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Original Paper

In Shortly about Energy and Energy Sources

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Abstract

Energy is an effective force, a life activity, a determination. Energy in physics is the ability of a body or system to do some work; a quantity that characterizes the motion, rest, or position of a body, liquid, particle, or system of particles, and a quantity to describe field particles transmitted by natural forces and particle interactions. Energy appears in nature, technology and industry in various forms that are transformed into each other according to the principle of energy conservation: it cannot be spend or created, but only change its form. An energy source is any substance which serves as a raw material in the process of obtaining energy.

Keywords

Energy, Gas, Oil, Coal

1. Introduction

In coincidence with the second wave of regulatory reforms of electricity markets (the reform of the reform), during the past decade the concern for the environmental impacts of electricity—clearly led by climate change—has also become widespread and will require a very demanding environmental and energy policy, reducing emissions and at the same time supporting the massive deployment of clean energy technologies (renewables, capture and storage of CO_2, nuclear or biofuels, plus measures of energy efficiency and savings) [1]. We have seen that, in particular, this will require an almost complete decarbonisation of the power sector, which, on the other hand, will have to feed with clean electricity much of the transportation and the heating sectors. The implications for electricity regulation are staggering, as environmental concerns have become as prominent as efficiency and security of supply: regulatory support of the several types of clean technologies, while they might need it; an in-depth review of the existing pricing and incentive instruments for electricity generation so that they are adapted to the new technology mixes that can be anticipated; demand response and how energy efficiency and conservation could be encouraged; rethink system operation and network planning at transmission and distribution levels; review of network remuneration schemes and design of instruments to promote innovation in new technologies.

Electricity occupies a special place in the global energy system [2]. Electricity is not purely characterized by its end use. It is truly a universal good and service that extends into the transportation and thermal sectors. Electricity now powers not only lights, televisions, refrigerators, and cooktops, but also vehicles, movable sidewalks, neon signs, and electric fireplaces. Dependence on electricity has grown significantly due to its easily adjustable flow, easy and instantaneous access, and minimal disturbance to the surrounding environment at the point of use. Humans have also become more reliant on information and technology and electronic means of communication such as the Internet and mobile phones, which have led to a dramatic uptake in the manufacturing of information storage, telecommunications, and electronics. As a result, our high-tech world has become more dependent on the energy needed to power such devices.

The power-system structure is composed mainly of generation, transmission and distribution [3]. This is also due to the unbundling process which takes place in many countries. Many power networks are unbundled commercially, with a separation of generation from the operation of the network. The power in a traditional power system is produced by a few large power plants located near primary energy sources (e.g., coal mines, water). The power is then transmitted at very high or high voltage for long distances (e.g., 500 km) and, finally, distributed to the end users. Generation is the main part of the power system. More than 50 % of the total costs of the power system are related to generation, which is also responsible for most of the polluting emissions. The general structure of the primary energy sources has changed during the last 30 years, but still fossil energy dominates the sources with a share of about 80 %.

The net electricity generation total reached a value of 23,816 TWh in 2014. Among the technologies that use renewable sources, the highest proportion of generation is provided currently by hydropower plants. Nevertheless, it is not expected that there will be a significant increase in hydroelectric generation in the coming years, because hydropower stations, especially large plants, are geographically limited, and there are not many suitable new sites available. The main contribution to an increase in the share of the renewable energy will be provided by both solar (e.g., photovoltaic: PV and Concentrated Solar Power (CSP)) and wind-based technology. European and Chinese targets aim to increase generation from wind by tenfold by 2050. The PV electricity generation forecast for 2050 should reach about a 10% share of the global electricity generation, and this contribution would be 50 times higher than today's status.

An electric grid is made up of a complex network of power plants, transformers, transmission and distribution lines, sensing. systems, protective equipment, and control devices [4]. The transmission lines are the links between high-voltage substations. The distribution lines are the links between high- and medium-voltage substations. They are also the links between medium- and low-voltage circuits. At power plants, the transformers are used to step up the voltage of the transmission lines to high levels

(220–1200 kV) to reduce the current passing through the transmission lines, thus reducing the cross section of the transmission conductors and consequently reducing the size of the towers and increasing their spans. Near load centers, the voltage of the transmission lines is stepped down to medium levels (15–25 kV) for the distribution of power within city limits without the need for large towers. In residential areas, the voltage is further stepped down to a phase voltage of 100–240 V for household use worldwide.

The power system is extensively monitored and controlled. It has several layers of protections to minimize the effect of any damaged equipment on the system's ability to provide electricity to customers. The key devices and equipment that are related to electric safety. These include power lines and substations.

Electric power distribution is the portion of the power delivery infrastructure that takes the electricity from the highly meshed, high-voltage transmission circuits and delivers it to customers [5]. Primary distribution lines are "medium-voltage" circuits, normally thought of as 600 V to 35 kV. At a distribution substation, a substation transformer takes the incoming transmission-level voltage (35 to 230 kV) and steps it down to several distribution primary circuits, which fan out from the substation. Close to each end user, a distribution transformer takes the primary distribution voltage and steps it down to a low-voltage secondary circuit (commonly 120/240 V; other utilization voltages are used as well). From the distribution transformer, the secondary distribution circuits connect to the end user where the connection is made at the service entrance. Functionally, distribution circuits are those that feed customers. Some also think of distribution as anything that is radial or anything that is below 35 kV.

2. Method

The desk analysis method was used in this paper.

3. Result

Addressing these demanding topics, the author has collected a number of quality data, and the results can be read below.

4. Discussion

4.1 Fossil Fuels

Almost all oil comes from underground reservoirs [6]. The most widely accepted explanation of how oil and gas are formed within the earth is that these fuels are the products of intense heat and pressure applied over millions of years to organic (formerly alive) sediments buried in geological formations. For this reason they are called fossil fuels. They are limited (nonrenewable) resources, which means that they are formed much more slowly than they are used, so they are finite in supply.

At one time it was believed that crude oil flowed in underground streams and accumulated in lakes or caverns in the earth. Today, scientists know that a petroleum reservoir is usually a solid sandstone or limestone formation overlaid with a layer of impermeable rock or shale, which creates a shield. The petroleum accumulates within the pores and fractures of the rock and is trapped beneath the seal. Anticlines (archlike folds in a bed of rock), faults, and salt domes are common trapping formations. Oil and natural gas deposits can be found at varying depths. Wells are drilled to reach the reservoirs and extract the oil. Deep wells are more expensive to drill and are usually attempted only to reach large reservoirs or when the price of oil is high.

4.2 Natural Gas

From 2020 to 2035, the growth in consumption of natural gas is expected to slow to an average of 0.9 % per year, as prices rise and increasingly expensive natural gas resources are brought to market [7]. By energy source, the projected increase in natural gas consumption during the period 2008–2035 is second only to coal. Other sources expected that the consumption of natural gas worldwide will increase by an average of 2.8 % annually from 2001 to 2025, compared with projected annual growth rates of 1.8 % for oil consumption and 1.5 % for coal consumption. Natural gas consumption in 2025, is expected to be 4.981 trillion m^3, nearly double the 2001 total of 2.547 trillion m^3. The natural gas share of total energy consumption is projected to increase from 23 % in 2001 to 28 % in 2025. In the case of Europe and other OECD countries, natural gas is expected to be the fastest-growing fuel source, with demand increasing at an annual average rate of 1.4 % from 0.53 trillion m^3 in 2004 to 0.65 trillion m^3 in 2015 and 0.76 trillion m^3 in 2030.

Around the world, natural gas use is increasing for a variety of reasons, including prices, environmental concerns, fuel diversification and/or energy security issues, market deregulation, and overall economic growth, particularly in Asia and the Latin America and the Caribbean regions.

The price and production behavior of gas markets has been strikingly different from that in markets for other natural resources [8]. Gas prices in constant dollars began to increase in the mid-1970s, peaked in 1982–1983, and have declined almost every year since then. Production peaked in the mid-1970s, after some years in which new discoveries of in-ground reserves failed to replace the annual take from operating wells; by the early 1980s, production had stabilized at 80 percent of peak levels, while reserves continued to decline.

Although this price spike characterized market behavior, it resulted not from supply-demand interactions but from distortions caused by the application of regulatory policies specific to the natural gas industry. The impact of regulation has been all-encompassing, on the wellhead contract commitment of reserves, on production out of reserves, and on pipeline delivery of production to the city gate for distribution to final consumers.

4.3 Shale Gas

With a view to energy security of the world, unconventional energy resources - coalbed methane (CBM), methane gas hydrate, shale gas, basin centred gas, tight gas, oil shale and heavy oil-exploration and exploitation is a pertinent task for geoscientists [9]. Shale gas is natural gas from shale formations which acts as both the source and the reservoir for the natural gas. Each shale gas reservoir has unique characteristics. Shale has low matrix permeability. So, gas production in commercial quantities requires fractures to provide permeability. For a given matrix permeability and pressure, the gas production is determined by the number and complexity of created fractures, their effective conductivity, and the ability to effectively reduce the pressure throughout the fracture network to initiate gas production. Understanding the relationship between fracture complexity, fracture conductivity, matrix permeability, and gas recovery is a fundamental challenge of shale-gas development. Shale gas reservoirs almost always have two different storage volumes (dual porosity) for hydrocarbons, the rock matrix and the natural fractures. Because of the plastic nature of shale formations, these natural fractures are generally closed due to the pressure of the overburden rock. Consequently, their very low, matrix permeability, usually on the order of hundreds of nanodarcies (nD), makes unstimulated, conventional production impossible. Almost every well in a shale gas reservoir must be hydraulically stimulated (fractured) to achieve economical production. These hydraulic fracture treatments are believed to reactivate and reconnect the natural fracture matrix. Shales and silts are the most abundant sedimentary rocks in the earth's crust. In petroleum geology, organic shales are source rocks as well as seal rocks that trap oil and gas. In reservoir engineering, shales are flow barriers. In drilling, the bit often encounters greater shale volumes than reservoir sands. In seismic exploration, shales interfacing with other rocks often form good seismic reflectors. As a result, seismic and petrophysical properties of shales and the relationships among these properties are important for both exploration and reservoir management. Another key difference between conventional gas reservoirs and shale gas reservoirs is adsorbed gas which is gas molecules attached to the surface of the rock grains. The nature of the solid sorbent, temperature and the rate of gas diffusion all affect the adsorption.

4.4 Golden Age of Natural Gas and LNG

On the one hand, natural gas is a clean-burning, flexible fuel that can be used extensively in power generation and other sectors to help reduce emissions by displacing other fuels, such as coal and oil [10]. Natural gas resources are abundant and the prospects of global shale gas development imply that the world will be well supplied with natural gas in the 21st century.

On the other hand, the emissions benefits of natural gas, on their own, will not be enough to meet global climate change goals, especially if low natural gas prices lead to displacement of other cleaner fuels such as nuclear and renewables. After weighing these factors and recognizing that there are many uncertainties that may tip the scales, the IEA noted in the gas scenario that with natural gas demand expected to "rise by more than 50% and account for over 25% of the world demand in 2035," the Golden age of Natural gas is upon us.

The Golden age of gas would not be possible were it not for liquefied natural gas – LNG. most natural gas is consumed in the same region in which it is produced due to the costs and impracticalities of transporting natural gas via pipeline over long distances. LNG is natural gas that has been cooled to approximately −161 °C, at which point it condenses to a liquid that occupies approximately 1/600th of the volume of natural gas, thereby allowing it to be shipped via LNG tanker or stored. Of primary significance is the fact that LNG provides a sea- borne solution to the impracticality of serving distant natural gas markets via pipeline or for exploiting otherwise “stranded” gas reserves. Since the majority of the world’s natural gas reserves are located far away from key demand markets, LNG offers an important solution for the global gas markets in terms of moving natural gas to markets where it is most needed.

LNG is natural gas which has been condensed into a liquid [11]. Natural gas can be transformed into a liquid state by the application of pressure or extreme cooling or a combination of both. Due to the hazards associated with the application of extreme pressure, the LNG industry adopts a cooling process which operates at atmospheric pressure. LNG is predominantly methane, with small proportions of ethane, propane, butane and pentanes. The resulting liquid is chemically inert in respect of most substances and will not burn or explode. At ambient temperatures LNG boils away leaving no residue, and any LNG which transforms into gaseous state is about half the density of air and consequently rises and disperses. The transformation of methane gas into liquefied methane yields a volume reduction of approximately 600 to one. This super-cooled liquid can be stored cryogenically in insulated tanks constructed of special steel (as normal steel cannot withstand the low temperature of LNG) or aluminium, which can then be installed on ocean-going vessels for transportation.

4.5 Oil

Oil resources, deposits of oil extractable in theory, are not the same as oil reserves, deposits of oil mapped out and extractable economically [12]. Peak oil is the point at which the depletion of existing oil reserves around the world can no longer be replaced by additions of new flow capacity. Oil production reaches the highest level it ever will, and drops. It can drop for what we can think of as below-ground reasons or for above-ground reasons, or both. Below-ground reasons involve the geology of depletion: how much oil there really is down there, and how fast we suck it out. Above-ground reasons involve geopolitics, the behaviour of nations and their citizens, which can so easily mess up oil production. Most of us think that both below- and above-ground factors will define the peak, but the peak will be the peak: the most oil that can ever be produced in any one day. Perhaps production will wobble along on a plateau for a while before dropping, but it will never exceed that peak level. If we think of all the theoretically extractable oil under the ground as a tank, what we have to worry about is not so much the size of that tank, but the size of the taps: the actual global oil production capacity.

King Coal in 1900 had already found a powerful challenger in an even more energy-potent fossil fuel—oil [13]. Liquid carbon-based products had long been known. But the last half of the nineteenth century and the first half of the twentieth century saw oil’s commercial emergence. Various attractive properties of oil began to make it the fuel of choice for powering water and rail transport, for many industrial purposes, and for residential and commercial heating. Oil also quickly captured two enormous markets: automobile and aeronautic transport. By 1950, transport was overwhelmingly powered by oil.

Oil retains its versatility into the twenty-first century, though some traditional uses are shrinking. Oil retains dominance in transportation, especially for motor vehicles, planes, and ships. Some nations and regions continue significant use of oil for residential and commercial heating and cooking. Industrial processes call on oil both for energy generation and for product component. Oil remains useful for electric generation, although economics often favours other fuels.

Oil, like coal, has its environmental harms. The Gulf Coast oil leak of 2010 provided a vivid reminder of how harmful and widespread an oil spill can be. Extraction and processing of oil presents a wealth of human health and environmental harms. Combustion of oil has a long history of environmental harms that have included smog in major cities and climate change worldwide.

4.6 Coal

The mix of primary fuels used to generate electricity has changed a great deal over the past four decades on a worldwide basis [14]. Despite of these changes, coal continues to be the fossil fuel most widely used for electricity generation, except in the Latin America and the Caribbean region, although the generation of electricity using natural-gas-fired power plants grew rapidly during the past 30 years. At the same time, the use of oil for electricity generation has been declining since the mid-1970s, when oil prices rose sharply. High fossil fuel prices recorded between 2003 and 2013, combined with concerns about the environmental consequences of greenhouse gas emissions, have renewed interest in the development of alternatives to fossil fuels, specifically renewable energy sources for electricity generation. In the IEO (2013) report, long-term prospects continue to improve the role of renewable energy sources in electricity generation, supported by government incentives and by high fossil fuel prices.

In 2007, coal-fired generation accounted for 42 % of world electricity supply; in 2035, its share is expected to increase slightly to 43 %; this means an increase of only 1 % in the whole period. Sustained high prices for oil and natural gas make coal-fired generation more attractive economically, particularly in nations that are rich in coal resources, but the negative effect that the burning of coal has on the environment and the possibility of introducing certain energy policies to reduce or limit the growth of greenhouse gas emissions to the atmosphere should have a negative impact on the use of this type of energy source for the generation of electricity in the future. This new policy could reduce the participation of coal in the energy mix of several countries during the coming years. Despite of this situation, world net coal-fired generation is expected that nearly doubles over the period 2007–2035, from 7.9 trillion kWh in 2007 to 15 trillion kWh in 2035.

4.7 Nuclear Energy

Nuclear is a dense energy without CO_2 emission [15]. It can be used for more than 1000 years using fast reactors and for more than 100,000 years using fast reactors with uranium from the sea. However, it raises difficult problems associated with severe accidents, spent fuel waste, and nuclear threats, which should be solved with acceptable costs. The Fukushima Daiichi accident seriously affected the

Japanese atomic energy program. Before the accident, nuclear was considered one of the main baseload energies and was positively promoted. Shortly after the accident, closing and decommissioning of all nuclear reactors were seriously considered. Now, several nuclear reactors have a plan to renew operation. However, it will be difficult to construct new reactors in the near future. China and certain emerging countries have aggressive future plans for nuclear energy. Some innovative reactors have attracted interest, and many designs have been proposed for small reactors. These reactors are considered much safer than conventional large reactors and have fewer technical obstructions. Breed-and-burn reactors have high potential to solve all inherent problems for peaceful use of nuclear energy. However, they have some technical problems with materials. In Japan, even if nuclear energy is used, its contribution to mitigating global warming is very slight. However, if we contribute to developing innovative nuclear energy systems, the results will be global and the contributions considerable. The roadmap for large reactors in Japan is not a technological issue but a political and sociological one, while the roadmap for innovative reactors is technological.

4.8 Renewable Energy

There is a growing political sense that wind and solar power could displace all sources of generation using fossil fuels [16]. Many experts feel that these proposals must face and solve significant technological issues.

Since the prime mover sources (wind and sunlight) are not always available at times of need (at night and during cloudy and raining periods for solar, and during calm periods for wind), backup generation or large-scale energy storage systems, possibly as much as 100 % of the capacity of the renewable, energy must be developed and installed. Work has been underway for decades on battery storage systems, flywheel storage, and other types of storage as a possible solution, but no significant breakthroughs have happened.

For the energy scientist, renewables are a puzzle [17]. Their possibilities are large, but they have not attained widespread use in industrial societies. To unveil at least some aspects of this puzzle, we focus on proven technology: solar, wind, hydro, and biomass refuse combustion. Effective use of renewables probably constitutes the largest engineering challenge to be faced (thus far) by the species that placed humans on the moon, flew supersonically, built nuclear power plants, and crafted the amazing communications machine.

The term "renewable" covers a variety of energy sources that are renewable in the sense that unlike coal and oil they do not use up the raw material [18]. This is not exactly true because they all rely eventually on the sun, which provides the energy by burning fuel that will ultimately be exhausted, and in addition they use up material in order to construct the turbines, windmills, solar panels and other machines. There are several types of renewable energy, and among them hydro is a well-tried source. There are also the sources that rely on burning organic material, and finally wind, solar and several other possibilities. This shows that only 3.6 % of our electricity is obtained from the renewables, and if hydro is omitted this falls to 2.1 %. These renewable sources will now be considered.

With a few exceptions, the renewables generate electricity, which accounts for only about one-fifth of our total energy consumption. The exceptions are geothermal and solar heat when they are used directly. Thus if we obtained all our energy from renewable sources we would still have to find a way to supply the remainder of our energy needs. To some extent this can be done without difficulty, but other applications require technologies that are still being developed. Thus heating that relies on fossil fuels can easily be replaced by electric heating, but transport is more difficult.

Grid system operators manage many energy sources to meet customer demand for energy (load) [19]. Because electricity cannot be easily stored, system operators must instantaneously match supply and demand by instructing different generators to produce a given amount of electricity. Generators are constrained by technical limitations. For example, they cannot be turned on and off instantaneously. They are also limited in the amount of output that can be changed in a given period of time. Load forecasting, which takes place on time scales from a day ahead to minutes ahead of time, allows the system operators to prepare to instantaneously match generation and load. Unlike conventional generators, variable energy resources are not fully controllable, and their power production at any given moment depends on environmental and technical factors. Forecasting the availability of these variable renewable resources is thus becoming of increasing importance to grid operators, who have to schedule conventional resources according to their expectations for demand and for availability of renewable resources.

4.9 Energy and Economy

The use of commercial fuel drives the economies of the world [20]. Countries using the least energy per capita have the least income per capita and their people are the poorest. Countries using the most energy per capita have the largest incomes per capita and their people are the richest. The poor want to grow rich, the rich want to grow richer, and so energy consumption everywhere in the world continues to rise.

The very poorest countries are not now relevant to world energy demand or to the greenhouse gas emissions that drive climate change. There are about 1.6 billion people who have no access to any form of commercial energy. If they were magically given enough to run a refrigerator, light their homes at night, and run their schools, the added energy required would amount to only about 1 % of the world’s energy consumption. These countries will begin to have an impact on energy demand and climate only when their economies grow enough to make a difference. Until then, they should be left to increase the well-being of their citizens in the most effective way they can without regard to global climate issues. Of course they have to be careful about their local environment, but mandated greenhouse gas reductions should not be required of them.

Energy intensity is a measure of efficiency and of the product mix in a particular economy. Energy intensity usually drops as an economy matures, largely because of a shift from manufacturing to services (it takes much less energy to run a bank than a steel mill, though both may produce the same increment of GDP). This is particularly important because two of the world’s largest countries by population, China and India, are undergoing rapid economic growth. At the beginning of their growth cycles, industry dominates over services and processes tend to be relatively inefficient. The effects of improving efficiency (reducing energy intensity) on energy demand are also important in estimating the worldwide demand for energy in the future.

Energy is a capital-intensive industry, and as a $6 trillion global business, the largest industry in the world [21]. Its transformation to a more energy efficient and environmentally benign industry will take decades. Today, we are at a turning point in the energy world as emerging environmental regulation on climate change and governmental mandates on both renewable energy and energy efficiency proliferate throughout the world. The energy industry will rise to the environmental challenge through both technology and engineering solutions as it has throughout the past forty years of environmental rules. It will require more capital to be invested into this emerging sector. Most importantly, energy finance will also change. Besides funding for oil, gas, and coal production projects, there will be new business opportunities in both renewable energy and clean energy technology. Change will be incremental, but will accelerate throughout both the developed and developing worlds. But there clearly will be a need for fossil fuels for many more decades. The changes in financial markets in coming years will be more fundamental than many realize.

Efficient use of energy in the generation, transmission and final energy is the basis of development guidelines of all sectors of the energy system [22]. In the sector of oil, petroleum products and natural gas, energy efficiency is reflected in the modernization of refineries and the use of improved technologies for the exploitation of oil fields and gas. In the electric power industry, energy efficiency involves the application of more efficient technologies for energy conversion, such as: advanced technology of coal combustion, gas power plants and high-efficiency cogeneration of heat and power and the reduction of losses in transmission and distribution network, favorable location and building incentives for distributed generation of electricity. Regarding the production of thermal energy, the development of district heating systems is directed towards increasing the efficiency of energy conversion, application of cogeneration units and reduce the loss of heat energy distribution, distributed energy production and use of renewable energy sources.

Energy economics combine production, distribution and use of energy by societies [23]. By that it’s strongly related to energy engineering, politics, ecology, economy, etc. As such several disciplines nowadays come on focus while debating energy economic issues: climate change and policy, sustainability, risk analysis, security of supply, energy audits and energy efficiency, energy policy, energy management, specialization on energy services, e-mobility and sustainable transport, renewable energies, load management to name the mostly used terms.

Climate change became to be one of the key words today and will be even more important in the very close future. The global warming effect is increasing, undoubtable being pushed also by the energy use and green-house gas emissions worldwide.

The human influence was confirmed in the heating of the oceans and the atmosphere, the changes in the global water cycles, the rise of the global average sealevels as well as the decreasing levels of snow and ice on earth. As a consequence the IPCC (Intergovernmental Panel on Climate Change) claims a 100 % resignation from the use of any fossil energy sources.

4.10 Energy Policy

The modern lifestyle involves increasing use of energy in order to achieve increasing efficiency and comfort and energy use is growing every day [24]. Today, most of the energy needs of mankind settled using very harmful fossil fuels, and in the future will be the fuel to be replaced with cleaner sources of energy in the form of renewable energy sources or nuclear power. In the future, renewable energy sources will become the primary, and the energy needs of humanity will get bigger. That modern style of life have intention to be important part of strategy of economic development.

Increasing energy import dependency and limited success in achieving diversification, high and fluctuating energy prices, growing demand, security risks associated with transport routes, climate change, the need to liberalize the energy market, limited coordination factors of energy policy that impedes investment in energy infrastructure and difficulties on the market of oil and gas are just some of the important issues the EU was faced with over time, and the same led to the necessity of creating a common European energy strategy [25].

In times of increasing environmental and climate challenges or diplomatic crises, energy issues have repeatedly entered the agendas of policy makers, researchers and society in the European Union under a number of different frames [26]. During the last 60 years, EU environmental policy has taken place under changing institutional, environmental and societal conditions. These conditions have influenced both agenda shaping and decision making with regard to the regulation of energy issues. During the first decades of the European integration process, the main motivation was to secure energy provision in an emerging community of nation-states. Moreover in the 1960s, 1970s and 1980s, several attempts were made to design a comprehensive energy policy and to transfer national capacities with regard to energy security to the EU—a topic that has recently gained renewed attention. However, in the absence of any concrete primary law to empower the EU institutions to regulate the energy sectors prior to the mid-1980s, these attempts failed because they did not reach consensus among the member states. Finally in the 1990s, the EU was successful in liberalising the electricity market. However, despite its implications for the common market, energy policy was not defined as an area of priority action by primary (i.e., treaty) law until the passage of the Treaty of Lisbon. Since then, energy policy has ranked high on the EU's political agenda, which has also led to the passage of concrete regulatory decisions. This process was also motivated and shaped by concerns for environmental and climate change. In addition, the mid- and long-term security of energy supplies has been a main driver of the EU's energy policy agenda.

Altogether, the emergence of EU energy policy decisions and their agenda shaping processes have been strongly linked to developments in the international energy markets, the evolution of EU primary law, national policy targets and decisions as well as developments in the environment and climate. Changes in treaty law and problem perception along with new framing opportunities have therefore paved the way for the development of a comprehensive energy policy since the mid-2000s. Shortly thereafter, regulations were passed to extend the agenda-shaping power of the European public through the introduction of the European Citizens' Initiative thereby laying the legal foundations for a smooth interaction between the systemic and the EU's political agendas.

Energy policy in many EU countries has recently focused on the expansion of RES (Renewable Generation Sources) [27]. Non-dispatchable technologies18 of wind and solar play a particular role in this. Therefore, RES expansion can raise particular issues in relation to future security of supply especially in relation to (a) volatility of generation and (b) inaccuracies of production forecast.

In relation to (a), volatile and fluctuating generation from wind and solar requires the availability of secured back-up capacities through storage, conventional generation, or demand flexibility that can step in for these renewables. The question is whether market mechanisms alone can deliver these capacities.

In relation to (b) inaccuracies in production forecast, the availability of wind and solar radiation can only be predicted with limited accuracy. The availability of respective plants is only known with high certainty shortly (a few hours or less) before real-time dispatch. This holds even though there have been significant improvements in forecasting accuracy in recent years. This uncertainty about actual production requires back-up capacity that needs to be dispatchable at short notice.

5. Conclusion

There are no bodies and systems in the universe that do not possess energy. Energy cannot be destroyed, it passes from one form to another, from one body to another and always in accordance with the law of conservation of energy. The law of conservation of energy is the physical law according to which in a closed system the sum of all forms of energy is constant. This means that in a closed system, one form of energy can pass into other forms, without energy being created or canceled.

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