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Prejeto/Received:
December 2011
Popravljeno/Revised:
Maj 2012
Sprejeto/Accepted:
Maj 2012

A STUDY OF KEY FACTORS FOR ENERGY POLICY MODELLING

Študij ključnih dejavnikov za modeliranje razvoja energetske politike

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Abstract

Environmental problems and high fossil fuel import dependency are core energy problems facing the EU, which has therefore committed itself to increasing its share of renewable energy sources (RES) to 20% by 2020. The implementation of planned measures is usually the most challenging issue in such a situation; therefore, energy models addressing this issue were studied. Because their specificity means that their usability is limited, we developed a more general model focused on the implementation of the planned measures for the development of a more sustainable energy policy with a higher share of RES. The key factors for modelling this transition were identified and examined, and a comparative analysis of Slovenian, EU, and global energy statistics and analyzed energy mix were carried out. In addition, RES potentials were evaluated, future energy demand was forecast, and compatibility of RES potentials and future energy demand was tested. Based on the results, two energy modelling approaches were developed.

Keywords: energy, renewable energy sources, energy policy modelling, Slovenia, renewable potentials

Izvleček

Okoljski problemi in visoka uvozna odvisnost od fosilnih goriv so ključni problemi energetike Evropske unije (EU), zato se je EU med drugim zavezala k povečanju deleža energije iz obnovljivih virov (OVE) na 20 % do leta 2020. Pri tem je posebej problematično izvajanje ukrepov za doseganje teh ciljev, zato smo proučili energetske modele, ki vključujejo tudi delež obnovljivih virov. Energetski modeli so zaradi specifičnosti le omejeno uporabni, zato smo razvili splošnejši model, osredotočen tudi na izvajanje ukrepov za doseganje ciljev energetske politike. Za razvoj trajnostne energetike, z višjim deležem OVE, smo identificirali ključne dejavnike za modeliranje prehoda v trajnostno energetiko. Izvedli smo primerjalno analizo energetske statistike Slovenije, EU in sveta, proučili mešanico energetskih virov, ocenili potenciale OVE in prihodnje povpraševanje po energiji v Sloveniji ter ocenili njuno skladnost. Na tej osnovi smo razvili dva pristopa k modeliranju energetike.

Ključne besede: energija, obnovljivi viri energije, modeliranje razvoja energetske politike, Slovenija, potenciali obnovljivih virov energije

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Naše gospodarstvo / Our Economy
Vol. 58, No. 3–4, 2012
pp. 28–37
DOI: 10.7549/ourecon.2012.3-4.03

UDC: 620.97(497.4)
JEL: Q42, Q48

1 Introduction

The 20th century has seen a 20-fold increase in energy consumption (IEA, 2010) and this trend is expected to continue (Combanous & Bonnet, 2008). The International Energy Agency (IEA) noted that, by 2030, the predicted increase in energy demand will simultaneously result in higher energy prices and greenhouse gas (GHG) emissions. Energy-related GHG emissions already account for 80% of all GHG emissions. Therefore, the IEA is drawing attention to the environmental problems caused by fossil fuels and proposing an international agreement to cut GHG emissions. Due to pollution, rising energy demands, and the high import dependency of energy, renewable energy sources (RES) are seen as a long-term solution to these problems. The EU is aware of these problems and supports the development of more sustainable energy comprising two key components: energy efficiency (EE) and RES (Afgan, 2008; Lund, 2010; Obrecht, Denac, Furjan, & Delčnjak, 2011). The use of local RES is of vital importance since RES cause less pollution, enable the use of local resources, lower import dependency, and increase EU competitiveness at the same time.

In 2001, the EU set the first (ambitious) goal of reaching a 12% share of RES by 2010; however, this aim was not reached. The second goal set was included in the energy climate package, known as the 20/20/20 objectives, requiring 20% of RES, 20% lower GHG emissions, and 20 % higher EE in the EU by 2020. The specific RES share target for Slovenia is 25%. Achieving this objective is also encouraged by the renewable energy Directive on the Promotion of the Use of Energy from Renewable Sources (EP, 2009), which requires member states to submit and implement a National Renewable Energy Action Plan (NREAP). Each plan must provide a detailed roadmap of how each member state expects to reach its legally binding target. The EU member states were obliged to define sectoral targets, the technology mix they intend to use, and the measures and reforms they will undertake (NREAP, 2010). The express purpose of these plans is to force the EU member states to commit fully to the 20/20/20 goals.

The energy industry and energy policy development have also affected the energy model development. The development of energy models flourished during the first oil crisis in 1973 (Lund, 2010). After studying more than 200 models for energy sector development and policy, models were divided into groups according to their similarities. Jebaraja and Iniyan (2006) proposed classification into six groups: energy planning models, energy supply-demand models, forecasting models, optimization models, emission reduction models, and neural networks models. Despite the relevance of sustainable development issues, the literature review did not identify many models with sustainable characteristics or any separate group of sustainable energy development models. Undoubtedly, new energy models must be developed in order to encourage sustainable energy policy development (Afgan, 2008). Furthermore, no model has been found to specifically address the problem of the implementation of planned energy policies.

The implementation of the planned measures is crucial; therefore, existing models are first identified in this paper. The core factors in energy policy planning are determined and examined based on a comparative analysis of the models studied and then integrated into two newly developed energy policy models. Our thesis is that the consideration of the analyzed factors and the development of future energy policy with an appropriate modelling approach will result in more efficient and sustainable future energy development.

2 Methodology

The key factors in energy policy development are identified and examined in order to determine the possibilities for energy policy modelling. The data for the study of the factors and for modelling were gathered from various independent sources, including specialized databases, statistical offices, national, international and private studies and analysis, scientific papers, and national energy balances. Data on energy consumption, national energy mix, RES share, RES potentials (total, technical and economic), and all other statistical data were analyzed, compared, complemented, and upgraded with data from specialized databases. The upgrading of the data with specialized databases and our own calculations (described below) was crucial for the comprehensive study of energy modelling factors and for developing new approaches to energy modelling.

First, the energy balance and the consumption structure of energy sources in Slovenia, the EU, and the world between 2000 and 2010 are analyzed and compared. Energy production and the share and growth of RES in Slovenia are compared with the average global and EU values (situation analysis). Our aim is to identify and combine the data, since individual data from different sources cannot be compared as they were obtained using varying methodologies. Using the combined data, similarities and differences in energy statistics among Slovenia, the EU, and the rest of the world are examined and compared. Second, Slovenia's energy mix is analyzed, placing special emphasis on an examination of the changes that occurred between 2005 and 2010. Third, Slovenian RES potentials were examined and evaluated. A large number of existing studies, evaluations and documents are examined and critically evaluated. Where the deviations in RES potential between individual studies are significant, the data are additionally upgraded and compared with our own calculations of RES potentials (i.e., the natural and physical characteristics of Slovenia, theoretical energy conversions). The estimation of solar potential is calculated based on the average annual solar radiation and total surface of Slovenia since wood biomass potential is calculated according to the annual increase of natural forests and annual forest cut-down rates and supported with the average heat of wood combustion. The survey and analysis of Slovenian RES potentials is carried out on the basis of currently established economical, technological and environmental acceptability.

Various forecasts of future energy use are then analyzed and the main findings synthesized into the modified forecast on the Slovenian energy future. This provides the basis for the compliance testing of RES potentials and the forecast of future energy demand. Using the factors mentioned for energy policy development, two different modelling approaches are developed and discussed. Although the same factors are employed in both models, the importance they are ascribed differs (with the goal of encouraging the implementation of planned energy policy measures).

3 Analysis of Key Factors for Energy Policy Modelling

3.1 Key Factors for Developing an Energy Policy

Researchers have proposed various factors for modelling energy development (Afgan, 2008; Jebaraj & Iniyan, 2006; Lund, 2010). Based on the analysis of energy models in Jebaraj and Iniyan's (2006) review of energy models, the World Energy model developed by IEA (2011), and an analysis of sustainable energy models developed by Afgan (2008), Foidart, Oliver-Solá, Gasol, Gabarrell, and Rieradevall (2010), Lund (2010), Kaya and Yokobory (1997), and Kyung-Jin (2000), the most frequently applied factors relevant for energy modelling were identified. Five were identified as core factors based on their effect on energy policy development. The identified factors and the additional reasons for selecting them are:

- National, EU, and world energy statistics (current energy use and RES share, future trend of energy demand and future RES share) as an indicator of the current state of the energy sector, which is important for the evaluation of the situation and trends in the global energy market;
- Energy mix (national) as an indicator of the current state of the energy sector, which is important for situation analysis and development of the national energy industry;
- RES potentials (national) as an indicator of available opportunities, which is important for the evaluation of the possibilities for the transition to more sustainable and domestic energy sources;
- Future energy demand (national, EU, and the world) as an upgraded combination of different forecasts of the future state of the energy sector, which is important for planning measures to direct future energy production and use; and
- Compatibility of RES potentials with future energy demand (national) as an indicator of the feasibility of possible transition to renewable energy.

It is important to consider that different key energy factors result in different energy modelling; therefore, our energy models are based on these identified factors only.

Comparative analysis of energy statistics in Slovenia, EU, and the world. In order to achieve the development of sustainable energy policy all over the world, an international agreement similar to the 20/20/20 objectives is necessary. The analysis of energy statistics is vital for the preparation of an international energy-climate agreement as well as for the effective modelling of national energy policy development.

Gross inland consumption of primary energy in Slovenia compared to the EU and the world from 2000 to 2009 is presented in Table 1, which shows that the EU RES share and the production of energy from RES increased more rapidly than in Slovenia. The pattern of RES share growth, based on the data from Table 1, illustrates that EU-27 is reaching its target of RES share much faster than Slovenia alone.

The share of RES in Slovenian gross primary consumption remained more or less constant from 2000 to 2009, with wood and hydroelectric energy accounting for the largest share. Minor changes in the RES share between 2000 and 2009 can largely be attributed to hydrological conditions in Slovenia. The RES share and energy production from RES have been growing steadily since 2007, while RES share in the EU-15, the EU-25, and the EU-27 has grown continuously since 2002.

The peak of gross primary consumption was reached in Slovenia in 2008, while the EU-15 and EU-25 hit peak consumption in 2005, the EU-27 in 2006, and the world in 2007 (Eurostat, 2011; IEA, 2010; SURS, 2011). A significant decline in energy production can be observed in all the analyzed objects in 2009, which reflects the cooling of the economy, especially in the most highly developed EU countries, and can be seen as a forecast of economic trends in the near future.

Because of the increased energy production and consumption in 2008 (the year of peak energy production), Slovenian energy intensity (the ratio between the energy consumption and the gross domestic product [GDP] for a given calendar year) also slightly increased in 2008. In 2009, it returned to the 2007 level (SURS, 2011). Meanwhile, EU energy intensity has been declining continually since 2003 (Eurostat, 2011) and is therefore independent of the EU's peak energy production and use. Thus, energy use in Slovenia in 2008 increased more rapidly than the GDP, contrary to EU trends.

The comparison of Slovenian and world energy statistics based on the data from Table 1 indicates some similarities as well, such as peak energy consumption and the RES share in world primary energy consumption. These pattern similarities are sometimes even stronger and more obvious than the similarities between Slovenia and the EU. However, world energy production from RES is growing although the RES share remains more or less constant, which could be explained by the fact that total global energy production and use are growing at almost the same level as global energy production from RES.

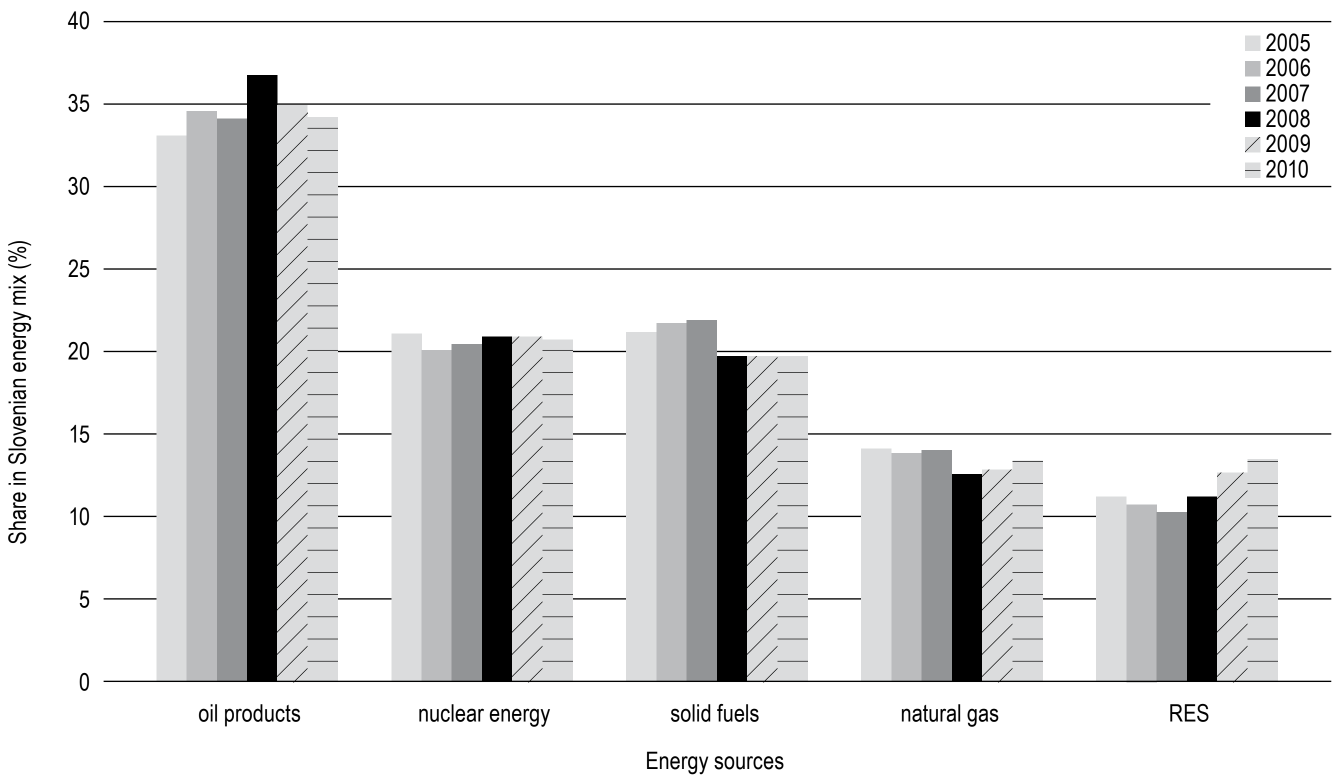
Energy mix of Slovenia. Energy mix represents the combination of energy sources for the production of energy in different geographical areas. The energy mix of a particular country, region, or organization can significantly impact future energy policy development. Energy policymakers must be aware of the current state of energy mix and the possibilities available; therefore, analysis and examination of energy mix are essential for efficient energy planning and evaluating the environmental impact of national energy production. Analysis of energy mix also enables the visualization of the trends in energy development in the "business as usual" scenario.

Table 1. *Total Primary Energy Supply (TPES), Energy Supply from RES, and RES share in TPES (2000-2009)*

Region/year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Slovenia[a, b]										
TPES (ktoe)	6360	6749	6820	6931	7129	7307	7318	7336	7749	6990
RES (ktoe)	761	776	716	714	822	774	768	735	845	874
RES share (%)	12.0	11.5	10.5	10.3	11.5	10.6	10.5	10.0	10.9	12.5
EU-15[c]										
TPES (Mtoe)	1454	1469	1502	1497	1530	1552	1552	1544	1527	n.a.
RES (Mtoe)	85	88	85	92	99	103	110	124	130	n.a.
RES share (%)	5.8	6.0	5.7	6.2	6.5	6.6	7.1	8.0	8.5	n.a.
EU-25[c]										
TPES (Mtoe)	1655	1668	1706	1702	1743	1766	1766	1764	1747	n.a.
RES (Mtoe)	90	93	97	95	103	111	115	123	137	n.a.
RES share (%)	5.4	5.6	5.7	5.6	5.9	6.3	6.5	7.0	7.9	n.a.
EU-27[c]										
TPES (Mtoe)	1724	1763	1759	1803	1825	1825	1826	1808	1799	1681
RES (Mtoe)	98	101	100	108	116	121	129	143	151	151
RES share (%)	5.7	5.8	5.7	6.0	6.4	6.6	7.1	7.9	8.4	9.0
World[d, e]										
TPES (Gtoe)	10,02	10,17	10,23	10,58	11,04	11,44	11,60	12,06	12,00	n.a.
RES (Gtoe)	1.29	1.29	1.31	1.33	1.37	1.41	1.44	1.50	1.47	n.a.
RES share (%)	12.9	12.7	12.8	12.6	12.4	12.3	12.4	12.4	12.3	n.a.

TPES – total primary energy supply
RES – renewable energy sources
Sources: [a] = Obrecht et al. (2011), [b] = Trpin (2010), [c] = Eurostat (2011), [d] = Combanous and Bonnet (2008), [e] = IEA (2010).

Figure 1: *Changes of Slovenian energy mix between 2005 and 2010 (SURS 2011)*



The Slovenian energy mix and the changes it underwent between 2005 and 2010 are presented in Figure 1. The situation and changes in the share of particular energy sources in the Slovenian energy mix also show the influence of the economic crisis, particularly the lower use of solid fuels and natural gas in 2008 and 2009. This could partially be a consequence of the substitution of conventional energy sources (CES) for RES. Because energy demand exceeds Slovenian production capacity, Slovenia imports approximately 50% of its energy (EU-25 average is 51%) (Eurostat, 2011). Data show that Slovenia and the EU are highly dependent on oil, leading to economical, political, and social vulnerability, which must be seen as an opportunity for the sustainable energy industry.

The constant increase in the RES share in the last four years can also be seen in Figure 1. This should be seen as encouraging for future development as it indicates a positive trend in the implementation of the 20/20/20 objectives, despite significant previous fluctuations in RES share. However, the biggest fluctuations can be seen in the use of oil products, the share of which increased in 2008 despite the economic crisis, mostly as a result of transport sector growth and increased transit through Slovenia. The impact of the economic crisis on the use of oil products was strongly reflected in 2009 in particular. However, the consumption of oil products in the transport sector in 2009 and 2010 remained at the same level as in 2008, which means that oil product consumption was reduced mainly in the industrial sector. The lower petroleum product prices than in neighbouring countries supports this conclusion as well.

The share of nuclear energy is more or less constant, mainly because of technological limitations (base load energy). The energy mix analysis indicates that, if we cannot place our expectations on the intensification of nuclear energy, Slovenia will have to limit its attention to sustainable energy technologies that could be introduced on a significant scale in the near future.

RES potentials in Slovenia. RES are the key factor in sustainable energy; we therefore examined and analyzed detailed data on RES potential in Slovenia (see Table 2). The presented data are not fully comparable, as they are combined from a variety of sources and studies of RES potentials in Slovenia that were or at least should have been considered in preparing national energy policy and compared with our own calculations. Differences also occur because forecasting RES potentials is not totally reliable. Indicative prices for RES energy plants are subject to investment in electricity (cogeneration) power plants only.

The diverse results in Table 2 are a result of the use of multiple studies and evaluations incorporated into the National Energy Programme Draft (NEP) as well as additional RES potential studies and our own RES potential evaluations. By presenting of a wide range of estimated RES potential, we wanted to show the complexity of renewable energy potential assessment.

Because of the wide range of estimated RES potential, it is very difficult to assess how efficient Slovenia will be in reaching its energy policy objectives. However, minimal technical potential and minimal economical potential by 2020 will both enable a 25% share of RES in final energy consumption in Slovenia by 2020.

A number of factors suggest that hydro electric power plants (HEPPs) should be the focus of the Slovenian energy industry: Slovenia's high hydro energy potential, the high efficiency of HEPPs, their long life expectancy (more than 100 years), their non-emission operation, and their cheap energy production. HEPPs can also significantly impact the mid-term replacement of CES. Slovenia's hydro energy potential allows for the construction of small HEPPs with an additional 100 MW installed power (HSE, 2010; Raner & Žebeljan, 2009). Small HEPPs also have a positive impact on the decentralization of the energy industry. The technical and economic potential of large HEPPs is much greater than the potential of their smaller counterparts; however, large

Table 2. *RES Potentials in Slovenia at the End of 2010*

RES	Total potential (TWh/a)	Technical potential (TWh/a)	Economical potential by 2020 (GWh/a)	NREAP 2020 goal[c] (GWh/a)	Investment costs[d] (million EUR/MW)	Installed, (MW)
Hydro	19.4[a]	9.1[a]	6370[b]	923		
large HEPP		8.6[a] -8.0[a]	6070[b]	837	1.5-2.6	953[g]
small HEPP		0.5[h]-1.1[h]	300[b]	86	1.3-3.0	118[g]
Solar	25835.4[h]	8.6[a]-2777.8[a]	139[a]-1300[a]	343	3.0-5.0	17[g]
Wind	15.6[a]	3.1[a]	226[a]-1000[a]	191	1.0-1.4	0[g]
Wood biomass	19.6[a]	2.9[a]-10.1[a]	300[a]-4305[h]	1249	2.0-4.5	115[g]
Biogas	47.3[a]	2.8[a]-4.3[a]	265[a]-927[f]	255	3.6	21[g]
Geothermal	>5.4[a]	0.6[a]	44.4[a] – 150[a]	38	4.6	0[g]

Sources: [a] = IJŠ (2010), [b] = HSE (2010), [c] = NREAP (2010), [d] = Obrecht and Denac (2011), [e] = Trpin (2010), [f] = KGZ (2010), [g] = Jarse (2011b), [h] = author's calculations.

HEPPs have a considerable impact on the environment whereas small HEPPs cause less environmental strain, can be built in a variety of locations, require relatively low total investment, attract private capital, and present social and economic benefits for rural areas.

The total solar energy potential is approximately 25.84 PWh/year. As shown in Table 2, technical potential is estimated to be approximately 8.6 to 2777.8 TWh/year (IJŠ, 2010). If Slovenia wants to achieve the maximum technical potential value, which is 10.8% of the total potential, then all appropriate surfaces in Slovenia should be covered. This is an unrealistic value despite the 57% growth of photovoltaic witnessed in 2010 (Jarse, 2011a; Jarse, 2011b). However, reference costs decreased by 20% in 2011, and a 30% decrease is expected in 2012 (Government of Republic of Slovenia, 2009); therefore, moderate growth can be expected in the future.

Wind energy potential in Slovenia is currently totally unexploited (Trpin, 2010) despite the fact that wind is one of the cleanest and fastest-growing RES in the world. The use of wind power plants (WPP) is limited due to the lack of appropriate geographic locations as well as the fact that almost 36% of Slovenia is included in the NATURA 2000 network. However, synergy with nature can be achieved by thoughtful and sustainable positioning of WPPs, especially in degraded areas near highways. We propose the installation of a few pilot WPPs and an analysis of their operation. The results obtained would facilitate decisions on new WPPs and address the criticisms of non-governmental organizations that oppose WPPs in Slovenia. Given the tendency towards WPP in the EU, Slovenia plans to compile a list of environmentally undisputed areas with sufficient wind to attract potential investors and enable faster development of WPPs.

The maximal technical potential of wood biomass estimated in the NEP seems excessively high. Technical potential is indeed estimated from 2.9 to 10.1 TWh/year (IJŠ, 2010); however, the estimated 2.9 TWh/year covers only wood biomass exploited in minor energy plants and households, while the maximum estimation also covers the wood biomass that can be exploited in major energy plants and as co-incineration in thermal power plants. The differences in wood biomass potential estimations are still significant and differ widely from our calculations. The annual increase in natural forests in Slovenia is 8 million m^3 and the average energy potential calculated from the average heat of combustion of 11 different types of domestic Slovenian wood is 2440 GWh per million m^3 of wood (IJŠ, 2010; KGZ, 2010). In order to achieve maximal technical potential, Slovenia should exploit approximately one half of that annual forest increase, which is almost impossible because of the wood processing industry and because the current annual cut down stands at approximately only 3 million m^3 of wood (KGZ, 2010). This figure has been overestimated, and such an ambitious goal for wood biomass will have to be well supported.

Slovenia's relatively high biogas potential also seems to have been overestimated. In similar studies, which were not included in the preparation of the NREAP and NEP (such as the study of BigEast), the estimated technical and total potential are both lower. However, the NREAP goal is not particularly ambitious. The KGZ (2010) study estimates biogas potential in 2020 at 927 GWh/year—almost 4 times higher than the NREAP goal for 2020.

Slovenia currently exports a large amount of organic waste to Austria (ARSO, 2011). Instead of exporting it, Slovenia should investigate ways in which organic waste can be exploited to a larger degree domestically. Stronger emphasis must be placed on the cogeneration of heat and electricity and the greater use of landfill gas. The use of heat from biogas plants is especially challenging because they are primarily situated in areas where few heat consumers live. Slovenia should also support proven effective private–public partnership that would be suitable for rural development and job creation in rural areas. Despite the planned measures, the main problem concerning biogas exploitation is whether to exploit rural areas for food or energy crops.

The estimated geothermal energy potential of Slovenia differs significantly because geothermal energy potential data are collected every five years. The last available data are from 2005. Nevertheless, the annual potential is at least 5443 GWh (IJŠ, 2010).

Future energy demand. The IEA (2010) reference scenario forecasts an approximately 52% rise in world energy demand from 2005 to 2030, while the World Energy Council forecasts a doubling of energy demand by 2050. Fossil fuels will remain the dominant energy source in the EU, covering approximately 75% of all energy needs until 2035 (Böhme, 2009; Combanous & Bonnet, 2008). Energy demand forecasts can vary widely and are particularly dependent on the economic situation, international agreements, transnational directions, and future technological development. Without limitations on emissions, RES and EE energy use would most likely increase much more rapidly.

Forecast energy demand in Slovenia is presented in Table 3. The NREAP predicts a moderate growth in energy use by 2015 and a slowdown by 2020. The calculation of future energy use in Slovenia for 2016 is based on the objections and methodology of the Directive on Energy End-Use Efficiency and Energy Services (EP, 2006). The NREAP forecast shows that the 20/20/20 objectives are achievable. Future energy end use in 2020, which is particularly dependent on transport sector development due to its rapid growth in Slovenia, is presented in the last column of Table 3. Future energy consumption in 2020 is not precisely defined; RES share is expected to increase by 25% or more. Electricity use is less problematic, as it has been decreasing constantly since 2006 (SURS, 2011). However, it is realistic to expect smaller growth in energy consumption by 2015 as a result of economic recovery.

Table 3. *Final Energy Consumption (FEC) in Slovenia*

Category	**2007**[d]	**2008**[d]	**2009**[d]	**2010** forecast[a]	**2010**[c]	**2012** forecast (Kyoto)[a]	**2016** objective (- 9%)	**2020**[a] objective (20/20/20)
FEC in Slovenia (ktoe)	4867	5232	4891	4927	5013	5031	4267[b] / 5214[a]	5232
RES in FEC in Slovenia (ktoe)	745	780	787	872	858	941	1137[a]	1324/ 25 % of FEC

FEC – final energy consumption

Sources: [a] = NREAP (2010), [b] = objective of directive on energy end-use efficiency and energy, [c] = author's calculations from partial data, [d] = SURS (2011)

In order to achieve efficient managing of future energy use, it is vital to bring about lifestyle changes as well as educate and inform the public about the measures and contributions that the individual can undertake.

Compatibility of RES potentials with future energy demand. The compatibility of RES potentials with future energy demand must be carefully examined because it is essential for future energy policy planning. The transition to sustainable energy can only be achieved through realistic planning and the implementation of efficient measures. According to current energy use analysis, future energy demand forecasts, and the evaluation of RES potentials in Slovenia, it is not certain that Slovenia has adequate technical potential for a complete transition to RES. The conclusions are:

- Slovenia's minimal technological RES potential can cover at least 50% of its energy demand;
- Slovenia's average technological RES potential can cover its entire energy demand; and
- Because of the differences in energy mixes and possibilities in various energy sectors (heating and cooling, electricity production, and transport), RES potential is compatible with heating and cooling and electricity production but is especially problematic in the transport sector (due to the problems in Slovenia's transport sector, as previously described).

3.2 Modelling Future Energy Policy Development

A number of facts must be taken into account when modelling future energy development. As an EU member state, Slovenia was obliged to submit a NREAP in regard to meeting the 20/20/20 objectives. The NEP, another strategic document, currently in preparation, should set clear directions for future energy development. The issue of disregarding Kyoto is also crucial. The planned closure of inefficient blocks of thermal power plants could be carried out by 2012 instead of 2014. As energy use declined in 2009 (Eurostat, 2011; SURS, 2011), this is a realistic option (Obrecht & Denac, 2010). With this measure, Slovenia would significantly reduce the possible penalty for failing to achieve Kyoto targets and strengthen the foundations for the next international agreement that will succeed Kyoto. However, implementation of the planned measures remains the most challenging issue in the Slovenian energy sector.

For more efficient energy development, two simplified energy policy models were proposed. These two models represent useful tools for greater RES exploitation, more accurate and predictable future energy policy measures, and the meeting of international agreements and objectives more efficiently. Model 1 is presented in Figure 2. Modelling based on model 1 begins with an analysis of energy statistics and energy mix. This step involves gathering data on the present situation while simultaneously evaluating RES potentials and forecasting future energy demand. Within this step, opportunities for more sustainable energy production and use are identified and the future situation in the energy sector is analyzed. In the third step, the compatibility of future energy demand with estimated RES potentials must be tested and the feasibility of the transition to sustainable energy, based on sustainable domestic RES, estimated. Based on all these factors and in accordance with international agreements, a new energy policy for a transition to more sustainable energy can be designed.

The second proposed energy model—model 2 (see Figure 3)—is similar but contains a very different final goal. Model 2 also starts with energy statistics and energy mix analysis (situation analysis). At the same time, RES potentials are evaluated to determine the most appropriate options for future energy production and use from the sustainability point of view. Based on these three factors and on the forecast future energy demand (in the "business as usual" scenario) and international agreements, a new energy policy can be shaped, with which future energy demand and supply can be designed and directed. In this model, the compatibility of future energy demand with new energy policy can also be tested.

As such, model 2 shapes the direction of future energy demand and energy supply in order to achieve the legally binding objectives and the transition to more sustainable energy.

Figure 2: *Energy policy model 1*

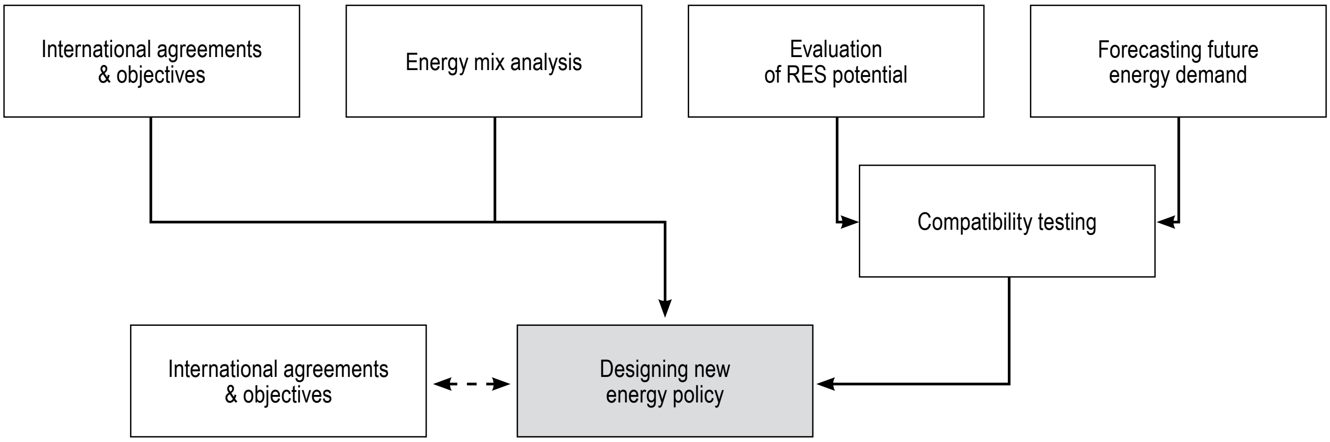
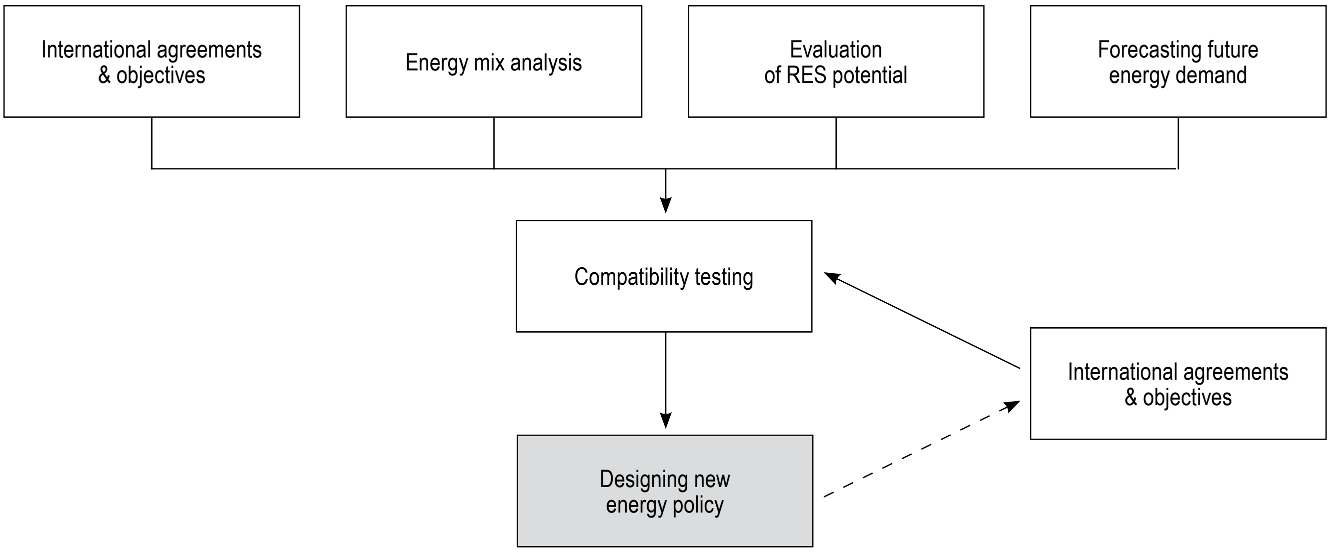


Figure 3: *Energy policy model 2*



The core difference between the two proposed models lies in their goals. The goal in model 1 is a new energy policy directed towards sustainable energy. Although this is an appropriate aim, its implementation is questionable. Thus, model 1 should be seen as suitable for countries or organizations with a strong commitment to energy policy goals. It is also more accurate because it tests the compatibility of RES potentials with future energy demand. However, as the review of best practices demonstrated, a strong commitment to energy policy goals is very rare; therefore, model 2 is preferable as it forces energy policymakers into action, thinking in the long-term and implementing measures for the transition to a more sustainable energy sector. Model 2 is especially appropriate for countries or organizations that have displayed a weaker environmental commitment to past goals in the energy sector. Space and time limitations mean that the detailed testing of the developed models will be addressed in future research.

4 Conclusions

This paper examined important factors for energy policy modelling, including energy statistics, energy mix, RES potentials, future energy demand, and the compatibility of future energy demand with RES potentials. The main findings are as follows:

– in some cases, Slovenian energy statistics are more similar to the global situation than that in the EU;

– the largest changes in energy mix are a consequence of the economic crisis and changes in energy policy;

– RES potentials differ significantly and render future energy planning partially inaccurate;

– the wide range of estimated RES potential makes it difficult to assess how efficient Slovenia will be in reaching its energy policy objectives;

– energy demand is expected to rise by 2015 and then slightly decrease by 2020; and

– the compatibility of RES potential and future energy demand is going to be particularly problematic in the transport sector.

Two models for energy development were constructed. Model 1 is more accurate but is appropriate only for countries with a strong commitment to international agreements. Model 2 is particularly suitable for countries with a poor commitment to international agreements because it encourages energy policymakers to take action. Increased EE and a gradual change in consumer habits should also be fully included in energy policy planning to ensure the best long-term opportunity for decreased and efficient energy use and to ensure sustainable energetics.

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