Energy development plan of the island of Brač

Final results
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SUMMARY

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1. INTRODUCTION

According to the modern perception, local planning is one of the key prerequisites of well-balanced, quality and sustainable development, both in energy sectors and other sectors. Adequate energy planning at a local level sets up a firm basis for decentralization and security of supply, helps in achieving competitiveness, rational use of energy resources and environmental protection.

Islands and coastal areas are specific natural resource in every country, so they require special attention and care even in the processes of defining future energy system development. Energy issues are of particular importance for islands because they are faced with growing economy and energy needs, inadequate energy supply and other related problems. The island of Brač is the case where wide variety of supply from old and new conventional and renewable energy sources, energy efficiency measures and DSM need to be balanced and optimized urgently.

Local communities and regional authorities on the island of Brač have recognised the importance of their inclusion in the energy planning process because this is the only way to make adequate decisions and develop sustainable energy systems, primarily in the best interest of the island’s inhabitants. They also recognised the importance of cooperation with planners, energy market actors and other actors.

In order to achieve the long-term energy sustainability, regional authority and local communities on the island of Brač need to be supported in their efforts by institutional framework of relevant organizations, educated and aware of social, economic and environmental impact of different energy sources.

The objective of this brochure is to present sophisticated approach and method for integrated energy planning which is developed for local-based energy system, particularly for islands. The result of this model, applied and tested on the island of Brač, is a Sustainable Energy Plan. Parallel to this plan, institutional framework for the implementation and realization of the activities described in the plan, is created. Such an approach helps local communities on the island of Brač to meet their own commitments and commitments set by the EU, national and regional energy and related policies.
2. ISLAND OF BRAČ

The island of Brač is one of the 50 permanently inhabited islands of the Croatian Adriatic. It belongs to Middle Dalmatian group of islands, and the town of Supetar and island’s seven municipalities (Sol, Milna, Nerežišća, Postira, Pučišća, Selca, Sutivan) make a part of Split - Dalmatia County. Apart from Middle Dalmatian group of islands this County includes local communities in coastal and inland areas, which makes it very heterogeneous in terms of demography, geography and economic development.

The population of the island of Brač, according to the 2001 Census, is 14,034; the most developed economic activity is tourism and manufacturing (stone and stone products), followed by trade, other services and agriculture. Reconstruction and opening of new small industrial and handicraft facilities in the recent years caused the stop of the population emigration.

Brač belongs to the Mediterranean climate area characterised by mild and rainy winters, dry and warm summers with an average of 134 sunny days per year and great differences in temperature between the places along the sea and those above 500 meters. In winter the north parts are exposed to the cold blows of the "bura" wind from the mainland, especially from Viuja below the Biokovo Mountain. Average sea temperature during the summer is approximately 22°C.

As usually in case of islands, energy supply on island of Brač is currently inadequate and unsustainable, and has not the capacity to meet long-term planned and growing needs. In addition to higher demand, energy system of the island is permanently faced with high seasonal load oscillations, caused by great differences in number of dwellers on the island between the summer and winter period.

The island of Brač, as well as other Croatian islands, is connected to the national power system. According to the final consumption balance from 2007, electricity is the most used energy source with a share of 46 percent, followed by fuel oil (30.5 percent), fuel wood (18 percent), and liquefied petrol gas (9 percent). Currently, the use of renewable energy sources and energy efficiency measures is negligible.

The island of Brač has been selected for the proposed project because of a number of conditions which have been met on the island lately. Intensive gasification program which is underway in the coastal area of Croatia opens the possibility to develop LPG gas distribution system on the island of Brač. Given the fact that the consumers are mainly oriented to the use of electricity from the national power system, the gasification project brings in new moments and certainly creates the need for new energy development plans.

Additionally, on the basis of terms of the national and regional energy development strategy, which provides a support to use of renewable energy sources and energy efficiency measures, it is necessary to overview such possibilities and potentials because of the expressed interest of the local population for this type of energy supply.

Figure 2.1 Town of Supetar and seven local communities on the island of Brač

Figure 2.2 Stone production in Pučišća and the most popular beach in Bol at the Adriatic sea
3. METHODOLOGICAL CONCEPT FOR THE CREATION OF THE ISLAND’S ENERGY PLAN

The Sustainable Energy Plan is to be based on various aspects of energy supply in order to study all the aspects of sustainable energy development. Island areas are particular areas which represent closed systems and can be observed separately from the influence of other areas. In order to examine all the possibilities on an island, it is necessary to develop an integrated approach for creating an energy plan that will examine and compare all the possible scenarios of the future energy system on islands. The methodological concept in particular assesses the economic, ecological and energy components of an individual scenario and also has a built in Demand Side Management (DMS) procedure and Least Cost Planning (LCP) approach. Integrated approach is composed of several key components.

- Gas network development plan

Based on the assessment of the existing and future thermal energy markets from the previous task, a theoretical potential of gas consumption (LPG or natural gas) is calculated for each town on the island. The next step is drafting the project of a network development and assessing the financial investment in the gas system in each town using special programmes. By defining the working parameters, drafting the gas network project and assessing the financial investments in the gas system is carried out using DIN norms, DGWG and SR-GAS guidelines. Using a computer simulation of the gas system performance (based on the Hardy-Cross method), the working pressure in the gas network is determined and the dimensioning of the complete network is carried out. This calculation is used to define the dimensioning of the gas network and optimization of the entire system in terms of cost and safety. The budgets and overview of the achieved results are conducted using a geographical information system (GIS). Based on the forecast of gas consumption and the required investments in the development of the gas system for the entire island, an economic optimization of the gas system development for the island is carried out. The basic criterion of the economic optimization of the natural gas network is economical feasibility of the system, meaning that the system will be built only for those consumers whose hook-up to the system is cost effective.
- Small district heating development plan

Similarly as for the gas network, local district heating network using biomass as a source is analysed. The analysis examines the available biomass production on the island and its cost as well as the possibilities for transport from the mainland.

- Power network development plan

The goal is to define the optimal power network development plan while taking other energy sources, especially gas, into consideration. To achieve this, the present status of the power network on the island is analysed resulting with a database suitable for further power network analyses. This database together with the data on power consumption for different scenarios of other energy sources available on the island is the input data for power network development analyses, based on the set of criteria regarding power flow limitations, voltage quality, continuity of supply and economic evaluation. Basic tools for power network planning are internationally recognised PSS/E and PRAO software packages.

- Evaluation of renewable energy sources potential

The model of renewable energy sources will include a separate model for each source, described with its energy-economy-ecology characteristics. Based on user (input) constraints (i.e., constraint on CO₂ emission), the results of such an analysis shows the potential of each renewable source, including its economic evaluation as well as possible subsidy needs.

- Evaluation of energy efficiency measure potentials

The model of energy efficiency measures, an optimisation model, enables the representation of each measure with complete energy-economy-ecology characteristics, by sector within the energy system. The results of such an analysis can show the potential of each measure in terms of energy consumption and also in terms of economic conditions (subsidies and taxes).

- Evaluation of other energy sources potentials

In addition to renewable energy sources, the model of the local energy system describes all other energy forms (fuel wood, fuel oil etc.), from the final energy side (supply side) to the demand side, that can be modelled in the form of final or useful energy consumption (for heating, hot water, cooling, cooking and non-thermal electricity consumption). Input data for such an analysis is based on the survey results for each specific consumption sector, together with other input data (energy demand projection, fuel prices projection, technical characteristics of each technology, etc). Based on the predicted energy consumption for a specific energy form (e.g., natural gas) such a model can provide answers to questions about energy consumption for all other energy forms in the system.

- Environmental analysis

The environmental analysis examines the integrated energy-economy-ecology influence of a specific energy system. Ecological analysis can be performed, either as a complete GHG analysis or as a specific analysis only (e.g., CO₂ emission calculation). In addition, this model enables specific user constraints (limits) to be set for emission values and this option ensures analysis of several scenarios based on different emission schemes. The model of emission tax is also possible with the MARKAL model.

- Sustainable energy plan

Energy supply options are usually described with expected scenarios in the future which provide framework for exploring different energy perspectives, including various combinations of technology options and their implications. More scenarios can better illustrate how energy system developments would affect the area of an island and design future energy plan compatible with sustainable development goals, such as improved energy efficiencies and the adoption of advanced energy supply technologies. Scenario development is also characterised by analysis of environmental impacts and equitable allocation of resources and wealth.
4. PRESENT ENERGY DEMAND AND FORECAST OF FUTURE USEFUL ENERGY NEEDS

On the basis of the previous energy consumption analysis and survey results in Split - Dalmatia County and on islands separately which was conducted as a part of several energy development projects, energy balance for the 2008 is constructed as well as the forecast of the future needs. All the analyses are performed for each consumption sector according to the final energy consumption and purpose of the consumption (thermal energy, non-thermal energy and cooling).

4.1. Present energy demand

Total final energy consumption for the households, services and industry in 2008 amounts to 335 Tj. Electricity has the biggest share in the total consumption with about 56,7 GWh or 57 %. Fuel wood consumption has a share of about 23 %, fuel oil 15 % and LPG 5 %. As regards consumption sectors, households spend the highest amount of energy – 60 percent, followed by services with 31 percent and industry with 9 percent.

Table 4.1 Total energy balance consumption on the island Brioš in 2008

<table>
<thead>
<tr>
<th></th>
<th>fuel oil</th>
<th>LPG</th>
<th>wood</th>
<th>elect.</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tj</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>households</td>
<td>30.2</td>
<td>15.3</td>
<td>82.5</td>
<td>85.8</td>
<td>213.7</td>
</tr>
<tr>
<td>services</td>
<td>8.0</td>
<td>2.2</td>
<td>0.2</td>
<td>102.0</td>
<td>112.4</td>
</tr>
<tr>
<td>industry</td>
<td>14.8</td>
<td>0.0</td>
<td>0.0</td>
<td>16.4</td>
<td>31.2</td>
</tr>
<tr>
<td>total</td>
<td>53.0</td>
<td>17.5</td>
<td>82.7</td>
<td>204.2</td>
<td>357.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>fuel oil</th>
<th>LPG</th>
<th>wood</th>
<th>elect.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t</td>
<td>t</td>
<td>tis m$^3$</td>
<td>MWh</td>
</tr>
<tr>
<td>households</td>
<td>707</td>
<td>326</td>
<td>13</td>
<td>23.82</td>
</tr>
<tr>
<td>services</td>
<td>186</td>
<td>48</td>
<td>0</td>
<td>28.34</td>
</tr>
<tr>
<td>industry</td>
<td>347</td>
<td></td>
<td></td>
<td>4.56</td>
</tr>
<tr>
<td>total</td>
<td>1,241</td>
<td>374</td>
<td>13</td>
<td>56.72</td>
</tr>
</tbody>
</table>

- *Survey on energy consumption in households in 1996, Energy balance, forecast of the future energy needs, project Regional energy development in Split - Dalmatia County, 1997*
- *Survey on energy consumption in households, Survey in services and industry, forecast of future energy needs, Study and preliminary project for the natural gas construction development in the larger settlements on islands, project Main energy plan for energy development for islands in Split - Dalmatia County 2004*
- *Survey on energy consumption in households, services and industry in 2008, Energy balance in 2008*
- *Studies in the field of the renewable energy sources and energy efficiency use*

Energy consumption by sectors in 2008 is presented on the figure above. Energy demand is calculated using bottom-up approach which allows distribution of the end-use consumption at the consumer level. Therefore calculation on the lower level, for municipalities, settlements and towns on the island is available as well as purpose of the consumption.

Example of distribution of energy consumption in local communities in 2008 is presented in figure 4.3.
Figure 4.2 Energy consumption by sectors in 2008

Figure 4.3 Distribution of energy consumption by municipalities

Legend:
- Fuel oil
- LPG
- Wood
- Electricity
4.2. Future end-use energy demand

On the basis of detailed energy analysis in 2008 and expected changes of crucial parameters in energy planning process (number of inhabitants, households, dwellings, dwellings size, central/room heated dwellings, services surface areas, normative of energy consumption and others) end-use energy consumption for thermal purposes, non-thermal consumption and cooling is modelled and calculated. This structure is important in the later analysis when energy supply scenarios are developed. Thermal energy consumption is the ground for the modelling of conventional and biomass energy consumption. Total end-use energy demand in the period concerned is expected to increase from 335 TJ in 2008 to 736 TJ in 2030.

![End-use energy demand forecast](image)

Structure of future energy demand shows the highest increase of energy for cooling needs, but its share in the total energy consumption will remain lower than 13% in 2030 (Figure 4.3).

![Present and future energy demand structure](image)

4.3. Future energy supply options

Energy development of the island of Brač is defined in the framework of four energy scenarios. They are based on the simulations of possibility of gas distribution network development and introduction of the energy efficiency measures (EE) through isolation of buildings and renewable energy sources (RUE) into energy structure consumption: solar heaters, biomass, etc. All scenarios are evaluated technically and financially and describe not only the overall energy system development on the island of Brač but spatial development of particular areas, like municipalities or towns.

Four scenarios until 2030 are described in the following way:

- Scenario 1 provides for slow energy structure and technology changes without gas network development and without support and incentives for introducing EE measures and RUE
- Scenario 2 provides for significant intervention and supports for the EE and RUE introduction but not construction of the gas network
- Scenario 3 is opposite to Scenario 2: concerns construction of the gas network but not support for introduction of the EE and RUE
- Scenario 4 is an optimistic scenario with strong intervention and supports for the EE and RUE as well as construction of gas network.

Parallel to these activities possible development of electricity distribution system is analysed in interaction with the results of the above mentioned scenarios. Special activity was directed to the analysis of the potential of the fuel wood on the island as a very important energy source in households and to possibilities of introduction of individual LPG containers for consumers.

![Penetration of solar collectors in households sectors](image)
Some of the main results show following:

- In 2030 consumption of liquefied petroleum gas (LPG) can reach, according to Scenario 3 and Scenario 4, 3,381 tons, or 2,556 tons respectively. This consumption is assumed only in the larger municipalities: Bol and Supetar.
- According to Scenario 2 and Scenario 4 the introduction of solar heaters will be realised in the 2,313 households or 1,850 respectively, and it can be expected about 6,900 m², or 6,250 m² respectively, of solar collectors in service sector.
- In order to achieve the goals of Scenarios 2 and 4, 2,413, or 1,690, of the old households should be reconstructed in terms of improved thermal isolation.
- Fuel wood will remain still a very important and significant energy source. According to Scenario 1 demand for fuel wood will remain at the level from the year 2008, but according to the optimistic Scenario 4 demand for fuel wood will decrease to 6 thousand m³, or to about 48 percent of the initial 2008 level.

Realisation of all these measures will in different ways affect the electricity distribution network development plans. However, growing standard and overall development will result in a continual increase of electricity demand and the corresponding need for network development and reconstruction. According to Scenario 1 electricity consumption will reach 110 GWh in 2030, while Scenario 4 shows consumption of about 85 GWh.
5. INSTITUTIONAL FRAMEWORK AND IMPLEMENTATION

Within the framework of the Governmental Program - Sustainable development of the island of Brač, which was created in 2004, special activity of the program was directed towards the creation of the institutional framework for the management of the development on the island of Brač. In this context, the detailed analysis of jobs, tasks and relations within the scope of local governments (LGs), regional governments and the state administration was performed.²

Raising the level of institutional capacity for managing sustainable development of islands is one of the key requirements that are resulting from the previous analysis as well as the need for finding more functional forms of cooperation and management at the level of the island as a whole which would be diminished by lack of “division” of the island.

According to the Law on Local and Regional Authorities there is a possibility of linking LGs and the establishment of their own bodies. So, the basis for strengthening the capacity exists, but the question is whether the LGs are capable to establish such a body which would be responsible, politically and professionally, for the implementation of various complex development projects like energy development projects. Another option that is also defined in the same law is that LGs can transfer their competences to the regional government, which is acceptable and realistic option for designing the institutional framework for implementation of energy projects, because of the established structure of the staff.

During recent years EU has, through special energy programs, supported setting up of the regional and local energy agencies in order to support and help public authorities and communities which serve, to improve their energy efficiency and make the most renewable energy sources in line with the objectives of the EU policy. Croatia has become a beneficiary of such programs in 2006 and since then several energy agencies were set up, while the interest of other communities is growing because the opportunity for new establishments still exists.

Apart from the EU programme there is the new program for the establishment of the energy offices as a part of the systematic energy management in cities (MINGORP / UNDP), with the task of managing the use of energy in public buildings owned by the regional administration.

As noted before, the development of the new institutional framework for energy development on islands is launched from several directions. However, what remains is a way to develop more detailed action plans and link individual institutions on particular levels of administrative structures.

Figure 5.1 Institutional framework for sustainable energy development on islands