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Professionl paper

WOULD INTERNALISATION OF EXTERNAL COSTS CHANGE COST-COMPETITIVENESS OF DIFFERENT ENERGY SOURCES?

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Abstract

The world currently stands witness to increasing energy demand mainly because of population growth and improvements in the standard of living. This causes highly negative environmental constraints since energy production, especially from conventional energy sources, is a very intense polluter. Therefore, any new energy infrastructure, especially new energy production facilities, must be carefully planned and designed and their cost competitiveness must be studied in details. Along with more traditional studies, considering mainly investment and production costs, external costs must be taken into account when making a feasibility study of a new power plant on a new country energy mix. Consideration of external costs is also crucial for efficient long term re-evaluation of different energy sources and technologies used in energy industry. The internalisation of external costs shows us the way to evaluate energy systems with inclusion of all environmental and social costs generated in the energy industry. In this paper we attempt to show which renewable energy sources are competitive with conventional energy sources if we internalize external costs. The study is made on the basis of external costs data for the European States which are interesting for the States of former Yugoslavia as well. The results have shown that competitiveness of renewables would change dramatically if all costs are taken into account.

Keywords: *external costs, production costs, renewables, Europe, polluter pays principle*

JEL Classification: *Q58, Q52, Q42*

Introduction

Environmental pollution and increasing energy demand are two main issues of global energy related problem area. By environmental pollution we mean emissions in air, water and land, climate changes, land filling, materials depletion, land use etc. and increasing energy demand is mainly caused by population growth, consumer life style, improved standard of living and increasing heated surfaces.

The issue of energy also includes high energy dependence of certain countries and European Union (EU) as a whole. The current energy demand in the EU is 55% covered by imported energy sources. Energy dependence renders the EU vulnerable, particularly in terms of the

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potential loss of energy supply. While pollution represents mainly an environmental risk, the energy dependence represents predominantly economic and socio-political risk as well as a challenge to restructure the EU energy sector.

Petroleum products which are a mixture of hydrocarbons cause toxic emissions in the process of combustion. Therefore, they affect human health and environmental sustainability. Modern lifestyle is highly dependent on oil and, in the case of supply shortfalls, also very vulnerable. Rarity of conventional energy sources (CES) in combination with growing energy demand increases the price of energy from CES on the global scale. Scarcity of resources, therefore, forces mankind to search for and implement new, alternative energy sources and utilize untapped potential of renewable energy sources (RES). Since the EU has very limited oil reserves, it is especially important to focus to the development of RES.

Energy related external costs represent the negative environmental and socio-economic effects generated by energy production, expressed in the form of money (Barle and Golc, 2014). External costs are getting a high priority in scientific and political debates. Research has been carried out about external costs of oil drilling in Africa (Amaefule, 2009), models for incorporation of external costs have been developed for optimization of national energy mix (Rabl and Rabl, 2013) and external costs of nuclear energy have been discussed, since its determination is highly arguable, because risk perception can be subjective (European Commission (EC), 2003). External costs are also becoming important for policy makers, especially in EU where external cost are already included in political debate and research activities that are financially supported by the EU (Rentizelas and Georgakellos, 2014).

Scientists, professionals and politics emphasize that market distortions will continue to feature the internal energy market until the principle-"polluter pays" is implemented and used in practice. EU already directs Member States to internalize the external costs of energy, including all environmental costs. The internalization of external costs (hereinafter: IEC) will introduce a new evaluation of various energy sources since it indicates the direction of the evaluation of energy systems with the life cycle approach. External costs are also partly incorporated in EU emission trade scheme (EU-ETS) and in national systems of RES promotion, such as feed-in tariffs or subsidies for investing in RES. EU-ETS seems to be a good concept for integration of external cost in production prices, but due mainly to the economic crisis, it is not very well implemented and the surplus of allowances is increasing (European Commission (EC) 2013). It is also focused especially on GHG emissions, rather than on other environmental and social constraints, such as materials depletion, land use, eutrophication, human health and quality of ecosystem. Feed-in tariffs are on the other hand only a financial instrument for greater implementation of mostly RES, while failing to take into consideration the environmental constraints. However the information on CES subsidies (such as subsidizing coal mines in Europe etc.) has revealed that, contrary to media coverage and widespread belief, even more funds are granted to CES than RES (The Economist, 2014).

Promotion of IEC in the EU is however already directly visible in the field of industrial pollution, packaging waste and GHG emissions. Although IEC would facilitate the development of renewable energy sources and also enable faster transition to sustainable energy, IEC in the energy sector is not yet fully activated, since the price of energy from CES would significantly increase. IEC in the energy sector is also prevented by powerful energy lobbies. Barle and Golc (2014) argue that the price of electricity produced from CES would increase for at least 5-7% if external costs would be internalized in energy price. Zorić and Hrovatin (2012) on the other hand found out that household willingness to pay for green electricity ranges from app. 2 % in households with extremely low monthly income and up to more than 7 % in households with high income and/or in the segment of high educated population (with acquired MSc or PhD). Knez, Jereb and Obrecht (2014) have also found out that willingness to pay for green product is higher in the segment of population with highly developed environmental awareness. However, we must still be aware that increases in energy prices are highly dependant on the methodology by which we define, identify and assess and evaluate external costs since defining them objectively can be very complicated and complex.

The goal of this paper is therefore to examine external costs in European countries, cross-comparing different research of external costs and identify average external costs as an important factor for future energy policy development. The structure of the paper therefore includes the outline of methodological approach, followed by evaluation and comparison of gathered data - different energy related costs, such as investment costs, production costs and external costs for most widely used energy sources and concluding remarks.

Methodology

In the context of the topic, the most important field of external costs that should be internalized are greenhouse gas (GHG) emissions. Polluters should pay the contribution for the released emissions. In this way social preferences could be changed and the structure of energy supply could become more sustainable. Therefore IEC is identified as an appropriate measure for the development of more sustainable energy.

In this paper we review scientific and professional literature to collect data on external costs in the energy sector, evaluated in different studies. Due to the large variations between the external costs in different countries, we decided to identify and examine the external costs of several selected European countries. The differences between external costs of different countries can be significant; therefore, we propose that for detailed studies, the examination of external costs must be done for a specific geographic area.

Based on literature review we identified external costs of individual European countries. Data were analysed with descriptive statistics, such as the average value of external costs for the examined European countries.

Additionally, we identified and cross compared electricity production costs by energy sources. We analysed the cost-competitiveness of individual energy sources when considering only production costs. We analysed whether RES are competitive to CES if external costs are not considered. These results were upgraded with external costs data. Production and external costs were merged to identify, whether RES are competitive with CES and if they are more competitive, when external costs are taken into account.

Evaluation and comparison of investments, production costs and external costs of RES and CES

Investments in energy infrastructure and energy production costs represent an essential factor in designing and planning future energy industry development. Investment costs include the amount of money required for the investment in a specific power plant before commencing operation. Production costs include all costs in time of operation of a certain power plant - costs of fuel and/or raw material, personnel and maintenance. It is believed that investment costs and production costs are in many cases lower for installations on CES. However, this comparative analysis has proven that RES are in many cases more competitive than CES even without the inclusion of external costs, which include environmental and societal costs expressed in money. Additionally it is believed that strong impetus for investments in RES comes from subsidies. In some cases (especially photovoltaic systems), RES were really not profitable without subsidies. However, data in REN (2010) report has shown that worldwide more subsidies and grants are awarded for CES(e.g. oil and gas exploitation grants, grants for purchasing new petrol or diesel car in Germany, regulated and artificially low coal and lignite prices etc.) (app. 53 % of all) than to RES (app. 47 % of all), therefore this is not necessarily true.

Renewable and/or sustainable energy sources are a very important part of sustainable energy industry. In Table 1 results of the analysis and comparison of investment and production costs of individual renewable and conventional energy sources are presented. The data present the indicative investment values and indicative production costs.

As presented in Table 1, the level of investment in hydropower, wind power, geothermal energy plants or in some cases solar power is already competitive with investment in coal or lignite fired power plant. The lowest investment is required for gas power plants and waste incineration. The highest investment is required for installation of biogas plants and small solar power plants. From the perspective of average production costs per kWh of energy, the best way to produce energy is in nuclear power plants, hydroelectric power plants and waste incinerators. REN Report (REN 21, 2012) stated that the investments in RES are getting more and more competitive since 2005. The same trend is expected also in the future.

Production prices may differ due to specific local conditions. We highlighted some essential factors that can affect the price of energy production, such as: the number of sunny days and the power of solar radiation in solar power plants, the number of windy days and wind power within wind power, the amount of water in rivers for hydro-electric power plants, calorific value of coal and wood biomass, international relations between gas/oil exporting and importing countries, calorific value of the waste in waste incineration plants and the efficiency of all types of energy industry facilities. All these factors have a significant impact on the production costs of energy in individual power plants.

When considering investment costs, it is also necessary to calculate the expected return on investment which can be significantly dependent on interest rates (if the investment is financed with a loan). The Oil Drum (2010) announced that in case when discount (interest) rate is 5 %, production costs of electricity from nuclear power plant are up to 60 % lower than when expected discount rate is 10%. Expected discount rate has a significant impact on the profitability of investments in energy installations. This is especially true for large power plants such as nuclear power plants that pay off in the very long run.

Table 1. Investment costs and production costs of energy from different energy sources (2011)

	Investment costs (million EUR/MW)	Production costs per kWh 2009 (EURO cent)
Hydro		
- large hydro >10 MW	2,6*	2,1-3,6****
- small hydro <10 MW	1,3-3,0	3,6-8,6
Photovoltaic		
- large PV > 200 kW	2,0-3,5	8,6-21,4
- small PV	2,5-5,0	14-35
Solar panels – heat	<0,7	0,7-5,7
Wind	1,0-1,4	3,6-14
Biogas – electricity/CHP	2,5-5,0**	3,6-12
Biogas – heat **	od 0,5	0,7-4,3
Geothermal – electricity	2,0-3,5	2,8-5
Geothermal – heat	0,8-2,0	0,4-1,4
Waste incineration – CHP	ca. 0,8	ca. 2
Thermal power plants	2,0***	4,5-5,5***
Gas powered power plant	0,7 - 0,8	14
Nuclear power plant	2,8	2,8-3,5
Biodiesel	0,2-0,9	0,29-0,57 EUR/ litter
Ethanol	0,6-2,2	0,21-0,57 EUR/litter

** average investment per MW in Lower Sava hydroelectric power plant chain*
*** average investment in biogas plants in Austrian Steyer*
**** investment in Thermal power plant Šoštanj, block 6 and its expected production costs*
*****production price of electricity from large hydro can be lower*
Sources: (REN 21, 2012; REN 21, 2011; Obrecht and Denac, 2010; LEV, 2003**; Obrecht, 2013***;TPPŠ, 2010***, Morgan, 2010; Risto and Aija, 2008; Ragwitz et al, 2009 and Nuclear energy institute, 2010)*

There are also some exceptional cases, where prices differ significantly, such as large-scale solar power plant Ivanpah Solar Electric in California. It uses solar energy to vaporize water and to produce electricity by steam turbine technology. The power plant is much cheaper than the reference price in Table 1. The investment in Ivanpah Solar Electric power plant (392MW) amounted to EUR 120 million (California Energy Commission, 2011), or approximately € 310,000 per MW of installed power.

Another case is a power plant using several fuel types, Danish Avedøre 2, which runs on straw, biomass, coal and natural gas. The total investment into this plant was approximately EUR 905,000 per MW and the efficiency of the plant is 50% when operating at 300 MW (Tomšič, 2010). This kind of technology enables us to use different fuel types at the same time and investment cost are more than 50 % lower than investment costs in thermal power plants. This is particularly important in light of the accessibility of specific local energy sources like wood biomass and because of gradual transition to RES and to the emission-free society, which must be the objective of energy policy.

There are however also many cases of power plants, where investments are even higher than investment costs presented in Table 1. The production costs of energy from RES are in some cases, as seen in Table 1, competitive with CES, especially in case of large hydro which can be 50 % lower than production costs of thermal power plants. The differences in investments in RES and CES are also getting smaller. It is expected that the investments in renewable energy sources are becoming an economically competitive alternative (REN 21, 2012; REN 21, 2011 and Obrecht, 2013). Therefore, new investments in RES will become a very strong promoter of making sustainable energy a reality. Nevertheless, the share of renewables in primary energy consumption in the world does not significantly increase. Growth in the share of RES is however clearly visible in the EU and we expect that this trend will also, due to raising environmental consciousness on a global scale (e.g. increasing number of publications about environmental protection, separate waste collection, raising energy efficiency), devastating climate change impacts (e.g. temperature raising, global dimming) and pollution (e.g. emissions to air, water and soil, respiratory particulate matter), have a significant impact on global primary energy consumption, where the share of energy from RES is currently already increasing very slowly, from10,0 % in2005, 10,5 % in 2009 to 12,3 % in 2011(Obrecht, 2013 and IEA, 2013).

An important factor of investing in energy sector is also the total amount of investment. The total investment in a nuclear or thermal power plant is for example much higher than the investment in a diversified renewable energy sources. Because large investments are rare in the period of economic crisis, relatively smaller investments in RES are more realistic possibility.

In contrast, renewable energy installations are more dispersed, dependent on natural resources, decentralized, and generally smaller than plants in CES. Therefore, phasal/ progressive investments are possible in the renewable energy sector, which is especially suitable for smaller organizations and the economies which have their own sources of renewable energy and want to gradually reduce their dependence on energy imports, but do not have large funds to invest in large central energy facilities on CES. Investments in renewable energy sources are also suitable for large economies and organizations since reduction of import dependence on fossil fuels reduces the risk of price volatility, very common for oil and have less impact on the environment.

In Slovenia for example, which is defined as a small economy, we propose gradual investments in diversified local renewable energy sources, to achieve environmentally friendlier energy mix and to reduce the pressure on public finances, have less impact on the environment (lower external costs) and mainly also positive social impact. Large and centralized power plants usually have negative effect on the equal regional energy supply within the country. In Slovenia we have 2 large central power plants – Thermal power plant Šoštanj and Nuclear power plant Krško. Regions where they are located are net exporters of energy to all other regions. In the winter of 2014 we faced strong freezing rain and glaze that totally damaged the energy infrastructure and blocked roads and rail. Because they were blocked and inoperable we have had huge problems with distribution of electricity and oil. It was discussed that it would be safer for local energy distribution if we had more dispersed energy production because distribution.

The competitiveness of renewables additionally increases if external costs are included. External costs significantly change the suitability of individual energy sources. External costs of electricity production from various energy sources in selected EU Member States and Norway are shown in Table2. As presented, external costs differ significantly between different geographical areas and are on average the lowest in cases of wind, hydro and nuclear. Besides, risk perception must also be considered when assessing external costs for nuclear energy. Nuclear power involve additional considerations that are difficult or impossible to quantify in monetary terms, for example, stability of the electric grid, energy independence and the risk of fuel price shocks (European Commission (EC), 2003) as well as possible nuclear accidents.

Experience that history taught us, especially such that was energy intensive as was the case with the industrial revolution shows us that the effect of external costs is sometimes impossible to evaluate at the time of energy production since their effect on eg. human health has long term consequences. This experience may offer lessons for climate analysis and policy-making (Fuoquet, 2011). It also highlights that the evolution of the demand for and supply of environmental quality in the context of economic growth is urgent in the long run and the principle “polluter pays” must also be incorporated in energy sector.

Table 2. External costs of electricity from different energy sources in different countries (in EUR cent per kWh)

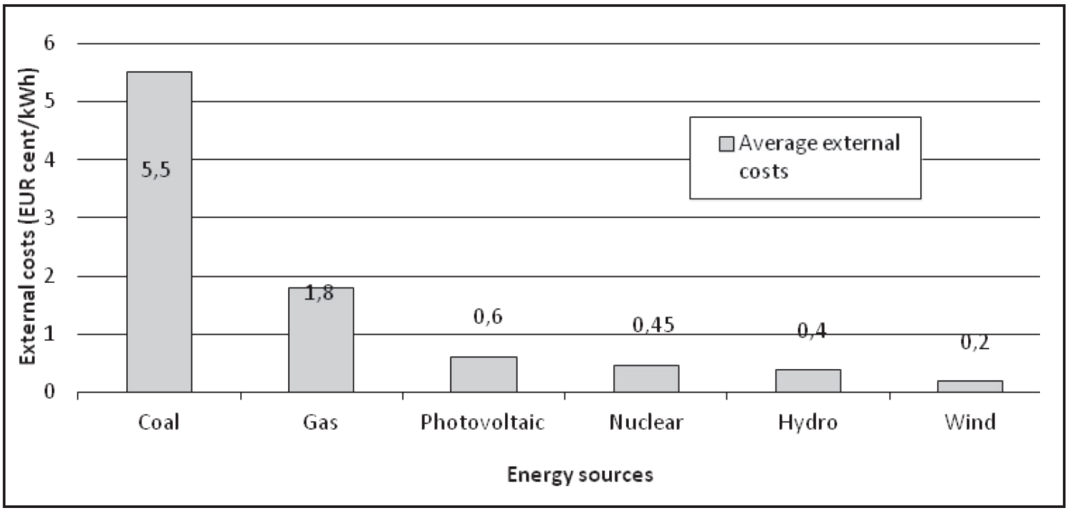
Country	Coal & lignite	Peat	Oil	Gas	Nuclear	Biomass/ biogas	Hydro	Photo-voltaic	Wind
Austria	*	*	*	1-3	*	2-3	0,1	*	*
Belgium	4-15	*	*	1-2	0,5	*	*	*	*
Germany	3-6	*	5-8	1-2	0,2	3	*	0,6	0,1
Denmark	4-7	*	*	2-3	*	1	*	*	0,1
Spain	5-8	*	*	1-2	*	3-5	*	*	0,2
Finland	2-4	2-5	*	*	*	1	*	*	*
France	7-10	*	8-11	2-4	0,3	1	1	*	*
Greece	5-8	*	3-5	1	*	0-0,8	1	*	0,3
Ireland	6-8	3-4	*	*	*	*	*	*	*
Italy	*	*	3-6	2-3	*	*	0,3	*	*
Netherland	3-4	*	*	1-2	0,7	0,5	*	*	*
Norway	*	*	*	1-2	*	0,2	0,2	*	0-0,3
Portugal	4-7	*	*	1-2	*	1-2	0,03	*	*
Sweden	2-4	*	*	*	*	0,3	0-0,7	*	*
G. Britain	4-7	*	3-5	1-2	0,3	1	*	*	0,2
Average	**5,5**	**3,5**	**5,7**	**1,8**	**0,4**	**1,4**	**0,4**	**0,6**	**0,2**

** data are not available*

Sources: European Commission (EC), 2003; GWEC, 2005; Obrecht, 2013; Barle and Golc, 2014 and own calculations.

For better notion of high differences between average external costs of electricity produced from different energy sources, external costs are also graphically presented on Figure 1. As seen in Figure 1, external costs of electricity produced from coal are almost 10 fold of electricity produced from photovoltaic system. The most appropriate from external costs perspective is electricity produced from wind and hydro, followed by nuclear energy and photovoltaic. Conventional energy sources eg. gas and coal have much higher external costs.

Figure 1. Average external costs of electricity from most widely used energy sources in Europe



However, during cross-comparing RES and CES, the production potential must be also considered. For example 1 kW of photovoltaic system cannot produce the same amount of energy as 1 kW gas power plant since RES are highly dependent on weather and natural conditions. Photovoltaic system for example can only produce electricity when the sun is shining. To achieve the same stability of energy supply with electricity mix based on RES, more power plants must be installed than in case of electricity mix based on CES.

According to the differences in the energy mix, geographic location, use of local resources and the technology used, there are also differentiations in external costs of energy from the same energy source. In certain geographical areas it can be more appropriate to produce energy with one energy source and again in other area another energy source can be the most appropriate. The distinction between external costs is notable already on the level of European countries, presented in Table 2. Marriot and co-authors (2010) stated that environmental impacts of individual energy sources in one State can be up to 100% different from the impact on the environment in another state. Therefore, external costs can also vary considerably.

Although the EU directs development of renewable energy industry, different EU Member states use different measures for promotion of RES and IEC. Most widely used measures for promotion of sustainable energy are feed-in tariffs (applied in almost all national legislations of the EU Member States), quotas (e.g. for biofuels in petroleum), evaluation of the origin of energy or electricity, subsidies and grants for investments in RES and increasing energy efficiency etc. Most of them are economic incentives and legal constraints. As a measure to promote IEC we also propose the implementation of economic incentives - the establishment of tax incentives for leading organizations in the field of environmental protection, both for energy producers and energy consumers. However, because complete elimination of pollution and GHG emissions only by economic incentives is however not the best long-term solution, economic incentives should only represent the initial phase of the transition to a sustainable society with consideration on external costs. In the long run, incentives should be based on ethical and moral changes, education and learning, changing lifestyles and different patterns of thinking.

The sum of the average production prices in kWh (data from Table 2) and the average external costs (data from Table 3) indicates that when we include external costs, CES are in most cases not competitive with RES any more. The results of the calculation of average production prices, the average external costs and the total cost of production and external costs in kWh of electricity are shown in Table 3.

The values in Table 3 are presented in intervals (min. – max.) and calculated in averages and are not the exact calculations, therefore the values in the column "Total costs" can vary. This is due to geographical conditions and natural resources (sunlight, number of sunny days, the average wind speed, the constancy of wind, water flow etc.). The results in Table 3 show that the average price of electricity from thermal power plant obtained with incineration of coal is much higher than, for example, the price of electricity from renewable energy sources (eg. hydro, wind and biomass).

As presented on Figure 1 and Table 3, RES will become much more competitive than CES if external costs are internalized. Because IEC could lead to the increase of the price of energy, the countries and organizations should start to reduce its energy use, increase energy efficiency, use environmentally preferable energy sources and alternative heating methods. This would indirectly change the lifestyle and increased energy efficiency. A similar strategy of increasing final energy prices for end-users as an incentive for increasing energy efficiency is already in use in Denmark, which effectively increases the share of RES, energy efficiency and efficiently prevents the growth of energy use. However, Danish energy system has its specificities such as integration in Nordpool, imports of energy mainly from Sweden (nuclear energy) and Norway (hydro energy).

In Table 3 it is also indicated that the electricity from coal fired power plant can be even more expensive than electricity from photovoltaic system. The high cost of production is noted by gas. However, the price of gas is also very volatile and plays essential role in production price since the investment in gas-steam power plant is among the lowest.

Table 3. Comparison of average production costs, average external costs and total sum of production and external cost of electricity in EUR cent/kWh (for different energy sources)

Energy sources	Production costs	External costs	Total costs	Average total costs
Hydro energy	2,1-3,6	0,4	2,5-4,1	3,2
Wind	3,6-14,0	0,2	3,8-14,2	9,0
Biomass-biogas	3,6-12,0	1,4	5,0-13,4	9,2
Sun	8,6-21,4	0,6	9,2-22,0	15,6
Coal / lignite	5,5	5,5	11,0	11,0
Nuclear	2,8-3,5	0,4	3,2-3,9	3,6
Gas	14,0	1,8	15,8	15,8

Source: Data from Table 1, Table 2 and authors own calculations

As presented on Table 3, good result was achieved also by nuclear energy. Because of the low assessed impact on the environment nuclear energy has low external costs, which are mainly the consequence of radioactive waste. Despite the low production cost the initial investment in nuclear power plant of peak power approximately 1000-1500MW is capitally very intensive and must be very carefully designed and even more carefully positioned in the appropriate area. In addition, it is necessary to take into account the managing of nuclear power plant at the end of its life cycle.

Conclusion

Based on the results of the analysis and comparison of investment prices, we found out that investments in energy industry are generally higher when investing in RES. Higher investment is also needed for investment in nuclear power. Further more, we analysed and compared production costs and identified that production costs of RES can be significantly lower that production costs of CES, especially in hydropower and in some cases also in biogas, geothermal and wind power. Nuclear power plant is also identified as cheap source of energy. When internalizing external costs, RES were far more competitive than CES. Average total costs (production costs and external costs) of hydro were 3,2 EUR cent/kWh which is more than three times lower than average total costs of thermal power plant on coal, which were even higher than wind and biomass. The exception is nuclear energy, where external costs are very low compared to coal or gas. However it should also be considered that the consequences of a nuclear accident are almost impossible to predict and assess.

The key findings based on a comparative analysis of production and external costs of energy produced from RES and CES are that environmentally preferable and more sustainable energy sources / energy production technologies are not necessarily more expensive. Furthermore, RES are mainly seen as a cheaper energy source when external costs are taken into account. However, prices of CES and RES could vary significantly if all subsidies and grants are excluded.

Even when external costs are not included, some environmentally preferable solutions such as hydro-electric power plants are not necessarily economically less feasible than CES.

Further assumption was made that RES (also sustainable energy sources) are particularly suitable for smaller economies (smaller countries or regions, local communities), such as the States of former Yugoslavia. These economies have less available resources and are unable to implement large capitally intensive investments and are, due to the small energy sector, easier to switch to RES. In this type of economy energy self-sufficiency is even more important since these economies are even more susceptible to change.

However, it is very hard to achieve stability and security of energy system only with RES, since RES are heavily dependent on weather conditions and its peak power should be highly overestimated to cover base load energy demand. Therefore, every country should examine its energy needs, RES potential and external costs and define the most appropriate energy mix for its specific case, combined (on a short term) from the most suitable RES and CES to achieve as stabile and sustainable energy sector as possible from technical, economic, environmental and social perspective.

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