Economic Harm of Promoting Photovoltaics

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Abstract **—**This paper looks at the developments in the area of generation of solar electricity in the Czech Republic and the increase in the volume of electricity produced in the last five years. Drawing on critical investigations and analyses of available data, it shows that the reality is fundamentally different from the goals set out by the government when advocating and promoting photovoltaics. It has transpired that photovoltaics does not deliver the economic and systemic benefits often attributed to it, which constitute the theoretical rationale for photovoltaic subsidies. On the contrary, there has been mounting evidence proving that promotion of photovoltaics and other 'renewable' sources inevitably entails significant economic difficulties, refuting popular claims that 'renewable sources' are a solution of economic and environmental challenges of the modern era. It turns out that massive support of sustainable energy sources introduces to the energy market rapidly increasing volumes of 'expensive electricity', which has to be sold at high rates, thus significantly damaging popular attitude towards 'sustainable sources' as they are rightfully considered a direct cause of rising electricity prices. In addition, higher energy prices have a negative impact on the competitiveness of manufacturing and other industries, including the services sector. Moreover, subsidies into 'renewable sources' undoubtedly contribute to a build-up of inflation pressures. Finally, the paper provides two correlation analyses, the first one assessing the development of the cost of sustainable energy subsidies and amount of renewable electricity generated between 2004 and 2001, and the second one evaluating the additional cost of sustainable energy sources and the cost of reducing emissions by one tonne of CO_2 equivalent.

Keywords**—**energy industry, ecology, energetic security, photovoltaics, renewable sources, correlation analyses.

I. Introduction

The main issue of 'sustainable energy sources' is low energy concentration. Comparing, for example, the energy content of one tonne of lignite with the energy contained in solar radiation or wind, one finds out that the technical issues of storing this amount coal are negligible compared to the difficulties of 'gathering' the equivalent amount of wind or solar radiation.

'Renewable sources' typically include solar radiation and elemental energy, i.e. wind, water and geothermal power. These sources are fully accepted by environmental organisations as allegedly having zero impact on the environment. A broader definition of 'sustainable energy sources' includes also biomass, biogas, secondary resources (solid municipal waste), landfill and sewage gas and other sources. However, similarly to coal or natural gas, energy from these sources can be generated by means of combustion only, making them far less ecological than the first group (most environmentalists strongly disapprove of waste incineration).

Ignoring the relevant economic aspects, one might think that renewables are available 'for free' and do not have to be paid for—unlike traditional fuels which have to be 'extracted', i.e. obtained using organized and often costly efforts, cultivated and, eventually, transformed into energy. From this perspective, 'sustainable energy' appears to be cheap and 'economical', whereas the use of traditional energy sources is 'expensive' and 'wasteful'.

Many do not realize, however, that the issue of 'obtaining, cultivating and transforming resources into energy' applies to renewables in very much the same way as traditional energy resources or nuclear fuel, oblivious to the fact that wind turbines and photovoltaic farms require significantly more material and energy, per GW-h of electricity generated than traditional or nuclear power plants.[1]

Over the last twenty years, public ignorance of these facts resulted in the introduction of various subsidy campaigns promoting 'sustainable energy' in an effort to curb conventional and nuclear sources as much as possible.

II. Problem Formulation

A. Main System Flaws

Similarly to many other countries, in the Czech Republic, too, the efforts to promote 'sustainable energy', combined with a substantial lack of understanding of the market, had a devastating and disruptive influence on the energy sector.

In simple terms, the EU's political goal [2] requiring from each member state to replace a certain percentage of its energy pool with 'sustainable energy' was implemented in the form of 'economic incentives'. In the Czech Republic, the government decided to use the concept of 'subsidized' purchase prices, with the regulation authority essentially forcing electricity distributors to purchase 'sustainable power' for fixed feed-in tariffs and allowing them to increase consumer prices accordingly.

As in all similar cases, however, the state proved to be utterly incapable of implementing the given political task in

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practice and set the economic incentives in such a way as to avoid devastating impacts on energy prices.

B. The Cost of Renewable Sources

Undoubtedly, with respect to the current level of technical progress and contemporary technological knowledge, renewable sources cannot be considered competitive in comparison with conventional or nuclear energy. The energy content of wind and solar radiation is too low for humankind to be capable of 'mining' these elements efficiently and economically at present. It can be discussed whether, with regard to the current state of the environment, combustion of coal, natural gas or heating oil for the purpose of electricity generation should be considered an 'environmental crime' or 'wasting'. Nevertheless, it is more than obvious that most countries are unable to switch to 'renewable' energy sources only.

Certainly, there are always exceptions to prove the rule. Countries with significant altitude differences and abundant water sources, such as Austria, Finland or Norway, can cover most of their electricity needs using hydroelectric facilities. There are countries, such as Island, with enormous geothermal energy potential. Other regions, such as Denmark, may be able, in future, to make extensive use of wind power, and very sunny countries may once be able to generate vast amounts of electricity from solar radiation. However, this is not the case of most European countries today. Despite this incontestable evidence, by adopting Directive 2001/77/EC the European Union required that a certain percentage of electricity generated in member states be electricity from 'sustainable sources'.

The situation in the Czech Republic shows that there are two kinds of high costs related to the use of sustainable energy. First, the regulated feed-in tariffs for 'renewable electricity' result in higher consumer prices; without renewable power facilities, consumer bills would be significantly lower. In 2011 alone, households and businesses will have to pay approximately CZK 16.4 billion (ca. GBP 0.6 billion) more, despite intense government efforts, in 2010, to change the subsidy programme and reduce the profitability of photovoltaic farms. Originally, the estimated year-to-year increase in the 'cost of sustainable energy' amounted to more than CZK 28 billion (GBP 1 billion), accounting for an electricity price increase of 18.2 per cent for businesses and of 12.7 per cent for households. After introducing the curbing measures, the increase was reduced to 5.5 per cent in both market segments. In total, between 2004 and 2010, the public bill for renewable energy soared to CZK 25 billion.

In addition, there are indirect costs too. Power grid operators are forced, because of fluctuating outputs of most renewable power facilities, to purchase more ancillary services. In addition, sustainable power producers are entitled to have their facilities connected to the grid almost anywhere, even if the required infrastructure is not present, effectively requiring ad hoc extensions of the distribution network as new facilities emerge. These investments increase coverage, without improving the quality of the grid. Moreover, the cost of grid regulation electricity has to be taken into consideration, too. Current estimates predict that consumers in the Czech Republic (both households and businesses) will have to pay a staggering CZK 654.6 billion (GBP 23.3 billion) for 'sustainable electricity' between 2010 and 2030. [3]

This figure can be understood as the price to be paid by Czech citizens and businesses for supposedly using fewer natural resources.

C. Flawed Logic

The system of renewable energy subsidies is based on two fundamental tenets:

- renewable sources are 'environmentally friendly' and their higher price is counterbalanced by significantly lower pollutant emissions,
- renewable sources decrease Europe's dependence on energy resource supplies, thus strengthening its 'energy security'.

Unfortunately, both assumptions are essentially wrong, casting serious doubt on sustainable energy incentives.

D. Fallacy of 'Environmental Friendliness'

First and foremost, 'environmental friendliness' of an energy source cannot be determined by the relevant production cycle only, i.e. considering solely the environmental impacts of the medium used to generate energy. Using this simplified logic, wind, water and geothermal or solar energies are, indeed, ideal energy sources. However, their utilisation requires sophisticated, state-of-the-art technology and considerable landscape improvements—in other words, a lot of material and energy.

Sustainable sources are usually defined as sources existing 'on their own' and available in a (theoretically) unlimited quantity—such as, for instance, solar radiation, wind power, geothermal energy, etc. This concept clearly assumes that the main difficulty of energy production is the medium processed. However, this view is too narrow and ignores other important factors such as energy or material prerequisites, as already mentioned above. An interesting theoretical study of a wind-turbine system sized to cover the energy needs of the Czech Republic shows that such a project would require immense amounts of non-renewable resources. In addition, a part of the wind turbines would have to be replaced on a regular basis, thus resulting in significant additional non-renewable costs every year, despite an assumed life cycle of 20 years (i.e. one in twenty wind turbines replaced every year) and highly efficient recycling (90 per cent). Low concentration of energy in wind and solar radiation inevitably implies extremely high material costs per GW-h of electricity generated. Comparing the initial material costs of a lignite power station and that of a photovoltaic facility, one might be surprised to discover that the 'renewable' source requires 2 to 10 times more steel, at least 100 to 250 times more copper and 15 to 150 times more aluminium, depending on the panels and technology used. At any rate, however, material requirements of photovoltaic facilities are higher by an order of magnitude.

The ratios are approximately the same for other conventional and nuclear plants. Looking at the huge towers of a nuclear power station, one might think that the cost of material or construction works per GW-h has to be much

higher than in the case of wind turbines. In fact, the reverse is true. The sustainable energy source, again, needs 10 to 250 times more resources. For instance, a nuclear power plant needs only ca. 420 kg of steel per GW-h of electricity produced (i.e. less than half a ton), whereas photovoltaic facilities require 1.7 to 25 tonnes. [1]

Once put into full-scale operation a nuclear plant 'returns' the total amount of energy required to build it (including technology used) after approximately 3 months. Wind turbines need between 6 months and more than a year, the lower margin applying in case of ideal locations, which, in continental Europe—and Central Europe in particular—are more than scarce. As for photovoltaic facilities, energy invested is returned in 6 to 12 years (in continental Europe after ca. 10 years). With the expected operational life cycle of photovoltaic panels ranging from 20 to 30 years, such facilities require between a third and a half of their lifespan to at least 'return to the world' the amount of energy invested during their construction. This ratio has been improving recently, the latest photovoltaic panels return the energy invested after ca. 3 years, i.e. a tenth of the facility's lifespan.

These figures prove that renewables are not 'environmentally friendly' by definition. The lifespan of photovoltaic facilities and wind turbines would have to be fifty times longer in order to generate the same amount of energy, per tonne of materials used, as lignite or nuclear power stations. Clearly, this calls the alleged 'environmental friendliness' of these sources into question.

Photovoltaic power stations have been promoted mainly as part of the efforts to decrease carbon dioxide emissions. This is also one of the motives behind the Directive 2001/77/EC, requiring EU members to generate 22.1 per cent of total energy from renewable sources.

The ultimate goal of these endeavours is to decrease the emissions of greenhouse gases, thus slowing down or stopping global warming. Let us accept, for the sake of argument and despite a high degree of scientific doubt, that global warming is, indeed, taking place and is caused by human activity. At any rate, it cannot be denied that conventional power stations have a significant impact on the environment and the effort to decrease CO_2 emissions is justified (irrespective of whether global warming is caused by humans or not).

However, in trying to achieve this goal, one must not ignore the expenses linked to the efforts, logically preferring the best and most cost-efficient solution.

Table 1: Cost of reduction of CO_2 equivalent emissions (CZK/tonne)

Photovoltaics	6,000 – 12,200
Building insulation	2,000 – 9,100
Heat pumps	1,500 – 8,800
Thermo-solar	2,000 – 8,000
Wind power	2,000 – 5,000
Geothermal energy	3,000 – 4,000
Biomass	1,500 – 4,000
Biogas	3,000 – 3,500
Small hydro-plants	2,000 – 2,500

Source: Zajíček, M., Zeman, K. [3]

The above table alone speaks volumes, showing that photovoltaic facilities are the most expensive method of reducing greenhouse gas emissions. Unfortunately, photovoltaics has also been the sector with the most incentives.

E. Fallacy of 'Energy Security'

The second key argument of photovoltaics advocates appears, at least at first sight, to be more tenable, being based on the assumption that there is only a limited quantity of natural resources and the supply will run out eventually, the last deposits remaining for the domestic consumption of resource-exporting countries. A good example in this respect is oil, with most of the remaining deposits located in countries that do not belong to the democratic part of the world or are hostile to the major western powers. However, at closer look, the whole notion seems to be unreasonable. There are no grounds to believe that in case of an oil shortage the UK or Norway, for instance, would send their last barrels to other EU countries more readily than, say, Saudi Arabia.

Usually, deliberations on this topic are less extreme, with proponents of renewable energy reminding of the oil crises of the 1970s, high price fluctuations in 2008 or the recent tensions in Northern Africa, in particular Libya, and many Middle East countries. In other words, there is a potential risk that countries with oil deposits might decide to cut supplies to western countries in an effort to make demands.

With the number of exploitable oil deposits gradually rising, it is clear today that, despite many catastrophic forecasts, there is enough oil to cover the needs in the coming decades. In other words, despite rising consumption, humans have access (and can extract) more oil today than, for instance, 50 years ago. Admittedly, this is not to say that there are unlimited reserves available; one day, oil deposits will be exhausted or too expensive to extract. However, this day is still far away, despite many affirmations to the contrary. The risk of coordinated supply interruptions, too, is very low. Despite the number of major oil-producing countries being rather low (there are less than 20), it is still sufficient to make the market highly competitive. Moreover, there is excess mining capacity (though not a surplus of supply), reducing the options of oil producers to exert pressure on the western world in an effort to push it to decisions it would not make otherwise. And last but not least, we must not forget that supply cannot exist without demand and, with oil being a key source of their income in

most cases, oil-producing countries need to sell it. Indeed, developed countries cannot live without oil supplies from oil-producing countries, but oil producers cannot live without supplies to the western world either.

F. Subsidies – An Economic Crime

In any event, incentives in the area of 'sustainable energy sources' are untenable. Renewable sources are neither (significantly) more ecological than conventional or nuclear energy, nor are they making any considerable contribution to Europe's 'energy security'. On the contrary—unwise subsidies can result in catastrophic scenarios and, adding fuel to the flames, inflict immense damage. The Czech Republic is a case in point.

Let us take a look at some photovoltaic data in the Czech context. We shall see that there is an intrinsic link between the scope and extent of government incentives and both size and installed output of photovoltaic projects. Understandably, the size of photovoltaic facilities and their installed output are directly proportional to the scope of subsidies granted by the government. However, the concept of a guaranteed purchase price (i.e. feed-in tariff) itself is deeply flawed. The government today has to buy all 'renewable electricity' regardless of the total installed output, effectively transferring the burden and full cost of 'sustainable energy subsidies' to consumers.

Undoubtedly, interfering in standard market principles by regulating purchase prices is a bad idea on its own. Leaving the dubious aspects of 'environmental friendliness' and 'environmental security' aside, the logic is painfully straightforward. Assuming that the average purchase price of electricity from conventional sources and nuclear power plants is, for instance, CZK 2.00 per kW-h (the real price is, in fact, lower), a 10 or 20 per cent share of 'renewable electricity' with an average purchase price of CZK 10 per kW-h will have a significant influence on the distributor's sell prices.

The calculation is a simple rule of three. Let us assume that the ambitious plans envisaged by the European Directive on Renewable Energy become true and 20 per cent of energy is generated from sustainable sources. Instead of buying 100 per cent of electricity for CZK 2 per kW-h, we now have to purchase 80 per cent for CZK 2 and 20 per cent for CZK 10. This effectively means a price increase of CZK 160 (i.e. from CZK 200 to CZK 360), attributable solely to electricity from 'renewable sources'.

Table 2: Development of regulated purchase prices for electricity generated by photovoltaic facilities.

Commi-ssioning	Yearly feed-in tariff rate (CZK/kW-h)				
	2006	**2007**	**2008**	**2009**	**2010**
2005	6.28	6.41	6.57	6.71	6.85
2006	13.20	13.46	13.80	14.08	14.37
2007	x	13.46	13.80	14.08	14.37
2008	x	x	13.46	13.73	14.01
2009	x	x	x	12.79	13.05
2010	x	x	x	x	12.15

Source: Czech Energy Regulatory Office, 2010

The market environment has been distorted and ceased to perform its intended basic functions; investments have been transferred from highly promising sectors (e.g. in terms of the price of emission reductions) to expensive segments with low efficacy, such as photovoltaics. Table 2 provides an overview of guaranteed purchase prices (feed-in tariff rates) for electricity generated by photovoltaic power stations. These lavish tariffs literally triggered a tidal wave of new facilities and sent the total volume of photovoltaic subsidies soaring. Strictly speaking, the whole issue comes down to a single fundamental question: How is it possible that, out of a wide range of 'renewable sources', the government opted for one which is not really suitable for fulfilling the original political goal?

Looking at table 2, it is small wonder that total installed output of photovoltaic facilities in the Czech Republic has skyrocketed in recent years, rising from 50 MW in 2008 to more than 400 MW by the end of 2009, and reaching, according to data by the Czech Statistical Office, 1951.1 MW on 31 December 2010, an output comparable with the Temelín nuclear power plant (2000 MW).

G. Decision Making Issues

In the European context, extensive subsidizing of 'sustainable energy sources', in particular photovoltaics, gives rise to a number of further problems, including serious accounting [4]-[7] and asset valuation [8,9] issues. Understandably, in connection with the decision-making processes, the impacts of the current situation have to be considered a consequence of human failure [10], to put it mildly.

It is quite obvious, that the difficulties are based on the rather traditional connection between the political decision-making processes on the one hand and rational economic behaviour on the other. The political decision adopted in 2001 by Directive 77 foreshadowed an inevitable clash between the will of the political echelons and the market environment. This conflict was predicted with appropriate urgency and, as it transpires, surprising accuracy well in advance. In view of these facts, one can hardly claim the current results to be 'unexpected' and 'surprising'.

It has been very clear and predicted since the beginning that incentives in the area of 'sustainable energy' will limit

the competitiveness of European economies by increasing energy prices (that is all energy prices, since a rise in electricity prices leads to price increases in other market segments as well). To add insult to injury, there has always been doubt as to whether subsidising renewables (including photovoltaics, the primary focus of this paper) will really enable Europe to reach the lofty goals of a greener economy and higher 'energy security'.

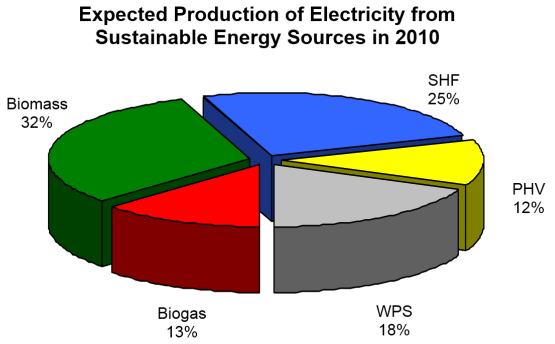
At any rate, looking at decision making in the Czech Republic over the past few years, the key vote took place on 23 February 2005, when Act No. 180/2005 Coll. was approved by votes more or less across all political parties. The bill was supported by a majority of the left-wing Social Democratic party, then in government, and most communist MPs (only six abstained). Despite both US-DEU (the Liberals) and KDU-ČSL (the Christian Democrats) being right-wing parties, they, too, were in the government coalition and supported the bill. Only conservative MPs from the Civic Democratic Party (ODS), then in opposition, kept swimming against the tide. ODS could have changed the situation a year later when it formed a government, albeit one with a razor-thin majority. However, there was no such attempt. Strangely enough, by the end of 2010, many Christian-democratic MPs voted in favour of serious cuts in photovoltaic subsidies, once a political consensus on the devastating impacts of the current law was established. The Social Democrats quickly decided to follow suit after it turned out that, unless the Act is amended, energy prices for small consumers and businesses would increase by 12 to 18 per cent. This threat shook the political landscape, since the situation could have jeopardized both the economy and the political stability of the country, thus threatening the popularity of the government and opposition parties alike.

III. Further Economic Context

When carefully examining the system of renewable incentives, it becomes obvious very soon that the rules set out by the government have been highly asymmetric, in particular with respect to the apparent and inexplicable imbalance between the share of photovoltaic facilities in the total volume of sustainable energy generated and the amount of subsidies given out by the government when promoting its use. As shown in the chart below, electricity generated by photovoltaic facilities accounted for 12 per cent of total renewable electricity generated in the Czech Republic in 2010. In terms of the volume of renewable electricity generated, biomass combustion ranked first, despite not being the cleanest renewable source, as it clearly involves greenhouse gas emissions. Apart from biomass, a quarter of the total renewable electricity volume was generated by small hydroelectric power stations.

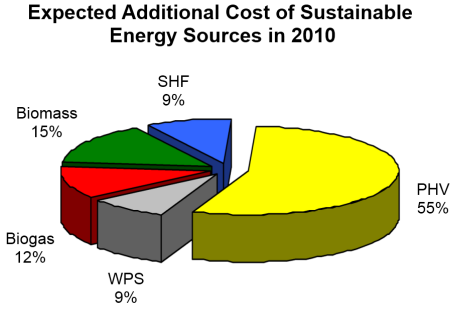
Considering that solar facilities accounted for only twelve per cent of total renewable electricity generated, it is extremely difficult to see why photovoltaics swallowed up 55 per cent of all subsidies used to promote 'renewable sources'. This disproportion is nothing short of shocking and calls for a deeper analysis.

Fig. 1: Expected renewable electricity production in 2010



Source: Světlík, J. [4]

Fig. 2: Expected additional cost of renewable electricity



Source: Světlík, J. [4], 2010
Legend:
SHF: small hydroelectric facilities
PHV: photovoltaic parks
WPS: wind power stations

Comparing these two charts with the cost of different methods of decreasing carbon dioxide emissions using 'renewable sources', one can immediately see a fundamental flaw in the government's policy, with the largest amount of 'green' subsidies ending in the segment requiring the highest expenses to achieve the required results. Presumably, this paradox cannot be explained by any economic foundations.

When speculating on possible reasons behind this illogical situation, it is possible that the government sees in photovoltaics the largest room for future development and technical progress, which could significantly increase the efficiency of solar power systems. Admittedly, with respect to the substantial increase in the efficiency of photovoltaic facilities in recent years and a significant decrease in the prices of solar panels, this assumption can be considered rational and in accordance with current scientific knowledge. A few years ago, a photovoltaic power station had to be operated for 70 to 140 months only to 'return' the energy consumed in producing the panels used, constructing the plant and making sure it could be put into operation. In other words, the panels had to be in use for an unbelievable 12.5 years in order to generate at least the amount of electricity needed to produce them. Currently, this indicator decreased to less than five years. Nevertheless, this score, despite huge improvements in recent years, has still to be considered extremely bad when benchmarked against traditional energy sources, with coal, gas and nuclear power stations needing

only three or four months to return the energy needed to build the structures and produce the equipment involved in the power generation process and wind and hydroelectricity power stations requiring about a year to achieve the same. It is quite possible that one day photovoltaics will live up to popular expectations and provide a suitable solution for the future; nowadays, however, it is fatally unsuitable for subsidy programmes, representing the most expensive and least efficient way of achieving the intended goal, i.e. reducing carbon dioxide emissions.

Table 3: Subsidies to different sources of renewable electricity (in CZK thousand).

Additional cost of sustainable energy sources (in CZK thousand per year)			
Additional cost of SES	2009	2010	2011
SHF	326,493	1,048,695	1,246,999,582
PHV	1,076,826	2,648,178	18,917,037,844
WPS	115,564	583,504	474,158,176
Biogas	272,165	1,104,950	2,318,048,530
Biomass	701,531	1,551,279	1,976,027,129
Total	2,492,579	6,936,606	24,932,271,261

Source: [3] (Zajíček, Zeman 2011)

Legend:

SES: sustainable energy sources

SHF: small hydroelectric facilities

PVF: photovoltaic parks

WPS: wind power stations

The total volume of subsidies into renewable energy in 2011 is expected to amount to up to CZK 25 billion (GBP 0.9 billion) and, at the end of the day, will be reflected in retail prices. Transferring the bill for sustainable energy subsidies to consumers can thus be understood as a hidden 'ecological' tax imposed on all businesses and citizens of the Czech Republic. As already pointed out before, this situation is a typical example of lowering a country's competitiveness.

It is obvious that the decision to support primarily photovoltaics when promoting sustainable energy sources cannot be rationally explained as endeavours to unlock the hidden potential of the technology, as current subsidies are clearly not incentives for further scientific research, being intended rather to introduce the technology in the current, unsatisfactory state of development, which hinders their efficient use in practice. It is as clear as day that current incentive initiatives are extremely unlikely to speed up photovoltaic research, but can be expected to severely discredit the notion of renewable energy sources in society, being quite justifiably seen by many as the primary cause of rising electricity prices.

IV. Mathematical Analysis

As one can expect, closer mathematical examinations reveal many dependencies between different aspects of photovoltaic subsidies. The first example provides a correlation analysis of the development of expenses incurred with respect to promotion of sustainable energy sources and the volume of renewable electricity produced in the period from 2004 to 2010, calculated in SPSS Statistics 15.

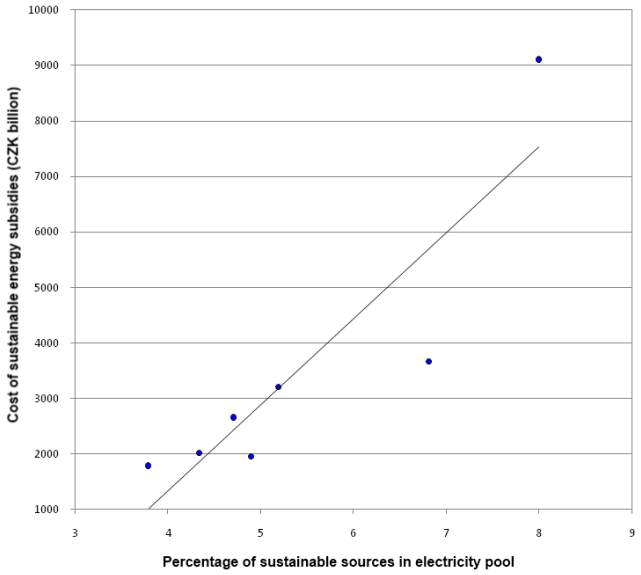
Table 4: Development of the cost of sustainable energy source subsidies and amount of renewable electricity generated over 2004 to 2011.

	Cost of sustainable energy source subsidies (in CZK billion)	Share of renewable electricity (in per cent)
2004	1,785	3.79
2005	2,017	4.34
2006	1,958	4.9
2007	2,659	4.71
2008	3,203	5.19
2009	3,665	6.81
2010	9,109	8
2011	16,400	

Source: Světlík, J.: Konkurenceschopnost českého průmyslu je ohrožena. In: Fotovoltaika a růst cen elektřiny. Collection of articles. CEP, Praha, p. 9-15.

An analysis of this data shows that the Pearson correlation coefficient amounts to 0.895950079 with a correlation significance (P) of 0.0063374. The results of these calculations are shown in Fig. 3 below.

Fig. 3: Relation of the cost of sustainable energy source subsidies and amount of renewable electricity generated.



Sources: Results derived from IBM SPSS Statistics 15 software

It is obvious that the share of renewable energy produced—the goal for 2010 was eight per cent of the electricity pool (as shown by the x axis)—is inextricably linked to the amount of money paid as subsidies, undoubtedly a direct consequence of the system of

guaranteed feed-in tariffs and sustainable energy purchase rates laid down by the Energy Regulatory Office (the Czech regulation authority determining energy purchase prices). Assuming the feed-in tariff rates determined by ERO remain high enough in future, the Czech Republic would very likely be able to achieve the ultimate and very ambitious target of a 22.1 percentage of sustainable electricity, waiting further down the line. However, the relation curve of the volume of subsidies and percentage of renewable electricity produced shows that such efforts would inevitably go hand in hand with huge continuous expenses, with current estimates amounting to approximately CZK 250 billion (ca. GBP 9 million) per annum. To Czech consumers, this exorbitant price would be utterly inconceivable and beyond any reason. It is quite plain that keeping the same subsidy approach as in the years 2006 to 2010 would have a devastating effect on industry and households alike, laying the Czech economy to waste.

The assumed annual expenses of CZK 250 billion are based on the following premises:

- the government's incentive policy remains unchanged, with subsidies being paid out in the same way as in 2006 to 2010 (however, this no longer applies as the Czech government decided to modify the rules in an effort to tackle soaring electricity prices and prevent the situation from spinning out of control),
- the incentives programme is maintained until the milestone of 22.1 per cent of renewable electricity is reached.

Empirical data shows that in order to increase the share of sustainable sources in the Czech electricity pool twice, the total amount of subsidies has to be increased tenfold. This estimate is based on previous experience and development of the renewable subsidies programme since the legislation was adopted in the middle of the 2000s. There are no reasons to believe that the trend should be different in the years to come. However, the expected expenses of CZK 250 billion assume that the share of renewable sources in the electricity pool would rise even with lower incentives, i.e. despite a decrease of feed-in tariff rates.

In addition, an analysis has been made of the correlations between the amount of additional cost of sustainable energy sources and the cost of reducing emissions by one tonne of CO_2 equivalent.

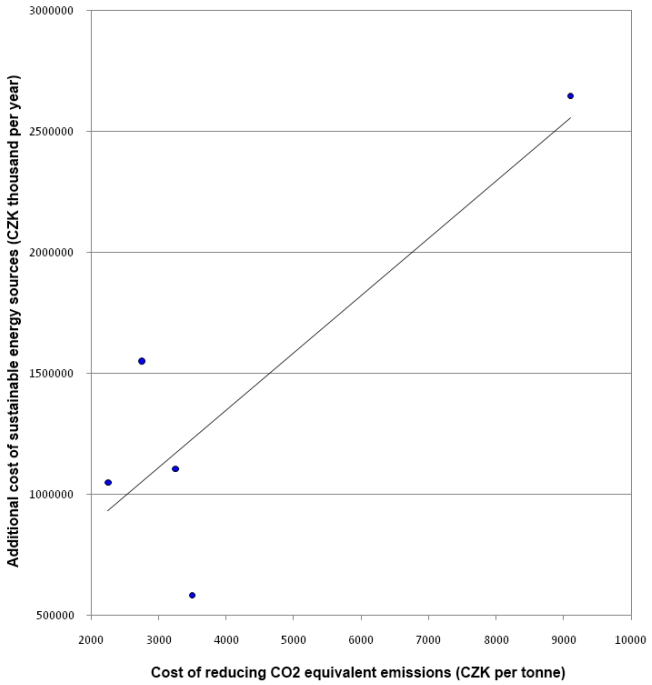
Table 5: Development of additional cost of renewable energy sources and cost of reducing emissions by one tonne of CO_2 equivalent.

	Additional cost of sustainable energy sources (in CZK thousand per year)	Cost of reducing emissions by one tonne of CO_2 equivalent (in CZK per tonne)
Small hydroelectric power stations	1,048,695	2,250
Photovoltaics	2,648,178	9,100
Wind power stations	583,504	3,500
Biogas	1,104,950	3,250
Biomass	1,551,279	2,750

Source: Zajíček, M., Zeman, K.: Účet za 700 miliard, Fotovoltaika a růst cen elektřiny, CEP Proceedings, 86/2010, pp. 55-80

An analysis of this data shows that the Pearson correlation coeficient amounts to 0.8473802 with a correlation significance (P) of 0.06991. The results of these calculations are shown in Fig. 4 below.

Fig. 4: Relation of the cost of reducing emissions by one tonne of CO_2 equivalent and additional cost of sustainable energy source subsidies



Source: Results derived from IBM SPSS Statistics 15 software

Like the first analysis of the correlations between the amount of subsidies and the share of sustainable sources in the energy pool, the second correlation analysis examining the mutual relations between the additional cost of sustainable energy source subsidies and the cost of reducing emissions by one tonne of CO_2 equivalent, too, clearly shows that these two parameters are firmly connected and that any efforts to reduce carbon dioxide emissions by large-scale photovoltaic incentives and new solar facilities would lead to a significant increase in the installed output and amount of electricity generated, which would be inevitably followed by a dynamic increase in the cost of reducing CO_2 equivalent emissions. In this context, too, efforts to reduce carbon dioxide emissions by means of photovoltaic subsidies would entail unreasonably high expenses, the correlation between these factors being comparable to the results of the first analysis.

V. Final Considerations

Czech experience shows that economic decisions of domestic politicians are often far from rational, especially when necessitated by long-term European policies and strategies. It is probably a common phenomenon, which may be partly the result of European integration, and deserves a more thorough research.

We must, however, not forget that in 2001, the year in which the EU Directive was approved, knowledge about the impact of sustainable energy subsidies was very different from the facts available by 2005, when the Directive was implemented into Czech law. At that time, Czech legislators were already familiar with their practical impacts and side effects. (For example, it turned out in the meantime that some solar plants in Spain were able to generate electricity also at night. To general surprise, the owners did not operate solar panels at all. Because of massive subsidies, these facilities produced electricity by running diesel generators, still making a huge profit despite this method being rather expensive. Their night deliveries of 'solar electricity' were simply a mistake of the engine operator.)

One can positively expect, that when Act No. 180/2005 Coll. was passed, a number of the MPs supporting it had certainly known, that it would be a serious threat for the competitiveness of Czech economy in the long run without delivering the intended benefits. In spite of it, these MPs voted in favour of the bill, guided by loyalty towards 'higher principles' and disregarding their convictions and conscience. This shows that there is a permanent tension between political decision making in an ever more united Europe, and economic rationality. Because of the exceedingly complex structure of the EU, community decisions have a momentum which cannot be easily reverted, thus posing a serious threat to the economies of both continental members and the UK. Directives, once adopted, are applied in their original intent, unless there is enough will to make them more rational. Photovoltaics has proved that this approach can results in severe economic harm.

Understandably, highly irrational decisions are carried over to the following stages, thus multiplying the impact of the consequences. On the other hand, one must not forget about other sources of market imbalances, such as corruption and political lobbying. Corruption can inflict serious harm on the economy and should definitely not be overlooked when analysing economically wrong decisions. It is very likely that corruption played a certain role not only in passing Act 180/2005 Coll., but also during the follow-up discussions, which, ultimately and entirely unreasonably, channelled most sustainable energy subsidies towards photovoltaics.

VI. Conclusion

Based on the above analysis of sustainable energy subsidies in the Czech Republic, we, unfortunately, reach the following two conclusions:

- Subsidies of 'sustainable energy sources' can be justified neither by environmental nor by economic considerations. This is not to say that 'renewables' do not have a place in certain regions and under certain conditions. However, in the current situation, when we unable to technologically master the issue of low energy concentration of these sources and incapable of using them in a way which can be considered economically rational, efforts to deploy and use them in mass scale bring no economic benefits, especially when ignoring the natural characteristics of individual countries.
- Political decisions, in particular when necessitated by long-term European strategies, inherit all irrational elements embedded in them. What is even worse, by implementing these strategies, the adverse economic effects are further enhanced. In fact, photovoltaics is nothing more than an 'investment bubble'—an investment bubble, it has to be pointed out, prevented from bursting by government guarantees. At the end of the day, any efforts to make it smaller (and, truth to be told, there is no other solution) will be paid by all consumers in the form of higher electricity prices.

In addition, it has to be said that further support of renewable electricity is objectively not possible for Czech economy. Attempts to meet the goals set out in the European renewable energy directive and the follow-up Czech regulations would result in a drastic increase in the cost of renewable energy incentives and, subsequently, a multiple increase in electricity prices for businesses and households.

In view of these facts, the Czech government promptly decided to reduce photovoltaic subsidies and to keep decreasing them further in the years to come, in an effort to minimise the adverse effects on citizens and businesses of wrong decisions made in the past. Nevertheless, this makes it virtually impossible for the Czech Republic to meet the goals laid down in the European sustainable energy directive, the country being unable to bear the cost of such a decision (and, more importantly, lacking the political will to do so).

Despite a gradual dismantling of the incentive system and decreasing feed-in tariff rates for electricity generated by photovoltaic facilities put into operation before the year 2011, the Czech power grid and energy market will have to cope with almost 2000 MW of expensive electricity coming from subsidised solar power facilities as well as the benefits and, in particular, drawbacks ensuing from this situation. The latter include mainly high output fluctuations resulting from local climatic conditions and other objective factors, which can, given the total installed output, pose a serious risk to the stability of the power grid. In addition and despite a continuous decrease in feed-in tariff rates, electricity produced by photovoltaic facilities will undoubtedly continue to exert pressure on consumer electricity prices in the long run, as the tariffs are guaranteed and cannot be changed retroactively. Nevertheless, in an effort to cut the cost of sustainable energy incentives the government decided to impose a special tax on income from photovoltaic facilities, resulting in a rather paradoxical situation, where a part of the lavish subsidies to promote renewable energy will have to be returned by the recipients. This will undoubtedly lead to litigations between the government and owners of photovoltaic facilities, as the

latter feel deceived, claiming that they were not aware of any such taxes at the time they decided to invest in solar parks. Therefore, the government's attempt to mitigate the impact of renewable energy incentives on consumers by requiring for the producers to be involved in the overall cost might fail. In such a case, the government would have to continue searching for a way out of the vicious circle. With public coffers almost empty, the most obvious solution appears to be an increase in consumer electricity prices.

The situation in the Czech Republic and its implications detailed above provide ample food for thought in terms of the steps to be taken by the government in the area of sustainable energy subsidies:

- First and foremost, subsidies have to be redirected from photovoltaics—which cannot ensure the required increase in the share of renewable energy without enormous cost (neither today, nor, considering the climatic conditions prevailing in the Czech Republic, in future)—to other sustainable energy sources,
- the Czech Republic will soon have to admit that she is unwilling to meet the targets of the European directive on sustainable energy in the envisaged timeframe and continue to increase the share of renewable energy as quickly as required.

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