KaMUN

The Black Forest Summit

"Shaping Tomorrow Today"

November 15th to 17th
Karlsruhe, Germany

Study Guide

United Nations Economic and Social Council

Pathways towards a Clean Energy Transition and their Socioeconomic Implications

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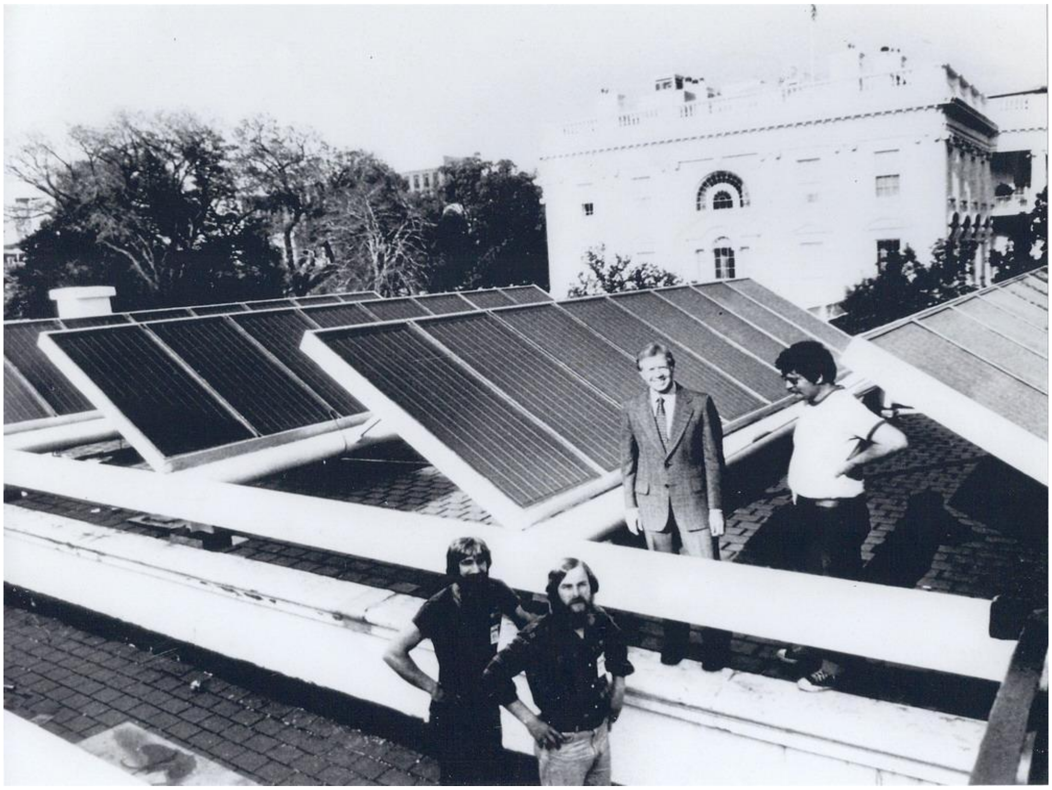

Jimmy Carter on the White House, 21st June 1979[1]

Jimmy Carter already installed 32 solar panels and a solar heating system on the White House in 1979 to provide the White House with abundant light energy. As you can see, energy transition is not a new topic but just now it receives the deserved attention.

But who can act on this attention?

"Over 70 % of global energy investments will be government-driven and as such the message is clear – the world's energy destiny lies with decisions and policies made by governments." – Dr. Fatih Birol, Executive Director, International Energy Agency (IEA)[2]

[1] See The New York Times, https://www.nytimes.com/1979/06/21/archives/carter-welcomes-solar-power.html, retrieved on 09.10.2019.

[2] See International Energy Agency (IEA), https://www.iea.org/newsroom/news/2018/november/world-energy-outlook-2018-examines-future-patterns-of-global-energy-system-at-a-t.html, retrieved on 06.10.2019

This quote emphasizes the importance of you, as a delegate of your country, that can give educated recommendations to your politicians and the world on what should be invested in and how to push for a clean, just and accelerated energy transition.

During our conference we would like to explore how this energy transition should look like, which solutions are affordable, clean and can be fast implemented and which affect the energy transition has on an economic and social level, keeping in mind the SDGs.

For the conference we would like to propose the following structure for the course of the debate:

Friday:	Introduction & Policy Statement
Saturday morning:	Current Status of Energy Transition and SDGs 7 & 13
Saturday afternoon & Sunday:	Pathways Towards a Clean Energy Transition

For your preparation for the committee sessions and policy statement we highly recommend you consider the following links and questions:

Learn about your country:

- Check out the linkage of NDCs (Nationally Determined Contributions) and the SDGs of your country at: https://www.climatewatchdata.org/ndcs-sdg.
- Research your countries energy matrix and energy flow charts.
- Revise which primary energy sources fuel which sectors at: https://www.iea.org/sankey/#?c=IEA %20Total&s=Balance
- Look at how production of the different energy sources is by region and which countries are largest net exporter and importers. This can help you in understanding political interest related to your countries imports and exports. https://www.iea.org/statistics/kwes/supply/.

Get detailed topic insights:

- Energy-supply sector, cost analyses and potential of greenhouse gas (GHG) mitigation: https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter4-1.pdf
- Asia Pacific countries: https://asiapacificenergy.org/
- https://globalenergymonitor.org/

For position statement:

1. What is the energy mix of your country?
2. Which resources does your country have?
3. What would be the best energy mix for your country and why?
4. What could be interests of your country when looking at the trade balance?
5. Which companies control energy generation and prices?
6. Are there regionally integrated energy transmission lines? (e. g. SIEPAC)

In case you have further questions, want to get feedback on your policy statement or have any other concern, please do not hesitate to contact us. Our email address is ECOSOC@KaMUN.org.

We are very much looking forward to meeting you all and spending a great time together, full of lively debates and fun socials.

Yours,
Louisa & Bo

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1. Introduction to Climate Change and Previous UN Actions Based on SDG 13: Climate Action

The ratio behind Sustainable Development Goal 13 (*Take urgent action to combat climate change and its impacts*) is one of the main reasons we are concerned about energy transition in the first place. As the electricity and heat sector accounts for approximately 72 % of human-made greenhouse gas emissions according to the 2014 IPCC report (page 516), clean energy transition is the most important step in order to combat climate change and its ecological and societal impacts.

The origin of climate action is the scientific conclusion that human-made greenhouse gas emissions lead to a change in the world's climate that has and will have a significant impact on ecosystems and would eventually lead to the world becoming uninhabitable for humans.

In order to measure the extent of climate change, the measure of 'increase in the world's median temperature compared to preindustrial levels' has been accepted as a universal measure. On the UN level, several global measures have been taken in order to combat climate change:

Starting in 1972, resolution A/Res/27/2997 established the United Nations Environment Program (UNEP). Their mission is to "provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations". It does so by "setting the global environmental agenda, promoting the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serving as an authoritative advocate for the global environment".

The Intergovernmental Panel on Climate Change (IPCC), which operates from the framework of UNEP, has released five assessment reports and three special reports on the state of climate change, winning the Nobel peace prize in 2007 for their "efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change." IPCC-reports are the most important sources for scientific data on climate change, with new reports spiking a climate debate all over the world.

Formed in 1992, the United Nations Convention on Climate Change (UNFCCC) is the first international treaty formulating the intent to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. It serves as a great foundation for global climate action up to this date, most notably for being extended by the 1997 Kyoto Protocol, which made participating nations legally bound to lowering their emissions, and the 2015 Paris Agreement that set the target for global warming to not more than 1.5 °C.

The current status of climate change is threatening, as industrialized countries, even though most ratified the Paris Agreement, are failing to incept measures capable of limiting global warming below the 1.5 °C goal.

As the report on the progress of the sustainable development goals mentions, due to rising greenhouse gas emissions, climate change is occurring at rates much faster than anticipated and its effects are clearly felt worldwide. While there have been positive steps, far more ambitious plans and accelerated action are needed, in particular the access to finance and strengthened capacities for developing nations need to be scaled up at a much faster state.

Globally averaged mole fractions of CO_2 in the atmosphere have risen from 400.1 parts per million (ppm) in 2015 to 405.5 ppm in 2017. In order to reach the 1.5 °C goal, CO_2-levels will need to peak as soon as possible, followed by rapid reductions.

With global climate demonstrations - organized by Fridays for Future - engaging roughly 6 million people at once according to The Guardian, it is only a matter of time until politics will be forced to respond to the harsh criticism brought forward by the protesters.

SDG 13 calls upon governments to "integrate climate change measures into national policies, strategies and planning" and also to "improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning". In order to financially support developing nations, SDG 13 formulates the goal that $100 billion shall be mobilized annually towards the Green Climate Fund, a measure committed to by developed nations through the UNFCCC.

Applying the targets of SDG 13 to energy transition, the goal of this conference should be to come up with a resolution that integrates energy transition into national policies, strategies and planning while at the same time mobilizing money for developing nations to reduce their costs of clean energy transition.

2. Status, Progress and Targets of SDG 7: Affordable and Clean Energy

The seventh sustainable development goal as a part of the 2030 Agenda, put into place via UNGA resolution 70/1 in 2015, manifests the need for access to affordable, reliable, sustainable and modern energy for all. SDG 7 is the Sustainable Development Goal concerned with clean energy transition: Its ambitious goal is to provide clean energy for everyone on the planet by 2030. In the following, we will explain the urgency for access to energy, the different, but intertwine targets of SDG 7 which provide a good blueprint on how to bring forward and measure energy transition.

Access to energy is important because of many reasons of social, developmental, environmental and humanitarian origin. A family without access to electricity needs to rely on fossil fuels for daily needs such as cooking, lightning or heating. Such usage of fossil fuels is not only unsustainable, but also causing a lot of pollution which is the cause of many premature deaths due to respiratory diseases. Even if wood as a renewable source is used for daily needs, the deforestation rates are usually so high that wood cannot be considered renewable in those areas anymore. Additionally, energy access is the foundation of economic development and enables communication to the outer world.

Lawmakers controlling the pace of the path towards universal access to affordable and clean energy can therefore not only put their attention towards the bad environmental impact of energy from fossil fuels but need to take into account the great humanitarian benefits universal access to energy brings with it.

SDG 7 pools different objectives regarding energy production and distribution to create an SDG that has to be an objective for all countries, not just developing nations. The different objectives are listed as 'targets' on the 'targets & indications'-tab on https://sustainabledevelopment.un.org/sdg7, while under 'indications', corresponding statistical indicators are presented.

Mainly, SDG 7 can be diversified into three main targets:

For target 1, this SDG looks towards universal access to energy. Reports of the World Bank[3] showed that while global electrification rose from 83 % in 2010 to 89 % in 2017, there are still some 840 million people who have no access to electricity. However, there is no universally agreed-upon definition of energy access, so these numbers base on a binary definition of electricity access as "availability of an electrical connection at home or the use of electricity as the primary source for lighting".

Therefore, the 89 % of electrified households do not take into account the quantity, quality and adequacy of service of these electrical connections. As a consequence, the number of households having a level of access to electricity that we as Germans would define as sufficient to cover basic electrified needs is a lot lower than the aforementioned 89 %.

This is also shown by another indicator of the same report, which shows how many households have access to modern cooking solutions. Per definition, a household has access to modern cooking solutions, when it primarily relies on non-solid fuels for cooking.

The report shows that only 59 % of the global population has access to such modern cooking solutions.

Reasons for areas with none or insufficient electrification are mostly directly or indirectly cost-related. Mostly, a reliable electric infrastructure is missing, giving households no possibility for reliable access to energy, while in other cases such infrastructure is present, but energy is too expensive for the gross majority of the population, leaving only the upper-class with the ability to afford it.

[3] http://documents.worldbank.org/curated/en/547241468162866312/Overview

All this data shows that there is still a lot of work needed to fulfil just the “access”-aspect of SDG 7. As the report of the World Bank wrote: “The SE4ALL [Sustainable Energy for All; UN program launched in 2011, closely tied to SDG 7] universal access goal will be achieved only if every person on the planet has access to modern energy services provided through electricity, clean cooking fuels, clean heating fuels, and energy for productive use and community services”.

Target 2 of SDG 7 focuses on the sustainability of energy production and therefore reaches out to all countries in the world but in particular towards the most energy-consuming countries.

Its goal is to increase the share of renewable energy in the total final energy consumption.

Between 2010 and 2016, this value has gradually increased from 16.6 % to 17.5 %, but according to the UN in its report about the progress of the SDGs in 2019, much faster change is required to meet climate goals. Although the main objective is to promote energy transition, increase of the total final energy consumption means that the non-renewable energy sector is still growing.

One point of focus therefore needs to be laid into countries, in which energy consumption increases due to economic development and increasing life standards in order to make sure that this surplus of needed energy originates from renewable sources.

Also, regarding target 1, it is important that the process of achieving universal access to energy is accomplished mostly by creating new renewable sources of energy.

Target 3 of SDG 7 focuses on how energy is used and wants to enhance energy efficiency. Energy efficiency means to use less energy for the same tasks, therefore trying to eliminate energy waste. This step is perhaps the most crucial one if we want to meet climate goals without lowering our living standards or slowing down development in developing countries. Energy efficiency is measured by looking at the energy involved in producing a unit of GDP. The measure is named energy intensity, with high energy intensity meaning a lot of energy is needed to produce a unit of GDP and a low energy intensity meaning energy can be converted into GDP at a lower price. It is measured in kilojoule per dollar. In order to reach Target 3 as set in SDG 7, energy intensity needs to be lowered by 2.7 % annually. From 2010 to 2016, this target has only been missed by a small margin, lowering the energy intensity from 5.9 to 5.1, an annual reduction of 2.3 %.

Looking at the numbers of individual countries, most European countries achieve a much better result compared to the United States of America. Particularly Italy points out, to be the most energy efficient country in the G8, largely due to traditionally high energy prices which have resulted in more efficient company and consumer behaviors.

However, since energy intensity is highly influenced by natural factors, such as extreme weather conditions which lead to a higher energy consumption due to heating/cooling and highly determined by the nation's developmental status, numbers of individual countries can only be compared with great caution.

Additional targets, aside from these presented, want to promote enhanced international cooperation and knowledge sharing of technological solutions and their distribution.

Even though SDG 7 operates in many different directions, it is to be seen as one goal with all three targets having to be achieved interconnectedly.

3. Greenhouse Gas Emissions

To understand the current situation of greenhouse gas (GHG) emissions we will know take an in-depth look at the greenhouse gas emissions, globally, of the largest emitters and per capita and finally you have the chance to research further on your specific countries GHG emissions. As mentioned in the first chapter on climate action (SDG 13) GHG emissions fuel climate change and reducing them is the only chance to keep global warming below the 1.5 °C target which is necessary to ensure a life on earth for future generations.

Which are the sectors emitting most greenhouses gases on a global scale?

The World Resources Institute (WRI) distinct five sectors contributing to greenhouse gas emissions[4] (GHG) as illustrated in Figure 1. The largest contributor of GHG emissions is the energy sector, which comprises electricity/heat, transportation, manufacturing/construction, other fuel combustion, and fugitive emissions[5], with 73 % of total GHG emissions in 2014.

[4] Greenhouse gases existed in the atmosphere in a certain composition before human activity started. Due to human made greenhouse gas emissions disbalanced this composition over time. Major GHG are carbon dioxide (CO_2), methane (CH_4), Nitrous Oxide (N_2O), Industrial gases and others including water vapor and ozone (O_3). See National Geographic, https://www.nationalgeographic.com/environment/global-warming/greenhouse-gases/, retrieved on 09.10.2019.

[5] Fugitive emissions are unintentional losses of gases, liquids and other substances arising from equipment leaks enabled by various causes, e. g. due to wear and tear of a gas pipeline.

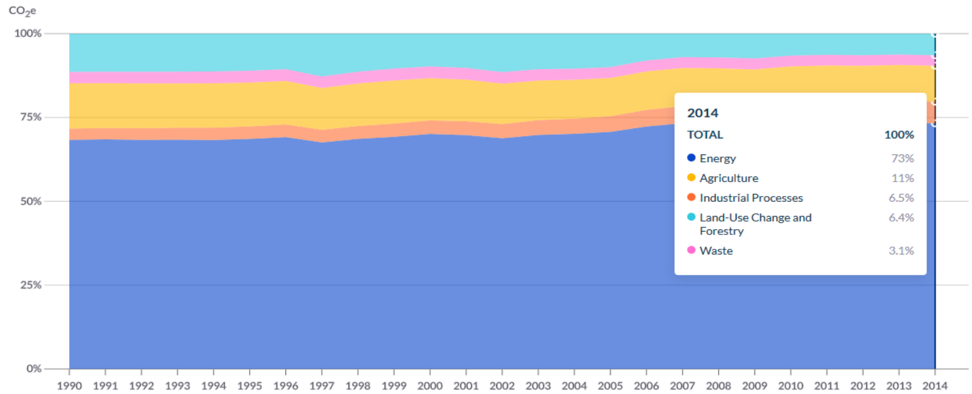


Figure 1: Global Historical GHG Emissions per Sector in % of CO_2e, Climate Watch

Following the premise of immediate and efficient climate action we will lay the focus on the energy sector as it accounts for the highest GHG emissions globally and can thus contribute to the largest reduction in emissions.

The energy sector is split into five subsectors which also differ significantly in emission levels. The subsector electricity/heat shows the highest emissions with 43 %, followed by transportation with 21 % and manufacturing/construction with 17 % as depicted in figure 2.[6] Our goal is to focus on the subsectors which affect the lives of many people and could be positively impacted by an energy transition in a socioeconomic way.

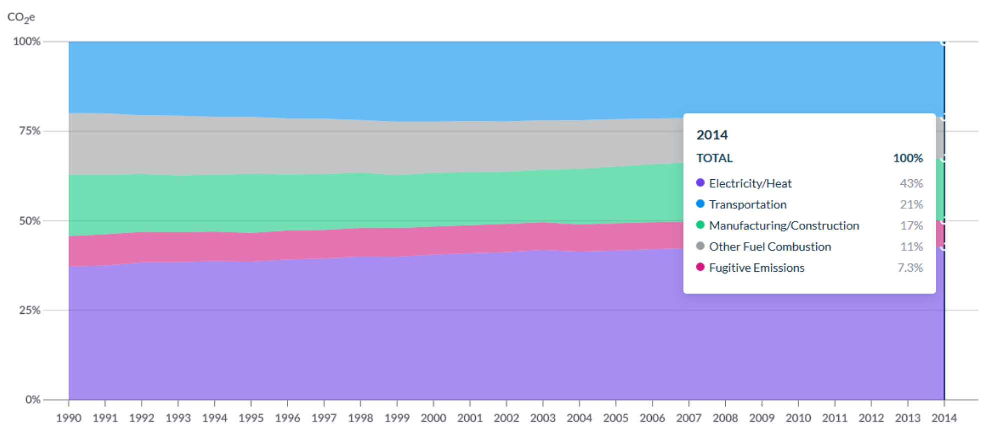


Figure 2: Global Historical Energy Sector GHG Emissions, Climate Watch

Electricity production for the industry, transport, building, and agriculture and forestry, is also the largest single emitter of fossil fuel CO_2 in 2010 with approximately 35 %[7], according to the IPCC Report 2014 and many mitigation scenarios they analyzed consist of three components: (1) decarbonization of power generation; (2) substitute electricity for direct use of fossil fuels in

[6] See Climate Watch, https://www.climatewatchdata.org/ghg-emissions, retrieved on 07.10.2019.
[7] See IPCC, Climate Change 2014 Mitigation of Climate Change, p. 516

buildings and industry and (3) reduce aggregate energy demands.[8] The remarkable part is, that of 43 % emissions generated by the sector electricity/heat then only approximately 8 % are due to private households, on a global scale.

Now, having insights on the sectors contributions to GHG emissions it will be of interest to relate the global emissions to countries. Large contributors of absolute emissions are important to identify as they can contribute most to reduce GHG emissions. Ultimately the value of absolute emissions is what counts regarding the GHG concentration in the atmosphere and thus determining the climate of the future.[9]

Which are the largest emitters of greenhouses gases on a global scale?

It is remarkable that the 10 largest emitters of GHG, depicted in figure 3, account for around 70 % of the global GHG emissions.[10]

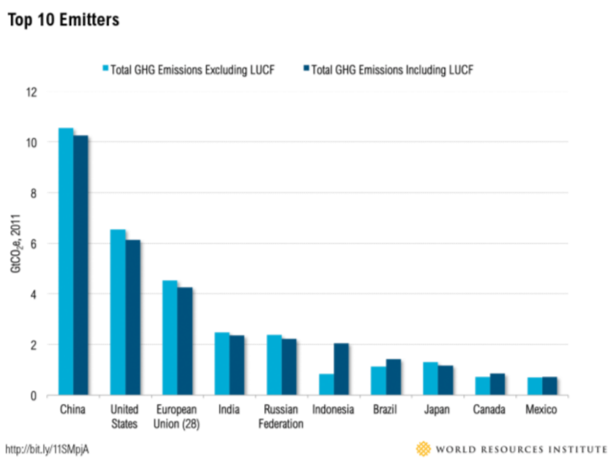


Figure 3: World Resources Institute[11]

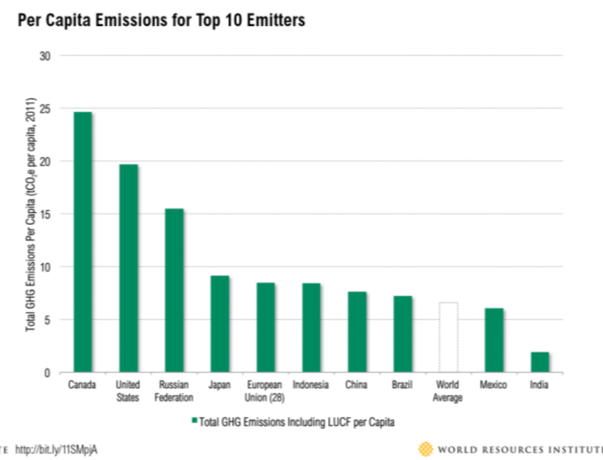


Figure 4: World Resources Institute[12]

Adding the individual level to the country perspective of emissions the order changes significantly. Even though Canada, for example, is the 9th largest emitter of GHG compared to other countries, it is the largest emitter per capita, as of figure 4. This means that Canada in relation to their inhabitants emits more GHG into the atmosphere than any other country.

[8] See IPCC, Climate Change 2014 Mitigation of Climate Change, p. 559
[9] See World Resources Institute, https://www.wri.org/blog/2014/11/6-graphs-explain-world-s-top-10-emitters, retrieved on 08.10.2019.
[10] See World Resources Institute, https://www.wri.org/blog/2014/11/6-graphs-explain-world-s-top-10-emitters, retrieved on 08.10.2019.
[11] LUCF means land use change and forestry. $GtCO_2e$ stands for gigatonnes of equivalent carbon dioxide.
[12] tCO_2e stands for total carbon dioxide emissions.

On a global scale two main drivers of GHG emissions were identified: Population and the economy size as GDP. It is worth noting that the 10 largest emitters comprise 60 % of global population and even 74 % of global GDP in 2011.[13] This relates back to chapter 2, in which it is stated that the GDP is highly relevant to measure the energy intensity. This leads to the assumption that economic growth in terms of GDP is linked to a high energy usage.

Another interesting relation that can be made, is linking the largest emitters to the leading export countries. Amongst the top 20 export nations are all the largest emitters of GHG and in 2017 China was the largest exporting nation, followed by the United States of America, Germany (as part of the European Union) and Japan.[14]

So far, the figures consider on the country level were related to a specific point in time, but as GHG accumulate in the atmosphere over time and lead to global warming, it is inconceivable to ignore historical emissions. The responsibility to mitigate climate change and global warming could be higher for countries that overall contributed more to the accumulated emissions in the atmosphere. Depending on the chosen time period the cumulated emissions vary, therefore figure 5 shows cumulative GHG emission from 1990 until 2011 and figure 6 carbon dioxide (CO2) emissions from 1850 until 2011. For the time period before 1990 no reliable data is available for all greenhouse gas emissions but only for CO_2 emissions.[15]

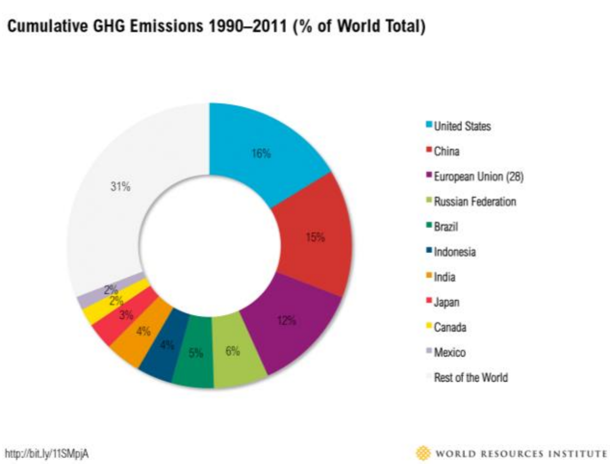


Figure 5: World Resources Institute

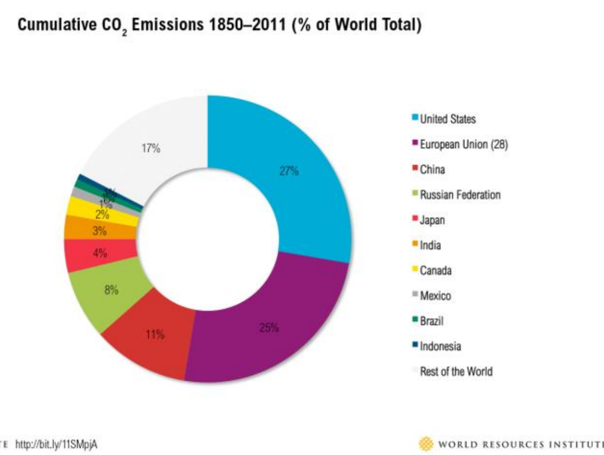


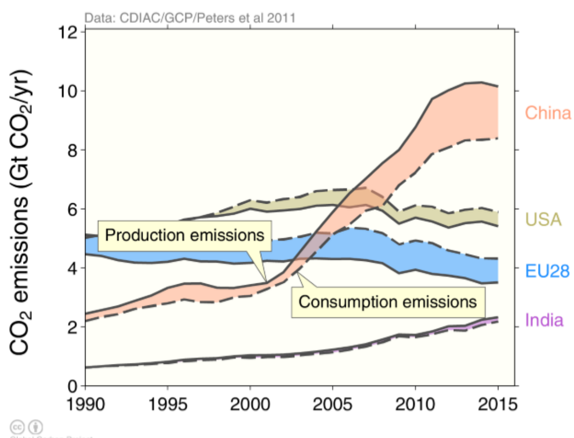
Figure 6: World Resources Institute

[13] See World Resources Institute, https://www.wri.org/blog/2014/11/6-graphs-explain-world-s-top-10-emitters, retrieved on 08.10.2019.
[14] See Statista, https://www.statista.com/statistics/264623/leading-export-countries-worldwide/, retrieved on 08.10.2019.
[15] See World Resources Institute, https://www.wri.org/blog/2014/11/6-graphs-explain-world-s-top-10-emitters, retrieved on 08.10.2019.

According to the World Resources Institute (WRI) the CO2 emissions in 2011 were 150 times higher than in 1850.16 This reflects the increasing hunger for power of humanity. So, in order to keep living standards without raising emissions further a transition in the energy sector is necessary.

Even though figure 6 does not include all GHG emissions the comparison of the two figures can give an idea of the emission development of selected countries over time.

It is important however, to emphasize the relation of importing and exporting countries. Because if country A produces a good to export it to country B, production emissions will be attributed to country A, even though the destination is country B. This implies that importing countries can save themselves the production of emissions which were nevertheless emitted for their consumption elsewhere. This concern can be solved when looking at consumption emissions versus the production emissions.



The graph ranging from 1990 until 2016 clearly shows that the United States of America and the European Union are net importers of emissions while China and India are net exporter. This adds another level of complexity to the discussion, as it is not reflected in the carbon budget. Through financial means countries can thus indirectly extend their carbon budget through acquiring goods produced abroad. With regards to a climate justice movement this can be seen very critical.

Now, having an overview of emissions by sectors and countries and it is necessary to identify where these emissions come from, meaning to take a closer look at the energy sources and their contribution to emissions and pollution.

[16] See World Resources Institute, https://www.wri.org/blog/2014/05/history-carbon-dioxide-emissions#fn:1, retrieved on 09.10.2019.

4. Types of Energy Sources

Which are the most common energy sources?

Energy sources are commonly split into primary and secondary energy sources. Two examples of a primary sources turned into a secondary source: Crude oil refined into Gasoline and solar radiation transformed to electricity.

Furthermore, primary energy sources are split into renewable and non-renewable sources which then through a transformation convert into secondary energy sources that can be directly used by human kind.[17] The following graphic illustrates the classifications for the most common energy sources.

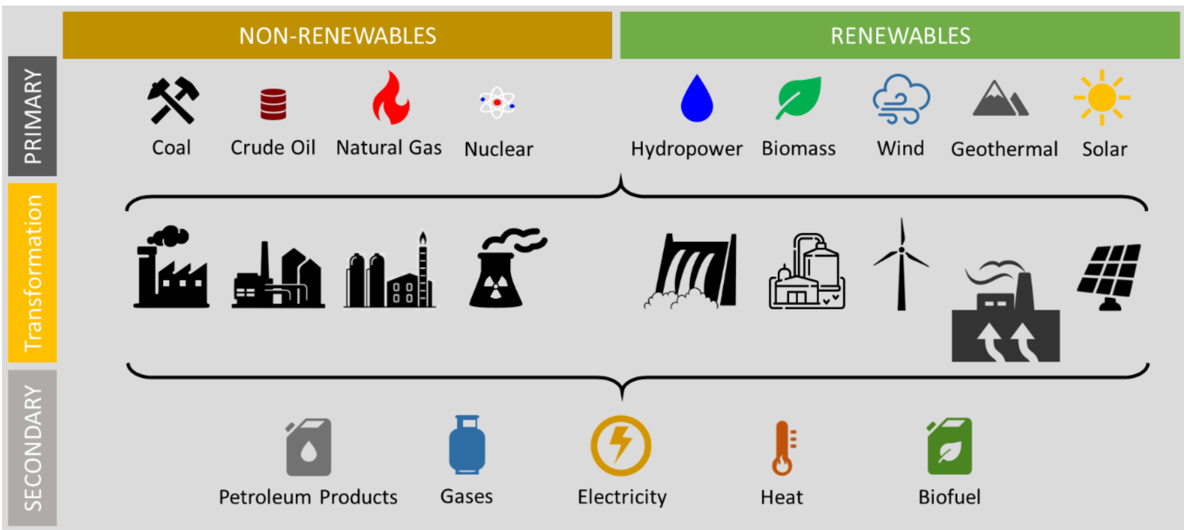


Figure 7: Own elaboration

The non-renewables in figure seven shows are also commonly known as fossil fuels. According to Eurostat fossil fuels are defined as non-renewable, carbon-based energy sources derived from decayed animals and plants over millions of years and from industrial processes that refine fossil fuels and transform them into other fossil fuels. Furthermore, it is estimated that roughly 80 % of all man-made CO2 and greenhouse gas emissions originate from fossil fuels combustion, which makes them highly relevant in the clean energy discussion.[18]

Renewable energy comes from natural sources or processes that are constantly replenished. For example, sunlight or wind keep shining and blowing, even if their availability depends on time and weather.[19]

[17] See FU Berlin, https://userwikis.fu-berlin.de/display/energywiki/secondary+energy, retrieved on 07.10.2019.
[18] See Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Fossil_fuel, retrieved on 08.10.2019.
[19] See NRDC, https://www.nrdc.org/stories/renewable-energy-clean-facts, retrieved on 14.10.2019.

You can find further details on primary energy sources, energy carriers, energy markets and energy supply and end-use-efficiency at: https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter4-1.pdf, p. 256 ff.20

After having classified energy sources, we will learn which are the most common energy sources on a global scale.

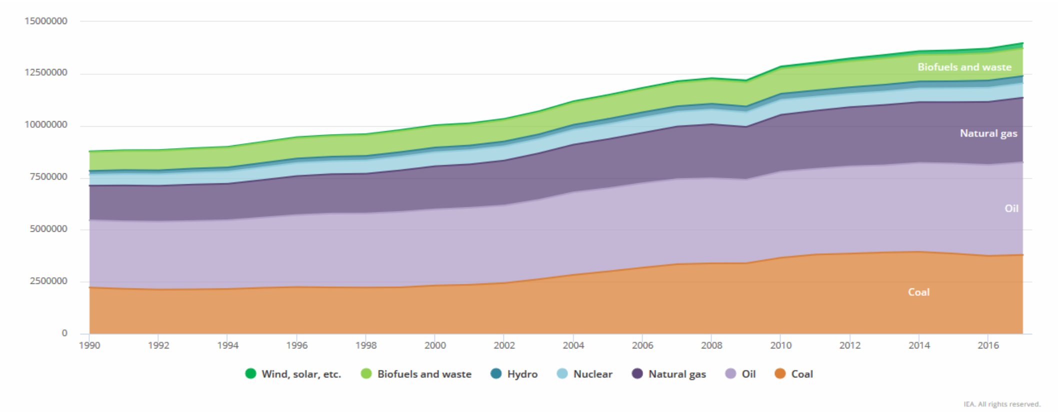


Figure 8: Total Primary Energy Supply (TPES) by source in ktoe, World 1990-2017, International Energy Agency[21]

As shown in figure eight coal and oil posed more than 50 % of the kilotons of oil equivalent, in almost equal parts, of total primary energy supply in 2016. Followed by natural gas, bio fuels and waste, nuclear and finally hydro and wind, solar and other.

Seeing the stakes, the different sources have in providing the world with energy we will continue with advantages and disadvantages of each of them. Therefore, we will compare their emissions according to the emissions factor that was established in the Revised 1996 IPCC Guidelines.

The emissions factors we will consider are tonne of carbon dioxide per terra joule. This means that each of the following fossil fuels is compared on how much carbon dioxide it emits per terra joule of energy generated, simplified: Amount of carbon dioxide emissions released when generating the same amount of energy. We selected two primary energy sources, crude oil and natural gas liquids, and several other secondary oil based fuels that could be of interest to you. You can for example see that gas/diesel oil is more pollutant than gasoline or liquified petroleum gas (LPG) in stationary combustion. The solid fuels listed are two types of coal (anthracite, a high-quality hard coal, and lignite which is low-quality soft coal) and peat, which is still harvested in certain areas of the world to produce electricity or heat.

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[20] See R.E.H. Sims et al. 2007: Energy supply. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter4-1.pdf, retrieved on 11.10.2019.

[21] See International Energy Agency, https://www.iea.org/statistics/, retrieved on 09.10.2019. Ktoe means kilotonnes of oil equivalent.

Oil based Fuels	Emission Factor (tC/TJ)
Crude oil	20.0 - 21.0
Natural Gas Liquids (ethane, propane, butane and condensate)	17.2 - 19.0
Gasoline	18.9
Jet Kerosene	19.5
Gas/Diesel oil	20.2
LPG	17.2
Solid Fuels	**Emission Factor (tC/TJ)**
Anthracite	26.8
Lignite	27.6
Peat	28.9

Table 2:Own elaboration, Emissions Factor of Selected Non-renewable Fuels[22]

These emission factors only give insights in emissions generated when combusting, but they ignore many other emissions, such as the production emissions and emissions arising from power plant construction and maintenance.

To include all the emissions the different energy sources generate per unit, the life cycle GHG emissions are calculated. These consider the overall global warming potential as they account for material use, ramp-up, maintenance, and other processes that emit carbon dioxide.

[22] See Tim Simmons, CO_2 Emissions from Stationary Combustion of Fossil Fuels, https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_1_CO2_Stationary_Combustion.pdf, retrieved on 14.10.2019.

Life cycle CO_2 equivalent (including albedo effect) from selected electricity supply technologies.[2][3] Arranged by decreasing median (gCO_2eq/kWh) values.

Technology	Min.	Median	Max.
Currently commercially available technologies			
Coal – PC	740	820	910
Biomass – Cofiring with coal	620	740	890
Gas – combined cycle	410	490	650
Biomass – Dedicated	130	230	420
Solar PV – Utility scale	18	48	180
Solar PV – rooftop	26	41	60
Geothermal	6.0	38	79
Concentrated solar power	8.8	27	63
Hydropower	1.0	24	2200[1]
Wind Offshore	8.0	12	35
Nuclear	3.7	12	110
Wind Onshore	7.0	11	56
Pre-commercial technologies			
CCS – Coal – PC	190	220	250
CCS – Coal – IGCC	170	200	230
CCS – Gas – combined cycle	94	170	340
CCS – Coal – oxyfuel	100	160	200
Ocean (Tidal and wave)	5.6	17	28

Table 3: Wikipedia with data from IPCC Annex III technology-specific Cost and Performance Parameters[23]

This tables shows that the highest emission per unit of energy generated is released by Coal and the lowest with wind onshore. This can serve as a guideline for actors deciding about future energy solutions, to look for a mix with overall low life cycle emissions.

5. Economic, Social, Environmental and Other Impact of Mitigation Measures

When discussing clean energy transition in the energy supply sector, the most crucial step is to come up with a plan that cuts down on emissions while maintaining quality and consistency standards in energy production and at the same time tries to limit the negative impacts in other fields such a transition has. What further adds to the difficulty of finding the right energy mix is that due to the geographical and budgetary uniqueness of each country, there exists no such thing as a blueprint for the "correct" energy transition.

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[23] See IPCC, p.1335, https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf, retrieved on 14.10.2019.

In the following you can compare various mitigation measures proposed by the IPCC and their effects on different aspects: A green arrow indicates a good impact of the respective measure while a yellow one indicates issues arising with said measure. Four out of five mitigation measures aim at replacing coal through other energy sources, as coal is the most polluting energy source.

Mitigation measures	Effect on additional objectives/concerns			
	Economic	**Social (including health)**	**Environmental**	**Other**
Nuclear replacing coal power	↑ Energy security (reduced exposure to fuel price volatility)[1] ↑ Local employment impact (but uncertain net effect)[2] ↑ Legacy cost of waste and abandoned reactors[3]	Health impact via ↓ Air pollution[4] and coal-mining accidents[5] ↑ Nuclear accidents[6] and waste treatment, uranium mining and milling[7] ↑ Safety and waste concerns[8]	Ecosystem impact via ↓ Air pollution[9] and coal mining[10] ↑ Nuclear accidents[11]	Proliferation risk[12]
RE (wind, PV, CSP, hydro, geothermal, bioenergy) replacing coal	↑ Energy security (resource sufficiency, diversity in the near/medium term)[13] ↑ Local employment impact (but uncertain net effect)[14] ↑ Irrigation, flood control, navigation, water availability (for multipurpose use of reservoirs and regulated rivers)[15] ↑ Extra measures to match demand (for PV, wind, and some CSP)[16]	Health impact via ↓ Air pollution (except bioenergy)[17] ↓ Coal-mining accidents[18] ↑ Contribution to (off-grid) energy access[19] ? Project-specific public acceptance concerns (e.g., visibility of wind)[20] ↑ Threat of displacement (for large hydro)[21]	Ecosystem impact via ↓ Air pollution (except bioenergy)[22] ↓ Coal mining[23] ↑ Habitat impacts (for some hydro)[24] ↑ Landscape and wildlife impact (for wind)[25] ↓ Water use (for wind and PV)[26] ↑ Water use (for bioenergy, CSP, geothermal, and reservoir hydro)[27]	Higher use of critical metals for PV and direct drive wind turbines[28]
Fossil CCS replacing coal	↑↑ Preservation vs. lock-in of human and physical capital in the fossil industry[29]	Health impact via ↑ Risk of CO_2 leakage[30] ↑ Upstream supply-chain activities[31] ↑ Safety concerns (CO_2 storage and transport)[32]	↑ Ecosystem impact via upstream supply-chain activities[33] ↑ Water use[34]	Long-term monitoring of CO_2 storage[35]
BECCS replacing coal	*See fossil CCS where applicable. For possible upstream effect of biomass supply, see Sections 11.7 and 11.13.6*			
Methane leakage prevention, capture, or treatment	↑ Energy security (potential to use gas in some cases)[36]	↑ Occupational safety at coal mines[37] ↓ Health impact via reduced air pollution[38]	↓ Ecosystem impact via reduced air pollution[39]	

Table 4: IPCC, 2014: Climate Change: 2014 Mitigation of Climate Change, s. 545[24]; RE = Renewable Energy, PV= PhotoVoltaic, CSP=Concentrated Solar Power, CCS=Carbon Capture and Storage, BECCS=Bio-Energy with Carbon Capture and Storage

Economically, it has to be looked on the influence of respective mitigation measures on energy security and lock-in of human and physical capital: Especially renewable energy sources often have the problem of only being able to operate effectively under ideal circumstances and therefore failing to maintain a level of reliability that guarantees energy security. Fluctuating winds and cloud patterns can reduce the energy production of solar and wind energy drastically and measures countering this by storing a surplus of produced energy on a good day are

[24] See IPCC, 2014: Climate Change: Mitigation of Climate Change, S. 545, https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf, retrieved on 07.10.2019.

expensive and in the case of mechanical pumped storage require pre-existing geographical conditions.

On the other hand it has to be considered that a lot of jobs and resources are locked in the fossil fuel industry that is to be replaced. Cutting all jobs in the coal industry for example would lead to high damages needing to be paid to companies operating in the sector and to prevent workers from sliding into poverty. For these reasons, a lot of research is going into CCS, which stands for Carbon Capture and Storage and aims to reduce emissions of coal power plants drastically by capturing and storing the produced CO_2 in the ground. This could be used as a temporary measure while slowly reducing coal energy.

The social impact of mitigation measures mostly circulates around health concerns. Less coal mining generally leads to a big health benefits, both to workers in the coal industry and to the general population as air pollution from coal power plants is reduced. However, replacing coal energy with nuclear energy will result in different kinds of health risks, both because of the risk of accidents during the energy production and the long-term issue of storing nuclear waste. Additionally, in the light of the nuclear catastrophes in Chernobyl and Fukushima, plans of expansion in the nuclear energy sector may cause public outrage and would need to be communicated cautiously.

Similar issues around nuclear energy exists when looking on the environmental impact these mitigation measures have: Nuclear waste reaching groundwater would cause an environmental catastrophe. Renewable energy sources often also have an environmental impact that is not to neglect: Since for example wind turbines influence the habitat of birds, effort needs to be put into correctly placing wind turbines in order to minimize this influence.

6. Further Challenges of the Energy Transition

Which are the challenges of the energy transition in general and of the subsector's electricity/heat and transportation in specific?

This chapter only includes two examples of challenges that could affect the energy transition, but you are free to research more challenges and even so viable and feasible solutions.

Technology lock-in:
A technology lock-in exists in case a current system only works with very specific technologies.

Electricity/heat:
The currently installed systems, such as heating and stoves, restrict the opportunity to change the energy source immediately. Neither it is not possible to suddenly run a gas stove with

electricity, nor is it possible to quickly change the installed heating system to run on another energy source.

Transportation:

Existing cars, busses, motorcycles, amongst others, are mostly build on a combustion engine, which again does not allow for an immediate or fast change at large scale to a different engine.

The technology lock-in effect is only possible to overcome in the medium to long-run.

Infrastructure:

Electricity/heat:

Large parts of the infrastructure might have grown over time to satisfy the demand for electricity and heat. It is not possible to shut down fossil fuel reliant energy production without prior installation of new facilities to their replacement.

Transportation:

Almost the entire existing transportation infrastructure is designated to road traffic, more precisely to automotive transport, so that a switch is only possible in the long-run because alternative transportation ways that could be powered by clean energy, such as trains, have long construction times. Therefore, the capacity cannot be increased easily or flexible.

A change of infrastructure is generally only overcome in the long-run; thus decisions need to be taken wisely.

7. Success Stories

Some countries successfully emit fewer GHG than others in their region and thus in the following we want to present a few countries that stand out positively with regards to a clean energy transition.

The African continent has abundant renewable energy sources available and is now standing at the cross-road to get a suitable energy mix. Especially as decisions made today will impact the energy sector for the next decades.[25] So far only 40 % of the population have access to electricity and the per capita consumption of sub-Saharan Africa (excluding South Africa) is only 180 kWh, compared to 6 500 kWh in Europe and even 13 000 kWh in the United States.[26] This shows that

[25] See IRENA, https://www.irena.org/africa, retrieved on 15.10.2019.
[26] See DLA Piper, https://www.dlapiper.com/en/uk/insights/publications/2019/06/renewable-energy-in-africa/, retrieved on 15.10.2019.

if hunger for power increases through connecting the remaining 60 % of population a good choice of investment can secure a clean and healthy future for many Africans.

Ethiopia is an interesting country with regards to its Total Primary Energy Supply (TPES) as 87.7 % is generated by biofuels and waste, 8.7 % by oil, 2.6 % by hydro power, 0.8 % by coal and wind, solar and other account for 0.2 %. Of the electricity generation Solar PV generated 0.8 %, wind 6.2 % and hydro power the by far highest share with 92.9 %. This makes Ethiopia very advanced in the sustainability of its electricity generation compared to other African countries.

Looking at the Asia-Pacific region it is remarkable that in many countries such as China, renewables, wind and solar, are growing at high rates, but at the same time also coal combustion is getting to new heights. The challenge lies within building new renewable sources but meeting the energy demand and as the energy demand is increasing significantly every year it might be hard for countries to keep pace with only considering new constructions. The Philippines are worth mentioning as their energy mix is very balanced with 28.9 % in coal, 33.8 % oil, 5.6 % natural gas, 1.4 % hydro power, 17.4 % biofuels and waste and 15.5 % of wind and solar.[27]

In general, it is worth noting that Latina America and the Caribbean has double the global average of primary energy originating from renewable energy sources.[28] Costa Rica is an interesting example for this region, as the country has a long story of clean and renewable focused energy policy which can be retraced here: https://www.iea.org/policiesandmeasures/renewableenergy/?country=Costa %20Rica. Also, of their Total Primary Energy Supply (TPES) 52.2 % were fossil fuels, mostly oil, and an outstanding 47.8 % was supplied through renewable sources in 2017.[29] Looking at the electricity sector even 98 % of the overall production in 2017 was generated through renewables, largely hydro power.[30]

For Europe, there are several countries that have good strategies to manage their energy transition and we are sure you already have some in mind. So, go ahead and find out more to fuel a lively debate at KaMUN – The Black Forest Summit 2019.

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[27] See IEA, https://www.iea.org/statistics/, retrieved 15.10.2019.
[28] See IRENA, https://www.irena.org/lac, retrieved on 15.10.2019.
[29] See IEA, https://www.iea.org/statistics/, retrieved 15.10.2019.
[30] See The Guardian, https://www.theguardian.com/world/2017/jan/05/costa-rica-renewable-energy-oil-cars, retrieved on 15.10.2019.