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Green Energy – Shortcut to Energy Independency or Cul-de-sack?

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Abstract: In the paper some of the problems accompanying transition from the classical power sources towards renewables as well as some of the publicly widely accepted persuasions of questionable credibility are being discussed. It is shown that the footprint of the so called green power sources is much larger compared to classical technologies and that the overhasty development of technologies aiming at energy dependence reduction may lead to an even higher energy dependence. The example of the "eco-land", Denmark, is presented and substituting oil with ethanol made of cellulose as well as nonsense of the CCS technology and CO_2 emission taxes are discussed. Fortunately, fossil fuels are not yet running short as some people fear. This, however, must not be the reason for getting stuck in developing renewables. However, it is reasonable to direct our efforts and resources, in the nowadays relative energy prosperity, into research and development to contribute to the national welfare. It makes no sense to subsidize China and its environmentally often questionable production and absurd activities, such as e.g. pushing CO_2 beneath the earth surface or taxing the CO_2-print.

Keywords: energy, renewables, fossil fuels, climate changes

1 Instead of introduction or: "Listen to Arthur!"

"In Durban flash of hope for earth's fate." "Poisonous gases from power plants – damnation for the planet." "Greenpeace Slovenia knows, how to replace electricity from the nuclear power plant with renewable power sources" "Carbon dioxide imperils earth's health." "Sea level is raising." "Planet's temperature is going to rise for several degrees till the end of century." "Floods in (wherever) are the result of anthropogenic climate changes." "Oil can already be replaced by bio-diesel and ethanol produced of crops." "Denmark a good example for other countries"

The listed invented sentences in the flood of news that are shot to people every day sound very familiar. In the last couple of years people have been faced with the information campaign which exalts various actions for "environmental preservation" and the so called renewable power sources to the level of, for the survival of the human race and of nature, necessary actions, that should be carried out immediately, "even more – yesterday." In Slovenia various environmental organizations have sped up their activities in the mass media just before the parliamentary elections (let us take the liberty of speculating), in order to enforce "environmental and energetic" obligations to political parties, which could result in lightening later providing with funds. The network application "Revizor" clears up many issues regarding funding of some environmental "clergymen", one is that about half of the money, of which a considerable part they get from the state, is spent for public relations. In spite of moral disputability, this funding will not ruin Slovenia. A positive impact of the environmental organizations (one without quotation marks, of course) on the people's awareness of the necessity of nature preservation, control of polluters and building positive human attitude with the environment, should be recognized.

The problems arise, which are a consequence of endless reiteration of the same doubtful and unfeasible strategies and policies in the field of energy (let us focus more or less on the electric power). Although some of the theses are more than doubtful, the words of Mr. Paul Joseph Göbbels's should be trusted, that a lie repeated one thousand times becomes the truth (translated from: *„Eine Lüge, tausend mal wiederholt, wird zur Wahrheit“*).

As politicians, at least outwardly, follow the public interest and as their time horizon is limited by their time in office, decisions may be taken regarding strategy of energy supply, which may be far from optimal and may cost the future generations dearly (it should be noted that time constants in the field of power management extend over 30 years).

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Figure 1. "Poisonous" carbon dioxide sneaking around our homes

Therefore, hearing statements by numerous "hobby-ecologists" and "hoby-power-experts" we cannot but asking ourselves: "Why for God's sake do we not exchange all the pollutants in the electric power sector by the so called renewables?" Let us in our considerations ignore the *NIMBY* and *BANANA* effect (*NIMBY* – Not In My Backyard, *BANANA* – Build Absolutely Nothing Absolutely Nowhere Around) as there are more than enough cases in Slovenia ; "we are for renewables, but against hydro power plants on the river Mura, against wind power plants, against power lines, etc.). Let us also ignore the Murphy's "natural law" (i.e."If it is too good to be true, usually it isn't true) and look upon some technical aspects of replacing the classical energy sources with renewables. It should also be noted that "there is not such thing like a free lunch," and that maintaining high environmental standards is costly (For the majority of the people ecology becomes unimportant at the moment they have to open their wallet).

Answers to issues of replacing classical energy sources by renewables are not exceedingly complicated and may be given on the basis of publicly accessible information, knowledge of basics of physics and first of all relying on our common sense. One should all the time keep in mind the wisdom of the philosopher *Arthur Schopenhauer*: "*Common sense can replace almost every level of education but no degree of education can replace common sense*."

It is unquestionable that the technology of renewable power sources should be developed and that we are all hardly awaiting the times in which we will screw solar panels on or glue "a solar foil" up a southern wall or roof of our house. There is also no doubt that certain technologies are going to be improved so as to be cheap enough to be able to compete with the fossile-fuel technologies without subsidization, paid by "ordinary citizens". However, providing energy from renewable sources on a global level is connected with certain physical limitations and strategically unacceptable hazards.

In the paper, some aspects and problems are discussed concerning providing the mankind with energy from renewable sources instead of using fossil fuels. Accessing energy sources is of a crucial importance for any society. False decisions can the long term reduce its chances to compete on the global scene. Therefore it is important that any single aspect is taken into consideration, and of course, also those (I would say especially the ones) which are most unpleasant.

2 Some basic features of energy sources

It is not necessary to be an expert to know the basic features of energy sources according to which they can be classified into various groups.

The most important feature is **availability**. An inaccessible energy source has no value for us. The technological progress has enabled this feature to increase greatly in recent years. In particular, this applies to new (revolutionary) methods of drilling and exploitation of oil and gas, wind farms "off shore" technology, etc. Unfortunately it is not the case with the energy source, whose importance is growing rapidly and its accessibility is of the highest importance, i.e. electricity (it is hard to store it and it is not portable). Electricity storage development cannot be labeled as revolutionary. The problem is how to use it geographically independently.

Predictability means that we can 'rely' on the energy source knowing where it is to be found and how to get it when needed. The most problematic is the meaning of this concept in case of electricity. Most of the power plants cannot be simply turned on and off when needed. This is a major problem of many renewable sources. Typical such representatives are wind power plants (see [1]). As it is not possible to predict their power production, they are not taken into account in power-system planning (as if they did not exist [2]) and it is necessary to have them 100% backed up.

The energy content (energy density) of an energy source defines the amount of energy (that can be used) stored in a certain quantity (mass, volume) of the "energy carrier". It is practical to deal with an energy carrier of high energy density because it can easily be stored or transported. At a gas station, energy flows over a pipe into a car of some 25 MW.

The electric car shown in figure 2 with a thin cable and single-phase 230 V plug is ridiculous. If we speculate and estimate that for the same range of a car four times less energy is needed than for the conventional car, it would still have to be charged (in order to achieve similar rate of energy filling) with approximately 6 MW of power, which at the 230 V level amounts to about 26 000 A.

Figure 2. Unfortunately impractical.

Assuming, optimistically that 1 mm^2 of copper can permanently lead the current of some 5 A (which is not true for thick cables) a copper cable of a 5200 mm^2 cross-section should be used. If car filling takes two hours instead of two minutes, almost 450 A should still be "pushed" into it, that corresponds to about 90 mm^2 thick cable (for the phase and for the ground). A two-hour charging from an ordinary home plug will probably not be an option for a long time. These considerations have been made assuming a single-phase outlet and cars of similar technical capabilities to the ones used today. In larger cities families having just one car cannot get around, so the electric car can only be imagined as a ‘second’ car, for shorter distances and whith a relatively low capacity engine.

High energy density is therefore one of the key advantages of fossil fuels compared to other types of energy sources.

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3 Energy and power

Explanation of this term is limited to a power system. The term "energy produced by this and this source" is in many cases abused by media and the public is manipulated with it. Mostly we hear or read that a power plant produces some amount of energy in MWh. This is likely to be true, but a power system operates on the principle of meeting needs of power and not energy demand. In other words, a power system has to produce as much of the electric power as the users require at a certain moment (including losses). The sum of the produced and consumed electricity (including transmission and transformation losses) must be equal at any moment. In the opposite case, the system frequency, which has to be kept within narrow limits, begins to change. Power plants must therefore continuously adjust their output in order to meet the power demand. Electricity available when not needed is useless. The produced energy represents only the sum of these powers (time integral).

Fig. 3 illustrates this aspect. There are also situations possible in which production exceeds the needs, but for technical reasons reducing production or tripping the conventional power plants is unacceptable. In such a situation wind power plants have to be turned off. However, as it is mandatory for the system operator to accept electricity from resources qualified as renewable, the owners of these types of power plants can get high indemnity to stop power plants. Data from the UK, November 2011: wind power plants - 180 GBP / MWh, taking into account the nominal power of power plants (that is, about four times the average price for MWh) – ***in order not to operate!***

a)

b)

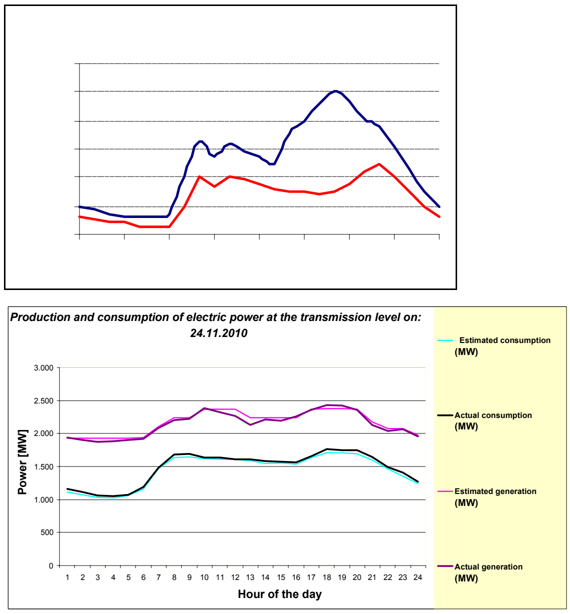


Figure 3. a) Consumption of a distribution - a typical day:
b) Balance - ELES 24th November 2010 [3]

4 »Back-up« Power Plants

The basic rule to followed in planning and operating the transmission power grid is the so called N-1 criterion. When met a normally operating power system withstands the loss of any of its elements at no impact on the power supplied to end consumers. When there is a fault taking place in the distribution power grid, this is generally not the case. Because of the radial structure of a distribution power grid, switching maneuvers to the back-up supply routes have to take place.

To apply the above mentioned N-1 criterion when operating renewable-source generation units (e.g. wind farms) reserve generation units should be used when the level of renewable source generation drops (e.g. low wind). As the wind intensity is unpredictable, each wind farm has to be provided with reserve generation. Experiences from the USA show that, despite the large number of wind farms, there are periods of time when their generation output is almost zero. That is why it has been decided that in planning power generation, the capacity of wind farms should not be taken into account. In other words because of the capacity of the installed wind-farm generation the required capacity of conventional power plants should not be reduced, but it may impose some adjustment on the conventional power plants. Hence, wind farms have to be 100 % backed-up. If this investment cost is added to the investment cost of installing a wind farm the cost of its electricity rises significantly.

EXAMPLE: Let us make an illustrative, simplified and idealized calculation on the Slovenian power grid (Fig. 4).

Let us assume a power plant supplying a quantity of electricity in the amount matching generation at 1000 MW mean power, with an irrelevant time profile of the output power, with several storage hydro power plants with large reservoirs that can offset any imbalances. This way electricity can be generated and stored in any desired manner. However this is an extremely idealistic example.

Let us take a look at the alternative, either a new nuclear power plant (i.e. JEK2) or wind farms. The new generation nuclear power plants – the so called III+ generation – currently offered in the market, guarantee a 92 % availability of their generation capacity overhauls and fuel-element exchange accounted for. This means that in the period of time with no overhauls and fuel-element exchanging the quantity of generated electricity will exceed the guaranteed 92% capacity of such power plant. At the given assumptions, the mean power of 1000 MW, the required capacity of the power plant amounts to 1000 MW / 0.92 = 1087 MW (this capacity coincides with the capacity of the variant foreseeing the least output for the planned nuclear power plant JEK2).

The availability of the wind farms in Germany is below 20 %, and according to some sources even below 15 %. Taking into account the 20 % availability of the Slovenian wind farms, the installed capacity for the same electricity output is 1000 MW / 0.2 = 5000 MW. To install large 2 MW wind turbines (such as those that are supposed to be installed in a legally blocked process in the vicinity of Dolenja vas) 2500 of such wind turbines would be required (or 6000 units of the type provided for the Volovja Reber wind power plant).

a) b)

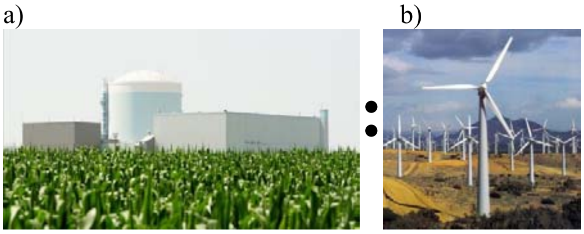


Figure 4. Nuclear power plant versus wind farms
a) The Krško NPP [4]
b) Wind Farm [5]

Also, the capacity of the transmission system elements (lines, transformers, switches, etc.) and pump storage units should be dimensioned to approximately. 5000 MW (for illustration this capacity can be transmitted over fifty 110-kV lines) compared to approximately 1100 MW foreseen for the variant of the nuclear power plant variant. The cost of all these assets would eventually exceed the cost of wind farms, not to mention the difficulties associated with spatial sitting of numerous power lines. The last but not the least important issue is the plant lifetime. That of a wind turbine is approximately three times shorter than that of a nuclear power plant. On a long term basis this thus increases the cost and thus worsens economic aspects of the wind farms.

Instead of a nuclear power plant any fossil-fired power plant can be adequately used to make this comparison.

5 Material consumption and environmental footprint

Exploiting any possible energy source more or less adversely collaterally affects the environment. To minimize or, in other words, to improve the so called environmental footprint and reaching at the same time adequate energy to maintain the present life standard at the same time, certain measures should be taken.

Let us focus on electricity which is an issue of the majority of environmental public disputes. One of its aspects is the land required for sitting each type of generation unit compared to its installed power – the energy density. A common scaled nuclear power plant unit in the world is a 2700 MW 2 reactor unit. A very conservative estimation of the ecological footprint is 48 km^2 of the compromised land [6], making the energy density amount to 56 W/m^2 (the compromised land being limited only to the land of the generation unit in a range of 100 times less). The energy density of wind farms is some 1.2 W/m^2 [7] and of photovoltaic approximately 6.7 W/m^2 [7]. The record breakers in the negative sense are biogas-fueled power plants whith biogas produced from corn-silage and bioethanol power plants, in which bioethanol is produced from corn. Their energy densities are only about 0.4 W/m^2 [7] and 0.05 W/m^2 [7], respectively. Exploiting these two energy sources for energy needs rather than for food is very controversial and should be criticized by ecological and humanitarian organizations immediately.

The above numbers might be to some extent questionable, but they can be substantiated by further studies. In [8], for example, corn bioethanol is assessed to have a 144 times, wind farms 30 times and photovoltaics 15 times worse ecological footprint compared to nuclear power plants.

Some generation units adversely affect the quality of life in their vicinity (e.g. wind turbines may cause light flicking and may also produce low-frequency noise, disturb birds etc.).

Besides, much space is required for transmission lines because of the distributed generation. Due to restrictions and public opposition they are hard to get build.

A comparison made for the material gives a similar result. The unfinished 2 MW wind turbine at Dolenja vas occupies ca. 500 m^3 (1200 tons of concrete for the base and ca. 150 tons of iron, 50 tons of that being in the base) [9]. The base of the wind turbine at Dolenja vas is shown on Fig. 5.

Figure 5. The base of the wind turbine at Dolenja vas [9]

As seen from [10], 90 m^3 of concrete and 40 tons of steel are needed for a nuclear power plant, 27 m^3 of concrete and 3.3 tons of steel (with no pipelines included) for gas power plants are needed for every MW installed power. Considering four to five times lower availability of the wind farms compared to a nuclear power plant (demanding larger installed power) the material used in constructing a wind farm is ca. 900 m^3 (over 2000 tons) of concrete and 450 tons of iron per 4 MW installed power which is in fact the energy equivalent of 1 MW nuclear power plant. NOTE: considerably shorter wind farm lifetime.

6 Energy (in)dependency

One of the arguments (in the author's opinion the most well-founded) speaking in favour of intensive development and use of renewable energy sources is energy independence. Europe imports over half of its natural gas and over 80% of its oil consumption (the situation in Slovenia is even worse). The effects of reducing this import dependency using renewable energy sources would be beneficial both strategically and politically. We can all well remember closing of the Ukrainian pipes. Dependence on one or several countries may result in both political and economical dependency.

Before further discussing energy independence, let us first pay our attention to what is important in creating modern technologies, either the so called energy-saving technologies, or technologies intended to produce electricity from renewable energy sources. One of the basic necessities is a high efficiency and a low weight modern motor or a generator (power per kilogram). It would be unreasonable to equip electrical vehicles with very heavy electric motors since they would use too much energy to move. The generator made to be mounted on a tower of a wind turbine cannot be too heavy either. The latter would make the entire construction much more expensive. Accumulators used in electrical vehicles (and most of portable electronics – cell phones, laptops, etc.) should be light, low-cost and highly efficient. Nowadays it seems that lithium accumulators are the best in meeting these criteria. Furthermore many photovoltaic cells need on cadmium telluride. Currently manufactured PC monitors cannot do without the elements such as yttrium and europium.

As one can see it is important to use rare earth metals such as lanthanides and some others seemingly exotic elements. The discussed motors and generators can be made only by using permanent magnets based either on praseodymium or neodymium or samarium or terbium or dysprosium, all belonging to the group of lanthanides. The same is true for europium (used in PC monitors). Although tellurium is not a rare earth metal, there is only one tellurium mine in the world. Lithium is not as rare as tellurium but will probably become scarce with the increase in the use of electric cars (and lithium batteries).

a) b) c)

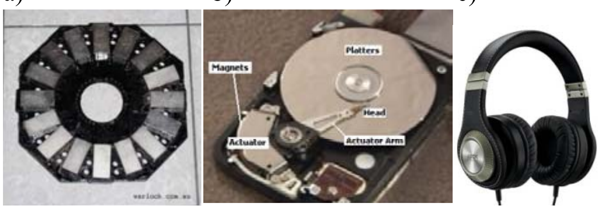


Figure 6. Application of neodymium magnets
a) Generator part of a small wind power plant [11].
b) Hard disc [12].
c) Top-quality earphones [13].

Let us now take a look at the geographic locations of the above rare elements (lanthanide oxides are referred to as "rare earths" as well). 90% of the lithium market is covered by only three states: Argentina, Chile and China [14]. Despite the large deposits of lithium in Bolivia, Evo Morales does not sell it to the "rotten capitalists". The lanthanide market is controlled by China in the extent of 95% to 100%. The only mine of tellurium is in China. Though these elements are not extremely rare their excavation is demanding and environmentally disputable.

The Chinese government being aware of its almost complete monopoly over the elements making the "green technologies" possible, these elements are not to be found in the free market anymore. Moreover, China is educating some 1000 post-graduate students in developing methods of gaining rare earth metals [15]. In other words, the state of the art almost entirely depends on the materials under control of China. Although the modern technologies were developed in the west, it is very likely that in a few years they will only be used in China since this will be the only way to obtain the materials needed.

Speaking in terms of energy independence, we are trying to exchange our dependency on 21 countries- that produce over one million oil barrels daily for dependency on a single country.

7 The Danish example of "eco-land"

Denmark is generally ranked as one of the most environmentally advanced countries and environmentalists often like to use Denmark as an example worth replicating in order to achieve energy independency as a society and, at the same time, to meet as much of our energy demand as possible, by using nature-(some may say "planet") friendly ways. In the seventies, the Danish have, as a response to the oil crisis, accepted a far-reaching and ambitious energy policy aiming at assuring energy independence, producing energy in an environmentally friendly way and decreasing the so called greenhouse gasses, mainly CO_2 .

The Danish are most active in the field of converting wind energy into electricity and they have the largest number of the wind power plants per capita. They meet 20% of their electricity demands using wind farms. As a result of such high share of unpredictable power production in the system, they have to adjust production of other power sources in the system in order to assure stability of their system. The most suitable for such task are hydro power plants (HPP), or more specifically pumped-storage hydro power plants (PSHPP). Denmark does not have many of the latter since it is a very flat land. Luckily, they are connected to Norway and Sweden over submarine cables and to Germany over overhead lines. By relying on these large systems Denmark can compensate its unpredictable production.

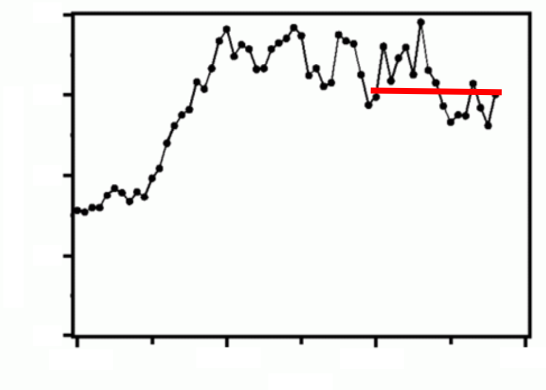


Figure 7. Estimation of the Danish CO_2 emissions in tons [16]

Especially suited for the task is Norway with its large share of HPPs and PSHPPs. When Denmark's electricity production is too large, they export some of it (or turn of their wind power plants still paying their owners full power production at the full subsidized price). In other words selling at any price in a situation like this makes sense.

Norway is of course very willing to buy such (very) cheap electricity and "save" it using its PSHPPs. When Denmark is not "windy" and their consumption is high they buy the electricity they need. Norway is then selling them the "saved" energy, the price of which- depending on demands in the rest of Europe – can be very high (the top-to-bottom price ratio of energy can be as much as five or more). Trying to be mean, one would of course say that the Norwegians are making money off of the Danish CO_2 emission reduction program and it would be hard to argue.

If the net reduction in the CO_2 emissions assured through the vast wind-power program were made out, it could (for some surprisingly, for others not) be concluded that between 1990 and 2008 the reduction would be about zero (see Fig. 7). Of course there is some result too. While the population remained practically the same at the observed time (in 1990 there were 50,7 million and in 2008 50,6 million citizens) electricity consumption has in fact gone up by about 20%. This shows some success but a lot smaller than anticipated. As seen from the graph in Fig 7 no important change can be made out.

The price for implementing such policies is of course paid by the Danish. In Denmark the electricity price is approximately four times higher than in the USA and almost three times as high as in France or Norway since electricity is highly taxed (where, if not from taxation, does the money for subsidies come from). As seen from the diagram shown in Fig.8 where one can find graphs regarding the data in [17] (The top curve clearly presents Denmark).

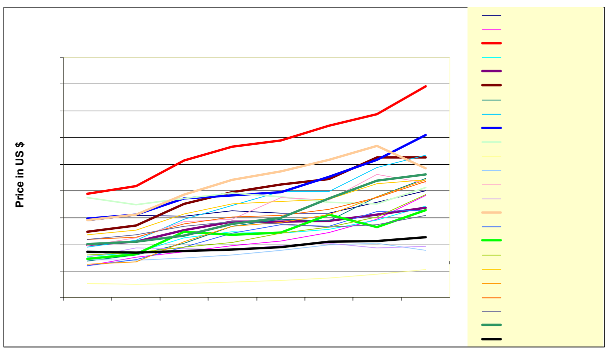


Figure 8. Household electricity prices for some countries

Being the largest electricity importer, Italy should have had the highest prices in Europe, but this does not stand for the household-consumed electricity.

Now let's take a look at the form of primary energy used in Denmark. One would expect the use of fossil fuels should have decreased due to Danish orientation towards “green technologies”. Fig 9 shows the data for the period 1980 - 2008.

a) b) c)

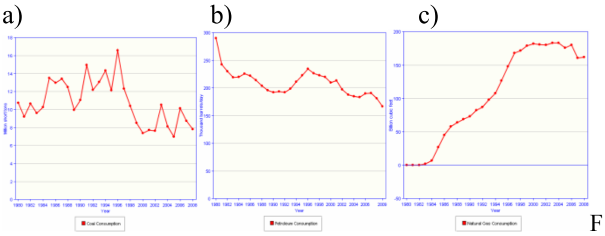
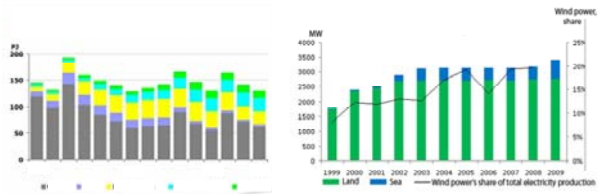


Figure 9. Use of fossil fuels in Denmark [18]
a) Use of coal.
b) Use of oil.
c) Use of natural gas.

As seen since 1990 the use of coal has not decreased significantly. The same can be said for oil. The use of natural gas has on the other hand increased noticeably. One might find it interesting that Denmark still covers over 50% of its power consumption with oil. Looking at the share of the wind power plant production in its total energy balance it is of some 4% (the annual wind power plant production is 12 million oil barrels energy equivalent while the annual oil production in the North Sea is approximately 300 million barrels). A large proportion of its oil is exported. Knowing that the Danish themselves being a society who has declared war to CO_2, one cannot help asking the question: “Is this how they fight for emissions reduction?" Would it not be more efficient to stop oil production for export and leave the most impact possible on the increase on oil prices and the related decrease on its use….?”

The share of the wind power in the total Danish electricity production is shown in Fig. 10. It is clear that since 2004, construction of wind power plants has lost the wind in its sails. It would be reasonable to know whether the cause for the current state is lack of funds or is it no longer possible for the Danish power system to sustain the wind power growth.

a) b)



Slika 10. a) Electricity production over individual energy sources in Denmark [19]
b) Construction of wind-power plants in Denmark [20]

Judging from the shown data and their interpretations, a conclusion can be drawn that even an environmentally aware and rich country such as Denmark is still far from being fossil fuel independent. Some “mean” calculations show that Denmark could have more cheaply reduce global greenhouse gas emission by importing coal and then burying it in order to increase the operating cost of thermal power plants in other parts of the world, than by using wind power plants[37].

8 Can bioethanol save us from importing liquid fuels?

We often hear that Slovenia is getting “overgrown” with vegetation. The proportion of the arable land is shrinking and the proportion of forests is increasing. Is it possible to mow, chop and grind everything from overgrown areas, put it in biogas-plant reservoirs and produce ethanol? At the current development stage of biogas technology, the answer is "NO". Biomass is converted to methanol by using microorganisms consuming sugar, starch and proteins and as a by-product emitting methanol. Pulp remains unused, which means that in today's biogas plants, only municipal waste and crops with a significant proportion of sugar and starch (cereals, mainly maize) can be exploited.

It was already in 1921 that the technology converting cellulose to ethanol was believed to be “available soon”. It soon turned out that the task was not a simple one. With the currently available technology conversion is possible, but CO_2 emissions per unit of energy are by 50 % higher than by burning gasoline. Moreover conversion requires large amounts of water (about 42 times more than production and processing of crude-oil to obtain gasoline). Currently this technology is not commercially viable. There are promises that in future conversion of cellulose into ethanol will be commercially available. If such be the case, all the agricultural waste, grass, wood waste and technically unusable wood could be converted into ethanol, thus replacing gasoline (but not the diesel fuel!!!). The potential is believed to be very large, but not as large as one would expect and want. In case of Slovenia if the entire annual increment of biomass (wood, agricultural waste – straw, corn stalk, unused grass and shrub ...) is burnt the energy outcome will be equal to about half of the energy used by TEŠ 6 unit [21, 22]. If converted to ethanol (at a 100 % efficiency), it would replace approximately one third of oil consumption. However, the question is how much money and energy would be required to prepare and transport the biomass to the power plant site and what would the conversion efficiency be. It would still not be enough to replace oil. It's hard to imagine Slovenia in the 21st century as a land of brushwood gatherers.

Calculations made for replacing 10 % of the U.S. annual oil consumption, would necessitate the biomass in the amount for which the truck trailers transportation when put in a single line would cover the distance from the earth to the moon and even more [23]. The U.S. would acquire such an enormous amount of biomass if the fast-growing vegetation were planted on 10 % of their fertile land [24].

Are there any other possibilities of substituting oil with ethanol? Ethanol can replace gasoline, but not diesel or kerosene for aircraft whose consumption is growing rapidly. In Slovenia, it is hard to sell a used gasoline driven car and most of new cars are the ones equipped with diesel engines. The road and sea transport is powered only by the diesel fuel. Airplanes almost exclusively use kerosene. The gasoline consumption is stagnating or is even in decline; on the other hand consumption of heavy-grade oil (including lubricating oils and bitumen used for insulation and asphalting roads) is increasing. The fact is that gasoline has become a by-product in oil processing. Viewed from this perspective, the use of bioethanol is unlikely to reduce oil dependence. Of course, it is possible to start producing gasoline- rather than diesel-driven engines, but the replacing the diesel engines is practically “mission impossible”. After all, why should we even do it?

9 Carbon capture and storage

Becoming increasingly obvious that in a short term renewable energy sources will not meet the energy needs, the "CO_2 danger" speakers contemplate the possibility of using fossil fuels (i.e. coal) in electricity generation with CO_2 captured. The technology is known by the acronym CCS (Carbon Capture and Storage or Carbon Capture and Sequestration). It is almost the only option of reducing CO_2 emissions by 80 % by 2050, as declared in certain commitments. These are politically motivated but unreachable commitments with no impact on the climate, but, on the otherhand, devastatingly impacting some economies. But this is the debate on the role of CO_2 in warming our planet.

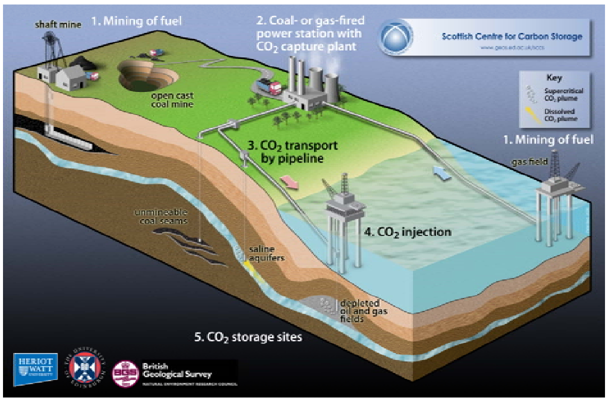


Figure 11 Carbon capture and storage – the future or imagination of the artist [28]

Despite adopting the Kyoto Protocol, the CO_2 emissions are increasing rapidly in countries that have ratified the protocol [25]. So, how to capture the infamous gas? Following the principle "facts are better than dreams", let us examine some facts.

According to the United States Congressional Research Service there is currently no technology available allowing economically viable CO_2 capture [26]. Let us ask ourselves how much CO_2 is emitted by burning fossil fuels. Burning 1 ton of coal in average produces 2.6 tons of CO_2, burning 1 ton of fuel oil produces ca. 2.9 tons of CO_2 and burning 1000 standard m^3 (ca. equivalent to 1 ton of oil) of gas produces approximately 2 tons of CO_2. Calculated according to the calorific value, these figures are: 0.335 t CO_2/MWh for coal, ca. 0.27 t CO_2/MWh for oil, and ca. 0.2 t CO2/MWh for gas.

The global annual consumption is an equivalent of ca. 3 billion tons of coal, ca. 5 billion tons of oil and ca. 3000 billion m^3 of gas (which is approximately the energy equivalent of 3 billion tons of oil). This figure for the CO_2 emissions are ca. 30 billion tonns. No matter how much the EU and the United States invest into the CCS technology, the task is simply too demanding, since this would mean 400 super tankers (2 million barrels of a useful volume) per day [27]. The question is how to get such huge amounts of gas to appropriate ports and where to transport then every day.

Separation and transport of such enormous quantities of CO_2 is not a simple process and is estimated to use ca. 28 % of the energy produced by a thermal power plant, thus reducing its efficiency from 40 % to about 28 % and increasing emission and energy cost (no cost of CCS included) by almost one half, which means waste of fossil fuels. Moreover, how to get around 40 % (1/(1-0.28)) of additional energy?

Furthermore, the question remains open of how to transport gas. Using pipelines now that we can’t even find place for laying power lines? Transport by train or trucks? Whatever be the case, the cost would be unthinkably high – in the range of the price of energy itself. When stuffing CO_2 underground, nobody knows in what time it will leak back to the surface. Or even worse, when exporting CO_2 with tankers to distant countries, it could be released in to air (control is impossible).

10 CO_2 market is a right solution

One of the ways of decreasing CO_2 emissions is to impose additional taxes. Despite the vast size and trade of the CO_2 emission market, it is hard to believe that it will survive in a long term because of the nature of its trading commodity. In the traditional market, trader’s expectations play a very important role. Similar can be expected for the CO_2 emission market. However, when revealing that expectations are much higher than the reality the market is "corrected", which brings stocks to their more or less realistic values. And here comes the main question: "What is the actual current value of an imaginary trading commodity, such as a CO_2 emission coupon?" This problem crashed the European CO_2 emission market in March this year after Hungary abused a hole in their law by »unjustifiably« gaining 2 million €. Comparing this number with 100 billion of the market turnover, the amount is rather negligible. Before the market was blocked, the value for 1 ton of CO_2 emission had decreased from 12 € to 1 € (at the moment, this value is some 9 €).

The past development of the today's developed countries has been made possible by unlimitedly exploiting fossil-fuel resources. This is why it is unethical and unjust to limit the economic growth of today's developing countries and their competitiveness on the world scale. That is the reason why countries like China and India will never agree with such limitations. Taxing CO_2 emissions can therefore be considered as a market with a single purpose which is sustaining its own existence. And of course, the main idea behind it would be to increase the wealth of few individuals on the account of the majority.

A far more reasonable approach to solving the environmental issue would be taxing air emissions of poisonous substances. Coal-fired power plants produce a considerable amount of heavy metals. This makes them by far the most dangerous environmental pollutants. The US Environmental Protection Agency (EPA) estimates that coal fired power plants are the source of some 40 % of the anthropogenic mercury emissions (Chinese coal-fired power plants alone produce 600 tons of the mercury emissions every year) [29]. This kind of pollution has worse consequences on the living environment than CO2.

11 In this world nothing can be said to be certain, except death and taxes

One of the alternatives to the CO_2 emission market is introducing a worldwide carbon tax. Here, an important role is played by politicians and the traditional opposing to new taxes. A former Slovenian minister, dr. Mihael Tomšič, once said: »A lot of economists are pro new taxes, but politicians have a panic fear against this option«. Despite this, dr. Bogomir Kovač expects the carbon tax to prevail in future: »In the CO_2 market, we have regulated the amount of emission coupons, but have left the prices to be defined by the market itself. As to the tax we fix the prices and vary the amounts«.

A possible approach to taxing carbon is to charge the so called »carbon footprint«. In Slovenia, there are a few people opting for this solution. Namely, the person or body granted the national concession for said activity would never have to worry about his/her financial status and the citizens should have to pay just one more tax, and many might ask themselves if they can soon expect a tax on the air they breathe.

12 Electric cars and the related problems

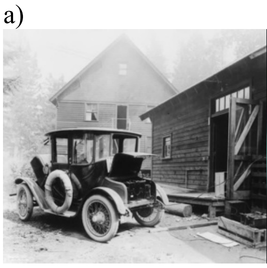
The idea of electrically-driven cars is far from being new. The first prototypes were put in operation as early as 1919. Therefore, in the last few years our generation is merely improving the technology of the old concept. Electric cars have a few important advantages compared to internal-combustion engines, such as better torque distribution, conversion efficiency from the electrical to the mechanical energy is much higher, there are no air emissions, etc.

On the other hand, there are a few major drawbacks of the electric car technology. First, electricity used for »fueling« electric cars and second, how to store enough electricity within the vehicle. The latter is the most important obstacle in developing electric cars, as the car-battery technology has made the smallest technological improvement since 1919 (Fig. 12) compared to other technologies. The density of accumulated energy in car batteries is just too low. Gasoline, for instance, contains 80 times more energy per kilogram than the Lithium-ion battery. This means a 20-times larger vehicle transportation range, despite the four times lower energy-conversion efficiency. This is the reason why batteries in electric vehicles (for example in Roadster Tesla) represent more than one third of the vehicle's total weight. The ratio between the production cost, life span and density of the accumulated energy just does not make electric vehicles economically sound for mass production.

The cost of batteries for electric vehicles is at the moment very high. It is impossible to predict the price trend of rare metals and lithium (Section 6) in case of a sudden mass production of lithium-ion batteries. As the total sales of electric vehicles are negligible compared to traditional vehicles, certain countries offer even subsidies for this kind of purchases.

Another serious issue of electric vehicles is also the infrastructure required for their recharging. The cost of appropriate system is definitely far from being cheap.

a)



b)

Fig. 12. Electric car:
a) in 1919 [30]
b) in 2010 [31]

13 The last drop of oil is being consumed

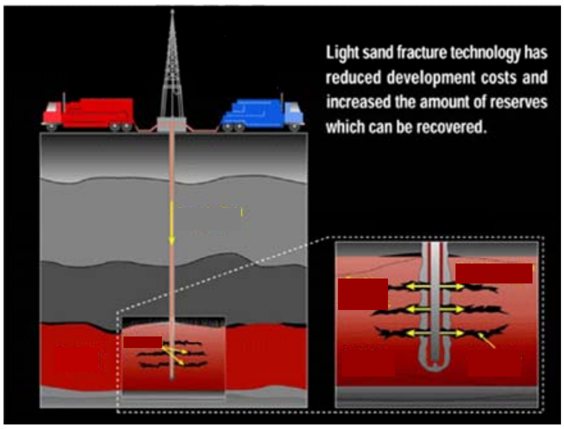
A careful examination of the past estimations of oil availability in the world shows that it is sufficient for 40 years. This estimation remained unchanged for the last 40 years for several reasons. Despite finding new oil fields lately, the oil consumption is higher than the amount of oil in the new fields. The increase in production is possible due to the improved drilling technology used and increased drilling depth in the sea. A very comprehensive movie clip can be found on this subject in [32] and photos/pictures in [33] and [34]. By using new technologies, the old already abandoned oil-resource locations can be further exploited. However, despite this fact, all the known resources will be drained out sooner or later, even though perhaps not as fast as in certain pessimistic scenarios. Of course, this will not be a sudden event, but it will take a longer period of time in which the oil prices will be constantly increasing. With other words, cheap oil will cease to exist. If we are willing to pay more for oil (for example 150 or 200 $ per barrel), the available kerogene resources in oil shales and bituminous sands can be estimated for another 40 years. Of course, oil production prices are higher by using kerogene, but still at least ten times cheaper compared to certain so-called »green technologies«.

14 The last breath of natural gas

The situation is even more promising with natural gas resources. In the last years, economically exploitable natural gas resources have drastically increased and therefore a few years old estimates are more or less useless. The reason lies within the development of technology for extracting gas from oil shales.

This technology, developed in the United States, is based on horizontal drilling holes used for pumping water and sand under very high pressure. In this way oil shales around the drilling hole crush and create several cracks. The sand is used to retain these cracks in the material, which are a source of the previously captured natural gas. Of course, more details about this technology are a business secret and therefore a mystery for the public knowledge. Despite being available only from 2005, the majority of natural gas in the US is obtained in this manner. The advantage of such approach is to make oil shale an economically exploitable source of oil, especially those with a low level of kerogen. Such resources in northern America cover vast areas (for example Marcellus Shale - approximately 130 000 km^2), according to conservative estimations, such resources can produce gas estimated in the amount of four times the equivalent of oil resources in the USA. Other countries like Brazil and China also have huge amounts of oil shale. Judging from the current consumption of natural gas in the USA, these resources would suffice for 100 years.

a)



b)

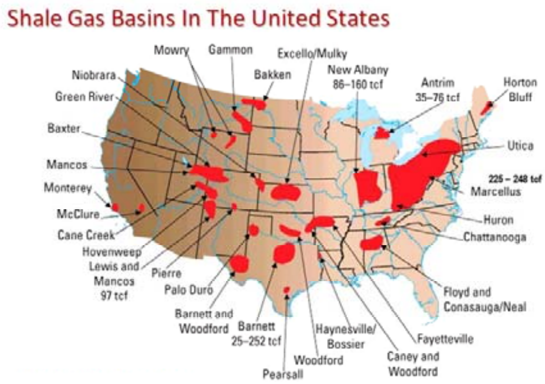


Figure 12. a) Gas production from shale [35]
b) Shale deposits in the USA [36]

Lately, an article was published in the newspaper Delo about oil shale resources in Europe. As it was shown in that Article, a large deposit of oil shale is also located under the northern part of Slovenia.

15 Conclusion

Based on publically available data the author highlights the issue of transition from the classical energy sources to the renewable ones and of some related socially-accepted beliefs of a questionable credibility. The field of energy production is, of course, too vast to be described in a single work. The author believes that the majority of the population is inclined towards optimally environmentally friendly energy production. We all want “clean”, always available, universally usable energy at an acceptable price. Yet nothing is for free and energy conversions always require a price to be paid, be it by the environment or taxpayers. New technologies (wind, solar power plants…) are still an open issue at least in terms of their availability and price.

It is briefly shown that the “environmental impact” of the so called “green sources” is relatively large compared to some classical energy sources and that ignoring dependency on importing the needed materials can in fact further increase energy dependency, since new technologies are based on some rare materials whose production has been monopolized. The example of the Danish "eco-state" is examined and assessed from an angle usually not seen by the public. A conclusion is drawn that biomass and ethanol do not considerably affect the fossil-fuel dependency.

Some believe that the anthropogenic CO_2 emissions are to be blamed for climate changes and promote ideas of capturing and storing them in the process of burning fossil fuels in order to prevent them from entering the atmosphere or taxing them. Irrespective of the fact that author believes CO_2 to be completely harmless [39], this work shows that neither of the two ways is feasible on a global scale.

Although the concept of the electric car is highly tempting the problem of an adequate mean of electrical energy storage, necessary for a wider use, it has not been sufficiently solved yet.

Humanity will continue to be dependent on fossil fuels for quite some time. Luckily, they will not be run out as quickly as some may fear. This, however, should not be the reason for humanity to stop developing environmentally sound energy sources. It would however be appropriate to focus our means and efforts, available in this present time of energy well-being, on researching and developing technologies producing some added value for the society as well. There is no point in subsidizing the already underpaid workpower in China and its often environmentally controversial production. Furthermore supporting the sector, whose only aim is ripping off taxpayers and gaining political power for some is socially unacceptable. Stuffing CO_2 underground and having it taxed is already a nonsense dearly paid by the Europeans. If taxpayers allow to be burdened by a tax on the "carbon imprint", this will be yet another large step in the series of nonsenses and limitations of personal freedom (as well as filling wallets for some). Resources spent in vain and the trust of many people lost will make the use of new technologies more difficult at a time when this will actually be a necessity.

Despite the arguments presented here, some will of course not change their beliefs for whatever reason this may be, be it because of their religious attitude towards the topic or because of their personal interests. There was an interesting response in the Delo newspaper by a reader who has been active in the field of power management for quite some time. He believes the position we face with regards to wind and nuclear power plants is not in place. The author believes that our academic freedom commits us to think outside the box and also to address issues of a less desirable nature. How can we be an example for free people if we ourselves do not feel free? This is why the Author agrees with Dante Alighieri in drawing his conclusion that:

"The hottest parts of hell are reserved for those, who, in times of great moral crisis, maintain their neutrality".

Figure 13. Dante was right

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