relevance of these sources on a long-term horizon, as their permanence or removal would have significant consequences on the volume of other sources—fossil or not—that the world will need in the future.

Biomass accounts for a large proportion of renewable energy supply. It is central to the decarbonization strategies of several countries such as Brazil, Sweden, or Finland, where bioenergy accounts for 20–30% of the total primary energy supply (IEA Bioenergy 2018). Yet, their future role is constrained by growing reconsideration of their environmental sustainability. Despite its critical role in decarbonization patterns, biomass attracts little attention in terms of geopolitical analysis. Biomass trade can be hardly weaponized. Despite serious social issues associated to processes of land-use change and commodity prices (Dalby 2020), there is limited record of direct connection to meaningful cooperative or confrontational transnational patterns, with the notable exception of trade complaints against restrictive practices (Ghosh 2016). Only a small proportion of biofuels are traded internationally, as large producers of biofuels are also the largest consumers, while tariff and non-tariff barriers play an important role in limiting the prospects for an enhanced trade expansion sought by producers such as Indonesia and Malaysia (IRENA Global Commission 2019).

Hydropower is currently one of the major sources of carbon-free electricity. In 2019, hydroelectricity accounted for 15.6% of power generation, and 60% of electricity produced through renewable energy.[5] For some countries—i.e. Brazil, Canada, Norway, and many other countries in South America and Sub-Saharan Africa—it even accounts as the main source of electricity. Yet, the production of hydroelectricity has been stagnating since the mid-90s everywhere except for China. As for the future, a sustained decline of capacity additions is putting hydropower off track with respect to the Sustainable Development Scenario of the IEA. Hydropower prospects are constrained by the challenge of climate change itself, which—acting on water's availability and variability—works as an amplifier of the elements of political contentiousness that already affect large hydropower infrastructure with a cross-border dimension (De Stefano et al. 2017). As such, regardless of uncertain future prospects, tensions around its use are likely to increase in certain geographical contexts (Hancock and Sovacool 2018). A relevant example is the current tension between Egypt and Ethiopia with respect to the Grand Ethiopian Renaissance Dam (GERD), which puts in conflict vital needs of the two countries: water and food security for Egypt and fighting energy poverty for Ethiopia, in a context complicated by expanding populations, domestic and regional tensions, and the impact of climate change on water resources. At the same time, cooperative patterns may emerge given hydropower's value for regional balancing markets. Notably, Norwegian and Swiss water reservoirs are likely to become increasingly central to lower the costs of the EU's grid stabilization as the continent increasingly relies on intermittent sources, or serve the production and export of green hydrogen.

Nuclear energy has been also frequently portrayed as potentially experiencing a rebirth thanks to decarbonization (Ramana 2016). Yet, the consumption of nuclear energy remained stable over the last decades—accounting for about 10% of power generation—with a slight contraction in Europe compensated by a rise in Asia. Nuclear energy has always been geopolitically relevant due to the dual use of nuclear technology and the concerns associated to nuclear proliferation (Van de Graaf and Sovacool 2020). The geography of its current development shows a dual dynamic. Stringent regulation, rising costs for decommissioning and waste disposal, and low popularity are making

[6] Author calculation on BP (2020).

nuclear energy a lesser attractive option for decarbonization with respect to easier-to-deploy renewable energy in western markets. On the other hand, the growing power demand of developing and emerging economy in a carbon-constrained world translates into a renewed interest for nuclear (Markard et al. 2020). Largely due to the US' opposition to nuclear proliferation, many emerging and developing countries are looking at the investment schemes proposed by state-owned nuclear actors from Russia and China—which benefit from state subsidies and are not bound by OECD export credit rules (Nakano 2021). Russia's Rosatom, already a key actor in the Iranian nuclear program, is building power plants in Turkey, Egypt, Belarus, Finland, and Hungary (Giuli 2017; Aalto et al. 2017; Schepers 2019), while China is active in the international marketing of its Hualong-1 type reactor by way of its realization in Pakistan, a country chronically affected by energy poverty and deeply entrenched in the network of China's infrastructure diplomacy and debt schemes (Small 2015). From the US perspective, strategic risks connected to the emergence of new dependencies of several countries on Russian and Chinese technology, as much as the commercial decline of western nuclear industrial actors on the world stage are reasons for concern. In response, the US is in a process of bipartisan reconsideration of its non-proliferation policy, raising the prospects of commercial and geopolitical competition in the definition of civil nuclear standards (Nakano 2020).

3.5 REDEFINING ENERGY MASTERY

The previous sections interpreted clean energy systems through the lenses of the geopolitical categories usually applied to fossil energy. Still, it needs to be acknowledged that the geopolitics of the energy transition will be played less and less on the chessboard of access to resources and increasingly on the mastery of innovation in processes and products, supply and value chains, integrated infrastructure, and influence on processes of standardization and regulation (Casier 2015; O'Sullivan et al. 2017; Ghosh 2016), so that those actors that are better placed in terms of innovative ecosystems, market size, financial availabilities, and administrative capacity will be more likely to achieve energy mastery in the XXI century (Criekemans 2018) and therefore geopolitical dividends in terms of acquiring revenues, status, and establishing relations of asymmetric dependence. Research, intellectual property, industrial (Rodrik 2014; Johnstone and Kivimaa 2018), trade (Jebe et al. 2012; Ghosh 2016; Marhold 2017) and tax and carbon pricing policies (Condon and Ignaciuk 2013) and their surrounding bureaucratic-industrial ecosystems are becoming the central instruments and actors in a geopolitics of energy where dominating technology is a more important determinant of power than accessing resources (Casier 2015; O'Sullivan et al. 2017), in contrast to the traditional role played by foreign policy and security bureaucracies and oil and gas companies in the framings and pursuit of energy security. Innovation agencies and public procurement authorities are going, as well, to provide resources, design policies, and practices, and create lead markets critical to the achievement of global primacy in clean energy systems.

Existing literature identified the number of RES patents, the weight of capital investment, and the density of commercial clean energy companies as indicators of power in the technological aspects of the geopolitics of renewable energy (Criekemans 2018; Månsson 2015; Paltsev 2016; Smith Stegen 2018; Escribano 2018). Results show significant geographical concentration—notably among economies with large domestic markets and innovation capacity such as the US, the EU, and China, with the addition of mid-size countries such as Japan, South Korea, and the UK. In the early 2000s, Germany, the US, and Japan were the only powers holding more than 10% share in global patents for wind energy, solar energy, and fuel cells. In Europe, investment in renewable energy – driven by the adoption of renewable energy targets—occupied more than 75% of clean technology investments, while clean energy companies were concentrated in the US, Europe—driven by Germany—and Japan (Criekemans 2018). In few years, the distribution rebalanced eastwards. In 2014, the value added of Chinese clean energy manufacturing[6] amounted to almost $40 bn,

[7] The data refers to wind turbine components, crystalline silicon PV modules, LED packages and lithium-ion battery cells (IRENA Global Commission 2019).

in contrast to Japan, Germany, and the US, which totaled each slightly more than $5 bn. In 2016, China cumulated almost 30% share of RES patents, followed by the US (18%), the EU, and Japan (14% each). In 2019, China was the top investor in clean energy globally ($83 bn), followed by the US ($55.5 bn) and Japan ($16.5 bn). As for firms, Chinese giants, such as Suntech and BYD, promise to become the clean energy challengers in a similar way Huawei and ZTE have established themselves in the digital sector. As such, besides almost monopolizing the extraction, processing, and exports of CRMs, China established itself as a leading exporter of clean energy products. China controls 77% of battery cell capacity and 60% of components, and 60% of global manufacturing in the solar supply chain. Based on a vast array of measures such as long-term planning, subsidization, government procurement, and local content requirements, combined with a large domestic market and social and environmental dumping, China achieved dominance over first-generation clean energy technologies, such as lithium-ion batteries, onshore wind, and crystalline silicon solar (Finamore 2021).

While the rise of China's clean energy technological and industrial capacity has contributed to rendering the early phases of the energy transition affordable for the climate frontrunners in the west, China's industrial primacy is no longer considered by other powers as just a neoliberalism and multilateral trade institutions' success story, but also—and increasingly—as a strategic challenge (Blackwill and Harris 2016; Allison 2017). The intensification of great power rivalry is, therefore, expected to inform the race for the next generation of clean energy technologies—i.e. floating offshore wind, perovskite solar cells, solid-state batteries. In the US, the race to clean energy is increasingly framed in antagonizing terms. At the beginning of 2021, President Joe Biden ordered a review of four critical foreign supply chains to address dependence on geopolitical rivals in essential sectors, including batteries for electric vehicles (The White House 2021). Without adopting a confrontational rhetoric, the EU is also showing interest to shorten strategic value chains, including those related to decarbonization. The European Green Deal strategy (European Commission 2019) and side-strategies underpinning it foresee a range of industrial policy measures aimed at reshoring battery manufacturing and enhancing the domestic processing and recycling capacity for CRMs, ranging from the relaxation of state aid discipline to the support to research and development, to a carbon border adjustment mechanism—notably, a tariff on the embedded carbon content of imports, whose prospects are generating acrimonious reactions among Europe's trade partners (Hook 2021). In the context of these competitive patterns, the big prize in terms of power and influence is the definition of clean energy standards for processes, products, and infrastructures' interoperability. In China's understanding, standards guarantee institutional influence on standardization agencies, originally created and dominated by the historical west; economic revenues, as mastering standards-essential patents provides royalties and reduces adaptation costs (Fägersten and Rühlig 2019).

It would be indeed too extreme and early to claim that the new clean energy powers are on the verge of technological decoupling (Meidan 2021). The complexity of emerging energy value chains lie also in the fact that the reshoring of certain productions (i.e. batteries) implies the rise of the dependence on other products (i.e. CRMs). Yet, signals are pointing toward a clean energy technology race entangled within a confrontational environment, marked by mercantilist tendencies and little appetite for multilateral frameworks and governance forms.

3.6 CONCLUSIONS

In this short summary, the geopolitical dimension of the transition was interpreted as the impact of shifting technical and geographical features of energy systems on inter-state patterns of cooperation ad conflict. The overview has shown that the energy transition is expected to have important geopolitical implications, raising strategic opportunities and risks.

Oil and gas exporters' foreign policy options are likely to shrink as the geostrategic importance of an asset they possess is diminished, while the foreign policy options of large importers are going to expand. Questions remain about the extent the transition will result in political and economic instability among petrostates, and whether oil suppliers and the large powers of the XXI century will undergo geopolitical realignments as a result of the transition. To be sure, energy is not the only chapter of interaction between large powers and oil suppliers. A vast array of issues including security, migration, climate change, and economic interlinkages will continue to bound actors together. Then, a question to explore is whether a fuel "disconnection" is likely to result in a factor that facilitates addressing other geopolitical issues, or instead as an amplifier of geopolitical risks. At least, in part, the answer to such a question will depend on the pace of the energy transition—as in the short-to-medium term low-cost producers and their NOCs may see their geostrategic centrality to temporarily increase before declining—on individual petrostates' characteristics, and their choices on how to deal with the transition.

On the other hand, a different geography of interdependences—smaller in economic volumes but bigger in complexity, actors, and articulations—is likely to emerge. Such a geography will be defined by the control on critical raw materials, processing capacities, and decarbonized systems' infrastructure, mastery over advanced technologies, and influence on the definition of regulation and standards. Whether these emerging patterns of interdependencies will lead *per se* toward cooperative or competitive patterns of inter-state interactions will largely depend on their interplay with broader geopolitical dynamics, mainly related to the rise of China and geoeconomic declinations of great power rivalry.

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