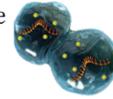


COMMENT

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ASHRAF MOHAMMAD MOHAMMAD ALAMRA/REUTERS



Solar panels decorate the desert in Dubai.

How the energy transition will reshape geopolitics

Paths to a low-carbon economy will create rivalries, winners and losers, warn **Andreas Goldthau, Kirsten Westphal** and colleagues.

Energy is at the root of many political ructions. President Donald Trump's intention to pull the United States out of the Paris climate agreement in 2020, the European Union's restrictive policies against importing Chinese photovoltaic cells and the political hostility towards the school strikes over climate-change inaction are all reactions to attempts to shift the

world to a low-carbon economy.

The future benefits of clean energy can seem distant when weighed against pay packets or votes now. Despite the impacts of climate change becoming increasingly evident in devastating cyclones, heatwaves and floods, politicians want to protect local jobs and incumbent industries, such as coal and manufacturing. Voters are swayed

by issues such as equity, health care and national security.

This bumpy ride is no surprise. Historically, most major transitions have proceeded in unexpected ways. Climbing the energy ladder from wood to coal between the eighteenth and nineteenth centuries, for instance, enabled industrialization. But it also disenfranchised large ▶

► parts of the working class, prompting Karl Marx and Friedrich Engels to write *The Communist Manifesto*. The transition to renewable energy sources will be disruptive, too. Yet the geopolitical implications are, for the most part, yet to be analysed.

International energy organizations have flagged some issues. Oil exporters might lose global influence, whereas importers will be empowered, concluded a report from the International Renewable Energy Agency (IRENA) published earlier this year¹. Economies that produce oil and gas could lose US\$7 trillion by 2040, the International Energy Agency has warned². And wider strategic quarrels will also emerge.

With their huge markets, industry leaders China and the United States are vying to dominate the clean-technology sector. And new relationships and allegiances, such as the Global Energy Interconnection Development and Cooperation Organization (a platform for companies and enterprises) might replace state-led clubs of old such as OPEC, the Organization of the Petroleum Exporting Countries. Competition over the use of land for energy production will have implications for food and water security and migration in developing countries. And energy is woven into the infrastructure investments and relationships that form China's Belt and Road Initiative.

We present here four geopolitical scenarios to illustrate how varied the transition could be by 2030 (see 'Four futures'). To minimize conflict and maximize equity, states' policy choices over the next decade will be crucial. Researchers and decision-makers should widen their focus to examine the implications of such alternative pathways to decarbonization — issues that go well beyond technology. Smoothing the road will take multilateral agreements, generous funding and cooperation.

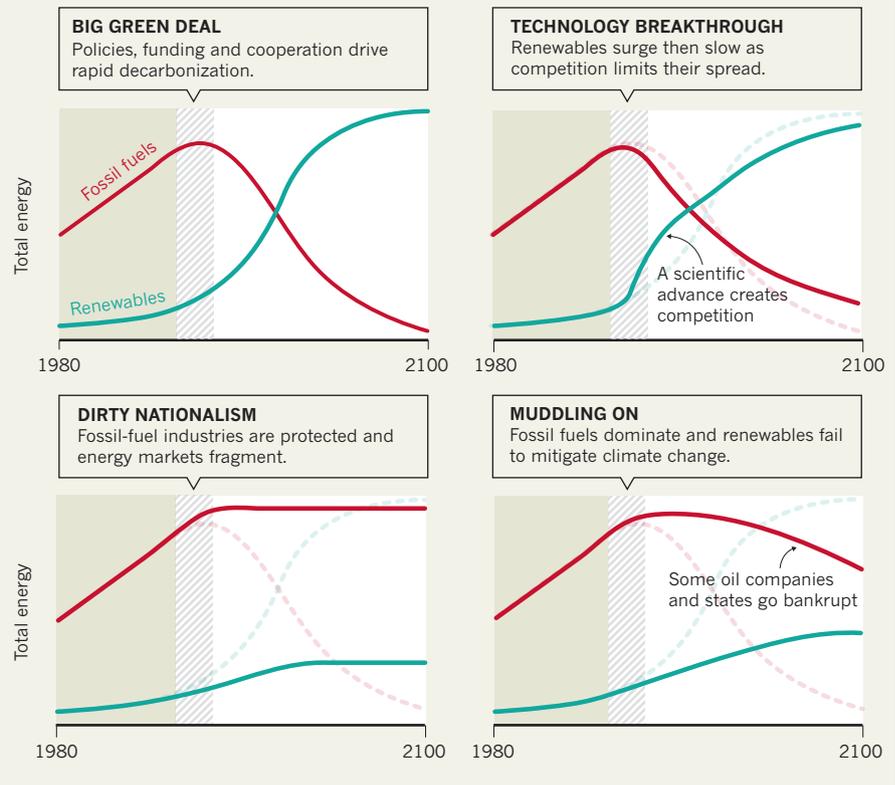
ALTERNATIVE FUTURES

These four trajectories were explored by a group of international energy and foreign-policy researchers in two workshops, in which we all took part. Participants discussed what drives global energy transformation, where and at what pace. The meetings were held in Berlin in 2018 at the German Institute for International and Security Affairs (SWP), convened by the Geopolitics of Energy Transformation 2030 (GET 2030) project in parallel with the 2019 IRENA report, and funded by the German Foreign Office.

1. Big green deal. This scenario assumes full cooperation — a global consensus for action on climate change leads to a concerted international policy drive. G20 countries build a generous Green Climate Fund, well above the \$100-billion-a-year

FOUR FUTURES

Geopolitics in the next decade (hashed regions) will dictate whether or how fast energy from renewable sources will outpace that from fossil fuels, as these four scenarios depict.



goal in the Paris climate agreement. Financial markets divest fossil-fuel assets and reallocate capital to low-carbon firms. Green-technology corporations dominate the Fortune 500 by 2030.

A wave of green globalization, as enshrined in the United Nations sustainable development goals (SDGs), allows all countries to share in the benefits of decarbonization. Petro-states are compensated to transition smoothly to a sustainable economy, avoiding a last-ditch attempt to flood the world with cheap oil and gas. The result is a win-win for climate and security. Geopolitical friction is low.

2. Technology breakthrough. A major technological advance steers the world along a different path. A step change, for example in energy storage, makes solar and wind power easier to integrate into the grid and even cheaper. The United States and China take the lead in scaling up the technology, given their large markets, tech-friendly regulatory environments and industry giants, such as Google and the State Grid Corporation of China. But competition between nations also spikes.

The world fractures into two camps in a clean-tech cold war. Technology leaders hold the power. Other countries gravitate towards one of the leaders, reinforcing regional blocs and increasing rivalry.

These blocs seek to control the materials needed, such as rare-earth metals, cobalt and lithium. They might also withhold access to technologies from nations outside their groups.

The renewables race helps to mitigate climate change, and displaces fossil fuels quickly, but some regions lose out. For instance, Europe lags behind China and the United States because its single market remains less integrated. Russia might align with China. Some developing nations are excluded from advanced energy know-how altogether, compromising the SDGs.

Fossil-fuel producers have to adapt rapidly to falling demand. Some don't manage, and political tensions rise in sub-Saharan Africa, the Middle East and Central Asia.

3. Dirty nationalism. Elections bring populists to power in the world's largest democracies, and nationalism grows. Nation-first policies put a premium on self-sufficiency, favouring domestic energy sources over imported ones. This drives the development of fossil fuels, including coal and shale production, as well as renewables.

States ring-fence their industries and zero-sum logic returns — one country's gain means another's loss. Public opinion turns against foreign energy investors. Energy markets fragment in the face of protectionism, which limits economies of

scale and slows progress towards decarbonization. Fossil-fuel exporters rush to produce as much as they can, despite falling prices and constraints on trade.

Power rivalries marginalize the UN and undermine multilateral institutions such as the UN Framework Convention on Climate Change (UNFCCC). EU nations disagree, weakening joint policies. This wrecks the Paris climate agreement and the mechanism of voluntary emission cuts underpinning it. With climate change unmitigated, food prices rise as a result of droughts and tariffs. Water and other shared resources are fought over as climate change amplifies stresses and multiplies risks.

4. Muddling on. Business as usual results in a mix of energy clubs, with little cooperation. As unit costs keep declining, renewables claim an increasing share of the energy mix by 2030. But fossil fuels remain dominant. The speed of the energy transition is too slow to mitigate climate change, but too fast for the fossil-fuel industry to adapt.

Some national oil companies go bankrupt and others consolidate into a handful of global energy giants. Exports concentrate in fewer countries and companies, which compete rather than cooperate. Exporting fossil fuels becomes a risky business, revenues falter and OPEC collapses. Oil-producing countries in the Middle East, Russia and Africa see political turmoil as government coffers empty.

Motivated by energy security as much as climate change, countries pursue diverse energy strategies. China is keen to improve air and water quality and build 'national champions' in industry. Europe is more concerned with climate change, and pursuing bilateral partnerships with like-minded and developing countries. The United States is on the sidelines.

Because some regions have inadequate regulation or fail to benefit from these partnerships, existing economic and geopolitical imbalances (such as global north-south relations) are reinforced and energy inequality rises, undermining the SDGs.

LESSONS LEARNT

What lessons can be drawn from these scenarios?

First, falling costs of technology — the focal point of current debates — will not by themselves deliver a low-carbon world. Politics will be an essential ingredient in success or failure. Some economists suggest a global carbon tax as a panacea. But the pace, scope and direction of the transition will depend on domestic political economies, regulations and access to finance and clean technology. Decisive factors include: the degree to which powerful fossil-fuel lobbies are able to resist change; whether incumbent regulatory environments hold back the advance of

renewables; and whether low-carbon know-how finds its way from the global north to the global south.

Second, a zero-carbon world does not do away with zero-sum games. It produces different ones. In the current energy system, the struggle is over secure and affordable access to oil, coal and gas. The United States has historically cultivated a special relationship with Saudi Arabia over oil, and the EU with Russia over natural gas. In a low-carbon world, the struggle will be how to finance the infrastructure and to control the technology needed to harness wind, solar and other renewable power sources, and how to secure access to the materials required for the manufacture of that technology.

Third, the pace of change matters. For example, should a tech breakthrough bring rapid change, unstable fossil-fuel producing states such as Venezuela or Algeria might not have time to adapt, and their internal conflicts could spill over into neighbouring regions. The problem here is not so much stranded assets³, as it is the degree to which countries share in the benefits of transformation.

Fourth, some pathways might not be politically palatable to all. For example, many Western policymakers assume that technological progress is best achieved in a liberal market underpinned by free trade. This is not necessarily the case. China has scaled up renewable energy through top-down rule and state planning. Brazil's success story in biofuels is in part a function of a former military junta seeking self-sufficiency and a more favourable trade balance. Thus, the 'one size fits all' approach based on Western norms in international organizations should be questioned.

NEXT STEPS

Three steps will help to put geopolitics at the heart of debates about the energy transition.

First, researchers and decision-makers need to shift their gaze from targets to pathways. Logistics need to be considered, as well as uncertainties. This process will involve more than green growth, economic diversification and energy access⁴. Governments might link low-carbon technology with foreign and security policy, as they did with oil and gas.

Second, policymakers need to draw lessons from past and parallel experiences. For example, digitalization, another deep transition, is doing more than reshaping economies and societies; it is throwing up questions related to individual freedom and political power. The path from planned to market economies meant economic

hardship for most of the former communist bloc; it also showed how elites can hijack transition processes for personal gain.

Third, abating carbon will create losers. So far, the policy focus has been on empowering the early winners of an unfolding renewable-energy race. It now needs to switch to the potential conflicts resulting from falling fossil-fuel demand, and the related economic and security risks. For example, rich countries such as Germany can throw billions of dollars at their coal sector to ease their transition pain, offering generous financial aid to lignite-producing regions. Nigeria or Algeria cannot do the same for their oil industry. Saudi Arabia and Kuwait might⁵, and should be encouraged to do so.

Who should take the lead on managing the transition? The G20 is one clear candidate. The UNFCCC involves 197 parties but, for all its achievements, it has failed to slow the growth of emissions. The G20 states account for nearly 80% of global emissions, and so could provide global leadership and financial support, building on their Climate and Energy Action Plan for Growth and cemented by a tripartite agreement between China, the EU and the United States.

The journey to zero carbon is fraught with geopolitical risk. By asking the right questions, identifying threats and offering solutions, we can get on the road to a just, peaceful and effective energy transition. ■

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1. Global Commission on the Geopolitics of Energy Transformation. *A New World: The Geopolitics of the Energy Transformation* (IRENA, 2019).
2. International Energy Agency. *Outlook for Producer Economies: What Do Changing Energy Dynamics Mean for Major Oil and Gas Exporters?* (IEA, 2018).
3. Van de Graaf, T. & Bradshaw, M. *Int. Aff.* **94**, 1309–1328 (2018).
4. Bazilian, M., Sovacool, B. & Moss, T. *Glob. Policy* **8**, 422–425 (2017).
5. Goldthau, A. & Westphal, K. *Glob. Policy* <https://doi.org/10.1111/1758-5899.12649> (2019).

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