ENERGY AND GEOPOLITICS VOLUME 1

FUNDAMENTALS

SAMUELE FURFARI

Energy and Geopolitics, Volume 1

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Energy and Geopolitics, Volume 1:

Fundamentals

By

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This book is dedicated to the memory of my parents. In the middle of the 20th century, they left Calabria (Italy) to immigrate to Charleroi (Belgium). My father passed from gathering oranges to a coal mine and my mother from olive gathering to washing a coal miner's clothes.

The great enemy of truth is often not the lie – deliberate, contrived and dishonest – but the myth – persistent, persuasive and unrealistic. Too often, we hold fast to the clichés of our forebears. We subject all facts to a prefabricated set of interpretations. We enjoy the comfort of opinion without the discomfort of thought.

—John F. Kennedy, Commencement Address at Yale University, 11 June 1962

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DISCLAIMER

The author has never had any professional relationship with oil, gas or coal companies, nor has he had any private interest in them, and he has never requested or received funding from any environmentally related agency or organisation.

FOREWORD

Energy geopolitics have always had to adapt to the new conditions and market forces brought about by technological changes, but also to various social and geopolitical situations. We have now moved on from the energy geopolitics paradigm that started in 1973 with the first oil shock and that was then exacerbated by the Club of Rome's ideology. Leaving one paradigm and adapting to a radically different one is never an easy task. Historians with the benefit of hindsight can identify markers which characterise such turning points, but those who experience the changes directly will not necessarily recognise them as markers of a clear turning point. However, yes, the energy paradigm has indeed changed; we have left an era characterised by fear of energy scarcity for one in which energy is abundant.

The energy 'quarantine' of 1973–2013 is now over. The 40 years of wandering in the wilderness are finally behind us and we are entering the Promised Land, one flowing with abundant oil and gas. Accordingly, geopolitics, which is always the first to react to new realities, has already adapted. While most have not even started to perceive the change, geopolitics is now reshaping international policy. As always in international relations, those that can identify changes earlier than others enjoy a broad advantage; consequently, intelligence is fundamental. However, the old patterns of thought are still shaping the reactions of most non-energy actors, including national and local policymakers. Thus, those who have not understood the changes are still defending the pre-2014 vision of energy policy.

Energy policy emerged against the backdrop of this dated paradigm. Energy policy is a rather new development; until around 1990 there was no such thing as energy policy. The field emerged with the creation of the concept of sustainable development and its corollary, climate change, at the Rio Conference in June 1992 and with the signing of the Kyoto Protocol in December 1997. In short, it was created by Green's policymakers.

Before that, it was only necessary to ensure the supply of oil, and later natural gas, by engaging in diplomacy, i.e. geopolitical measures, and the need to ensure a constant supply of electricity by investing in power plants and electricity networks, an activity carried out by national companies or private companies strongly linked with the governments. Green policymakers introduced political decisions (choices which were not necessarily rational like production of oil products with farming products – see later) in a field that was until then only driven by rationality (market laws and technology). We will see that under free market conditions, engineers would have not made and adopted the many decisions and resolutions taken across the EU and other developed countries simply in the name of climate change. In developing countries, such irrational decisions were resisted because those countries could not afford to waste their scarce resources in favour of political expediency. This political conundrum is the one the world finds itself with.

However, there is a (missing) fact that needs to be integrated into (current) energy policy: people in developed countries today can be deemed as *Homo Energeticus*; they need and depend on energy for their daily lives and work. As the rest of the world's population aspires to a quality of life like that of the developed nations, the demand for energy is poised to grow. Economic growth in China, India, Africa and other non-OECD countries will enable some 3 billion people to join the middle class. It will be the largest collective increase in living standards in history. This will inevitably lead to an increased demand for food, travel, housing, schools, hospitals, water, sanitation, and businesses. It will mean better lives for billions of people. It will mean that the infinite jump in the improvement of the quality of life that OECD countries have experienced will become a reality for the rest of humanity.

This change requires more energy … significantly more energy. Contrary to mainstream ideas, the more energy than a society uses, the better it is for the environment. This is because a prosperous society is an efficient one. Richer people are much more careful about environmental issues, and they can better afford the development of solutions to deal with these issues. Karl Marx mocked Adam Smith's school of thought for its willingness to be efficient and to recycle. Yet, efficiency curbs growth in both energy demand and emissions. The net effect of these changes is best seen in the EU where the quality of life is improving while energy demand and polluting emissions have already fallen and will continue to fall further.

Today's energy situation is ushering in a new paradigm. It is not easy to grasp the new reality because we are living within the old paradigm. An external observer would see that immediately, but since we are actors within the old paradigm, our thinking is shaped by it and it is, therefore, not easy to discern the change. In life, nothing is eternal or linear. Moisés Naim – a well-known Venezuelan economist – shows in his book 'The End of Power'[1] that (1) institutions that were all-powerful in the past are now feeble as never before, (2) life has been revolutionised by abundance, (3) there has been a revolution in mentalities, and (4) mobility has greatly increased, all which has resulted in instability. There is no reason to think that what was true in 1973 will always remain so. No, the 'energy quarantine' – forty years of fears about oil scarcity and concerns that we will run out of resources – is now over. It is now time to build a new energy era for the good of all.

At this point, the reader may think that the new paradigm that I am referring to is the 'energy transition' to a low-carbon economy which is so popular now. The new geopolitical energy paradigm is one rather saturated by the abundant and apolitical supply of fossil fuel energy. Fossil fuels have never been as abundant as they are now. We will show how the quarantine imposed by OPEC in the early 1970s – i.e. the politicisation of fossil fuel energy – has ended thanks to technological advances and new maritime territories opened for exploration and production. The background to this transition is a broad panorama of global oil and gas resources being discovered and yet to be extracted. The shale gas and shale oil revolution are just beginning, and the implications for geopolitics are huge since it is reshuffling the cards at the global level of power.

Then, the usual question arises: if the world will be one with fossil fuels, what about the energy transition so desired, promoted, and even imposed? Oh yes, it will come about … one day! Nevertheless, not immediately as some hope and proclaim. The energy transition will emerge naturally without obligation when new technologies based on new science, now under investigation and technical development in leading laboratories, is sufficiently mature for large-scale implementation.

The problem of the energy transition to a low-carbon society is economy; the political will is at a maximum. Research technology and development have been widely supported over the last 40 years to the point that some mature technologies are now available. However, their competitiveness remains to be demonstrated. The current solutions for the energy transition to a low-carbon economy in Europe raise the huge and difficult question of cost. Now we have expensive options whereas the rest of the world is reaping the benefits of abundant and cheap fossil energy. Alone, a country or a corporation can do what it wants; in a global world, it is impossible to be right alone. Justifiably, businesses expect a level playing field for social and working conditions, and they also expect a level playing field for energy, i.e. for energy costs.

Nothing is stable forever in the world; not countries, nor boundaries, nor structures, nor institutions, and the list goes on. There is no reason for energy policy and energy geopolitics to remain static. One day when we abandon the use of fossil fuels, it will be because the new forms of renewable energy that scientists are developing in sophisticated research labs will have become economically viable, then we will have a new geopolitical energy landscape and new energy policies. Meanwhile, we live in an era of abundant fossil fuels that shape international diplomacy. While the public awaits an energy revolution, it does not realise that the counter-revolution has already been completed.

I realise that this statement right at the beginning of this book may surprise, shock, or even make the reader angry. I recognise that it is politically incorrect. However, it is a hard reality based on facts and numbers. Numbers are stubborn; therefore, I invite the reader to proceed with the demonstration.

Knowing that it will not be easy to convince the sceptical reader that this thesis is correct, I have tried to write this book as – I hope – a didactic demonstration, as if the writer was talking to the reader face-to-face. Consequently, the book is packed with a lot of facts, numbers and figures, and even anecdotes. Progress will inevitably be somewhat slow but pedagogic, explaining each new notion or concept as it is introduced, sometimes even lengthily with redundant examples and many cross-references. This is essential, however, to justify such a controversial position; nonetheless, it is a common one among energy specialists.

The reader might ask, 'if it is so common, why is it not better known?' Energy specialists in energy companies are paid by their shareholders to develop and raise the value of their companies; they are not remunerated to convince people – especially activists – that the world is full of cheap energy. Academics, on the other hand, receive funds for research that is decided by politically correct administrations and, therefore, their field of research is much oriented by policy decisions and not necessarily by facts. Today, if you do not introduce the word 'climate' in a research programme, it will be refused. Anyway, those that do not want to listen to energy specialists will dismiss them by saying, 'They are paid by oil companies,' which just translates to, 'they are not credible, it is better to rely on NGOs'.

This textbook is divided into three volumes. The first volume lays the foundations for an understanding of energy; this is essential to grasp the ideas presented in the second volume. As this demonstration goes against the grain, we start with a first part dedicated to the fundamentals of energy to understand what it is, to learn the essential truths of physics – based on universal laws that never change. Chapter 2 presents the fundamentals of data; without numbers, it is impossible to speak about energy. Chapter 3 is on the fundamentals of sustainable development, a political vision of society that heavily influences energy policy (but not energy geopolitics so much). Chapter 4 address the strong link between today energy policy and geopolitics and climate change issue. Volume 2 will then analyse all primary energy and some final energy. We will see how they are produced, their reserves, their markets, and the main actors.

In the third volume, all acquired pieces of knowledge will be brought into perspective to allow the reader to analyse present-day energy geopolitics.

The geopolitics of energy is closely linked to history. If we don't know what Winston Churchill did to establish the British oil industry in Iraq and Iran, we will find it difficult to believe in the real state the oil reserves of these countries. If we have never heard of the Quincy Pact agreed upon between President Franklin D. Roosevelt and King Ibn Saud on 14 February 1945, we are likely to misunderstand the present situation in Saudi Arabia. Overlooking the role of Muammar al-Gaddafi in the oil crisis of the 1970s would lead to a misunderstanding of the role of the Arabs and OPEC. Ignoring the role played by Boris Yeltsin in the post-Soviet era will make it difficult to understand Putin's policy today. Therefore, nearly every other page contains a reference to a historical event which puts the present situation into perspective. Occasionally, I illustrate this with some personal or semi-personal anecdotes.

The great economist John Maynard Keynes said, 'When the facts change, I change my mind. What do you do?' Even if some have claimed that Keynes did not make this statement, its meaning is so profound that it is often cited. It emphasises the need to stick to facts rather than wishful thinking or even ideology. Therefore, I opened this book with a quote from J. F. Kennedy. I sincerely hope that you will share my understanding of the changing world of energy and the associated geopolitical challenges, and that you may even change your mind on energy policy.

When the Apostle Paul spoke in the Areopagus in Athens, some sneered, but others said, ‘We want to hear you again on this subject,’ and some people believed. The outcome will probably be the same with at the end of this book.

1 ENERGY FUNDAMENTALS

Energy is a buzzword in our world, but it is much more complicated than it is usually assumed. In this chapter, we will lay out the foundations required to understand the rest of the book. After defining 'energy', we explain the difference between energy and power, how to measure energy, and how to establish the essential difference between primary energy and final energy. This will put us in a position to set out the three ways of using energy – heating, transportation, and electricity – showing that the physical characteristics of primary energy sources define their optimal uses.

Today we live in an era in which ubiquitous energy availability just seems normal. Children will find it normal to connect to an electrical outlet to charge a smartphone so they can play one of their favourite games. Electricity, gasoline stations, heating, and lighting are so banal that it is not at all surprising that some children believe that electricity just comes out of the wall. My parents' generation (born around 1910) grew up without the availability of energy. Thanks to energy, they were the only generation in history that saw the world change so profoundly.

1.1 What is energy?

In the first section, we will note that energy is, first, a matter of physics. The notions of physics outlined were developed during the 17th or 18th century throughout the Scientific Revolution by great scientists such as Galileo or Newton. They defined the theory, but unlike those born in the early 20th century, their daily lives did not change, nor did those of their children and grandchildren. It is only after the use of fossil energy became a reality, that world development adopted a different pace. Once humans domesticated the use of energy, their life was turned upside down or rather downside up.

1.1.1 First, energy is a physics concept

The etymology of energy, *energeia* in ancient Greek, means ‘activity’ or ‘operation’. In the modern physical sciences, particularly mechanical physics, ‘energy’ refers to the capacity of a physical system to do something, to perform work. Energy is work and work is energy.

Energy is classified into two types, kinetic and potential. Kinetic energy refers to movement, whereas potential energy refers to stored energy. Energy can take on many forms, such as mechanical, thermal, electrical, chemical, and nuclear. Briefly, mechanical energy is about objects in motion; thermal, about the vibration of particles; electrical, about the flow of charged electrons; chemical, about the energy stored in the bonds between atoms; and nuclear, about the energy stored within the bounds of atoms. Some of these forms, like mechanical or electrical, can embody both kinetic and potential energy, whereas others like chemical and nuclear are exclusively potential energies. If the energy from these forms can be harnessed, it can be used to perform ‘work’.

Work (*W*) is the integral of the scalar product of two vectors, a force (*F*) over displacement (*du*).

$$W = \int \vec{F}.\overrightarrow{du}$$

The work of a constant force F for a rectilinear displacement d in the direction of the force that caused the movement is the scalar product of the vectors F by d.

$$W = \vec{F}\,.\vec{d}$$

If the direction of the force is different of that of the movement, the value must be multiplied by the cosine of the angle ($cos\ \theta$) formed by the direction and the force. When you move any force, starting with your weight, you are performing work using energy.

$$W = F . \cos \theta .d$$

If you are climbing a staircase, for example, you move your mass, but because of the law of gravitation, your body is a weight, i.e. a force *F* (measured in Newtons) whose value is the result of your body mass *m* (measured in kilograms) multiplied by gravitational acceleration *g*[a].

$$W = m.g.d$$

The work you perform is calculated by multiplying your weight (in Newtons) by the distance (in metres towards the force). The unit that measures work, and therefore energy, is the Joule; one Joule being the work or the energy of a force of one Newton moved over one metre.

Moving a force, whether you climb a hill or use an elevator, or whether a rocket is launched in space, consumes energy. The larger the force and the greater the distance towards the force, the greater the work performed will be and, therefore, the greater the energy consumed will be. To this energy, we must also add the required energy for overcoming friction, i.e. overcoming the rolling and aerodynamic resistance varying with the square of the speed. Consequently, reducing energy consumption requires moving smaller forces over shorter distances. Thus, this explains why a large car needs more energy than a small one and why a long trip will require more energy than a short one. This might look trivial, but it has major consequences on energy policy particularly when it comes to energy saving.

Remaining motionless is the only way to limit energy consumption. Here we use the word ‘limit’ and not ‘nullify’, because, even when remaining motionless, energy is consumed. Our body, for example, consumes energy for pumping blood through our veins and moving air in and out of our lungs. Food

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[a] $g = 9.81\ m.s^{-2}$.

is not only a pleasure; it is foremost the energy that our body requires. Just as an idle automobile will eventually shut off if not refilled, our bodies will die if not provided with energy. No matter what you do, the blunt truths of physics teach us that it is impossible to do anything without energy. Because it is impossible to do the smallest work without energy, we should, therefore, try to be as efficient as possible. This, however, is also much more complicated than it sounds. We will later note that more people wanting to work, and to move, will have a dramatic consequence on the world's energy consumption.

1.1.1.1 Conservation of energy

Now, we need to introduce a fundamental notion called the first principle of thermodynamics. It asserts that energy is conserved; energy does not disappear and, therefore, that the sum of the various forms of energy is constant.

Energy contained in wood, for example, can be converted to heat, and wind energy can be transformed into electricity. In that sense, what we call 'renewable energy' is not renewable; a more correct name would be 'readily available' energy or 'flux energy' to oppose the other kinds of energy, like gas or petrol, that are considered 'stocked'. Renewable energy results from the action of the sun on water, air, and CO_2 to transform them into rain that will be accumulated in reservoirs to generate hydroelectricity, wind energy that would power wind turbines, or biomass that can be used as fuel. If the Earth were an isolated system, we would end up without energy. However, since we live in an open system, we receive an energy flux so long as the sun exists. The available energy in the world ultimately resulted from the gigantic 'big bang' blast that initiated the life of our universe; that energy can only be used and transformed from one form to another, but never created.

Let us take another example from daily life. When you want to prepare, say, spaghetti, the energy released by the combustion of natural gas in your stove is required for heating the water and cooking. Before the water temperature rises, the temperature of both the cooker and the pan will increase, although your goal may not necessarily be to heat them specifically. A part of the energy, furthermore, ends up in the form of water vapour on top of the pan. The total energy of the gas used is transformed into successive lost energy that heats the cooker, the pan, and the water, produces water vapour, and lastly causes the useful outcome which is to cook the pasta. Therefore, the energy used for your intended purpose is only a fraction of the total energy consumed.

All processes using energy are inefficient and some are inefficient, resulting in losses or huge losses of valuable energy. The dividend between useful output energy and total input energy is what we call ‘efficiency’ (symbolised by the Greek letter eta η). To transform heat into work or work into heat, thermal equipment requires a hot source and a cold source. The efficiency of such equipment is defined by the Carnot principle, named after Sadi Carnot, the famous French scientist and engineer who formalised this theory.

$$\eta=1-\frac{T_1}{T_2}$$

where T_1 and T_2 are the absolute temperatures[a] (in Kelvin) respectively to the cold source (usually the ambient air temperature) and the hot source.

As an example, a thermodynamic machine functioning at 20 °C environmental temperature and with a hot temperature of 500 °C will have a theoretical efficiency of

$$\eta=1-\frac{(20+273)}{(500+273)} = 0.62 \text{ or } 62\%$$

[a] Absolute temperature it the temperature above the zero absolute, i.e. above -273.15°C.

1.1.1.2 Degradation of energy

Unfortunately, there is another law of physics called the second law of thermodynamics, also known as the principle of degradation of energy that strongly upsets our energy situation. The second law states that the quality of energy degrades irreversibly, making it less available for work. We can observe that heat always goes from a hot object to a cold object and never the other way around. This loss is explained by entropy, a physics notion that measures the effectiveness of energy. When entropy increases, energy quality decreases. After all, energy is a quantity but also quality.

To illustrate, let us return to the kitchen. The energy of the hot water required for cooking the pasta will end up in the sink. According to the first principle of thermodynamics, the energy finishing in the sink is part of the total energy used, but it is useless energy because it is impossible to use it. It is impossible to transform this energy into more valuable energy[a]. The energy contained in the sink cannot have the same quality of energy which was contained in the natural gas. This is just impossible. It is impossible to do the same work with 100 litres of water at 1 °C that can be done with a litre of water at 100 °C, although they contain the same amount of energy.

Except for energy, everything on Earth, in theory, can be recycled (this is a new fashion – the circular economy). Unlike natural resources such as steel, aluminium, water, and stone, it is impossible to recover the energy from consumed energy, because at each manipulation it is constantly degraded to less noble energy. This peculiarity of energy causes the fear inherent in environmental movements that claim that in the future there will not be enough energy.

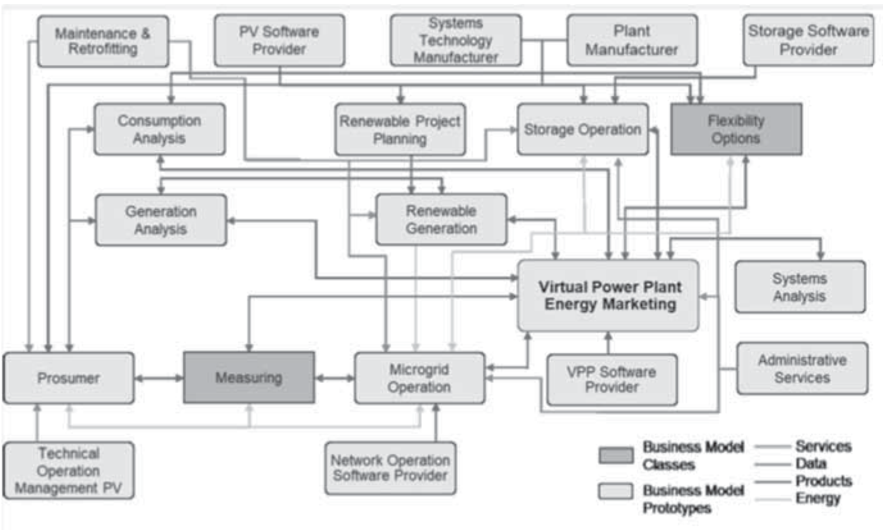
Among all energy types, electricity is more surprising. We will develop the topic in more depth in a later chapter, but now, it is

[a] To be precise, heat pumps can do that; however, they need energy to perform this action (see Volume 2).

enough to point out the strange nature of electricity: it can only be produced if it is used at the same moment – instantaneously, immediately – and, therefore, destroyed. It is impossible to produce electricity if it is not used and, therefore, destroyed at the same moment. We will see that this creates a huge difficulty for the generation of electricity. Of course, enthusiasts will answer that it is possible to store it. True, but for now only small quantities can be stored and, therefore, this does not solve energy policy.

Complex systems are often presented as feasible solutions to challenges in energy policy. Processes are integrated with other processes since, for some people, the more that processes are combined, the better the final result will be (Figure 1-1). The rationale behind this is probably that although people realise that there are efficiency losses at every step, they hope to recover them using a more complex system.

Figure 1-1 The complex German concept for its energy transition



One recent example is the idea of producing artificial natural gas. Some claim that an excess of electricity produced by wind energy could be used to produce hydrogen by water electrolysis.

This ‘free’ hydrogen would react with the CO_2 emitted by a gas-fired power plant, producing natural gas according to the Sabatier reaction. It seems like a miracle … free wind energy reacting with free fumes to produce valuable natural gas!

Who would be against such a nice presentation? He who knows how to calculate! Let us consider a process with the efficiency of 80%, which is an efficient process. If you introduce 100 units of energy, you will get only 80 units at the outlet. If this process is followed by another having the efficiency of 80%, the final efficiency will be:

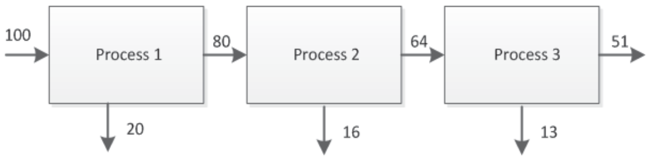
$$0.8 \times 0.8 = 0.64$$

With a three-step process, each having the efficiency of 80%, the total efficiency will be:

$$0.8 \times 0.8 \times 0.8 = 0.51$$

With just a succession of three efficient steps, half of the initial energy has disappeared. Clearly, energy does not like to be manipulated.

Figure 1-2 Inefficiency in multiple-step process



To sum up this subsection, the laws of physics explain that it is impossible to do anything without using energy, and that energy degrades constantly. It is therefore normal that we are in a huge impasse, the energy dilemma: humanity does need a lot of energy, but its use is inefficient and is also degrading. Accordingly, the less we manipulate energy, the less it degrades and the lower the losses. Burning wood in a power plant to transform water into vapour, then converting it into electricity used for heating the shower water is much more inefficient than heating the shower water directly with wood. Although it is inefficient, it is much more convenient. This demonstrates the energy dilemma.

1.1.2 Work is hard, but necessary for growth

Who has not sweat whilst working? Work is painful and, to escape it, people engineered solutions. They quickly realised that it was more comfortable to have work done by somebody else. First, they domesticated animals; oxen, donkeys, camels or horses were – and still are in some parts of the world – nothing more than energy substitutes for human work. They transform grass or hay into energy, i.e. they use renewable energy to work.

Box 1-1 Energy and slavery

With time – regrettably – violent people discovered that they could dominate others forcefully by obliging them to work in their benefit. A slave was considered by his owner nothing more than a cheap form of energy. At a time when there were no tractors or other machines, slaves were used as free energy, working on just a small portion of food. Thanks to great men's actions, like William Wilberforce, the abolition of slavery finally became a reality at the beginning of the 19th century. This English parliamentarian, as an Evangelical Protestant, fought all his life for this cause, and finally, shortly before his death, obtained the abolition of slavery in the UK. This stimulated the French abolitionist writer Victor Schoelcher to do this at the same time in the colonies.

However, humanitarian considerations were not the only reason to abolish slavery; another main driver was the emergence of the use of fossil fuels, facilitating this moral victory. It was easier and more convenient to use a tractor than a group of slaves; tractors are more obedient, more docile, more powerful, and more efficient. Slavery did not go alone; it covered a whole range of jobs such as a washerwoman, since it is much easier and even cheaper to do the laundry with a washing machine than having a person designated for this task. The development of energy supply eliminated slaves and house workers.

Today, thanks to fossil energy, we can easily clean our clothes, we can enjoy a hot shower, we can enjoy comfortable temperatures at home independently from the outside temperature, and we can move anywhere easily. I am not ignoring the scandalous working conditions of some workers or even children in some parts of the world. Unfortunately, today slaves are still used as a cheap energy source.

Indeed, we changed slavery by using 'virtual slaves', those who are replaced by energy. Jean-Marc Jancovici calculated that an average European is using the energy equivalent of about 400 workers or 'virtual slaves'[2]. He worked out that about 23 slaves would be required for producing our food, 237 to serve us at home and provide services, 145 for producing industrial goods which we enjoy, and 22 for transporting us. Criticising energy utilisation is easy, but once we have to decide which tens of slaves, we should eliminate to put our nice words and behaviour into practice, it proves to be difficult. For example, it is common to criticise people for using their cars rather than public transport, but I have never met someone eager to launder their clothes as done only 60 years ago by our grandparents. Jancovici's numbers show that it is precisely for our comfort, and in our homes, that we use the larger part of energy, not in transport. Environmentalists would have been wiser to criticise washing machines and refrigerators rather than promoting cycling.

In the past, the unit of power was the horsepower (HP), equivalent to 736 watts (we will come back to this in a few paragraphs). Since the power of a man is around 100 watts, a horse force is the equivalent of 7.36 men. According to the last data of the World Bank, in 2000 there were 25 million farming tractors in use in the world. Twenty years later, we can estimate that they are 30 million now. Therefore, with an average of only 100 HP[a], we arrive at

$$30 \text{ million tractors} \times 100 \text{ HP} \times 7.36 = 22 \text{ billion.}$$

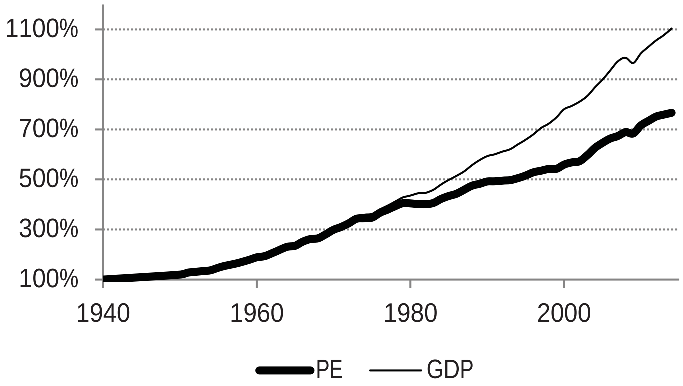
To perform the work of all the tractors operated with fossil fuels it would require three times the world total population, the elderly and children included. For sure, fossil fuels have largely replaced slavery.

Although the world's total primary energy demand accounts only for 2% to 3% of global GDP, obviously it has a major impact on the economy, indeed not proportional to this small ratio but much higher due to the inelasticity of the demand. We can observe (Figure 1-3) that there has been a correlation between global GDP and primary energy consumption from 1940 until the oil crisis of the 1970s. Cheap energy, specifically cheap oil, fuelled the economy. As a reaction to the oil shocks, we observe a slower increase in the primary energy consumption compared to GDP growth. This is due to the energy efficiency triggered by the increase of oil price and the price of the other energy sources. These last years, the gap is also increasing because GDP has been in a way 'manipulated' by a new definition (now including things like art markets, smuggling, and prostitution). Anyway, historically, there is no reduction of the primary energy demand while GDP is growing. The crisis of 2008-2009 is visible on the graph and demonstrates the unique moment when the global GDP was reduced, but this was correlated with a corresponding primary energy reduction. Our conclusion is clear: an increase in GDP irremediably triggers an increase in primary energy despite the progress of energy efficiency.

[a] The range of the most sold tractors is that of 200 HP and more. Deere is proposing a machine of 620 HP.

Figure 1-3 Evolution of world GDP and primary energy compared to 1940

1940 = 100% – Data of Jean Laherrere[3,a]

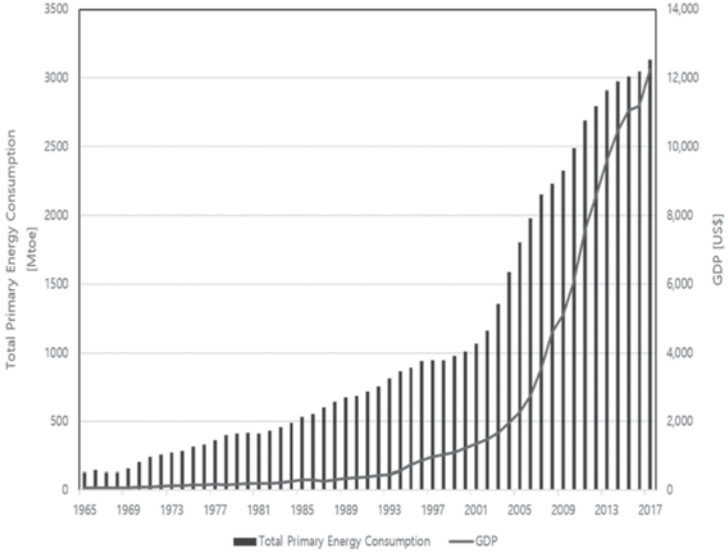


This trend is most visible in China's correlation of GDP growth and primary energy consumption. The impressive growth of its economy started around the year 2000 with parallel explosion in its demand for energy. In the last years, the slowdown of the economy has also correlated with a reduction of energy demand growth, even if this growth is however ongoing.

[a] Real GPD in constant $2010 but not corrected by PPP.

Figure 1-4 GDP and primary energy demand of China

Data Source: BP Statistical Review of World Energy (2018) and World Bank Data (2018)



1.1.3 But today, energy is also policy

Energy is the blood that flows through the veins of our economy. Essential to all human daily activities, from basic to extravagant, it is the engine of our growth. Only when we are deprived of it, we realise how its use is essential in our modern society. That is why today there is a lot of ‘policy’ in this sector.

When in 1978 I started working in this field, only knowledgeable people had the authority to talk about and decide energy issues; citizens ignored the topic. Until about 1990, energy was mainly a question ran by engineers. Since it was led by engineers, energy was readily available and not expensive. Specialists knew how to design and to invest for most Western citizens, thus allowing them to enjoy the advantages of energy services. Thanks to the knowledge of energy engineers, the OECD countries changed drastically towards more prosperity and comfort. Some few high-level policymakers were following the international aspects of energy supply, i.e. geopolitics, but the other politicians were ignoring this sector. After all, the result was not too bad.

Since the emergence of sustainable development, energy has become a popular sector. However, popularity is not always in phase with rationality, just as sentimentalism is not always wisdom. As a consequence, we saw too much dreaming these last few years in what a hardware sector is foremost. Rarely will citizens discuss how a brain surgery should be performed, or on which orbit a satellite should be placed. However, energy, particularly electricity, each citizen becomes a specialist proclaiming their ideas. Only in energy is it possible to meet people having no notion of energy whatsoever, but still pretending to know more than energy engineers. This contrast is surprising. What is the reason? Why are Europeans abruptly becoming energy specialists? Consequently, policymakers also have to show to their electorate that they are energy specialists. This situation will be analysed under Volume 3.

Accordingly, policymakers today have more weight than engineers in the decision process of the electricity sector to the point that investment decisions are not based on rational economic evaluations, but mainly depending on political choices. Electricity companies cannot decide what power plant they will build (investing their money), but policymakers will decide how to spend the money of entrepreneurs. Energy engineers cannot decide which renewable energy is better to be exploited, but policymakers get to cherry-pick. If this looks like a democratic process, the results that are becoming apparent today should raise questions on this way of proceeding. We will note along with the pages of this book that too often what is perceived as a common good and sound policy can trigger surprising results.

Politicians are willing to impose a so-called fuel mix using policy decisions. This widely used concept indicates the share of different primary energies used in the area under the authority of the policymaker. This is particularly the case for electricity generation; the ‘fuel mix’ being widely debated among policymakers: nuclear energy yes, nuclear energy not; or wind yes, wind not…

As we speak of electricity and legislators, it is worth mentioning that often policymakers, the media, and citizens confuse ‘energy’ and ‘electricity’. They use both indistinctly. Would you imagine confusing the word ‘transport’ with ‘aviation’? If it were just a confusion of language, it would not be a serious issue, but this has serious implications.

Box 1-2 Confusing energy and electricity

On 26 January 2015, I was invited on a Belgian TV programme for debating with a renewable energy specialist about the problems that people have for heating their homes [4]. During make-up, I congratulated the journalist for having chosen to talk about the heating issue and not on electricity generation as usual. However, from the first sentence the other panellist (a university professor), started talking about nuclear energy. I interrupted to mention that we were invited to speak about heating and not electricity. Despite his acknowledgment, I had to bring him back several times as he was always drifting to electricity. I even had to stop the journalist herself when she raised questions about electricity and confused electricity with energy more than once. When we left the set, the astonished journalist asked me why she herself also made this mistake. I reassured her that even qualified friends in the energy sector and many policymakers have this confusion[a].

[a] Reportedly, in 2005 at the Hampton Court European Council, when British Prime Minister, Tony Blair, launched the idea to set a target for renewable energy, he made also the same confusion. He meant a target of 20% for electricity generation and talked about 20% for energy. UK electricity experts confirmed me this confusion during private communications.

In the EU the average electricity demand represents 22% of the total final energy demand. So, when people mention 100% renewables, they often mean that for only ⅕ of the total final energy demand.

1.2 Measuring energy

We noted that work results by the vector multiplication of force by distance. The unit of work or energy is named joule, in honour of a famous English physicist named James Prescott Joule. Moving a force of one newton over one metre in the same direction of the force results in a work of one joule and consumes one joule of energy.

However, since this unit is too small, it is better to work with multiples. In energy policy, the megajoule (1 MJ= 10^{6} joules) or petajoule (PJ = 10^{15} joules) are used. In the USA they use the Q unit equivalent to 1.055 × $1,0^{21}$ joules. Furthermore, because it is more telling and because oil is the dominant energy in energy policy, it is common to use the 'tonne oil equivalent' (toe) or even a multiple of toe (million toe = Mtoe). The toe is a standardised conventional unit based on one tonne of oil with a net calorific value of 41,860 kJ / kg; a toe, therefore, has energy content of 41.8 GJ (Giga joule = 10^{9} joules).

In the oil sector, the common unit is 'barrel per day' (b / d) or its multiple (million b / d = Mb / d) with a barrel (b) equivalent to 159 litres; a million toe per year is equivalent to 20,000 b / d. In the gas sector, the usual measurement unit is 'BCM' meaning 'billion cubic metres'; however, in the International system of units, it is more appropriate to use the Gm^3 (10^{9} m^3)[a].

[a] Some experts find that the unit Gm^3 can be ambiguous; they are afraid that it can be interpreted as $(Gm)^3$. In the normal understanding, the cube refers only to meter and not to the 'Giga'. To stick to the International System of Units they recommend using $G.m^3$. However, we will keep the common practice in writing Gm^3.

Table 1-1 Some measurement units in energy policy

Energy	Unit
International System	joule (J)
Oil	Tonne oil equivalent (toe) = 41.8 GJ 1 barrel = 159 litres 1 toe = 1,165 litres = 7.33 b 1 Mtoe / day = 20,000 b / d
Natural gas	1 bcm (Gm^3) = 0.9 Mtoe = 1.73 Mt of LNG = 6.29 Mb
Coal	1 tonne of coal equivalent (tce) contains 23.3 GJ or 0.55 toe 1 tonne of lignite is equivalent to 1 / 3 of toe
Electricity	1 mega Watthour (MWh) = 1,000 kWh = 10^6 Wh = 3.6 GJ

We will shortly see that each primary energy has a specific use. What can be done with a toe of oil cannot necessarily be done with a toe of coal or wood. We must compare apples to apples, yet, we are forced to compare apples to oranges. There is a deadlock and a ‘dictatorship of the toe’ whereby the other units having to submit to the one of oil because oil was the first energy to be traded globally. Table 1-1 provides some conversion factors make it possible to add oil, coal, gas and electricity.

Finally, it should be stressed that in energy policy and geopolitics, numbers with more than three significant figures should not be used. This field is not a science. The data are imprecise, and also depend on the sources used. Orders of magnitude, trends are significant, not decimals. Therefore, we also prefer to present the data in this book in graphical form rather than in table form.

1.3 Power

In the last line of the table above, a strange unit appears. What is a 'Wh' (Watthour)? Strangely enough, this unit of energy is derived from a unit of power. In physics, power is the speed at which work is performed, i.e. it measures the energy delivered or consumed per unit of time.

$$P = \frac{W}{t}$$

Climbing a staircase over the course of 10 seconds performs the same amount of work and consumes the same quantity of energy as climbing it over the course of 20 seconds, however, in the first instance, the power required is doubled. The unit for measuring power is 'joules per second' (J/s) which are called watts, in honour of James Watt, an English engineer who improved Thomas Newcomen's steam engine (this engine was crucial to pump the water of the coal mines; this interesting story is well described by Richard Rhodes in chapter 4 of its book Energy, a human history[5]). Since, in practical life, the watt is too small (because the Joule is too small), energy professionals use multiples: kilowatt (kW = 10^3 W), megawatt (MW = 10^6 W), gigawatt (GW = 10^9 W) or terawatt (TW = 10^{12} W).

Another common confusion in the English language is when 'power' is used interchangeably to mean 'electricity'. Conversely, you might also come across 'wattage' to qualify power, as if you eve described a distance with 'meterage'. We will try to avoid these confusions since we will stick to the physical notion of power.

An electricity generation plant is characterised by its 'capacity' to deliver power; this is why it is also called a power plant. Therefore, the size of a power plant is called 'capacity' and is usually expressed in MW. For example, a typical wind turbine has a capacity of about 3 MW; a gas-fired or a coal-fired power plant might have a capacity of 150 MW to 500 MW, while a nuclear plant usually has a capacity of 1,000 MW or even 1,600 MW for some new plants under construction. The capacity of these power plants is used to measure their power and not the energy produced. To work out the energy produced, it is necessary to multiply the watt (J/s) by the time (s) to get J, or, more specifically in the electricity sector, to multiply the megawatt capacity (MW) by the number of operating hours (h) to get the energy produced in megawatt-hour unit (MWh).

This proximity between MW and MWh is confusing to novices who may mingle the size of a power plant (MW) with the electricity generated (MWh). It is like confusing the diameter of the tube with the flow of water that passes in it. Energy professionals love to mock politicians who make this common confusion.

A human whose daily caloric intake is about 2,100 kcal, or about 2,400 Wh/day cannot physically provide more than 2,400/24 = 100 W permanently, and due to the heat loss of our organisms, more like 80 W (or 0.064 kWh).

1.4 Primary and final energy

One of the main fundamentals of energy is the distinction between ‘primary energy’ and ‘final energy’. Primary energy is contained in the energy sources found in natural resources like coal, oil, gas, uranium, wind, biomass, the sun, and other renewable energy sources (Figure 1-6). In most statistical reports, energy from the burning of wood, wood wastes, charcoal and dried animal dung are not accounted for. Final energy, also known as secondary energy, is the energy used by the final energy consumer. Often, passing from primary energy to final energy requires a transformation that leads to some loss of the energy content. To enjoy the service of final energy, it needs to be delivered to the final user; however, this creates other losses (Figure 1-7).

We have seen that energy does not like manipulations because at each transformation step some entropy is created and the useful energy is degraded. Nevertheless, primary energy is commonly not easy to use or to handle. Therefore, it is converted into an easier form of energy to be used to offer a service; this transformation into final energy occurs in power plants or oil refineries. Accordingly, the quantity of final energy is always lower than the quantity of primary energy, and sometimes the difference is huge. Furthermore, final energy must be transported to the final consumer, and this creates further losses, especially in the case of power lines transmitting and distributing electricity to the end user. To further complicate the situation, some primary energy can also be used as final energy. When natural gas is burned to heat a house, it is used directly without any transformation; it is, therefore, final energy. When used in a power plant to generate electricity, it is primary energy. It is the same for firewood, or hot water produced by solar water heaters.

In 2017, the primary demand in the EU was 1,675 Mtoe while the final demand was 1,060 Mtoe and, therefore, the loss was 615 Mtoe, i.e. 37%. Practically all these losses are caused by the transformation of primary energy into electricity (Figure 1-5). Oil refineries are efficient because only 0.6% are lost during the transformation of crude oil into oil products.

Figure 1-5 Losses in EU-28 in energy transformation

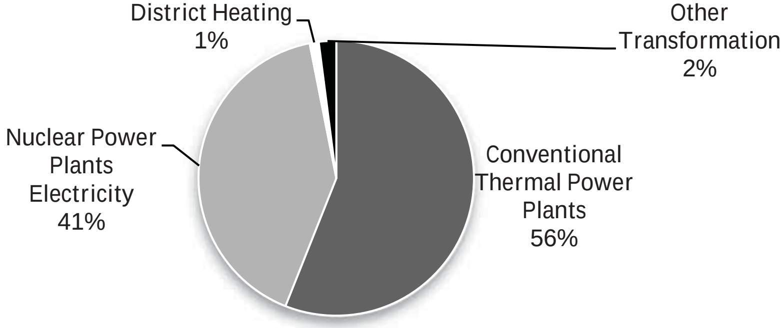
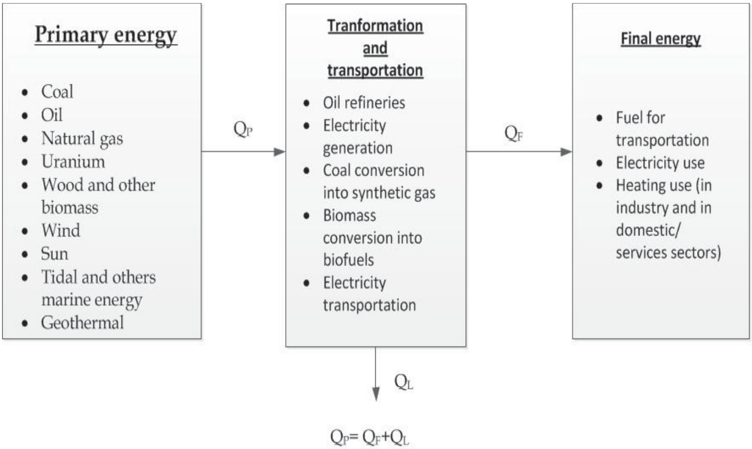


Figure 1-6 Primary and final energy



Energy provides three main types of 'services', each better adapted to a form of final energy; there are only three forms of final energy, heating, transportation, and electricity:

1. service to produce heat or refrigeration, which is also called 'stationary use' (whether for the needs of the industry or domestic or services uses like heating or hot water); this production uses almost exclusively fossil fuels or biomass (wood);
2. transport service; 94% of it relies on 'petroleum products' produced from oil in a refining plant;
3. service of electricity generated from hydro, combustion of fossil fuels, nuclear energy, and renewable energy sources.

The reader might be surprised by the repetition of the word 'service' in the previous paragraph. It is important to underline that nobody needs energy *per se,* but needs the services offered by the final energy. When you are refuelling your car, you are not buying MJ of gasoline, you are measuring it in money. You are not buying 'energy', but a product that will 'service' you.

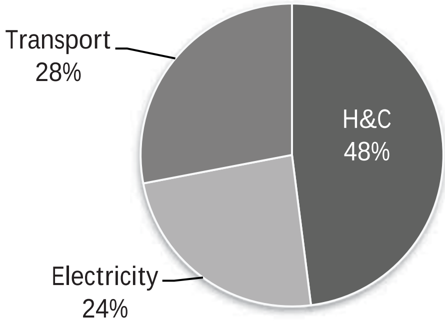
1.4.1 Heating and cooling

Where do we use final energy? Figure 1-7 shows that the most important final energy is heating and cooling although it is least considered in energy policy. In the EU, half of final energy is used to heat or cool houses and services and industrial processes. Strangely enough, the share of electricity is the least important one although this sector receives the maximum amount of attention from policymakers. In most energy debates, electricity is always the sole energy considered, and yet it is less important in terms of share. Consequently, when addressing energy efficiency policies, we will note that it is probably in the sector of heating and cooling that the larger potential for improvements exist.

This is due to various reasons: first, there is no market or only a marginal one for heating and cooling whilst there is a huge one for electricity or oil products. District heating networks occur in only a few countries. Furthermore, the lack of a strong market for heating and cooling leads to a lack of sound economic data. For heating and cooling, market deployment is the issue rather than technology, even if there is room for improvements. Despite energy professionals claiming that this sector presents so much potential for energy savings, including economic benefits, why are neither the market nor the policymakers interested in it? This question remains to be answered. Indeed, this is the core of the issue. After 40 years of modern energy policy, heating and cooling remains the poor cousin, particularly in renewable energy sources where it would have been much cheaper to promote heating rather than electricity.

Figure 1-7 Shares of final energy demand in the EU.

H&C= heating and cooling, 2020 European Commission data



Box 1-3 Energy for cooking

Preparing food most of the time requires heating. Therefore, in energy policy, the heating sector also contains the consumption of energy for cooking. For the larger part of human history, the energy used for cooking was wood. It is, unfortunately, still the case in many parts of the world, because poverty does not enable the use modern energy (see Section 3.4).

Today, in modern countries, the most common types of energy used to cook food are electricity, natural gas (methane) when it is distributed in dwellings or butane/propane mixture (LPG) in canisters. Depending on eating habits, the energy can vary greatly. For example, in Greece, charcoal is widely used for grilling. This is omitted in the energy statistics, although it is significant since the heat energy used to heat the homes is much smaller and therefore the share of cooking energy is higher than elsewhere. In the small islands or rural areas, natural gas is not distributed, and therefore the cooking energy, most of the time, is a mixture of LPG and charcoal (see Figure 1-8).

Figure 1-8 Transport of cooking energy in Kos Island (Greece)

Photo by the author

1.5 Playing with primary and final energy

What do the statistics on final energy and primary energy tell us? This is particularly important in the context of EU-imposed decarbonisation. Above all, it should be considered that, in the European directives, the renewable energy target is expressed as a share of the final energy (we will see that in the chapter on renewable energy in Volume 2). Let us assess the importance of intermittent renewable energy in the EU’s primary energy balance sheet today. It is this one that counts when we are concerned about energy, whether it is for geopolitical aspects, the balance of payments and decarbonisation.

We have just seen that electricity is the least important of the final energies in terms of volume. At the same time, ensuring the safety of electrical power supply is essential in our modern life, as this reason for public health reasons (the Covid crisis is won through availability without the intermittent power supply), safety or economic reasons (our digital society fully depends of electricity availability). Electrical engineers make it a point of honour to meet this need.

In the EU-27, wind and solar renewable energy represent 14.9% (in 2018). But since it is the least important in volume, reported in primary energy the result is that the 14.9% of wind and solar electricity in electricity consumption represent only 1.9% for wind energy and 0.6% for photovoltaic solar. Solar and wind, because they are not used in the most important energy uses (heating and transport), see their share melt into primary energy, the fundamental indicator. So, 97.5% of primary energy in the EU is not wind and solar. In France, wind and solar photovoltaic energy account for only 1% and 0.4% of primary energy respectively. Even in Germany, considered the champion of the energy transition, these energies, which are constantly being promoted, account for only 4.3% of primary energy. Le Table 1-2 gives this data for a few Member States.

Table 1-2 Percentage of wind and solar photovoltaic primary energy savings for some EU Member States

Member state	% wind energy	% solar photovoltaic
EU-27	1.9	0.6
Germany	3.0	1.3
Belgium	1.2	0.6
Spain	3.4	0.5
France	1.0	0.4
Italy	1.0	1.2
Poland	1.0	0.0

The most popular energies in the media account for only 2.5% of primary energy in the EU. These data provide a measure of the effort that would be required to achieve 100% renewable energy, which is thought by the most enthusiastic that this production will be made entirely from wind turbines and photovoltaic panels. It would be good if this simple consideration of energy policy were well understood by those, policymakers or lawyers, who like to talk about energy without knowing anything about it. Especially since the promotion of wind and photovoltaic solar dates to 1974.

1.5.1 Energies are not all the same

Paper to print a newspaper, paper to print on your printing device, toilet paper or rolling paper, and even cardboard are all papers. However, their physical characteristics define their usages. Similarly, with energy; even having the same energy content, primary energies are not interchangeable. Table 1-3 shows the main use of the primary energies. Please note that renewable energy is indeed the more versatile primary energy and that oil (indeed oil products) is mainly used for the transport sector as 94% of the transport sector in the EU operates with oil products.

The density of primary energies also determines their use. Some energy sources have a high density, while others are much more diluted, particularly gaseous ones (Table 1-3).

Table 1-3 Main use of primary energy sources

Primary energy	Main use
Coal	• Electricity, heating networks (domestic use is now marginal in most OECD countries except Poland)
Oil	• Transport • Heating (but limited use)
Natural gas	• Electricity • Heating
Nuclear energy	• Electricity
Renewables	• Heating (wood / biomass, thermal solar) • Electricity (wind, ocean energy, PV) • Transport (biofuels)

Table 1-4 Typical energy density of some energy sources

Energy	MJ/kg	MJ/ℓ
Hydrogen	140	5.6
Methane	56	0.036
Oil	42	35.8
Coal	25-30	
Wood	16.2	-
Straw	12-15	
Lead-acid battery	0.17	
Li-ion battery	0.46-0.72	-

Hydrogen has the higher density, but it has a lot of drawbacks starting with the fact that it does not exist in nature and that it needs to be produced. Methane has an interesting density if the unit is expressed in MJ/kg, but it is low in MJ/ℓ. From time to time people launch the strange idea of using compressed air as an energy vector. Nearly everything is, of course, possible but not everything is practical. This can be easily demonstrated with only 3 numbers: 50 litres of compressed air at 500 bar released at atmospheric pressure is equivalent to 4 kWh (this requires a 3 cm thick steel reservoir for supporting 500 bar); the same volume of 50 litres of gasoline liberates 440 kWh; batteries are not better because 50 litres of a lithium battery contains only 20 kWh.

2 FUNDAMENTAL DATA

Energy geopolitics cannot be analysed based on vague qualifiers like large or expensive. It must be rationalised based on specific, objective and transparent data. That is why this book contains a lot of data, tables, and figures. After presenting the main sources of data used in energy geopolitics, this chapter will briefly present the models used to define the potential energy future. It will then explore the indicators required to both evaluate future energy consumption tendencies and to act today. A significant part of the chapter is then dedicated to the past, present, and future of global and European energy consumption. This will be contextualised for primary and final energies, and specifically as they relate to electricity consumption.

2.1 Data and energy scenarios

Having developed a common understanding on the meaning of energy and power, and recognising that it is better to avoid any energy transformations for efficiency purposes, we should be ready to begin looking at the energy world quantitatively. To be able to act, it is necessary to measure. As the saying goes ‘If you don’t count, you don’t count.’ To do that, we need numbers, not qualifiers.

I remember reading an Italian book on energy geopolitics without any numbers in it; it took me some time to realise why I was not at ease with it until I grasped that its content was all words and no numbers at all. In the words of Lord Kelvin[a], the famous British scientist whose name is recalled each time when absolute temperature is mentioned, ‘*I often say that when you can*

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[a] Lord Kelvin of Scotland is the same scientist also known as William Thomson.

measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be.'[6] Consequently, this and the following chapters are packed with numbers.

In the present book, rather than presenting lists of numbers in tables, charts will be prioritised. However, these graphs incorporate much data. Indeed, this book is packed with thousands of data in the background. The greatest care has been taken to ensure that all of them are correct and up to date. This has been the most time-consuming undertaking in writing this book.

2.1.1 Data sources for evaluating the world of energy

Several major international sources are used for energy data. European data in this book primarily emanates from the European Commission and, specifically, its statistical office (Eurostat) and its Directorate General Energy. When not specified, tables and figures are based on these European Commission data. The US Energy Information Administration (EIA) is a major source of international data. Many international data and many briefings are offered by this administration, where about 3,000 people work[a]. The International Energy Agency (IEA) is another major source of data; yearly, it publishes the World Energy Outlook and other more specific and valuable reports. Specific data on oil is available from OPEC. Since 1952, BP has annually published its 'BP Statistical Review of World Energy'. These are all widely recognised sources of reliable data.

One of my students raised a question about the trustworthiness of an oil company to analyse energy geopolitics. It is appropriate to underline that the authority of this annual review is recognised

[a] This is to allow the whole US energy industry to have access to sound data in a level playing field. This is to support them internally and geologically.

by all and its credibility does not warrant any criticism as it would not have survived as a reliable reference since 1952. It is noteworthy to observe that in this review, while hydroelectricity data has always been provided and available, data on new renewable energy has been reported only since 2011.

Table 2-1 Main energy data sources links

Data source	Link
European Commission (Eurostat)	http: / / epp.eurostat.ec.europa.eu / portal / page / portal / energy / data / main_ tables
European Commission (DG Energy)	http: / / ec.europa.eu / energy / observatory / statistics / statistics_en.htm
US EIA	**http://www.eia.gov/countries/**
IEA	http: / / www.iea.org / w / bookshop / add.aspx? id=455
OPEC	**http://www.opec.org**
BP	http: / / www.bp.com / sectionbody copy.do?categoryId =7500&contentId=7068481
Enerdata	Enerdata.net

2.1.2 Models and forecasting

The development of computers provided the development of models and scenarios as a corollary. There are different types of models:

- Business as usual (BAU) scenario gives the trend as if the same energy policies are pursued without any major changes.
- The prospective scenario analyses the impact of new energy policies.

- The normative model considers the energy policy that must be implemented for reaching a result (this is a command and control approach).

Energy models are based on a set of assumptions. The principal variables (for these models) are the following:

- demography and age pyramid by countries or regions[a],
- evolution of familial structure,
- macroeconomic development forecasts over a period (GDP),
- policies and measures in force or already decided,
- policies and measures under discussion,
- programs underway or in preparation,
- environmental constraints,
- technological changes,
- lifestyle evolution.

Evidently these assumptions are subject to interpretation and the data backing them up is highly uncertain; therefore, they are called ‘variables’. For example, during the period 2005–2007 everyone in energy policy was convinced of the strong development of environmental policies because it was foreseen that the economic growth would have helped to overcome the cost of this policy. That is why the policy in favour of renewable energy has been so enthusiastically implemented. However, the huge economic crisis which started in 2008, and is still lasting years after, has changed some hypotheses elaborated in 2005–2007. One, therefore, must admit that scenarios have to be taken as a forecast of a set of possible futures (that should include probability estimates, but it is rarely the case) and not a prediction. However, it is widely demonstrated that NGOs sharing the vision of the results of these forecasts use them as an ‘instrument of propaganda’ to defend their position. Any precautionary language strangely disappears, and what a computer computes becomes a reality in their communication.

[a] Region in the sense of a group of countries and not a sub-country entity.

Box 2-1 POLES and PRIME, 2 main energy forecasting models

The EU Commission, since 1990, has financed the development of models to simulate the worldwide supply and demand for energy. The scenario POLES, the acronym for Prospective Outlook on Long-term Energy Systems, has become a world reference in simulating the development of energy scenarios until 2050. It is being applied for scenarios and projections of energy demand, supply, and prices, such as the World Energy Technology Outlook, to analyse CO_2 emission and the impact of technological change. The dynamics of the model are based on a recursive (year by year) simulation process of energy demand and supply with lagged adjustments to prices and a feedback loop through international energy prices. Indeed, contrary to other energy models, international prices are calculated endogenously in the POLES model. The main exogenous variables in the model are GDP and population for each of the countries/regions.

Another widely used model is the PRIMES Energy System Model, initially developed by the University of Athens. It is a partial equilibrium model simulating the entire energy system, i.e. demand and supply operating separate modules for each demand and supply sector with separate decision-making. It is a market-oriented model since the market equilibrium prices drive the energy balancing of demand and supply per energy commodity: the demand is a function of the price, the supply equals the demand, and finally, the price is a function of the supply. Continuous iterations deliver the final price once the equilibrium is reached.

Nowadays there is a tendency to define the future of energy; this is exactly what is happening with climate change theory. Historically, mankind analysed the past to make decisions. Analysing the past helped to avoid reiterating the same missteps. For the reason for the sustainable development concept, the tendency now is to develop models predicting the future and to use these predictions to force present actions. In a reversal of the historical logic, the future governs the present. As the future is unknown, mistakes will be acknowledged … in the future.

Literature is full of previsions – some affordable, others much less. Developed by international organisations, oil companies, electricity companies, NGOs and environmental organisations, the reader will find a lot of them. My experience, developed after many years of concrete work on outlooks, gives me only partial confidence in some of them, but not all. Therefore, this book does not present outlook results. There are many reasons why I am reluctant to give too much weight to computer-run results. Hereafter there are ten warnings:

1. history demonstrates that most of the previsions were wrong (we will soon see an example);
2. the results of the runs strongly depend on the quality of the data introduced in the model (the expression 'rubbish in – rubbish out' also applies here), but more than that, the assumptions introduced in the model are extremely variable and questionable;
3. results are nicely presented on glossy papers or pretty websites. But we know scenario experts can have a strong influence on the results of computer runs. Nobody has the time, capacity, and resources to analyse the details of these data and the equations supporting the silken results;
4. my experience is that energy policy influences outlook results and not the reverse;
5. it is so easy, especially in huge studies, to hide a bias. For example, the Stern Report, demonstrating the cost of inaction on climate change policy, contains many internal contradictions on increasing costs. For example, the study foresees that Africa will develop so much to the point that it will use a lot of energy. It forecasts the number of SUVs, but at the same time it considers that Africans will not be

able to treat malaria, and, therefore, this is taken as a negative account[7];

6. model equations are also assumptions; they are adjusted to fit the objective of the study sponsor by what is deemed as ‘massaging’, indicating that a small change in one of the decimals of one equation can lead to different results. Only the operator of the model can control that;
7. the one who pays reserves the right to influence results. Did you see a scenario showing results contrary to the interest of the company which paid for the study? When results do not fit the interest of the backer, the study remains locked up;
8. the energy world is not stable and major disruptions can occur; nobody was expecting the drastic change that the shale gas and shale oil revolution would have on global energy policy;
9. when the development of models started, nobody would have dared to consider scenarios for more than 20 to 25 years; some studies looking 40 years ahead were just prospective intellectual scenarios. In the 1980s, the IEA published energy outlooks with a horizon of 20 years; they were extensive books. In the same period, they also published visions at 40–50 years in the future, but these prospective intellectual exercises took up only a few pages because there was not a lot to demonstrate. Today, the further your horizon is, the more success you will have with the media and NGOs. However, nobody will still oversee the same dossier in 40 years, which by then will be considered ridiculous;
10. finally, the strongest reserve: previsions are based on linear extrapolation. In nature, nothing is linear. However, this concept is enshrined in our way of thinking. It is rather difficult to introduce non-linear equations in models because the non-linearity cannot be perceived. Science, technology, and energy often evolve by impulsion and not linear evolution.

Physics Nobel Prize winner Niels Bohr humorously, though rightfully so, once said that '*prediction is tough, especially if it's about the future*.' This, therefore, should trigger scepticism when announcements on the future of energy are asserted.

For all these reasons, I am extremely prudent on the results of 'studies'. '*With four parameters, you can fit an elephant to a curve. With five, you can make him wiggle his trunk*,' said the famous Hungarian mathematician John Von Neumann. The sociologist William Bruce Cameron said, '*Not everything that can be counted, counts. Not everything that counts can be counted*.' I will add, '*he who counts, counts wrongly because he does not count everything, and, sometimes, what is not counted is what counts the most'.*

Box 2-2 The errors of the Club of Rome

Let us now have a look at an incorrect model report which had huge financial consequences, both for the private and public sectors. It was back in the seventies. At that time, the Club of Rome was famous. It was an informal association of independent leading personalities from politics, business and science, concerned over the future of humanity and the planet. They were thinking in a systemic interdisciplinary and holistic manner about a better world (of course, according to their criteria).

The Club of Rome propagated what was known as 'the Meadows report'[8] of 1972. It was named 'The Limits to Growth'[8] and used state-of-the-art computer models, based on exponential economic and population growths with the limited resource (an old and still ongoing mistake); this model established that production of oil and food were reaching a peak. Translated into 30 languages and sold at 12 million copies[9] it was as popular as the catastrophic previsions on climate change are today. Indeed, we can say that the Meadows report[a]

[a] Its authors were Donella H. Meadows and her father Dennis L. Meadows, Jørgen Randers, and William W. Behrens.

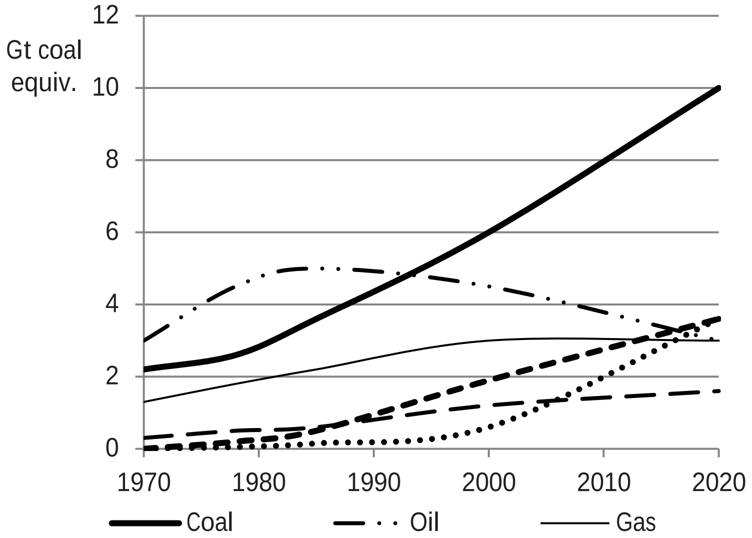
was the equivalent of the reports of the International Panel on Climate Change (IPCC) and that the Club of Rome was the equivalent of the UN Framework Convention on Climate Change (UNFCCC). Indeed, everyone believed the mantra of the end of oil calculated by the models used by the Meadows[8]. This politically correct position repeated by all policymakers of that period triggered public administrations to offer financial support for all possible solutions that hoped to produce substitutes to oil. Even the author of this book was influenced as his PhD was on hydropyrolysis of coal, a technique aimed at producing a substitute for oil from coal using hydrogen. The doomsday scenario was incorrect[10] but nobody stood up to denounce its errors and absurdity.

The Club of Rome convinced the entire world that the oil reserves of 90 Gtoe at that time would be depleted by the year 2000 based on models, or better yet based on the equations that the Meadows had introduced in the model. It predicted that we would have only 35 years for finding substitutes for oil by developing 'alternative energies'. Who would not have panicked when the oil reserves of Europe amounted to only 2 billion toe and the then European consumption totalled 0.7 billion toe? EU reserves of only 3 years were indeed worrying. The Club of Rome gave Muammar al-Gaddafi the ammunition he needed to impose on us his anti-Israeli policy in triggering the Oil shock of 1973 (see Volume 3).

The obvious solution was to prepare alternative energies and, meanwhile, to rely on the abundant world coal reserves.

Figure 2-1 from the 1977 textbook of my Prof. René Cyprès indicates the forecast of this extraordinary increase in coal consumption, the reduction of oil demand from 1985, the stabilisation of the gas consumption from 2000, a linear increase of nuclear energy production and an exponential development of the renewable energy to the point that by 2020 their production will be higher than that of oil, that of gas equals that of nuclear energy. All these previsions appear to be wrong and, indeed, ridiculous.

Figure 2-1 Evolution of energy demand by fuel type as forecasted in 1970s Prof René Cyprès course[11]



The EU has developed objectives based on these scenarios that, with time, also appear to be wrong. The Council Resolution of 9 June 1980[12] sets objectives for the year 1990; it foresaw

- to reduce to 0.7 or less the average ratio for the whole Community of growth rate in gross primary energy consumption to the growth rate of GDP;
- to reduce the Community oil consumption to a level of about 40% of gross primary energy consumption;
- to cover 70 to 75% of the primary energy requirements for electricity production using solid fuels and nuclear energy.

Thirty-five years later, we can be surprised that such forecasts were made. Who dares say today that ¾ of EU electricity should be produced with such non-politically correct energy sources?

Anyway, the common understanding of trustworthy organisations and energy companies gives the same forecasting trends for all with minor differences among sectors or energies:

- the world energy demand will grow steadily, certainly until 2040 and might start to stabilise after that;
- the future of energy will rely massively on fossil fuels. Renewable energy will only be able – despite an impressive growth in absolute value – to absorb a part of the increased demand;
- while fossil fuels represent 87% of today’s world demand, their share might shrink to approximately 80%, but of a much larger global energy consumption. Therefore, the absolute global demand in fossil fuels is set to increase.

2.2 Indicators and analysis

In any analysis, it is necessary to compare data to be able to evaluate policy results. This is called benchmarking. In energy, a set of energy indicators aims at developing a correct energy analysis. The main indicators available to energy analysts are

- energy consumption per capita;
- electricity consumption per capita;
- energy consumption per capita in transport;
- energy intensity;
- carbon intensity;
- CO_2 emissions per capita;
- Etc.

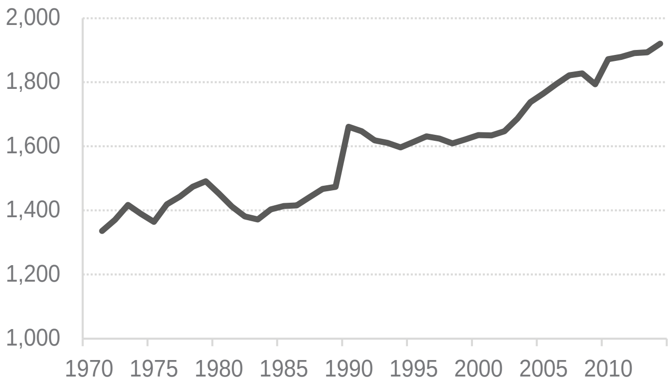
However, just comparing indicators is not enough. In complex issues like those found in energy policy, a deep sense of analysis and varied and multidisciplinary knowledge is required. Just comparing an indicator can sometimes lead to an inappropriate conclusion. For example, the per capita consumption of a small country like Luxembourg will lead to a wrong conclusion. Italian authorities like to present the country as virtuous in terms of energy efficiency, but Italy is a country that produces fashion and luxury goods. To produce an expensive Ferrari will not require much more energy than to produce a small cheap car. As a result, the country's energy intensity is lower than in other countries. We will see other examples in the following paragraphs.

2.2.1 Energy per capita

Forecasting energy trends starts with a simple fact: people need energy for living and working. The most used energy indicator is energy per capita since it is simple to understand because it refers to human beings. It is measured in toe (or koe[a]) per inhabitant.

Figure 2-2 World energy demand per inhabitant

kg of oil equivalent per capita



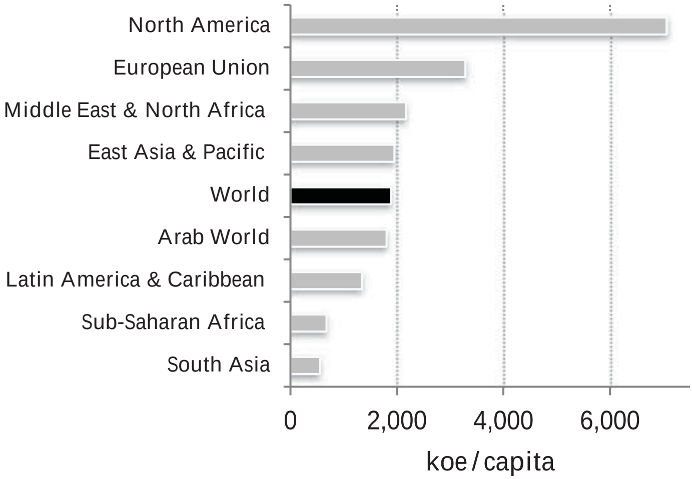
Using World Bank data, Figure 2-2 shows the astonishing ongoing increase of the world's energy demand. From 1970 to

[a] Kilo oil equivalent = 10^{-3} toe.

2015, it has increased by 44%; i.e. 1% per year. We can observe the decrease of the demand per capita each time that a crisis occurs (the oil shocks of the 1970s and the subprime crisis in 2008–2019).

Figure 2-3 Energy consumption per capita by regions

World Bank, 2014 data[9]



Once again, using World Bank data, Figure 2-3 shows that North America has the highest energy consumption per capita[13] by far. The USA had a per capita consumption of 12.4 toe in 2011 – electricity or energy per capita consumption more than double that of the EU, and more than four times that of the world average. This indicates that 'the American way of life' is based on large energy consumption.

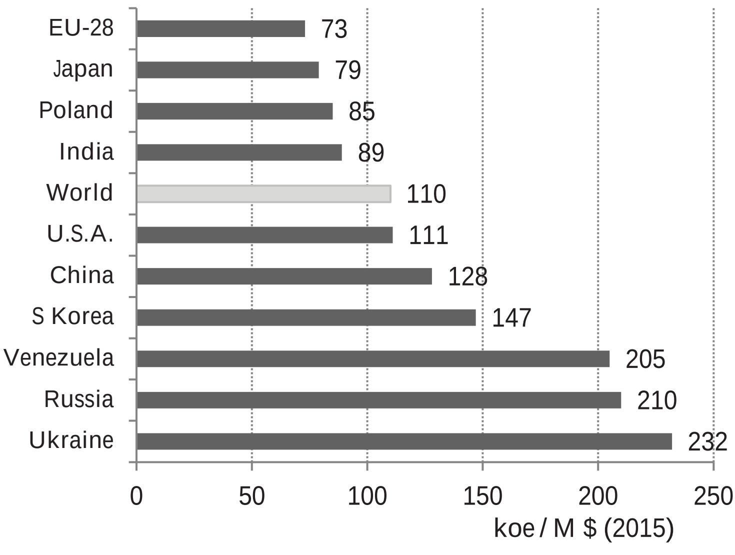
2.2.2 Energy intensity

The most important indicator is energy intensity, a ratio between energy consumption and the economic activity indicator (GDP). In practice, it is obtained by dividing the quantity of energy expressed in toe by the GDP expressed in millions of euro (or dollars). This unit is, therefore, expressed in toe / €M or toe / $M. The lower this indicator is, the less energy is required to produce one unit of economic development.

A country's energy intensity depends on various elements, such as the level of economic development (a rich country is usually more efficient than a poor one), the structure of energy prices, the meteorology, the geography and the size of the country, but also of the culture and lifestyle. Figure 2-4 shows different energy intensity in various parts of the world.

Figure 2-4 Energy intensity in various countries

2020 Enerdata data



It is an indicator, nothing more. It is impossible to arrive at solid conclusions based only on this indicator. It might be misleading to just look at it. Since energy intensity is a ratio, it falls when the economy is growing faster than relative energy consumption. Inversely, if GDP tends to fall faster than energy consumption (like in a recession period), energy intensity rises. This might occur without changes in energy efficiency. Therefore, the energy intensity indicator cannot be used blindly for qualifying progress in energy efficiency.

The energy intensity of Ukraine in 2019 was 232 koe / $1,000, i.e. 3.2 times worse than that of the EU-28[14]. When compared to Poland, which has an energy intensity of 85 koe / $1,000, Ukraine is 2.7 times less efficient. Imagine the potential for energy savings! Rather than blaming the price of Russian gas, Ukraine should first reduce its large energy wastage.

Russia has a high-energy intensity indicator (indicating low efficiency) for various reasons. The first reason is that the industrial sector is old and therefore inefficient, but also because, being a cold country, it needs much more energy than a milder country. Furthermore, the size of the country is huge, necessitating people and goods to travel long distances. This leads to a high indicator number; a part of it will never improve regardless of the country's energy efficiency policy.

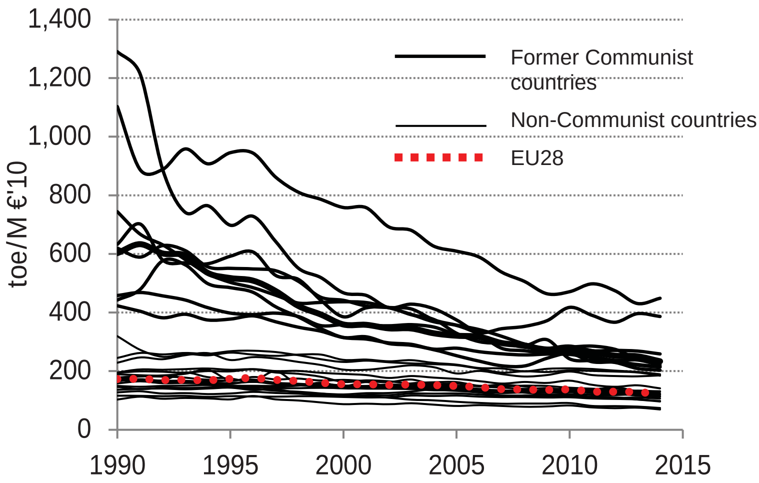
Japan and the EU have the lowest energy intensity worldwide. This is due to the reasons juxtaposing those that lead to a high energy intensity in Russia. Japan and the EU have planned a strong energy policy in favour of energy efficiency, and its industry is rather new. Furthermore, Japan in contrast to Russia, its land mass is small, and its population density is high, meaning that less energy is necessary for its transport sector.

Figure 2-4 further shows the energy intensity in the USA is not as good as that in the EU or in Japan. It is a developed country but with an 'American way of life' having consequences on energy consumption. Large houses, large refrigerators, and large cars lead to an energy intensity more than double that of the EU. While participating in 1996 in the second Conference of the Parties (COP) of the UNFCCC in Geneva, I was impressed by a statement made by the US Ambassador to the UN in Geneva: he stood up and stated with authority, '*you are not going to impose the size of our refrigerators; you are not going to change our American way of life*.'

The detailed analysis of the energy intensity inside the EU allows for critical conclusions, particularly if the aim is to promote energy efficiency (Figure 2-5). As there are 28 lines in this graph, the aim is not to analyse the energy intensity of each Member State, but to draw out the two evident deductions that this graph is showing in two groups of lines.

Figure 2-5 Energy Intensity in EU Member States

European Commission data



First, there is a group of Member States that, in 1990, started with an energy intensity about 2 to 6 times higher than the other. Their energy intensity was about 400 to 1,300 toe/€M in 2010 while the other Member States had an energy intensity about 170 toe/€M in 2010. These countries were those that previously operated on a planned economy.

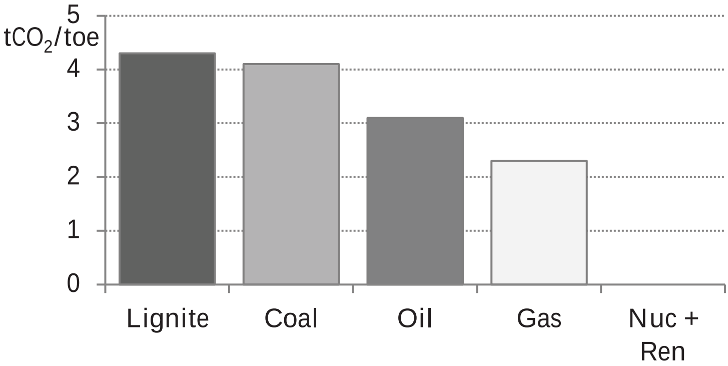
In these former USSR satellites, there was no energy market, and, therefore, the price of energy was not fixed by market law but by government decisions. The consequence was that the price of energy was low and that there was no incentive whatsoever to behave efficiently. For example, the temperature in houses was regulated by the size of the opening of the windows. Since they started to apply market laws progressively, their energy intensity decreased, sometimes rapidly and radically. Their energy intensity is still higher than those of the 'old Member States' but the gap is progressively decreasing. The top line represents the energy intensity of Bulgaria, a state that still has a lot of progress to implement to reach the average EU energy intensity.

The second clear message is that for the 'old Member States', there are no more low-hanging fruits. Since 1995, energy intensity has been decreasing, but at a slower pace. Efforts on energy efficiency must be reinforced to continue the improvement of this basic indicator. This will be discussed in detail in the chapter on energy efficiency in Volume 2.

2.2.3 Carbon intensity

The second most important energy policy indicator is carbon intensity as it is a key benchmark in the framework of climate change policy. Carbon intensity is the ratio between carbon emissions and energy consumption. In practical terms, it indicates the tonnes of CO_2 emitted for a tonne of energy used. The unit is tonnes of CO_2 per toe (tCO_2 / toe) or also kg CO_2 / GJ. Carbon intensity is only a characteristic that applies to the fuels themselves and not of the greater process, economy, or human behaviour. Renewable and nuclear energy, therefore, have a carbon intensity of almost nothing as they do not release any CO_2; methane has a much lower carbon intensity compared to coal (Figure 2-6).

Figure 2-6 Carbon intensity by fuel type

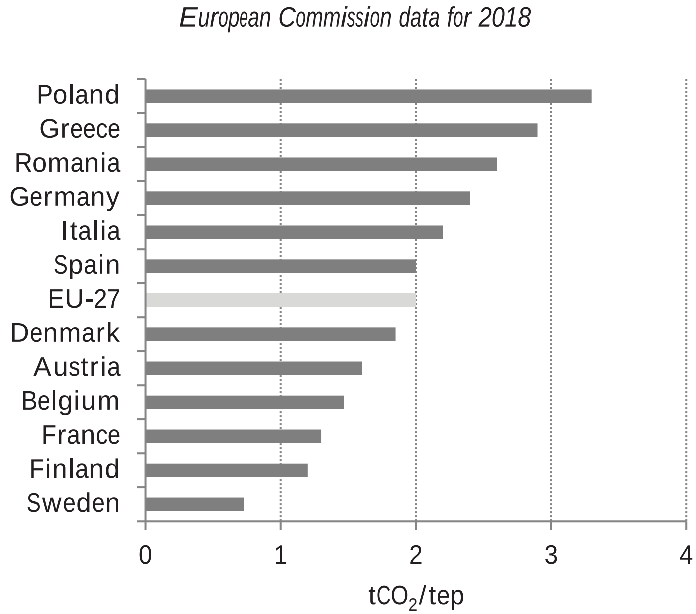


Some people also use the CO_2 per unit of GDP (t CO_2 / €M) but this is not an independent indicator because it is just a linear combination of energy intensity and carbon intensity.

Carbon intensity can also be analysed on an overarching country basis but it still remains a characteristic of the fuel used, for indirectly showing how much CO_2 is emitted by the fuel mix used in the country (Figure 2-7). Without surprise, the Member States using a lot of nuclear energy (like France) or renewable energy (like Sweden[a]) present the lowest carbon intensities. On the contrary, Greece has high carbon intensity because it consumes a lot of national lignite, the fuel with the worst carbon intensity. Poland has high carbon intensity because it exploits a lot of coal, as 87% of its electricity is generated with coal. The same can be said for Germany and Romania. Denmark despite its image as a renewable-energy-friendly-country also has a high carbon intensity because wind energy is not sufficient to generate all the electricity the country needs; Denmark, in fact, uses a lot of coal (45% of its electricity is generated with coal, 28% with renewable energy and 19% with gas).

[a] Sweden uses indeed both a lot of nuclear and renewable energy.

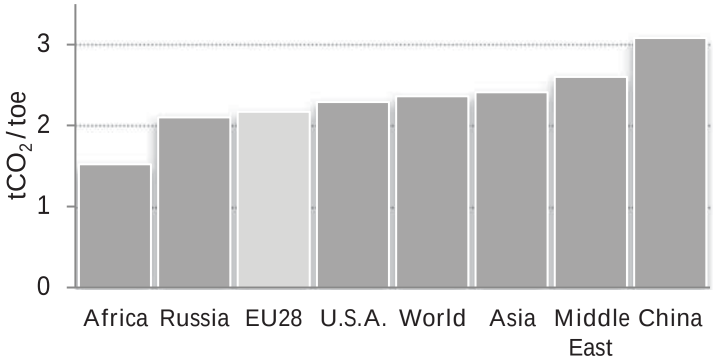
Figure 2-7 Carbon intensity in some EU Member States



If we now look at the same indicators globally, there are not so many discrepancies among regions (Figure 2-8) as there are in the energy per capita indicators. This is because the fuel mix is more homogeneous than energy consumption; after all, with the big exception of nuclear energy, all countries are massively using fossil fuels, and, therefore, broadly have the same carbon intensity. However, Africa has lower carbon intensity because it uses a lot of traditional biomass, and China has the highest carbon intensity because of the massive consumption of coal, as we will later see.

Figure 2-8 Carbon intensity of different countries or regions

2020 Enerdata data



2.3 Primary energy balances

In the following pages, we will analyse the balances of primary energy and final energy worldwide and in the EU. Only the trend of the last decades and the current situation will be presented, as explained above. We will avoid speculation on the outlook, because as already stated fossil fuels will continue to largely dominate and even increase world energy demand in the foreseeable future. Therefore, despite strong developments in renewable energy, demand for fossil fuels will grow steadily.

2.3.1 Historical trends in energy demand

The first primary energy used by humankind was wood. Wood is integrated as a 'biomass' in the energy policy field. According to the EU Directive which has fixed an objective of 20% for renewable energy by 2020[15], 'biomass' is the biodegradable fraction of products, the waste and residues of biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture[a], and the biodegradable fraction of industrial and municipal waste. Wood is by far the most relevant biomass. It has been used for thousands of years and is still massively used today; indeed, its demand has grown steadily.

Figure 2-6 shows that energy types have added to each other, none has disappeared because a new one showed up. The use of wood energy has not disappeared when coal was mined. Likewise, the use of the latter has not been abandoned when oil was pumped out of the ground. Similarly, natural gas and nuclear energy did not oust any primary energy sources that preceded them. Presently the rather impressive development of renewable energy sources is unable to eliminate the use of coal, oil, gas and nuclear energy. We will need them all; accordingly, we need to eliminate this misconception that the development of renewable energy sources will lead to the end of the use of fossil fuels. No energy specialist is naive enough to believe such nonsense, at least for long.

Coal started to become a major fuel around 1870 with the Industrial Revolution, which should rather be termed ‘the fossil fuel energy revolution’. Oil was used in ancient times, but it is only around 1900 when electrical cars were replaced by gasoline cars that its usage started to and continues to grow. Natural gas emerged in the 1960s in the USA and then in the 1970s in Europe along with the development of nuclear energy. Renewable energy sources other than hydroelectricity and biomass stood off around 2000.

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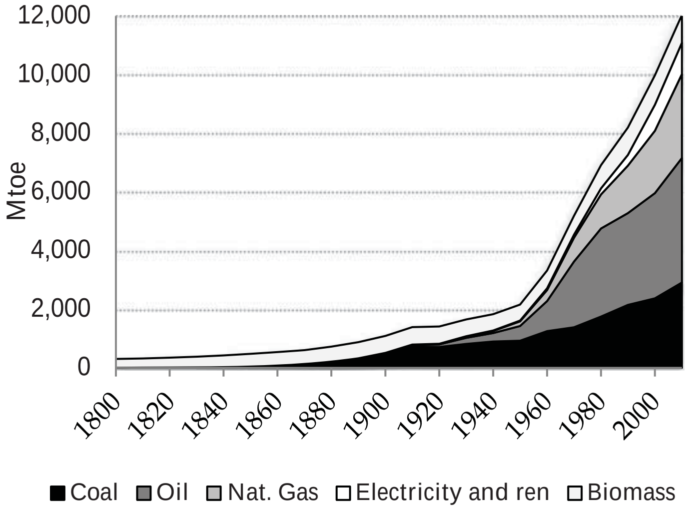
[a] Only policymakers can believe that the waste of aquaculture might be a fuel worthwhile mentioning in energy policy; unless this definition is there to pick up any subsidies to achieve the objective of this Directive.

Figure 2-9 Evolution of world energy demand by fuels

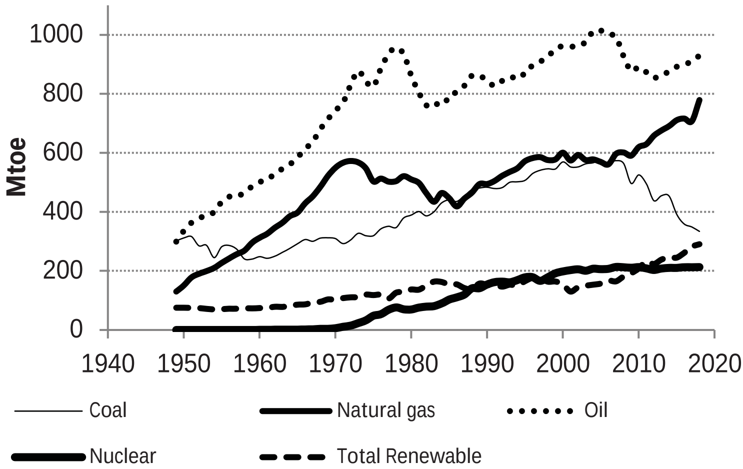
Enerdata and EC data



The US EIA presents an interesting graph showing how energy consumption has evolved in the USA since 1949. The clear message is that the consumption of each energy source has increased when a new one appears. Of course, the crisis of the 1970s and 2008 temporarily reduced the consumption of oil. In energy, 'and' is more important than 'or'. The only exception is the recent decrease in coal consumption due to the cheap shale gas that is now available.

Figure 2-10 Evolution of the historical consumption of energy in the USA

EIA Source[16]



2.3.2 Recent trends in world energy demand

The world uses a gigantic quantity of energy; more than 13,000 Mtoe per year. Confronted with large numbers, people do not realise what they represent[a]. The EU oil consumption represents, on average, 52 litres of oil per day per person. At the world level, oil is consumed at the extraordinary rate of 150,000 litres per second; when the price is around \$50/b, this represents a payment of \$1,500 billion/y or \$95,000/second. For natural gas, the world consumption of around 3,200 billion m^3/y can be illustrated by more than 2,000 billion traditional butane canisters containing 13 kg of gas. The common butane canister has a diameter of 31 cm, so if they are put in a row, the total length

[a] Do you know what a billion euros is, let's figure it out? If you stacked €200 banknotes - the highest denomination in euros - to reach this amount you would reach a height equivalent to 1 700 Eiffel Towers.

would be 635,000 km. Is this a lot? If you do not realise how much this is, it represents the Earth's circumference 18 times over.

Figure 2-11 World energy demand by economic regions

2020 Enerdata data

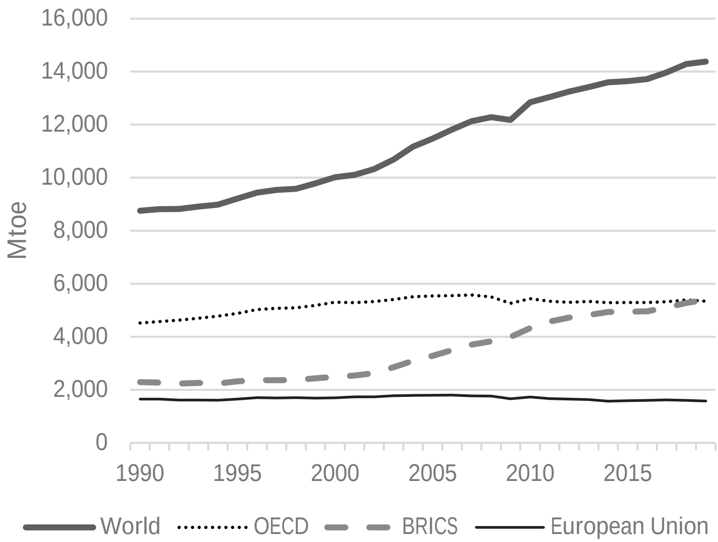


Figure 2-11 shows that the recent growth in world energy demand is mainly due to development of demand in non-OECD countries and sluggish demand in Europe. It is possible to recognise the huge consequence that the economic crisis of 2008-2009 had on energy demand. This figure also illustrates that the non-European OECD countries consume almost twice as much as the European ones. This benchmark shows that the EU is not a major player in energy demand, and therefore, in defining their energy policy, the IEA needs to balance the positions of each group.

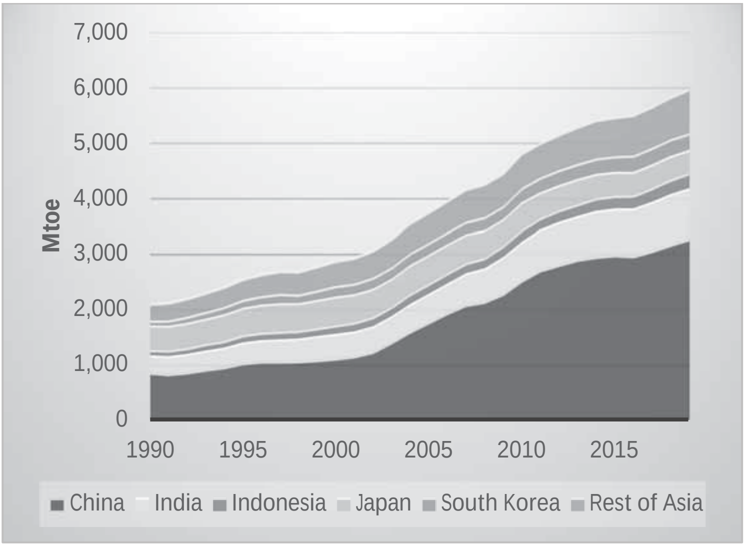
It is appropriate to look more carefully at the situation in Asia, observing that while China and Japan were using the same quantity of energy in 1980, in 2011 China was using five times that of Japan. This fact indeed strongly structures world energy demand and it is likely that this strong demand for China will not stop soon. The main reason for this being that the country needs a more homogeneous growth mode. Some regions, particularly around Shanghai, are as equally developed as OECD countries so we can state that around 400 million Chinese enjoy an occidental lifestyle. At the same time, one billion people desire to reach or at least approach the quality of life of the OECD countries. This will request a national GDP growth of some 8% per annum to avoid too many social disparities among the various parts of the country; the government appears to be paying due attention to this need. As we saw in Section 1.1, this can only be achieved through a strong increase in energy demand. It is not necessary to run sophisticated models to foresee that China will require more and more energy in the future. The same conclusion can be drawn for India even if their past growth has been much slower than that of China's.

Figure 2-12 shows that the inflection point of the energy demand of China appears around 2000-2002. This is due to the emergence of a global market. This international fundamental change is restructuring the world economy, and consequently, world energy demand. Since this will not stop – on the contrary – it is obvious that demand is foreseen growing steadily. In the following chapters, we will observe that there is no physical energy resource problem; this means that international geopolitics should aim at designing energy policies that will be able to fuel the global market.

In the chapter on sustainable development, we will see that there are, of course, environmental consequences for the use of fossil fuels, however, the fear triggered by computer models will not be sufficient enough to limit the thirst for energy demand. The US Administration has understood that it is better to help China (and other countries) fulfil their energy demand than to have tensions and possibly wars (see Volume 3, Chapter 1). At a meeting organised by Javier Solana [17], Ambassador Carlos Pascual, the Obama Administration envoy for energy at that time, made clear that the USA is willing to help China satisfy its growing energy demand to stabilise energy prices, and, therefore, the entire energy arena. He insisted on saying, '*you in the EU, and we in the USA, have an interest that China satisfies its demand*'.

Figure 2-12 Energy demand in Asia

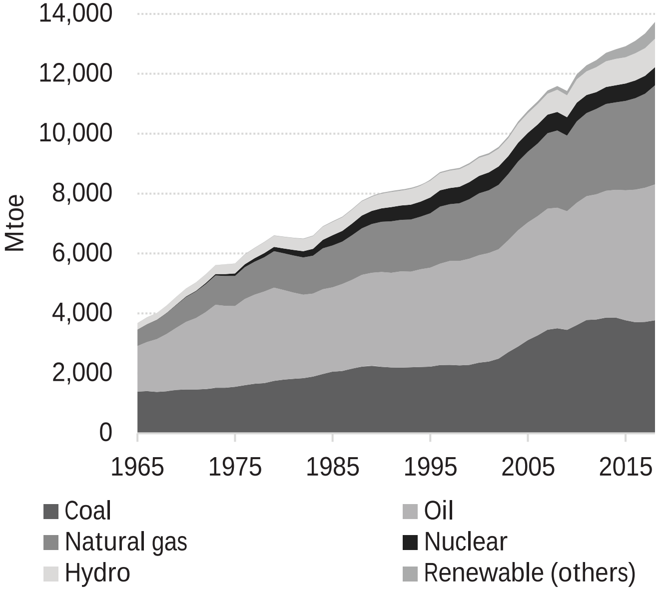
2020 Enerdata data



Looking at the fuel used in the world, a clear message is drawn from Figure 2-13. World energy is largely dominated by fossil fuels as they represent 87% of the total primary energy consumption. The figure does not report non-commercial biomass energy (mainly non-commercial wood). Oil dominates primary energy demand during the whole period under review. Nuclear energy represents only 4% globally even if its share is 14% in the EU. Despite all the sympathy and enthusiasm of certain citizens and policymakers' support, the non-hydroelectric renewable energy sources represent only 4% of world energy consumption and more particularly it is just 3% for the intermittent wind and solar energy; i.e. next to nothing and are practically invisible on the top of the left chart found in Figure 2-13.

Figure 2-13 World gross energy demand by fuel types

BP 2019 Data – biomass is excluded



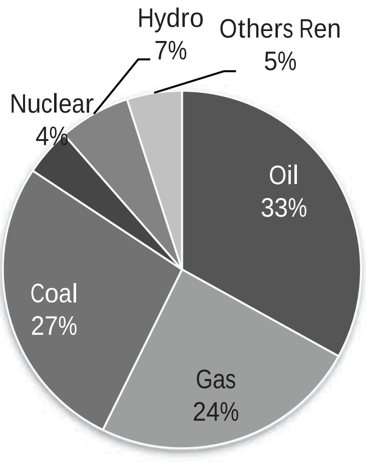


Table 2-2 gives the change in the percentage of the primary demand for all primary energies for the last forty years. Except for a small decrease in nuclear energy production, the demand for any single primary energy source has been increasing. This is the case even for hydroelectricity, which is too often represented as the energy of the past –, an unrealistic statement. This is why we will return to the importance of hydroelectricity in the chapter on electricity in Volume 2.

Table 2-2 Growth of primary energy by fuel over 40 years

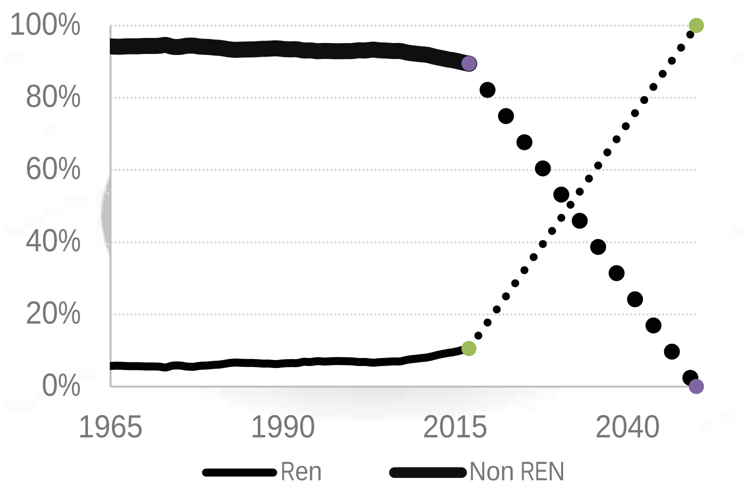
2014 BP Data – Biomass excluded

Fuel	Consumption 1978 Mtoe	Consumption 2018 Mtoe	Growth over 40 years (1978-2018) – %
Oil	3,120	4,662	49
Natural Gas	1,297	3,309	155
Coal	1,879	3,772	101
Nuclear energy	156	611	292
Hydroelectric	400	949	137
Renewables	9	561	6,015

Table 2-2 shows that all types of energy have grown during the last 40 years. Oil increased by nearly 50%, while gas consumption has been multiplied by 2.5. The demand for coal and the production of nuclear energy more than doubled. The generation of hydroelectricity doubled. The growth of new renewable energy sources is impressive. Of course, this is because it started from a low level. Nevertheless, this growth figure is misleading because it represents only 4% of the total. While most European citizens believe that coal is an energy of the past, its share is still growing and represents 30% of global energy demand.

The concept of an energy transition has been coined in Germany with the expression EnergieWende, meaning ‘turning around’. In English, the word ‘transition’ has been imposed; it is also fitting in French, Italian or Spanish. The hope is that the world will abandon fossil fuels and nuclear energy to arrive at 100% renewable. We will study that in Chapter 10, dedicated to the much loved but not necessarily realistic energy. This transition is just an illusion, at least during this century. If, after 40 years of support for renewable energy, the wealthy EU is only able to produce 1.9%, 0.6% and 0.3% of its primary energy respectively from wind energy, photovoltaic solar energy, and solar thermal energy, how can we expect the world to produce 100% any time soon (see Figure 2-14)? This is just nonsense.

Figure 2-14 A decarbonised world by 2050?

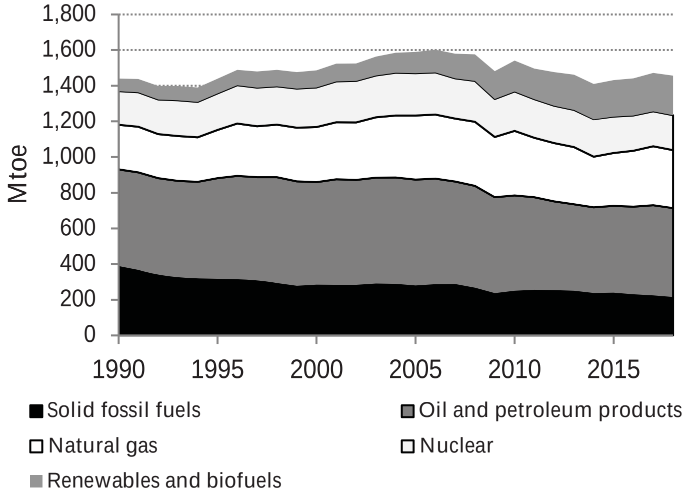


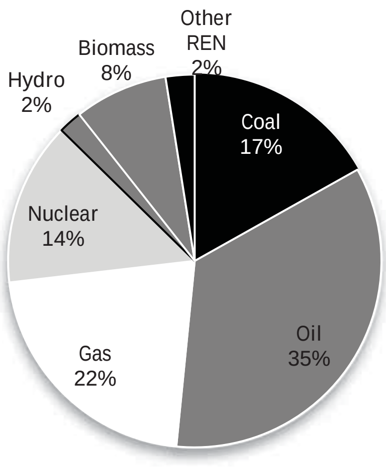
2.3.3 Recent trends in the EU energy demand

Contrary to world demand, primary energy demand in the EU tends to decrease or at least to stabilise (Figure 2-15.). This has various causes:

Figure 2-15 Gross energy demand in EU-28 by fuel types

2020 European Commission data

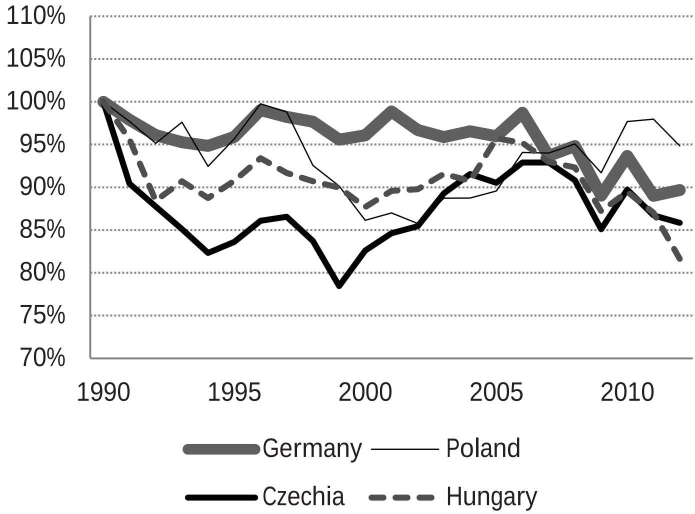




1. First, the enlargement of the EU had consequences on energy consumption in the industry sector. German reunification might seem far-away, but it took place only in 1992. Obsolete and polluting equipment was immediately discarded, drastically cutting the energy consumption of unified Germany (Figure 2-16). Of course, after that, rebuilding the Eastern part of Germany required more energy, but despite this increase, the trend in Germany around 1995 was one towards an ongoing energy demand reduction. Similar conclusions can be drawn for the former Communist countries that are now members of the EU. It remains clear that fossil fuels still make up ¾ of the primary energy demand despite that the share of renewable energy has reached 12%; it remains that biomass is still 2/3 of the total renewable energy sources consumption. Figure 2-16 shows how the demand for primary energy plummeted severely for some of these new EU Member States.
2. The second reason is that energy efficiency is a reality in the EU. We will see that in more detail in the chapter on energy efficiency in Volume 2.
3. The third reason is that the EU is in a huge process of deindustrialisation. Today's industry represents only 16% of the EU GDP; alerted by this worrying situation, the EU Commission has published a strategy aiming for a target of 20%[18]. Of course, the economic crisis that badly hit a large part of the EU countries is also leading to a demand reduction as we already stated.

Figure 2-16 Germany, Poland, Czechia[a] and Hungary gross inland consumption

1990 = 100%, European Commission data



Even in the EU, oil is still the leading primary energy. In 2015, it represented more than 1/3 (35%) of the gross inland energy consumption. Strangely enough, the energy policy interest for oil is inversely proportional to its real importance, policymakers being more interested in new renewable energy which makes up only 2% of primary energy consumption even in the EU. Gas is the second most used energy with 22%, and coal still represents 17%.

2.4 Final energy demand

We have already seen that for final energy demand, heating is the most important part. Here, we will only briefly analyse the recent evolution of the final demand by sector to be able to draw

[a] As of July 2016, the Czech Republic has a new official English name: Czechia.

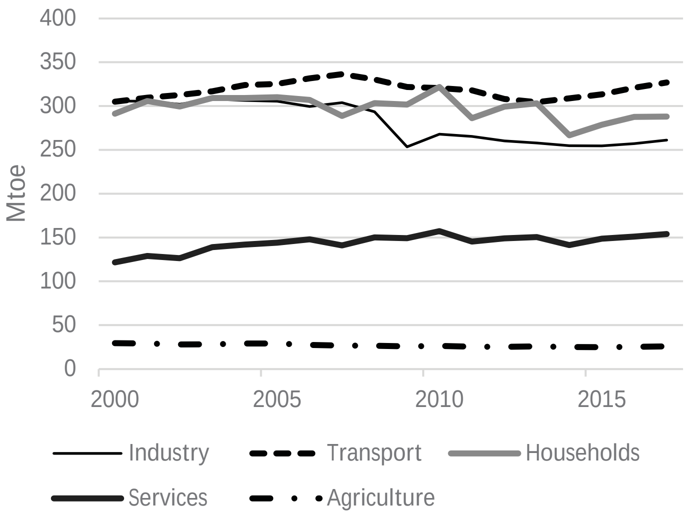
some conclusions in terms of energy policy. In the following section of this point, we will analyse the electricity final demand. The transport sector will be analysed in a specific chapter in volume 3.

2.4.1 Final demand by sectors

Figure 2-17 points out a strong rising energy consumption tendency in the transport sector, except for the period during the crisis of 2008-2012. In the EU, the increase is for all transport sectors; it continues to use some 30% of all final energy consumed in Europe. Of this, 80% is consumed by road transport and 15% by air.

Figure 2-17 Final energy demand in the EU per sector

2019 European Commission data



Energy demand in the transport sector did not react to measures for curbing consumption to date. In freight, it is the consequence of the creation of the single market: more products circulate inside the entire EU to be marketed or to be sent to factories, including SMEs. Furthermore, it is also a consequence of the societal evolution – with more displacements of elderly people, working people, youth, and even children; tourism and leisure are not indifferent to this increase. The consequence of the financial crisis is visible with an inflection in energy demand around 2009. Indeed, this decrease is parallel to the decrease of energy consumption in the industry sector, also noticeable on the graph. Before the crisis, energy consumption was stable, at around 330 Mtoe / y. Final energy in the household sector is also rather stable because it is an inelastic demand; houses must be heated, hot water is needed in bathrooms and food must be cooked. We will see in the chapter on energy efficiency in Volume 2 that it is important to improve energy efficiency in the building sector, but results come slowly. As the economy of the EU is evolving towards a service economy, the final demand in this sector is also growing by some 2% per year.

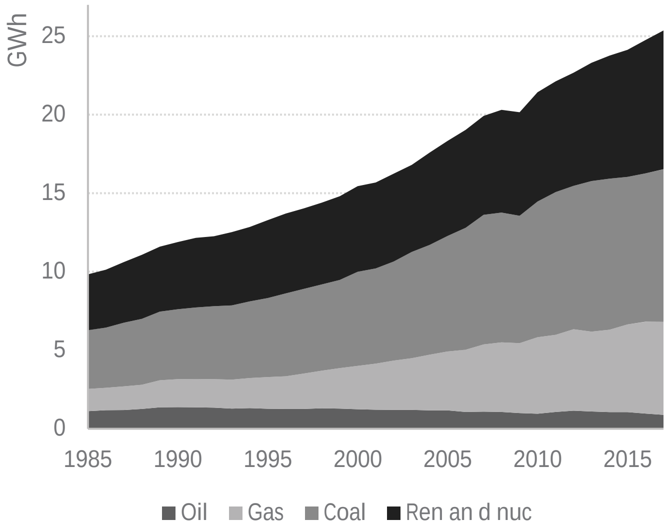
Although gains in energy efficiency did not automatically translate into a reduction in energy consumption, energy demand would have been even higher without energy efficiency improvements. The relation between savings achieved through energy efficiency measures and the consumption pattern is determined by the level of economic growth and behavioural aspects. Although the products and the transportation modes we use, and the buildings we live, learn, and work in are continuously becoming more energy-efficient, our total final energy consumption continues to grow in nearly all sectors. This is because with higher disposable incomes, the level of comfort rises, the number of households increases, more appliances are bought, longer distances are travelled – often with larger cars and by plane – , and homes tend to become bigger and better adapted to seasons (warmer in winter, colder in summer). To summarise, although energy efficiency has improved in all sectors, energy consumption has increased more. It has, however, increased by less than it would otherwise have without energy efficiency improvements.

2.4.2 World electricity generation

Figure 2-18 shows the nearly linear growth of total worldwide electricity generation during the period from 1988 to 2010. Electricity generation is dominated by coal; it represented 38% in 2017, and its share has been even slightly growing since 1988. Generating electricity out of oil is the easiest way to generate it, but it is also expensive. Therefore, its share dropped from 12% to 3.5% from 1988 to 2017. In 2017, natural gas generated 23% of world energy, nuclear energy represented 10%, hydroelectricity 16% and the remaining 9% was generated by the new renewable energies.

Figure 2-18 Historical world electricity generation by fuel

BP 2018 data



The major change in relative terms has been the development of gas burning in power plants, as this fuel represented only 13% in 1988 and its share is now 23%. As the development of nuclear energy has been limited during the period (i.e. 1988 to 2017), its part has decreased from 17% to 10%. Hydroelectricity is relevant worldwide (16%), but other renewable energies represent only 9%. Presenting data in terms of growth might give the illusion that renewable energy is catching up to fossil fuel generation, but it is far from being the case. It must be constantly reminded that for the next few decades the growth of renewable energy can only capture a part of the total energy growth and the same can be said for electricity generation.

The impact of the subprime crisis in 2008-2009 created a reduction in electricity demand. Once more, this demonstrates that energy demand and, therefore, electricity demand depend on the economic activity.

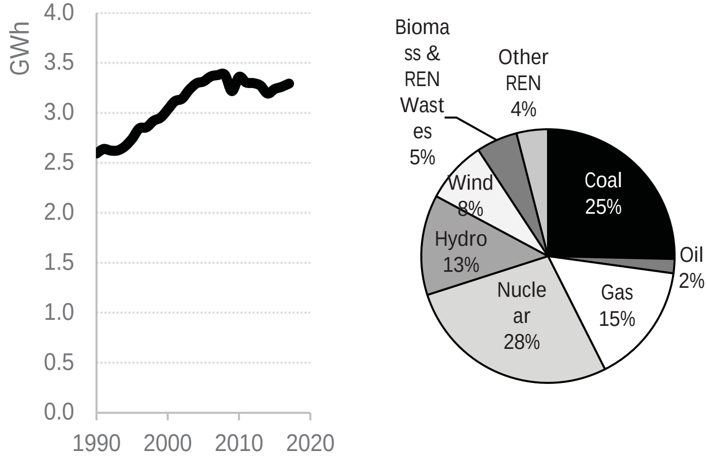
2.4.3 The EU electricity generation

In the EU, electricity generation grew until 2008 and has been rather stable since then (Figure 2-19). The impact of the 2008 / 2009 financial and economic crises (subprime crisis) is visible on the graph. To be noted that coal represents only 25% of the fuel generating electricity, while its share is 38% worldwide.

Coal demand in power plants reached a minimum in 2008 but is again growing since then. This is due to different reasons. First, coal remains a cheap fuel as its price contrary to gas is not indexed on the price of oil. Second, there is no incentive to replace a high CO_2 production fuel (the ETS market is not working properly – see Section 4.3). Third, the development of shale gas in the USA leaves huge quantities of coal in the mining yards; therefore, this cheap coal is crossing the Atlantic, and finding clients in the UK and Germany principally. The Wall Street Journal calculated that 47.2 Mt of US coal went to the EU in 2013 a steady increase as shown by Figure 2-20. since it was around 15 Mt in 2008 before the shale gas boom.

Figure 2-19 Electricity generation in the EU

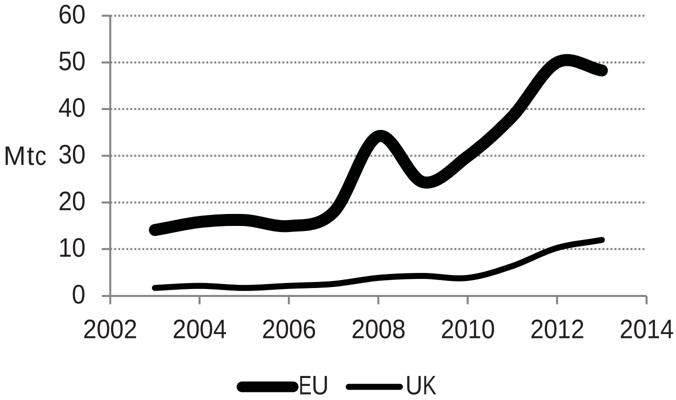
2019 European Commission data for 2017 – left: evolution with time; right: share in 2017



A further large difference is nuclear energy; it represents 28% of the electricity generated in the EU, more than twice that of the global level. Gas was the growing fuel in electricity generation until 2008 when it reached 25%, but due to the priority of dispatching of the electricity generated from renewable energy, its share dropped to 15% while renewable energy passed from 7 to 13%. We will see that to promote renewable energy, electricity generated by wind or solar energy has the priority compared to others cheap form of production to be sent to the consumer, whatever its price is. Hydroelectricity remains stable at about 13%. It should be underlined that hydroelectricity represents 44% of the electricity produced from renewable energy. Therefore, adding up nuclear energy, hydroelectricity and other renewable energy sources, the EU produces 57% of its electricity without any CO_2 production. This is a world record.

Figure 2-20 USA coal export to the EU

Source WSJ[19]



Since the oil shocks of the 1970s, using oil products for electricity generation in the EU has nearly disappeared and is only used in emergencies and isolated systems like those found in the Greek islands; Cyprus and Malta are other exceptions; the gas development prospect in the Cyprus maritime area will change this situation (see Volume 3).

3 SUSTAINABLE DEVELOPMENT AND ENERGY

Thirty years ago, this chapter would not have been written. Today, energy is so closely related to sustainable development, and because of the importance of these two key sectors in our society, the chapter became extensive. In the first part, we will analyse what sustainable development means within the framework of energy. This will include tracing the historical evolution of sustainable development and the fundamental principles of its relation to energy. After presenting air pollution, offshore oil pollution and the energy dimension of urban waste, we will address the notion of fuel poverty both at the global and EU levels. Climate change and energy policies being closely linked, they will be addressed in the following chapter.

The previous chapter explained that limiting energy consumption is a challenge *per se*. If, moreover, we rightly must add environmental protection, we find ourselves in an extremely complex situation. There are no doubts that:

- environmental protection is indispensable because pollution creates severe problems both to humans and nature;
- energy use has an impact on the environment, as does renewable energy;
- poor people – mainly outside the OECD countries – endure more difficult living conditions than citizens of developed countries because of their lack of energy;
- climate change has become a central part of energy policies.

Pollution, from the Latin word *pollutionem* (nominative *pollutio*), meaning 'to make dirty', is not a new word. It was used since the 12th century in the same sense as it is today. At that time, cities were polluted by organic matter (urine, excrement, tripe, fat, viscera near slaughterhouses or fishmongers – all disposed directly on the streets), and by atmospheric pollution from fumes produced by artisans, by heating homes, or by cooking; tanners also created pollution[20]. Unfortunately, this pollution still exists today.

3.1 The new faith

Finding realistic and workable solutions is a must for modern societies, both for economic and social reasons, but also for reconciling the growing energy demand whilst limiting its impact on the ecosystem. However, although environment protection is not optional, certain people use this legitimate issue as an opportunity to attempt to change our societal model. Though this might be possible and, in some respects, desirable, there is no logic for linking the two if the latter were a normal consequence of the former; reconciling energy demand will ultimately limit its impact on the ecosystem.

Today, any new energy infrastructure faces harsh opposition from people afraid of the real or perceived impact on the environment that it could have. However, the use of energy always has an impact, even when sometimes it is only a minor one. Consequently, it has become impossible to do anything without immediately triggering opposition from local or global environmental NGOs. The problem is not only European since European NGOs were quick to teach developing countries on how to follow in their footsteps.

The same situation exists in the US where in the 1970s the acronym 'NIMBY' meaning 'Not In My Backyard' was created. In the case of shale gas, NIMBY becomes 'NUMBY', for 'Not Under My Backyard'. There are other similar acronyms like 'BANANA', coined by The Economist, for 'Build Absolutely Nothing Anywhere Near Anything' (or 'Anyone'), or 'NOPE', for 'Not on Planet Earth'. The worst acronym is probably 'NIMTO', meaning 'Not In My Term Of Office'; allowing policymakers to please certain people by not according to a priority to the majority's interest, but to a well-organized minority. The increase of local authorities' decision power accentuates this NIMTO phenomenon because, the closer they are to an election, the more policymakers hesitate to make a decision. They don't seem to be aware that in the medium-term, infrastructure is much more interesting, important and profitable for their territory and that a little courage would sustain local development. Finally, let us mention 'NIMPO', meaning 'Not In My Pocket', where certain people want others to pay for what they consider extravagant expenses with a minimal environmental impact.

These expressions may appear amusing, but the underlying ideology is worrying because, ultimately, they all result in opposition to any development. A proposal for a highway, railway, canal, coal-fired power plant, nuclear power plant, hydroelectricity dam, drilling for oil or gas – and even for a wind farm – immediately triggers one of the above syndromes. There are even organisations specialised in preparing opposition files. Few well-organised opponents can derail a project or at least delay it for many years.

We will analyse all those aspects from a technological and legislative viewpoint in the following chapters. Considering the environment only from the perspective of the willingness to avoid pollution is misleading. There are other dimensions. It is not the only change that caused policies to intrude so rapidly and vigorously into the energy question shortly after the collapse of communism. The spiritual dimension of environmental protection should not be ignored since there are clear signs that nature protection is linked to nature worship and neo-paganism. All this greatly complicates the energy question. We will need to proceed gradually in this sensitive domain allowing everyone to formulate his / her decisions and choices.

3.2 Fundamentals of sustainable development

3.2.1 The UN process for sustainable development

The concept of sustainable development was born in 1962 with the publication of Rachel Carson's book 'The Silent Spring'[21]. It warned about the agricultural use of synthetic chemical pesticides and the necessity to respect the ecosystem for human health and environmental protection.

Following this alarm, the United Nations (UN) convened a conference on the Human Environment in June 1972, which took place in Stockholm, at the initiative of the Swedish Government. The UN nominated a Canadian diplomat, Maurice Strong[a], for leading the Conference as Secretary General. Soon after, in December 1972, the UN General Assembly established the United Nations Environment Programme (UNEP), to globally steer the environmental efforts of the United Nations family. Afterwards, the European Commission created a Directorate General for the Environment[b], for protecting, preserving and improving Europe's environment for present and future generations.

Independently, and meanwhile, as we have seen, the Club of Rome issued its set of alarming reports. In 1983, the Secretary General of the UN invited Ms Gro Harlem Brundtland, a former Prime Minister of Norway who was also a former Environment Minister, to create and chair a 'World Commission on Environment and Development'. In April 1987, a pioneering Brundtland report on 'Our Common Future'[22] was published.

[a] He died on November 2015 at the start of the COP-21.

[b] At that time, this DG was also in charge of Consumer protection. When I joined the European Commission in 1982, the Directorate-General for Energy and the Directorate General for Environment were located in the same building, the latter occupying only one floor.

The report had 300 pages and developed the concept of sustainable development for the public domain. This report defined sustainable development as '*a development that meets the needs of the present without compromising the ability of future generations to meet their needs*'. However, this was not an original consideration; as early as 1909, US President Theodore Roosevelt, a Republican, made a similar point in a Special Message to the Senate and the House of Representatives[a]: '*If we of this generation destroy the resources from which our children would otherwise derive their livelihood, we reduce the capacity of our land to support a population, and so either degrade the standard of living or deprive the coming generations of their right to life on this continent*'[23].

After the adoption of the Brundtland report on sustainable development, the UN machine roared into operation and has not stopped roaring since. The starting point was the 'Earth Summit', a UN conference in Rio de Janeiro in June 1992. At this summit, the Rio Declaration was adopted, acting as an environmentalist manifesto that proposed an ideological basis for all the Planet's policymakers. The summit also endorsed the so-called Agenda 21, an environmental roadmap for the 21st century, to be used by all the supranational, national, regional and local authorities. In many developed countries, officials at the national level, but much more at local levels, were called to ensure the integration of the principles of the Rio Declaration and the Agenda 21 objectives in their policies and actions. The Rio Conference additionally adopted the United Nations Framework Convention on Climate Change (UNFCCC) which will be developed in Chapter 4.

The UN joined the 'Earth Council', which brought together the major Environmentalist NGOs (ENGOs) of the Planet, a group established a few months before the Rio Summit at Maurice Strong's initiative, since he would take over the proceedings as Secretary General of the Earth Summit. The countless ENGO activists, federated within the Earth Council, were responsible for

[a] Regarding the transmission of the National Conservation Commission report on the conservation of natural resources.

ensuring the implementation of Agenda 21 and had to report any breaches to their hierarchical authorities.

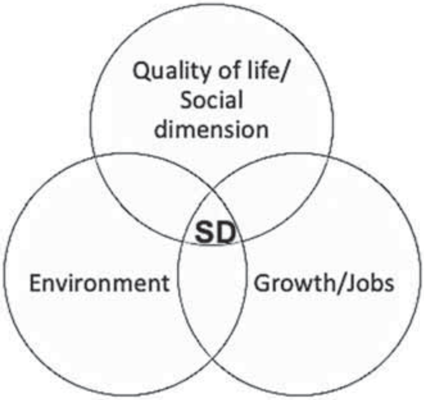
Thus, a strong relationship between the UN process and the ENGOs was demonstrated, but it also explained why there was a massive channel for steering public money towards environmental NGOs. Critics of this process assume that the UN aims to reduce the democratic powers of national states and that if, furthermore, entails the transfer of a huge part of sovereignty to an international organisation without global control by citizens.

Ultimately, the EU adhered to the concept of sustainable development as Article 2 of the Lisbon Treaty states: '*The Union shall […] work for the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment. It shall promote scientific and technological advances. […] It shall contribute to peace, security, the sustainable development of the Earth, solidarity and mutual respect among people, free and fair trade, eradication of poverty and the protection of human rights, specifically the rights of the child, and to the strict observance and the development of international law, including respect for the principles of the United Nations Charter*.' The EU aims for more than only protecting the environment, it also aims for the '*improvement of the quality of the environment*', de facto recognising that environmental damages had indeed been incurred in the past.

3.2.2 Sustainable development is not a science

Too many people restrict the idea of sustainable development to the protection of the environment. However, and even much more important, the notion of sustainable development should not be limited to environmental protection. Sustainable development is the balance between environmental protection, economic development and quality of life (Figure 3-1).

Figure 3-1 Sustainable development is more than environment protection



That is why sustainable development is difficult to reach. Banning cars from cities would make the air much cleaner, the environment would be protected, and there would be much less noise pollution, but it would cause an unbearable unemployment rate, since 12.1 million people – 5.6% of the EU workforce – are active in the automotive sector. Conversely, if unemployment is nil but the environment is strongly polluted (a reality in the former USSR), it would not be sustainable development. Remember that *sustainable* is an adjective to the word development, which means that economic development is required indeed.

The problem of sustainable development results from the fact that each citizen and each group react according to their interests or their socio-political vision of the world and would prioritise only one of the three components of sustainable development. The claim of ecologists to first emphasise ecology without much regard to development may lead to a no-growth economy. Free market defenders prioritise economic growth and a lower priority for the depletion of natural resources. Trade unions put safeguarding jobs and job creation before protecting and preserving natural resources[a] and economic dynamism. The balance between the three dimensions of sustainable development requires knowledge and political will, but also mainly, and above all, time. Economic systems, particularly concerning energy, are so complex that trends cannot easily be reversed, however desirable that might be, without taking time.

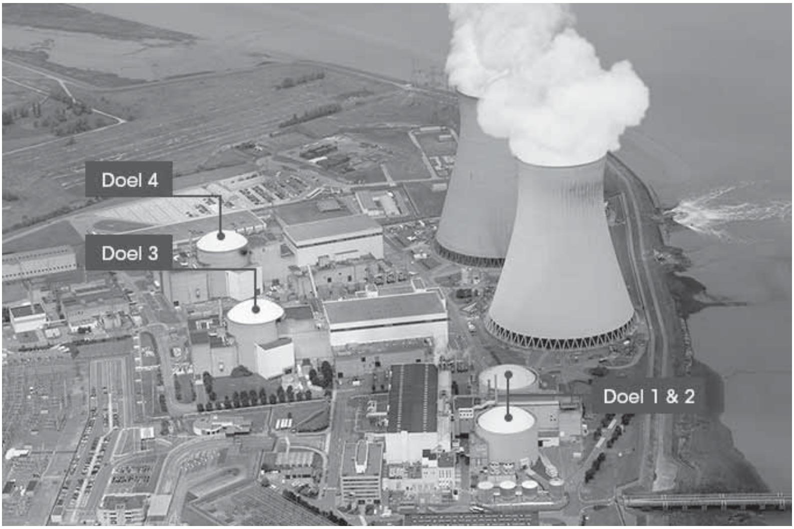
Sustainable development is not a science such as chemistry, physics or biology, but rather a political vision of society. Edwin Zaccai, professor of sustainable development at the Free Brussels University, summarises the situation as follows: '*When you look at the genealogy of sustainable development, it appears that it is in its political dimension in the broad sense, rather than in sciences, that one has to look for what might by analogy be called its matrix. Certainly, scientists have helped in providing alarming reports on environmental degradation, but it is when they entered a political register, encompassing, and mixed in various measures with findings and ethical issues on human development, that sustainable development register has been set off*'[25].

Unfortunately, exaggeration is constant for radical sustainable development advocates. Everything appears to be done to frighten people. In their climate change articles, mass media often includes pictures of electricity power plants emitting large plumes of white fumes (see Figure 3-2) as if it were pollution, whereas it is mere steam condensation, the same substance that is produced by your cooking pan when boiling pasta, rice or potatoes.

[a] In October 2016, under protest of the Union, the French government scrapped a plan for an electricity levy on the four coal-fired power stations, backing down on a symbolic promise made by President Hollande. The CGT, a leftist Union, declared that this would have cost 5,000 jobs[24].

Figure 3-2 The Doel Nuclear Power Plant near Antwerp

Photo courtesy of Engie-Electrabel



3.2.3 The precautionary principle

One of the corollaries of sustainable development is the institution of the precautionary principle, a real weapon against progress and its consequence of the world population. In the Rio declaration on environment and development[26], Principle 15 states: '*To protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*.'

The concept behind this principle was first set out in a European Commission communication adopted in February 2000, which defined the concept and envisaged its implementation. The precautionary principle is detailed in Article 191 of the Lisbon Treaty: *Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary* *principle and on the principles that preventive action should be taken that environmental damage should as a priority be rectified at source and that the polluter should pay.* In 2005, French President Jacques Chirac introduced the precautionary principle in the French Constitution, a decision that still divides the French[27].

It is a risk management approach: if there is a possibility that a policy or action might cause harm to the public or to the environment and if there is still no scientific consensus on the issue, the policy or action in question should not be pursued. The situation should be reviewed if additional scientific information becomes available. The precautionary principle may only be invoked in the event of potential risk and can never justify arbitrary decisions.

Invoking the precautionary principle has become much easier. For example, because chemical analysis is getting more sensitive, it makes it easier to measure infinitesimal traces of any chemical compound. DDT is the first massively powerful chemical pesticide used after World War II to combat mosquitoes that cause malaria and tsetse flies that provoke sleeping sickness. It produced extraordinary results by eradicating malaria in Europe and North America. However, in 1970, environmentalists succeeded in prohibiting its use under the pretext that it thinned the thickness of eggshells of certain birds. The precautionary principle was therefore invoked for birds' eggs, but it neglected the dramatic consequences on humans. Malaria reappeared due to the end of the use of DDT, killing a child every two minutes and causing 200 million new cases yearly[a].

Similarly, because it is easy for an environmental NGO to call on this principle particularly the '*lack of full scientific certainty*' to oppose the implementation of an energy project, whatever is undertaken energy must consequently be done carefully. This was the start of blockages to nuclear energy, fossil fuel and renewable energy projects.

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[a] https://www.who.int/news-room/facts-in-pictures/detail/malaria.

Based on such a precautionary principle, perhaps driving cars should not be tolerated as nearly 26,000 people die yearly on European roads[a]. The same applies to aviation: although flight safety progresses continuously, logically flights should be banned because the risk of a plane crash on a home cannot be excluded. These daily life examples illustrate the difference between the 'precautionary approach' applied in the USA and the 'precautionary principle' enforced in the EU.

Whereas in the United States, the preferred approach is to authorise commercialisation of a product if no negative impact has been proven, the European regulatory approach is a precautionary one: the market introduction of a product is regulated or prohibited when considered a risk. Based on the European mentality, we could only cross a street with '*full scientific certainty'*, and so we would probably have to remain on the same sidewalk. This is the argument invoked to oppose shale gas development, while in the USA the contrary created a new energy Eldorado and radically changed the geopolitical situation (for the benefit of the USA).

According to the French economist Professor Henri Lepage, the precautionary principle cannot be a legal concept, nor a founding concept of law. Simply because talking about 'collective responsibility' is a semantic inconsistency, but it is also a contradiction of terms. Indeed, the notion of responsibility can only be personal: responsibility can only be an attribute of people endowed with conscience, and therefore, with a moral sense. However, the notion of consciousness – and hence of responsibility – cannot be applied to collective entities. Therefore, the formulation of the precautionary principle is fake. One cannot expect a community to be endowed with either conscience or a moral sense other than that attached to the individuals that are a part of it.

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[a] 26,200 in 2013 but decreasing a lot yearly (31,500 in 2010).

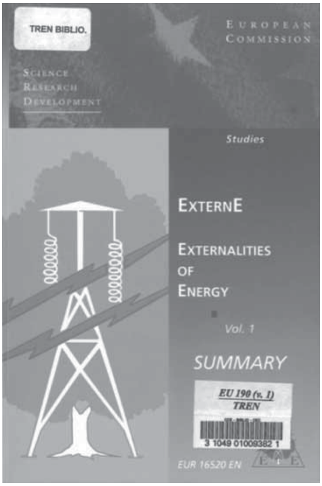
For Lepage, *'we are presented with an intellectual system that gives us a comforting appearance of objectivity: it is enough to evaluate, to measure the risks, and to compare to make decisions. Scientists and policymakers will have to decide to follow what the specially created agencies will tell them. This reasoning confers risk on the attributes of a measurable quantity meeting all the criteria of objectivity, now being considered as the prerogative of a scientific approach. […] This is not […] at all the case. There are no objective risks. But there are personal expectations that, according to expectations of gains or losses, manage ex-ante our actions. Risks only appear ex-post when trying a posteriori to reconstruct the statistical probabilities that we had to assume but not our hopes. As this subtle distinction surpasses the minds of most people, even those of judges, the making of the precautionary principle as a criterion of responsibility leads to the situation where the courts are made responsible for adjudicating or resolving conflicts of responsibility, based on information which did not exist at the time when the decision that triggered the damage were taken. In other words, judges will be asked to punish you by deciding a posteriori what you should have done (or not done) based on information not being available at the time the decision had to be taken*.'[28]

Throughout the history of mankind, it is not the future that has determined the present, it is the past that has enlightened us on our present conduct. The aim in analysing the earlier period was to avoid repeating mistakes as in the past. This was unfortunately met with mixed success since human beings seem to have difficulty drawing lessons from the past. Nowadays, we establish prediction models to better shape our present actions better. The future, therefore, is used to determine the present. This is a major change now and encompasses many risks and consequences. The major flaw is that we do not know the future for sure, and so our decisions end up not being wise. Mistakes will be identified … in the future.

3.2.4 The internalisation of external costs and benefits

Together with the precautionary principle, using an economic term like the 'internalisation of external costs', 'side effects', or 'externalities' is a major instrument for the promotion of sustainable development. The concept of internalisation of external costs in the energy sector is the integration of externalities to the basic cost of energy as an additional extra cost. To apply this extra cost, the first step is to identify all impacts of energy use (all impacts refer to first-order impacts and all impacts of a higher order), to quantify them, then to finally monetise these quantification (Figure 3-3).

Figure 3-3 The ExternE report's cover



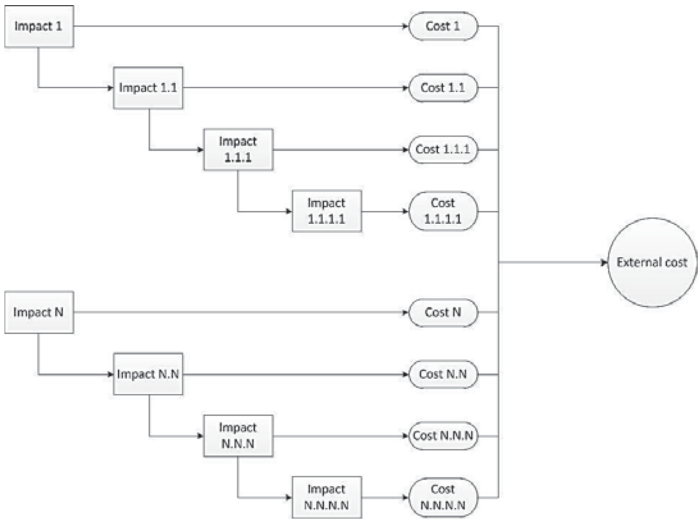
As an example, in the road transportation sector, the internalisation of external costs consists of assessing the impact of all nuisances (air pollution, noise and visual, water runoff, etc.). Air pollution may create breathing illness for children or adults. This cost is a first order impact. The impact of the ambulance driving the patient to the hospital creates a second order of costs (pollution, but also road deterioration). The cost to employ a lung specialist is also of third order. The cost to build a medical faculty is fourth order, and so and so on. At each step, there are first and superior order has indirect impacts (the car that the student uses to go to the university, hours lost in traffic jams, loss of life quality of life, etc.).

After this hazardous bottom-up quantification, it is necessary to monetise these impacts. With all these additions, the exercise of calculating the externalities becomes impossible. In the early 1990s, the European Commission attempted to develop this theory. Once its complexity was acknowledged, the Commission invited the US Department of Energy (DOE) to join the effort in a project named ExternE, the acronym for 'External Costs of Energy' being a synonym for a series of projects starting from early 1995 until 2005[29]. The conclusion was that it is physically impossible to quantify the external costs of energy use in a consistent, transparent, and neutral manner.

Consequently, to promote alternative energies, the external costs were gradually internalised by legislation (particularly after 2000) and not by imposing the external costs. The mandate for producing renewable energy created a way to bypass the impossibility of calculating external costs. Figure 3-4 illustrates the process. Since there is an external cost for the use of non-renewable energy sources, its total cost should be higher than the market cost. However, since it is impossible to calculate the external costs, it is consequently also impossible to evaluate the total cost (left side of the graph). To stimulate the development of renewable energy sources, a support scheme was allowed, making the renewable energy sources market competitive (third arrows from the left). To ensure that renewable energy sources would be developed, the support scheme is accompanied with another support scheme. This 'encouragement' cannot be properly calculated and probably leads to the fact that certain projects receive inadmissible benefits (right-hand arrow).

Revisiting this concept by reconsidering the external cost mechanisms for penalising fossil fuels as some NGOs are trying to do can only be of dubious academic interest. Certainly, over the past 25 years, modelling has made some progress, but the fundamental weakness that led to dropping the ExternE project remains valid. Wanting to identify all the external impacts is an illusion, it is also an illusion to quantify them, and a further illusion is the desire to monetise them into euros or dollars (Figure 3-4). In reality, the ultimate goal is just taxation!

Figure 3-4 External cost evaluation



Box 3-1 The depletion cost

A concept worse than the internalisation of external costs exists and is being rejuvenated: 'depletion cost', a concept invented in 1931 by Harold Hotelling. In the energy sector, the depletion cost is today's cost of the disappearance of future fossil fuels. In line with the paradox of Jevon (see Volume 2), Hotelling elaborated his theory for all the natural resources because he was concerned by the exploitation of natural resources, claiming that they were too cheap and it would be normal to pay more. This smoky theory was abandoned for about 80 years until the environmental movement brought it back into fashion for opposing the exploitation of natural resources.

This approach establishes a tax that would compensate for the future alleged lack of resources. Little academic work exists on the subject, but the price of fossil fuel already internalised the future limited availability. This is apparent as the price of production of oil in the Middle East is around $2/b and being sold at around $50/b in 2016 but around $100/b in 2014 – is this not an internalisation of the future? Furthermore, the various taxes and levies on automotive fuels are equivalent to a CO_2 cost of about €365/t CO_2 for gasoline (petrol) and €270/t CO_2 for diesel oil while the CO_2 cost in the ETS system is about €5/t CO_2 (see Section 5.2.2). Furthermore, claiming today that we will know the available reserves in 50 years is complete nonsense. Oil reserves in 1973, i.e. before the oil shocks, amounted to 720 billion barrels, and today that number is 1.7 trillion barrels. We will see in Volume 2 that the EU banned the use of gas in power plants for 17 years out of fear that globally there were not enough gas resources. On what basis should the promoters of this theory calculate the cost of depletion? On today's estimated reserves? What would happen if they increased? Who would reimburse those who paid the 'tax on the future'?

At best, one might want to follow the example of Norway by operating the Norwegian Government Pension Fund Global (see Volume 2) for assisting Norwegians the day hydrocarbons would be depleted; this sovereign wealth fund is evaluated at $840 billion. This logic only applies to the producing countries. Following the discovery of large gas reserves, Israel is also planning such a fund. However, it is nonsense that a consuming country would be paying for the depletion of the natural resources of a producing country. Moreover, those fearing depletion should wait patiently for it to happen, because, when depletion would be approaching – if it does – the cost of fossil fuels would become prohibitive and renewable energy sources would automatically have become competitive. It is disappointing to note that certain people want to embark on new ways for further increasing energy prices whilst the rest of the world is struggling to reach the opposite.

Figure 3-5 The external costs and the support scheme for renewable energy

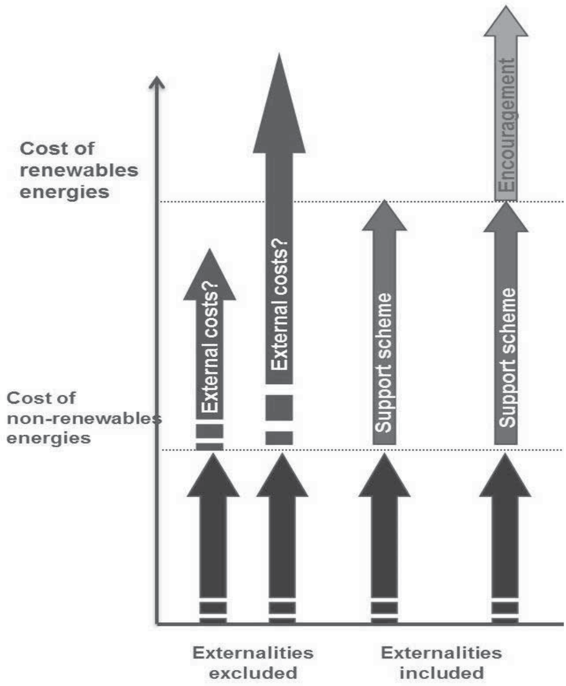
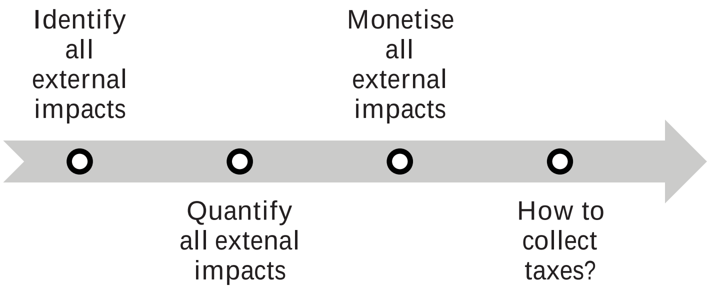


Figure 3-6 How to transform external impacts into taxes



Furthermore, in this analysis, the burden of proof is always on the prosecution and not on the defence. Accordingly, benefits of energy use are not considered. Low-cost airlines, for example, are often criticised because they do not integrate the cost of their environmental impact into the cost of the tickets. Yet, a trip in question might be a necessity for a couple that is going through a difficult matrimonial period; a trip to Venice or anywhere might reconcile the partners and, thus, avoid a divorce. Who will internalise those benefits? A divorced couple might possibly double its energy consumption, as it would need two cars, two apartments with refrigerators, two television sets, and two illumination systems instead of one. Furthermore, this would prevent the commuting of children between parents and possibly grandparents. This illustrates the evident fact that external benefits and not only external costs exist.

In another example, researchers found that oil and gas platforms off the coast of California have the highest secondary fish production per unit area of the seafloor of any marine habitat that has been studied, an order of magnitude higher than fish communities from other marine ecosystems[30]. Environmentalists may spend public and donor money to calculate the negative impacts of oil and gas platforms, but they would never calculate its benefits regarding biodiversity. Later in this same chapter, we will note that life expectancy is a positive externality of energy use, and consequently, of its associated pollution.

3.2.5 Kuznets' theory

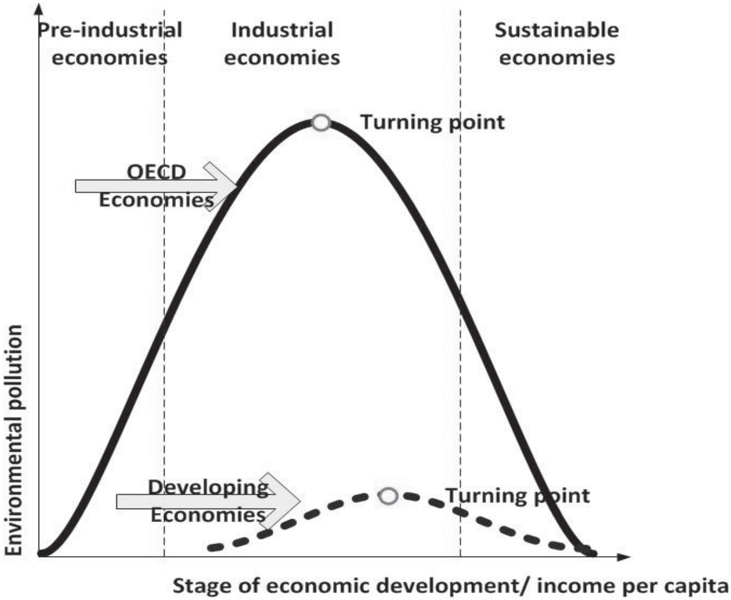
In the 1970s, the well-known French philosopher Jacques Ellul believed that the real crisis of Western society was caused by progress. He castigated progress because he believed that it is the cause of poverty, pollution and nature's destruction. For this philosopher, technology is an embodied force whose progress and evolution are self-powered; it perpetuates itself according to the logic of self-growth. As such, pollution is a consequential by-product of this autonomous progress[31]. Ellul did not like technology because it proposed technical solutions that create other drawbacks and consequently, in a spiral movement, more shortcomings are generated. This Protestant philosopher was among the first in the 20th century to propose the stopping of growth, to the point that he could be considered being the spiritual father of 'degrowth', that some describe as 'a-growth'.

Mikhail Bernstam, an American economist also admits that industrialisation is initially characterised by a negative relationship between growth and environment. However, in free-market conditions, at a moment, this relationship is reversed by an 'environmental invisible hand' so that growth is accompanied by an increase in productive resources and a decrease in waste: 'Simply put, as economies grow, discharges to the environment increase rapidly, they decelerate, and eventually decline'[32]. For Bernstam, economic growth is the best way to avoid pollution; much more effective than speeches, laws and international protocols or agreements.

In his book 'The Sceptical Environmentalist, Measuring the Real State of the World'[33], Bjorn Lomborg criticises what he calls 'litany', which questions the model of Western society, pushing for its substitution towards a different society based on fears of environmental degradation. History shows that humanity ends up abandoning fears, superstitions, or prohibitions, but sadly creates others. It is realistic to expect that the hypothetical ongoing fears about the environment, created by pollution and growth, will become more realistic and that Ellul's forecast will not take place, but that other fears will emerge and take their place.

Ellul was, however, right on one thing: technology proposes measures for correcting its mistakes! This is well described in the works of Simon Kuznets, a Belarusian-American economist and the 1971 Nobel laureate, on economic development in the 1950s. In a major study published in 1955, *Economic Growth and Income Inequality*,[34] he demonstrated that income inequality fade with economic development progress. Inequality increased in the early phases of industrialisation (entrepreneurs became richer in exploiting defenceless working classes), but afterwards, they decreased spontaneously in advanced stages of economic development due to wage rises, the competition of new entrepreneurs and technological innovation.

Figure 3-7 Environmental Kuznets Curve



This could be applied to environmental degradation and per capita income. Environmental degradation is an accompanying phenomenon at the start of economic development. Every country experiences increasing pollution in the early stages of economic growth up to a certain degree (the ‘turning point’), which varies according to various indicators, but beyond a certain level of income, the trend reverses. This process is called the ‘Environmental Kuznets Curve’. Represented graphically, it is a bell-shaped curve (Figure 3-7). It explains that when the development of a process starts, there is no sufficient care on the environment or sustainable development, but at a ‘turning point’, once the negative impacts become visible, measures are implemented for limiting the negative impact and solving them. This is what has occurred in the 1970s when OECD countries reduced their polluting emissions by using new technologies.

Although more expensive at the start, by following market mechanisms, prices decrease over time. For developing countries, the awareness of environmental damage and the availability of best available technology (BAT) permit them to potentially ‘leapfrog’, thereby flattening the bell shape of the Environmental Kuznets Curve and limiting harmful environmental degradation.

Although this theory has been confirmed by many examples, opponents to progress dispute it. We sum up with Friedrich Hölderlin, one of the German Romantics of the late 19th century, who explained that ‘*where the danger is, also grows the saving power*[35]’.

One of the fundamental creeds of sustainable development is that resources are limited. In the chapter on oil, we will analyse the sharp difference between the key concepts of ‘resources’ and ‘reserves’, explaining the reasons why doom predictions have always been wrong. Similarly, the theory of the ‘overshooting day’ may look nice, but it is outrageously misleading.

3.2.6 Strategies, policies, and measures for environmental protection

Pollution occurs at three levels and at each level the right choice of policy and corresponding measures are required for reducing its negative impact (Table 3-1).

To neutralise the negative environmental impacts created by energy consumption, a set of policies and measures were gradually developed and implemented by the EU and other OECD countries; emerging economies are starting to implement some of them. They can be classified into seven categories (Table 3-2).

Table 3-1 Pollution levels

Level	Pollution	Example
Local	• Air pollution • Water pollution • Waste production	EU developed policies and measures for improving the local environment
Regional	• Acid rains	The EU developed policies and measures for improving the regional environment (LCPD and NEC) (see Section 3.3.1)
World	• Climate change	The EU developed policies and measures for limiting CO_2 emissions (see Section 4.4)

Table 3-2 Policy and Measures to limit pollution or CO_2 emissions

Instrument	Action and examples
Civil liability or ‘polluter pays’.	Authorities can penalise pollution or CO_2 emissions. The efficiency of this policy depends on the penalty. If penalties are insufficient, the industry could be induced into polluting rather than acting. However, not too much credit should be given to this hypothesis because ENGOs have achieved such a level of communication today, making it more convenient to adhere to environmental protection; industry prefers to avoid the additional costs induced by environmental protection rather than minimise trouble, for only a short time.
Voluntary agreements	Before the rise of environmentalism, various industries proposed to unilaterally adopt environmental protection measures. For industry, it is obvious that nobody wants to live in a polluted world that degrades everybody’s health. Certain industries thus proposed to engage concretely and

Instrument	Action and examples
	deliberately on goals they agreed to, thereby avoiding new legislation. A successful EU example is the Auto Oil program, which enabled the auto industry and the oil refining industry, under the umbrella of the European Commission, to improve fuel quality and reduce harmful engine emissions. Results are visible in Figure 3-8. ENGOs criticise this approach arguing that the industry is making the law; they also condemn the European Commission, which, in their view, was subdued by industry. The positive results show that these criticisms were unfounded. Even today, there is a significant potential for environmental improvement to be exploited with this simple instrument (e.g. plastics recycling).
Standards	National standardisation bodies may set standards in various areas which the industry has to apply. This gives serenity to everyone. The Ecodesign Directive is a good example of the progress that this instrument provides. Products not meeting these standards cannot be sold in the EU.
Legislation	Regulatory measures have become the preferred instruments for sustainable development. The EU became a master in this field by adopting a large set of legislation and regulations delivering concrete results. However, the process is slow, especially at the EU level because, after the EU adoption, the EU legislation must be transposed in Member State law. This also generates a lot of lobbying from all sides (industry and environmental NGOs) and creates work for law firms. It is also a heavy bureaucratic burden.
Taxes and fiscal measures	Taxes and fiscal measures can be used to encourage specific behaviour. These include excise duties on fuel; however, they depend on economic elasticity; transportation is inelastic and fuel price increases do not have sufficient impact to shift

Instrument	Action and examples
	behaviour (tobacco is another example). It should be remembered that at the EU level, based on Article 194.3 of the Lisbon Treaty, measures on taxation require unanimity, meaning that there is little hope for adopting taxes that will drive environmental decisions.
Market mechanisms	This instrument was designed in the US for reducing sulphur dioxide emissions from coal-fired power plants; it delivered excellent results, SO_2 emission rights were bought and sold on an ad hoc market. The European Union applied this instrument for curbing CO_2 emissions.
Research and technological development	The race against pollution or CO_2 limitation cannot be won with any of the above instruments if they are not supported by the deployment of new technologies. This explains why government and public authorities, to improve the environment, offer incentives for 'clean' technology developments. These include, e.g. significant support for the development of renewable energy, nuclear energy or carbon sequestration (CCS). Scientific advances bring new solutions and are probably more effective and cheaper than legislation.

3.3 Energy pollutants

The links between energy and environment are numerous enough to affirm that there is no use of energy without direct or indirect impact on the environment. Table 3-3 shows the use of energy being the source of many different types of pollution. Consequently, ENGOs are hostile towards energy and watchful for energy policies.

In the following table, we will analyse only certain pollution aspects.

Table 3-3 Energy impacts on the environment

Pollution	Pollutants
Air	SO_2, NOx, CO Polycyclic hydrocarbons and carcinogens Heavy metals and particulates Noise Bad smell
Climate change	energy-related greenhouse gases (CO_2, CH_4, N_2O)
Land conservation	Landscape and open-cast mines Power lines Wind turbines Dams
Transportation Security	Oil and LNG tankers Pipelines Trucks
Waste Storage	Urban waste Tailings (waste dumps) Ashes and bottom ash Nuclear waste
Security	For workers: oil platforms, oil refineries, coal mines For neighbours: explosions (gas, oil), industrial emissions, nuclear accidents

3.3.1 Air pollution control

At the beginning of the 1980s, many northern European trees were suffering and dying from a strange disease. That was the time when the development of the UN process on sustainable development started, and the culprit was quickly determined: combustion of fossil fuels was causing the acidification of the soil and the water[36]. Reducing this pollution was mandatory.

Typically, sulphur dioxide (SO_2) and nitrogen oxides (NOx)[a] are emitted when fuel or other materials containing sulphur are burned. They are pollutants creating acids, which, in turn, can lead to soil and water quality changes. The subsequent impacts of acid droppings can be significant, including negative effects on aquatic ecosystems in rivers and lakes and damage to forests, crops and other vegetation. SO_2 emissions also aggravate asthma conditions and reduce lung functions and inflame the respiratory tract. They also contribute, as a secondary particulate pollutant, to the formation of particulate matter in the atmosphere, an important air pollutant in terms of its negative impact on human health. Furthermore, the formation of sulphate particles in the atmosphere caused by the release of SO_2 cause reflection of solar radiation, leading to net atmosphere cooling. NOx is created in all combustion processes, including by fuels without nitrogen or biogas as NOx is mainly created by the nitrogen in the air. NOx has adverse health effects because it is the main precursor to ground-level ozone, causing significant respiratory problems that lead to premature deaths sometimes.

In the early eighties, the European legislator decided to eliminate SO_2 and NOx, acidifying and atrophying pollutants and ozone precursors, and did so by combining two measures: first, financial support was extended for research and demonstration of abatement technologies (see Volume 2)[b]. Furthermore, the legislator decided to impose emission limits for large combustion plants through the 'Large Combustion Plants Directive' (LCPD)[37]. This directive was updated in 1994 and 2001[38]. Plants with rated thermal input equal to or greater than 50 MW must follow the strict emission limit values for SO_2, NOx and dust. For each Member State, the Directive on National Emission Ceilings for certain pollutants (NEC Directive[39]) sets upper limits on total emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level ozone pollution

[a] NOx means nitric oxide (NO) and nitrogen dioxide (NO_2).
[b] The author was in charge of this file in the European Commission.

(sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia), but it remains up to the Member States to decide which measures – on top of the Community legislation for specific source categories – will be taken for compliance. The NEC Directive will be amended with new emission ceilings to be respected by 2020 for SO_2, NOx, non-methane volatile organic compounds (NMVOCs), and NH_3, and for the primary emissions of particulate matters ($PM_{2.5}$).

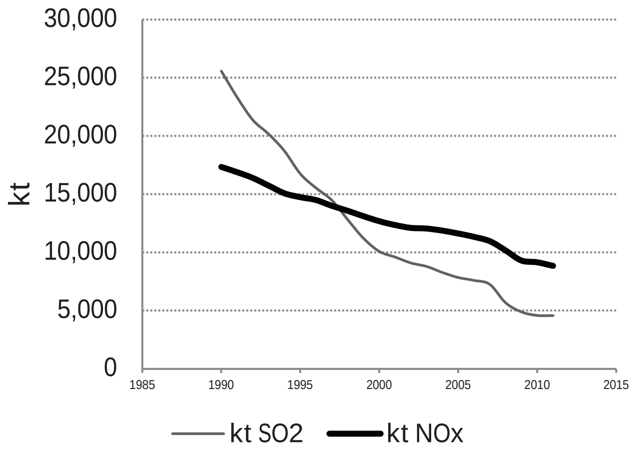
The European Environment Agency (EEA)[40] declared that SO_2 emissions have decreased by 74% between 1990 and 2011 (Figure 3-8). In 2011, the most significant sector producing SO_2 emissions was ‘energy production and distribution’ (mainly electricity generation), with 58% of total emissions, followed by emissions occurring from ‘Energy use in industry’ (20%) and in the ‘Commercial, institutional and households’ sector (15%).

These measures enabled constant reduction of harmful emissions through the cooperation of legislation and technological developments. These examples illustrate a basic principle: there is a risk that pollution persists as long as measures are not taken; however, if action is implemented – and this was the merit of the first environmentalists – degradation of the past can be compensated for. From a technological perspective, this emission reduction since 1990 was achieved by the combination of technological measures, such as the fitting of flue gas desulphurisation (FGD or DESOX) abatement technology in industrial facilities (see chapter 2), but also thanks to fuel-switching, away from high-sulphur solid and liquid fuels to low-sulphur fuels like natural gas in energy-related sectors. In addition to the LCPD, there was also the impact of EU directives relating to the sulphur content of certain liquid fuels.

All of the EU-28 Member States reduced their national SO_2 emissions below the level of the 2010 emission ceilings set in the NECD.

Figure 3-8 Evolution of SO_2 and NOx emissions in the EU-28

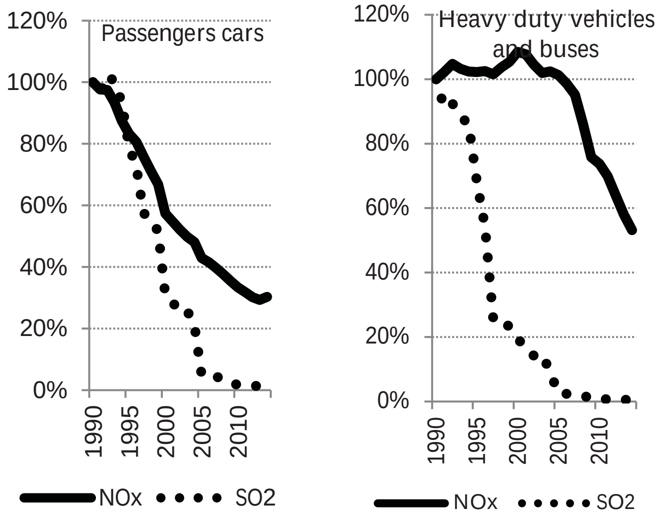
2015 EEA data[40]



In the EEA (European Economic Area), NOx emissions decreased by 44% between 1990 and 2011 for all 33 EEA countries except for Turkey, Cyprus, Luxembourg, and Malta which reported even lower NOx emissions. The economic crisis that started mid-2008 was a key driver in the reduction of NOx emissions between 2007 and 2011, primarily due to reductions in the level of industrial and transport activities across Europe. Total emissions were reduced by 17% during these years, as compared to only 7% between 2003 and 2007. More progress was made by the newer Member States of the European Union for meeting their respective 2010 NOx ceilings as compared to the other EU-15 Member States. They reduced emissions beyond what was required under the National Emission Ceiling Directive[39]. In contrast, only eight EU-15 Member States had 2011 emissions below their respective national ceiling. However, they all broadly achieved similar reductions in NOx emissions since 1990, of 49.1% and 48.7% respectively. Progress has been ongoing since then.

Figure 3-9 Progress in road transport emissions abatement

1990 = 100, EEA data[41]



Europe's transport sector is the largest single contributor to the total ambient NOx concentrations (about 40%). Standards regulating NOx from passenger cars in the EU (the so-called Euro standards) have become more stringent. The EU set Euro standards for limiting these emissions. Since September 2014, Euro 6 limit emissions to 80 mg / km i.e. a reduction of about 85% compared with 15 years ago. Figure 3-9 shows that since 1990, the SO_2 emissions in the transport sector were drastically reduced both for passenger cars and heavy-duty trucks. This resulted from a voluntary agreement, named 'Auto Oil', between the oil refining industry, car manufacturers and the European Commission. However, progress regarding NOx emissions, although effective, was not as good as for sulphur emissions and was particularly bad for the heavy-duty sector. Further progress is required as we will see that a solution is readily available (see Volume 3).

3.3.2 Offshore oil and gas protection

The Deepwater Horizon oil spill in April 2010 was a catastrophe that forced changes to the regulations concerning EU production of oil and gas. The explosion and sinking of the Deepwater Horizon oil rig named the Macondo Prospect in the Gulf of Mexico killed eleven people. It seems to be the largest accidental maritime oil spill in the history of the petroleum industry. Immediately, Commissioner Gunther Oettinger requested a review of the situation in the EU and a legislation improvement for minimising the environmental impact of offshore operations. The European Commission proposed further development of the international legislation. A 2013 directive on the safety of offshore oil and gas operations reinforced this international legislation for the Member States[42]. It defines general measures for preventing the occurrence of major accidents during offshore oil and gas operations, limiting the consequences of such accidents. To achieve this, risk-based planning and operations are defined, and the obligation to implement best practices for operators and regulators to prevent major accidents. EU legislation established minimum conditions for safe offshore exploration and exploitation and improved the response mechanisms in the event of an accident. It thus increases both the protection of the marine environment and the coastal economies against pollution.

A fundamental provision is to impose transparency on all parties and obligate them to share knowledge, information, and experience. Member States are required to play an active role in sharing planning and information. The coordination and cooperation among regulators will help to reach these objectives. The directive also imposes an environmental liability (the licensee is financially liable for the prevention and remediation of environmental damage) and requests that the Member States define the penalties for infringements. Member States should also be ready to act in case of emergency and deliver appropriate responses. Total access to all relevant information and the ability to assess the effectiveness of measures should be made available through the information-sharing obligation among the Member States. The Member States must prepare external emergency response plans covering all offshore oil and gas installations in potentially affected areas within their maritime area. The information should also be made available to third countries, and the Commission shall promote cooperation between the Member States undertaking offshore oil and gas operations in the same maritime regions, by facilitating the exchange of information. The directive requires that the EU registered companies conducting offshore oil and gas operations as licensees or operators shall report, either themselves or through non-EU subsidiaries, any major accident in which they were involved to the Member State competent authority. This legislation will define conditions that are particularly relevant for further offshore oil and gas operation. Conditions are defined for avoiding a major accident as much as possible.

Regarding the Mediterranean Sea, we refer to the Barcelona Convention, a convention within the framework of the Regional Seas Programme of the United Nations Environment Programme (UNEP). Its objectives are to assess and control maritime pollution; ensure sustainable management of natural marine and coastal resources; integrate the environment factor in social and economic development; protect the marine environment and coastal zones through prevention and reduction of pollution; and, as far as possible, eliminate pollution whether land- or sea-based, to protect natural and cultural heritage, to strengthen solidarity among Mediterranean coastal states, and to contribute to the improvement of the quality of life. This convention applies to all maritime waters of the Mediterranean Sea.

Originally adopted in 1976, the convention was amended in 1995, with the amendments entering force on 9 July 2004. This framework convention sets out several general obligations and specific norms related to dumping, pollution from ships, etc. Like other framework conventions, the Barcelona Convention foresees a set of protocols to be adopted by diplomatic conferences of the

Contracting Parties. The protocols require the State Parties to implement their provisions into their national legislation. We are interested in the protocol for the protection of the Mediterranean Sea against pollution, resulting from exploration and exploitation of the continental shelf and the seabed and its subsoil, agreed upon in Madrid on 14 October 1994, entered force on 24 March 2011. Therefore, while Article 77(1) of the United Nations Convention on the Law of the Sea (UNCLOS – see Volume 2) provides that a coastal state exercises sovereign rights for exploring and exploiting its natural resources, and gives the exclusive right to authorise and regulate drilling on the continental shelf to the coastal state (Article 81), the protocol for the protection of the Mediterranean Sea obliges coastal states to take measures to avoid pollution.

This environmental care is also an obligation of the UNCLOS convention. Coastal states have a general duty to protect and preserve the maritime environment and to exploit natural resources following this duty. All the State Parties have a general obligation 'to protect and preserve the maritime environment' (Article 192). As I explained in the paper 'protecting the Mediterranean Sea's environment, thanks to gas' the UNCLOS' Article 193 '*specifies that coastal states have the sovereign right to exploit their natural resources pursuant to their environmental policies and in accordance with their duty to protect and preserve the maritime environment*' [43]. The conventions also make clear that waste dumping at sea requires express permission of the coastal state. Dumping waste at sea is not authorised onshore nor offshore, and it is a major daily issue that will be studied in the following paragraph.

3.3.3 Waste and energy

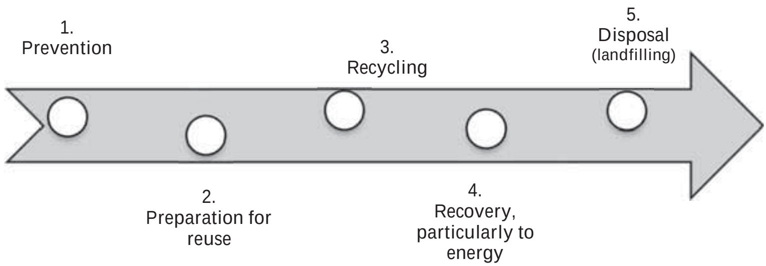
In this section, we address the basic principle of the link between waste and energy, but we limit it to urban waste. Why is this question important in the framework of an energy policy? Because a sorted waste is an energy source!

About 50% of the waste is a source of renewable energy, as indisputably defined in the EU directives on renewable energy[15]. The directives of 2001 and 2009 state: '*renewable energy sources' shall mean renewable non-fossil energy sources: wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogas*' and '*biomass' shall mean the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, and the biodegradable fraction of industrial and municipal waste*'. During the negotiations of these directives, in 2000 and 2008, there was fierce lobbying to oppose this definition because, for some NGOs, it was an anathema to consider producing renewable energy from waste. The legislator was only logical by considering that the organic fraction is biomass. A lot of what we throw in the trash bin is manufactured using natural products (dirty papers, cotton sticks, corks, tea bags, etc.). Even if it is renewable energy, it has already provided a service to society prior to being burned.

The EU waste policy prioritises what should be done with waste to minimise the use of natural resources and minimise their environmental impact. The Waste Framework Directive[44] sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling and recovery. It introduces and defines basic concepts and lays down waste management principles such as the waste hierarchy where waste prevention is the preferred option and the last thing to do is to landfill waste (Figure 3-10). The European Commission is right to say that 'from an environmental perspective, dumping or landfilling is the worst waste management option. It uses up space and can be the cause for future environmental liabilities[45].' It is also a waste of resources. EU legislation introduced high standards for landfills to prevent soil and groundwater pollution, whilst reducing air emissions – for example, of methane, a powerful greenhouse gas. However, sometimes the legislation is poorly implemented – there are still thousands of mismanaged and unauthorised landfills across the Member States.

Incineration is now regulated by stringent EU standards, leading to significantly reduced emissions. For example, emissions of dioxins, a highly toxic group of substances, by the incineration of municipal waste dropped to about 0.5% of the total dioxin emissions in the EU 25. Incineration can also be useful in recovering energy from waste.

Figure 3-10 Hierarchy of waste management



Every EU citizen produces on average 444 kg household waste yearly, a figure expected to increase. However, the average hides significant differences between the Member States. It represents about 10% of total EU generated waste. It is an environmental issue, and also a societal one linked to the Europeans modern way of life. Consequently, it was only normal that the EU developed a strategy for properly and comprehensively addressing the issue. In 2013, a large share (37%) of municipal solid waste was still landfilled. Today the trend is to recycle / compost (40%) or incinerate with energy recovery (23%), for different waste streams instead of landfilling. In Volume 2 we detail how to valorise the renewable energy contents of urban waste.

Recycling provides environmental benefits by diverting waste away from landfill, thereby allowing a second usage of materials, curtailing the extraction, and sometimes also reducing polluting emissions:

- recycling glass bottles or aluminium cans is a sound practice because the material can be recycled infinitely. Landfilling them, although not creating pollution, is economic nonsense;
- recycling paper is economical, but it cannot be done infinitely, and landfilling creates pollution through the rotting of cellulose.

Recently, the 'Circular Economy' has emerged as a new concept. 'Circular Economy' refers to keeping the added value in products for as long as possible and eliminating waste. Resources would be kept within the economy after reaching the end of product life; thus, repeatedly reusing and creating further value. Transition to a more circular economy requires changes throughout the value chains, from product design to new business and market models, from new ways of turning waste into a resource to new modes of consumer behaviour. This implies full systemic changes, and innovation in technologies also in organisation, society, financing methods and policies. Note that in the past, until the 1960s, a large part of the OECD economy was indeed 'circular' (shoes were repaired, cloths were altered for children); this has been progressively abandoned because labour costs overtook material costs. This remaining the case, a large implementation of the 'circular economy' still needs to be validated.

One argument regularly heard to oppose the plastic material recycling, or its incineration is that it can be recycled into oil, 'The chemistry of oil is so nice that it is stupid to burn it.' One ongoing video on YouTube tagged as 'University of United Nations' pretends to produce oil out of plastic wastes. This is simply a process called pyrolysis, neither new nor cost-effective. Without sorting plastic waste, the best way to recover energy from polymers is to burn them!

After sorting, thermoplastic polymers obtained by polycondensation (as PET) can be totally recycled provided they are depolymerised (i.e. hydrolysed) previously to the state of the monomers (or oligomers). It is why some people advertise that polyester fibres and clothing could be produced from former bottles. For thermoplastic polymers obtained by poly-addition such as PE, PP, PVC and PS they cannot be recycled as valuable products because it is impossible to mix or blend them, and their waste constitutes a poor, variable and uncontrollable quality material. At best they can be heated and compressed to form heterogeneous objects with poor mechanical properties. Finally, thermosetting or cross-linked polymers (various resins or vulcanised tyres) can only be used after grinding and combining them in blends with other materials. Chemistry has its laws, and they do not follow policy wishes.

3.4 Energy poverty

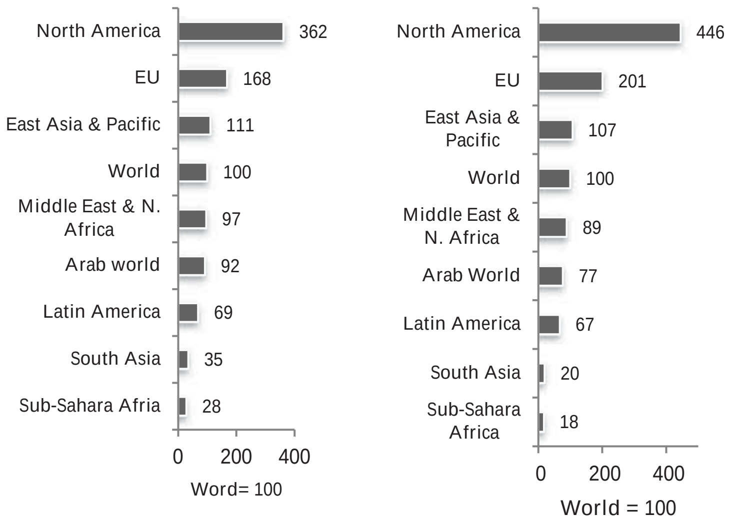
What is energy poverty? Some scholars make a difference between ‘energy access’ and ‘energy poverty’ [47], but in the framework of this book, we will not enter such details. In the EU, the UK was the Member State that attempted to address this question seriously, long before the ENGOs started to focus their attention on this subject. The UK referred to the issue as ‘fuel poverty’, and the EU used this definition.

3.4.1 Rich and poor, poles apart in energy

Energy consumption globally is different. This is illustrated in Figure 3-11. Compared to the global average, a North American citizen uses 3.6 times more energy, and an EU one 1.7 times. Inversely, an inhabitant of South Asia uses only 35% of the world average energy, and a South-Sahara African only a poor 28%. Please note that the difference is stronger for electricity than for energy consumption. This is because electricity is linked to prosperity and well-being: lighting, refrigerators, TV sets, and ironing are all symbols of a prosperous society. When compared to the global average, a North American citizen uses 4.5 times more electricity, and an EU inhabitant uses 2.0 times more. Inversely, an inhabitant of South Asia uses only 20% of the world average electricity and a South-Sahara African only a lousy 18%. Energy poverty is a sad, worrying and inadmissible reality. Figure 3-11 also shows the consequences of the 'American way of life', viz. a society based on energy particularly electricity consumption. It is not only a question of inefficiency and wastage; it is a way of life. In a democracy, everybody should be free to choose one's priorities and way of living. Freedom should be the norm, and choices should be respected. Do governments in Africa, Asia and Latin America accept their way of life, living in poverty, without reacting? No! They act to bring prosperity to their citizens, meaning that they will undertake whatever is possible to reach World averages, or at least those of the EU.

Figure 3-11 Energy and electricity consumption per inhabitant

Energy (left) and electricity (right). World Bank data – 2015 for the year 2011 – world=100



Right initially, we saw (Figure 1-3) that GDP is strongly linked to energy consumption and vice versa. We now have to come back to this reality to illustrate the needs of poor people. The race for material well-being will imperatively increase energy consumption. The facts unequivocally demonstrate this physical reality: as people get wealthier, they require more energy; numerous studies document this. Although this looks evident, it is better to demonstrate it through numbers and facts. Figure 3-12 plots the energy consumption per inhabitant versus GDP for the 28 EU Member States. The relation is evident; the extreme point on the right represents Luxembourg a particularly rich EU country. Inversely, the point at the extreme left represents Bulgaria and the point at the extreme bottom marks Romania. The circled point is the EU average. The richer the people, the more energy they use.

Figure 3-12 Energy consumption per capita in the EU is a function of GDP per capita

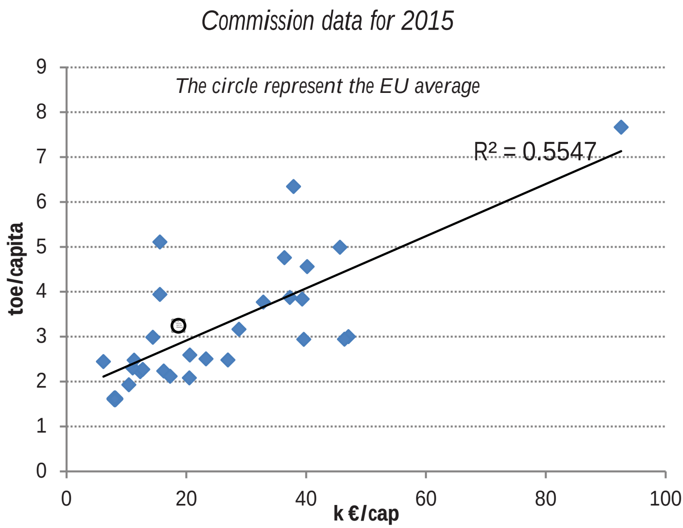


Figure 3-13 Evolution of energy consumption per inhabitant versus revenue per inhabitant

Include energy as food. Source: Bioscience [48]

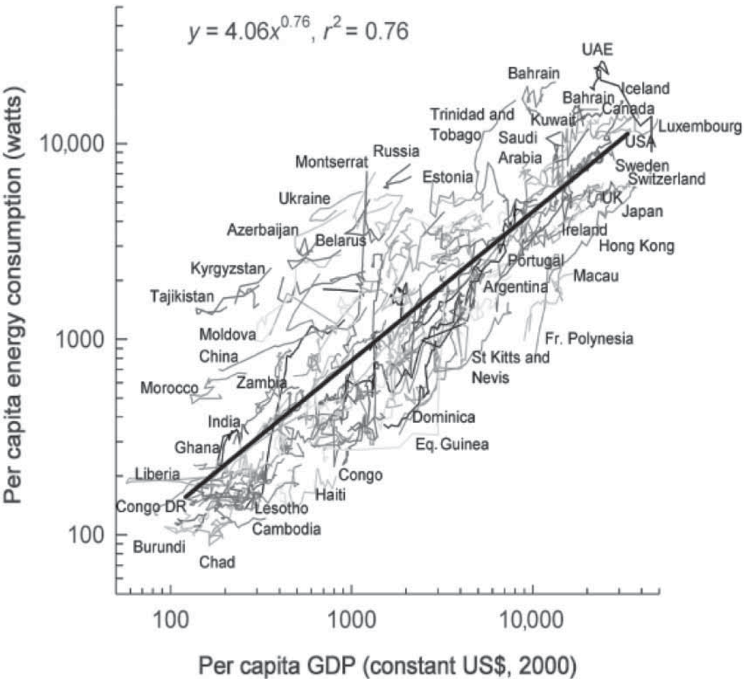


Figure 3-13, prepared by a team of biologists, offers the same lesson. Contrary to previous EU graphs, it is rather original since the energy quantity reported per inhabitant includes not only primary energy consumption, it also includes the energy needed for our metabolism, i.e. our food. The scales of this graph are both logarithmic and the curved lines represent the evolution of a single country between 1980 and 2003. The regression line indicates that the total amount of energy used per capita (E / H) varies with GDP (GDP / H) according to the exponential equation.

$$\frac{E}{H} = 4.06\left(\frac{GDP}{H}\right)^{0.76}$$

The sub-linear slope of 0.76 indicates that energy consumption per capita associated with larger economic activity increases less than GDP. This is because countries with larger economies benefit from economies of scale and more efficient new technologies.

This point is critical to show what might be called ‘energy injustice’: people in poor countries have more difficulties acquiring energy than those in rich ones. The figures also demonstrate that countries with similar GDP per capita differ by more than an order of magnitude on the per capita energy consumption, thereby indicating that local considerations beyond GDP need to be considered (e.g. cold temperatures in Russia). However, it also shows that energy efficiency varies among countries: a vertical line passing from the UAE point indicates that the GDP / H is the same as the one from the UK or Japan, but the energy consumption per inhabitant is much higher. This could be explained in part by the hot atmosphere in the UAE, but also by the extravagant consumption, wherein Dubai, for example, it is possible snow skiing in the desert.

The poorer countries of the planet are in the bottom-left part of the graph, and inversely those in the top-right part are the richer ones. The quality of life varies along the regression line. Before the Internet era, the population of the countries in the bottom-left part ignored that another life was possible; today, if not everyone, at least a large part and certainly the young know that another ‘way of life’ is possible. They want to take the ‘energy lift’ to change their lives. The policymakers of these countries are obliged to adapt their policies to satisfy this legitimate quest for comfort. ENGOs claim that since we have only one planet, these people should not live like Americans. First, this is unfair to the rest of the world, and second, it makes the wrong assumption. Who said that they would need to pass from about 500 kWh / capita to 13,500 kWh / capita to overcome the effects of energy poverty? Why assume they would jump from ‘nothing’ to ‘wasting’? Small changes can drastically change the situation. Anyway, the citizens and policymakers of these countries are uninterested in such considerations, they will just use more energy!

3.4.2 Energy poverty, a worrying reality

According to the World Bank, 1.1 billion people still have no access to electricity, while the International Energy Agency (IEA) evaluates the energy-poor population at 1.3 billion, being equivalent to 15% of the world's population or every seventh person. There is, however, even more alarming data.

Again according to the World Bank, 2.9 billion people do not have access to modern fuel for cooking, while the IEA cites the figure at 2.7 billion, of which 84% are located in rural areas[49]. This means that more than 50% of the world's population does not have access to clean cooking fuels.

These numbers are rough estimates calculated by a top-down approach. We can therefore state that roughly 1.1 billion do not have access to electricity and that 2.8 billion eat food cooked with traditional fuels. Poor people cannot afford fossil fuels and they use only locally affordable, 100% renewable energy: biomass (Figure 3-14 and Figure 3-15) and animal dung (Figure 3-17), and sometimes even worse sources like burning plastic waste.

The negative effects on health are dramatic. According to the World Health Organisation (WHO)[50], the annual number of deaths caused by breathing smoke from these 'natural' fuels is at least 1.4 million, probably closer to 2 million. More people are killed by using this renewable energy than dying from malaria, tuberculosis and HIV. According to a WHO estimate, exposure to indoor air pollution causes acute respiratory infections, causing about 19% of child deaths under five years old in developing countries[51].

Since men usually go out to work, women and children are the main victims of the burning of biomass in the traditional and rustic way. This pollution of the ambient air inside homes increases the risk of chronic obstructive pulmonary diseases and acute respiratory infections for children[52]. In developing countries, this appears to be the most important death cause for children below five years and the cause of low birth weight. Additional evidence shows that perinatal mortality, pulmonary tuberculosis, nasopharyngeal and laryngeal cancer and cataracts also increase.

People can survive without modern energy and clean modern fuel; however, the energy services provided through access to modern sources of energy bring substantial developmental benefits. Table 3-4 gives some areas that are being positively impacted by energy access. Table 3-5 shows the low efficiency of traditional fuel.

Modern fuel is much more energy-efficient, the exception being coal because, in coal stoves used for cooking, combustion is not different from the 'traditional' way. Similarly, traditional fuel particularly animal dried dung cake emit a lot of fine particles. This cheapest form of energy requires only the time to collect it. It is indeed an inefficient and polluting fuel despite being a form of renewable energy. From many points of view, LPG is the solution for clean cooking; after all, this is exactly what took place in the EU during the 1960s, when coal and wood were abandoned in favour of LPG canisters.

Table 3-4 Some advantages of access to modern energy

Economy	poverty eradication diversify economic activities development of SMEs and commercial activities development of rural regions
Clean water access	access to water use of electric pumps to raise water water purification wastewater treatment
Health	reduction of air pollution avoid respiratory diseases particle matter reduction sanitation progress hospital and medical clinic development food preservation fewer illnesses

Education	more time available for studying possibility to study at night access to the Internet
Ethic	reduction of the wood and dung collecting time by women and children less violence to women, including rapes, and children when in an isolated area to gather traditional energy protect children from a form of slavery
Environment	less environmental pressure thanks to the substitution of biomass avoid deforestation
Energy Efficiency	limiting inefficient traditional combustion

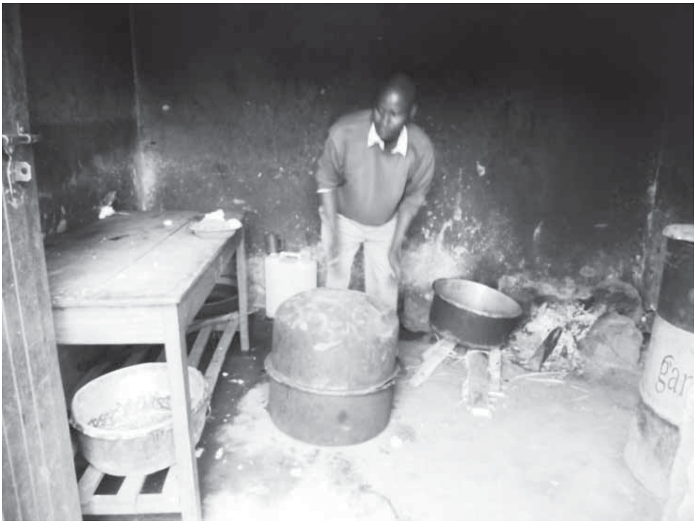
Table 3-5 Stove efficiency and PM10 emissions in traditional cooking

From Singh et al.[53]

Fuel	Cook stove efficiency	PM_{10} equivalent pollution (kg)
Crop residue	11%	7.5
Dung cake	8.5%	16.3
Firewood	13.5%	4.3
Charcoal	17.5%	0.4
LPG	57%	0
Biogas	55%	0.7
Kerosene	47%	0.5
Coal	15.5%	17.9

Figure 3-14 Indoor traditional cooking in Uganda

Photo: Orlando Furfari, 2011



Sub-Saharan African, South Asian, and to a lesser degree, Pacific Asian inhabitants lack access to modern energy. However, not all countries face the same problems. Two thirds of those lacking access to electricity are living in India, Bangladesh, Pakistan, Indonesia, Nigeria, Ethiopia, DR Congo, Tanzania, Kenya and Uganda. Because of its huge population (1.2 billion), India is the country most affected by energy poverty in absolute terms, thus making this topic relevant since, according to the World Bank, 289 million people (almost as much as the US population) have no access at all to electricity. Probably around one billion have only intermittently or poor-quality access.

Sub-Saharan Africa is in the unenviable position to be the least electrified area of the world with less than 50% access to electricity, furthermore, intermittent. Only 12% of the world population lives there, but it constitutes almost 45% of the world population without electricity. Table 3-6 shows, with only two exceptions (Mauritius and Seychelles), that the lack of electricity in Africa is a real problem: in Chad, only 6% of the population has access to electricity, but the lowest is South Soudan with 5%. In the DR of Congo, a country that possesses gigantic hydropower energy potential, only 16% of the population has access to electricity.

Figure 3-15 Outdoor traditional cooking in Uganda

Photo: Orlando Furfari, 2011

Figure 3-16 Animal dung as cooking and heating fuel in Turkish Kurdistan

Photo: Orlando Furfari, 2012

Table 3-6 Percentage of population having access to electricity in Sub-Sahara African countries in 2014[a]

2016 World Bank data for 2014[54]

Country	%
Angola	37
Benin	38
Botswana	53
Burkina Faso	13
Burundi	7
Cameroun	54
Cabo Verde	71
Centre Africa	11
Chad	6
Comoros	69
Congo, Brazzaville	42
Congo, DR	16
Côte d'Ivoire	56
Equatorial Guinea	66
Eritrea	36
Ethiopia	27
Gabon	89
Gambia	35
Ghana	64
Guinea	26
Guinea-Bissau	61
Kenya	23
Lesotho	21
Liberia	10
Madagascar	15

Country	%
Malawi	10
Mali	26
Mauritius	100
Mauritania	22
Mozambique	20
Namibia	47
Niger	14
Nigeria	56
Rwanda	18
Sao Tomé-&-Principe	60
Senegal	57
Seychelles.	100
Sierra Leone	14
Somalia	33
Soudan	33
South Africa	85
South Soudan	5
Swaziland	42
Tanzania	15
Togo	31
Uganda	18
Zambia	22
Zimbabwe	40
Total Sub-Saharan Africa	**35**

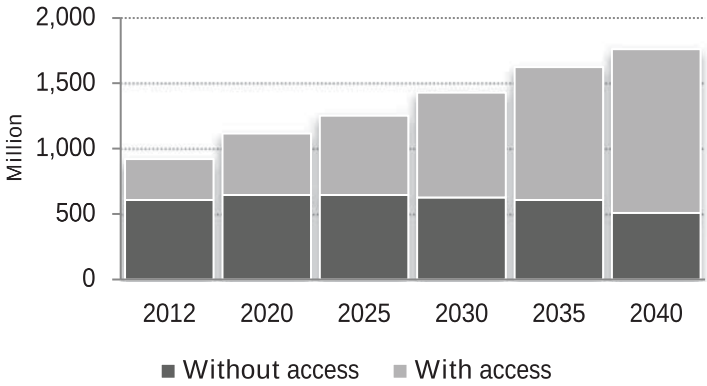
Based on demographic information, the IEA estimates that the number of people relying on traditional use of biomass, including animal dung, will remain at around 2.8 billion in 2040, of which one third (i.e. 0.9 billion) live in Sub-Saharan Africa. The population share relying on biomass is expected to fall in all

[a] These statistics are always issued with delay.

regions, however, the pace of change to modern cooking fuel is slowest in Sub-Saharan Africa and so the slowest changes will be seen there. In this area the number of people having access to modern cooking fuel is expected to increase from about 0.3 billion to 1.3 billion, but the number of people with access only to biomass energy will only decrease from 0.6 billion to 0.5 billion in 2040. Progress is effective but not sufficient to absorb the population growth. Is this a sustainable situation?

Figure 3-17 Number of people in Sub-Saharan Africa having access to Modern cooking fuel

EIA data[55]



3.4.3 Maslow's theory and energy

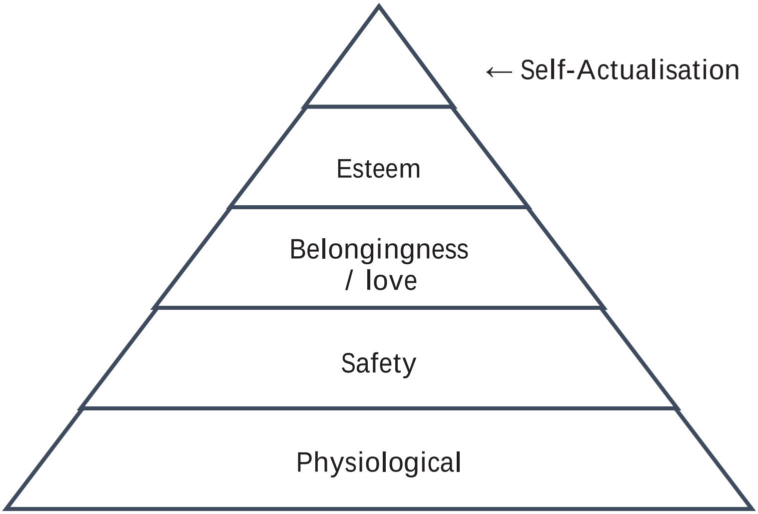
To indicate the magnitude of this problem, the 1.2 billion people not having access to electricity is equivalent to the combined population of the US, Canada, Mexico, and the EU. Even worse, the 2.8 billion people cooking with renewable energy is equivalent to nearly six times the EU population. How can these people be assisted in getting access to modern cooking fuel? How could they be interested in sustainable development at all?

This is not a political statement, but rather the outcome of human behaviour. William Booth, the British Methodist who founded the Salvation Army in 1885 was convinced that '*you can't tell a man about the love of God if he has an empty stomach!*[56]' Similarly, today, you cannot tell a man about climate change if he has no electricity or clean food to cook. This evidence was theorised by Abraham Maslow.

Abraham Maslow is the son of a Jewish immigrant to New York whose work became a worldwide reference for psychologists. It includes 'the satisfaction quest' on 'humanistic psychology and transpersonal psychology', which focuses on the spiritual dimension of man. In the early 1950s due to his many works on motivation and the feeling of fullness, he shredded light on a theory of motivational needs known as the 'Maslow hierarchy of needs' or the 'Maslow's pyramid of needs' (Figure 3-18).

He observed that in a society, some prerequisites must be met before even thinking of other nobler aims. The hierarchy has five levels, implying that a person cannot achieve full psychic development without first satisfying all the lower hierarchy levels. This theory explains that people primarily have physiological needs (eating, drinking, sleeping, sex, etc.). Only if these biological needs are satisfied, they can start worrying about safety and protection (habitat) to ensure their survival. Afterwards, they will try to belong to a group (family, clan, tribe) to meet social needs and love. Furthermore, they will seek self-esteem through recognition (be somebody, have a name, a position, a function). Once these needs are also met, people would be concerned with self-fulfilment (culture, selflessness, commitment). The environment was not an issue when Maslow developed his theory; today he would doubtlessly add sustainable development to this last level.

Figure 3-18 Maslow hierarchy of needs or motivation



Environmental protection, care for the next generation, and attitudes that offer the feeling of fulfilment are only possible at the top of Maslow's hierarchy. Do not expect someone to care for climate change or avoid the use of resources when they are unable to enjoy access to a tap with clean running water, a refrigerator, or even cooking without using dung.

Muzee, the person on the picture (Figure 3-14), is not concerned with the rise of sea levels in 2100. He desires only one thing: to live in Uganda with access to electricity (only 18% of the Ugandan population have access to electricity). Muzee and all others like him suffering from energy poverty welcome and even request 'Western pollution' from their leaders so long as it means having access to electricity. The black colour behind him is produced by PM_{10}, the particulates that are so chased after in the automotive sector. There is not enough space in this book to develop the appalling consequences which interior smoke provokes to energy-poor people. When nearly unmeasurable particles are being pursued in the OECD, one can easily imagine the dramatic consequences of the black fumes that poor people have to breathe in daily.

People without access to modern cooking technology just have fires, often inside their homes, causing toxic air pollution, killing nearly 2 million people yearly. Millions are dying because they do not have access to something as simple, as ordinary, and as vital to their survival as a stove.

3.4.4 Monitoring progress

Institutions and NGOs try to theorise the notion of energy poverty. For the IEA, electricity access means household consumption of 250 kWh per year in rural areas and 500 kWh per year for urban dwellings, based on a household of five persons[57]. The IEA considers that 'modern energy access' at the household level is reached when a household has reliable and affordable access to clean cooking facilities, starting with a connection to the electric grid and increasing electricity consumption over time[58].

There is also a set of other indicators to quantify the issue. Despite that, there is no general agreement on this issue, only useful indicators exist. For example, the IEA's index for measuring the progress of access to energy services provided by electricity, 'modern fuels', and 'clean cooking facilities'[59] is called the Energy Development Index (EDI). The EDI is a monitoring tool that ranks developing countries according to their progress towards modern energy access. EDI aggregates quantitative energy access at the household and community level for 80 developing countries. Thus, a broader appreciation of the penetration of modern energy sources in the societies of developing countries exists[60].

We have just seen that the 'Human Development Index' (HDI) is another important indicator.

3.4.5 Let there be light

How could the motto ‘let there be light and cooking heat for all’ be achieved? Many global initiatives are ongoing. The Clean Cookstoves[61] initiative is a public-private partnership between 66 universities, 16 foundations, 58 governments, 23 multilateral organisations, 330 NGOs, and many others. It aims to raise funds for replacing traditional cooking modes with less polluting systems. This initiative aims to deliver 100 million clean cooking devices by 2020, but a simpler solution also exists. The solution that revolutionised cooking in the OECD countries after WW2 could be applied. Before WW2, most people used wood, coal or charcoal for cooking in stoves. They switched to using propane / butane bottles or LPG (see Volume 2). Gas cylinders and / or canisters were introduced in France in 1938, but were developed quickly throughout the EU only after WW2. This was a great revolution since these ‘13 kg’ cylinders offered easy, smokeless cooking, lasting about one month for a family of four. It would be easy to create an LPG market in these countries. Kerosene is also a possible solution, but this has not been widely used in the OECD, so why should it be superior to using LPG? Kenya, Gabon, and Senegal are successful examples of government strategies aiming at the creation of an LPG cooking market.

ENGOs insist on using biogas, solar ovens or alcohol stoves, but these are all unsustainable solutions presented by people who abhor fossil fuels and related simple solutions. Public financial support for several worthwhile projects is also ongoing. However, nothing would be cheaper, cleaner and more immediate than LPG; its only inconvenience is that it is a fossil fuel.

The environmental NGOs’ slogan ‘small is beautiful’ about electrification is misleading. They mainly proclaim that countries without energy should not follow our example of centralised electricity production, but rather promote decentralised production with isolated electricity networks. However, and much to the contrary, countries without decent energy access – African countries specifically – require centralised solutions. Twenty-five years ago, there was only one African city with over one million inhabitants; today there are 28. Thinking that Africa will only need a few PV panels, providing at least electricity for children to learn to read, is an insult to their population. They need massive economic development for urban areas and the proposed environmental NGOs' solutions are in reality humiliating. All the countries lacking electricity need massive centralised electricity production, and this can only be achieved with a modern clean power generation, often based on cheap and sometimes locally available coal and hydroelectricity. Proposing these countries to develop solely renewable electricity is outrageous.

Certainly, renewable energy will not solve the energy access problem in Africa. Renewables can deliver immediate and simple solutions for SMEs, schools and even small hospitals. Transitioning from nothing to off-grid electricity generating a few solar-kWh would be a real change and should be encouraged, but real development will require massive, and therefore, central electricity generation. Whilst the off-grid solution is pushed by NGOs as 'the' solution, it should not be forgotten that Africa will require both electricity generation methods. And the centralised one will require massive investment and not charity-type solutions brought enthusiastically by NGOs; this is meritorious but insufficient.

Nigeria is a critical country for oil and gas production. However, it is considering producing its coal for clean electricity production using Chinese technology. Because less than 60% of the population has access to electricity, the country badly needs more electricity generation and it does not want to rely only on its gas for producing it. It is better to export gas than to use it for power generation because electricity can be generated with coal[62]. In July 2016, the energy minister declared, 'It is not gas alone that will allow us to achieve incremental power.' Presently Nigeria has no coal-fired power plants and negligible coal domestic production, though it has interesting coal reserves in the Kogi, Benue and Enugu states. Coal-fired power plants could deliver 1,000 MW by 2020. Chinese investors are proposing such projects. Consequently, not only will Nigeria develop electricity generation from coal, but it will also help the Chinese economy.

Since renewable electricity is too expensive in OECD countries, why should we impose it on countries suffering from energy poverty? Should they put their scarce financial resources in those solutions? During the French Revolution of 1789, Queen Marie-Antoinette wondered why people were upset. She was told that people did not have bread to eat to which she replied, '*if they have no bread, let them eat cakes*!' Imposing renewable energy on those who cannot afford this expensive way of generating and refusing the use of fossil energy seems strange, unfair and unrealistic. Maybe some niches could be exploited, but a real and comprehensive solution cannot be built by adding up niches.

Anyway, many countries like India or Brazil are developing strategic plans for expanding their electricity production. In June 2013 at the Cape, President Obama launched a new initiative named 'Power Africa'[63], aiming at increasing the electricity generation and access in six energy-poor target countries: Liberia, Tanzania, Kenya, Ethiopia, Nigeria and Ghana. From 2013 to 2018, the US government committed over $7 billion in financial support and loan guarantees for powering Africa. These means will be leveraged by the private banking sector by adding a dollar for every dollar contributed by the US administration.

Would this destroy the planet even more? Studies demonstrate that universal access to electricity does not necessarily heavily increase CO_2 emissions. A study (Pathways to achieve universal household access to modern energy by 2030) showed that worldwide universal energy access would increase greenhouse gases (GHG) emissions in 2030 by only about 2-4% above the baseline scenario. There are even estimates that a reduction of CO_2 emissions is possible, because of the reduction of traditional biomass emissions[64]. The energy solution – i.e. universal access to electricity through the efficient use of fossil fuels, and replacing renewable biomass and dung which are polluting and energy inefficient – would be a win-win for planet Earth and its poor people's health!

Furthermore, those concerned with the environmental impact of the electrification of the poor should also consider that this energy service produces a reduction in birth rates and, thus, stabilises energy demand, at least partly. The evidence is clear in OECD countries. A 2008 World Bank study covering eight countries showed that except for Nicaragua, electrification reduced the birth rate in all of them (Table 3-7)[65].

Some people believe that electrification would reduce the sexual intercourse frequency by increasing waking hours, but this is not true because more light, television and radio provide for 'alternative recreation'. Watching TV affects sexual activity significantly in only one of eight cases. Rather, electrification indirectly increases sexual activity: more sex occurs when more women use modern contraception, through knowledge provided partially by television. This study states that electrification provides a median fertility reduction impact of 0.6 children.

Table 3-7 Impact of electrification on the number of children per women

Source: World Bank[63]

Country	Before	After	Difference
Bangladesh	5.83	5.68	-0.15
Ghana	6.35	5.77	-0.58
Indonesia	4.63	4.26	-0.37
Morocco	6.32	5.67	-0.65
Nepal	5.98	5.46	-0.52
Nicaragua	7.35	7.51	0.26
Peru	6.57	6.45	-0.11
Philippines	5.54	4.63	-0.91
Senegal	7.42	6.23	-1.19

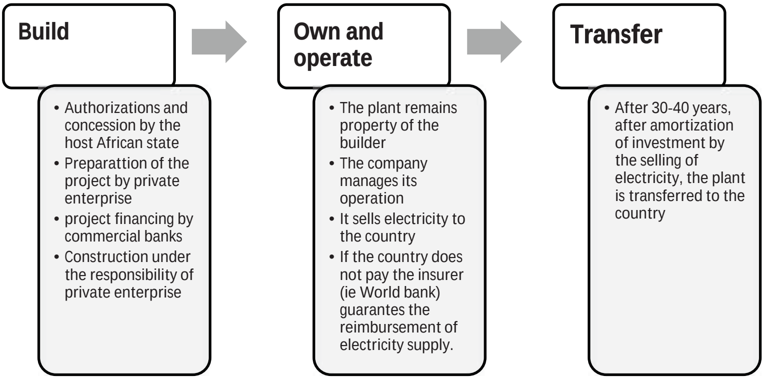
3.4.6 How to finance the electrification of Sub-Saharan Africa?

Providing abundant and cheap electricity – and not expensive, intermittent solar and other renewables – for Africa requires many power plants which cannot be built because of the lack of technology, skills, and funding. Multinationals able to build such infrastructure naturally expect to be paid, profit being a vital purpose of their activities. This requires billions of dollars and, optimally, a World Bank or similar institution's guarantee for financing. These institutions can offer African countries only a few hundred million dollars for all projects (water, energy, agriculture, hospitals, roads, teachings, etc.). For example, projects in Ghana received $323 million in 2015 and $342 million in 2016[66]. Thus, clearly Africa, already over-indebted, will never receive the electricity required for its development. Furthermore, when a country manages to mount a financial project, there is often the requirement for financing the supply of primary energy. For example, assuming that it would be a natural gas-fired power plant, it requires gas deliveries, requiring investments of around one billion or more, adding a further step to the blockage. If Africa remains without electricity, all involved actors will lose.

Furthermore, if African countries and/or international companies succeed in producing and distributing the kWh, the national electricity company does not always have its bills paid, without forgetting to account for the fraud and theft of electricity from power lines. Many African countries have colossal arrears of electricity bills.

A possible solution, such as the one promoted by the Foundation BRIDGIN[67] based in Brussels, would be to develop Build-Own-Operate-Transfer (BOOT) projects, in opposition to the more classical Build-Operate-Transfer (BOT) solution. BOOT encourages private companies to invest. Indeed, they keep total control of the plant. The investor injects private money into the economy of the host country, provides labour and expertise, ensures that the project will be completed on time following the state of the art, ensuring that the host country can thus get electricity without investing its scarce resources.

Figure 3-19 Principle of the BOOT



BOOT projects are an operational answer to the urgent African electrification needs with a 'win-win' virtuous approach. At this stage of development, Africa needs to produce kWh and not to power plants. Building power plants by enterprises which retain ownership could create a positive environment for business development. This would give African countries access to electricity, and western companies a valuable access to this growth whilst financial and international institutions would make optimal use of their limited subsidies.

Ultimately, African nations and their children would hopefully regain dignity by not having to cross the Mediterranean Sea with all the duress, risks and the ensuing casualties. Instead of trying to solve the consequences of a sad situation, action should be taken to go to the root of this wickedness by providing the development with abundant and affordable modern energy. Solving the electricity question will not solve all poverty issues in Africa, but it would be a good starting point. Water, refineries, cement plants, roads, universities and training centres, to name only a few, could also benefit from the same procedures.

3.4.7 Fuel poverty in the EU

Electricity access is universal in the EU, but more and more people cannot afford to pay their electricity bills. Price increases, caused by taxation and various obligations burdening electricity production and distribution, are hitting consumers. In France, the energy ombudsman estimates that 3.8 million households are in fuel poverty, i.e. about 8 million people[68]. In Wallonia at the end of 2013, there were 158,000 protected electrical customers, representing over 10% of the number. According to a second study on energy poverty in Spain, carried out by the Environmental Sciences Association, 7 million Spaniards struggle to pay their electricity bills, a situation all the more serious since unemployment is heavily hitting this country[69]. Inability to pay electricity bills is a clear sign of EU fuel poverty.

The main issue is heating, which, of course, depends on warm or cold local climates. The Scottish situation is, of course, strongly different from the Sicilian one. Poor Scottish people cannot afford to heat their badly insulated dwellings whilst history shows that Sicilians support the heat. Twenty-four thousand is the estimated number of excess deaths during the winter of 2011-2012, caused by fuel poverty in England and Wales. Mostly people above 75 years were concerned; totalling 19,500 only for this age group, compared to the 4,500 people under 75 years[70]. The UK tried to raise the issue of fuel poverty at the EU level for several years, but since this was not an EU-wide issue, the response was slow. With the arrival of the Eastern Member States, the situation in the EU changed because the heating issue is a real problem in those countries. Particularly because during the previous Soviet period, the buildings were erected without any consideration for energy efficiency, but they still are – and will remain – dwellings. The situation is particularly worrying in the Baltic Countries where the Soviets built so-called panels, solid buildings (even difficult, and therefore, expensive to demolish) but totally energy inefficient.

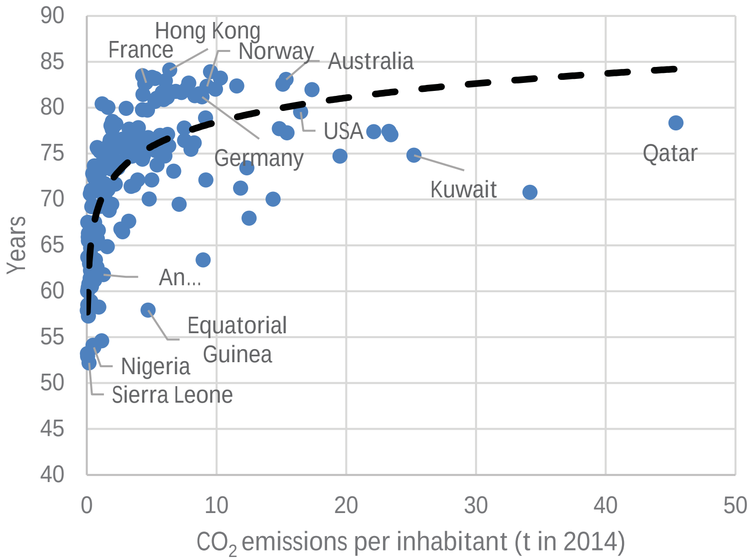
Finally, while the EU directives for the energy markets also address the notion of ‘fuel poverty’, however, the EU directive does not define what ‘fuel poverty’ is and how to address it, but leaves this responsibility is left to the Member States. The role of the European Commission is rather limited, it can only coordinate common actions, exchange information and monitor progress.

3.4.8 Energy and CO_2 emissions are good for the quality of life

It is important to understand that here is a strong link between human progress and energy consumption, especially when considering fuel poverty. It is irrefutable that the life expectancy of a population is correlated with its energy consumption. If in Europe we reached a life expectancy level above 80 years, it is because hygienic and sanitary conditions reached unprecedented historic levels thanks to energy consumption. Without energy, there is no health care, no medicines, no hospitals, and ultimately life expectancy regresses. Figure 3-20 illustrates this plainly. A small additional energy consumption dramatically increases life expectancy (left-hand side of the figure). However, this is not linear because consuming much more energy does not extend life (right-hand part of the figure). Energy is necessary to have a long life, but wasting energy does not increase life expectancy, as we can see on the right of this graph where the Persian Gulf monarchies are. In a conference when using this argument, I was surprised when a lady told me that it is not necessary to live longer because it increases pollution – this is not the vision of people with less than a fifty-year life expectancy.

Figure 3-20 Life expectancy related to the CO_2 emission per inhabitant

Data of UN HDI[70] (see also[71])



The United Nations has developed the Human Development Index (HDI), a benchmark indicating whether 'a decent standard of living' is reached[72]. It is calculated as a 'summary measure' of average achievements in key dimensions of human development: life expectancy, education, nourishment, sheltered, healthy, having worked, voting, participating in community life, and energy consumption. It is an indicator describing whether a country has reached 'developed' status.

Figure 3-20 suggests that increases in energy consumption up to around 100 GJ / capita are associated with substantial increases in human development and well-being, after which the relationship flattens out. As with life expectancy, wasting energy does not improve HDI. Around 80% of the world's population today lives in countries where the average energy consumption is less than 100 GJ / capita. Countries in which energy consumption is much greater than 100 GJ / capita are not cautious in their energy use.

Figure 3-22 plots the HDI with the CO_2 emissions per capita with data of the UN HDI databank. As in the previous graph, there are many countries on the left-hand side of the figure, indicating the evidence of the positive impact of the CO_2 emission per inhabitant on the quality of life. Again, points on the right-hand side are those wasting energy. Some countries, like Canada or Norway, are plotted with a high HDI and a lower CO_2 emission but they are the exception. Broadly, we can state that to have a good and an average HDI, it is necessary to emit 5t of CO_2 per inhabitant.

Figure 3-21 Human Development Index as a function of energy consumed by inhabitant for the UN countries

Data of UN HDI[71]

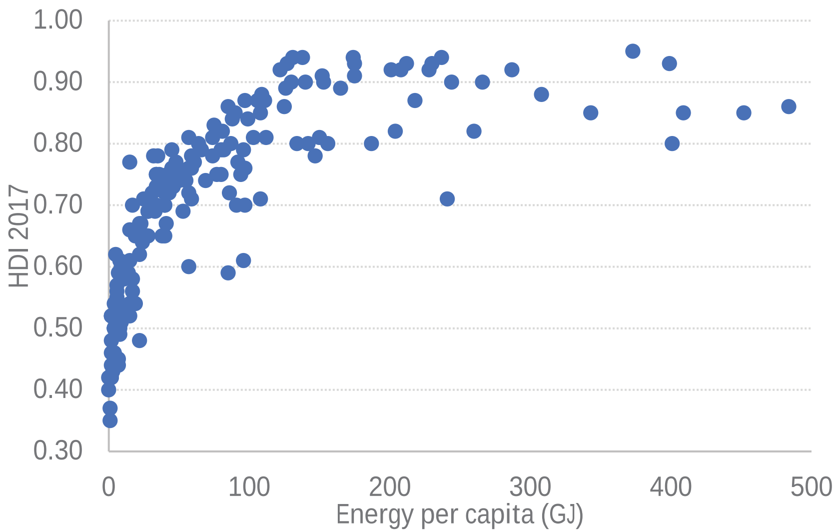
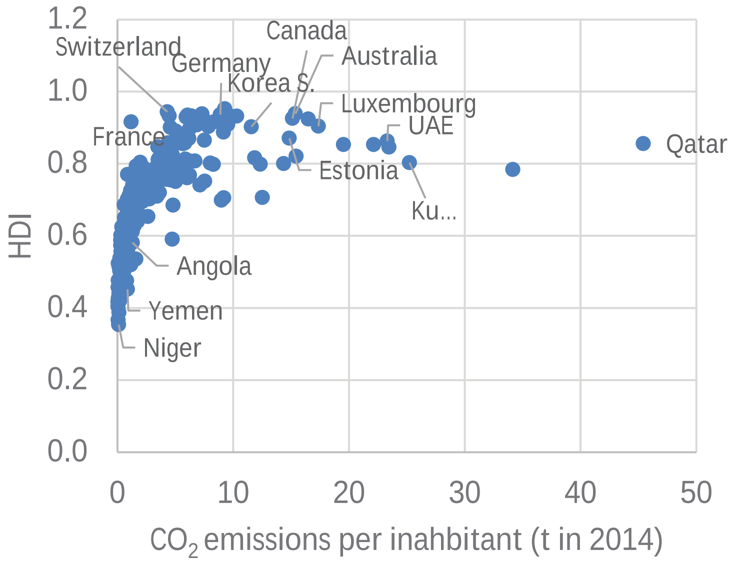


Figure 3-22 Human Development Index as a function of CO_2 emitted by inhabitant for the UN countries

Data of UN HDI[73]

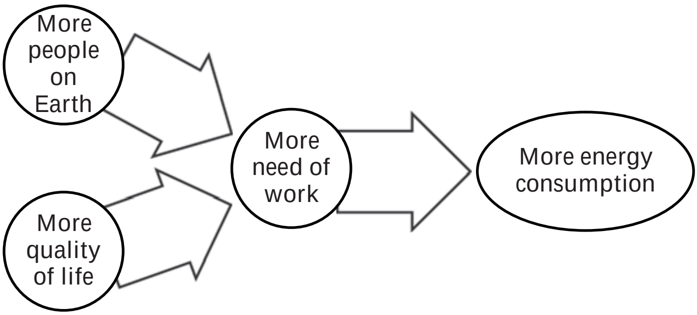


In the previous graphs, the regression curve presents a clear tendency, but there are always exceptions. Norway has a high life expectancy and a high HDI, but thanks to the large hydroelectricity generation, they have a low CO_2 emission. All points outside the regression curves can be justified by specific conditions. We do not have time to address all of them here.

Ultimately, these charts make clear that energy fuels life and prosperity. History demonstrates that progress in energy consumption went hand in hand with increased productivity and real income and consequently, less poverty. Energy consumption growth never increased the proportion of poor people in a country. To the contrary, to remove world poverty, the basic condition is using more energy[a]. This is not a sufficient, but a necessary condition; it is physically impossible to remove poverty without increasing global energy demand. This was shown when explaining the physics of energy.

This proven relationship derived from the physical law of work is not universally accepted, however. Paul Ehrlich, a biologist from Stanford University and the author of the 1968 bestseller, ‘The Population Bomb’, which triggered the Club of Rome’s fears, said that ‘*giving society cheap, abundant energy would be the equivalent of giving an idiot child a machine gun*’[74]. Although his prediction on the fate of the planet proved wrong, Ehrlich is still considered as an ‘expert’ on sustainable development by certain media. Despite this, the UN Sustainable Development Goals, which were reformulated in September 2015, recognise the fundamental need to ‘ensure access to affordable, reliable, sustainable, and modern energy for all’ (goal number 7).

Figure 3-23 Energy to remove poverty, a physics process



[a] For a complete coverage of this question see ‘L’urgence d’électrifier l’Afrique’, Furfari Samuele [44]

Figure 3-24 Economic growth and life expectation

Considering all this, we conclude this chapter by paraphrasing Thomas Hobbes, the great 17th-century philosopher who, in Leviathan, wrote that natural life is 'poor, nasty, brutish, and short'[75]. Without modern energy, life for us will become – and for poor people will continue to be – 'poor, nasty, brutish and short'. We must teach and endlessly repeat this simple statement.

4 Climate change and Energy

Climate change is a central debate in energy policy. This chapter briefly explores this debate by surveying its controversial political origins, its evolution, and the challenges it has encountered in its search for support. After we summarise the EU's commitment to the cause, we look at emissions, trends, and instruments used to manage them like carbon capture technologies and cap-and-trade policies. Some main criticisms of the debate are then outlined and it is argued out that it is difficult to establish anthropic cause to changes in the climate. The discussion is then rounded out by returning to the subject of climate change policies and the ideologies behind the movements that inspire them.

Nobody ought to question whether climate change is taking place. It is a tautology, a truism; it is true by definition. It is a part of the Earth and a consequence of the existence of the atmosphere. The question rather is: is man affecting climate change and, if yes, how much?

Is climate changing an anthropic outcome? The International Panel on Climate Change (IPCC), most policymakers, and the media in the EU answer with a 'yes', a growing minority in the EU and a majority in the US say 'no'. The debate is far too complex to be treated here properly, but since today's energy policy is strongly shaped by climate change policy, we cannot escape addressing – although briefly – this decisive question.

The IPCC claims that there is a causal relationship between the growth of anthropogenic CO_2 emissions and this increase. However, others question this. Since the Industrial Revolution, which was made possible using fossil fuels, global temperature has risen by 1.24°C, almost one degree of which occurred up until 2000. The extent and regionalisation of the impacts of global warming on the Earth remain complex to establish.

Climate science is ultimately a young science. It cannot therefore be claimed that we know everything about climate phenomena. Therefore, IPCC reports are extremely cautious – as is appropriate in science – and use many conditional statements. The margin of uncertainty is particularly large in estimating the impacts of human activities on the climate, but one thing is certain: catastrophism is irrelevant.

Box 4-1 CO_2 is natural

As we will deal with CO_2 (carbon dioxide) in this section, prior to moving on, be mindful of the fact that carbon dioxide is a natural constituent of the atmosphere, where its concentration varies from 0.03 to 0.06% (Vol/vol = 300 ppm to 600 ppm). CO_2 is a substance synthesised by the human organism via cellular respiration. It is therefore not a pollutant like SO_2 (sulphur dioxide); it is a natural product produced by our body. CO_2 is widely used in the industry and for certain medical applications. The molecule is especially known in the context of energy as a combustion product, but also as the result of rotting and fermentation. In houses or offices, its concentration is between 0.035 and 0.25% (350 ppm to 2,500 ppm) depending on human occupation and air renewal[76].

4.1 The IPCC and its opponents

The ongoing majority credo in the EU is that humans influence global warming (now called climate change). As a result, it is qualified as ‘anthropogenic’. In using fossil energy, humans are emitting the so-called greenhouse gases that will ultimately destroy the earth and humans. Faced with this possibility – and in the application of the precautionary principle foreseen in article 191.2 of the Lisbon Treaty – preventive actions have to be taken. To address this matter, the UN created the IPCC in 1988 to supply scientific evidence in support of anthropogenic climate change. The mandate of the IPCC is not to study the causes generating climate change, but rather to specifically study the impact of humans on climate change. It is, therefore, not surprising that the panel strongly investigates the role of energy in this complex issue.

It is indeed a complex scientific issue and, consequently, the IPCC's task is also extremely complicated. The IPCC collects, compiles and appraises scientific findings of human influence on climate. Three Working Groups of selected scientists were set up to handle this complex matter:

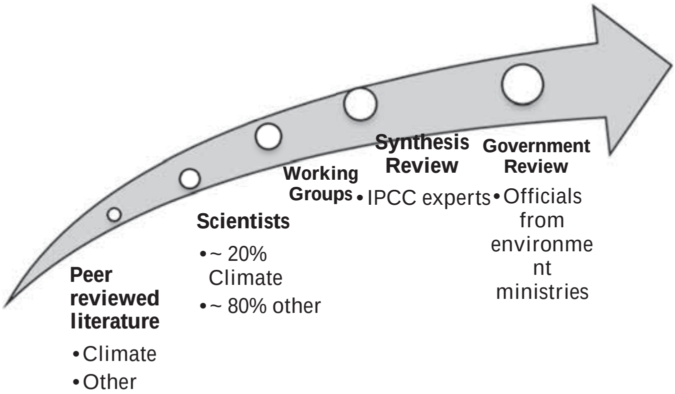
- Make a synthesis of the scientific literature on anthropogenic climate change.
- Evaluate the negative impacts of anthropogenic climate change on humans.
- Assess policy and measures for mitigating the negative effects.

For more than 25 years, owed to large human resources, the IPCC has become the only audible voice in the climate science community. Although the IPCC Working Groups are composed of about 2,500 scientists, they have always been close to officials of environmental ministries or government administrations. The 'I' in IPCC refers to 'Intergovernmental', demonstrating that it is indeed a political body.

Figure 4-1 illustrates how the IPCC operates. It collects and reviews scientific papers and makes a synthesis which turns into annexes of the final report. The latter, used by the media and policymakers, is co-drafted by IPCC *and* Government officials. The conclusions drawn by the IPCC Working Groups become the official position of the IPCC only after being accepted by the plenary assembly, which is mainly composed of government officials or their representatives. This is laid out in Article 11 of the Principles Governing the IPCC Work[77], '*Conclusions drawn by IPCC Working Groups and any Task Forces are not official IPCC views* *until they have been accepted by the Panel in a plenary meeting*.' Its reports, therefore, ultimately become political instead being purely scientific.

Whilst the media and policymakers present the IPCC as a 'scientific body' composed of honest scientists, as shown it is not exclusively so. Most of the people in the plenary assembly are not scientists, but government representatives and civil servants, NGOs, etc., most of the time with poor or even without any scientific credentials. Policy should not be confused with morale and, accordingly, the IPCC's role should be strictly limited to science and the reporting of facts as it claims; it should avoid trying to influence society's choices for moral reasons via policy.

Figure 4-1 The IPCC's reporting process



Moreover, the IPCC is plagued with virtue-signalling. In its mandate, the IPCC states that its role is '*to assess on a comprehensive, objective, open and transparent basis, the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation'.* Some of these objectives require value judgments, which are of political nature, not scientific. This also explains why the IPCC received the Nobel Prize for Peace and not the Nobel Prize for Physics or Chemistry.

It further states that its role is strictly to report to the UN on climate change science, but again this is not the case. Nobody explains this better than John Broome, a member of IPCC: '*The Intergovernmental Panel on Climate Change (IPCC) recognises that climate change is a moral problem or, to use its cautious language, it raises ethical issues. The authors of the IPCC's recent Fifth Assessment Report, therefore, included two moral philosophers. I am one of them*.'[78] The third part of the Fifth Assessment Report ('AR5'), Working Group III published in 2014 and 2015, urges Western countries to opt for 'degrowth', i.e. negative growth. This is not an objective scientific statement but one that extends beyond science and makes subjective political proposals with economic implications. Again, this makes it impossible to claim that the IPCC is solely scientific.

IPCC's final decisions are consequently and logically more political than scientific. This process, being the antithesis of science, is a reality imposed by the statutory principles of the IPCC and is widely demonstrated by its modus operandi. Indeed, the nature of the IPCC is the key in question. The Belgian philosopher Drieu Godefridi claims that it is a fraud to present the IPCC as scientific, and that this is the greatest fraud in modern science due to its binding and planetary impact[79].

Scientists should be independent thinkers, reaching their conclusions independently of politics. After all, as Karl Popper explained, a theory in science can never be proven, but it can be falsified and if the outcome of an experiment contradicts the theory – which is the case with the IPCC's models – scientists should not be searching for justification of the theory. Popper stated the opposite of what Al Gore and environmental NGOs do; the former said, 'I know that I do not know,' while Al Gore claims, 'the debate is closed, we need to act'. For Karl Popper science does not exist to claim that ‘this is the truth’, but rather to denounce errors[a].

As a demonstration of Popper’s position, science is full of errors. Since 1961 cholesterol was an obsession in dietary warnings for Americans because there was a consensus that eating food-containing cholesterol provoked heart diseases. Two generations were discouraged from eating eggs and bacon at breakfast based on scientific consent. However, in 2015, this consensus collapsed[80]. Accordingly, climate change ‘deniers’ have a scientific approach, while those calling them ‘deniers’ do not. This is especially so when trying to marginalise and denigrate anyone disagreeing and even prevent ‘deniers’ from publishing in scientific papers, as the 2009 Climate Gate scandal demonstrated[81]. Therefore, climate change ‘deniers’ should be respected provided they have a scientific approach and ENGOs should stop their total opposition. The progress of science needs continuous critical reviews of its conclusions so that they remain continuously challenged and confronted with evidence from observations obtained by experiments[b].

From a scientific viewpoint, the exaggeration in this sector is shocking. There are ongoing claims that extreme weather – hurricanes, tornadoes, droughts, floods, etc. – may be caused by climate change. However, there are no data showing an increase in the number or intensity of such events. Even the IPCC acknowledges[82] the lack of any evident relation between extreme weather and climate.

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[a] Honest people exist in all social groups, all professions, all political parties, etc. Reversely, dishonest ones are also found in the same groups. Consequently, it is not surprising that some researchers are dishonest. It's just the sad reality of life.

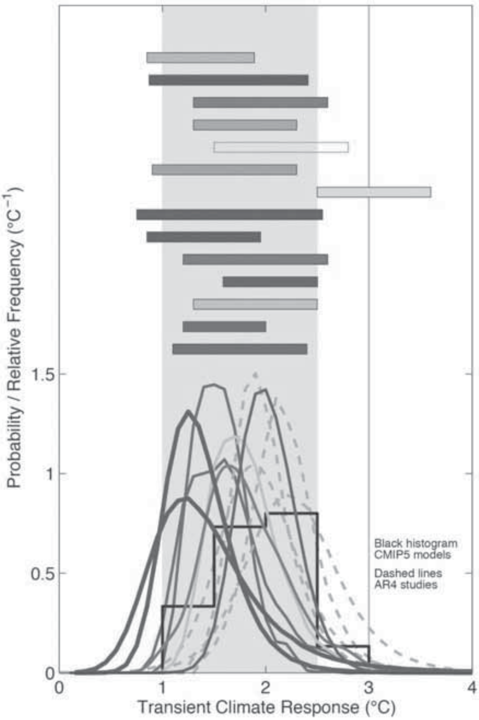
[b] In February 2015 a symptomatic case exploded with an article published in the New York Times (NYT) about Willie Soon, a scientist at the Harvard Smithsonian Centre for Astrophysics, who for over 25 years, argued for a primary role of solar variability on climate. NYT argued that he was paid by fossil fuels industry triggering a scandalous political witch-hunt. Details are on Internet.

As another example, the media widely repeated, particularly on the blogosphere, that 2014 was the hottest year[83]. Climate change sceptics questioned the statements and discovered that there was a 38% probability that it was indeed the hottest year, meaning that with a 62% probability it was not. Furthermore, the possible increase was 0.02 °C; considering a normal measurement error of 0.1 °C[84], it's easy to see the scam. In any scientific field, this information would be discarded as statistically not valid and, because of the error margin, considered anyhow insignificant.

It is undeserving to see examples of heating of 4-5°C since the IPCC projections for such warming have a low probability of 0-1% (Figure 4-2.). In June 2019 during the heat wave in France, Jean Jouzel, a French member of IPCC, stated that '*if we let the warming go towards 4° C to 5°C at the end of the century, the heat peaks could be 8° C to 10°C higher than they are now. We'd move on to another world. At European level, we could reach 150,000 victims yearly, mainly because of these heat waves*'[85]. According to the Panel he is a member of, 'with high confidence the transient climate response (TCR) is positive, likely in the range 1°C to 2.5°C and extremely unlikely greater than 3°C, based on observed climate change and climate models'[86]. The report says that the warming of 3°C is extremely unlikely; don't even talk about 4° C.

Figure 4-2 Probability of the increase of temperature

Source: IPCC AR5, 2013 TFE.6, Figure 2[87]



Box 4-2 The IPCC also deals with non-climate change issues

On 8 August 2019, the IPCC published its report, 'Climate Change and Land'[88]. It is one of three special reports that the IPCC is preparing for the Sixth Assessment Report cycle. The IPCC declares that the report was prepared under a scientific leadership.

This report explains that '*the production and use of biomass for bioenergy* [biofuels[a]] *can have co-benefits, adverse side effects, and risks for land*

[a] Biofuels are rebranded as bioenergy.

degradation, food insecurity, GHG emissions and other environmental and sustainable development goals'. For IPCC, the production of biofuels can be bad for climate change. As it also says that '*most mitigation pathways include substantial deployment of bioenergy technologies*', this means that IPCC is worried by the deployment of bioenergy.

This report also states that women are more victimised by climate change. In its Section C4.4., one can read that '*empowering women can bring synergies and co-benefits to household food security and sustainable land management. Due to women's disproportionate vulnerability to climate change impacts, their inclusion in land management and tenure is constrained. Policies that can address land rights and barriers to women's participation in sustainable land management include financial transfers to women under the auspices of anti-poverty programmes, spending on health, education, training and capacity building for women, subsidised credit and program dissemination through women's community-based organisations.*'

Isn't this a political statement? Is it so important to state a feminist position to defend climate?

Similarly, the report pushes policies in favour of indigenous populations. In its Section 4.3 '*Agricultural practices that include indigenous and local knowledge can contribute to overcoming the combined challenges of climate change, food security, biodiversity conservation, and combating desertification and land degradation (high confidence). Coordinated action across a range of actors including businesses, producers, consumers, land managers and policymakers in partnership with indigenous peoples and local communities enable conditions for the adoption of response options*.'

Isn't this another political statement? Surely, this 'scientific' IPCC statement has been used by Pope Francis in October 2019 when he defended the religion of Amazonians.

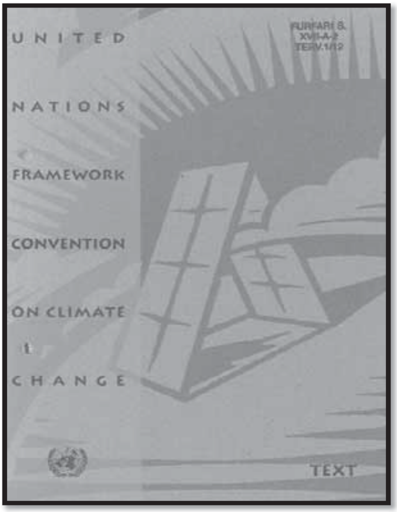
4.2 The UN trip from Rio to Paris

Figure 4-3 UN Climate change process

1992 Rio de Janeiro	1999 Kyoto	2009 Copenhagen	2015 Paris
• UN Framework Convention on Climate change • Sets a process of Conferences of Parites	• Adoption of the Kyoto Protocol • Adoption for developped countries of GHG reduction targests by 2008-2012	• Failure of the tentative to adopt new targets for "Post-Kyoto"	• Paris Agreement

Figure 4-4 UNFCCC cover of the official document

Photo by the author



After the UN's adoption of the Brundtland report on sustainable development, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the

Rio Conference of June 1992. The UNFCCC defines guidelines and a methodology for reducing greenhouse gas (GHG) emissions; it sets the scene for future steps, however, at this juncture, no target has been set. It also created a process called the Conference of the Parties (COP)[a].

4.2.1 COP-3, Kyoto – a great hope

In December 1997 in Kyoto at the third COP (COP-3), targets were decided within the Kyoto Protocol. This 'legal instrument' was presented as a major success because targets were adopted and presented as binding by the developed countries listed in the so-called Annexe 1 Parties section.

After much haggling, the reduction targets were differentiated by country / region: the EU 8%, the USA 7%, Japan 6% and Russia 0% to reach for the world 5.2%. Because of the pressure from environmental NGOs, the target date for this reduction was the subject of another bargaining resulting in a bizarre solution: these objectives had to be reached by 2008-2012. Knowing the difficulties for reaching these reductions, it was silly – as afterwards the results demonstrated – hoping that the targets could be reached in 2008 rather than in 2012. However, despite this dilemma, the Kyoto Protocol contained the strange provision obliging countries to reach a target in 2008-2012!

In preparation of the Kyoto Conference, the US Senate passed the Byrd-Hagel[b] resolution in June 1997 with a unanimous vote, asking the Clinton-Gore Administration not to adhere to any climate protocol that would be decided at the COP-3. This resolution stated that:

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[a] Parties means signatory parties to the Convention.

[b] Chuck Hagel is a Republican nominated Secretary of Defence by Barack Obama, but he remained only shortly in this position. Obama called him a 'true patriot' and said, '*you've always been guided by one interest: what you believe is best for America*.'… This is a rare compliment for a sceptic of climate change.

(1) The US should not be a signatory to any protocol to, or other agreement regarding, the UNFCCC of 1992, at negotiations in Kyoto in December 1997, or thereafter, which would:

(A) mandate new commitments to limit or reduce GHG emissions for the Annexe I Parties, unless the protocol or other agreement also mandates new specific scheduled commitments to limit or reduce GHG emissions for Developing Country Parties within the same compliance period, or

(B) result in serious harm to the economy of the United States; and,

(2) any such protocol or other agreement which would require the advice and consent of the Senate to ratification should be accompanied by a detailed explanation of any legislation or regulatory actions that may be required to implement the protocol or other agreement and should also be accompanied by an analysis of the detailed financial costs and other impacts caused by the implementation of the protocol or other agreements on the economy of the United States.

The message was clear, bipartisan, and unanimous. This included the Democrats in substance telling Al Gore, ‘You can travel to Kyoto but do not come back with a US commitment on climate change.’ Considering the opposition expressed in the Byrd-Hagel resolution, and despite Al Gore being a champion of the climate change fight, the Clinton-Gore administration did not submit the Kyoto Protocol to the Senate for ratification. In conformity with the Constitution, the resolution was thus not binding for the US. During the Georges W. Bush Administration, green NGOs continuously criticised the President for not submitting the Kyoto Protocol for ratification, although his predecessor was not criticised for the same behaviour. In 1997 and the following years, the Kyoto Protocol was presented as a success, but history demonstrated that it was indeed an unsuccessful agreement, the promises were not met; though, no communication was made on this failure.

Box 4-3 Kyoto success?

The Kyoto Protocol, adopted the 11 December 1997 at the COP-3, was presented as a major step towards the mitigation of climate change, raising great fervour[a]. However, it has been a total failure. Even more, its pale results have not been widely presented because there was nothing to be proud of. Countries–particularly the EU Members States–engaged on a significant CO_2 reduction, but they have been unable to deliver.

Figure 4-5 Kyoto objective and results

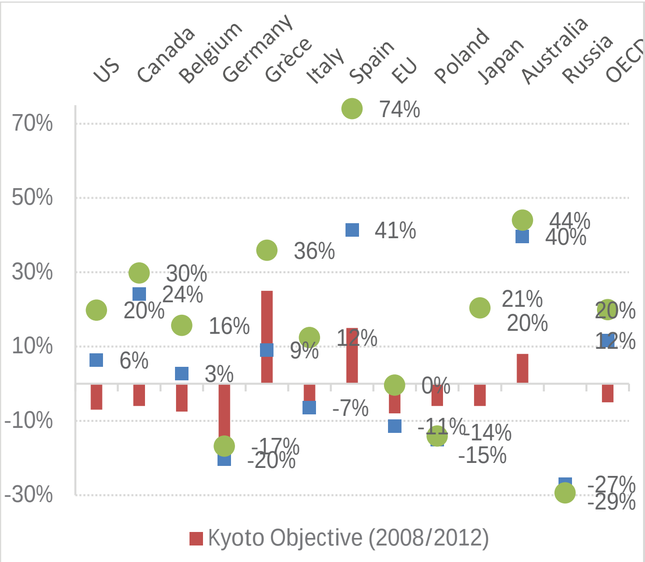

Figure 4-5 is loaded with much information, but it is necessary and interesting to evaluate the Kyoto Protocol results. The bands indicate the accepted objectives of CO_2 reduction in the framework of the Kyoto Protocol by a set of countries. The square markers mark the results in 2012. Optimistically, one can try to deduct that some results have been reached. However, the circle markers indicate the result in

[a] The author has participated to the preparation to the Kyoto Protocol negotiation.

2007, the year just before the subprime crisis. The gap with the objective was huge, demonstrating that the partial success of the Kyoto methodology was not due to the policy adopted by the EU Members States to reduce emissions, but by the effect of the crisis. Without the crisis, not one country would have reached the Kyoto Protocol objectives. It is not irrelevant to observe that the objectives were due to be reached by ’2008-2012’; this strange range was the result of a compromise: NGOs wanting to ‘immediately’ reach ambitious results, a strategy still in force today, while the Parties to the UN Convention were more prudent. Both have been successful thanks to this odd reference year range of ’2008-2012,’ as if in 1997 it was plausible to envisage such a huge reduction.

4.2.2 COP-15, Copenhagen – a great disappointment

The COP-15 in Copenhagen was a great disappointment. In December 2009, the world met in Copenhagen to decide the future of the planet – nothing less – as stated by environmental NGOs. The EU prepared its negotiation position: a 30% reduction of greenhouse gas emissions by 2020 as compared to 1990 levels, provided that a general international agreement would be reached, otherwise a unilateral reduction of 20%. Contrary to COP-3, COP-15 invited Environment Ministers and also heads of Government. Even President Barack Obama was present for a few days; he tried to reach agreements but failed. From the EU Member States, the most active were the UK PM Gordon Brown and the French President Nicolas Sarkozy. COP-15 raised great hopes, but those hopes became a huge disappointment. Governments tried to minimise the failure, but during the following COP in Cancun it was impossible to hide the failure, the new refrain was ‘after the failure of Copenhagen’.

What were the reasons for this fiasco, despite plenty of media pressures?

- Back in September 2009, most people thought that it would be possible to get an agreement, although the negotiation papers contained too many square brackets[a]. The meeting took place because it was impossible to postpone it, but the various positions were divergent.

- Expectations were excessive. ENGOs and the media had insisted that a drastic reduction of GHG emissions was possible. This did not prove to be true.
- The heads of Government realised that climate change policies would strongly impact economic and social activity negatively. In Kyoto, reaching an agreement was easy since the conference was attended only by environment ministers and green activists who shared the same ideas. In Copenhagen, the Heads of Government had to integrate all aspects of climate policies.
- Contrary to the Kyoto Protocol, the burden had to be shared between developed and developing countries, the difference in their obligations termed the so-called firewall. China alone consumed as much coal as the USA, EU, Russia, Japan and Korea combined. How could the country cut its coal consumption to reduce its GHG? Developing countries were not ready to agree to the same commitments as rich countries in terms of sustainable development (see Maslow's theory Section 3.4.3.).
- Many politicians claimed that the issue went far beyond climate change i.e. some of them wanting to use the opportunity presented by this COP-15 to change society. The former Bolivian president, Evo Morales, blamed capitalism directly for climate change: '*The real cause of climate change is the capitalist system. If we want to save the earth, then we must end that economic model. Capitalism wants to address climate change with carbon markets. We denounce those markets and the countries which [promote them]. It's time to stop making money from the disgrace that they have perpetrated*'[89]. These claims may be legitimate, perhaps even honourable, but it is better to play fair and not

[a] In preparation papers, sentences that have not reached an agreement are written within square brackets.

exploit climate catastrophism in favour of Marxist ideas; don't try sneak Karl Marx back in through the window when others kicked him out through the front door.

Several months before the Cancun COP-16 the various chancelleries knew that this meeting was not going to produce real results. Therefore, unlike in Copenhagen, heads of state did not attend. Indeed, they did not attend another COP until COP-21. Again, to reverse the image, Cancun was presented as a success. A Belgian vice president dared to call it a 'historic success'! The 30-page document adopted in Cancun was a list of nice phrasing but nothing else[90, a].

4.2.3 COP-21, Paris – a renewed hope

The next important COP was the Paris gathering in December 2015. The COP-21 was well prepared to avoid a repetition of the failure of the COP-15. Mr Ban Ki-moon, the Secretary General of the UN, declared, '*After Copenhagen, many world leaders believed that the United Nations process would no longer work for tackling climate change. This was deeply disappointing and painful*'[91].

To ensure success, France activated its wide and efficient diplomatic service (the second largest worldwide); France's diplomats met and negotiated with the 196 members of the COP before their trip to Paris. This led to collective success. The Encyclical Letter of Pope Francis, *Laudato Si*[92], also contributed to paving the way for the adoption of the Paris Agreement. The entire French media cooperated – *ad nauseam* – to this fabulous mobilisation. With lyricism, the COP-21 was considered the equivalent of 'The Universal Declaration of Human Rights' of 1948. Contrary to Copenhagen, the French Presidency avoided the presence of heads of Governments at the conference's end, thus, avoiding being confronted to a possible failure like

[a] For a complete analysis see 'A Cancun è nata una nuova politica energetica?' by Samuele Furfari.

Copenhagen. One hundred and fifty of them were invited to the opening to stimulate the negotiations, then they left Paris.

Laurent Fabius, the French Foreign Affairs Minister and Chairman of the COP-21, played a key role to reach the agreement. In confession-type bilateral meetings with all the delegations, he cut deals without showing any negotiators the final text. In an original approach in the COPs, including with the *savoir-faire* of the French cuisine, he avoided the deterioration of the atmosphere; the Presidency did not release the final text before the final session when President François Hollande was on the stage alongside Fabius and claimed with boldness that there was a deal. With all due respect to the Danes, this would have not been possible in Copenhagen. Although, President Hollande needed, for internal purposes, a big international success and did get it, the euphoria, and even the emotion of Laurent Fabius, at the end of the conference is a demonstration that he knew that failure was also an option (this was the reason to prevent the presence of the heads of Governments). The EU played a large role behind the scenes for the success, with a key role played by the climate change Commissioner Miguel Arias Cañete.

However, the price to avoid failure was high. The Paris Agreement[93] is a catalogue of good intentions but without any obligations. It remains to be seen whether the implementation will deliver more effective results than the Kyoto Protocol. As for the latter, the Paris Agreement's entry into force was governed by rules agreed to by the UNFCCC Parties. These rules stipulate that at least 55 Parties to the Convention, accounting for at least an estimated 55% of the total global greenhouse gas emissions, have deposited their instruments of ratification.

The Paris Agreement aims to strengthen the global response to the threat of climate change, in the context of sustainable development and eradication of poverty. Strangely enough, the Paris Agreement never mentions CO_2 but refers only to GHG, probably because it is easier to limit all GHG than sole carbon dioxide. For that, inter alia, it aims at holding the increase in the average global temperature to 'well below' 2 °C above pre-industrial levels and to '*pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels*', recognising that this would significantly reduce the risks and impacts of climate change. The mention of 1.5 °C was a necessary condition to get the agreement of the Alliance of Small Island States (AOSIS[a]) (like Tuvalu and the Marshall Islands).

Article 4.4 states that '*parties aim to reach global peaking of GHG as soon as possible, recognising that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter. Developed country Parties should continue taking the lead by undertaking economy-wide absolute emission reduction targets*.' The Parties are free to determine their emission reduction plans; they are immune from challenges by other governments or international mandate. Contrary to the Kyoto Protocol, developing countries are now involved in the mitigation effort. They '*should continue enhancing their mitigation efforts and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances*'. However, for them, there is no mention of 'absolute emission reduction'. Developing countries, led by China and India, would refuse a reduction of their emissions, because they could not afford holding back their economic growth by decreasing their fossil fuel consumption.

4.2.4 Is the Paris Agreement binding?

Is it a binding agreement? It depends on what you are talking about. The document agreed in Paris contains 141 uses of 'shall' and 41 uses of 'should'. However, the difference of 100 between them is not enough to say that it is binding. Qualitative analysis

[a] AOSIS is the small island organisation whose members or observers are from Africa, the Caribbean, the Indian and Pacific Oceans, the Mediterranean and the South China Sea. They have come together because they believe they are vulnerable to rising sea levels, which they attribute to climate change. The number of their inhabitants is less than 1% of the world population.

is more important than a quantitative one to determine whether it is binding or not. Most of the uses of 'shall' refer to administrative obligations of the parties (submitting reports, or the functioning of subsidiary bodies, or procedural actions). There are also a few uses of 'shall' to ensure flexibility. Inversely, the uses of 'should' are referring to the agreement's substance. Yet, this agreement, once it enters in force, will be binding for the signatories.

However, there is no supranational jurisdiction able to sentence a non-fulfilling party, and there will not be before long such legal court. During the COP-21 preparation, there was a tentative notion to create an 'International Climate Justice Tribunal', a particular jurisdiction for climate change. Buried in page 19 of the 34 pages of an official document[94] this proposal, although still bracketed, was removed by John Kerry, US Secretary of State, who a few weeks before the Paris conference had warned that talks could not deliver a 'treaty' legally requiring countries to cut their CO_2 emissions.

He was perfectly right. There is no obligation for any party to the Paris Agreement to cut their emissions by a value. The only mention of the word 'target' is in Article 4.4 quoted here above.

Long before the Paris Conference, the Obama-Biden Administration made it clear that trying to impose a target would inevitably lead to the failure of the conference. They asked for 'a new narrative' that would please ENGOs and policymakers without jeopardising the world economy. However, there was a last-minute incident. Either purposely or mistakenly Article 4.4 mentioned that '*developed country Parties shall continue taking the lead by undertaking economy-wide absolute emission reduction targets*' while in the previous draft the verb was 'should'. This was crucial because 'shall' implies a legal obligation and 'should' does not. John Kerry explained that '*when I looked at that, I said, we cannot do this and we will not do this, […] whether it changes, or President*

Obama and the United States will not be able to support this agreement.
'95, a

Parties are requested to communicate their 'Intended Nationally Determined Contributions' (INDC). The word 'intended' is there intentionally because there is no obligation to reach the 'contribution' to reduce emissions. The COP-21 'notes with concern' that the submitted contributions lead to a projected emission level of 55 Gt of GHG (not only CO_2 and this makes a great difference) by 2030, which according to the IPCC will result, in an increase of 2.7-3.0°C, whilst for limiting the increase to 2° C emissions should be reduced to 40 Gt. There is a large gap between the expected 'contribution' and the 'suitable target'.

Table 4-1 shows that only the EU has a serious engagement even if it remains to be seen if it will be achieved by 2030. Japan's engagement of 25% reduction can give the illusion that it is ambitious, but it is not the case because its reference year is 2013, the year in which Japan was producing its maximum CO_2 emissions because all nuclear plants were out of operation following the Fukushima accident. Compared to the EU, in 2030 Japan will have an advantage of 30 points… (Figure 4-6). The fact that each party to the convention can even select its reference year demonstrates how ineffective the Paris Agreement is.

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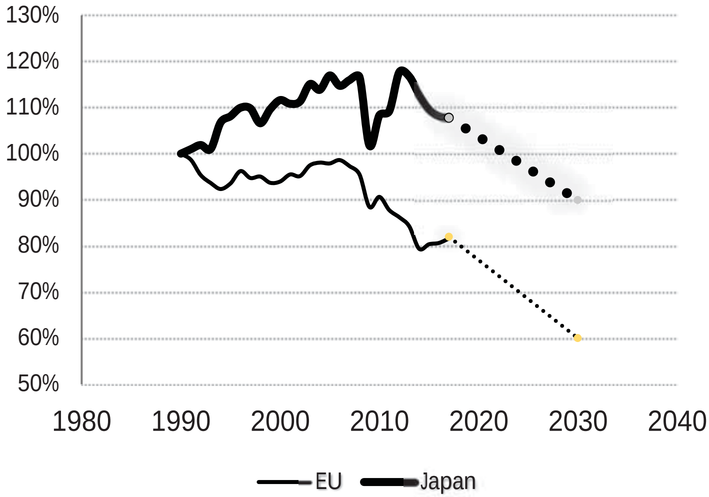
[a] Nicaragua was refusing this change; personal interventions of Barack Obama and Raúl Castro were necessary to save the agreement.

Table 4-1 Engagement by parties in the framework of the Paris Agreement

Country	INDC	From year
EU	- 40%	1990
Japan	- 25%	2013
S. Korea	-37%	?
Australia	-26 / 28% Fall of PM Turnbull and election of a new government unfavourable to the Paris Agreement	2005
Russia	25-30% might be a long-term indicator, subject to the maximum possible account of absorbing capacity of forests	1990
Iran	-4%	./. BAU
India	to reduce the emission intensity of its GDP by 33 to 35%	2005
China	Stop growth around 2030	
USA	Left the Agreement	

Figure 4-6 Japan and EU CO_2 emissions to reach the reduction objective for 2030



A provision imposed by a coalition of developed countries and the AOSIS would have obliged the governments to revise their emission-reduction plans in 2023 and every five years thereafter. The phrasing in Article 4.2 (‘*Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions*’) is sufficiently vague not to oblige a party to further reduce its ‘contribution’. Furthermore, the word ‘transparency’ appears 31 times in the agreement. This indicates data are not always reliable, either because measurements are complicated or there are no common reporting rules; not all Parties correctly report their data.

In the Paris Agreement[96], the only sentence mentioning energy is the following and it is in the Preamble: ‘*Acknowledging the need to promote universal access to sustainable energy in developing countries, specifically African ones, through the enhanced deployment of renewable energy*.’ The Paris Agreement aims at reducing GHG emissions, but it does not explicitly state what should be done: energy remains a topic so close to national political power that the COP-21 has been unable to explicitly promote specific energy means.

Before the conference, the draft document stated that the air and maritime transport sectors should ‘*pursue the limitation or reduction*’ of emissions, ‘*to agreeing concrete measures addressing these emissions, including developing procedures for incorporating emissions from international aviation and marine bunker fuels into low-emission development strategies*.’ However, the word ‘transport’ does not appear at all in the Paris Agreement, not even in the Preamble. This confirms that air transport and maritime transport are excluded from any measures to be taken within the agreement. Shipping and aviation are regulated by separate United Nations organisations, the International Maritime Organisation (IMO) and International Civil Aviation Organisation (ICAO), and are not formally part of the COP agreements. Aviation and shipping are responsible respectively for 5% and 3% of the world’s CO_2 emissions. Note the incongruity of the Marshall Islands, a Pacific country made up of over 1,100 lowlying islands and about 53,000 inhabitants, claiming that the islands are at the risk of disappearing under rising oceans, whilst being the world's third-largest ship registry, after Panama and Liberia. The IMO requires that ships built in 2025 should be 30% more energy efficient than those of 2015. However, thanks to LNG (Liquid Natural Gas), solutions are already being prepared for improving energy efficiency and reducing CO_2 emissions in the maritime sector (see Volume 2). For aviation, ICAO plans to adopt a new CO_2 certification standard.

Another excluded sector of the Paris Agreement is food production, which in the context of efforts for eradicating poverty, should not be threatened with energy restrictions.

4.2.5 The Green Fund

The Green Climate Fund is a fund decided upon at the COP-16 to assist developing countries in adaptation and mitigation practises to counter climate change. As requested in the Cancun mandate (COP-16), the Paris Agreement also contains provisions to transfer massive funds from rich countries to poor countries. The agreement "*strongly urges developed country Parties to scale up their level of financial support, with a concrete roadmap to achieve the goal of jointly providing USD 100 billion annually by 2020 for mitigation and adaptation whilst significantly increasing adaptation finance from current levels and to further provide appropriate technology and capacity-building support; […] before 2025 the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall set a new collective quantified goal from a floor of USD 100 billion per year, taking into account the needs and priorities of developing countries*".

The nature of these funds is not specified; are they gifts or loans, and in the case of loans, with or without interest? The agreement does not specify the origin of this huge annual amount: should it come from the governments of the developed nations, or private funds, or taxes? All of this is open. Usually, however, these types of UN promises are not respected. Some opponents consider that although these policies are costly even for developed countries; ultimately, it will be money withdrawn from taxpayers. The late prof Istvan Marko said, '*Who are the losers? The poor in rich countries. Who are the winners? The rich in poor countries*'[97].

However, there is no mention of carbon pricing with the exception or recognition that it is a tool of domestic policy for the non-Party stakeholders. This is surprising because during the months leading up to the COP-21 there was strong pressure from many climate defenders to introduce a carbon price; even the major EU electricity companies and some other energy industries favoured this policy. James Hansen, a former NASA scientist who strongly contributed to initiating the science of climate change, called the Paris Agreement 'a fraud, a fake'[98]. He insists that there be no action and only promises. He is personally convinced[99] that only an increase of the carbon price, the introduction of a fee, can limit its production. The Paris Agreement does not mention this point at all.

Like in the Kyoto Protocol, Article 6 of the Paris Agreement allows the Parties to engage voluntarily in cooperative approaches that use internationally transferred mitigation outcomes towards nationally determined contributions and ensure environmental integrity and transparency and shall apply robust accounting to ensure the avoidance of double counting. According to this article, the EU and its Member States shall set up and maintain registries to accurately account for internationally transferred mitigation outcomes[100].

The Paris Agreement also recognises the importance of adaptation; calling on the parties to increase their ability to adapt to adverse impacts of climate change and foster climate resilience. i.e. the fund is for mitigation, and also for adaptation.

The Paris Agreement does, indeed, mark a historic turning point. It appears that it saved the 'hope' possibility. It also appears that the new climate regime, emerging from the Paris negotiations, is rather about 'sharing opportunities', not 'sharing burdens'; this is also confirmed by the nomination of the new chairman of the IPCC, Dr Hoesung Lee, perceived as more pragmatic and less ideological than the previous IPCC leadership. Eighteen years after the Kyoto Protocol, climate change activists needed to perceive the Paris Agreement as a success. They called it universal and historical although it only remains a framework. Activists do hope that the binding could be imposed by a strategy of 'name and shame' by civil society, i.e. the environmental NGOs[101]. Months before the COP-21, Ban Ki-moon warned that Paris was not the final destination but a step and that it was the beginning, 'I am, therefore, optimistic'[102]. This is also what climate activists believe; their position can be summarised by stating that the Paris Agreement avoids the catastrophe of a 5 °C surge but does not prevent the predicted disaster of a 3 °C rise.

4.3 The EU's policy and Emission Trading Scheme (ETS)

The EU was dedicated to climate change policies from the start. In December 2019, the European Commission and the European Council make critical decisions to address climate change. They called that strategy the 'Green Deal'. This will be analysed in Volume 3.

Carlo Ripa di Meana was the European Commission's Energy Commissioner in 1992 when the UN launched the UNFCCC. He was committed and, before the Rio Conference, together with Jacques Delors, President of the European Commission, proposed for an EU energy-carbon tax; jointly they proposed to stabilise the CO_2 emissions at the level of 1990 by 2000. Ripa di Meana declared that '*my work over the previous three years has been positioning the European Community as an environmental policy leader. But at the last moment, Kohl, Gonzales, Major, Mitterrand and Delors, eager not to isolate Bush, decided to bury this proposed European tax, which would have combated climate change at the macro* *level. Delors went to Rio but was not given the floor'*[103]. France was also opposed to this macro-level proposal because it would also have taxed nuclear energy; France's position was 'You do not tax lemonade to fight against alcoholism'. A few years later, the opposition of the Members States obliged the European Commission to withdraw its energy-tax proposal. Several years later, Carlo Ripa di Meana changed his opinion on climate change. He became a sceptic and contributed to diffuse this position[101].

In 2007, during the EU German Presidency[a], Mrs. Merkel asked the European Commission to prepare a roadmap for the promotion of renewable energy and to mitigate climate change. The Commission issued its package on climate change and energy, which, pushed by the dynamism of Nicolas Sarkozy during the France Presidency, was adopted in record time. A timely target had been set to be tabled at the Copenhagen COP as the EU negotiation position (Table 4-2). There were two major instruments for delivering this target, the promotion of renewable energy, which will be covered in the specific chapter on renewable energy, and the so-called Emission Trading Scheme (ETS), a carbon market for limiting emissions of pollutants, whilst providing economic incentives.

Table 4-2 Climate change EU objectives

Year	Policy	Target date	Objective
1992	Rio de Janeiro Earth Summit	2000	Stabilisation
1997	Kyoto Protocol	2008-2012	-8% CO_2
2009	Energy and climate package	2020	-20% CO_2
2014	Energy and climate package	2030	-40% CO_2
2020	Green Deal	2050	Carbon neutrality

[a] First semester of 2007.

Jos Delbeke, a European Commission official, introduced the EU ETS scheme. He successfully proposed a B2B trading scheme based on successful similar experiences in the US for the ‘ozone hole’ and the ‘acid rain’ issues. In the 1990s, the USA’s chemical companies created a scheme to phase out of CFCs[a]. The reduction of CFCs was possible since there were other chemicals for the same purpose. For the US chemical industry, it was only a matter of economic efficiency whether plants producing CFCs should be closed and when. Similarly, the US 1990 Clean Air Act set up an ETS scheme limiting the emissions of SO_2 and NOx.

Buying ‘pollution rights’ from non-polluting companies made economic sense for certain companies since it would keep their power plants operating. Progressively, these old polluting plants were phased out and the ETS scheme was not any longer required. These market successes were possible because alternative ‘other solutions’ existed (shifting to low-sulphur coal, installing scrubbers in existing or new plants). Unfortunately, for CO_2 mitigation, these cheap and efficient solutions do not exist, there are no such alternative solutions. The ETS for the CO_2 mitigation was erroneous from its foundation.

The EU CO_2 ETS operates according to the ‘cap and trade’ principle. A ’cap – i.e. a limit – is set on the total emission of certain GHG by the factories, power plants and other installations in the system. The cap is reduced over time for total emissions to fall. In 2020, emissions from sectors covered by the EU ETS should be 21% lower than in 2005. By 2030, the Commission proposes, they should be 43% lower. Within the cap, companies receive or buy emission ‘allowances’ which they can trade as required. They can also buy limited numbers of international credits, Clean Development Mechanisms (CDMs), from emission-saving projects around the world. The limit on the number of available allowances ensures that they represent market value.

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[a] CFC are chlorofluorocarbons substances used in refrigerators, destroying ozone in the higher atmosphere.

A company must yearly surrender enough allowances to cover all its emissions, or otherwise incur heavy fines. If a company reduces its emissions, it can keep the spare allowances to cover future needs or else sell them to another company short on allowances. The flexibility that trading brings ensures that emissions are cut where it is most economical. By putting a price on carbon and thereby giving a financial value to each saved ton of emissions, the EU ETS placed climate change on the agenda of company boards and their financial departments across Europe. A sufficiently high carbon price also promotes investment in clean, low-carbon technologies. In allowing companies to buy international credits, the EU ETS also acts as a major driver of investment in clean technologies and low-carbon solutions, particularly in developing countries.

Long-time economic calculations indicated that to achieve the original objective of profoundly altering the use of fossil fuels, the EU ETS trading price needs to be well over €40/t CO_2. Unfortunately, for various reasons, including the fact that the Member States were authorised to fix their permit allocation from 2005 to 2012, and most of them provided to be generous free allocations, the market price was never anywhere close to this level. Furthermore, as allowances do not expire, electricity producers bought up huge reserves of permits at knockdown prices.

Similarly, at its meeting of October 2014[104], the European Council endorsed a binding EU target of at least 40% domestic reduction in GHG emissions by 2030 as compared to 1990. To that end, the target would be delivered collectively by the EU in the most cost-effective possible manner, with reductions in the ETS and non-ETS sectors amounting to 43% and 30% by 2030 compared to 2005, respectively; all Member States would participate in this effort, balancing considerations of fairness and solidarity.

The novelty is that contrary to the climate/energy package of 2009 the 2014 package does not fix specific targets for the Member States. In other words, the EU has an ambitious objective, but we do not know who will be delivering the reduction. Furthermore, the expression '*in the most cost-effective manner possible*' illustrates that the Member States are worried about the cost of reaching the objective.

The EU Council of October 2014[102] confirmed that the Emissions Trading System (ETS) will be the main EU instrument for achieving this target. To avoid carbon leakage, the Council agreed that free allocations by National Governments will not expire; present measures will continue after 2020 to prevent the risk of carbon leakage due to climate policy, as long as no comparable efforts are undertaken in other major economies, with the objective of providing appropriate levels of support to sectors being at risk of losing their international competitiveness.

4.4 Technology and CO_2 emissions

The main GHG is carbon dioxide. Methane[a] is an even more powerful greenhouse gas than CO_2, however, its longevity in the atmosphere is shorter and therefore, its emissions are not a worrying issue. Since we deal with energy, we set aside the other chemical greenhouse gases. We, therefore, concentrate our analysis only on the CO_2 emitted by fossil fuels. Globally, the CO_2 emissions are generated by about 40% by oil, 40% by coal, and the remaining 20% by natural gas. Consequently, it appears logical that the environmental movements focus their actions on coal-fired power plants and the automotive transportation sector.

[a] Methane in the energy sector may escape from oil and gas fields, during exploration, production and transport. Agriculture is also a large source of methane emissions either by the fermentation of rice in a paddy field or by the belching of ruminants.

Figure 4-7 World CO_2 emission by fuel

2013 US EIA data

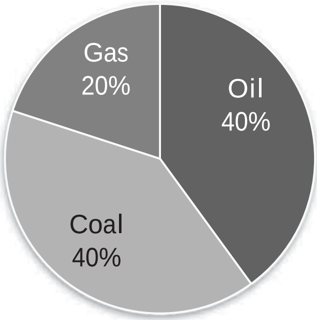
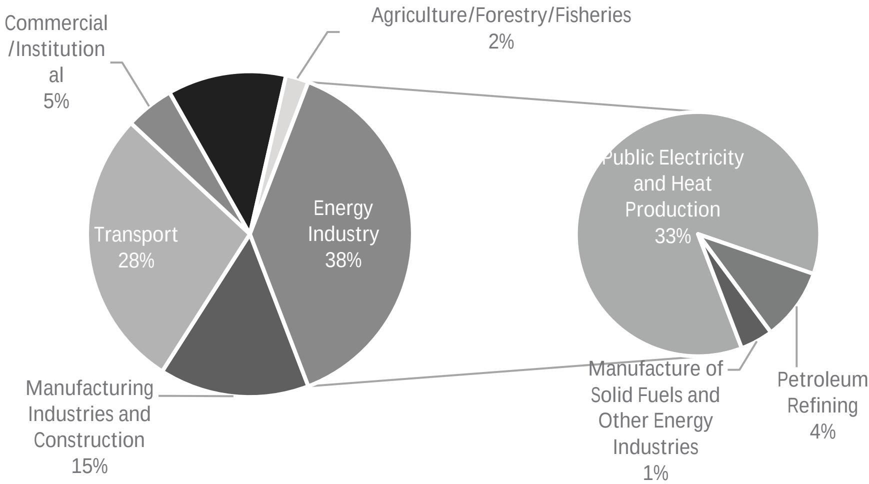


Figure 4-8 presents the sectors contributing to the emissions of GHG. Agriculture appears in this graph because it is a sector emitting methane. However, regarding energy consumption, farming is trivial (only 2%, including the fishing industry). Electricity generation, oil refineries, and industry represent nearly half of GHG emissions. One third is due to household and service sectors, i.e. ‘you and me’ directly.

Figure 4-8 GHG emissions in the EU by sectors

Eurostat 2018 data



The emissions of CO_2 produced by the energy sectors respond to the following logical formula:

$$CO_2 = \left(People \quad x \quad \frac{GDP}{People} \; x \; \frac{Energy}{GDP} \; x \; \frac{CO_2}{Energy}\right) - storage \quad (ccs\ ;\ trees)$$

Table 4-3 CO_2 mitigation policies and main influencing actors

Policies	**Actors**				
	Personal choice	Rational	Technology	Market	Government
People	✓		✓		✓
Growth			✓	✓	✓
Energy intensity	✓	✓	✓	✓	✓
Carbon intensity			✓	✓	✓
Storage			✓		✓

Practically, emissions are not calculated with this formula, but it helps to understand why we have a major difficulty with CO_2 mitigation. Table 4-3 indicates the actors that could implement these mitigation policies.

- The first element of this equation is the population. Human activities require energy, and therefore, the more people there are on planet Earth, the more energy will be required. Birth control is a personal choice, but more often – and effectively – it could also be government policy.
  - China uses this argument in COPs, claiming that with their birth control policy they effectively limited the emissions of CO_2.
  - The UK Government has used £166 million from its climate change budget to support the sterilisation of Indian women to curb the Indian population[105].
  - Barry N. J. Walters, Clinical Associate Professor of Obstetric Medicine wrote a '*Baby Levy in the form of a carbon tax should apply, following the "polluter pays" principle. Every family choosing to have more than the defined number of children (sustainable*

population in Australia suggests a maximum of two) should be charged a carbon tax for funding the planting of enough trees to offset the carbon cost generated by a new human being'[106].

- o Yves Cochet, French Green policymaker, has proposed to limit the family support from the third child onwards. The popular Captain Cousteau stated something similar[a,107]. Hysteria in the EU is pushing young people to sterilise themselves to avoid having children[108].

- The second element of this equation is the size of the yearly Growth Domestic Product (GDP) expressed per capita i.e. the Domestic Product is related to the per capita energy consumption. Some environmentalists recognise that economic growth is only possible with increased energy consumption and, accordingly, they aim for de-growth of the economy. GDP is influenced by technology evolution, market efficiency and government policies.
- The third element concerns energy intensity (see Section 2.2.2). Energy efficiency will be elaborated in the last chapter of Volume 2. Energy efficiency can be improved by personal choice, rational choice, technological progress, market efficiency and government policies. Energy intensity is a policy influenced by many factors.

Box 4-4 The market is efficient for CO_2 mitigation

CO_2 is the exhaust gas of life's exhaust pipe. Nobody has an interest in emitting CO_2, it is a by-product and not an objective. In a competitive economy, it is essential to limit production costs and hence to limit energy consumption, ergo, to limiting

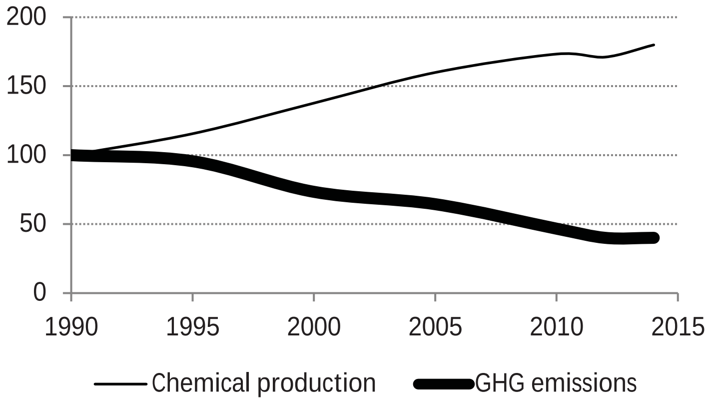
[a] According to Luc Ferry[100] 'It's terrible to have to say this. World population must be stabilized and to do that we must eliminate 350,000 people per day. This is so horrible to contemplate that we shouldn't even say it. But the general situation in which we are involved is lamentable.' However, Cousteau added, 'we certainly should control our population, but not by violence or by eugenics: but by improving the poor's standard of living and especially through education'.

CO_2. Since there is no incentive to directly limit CO_2, sometimes market failures occur because it is not economical to replace an inefficient plant by a more efficient one. If this can be true during a certain time in an open, plane level-field and economic market, this could not be the case for long, and therefore, the industry will make all efforts to be efficient, reducing its emissions at the same time. This is a fact; it is not speculation or wishful thinking.

Let's illustrate that with an example. The chemical industry in Europe has a strong track record in energy and CO_2 efficiency as illustrated by Figure 4-9. Compared to 1990, in 2014 the production has increased by 76% while the greenhouse gases have decreased by 60%. This demonstrates that the quest for energy efficiency is a powerful instrument to reduce CO_2 emissions. It is probably the only rational instrument to curb CO_2 emissions.

Figure 4-9 Chemical production and greenhouse gases

Data of CEFIC based on EEA[109]



- The fourth element is carbon intensity (see 2.2.3) which depends on the energy used. Nuclear energy and renewable energy such as hydropower practically produce zero emissions. This will be developed respectively in chapters 10 and 12.
- Finally, when it is impossible to limit the emissions of CO_2 it is possible to sequestrate or store these emissions. Carbon Capture and Storage and planting trees are policies that depend on technology and government policies.
    - From 1990 to 2010 the forest area in the EU increased by 8.4 Mha (84,000 km²) the size of Austria[110]. According to Eurostat, EU-28 forests gained 322,800 hectares yearly. To visualise this growth, European forests are increasing by the size of a football field every minute. With the increase of forests and other land-use changes in the EU, more CO_2 was removed from the atmosphere, equivalent to 7% of total emissions.

Globally it appears that the policy encompassing most actors is the energy intensity improvement, and the actions impacting the more are technological development and government decisions. Therefore, in this book, we insist on technological development and on the role of policymakers.

4.4.1 CO_2 emissions of energy types

However, CO_2 emissions from energy are an ongoing subject of discussion between defenders of each energy type. Regularly, opponents of nuclear energy state that this energy is not so CO_2 neutral when the complete cycle of uranium is considered (see Volume 2). Reversely, fossil fuels defenders state that wind power turbines are not so clean due to the rare metals needed for the motor, and the huge quantity of concrete necessary to anchor the pylon to the soil or solar PV panels because they need pure silica, or because they are built in China using electricity generated from coal. The Table 4-4 should be regarded as a good proxy, for at least giving a broad idea. The bottom-up calculations are hazardous, and their results are to be taken as first approximations to only compare relatively the merits of each source of power generation. According to the IPCC [111] hydropower and nuclear energy have the lowest emissions, but there is no mention that both additionally have the great advantage that they operate continuously[a].

Geothermal steam generation also emits CO_2 from the underground. In the case of the most famous geothermal production in the EU, according to prof Riccardo Basosi[b], in Lamiata (Larderello, Tuscany), the emissions are 380-1 045 g CO_2 eq./kWh [112]. Therefore, the EU legislator is limiting the development of this renewable energy (see electricity chapter in Volume 2).

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[a] Other renewable energy production, such as wind and solar power is intermittent and needs backup power (see renewable energy chapter in Volume 2). Wind turbines do not operate with wind speeds that are too low or too high and solar does not operate around the clock. When wind or solar power generators stop, the power network requires back up power to prevent blackouts. This backup power is normally generated by standby gas turbines or other non-intermittent power generating units such as coal or hydropower, for up to 75 % of the time. For solar and wind power generation, Life Cycle Emissions should include emissions from backup power generation as calculated below. Wind and solar produce power intermittently, during about 25% of the time, and backup power is therefore needed 75 % of the time. With gas turbines providing necessary backup power, the total life cycle GHG emissions assessment for wind and solar required backup power would be as follows (for the 50th percentile): Wind power: 12 x 0.25 +469 x 0.75 = 3 +352 = 355 CO_2 eq/kWh and for solar PV power: 46 x 0.25 + 469 x 0.75 = 12 + 352 = 364 CO_2 eq/kWh.

[b] Prof Ricardo Basosi teaches thermodynamics at the University of Pisa.

Table 4-4 GHG emissions of Life Cycle Assessment for electricity generation technologies

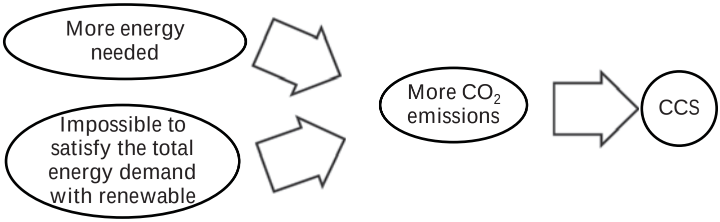
g CO_2eq/kWh, Source IPCC[109]

Values	Minimum	25th percentile	50th percentile	75th percentile	Maximum
Biopower	-633	360	18	37	75
Solar PV	5	29	46	80	217
Solar CSP	7	14	22	32	89
Geothermal energy	6	20	45	57	79
Hydro-power	0	3	4	7	43
Ocean Energy	2	6	8	9	23
Wind Energy	2	8	12	20	81
Nuclear Energy	1	8	16	45	220
Natural Gas	290	422	469	548	930
Oil	510	722	840	907	1,170
Coal	675	877	1,001	1,130	1,689

4.4.2 Carbon capture and storage–CCS

Carbon capture and storage (CCS) or carbon capture and sequestration is the process of capturing waste carbon dioxide from large emitting sources, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological place like, a reservoir rock. Since it will be impossible to avoid the use of fossil fuels during this century and therefore to limit the CO_2 concentration in the atmosphere, to decarbonise totally, CCS is promoted by policymakers in the EU. Practically, the coal-fired power sector was first targeted.

Figure 4-10 Decarbonisation needs CCS



Proponents of this solution now also consider applying CCS to gas-fired power plants and for carbon-intensive industries like iron and steel, cement, refining and chemical sectors. They also pretend that CCS complements the intermittent production of renewables (wind and solar power), since it provides flexible back-up capacity, contributing to the stability of the energy system. However, they underestimate the fact that CCS is mainly a chemical process and that a fundamental principle of chemical engineering is that flows must be smooth. Even if it is still only experimental, CCS appears to be a possible technical solution; however, its economic value must be further analysed and confirmed, which may be doubtful.

The principle of CCS is to concentrate the CO_2 contained in the fumes, transport it and dispose of it underground. The first step is based on a well-known chemical process. This is not a technically complicated solution, but it increases electricity generation costs. The transport of captured CO_2 is also banal. The real issue – besides the cost – is to find an appropriate geological structure close to the power plant for limiting transportation costs. These are not necessarily available close to existing or future power plants. The enthusiasm for CCS also pretends to create a network of CO_2 pipelines to collect the captured gas to transport it to a suitable site; they even propose to do that across Member States' borders. Noting the inexistence of solidarity on several issues this proposal must raise doubts. The process to capture CO_2 requires energy; thus, it reduces the global efficiency of the power plant by approximately 10%. The efficiency of a coal-fired power plant being about 50%, shrinking it to 40% is a great inconvenience which might oblige the burning of more coal and increase the price of the generated electricity as shown hereafter.

Furthermore, CCS is only technically feasible for large stationary power plants; one can hardly imagine capturing the CO_2 emitted by vehicle or even industrial and domestic boilers.

4.4.3 Capturing CO_2

Capturing CO_2 is a simple process in the chemical industry, but in a power plant it is more complicated by the fact that the combustion of fossil fuels is done with air, and the air is composed of 79% nitrogen and only 21% oxygen; therefore, the CO_2 is much diluted in the fumes. Furthermore, to ensure that a maximum of fuel is completely burned, a high air excess is injected into the furnace. Consequently, the CO_2 is highly diluted, with plenty of nitrogen and oxygen and its recovery is thus, more difficult. Capturing the CO_2 in these conditions is in principle not more complicated, but requires larger equipment, more energy and ultimately becomes more expensive.

There are three possible ways to capture CO_2 (Figure 4-12):

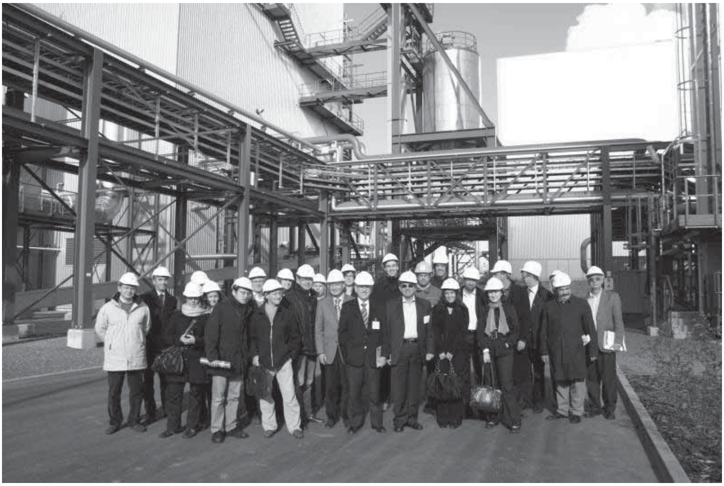
1. Post-combustion: amines[a], having the capacity to react with CO_2, absorb the CO_2 contained in the flue gas. In a second step, amines are regenerated by releasing CO_2, avoiding the loss of this compound. A more modern process concentrates the CO_2 through porous membranes. Since all these operations occur after combustion, the process is called post-combustion. Again, the process is complicated by the fact that the CO_2 is diluted in a large quantity of the nitrogen of the combustion air.
2. Oxy-combustion: To avoid the annoying low concentration of CO_2 in the flue gas, combustion does not

[a] Amines are organic compounds produced from ammonia that contain a basic nitrogen atom.

take place with air but rather with pure oxygen. Oxygen production is a common operation of chemical engineering, but for combustion with oxygen instead of air, the furnace requires special materials to resist these conditions. This solution provides the additional benefit of a drastic reduction (>90%) of the NOx emissions because there is no nitrogen in the combustion. However, the cost of the material for this furnace is expensive and therefore this way is practically abandoned.

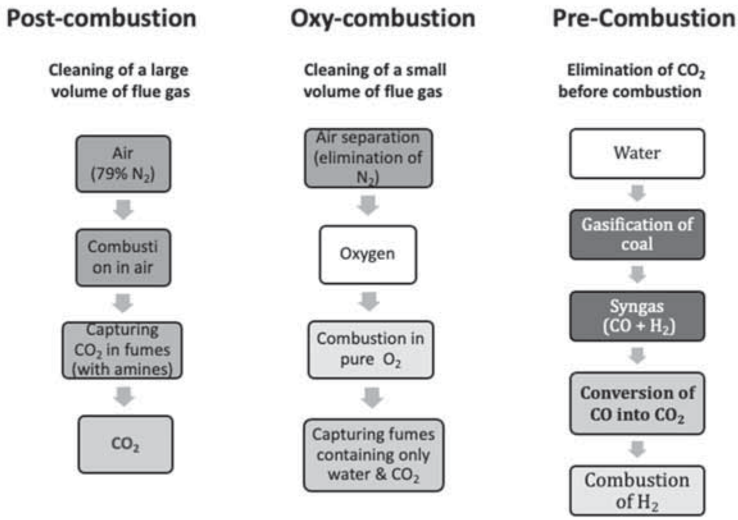
3. Pre-combustion through transforming fuel (in this case mainly coal) into synthesis gas as will be shown later in the IGCC technology (.

Figure 4-11 Visit of the European Energy Forum at the oxy-combustion at Schwarze Pumpe (Germany)



Once the CO_2 is eliminated from the fumes, it is transported to the geological site where it will be injected forever into the geological structure. Thus, a precondition for the development of CCS is to have the nearby geological conditions to sequestrate the carbon dioxide. This is impossible everywhere and, consequently, countries like Japan and South Korea are, for example, not at all interested in CCS.

Figure 4-12 Processes to eliminate CO_2 in flue gases



Box 4-5 The CCS EU dream

In March 2007 the EU Presidency tabled conclusions that give the illusion that CCS was becoming a reality because policymakers would decide to make it so. It said '*aware of the possible huge global benefits of a sustainable use of fossil fuels, the European Council […] urges Member States and the Commission to work towards strengthening R & D and developing the necessary technical, economic and regulatory framework to bring environmentally safe carbon capture and sequestration (CCS) to deployment with new fossil-fuel power plants, if possible by 2020; [the Council] welcomes the Commission's intention to establish a mechanism to stimulate the construction and operation by 2015 of up to 12 demonstration plants of sustainable fossil fuel technologies in commercial power generation*.'[113] Therefore, the EU has spent at least €587 million in grants, subsidies, and public procurement for at least 63 projects CCS, including smaller-scale grants and subsidies under EU scientific programme.

To ‘recover’ from the Subprime crisis, the European Energy Programme for Recovery (EEPR)[114], set up in 2009, committed €1.05 billion to 13 large-scale demonstration projects. But today the EU has zero CCS demonstration projects. The EU court of auditors issues as special report stating that ‘*intended progress not achieved in the past decade*’[115].

One of the 12 projects was ROAD, the Rotterdam Opslag en Afvang Demonstratieproject (Rotterdam Capture and Storage Demonstration Project) funded by the EU; it is one of the largest, integrated CCS demonstration projects in the world applied to a coal-fired power plant. Since the first half of 2012, the ROAD project has been slowed because of the financial gap caused by structural low carbon prices (EU ETS). In June 2017 the Dutch government reported that the two energy companies behind the ROAD project have pulled out.

The same can be reported for the other projects. Despite supportive EU regulations and co-funding, CCS did not develop as expected.

A 2013 consultation by the European Commission found that:

- whilst over 20 small-scale demonstration CCS projects are globally operating, none of them is in the EU;
- at current low carbon prices, companies do not have the economic rationale to invest in CCS;
- the cost of a first-generation CCS power plant is expected to be 60%- 100% above the cost of a similar conventional plant;
- the CCS cost is expected to decrease eventually because of research and development activities and building economies of scale

Pretending to be a decarbonisation leader, the European Commission has been most active in multilateral platforms such as the Carbon Sequestration Leadership Forum[116], alongside the UAE, and engaged bilaterally, for example with Australia on research, but also with other economies, such as China.

CCS is an EU contentious issue. Some industries and some environmentalists see it as a crucial tool to cut emissions immediately until the world adopts definitively cleaner technologies. Countries like Poland push this technology for enabling electricity generation by coal. Others worry that CCS would lower the pressure for abandoning coal electricity generation. Furthermore, the long-term safety of burying CO_2 underground is also doubted, CO_2 could eventually leak out of its storage, defeating the whole purpose of this expensive exercise. Since CCS is a potentially powerful CO_2 solution, the EU, in cooperation with some Member States and the private sector, has supported research, development and demonstration efforts aimed at advancing CCS technology towards commercial implementations.

In April 2009, during the G20 that took place in L'Aquila, following the earthquake of this Italian city, the Global CCS Institute (GCCSI)[117] was formally launched, as a not-for-profit entity, initially funded by the Australian Government over a four-year period. The Australian government coalition was at that time strongly in favour of climate change policies and since the country is a major fossil fuel producer, they believed that CCS could be a solution for climate change mitigation. With a team of almost 40 professionals GCCSI, an advocacy NGO, drives the adoption of CCS as quickly and cost-effectively as possible by sharing expertise, building capacity and providing advice and support so that this technology can play its part in reducing greenhouse gas emissions. They include the governments of the United States, the United Kingdom, China, Japan and Australia, and multinationals such as Shell, ExxonMobil, Toshiba, Kawasaki and BHP[a]. However, it is piquant to observe that the 2018 Report

[a] A founding member of the Institute back in 2009, the European Commission became in 2011 a 'Collaborating Participant' — a system ensuring the Commission's continuous support for CCS and the Institute's work, without legal obligations, nor voting rights (a status also enjoyed by the IEA, OPEC and the World Bank) and in January 2015 became an 'Associate' member with a modest fee.

states that there are ‘diverse new endorsements of CCS by supporters, including explorers, economists, academics, religious leaders, unions, environmental NGOs, mayors, the media, movie makers and military’[118]. Like the IPCC, we are far from science – this is politics.

CCS in oil and gas production projects is profitable. We will see that to increase the proportion of oil and gas recovery, the industry developed the enhanced oil recovery technology (EOR – see Oil Chapter in Volume 2).

- The first major project in this field was the Norwegian Sleipner project. The Sleipner natural gas contains up to 9% CO_2 while the maximum content to deliver gas is 2.5% CO_2. Therefore, since 1996 (before the Kyoto Protocol), a platform with a CO_2 removal facility has been built offshore. The CO_2 withdrew on the Sleipner T treatment platform is transported to the Sleipner A platform where it is injected into the play through a dedicated well 1 km under the seabed.
- Abu Dhabi launched a CCS Project in Masdar for capturing CO_2 from the Emirates Abu Dhabi Steel Factory and transports it to the storage tanks of the Abu Dhabi National Oil Company (ADNOC) for EOR reasons. The Shah plant processes about 360 Mm^3/d of gas and associated condensates. By 2025, modifications to the facility would enable the gases to be captured as part of the sulphur recovery process and converted into pure CO_2 for enhanced oil recovery (EOR).
- In Canada, the Boundary Dam plant was opened in 2015 on a coal-fired power plant. It received $240 million (Canadian) in federal government support; and signed a 10-year contract to sell the captured CO_2 for an EOR project.

Sleipner, Masdar and Boundary Dam projects are viable projects because CCS is not implemented to ‘save the planet’, but for practical reasons linked with more efficient oil and gas production.

According to the European Commission, CCS could be applied on between 0.3% and 12% of the 2030 and 2050 electricity generation. These small numbers seem to be mere speculation. Consequently, its industrial application, should not take off before the mid-2,030s, if ever. As a result, lobbies are putting pressure on the European Commission to 'effectively and rapidly widen the uptake of CCS in Europe'[119].

The US Department of Energy (DOE) acknowledges that 'the cost of deploying available CCS technologies is high, and that to be effective as a technology for mitigating GHG emissions from power plants, the costs for CCS must be reduced'. For example, DOE stated that the cost of deploying available CCS post-combustion technology on a supercritical pulverised coal-fired power plant would increase the cost of electricity by 80%[120]. Retrofitting plants for CCS would increase electricity prices even more. Since the DOE's study was made before the current drop in coal and gas prices, the economics of CCS have become even more doubtful. For many decades, CCS will be hugely expensive, and it is doubtful whether it will be commercially viable. It also remains doubtful whether CCS will become a viable solution. Other cheap solutions might probably emerge before CCS could become competitive. But this was before the Trump Administration decided to promote clean coal technology to fulfil its election promise. Therefore, the DOE revised its position and in September 2019 announced approximately $110 million in federal funding for cost-shared research and development[121]. This Administration says that it is committed to providing cost-effective technologies to advance CCS around the world to ensure that the USA continues to safely use their vast fossil energy resources. These decisions are not based on science but politics.

4.4.4 Carbon Dioxide Removal – CDR

In its Special Report n° 15 'Global warming of 1.5 °C'[122] (SR15), IPCC proposes four scenarios that should allow keeping the Earth's temperature increase within 1.5 °C. In all the scenarios, CO_2 emissions are kept at virtually zero by 2050. These scenarios are based on technology that will remove CO_2 from energy by a process named Carbon Dioxide Removal (CDR), that compensate for anthropic CO_2 emissions. The IPCC defines CDR as following:

> '*Carbon dioxide removal (CDR): Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage but excludes natural CO_2 uptake not directly caused by human activities*' (page 26).

The report says:

> '*All pathways that limit global warming to 1.5 °C with limited or no overshoot project the use of carbon dioxide removal (CDR) nearly 100–1000 Gt CO_2 over the 21st century. CDR would be used to compensate for residual emissions and, usually, achieve net negative emissions to return global warming to 1.5 °C following a peak. CDR deployment of several hundreds of Gt CO_2 is subject to multiple feasibility and sustainability constraints. Significant near-term emissions reductions and measures to lower energy and land demand can limit CDR deployment to a few hundred Gt CO_2 without reliance on bioenergy with carbon capture and storage (BECCS)*' (page 19).

The fourth scenario recognises the logical and inevitable increase of CO_2 emissions if the world must continue its growth to remove poverty and allow Asian and African countries to develop. Therefore, this scenario is based on a massive use of the CDR techniques, as the report says: '*Emissions reductions are mainly achieved through technological means, making strong use of CDR*.'

Indeed, CDR is just a rebranding of the CCS concept; therefore, this is a dead-end technology. Not to mention the opposition of the populations living near these sites, because they will probably reject this storage under their feet.

There remains, therefore, only one way to transform the CO_2 into other products. Is it possible to reuse the CO_2? We will explore this in the next section.

4.4.5 Carbon capture and usage–CCU

Yes, it is possible to reuse CO_2 … provided energy is injected in the system and, indeed, as much energy that has been produced to generate the CO_2! Carbon capture and usage (CCU) looks like the new mantra used to justify the development of renewable energy. We will see in the chapters on electricity and renewable energy that the intermittence of wind and solar energy are a real drawback penalising electricity cost much. To cope with this intermittency, widely put into evidence by the German development of renewable energy, German institutes are proposing the power to gas technology. In a nutshell (we will come back to this later), the idea is to use the electricity generated when there is no electricity demand to transform the CO_2 into valuable products.

With a few chemical reaction equations, we will see that this is only possible by introducing massive energy in the system.

The oxidation (combustion) of methane

$$CH_4 + 2\ O_2 \rightarrow 2\ H_2O + CO_2$$

liberates

$$\Delta H° = -802.88 \text{ kJ à } 25°C$$

The reduction of CO_2 in methane with the two following and successive equations

$$2 \times (2\ H_2O\ (gas) \rightarrow 2\ H_2 + O_2)$$

$$\underline{4\ H_2 + CO_2 \rightarrow CH_4 + 2H_2O\ (gas)}$$

$$2\ H_2O + CO_2 \rightarrow CH_4 + 2\ O_2$$

needs for the first equation

$$\Delta H° = 2 \times 483.88 = 967.76 \text{ kJ à } 25°C$$

and for the second equation

$$\Delta H° = -164.88 \text{ kJ à } 25°C$$

Therefore,

$$\Delta H° = 802.88 \text{ kJ à } 25°C$$

Thus, producing methane out of CO_2 with hydrogen generated by the excess intermittent electricity will need the same quantity of energy as the one which has been generated by the combustion of methane. Furthermore, as the chemical processes are never totally efficient, it will indeed require more energy.

To avoid a complete reduction of CO_2 into methane we can, for example, produce methanol (that can also be used as a fuel). A similar calculation gives the following:

Reduction of CO_2 in methanol (with water as a source of hydrogen) also in two steps reactions

$$3 \times [2\ H_2O\ (gas) \rightarrow 2\ H_2 + O_2]$$

$$\underline{2 \times [3\ H_2 + CO_2 \rightarrow CH_3OH + H_2O\ (gas)]}$$

$$4\ H_2O + 2\ CO_2 \rightarrow 2\ CH_3OH + 3\ O_2.$$

will needs

$$\Delta H° = 3 \times 483.88 = 1{,}451.64 \text{ kJ à } 25°C$$

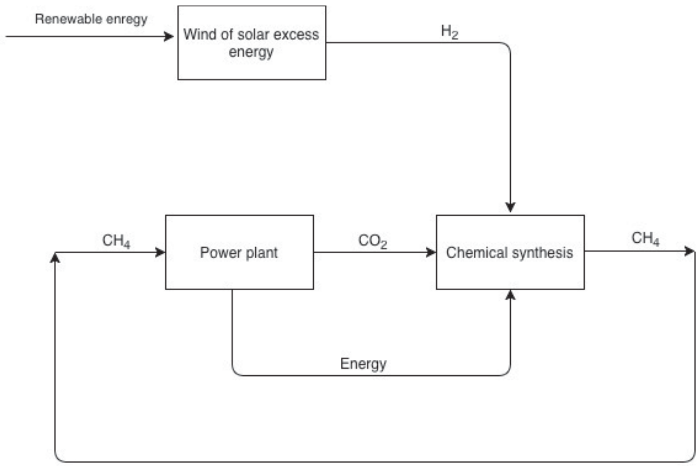
$$\Delta H° = 2 \times (-87.02) = -174.04 \text{ kJ à } 25°C$$

Therefore,

$$\Delta H° = 1{,}277.6 \text{ kJ à } 25°C$$

Overall, it is necessary to provide 638.8 kJ per mol of CH_3OH formed or per mol of CO_2 transformed. This is less than for CH_4 production because carbon is less strongly reduced as methanol still contains one atom of oxygen. Again, with the inefficiency of the chemical process, the energy needed will be higher.

Figure 4-13 A useless process, producing nothing



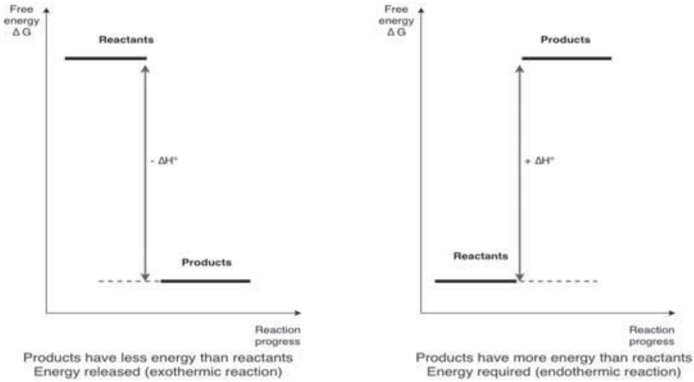
These are simple basic considerations of chemical thermodynamics known as the free energy Gibbs law. A chemical reaction can occur if it is exothermic (it liberates energy). Once products are produced by this reaction, energy needs to be injected into the system to transform the products in other reactants:

Reactant ➔ products with energy liberated (ΔH° negative)

Reversely

Products plus energy ➔ reactants (ΔH° positive)

Figure 4-14 The free energy Gibbs law



Box 4-6 Adaptation, a UNFCCC policy

Economists, keen to work with financial instruments, are proposing to introduce a high-carbon price for curbing CO_2 emissions. They pretend that this has the advantage that each country can decide its tax base and rate. Can you imagine poor countries being enthusiastic with such a proposal, just aiming to increase energy prices for replacing cheap fuels with expensive alternative solutions?

However, even if this extensive increase in energy prices would be decided – which probably it will not, at least not worldwide – its effect would likely be insufficient. The aim of not exceeding a limit of 2° C temperature above pre-industrial levels by the year 2100 is unlikely to be reached without a massive deployment of CCS, a technology that cannot be globally implemented because of its high cost. People would probably be strongly opposed, and geology is not globally suitable for sequestration; furthermore, this solution is only technically feasible for large stationary power plants.

Therefore, adaptation seems a more economical solution than mitigation. Adaptation also offers solutions for non-anthropic climate change while mitigation does not at all influence naturally caused climate change.

Parties to the UNFCCC and its Paris Agreement recognise that adaptation is a key component of the long-term global response to climate change to protect people, livelihoods and ecosystems. Parties acknowledge that adaptation action should follow a country-driven, gender-responsive, participatory and fully transparent approach, considering vulnerable groups, communities and ecosystems. Within the UN climate change regime, Parties carry out adaptation-related activities in several workstreams, through work programmes and in specialised groups and committees.

4.5 CO_2 emissions

4.5.1 Global CO_2 emission trends

In 2014, the International Energy Agency (IEA) announced for the first time, that energy-related emissions had not risen even with a growing economy. This was repeated in 2016 with roughly flat emissions. But in 2019, the IEA reported that global energy-related carbon emissions rose to a record high in 2018 as energy demand and coal use increased, mainly in Asia. CO_2 emissions rose by 1.7% to 33.1 Gt from the previous year, the highest rate of growth since 2013. Fatih Birol, the head of the IEA, said the rise in energy demand was exceptional and a 'surprise to many', which moves the world further away from the promises to reduce CO_2 emissions.

This is not surprising. With a few exceptions, CO_2 atmospheric emissions are increasing at a nearly constant rate. Since the reference year of the Rio Conference (1990) to 2018, global CO_2 emissions have increased by 58%, i.e. 2% per year; this demonstrates that it is difficult to limit the emission (Figure

4-15[a]). The effects of the oil crisis of the 1970s and the Subprime crisis in 2008 are visible on the graph, making it evident that recessions effectively limit CO_2 emissions.

Figure 4-15 World CO_2 emissions

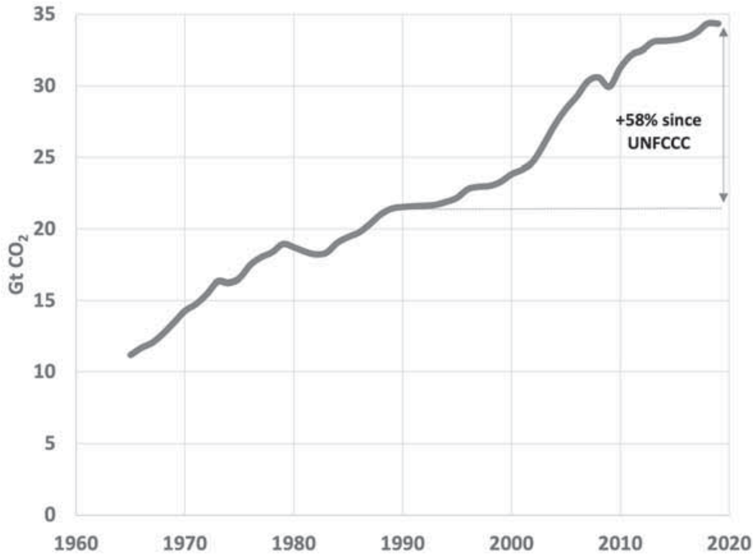


Figure 4-16 and Figure 4-17 show who the main CO_2 emitters are, and, thus, it is already possible 'to point to the culprit'. In 2018, world CO_2 emissions were dominated by emissions from China (27.6%), the USA (15.2%), the EU-28 (10.6%), and India (7.0%), the only countries or regions with more than 5% of the global emissions.

China and India are leading the increase of the CO_2 emissions today and will continue to lead moving into the future. India in its report on the Paris Agreement announced that it will multiply its GDP per capita by three, and therefore, also its electricity demand[124].

[a] The Global Carbon Project[114] calculates carbon dioxide emissions based on reliable data (US Oak Ridge National Laboratory, UN Energy Statistics, US Geological Survey and BP); these data cover fossil fuel emissions including cement production.

Figure 4-16 CO_2 emissions by regions and GDP

Data: BP 2019 and World Bank 2019

BP 2019 Data

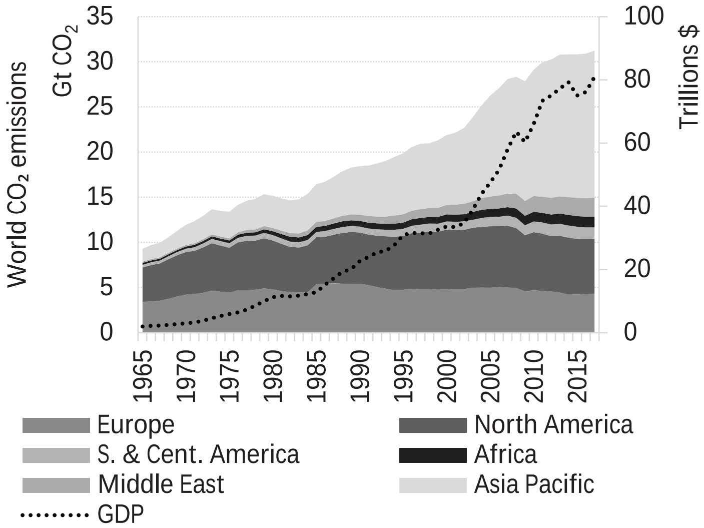
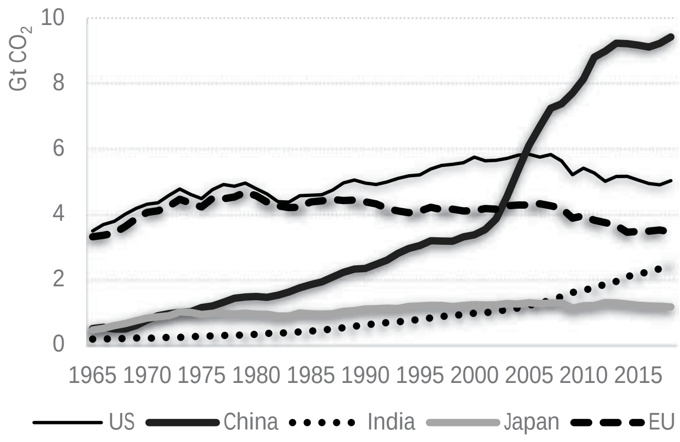


Figure 4-17 Main CO_2 emitters

BP 2019 data



Since coal is the main fuel used in India for electricity generation, even if it announces that '*a share of 46.8% of installed capacity is expected to come from non-fossil sources such as nuclear energy, hydroelectricity and renewable energy*' we should not be surprised that the country is not at all ready to reduce its CO_2 emissions. How can India be able to reduce its emissions, when it proudly announces a one-billion-ton coal production target by 2019? To ensure an adequate coal supply, Coal India Limited committed to an ambitious target of producing one billion tons of coal by 2019, from a level of 500 million tons (+ 18% in 4 years)[125].

Table 4-5 Excerpt from the India INDC report to the Paris Agreement[123]

Indicator	India in 2014	India in 2030	
Population (billion)[a]	1.2	1.5	
Urban population (million)[b]	377 (2011)	609	
GDP at 2011-12 prices (in trillion)[c]	INR 106.44 (USD 1.69)	INR 397.35 (USD 6.31)	
Per capita GDP in USD (nominal)[c]	1408	4205	x 3
Electricity demand (TWh)[c]	776(2012)	2499	x 3

Source: a: Population Foundation of India; b: UN World Urbanization Prospects, 2014; c: Government of India.

Table 4-6 displays the countries where CO_2 emissions are growing at a pace of more than 3%/y. This indicates that any decision to act in any EU Member State, with its 10.6%, will have a marginal impact on global emissions. IEA projections for 2035 indicate that the EU share will reduce to 6.5%. Consequently, it is impossible to admit that EU policies and measures alone would be able to influence global CO_2 emissions. Thus, the determination of the EU to proceed on this track is questioned whilst major CO_2 emitters are reluctant to follow EU leadership. Furthermore, there are some EU Member States that are unable to reduce their emissions.

Table 4-6 Evolution of CO_2 emissions for the twenty countries that increased their emissions the most between 1990 and 2018

BP data, 2018

Country	Increase since 1990
Vietnam	1157%
Bangladesh	609%
Qatar	544%
Oman	533%
Kuwait	434%
Sri Lanka	426%
Malaysia	328%
India	311%
China	305%
Indonesia	294%
Iran	244%
Pakistan	239%
UAE	237%
Thailand	232%
Philippines	231%
Singapore	229%
Chile	202%
South Korea	196%
Morocco	194%
Iraq	190%

Figure 4-18 Since 1965 world CO_2 emissions are a function of GDP

Data: BP 2019 and WB 2019

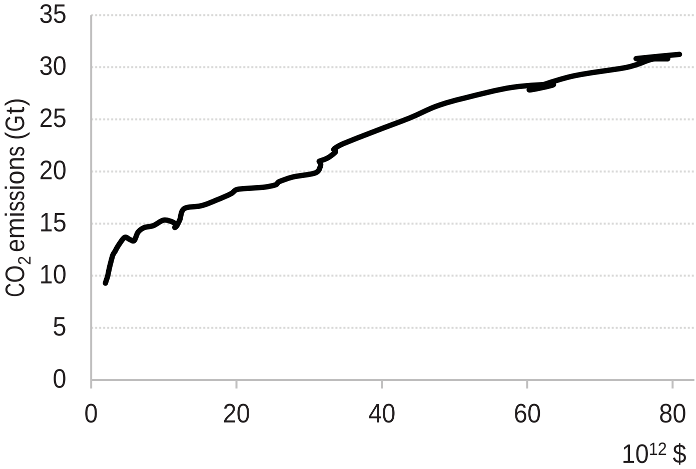


Table 4-6 helps us to observe that developing countries are far from being concerned about the climate or at least about their CO_2 emissions. Figure 4-18 proves that since 1965 there has been a strong relationship between economic growth and CO_2 emissions. Reversing that trend will not be an easy task. This has never occurred until now. These countries have understood that their future depends on economic growth and that they must, therefore, use fossil fuels. It is easy to see that Asian countries have impressive growth rates; they want to grow, and their energy demand is growing as well. On the other hand, there is only one African country – Morocco – in this list, but it is from North Africa. There are no countries in Sub-Saharan Africa.

4.5.2 CO_2 emission in the USA

The USA CO_2 emissions reached a maximum in 2007 when they reached 5.8 Gt. Since then, they have reduced emission by -1.7% / y. There are two main reasons: the development of natural gas instead of coal and the improvement of consumption of the automobiles. Figure 4-19 illustrates the evolution of electricity generation in the USA thanks to the development of shale gas. Natural gas is nowadays so cheap that it can displace the historical generation of coal. For decades, coal was the major fuel (more than 50%) used to generate the American electricity. Now, gas is burned in power plants built originally to operate with coal. It is not even necessary to build new plants with a gas turbine to increase the efficiency of the plant. Natural gas is so cheap that it is not needed to invest to reach the high efficiency of the combined cycle power plant.

Figure 4-19 Shares of fuel for electricity generation in the USA

Data: EIA[126]

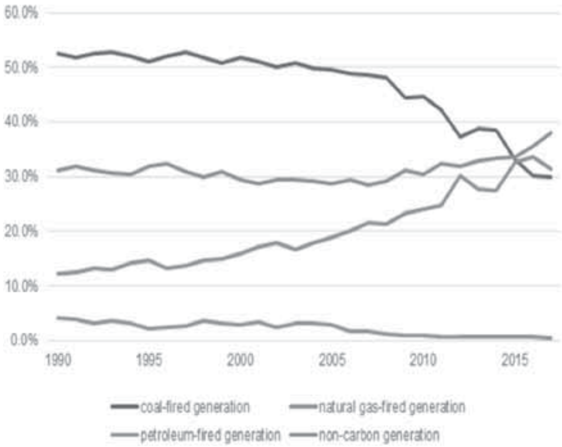


Figure 4-20 CO_2 emissions of US electricity generation

Data: EIA[127]

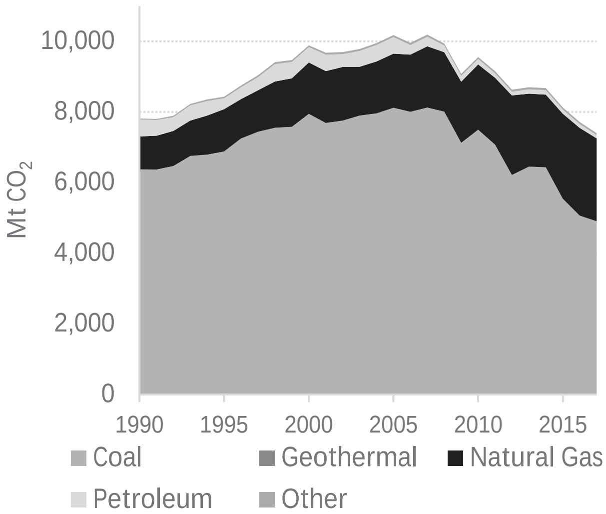


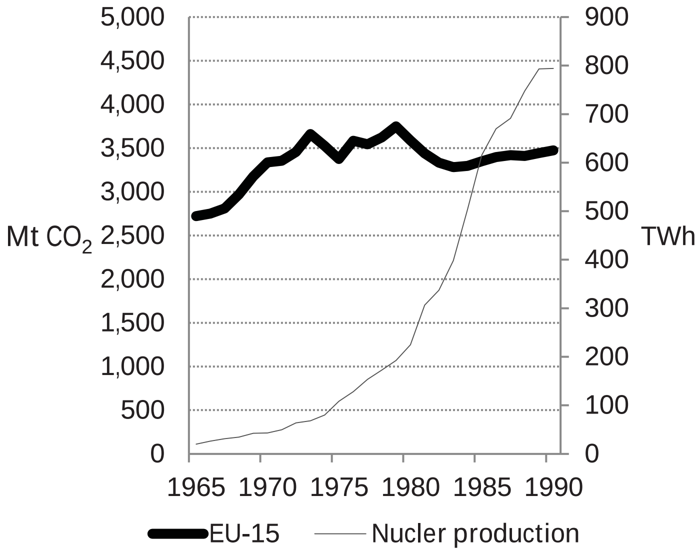
Figure 4-20 shows the clear consequence of the development of gas-fired electricity generation instead of coal-fired: a drastic reduction of the emissions in US electricity generation. Both figures indicate that the change occurred before COP-21. President Barack Obama knew that, and this explains the reason why he was keen to accept a reduction of CO_2 emissions because indeed this was already underway thanks to the shale gas revolution.

4.5.3 CO_2 emission in the EU

Figure 4-21 shows that after 1965, the EU's CO_2 emissions grew because of GDP growth. In the middle of the 1970s, the emissions in EU-15 decreased due to the oil crisis then started again to rise. The second oil shock had also an impact but much less because of the simultaneous deployment of nuclear power plants in the EU-15. The massive reduction during 1980-1985 is mostly due to the starting of nuclear power plants. The light line shows the correlation between the large nuclear power plants' electricity generation and the cut in CO_2 emissions. Following the 1970s oil crisis, old polluting coal-fired or oil-fired power plants were replaced by nuclear reactors not emitting CO_2. This demonstrates that nuclear power plants are a historical solution for decarbonising part of the economy at competitive costs without demonstrating new technologies and manipulating the electricity market with subsidies for electricity generation. In chapter 12, we will see that the development of renewable energy in Germany within the framework of the EnergieWende is not delivering the expected CO_2 reduction.

Figure 4-21 CO_2 emissions evolution in the EU-15 and nuclear generation

BP data (CO_2 emission left axe, nuclear generation right axe)



From 1989 onward, the CO_2 emissions in the former communist countries decreased because of the political crisis which reduced economic development and progressively with the phasing out of old polluting power plants and inefficient automotive vehicles

(Figure 4-22). In the 1990s the absorption of the former East Germany (DDR) into the Federal Republic of Germany (FRG), and the restructuring of Communist-style economies introduced a further reduction of CO_2 emissions. They never reached the emission levels of the communist period again.

Figure 4-22 CO_2 emissions evolution in the EU-15 (old) and EU-13 (news)

2019 Commission data

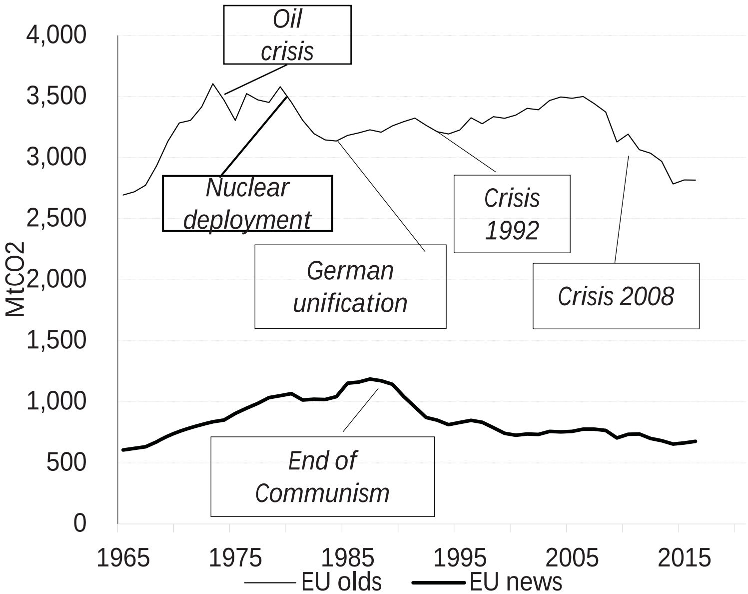
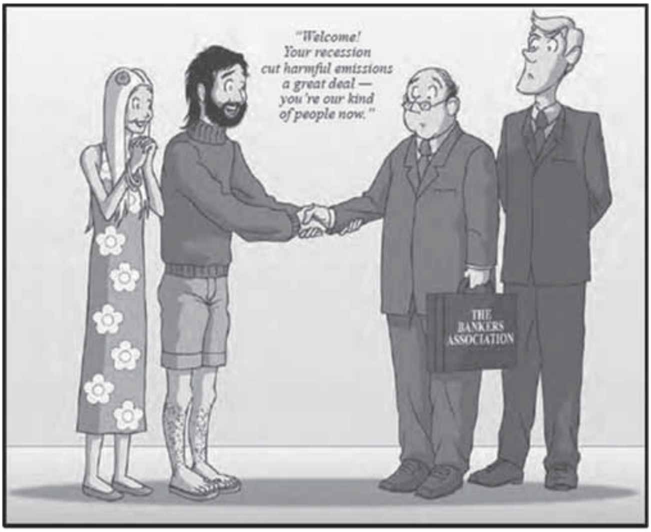


Figure 4-23 Cartoon illustrating an interview of the author for Energy Time



A further fair conclusion is, of course, that a free market is more efficient for decarbonisation than a planned one.

For the EU-15, from 1992 until 1995, the reduction of emissions was caused by the economic crisis, but afterwards, emissions continued to rise. The decision to limit the emissions started in 1992, whilst from the end of this economic crisis until the following one in 2008, there was no impact of EU mitigation policies on CO_2 emissions. The larger effect arrived with the subprime crisis. The smaller impact of this last crisis on the new Member States (EU-13, mainly the former communist ones) is interesting. One could argue that the emission decrease since 2008 is also due to the development of renewable energy, but this is difficult to justify, as we will observe in the chapter dedicated to renewable energy.

The clear message is that historical data of EU CO_2 emissions for the last 50 years demonstrate that to reduce the CO_2 emissions substantially, two efficient methods exist: development of nuclear energy and / or economic crisis.

Table 4-7 Reduction of CO_2 emissions for the EU Members States compared to 1990

Data of the EU Commission for 2017

	1990 = 100
LT	32%
LV	36%
EE	43%
RO	46%
SK	48%
BG	62%
CZ	64%
HU	64%
DK	65%
UK	70%
SE	73%
DE	75%
FI	76%
HR	77%
EU	**79%**
MT	81%
PL	82%
BE	83%
IT	84%
FR	85%
LU	86%
SI	92%
EL	93%
AT	102%
NL	103%
PT	118%
IE	119%
ES	120%
CY	153%

The sectoral distribution of the CO_2 emissions illustrates that the largest sector is the energy industry and more specifically the electricity generation sector with one third of all the EU emissions. Oil refining is efficient as we have already seen and therefore, its CO_2 emissions are only 4%. The transport sector, essentially road transport, is 28%. Farming, a major target of environmental NGOs – insisting on banning red meat – is only 2%. Their target just demonstrates that they are acting by ideology and not to reduce the CO_2 emissions.

Regarding the CO_2 evolution of the EU Member States, most of them have been able to reduce their emissions. In 2018, only six countries have more CO_2 emissions than in 1990. Is this due to the ongoing economic recession or the effectiveness of their climate policy? It is too early to answer; a fair conclusion will be drawn when and if we are again in an economic growth cycle. However, it must be strongly underlined that all the former Communist countries (the USSR Republics – the Baltic Countries and its 'satellites') had an easier CO_2 reduction task by replacing outdate and inefficient plants with modern best-available technologies.

4.6 Are anthropic emissions changing the climate?

Another title of this section could have been 'is CO_2 a thermostat control knob for the world temperature'? Since the adoption of the Kyoto Protocol, in December 1997, the Western population has been widely, deeply, and extensively told by the IPCC and the media that climate change is caused by human activities particularly by the combustion of fossil fuels. There are other major sources of greenhouse gases as methane produced by ruminants [a] , CF_4 and C_2F_6 produced during aluminium electrolysis or methane produced in rice fields. There is enough

[a] Contrary to what is generally believed, this CH_4 production is more from 'the front side' rather than the 'back-side' of animals.

literature on this topic to avoid repeating here the rationale proposed for justifying this theory. After having worked for years on the topic and taken part in the negotiations on the climate change issues, the author's position on this subject has evolved progressively and it will be explained here.

4.6.1 Climate is a new and complex science

First, we have to remind ourselves that climate science is different from meteorological science. The latter analyses the short-term evolution of the weather; the former analyses long-term changes to the climate. The time horizon for climate science is at least 30 years. Accordingly, all the frenzies proclaimed following a hotter season in one specific year, warmer or colder than the previous few years, are in no way indications of climate change. Any meteorological epiphenomenon cannot be presented as proof of the impact on the climate from human activities such as the use of fossil fuels.

We have already seen that the IPCC's mandate is to *only* study the impact of humans on the climate, and not to study the natural causes for climate change. Geology, history, and current evidence prove that climate and weather fluctuations are driven by activities of the sun and other powerful, complex, interactions of natural forces. Historians know that the Medieval Warm Period (950-1250 AD) and the Little Ice Age (1350-1850) were two periods when temperatures were respectively above and below the 'normal' [128]. Emmanuel Garnier concludes his scientific historical overview of 500 years of drought and heat wave in France and neighbouring countries, by stating that '*it is clear that there is a kind of mismatch between the historical reconstructions of droughts and alarmist predictions presented by the various models of climatologists. De facto, looking back 500 years, nuances strongly the contemporary certitude of an unprecedented upsurge of droughts in Europe*'[129].

All this is extremely complex, and it is false to pretend that the science is settled. This cannot be, first because science is always progressing, and because the research on climate change is rather new, with major studies starting precisely after 1992 when the UN stated that climate change was a major issue.

As the COP-21 demonstrated, and as it has been widely proclaimed by the media, a consensus seems to exist among the world's scientific community regarding the negative impacts of climate change and the fact that energy consumption is triggering the changes. Nevertheless, many scientists insist that fossil fuel emissions cannot be blamed for natural phenomena. These scientists point out that the fluctuations of the Earth's temperature are normal and are mostly caused by heat waves generated by the sun.

'Climate change sceptic' is not a correct definition because none of them denies that the climate is changing; they should rather be named 'IPCC Sceptics'. Let's just call them 'climate realists'.

4.6.2 Some reasons to admit it is complex

What are the main arguments of climate realists? Since it is not the aim of this book to develop these points, we will just mention a few points without expanding them or giving many references.

- Climate has always changed; there were periods during the past 2,000 years with warmer and cooler periods than today. Is there unprecedented warming? It depends on the period: since 2000, no because there is a pause (more detail hereunder), since 1950, yes; since 1850, yes. Is the warming unprecedented for millennia? No.
- Climate science is young and after only 30 years of climate research, there is no consensus whether or not humans influence the climate, and consequently, it is pretentious to claim that the debate is completed. Science is never settled, has never been and will never be settled because science is always developing. Numerous serious climate scientists question the mainstream position that climate science is settled.

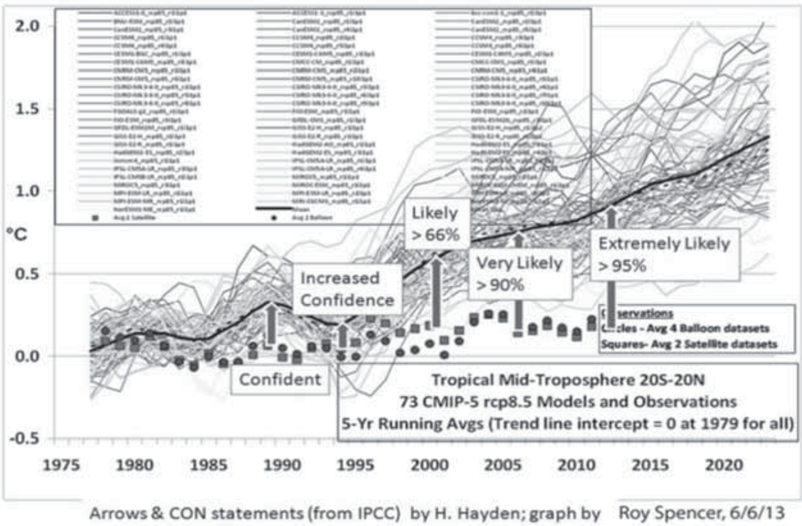
- o In the middle of the COP-21 four prestigious Italian scientific organisations, the Italian Physics Society, the Italian Chemistry Association, the Historical Oceanography Society, and the Union of Agricultural Academies refused to sign a statement drafted and addressed to the Paris conference by other Italian associations. 'There is no such equation of climate' said the President of the Physics Society[130], Professor of Economics Richard Tol, who withdrew his name from the fifth IPCC Assessment Report (AR5), economics section, because it was too alarmist, although he was a coordinating lead author; he concluded, '*Politically correct climate change orthodoxy has destroyed our ability to think rationally about the environment*.'[131]

- As with the 1970s anxieties of the Club of Rome, the basis for climate fear is computer modelling, without real-world observations. The IPCC Assessment Reports do not claim catastrophes; it is the media that constantly reports so. Models can only provide a rational expectation when they are validated by real-world observations, this has not yet been the case. So far predictions have been proven wrong (Figure 4-24).
  - o This should not surprise since the IPCC itself writes, '*In sum, a strategy must recognise what is possible. In climate research and modelling, we should recognise that we are dealing with a coupled non-linear chaotic system, and therefore, that the long-term prediction of future climate states is impossible*'[132]. The climate system is represented by many differential equations that describe a highly non-linear system with many positive and negative feedback, each having different time constants. Therefore, the distribution of results does not follow a normal distribution, but a multimodal

distribution. The signature is, therefore, chaotic. Concretely, this means that due to the nature of the system, the evolution of climate is mathematically unpredictable. This position is different when compared to mainstream media reports.

- o If the models' errors were random, the result of their simulations should be randomly distributed above and below the real temperature. But to the contrary, all of them show an overshoot of the average temperature.
- o Although, while the model predictions prove to be wrong, the IPCC's confidence increases. Rationally one would expect the contrary.

Figure 4-24 Prediction of climate evolution by various models and real measurement



- None of the models could explain the stabilisation of the temperature over the past 18 years. The IPCC recognised the temperature standstill but labelled it 'a hiatus': the title of Box 9.2 in the Assessment Report is 'Climate

Models and the Hiatus in Global Mean Surface Warming of the Past 15 Years'[133]. It says, '*The observed global mean surface temperature (GMST) has shown a much smaller increasing linear trend over the past 15 years than over the past 30 to 60 years*.' To justify that this is not a stop of the increase of global temperatures it is reminded that in climatology trends should be observed over 30 years. However, at the end of the 'hockey stick', ten years was the right period time for predicting future climate. But now arriving at the end of many years of trendless fluctuation, it is recognised that a period of thirty years in necessary to observe climate evolution. The temperature remained stable or paused, although according to the IEA, during this same period the CO_2 atmospheric concentration increased from 364 parts per million (ppm) to 397 ppm in 2013 and around 400 ppm in 2015. Accordingly, there is no correlation between the increase in CO_2 concentration and temperature stabilisation. Only for a few years, i.e. during the period around 1980-1997, there is some correlation between the carbon dioxide concentration in the atmosphere and temperatures. Without correlation, casual connection is impossible, causality is inconceivable.

- Contrarily, solar experts forecast that a near-term cooling is likely to come[134]. This would be a major calamity facing the population of our planet. A new 'Little Ice Age', like the one which occurred between 1750 and 1850, may happen within decades.
- The IPCC has been able to impose its theory 'of the anthropic origin of climate change' on most policymakers in Europe, thus, creating the popular belief that the theory of the anthropic origin of climate change is valid. However, many scientists criticise the IPCC because its theory has not been validated by observations i.e. it remains a hypothesis, and consequently, lacks a solid scientific foundation. The weakness of the IPCC theory is

its basic assumption is in contradiction to the basic principles of chemistry and physics.

- This is the case for the interpretation of the theory of the black body and the misuse of the Stefan-Boltzmann relationship to calculate the Earth's temperature. The Stefan-Boltzmann equation is not applicable to a planet with an atmosphere. The scientists criticising the IPCC consider that climate change caused by carbon dioxide is insignificant. This is because the CO_2 molecules that absorbed a fraction of the thermal radiation of the Earth deactivate by collisions and not by back radiation of the absorbed wavelength. The absorption of a fraction of the thermal radiation of the Earth by CO_2 is the consequence of numerous collisions with the surrounding molecules, by a tiny increase of their average kinetic energy corresponding to an insignificant temperature increase of the lower atmospheric layers[135].

- Scientists critical of IPCC deny the notion that humans could prevent natural fluctuations of the climate, by ending or limiting fossil fuel consumption because CO_2 plays an insignificant role in climate change. For them, it is nature that dictates weather and climatic events. However, according to the IEA — the Earth temperature stabilised since the adoption of the Kyoto Protocol although CO_2 atmospheric concentration increased from 364 ppm in 1997 to 400 ppm in 2018 i.e. an increase of 9%. Also, according to IEA, CO_2 emissions increased worldwide by 45% during the same period. This is not what one could call a success for the Kyoto Protocol regarding the mitigation of CO_2 emissions.
- The 2013 IPCC report estimates an increase of the global surface temperature by 1.5 °C – 4.5 °C if the CO_2 concentration in the atmosphere doubles as compared to

1850. This is nearly the same range as in the ‘the Charney report’ of 1979 for the US National Academy of Science by a particular group under MIT meteorologist Jules Charney [136] ; this report predicted a global surface warming of between 2° C to 3.5 °C for the same assumption.

- The IPCC models are, after more than 35 years of research, still unable to narrow this estimate; evidently, because there is a lack of progress in the climate science embodied by the IPCC. This demonstrates that, contrary to what is constantly repeated, climate science is not settled. On the contrary, climate science is a new discipline that requires a lot of research and considers all-natural and human factors influencing the climate for beginning to understand the complexity of the global system.

- Furthermore, measuring CO_2 emissions is also a caveat. People think that this part of the issue is also ‘settled’, but this is not the case, especially regarding coal. Most statistics use coal as if it was a simple product like methane. This is not at all the case! Each coal has its calorific value and, therefore, different CO_2 emissions.
  - Specifically, the calorific value varies a lot between lignite, subbituminous coal, and bituminous coal (see coal chapter in Volume 2). The gathering of statistics is not sufficiently precise to discriminate the calorific values of different types of coal. The fact that the Bonn office of the UNFCCC is delivering data that looks precise can only mislead people without knowledge about coal.
  - A study published in Nature[137] demonstrated the large accounting error for CO_2 emissions produced by coal combustion in China. Confusion of the types of coal being burned in

Chinese power stations caused a significant overestimation of the country's carbon emissions. Research published in the journal Nature state that CO_2 calculations used a globally averaged formula. However, when scientists tested the types of coal being burned in China, they found that they produced 40% less carbon than assumed. The researchers stated that the discrepancy is significant. Over the period 2000-2013, they found that China emitted almost 3 Gt of carbon less than earlier estimates, which is around 10% of the annual global total. This changes the global pattern.

- If any, climate change is an accumulation problem, not a critical threshold problem. Some people explain that beyond a certain CO_2 concentration there will be a collapse of the whole Planet Earth. These critical thresholds are presented by doomsayers, likely Malthusian, to create fear by airing an apocalyptic threat.

4.6.3 The climate hiatus

Let us reflect somewhat on the 'hiatus' because it is a key point in this discussion. According to the IPCC, after the increase of the global mean surface temperatures from the end of the 1970s, the temperature has been relatively flat over the 18 recent years to 2015. Many mainstream scientists are now obliged to admit this, including the official UK meteorological service[138]. One may wonder why it was not even released, for example, ten years after reaching the maximum temperature. This is known by sceptical scientists but not usually by people. Media and policymakers are still ignoring this temperature plateau.

For climate realists, this proves that there is no human-induced global warming, or at least that it is much smaller than predicted. Others maintain that this is a temporary pause and that temperatures will rise again at rates seen previously. The Global

Warming believers quickly developed many theories, over 50 different ones, justifying the hiatus in global warming. One example is a study of the Colorado University stating that volcanic aerosols reduced this Earth warming[139] during the last 18 years.

Some scientists pretend that the 'lost' temperature is trapped in the oceans; for them, the temperature of the atmosphere is not increasing because the oceans have absorbed this heat. Because the measurements made by buoys could not show this increase in the ocean's temperatures, a new hypothesis is proposed: the temperature increase is buried in the bottom of the oceans. From the thermodynamic point of view, it is a fact that the largest thermal storage capacity is in ocean waters; glaciers, arctic ice cap or the atmosphere are far less important regarding the storage of energy. Oceans are the main engine of the Earth's thermostatic system. Water vapour in the atmosphere and clouds are the cold source and oceans the hot source of the Globe's thermodynamic system. However, this new hypothesis ('The missing heat is hiding in the deep ocean') explaining why there is no atmospheric temperature rise has also been dismissed. Scientists of NASA analysed satellite and direct ocean temperature data from 2005 to 2013 and found the ocean depth below 1995 metres did not measurably warm[140, 141]. These studies advocate that the upper layer of the ocean warmed more than previously believed, whilst the deep ocean cooled became cooler than warmer in recent years.

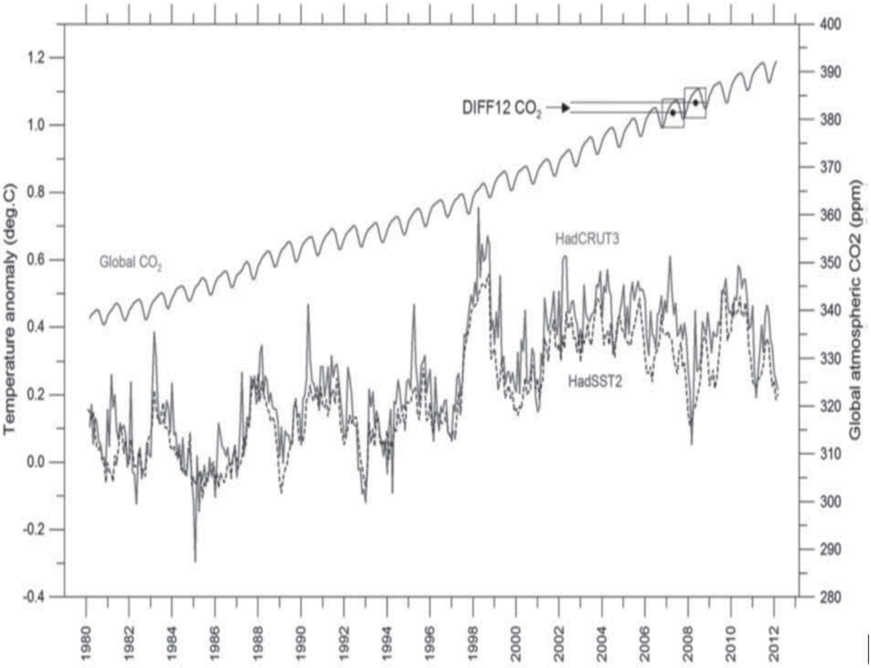
The facts and numbers are now widely available for anybody and demonstrate that since the end of the previous century, the world average temperature (as measured by satellites) has declined. The other fact is that during the same period the CO_2 emissions increased, leading to CO_2 atmospheric concentrations from 364 ppm in 1997 to 397 ppm presently, an increase of 9%. Meanwhile, the global temperature remained stable or declined slightly. Consequently, there appears no correlation, let alone causation, between the global temperature and carbon dioxide.

The evolution of the global temperature is unknown. However, even if global warming resumed in future, this would not restore the causal link between climate and human activities or the confidence that one can have in the simulation models.

Not only does the correlation between CO_2 released from energy consumption and the global temperature not appear, but research also shows that a clear time lag relationship between changes of atmospheric CO_2 and temperature records[142] exists. Without correlation, causation is difficult to establish, because many other influences may dominate. That appears to be the case in the CO_2 – temperature relationship. Changes in global atmospheric CO_2 lag about 11–12 months behind changes in global sea surface temperatures, 9.5–10 months behind changes in global air surface temperatures and about 9 months behind changes in global lower troposphere temperatures. Ocean temperature changes since January 1980 seem to explain a substantial part of the observed changes in atmospheric CO_2. This research concludes that CO_2 released from anthropogenic sources has little influence on the observed changes in atmospheric CO_2, and changes in atmospheric CO_2 are not following changes in human emissions. Consequently, there is no correlation since about 1997, but also when correlation existed between 1980 until 1997 the CO_2 increase was probably a consequence of temperature increase.

Figure 4-25 Monthly global atmospheric CO_2 concentration and monthly global temperature evolution since 1980 until 2012

From Ole Humlum et al.[143]



Box 4-7 Are the oceans more acidic?

Since we are dealing with oceans, it is worth mentioning that the ocean acidification is a popular but misleading narrative of doomsayers. ‘Acidic’ is a word that raises instantaneous fears to non-chemists. This is because chemistry comprehension is not largely spread. Oceans are not acidic; they have a pH of about 8.1, which is alkaline, the opposite of acidic. Chemists use the pH logarithm scale to measure the acidity or alkalinity (or basicity). A pH of 7 is neutral, below 7 is acidic, and above 7 is alkaline. According to some alarmist researchers, the pH of the oceans diminished by 0.075 over the past 250 years. However, how did they manage to measure the pH 250 years ago since the pH was only introduced as a unit in 1909 by the Danish chemist Søren Sørensen? One wonders how it is possible to measure a difference of three decimals. All these theories are based once more on computer models. Furthermore, chemistry demonstrates that some liquid solutions have a buffering effect; they are widely used to keep pH at a nearly constant value. The salt content of seawater gives the seas and oceans a huge buffering capacity against pH variations. Small additions of acidic and alkaline substances can easily alter the pH of freshwater, whereas seawater can buffer large additions of acidic and alkaline substances. Contrary to mainstream thinking, scientific literature shows and unequivocally that an increase of the CO_2 content in oceans results in growth and calcification, the reverse of the catastrophic scenario widely propagated by environmental NGOs.

Faced with the stabilisation of global temperature since 1997 — coincidentally the year of adoption of the Kyoto Protocol — the failure of the climate models is obvious and the IPCC should lose credibility firstly in hiding this fact for too long then to justify the stabilisation with around 50 latter-day explanations for the lack of warming. Some of these explanations are inconsistent with others, and many represent natural causes, which according to the October 2014 IPCC Summary for Policymakers, should have been considered in the original reports.

Emotional issues such as species extinction and dramatic sea-level rises are based on these irrelevant energy scenarios. We can conclude that the Earth is insensitive to increasing greenhouse gas emissions, and that climate fears are based on energy scenarios that will never be implemented.

4.6.4 It is about policy

Let us conclude this short introduction to an unconventional climate change position with a statement of Richard S. Lindzen, the Alfred P. Sloan Professor of Atmospheric Science at MIT. He is one of the rare sceptics that nobody of the mainstream dares to criticise, possibly because he was a lead author of the IPCC and resigned by opposing to the political shift from science stating: '*Significant doubts persist concerning the remarkably politicised issue of global warming alarm*'[144]. Lindzen has noted that too many environmentalists '*ignore the fact that the earth and its climate are dynamic; they are always changing even without any external forcing. To treat all change as something to fear is bad enough; to do so to exploit that fear is much worse.*' The respected MIT Professor is also famous for having said: '*If you control carbon you control life*.' For him '*Individuals and organisations highly vested in disaster scenarios have relentlessly attacked scientists and others who do not share their beliefs. The attacks have taken a threatening turn*'[145].

Finally, we repeat that science consists in elaborating a hypothesis, testing it with experiments, evaluating the results and comparing them with the initial hypothesis to validate the theory and, if necessary, to adapt it as required. Climate modelling can approach science, but it is far from being a science because there is no factual demonstration. Surely, scientists are doing a good job, and, of course, their science is correct. It's the conclusion following the sums of these sciences which is premature. It is not demonstrated that there is a dominant influence of global warming due to greenhouse gases nor that global (climate?) change has halted! Temperatures may remain stable, may decrease, or increase; anyway, this does not demonstrate the validity of the theory.

We should admit that we do not understand the complexity of the climate system, that there are too many different factors interfering with this recent theory. At least one should admit that climate change, including the present global temperature plateau or hiatus, is not scientifically proven to be caused by humans. After 30 years of the IPCC proclaiming that humans cause climate change, unequivocal scientific proof is missing.

Evidently, with this experience and hard reality, it appears advisable to avoid the disruption of our economy by imposing 'act now' policies and measures for limiting emissions of gases whose influence on the climate have not been demonstrated. Furthermore, should we 'act now' at the risk of wasting a lot of money for future generations on a possible non-problem? Bjorn Lomborg explains: '*Whatever is spent on climate policies saving one person from hunger in 100 years could instead save 5,000 people today*'[146].

Indisputably, pollution must be limited. We noted in the first part of this chapter that this is the policy in all OECD countries. This will continue and the mutual enforcement of technology and legislation progress will endure. However, claiming that CO_2 is a polluter is indeed claiming that human beings are parasites since we ourselves produce CO_2 when we breathe. CO_2 is the source of life on earth for vegetation, animals and humans. Without CO_2 life on earth would be impossible.

Eija-Riitta Korhola, who served as a Finnish member of the European Parliament for 15 years, defended her PhD thesis on 'The Rise and Fall of the Kyoto Protocol: Climate Change as a Political Process'[147] in 2014. In her academic dissertation, she described the annual climate summits from COP 1 (Berlin 1995) through COP-18 (Doha 2012), and analysed the solutions proposed by the summits. The key message from the Korhola dissertation is that despite climate actions like the Kyoto Protocol, global emissions have been increasing forcefully; UN climate conferences are a series of failures; climate science has not proven that climate change due to humans is the problem. Climate change has turned out to be what Korhola called a wicked problem, hard to define, hard to solve, and whose solving does not have a clear end point, and whose resolution attempts to generate additional problems.

Box 4-8 Which temperatures are we talking about?[a]

Is it the increase in temperature during the period 1980-2000 that has triggered a strong interest in the climate change issue? But actually, which temperatures are we talking about, and how reliable are the corresponding data?

Fist, IPCC is considering *global temperatures* averaged over the Globe, although the temperature is an intensive variable, a category of variables having only a local thermodynamic meaning, and although we know the Earth exhibits different well documented climatic zones.

The data used are those of the meteorology stations records and are supposed to be representative for a zone surrounding each of these stations, and which is the locus of all points closer to that station than from any other one. As the stations are not spread evenly and as their number has changed considerably over time, 'algorithmic errors' are associated with this spatial averaging method.

Also, many meteorology stations were initially on the countryside, but these locations became progressively urbanised, causing an 'urban island' effect, increasing the measured temperature artificially.

And what about the temperature over the oceans (representing about 70% of the Earth surface)? Until recently, these temperatures have been only scarcely

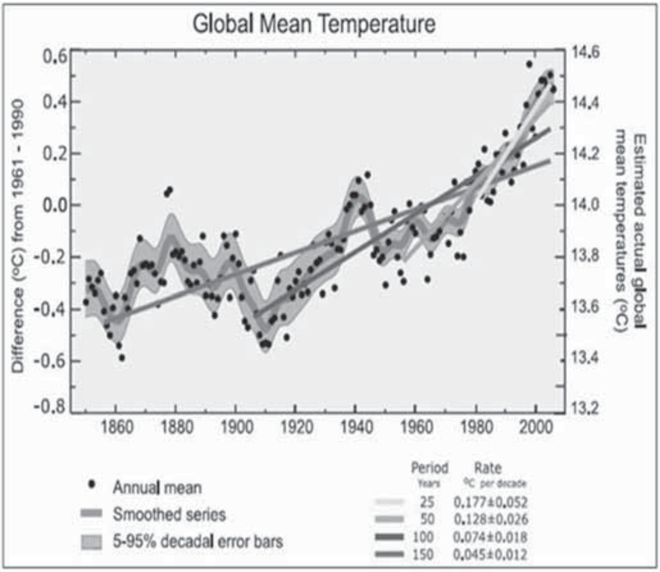
[a] This box has been written with Prof. Henri Masson and published in Science-climat-énergie in 2019[138].

reported, as the data for SST (Sea Surface Temperature) came from vessels following few commercial routes. More recently Argo floats (buoys) were spread over the oceans, allowing a more representative spatial coverage of SST.

Secondly, at a moment, the temperature on Earth may vary by as much as 100 °C (between spots in polar or equatorial regions). To overcome this problem, IPCC is not referring to absolute temperature but to what is called ‘anomalies of temperature’. For that, they first calculate the average temperature over fixed reference periods of 30 years: 1931-60, 1961-1990. Next period will be 1991-2020. They then compare each annual temperature with the average temperature over the closest reference period. Presently and up to the year 2021, the anomaly is the difference between the ongoing temperature and the average over the period 1961-1990. This method is based on the implicit hypothesis that the ‘natural’ temperature remains constant and that any trend detected is caused by anthropogenic activities. But even so, one may expect to have to proceed to some adjustments, when switching from one reference period to another, a task interfering with the compensation of an eventual ‘urban isle’ effect, and that is a source of error and bias.

But the key problem is that the temperature records undergo locally natural polycyclic, not exactly periodic and non-synchronised fluctuations (Ewert [149]). The fact that those fluctuations are not exactly periodic makes it mathematically impossible to ‘detrend’ the data, as is commonly done, for example, when eliminating seasonal effects from data.

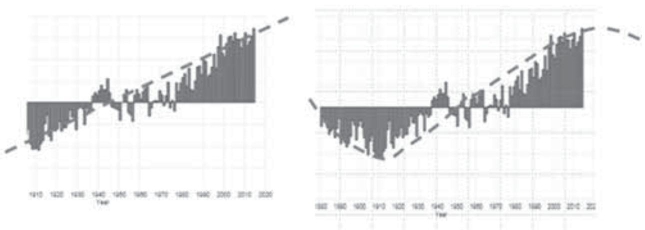
The length of these cycles’ ranges from one day to annual, decennial, centennial, millennial components and beyond up to tenths of thousands of years (the Milankovitch cycles).



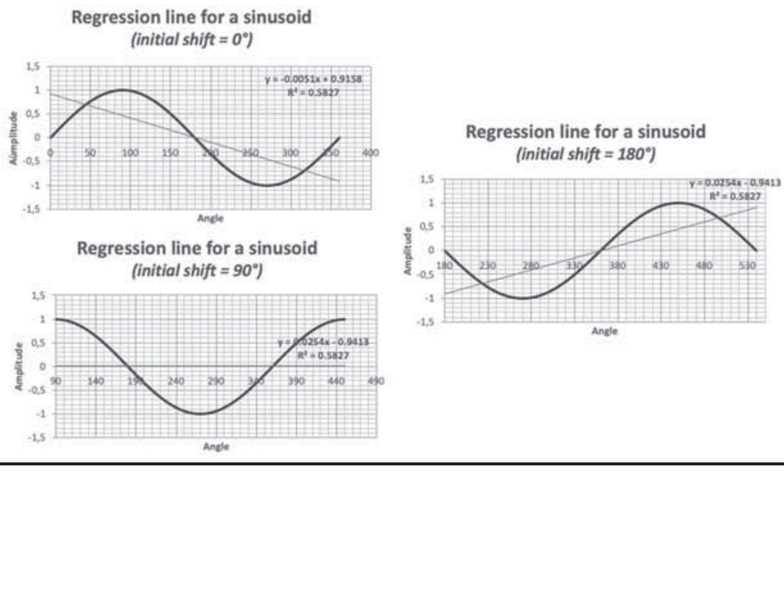
The third fundamental critic on the way IPCC is handling temperature data relates to their choice to rely exclusively on linear regression trend lines, although any data scientist knows that one must at least consider a time window exceeding 5 times the period of a cyclic component present in the data to avoid ‘border effects’. Most of the climate data show significant cyclic components with (approximative) periods of 11, 60 and 180 years, while, on the other hand, IPCC considers time windows of 30 years for calculating their anomalies.

Therefore, IPCC creates artificial ‘global warming acceleration’ by calculating short term linear trends from data exhibiting a cyclic signature. With the following figure from FAQ 3.1 from Chapter 3 of the IPCC AR4 2007 report[150] IPCC states ‘*Note that for recent shorter periods, the slope is greater, indicating accelerated warming*.’

The following graphs illustrate the issue. They show average annual global temperature since 1880 compared not with 30 years but the long-term average from 1901 to 2000[151]. The zero represents the long-term average for the whole planet, the bars show the 'anomalies' above or below the long-term average for each year. The claimed linear trend represented on the left part of the figure is (more than probably), as shown on the right part of this figure, nothing else than the ascending branch of a sinusoid of 180 years, which is another way (the correct and simplest one?) to explain the existence of the 'pause' or 'hiatus' that has been observed over the last 20 years.



Finally, the following graphs from Henri Masson[152] illustrate the 'border effect' mentioned previously and show the potential errors that can be made when handling with linear regression method data having a cyclic component with a (pseudo-) period of a length comparable to the time window considered.



4.7 There is no climate emergency and therefore policies should be carefully evaluated

André Berger is a world-renowned climatologist, a great scientist who has received five honorary doctorates for his atmospheric research. While he still recognises the effect of CO_2 on the global temperature, he is of the advice that there is no impending disaster[153]. On the other hand, the solutions proposed to counter climate change are not appropriate. Climate is changing, has always changed and will continue to change, because it is a natural phenomenon linked to the physics of the Sun-Earth system. Human activities — mainly CO_2 emissions resulting from the use of fossil fuels — also contribute, according to the greenhouse effect theory, to this change. However, we have witnessed the breaking of the moorings of common sense. The most implausible announcements are being propagated by the media and social networks, which has led European politicians to follow this inflation. Just to show the exaggeration that prevails today, let us pretend that the regular and historical phenomenon of the 'acqua alta' in Venice and the floods in flood-prone areas are exclusively due to our CO_2 emissions, and therefore to our aeroplane flights or our consumption of red meat. This frenzy at the antipodes of science is pushing the political world to make energy policy decisions that are just as inconsiderate as the prevailing catastrophism.

According to UN Environmental Programme annual reports 'Global trends in renewable energy investment'[154]), between 2010 and 2018, the world has spent 2.6 trillion promoting the renewable energy. This report states that the European Commission and its Members States spent 0.7 trillion for the same period. Since 2000, I estimated that in the EU in the order of one trillion euros has been spent to achieve a 1.9% share of wind energy and 0.5% share of photovoltaic energy in the EU primary energy balance. This is economically aberrant.

With such disappointing results why do we continue to spend public money — which we have less and less of — in the hope of doing better? It is time we recognised the failure of renewable energy policies. This must be put into perspective with the spectacular increase in global CO_2 emissions since COP-1: + 58%! We are penalising our economy with new CO_2 taxes in sight, while the rest of the world continues to use more abundant and competitive fossil fuels. China continues to invest massively in nuclear power plants and in hypermodern, clean coal-fired power plants that will operate for another 40 years. The stinging failure of COP-22-25 is an undeniable symptom of this.

Clintel, for Climate Intelligence, is a global network of +700 scientists and professionals claiming that 'there is no climate emergency'[155]. For Clintel, climate science should be less political, while climate policies should be more scientific. Therefore, scientists should openly address uncertainties and exaggerations in their predictions of global warming, while politicians should dispassionately count the real costs and the imagined benefits of their policy measures.

Box 4-9 The Clintel declaration

Natural and anthropogenic factors cause warming: the geological archive reveals that Earth's climate has varied as long as the planet has existed, with natural cold and warm phases. The Little Ice Age ended as recently as 1850. Therefore, it is no surprise that we now are experiencing a period of warming.

Warming is far slower than predicted: the world has warmed significantly less than predicted by the IPCC based on modelled anthropogenic forcing. The gap between the real world and the modelled world tells us that we are far from understanding climate change.

Climate policy relies on inadequate models: climate models have many shortcomings and are not remotely plausible as global policy tools. They blow up the effect of greenhouse gases such as CO_2. Besides, they ignore the fact that enriching the atmosphere with CO_2 is beneficial.

CO_2 is plant food, the basis of all life on Earth: CO_2 is not a pollutant. It is essential to all life on Earth. Photosynthesis is a blessing. More CO_2 is beneficial for nature, greening the Earth: additional CO_2 in the air has promoted growth in global plant biomass. It is also good for agriculture, increasing the yields of crops worldwide.

There is no statistical evidence that global warming has increased the number nor the intensity of natural disasters (hurricanes, floods, droughts and suchlike natural disasters), or making them more frequent. However, there is ample evidence that CO_2-mitigation measures are costly.

Climate policy must respect scientific and economic realities: there is no climate emergency. Therefore, there is no cause for panic and alarm. We strongly oppose the harmful and unrealistic net-zero CO_2 policy proposed for 2050. If better approaches emerge, and they will, we have ample time to reflect and readapt. The aim of global policy should be 'prosperity for all' by providing reliable and affordable energy. In a prosperous society, men and women are well instructed, birth rates are low, and people care about their environment.

4.8 Climate change policy, a convergence of religion, anti-market and business?

In this short section, we only mention that some academics consider that the surprising 'universal' attention on climate change is caused by the convergence of strange interests of religion, global anti-market and business actors.

The origin of the green movement is enshrined into the rejection of Judaeo-Christianity. Prof Lynn White wrote in 1997, '*Christianity is the most anthropocentric religion the world has seen. […]. We shall continue to have a worsening ecological crisis until we reject the Christian axiom that nature has no reason for existence save to serve man. […] Since the roots of our troubles are so largely religious, the remedy must also be essentially religious, whether we call it that or not. We must rethink and refuel our nature and destiny*'[156]. Since then, the ongoing phasing out of traditional religions in the OECD countries was replaced by a form of neo-paganism, a return to the deification of nature. What Judaeo-Christianity has desacralised[a] is now again sacralised. Ecology is a science; 'ecologism' is a religion. According to the new religion, the process consists of re-enchanting the world, to return to paganism or to invent a new religion as the New Age.

The former president Evo Morales from Bolivia, for example, does not hide that he worships Pachamama, the goddess Earth, Mother Earth. He imposed in its country a festival in honour of this pagan divinity in his country, and he managed to convince the United Nations to fix 22nd April as the International Mother

[a] In 724 Saint Boniface, Apostle of Germany, desacralized the oaks worshipped by pagans specifically by the Frisons, a German tribe. Today, for some people cutting a tree is a sacrilege. This is also why burning waste is so opposed by some environmentalists refusing to burn what nature created. In my office, a Greenpeace representative admitted that the best solution for waste disposal is incineration but refused to allow it for religious reasons.

Earth Day in all countries by 2014. The Paris Agreement also specifically mentions this (‘recognised by some cultures as Mother Earth’) and has been opened it for ratification in New York on this same day of 2016.

This religious approach is growing in the US. In the EU, the failure of Communism has given an impetus to transform ecology into a new society vision. For generations, this ideology was the emblem of a quest for justice, fraternity and better conditions for all humans. After its collapse, the anti-market ideology was reconverted into political ecology. We should observe the nonsense of the expression ‘political ecology’, if it is ecology — science — it not political, and, if it is political, it is not a science. Green parties in Europe are all left-wing; they are the reincarnation of the Communist Party. Progressively, these two approaches to environmentalism — religious and anti-market — have merged, and with nuances, of course. Paganism is penetrating the anti-market ideology. I have written an essay on this double birth of political ecology[157].

More recently, it became clear to me that there is a new element that merged into this double force: the financial institutions understood that climate change can be a lever to handle much public money all around the world. Banks, insurance companies, pension funds and other financial institutions have a stake in climate change policies. They are active in shifting subsidies into this sector because — ultimately — for them, the circulation of money is important, not the final aim.

Furthermore, many companies practise greenwashing, presenting themselves as environmental caretakers; even oil companies are using greenwashing, investing in renewable energy as they invest in advertisements. The CEO of Petrobras dared to say that, but it was after the election of Jair Bolsonaro as president of Brazil [158]. The lobbyist of a major equipment multinational company told me that it is trivial what they sell, renewable energy or fossil fuel equipment, as long as they are selling. A large part of the budget of the Paris COP-21 was provided by energy companies. However, lately, some ENGOs are discovering that their allies do not have the same final aims and possibly the apparent convergence of interest may disappear.

It is a wrong perception to believe that oil companies finance climate change sceptics. The oil industry enterprises are owned by shareholders, who invested their money for making a profit on the exploration, drilling for and production of oil and natural gas. They do not invest their money in science projects, particularly not junk science projects. They are uninterested in demonstrating that climate change is unsound. They do not want to waste money on that for four reasons:

1. It will cost money to finance scientists whilst they aim to make money.
2. If they communicate against climate change, they will immediately be attacked by ENGOs and the media. Their position would not be credible.
3. They do not care about policy, because they know that for the coming decades the future of oil consumption is ensured.
4. However, more fundamentally, as one oil lobbyist told me, '*People did not like us in the past, they do not like us today and they will not like us in the future*.'

Anyway, more than ever, ENGOs insist on the necessity to stop economic growth. They admit that it is impossible to limit CO_2 emissions while growing economically, as explained in the first chapter. Consequently, they are now obliged to admit that there are plenty of fossil fuels and that their old mantra of the near end of fossil fuels availability is ridiculous; therefore, they now insist that fossil fuels should remain underground.

Box 4-10 Give the money I will earn with oil production and I will not produce it

When Rafael Correa took the presidential office in 2007, he announced that Ecuador would impose a permanent ban on oil extraction in the Ishpingo-Tambococha-Tiputini ‘block’ of the Yasuní National Park, but this only if provided that the rest of the world helped compensate the loss in revenue by donating $3.6 billion. The deal he proposed was you give me the money that I could gain from oil and I will not extract it to protect the planet. However, Correa WhatsApp unable to attract the international support he sought, raising only around $13 million in pledges, not commitments (anyhow a tiny amount when compared to the billions of the oil revenues). Consequently, in August 2013, the Ecuadorian president suddenly announced that he would open the Ishpingo-Tambococha-Tiputini block for oil exploration.

A large part of ENGOs aim to stop population growth, and stop progress and quality of life improvements for everybody. They are convinced that this is necessary to stop using natural resources. We noted that it is impossible to work without energy and impossible to keep a good standard of living for everybody without energy, ultimately the new religion requests to stop growth, this being a remote possibility, to say the least. If carbon emissions are to be cut, this would require far more interventionist measures regulating our behaviour and intervening in our lifestyles than until now encountered. Václav Klaus, the former president of Czechia[a], made this same point when he declared: ‘What is at risk is not the climate, but freedom.’

With so many alarmist discourses ongoing particularly on energy issues, anxiety and fear are now driving occidental mankind thinking. Fear today has become a feeling that one shows while in the past it was hidden from view. While our societies are more developed, peaceful and secularised, we are

[a] Czechia is the new official name of the Czech Republic.

still seeking the apocalypse. It's like our lives are more exciting at the idea that the world can end if we do nothing. In other words, people are afraid and show it, they are suffering from anxiety, and they make it known. They even congregate in mobs to collectively exhibit this angst as is what is occurring with students in Europe following doomsayer Greta Thunberg.

But should fear or anguish guide our political actions especially when it is our future that is at stake? This question is crucial because it places emotions at the heart of public action. The American political scientist Georges E. Marcus explains that '*either understand what is fair, equitable, and just, but do nothing, or be moved to action by emotions that are partial in their goals and partial in their effects. [Reason] enables us to imagine a world of freedom, justice and rights equitably secured for one and all. [Emotion] enables us to reach and move people thought too often unguided by the dictates of reason*.'[159] This argument can be used, trust and implement by politicised scientists. For the engineer, the technology scientist that I am, this is odd.

5 ANNEXES

5.1 Conversion factors

Table 1 Physics energy units (heat and work)

	J	kWh	kcal
Joule (J)	1	$2.778.10^{-7}$	$2.389.10^{-4}$
Kilowatt-hour (kWh)	$3.6.10^{6}$	1	860
Kilocalorie (kcal)	$4.185.10^{3}$	$1.163.10^{-3}$	1

Units used in the USA.
1 Therm = $0.10551.10^{9}$ J
1 Quad = $1.0551.10^{18}$ J

Table 2 Conversion factors for Crude oil

From	To convert			
	toe	**1,000 litres**	**Barrels**	**t/ year**
toe	1	1,165	7.33	–
1,000 litres	0.8581	1	6.2898	–
Barrels	0.1364	0.159	1	–
Barrels / year	–	–	–	49.8

Table 3 Units of energy (heat and electricity) in the energy field

From	To convert				
	Mtoe	Mtce	Gm³ GN (bcm)	GJ	MWh
Million ton oil equivalent (Mtoe)	1	1.5	1,047	$4.19.10^7$	$1.16.10^7$
Million tons coal equivalent (Mtec)	0.67	1	0.70	$2.8.10^7$	$7.7.10^6$
Giga cubic metre of natural gas (Gm^3 GN) also known as BCM or bcm	0.955	1.43	1	$4,10^7$	10.81
Giga Joules (GJ)	$2.38.10^8$	$3.57.10^8$	$2.5.10^{-8}$	1	0.278
Megawatthour (MWh)	0.086	0.129	0.09	3.60	1

Table 4 Conversion factors for natural gas

From	To convert			
	Gm³	Mtoe	Mt LNG	Mb
1 Gm^3 Billion cubic metres of natural gas	1	0.90	0.74	6.60
1 Mtoe 1 million tonnes of oil equivalent	1.11	1	0.82	7.33
1 Mt LNG 1 million tonnes LNG	1.36	1.22	1	8.97
1 Mb 1 Million barrels of oil equivalent	0.15	0.14	0.11	1

Table 5 Other unit conversion factors

Unit	Equivalent
1 kilolitre	6.2898 barrels
1 kilocalorie (kcal)	4.187 kJ = 3.968 Btu
1 kilojoule (kJ)	0.239 kcal = 0.948 Btu
1 British thermal unit (Btu)	0.252 kcal = 1,055 kJ
1 kilowatt-hour (kWh)	860 kcal = 3600 kJ = 3412 Btu

Table 6 Calorific equivalents of one tonne of oil equivalent (toe)

1 toe equals	
Heat units	10 million kilocalories 42 gigajoules 40 million Btu
Solid fuels	1.5 tonnes of hard coal 3 tonnes of lignite
Electricity	12 megawatt-hours
Biofuels	1.75 tonne of ethanol 1.16 tonne of biodiesel

5.2 List of Abbreviations and Acronyms

Abbreviation	Meaning
ACER	Agency for the Cooperation of Energy Regulators
ASPO	Association for the Study of Peak Oil
BTC	Baku-Tbilisi-Ceyhan
CAC	Central Asia – Center pipeline
CCS	Carbon Capture and Storage
CCT	Clean Coal Technology
CEA	Commissariat à l'énergie atomique (French agency for nuclear energy)
CCU	Carbon Capture and Use
CEER	Council of European Energy Regulators
CEF	Connecting Europe Facility
CFBC	Circulating Fluidised Bed Combustion
CRM	Capacity Remuneration Mechanism
DDR	Deutsche Demokratische Republik
DH	District heating
DOE	Department of Energy (USA)
EC	European Commission
ECA	Emission Control Areas
EEZ	Exclusive Economic Zone
EFSI	European Fund for Strategic Investments
EIA	Energy Information Administration of USA
EITI	Extractive Industries Transparency Initiative
ENEF	European Nuclear Energy Forum
ENGO	Environmental Non-Governmental Organisation
ENSREG	European Nuclear Safety Regulation Group
ENTSO	European Network of Transmission System Operators for Gas or Electricity
EOR	Enhanced Oil Recovery
EPA	Environmental Protection Agency (USA)
EPR	Evolutionary Power Reactor

Abbreviation	Meaning
ESA	Euratom Supply Agency
ETS	Emissions Trading System
FGD	Flue gas desulphurisation
FID	Final Investment Decision
FRG	Federal Republic of Germany (former name of the non-communist Germany)
GCCSI	Global CCS Institute
GDR	German Democratic Republic
GECF	Gas Exporting Countries Forum
GERD	Grand Ethiopian Renaissance Dam
GGFR	Global Gas Flaring Reduction Partnership
HDD	Heating Degree Days
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IGCC	Integrated Gasification Combined Cycle
IOCs	International Oil Companies
IPCC	International Panel on Climate Change
IPI	Iran–Pakistan gas pipeline
ITGI	Interconnector Greece-Italy
JBIC	Japanese Bank for International Cooperation
LSE	Liquid Solvent Extraction
MWh	Megawatt-hour
NGO	Non-Governmental Organisation
NIOC	National Iranian Oil Company
NS2	Nord Stream 2
PC	Pulverised coal
PCI	Project of Common Interest
PSA	Production Sharing Agreement
PV	Photovoltaic
PWR	Pressurised Water Reactor
RoW	Rest of World
SCP	South Caucasus Pipeline
SCR	Selective catalytic reduction
SMR	Small Modular Reactor
TANAP	Trans-Anatolian Pipeline

Abbreviation	Meaning
TAP	Trans Adriatic pipeline
TCP	Trans Caspian Pipeline
toe	Tonne oil equivalent
TWh	Terrawatt-hour
UAE	United Arab Emirates
UCG	Underground Coal gasification
UNFCCC	UN Framework Convention on Climate Change
WB	World Bank

References

1 Naim Moises, The End of Power: From Boardrooms to Battlefields and Churches to States, Why Being In Charge Isn't What It Used to Be, 2013, Basic Book

2 Jean-Marc Jancovici; Combien suis-je un esclavagiste, http://www.manicore.com/documentation/esclaves.html

3 Laherrere Jean, Sophia Antipolis master course, 2014

4 RTL-TVi, Pour ou contre: chauffe, baisser la facture grâce aux énergies renouvelables ?, 26 January 2015, http://www.rtl.be/rtltvi/video/523756.aspx?CategoryID=4731

5 Rhodes Richard, Energy, a human history, Simon & Schuster Paperbacks, 2018

6 Lord Kelvin, Electrical Units of Measurements, Lecture 3 May 1883, https://archive.org/stream/popularlecturesa01kelvuoft#page/72/mode/2up

7 Tol Richard, Climate Economics: Economic analysis of climate, climate change, and climate policy, Edward Elgar; 2014

8 Meadows Donella, et al., The limits to growth: a report for the Club of Rome’s project on the predicament of mankind, London: Earth Island, 1972.

9 L’histoire du Club de Rome, http://www.clubofrome.org/?p=4760

10 Furfari Samuele, Les erreurs du Club de Rome, La Libre (supplement économie), 8 september 2007

11 Cyprès René, Question de Carbochimie, Université Libre de Bruxelles, 1977

12 European Union, Council Resolution of 9 June 1980 concerning new lines of action by the Community in the field of energy saving, Official Journal C 149, 18 June 1980, pp. 3-5.

13 World Bank, http://databank.worldbank.org/data/views/reports/tableview.aspx

14 Furfari Samuele, Russia cuts the gas tap, it can forget its dream of selling gas to China one day, Energy Post, April 30, 2014

15 European Union, Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/ European Commission, Official Journal of the EU, L140 of 5.6.2009

16 US EIA, Fossil fuels still dominate U.S. energy consumption despite recent market share decline, 1 July 2016, http://www.eia.gov/todayinenergy/detail.php?id=26912

17 ESADE Spanish business school, The Global Energy Market, 5 November 2013

18 European Commission, Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee, A vision for the internal market for industrial products, COM(2014) 25/2, 22 January 2014

19 Wall Street Journal, Dirty USA Coal Finds a Home in Europe, 5 May 2015, http://www.wsj.com/articles/SB10001424052702303417104579543814192542586

20 Leguay Jean-Pierre, La pollution au Moyen Âge, Editions Gisserot, 1999, 2013

21 Carson Rachel, Silent Spring, Houghton Mifflin, 1962

22 http://www.un-documents.net/our-common-future.pdf

23 Roosevelt Theodore, Special Message of 22 January 1909, To the Senate and House of Representatives, http://www.presidency.ucsb.edu/ws/index.php?pid=69658&st=conservation&st1=energy

24 Le Figaro Economie, Centrales à charbon: le gouvernement renonce à la taxe, 21/10/2016, http://www.lefigaro.fr/flash-eco/2016/10/21/97002-20161021FILWWW00109-centrales-a-charbonle-gouvernement-renonce-a-la-taxe.php

25 Zaccai Edwin, «Développement durable et disciplines scientifiques», Natures Sciences Sociétés, vol. 15, n° 4, 2007, p. 379-388, www.nss-journal.org.

26 United Nations, General Assembly, report of the United Nations conference on environment and development (Rio de Janeiro, 3-14 June 1992), Annex I Rio declaration on environment and development,

http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm

27 Victori Jean-Marc, Les Échos, Le vrai problème avec le principe de précaution, 27/02/2015, http://www.lesechos.fr/27/02/2015/LesEchos/21887-025-ECH_le-vrai-probleme-avec-le-principe-de-precaution.htm#tqXRW0OQM66xgAgB.99

28 Lepage Henri, "Le libéralisme aujourd'hui", Arguments – Revue européenne de science, vol. 1, n°2, hiver 2016, http://revue-arguments.com/articles/index.php?id=8.

29 European Commission, ExternE, Externalities of Energy, ISSN 1018-5593, EUR 16520 EN, 1995, More details on http://www.externe.info/externe_d7/

30 Claissea J. et al, Oil platforms off California are among the most productive marine fish habitats globally, Proceedings of the National Academy of Sciences, 2014-10-13, http://dx.doi.org/10.1073/pnas.1411477111

31 Porquet Jean-Luc, Introduction à la pensée technocritique de Jacques Ellul, par https://journaldecologiecritique.wordpress.com/2019/04/29/introduction-a-la-pensee-technocritique-de-jacques-ellul-par-jean-luc-porquet/

32 Bernstam Mikhail S., The Wealth of Nations and the Environment, Population and Development Review, Vol. 16, Supplement: Resources, Environment, and Population: Present Knowledge, Future Options (1990), pp. 333-373 (41 pages)

33 Lomborg Bjorn, The Sceptical Environmentalist, Measuring the Real State of the World, Cambridge University Press, 2001

34 Kuznets Simon, “Economic Growth and Income Inequality,” The American Economic Review XLV, no. 1, 1955

35 Hölderlin Friedrich, in the poem "Patmos"

36 Roqueplo Philippe, Pluies acides: menace pour l'Europe, Economica, 1988

37 European Union, Council Directive 88/609/EEC of 24 November 1988 on the limitation of emissions of certain pollutants into the air from large combustion plants, Official Journal L 336, 07/12/1988 P. 0001 – 0013

38 European Union, Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants, Official Journal L 309, 27/11/2001 P. 0001 – 0021

39 European Union, Directive 2001/81/EC of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, 2001, OJ L0081 of 20.04.2009

40 European Environment Agency, http://www.eea.europa.eu/data-and-maps/indicators/eea-32-nitrogen-oxides-nox-emissions-1/assessment.2010-08-19.0140149032-3

41 European Environment Agency, Data: http://www.eea.europa.eu/data-and-maps/data/data-viewers/air-emissions-viewer-lrtap

42 European Union, Directive 2013/30/EU of the European Parliament and of the Council of 12 June 2013 on safety of offshore oil and gas operations and amending Directive 2004/35/EC Text with EEA relevance, OJ L 178, 28.6.2013, p. 66–106

43 Furfari Samuel, Protecting the Mediterranean Sea's environment, thanks to gas, in energy in the Eastern Mediterranean: promise or peril? Joint Report by the Egmont Institute and the Atlantic Council, Sami Andoura and David Koranyi (EDS.),Egmont Institute, May 2014

44 European Union, Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, OJ L 312, 22.11.2008, p. 3–30

45 European Commission, Questions and Answers on the Thematic Strategy on the prevention and recycling of waste, MEMO/05/496, 21 December 2005

46 Furfari Samuele, L'urgence d'électrifier l'Afrique, L'Harmattan, Paris, 2019

47 Srivastava, L, Goswami, A, Diljun, G M & Chaudhury, S 2012. "Energy access: Revelations from energy consumption patterns in rural India", Energy Policy, vol. 47, no. 1, pp. 11-20

48 Brown James H. *et al.,* Energetic Limits to Economic Growth, January 2011/Vol. 61 No. 1 • BioScience 19,

www.aibs.org/bioscience-press-releases/resources/Davidson.pdf

49 World Bank, Progress towards Sustainable Energy 2015. Global Tracking Framework Report, http://trackingenergy4all.worldbank.org/~/media/GIAWB/GTF/Documents/GTF-2105-Full-Report.pdf

50 Smith K, et all. Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors, Indoor air pollution from household use of solid fuels, Eds Ezzati M, Lopez A et all., World Health Organisation, Geneva.

51 Emmelin A, Wall S., Indoor air pollution: a poverty-related cause of mortality among the children of the world, Chest. 2007 Nov;132(5):1615-23

52 Bruce N., Perez-Padilla R., Albalak R., Indoor air pollution- in developing countries-: a major environmental and public health challenge, Bull World Health Organ. 2000;78(9):1078-92.

53 Singh P, Gundimeda H & Stucki M,. "Environmental footprint of cooking fuels: a life cycle assessment of ten cooking fuels used in Indian households", Supplementary material, International Journal of Life Cycle Assessment, 2014, vol. 19, pp. 1036-1048

54 World Bank-, World DataBank, World Development Indicators, http://databank.banquemondiale.org/data/views/variableselection/selectvariables.aspx#

55 IEA-, Africa Energy Outlook, 2014

56 Salvation Army, Lessons from the founders¸ http://salvos.org.au/scribe/sites/more/files/downloads/life/LIFE_-_Lessons_from_the_Founders.pdf

57 IEA-, 2015 Defining and modelling energy access, OECD/IEA, Paris, Available, 2015, http://www.worldenergyoutlook.org/resources/energydevelopment/definingandmodellingenergyaccess/

58 IEA-, World Energy Outlook — Methodology for Energy Access Analysis, OECD-/IEA, http://www.worldenergyoutlook.org/media-/weowebsite/energymodel/documentation/EnergyAccess_Methodology_2012_FINAL.pdf

59 IEA-, Energy poverty-,

https://www.iea.org/topics/energypoverty/
60 IEA, World Energy Outlook, IEA, Paris, 2012
61 http://www.cleancookstoves.org/
62 Raji Fashola Babatunde, Minister Of Power, Works And Housing, 2016 Annual Conference of the National Association of Energy Correspondents, Lagos, July 2016
63 http://www.whitehouse.gov/the-press-office/2013/06/30/fact-sheet-power-africa
64 Pachauri S., van Ruijven B. J., Nagai Y., Riahi K., van Vuuren D. P., Brew-Hammond, A, Nakicenovic N., 2013. “Pathways to achieve universal household access to modern energy by 2030”, Environmental Research Letters, 8(2), 024015
65 World Bank, The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits, 22 janvier 2008, http://siteresources.worldbank.org/EXTRURELECT/Resources/full_doc.pdf
66 World Bank, http://www.worldbank.org/en/country/ghana/projects
67 http://www.bridgin.eu/
68 Médiateur de l'énergie, Rapport d'activité de 2011, http://www.energie-mediateur.fr/fileadmin/user_upload/Publications/RA_MNE_2011.pdf
69 Asociación de Ciencias Ambientales, Pobreza energética en España. Análisis de tendencias”, 2014
70 Excess Winter Mortality in England and Wales, 2011/12 (Provisional) and 2010/11 (Final), http://www.ons.gov.uk/ons/rel/subnational-health2/excess-winter-mortality-in-england-and-wales/2011-12--provisional--and-2010-11--final-/index.html
71 Steinberger Julia K, Energising Human Development, UN Development programme, 14 April 2016, http://hdr.undp.org/en/content/energising-human-development
72 UNDP, Human Development Index (HDI), http://hdr.undp.org/en/content/human-development-index-hdi
73 UN Development Program, Human Development Reports, 2018 Statistical Update,

http://hdr.undp.org/en/2018-update/download

74 Tyrrell R. Emmett, The American Spectator, 6/09/1992

75 Hobbes Thomas, Leviathan, Chapter XIII, Of the Natural Condition of Mankind as Concerning Their Felicity and Misery, The Harvard Classics. 1909–14

76 ANSES, Concentrations de CO_2 dans l'air intérieur et effets sur la santé, Avis de l'Anses, Rapport d'expertise collective, Juillet 2013

77 IPCC, Principles, https://www.ipcc.ch/pdf/ipcc-principles/ipcc-principles.pdf

78 BROOME John, A Philosopher at the IPCC, 20 May 2014, International Society for Environmental Ethics, https://enviroethics.org/2014/05/20/a-philosopher-at-the-ipcc/

79 Godefridi Drieu, The IPCC A scientific body? 2012, Texquis

80 USDA, Scientific Report of the 2015 Dietary Guidelines Advisory Committee, February 2015, https://health.gov/dietaryguidelines/2015-scientific-report/PDFs/Scientific-Report-of-the-2015-Dietary-Guidelines-Advisory-Committee.pdf

81 MONTFORD A.W., The Hockey Stick Illusion: Climategate and the Corruption of Science, Stacey International, 2010

82 IPCC http://www.ipcc-wg2.gov/SREX/

83 http://www.washingtonpost.com/blogs/wonkblog/wp/2015/01/16/its-official-2014-was-the-hottest-year-in-recorded-history/

84 Daily Mail, interview of Gavin Schmidt, http://www.dailymail.co.uk/news/article-2915061/Nasa-climate-scientists-said-2014-warmest-year-record-38-sure-right.html

85 Jouzel Jean, France Info, 22 June 2019, https://www.francetvinfo.fr/meteo/climat/fortes-chaleurs-ces-periodes-caniculaires-sont-vraiment-liees-au-rechauffement-climatique-assure-le-climatologue-jean-jouzel_3501341.html

86 IPCC AR5, 2016, Technical Summary, TS.5.3, page 81, https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_TS_FINAL.pdf

87 IPCC AR5, 2013 TFE.6, Figure 2,

https://www.ipcc.ch/site/assets/uploads/2018/02/FigTS_TFE.6-2-687x1024.jpg
88 IPCC, Climate change and land, August 2019, https://www.ipcc.ch/site/assets/uploads/2019/08/4.-SPM_Approved_Microsite_FINAL.pdf
89 The Guardian, Evo Morales stuns Copenhagen with demand to limit temperature rise to 1C, 16 Dcc 2009, https://www.theguardian.com/environment/2009/dec/16/evo-morales-hugo-chavez
90 Furfari Samuele, A Cancun è nata una nuova politica energetica?, Instituto Bruno Leoni, IBL Focus 194, 29/11/2011
91 The New-York Times, A Climate Deal, 6 Fateful Years in the Making, 13 December 2015, http://www.nytimes.com/2015/12/14/world/europe/a-climate-deal-6-fateful-years-in-the-making.html?_r=0
92 Encyclical Letter Laudato Si' of the Holy Father Francis on care for our common home, http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html
93 UNFCCC, Adoption of the Paris Agreement 12 December 2015, http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf
94 UNFCCC, Ad Hoc working group on the Durban platform for enhanced action, Second session, part eleven, 19-23 October 2015, Bonn, Germany http://unfccc.int/files/adaptation/application/pdf/mechanical_light_editing.pdf
95 Politico, The one word that almost sank the climate talks, 12 December 2015, http://www.politico.com/story/2015/12/paris-climate-talks-tic-toc-216721
96 United Nations FCCC, Adoption of the Paris agreement, http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf
97 Marko Istvan, Le CO_2 n'est pas un poison!, Contrepoint, 21 April 2015, https://www.contrepoints.org/2015/04/21/205301-le-co2-nest-pas-un-poison
98 The Guardian, James Hansen, father of climate change awareness, calls Paris talks 'a fraud', 12 December 2015,

http://www.theguardian.com/environment/2015/dec/12/james-hansen-climate-change-paris-talks-fraud

99 Hansen James E., Environment and Development Challenges: The Imperative of a Carbon Fee and Dividend, The Oxford Handbook of the Macroeconomics of Global Warming, http://csas.ei.columbia.edu/2015/11/11/environment-and-development-challenges-the-imperative-of-a-carbon-fee-and-dividend/

100 European Commission, proposal for a Regulation on the Governance of the Energy Union, COM(2016) 759 final, 30.11. 2016

101 RTBF, 13 December 2015, http://www.rtbf.be/info/monde/detail_jean-pascal-van-ypersele-la-cop21-est-un-moment-historique?id=9163447

102 Ban Ki-Moon: Nous n’avons plus de temps à perdre » sur le climat, Le Monde, 26.08.2015, http://www.lemonde.fr/paris-climat-2015/article/2015/08/26/sur-le-climat-nous-n-avons-pas-de-temps-a-perdre-estime-ban-ki-moon_4736798_4527432.html#MzKex0XIqWcF575B.99

103 Ripa di Meana Carlo, Foreword of Climat, 15 vérités qui dérangent, Texquis, 2013

104 European Council, Conclusions on 2030 Climate and Energy Policy Framework, 23 and 24 October 2014, http://data.consilium.europa.eu/doc/document/ST-169-2014-INIT/en/pdf

105 The Guardian, UK aid helps to fund forced sterilisation of India's poor, 15 April 2012, http://www.theguardian.com/world/2012/apr/15/uk-aid-forced-sterilisation-india

106 Walters Barry N J, Personal carbon trading: a potential “stealth intervention” for obesity reduction?, Med J Aust 2007; 187 (11): 668. https://www.mja.com.au/system/files/issues/187_11_031207/wal10921_fm.pdf

107 Ferry Luc, "Luc Ferry" "Le Nouvel ordre écologique", 2002, Le Livre de Poche

108 Reporterre, Pour « sauver la planète », ils et elles ont choisi de ne pas avoir d’enfant, 28 juin 2019,

https://reporterre.net/Pour-sauver-la-planete-ils-et-elles-ont-choisi-de-ne-pas-avoir-d-enfant

109 Brouwers Els, Brussels, Safeguarding the future of the Chemical Industry, 14 November 2016

110 Eurostat, http://ec.europa.eu/eurostat/news/themes-in-the-spotlight/cop21

111 IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, Annex II, p 982, http://www.ipcc.ch/pdf/special-reports/srren/Annex%20II%20Methodology.pdf

112 Bravi Mirlko and Basosi Riccardo, Environmental impact of electricity from selected geothermal power plants in Italy, Journal of Cleaner Production, 18 November 2013, http://www.arpat.toscana.it/notizie/arpatnews/2014/122-14/Bravi%20M%20Basosi%20R%20Environmental%20impact%20of%20electricity%20from%20selected%20geothermal%20power.pdf

113 EU Presidency Conclusions, Brussels, 8/9 March 2007, https://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/93135.pdf

114 European Union, Regulation (EC) No 663/2009 of 13 July 2009 establishing a programme to aid economic recovery by granting Community financial assistance to projects in the field of energy, OJ L 200, 31.7.2009, p. 31–45, https://eur-lex.europa.eu/legal-content/EN/AUTO/?uri=celex:32009R0663

115 European Court of Auditors, Special report n°24/2018, https://www.eca.europa.eu/en/Pages/DocItem.aspx?did=47082

116 http://www.cslforum.org/

117 http://www.globalccsinstitute.com/

118 GCCSI, Report 2018, https://www.globalccsinstitute.com/resources/global-status-report/

119 Zero Emissions Platform, An Executable Plan for enabling CCS in Europe, September 2015, http://www.zeroemissionsplatform.eu/downloads/1545.html

120 Folger Peter, Carbon Capture and Sequestration: Research, Development, and Demonstration at the U.S. Department of Energy, February 10, 2014, http://www.fas.org/sgp/crs/misc/R42496.pdf

121 Department of Energy, U.S. Department of Energy Announces $110 M for Carbon Capture, Utilization, and Storage, 13 September 2019, https://www.energy.gov/articles/us-department-energy-announces-110m-carbon-capture-utilization-and-storage

122 IPCC Special Report 15, 2019

123 http://www.globalcarbonproject.org

124 India report to UNFCCC, https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf

125 Message from the Energy minister of India, no date mentioned, http://www.piyushgoyal.in/uploadedfiles/views/ministry_english_booklet.pdf

126 US EIA, 2019, https://www.eia.gov/electricity/annual/html/epa_09_01.html

127 US EIA, 2019, https://www.eia.gov/electricity/annual/html/epa_09_01.html

128 Le Roy Ladurie Emmanuel, Histoire du climat depuis l'an mil, 2009, Champs Histoire

129 Emmanuel Garnier, Exceptional meanness water and hot weather 500 years of drought and heat wave in France and neighboring countries, UMR CEA-CNRS Saclay et UMR CRHQ Université de Caen (http://www.gisclimat.fr/sites/default/files/Garnier_SHF_2009.pdf)

130 La Repubblica, L'appello sul clima bocciato dai fisici: "Il ruolo dell'uomo non è provato", 05/12/2015

131 Tol Richard, American Interest, Dec 10, 2014, http://www.the-american-interest.com/2014/12/10/hot-stuff-cold-logic/

132 IPCC, 3rd Assessment report (2001) – page 774

133 IPCC, AR 5 Group I chapter 9, 2013, "Evaluation of Climate Models" Section 9.4.9.4.1 Box 9.2: "Climate Models and the Hiatus in Global Mean Surface Warming of the Past 15 Years",

page 769, http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter09_FINAL.pdf
134 Casey John L., Dark Winter: How the Sun Is Causing a 30-Year Cold Spell, Humanix Books, 2014
135 Geuskens Georges, private communication
136 Ad Hoc Study Group on Carbon Dioxide and Climate, Carbon Dioxide and Climate: A Scientific Assessment, National Academy of Sciences, Washington D.C., 1979, http://web.atmos.ucla.edu/~brianpm/download/charney_report.pdf
137 Liu Zhu and al, Reduced carbon emission estimates from fossil fuel combustion and cement production in China, Nature | Letter, 524, pages 335–338, 20 August 2015
138 UK MetOffice (http://www.metoffice.gov.uk/research/news/recent-pause-in-warming) or http://www.nature.com/ngeo/journal/v7/n3/full/ngeo2105.html
139 Neely Ryan, Recent anthropogenic increases in SO2 from Asia have minimal impact on stratospheric aerosol, Geophysical Research Letters, Volume 40, Issue 5, pages 999–1004, 16 March 2013
140 Llovel William et al. Deep-ocean contribution to sea level and energy budget not detectable over the past decade, journal Nature Climate, doi:10.1038/nclimate2387, 5 Oct. 2014.
141 Durack Paul J et al., Quantifying underestimates of long-term upper-ocean warming, Nature Climate Change (2014) doi:10.1038/nclimate2389, 5 Oct. 2014
142 Humlum Ole et al., The phase relation between atmospheric carbon dioxide and global temperature, Global and Planetary Change 100 (2013) 51–69
143 Humlum Ole et al., The phase relation between atmospheric carbon dioxide and global temperature, Global and Planetary Change, 100 (2013), 51–69
144 Lindzen Richard S., Taking greenhouse warming seriously, energy & environment, volume 18 No. 7+8 2007
145 Lindzen Richard S., The Political Assault on Climate Skeptics, Wall Street Journal, 4 March 2015

146 Lomborg Bjørn, A New Dawn, The Wall Street Journal, 8 November 2008

147 Korhola Eija-Riitta, Academic Dissertation, The rise and fall of the Kyoto Protocol: climate change as a political process, Faculty of Biological and Environmental Sciences University of Helsinki, 2014

148 Furfari Samuel and Masson Henri, Climate: about which temperature are we talking about? Science-climat-énergie, July 2019, http://www.science-climat-energie.be/2019/07/24/climate-about-which-temperature-are-we-talking-about/#more-5715

149 F.K. Ewert (FUSION 32, 2011, Nr. 3 p31)

150 IPCC, http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter3.pdf]

151 http://climate.gov/news-features/understanding-climate/climate-change-global-temperature

152 http://climate.gov/news-features/understanding-climate/climate-change-global-temperature

153 Berger André and Furfari Samuel, Le nucléaire, solution à la transition énergétique, Le Vif, 11/01/2020, https://www.levif.be/actualite/environnement/le-nucleaire-solution-a-la-transition-energetique/article-opinion-1237715.html?cookie_check=1578667297

154 Frankfurt School-UNEP Collaborating Centre, Global trends in renewable energy in 2019, https://wedocs.unep.org/bitstream/handle/20.500.11822/29752/GTR2019.pdf?sequence=1&isAllowed=y

155 Clintel, Science behind the World Climate Declaration https://clintel.org/world-climate-declaration/

156 White Lynn, The Historical Roots of Our Ecological Crisis, Science, N° 3767 (10 March 1967), Pp. 1203-1207

157 Furfari Samuele, Chrétien écolo ? Le retour du paganisme, Kindle Publishing, 2019 and Dieu, l'homme et la nature, Bourrin Editeur, Paris 2010

158 Recharge Transition, Brazilian oil giant Petrobras exits renewables business, 05 August 2019,

https://www.rechargenews.com/transition/1833012/brazilian-oil-giant-petrobras-exits-renewables-business

159 Marcus George E., The sentimental Citizen: Emotion in Democratic Politics, The Pennsylvania State University Press, 2002

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