

# INFLUENCE OF IMPLEMENTATION OF RENEWABLE ENERGY SOURCES ON SUSTAINABLE DEVELOPMENT OF ENERGETIC SYSTEM OF THE REPUBLIC OF CROATIA

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## SUMMARY

### Purpose

The doctoral thesis investigates the issue of the energy system with a focus on the electric power system and the electricity market in the Republic of Croatia, looking at the possibilities of economic profitability of electricity production from renewable energy sources in order to achieve energy independence and greater sustainability. The purpose of the research is to provide an insight into the state of the electric power system and the potential of renewable energy sources in the sustainable production of electricity. The main objective of the research relates to possible projections of the economic profitability and competitiveness of renewable energy sources on the Croatian electricity market.

The growing need for electricity in the Republic of Croatia, as well as in other countries of the world, calls for an answer to the question of how to make one's own electricity system sustainable. An alternative to fossil fuels, which produce harmful greenhouse gases when burned, can be seen in renewable energy sources. Reducing dependence on fossil fuel imports, reducing greenhouse gas emissions and sustainable development are the main goals in promoting greater use of renewable energy sources and high-efficiency cogeneration in the production of electricity in the Republic of Croatia.

The development of technology for the use of renewable energy sources, together with the growth of fossil fuel prices, has further accelerated the need for the fastest possible implementation of renewable energy sources in the last few years, which is encouraged in all countries of the European Union, including in the Republic of Croatia, all in order to achieve the goals of zero greenhouse gas emissions. In the Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050, the Republic of Croatia has given strategic guidelines for energy development with the aim of building a sustainable energy system, i.e. a system that will ensure the security of energy supply and the competitiveness of the energy system with sustainable energy development, which implies an increase in the share renewable energy sources.

### Methodology

The basic scientific hypothesis was proposed in the doctoral thesis: H0: The introduction of renewable energy sources and integration into international electricity markets are a necessary prerequisite for the sustainable development of the energy system. Proving the basic scientific hypothesis leads to the definition of the following auxiliary hypotheses:

H1: Initial investment costs prevent the efficient development of renewable sources of electricity.

H2: The existing mechanisms for encouraging renewable energy sources in the Republic of Croatia negatively affect the sustainability of the development of the energy sector as a whole.

H3: The increase in electricity prices at CROPEX has a positive effect on the economic profitability of renewable energy projects in the Republic of Croatia.

Renewable energy sources represent an important component of modern power systems aimed at green transition and sustainable development of the power system in the Republic of Croatia. The optimal model for the introduction of renewable energy sources in the Republic of Croatia was simulated using the PLEXOS model, by setting the scenario of economic profitability and competitiveness of the model with six power plants (three wind power plants and three solar power plants) and four scenarios with prices formed on CROPEX DA (one day ahead of the market) and peak load in 2019 and with a forecast for the period from 2022 to 2047.

## Findings

The results of the research prove the profitability of wind power plants and solar power plants in the scenario “with an increase in the base price by 6% per year” already in the first year of putting the power plant into operation. The research results also prove that the production of electricity from wind power plants and solar power plants with an installed capacity of 10 MW is not economically profitable without state support at prices that are formed on the market (except for prices in extreme conditions such as the energy crisis) and with high initial investment costs for the construction of power plants to renewable energy sources (solar energy and wind energy). With the minimal predicted price growth in the simulation model (6% per year compared to 2019 prices formed on CROPEX DA), faster construction of new power plants based on renewable energy sources in the territory of the Republic of Croatia can be expected.

The simulation model also proved the auxiliary hypothesis H1 of the doctoral dissertation: Initial investment costs prevent the efficient development of renewable sources of electricity. The research showed that with the prices formed on the market (with the exception of prices in extreme conditions such as the energy crisis) and with high initial investment costs, the construction of power plants based on renewable energy sources (solar energy and wind energy) shows economic unprofitability without government support. Along with the predicted increase in electricity prices, a faster growth in the number of power plants based on renewable energy sources in the territory of the Republic of Croatia can be expected, and thus the efficient development of renewable energy sources and an increase in the electricity independence of the Republic of Croatia.

The paper investigated the justification of the support system for the production of electricity from renewable sources. The Republic of Croatia introduced a system of incentives for renewable energy sources in order to encourage the development of renewable energy sources and increase their share in the energy balance. The reason for this is the fact that the price of electricity produced from renewable energy sources (with the exception of hydropower plants) is significantly higher than the average production price in conventional power plants, which discourages investors. By lowering input costs, construction subsidies and incentive prices enable new companies to compete with existing fossil fuel companies, driving market dynamics. The Law on Renewable Energy Sources and High-Efficiency Cogeneration regulates operational support, i.e. payment of state support based on delivered electricity, but the support system essentially encourages the construction of new plants that will produce electricity from renewable energy sources. In the period until 2021, the amount of the incentive price was lower than the prices that formed on the market, thus giving investors business security. However, in 2022, due to the energy crisis, CROPEX prices will rise significantly and are higher than the incentive prices. In such circumstances, privileged customers who have fulfilled their obligations to HROTE and HERA leave the incentive system and participate in the electricity market. In the period from 2022, a decrease in the number of plants, installed capacity and production of electricity from renewable sources in the incentive system was recorded. The lower price of electricity compared to CROPEX led to disruptions in the electricity system and called its efficiency into question. The conducted analysis, however, did not confirm hypothesis H2: The existing mechanisms for encouraging renewable energy sources in the Republic of Croatia negatively affect the sustainability of the development of the energy sector as a whole. It is evident that the incentive system had a positive effect on the growth of renewable energy sources.

## Originality of the research

The scientific contribution of the work is manifested in the acceptance of the set scientific hypotheses, which proved that the introduction of renewable energy sources affects the sustainable development of the electric power system and increases the electric power independence of the Republic of Croatia, which is also the basic hypothesis of the doctoral thesis (H0).

## Keywords

renewable energy sources; energy system; economic profitability of solar and wind power plants; Plexos model; sustainable development

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