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Energy at the Core of the Problem

CHAPTER 3

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3. Energy at the core of the problem

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Introduction

The great transformation of human conditions, which entailed an enormous impact on the conditions of the planet, began with one revolution, agriculture, and went on with two, scientific and industrial. In the blink of an eye, one species rose to such complete dominance of the biosphere, first accidentally, now capriciously and sometimes maliciously[1].

Agriculture changed the conditions for humanity on Earth, it allowed the population to grow much larger than previously and for many to enjoy higher standards of living. Agriculture also led to empire building, urbanisation, and the development of trade. It was however not until James Watt made the coal fired steam engine more reliable and efficient at the end of the 18th century that the economy started to grow significantly. First, the steam engine was adopted in mines and factories across the UK, and then it paved the way for the rise of the railway system, a major innovation of modernity. After the steam engine came electricity, bringing light, telephones, televisions, refrigerators and much more. This process of prompt and profound innovation culminated with the introduction of modern concrete and mass steel production, which allowed for massive urbanisation and a wide-spread road system. All of these modern inventions allowed for the Global economy to grow like never before and required ever increasing amounts of energy.

As we saw in previous chapters, the pursuit of economic growth has been the single dominant narrative for nations since WW2 as the only model that would bring well-being, prosperity, and stability to nations. This growth has come with a heavy price-tag. Growth based on the burning of fossil fuels and natural resource extraction is clearly established as interfering with the stability of Earth's climate, rendering it progressively less resilient. The solution is not to simply stop economic growth, as billions of people still need to be lifted out of poverty, rather alternative solutions must be identified and implemented.

To keep the temperature below 1,5C°, as recommended by the IPCC scientists, we must curb our GHG emissions and reach net-zero emissions by 2050 at the latest[2]. Currently we emit approximately 50 billion tonnes a year, the task at hand is not a small one.

To understand what needs to be done, in this chapter we will explore how and why energy is fundamental to human development and why, despite having such detrimental effects on the climate on Earth, access to modern energy has been identified as one of 17 goals of the SDG. We will then analyse energy use and CO2 emissions in different regions worldwide to prepare for the next chapter, which explores potential solutions. Finally, we will take a look at the Paris climate agreement and examine if it provides adequate governance tools to tackle the climate challenge on a global scale.

3.1 The energy paradox

Access to energy is key to human and economic development

"Energy is central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential. Transitioning the global economy towards clean and sustainable sources of energy is one

[1] Johan R, Breaking Boundaries, 2021

[2] IPCC 2018 Special Report on Global Warming of 1.5°C highlights that limiting global warming to 1.5°C compared to 2°C will have clear benefits to people and natural ecosystems and will require rapid, far-reaching and unprecedented changes in all aspects of society including Global net human-caused emissions of carbon dioxide (CO2) to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050. This means that any remaining emissions would need to be balanced by removing CO2 from the air.

of our greatest challenges in the coming decades. Sustainable energy is an opportunity – it transforms lives, economies and the planet."[3]

Sustainable Development Goal 7 (SDG7) strives to ensure access to modern energy for all. However, we find ourselves in the 'energy paradox', on the one hand energy is key to human development, as it is an enabler of many of the other SDGs, while at the same time also the main cause for the increased anthropogenic GHG emission over the past 70-100 years. As such, SDG7 aims to address both issues simultaneously by proposing that access to energy is fundamental for human development, but that this energy must be modern, i.e., it must come from renewable sources and its use must be as efficient as possible in order not to have negative consequences on the planet's climate. SDG7 is relevant to both developing and developed/emerging countries. It addresses the lack of energy access, which is prevalent in developing nations, and it is also these countries that will face the majority of future energy demand. Moreover, it is also pertinent to developed and emerging countries due to their high levels of fossil fuel consumption and related CO2 emissions.

To incorporate all these elements, the SDG7 includes four distinct goals that need to be tackled and improved simultaneous at varying degrees depending on the situation in the given country or location to meet the universal access to modern energy goal:

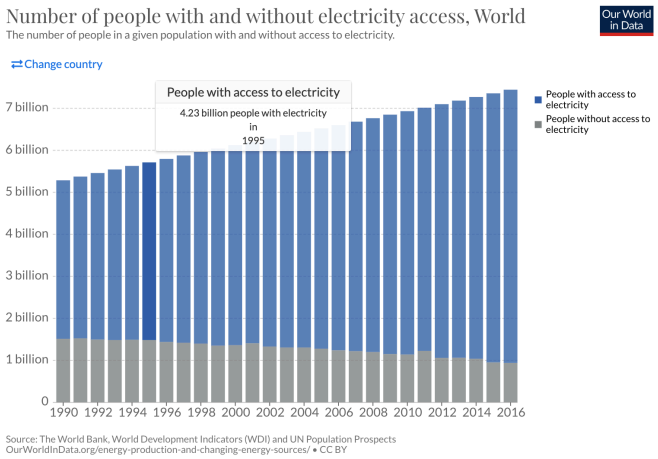
SDG7: Ensure access to affordable, reliable, sustainable and modern energy for all

i. Access to electricity

Definition: The proportion of population with access to electricity.

Access to electricity is measured as the share of people with electricity access at the household level. It comprises electricity sold commercially, both on-grid (the main electricity network) and off-grid (producing decentralised electricity, mostly with innovative technologies).

Global access to electricity has been steadily rising in recent decades. In 2001 1.4 bill people did not have access to electricity, and by 2019 this number had halved to 700.000 million[4]. Between 2005 to 2016, 1.26 billion got access to electricity for the first time, an impressive 126 million per year (Fig 1).



[3] UN, SDG Tracker: https://sdg-tracker.org/energy#:~:text=The%20UN%20explains%3A%20%22Energy%20is,energy%20for%20all%20is%20essential.&text=Sustainable%20energy%20is%20an%20opportunity,%2C%20economies%20and%20the%20planet.%22

[4] World Bank, Tracking SDG7, The energy tracking report, 2021

Fig 1: Number of people with and without access to electricity, 1990-2016

Despite such impressive numbers, one continent is lagging: Africa. Sub-Saharan Africa is today home to 75% of the world population without electricity access. In Africa the number of people without access to electricity, which peaked at 610 million in 2013, has declined progressively to around 580 million in 2019[5] (Fig 2).

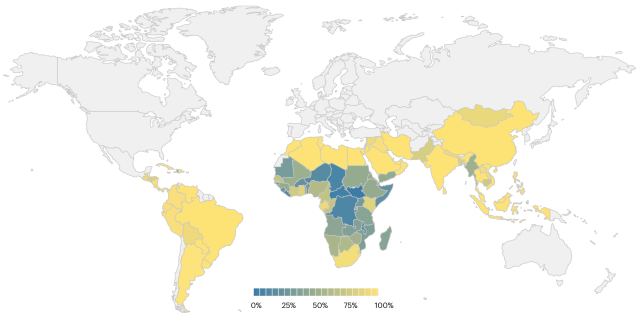


Fig 2: Proportion of the Population without access to electricity, IEA, 2019

Goal: By 2030 ensure universal access to affordable, reliable and modern energy services. This concerns around 700 million people worldwide (approximately 10% of the world population), mainly living in emerging economies where still many households, public buildings (schools, health clinics, local authorities' offices) and businesses do not have access to electricity, and where services like lighting in public spaces are missing. It therefore requires that all homes, public institutions and businesses worldwide will have access to electricity by 2030.

ii. Access to clean fuels for cooking and heating

Definition: The proportion of population with primary reliance on clean fuels and technology for cooking and heating.

Access to clean fuels is measured as the share of the total population with access to clean fuels and technologies for cooking and heating. Access to clean fuels or technologies such as liquefied petroleum gases (LPG) or clean cookstoves reduce exposure to indoor air pollutants, a leading cause of premature death in many low-income households.

The number of people without clean cooking facilities has been declining gradually over the last two decades, only just keeping ahead of population growth (Fig 3). Since 2010, over half a billion people have gained access to clean cooking with a vast majority of these being in India and China as a result of liquefied petroleum gas (LPG) programmes and clean air policies[6].

[5] IEA, Universal Access to Sustainable Energy Will Remain Elusive Without Addressing Inequalities, 2021
[6] IEA, WEO 2017, Special Report on Energy Access, 2017

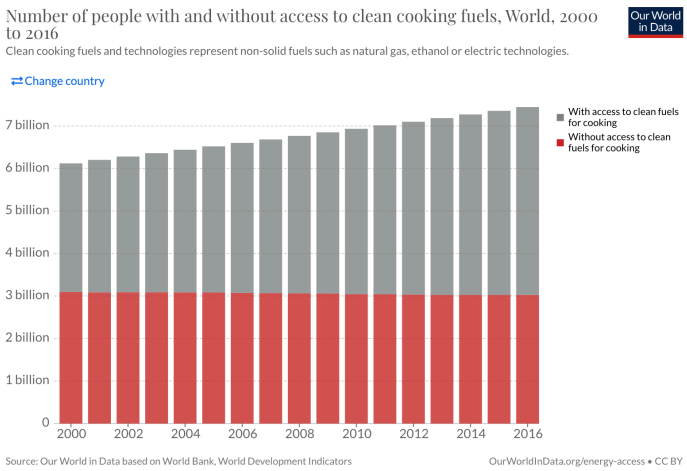


Fig 3: Number of people with and without access to clean cooking fuels, World Bank, 2000-2016

Today, more than 2.6 billion people worldwide still do not have access. 65% of the global population without access are in Developing Asia with 1.6 billion people lacking clean cooking facilities. Seven-times more people lack clean cooking access than electricity in this region. In sub-Saharan Africa the situation is acute and since 2015, only 25 million people have gained access to clean cooking in the region, and as a result the number of people without access increased to around 900 million by 2018 as population growth outpaced the provision of clean cooking[7] (Fig 4).

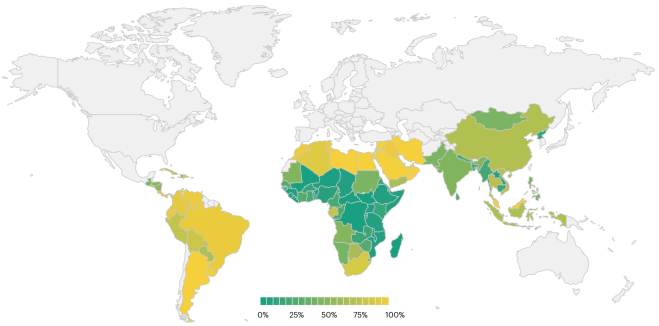


Fig 4: Proportion of the population without access to clean cooking facilities, IEA, 2018

Goal: By 2030 ensure universal access to affordable, reliable and modern energy services.
This concerns around 2.6 billion people worldwide[8] (approximately 36% of the world population) that continue to cook and heat their homes over an open fire. It requires that all homes have access to cleaner fuels, such as LPG, and/or to modern technologies for cooking, such as improved cookstoves by 2030.

iii. Renewable energy

Definition: The share of renewable energy in the total final energy consumption.

This is measured as renewable energy (inclusive of solar, wind, geothermal, hydropower, bioenergy and marine sources), as a share of final energy consumption.

Global consumption of renewable energy has increased significantly over the last two decades, with a distinct upward trend from 2005 (Fig 5). Despite its rapid growth, renewable energy consumption

[7] IEA, WEO 2017, Special Report on Energy Access, 2017
[8] IEA, WEO, 2020

remains far below that of fossil fuels and great efforts must be made by all sectors to accommodate increasing amounts of renewables in the energy mix. The growth of renewable energy since 2005 has been largely due to reduction in technology costs and is expected to continue. Using clean energy technologies along with energy efficiency solutions will be key to reducing GHG emissions.

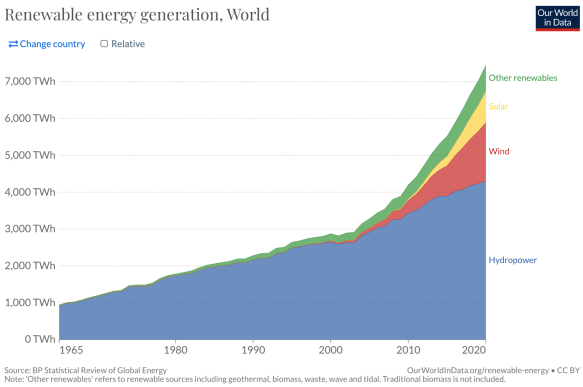


Fig 5: Renewable energy generation, World

Goal: By 2030, substantially increase the share of renewable energy in the global energy mix. This requires that a substantial amount of the energy consumed in developed countries be replaced by renewable energy, and that a substantial amount of the households and business in emerging economies that gain first time access to electricity, do so through renewable energy.

iv. Energy efficiency

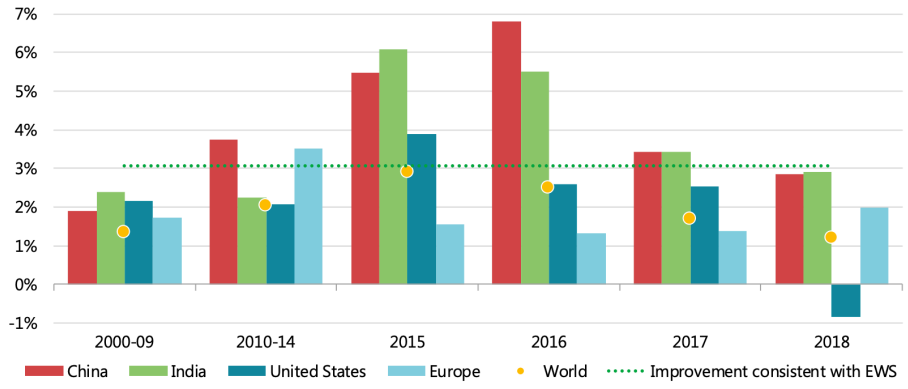
Definition: Refers to minimizing the amount of energy needed to obtain the same or better energy service through better technology and fuel usage.

Energy efficiency includes both a more efficient transformation of primary energy into final energy (reduce losses in generation and transmission of electricity) and an efficient use of final energy (for personal and productive uses). When striving for energy-efficiency in homes and buildings, the goal is to use less energy to heat, cool, and run appliances and electronics. When implementing energy-efficiency in manufacturing facilities the goal is to use less energy to produce the same goods.

Even though energy efficiency has tremendous potential to boost economic growth and avoid GHG emissions, the rate at which technologies and processes are becoming more energy efficient has been slowing globally in recent years due to a combination of certain factors including increased demand for primary energy for industry, cooler winters and warmer summers, demand for bigger cars and increased residential living area as well as increased per person device ownership and use. Regional differences are noticeable (Fig 6).

Energy efficiency will need to increase globally from 1.2% in 2018 or 1.7% in 2017 to at least 3% to achieve a level of energy intensity improvement consistent with meeting global climate change and sustainability goals and can be supported through continued technical efficiency improvements, better and stronger policies, digitalisation, and increased investment[9].

[9] IEA, Energy Efficiency 2019, 2019



Source: IEA (forthcoming), *World Energy Outlook* 2019; IEA (2019a), *World Energy Balances 2019* (database).

Fig 6: Primary energy intensity improvement

Goal: By 2030, double the global rate of improvement in energy efficiency.
This requires that we improve insulation of buildings and replace old, inefficient electric devices and vehicles with modern, energy efficient technologies, which should meet stricter global energy efficiency standards.

Link between energy and development

It is not possible to establish direct causation[10] between energy access and human development because too many external variables compromise the reliability of causality between the two. However, over the past 200 years we have observed a correlation between economic and social development with energy sector transformation. As we can observe in Fig 7, the richer a country gets the lower its reliance on traditional use of biomass (negative correlation) while electricity use and its per-capita energy use rise[11] (positive correlation).

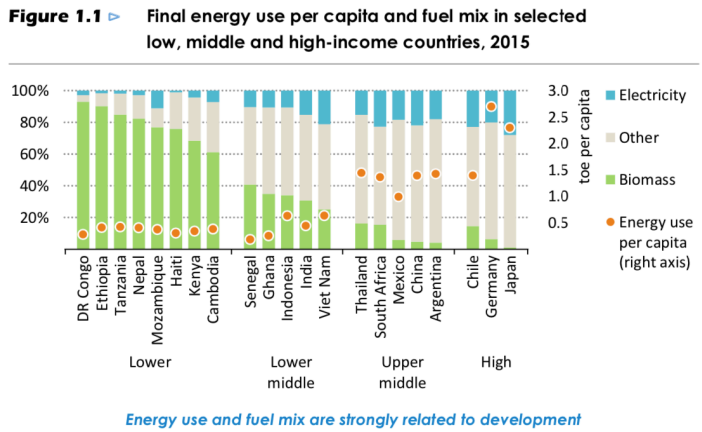


Fig 7: Final energy use per capita and fuel mix in selected low, middle and high-income countries, 2015

Therefore, despite not being able to establish direct causation, access to energy is recognised as one of the main drivers and essential conditions for economic and human development. Insufficient access to energy can cause the marginalisation of entire villages or cities, as well as undermine access to quality health and educational facilities as well as business opportunities for the individuals. Women and children suffer the most from the lack of energy, as they are primarily responsible for the household's energy and water supply, food preparation and cleaning. This causes physical drudgery, with additional physical consequences. Biomass (wood, dung and agricultural

[10] Causation means that one event causes another event to occur
[11] IEA, WEO 2017, Special Report on Energy Access

waste) is in fact most frequently burned on inefficient traditional stoves and open fires. No, or limited, access to energy not only reduces women and children's empowerment and increases inequalities, but also affects the entire household's health, as toxic fumes are produced by inadequate combustions.

The poor and those without modern energy access are often the same and having access to modern energy is not only a necessary condition for overall poverty alleviation but is also in many cases an added obstacle to break the vicious circle of poverty as they are forced to spend a large share of their income on low quality and often expensive energy sources for lighting (kerosene and candles), as well as pay high prices for mobile phone and battery charging. The same is the case regarding basic cooking needs, where they are dependent on inefficient and polluting fuels and technologies which are time consuming to acquire and use.

While cost and affordability of energy access is a key concern for the poorest households, other barriers exist with regard to transitioning to cleaner household fuels including social, cultural and individual characteristics such as perceptions about the security and reliability of supply of alternatives to biomass. Such barriers remain relevant for medium and upper-level income families which explains why a significant number of families within these income categories do not have access to electricity[12] (Fig 8).

The transition to modern energy use can therefore be a challenge not only for low-income families. Use of modern energy services requires those services to be technically available (i.e., either through grid-based connection or decentralised solutions), affordable (i.e., at a price that does not prohibit use and where initial connection is reasonable compared to family income), adequate (i.e., sufficient supply and quality of supply), acceptable (i.e., in line with historical or cultural factors) and reliable (i.e., available and usable for most of the time). Even in countries that have achieved universal access to energy, such as in most high-income countries, the quality and affordability of access to modern energy often remains a challenge.[13]

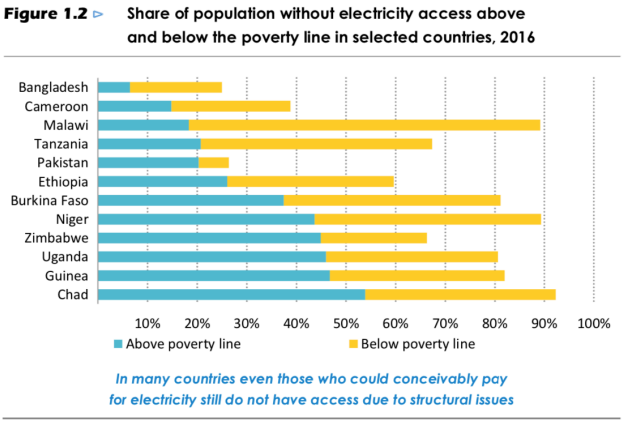


Fig 8: Share of population without electricity access above and below the poverty line, 2016

[12] Michael U. Treiber, Fuel and stove diversification in the light of energy transition and technology adoption theory, Noragric Department of International Environment and Development Studies, 2012

[13] IEA, WEO 2017, Special Report on Energy Access, 2017

Achieving a just energy transition is a global issue

Tackling climate change requires a swift energy transition, moving away from fossil fuels by optimising energy efficiency and renewable energy in developed and emerging economies and reducing biomass reliance and loss of forests by promoting renewable as the first-time access in developing economies.

To ensure a just transition, it is crucial not to leave anyone behind and to treat those whose livelihoods and environments are disproportionally impacted with fairness and consideration. This includes the workforce in the shrinking fossil fuel industry, that should receive adequate training to be fit for job opportunities in innovative industries. It also includes addressing energy poverty, a phenomenon that not only concerns developing countries but is also a reality for many families living in developed countries. SDG7 strives to provide modern energy to all and to achieve this it is of the uttermost importance to safeguard vulnerable families from the adverse and potentially disruptive effects of the energy transition

Another dimension of assuring a just energy transition concerns the effects of climate change. From extreme weather and increasing temperatures to rising sea levels, the effects of climate change often have disproportionate effects on the marginalised or underserved communities and most often it is the poor and vulnerable that will suffer first and will be the worst hit.

Noah Diffenbaugh and Marshall Burke have in a recent research analysis concluded that climate change has already made it significantly harder for poorer countries to catch up economically with richer countries, and that this is a phenomenon that will only increase in the future. The fact that developing countries are, and will continue to be, the hardest hit by the effects of climate change is linked to a variety of issues, but the primary driver is the parabolic relationship between temperature and economic growth, with warming increasing growth in cool countries and decreasing growth in warm countries[14]. Such trans-national issues can only be adequately addressed by global energy governance as some form of compensation is justified for those countries that are least responsible for past and present GHG emissions and yet are paying the steepest price.

Climate change is also expected to affect low-income communities in developed countries harder than high-income communities. Low-income communities are more likely to live in suboptimal housing conditions with bad insulation, have relatively high energy bills and low income which may significantly impact the health and social welfare of the family. As families living in low-income communities have less means to be able to adapt to climate change, such as installing air-conditioners and preparing for extreme weather events, they are more likely to be greater affected by the effects of climate change.

Given the strong connection between energy access and human and economic development on the one hand, and energy and climate change on the other, it is clear that achieving the SDG7 is closely tied to achieving many of the other SDGs. In fact, access to modern energy is key to the overall objective of Agenda 2030 which is to increase equality and prosperity for all while leaving no one behind. Let's take a closer look.

[14] Diffenbaugh N. S., Burke M., 2019. Global warming has increased global economic inequality, Proceedings of the National Academy of Sciences, p.116

Poverty | SDG1: "End poverty in all its forms everywhere"

The International Poverty Line is set by the World Bank and is today fixed at 1.90$ a day[15]. It is important to emphasise that this is extremely low and people living well above the International Poverty Line may still be living in hardship and poverty.

People living in poverty, especially extreme poverty, are often hungry, have no access to education or health services, and no access to light at night. Therefore, poverty is often referred to as a 'trap', as the elements that could help them escape poverty are not accessible like education, nutritious food and clean water, access to health and energy services. As such, poverty cannot be addressed in isolation, and it will take a holistic approach to assist people in rising out of poverty.

Access to energy has an important role to play in addressing poverty. Lack of energy is considered not only as a form of poverty, but also a consequence and a cause of it.

• Lack of energy is a form of poverty because it prevents people from meeting their basic needs, as well as empowering and developing on personal level.
• It is also a consequence of poverty, as low-income households often cannot afford energy services, although indispensables for daily living. As a result, they either do not manage to pay their bills (and their energy supply is interrupted) or opt for non-adequate, unhealthy, and dangerous solutions to heat the house or to cook (just apparently cheaper, but expensive to maintain).
• It is also a cause of poverty because it precludes possibilities of income generation. With no or limited energy, it is difficult to develop at personal level (i.e., studying or reading at night, watching TV, etc…) or to run a business, and therefore the possibilities of rising from the poverty status are very limited.

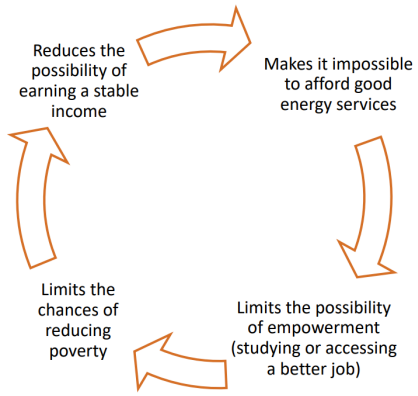


Fig 9: Energy Poverty: A vicious circle

In many parts of the world, women are responsible for supplying energy to the household and therefore, often disproportionally affected by this vicious circle. Not only do they not have access to modern energy services, but they often have to spend several hours every day to collect firewood to cook and heat the homes over an open fire. To break this vicious circle, modern energy services need to be affordable to low-income families, in a way that can be sustained in the long run (and not only for a short period, as in the case of a one-time discount). This principle applies both to developed and developing countries. For this purpose, specific policies and subsidies could be adopted to reduce energy prices for vulnerable consumers.

[15] World Bank, www.worldbank.org

Food | SDG2: "Zero Hunger"

SDG2 seeks to end hunger and all forms of malnutrition and double agricultural productivity. Malnutrition is the result of not having access to sufficient food, or not consuming adequate nutrients, and can therefore be a result of poverty due to access to limited resources, or the result of inadequate calories consumption often leading to obesity, the other side of malnutrition. (More in chapter 4)

Ensuring sustainable access to nutritious food universally will, on the one hand, require sustainable food consumption and production throughout the world. On the other, it will require access to modern energy and cooking facilities that will allow families to prepare their food adequately so they can be sure the quality and quantity of their every-day meals meet the nutritional needs of their family members. Just imagine how hard it is to prepare a meal without the possibility of boiling water, or baking bread?

Improving access to modern energy and cooking technologies contributes to achieving the SDG2: "Zero hunger".

• Access to modern energy forms is important for small-scale farmers to produce enough food for their families. Giving farmers access to modern energy to irrigate their lands and using modern farming technologies, allow them to improve food security for themselves and their families. This reduces poverty and hunger in the short and long-term.
• Access to modern fuel types, such as electricity and LPG, makes the preparation of nutritious meals easier and avoids the problems related to fuelwood scarcity, which may lead to consuming foods that do not need cooking. More nutritious food is usually more elaborate and needs to be cooked to become digestible or safe enough to be eaten (i.e., meat, beans, eggs …), and to be preserved adequately for future consumption. If those options are inaccessible because of the lack of energy, the average consumption of proteins and carbohydrates will be reduced, leading to poor nutritional balance and malnutrition as well as food poisoning.
• In developing countries, collecting firewood for cooking and heating can be very time and energy consuming, as forests are often not close to villages. This physical drudgery requires a higher caloric intake that is not always possible to satisfy, and often aggravates health conditions. When wood or alternative fuels (like kerosene) must be purchased, energy has a strong effect on the family finances. In fact, a big part of their income must be used to purchase fuels for cooking, rather than food itself.
• Biofuels, such as crop residues and dung, are often burnt to fuel cooking in developing countries, when they could be used as fertilizers to increase land productivity.

Health | SDG3 "Ensure healthy lives and promote well-being for all at all ages"

SDG3 aims to ensure healthy lives and promote well-being for all at all ages. Crucial to healthy lives is access to health facilities that can provide necessary services by qualified staff and the avoidance of unnecessary exposure to external factors that are bad for our health, like air pollution and inadequately managed water and sanitation. Having access to modern forms of energy and cooking facilities is important for both of these reasons. Far too many deaths continue to occur because health facilities do not have access to electricity and cannot provide the help needed. The lack of light during child-labour at night, lack of cooling facilities to store medication and immunisation securely are examples of this.

According to the World Health Organisation (WTO), there are around 4 million premature deaths every year worldwide as a direct result of household air pollution caused by domestic smoke

deriving from dirty cook stoves and fuels[16]. Most of these victims are women and children, as they spend more time in the house and are responsible for collecting firewood, cooking, and heating.

Providing access to modern energy will therefore contribute to achieving the SDG3: "Ensure healthy lives and promote well-being for all at all ages".

• Electrification enables doctors and health workers to intervene during emergencies at any time. Hospital refrigerators allow storage of medicines and vaccines and make modern treatments and disease prevention accessible.
• When modern technologies and fuels are not available, traditional biomass (wood, agricultural residues, animal waste) is burned to cook. Similarly, when electricity is not accessible, candles, kerosene, or other highly polluting fuels are used for lighting. This, together with scarcely ventilated homes, leads to serious health consequences, in particular, lung diseases.
• Firewood collection is a drudgery that heavily affects people's health. The average firewood load varies from 25 – 50 kg, with damaging consequences to postures, as well as back and muscle pain.
• Without electricity is impossible to watch TV or make the fridge work. Having a functioning refrigerator in the house reduces the risk of food poisoning and makes food, vaccines, and medicines last longer. Watching TV give people access to more information about health, hygiene, social norms and sexuality, topics that may be taboo in many countries due to a lack of information about them.

Education | SDG4: "Quality Education"

Education enables upward socio-economic mobility and is a key to escaping poverty, especially in childhood but also in adult life when one must adapt to changing circumstances. According to UNESCO, about 258 million children and youth do not have access to education worldwide[17]. This is because most of these families cannot afford to send their children to school regularly (school fees, stationary, books and material) and often they need the extra income the children generate from work. Children are also often responsible for firewood and water collection, meaning they have limited time to study and attend school. Having access to electricity at home and at school, allows students to extend studying hours, read at night, watch TV and have diversified sources of information.

Enhancing access to energy therefore supports the achievement of SDG4: "Quality education".

• Lack of access to energy particularly affects women and young girls, as they are responsible for collecting firewood and water as well as cooking and heating the houses. This time is taken from more educative and empowering activities such as reading, studying, and attending school.
• Without electricity it is difficult to study, to do homework, to read in the evenings, and impossible to compete with students in other parts of the world or sectors of society that can turn on the computer, charge the phone and browse on the internet to get better informed. Worldwide, an average of 69% of primary schools have access to electricity, while in least developed countries this falls to 34% with Sierra Leone with the lowest percentile at 4%[18]. Electrification also makes peripheral schools more attractive to more innovative teachers. Access to electricity, in fact, triggers innovation and increases the quality of teaching, allowing the usage of computers, tablets, mobile devices and internet connection.

While the Covid-19 pandemic and lockdowns affected over 1.5 billion students worldwide, the long-term social and economic consequence have been particularly severe for the most vulnerable and marginalised students and families. The disruptions exacerbated already existing inequalities,

[16] WHO, Household Air Pollution, 2018 http://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
[17] UNESCO, UIS (UNESCO Institute for Statistics), 2018 www.uis.unesco.org
[18] UNESCO, What makes a good classroom? New UIS (UNESCO Institute for Statistics) data on school conditions, 2019

especially where distance learning was not possible due to lack of access to electricity and relevant technology.

Equality | SDG 5: Achieve gender equality and empower all women and girls & SDG 10: Reduce inequality within and among countries

While most of us agree that men and women are born equal, there continues to be discriminatory laws, as well as social norms, which are obstacles to women having the same rights and opportunities as men. Worldwide, nearly 1 in 4 girls between the ages 15-19 are neither employed or in education or training – compared to 1 in 10 boys[19]. As a result, women continue to be underrepresented at all levels of political leadership and get less pay for the same work. As women and girls perform a disproportionate share of unpaid domestic work (as they are responsible for collecting firewood and water, food preparation, taking care of the very young and old family members and cleaning the house and clothes), they are often the most affected by the lack of modern energy. This has a strong impact on their health (because of the physical drudgery needed to collect firewood, as well as the inhalation of toxic fumes), but also on their empowerment possibilities (limited time to study, read, earn a salary, etc.). This also translates into long-term lower economic income. If women lack the opportunity or capability to earn a stable income, it hinders the potential for approximately half of the national population to generate wealth, consequently impeding overall economic growth.

Improving access to energy will therefore contribute to achieving SDGs 5: "Gender equality" and 10: "Reduced inequalities".

• As some girls have very little or no time at all to study, they suffer the most from illiteracy or inadequate education. A low level of education also means limited chances to earn a stable salary and be independent from the family of origin or from the husband. Formal education is a source of higher individual satisfaction and a healthier life.
• Because of the poverty status, families in developing countries make their children, especially girls, marry before they turn 18. This way, their families can benefit from a payment, favours, or other benefits, granted by the husband (who is usually much older than the bride). However, child marriage can be prevented by improving access to modern energy. Given the positive correlation between access to electricity and higher educational outcomes, the first can be considered as a contributing factor in preventing child marriage. Girls in secondary school are up to 6 times less likely to marry, compared to those with no or little education[20].

Water | SDG 6: Ensure access to water and sanitation for all

Humanity has always tried to settle close to water, as fresh water is a precious resource that is essential to human health and for the provision of food. Population growth is putting a huge strain on the limited resources of fresh water we have worldwide.

In the future, both energy and water demand are expected to grow substantially due to population increase and climate change. The IEA estimates that the interdependency of water and energy is set to intensify in the coming years, with significant implications for both energy and water security. Over the next 25 years (2014-2040) the amount of energy used in the water sector will more than double, mostly because of desalination projects, while with energy-related water consumption is expected to increase by nearly 60%.[21]. While demand will increase globally, this is especially true in developing countries, particularly in Africa, where the population is expected to double by 2050

[19] UNICEF, Gender equality – Equal rights and opportunities for girls and boys help all children reach their full potential,
[20] World Bank, Economic Impacts of Child Marriage: Global synthesis report, 2017
[21] IEA, WEO – Special report: Water-Energy Nexus, 2016

which will increase demand for water and energy as a result of increased food production, industrial and agricultural products, heating and cooling, as well as first time access to energy, water and sanitation by a new wealthier segment of the population.

The energy sector is responsible for a high consumption of water, as it is needed for the generation of energy and for the extraction and processing of fossil fuels. On the other hand, energy is needed to extract, treat, and transport water to where it is most scarce. In most developing countries, energy and water are also vital to growing crops used as biofuels for heating or cooking.

The connection between energy and water is indisputable: improving access to modern energy will also enhance the SDG 6: "Clean water and sanitation".

Innovative and technological solutions will play an important role in reducing energy and water consumption and waste. To do so, combining renewable energy sources with extractions or filtering technologies will be key. For instance, photovoltaic solar panels (PVs), can be installed in peripheral areas with no access to the national grid and could be used to power automatic wells to extract water (instead of using a more polluting and expensive generator).

Economic Growth | SDG 8: Promote inclusive and sustainable economic growth, employment and decent work for all & SDG 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation

Sustainable and inclusive economic growth, along with strengthened infrastructure, play a pivotal role in driving progress and fostering innovation in industrialisation. These factors not only boost trade but also create decent jobs, ultimately elevating living standards. Energy is instrumental for sustainable economic growth and industrialisation. At the individual level, lack of energy leads to limited education and business opportunities, and therefore to a lower salary or unemployment and a poorer quality of life. Nationally, insufficient energy infrastructures can leave entire villages or cities in the dark, causing their marginalisation and economic stagnation.

There is a strong interconnection between access to energy and the achievements of both the SDG 8: "Decent work and economic growth" and SDG 9: "Industries, innovation and infrastructures".

• Access to electricity increases industrial and agricultural productivity, as it makes productive processes faster and more effective, but also facilitates self-empowerment. Running a shop, a restaurant, a barber shop, hair saloon or any other business activity is difficult without electricity!
• Renewable energy represents an important resource for achieving access to modern energy in developing countries and at the same time creating new, sustainable, business opportunities. New jobs, such as the solar panel installer, or businesses (for instance, opening a shop dealing solar panels technologies, batteries, etc.) are created at the local level.
• Access to energy is also important for connecting to internet and mobile networks. Internet and mobile phones provide access to an infinite amount of information (that can inspire new opportunities) and new services (for instance paying utility bills by mobile phone), even in marginalised rural areas.

Sustainable Communities and Consumption| SDG 11: Make cities inclusive, safe, resilient and sustainable & SDG 12: Ensure sustainable consumption and production patterns.

As more and more people look for better jobs and living conditions, migration from the countryside to the cities will be a continuing phenomenon in the coming decades. For this urbanisation process not to create any more social injustice and worsen environmental degradation, it is important that cities be planned and organised in the most sustainable way. This means that the urbanisation process, and the consequential economic growth and increased productive processes will have to

consume resources sustainably. As much energy will be needed to meet these needs, renewable sources and technological innovations will play an important role to keep cities, their populations, and the environment in general health. Improving access to energy is therefore instrumental to building sustainable communities and ensuring sustainable consumption and production.

• Accommodation will need to be built according to higher standards in terms of energy efficiency and construction materials, heating, insulation etc., to have as little dispersion and consumption of energy as possible.
• All productive processes should aim to improve energy efficiency and increase the usage of renewables, in order to have a smaller impact on the environment and society.
• It is important that local governments provide the right incentives for their citizens to buy less polluting cars (electric or hydro cars, for instance), but also to renovate their fleets with hydrogen or solar busses.
• Governments should also be responsible for educating people to efficient waste collection and to the importance of recycling.

Climate Change | SDG13 Take urgent action to combat climate change and its impacts

The most urgent area for action today is climate change. If we do not cut record high GHG emissions now, global warming is projected to reach beyond 1.5°C above the pre-industrial level in the coming decade (more in chapter 2).

As we are already seeing, the compounded effects will be catastrophic and irreversible: increasing ocean acidification, coastal erosion, extreme weather conditions, higher frequency and severity of natural disasters, continuing land degradation, loss of vital species and the collapse of ecosystems. These effects, which will render many parts of the globe uninhabitable, will also affect the poor the most. They will put food production at risk, leading to widespread food shortages and hunger, and potentially displace up to 143 million people in Sub-Saharan Africa, South Asia and Latin America by 2050[22]. The exploration, development and deployment of all forms of renewable energy sources is key to ensure clean, affordable and sustainable energy, especially in marginal areas, while at the same time contributing to fight climate change and reduce GHG emissions. Improving access to energy is therefore crucial to meet the SDG 13: “Climate action”.

• To respect the commitment taken with the Paris Agreement and keep the global temperature increase below 1.5°C, it is important that both developing and developed countries reduce energy consumption and improve energy efficiency in all productive sectors. It is also crucial to increase the usage of renewables, both at national level (generating energy from renewable sources, instead of fossil fuels), but also within households (by producing the energy needed for the family with a solar panel on the rooftop, for instance) (more in chapter 4).
• Studies have shown that achieving the universal access to modern energy by 2030 would increase CO2 emissions by only 0.7%[23]. This means that providing universal access to energy will have limited impact on the global increase of CO2 emissions. Nevertheless, it is important not to underestimate the effort and ensure a clean and sustainable transition to a low-carbon economy, in both developed and developing countries.

[22] World Bank, Groundswell: Preparing for Internal Migration, 2018
[23] IEA, An achievable goal: Giving modern energy to the billions who lack it, 2011

3.2 Energy consumption – where are we now and where do we need to get to

Energy consumption today

According to the International Energy Agency (IEA), the energy sector is responsible for approximately three-quarters of GHG emissions[24], which is why we urgently need to shift away from fossil fuels to an energy mix dominated by low-carbon sources of energy.

Fossil fuels account for more than 80% of energy consumption globally today. We get the largest share of our energy from oil, followed by coal, gas, then hydroelectric power[25] (Fig 10).

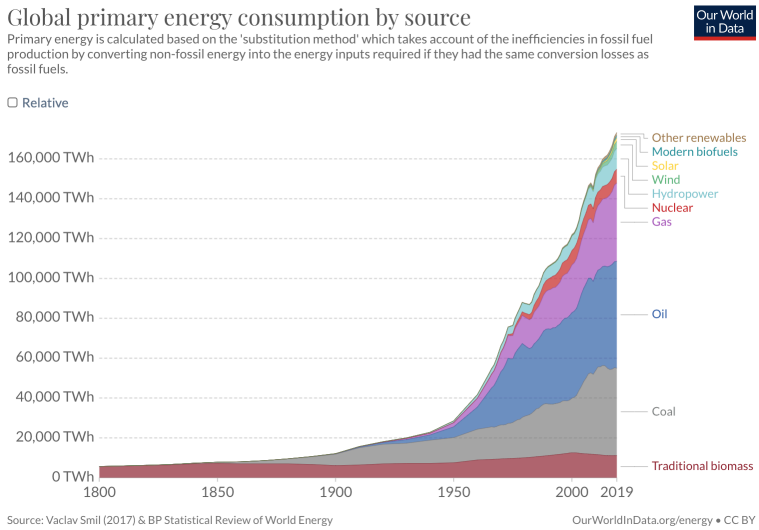


Fig 10: Global primary energy consumption by source from Vaclav Smil's work Energy Transitions: Global and National Perspectives

Fig 10 presents global primary energy consumption by source dating back to the year 1800, and indicates that until the mid-19th century, traditional biomass (wood, crop waste, or charcoal) was the dominant source of energy used across the world. With the industrial revolution came the rise of coal, followed by oil and gas, and by the 1970s hydropower and nuclear were added. It was only in the late 1980s that the 'modern renewables', including solar and wind, were added[26].

What is noteworthy with Vaclav Smil's graph is the speed at which the energy consumption has increased over the past 70 years (1950- 2020). However, the speed at which we need to reach net-zero CO2 emission must be even faster (Fig 12), as we only have 30 years to reach the inverted results (2020-2050) i.e., take global fossil fuel consumption to net-zero.

When observing the primary energy consumption by source since 1965 (Fig 11) and comparing it to where we need to get to by 2050 if we are to implement the GHG reductions needed to assure a stable climate (Fig 12), it becomes clear that we stand at a crossroad. One road continues along the trends of the past, increasing the consumption of fossil fuels and the emission of GHGs that comes with that. The other road reaches peak energy consumption in 2019 where an energy transition starts, progressively replacing the primary energy consumption from fossil fuels (coal, oil, natural gas) with renewables (wind, solar and other modern fuels) by 2050.

[24] IEA, NetZero, 2021
[25] Our World in Data – Energy Mix – https://ourworldindata.org/energy-mix
[26] Please find a table of all types of fuels and their related GHG emission in Annex

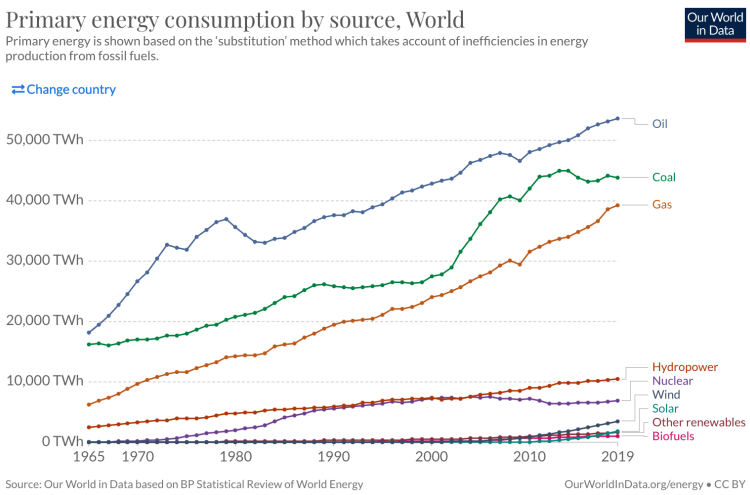


Fig 11: Primary energy consumption by source, 1965-2019

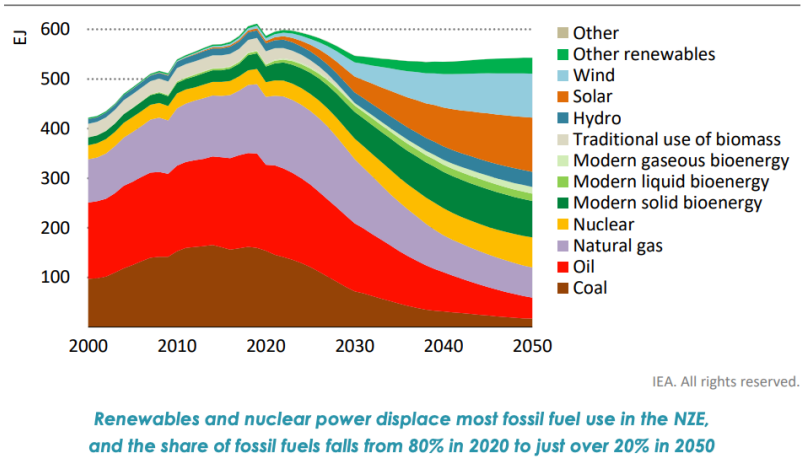


Fig 12: IEA, Net-Zero primary energy consumption by source, 2000 - 2050

Only by pursuing the second road can we hope to keep average temperature increase below 1.5 °C relative to the pre-industrial temperature and somewhat limit the effects of climate change. It requires a global effort, however the starting point for various countries differ greatly.

Unfortunately, the global consumption of fossil fuels did not peak in 2019, despite massive efforts to introduce new renewables as an alternative, hence time and scale is becoming of increasing essence.

High and low energy and CO2 emitters

As we can observe in Fig 13, the energy consumption per capita and the energy mix differs greatly by country. The energy consumption in the US per capita in 2019 was much higher than most other countries, including other developed countries, and was based primarily on fossil fuels. Compare this to Sweden, which also had a high per capita consumption, but mainly based on low-carbon sources (nuclear, hydro and to a lesser degree wind and solar), or with India that had a much lower per capita consumption, however primarily coming from fossil fuels. Clearly the path to net-zero for these countries will vary greatly. The US must strive at reducing overall energy consumption through energy efficiency measures and by replacing the fossil fuels with low-carbon energy. Sweden must consistently pursue its virtuous and fruitful mission to replace the residual fossil fuel with low-carbon energy with the help of energy efficiency and renewables. Finally, as India's per capita energy

consumption is expected to increase in the coming years, it is pivotal to make sure this new demand is met as efficiently as possible by low-carbon energy while gradually replacing fossil fuels consumption with low-carbon energy.

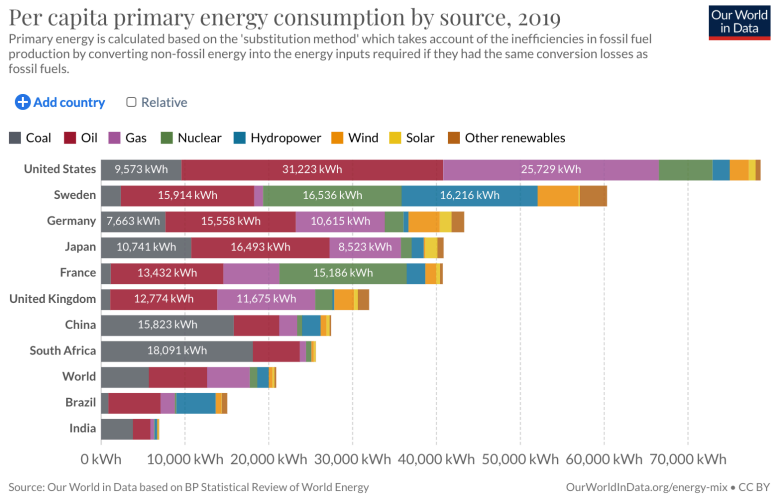


Fig 13: Per capita primary energy consumption by source, 2019[27]

Scaling up low-carbon sources

In all countries, no matter their current situation, scaling up low-carbon sources of energy will be fundamental to reaching net-zero by 2050. Fig 14 indicates that in 2019, 15.7% of global primary energy came from low-carbon sources. Low-carbon sources are the sum of nuclear energy and renewables (hydropower, wind, solar, bioenergy, geothermal and wave and tidal). 11.4% came from renewables and 4.3% came from nuclear. Hydropower and nuclear account for most of our low-carbon energy: combined they account for 10.7%. Wind produces only 2.2%, and solar 1.1%, however both sources are growing quickly. While low-carbon sources have more than doubled since the 1960, progress has been slow since much of the gains made in renewables has been offset by a decline in nuclear energy[28].

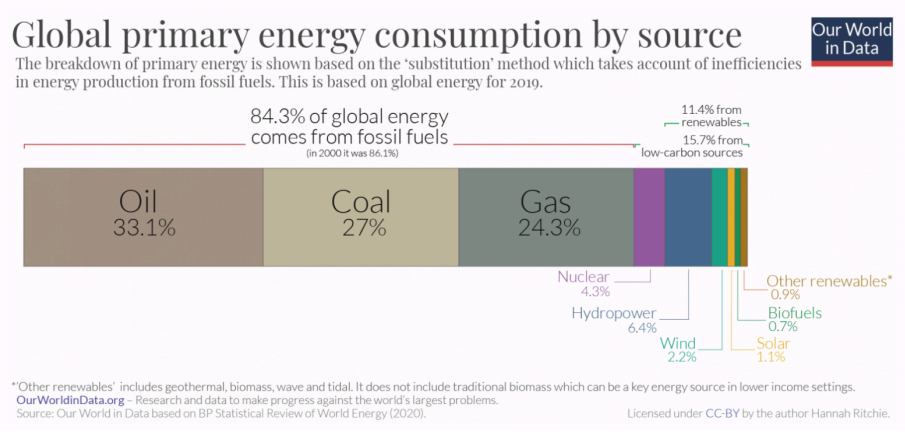


Fig 14: Global primary energy consumption by source

[27] Note these figures don't include energy produced from traditional biomass as there is no reliable data on this.
[28] Our World in Data – Energy Mix – https://ourworldindata.org/energy-mix

Which countries get the highest share of energy from low-carbon sources?

While the global average of low-carbon sources was 15.7 in 2019, there are huge discrepancies between countries (Fig 15).

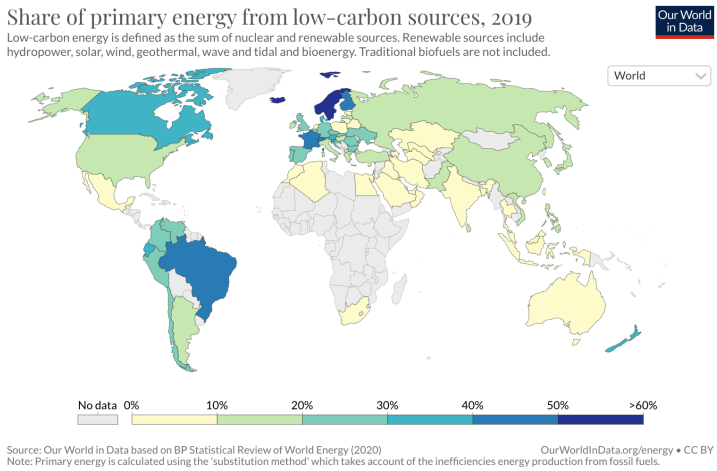


Fig 15: Share of primary energy from low-carbon sources, 2019

In 2019, Iceland got 79% of its energy from low-carbon sources, being one of the highest in the world. Most of this came from hydropower (55%) but also other renewables, mainly geothermal energy (24%). Other countries also get a significant percentage of its energy from low-carbon sources, including Sweden (69%); Norway (66%) France (49%) and Switzerland (49%)[29].

While some countries are faring very well, others continue to rely almost entirely on fossil fuels. This concerns many of the world's oil-producing countries, including Saudi Arabia, Oman, and Kuwait, who all got less than 1% from low-carbon sources in 2019.

Amongst the largest emerging economies, in 2019 South Africa produced only 5% from low-carbon sources, India got 9% from low-carbon sources, and China 15%. Brazil, on the other hand, produced 46% from low-carbon sources in 2019[30].

Progress in shifting towards a low-carbon economy has been slow globally. That may leave us pessimistic about the future. However, some countries with high carbon footprints have demonstrated that significant progress on decarbonising energy systems, including: Morocco (with the Noor Ouarzazate complex – the largest solar farm in the world covering the equivalent of 3500 football fields), India (having established a goal of generating 40% of its power through renewables by 2030, a realistic goal given its progress so far), Costa Rica (one of the global leaders striving for 100% of the electricity production to be renewable by 2021), the European Union (with the EU Green Deal targeting 55% net GHG emissions reduction by 2030)[31] [32]

Poorer countries face an extra challenge: they must grow their economies, giving their increasing populations access to energy, healthcare and education all while avoiding the carbon-intensive pathways today's rich countries have taken. To do this, clean energy needs to be cheap, undercutting fossil fuel alternatives. In this regard, the world's richest countries also have a role to play in the scaling-up low-carbon energy, which should help to drive down costs. We have already seen this effect with the rapid decline in solar prices in recent years.

[29] Our World in Data – Energy Mix – https://ourworldindata.org/energy-mix
[30] Our World in Data – Energy Mix – https://ourworldindata.org/energy-mix
[31] National Geographic, Climate change report card: These countries are reaching targets, 2019
[32] European Commission, 2030 climate and energy framework

3.3 Global Governance

The Brundtland Report was innovative at the time of its publication and laid the groundwork for many of the international agreements that have been developed since. This is especially true for the Earth Summit, which took place in Rio de Janeiro in 1992. It provided a platform for UN Member States to collaborate on issues related to sustainability which were too immense for single Member States to handle on their own. This Forum became the place where the issue of climate change was first addressed. During the following years, the climate change debate emerged as a crucial aspect of environmental protection, and its threat became more and more disturbing. This resulted in the adoption of the international environmental treaty called the Framework Convention on Climate Change (FCCC). In due course, it led to the adoption of the Kyoto Protocol in 1997, (first commitment period from 2008 to 2012 and second commitment period from 2012 to 2020) and successively the Paris Agreement in 2015 (entered into force on 4th November 2016), the two main global agreements addressing climate change.

From Paris Agreement and beyond

While the threats of climate change had been acknowledged for some time, it was only in Paris in 2015 that the scale and urgency converged with the visions and actions needed. This unique momentum allowed 195 countries to agree on a framework that could lead to a serious response to climate change. Whether this new framework will succeed in reversing the trend of catastrophic climate change remains to be seen, but several new factors can give some optimism according to Henry Claude and colleagues[33].

The first factor is the risk perception. Growing awareness of the magnitude of climate risks has changed the understanding of most governments and in the face of pressure exerted by public opinion led many to adopt a more proactive attitude on climate policies[34].

The second factor is economic. The declining costs of low or zero carbon solutions like solar and wind, coupled with advancements in energy efficiency, have generated significant interest in their implementation. These solutions not only offer immediate social benefits, promoting public health and reducing traffic congestion, but also pave the way for a sustainable future.

The growing sense of urgency to address climate challenges, together with the availability of affordable solutions discussed in Paris, led nations to express willingness to present voluntary climate plans or Nationally Determined Contributions (NDC). NDCs provide a bottom-up approach that resulted in the extraordinary result of 189 countries, covering more than 95 percent of global emissions, presented their voluntary climate plans either before the conference or at the meeting[35].

Although the commitments made in Paris fell short of ensuring the goal of limiting average temperature increase to 1.5°C above pre-industrial levels, the framework was designed to facilitate the possibility of resubmitting commitments as technology advanced, and improved financing and policies allowed for setting more ambitious goals.

Every single member state can therefore revise and resubmit more ambitious NDC goals on an ongoing basis. NDCs comprise nationally determined climate change mitigation and adaptation goals, including further contributions such as climate finance, technology, and capacity building, and when submitted they can be monitored on an international level. COP26 in Glasgow in November 2021 provided a opportunity for parties to submit ambitious revisions as will every COP to follow.

[33] Henry, Claude; Tubiana, Laurence. Earth at Risk. Columbia University Press.
[34] Please refer to the chapter IPCC 2018 Special Report outlining the risks p. 18
[35] Henry, Claude; Tubiana, Laurence. Earth at Risk. Columbia University Press.

Another noteworthy aspect of the Paris process was the attempt to engage the public at large including women, children, youth, indigenous people, NGOs, local authorities, workers and trade unions, business and industry, the scientific and technological community, and farmers. All these groups are directly impacted by climate change and by the NDCs but are also themselves able to contribute with their own actions and financial commitments through the so-called "Climate Action Agenda". The idea is that there is not a single institution, or process, that alone can coordinate the response to climate change, but rather that we are collectively responsible, and we can all contribute to the plethora of initiatives that synergistically contribute to achieve this ambitious goal. The result of engaging the public at large has been the active participation of all sectors of society and indeed, recent research shows that citizens are starting to reckon a zero-carbon future as their most desirable option.

IPCC 2018 Special Report

The perception of the risk posed by increased GHG emissions became undisputable in 2018 after the publication of the IPCC Special Report, subsequently confirmed in the 6th IPCC Assessment Report 2021 published in August 2021. The 2018 IPCC Special Report examined the impacts of global warming of 1.5°C above pre-industrial levels, and related global GHG emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty[36].

The conclusions of this Special Report were dramatic, documenting that keeping temperatures below the 1.5c° threshold is humanity's best chance to avoid truly catastrophic unravelling, a task that is still possible, but would be extremely difficult, as it translates into cutting global emissions approximately in half by 2030, and getting to net-zero by 2050.

The IPCC 2018 Special Report was not the first of its kind to make such blunt and terrifying calls for change. Since the IPCC was created specifically by the UN to provide policy makers with the most reliable information possible, it does not only strive for the highest level of scientific accuracy supported by a large pool of leading scientists, but everything published must also be signed off by the 195 governments themselves. As a result of such rigorous process (both scientific and political), previous IPCC projections have been extremely conservative, often dangerously underestimating risks as the projections. The publication of the 2018 Special Report was therefore a clear acknowledgement and statement from the Global community that our common house is "on fire".

This is the reason why the IPCC 2018 Special Report got such attention worldwide and justified the mission of many important social movements including Greta Thunberg's School Strike for the Climate, Extinction Rebellion in the UK, the Sunrise Movement in the US, 350.org and many more climate campaigns. The voice and impact of these movements are growing by the day and are calling on Governments and political leaders as well as CEOs and the public at large to come together to present a new economic model addressing the shortcomings of the capitalist model which is failing many people and the environment on multiple fronts.

The transformation that is called for goes beyond the short-term political cycles and would result in economies built to protect and to regenerate the planet's life support systems (the many ecosystems and biodiversity), and to sustain all the people (with no discrimination) who depend on them. Proposals on how such revised economic models could look are surfacing in many places including the EU Green Deal and the US Green New Deal and are laying out the first plans on how such a new economic model could look while halving emissions by 2030 and getting to net-zero by 2050 (more in chapter 4).

[36] IPCC Special Report, 2018

Since the Rio Earth summit in 1992 there has been many calls for change so why should we believe, it will finally happen? Several fundamental aspects have changed substantially and are worth noting. First, the tragic consequences of a climate collapse are no longer some far-distant possibilities for most people as they are already visible in most of our every-day lives and every year increasingly so. Secondly, for the first time we actually have the technology needed to start making many of the needed changes, and they are finally cost-effective. Furthermore, an ever-increasing number of political leaders have expressed personal commitments to change the course of affairs by harmonising social and economic dynamics with environmental needs in order to pursue a safer and sustainable future for ourselves and the future generations. Finally, companies are acknowledging the demand for low-emission products and services and are working hard to deliver them, while the population at large is getting increasingly informed and actively engaged in changing old habits with new more sustainable ones.

Time is of essence if we need to half the GHG emissions by 2030. However, history shows us that under severe pressure, ambitious goals supported by solid and well-thought policies can indeed lead to a swift and profound transformation of society in a very short period. The evidence and risks are clear, and the failure to address these issues is a matter of choice, not the inevitable destiny of humankind.

Global target - Net Zero by 2050

Reducing global GHG emissions to net-zero by 2050 is consistent with efforts to limit the long-term increase in average global temperatures to 1.5˚C stated in the Paris Agreement and calls for a complete transformation of how we produce, transport, and consume energy, with an unprecedented scale and speed.

While encouraging signs have been coming from many governments throughout the world, such pledges must now be underpinned by adequate policy and prompt action. There is still a lot of work to be done, and decisions over the next decade will play a critical role in determining the pathway to 2050[37](Fig 16).

The path to net-zero is challenging and thus requires immediate and massive deployment of all available clean and efficient energy technologies, such as low-carbon electricity generation and energy efficiency technologies. It also requires additional investments in solutions that are still not 100 percent cost-effective such as advanced batteries, hydrogen electrolysers, and direct air capture and storage[38]. Emission reductions in industry, aviation and shipping as well as the building sector must progress substantially over the next 5-10 years and be ready for deployment by 2030 (more in Chapter 4).

While the world economy is expected to grow substantially by 2030 (40% larger than today) it is expected to use 7% less energy, thanks to energy efficiency measures. Making net-zero emissions a reality hinges on a singular, unwavering focus from all governments – working together with one another, and with businesses, investors, and citizens. The IEA estimates that around 55% of the cumulative emissions reductions that will happen between today and 2050 are directly linked to consumer choices concerning modes of transport, heating and cooling of homes, as well as the food and goods consumed (more in Lesson 4). Many aspects of the energy transition may be challenging to implement, which is why it is important that Governments ensure that decisions are transparent, just, cost-effective and are people-centred and inclusive[39].

[37] IEA, WEO 2020
[38] IEA, NETZERO, 2021
[39] IEA, NETZERO, 2021

According to the IEA four regional patterns are likely to emerge during the period up to 2030:

- In advanced economies, including the European Union and the United States, demand for energy peaked in 2019 and recovery will accelerate the deployment of renewables and the decline of coal.
- In the Asia Pacific region, including China and India, rising economic growth will drive up demand for all fuels. Renewables will lead in terms of absolute growth, followed by natural gas, then oil. Asia Pacific is the only region that will witness a growth in coal demand, primarily in India and Southeast Asia.
- In oil and gas exporting economies, especially the Middle East and Eurasia, lower oil and gas revenues will end up reducing overall economic activity. Gas and oil will mostly satisfy the growth of domestic energy demand, but renewables are expected to gain some ground amid efforts to diversify electricity supply. The outlook in these economies depends both on the speed at which global energy systems transition away from imported oil and gas, and on the success of domestic efforts to diversify their economies away from fossil fuels.
- In emerging markets and developing economies, including in Africa and Central and South America, increasing levels of energy use per capita will drive rapid demand growth. Renewables will account for most power system growth, and oil for most transport demand growth.

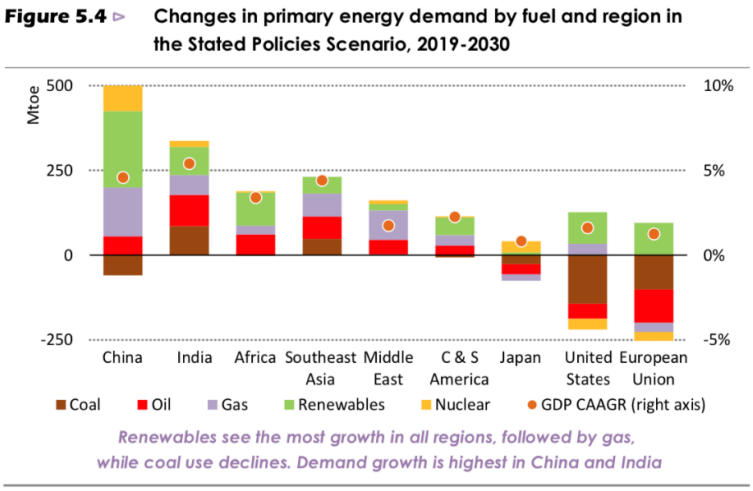


Fig 16: Changes in primary energy demand by fuel and region in the SPS, 2019-2030, IEA, 2020

3.4 Concluding Remarks

We know that humanity is changing the Earth's climate. This fact has been acknowledged in several parallel global processes, starting with the Earth Summit in 1992 and culminating in 2015 with the Paris Agreement, confirmed in the IPCC Special Report in 2018 and subsequently in 6th IPCC Assessment Report 2021. The signs have been there for several decades, but for the first time we now have Global consensus that anthropogenic GHG emission is causing climate change and that there is a real urgency in addressing this issue. Now that we have a Global framework, we can take collective action.

The task at hand for humanity is to keep average temperature increase below 1.5 °C relative to the pre-industrial temperature. To do this we must find affordable and equitable ways to bring every

sector of the global economy to net-zero carbon emissions no later than 2050. At the same time, we must adapt to effects of climate change we can't prevent, taking special care for those with the fewest resources, who have contributed least to the problem but, at the same time, are likely to be disproportionally affected.

Over the next 30 years, with the global population growing and the demand for higher living standards increasing the profound societal transformation that we are embarking on to maintain a habitable Earth must engage all spheres of society, from policy makers to business leaders, individual citizens, and especially young people. The changes will affect multiple aspects of people's lives, from transport, heating and cooking to urban planning and jobs. The IEA estimates that around 55% of CO2 emissions are linked to consumer choices and will require significant behavioural changes.

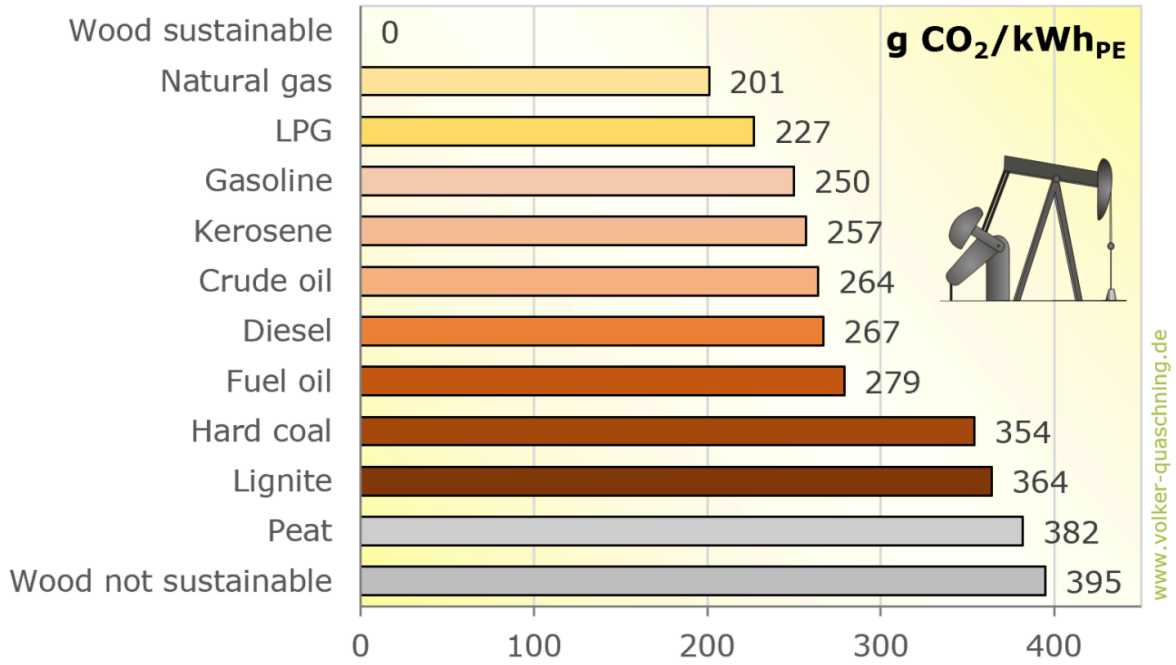
To successfully decarbonize our economy in three decades we need to take bold steps and take them fast. Some of the technical solutions that will take us to zero-emissions by 2050 already exist and must be deployed extensively. Other technologies are still in the research phase, particularly in the industry and transportation sectors, and must therefore be brought to market and scaled as soon as possible to be able to make a decisive impact towards success. The IEA suggest that some of the biggest innovation opportunities concern advanced batteries, hydrogen electrolysers, and direct air capture and storage[40]. Increase in both public and private investment in research and development in science and technology is an essential part of the path that will lead us to a zero-emission economy and restored global biodiversity.

While decarbonizing the economy by 2050 will be a challenge in its own, it is fundamental that this is achieved with equitable and fair procedures and goals. The world's energy systems must be decarbonized at the same time as living standards improve and demand for energy increase for all people in the developing world. Furthermore, vulnerable communities everywhere, that are likely to be disproportionally impacted by climate change must be given adequate resources to protect themselves. It is key to acknowledge that we will not solve the climate problem without simultaneously solving the intertwined problems of equity and economic development.

[40] IEA, IEA, NETZERO, 2021

Annex 1

Specific Carbon Dioxide Emissions of Various Fuels



It is important to note that the CO2 emission per kWh varies depending on the source from which energy is derived. This explains why it is important to prioritise the phasing out of high-emitters (peat, lignite, coal) first, and why relatively low-emitters such as natural gasses are the preferred "bridge" fuel till renewables can provide sufficient energy for all fossil-fuels to be phased out.

Sustainable wood refers to wood that has been harvested responsibly from well managed forests that are continuously replenished and in which there is no damage caused to the surrounding environment, or to native flora and fauna. Wood from unsustainable sources, on the other hand, is chopped down leaving bare areas that usually never really recover.

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