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Theoretical Aspects of Sustainable Energy

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Abstract The concept of sustainable development is slowly starting to be deployed to the various sectors of the economy. One is energy, which plays a key role in the modern development. The concept of sustainable energy is widely used and intuitively understood, but it is difficult to discern the full definition of this phenomenon. The purpose of this article is to define the concept of "sustainable energy". It takes into account both the issue of permanence, as well as the inclusion of social and environmental needs for economic development. Moreover, in general characterized the main areas of application of this concept, the basic tool for the study was to analyze available, domestic and foreign literature.

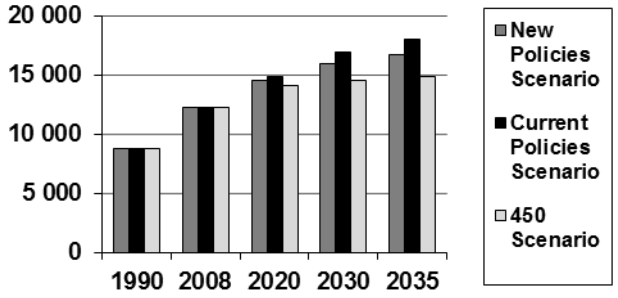
Keywords Sustainable Development, Sustainable Energy, Theory of Sustainable Energy, Renewable Energy Sources, Energy Policy

1. Introduction

Global prognoses regarding energy consumption demonstrate a further growth of energy demand (compare: fig. 1). These predictions contain also valuable information on future structure of energy sources [1]. Further domination of fossil fuels is predicted until 2035 and even 2050, which means the influence of man on the environment will persist and even increase. This causes concern over retaining stable access to energy reserves and the possible reduction of the pace of climate changes.

The concerns regarding the durability of current energy policy result in growing interest in the concept of sustainable development. Stable access to energy, especially electricity is considered to be one of the key factors in the development of civilization [2]. However, in the literature and policy documents it is difficult to discern a clear definition of how energy sector development strategy should be modelled under the concept of sustainable development. It usually boils down to two aspects, i.e. the development of renewable energy sources and energy efficiency implementation processes [3].

The purpose of this article is to define and characterize the concept of "sustainable energy", which is often mistakenly replaced with "renewable energy". The first expression is much wider, as the issue of sustainability applies not only to generate energy, but also its consumption. Analyzing a balanced approach to energy should be considered not only a problem of sustainability, but also the inclusion of social and environmental needs for economic development.



Source: Based on: World Energy Outlook 2010, International Energy Agency, Paris 2010, s. 618-619.

Figure 1. Global primary energy demand (Mtoe)

2. Definitions of Sustainable Energy

The concept of sustainable energy is derived from the attempts to implement the principles of sustainable development. Access to energy is a key factor in the development of civilization of modern societies. For this reason, the energy sector should be one of the first that will be transformed towards sustainable development. The direction in which the change should occur is not always obvious. For this reason, it is necessary to define what it is now and then should be sustainable energy future. Contrary to appearances, this is not as clear and unambiguous as one might expect. The very definition of the term is not clear. There is no leading definition that describes the sustainable energy, and even one can see that in many cases the authors themselves, for their own use, try to describe the concept, creating a very similar descriptions differ from each other only by design. This is particularly evident in the case of paraphrase of the definition of sustainable development put forward by the Brundtland Commission, which recognizes the development in accordance with the needs of the present generation, not reducing ability of future generations to meet their needs [4]. This sentence has become the basis for at

least a few definitions differ only in style e.g. [3, 5, 6].

These definitions focus primarily on issues of permanence. This is the right approach, because the long-term availability should always be the primary area of interest for this concept. It is important that this availability was offered according to the needs of the environment. However, it is worth noting that the concept of sustainable development consists of three pillars. The third one is the community. Its presence is not as highlighted as environmental issues, but also appears in the definitions of sustainable energy [6, 7].

This attitude also dominates in many other works, including H. Rogall that describes sustainable energy policy in three dimensions: ecological, economic and socio-cultural. In this way, the sustainability criteria adopted are:

1. The ecological dimension: global warming, natural tolerance, consumption of non-renewable resources, overuse of renewable resources, hazards to human health.
2. In the economic dimension: the impact on the national economy, meeting the energy needs, short-term security of supply, the relevant prices, preventing concentration and cost-effectiveness of the energy market, the economic dependence on raw material supply and the efficiency and competition for the use by different sectors of the economy (e.g, energy and chemical industry).
3. In terms of socio-cultural: social tolerance, permanent assurance of supply, the integration with the existing infrastructure, avoiding participation in global conflicts, security [9].

Three pillar division of sustainable energy is also provided by G.P. Hammond and C.I. Jones [10], who use slightly different criteria to be met by energy considered to be sustainable. These include:

- As part of the environmental pillar, the effects of the use of particular technology should be a subject to environmental assessment. In that regard the analysis should be undertaken in terms of volume by the effects of environment and energy. Tools for such an analysis can be life cycles and full fuel cycles. This is possible through the use of processes of thermodynamics analysis (energy and exergy) and environmental life cycle assessment (LCA).
- The economic pillar should be analyzed by an environmental cost-benefit analysis.
- In the social pillar it is more difficult to use measurable criteria, but partly possible, for example, by the level of involvement of stakeholders, customer research, mapping preferences, etc. On the other hand, it is also advisable to use ethical assessment of the impact of existing and future energy systems on society and the environment. One aspect of this assessment is also the issue of intergenerational equity in terms of access to sources of energy and the cost of its acquisition.

Citing authors emphasize that formed on this basis maps of balance between the individual energy technologies are characterized by a large margin of error that results from taking the initial assumptions. The result evaluation of the source may vary, even in the range of 20 percent. This includes not only the use of appropriate weights assigned to specific factors, but even their choice. In addition, such maps can be different becouse of selection of adopted measures. One of the simplest sets of criteria presents H. Rogall by dividing them into:

Environmental criteria:

1. Climate protection: the amount of greenhouse gases per kWh.
2. The tolerance limits of nature: the consumption of surface per kWh, the impact on protected species.
3. Use of resources: non-renewable resource consumption per kWh.
4. Use of resources: the share of renewable energy produced in a sustainable way, per kWh.
5. Threats to health: harmful emissions, radiation and hazardous waste per kWh.

Economic criteria:

1. Economic effects: jobs per kWh, trade turnover of industry.
2. The certainty of supply in the short term: the availability at any time.
3. Appropriate prices, the profitability and concentration: the cost per kWh.
4. Contribution to the economic independence of supply of raw materials.
5. Technical Efficiency: efficiency, energy depreciation.

Socio-cultural criteria:

1. Social Tolerance: acceptance of people.
2. Long-term security of supply: energy sufficiency, potential.
3. The ability to integrate with existing structures.
4. Global conflict prevention.
5. Security: the cost of most dangerous possible disaster [9].

As seen above, not all of these criteria have specified measures, which may lead to different interpretations of the results obtained using this kit. In addition, some of the indicators may raise doubts in the assessment of the use in a given country, such as global conflict prevention. Countries with large coal reserves, using them for energy production withdraws from global markets and thereby contributes to reducing the upward pressure on demand and prices of substitutes such as natural gas. On the other hand, that same coal imported into a country may be the cause of political tensions in the case of inadequate supplies.

The same concerns may raise renewable sources. In this regard, it is easiest to recall dispute between Tajikistan and Uzbekistan on the use of rivers. The first of these countries through the construction of hydroelectric power station on the river Wachsz can become energy independent from their neighbors. However, the construction of the dam and filling the water reservoir can reduce the possibility of access to water in neighboring Uzbekistan. Diplomatic conflict has been going on for several years and one cannot see its end.

So hydropower, which should not cause international tension has a significant impact on international relations in areas where water is scarce.

An interesting definition of sustainable energy represents LG Action organization, which brings together local governments, committed to sustainable development. According to the representatives sustainable energy is one whose production and use does not cause (or only minimally) the negative impact on human health, the environment and the functioning of natural systems. The aim is to ensure energy security for present and future generations. It is to be achieved through a combination of savings, efficient solutions and technologies, and the use of renewable energy. [11]. This broad description in the best way captures the essence of this concept, as it highlights not only the issue of permanence, but also indicates that approved for use can be sources of energy causing slight damage to the environment and human health. This provision is important because, in practice, there is no source of energy causing no damage to the environment, so any theories assuming the possibility of obtaining energy without any environmental costs are utopia.

This definition also shows that in many cases energy is regarded not only as a factor (energy source) permitting enforcement of the specific action (change in temperature, lighting, transport, etc.), but also the entire system of relations allowing to obtain, transport and transfer of energy to final customers. However, the distinction between sustainable energy and sustainable energy system is pointless, because in most cases (even among those involved in energy policy), the terms are used interchangeably. Can attest to the fact, among others the definition of C. Mitchel [12], on the energy system, which in practice is not much different from the definition based on the Brundtland Report. From the point of view of the concept of sustainable development seems to be more important creation of the energy system that will meet the requirements of this concept, than the sources of the acquisition, since the issues related to efficient energy management are as important as its production.

3. Sustainable Energy Sources

In the context of building energy sustainability issue comes down to the use of such energy sources:

- that are not significantly depleted by continued use;
- the use of which does not cause emission of pollution or other hazardous substances to the environment at large scale;
- the use of which does not involve the consolidation of the major threats to the health or social injustice [13].

Despite the high generality of the foregoing criteria, it is difficult to identify a source of energy that meet them at 100 percent. For this reason, the concept of sustainable primary energy is relative, since the same source in a single situation may be sustainable, but not in another one. The difference in approach stems from the lack of unanimity within the concept of sustainable development itself. The debate on the necessity of implementing it in either its strong or weak form is still relevant due to the very existence of the four primary forms of the sustainability rule. As a result, it is difficult to expect unanimity in energy sector. As it would be impossible to implement the most restrictive form of sustainability (because of the insufficiency of sources and systems and the fact that the economy would have to undergo major changes), weak sustainability should be treated as a dominant form during the transitional period.

Economic development without changes in the coverage or the nature of energy flows is not possible, because energy is a basic unit of the physical world. For this reason it is fundamental to the world, and each change in the flow involves environmental implications. For this reason, all decisions relating to the acquisition of energy are associated with compromises. It is important to select the solution that will be associated with a greater development (e.g. by increasing efficiency) and smaller damage to the environment.

Recognition of strong sustainability as a leading solution for sustainable energy means that only renewable sources can be considered sustainable. This is mainly due to their renewability, which means that in the foreseeable future cannot be exhausted. In this way, the basic question is provided, which is their durability. In addition, renewable energy sources cause relatively little harm to the environment. However, the synonymous use of the terms "sustainable" and "renewable" should not have happened, because in many cases, renewable energy sources, especially on a local scale can result in negative consequences, destructive for the whole concept. An example is the provision of 100% of the energy to an isolated, local energy system with only one source, such as wind power. In the event of adverse weather conditions such installation will not provide energy, and therefore will not be effective. Another example of an incorrect application of renewable energy can be the creation of a large installation using biofuel, the processing capacity will cause the need to source raw materials from long distances. In drastic situations, the energy value of the load can exceed the cost of the energy used for transportation. In this way, despite the fact that the environmental costs of the plant (emissions) continue to meet the high standards, violation occurs at social aspects of sustainable development. Finally the idea of sustainable energy is about its permanent provision for mankind. For this reason, a sustainable renewable energy sources are those which are inexhaustible, not harmful to the environment, socially acceptable and climate-friendly [14].

The variability and partially unpredictable character of renewable energy, as well as storage problems (especially in case of electricity) often make it challenging to implement it into the energy systems [15]. For this reason spatial planning plays an important role in the process of building sustainable energy. It involves several aspects: 1 it may lead to a reduction in energy demand, 2 it should include areas of

increased predisposition to energy conversion, such as the areas for solar panels or windmills, 3 development of power plants should take into account the local capacity to produce energy, not to over-extend their distance of transport (in particular in the field of biomass), 4 coordinating of spatial planning and energy allows optimal use of energy sources and transmission networks [16].

Another example of incorrect use of renewable sources is the use of full-value timber. Such consumption in developing countries, and on a small scale can be justified (especially in the absence of other reasonable alternatives), but the use of wood for fuel in large boilers in order to meet legal standards, e.g. in Poland and Great Britain, should be considered not only as irrational, but actually harmful to the environment and humans. It should be noted that the utilization of wood waste is not in doubt. These include the public initiatives e.g. combustion of natural Christmas trees. At a time when they are no longer needed at the home, it is better to use them in industrial furnaces than leaving it in refuse heap. Moreover, such an action and its results are usually publicized, resulting in drawing attention to the environmental problems of energy.

In practice, there is no doubt that renewable energy sources as a group are the most sustainable technologies, but their use must take into account many factors, including capacities, access to resource, demand for energy in the area and the size of the dispersion. It is also important to note that the obtaining energy from renewable sources also causes environmental costs. For this reason, in some studies it is stressed that none of the sources known to man today cannot fully deserve to be called sustainable [4]. However, such thinking is to be only an incentive to look for new and improving existing solutions.

It is difficult to imagine a situation in which all of the energy would come only from renewable sources. This is due to many factors. The main barriers are: limited human capacity for energy storage, high costs, lack of universal ability to mass production of installations, and above all, lack of political will.

Environmental circles are dominated by the idea that humans need to apply the most restrictive rules for sustainability, i.e. renewable sources only. In some countries, however nonrenewable technologies are also recognized as sustainable. In particular this concerns the use of hydrogen and nuclear energy. This attitude is especially noticeable in the U.S., the UK and France, where there is a strong tendency to consider nuclear power as a sustainable [17]. Moreover, it is pointed out that due to the limited ability of humans to acquire bulk quantities of energy from renewable sources, it is necessary to temporary consider as sustainable systems based even on traditional fossil fuels. In the literature it is referred to as creating the right energy mix [18]. Its best-known example is the energy development strategy of the European Union until 2050, which brings together measures to increase energy efficiency, while increasing the share of gas at the expense of other, more harmful fossil fuels [19]. In this way it is possible to achieve the reduction of environmental impact. However, it must be assumed that this strategy is only a temporary action that in the subsequent period (i.e. after 2050) will lead to further reductions in emissions, which can be recognizable as the move away from gas as a primary source of energy [20]. Despite the inclusion of gas to the strategy of building sustainable energy systems, nobody is going to treat this as a sustainable source.

A slightly different approach is noticeable for the use of the atom, where there is a strong division between supporters and opponents of this method of generating energy. Discussion of both groups not only takes the theoretical nature, but also translates into a policy of many countries. Thus, countries such as Austria and Denmark are considered traditional enemies of the technology. An interesting example is Germany, where the pressure of the opponents led to the discontinuing the expansion of nuclear energy and a slow closing of existing reactors [21]. Similar decisions were made in Japan as a result of the disaster at Fukushima [22]. On the other hand, as an example, one can present France, where nuclear power accounts for nearly 40% of the consumption of all types of primary energy [23]. Similar positive attitude towards this type of technology is apparent in China, South Korea and South Africa. In addition, there is a large group of countries that have decided to build a new power plant, despite moderate social acceptance for such initiatives. These include, among others Czech Republic, Finland and Poland.

Positive attitude towards nuclear power stems from the belief of a relatively low hazard to the environment of the plant. In this regard, typically emphasizes zero CO_2 emissions to the atmosphere in the process of obtaining energy, resulting in significantly reduction of the impact of energy on the formation of global warming. It is quite debatable thesis, because in many cases, does not take into account the high environmental costs of nuclear plant construction (requiring among others CO_2 emissions) and the risk of industrial accidents. On the other hand, the levels of costs in the case of other technologies is not significantly smaller. A major problem associated with nuclear energy remains the issue of nuclear waste, which pose the greatest risk of environmental contamination.

In the context of sustainable energy sources it is often mentioned about new technologies which are not entirely explored. They may become crucial for future development. The most frequently mentioned are the use of hydrogen and building of thermonuclear reactor. However, it is worth noting that both the implementation of inventions, as well as the dissemination of innovation takes time. According to P. Voser[24], Director of Royal Dutch Shell, in the energy sector, from design to gain one percent market share it takes about 35 years. In addition, in the case of hydrogen and often related fuel cells technology, the qualification as a clean technology (not emitting CO_2) is connected with the fuel production technologies. In circumstances where it is collected in the renewable process, it should be justified as a sustainable source [25], in other cases there are doubts.

In view of the above arguments should be noted that it is

impossible to clearly determine which energy sources should be regarded as sustainable. Always such a study should be placed in a specific context, where the coexistence of different technologies (energy mix) should be tested on the basis of existing conditions. They should take into account not only the emissions caused by the energy conversion process, but also in the transport of primary energy. Technologies based on combustion of natural gas may be as harmful as burning coal, if there are recorded significant transmission losses due to bad condition of pipelines.

Taking into account the laws of thermodynamics, in particular the right of entropy, finding a 100% sustainable energy sources seems to be impossible. For this reason, analysis of energy transformation in the context of sustainable development should be used more flexible approach. This means that as a sustainable must be considered a source having a relatively long cycle of life, and low environmental impact.

4. Energy Consumption

One of the leading terms connected with the concept of sustainable development is the demand for dematerialization of consumption e.g. [26]. Its primary objective is to seek to reduce the pressure on the environment resulting from the need to have more and more goods, thus increasing demand for natural resources. This problem is also apparent in the modern energy sector, where one of the most important issues is the question of security of supply of non-renewable energy resources. This problem is also apparent in the modern energy, where one of the most important issues is the question of security of supply of non-renewable energy resources. This problem is a matter of concern not only to economists, but also politicians. Evidence of this include recognition of energy as one of the key factors in a series of reports, named Global Trends [25, 26]. In particular, it relates to oil and the phenomenon known as peak oil. It is a momentum, when one can extract maximum possible amount of raw materials from the field. Later the productivity will drop due to the technical barriers [29]. This is the first and most important warning signal exhaustion of the source.

According to the Brundtland Commission [4], energy efficiency should be the basis of the energy policy of all countries. This is particularly important in the absence of the possibility of universal application of inexhaustible and environmentally friendly energy technologies. One of the pillars of this action is to reduce primary energy demand by increasing the efficiency of the devices. In addition, energy efficiency leads to a reduction of dependence on imported fossil fuels and reduce pollution [30]. It is worth remembering, however, that effectiveness itself is not a solution, but only an extension of the possibility of using the current methods of acquiring final energy [31].

The simplest and most general way to describe energy efficiency is as reducing the amount of energy required to perform a specific job (for example, produce the product or the service). This approach is also present in the European Union, where it is defined as: “a ratio between an output of performance, service, goods or energy, and an input of energy” [32, p. 67]. It is worth noting that in the same document the difference between efficiency and energy savings is highlighted. The latter term is defined as: “an amount of saved energy determined by measuring and/or estimating consumption before and after implementation of one or more energy efficiency improvement measures, whilst ensuring normalisation for external conditions that affect energy consumption” [32, p. 68].

Reduction of consumption and thus energy demand can therefore be achieved either through the implementation of more effective solutions, and by saving energy. The second of these processes is addressed only to final consumers (households and businesses) who, through proper attitudes may lead to a reduction in the demand for this good. The processes of efficiency can be applied in the energy conversion, transmission and consumption. Systems with higher efficiency (i.e. car engines or generators) can contribute significantly to a reduction in consumption. However, the greatest benefits in terms of performance can be observed in the process of cogeneration, that is in simultaneous production of electricity and heat. Similarly, attention to quality and construction of the transmission lines and dispersed production systems based on locally available energy sources can contribute to increased efficiency. Ultimately, however, the end user is a key link in the efficiency, since energy consumers choose the specific technology. This applies to both production lines, as well as the purchase of household appliances (e.g. washing machines or refrigerators). It is worth remembering that these costs relate mainly to small consumers (households and small and medium-sized enterprises). These entities will be most interested in buying a new, more efficient equipment, consuming less energy. However, such actions are only possible with a sufficiently high price of energy, which creates an incentive to replace existing devices by more efficient ones. Usually less energy consuming products have a higher price resulting from the advancement in technology or marketing. The decision to purchase made by the consumer must be justified by future benefits, the savings resulting from the reduction of energy consumption. However, it must be noticeable to affect the purchase of the device. For this reason, the high price of energy is an important stimulus of energy efficiency. However, on the other hand it is worth remembering that sustainable development means meeting the needs of present generations. In the case of energy it is understood as the shaping the price of the good, it does not become a barrier to access for the average citizen. This implies the need for a cautious approach to price as a stimulus for the growth of efficiency.

Follows from the above that the end users are the primary agent of change in energy efficiency. However, in many cases the actions result from factors other than economic incentives. This is due to difficulties in precise calculation of

the benefits of efficiency [33]. For this reason, the state plays an important role as a regulator, which may indicate or force trends. The experience of recent years shows that in most world biggest economies were undertaken initiatives to intensify activities in the field of energy efficiency (including China, Japan, EU, USA). It is estimated that in 2010 brought it a global effect of reducing energy consumption by about 35% [30].

Analyzing the efficiency issue, it is worth to pay attention to Jevons paradox. The nineteenth-century English economist showed that increasing the efficiency of coal use leads to a decline in the price and thus increase of consumption. In the final effect, with an increase in the efficiency of the equipment using the type of primary energy consumption increases. Observations before almost 150 years are also confirmed in the present study carried out in various countries in Europe and America [34]. This means that the increase in efficiency is only apparently effective tool for achieving sustainable energy. Similarly difficult is the use of energy-saving, because on the one hand people in highly developed countries highlight the need to save energy, but also use more and more devices consuming it. For this reason, most forecasts for the consumption indicate its further growth.

5. The Social Dimension

The concept of sustainable development is based on three pillars: economic, environmental and social development [4]. Analysis of energy and its efficiency usually focus on environmental aspects, sometimes taking into account economic issues. The third pillar is marginalized or even ignored. The result is that most of the energy policies take account of environmental issues should be considered more as a climate policy than sustainable.

The importance of energy for the development of civilization is evident. However, still about 1.5 billion people have no access to electricity and another billion use unsafe network. In addition, about 3 billion people use only biomass to prepare food and provide heat [35]. This means that over 40% of the populations have problems with access to energy. This group should be regarded as excluded from the path of development. The international community take the initiative to change this situation, but it seems that, despite attempts to grant them the right rank, e.g. in the form of one of the priority tasks of the Millennium Development Goals, the results are unsatisfactory [33–35].

In this situation, given that the energy is one of the main factors of development, the social aspects of sustainable energy should be a primary issue of this concept. However, we can see just the opposite tendency, i.e. actions excluding these issues. Initiatives to as early as possible implementation of renewable technologies are often made against the needs of society. In this respect, usually attention is attracted to measures to reduce the development of dirty energy technologies in developing countries. This is explained by the need to care for the Planet. However, usually it turns out that greenhouse gas emissions per capita are much lower in developing countries, than in developed ones. This means trying to regulate the world without the principles of social justice.

Increasingly, can be observed that the regulations aimed to make high-quality environmental standards result in higher energy prices also in countries regarded as developed. It is sometimes so significant that in these areas there are also groups of excluded people who can not afford the unrestricted use of energy. These trends can be seen among others in Germany, which is the most developed renewable energy market in the world [39]. Another problem associated with the use of renewable energy sources are massive fluctuations of voltage in the mains. In many cases, especially in enterprises, they can lead to serious consequences and costs, due to shut-off of the sensitive automatic equipment, such as machinery or computers [40].

Connecting to a network large amounts of renewable power, particularly wind also increases the risk of failure, because energy can not be stored, which means that during periods of high production (with proper, strong wind) there is an excess of energy, which must be used. This problem is noticeable everywhere in the world. In Central Europe, it leads up to the political disputes. Because of excess of wind energy in Germany cause problems not only in this country but also in the neighboring ones, including in the Czech Republic and Poland e.g. [41].

In recent decades, you can see a clear trend to reform energy markets, such as the shift from monopoly to the greatest possible marketability and competitiveness. These initiatives have resulted in the need for price competition in the sector of producers and intermediaries. The result is access to cheap energy. From a social point of view it is desirable. However, such action may cause a number of negative consequences. The first is the previously mentioned decline in propensity to save energy at low prices. Another is a lack of investment in new technologies and transmission networks. This is particularly evident in Europe, where up to 2020 it is necessary to replace about 1/3 of the ability to produce energy, and about 30 000 km of transmission lines [42]. Investment restrictions apply not only to modernization of the existing infrastructure, but also limit innovation and increase of efficiency and decrease of environmental harm resulted from energy conversion installations. The best example is the European market, where, despite a number of initiatives, such as the emissions trading and green certificates, electricity production costs of the clean technology are higher than market prices, causing little interest in the market. It is expected that due to the situation in the near future the European Commission will put pressure on Member States to amendments to the emissions trading scheme to manually increase the price of single permit.

Such actions cause that the analysis of sustainable energy should focus more on social and market issues, not only environmental one. Processes of increase the energy

efficiency are slow and last for years. The result is that one should not expect rapid technological change. Factors that may cause greater changes are: social awareness and markets. If people are aware of the consequences of their behavior, they are able to change them. For this reason, it is advisable to promote more reliable knowledge about the opportunities and threats from specific technologies rather than creating administrative rules for their implementation. Many more challenges are associated with the market, which on one hand should be as open as possible and have low barriers to entry, on the other hand controlled in the area, enabling both cost-effectiveness of implementing new technology and to ensure the lowest possible prices that provide access to end users. One example of market failure is little interest in technologies, CO_2 capture and storage because they can be implemented only in large companies whose managements are responsible for generating profits. Implementation of this technology is acceptable from an environmental point of view, but economically unprofitable (even in view of approximately 10 years). This may be the basis for accusations of mismanagement of the board. It is therefore difficult to expect that such decisions will be made solely on the basis of market-based solutions. On the other hand, the CCS systems, like energy efficiency and an increase in the use of renewable energy, are treated as one of the primary tools in building the future sustainable world [43].

6. Conclusions

Sustainable development is a concept designed to provide a man (different generations) the possibility of development in the long term. One of the pillars of modern development is energy. For this reason it is necessary to devote a lot of attention to this subject.

Basing the concept on two pillars, namely renewable energy and efforts to increase the efficiency and reduction of consumption of the good, is the most common way of describing sustainable energy. However, such approach gives an incomplete picture of this concept, because it does not take into account the markets, which are a key factor determining the availability of energy for the people and the profitability of the investment undertaken. Taking into account the three pillars of sustainable development means that energy should be considered broadly, i.e. in terms of processing, transportation, distribution, and consumption. For this reason, by the concept of sustainable energy one should have in mind whole energy system. The extent of the impact will vary, ranging from local markets to the global relationships. However, in any case, it should be specified, separated whole allowing the end user to provide energy.

To summarize the above discussion it is clear that describing the concept of energy should be based on three fundamental criteria:

- clear determination of what is the object of description,
- allowing the distinction between sustainable and unsustainable (or less sustainable) phenomena,
- the possibility of operationalization, i.e. defining indicators to measure sustainability [44].

The first two should be included in the definition of the term. A third of them requires a different description, which should be complementary to the definition. Only on this basis one can try to create a sustainable energy policy. The sustainable energy must therefore be regarded as system of processing, transportation, distribution and consumption of energy, which will be characterized by a constant, overwhelming reduction in consumption of non-renewable resources and environmental damage, while providing, at socially acceptable prices, universal access to energy.

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