Chapter 4

# Moving from New and Renewable Energy to Renewable and Carbon-Neutral Energy

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## A. Overview of Renewable and Carbon-neutral Energy

Energy is an essential part of human life. The discovery of woodfires in the early ages of civilization has helped the human population survive cold winter days, increased life expectancy, and resulted in better sanitary practices in nutrition, i.e., no longer eating raw meat. In the centuries that followed (19th century), we discovered that we were sitting on years' worth of energy naturally deposited deep within the Earth's crust in the form of fossils. Fossil fuels differ in their forms and uses. For instance, coals were used to generate steam, while oils were refined to produce liquid transportation fuels. Our decades of reliance on fossil sources have led to the technological advancements used in

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their exploitations. Oil and gas explorations have even shifted from land to offshore activities, where new deposits have been discovered lately.

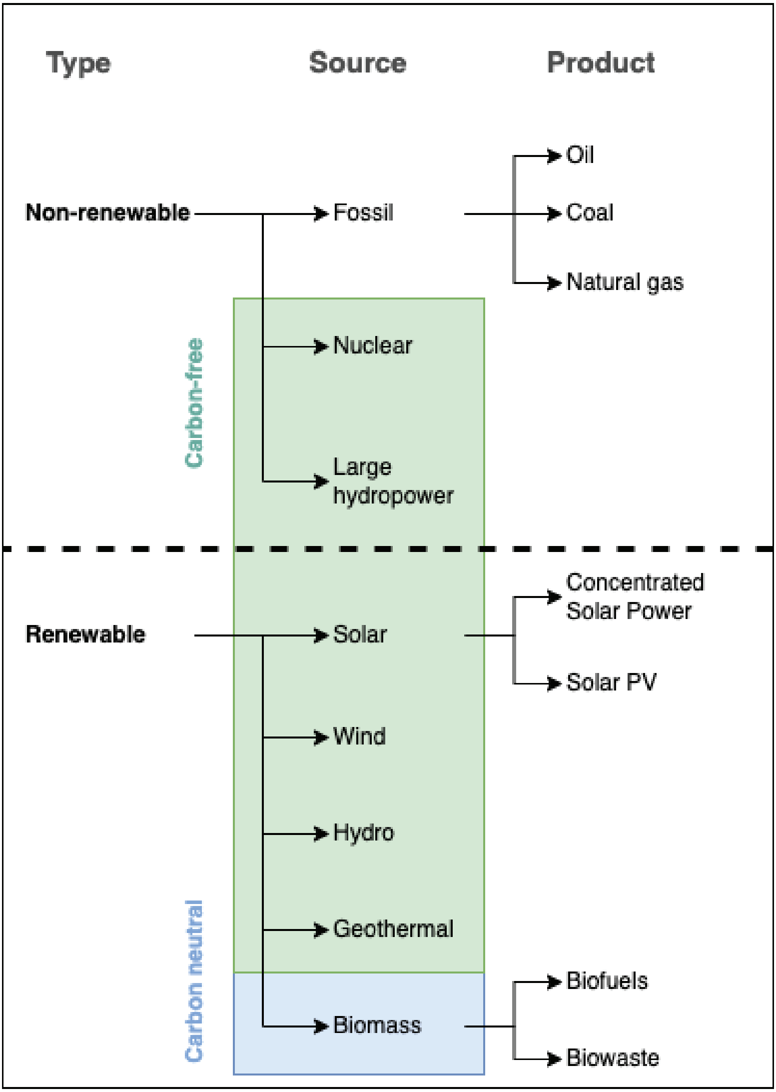
Despite their conveniences, fossil fuels have long been at the heart of the sustainability debate. Proponents of the climate crisis have put a share of the blame for global temperature rise on the activities that involve fossil use. This allegation is not without reason because burning up fossil fuels releases carbon into the atmosphere ($CO_2$) along with harmful gasses, such as nitrogen oxides ($N_2O$, NO, and $NO_2$) and sulfur oxides ($SO_2$ and $SO_3$). In the case of sulfur, the operation of coal power plants generates around half of the total industrial $SO_x$ emissions in a case study in China (Wang et al., 2018). These gasses work a range of harmful actions on the atmosphere, partly responsible for the global warming. The Earth's global surface temperature has reached terrifyingly worrying levels, an increase of 1.19 °C compared to pre-industrial levels (Lindsey & Dahlman, 2021). The number is already close to an agreed limit of 1.5 °C set to avoid inciting devastating effects globally. This phenomenon has not escaped the public's attention and the world's governing officials. Most recently, world leaders around the globe met at the COP26 Climate Change Conference forum in Glasgow (UK) to convene on global actions required to halt the progression of looming climate disasters. The COP26 forum can also be recognized as the five-year check-in of the Paris climate agreement and our collective progress thus far. This chapter aims to check on our progress in halting the climate crisis by looking at the energy transition and outlining a way forward towards our carbon emission mitigation goals using a mix of low carbon energy sources.

To fulfill its goals, this chapter discusses the status of renewable energy use globally, elaborate on the carbon impact of energy shift from fossil to renewable sources, and introduce a new criterion in renewable energy: carbon-neutral energy.

## B. Checking-in on Renewable Energy Sources in 2021

The term 'renewable energy' can be loosely assigned to non-fossil-derived energy sources. The International Energy Agency (IEA) defines renewable energy as "all forms of energy that are produced sustainably from renewable sources " (IEA, 2002 in S.G. Banerjee et al., 2013). In this case, the agency further elaborated that renewable energy sources are derived from natural processes with a higher rate of replenishment than consumption (S.G. Banerjee et al., 2013). The definition allows for a new type of energy to come in and is classified as renewables. As far as this chapter concern, we will be looking at the status of several types of renewables already widely applied: solar, wind, hydropower, biomass, geothermal, biofuels, and hydrogen obtained from renewable resources (S.G. Banerjee et al., 2013). Renewables can be further grouped based on their carbon status: carbon neutral or carbon-free. The two groups will be discussed in more detail in the coming section of this chapter.

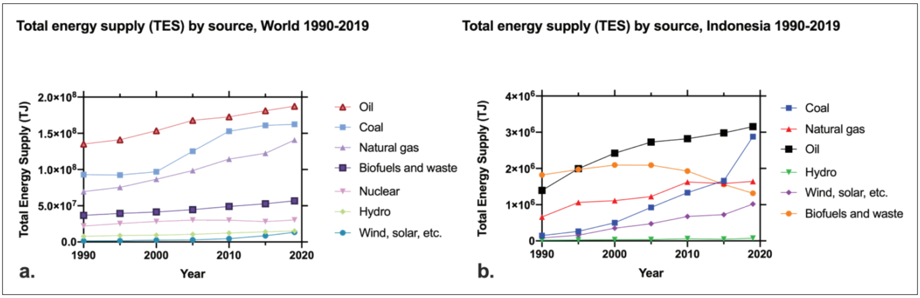
The classification used in this chapter is presented in Figure 4.1. We divide the type of energy into two categories of energy sources: renewable and non-renewable. Non-renewable energy sources consist of fossil, nuclear, and large hydropower. Fossil sources can be further divided into several products: oil, coal, and natural gas. Oil is commonly used as transportation fuel, while coal is widely known as the feedstock of coal power plants' electricity generation. Natural gas may serve several purposes, mainly heating and electricity generation. The three derivations of fossil sources are targets for alternative energy sources to replace. The second type of non-renewable energy source is nuclear. Albeit posing major advantages over other renewables, especially in terms of carbon emission, nuclear power plants require feedstocks available in finite amounts on Earth. Hence, it is still categorized as the non-renewable category. Lastly, large hydropower is considered non-renewable due to the high environmental risk they pose that weighs over the technology's potential for clean energy generation.




Note: Renewable and non-renewable energy sources are separated by a dash (--) line.

**Figure 4.1** Energy Resources Typing and Classification

The second category is renewable energy. In this type, we can find various energy sources like solar, wind, hydropower, geothermal, and biomass. The use of solar energy can be divided into two: electricity from solar photovoltaic (PV) panels or heat from concentrated solar power (CSP). For biomass, we can separate the product into two: energy coming from the conversion of biowastes or from a crop specialized to produce biofuels. We will discuss these energy sources in detail in this chapter. Finally, Fig. 4.1 divides these energy sources based on their carbon-emitting characteristics. Those considered carbon-free are nuclear, hydropower, solar, wind, hydro, and geothermal, if we think only the energy sources converted to the end product. However, considering the project's whole lifecycle, no power plant is really carbon-free since construction involves carbon emissions. Biomass is considered carbon-neutral because it requires assimilating carbon as a principal nutrient for growth, taking up carbon from the environment.




Note: a. World scale, b. Indonesia
Source: Adapted from IEA (2021a)

**Figure 4.2** Total World Energy Supply from Various Energy Sources

## 1. Solar

Solar energy is one of the most famous forms of renewable energies. The technology relies on converting sunlight to electricity as a usable form of energy. Sunlight is captured using specific light-harnessing panels, called Photovoltaic (PV) panels. The challenge with solar power lies in the varying amount of sunlight received by a geographical surface throughout the day due to weather factors and seasonal variations in a year, which poses a stability challenge in generating steady electricity output. Moreover, solar panel installations on dedicated sites require large amounts of land, which pose land use problems due to the clearing of lands to provide space for the panels. To overcome this drawback, solar panels can be installed on already functionalized areas, for example on the roofs of houses in residential areas. The main advantage of solar power lies in the ability of the panels to be installed in remote areas with relative ease compared to installations like wind turbines or dams. Due to this feature, solar energy is one of the most widely applied types of renewable energy worldwide.

In 2019, solar power generated 680,952 GWh of electricity worldwide (IEA, 2021a). In Indonesia, solar is underutilized relative to its potential at 0.04% in an installed capacity of 78.5 MW (Rencana Umum Energi Nasional, 2017). The latest IEA data showed a significant increase in solar PV electricity generation in the country at 118 GWh in 2019 (IEA, 2021a). Nevertheless, China has installed a lot more solar PV in Asia.

## 2. Wind

Wind power can be converted into electricity using turbines. However, wind turbines are large in scale and difficult to install due to the limited availability of materials required to construct them, leaving environmental footprints in the process. Nevertheless, this drawback is little compared to its benefits. The carbon footprints of wind installations can be paid off by themselves in less than six months of operation (Sayed et al., 2021). Wind power and solar are considered the most technologically advanced renewables (Sayed et al., 2021). It is also incredibly eco-friendly in terms of gaseous emissions. In European countries, wind turbines can be found abundant on land, in contrast to Indonesia with little to no full-scale prototype installed. This contrast is often attributed to the characteristics of the region in Indonesia, in which wind power is considered low in potential compared to solar.

Countries with the most wind power electricity output are usually characterized by strong regional wind profiles. For this reason, Indonesia is not geographically strategic to rely on wind power. Therefore, we need to look to other renewables instead. However, research on wind power in Indonesia is still necessary to move past geographical limitations. Exploration of areas with a large potential for wind power needs to be intensified. Geographical mapping shows that despite the few availabilities, compared to the total land area, the country has areas with windspeed above 6 m/s. For instance, though rare, wind power is slowly implemented in locations such as in the South Sulawesi region, where the country's largest wind power plant project is located, i.e. PLTB Sidrap at 75 MW capacity with plans for expansion in the future.

### 3. Hydro

Hydroelectric energy is one of the biggest contributors to the renewable energy market. Power generated from hydro is bigger than all other renewables combined. However, its electricity generating potential also comes with a major drawback. The nature of hydropower installations involving dams has concerned many. If we look at hydropower from the perspective of the environment, this type of electricity generator is not sustainable in the long run. Dams have shifted water flows and disrupted the seasonal migration of water organisms. To overcome the drawback, solutions such as micro hydro power generators are proposed. It is expected that by limiting the scale of the generator, ensuing detrimental environmental effects can be limited.

Indonesia has planned on developing hydropower in the future. A cooperation was made between the ministry of energy and mineral resources (Kementerian ESDM), the state-owned electricity company (PT PLN Persero), and Japan international cooperation agency (JICA) to assess hydropower development in Indonesia (JICA, 2009).

## 4. Geothermal

As the name suggests, geothermal energy is sourced from heat stored within the Earth. Because of its nature, geothermal energy can be used directly for heating or converting it into electricity. To use geothermal, first, users need to overcome challenges like the isolated nature of sites with geothermal potentials. Luckily for Indonesia, areas with abundant geothermal potential are widespread. Challenges may lie in the energy distribution, if we consider the country's archipelagic nature. Another potential hurdle is the need for large capitals upfront, in contrast to alternatives like solar and wind. Nonetheless, geothermal energy is more stable compared to solar and wind.

Indonesia is considered a geothermal powerhouse. As a result of the country's location, which sits above the Ring of Fire, 276 geothermal sites with abundant geothermal energy potentials have been identified in the country. It is estimated that around 40% of the world's geothermal reserve, the largest in the world, is located in Indonesia (ADB & Bank, 2015). The country has several working geothermal power plants, in descending order of production output are: Gunung Salak (375 MW), Wayang Windu (227 MW), Darajat (255 MW), Kamojang (200 MW), Dieng (60 MW), Lahendong (60 MW), and Sibayak (12 MW) (Samyanugraha & Lestari, 2011). The management of geothermal working areas (GWAs) in Indonesia was previously managed only by PT Pertamina. PT Pertamina is the Indonesia's state-owned oil and gas company, and operates most of Indonesia's oil and gas resources. However, GWAs can now be managed by private entities through tender mechanisms.

## 5. Biomass

Living matter contains energy in the form of chemical substances. In principle, biomass is similar in utilization to fossil fuels. However, the time needed to regenerate usable biomass is much shorter than fossils. Hence, they are categorized as renewables. The main energy storage of biomass can be found in the forms of fats and oils. Vegetable oils, i.e., palm oil, are already utilized as biofuel in the form of biodiesel through physicochemical conversion processes. Carbohydrates can be fermented to produce ethanol, another form of liquid biofuel used in transportation. Biomass' versatility means that it can be used as solid, liquid, and gaseous fuels according to demand.

Biomass holds an important position in the energy mix since adopting electric vehicles will need some time to complete. It is predicted that in 2050 fuels will continue to contribute significantly to the global energy mix. Biomass can also generate electricity through combustion processes, namely direct combustion, co-firing, or converted into biogas. The versatility of biomass to play a role in the energy sector made this energy source very attractive, both in the academic setting and industrial.

Indonesia's share of renewables is also dominated by bioenergy. Indonesia came second (after Spain at +1.7%) in terms of renewable energy growth (+1.4%) back in 2018 due to the use of bioenergy for power generation (IEA, IRENA, UNSD, WB, 2021). Biofuels are an inseparable part of our current energy transition strategy. At least in the short term, the Government has planned a complete phasing in of biodiesel to a final mix of 100% termed B100 from B20 or 20% biodiesel mix. Indonesia is a major palm oil exporter. In the production of palm oil, energy-rich wastes are generated. These wastes can be converted to obtain energy, for example, biogas, biodiesel, or bioethanol. The conversion of palm oil waste to biofuels is a hot topic among Indonesian researchers.

## C. The Carbon Impact of Energy Shift

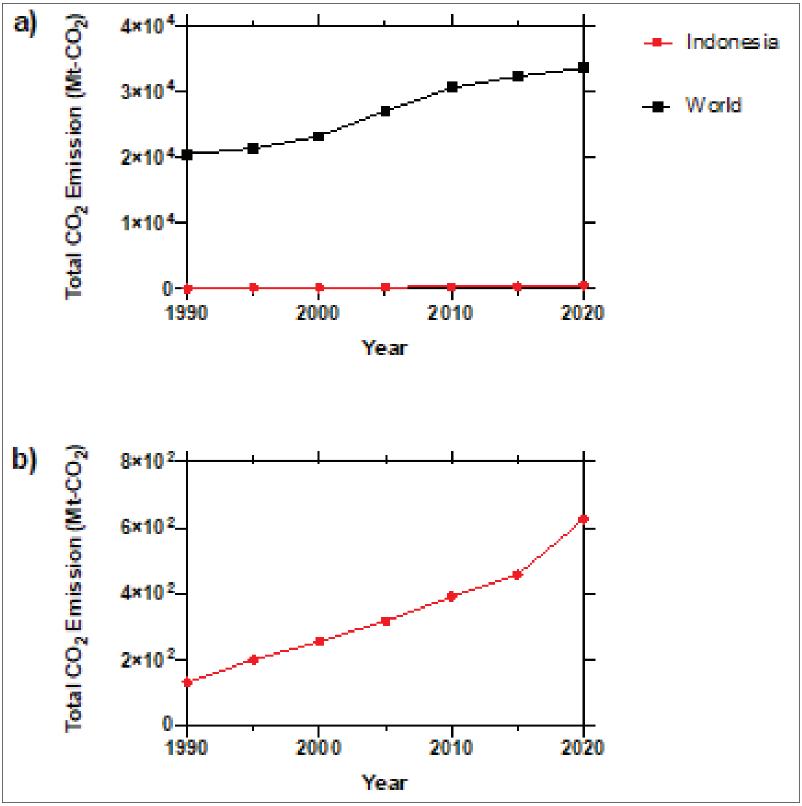
The ultimate goal of shifting from fossil-based energy resources to renewables is to reduce the anthropogenic impact on the rise of global surface temperature, which will ultimately lead to a climate crisis. Carbon is commonly regarded as the 'currency' to measure this impact. The use of carbon to measure environmental impact stems from the idea that the combustion of fuels generates carbon, often in the form of $CO_2$. The release of $CO_2$ into the atmosphere leads to an enhanced greenhouse effect, wherein energy received by the

Earth from the sun is trapped within the atmosphere. Normally, this radiative energy is only absorbed in 70%, with the rest released back to outer space (WMO, n.d.), and heat is trapped within the atmosphere to support organic life. However, human activities have disturbed the natural $CO_2$ balance in the atmosphere to the degree that the Earth is warming up abnormally over time.

The energy sector is a major contributor to $CO_2$ emissions. A shift to renewables is expected to bring carbon emissions down, coupled with other $CO_2$-targeted measures, which are anticipated to hold global surface temperature rise at 1.5°C. Collectively, the world generated 34,156 Mt of $CO_2$ back in 2020, this number is slightly lower than the year preceding it at 35,966 Mt yet higher by almost 2,000 Mt $CO_2$ than ten years ago at 32,345 Mt $CO_2$ (IEA, 2021b).

The reduction in emissions in the year 2020 is attributed to the global emergence of the COVID-19 pandemic. The pandemic caused a global phenomenon of sudden and drastic decrease in human activities, which is the main cause behind large $CO_2$ emissions in normal conditions. To emphasize, global pandemic finally lowered our total $CO_2$ emissions. Thus, it is hard to imagine the effort required to reduce $CO_2$ emissions to a level compatible with the sustainable development goal of only 28,487 Mt $CO_2$ by 2030 (IEA, 2021b). It is a large target if we look at the relationship between $CO_2$ emissions, economic growth, and human activities that tend to go together without special interventions. The impact of the COVID-19 pandemic on energy shift is expected to be significant and directly observable in the next few years. Ever since the pandemic hit, world governments have pledged a staggering USD 16 trillion in fiscal support to counter the impact of the crisis. From this number, around USD 380 million is aimed at the sustainable energy sector (IEA, 2021b).

Global and Indonesia-specific trends of $CO_2$ emissions can be consulted in Figure 4.3. The differences are stark within the last two decades (the year 2000 onwards). Indonesia's emissions are showing a drastic increase, while world emissions are levelling off between 2010–2020 compared to 2000–2010. Under the current policy scenario (CPOS) model, the Government of the Republic of Indonesia, will not be able to meet its Paris Agreement target with the $CO_2$ emissions trend expected to continue to increase until after 2030. The Paris Agreement compatible scenario (LCCP) is expected to meet Indonesia's 2050 $CO_2$ emissions level (GOI, 2021).




Source: Adapted from IEA (2021a)

**Figure 4.3** Total $CO_2$ Emissions at (a) Global Scale and for (b) Indonesia

Through a long series of analyses and discussions, eventually, world governments have mostly agreed to a Net-Zero Emission (NZE) target by 2050. This scenario is the most ambitious to date in terms of emissions reduction.

## 1. Inequality in the Global Push for Emissions Reduction

At the dawn of the era of industrialization, the West was leading in technological developments and innovation. As a direct result of the intensification of human activities driven by industrialization, $CO_2$ emissions skyrocketed. The lag between Western countries and the rest of the world was large for the following decades. Only recently have large and densely populated economies like China and India caught up in renewable energy growth and reforestation efforts. In recent years, almost half of the global increase in renewable energy production is a Chinese contribution. As the major economy in Southeast Asia, Indonesia contributes to renewable energy production in the region, which is not the case as the country still lags behind other fellow Southeast Asian countries in renewable power generation. On the other hand, Western countries have mainly developed and are less dependent on fossil resources. These countries are also the ones that are vocal in pushing for global emissions reduction. However, international cooperation is necessary for the rest of the world to achieve what Western countries have succeeded in decoupling $CO_2$ emissions from economic growth trends.

A carbon budget is a way to gauge carbon emissions limit to avoid a catastrophic rise in global surface temperature. Much like its counterpart in finance, it means the acceptable amount of CO2 emitted globally. Using cumulative CO2 emissions puts both large and small economies responsible for reducing emission. According to Friedlingstein et. al. (2022), the decrease of global CO2 emissions in 2020 was at 5.4%, back to the 2012 level, yet it rebounded quite fast in 2021 by 4.8%, almost on par with 2019 levels at 36.7 ±1.8 Gt-CO2/year). The recent IPCC (intergovernmental panel on climate change) report suggests that the remaining global carbon budget to stay under 1.5°C of surface temperature rise is only 400 billion tons of CO2 (starting from 2020). This can be paraphrased into a remaining nine years to evade climate catastrophe and environmental collapse (IPCC, 2021).

Countries belonging to the organization for economic OECD group peaked in their fossil CO2 emissions by around 2005 (Friedlingstein et al., 2022). Still to the same report, in the decades that followed (2010–2019), 23 countries with significant economic growth (dominated by large economies in the Northern hemisphere) combined only produced around 25% of the world's fossil emissions. Hence, most fossil emissions are produced from non-OECD countries during the aforementioned timeframe. Knowledge transfer and cooperation between countries with different technological advancements on low-carbon technologies and renewables are necessary. This point is reinforced as one of the target actions of SDG 7 on energy, namely to promote access to research, technology, and investments in clean energy by putting forward international cooperation (United Nations, 2018).

## 2. Emerging Carbon-Neutral Technologies

We have presented an overview of traditionally recognized renewable and carbon-neutral energy options in the previous sections. Solar, wind, geothermal, and biomass are well-known energy sources aimed to feed into our current energy system as fuel, heat source, or to generate electricity. We have not recently discussed the future of non-fossil-based sources that are gaining momentum recently. In this section, we are looking into hydrogen and nuclear, specifically. Hydrogen is widely dubbed the future of renewables, while nuclear is a controversial subject with a large potential, yet strong voice of opposition.

Hydrogen in the energy sector refers to the highly energetic, combustible dihydrogen ($H_2$) gas. $H_2$ can be derived from fossils or renewables, in which the carbon footprint of the hydrogen production process will define the final $H_2$ product as either 'clean' or 'unclean'. In 2018, almost all (99%) of hydrogen obtained from dedicated production facilities (a total of 70 Mt) was derived from natural gas or coal, while 45 Mt was obtained as a by-product of other industrial processes (Energy Transitions Commission, 2021). The versatility of hydrogen as energy storage in the power system has gained momentum these past decades. The hydrogen-based economy is planned on the horizon by multiple countries, including Japan which started this campaign in 2017 and France with a big pledge to build the hydrogen economy. The year 2020 saw world governments seriously planning on integrating green hydrogen into their national energy strategies, at least 33 countries have committed themselves to this goal (Lee & Zhao, 2021). All previously identified renewables were identified in the literature to contain significantly lower power density than fossils and nuclear; even coal scored higher than solar (van Zalk & Behrens, 2018).

The Hydrogen Council has identified the roles hydrogen could be a vital aspect in our road to net-zero emissions. These roles are divided into seven (Hydrogen Council, 2017):

1. Enable large-scale and efficient renewable energy integration,
2. Allow energy distribution across regions and sectors,
3. Function as a buffer to ensure energy supply,
4. Act as a solution for hard-to-transport energy needs (long-range transport, intensive energy-consuming industries, residential heating),
5. Decarbonizing feedstocks in coupling with CCU or CCS.

Hydrogen presents a way to bypass challenges faced by renewables. It allows storage of renewables, reducing intermittency problems. Additionally, hydrogen is not only energetic, but also used in chemical industries.

Nuclear energy is often regarded as the hot seat of non-fossil energy sources. Everyone wants nuclear power plants, but all fear the occasion of failure that would lead to nuclear disasters. Nuclear energy relies on specific materials that are only present in finite amounts on Earth, making it non-renewable by design. The material in question is uranium isotope 235 ($^{235}U$), which usually only accounts for 0.711% of the uranium in nature. Currently the world's combined identified recoverable uranium reserves stood at 9.24 million tons of uranium across all cost categories (OECD & IAEA, 2020). According to the same report, our current identified resources can sustain our needs for over 135 years if we base consumption on 2019 data (OECD & IAEA, 2020).

Discussions on nuclear energy are always polarized. Proponents of nuclear energy base their arguments on technology's energy generation potential and low emissions aspect. Meanwhile, the opponents are more focused on the environmental impact of radioactive waste and risk avoidance of a nuclear accident. In terms of potential, nuclear energy came in at the top of the list of other renewables. It is mainly due to the feedstock's potential stability and energy density.

Australia is the world leader in uranium reserves, accounting for up to 28% of the global identified resource (OECD & IAEA, 2020). Indonesia has also reported uranium reserves under the cost categories of <80 USD/kg-U, <130 USD/kg-U, and <260 USD/kg-U missing only the lowest cost category in its arsenal (OECD & IAEA, 2020).

## D. Renewable Energy from the Carbon and Environmental Perspectives: Weighing the Ecological Cost of Renewables

When we talk about carbon-free energy, the term renewable almost always comes to mind. However, the reality is that carbon-free energy does not always mean 'renewable'. For example, in most nuclear power plants (NPW) energy is released from the nuclear fission of the Uranium atom. As a result, supply becomes the barrier that separates nuclear from other carbon-neutral renewables, effectively placing nuclear in the non-renewable category.

Aside from the problem of supply, ecological impact matters. It is particularly highlighted when discussing the case of large hydropower. To harness kinetic energy from water into a large-scale electrical energy, the building of dams is required. The problem with the construction of dams is not limited to the construction phase only, but the effect is long-term. Water flows are disturbed, affecting aquatic life and the migratory habits of several aquatic organisms (Gasparatos et al., 2017). Due to this ecological effect, large hydropower cannot be classified as renewable, albeit carbon-neutral. Since the energy generated from this setup is not sustainably produced.

The question with carbon-neutral energy sources can be summarized as "can [a particular energy source] be used to generate energy sustainably?". This question is important to consider when assessing alternative energies since the main motivation for energy shift is to avoid environmental disasters, including biodiversity collapse. We need to carefully thread the balance between our energy needs and environmental protection.

One important backbone of a green economy is energy transition. Economically, energy transition would open opportunities, ultimately driving economic growth in the long term through climate change mitigation, new job opportunities, and better health from a higher quality of living. Therefore, energy transition from fossil to renewable resources is non-negotiable. However, transitioning from one source to another needs to consider its impacts in a multisectoral view that involves the human aspect, and other living systems, in other words, biodiversity.

The shift from fossil-based energy infrastructure to renewables will involve heavy construction and installation in multiple sites worldwide. The process will undoubtedly leave significant environmental and carbon footprints in the early stages. Carbon emission as a way to measure environmental impact does not consider parameters like biodiversity loss. It is the case when land use is shifted, reducing forest coverage, i.e., plantation and power plants. The drawback of construction and specific land use can be justified in the long term if we evaluate the project based on its emission reduction potential. Although the end goal is still carbon emissions reduction, it is worth considering another aspect of the environment when aiming for sustainable energy transition practices, namely biodiversity conservation. Previous studies have tried to identify the ecological costs of energy transition for several types of renewables from solar, wind, hydropower, and bioenergy (Sayed et al., 2021).

Solar energy is generally regarded as environmentally friendly since the basic principle of harnessing and utilizing solar power generates no carbon dioxide. Solar panels can also be installed in urban settings, for example, on the roof of houses. The impact is aggravated when solar panels are installed on large surface areas as is the case for the CSP that was initially green areas like forests. In the end, the ecological impact of solar panels is minimal and does not outweigh their benefits in fulfilling of the world's ever-rising energy demands.

We can also examine the case of biomass energy from palm oil utilization. The problem starts with land use. Deforestation is carried out to clear out lands to provide space for palm oil trees, usually in areas that were previously forests. In Indonesia, palm oil industries thrive on the islands of Sumatra and Kalimantan, replacing rainforest-covered areas with palm oil plantations. In the land-clearing process, the ecological impact is significant that palm oil industries are closely associated with unsustainable business practices. Biodiversity loss easily occurs due to replacing various vegetation types with a single type of vegetation. The loss of biodiversity has threatened the extinction of endemic species in the region. Indonesia, one of the world's leaders in palm oil export, is facing this issue head-on since the region is also regarded as one of the world's leading biodiversity hotspots.

## E. Conclusions

The information discussed in this chapter aims to bring our focus back to terminologies often used when discussing energy sources. Renewable energy is often regarded as a way out of our dependency on fossil fuels. However, the term renewable energy can vary according to how we assess energy sources. Classical discussion on renewables almost always includes solar, wind, geothermal, and biomass energy. While these renewables are rightly in their spot as contenders to replace fossil energy, their adoption still has a long way to go to fulfill the requirement of global energy mix targets.

In this chapter, we have discussed how nuclear energy, despite being classically considered non-renewable, may provide a lasting solution to enhance the energy transition rate. In this case, the fact that its source material, $^{235}U$, is present in a finite amount on Earth can be outweighed by nuclear energy's carbon-free characteristics and potential. On the other hand, in the case of large hydropower, although generally considered carbon-neutral, the environmental damage of large hydropower installations is not negligible in the long run. Despite their renewable nature in terms of resources, large hydropower has been put into the non-renewable category due to its harm to biodiversity.

The energy transition is a complex goal that involves multi-sectoral components, including the environment. Environmental parameters play an important role in pushing for the transition. To assess impact, carbon ($CO_2$) is most used compared to other parameters. $CO_2$ is a well-known greenhouse gas that is involved in the progression of climate change, so the aim is to lower $CO_2$ released into the atmosphere in human activities.

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