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Opportunities for Transition to Sustainable Energy Strategy in Slovenia

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Abstract
In this paper, we present new possibilities and potentials for the development and transition of Slovenian energy industry into sustainable energy industry based on higher energy efficiency and renewable energy sources. On the basis of current and planned electricity consumption, renewables potentials are drafted and new sustainable energy investment strategy is proposed and compared with current energy strategy of Slovenia from the economic and environmental viewpoint. The costs for implementation of proposed investments are economically analysed and potential environmental impacts of current and proposed energy strategy are identified.

Keywords
Energy management, energy strategy, sustainable energy, renewables, Slovenia.

Introduction

Pollution, greenhouse gas emissions (GHG), rising energy demand and high energy import dependence present the core of energy problems both in the European Union (the EU) as a whole as well as in Slovenia. The current energy import dependence in the EU is 50% while in Slovenia it is 55% (Government communication office, 2009). This dependence, which causes economic, political and social vulnerability of the EU, must be seen as a challenge and opportunity for sustainable energy policy.

Renewable energy sources (RES) are seen as a long-term solution and a short-term reduction of the above stated problems. The EU is aware of the issues related to conventional energy sources (CES) and supports the development of RES and sustainable energy policy. Sustainable energy policy means an effective provision of energy in order to meet the needs of the future without compromising the ability of future generations to meet their own needs. Sustainable energy comprises two key components; namely, energy efficiency, i.e. efficient energy consumption (EEC) and RES. The investments in efficient energy (EE) and RES are highly important since RES cause little (or no) pollution and enable the use of local resources. In addition, they decrease import dependency and increase the EU competitiveness at the same time. Because 80% of all GHG emissions in the EU and in Slovenia are caused by energy industry (Government communication office, 2009 and EEA, 2007; Institute of Jožef Štefan (IJŠ), 2008), the EU intends to lower CO_2 emissions by 20% while increasing the share of RES up to 20% and enhancing EE by 2020. Directive 2009/28/EC within the climate and energy package is mandatory for Slovenia as well. Slovenia's goal is to have 25% of RES in final energy consumption electricity by 2020. Although 20/20/20 objectives are well set at the EU level, there is a lack of common strategy for their implementation since the implementation strategy remains within the competence of an individual Member State. In Slovenia, the implementation strategy is laid out in the National Energy Programme draft (NEP); however, this document is not consistent with the 20/20/20 objectives because it does not foresee any active increase in the share of RES and EEC with regard to long-term energy industry development.

The purpose of this paper is therefore to evaluate the potentials of renewables and the possibilities for restructuring Slovenian energy industry into a sustainable energy industry consistent with the 20/20/20 objectives and focused on RES, EE and reduced energy consumption. By studying the available information and literature, we examined the current situation and forecasts about energy consumption and analysed the pros and cons of current energy strategy. Based on our analysis, we propose an alternative strategy, based on renewables and consistent with the 20/20/20 objectives. Furthermore, both strategies and all the options and possibilities are compared in order to demonstrate the economic acceptability of RES. The comparisons are grounded on the assumptions that the achievement of the 20/20/20 objectives is the priority of Slovenian energy industry. It has to be pointed out that our paper focuses on electrical energy only. The proposal presented in this paper is based on the installed power and not on the actual electricity production.

1. Review of the current state in Slovenia and available alternatives

Energy consumption has been growing in the last decade by 1-2% annually. In order to reach the 20/20/20 objectives, it is necessary to curb and reduce energy consumption. We anticipate that a medium-term reduction of fossil fuel consumption in transport will result in a higher growth of electricity consumption in comparison with other fuels. Electricity consumption (in Mtoe) and the share of renewables in electricity production (in %) are presented in Figure 1.

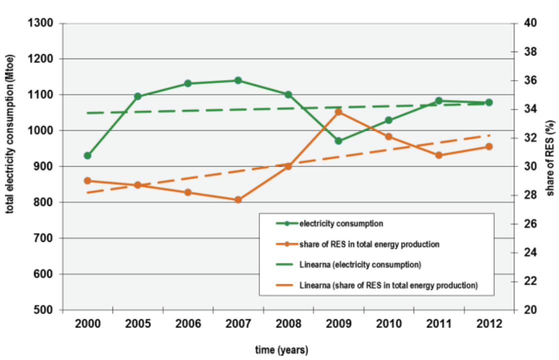

Figure 1 Electricity consumption and share of RES in total energy production in Slovenia
Source: Eurostat, 2014

Figure 1 clearly shows that, on the one hand, energy consumption grew strongly between 2000-2007 and has remained almost the same or has even decreased since 2007, which is mostly due to the current economic situation. On the other hand, the share of RES has been fluctuating. Thus, the changes in energy consumption must be considered in planning long-term energy strategy.

According to the provisional data, energy dependency of Slovenia in 2010 was 50%, which is slightly more than in 2009 but still relatively low in comparison with other EU Member States.

In 2010 the gross production of electricity was 16,433 GWh. Most electricity was produced in thermal power plants (37%), followed by the nuclear power plant (34%) and hydro power plants (29%).

Table 1 Energy data for Slovenia

Year	**2000** (TWh)	**2005** (TWh)	**2008** (TWh)
Total electricity production	13.624	15.117	16.398
Nuclear	4.761	5.884	6.273
Hydro and wind	3.834	3.461	4.018
Thermal (incl. RES)	5.029	5.772	6.107
RES	NA	0.120	0.292
Coal	NA	5.275	5.323
Liquid fuels	NA	0.037	0.017
Natural gas	NA	0.340	0.475

Source: SURS, 2013

The current energy strategy is not designed to address the reduced and more efficient energy consumption, but it rather fills the gap between supply and demand with a new thermoelectric power plant (TPP). That also leads to high emissions, reduction of needs and investments in (for) RES because consequently less capital will be available for new investment in renewables. The new block of the thermoelectric power plant Šoštanj (i.e. TPPŠ 6), which is to be built by 2015, will undoubtedly strengthen the dependence on fossil resources and will have negative effect on the achievement of the 20/20/20 objectives since the lignite-fired TPP is responsible for about 30% of all GHG emissions in Slovenia (IJŠ, 2008). The new lignite-powered block will be more effective and consistent with the IPPC Directive for Integrated Pollution Protection and Control (Council Directive 96/61/EC) and its key principle, i.e. best available techniques (BAT). Although it will cause less emission than the current blocks with its efficiency of 43%, it will nevertheless use a limited fossil fuel as source of energy, which will result in high emissions of GHG. Technology of coal dust firing with supercritical parameters, which will be used in TPPŠ 6 (BAT for lignite TPP), will result in 3.1 million tons of CO_2 emissions annually. The justification for the investment is argued with efficiency that reaches requirements of BAT (condition for European Investment Bank loan) which would be accessible only with at least 600 MW block, the social problems of the region and the already paid-up funds instead of analyzing and forecasting needs and consumption of Slovenia. The investment in TPPŠ 6 (600 MW block) is worth EUR 1.2 billion (Rotnik, 2011) (i.e. 2 million EUR per MW), with additional investment needed for the CO_2 capturing technology, which has not yet been fully developed. That is why we define it as an economic issue. In addition, the projections of emission allowance prices in the next 40 years (i.e. the life expectancy of TPPŠ 6) are merely speculative. The time frames for the existing TPP Šoštanj blocks (TPPŠ 4 and TPPŠ 5) closure are also poorly defined.

The launch of TPPŠ 6 is planned in 2015, i.e. 3 years after the cut-off date set by the Kyoto Protocol and 5 years ahead of the cut-off date for the 20/20/20 objectives. Furthermore, the planned TPPŠ 5 efficiency increase during the TPPŠ 6 construction is also debatable if TPPŠ 5 is to become a cold reserve. The investment in TPPŠ 6 is based on the predicted increase of electricity use in Slovenia, which cannot be seen in statistical data analysis (see Figure 1). It is further supported by the fact the existing TPPŠ blocks are inefficient, and by the desire for energy independence. However, the future of TPPŠ 4 and TPPŠ 5 is rather questionable since they should be gradually closed but are still to remain in cold reserve by 2027. The latter fact is the most problematic as these two blocks will become inefficient and technologically obsolete. A further concern is the adequate supply of lignite for all blocks. The current Slovenian energy strategy prefers security and adequate energy production at the expense of environmental costs. It foresees a complete (unsustainable) use of lignite reserves in Slovenia and it lays too little emphasis on environmental costs. Alongside the TPPs, the construction of new hydroelectric PP, gas-steam PP and nuclear PP as well as small RES PPs is planned. All of these are economically and environmentally more appropriate and sustainable, but are currently of secondary importance for Slovenian energy policy.

Contrary to the current energy strategy, we believe that Slovenian energy strategy must be based on a reduced and EEC as well as on the substitution of CES with RES. Namely, the central idea of sustainability are circular flows and self-regeneration. The EU energy policy defines sustainability as the development of competitive RES and all other low-carbon sources of energy carriers by reducing energy demand within the EU and by directing the collective efforts to halt climate change and to improve local air quality. Following these three criteria, the construction of thermal power plants is inappropriate. In fact, sustainable development must not be perceived as meeting the needs of the present at the expense of future generations. At a time when we are beginning to realize the global environmental constraints, we still base our development on a quantitative increase in the use of raw materials and energy. We have to move away from restrictive assumptions and change our patterns of thinking with regard to the energy sector and to our everyday lives as this is the only way to a sustainable energy policy.

<u>The analysis of a number of indicative prices and opportunities for investment in RES in Slovenia</u> shows, for example, that Elektro Primorska indicates that the estimated price of wind PPs at selected locations in Slovenia ranges between EUR 1-1.37 million per MW, which is, on average, approximately 40% less than the investment in TPPŠ 6. What is more, wind PPs are emission-free during the production of electricity and have low operating and maintenance costs. The investment in hydro-electric PPs varies quite substantially because of the diversity of the environment and the specificity of each project. For example, pump-storage PP Avče cost EUR 1.54 per MW while hydro-electric PP on the Sava River cost EUR 2.63 per MW. When discussing the operations of hydro-electric PPs, the minimum costs of emission-free energy production in a hydro-electric PP have to be taken into account. Because the hydrological potential of Slovenia is rather high, we see the great opportunities in hydro-electric PPs. Hydro-electric PPs can be divided into large, pump-storage and small hydro-electric PPs with current installed power of 85 MW and estimated untapped potential of 180 MW. The price for the installed MW in a small hydro-electric PPs is estimated at EUR 1300-3000

(Žumbar, 2006) and depends on the size of the plant. Such power plants represent a relatively cheap energy source and are becoming more and more economically competitive. Second are biogas plants that provide peak (trapezoid) energy and costs around EUR 3.6 million EUR per MW of installed power (LEV, 2003). Additionally, the production of biological waste/raw materials in Slovenia is sufficient for several tens of MW of installed power in a biogas plant. The investment in solar power plant (solar PP) is similarly high but decreasing rapidly. Electricity generation from RES is also additionally supported by the system of guaranteed purchase price.

2. Proposal of alternative energy strategy

To achieve a long-term sustainable energy production and consumption as well as to reach the Kyoto Protocol targets and the 20/20/20 objectives, we propose the energy strategy as presented in Figure 2.

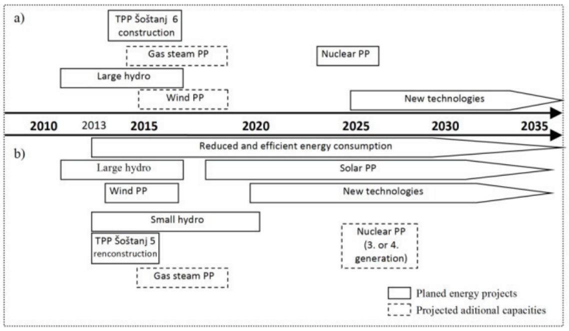

Figure 2 Estimated development of the Slovenian energy sector over time, existing and proposed strategy
Source: Authors

Investments in existing and proposed strategy are presented on the time axis while the priorities are written from the top down. The facilities in dotted-line cells are only an option if the needs arise. The reduction of energy consumption and the increased EEC must present the core of sustainable energy strategies in Slovenia.

Proposal 1: The reconstruction of TPPŠ 5 is a realistic option since electricity shortages can be replaced by Avče PSP and the HEPPs on the Sava River. The closure of TPPŠ 4 is also possible after the energy plants as presented in Figure 2 are built. The TPPŠ 5 emissions would also be reduced after its renovation by approximately 15%, i.e. to the level of TPPŠ 6. Furthermore, we predict the increase of the installed power for around 50 MW as a result of better efficiency. We estimate the investment in renovation or complete replacement of the installation to be more economical than the investment in the construction of a new TPPŠ block since some of the existing components can be used despite the change of technology. For instance, the total investment in the renovation of TPP Kostolac (renovation of two existing 400 MW blocks, the mine and the construction of the new block) is amounted to around EUR 860 million.

Proposal 2: Another possibility is technology change. One possibility is the introduction of a power plant using several fuel types. A good example of such power plant is Danish Avedøre 2, which runs on straw, biomass, coal and natural gas. The total investment into this plant was approximately EUR 905.000 per MW and the efficiency of the plant is 50% when operating at 300 MW (Tomšič, 2010). This kind of technology enables us to use different fuel types at the same time. This is particularly important due to the accessibility of specific local energy sources like wood biomass in Slovenia and because of gradual transition to the emission-free society. Another alternative to a lignite plant is a GS power plant. An 800 MW gas-steam PP that can replace TPPŠ 6 was already planned in Kidričevo, with predicted investment costs at EUR 0.75 million per MW. The main advantages of gas-steam PP are significantly lower emissions than in a lignite-fired thermal power plant, lower investment, a possible coverage of peak energy consumption and a more reliable natural gas supply upon the completion of South Stream and Nabucco pipelines. The essential weaknesses of a gas-steam PP are the dependence on foreign sources of energy and gas price volatility. Although natural gas is a CES, it produces fewer emissions than other CESs. For that reason, we see gas-steam PPs as an appropriate mid-term technology for transition to carbon-free energy industry if the price of gas would be fixed.

Proposal 3: The 3rd and most sustainable proposal is based on transition to renewable energy sources. Elektro Primorska is currently examining the possibilities to build 180 MW of wind PPs on three wind fields in Slovenia. However, such possibilities are limited in Slovenia because appropriate geographic locations for wind PPs are few and even those which are suitable lie within the NATURA 2000 network. Although we can achieve synergy with nature by thoughtful and sustainable positioning of wind PPs, especially in degraded areas near roads, the WPP construction can represent significant intervention in the environment. Therefore, we assume that we can assure 90 MW installed in wind PPs. Based on the above mentioned estimates, the investment into 90 MW wind PPs should amount to around EUR 105 million. We propose the installation of a few pilot wind PPs and the examination of their operations. The results obtained would facilitate the decisions about new investments in wind PPs.

A large water potential of Slovenia, a high efficiency of hydro-electric PPs, a very long life (over 100 years) and non-emission operation together with cheap energy obtained from hydro-electric PPs should make investments in new hydro-electric PPs the priority of the Slovenian energy industry. In Slovenia, pump-storage PPs are of particular importance in the most critical peak energy consumption. New and planned pump-storage PP facilities will produce additional 618 MW or 1300 GWh of electricity which is created in the peak of consumption (pump-storage PP Avče – 178 MW and planned pump-storage PP Kozjak 440 MW – Raner and Žebeljan, 2009). We therefore suggest that new suitable locations for new pump-storage PPs are identified and considered in line with a long-term strategy, since they constitute an appropriate, reliable and clean source of energy at peak. The price of investment in the pump-storage PP Avče was EUR 1.54 million per MW (HSE, 2010), which is app. 25% less than TPPŠ 6. The investment in large hydro-electric PPs on the Sava River will result in additional 482 MW of installed power (Raner and Žebeljan, 2009 and HSE, 2010). The average price of hydro-electric PPs on the Sava River's lower stream is EUR 2.63 million per MW. Additional 118 MW of hydro-electric PPs (Raner & Žebeljan, 2009) power could also be potentially realised on the Soča River.

Even so, the investments in large and small hydro-electric PPs should, in our opinion, be a priority since such hydro-electric PPs can be Slovenia's biggest source of RES and can have a significant impact on mid-term replacement of CES. Small hydro-electric PPs with 85 MW of installed power are also very important. The water potential in Slovenia allows the construction of additional small hydro-electric PPs, which could produce at least 100 MW of electricity. Small hydro-electric PPs also have a positive impact on the decentralization of energy industry; moreover, they have the efficiency over 90% and cause less environmental impact. They can be built in many locations and require relatively small investment. For that reason, small hydro-electric PPs are attractive for private capital. The main hindrances to building small hydro-electric PPs are currently low guaranteed purchase price and the complicated procedures for obtaining the necessary documentation. To popularize small hydro-electric PPs installing a few units on the Ljubljanica River would also be appropriate for its promotion and education of the public as well as for the integration into the city electricity grid. We propose the investment in the total amount of EUR 215 million into 100 MW of power installed in small hydro-electric PPs (average price EUR 2.15 million per MW). Cost reduction is possible mainly with the development or by purchasing cheaper components (i.e. installations). For example, in China and India the components and installations with comparable efficiency cost around EUR 500,000 per installed MW.

Biogas plants present another interesting option as they can produce trapezoidal energy. Energy sources used in biogas plants are biological waste, sludge, animal manure and energy crops. Cases from Austria and Germany, where biogas plants are more common, show us that biogas plants are very positive for the development of countryside and agriculture, too. At the same time, local sources are used and the problems of bio-waste disposal are solved. The technology of cogeneration enables us to achieve high efficiency when we use generated waste heat in industry processes or for household heating. In addition, by-product is also useful as a fertilizer. We estimate that 50 MW of biogas plants can be installed in Slovenia by 2020 and the investment is evaluated at approximately EUR 180 million.

In addition, solar power plants are potentially of interest because they use free energy of the sun, but are not yet highly efficient. Efficiency of available solar modules ranges between 8 and 20%. In our research, electric characteristics of semi-crystal silicon photovoltaic modules of the company Bisol d.o.o. from Slovenia were taken into account, where the average efficiency of cell transformations (at temperatures of 25˚C and 44˚C) is 14%. Average solar radiation per square meter of horizontal surface in Slovenia is higher than 1,000 kWh/m^2. Ten-year average of the measured (1993-2003) annual global radiation is between 1,053 and 1,389 kWh/m^2 (presented on Figure 3). Half of Slovenia receives between 1,153 and 1,261 kWh/m^2. For comparison - in Germany, the radiation is around 1,000kWh/m^2 in subtropical areas it is around 2,000 or 2,500 kWh/m^2 (Lead, 2009).

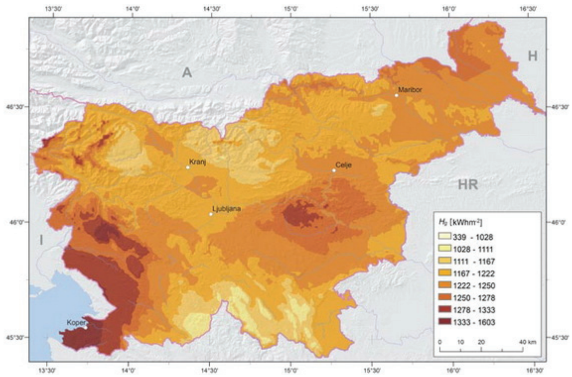

Figure 3 Annual solar radiation on a horizontal surface in Slovenia
Source: Kastelec, Rakovec, & Zakšek, 2007

The construction of solar power plants in Slovenia show extremely rapid growth. In a few years we have come to a level of more than 1.390 plants connected to the grid. Total electricity production at the end of 2011 was more than 90 MWh, but in 2012, we have already produced more than 130 MWh.

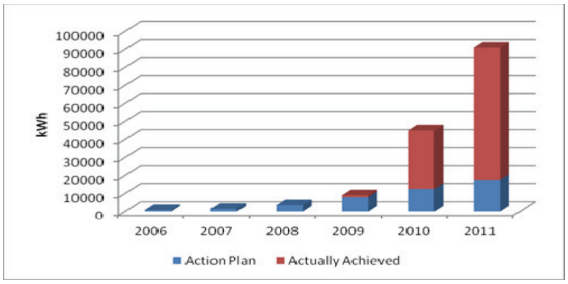

Figure 4 Electricity produced in solar power plants in Slovenia
Source: Nemac, 2012

If we extrapolate this trend to 2020, we can very easily forecast high expansion of solar power plants. Based on trend extrapolation, we propose installation of additional 60 MW of solar power plants by 2015. This investment is estimated on EUR 100 million. More solar power plants must be considered as supplements for CES by 2020, when the technology will become even more efficient.

Finally and in accordance with other presented renewables, the possibilities of thermal energy exploitation in Prekmurje should be explored and examined, too, primarily as a source of heating and possibly as a source for peak electricity generation as well. If the geological research and pilot projects are successful, thermal energy exploitation is sensible.

Conclusion

The electricity produced as the result of proposed transition to a sustainable energy production would have numerous positive effects such as lower environmental costs, less pollution, the achievement of 20/20/20 objectives, the income from the sale of allowances, the use of local resources, sustainable economic and social development, etc. In this paper we have proven that the transition to sustainable energy industry is both feasible and economical.

We have proven that competitive alternatives for investing in more sustainable renewables exist in Slovenia, in the form of appropriate mix of hydro-electric PPs, biogas PP, solar PP and wind PP. From the trapezoidal energy consumption aspect, pump-storage PPs and biogas PP are the most important while small hydro-electric PPs are the most suitable from the social viewpoint. Namely, the latter represent only a minor interference in the environment and facilitate the development of rural areas together with the exploitation of unused water sources. However, large hydro-electric PPs still remain the largest producers of energy from renewables in Slovenia.

If proposed diversified energy systems - the new wind PPs, small hydro-electric PPs, biogas plants and solar PP are built as presented in this paper, Slovenia could gain additional 300 MW of power from renewables in the value of EUR 600 million (i.e. EUR 2 million per MW which is the same investment as in TPPŠ 6). This RES could present the reduction of peak power in the thermal power plant in Slovenia TPPŠ 6. Moreover, if the output of new large hydro-electric PPs, pump-storage PPs and partially gas-steam PPs is added, the new TPPŠ block is unnecessary and inadequate from the environmental, economic and social perspectives.

Therefore we conclude that the development and transition of Slovenian energy industry into a more sustainable one is realistic, cost competitive and sensible. A fundamental change is needed in the mind-sets of the energy policy planners and the public. The energy policy and energy consumption should be founded on the promotion of reduced and EE and not on the increasing consumption that will undoubtedly exceed sustainable development. SM

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