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Renewable energy and geopolitics: A review

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A B S T R A C T

This article reviews the literature on the geopolitics of renewable energy. It finds that while the roots of this literature can be traced back to the 1970s and 1980s, most of it has been published from 2010 onwards. The following aggregate conclusions are extracted from the literature: renewable energy has many advantages over fossil fuels for international security and peace; however, renewable energy is thought to exacerbate security risks and geopolitical tensions related to critical materials and cybersecurity; former hydrocarbon exporters will likely be the greatest losers from the energy transition. Many of the reviewed publications share some weaknesses: a failure to define "geopolitics"; an unwarranted assumption that very little has been published in the field previously; limited use of established forecasting, scenario-building or foresight methodologies; a lack of recognition of the complexity of the field; a lack of theorisation. Most authors do not distinguish between the geopolitical risks associated with different types of renewable energy, and only a few distinguish clearly between the geopolitics of the transitional phase and the geopolitics of a post-energy transition world. A disproportionately large part of the literature is dedicated to critical materials and cybersecurity, while only a small part concerns the decline of former fossil fuel powers. Among those publications that do discuss the decline of fossil fuels, there is also an over-focus on oil producers and a lack of attention to the countries that rely heavily on coal, for example Australia, China, Germany, Indonesia, Poland and the United States.

1. Introduction

Geopolitical consequences of transition to renewable energy (RE)

Can electricity transmission be used as foreign policy instrument or weapon?

- Similar to how oil and gas have been used in the past

Will RE leaders like China, Denmark and Germany strengthen their position in world affairs?

- Will there be a backlash from declining petrostates?

Geopolitics = connection between

- geography
- space
- power of states

This paper examines the consequences of the growing use of RE for

- power of states
- international conflict
- energy security

Core themes in the literature (1950-2019)

- Peace potential of renewables
- Geopolitical winners and losers in the energy transition
- Impact of RE on international relations (IR)
- Critical materials
- Cybersecurity

List of abbreviations

GeGaLo	The Index of Geopolitical Gains and Losses
HVDC	High-voltage direct current
ICMM	The International Council on Mining and Metals
IEA	The International Energy Agency
IISD	The International Institute for Sustainable Development
IRENA	The International Renewable Energy Agency
LNG	Liquefied natural gas
MENA	Middle East and North Africa
NASA	The National Aeronautics and Space Administration
NSF	The National Science Foundation
OECD	The Organisation for Economic Co-operation and Development
VUCA	Volatility, uncertainty, complexity, ambiguity

2. History of the field

2.1. Defining the field

RE definition by IEA

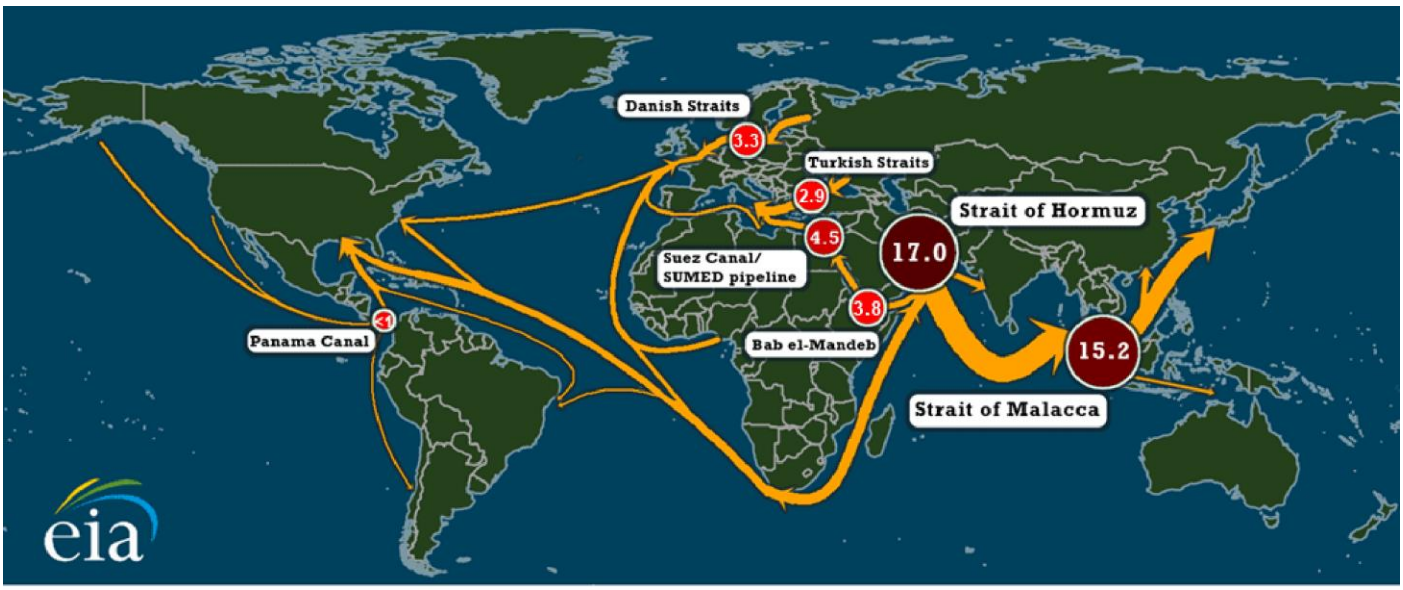
- Energy that is derived from natural processes that are replenished constantly
  - solar
  - wind
  - biomass
  - geothermal
  - hydropower
  - ocean resources (tidal and wave)
  - biofuels

Geopolitics initially conceived as

- Deterministic causal relationship between geography and IR focused on the permanent rivalry, territorial expansion, and military strategies of imperial powers

Over time, geopolitics = influence of geography on the power of states and IR

- Less emphasis on determinism
- More emphasis on
  - strategic importance of natural resources, their location, transportation routes, and chokepoints



All estimates in million barrels per day. Includes crude oil and petroleum products. Based on 2013 data.

Main divide in the field

- Classical geopolitics
- Critical geopolitics
  - Geographic arrangements are seen as social constructions that are changeable over time depending on political, economic, and technological changes

For the purposes of this paper

- Geopolitics = great power competition over access to
  - strategic locations
  - natural resources

Relating notions of space and territoriality to RE

- Political geography has highlighted many important considerations that energy security and geopolitical analysis should take into account

2.2. Origin of the literature

From the 1950s, the energy geopolitics literature has dealt with

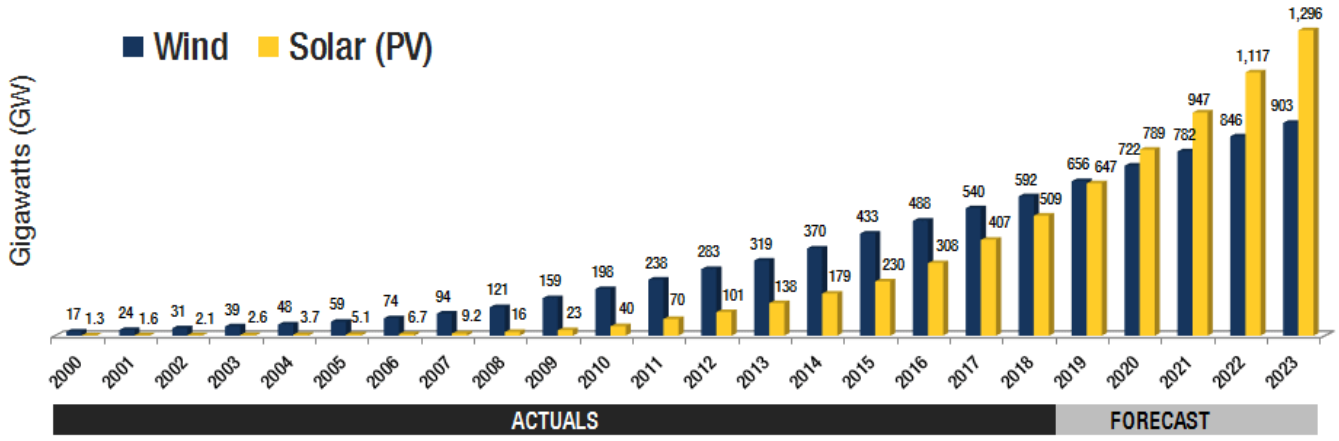
- IR
- petroleum resources

It was included in curricula of university courses in

- IR
- global governance
- foreign policy
- security studies
- energy studies

As of 2018, oil and gas still dominated the geopolitics research agenda

Solar and wind power installations started expanding exponentially since 2006



From 2010, the geopolitics of RE received increasing attention from the expert and academic communities

It is not such a novel topic

In 1972, the National Science Foundation (NSF) and NASA argued that

Solar power is of strategic importance to the US

Solar energy utilization will inevitably have environmental, social, and political consequences

In 1974, it was noted that

Large-scale adoption and use of solar energy would avoid the international energy crises associated with the consumption of fossil fuels

In 1980, the California Academy of Sciences prepared a report for the US Federal Emergency Management Agency on

How RE could lessen US energy vulnerabilities and the likelihood of war

> Current US energy systems (fuels and electricity) are highly vulnerable, due to requirements for imported resources and due to the centralised nature of the systems themselves. Dispersed, decentralised and renewable energy sources can reduce national vulnerability and the likelihood of war by substituting for vulnerable centralised resources (p. 2).

In 1980 and 1988, the positive impact of RE on the global economy and international security was stressed

2.3. Resurgence of the topic

1970s and 1980s

US scholars and experts were the first to raise the issue of geopolitics in RE

After 2000

Northern European researchers dominated the field

Modern renewables like wind and solar power took off in Northern Europe

Scholars in Germany and the Benelux countries were among the pioneers in the study of RE geopolitics

Nordic academics joined the debate, reinforcing its distinct Northern European flavor

High level of activity among Northern European researchers driven by the ministries of foreign affairs in

Finland

Norway

Germany

Netherlands

Research was initiated and funded

A major international analytical initiative (mainly by the German Foreign Office, the Ministry of Foreign Affairs of Norway, and IRENA) led to the formation of the

Global Commission on the Geopolitics of Energy Transformation (under IRENA, 2018)

https://www.geopoliticsofrenewables.org/

«The Global Commission on the Geopolitics of Energy Transformation, is an independent initiative that was launched during the IRENA Assembly in January 2018. Its purpose is to examine how the large-scale shift to renewable energy is disrupting the global energy system, impacting economies and changing the political dynamics within and between countries.»

3. Core themes

Will increased use of RE stabilize international energy relations?

What about RE's peace and conflict potential?

Critical materials and possible competition over them are important

Critical Materials for Green Energy Technologies (https://youtu.be/hHtzIqxgD3Y)

Which countries are the potential winners and losers in the transition to RE?

What are the overall consequences of RE production for IR (beyond the energy domain)?

Table 2
Comparison of fossil fuels and renewables according to the literature.

Main issues	Fossil fuels	Renewable energy
Resource scarcity	Very significant	Not significant, except for critical materials
Importance of location	High	Moderate
Control over resources	Centralised	Decentralised
Geopolitical power	Asymmetric	Less asymmetric
International competition	High	Low
International interdependence	High	Low if renewables domestic/high if imported
Security of supply	Highly important	Moderately important
Geopolitical tensions	Frequent	Opinions vary greatly[a]
Conflict type	Large-scale and violent	Small-scale and non-violent
Critical materials	Unimportant	Important
Cybersecurity	Unimportant	Important
Key market aspects	Demand and supply, exports and imports	Storage, intermittency, infrastructure management

[a] See the discussion on the two different camps in Section 3.1 regarding the security implications.

3.1. More conflict or more peace?

A divide over the security implications of RE growth

Two main groups of perspectives

Renewed conflict camp

Energy transition is not likely to reduce energy-related conflict

Reduced conflict camp

Greater self-sufficiency will reduce the amount of energy-related conflict between states

Renewed conflict camp

A world that derives most of its energy from renewable sources will be no less conflictual than one running on fossil fuels

Renewables lead to

the same types of conflict as those caused by fossil fuels

new but just as severe types of conflict

If the transition to renewables occurs under conditions of continuing high energy consumption, this would lead to new energy security vulnerabilities similar to the old ones

Interrupted energy supplies

Geopolitical instability in energy producing countries

RE may take over the role played by fossil fuels and become a driver of new geopolitical tensions

Projects like the Desertec and the Mediterranean Solar Plan adopted counter-productive geopolitical narratives

They presented themselves as the mere substitution of hydrocarbons and pipelines by renewables and electricity lines

Desertec: What Went Wrong? (https://www.ecomena.org/desertec/)

«This goal of 'interdependence' is reminiscent of previous French prime minister Edgar Fouré's famous coinage back in 1956, 'L'indépendance dans l'interdépendance', (independence in interdependence), a strategy promoted by successive French governments to maintain control and domination of the new 'independent' African countries.»

The DESERTEC Vision (https://youtu.be/QXx02iMsDqI)

LOCAL ENVIRONMENT
2018, VOL. 23, NO. 7, 747–776
https://doi.org/10.1080/13549839.2018.1469119

Routledge
Taylor & Francis Group

Check for updates

(Why) did Desertec fail? An interim analysis of a large-scale renewable energy infrastructure project from a Social Studies of Technology perspective

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ABSTRACT

In 2009 the Desertec Industrial Initiative (DII) was founded by several, predominant German enterprises. The objective of DII was to organise the conditions for the realisation of the Desertec idea, which aimed to both (a) supply Europe, in a large-scale manner, with electricity produced in solar power plants in North Africa and the Arabic peninsula and (b) contribute to the self-supply of the Middle East North Africa region (MENA). Protagonists of the desert energy idea saw this megatechnic project as a starting point for a new trans-Mediterranean EU-MENA union, critics in contrast as a neo-colonial project. Disputes over the adequate interpretation and implementation of the Desertec idea broke out from the beginning. In 2014/2015, the media talked of the failure of DII and of the Desertec concept. The majority of the members left DII at the end of 2014. On the other hand, in some MENA countries renewables are playing a crucial role in securing the future of the energy sector. This paper analyses the development of DII and the Desertec idea by using concepts from Social Studies in Technology, and especially by the multi-level perspective approach in Transition Studies. It shows how the interplay of different factors, such as technological developments, entrepreneurial performances and political processes, lead to internal conflicts and the non-realisation – up to now – of related large-scale energy projects. As an important aspect of the paper, different understandings of the future of our energy supply and of North–South relations are presented in detail.

ARTICLE HISTORY
Received 11 October 2017
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KEYWORDS
Renewable energies; Transition Studies; Social Studies of Technology; geographies of energy; MENA region

«Yes, there was a Mediterranean Solar Plan (MSP) a few years ago, but it got lost in politics and produced more PowerPoints than actual power plants. Yes, there was a Desertec Industry Initiative (Dii) of some mainly European companies, but when Europe went into financial crisis in the last decade, they became too short-termist and protectionist to be interested in importing cheap energy from the Southern Mediterranean.»

http://helioscsp.com/covid19-and-eus-green-deal-has-the-time-come-for-mediterranean-clean-energy/

RE is seen as putting an end to petroleum wars

Also potentially giving rise to international economic conflicts in the form of trade wars

Another branch of the renewed conflict camp

Leading to new types of conflict

Somehow different from those associated with fossil fuels

In a new international system *«there will be new types of conflicts, controversies, and unwelcome surprises»*

Critical materials are a major issue

Required for RE generation, distribution, storage technologies

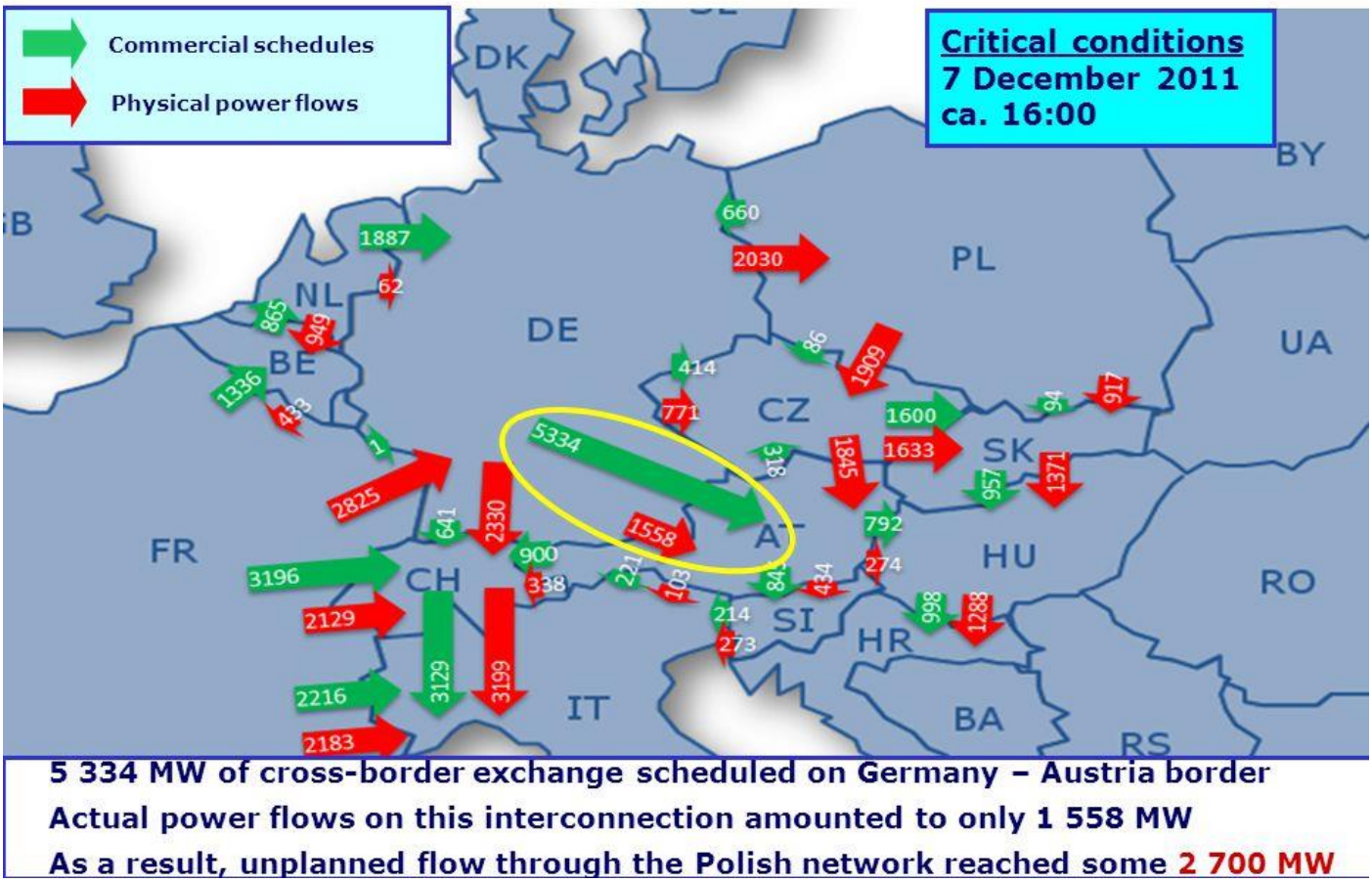
Could pose a similar dependence on countries that possess them

The geopolitical costs of a new dependence on rare earth materials could be even more dramatic than those in the previously observed dependence on oil

Another issue is the availability of electricity at the right time, due to the intermittent nature of renewables

Disputes between Germany and its neighbors

Unwarranted cross-border electricity flows triggered by excessive wind power production



Increased risk of cyber attacks

Reduced conflict camp

Geopolitical tensions are less likely in a world that has renewables as its main sources of energy

It is more difficult to control, cut the supply or manipulate the price of RE than fossil fuels

The expansion of renewables will lead to

greater energy self-sufficiency

less conflict

The focus shifts from the external to the internal supply of energy

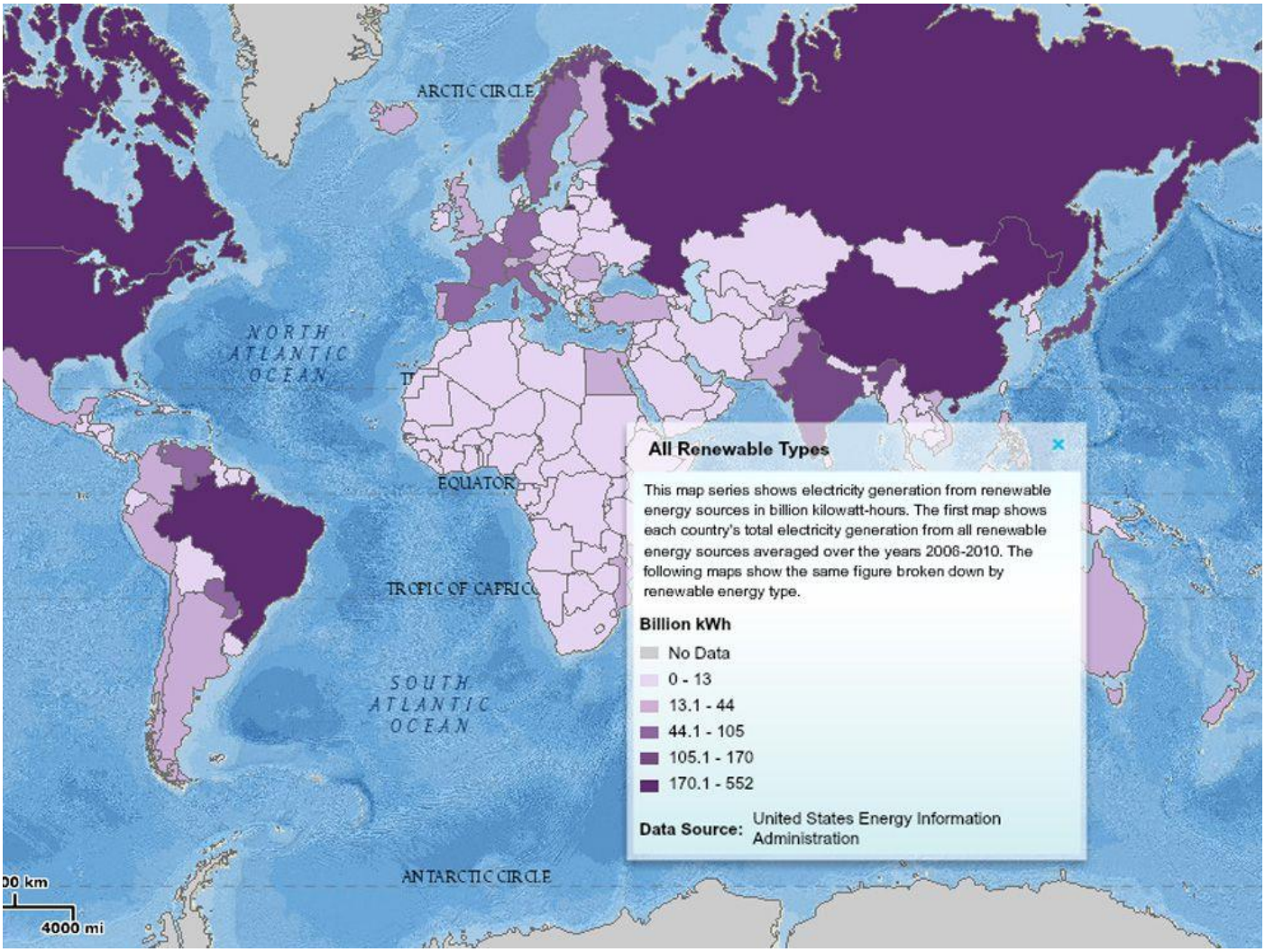
Reduces the scope of conflict among states

Renewables are more difficult than fossil fuels to manipulate

Less dense

More evenly distributed geographically

Interactive maps at https://ourworldindata.org/renewable-energy



- Due to its geographic and technical characteristics
  - RE creates few geopolitical motivations for states to start conflicts in order to control it
- Developing RE would lead to reduced geopolitical tensions due to
  - more equitable energy distribution
  - energy-based economic power
- Geopolitical power will be more evenly distributed
  - After a complete transition to RE
- The creation of international solar energy partnerships would
  - have geopolitical advantages
  - reduce economic imbalances between the North and the South
  - eliminate conflicts over scarce resources

A resource scarcity perspective to the geopolitics of oil

- Triggers energy insecurity anxiety among states
- Justifies aggressive behavior in resource conflicts

Such a perspective is not simple to transport onto renewables

- Non exhaustible
- Abundant
  - Except for critical materials

Geopolitical arguments have been used to convince Israeli decision makers to adopt RE to

- reduce the country's energy dependence
- improve its security

Compared to fossil fuels in a system dominated by renewables

- Access to resources is less important than distribution and infrastructure management
- Energy dependence and security of supply lose geopolitical relevance
- Technical and regulatory aspects gain weight

Publications share the understanding that the location of RE resources is as important as that of fossil fuels

- However, location as a geopolitical concern is mainly relevant for the large scale
  - Not for the small scale, domestically oriented production and transmission of electricity from RE

Countries like Algeria, Mexico, Morocco, or transit countries, or actors like the Islamic State, could still try to leverage their geographical position

- In case of conflict, they could threaten to interrupt electricity supplies

Authors ask whether an external supply of electricity can be used as an energy weapon

- RE infrastructure could be an easy target for terrorists
  - the Desertec project
  - the location of biofuels

Production of electricity from domestic renewable sources

- Geopolitical tensions and risks may recede due to
  - falling energy imports
  - reduced interdependence between countries
- The geopolitical risks associated with domestically produced RE are close to zero

Small scale photovoltaics (PVs) and nuclear power technologies are likely to promote

- secure low-carbon transition with reduced geopolitical risks

The consumption of RE at the location of production will prevail over large-scale regional production and distribution

- It is more efficient and cost effective compared to
  - long-distance distribution of electricity

Such authors consider geographical location as less important for RE resources than for fossil fuels from a geopolitical perspective

There is a risk of local conflicts involving non-state actors

- Potentially caused by increased global competition for the land required for RE installations

Issue stuck between the two camps

- New interdependencies among states as a result of electricity interconnections
- Possible emergence of new and unfamiliar inner-state interdependencies
- More electricity interconnectors between countries
  - Greater interdependence
  - Reduced international security

- Division of costs and benefits among members of the integrated North Sea grid
  - Similar to the difficulties caused by major pipeline projects
- IR should benefit from renewables in many ways
  - Their distribution will not be exposed to the political and strategic dilemmas brought about by the dependence on hydrocarbons
- The use of hegemonic power to cut off transport bottlenecks will be greatly reduced
  - Increased rerouting possibilities
  - Decentralized power generation
  - Absence of global electricity connections
- Some tensions are possible due to increased interdependencies in areas like
  - high-voltage direct current transmission (HVDC)
  - *«Edison's rivals George Westinghouse and Nikola Tesla pounced on the shortcoming, and their system transforming and transmitting alternating current, or AC, has since become the norm all over the world.»*
  - https://www.ge.com/news/reports/power-play-edison-lost-war-currents-dc-networks-now-making-big-comeback
  - Understanding HVDC Transmission (https://youtu.be/U2cmkVunL_s)
- RE may
  - strengthen energy security
  - facilitate the emergence of new interdependencies among states

Agnostic group of scholars

- Implications of energy transition remain unclear
- Premature to draw conclusions about future geopolitical tensions

Creation of multiple, contrasting scenarios of the future renewable-geopolitics nexus

- Continental scenario
- National scenario
- The future energy system will likely be a mix of both
  - Still more conflict than present situation

The geopolitics of renewables will probably be different than the geopolitics of fossil fuels

- Peaceful or not
  - Some tensions will be alleviated
  - New challenges are likely to be created

Energy security concerns will shift

- from a strategic emphasis on (the location of) energy resources
- to a focus on energy distribution

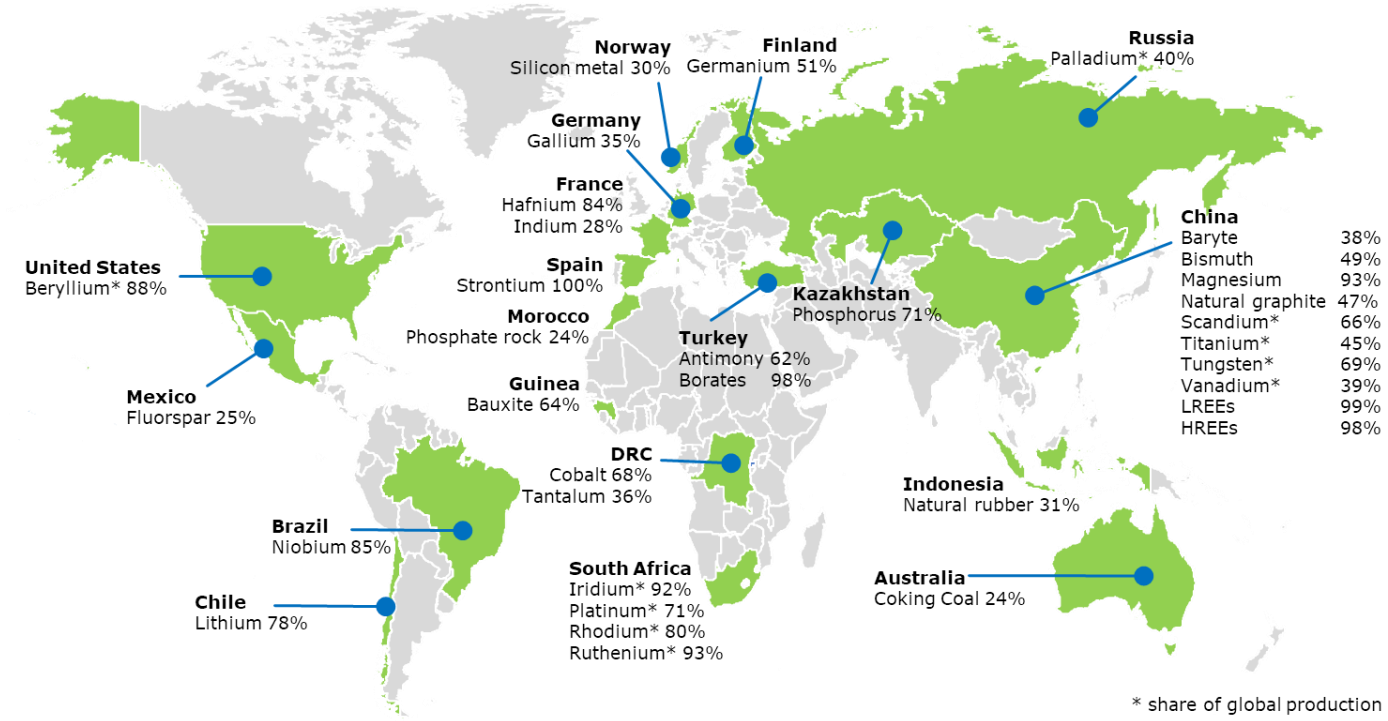
Power generation will see new challenges replacing the old ones

- Critical materials

Table 5
Critical materials for clean-energy technologies.

	Solar power	Wind power	Electric vehicles, storage
Bauxite & aluminium	x	x	x
Cadmium	x		
Chromium		x	
Cobalt		x	
Copper	x	x	x
Gallium	x		
Germanium	x		
Graphite			x
Indium	x		
Iron	x	x	x
Lead	x	x	x
Lithium			x
Manganese		x	x
Molybdenum		x	
Nickel	x		x
Rare earths		x	x
Selenium	x		
Silicon	x		x
Silver	x		
Tellurium	x		
Tin	x		
Titanium			x
Zinc	x	x	

Source of data: IISD [180], IRENA [76].



Energy security can be strengthened as a result of large-scale RE use in the long-run

Renewables are likely to carry security-related features similar to those of fossil fuels

(at least) during the transitional phase

Few scholars give concrete and detailed examples of the potential risks and conflicts

Decline of petrostates

3.2. Geopolitical winners and losers

A global transition to RE will lead to a geopolitical and strategic reshuffle

Emergence of new winners and losers

Fossil fuel exporters risk their fossil fuel assets becoming stranded

Their economies will weaken

Their geopolitical power will become nullified

Fossil fuels will become stranded

Petrostates will be affected

Their economic and geopolitical power will decline

The entrenched interests of the fossil fuel industry in a country's political, economic and social institutions have created a carbon lock-in

This has resulted in resistance to institutional change by fossil fuel players

The demand for the products of traditional hydrocarbon exporters will be affected

Countries that are industrial leaders in clean technologies will emerge as winners

Core components of RE

Technologies

Intellectual property

Obvious growth markets

- Producing and exporting large amounts of RE generation equipment or support services such as storage

When RE becomes the main source of energy

- Rise in cyberwars and trade conflicts
- Reduction in open conflicts over oil and gas
- Trade wars over technology exports

Scholars have tried to systematically work out which countries or regions are the main potential winners or losers

- Big oil exporters are likely to be hit particularly hard by the energy transition
  - Stranded geopolitical assets are likely for
    - Russia
    - Saudi Arabia
    - Nigeria
    - Venezuela
    - Brazil

Other scholars do not see Brazil as a potential loser

- Biofuels have
  - made Brazil a RE power
  - strengthened its position in international affairs

MENA (Middle East and North Africa) has significant advantages

- High levels of solar radiation
- Available space for RE infrastructure

Stability could improve in

- MENA
- Russia

Countries that will be winners because they will not need to import oil (and thus be alleviated of a significant burden)

- The US
  - Oil and petroleum products explained (US Energy Information Administration, https://www.eia.gov/energyexplained/oil-and-petroleum-products/imports-and-exports.php)
- China
  - Economic Update: China: Capitalist, Socialist or What? (https://youtu.be/3Tbf2bpgs-E)
- EU member states
- Japan

Contrary view

- China and the US lose more geopolitically due to their excessive dependence on fossil fuels (especially coal)

A typology of winners and losers in the transition to RE

- Country scores on three indicators

RE potential

Political receptiveness

Hydrocarbon lobby

Index of geopolitical gains and losses (GeGaLo)

156 countries

Indicators

Fossil fuel production ~ geopolitical losses (–)

Fossil fuel reserves ~ geopolitical losses (–)

RE resources ~ geopolitical gains (+)

Governance and conflict ~ capacity to handle changes in geopolitical strength

Table 3

Typologies of winners and losers.

Least and most exposed to EU energy transition [70]	Geopolitical winners vs laggards [99]		GeGaLo Index of 156 countries [101]
• Saudi Arabia (least exposed) • Qatar • Kazakhstan • Egypt • Libya • Russia • Algeria (most exposed)	Main winners: • Uruguay • Namibia • Kenya • Mali • Sweden • Finland • France • Nicaragua • Honduras • India • Jordan • Mongolia • Sri-Lanka • China • USA • Algeria	Main losers: • Brunei • Qatar • Bahrain • Kuwait • Timor-Leste • Trinidad & Tobago • Bhutan • Slovakia • Belize • Georgia • Bangladesh • Gabon • Samoa • Puerto Rico	Main winners: • Iceland (no. 1 in the index) • Mauritania (2) • Guyana (3) • Bhutan (4) • New Zealand (5) • Uruguay (6) • C. African Rep. (7) • Mauritius (8) Main losers: • Nigeria (149) • Sudan (150) • Venezuela (151) • Qatar (152) • North Korea (153) • DRC (154) • Iraq (155) • Yemen (156)

Table 4
Overview of indicators.

	Sub-indicators	Sources
Fossil fuel dependency (FFD)		
Exports subtracted from imports, then subtracted from domestic production, divided by population, normalized 0–100, negative/positive values inverted	Coal	MIT 2018 [80]
	Oil	MIT 2018 [80]
	Gas	MIT 2018 [80]
Fossil fuel resources (FFR)		
Resources divided by population, normalized 0–100, inverted to negative values	Coal	UN 2015 [81]
	Oil	CIA 2018 [82]
	Gas	CIA 2018 [83]
Renewable energy sources (RES)		
Calculated as GWh, the three indicators summed up, divided by population, normalized 0–100	Solar	NREL 2018 [84]
	Wind	NREL 2018 [85]
	Hydro	UN 2015 [81]
Governance (G)		
Normalized 0–100 or 0–1, depending on index version	Governance	WB 2018 [86]
Conflict (C)		
Normalized 0–100 or 0–1, depending on index version	Conflict	IEP 2018 [20]

Note: CIA = Central Intelligence Agency; EIA = Energy Information Administration; IEP = Institute for Economics and Peace; MIT = Massachusetts Institute of Technology; NREL = National Renewable Energy Laboratory; UN = United Nations; WB = World Bank.

Table 6
Versions of index.

No.	Formula	Description
1	FFR + RES	Basic index with only fossil fuel reserves and renewables.
1b	FFR * ([G + C]/2) + RES	Adds weighting of fossil fuels by governance and conflict.
2	FFR + FFD + RES	Back to basic index, now with two fossil fuel indicators.
2b	(FFR + FFD) * ([G + C]/2) + RES	Adds weighting of fossil fuel by governance and conflict.
3	FFR + FFD + RES + G + C	All indicator groups simply added up with equal weights.

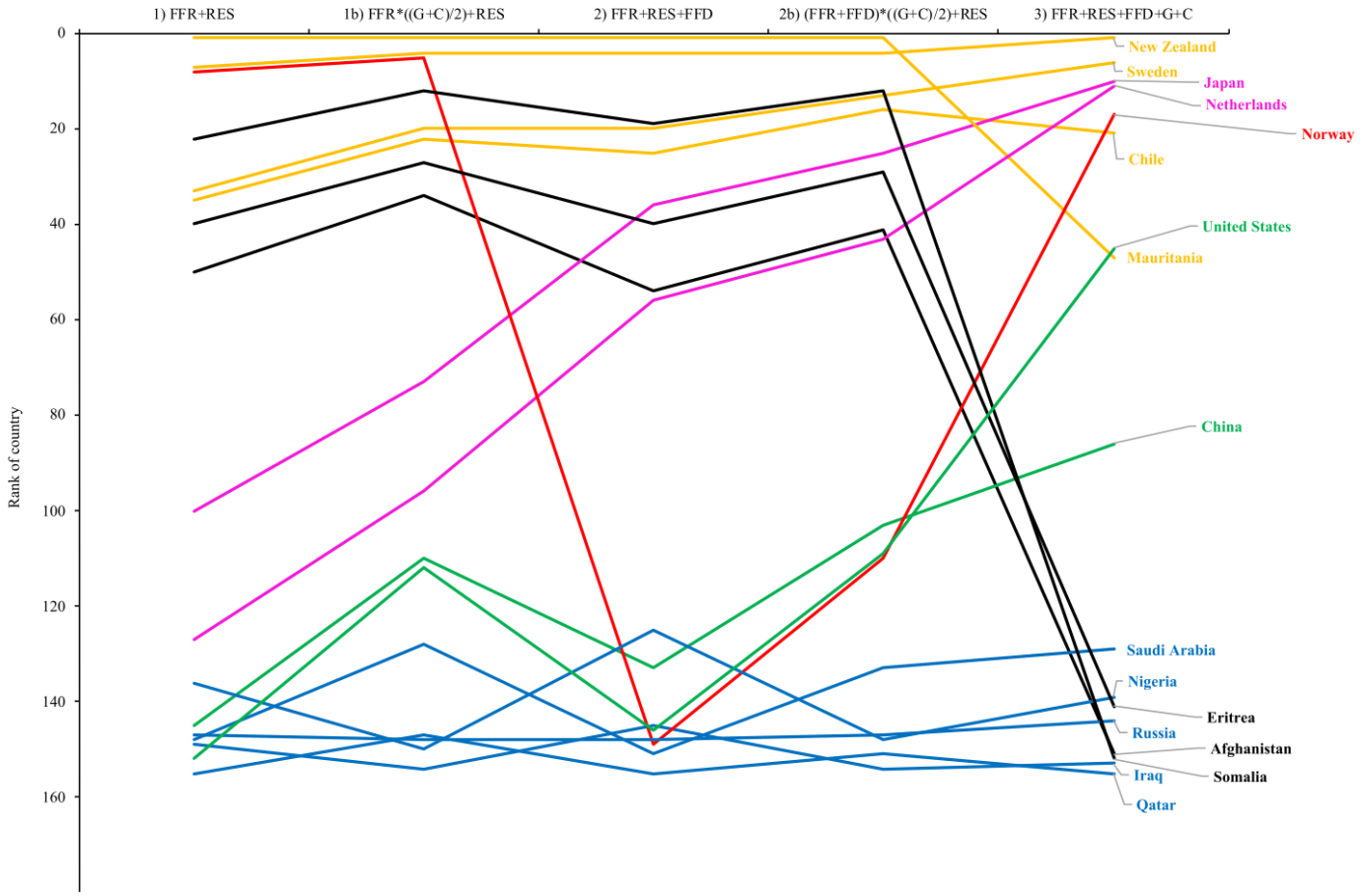


Fig. 4. Selected countries compared across five index versions.

Table 7
Comparison of GeGaLo version 2b with Van de Graaf and Smith Stegen.

	Van de Graaf	GeGaLo	Smith Stegen
			Algeria
		Bhutan (4)*	*China*
		Brazil (27)	Finland
		Finland (22)	France
		France (37)	Honduras
		Georgia (24)	*India*
		Honduras (52)	Jordan
		Japan (26)	Kenya
		Jordan (57)	Mali
		Kenya (64)	*Mongolia*
		Mali (11)	Nicaragua
	*China***	Nicaragua (31)	*Sri Lanka*
	Europe	Slovakia (53)	Sweden
	Japan	Sweden (14)	*USA*
GAINERS	*USA*	Uruguay (6)	Uruguay
LOSERS	*Brazil*	Algeria (132)	Bahrain
	Nigeria	Bahrain (130)	Bangladesh
	Russia	Bangladesh (96)	*Bhutan*
	Saudi Arabia	China (104)	Gabon
	Venezuela	Gabon (122)	*Georgia*
		India (97)	Kuwait
		Kuwait (146)	Qatar
		Mongolia (113)	*Slovakia*
		Nigeria (149)	Timor-Leste
		Qatar (152)	Trinidad and T.
		Russia (148)	
		Saudi Arabia (134)	
		Sri Lanka (83)	
		Timor-Leste (103)	
		Trinidad and T. (125)	
		USA (110)	
		Venezuela (151)	

Notes: Countries marked with italics diverge significantly from GeGeLo index. Numbers in parentheses represent ranks in GeGaLo.

Australia, Canada, and Norway

Likely to lose substantial revenues from fossil fuel exports

- More economic resources to adapt to the energy transition than other hydrocarbon countries

Scant methodological explanation

- How countries will become winners or losers
- Why some countries might be more vulnerable than others
- Potential response strategies of the (so-called) losers

Simplistic dichotomy

- Advanced RE leaders will win the day
  - Prospective winners will promote the full-scale adoption of RE
- Traditional fossil fuel exporters will lose out
  - Prospective losers will drag their feet on energy transition and stick to fossil fuels

Saudi Arabia and the United Arab Emirates

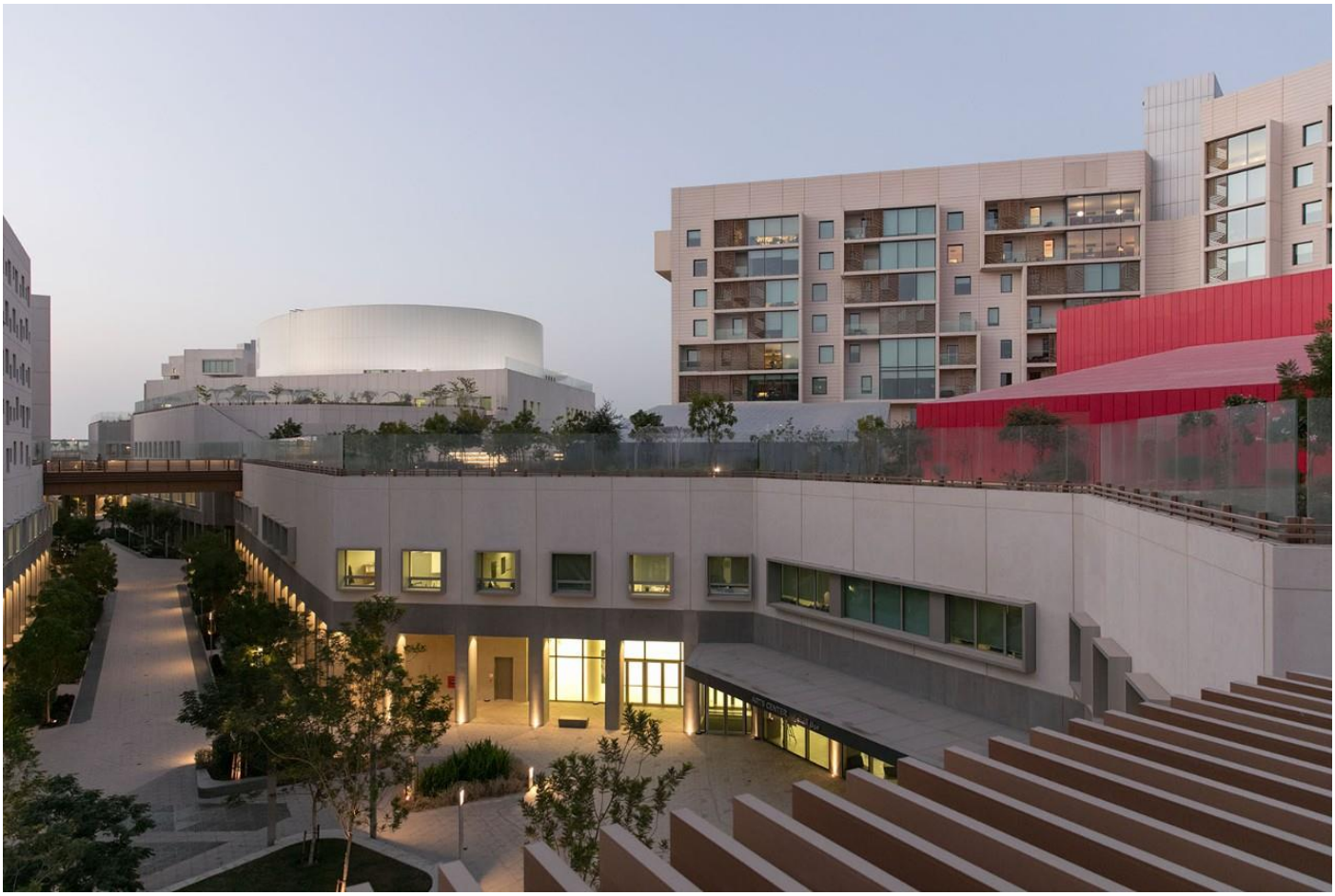
- Became increasingly aware of the risks that the energy transition poses to them
- Started to introduce measures
  - Increasing the RE share in their energy supply for domestic consumers
  - Diversifying their financial holdings
  - Partially privatizing national oil companies

National and Emirate capitals

Abu Dhabi

Louvre Abu Dhabi: first look inside the £1 billion art museum in the desert (https://www.telegraph.co.uk/travel/destinations/middle-east/united-arab-emirates/abu-dhabi/articles/louvre-abu-dhabi-first-look-review/)

NYU Abu Dhabi Campus Tour (https://youtu.be/LC2akgHek0Q)



Such efforts may

- lessen negative consequences
- render black and white images of winners and losers less relevant