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# Energy Geopolitics

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**Summary**
For energy security and geopolitics, the control of energy reserves and resources, of transportation routes and critical production steps are essential. This working paper provides an introduction into energy geopolitics by analyzing the control of energy reserves and resources, of transportation routes, critical production steps and the actual topics.
If the nation states implement their policies without any further additions, changes or developments, oil, coal, and gas will still dominate the global energy production. The Middle East will keep its position as important oil producer, the year 2030 will definitely not be the time 'after the oil'. Nuclear energy keeps a small, but stable proportion.
Renewable energy production will increase from 74 to 116 Exajoules, but will still be a small proportion of the total energy production of 673 Exajoules in 2030. The energy supply can cover the energy demand, i.e., there will be no 'energy crisis'. This does not exclude temporary supply crises (e.g., the Russian gas restrictions in 2022). Due to decarbonization policies, the carbon dioxide ($CO_2$) emissions can be stabilized, but will not decline (there are further sources of $CO_2$ emission as well, such as agriculture). The decarbonization will be mainly done by replacing fossil energy with electricity from other sources. The use of renewable energy for electricity is increasing and will be already close to fossil fuels in 2030. But while fossil fuels (oil, gas, coal) will decrease in the global energy mix, even for 2050 a proportion of 60% is expected.
Compared to the presented moderate scenario there are more ambitious alternative scenarios in literature based on the Climate Goals from Paris 2015, where renewables will mostly replace all other forms of energy until 2050, but the states already struggle with the energy transformation and the climate goals. The Intergovernmental Panel on Climate Change (IPCC) noted for example that despite progress, adaptation gaps exist, and will continue to grow at current rates of implementation. The World Meteorological Organization (WMO) expects that global warming will reach the 1.5°C level already between 2023 and 2027 with 66% likelihood and not in 2050. The energy transition is not done with the same speed and intensity all over the globe and the production of renewables cannot fill the gaps if fossil fuels would be removed as part of the decarbonization strategy.
Due to the size of its population and economy, the leadership of China in many energy sectors could be expected, but its overproportioned control of renewable resource markets and rare earths and critical minerals shows that the turn to renewable and clean energies creates new dependencies and capital transfers for the Western states. Geopolitical topics are the steadily growing influence of China and the Shanghai Cooperation Organization SCO in Central Asia, the European dependency from Russian gas which now requires a massive transformation of energy sources like Liquid Natural Gas (LNG) and the intense competition between United States and China, in particular in the Gulf and MENA region.

## Content

# 1. Introduction

For energy security, the control of energy reserves and resources, of transportation routes and critical production steps are the focus of energy geopolitics.

After World War 2, the Western industry states became increasingly dependent from oil imports, in particular from the *Organization of the Petroleum Exporting Countries (OPEC)* which was founded in 1960 with 5 member states Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela and expanded stepwise with Algeria, Angola, Congo, Equatorial Guinea, Gabon, Libya, Nigeria, and United Arab Emirates[1]. The aim of the OPEC was not only to control prices, but also its own resources which were originally often controlled by Western multinational companies. At the same time, the communist Soviet Union could rely on its own fossil resources in Russia and Central Asia.

The *Yom Kippur War* of 1973 led to an oil embargo by Saudi-Arabia and in response by the industry states to the creation of the *International Energy Agency IEA* within the *Organization for Economic Co-operation and Development (OECD)* in 1974 with the focus on energy security and strategic oil reserves[2]. The IEA is closely observing and reporting about the global energy market until today. While the oil embargo was only a temporary event, the OPEC realized its market power and the rising oil prices led to a growing wealth in the Gulf Region and a massive capital transfer from the West to the oil producers. When the wealth and investments of the oil states increased, this limited their options as they could not afford strict oil production cuts anymore[3]. After the end of the cold war, the OPEC tried to coordinate their activities with non-OPEC members, such as Russia in the OPEC+ format in 2019[4]. In principle, the imbalances on the oil market existed also for gas where only a few main producers exist, such as Qatar.

The main alternative to fossil fuels after World War 2 was the nuclear energy which had setbacks due to accidents of Chernobyl and Fukushima where radioactive material was released. Also, coal was still used, but from 1925 to 2015, the share of coal in the global energy mix decreased from 82.9% to 29.4%[5]

A major shift in the past decade was the rapid growth of Chinese energy production and demand due to its economic growth and the change of the United States from a net oil and gas importer to a net exporter after the *shale revolution* which gives the US a strong position in the energy sector[6].

In the 21st century, the climate change and *greenhouse gas (GHG)* emission caused by fossil fuels became an increasingly urgent problem. Within the *United Nations Framework Convention on Climate Change (UNFCCC)* with 197 members, the *Paris Agreement 2015* at the *UNFCCC's conference of parties 21 (COP21)* resulted in voluntary obligations to limit anthropogenic GHG emissions to limit global temperature increase to 1.5°C. In a broader context, this activity is part of the United Nation's *Sustainable Development Goals* [7].

The *decarbonization strategy* has an environmental and a strategic dimension[8] and should happen by using and producing electric energy from alternative sources which are renewable energies and nuclear power, e.g., like Sweden which uses both renewable energy and nuclear

[1] Qatar removed its OPEC membership in November 2018 after tensions with its neighbors and to focus on its role as gas producer, IEEE 2019
[2] Hübner 2015
[3] Siripurapu/Chatzky 2022
[4] IEEE 2019, Katulis et al. 2022
[5] Lehmann 2017
[6] Siripurapu/Chatzky 2022
[7] Hafner/Tagliapietra 2020
[8] National Intelligence Estimate 2021

power. This also includes the development and promotion of e-mobility, i.e., electric cars. Electric Vehicles (EVs) with lithium-ion batteries as energy storage medium are the globally dominant solution, but an important difference between oil and lithium is that lithium is only an energy storage medium and the stored energy needs to come from external electricity sources, e.g., renewable energy or nuclear power[9]. Also, carbon removal technologies are under investigation[10]. The switch should also significantly reduce the massive capital transfer from the West to the oil and gas producers. The geopolitical difference is also known as difference between 'Electro states' and 'Petrostates'.

Renewable energies like solar energy (photovoltaic PV) and wind turbines, but also lithium batteries for electric cars are complex technologies which require specialized production capacities and minerals. The access to critical minerals is crucial. These areas can create new dependencies, and one of the key questions of modern energy geopolitics is who controls the technology production for renewables. The fight against plastic pollution, e.g., caused by microplastic, is part of the decarbonization strategy as plastic is an oil product.

This working paper provides an introduction into energy geopolitics by analyzing the control of energy reserves and resources, of transportation routes and critical production steps and the actual topics.

# 2 Energy supply and demand

## 2.1 Overview

Table 1 provides the world energy supply in Exajoules (1 joule x $10^{18}$)[11].

**Table 1 World energy supply in Exajoules**

| | 2021 | 2030 |
|---|---|---|
| **Total** | **624** | **673** |
| Oil | 183 | 197 |
| Coal | 165 | 151 |
| Natural gas | 146 | 151 |
| Nuclear | 30 | 37 |
| Renewables, thereof: | 74 | 116 |
| Solar | 5 | 18 |
| Wind | 7 | 17 |
| Hydro | 16 | 18 |
| Bioenergy* | 41 | 56 |
| Traditional use of Biomass | 24 | 20 |
| Other | 5 | 8 |
| **Top supplier states** | | |
| China | 156.8 | 166.4 |
| United States | 91.4 | 87.3 |
| India | 39.5 | 53.3 |
| European Union | 59.3 | 53.2 |
| Africa | 36.4 | 44.0 |
| Middle East | 34.8 | 41.8 |
| Russia | 33.6 | 41.8 |
| **Co2 Emissions (Megatons)**** | **36639** | **36211** |
| *Energy content in solid, liquid and gaseous products derived from biomass feedstocks and biogas such as liquid biofuels and biogases Source IEA Energy Outlook 2022, STEPS scenario<br>**Includes emissions from industrial processes and flaring | | |

[9] National Intelligence Estimate 2021
[10] National Intelligence Estimate 2021
[11] IEA 2022. Peta = $10^{15}$, tera = $10^{12}$ (trillions), giga = $10^{9}$ (billions), mega = $10^{6}$ (millions).

The statistics in this working paper are based on the so-called *Stated Policy Scenario (STEPS)* of the *International Energy Agency IEA* which is based on the current energy and environamental policies as they currently are[12]. This scenario is moderate as this only assumes that states implement their policies without any further additions, changes or developments. The complexity and uncertanties of future energy and environmental policies explain why scenarios differ in literature and makes it difficult to make robust predictions for 2050[13]. However, literature widely agrees that in future decades renewable energy will be increasingly important, if not leading and also hydrogen as clean energy will become more relevant.

As China and India together have 2.8 billion people and China is already the second largest global economy, China and the Asia-Pacific region dominate the energy statistics, typically followed by the United States as the largest global economy, but with less people. In 2021, 4.250 of 7.835 million people lived in Asia-Pacific, while 335 million people lived in the United States[14].

There are more ambitious alternative scenarios in literature where renewables will mostly replace all other forms of energy until 2050[15], but while these scenarios make sense from an environmental perpective, the states already struggle to achieve the climate goals from 2015, see Section 3 of this paper.

Table 1 shows that oil, coal and gas will still dominate the global energy production. The Middle East will keep its position as important oil producer, the year 2030 will definitely not be the time 'after the oil'. Nuclear energy keeps a small, but stable proportion.

Renewable energy production will increase from 74 to 116 Exajoules, but will still be a small proportion of the total energy production of 673 Exajoules. The energy supply is able to cover the energy demand, i.e., there will be no 'energy crisis'. This does not exclude temporary supply crises (such as the Russian gas restrictions during since the attack on the Ukraine on 24 Feb 2022).

Due to decarbonization policies, the carbon dioxide $CO_2$ emissions can be stabilized, but they will not decline (there are further sources of $CO_2$ emission as well, such as agriculture). The decarbonization will be mainly done by replacing fossil energy by electricity from other sources.

[12] IEA 2022
[13] IRENA 2022
[14] IEA 2022
[15] IEA 2022, IRENA 2022

## 2.2 Electricity

The global electrification trend is shown in Table 2.

**Table 2 World Electricity Production in Terawatthours (TWh)**

| | 2021 | 2030 |
|---|---|---|
| **Total** | **28334** | **34834** |
| Fossil fuels | 17436 | 16323 |
| Renewables | 8060 | 15073 |
| Nuclear | 2776 | 3351 |
| Hydrogen and ammonia* | 0 | 9 |
| **Top producers** | | |
| China | 8539 | 11136 |
| United States | 4371 | 4625 |
| European Union | 2963 | 3238 |
| *Ammonia $NH_3$ with its higher energy density is used for $H_2$ storage and trade Source IEA Energy Outlook 2022, STEPS scenario | | |

The use of renewable energy for electricity is increasing and will be already close to fossil fuels in 2030. However, electricity is only a part of the global energy demand, as e.g., fuels and heat need to produced as well. While the production in US and European Union will only slightly increase, Chinas electricity production will expand by more than 20%[16].

A critical strategic issue is the energy need for electric vehicles with a growing demand for electric power[17]. The projected number of new electric and hybrid cars underestimates the lithium battery and energy demand, because the average batteries may become larger and dense to increase the range of the cars and also to allow the construction of electric busses and trucks. The electric grid will also be stretched by other clean technologies like the heat pump. As a result, already now there are concerns that current electric grids could be stretched by clean technologies[18].

## 2.3 Fossil energy

### 2.3.1 Oil

Table 3 shows the expected oil production and demand.

**Table 3 World oil production and demand in million barrel per day (mb/d)**

| | 2021 | 2030 |
|---|---|---|
| **Total** | **90.3** | **99.9** |
| **Top producers** | | |
| Non-OPEC | 58.8 | 64.0 |
| OPEC | 31.5 | 35.9 |
| Middle East | 27.9 | 33.9 |
| North America | 24.4 | 28.6 |
| **Top consumers** | | |
| United States | 17.7 | 16.7 |
| China | 15.1 | 16.2 |
| European Union | 9.2 | 7.7 |
| Source IEA Energy Outlook 2022, STEPS scenario | | |

[16] IEA 2022
[17] Proedrou 2023
[18] Klatt 2023

In 2022, the top producing countries covering almost half of the global production were the United States with 20.2 million barrel per day (mb/d), Saudi-Arabia with 12.1 mb/d, Russia with 10.9 mb/d, Canada with 5.7 mb/d and China with 5.1 mb/d. The top 10 producers of covered 73% of the production of crude oil, petroleum liquids and biofuels[19].

Private companies play an important role in oil trade, the top 4 companies with more than 200 billion US-Dollar market capitalization are *Aramco* (Saudi-Arabia) with 2081 billion dollars, *ExxonMobil* (US) with 425 billion dollars, *Chevro*n (US) with 298 billion dollars, *Royal Dutch Shell* (UK/NL) with 200 billion dollars, closely followed by *PetroChina* with 186 billion dollars[20]. Due to the ownership structure, *Aramco* is factually still under sole control of Saudi-Arabia and *PetroChina* of China.

The oil-based energy production will increase further. The OPEC is not the market leader, but will continue to control approximately one third of the global production. Within the OPEC, the Middle East will maintain its dominant position. The most important change in the past decade was that the United States are now net exporter of oil based on shale oil exploitation and not dependent from the OPEC anymore.

The current proven oil reserves are 1752 billion barrels[21], thereof 887 billion barrels in the Middle East and 6192 billion barrels of potential resources, thereof 2424 billion barrels in North America and 1139 billion barrels in Middle East[22].

The IEA expects in their moderate state policies-scenario an increase of oil-derived liquids, from 92.8 million barrels per day (mb/d) in 2021 to 100.8 mb/d in 2030 and constant demand until 2050 with 100.5 mb/d. While fossil fuels (oil, gas, coal) will decrease in the global energy mix in the long run, even for 2050 a proportion of 60% is expected, i.e., fossil products will still dominate the global energy market[23]. In other words: the time ‘after the oil’ may come in some developed industry states sooner, but globally, this will happen several decades in the future. Even the oil-producing Gulf states expected this timepoint earlier which is reflected by diversification plans of their oil-based economies which typically target the years 2030 and 2035[24].

Decarbonization will be challenging, as important petrochemical products depend on oil and natural gas as basis. Oil is the basis of naphtha, which is transformed to basic chemicals like ethylene, propylene, butadiene, olefines, benzol, toluol, xylol, hydrogen, methane, heavy oil while gas is needed for methanol and ammonium production. These substances are the basis for thousands of chemical products[25].

[19] EIA 2023
[20] Companiesmarketcap.com 03 Aug 2023
[21] If 99 million barrels are produced per day, the proven reserves of 1752 billion = 1752000 million barrels would cover 48 years.
[22] IEA 2022
[23] IEA 2022, Figure 1.9, STEPS scenario
[24] IRENA 2019
[25] Tang 2023

### 2.3.2 Natural Gas and LNG

Table 4 shows the expected gas production and demand.

**Table 4 World gas production and demand**

| | 2021 | 2030 |
|---|---|---|
| **World gas production in billion cubic meters (bcm)** | | |
| **Total** including: | **4149** | **4372** |
| Conventional gas | 2964 | 2962 |
| Shale gas | 790 | 995 |
| **Top producers** | | |
| North America | 1189 | 1283 |
| Eurasia | 998 | 831 |
| Middle East | 660 | 853 |
| **Top consumers** | | |
| United States | 17.7 | 16.7 |
| China | 15.1 | 16.2 |
| European Union | 9.2 | 7.7 |
| **Natural gas energy generation in Terawatthours (TWh)** | | |
| **Total** | **6551** | **6848** |
| **Top producers** | | |
| United States | 1641 | 1555 |
| Middle East | 888 | 1198 |
| Russia | 535 | 589 |
| Southeast Asia | 361 | 529 |
| China | 291 | 345 |
| Source IEA Energy Outlook 2022, STEPS scenario | | |

The gas production is expected to increase this decade; while conventional gas production will remain stable, shale gas will be increasingly important. As for the other fossil resources oil and coal, the United States are the top producer with large potential resources. The Middle East can expand its production and will keep its strong market position. In Eurasia, Russia, and Turkmenistan[26] have large gas fields and production capacities.

With exception of the Russian company *Gazprom*, the largest global natural gas producers are combined oil and gas producing companies. *Gazprom* is by far the largest producer in 2021 with 515.6 billion cubic meters which equals 18.2 trillion cubic feet (tcf). The next largest producers are *China National Petroleum (PetroChina)* with 4.4 tcf, *ExxonMobil* with 3.1 tcf, BP with 2.9 tcf and *Chevron* with 2.8 tcf.[27]

The current proven gas reserves are 219 trillion cubic meters (tcm), thereof 81 tcm in the Middle East and 69 tcm in Eurasia (mainly Russia and Turkmenistan), while there are 806 tcm of global potential resources, thereof 120 tcm in the Middle East and 168 tcm in Eurasia, but also 148 tcm in North America and 138 tcm in Asia-Pacific [28], i.e., the future market will see additional global providers[29].

Currently, there are three main clusters of natural gas pipelines, in North America with a focus on the US East Coast, in Europe and Russia where Russian pipelines are directed to Western

[26] Turkmenistan had in 2013 17.5 trillion cubic meters proven gas reserves, Smith Stegen/Kusznir 2015
[27] Investopedia 2023
[28] IEA 2022
[29] IEA 2022

Europe and in China. There is only little physical connectivity between Russia and China which is now a strategic challenge as it is difficult for Russia to redirect gas trade quickly to China.[30]

In 2022, the EU still imported 81.3 billion cubic meters of Russian gas through Ukraine and Türkiye for almost €60 billion, compared to 154 billion cubic meters in 2021, respectively[31]. Europe tries to switch the gas supply to Western democratic states like the United States by *Liquid Natural Gas (LNG)* shipping, Norway, and other providers. This means that US will replace Russia as most important gas supplier until 2030. In 2021, Russia followed by Norway provided most of the gas to Europe while in 2030, the United States are expected to be the main provider, again followed by Norway.

The countries with the largest LNG export capacities in 2022 were Australia with 87.6, Qatar with 77.4, United States with 73.9, Malaysia with 31.5, Algeria with 29.3 and Russia with 28.9 million metric tons per year.

Private companies play an important role in LNG trade. The largest companies by LNG storage capacity in 2022 were *QatarEnergy* with 56.2, *Cheniere Energy* (US) with 44.5, *Royal Dutch Shell* (UK/NL) with 40.7 and *Petronas* (Malaysia) with 29.6 million metric tons per year. Fruther large companies are *Sonatrach* (Algeria), *ExxonMobil* (US), *TotalEnergies* (France), *Chevron* (US) and *BP* (UK)[32]. Instead of pipelines, shipping plays a major role for LNG supply, the largest shipping companies are *ExxonMobil, Chevron, Royal Dutch Shell*, the *China National Petroleum Corporation* and *TotalEnergies*[33].

The LNG shipping requires to liquify, transport, and regasify natural gas which makes LNG more expensive than natural gas. Energy security by LNG will mean higher gas prices for consumers[34].

### 2.3.3 Coal

From 1925 to 2015, the share of coal in the global energy mix decreased from 82.9% to 29.4%[35]. The role of coal will be declining in global energy production, but it is still used for electricity production in power plants.

The world coal production was 5826 megatons coal equivalent (mtce) in 2021 and is expected to decline to 5149 mtce in 2030, in North America from 478 mtce to 188 mtce. The Asia-Pacific region is by far the largest main producer with 4428 mtce in 2021 and 4282 mtce in 2030, which will be almost completely needed for the own demand of 4460 mtce in 2021 and 4444 mtce in 2030[36].

In line with these figures, the energy generated with coal in Terawatthours (TWh) was 10202 TWh in 2021 and is expected to decline to 9049 TWh in 2030, in North America from 994 TWh to 188 TWh. In the Asia-Pacific region, China is the main producer with 5363 TWh in 2021 and 5239 TWh in 2030, followed by India with 1234 TWh in 2021 and 1504 TWh in 2030[37].

Of the proven coal reserves of 1024 billion tons, the majority is located in Asia-Pacific with 460 billion tons, followed by North America with 257 billion tons and Eurasia with 191 billion tons. The potential global potential reourcesces are much higer with 20803 billion tons, thereof 8974 billion tons in Asia-Pacific and 8389 billion tons in North America. The use of coal is

[30] IRENA 2022
[31] DeJong 2023
[32] Statista 2023
[33] Marine digital 2023
[34] CSCE 2019
[35] Lehmann 2017
[36] IEA 2022
[37] IEA 2022

environmentally problematic due to the emissions and is therefore a main target of decarbonization; on the other hand, its reserves and resources could last for centuries.

## 2.4 Nuclear energy

As mentioned above, nuclear energy will keep a small, but stable proportion of energy production. From the environmental perspective, nuclear energy can provide a stable energy supply (which solar and wind energy sometimes cannot) and is greenhouse gas (GHG) emission-free, but there is the risk of accidents with radioactive fallout as in Chernobyl and Fukushima and as long-term problem the handling and storage of nuclear waste. Nuclear energy fits with the decarbonization strategy and oil-rich countries like Saudi-Arabia are planning nuclear energy plants to prepare for the time after the oil.

But nuclear energy has also a military and strategic dimension. The products enriched uranium and plutonium can be used for nuclear bombs, but nuclear reactors are also important for large very-long range submarines (and maybe needed for space travel as well[38]). The dual-use aspect of nuclear energy raises concerns if countries want to set up nuclear programs.

The nuclear energy generated in Terawatthours (TWh) was 2776 TWh in 2021 and is expected to inrease to 3351 TWh in 2030, in the United States only slightly from 813 TWh to 807 TWh, followed by the European Union with 733 TWh in 2021 and 656 TWh in 2030 and China which will massively expand its production from 408 TWh in 2021 to 643 TWh in 2030[39].

Of the 32 countries with nuclear power plants in 2021, only France, Slovakia, Ukraine and Belgium use nucear energy as main source of electric power[40].

The uranium demand for reactors is globally stable since 2005 with around 65.000 tons per year. The demand is covered by mining and recycling. About two-thirds of the uranium mining production comes from Kazakhstan, Australia, Namibia and Canada. The standard mining method is meanwhile *in-situ leaching* with 56%. Uranium is typically dried and packed as $U_3O_8$[41].

While Kazakhstan is by far the largest producer, the largest owner of the estimated global resources of 6 million tons is Australia (28%), followed by Kazakhstan (13%), Canada (10%), and Russia and Nambia (both 8%)[42].

While US is focused on uranium-based technology, China is currently evaluating an alternative concept of nuclear energy, the *thorium-based molten salt reactors*. This technology has the major advantage that the nuclear process is self-limited in case of thermal expansion, i.e., no risk of severe nuclear accidents of the Chernobyl or Fukushima type. Thorium is far more common and cheaper than Uranium. Thorium-Fluoride (ThF4) salt is very stable. Further, thorium reactors create less nuclear waste with substantially shorter half-life times of radioactivity, i.e., is promoted by its supporters as clean and safe nuclear energy[43]. The discussion to use thorium is as old as nuclear reactors are, but historically the chance to gain material for nuclear weapons was seen as key advantage of uranium-based technologies. China is testing two *thorium molten salt reactors* in the Gobi Desert region.

[38] USA 2019
[39] IEA 2022
[40] Wikipedia entry Nuclear power by country Last accessed 04 Aug 2023
[41] WNA 2023
[42] WNA 2023
[43] Cannara 2011

## 2.5 Renewable energy

The large majority of global investments in clean energy is done by Asia (China followed by Japan and India), the EU and the US which is in line with their leadership in renewable energy production.[44] In the European Union, Germany leads with almost 31,000 renewable energy patents and promotes its the'Energiewende' (energy transition) policy[45].

Table 5 shows the renewable energy production.

**Table 5 Renewable energy production**

| Energy generation in Terawatthours (TWh) | Renewables | | Wind | | Solar (Photovoltaic PV) | |
|---|---|---|---|---|---|---|
| | 2021 | 2030 | 2021 | 2030 | 2021 | 2030 |
| **Total** | **8060** | **15073** | **1870** | **4 604** | **1003** | **4011** |
| **Top producers** | | | | | | |
| China | 2466 | 4901 | 655 | 1543 | 326 | 1474 |
| United States | 874 | 2034 | 379 | 948 | 145 | 668 |
| European Union* | 1112 | 1971 | 396 | 893 | 151 | 461 |
| Source IEA Energy Outlook 2022, STEPS scenario<br>*In Europe in 2019, the largest producers were Germany with 242 TWh and Norway with 131 TWh; Siddi 2021 | | | | | | |

The renewable energy production will significantly increase within this decade and is expected to grow further in the following decades. Based on its much larger population and energy need, China is the top producer, followed by the United States and European Union. The remaining renewable production is based on bioenergy, i.e., energy content in solid, liquid and gaseous products derived from biomass feedstocks and biogas such as liquid biofuels and biogases.

The share of renewable energy in the European Union's energy mix increased to 20% in 2019, with a goal of 32.5% by 2030, but natural gas consumption increased as well, because gas is cleaner than oil and coal with less carbon dioxide emissions for the same amount of energy[46].

A special topic are biofuels such as ethanol and biodiesel. Politicians expect a significant contribution of biofuels to renewable energies. Oil crops and sugar require processing for use as food and fuel. In 2019, 207.5 million tons of vegetables were produced, such as palm oil, soybean oil, rapeseed oil and sunflower oil. The production of the main vegetable oils is quite concentrated, e.g., palm oil is mainly produced by Indonesia (57%) and Malaysia (27%).[47] However, biofuels may not be an alternative to largely replace fossil fuels, because if the European Union would replace 10% of petrol and diesel from fossil sources with biofuel from their own resources, this would need 75% of its arable land[48]. Biofuels contributes to food price increases and the real production costs are underestimated as the water usage is not considered[49].

For photovoltaic (PV) technology (solar energy), China produces about 80% of the polysilicon, 95% of wafers, 80% of cells and 70% of modules. Of the 14 largest PV companies in 2021, 10 were from China including the 4 largest while 2 companies are from US, and one from Canada and South Korea each[50].

[44] IEA 2023a
[45] IRENA 2019
[46] EPRS 2021
[47] FAO 2022
[48] Rey 2011
[49] ICA 2015
[50] Bosch/Rondón 2022; Wikipedia Entry List of photovoltaics companies Last access on 05 Aug 2023

China has almost 50% of the global wind turbine manufacturing capacity[51].

The overproportioned control of renewable resource markets by China shows that the turn to renewable and clean energies creates new dependencies and capital transfers for the Western states.

Historically, hydropower is the renewable energy with the longest history, but due to the climate change with a difficult future. The increasing frequency of severe droughts leads to a decline of hydropower energy and makes it less reliable. This is critical, because globally many regions rely on filled water reservoirs for hydropower generation. European hydropower generation declined by 15% (80 TWh) in 2022 to 460 TWh, the lowest level since 2004[52].

## 2.6 Hydrogen

Hydrogen gas is used for crude oil refining, ammonia synthesis (primarily for nitrogen fertiliser production) and methanol production for chemical products like plastic[53]. Around 120 million tons of hydrogen are produced globally, with China as largest producer and consumer of hydrogen. Hydrogen is meanwhile increasingly used as a fuel as it can be stored in fuel cells and generate heat of more than 1000°C without emitting $CO_2$. Burning hydrogen however emits nitrous oxide as a major air pollutant[54]. The role of hydrogen in the overall energy production is still small, but is expected to grow. The global hydrogen demand in Petajoule (PJ) is expected to grow from 13438 PJ in 2021 to 16822 PJ in 2030[55].

Hydrogen ($H_2$) is no primary energy source as it usually needs to be produced with input from other energy sources. There are a few small hydrogen gas pockets known as natural hydrogen or *gold hydrogen* in France, Mali, and the US[56]. Statistics that present $H_2$ as 'energy source' can therefore by misinterpreted, as most of it cannot be mined, drilled, leached etc. *Grey hydrogen* is produced by reforming or gasification of fossil fuels, *blue hydrogen* by reforming or gasification of fossil fuels with carbon capture while *green hydrogen* is produced with renewable energy[57].

Ammonia $NH_3$ with its higher energy density is used for $H_2$ storage and trade, but also as fertilizer and can produced with air (which contains nitrogen N), water and electricity. Frozen liquid hydrogen transportation is still in an early stage[58]. Various countries try to diversify the hydrogen imports by long-term contracts ('hydrogen diplomacy'), e.g., Germany, The Netherlands, Belgium, Japan and South Korea[59].

## 2.7 Critical minerals

Access to critical minerals and rare earth elements is critical for the modern geopolitics of energy. In addition to rare earths, lithium and cobalt are essential for the energy transition[60].

The production of minerals such as lithium, cobalt, nickel, and graphite will need to increase by nearly 500% by 2050 to meet the growing demand for clean energy technologies[61].

[51] Meidan 2021
[52] IEA 2023b
[53] IRENA 2022
[54] IRENA 2022
[55] IEA 2022
[56] IRENA 2022
[57] IRENA 2022
[58] IRENA 2022
[59] IRENA 2022
[60] Siddi 2021
[61] Wang et al. 2023

China had in 2010 a 97% market share[62] for rare industry metals such as niobium, germanium, indium, palladium, and tantalum. The high market share resulted from low prices of Chinese metals which led to resignation of most competitors; however, the search for and exploitation of such metals was then restarted resulting in decreased prices.

In 2022, Australia was the top producer of lithium with 61,000 tons, followed by Chile with 39,000 tons, China with 19,000 tons and Argentina with 6,200 tons, respectively[63]. China produces in early 2023 60% of the global lithium products and 75% of all lithium-ion batteries[64]. China controls 89% of the global lithium refining capacities while Chile contributes the remaining 11%[65].

China dominates the processing of further materials[66]. It refines 69% of nickel, 75% of cobalt, 40% of copper, and almost all graphite for batteries[67].

The top cobalt producers are *Glencore* (South Africa) with 19.3% and *Eurasian Natural Resources* (controlled by Kazakhstan) with 11.6%[68], but the *Democratic Republic of Congo* provides more than 70% of the global cobalt that is needed for batteries, wind generators, and digital technologies and China owns meanwhile 70% of Congo's mining industry[69]. To achieve this, China secured equity stakes and supply agreements with over half of the local cobalt producers[70].

The copper market is less concentrated, top producer is Chile with 27.8%, Peru with 10.4% and China with 8.3% and no company currently has more than 8.4% market share[71]. The nickel market looks similar, top producer is Indonesia with 39.4%, the Philippines with 12.5% and Russia with 8.9% and no company currently has more than 6.7% market share[72].

From a geopolitical perspective, the overproportioned control of critial minerals, rare earths and processing of these materials by China is strategically challenging for Western states.

# 3 Energy and Climate Policy

Compared to the presented moderate scenario there are more ambitious alternative scenarios in literature based on the Climate Goals from Paris 2015, where renewables will mostly replace all other forms of energy until 2050, but the states already struggle with the energy transformation and the climate goals.[73] The *Intergovernmental Panel on Climate Change (IPCC)* noted for example that despite progress, adaptation gaps exist, and will continue to grow at current rates of implementation[74]. The *World Meteorological Organization (WMO)* expects that global warming will reach the 1.5°C level already between 2023 and 2027 with 66% likelihood and not in 2050[75].

[62] Büschemann/Uhlmann 2010, p.19
[63] Vásquez 2023. The numbers presented in this section sometimes vary in literature, because the market is very dynamic and sometimes the numbers are based on estimates.
[64] Zhang 2023
[65] Sanchez-Lopez 2022
[66] Zhang 2023
[67] Bosch/Rondón 2022, Sanderson 2023
[68] Leruth et al. 2022
[69] van Wieringen/Fernández Álvarez 2022
[70] Meidan 2021
[71] Leruth et al. 2022
[72] Leruth et al. 2022
[73] IEA 2022, IRENA 2022
[74] IPCC 2023
[75] WMO 2023

Even for a 2°C global warming goal still 80% of coal, one-third oil, and half gas reserves would have to remain unutilized which is challenging[76]. But the IEA expects even for 2050 a proportion of 60% fossil fuels (oil, gas, coal) in the global energy mix, i.e., fossil products will still dominate the global energy market[77]. In addition, oil and gas are still needed for the petrochemical industry.

Important aspects are:

- Although the European Union *Green Deal* from 2019 foresees a carbon-neutral Europe by 2050, natural gas remains a key part of the energy mix as coal is phased out and renewable energy cannot fill the gap[78]. The share of renewable energy in the European Union's energy mix increased, but the natural gas consumption increased as well, because gas is cleaner than oil and coal with less carbon dioxide emissions for the same amount of energy. The climate change already negatively affects the production of hydropower[79].
- So far, the energy transition is primarily happening in larger economies, e.g., China, Japan and India in Asia-Pacific, the United States and the European Union EU, but even in the EU with different intensity.
- In 2019, 80% of the world population lived in countries which were fossil fuels net importers.[80] This includes many less and least developed countries who may not have the financial resources for the investments in energy transition (which in turn means that these countries may need foreign support).
- A widespread tool to reduce greenhouse gas GHG emissions are prices by ton of released $CO_2$, but in 2022, approximately 80% of the global GHG emssions had no price and further >10% of less than 10 US-Dollar per ton. Higher prices are only foreseen for a few percent of the emissions[81]. There is no coherent pricing system which bears the risk of market biases on favor of cheaper and 'dirtier' productions.
- The decarbonization with electrification of cars and energy production[82] (hydrogen, heat pumps) requires a significant expansion of electricity production and grids. It is uncertain whether the regional grids will suffice for the predicted consumption growth[83].

# 4 Energy geopolitics

Geopolitical topics are the steadily grwoing influence of China and the *Shanghai Cooperation Organisation SCO* in Central Asia, the European dependency from Russian gas which now requires a massive transformation of energy sources like *Liquid Natural Gas (LNG)* and the intense competition between United States and China, in particular in the Gulf and MENA region.

## 4.1 The New Great Game and Heartland Theory

At the beginning of the 19th century, US started to expand into the Pacific Area (Panama Channel, Philippines) which stimulated the development of geopolitical concepts. Halford MacKinder 1904 had the focus on land power. His idea was that Central and Eastern Europe form the strategically most important region called *Heartland* and that the European-Asian continent is the most relevant super-large island on the globe, thus called *World Island*. His concept is the most influential in geopolitical literature and US geostrategy until today: *"Who*

[76] Goldthau et al. 2018
[77] IEA 2022
[78] EPRS 2021
[79] IEA 2023b
[80] IRENA 2019
[81] IEA 2023c
[82] Proedrou 2023
[83] Klatt 2023

*rules Central and Eastern Europe, controls the Heartland. Who rules the Heartland, commands the World Island. Who rules the World Island, rules the World*". At the end of the cold war, the US Presidential security advisor Zbigniew Brzezinski re-freshed this concept and emphasized that the United States should keep their influence and presence in Europe[84]. At that time, China's economy was still small and not a major geopolitical and geoeconomic factor.

The dissolution of the Soviet Union resulted in independent states around the Caspian Sea which resulted in the so-called "*New Great Game*" for regional influence[85]. During the Afghanistan war, US military bases were established in 2001, but as demanded by the *Shanghai Cooperation Organization SCO*, American forces left Uzbekistan in 2005, and its only Central Asian airbase in Kyrgyzstan in 2014[86].

China and the SCO changed the focus from (military) geopolitics to geoeconomics, by construction of oil and gas pipelines from Central Asia to China, competition of Chinese companies (*China National Petroleum Corporation CNPC, China National Offshore Oil Corporation CNOOC, China Petroleum and Chemical Corporation SINOPEC* and *Petro China*)[87] with Western companies such as *Chevron, ExxonMobil*, and *BP* and rapidly growing trade relations[88].

In 2013, the *Belt and Road Initiative (BRI)*, formerly known as *One Belt, One Road (OBOR)* initiative (or as *New Silk Road* as reference to the historic silk road as most important Asian trade route), was set up and China engaged in meetings and various *Memoranda of Understanding (MoUs)* were signed with the states along the trade routes which reaches from China to Africa and Europe, but also into the Oceanian space. This includes cooperation in infrastructure, traditional and new energy, digitalization, trade, and non-traditional security like anti-drug trafficking and anti-terrorism[89].

The Caspian states turned to China as an alternative market and counterbalance to Russia[90]. As a result, the Caspian region has turned to the SCO and the *New Great Game* has ended. To say it with MacKinders terms, the Asian parts of the *World Island* are now seeking self-control.

[84] Brzezinski 1997
[85] The great game was a Russian-British regional competition in Central Asia in the 19th century
[86] Jiang 2022
[87] Chen/Fazilov 2018
[88] Chinas trade within the SCO increased around 20 times from 2001 to 2020; Achmad 2022
[89] Jiang 2022
[90] Smith Stegen/Kusznir 2015

## 4.2 Pipeline politics

Already in the 1980ies, Russia started to export gas in pipelines to Western Europe which was systematically expanded over time. All pipelines are owned by the Russia gas company *Gazprom*[91].

Table 6 presents the pipelines, their start date, and their capacity.

**Table 6 Russian gas pipelines**

| Pipeline | Direction | Start Date | Theoretical Capacity in billion cubic meters (bcm)/year |
|---|---|---|---|
| North Stream 1 | Russia via Baltic Sea to Germany | 2011 | 55 |
| North Stream 2 | Russia via Baltic Sea to Germany | [2022] | 55 |
| Yamal | Russia via Belarus to Germany | 1996 | 33 |
| Bratstvo/Brotherhood | Russia via Ukraine to Central Europe | 1984 | 146 |
| Turkstream | Russia via Black Sea to Türkiye | 2022 | 32 |
| Blue Stream | Russia via Black Sea to Bulgaria | 2003 | 11 |

(Source: consolidated from Wikipedia entry "Natural gas transmission system of Ukraine" and EPRS 2021)

The current export volume was 199 bcm in 2019 compared to more than 330 bcm transport capacity, i.e., there is a lot of over-capacity. From this perspective, the question is why *North Stream 2* was constructed since 2015 (and then destroyed by sabotage in 2022)? In 2009 already, there were tensions between Russia as producing country and Ukraine as transit state which motivated Russia to build bypasses[92]. The *Brotherhood* pipeline was already underutilized and the completion of *NorthStream 2* and *Turkstream* would worsen the situation for Ukraine by loss of transit fees[93]. Another problem is the steadily declining domestic gas production by the European Union.

For these reasons, the United States expressed security concerns as they found that thirteen European countries, mostly from the former Soviet bloc, were dependent on Russia for 50 to 100 percent of their domestic gas demand[94]. The United States tried to stop the *North Stream 2* construction by sanctions based on the *Protecting Europe's Energy Security Act (PEESA)* from 2019. Despite United States experts considered *Turkstream* as equally dangerous[95], United States did not stop the activation of *Turkstream*.

In 2022, the EU still imported 81.3 billion cubic meters of Russian gas through Ukraine and Türkiye for almost €60 billion, compared to 154 billion cubic meters in 2021[96]. Europe tries to switch the gas supply to Western democratic states like the United States by *Liquid Natural Gas (LNG)* shipping, Norway, and other providers. This means that United States will replace Russia as most important gas supplier until 2030.

The LNG shipping requires to liquify, transport, and regasify natural gas which makes LNG more expensive than natural gas. Energy security by LNG will result in higher gas prices for consumers[97]. The LNG shipping has to go through the same maritime chokepoints as the oil which is also a security issue[98].

[91] EPRS 2021
[92] CSCE 2019
[93] CSCE 2019
[94] CSCE 2019
[95] CSCE 2019
[96] DeJong 2023
[97] CSCE 2019, Pepe 2022
[98] DeJong 2023

## 4.3 Competition between United States and China

During and after World War 2, it was essential to maintain energy supply for the Western States. In addition to the large Western oil producing companies, military presence should protect the sources and the transportation routes of oil (and gas).

In 2019, the *Strait of Hormuz* with 19 million barrel per day and the *Strait of Malacca* with 16 million barrels per day followed by the *Cape of Good Hope* and the *Suez Channel* with both over 5 million barrrels per day trasnportation were the martime oil chokepoints[99].

The United States has built a security belt around the globe with its military presence. A system of allied forces and US troops secures the maritime routes from Europe to Asia. Despite the withdrawal from Afghanistan, US maintained its global presence.

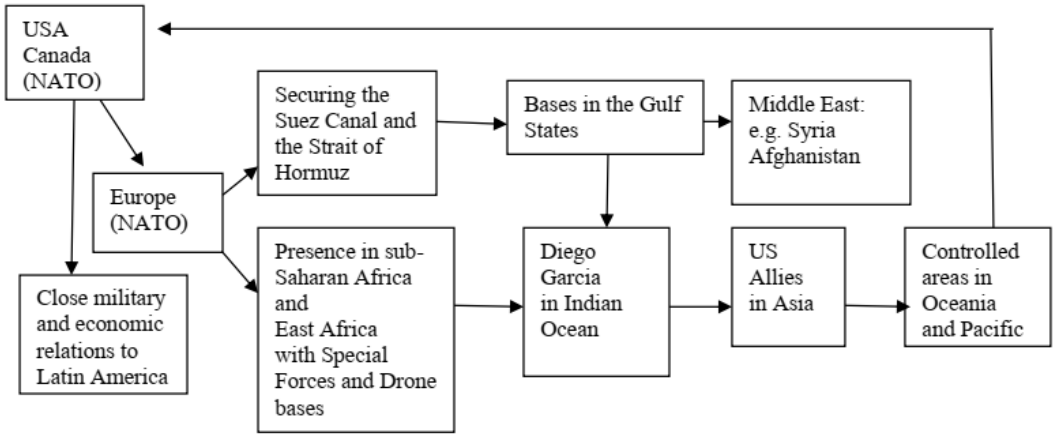


Figure 1 Source: own creation

The Western states ensure the military security of the Gulf region by the strong presence of US and UK troops in several Gulf states[100]. Furthermore, the West is still leading in arms sales to the region and by this of technological relevance as well. The *US State Department* emphasized the importance of the US-Saudi relations in its recent strategy paper[101].

The *Shanghai Cooperation Organization (SCO)* with headquarter in Beijing was founded in 2001 as successor of the *Shanghai Five* group from 1996. In September 2022, Saudi Arabia, Qatar, and Egypt got the status of *dialogue partners*, United Arab Emirates, Bahrain, Kuwait, Myanmar, and the Maldives were approved as future *dialogue partners* at the same time, their status will be granted (confirmed) soon.

The integration of the Gulf Peninsula as dialogue partners expands the SCO now over parts of the Mediterranean Sea (Türkiye), the Suez Channel (Egypt), the Strait of Hormuz (Saudi Arabia, Qatar, and Iran; United Arab Emirates, Bahrain and Kuwait will join soon) and most parts of the Asian trade and shipping routes which is a challenge for the security architecture of the United States for the Middle East/North Africa (MENA) region.

This does not mean that China or the SCO will or wants to replace the United States (and United Kingdom) as security partner of the Gulf States, but expand its influence to support the

[99] IRENA 2019
[100] Satloff 2023, Loft et al. 2022 The US has bases in Kuwait, Saudi Arabia, Oman, the UAE, Bahrain, and Qatar with 13,500 troops in Kuwait, and 5,000 in Bahrain in 2021. The UK has military forces in Oman, Bahrain, Saudi Arabia, the UAE, Qatar, and Kuwait.
[101] State Department 2022

economic and energy policy[102]. The new orientation to the SCO aims to create alternatives to the United States and to create additional partnerships.

The initial focus of the SCO on security later shifted to economic issues and now also to energy policy. The energy policy does not only focus on securing the sources of oil and gas, but also on the physical security of the transportation routes which is vital for the growing economies of the SCO areas, in particular for China.

The *SCO Energy Club* initiated by Russia was founded to serve these goals as a platform for energy producers, consumers, and transit countries to discuss problems and issues of common concern and had its first meeting in 2017. The memorandum was signed in Moscow by Russia, Afghanistan, Belarus, Kazakhstan, China, Mongolia, India, Tajikistan, Türkiye, and Sri Lanka.[103]

The SCO members are also important for nuclear energy. Kazakhstan has the world's second highest reserve of uranium, and it was by far the biggest producer of uranium in 2021, accounting for almost half of the global total amount while Uzbekistan was the fifth largest producer of uranium[104].

China's orientation to the Middle East/North Africa (MENA) region can also be explained with the growing proportion of oil imports which in the last two decades increased from a few percents to 45% until 2021[105]. Already in 2015, Qatar launched the first Renminbi clearing hub in the MENA region, primarily to settle payments in China's currency for exports of oil and gas[106]. In November 2022, China's *Sinopec* and *Qatar Energy* agreed to a 27-year *Liquid Natural Gas (LNG)* supply deal[107].

In 2021, the value of China's bilateral trade with the *Gulf Cooperation Council (GCC)* states and Iran was US$248 billion. This was four times greater than the GCC trade with the US[108]. The stepwise inclusion of Gulf States to the SCO will increase the influence of the SCO on the expense of Western states.

By taking the lead on renewable energy, China has improved its geopolitical position by reducing its reliance on fuel imports and the risks of energy disruption which could affect its economy[109].

# 5 Conclusions

This working paper provided an introduction into energy geopolitics by analyzing the control of energy reserves and resources, of transportation routes and critical production steps and the actual topics. Assuming that the nation states implement their policies without any further additions, changes or developments, oil, coal and gas will still dominate the global energy production. The Middle East will keep its position as important oil producer, the year 2030 will definitely not be the time 'after the oil'. Nuclear energy keeps a small, but stable proportion.

Renewable energy production will increase from 74 to 116 Exajoules, but will still be a small proportion of the total energy production of 673 Exajoules in 2030. The energy supply is able to cover the demand, i.e., there will be no 'energy crisis'. This does not exclude temporary supply crises (e.g., the Russian gas restrictions in 2022).

[102] Blanchard et al. 2023
[103] Panedey 2022
[104] Jiang 2022
[105] Blanchard et al. 2023
[106] CRS 2023
[107] CRS 2023
[108] Loft et al. 2022
[109] IRENA 2019

Due to decarbonization policies, the carbon dioxide ($CO_2$) emissions can be stabilized, but will not decline. The decarbonization will be mainly done by replacing fossil energy with electricity from other sources. The use of renewable energy for electricity is increasing and will be already close to fossil fuels in 2030. But while fossil fuels (oil, gas, coal) will decrease in the global energy mix, even for 2050 a proportion of 60% is expected[110].

Compared to the presented moderate scenario there are more ambitious alternative scenarios in literature based on the Climate Goals from Paris 2015, where renewables will mostly replace all other forms of energy until 2050, but the states already struggle with the energy transformation and the climate goals[111]. The *Intergovernmental Panel on Climate Change (IPCC)* noted for example that despite progress, adaptation gaps exist, and will continue to grow at current rates of implementation[112]. The *World Meteorological Organization (WMO)* expects that global warming will reach the 1.5°C level already between 2023 and 2027 with 66% likelihood and not in 2050[113]. The energy transition is not done with the same speed and intensity all over the globe and the production of renewables cannot fill the gaps if fossil fuels would be removed as part of the decarbonization strategy.

Due to the size of its population and economy, the leadership of China in many energy sectors could be expected, but its overproportional control of renewable resource markets and rare earths and critical minerals shows that the turn to renewable and clean energies creates new dependencies and capital transfers for the Western states. Geopolitical topics are the steadily grwoing influence of China and the *Shanghai Cooperation Organisation SCO* in Central Asia, the European dependency from Russian gas which now requires a massive transformation of energy sources like *Liquid Natural Gas (LNG)* and the intense competition between United States and China, in particular in the Gulf and MENA region.

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