TOWARDS A LOW-CARBON ISLAND SOCIETY BY STRONG IMPLEMENTATION OF ELECTROMOBILITY

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Abstract. Island specifics, such as relative isolation, manifested in limited transport capabilities and difficult energy and other resources delivery, are a burden for their economies. Economy on islands is also often mostly dependent on variable weather conditions. The challenges of local economy development are further reinforced by the depopulation of a generation that should be the bearer of new economic momentum.

On the other hand, modern technologies open up opportunities for development, which can be extremely suitable for smaller communities gathered around shared goals, given the possibilities of integrated action within the whole. By carrying out a series of measures in various spheres of life on the islands and by continuing education and encouraging people to participate actively, the islands represent the ideal candidates for the development of a sustainable development program.

The examples presented in this paper illustrate the challenges and opportunities of successfully implemented sustainable island development projects, such as electromobility, with a goal of reducing greenhouse gas emissions, i.e. the establishment of a low-carbon society.

It should be pointed out that in addition to long-term environmental goals, the programs should focus on development of local entrepreneurship based on the application of acquired knowledge and skills, i.e. creation of value added for stakeholders, both for the island population through the concept of cooperative and communal ownership of the infrastructure as well as visitor visit destinations that through the use of modern technologies develop innovative resource management concepts.

Introduction

In the period of global-level change triggered by excessive exploitation of fossil fuels, which has led to an adverse impact on the climate system with an increase in greenhouse gases in the atmosphere, the focus is on a transition process to a low-carbon society/economy. For this reason, at the UN Conference on Climate Change COP21 held in Paris in late 2015 the goal of international coordination on the limit of global warming to 2K in relation to pre-industrial times was set. The 2K is a threshold that must not be overcome in order to avoid irreversible adverse consequences on many regions on the planet. It is also the goal of relieving dependence on limited natural resources.

The transport sector is one of the main generators of greenhouse gas emissions and is one of the fastest growing in the world. The population has doubled since 1950, while the number of vehicles has increased almost tenfold. Today, the global fleet is nearly 600 million vehicles, and this figure will only grow over time if substantial innovations were not introduced.

Sustainable island development

Recent research indicates that Arctic ice melting as a result of global warming could increase sea level up to 150 cm [2]. For this reason, island communities, although having a small share in greenhouse gas emissions, are very interested in implementing sustainable development concepts, as an example for other communities.

Analysis of economic and social flows on the islands suggests a strong dependence on oil derivatives [3]:

- the arrival of tourists, the supply of food and other goods, and the delivery of products from the mainland, primarily via vehicles/vessels powered by internal combustion engines,
- processing of agricultural areas mainly by motorized tools (oil), the addition and protection of chemicals (natural gas, oil),
- waste disposal, the functioning of administrative and emergency services, transport of students and complete internal transport system depend heavily on petroleum products.

Usually, the island power system is an infrastructure that is poorly connected with the land system or it is not connected at all. If the island power system is connected to the rest of the power system, this connection is usually realized by laying one or more submarine cables. Most of the islands in Croatia are also mutually connected via submarine cables, thus achieving a certain level of the power supply reliability. Nevertheless, there is a realistic danger of interrupting the electricity supply due to technical or other reasons, such as weather conditions or human caused faults. Although such cases are rare, they have direct consequences on the overall life of the island and significant impact on many sectors. The additional specificity of the island system is that during the tourist season peak loads are significantly higher than those during the rest of the year, so the grid must be dimensioned in this respect [1].

In many examples worldwide, islands that are far away from the mainland and are completely isolated from the mainland energy system use production facilities that, by using fossil fuels, pose a severe threat to the ecosystem of the islands, while the supply of primary energy makes electricity much more expensive. In these cases as a possible solution may be renewable energy sources. Also, a possible solution for reducing shore energy dependence and thus reducing greenhouse gas emissions is the construction of distributed energy sources as close to consumers as possible. In order to make the energy system as efficient as possible, and the transition to the green sources as quick as possible it is necessary to encourage the construction of renewable energy sources at consumer locations. Technologies that are suitable for use on islands are solar cells, wind turbines, heat pumps and biomass plants. It is desirable to produce as much energy as possible using proprietary resources on the islands and, if necessary, exchange energy with the rest of the system.

Renewable sources are unpredictable, and cannot sustain constant output, some renewable sources are not able to produce energy under certain conditions, for example, solar cells do not produce energy during the night. That is why it is necessary to use energy storage units. Same storage units can be used to relieve existing power lines that connect island with the rest of the power system. Energy can be stored during low demand and used in high demand periods. Some of the energy storage technologies available for island systems are pumped hydroelectric energy storage and battery storage systems. The integration of a large number of electric vehicles into the grid is being investigated more and more as a type of energy storage solution. Greater use of energy storage helps to integrate renewable energy into the system. Use of smart meter can also help with power consumption redistribution which is needed because of the unpredictability of renewable sources and help reduce their negative impact on the network.

The integration of smart meters would give a consumer insight into real-time energy prices so that he could manage his consumption more efficiently. The electric car charger can use that technology to charge the car only at the time when electricity is more available, thus shifting the load from other times of the day.

Development of the transport sector should take place systematically and in parallel with other sectors. By doing so, transportation of people and goods to and from the island must be diverted to marine traffic, or to rail traffic. These types of transport are greener alternatives to road transport. Traffic on the island should focus on the concepts of electric mobility of tourists during the tourist season, but also of the local population throughout the year. The prerequisite for electrification is the setting up of an electric charging station grid next to the main roads in prominent tourist locations and on sideways roads.

Project within the institutional framework

The transport sector is one of the most important economic sectors and contributes 4.8% of total gross value added in the EU-28 group (548 billion euros) and creates 11 million working places in Europe. The European Commission aims to develop and enforce an effective, secure and sustainable transport policy that meets the conditions for a competitive industry and new jobs. To do so, the EU is striving to tackle the problems that are in our transport systems through its transport policy:

- **congestion** on roads costs Europe1% of annual GDP.
- **oil dependence** - despite increased energy efficiency, the transport sector still depends on oil for 96% of its energy needs.
- In the future, oil reserves will be getting smaller and located in unstable parts of the world. The price of the oil is expected to double by 2050 compared to the price in 2005.
- **greenhouse gas emissions** - if the global warming rise is to be limited to just 2K, the EU needs at least halved emissions in the transport sector from 1990 levels by 2050.
- **infrastructure quality** - uneven across the EU.
- **competition** - the EU transport sector faces increasing competition in the rapidly growing transport markets of other regions.

The EU supports innovation, research and the efficient application of new, more environmentally-friendly, transport technologies. For example, EU-1 members are obliged to promote clean technologies (electric cars, trucks and gas-powered vehicles) by building a number of charging stations and gas stations along its roads.

Traffic is one of the key factors of economic and social development both in terms of the share of revenue in GDP and in terms of basic living needs of modern society, which is the need for mobility. Traffic and mobility directly affect the development of the industrial market by stimulating economic growth and improving living standards and competitiveness between regions. Traffic and mobility are important economic areas in Croatia. They can make a significant contribution by addressing the global challenges of smart, green and integrated transport.

Ecologically acceptable traffic solutions

The traffic electrification provides an opportunity for the scientific research sector as well as the Croatian Republic's transport industry to develop a new, innovative solution that has great potential for commercialization in this area. It is essential to develop the technology and the products related to green vehicles and vessels, but also to carry out a specific analysis of the impact of bulk electric vehicle charging to the power system.

Intelligent transport systems and logistics

Several global social challenges (traffic congestion, CO2 emissions related to traffic and road deaths) need to be overcome so that the European transport system can fully fulfill its role of satisfying the needs of the European economy and society's mobility. The objectives of EU transport policy 115 are to set cleaner, more efficient and safer traffic. The above-mentioned challenges also apply to the Republic of Croatia. The response to these global social challenges cannot be just the application of traditional measures. Research, development and innovation will play an important role in finding appropriate solutions across EU.

An example of the island of Krk

Recommended methodology for the sustainable development of islands for low-carbon society is presented on the example of the island of Krk, located in the Republic of Croatia, which aims to reduce greenhouse gas emissions and develops sustainable development programs.

Due to good connections (bridge to land, sea links with neighboring islands, airport with international flights) the island of Krk is an attractive destination for both domestic and foreign tourists and a desirable place to live. As a result of the relative high number of nights tourists spent on Island of Krk in relation to other Croatian islands, the local communal society together with the representatives of the local self-government units decided to move forward and develop the sustainable development model to give the destination additional recognition.

The view of actions needed to establish a sustainable community that needs to be implemented in all sectors [4]:

- development of projects and integration of renewable energy sources into the system
- establishment of charging and procurement network of electric vehicles (cars, scooters, electric bicycles), equipped workshop and established conversion team for electric vehicles
- implementation of energy efficiency measures in buildings and public lighting (GIS, control plan and lighting system management system), systematic energy management in the public sector
- elaborate separate waste collection and management systems (biomass heating plant) and water resource management;
- development of broadband IT infrastructure
- an advanced power network development plan
- a project team for attracting funds from national and EU funds has been established
- continuous education activities through the energy co-operatives and local action groups with the plan for building an educational and research center and promotion activities for more intensive local population involvement and information to the general public.

Taking into account the data on the annual electricity consumption of the island of Krk, the calculation of the required installed power of the renewable sources of energy for achieving the energy self-sufficiency provided by the literature, total consumption is assumed. This is based on the ratio of the population of the island of Krk and all the inhabited islands in the Croatian part of the Adriatic sea. The first scenario is to calculate the required installed power assuming that the same amount of electricity is produced in photovoltaic on roofs and wind turbine, while another scenario instead of wind turbine introduces photovoltaic on the ground. A necessary prerequisite for the realization of the scenarios mentioned above, is a transition to electromobility, the implementation of energy storage technologies, the implementation of energy efficiency measures or the establishment of an advanced power grid. As mentioned above, this paper proposes a gradual transition to energy independence, i.e. the retention of existing electricity connections with the land-based power system, with the aim of maximizing the production of electricity with renewable energy sources with the possibility of two-way energy exchange with the rest of the power system. The produced energy would also be used for electromobility. Figure 1 shows the electric vehicle converted by the local e-mobility team on the island of Krk, while Figure 2 shows the mobile application developed for the island of Krk, where location of charging stations are given.

Figure 1: Electric vehicle converted by the local e-mobility team on the island of Krk

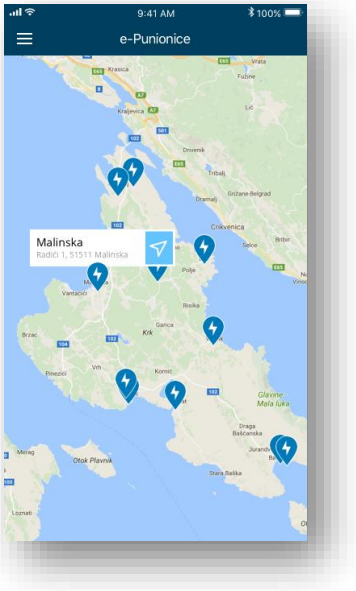

Figure 2: The mobile application for the island of Krk

The next phase of the research will be the proposal of appropriate technological solutions for the monitoring, protection and control of the power system of the island of Krk, i.e. the development of intelligent energy management programs aimed at the gradual development of the electric power system of the island of Krk and the advanced power grid. Additionally, apart from mobility, there is a huge potential of sea that can be used for energy generation, which represents another interesting topic for future development.

Conclusion

Global trends associated with climate change, and measures to mitigate the same, indicate that the current techno-economic challenges should be seen as opportunities that form the basis for new development models. In particular, the principles of sustainable development, development of energy projects and related sectors should be taken into account. Solutions need to be integrated and interdisciplinary, with planned return periods of investment that will attract capital for implementation.

Island energy issues are manifested in a series of small specific cases that result in the reduced competitiveness of the final product and service market. In addition, the direct consequences of adverse climate change are an additional motive for local communities in terms of project development in a number of sectors. Energy is thus one of the key areas of focus in the pursuit of the establishment of a low-carbon society. Therefore, examples of good practices in the implementation of technical solutions and concepts based on modern technologies should be studied and applied appropriately in domestic conditions. Particular attention should be given to maximizing their own resources in order to provide adequate support to the local community, i.e. to create new jobs with high added value.

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