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The Potential of Solar Energy as a Driver of Regional Development - Challenges and Opportunities

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ABSTRACT

Dependence on energy products, especially on fossil fuels, greatly affects the long-term development and diplomatic capabilities of any country. The EU has been allocating considerable funds to strengthen its cohesion, promote balanced development in the different regions, support investments in renewable energy sources, and gain energy independence. The funds earmarked by the EU for these types of investments have the potential to be the main drivers of long-term sustainable economic growth and development, thus enhancing cohesion. Investing in renewable energy sources, in particular in the solar energy, can spur the growth and development of other sectors, attract new investments and thus strengthen the capacity for providing social support to the most vulnerable population. For underdeveloped regions, this would mean new opportunities and investments while preserving the environment for future generations. Implementing sustainable solutions might be relatively simple, given that regulatory, economic, as well as natural and infrastructure components exist. This is evidenced by a significant body of research, which provides a robust basis for a development model based on the investment potential of solar energy to address the issue of regional disparities in the EU and its energy dependence.

Keywords: Renewable Energy Sources, Energy Efficiency, Solar Energy, Regional Development

JEL Classifications: O21, O380, R280

1. INTRODUCTION

Today, solar energy provides a long-term energy perspective, especially considering the fact that, as a renewable energy source, it is available both to developed and developing countries. The availability of solar energy and the fact that it can be easily converted into other forms of energy open up a number of opportunities to use its potential to support the development of less developed regions, ensure energy stability and independence, as well as to alleviate the negative impacts on the environment by reducing CO₂ emissions. This should result in increased energy independence and facilitate sustainable economic growth and development. As early as 1974, there were claims that solar energy had the potential to meet the energy needs of the global population practically without any harmful emissions (Landsberg, 1974,

in: Madsen and Hansen, 2019). As much as 25% of greenhouse gases (GHG) are emitted by the generation of electricity and heat (IPCC, 2014, in: Jenniches, 2018). Annual damage due to river floods in the EU could reach 112 billion euro by 2100, from the current five billion euro (COM, 2018, p. 773). Oberle et al. (2019) point to the well-known fact that since the 1970s, the global population has doubled, and the world's gross domestic product has quadrupled. Nevertheless, the extraction of natural resources reached 92 billion tonnes in 2017 compared to 27 billion tonnes in 1970. One should not overlook the fact that only 10 countries were responsible for more than 68% of the global extraction in 2017. Based on their analysis of 273 internationally supported energy efficiency projects implemented between 2005 and 2016 in developing countries, Hsu et al. (2017) concluded that GHG emissions reductions would be around 0.3 gigatonnes of carbon

dioxide (GtCO₂) annually by 2020. Jakovac and Vlahinić-Lenz (2016) point out that power generation, transport and consumption are definitely the most significant sources of environmental pollution. It is estimated that approximately three quarters of carbon dioxide emissions into the environment come from fossil fuel combustion. Power generation and consumption is the largest polluter, accounting for 24% of total GHG emissions. Land use is another major polluter with an 18% share, while the industrial, transport, and agricultural sectors account for 14% each.

The GCC¹ is among the 25 countries responsible for generating the highest GHG emissions per capita. Taking into account population growth trends in these countries, as well as the continuous growth in living standard (along with increasing urbanization and electricity demand) there is a need for energy efficiency projects, as pointed out by Munawwar and Ghedira (2014). Furthermore, since 1993, the Chinese economy has been dependent on crude oil imports and is the largest importer of crude oil in the world. For example, crude oil imports increased from 53% of total consumption in 2009 to 68% in 2017 (more details in: CEIC database²). In general, about 70% of international oil trade will end up in Asia in 2040 according to the analysed scenarios (largely due to the doubling of Indian import needs) (more on this in: IEA, 2019c). Norway, Finland, Japan, the US, France, Canada, and Germany topped the Global Energy Innovation Index ranking in 2019 (Cunliff and Hart, 2019). Interestingly, despite declaring its intention to withdraw from the Paris Agreement, the US is making major contributions to the global clean energy innovation system. Moreover, in absolute terms, the United States invests in clean energy research and development significantly more than any other country in the world (Cunliff and Hart, 2019). There is no doubt that climate change remains a topic on the political agenda; however, there is a serious problem: Small, low-cost steps are taken, and a comprehensive solution is lightly dismissed as not worth the cost (more on this in: Paul et al., 2019). Furthermore, as Cunliff and Hart (2019) and Seetharaman et al. (2019) point out, despite the fact that significant efforts are being invested in promotion, as well as the fact that South Korea, France, Italy, the Netherlands, Australia, Sweden, Denmark, Norway, and Finland, and, in principle, the entire EU (Cunliff and Hart, 2019) (Mission Innovation Initiative³, MI) joined the Paris Agreement and committed to double their investments in clean energy R&D, in 2019, they invested less in absolute terms than they did in 2015. Moreover, it is interesting to note that, for example, in 2018, China, Saudi Arabia, the United Arab Emirates, Indonesia, India, Mexico, and South Korea subsidized their consumption of fossil fuels by 171 billion US dollars. The same year, 23 EU Member States together invested USD 22.7 billion in clean energy R&D (Cunliff and Hart, 2019). Table 1 presents an overview of the installed capacity of solar power plants in the top 10 countries.

Table 1: The 2015 global ranking for solar power generation capacity

World ranking	Country name	Total capacity (MW) at 2015	Installed (MW) in 2015
1	China	43,180.00	15,130.00
2	Germany	39,553.00	1,418.00
3	Japan	33,300.00	10,000.00
4	USA	27,400.00	7,260.00
5	Italy	19,160.00	700.00
6	UK	8,437.00	3,109.00
7	Spain	6,967.00	6,946.00
8	France	6,680.00	1,020.00
9	Australia	5,049.00	913.00
10	India	4,680.00	2,048.00

Source: Kabira et al., 2016

Jenniches (2018) points out that the following steps should be taken to assess the economic impacts of renewable energy sources on regional economies: (1) Choosing a region, (2) defining the technology, (3) defining the period to be evaluated, (4) defining the impacts to be evaluated and 5) choosing the evaluation method. Ruiz et al. (2019) point out that in order to assess wind, solar and biomass energy potentials, it is important to distinguish between four key evolutionary issues:

- 1) Initial assessment of resources at the global level, triggered by the debate on the feasibility of projects (and plants) related to renewable energy sources and CO₂ reduction;
- 2) Techno-economic analysis, aimed at clarifying technical and economic efficiency gains, that are crucial input for developing models and projects (plants);
- 3) Variability and dynamics of wind and solar power and sustainability of biomass inputs;
- 4) Local impact and regional studies with detailed local potential evaluation.

As reaffirmed by Rawat and Sauni (2015, in Seetharaman et al., 2019), energy has always been considered one of the most important inputs for economic growth and social progress. Drvenkar and Marošević (2014) claim that the concept of green growth is an alternative to the conventional economic paradigm of resource exploitation, and a driver of growth. It involves sustainable use of natural resources, greater energy and resource efficiency, and enhanced natural capital. Green industrialisation does not involve merely the development of green jobs in some well-defined sectors. It entails reshaping and revitalizing the entire European industry. However, the many barriers to deployment of renewable energy should not be overlooked. Seetharaman et al. (2019) point out that there are social, economic, technological, and regulatory barriers, as well as barriers relating to key stakeholders, i.e. economic policy makers in a country. Often, people support environmental protection actions and projects, but at the same time there is also the so-called “not in my backyard” syndrome, as they often clash with the particular interests of individuals, political leaders, local organizations, national interest groups and, in some cases, even environmental groups (more on this: Jianjun and Chen, 2014 in: Seetharaman et al., 2019).

1 The Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates) was founded in May 1981.

2 CEIC data, UK, CityPoint, London, available at: <https://www.ceicdata.com/en/indicator/china/oil-consumption>

3 For more information on the initiative, visit the official website: <http://mission-innovation.net/>

2. CHARACTERISTICS OF SOLAR ENERGY AND CURRENT CHALLENGES IN ENERGY

In relatively moderate scenarios predicting climate change, solar technologies can generate up to 30% of the world's electricity (IEA, 2019). Investments in energy efficiency projects can have significant economic and overall positive social effects, as well as additional multiple benefits (more on this in: Payne et al., 2015; Jakovac and Vlahinić-Lenz, 2016; Cini et al., 2017; Jenniches, 2018; Benedek e al., 2018; IEA, 2019a, Munari and Roecker, 2019, Madsen and Hansen, 2019), help to reduce energy poverty (Yadav et al., 2019), and reach the Nearly Zero Energy Building standard (NZEB) (Paduos and Corrado, 2017; Minergie, Minergie and Eco, SIA 380/1 and Directive 2010/31/EU, in Munari and Roecker, 2019). According to Cambridge Econometrics and Verco (2014, in Payne et al., 2015), an investment of 1 euro in energy efficiency results in a growth in GDP of 3.20 euro. Furthermore, Janessen and Staniaszek (2012) analysed 35 pieces of data collected from more than 20 sources (EU and US) and found that an investment of one million euros directly contributes to the creation of an average of 19.3 jobs (10.4 direct and 25 indirect). In addition, the annual growth rate of solar energy generation since the turn of the century has been significant, with an average rate of almost 50% from 2006 to 2016, and a 32% rate in 2017, which suggests that solar energy can play a major role in the energy transition, as indicated by Madsen and Hansen (2019). Projections suggest that, at the regional European level, solar energy will account for 27% of total electricity consumption by 2030 (Breyer et al., 2017, in: Madsen and Hansen, 2019). Taking into account the REmap analysis, Gielen et al. (2019), underline that the share of renewables in power generation would need to increase from about one-quarter in 2015 to about 60% by 2030 and 85% by 2050 for energy sector decarbonisation. Therefore, the annual growth rate of renewables in total generation, which has been 0.7% over the last 5 years, needs to more than double (more on this in: Gielen et al., 2019, p. 40). The greatest contribution to the research of regional economic effects of energy efficiency projects, considering only those published in English and German, has been made by authors from the USA (33), followed by Germany (12), Spain (5), Austria (2), and the United Kingdom (2) (Jenniches, 2018). Research at the regional level (for example, NUTS 3) is most represented in the USA, followed by Germany (Table 2).

3. SOLAR ENERGY AS A DRIVER OF RURAL AND REGIONAL DEVELOPMENT

The proportion of available supplies of energy and energy demand is quite uneven. Therefore, it is necessary to develop a technology that will serve as a secondary energy source and alleviate the energy crisis. Solar energy is promising and freely available, and the solar industry is constantly evolving around the world, as pointed out by Kannan and Vakeesan (2016, in: Rozentale et al., 2018). In spite of constant improvements in photovoltaic (PV) efficiency, rapidly falling costs, and the fact that it is a mature technology, the main investment costs are still high for many potential solar energy buyers. This is why market and

Table 2: Number of assessed economic impacts in the reviewed publications

Number of evaluations (n=54)	in %	Impact categories
50	93	Number of employees (incl. FTE)
31	57	Number of employees in full-time equivalents (FTE) or person-years
32	59	Regional taxes
27	50	Salaries of employees
21	39	Landowner benefits
19	35	Gross output
15	28	Other economic impacts
13	24	Gross value added
11	20	Owner of plants revenues
9	17	Proprietor income of firms
4	7	Investment
4	7	Regional GDP
1	2	Turnover

Source: Jenniches, 2018

political risks for solar technologies must be kept to a minimum (IEA, 2019). In Lagos, as in many other Nigerian cities, private companies are in the process of developing new approaches to make solar energy more accessible and affordable. As Hsu et al. (2017) point out, a partnership between a solar start-up and local telecommunications provider has brought solar power to 50,000 homes, clinics, schools and businesses, thus benefiting 250,000 people and creating 450 new jobs. Furthermore, in Mexico City a Sustainable Buildings Certification Programme was developed and implemented in partnership with the local construction and building industry. It covered 8220 square meters of floor area in 65 buildings and reduced carbon dioxide emissions by 116,789 tonnes, saved 133 million kWh of electricity, 1,735.356 cubic meters of drinking water, and created 68 new jobs between 2009 and 2017. It should be noted that numerous studies confirm that the regional solar energy potentials support future regional energy development strategies (e.g. Castillo et al., 2016, more on this in: Benedek e al., 2018). Energy efficiency projects also contribute to decentralisation. When renewable energy sources owned by local government/cooperatives/entrepreneurs/individuals are supported through local investments, local needs can be met. Energy security increases while technical, technological, environmental and financial risks at the local/regional level are reduced. In addition, thanks to renewable energy sources in their area, lagging regions have the potential to become electricity exporters. For example, Schleswig-Holstein, a less developed region of northern Germany, has aimed to achieve a share of 300% of its gross electricity consumption from renewable sources by 2025 (more on this in: Schleswig-Holsteinscher Landtag, Drucksache 18/3074, in: Jenniches, 2018). In addition, due to the location diversity (natural conditions such as climate, geography and land availability), it is necessary to assess the economic effects of energy efficiency projects at the regional level and take adequate steps. For example, as Jenniches (2018) points out, the average annual full-load operating hours of wind farms are approximately one-third higher in Schleswig-Holstein than in Bavaria. The 2030 strategy is a comprehensive EU strategy setting out sustainable development goals with a view to guiding the activities of the EU and its Member States. In addition to setting a target for renewable energy generation, it also prescribes the need to reduce GHG

emissions by 40% compared to 1990 and achieve savings in energy consumption of at least 27% compared to the business as usual scenario. In 2018, renewable energy sources accounted for 18% of energy consumed in the EU (which is close to the 2020 target of 20%). In addition, the share of energy from renewable sources used in transport in the EU reached 8% in 2018 (Eurostat, 2020). Becoming the first climate-neutral continent by 2050 (see also: COM, 2018, p. 773, A Clean Planet for all) is a key goal underlined in the European Green Deal (COM, 2019, p. 640). This is the most ambitious package of measures which should enable European citizens and businesses to take advantage of a sustainable green transition. Between 1990 and 2018, the EU reduced its greenhouse gas emissions by 23%, while at the same time the economy grew by 61%. However, current policies will only reduce emissions by 60% by 2050, so it will be necessary to set much more ambitious goals for the next decade (COM, 2019, p. 640).

The HELIOSAT method is a very reliable method which has been used for many European projects. It estimates solar radiation received at ground level based on satellite images (more on the method in: Dribssa et al., 1999; Rigollier et al., 2002; Rigollier et al., 2004). Using this method at NUTS 2 level, Ruiz et al. (2019) point out that the potential electricity production of 11,000 TWh is extremely large, as it is equivalent to three times the EU's total electricity demand in 2016; however, this would require 3% of the available non-artificial areas or 1.4% of total EU land. This will be discussed in more detail below. Šuri et al. (2007) and Huld et al. (2016) investigated regional and national differences in solar energy resources and assessed photovoltaic (PV) potential in 30 countries (EU Member States and candidate countries - Northern Macedonia and Turkey), further confirming that the Republic of Croatia, along with Portugal, Spain, southern France, Italy, Greece, the Republic of North Macedonia, and Turkey, has the greatest potential in the EU for solar power generation. In 2007, the same authors warned that the EU does not fully recognise the potential of solar energy as one of the key technologies of the future⁴. In their study exploring solar systems in rural areas, Yadav et al. (2019) highlight the factors that significantly influence the increase of solar energy use: (1) Income, (2) level of education, (3) duration of the system, (4) use of solar energy, (5) user satisfaction with the systems, (6) time of day for power supply, and 7) financial support for the purchase of the system. This research is particularly interesting because it points to a paradox which has been highlighted in this paper as well. Namely, Yadav et al. (2019) note that subsidies, often widely used as socio-political tools, are practically useless in regions burdened with economic problems, and instead of current practices, attention should be focused on structural aspects of the energy system and administrative (and even political) procedures.

Decentralized solar power generation is increasingly used as a significant and sustainable alternative in addressing the existing challenges of electrification of rural areas. Yadav et al. (2019) surveyed 249 Indian households grouped as follows: (1) 105 households that are solar PV users and (2) 144 households that

are PV users and also distribute to the main grid. The research aimed to answer the following questions: (1) Are rural households satisfied with the use of decentralized solar power? (2) Household characteristics (income, level of education, duration of solar use and hours of power supply as an advantage or disadvantage in further use of solar energy) and (3) Does free and available solar power supply increase the desire to continue using it as an energy source? An interesting finding of this study is that a 1%-change in household satisfaction increases the desire for solar energy by 0.16% (Yadav et al., 2019). Furthermore, more than 80% of households received solar electricity for over four hours per day, which was made possible by electricity stored in their battery (for lighting, charging of mobile devices, occasional use of fans after sunset). It was to be expected that some households would raise concerns about battery life and future battery replacement. It is interesting to note that households that received their photovoltaic system for free were less inclined to desire more solar energy than those who paid for their systems in full or had received a partial subsidy. The following is an illustration of an energy justice model that proposes a key role for public-private partnerships to advance a universal approach to environmental protection, while being both fair and affordable.

Rozentale et al. (2018) analysed 15 case studies of households with solar panels in Latvia to determine the profitability of the investment within five or fewer years, taking into account the known variable - electricity bill with all cost elements, as well as availability and the efficiency of solar panels. The average efficiency rate of solar panels was about 16.92%, and the average cost of installing the system was about EUR 5,000. Based on the collected data on electricity generated by solar panels and the amount of electricity fed into and collected from the grid, the average monthly electricity bills before and after the installation of solar panels, and all other indicators, the return on investment period was found to be on average 13 years, as stated by Rozentale et al. (2018). However, numerous experiences have confirmed that the electricity bills were three times lower, and installation costs varied (for example, some were available for as little as EUR 3,100). However, Rozentale et al. (2018) point out that an investment of 2,850 EUR, for example, is not proportional to a significant reduction in the electricity bill, because the return on investment period is more than 11 years. They list four key factors that can significantly affect these indicators: (1) Efficiency of solar panels and models, (2) price of solar systems, (3) support and subsidies by the government, and (4) components of the electricity bill. In their study, Castellazzi et al. (2016) take into account the financial aspects of the change and installation of a heating system, as well as the depreciation time of new solar systems and emphasize that detailed solar data as well as data on electricity supply by photovoltaic modules are hard to find, despite the "popularity of the topic." In addition, they emphasize the problem of high building density with frequent shadowing of roof areas despite favourable climate or roof position/slope. Talaei et al. (2017) note that window size and tilt, facade, vertical gardens, algae technology and similar aspect also affect the overall financial and energy outcomes. The mentioned study and other similar studies highlight the challenges for urban areas, which may be an opportunity for rural areas. Furthermore, there

4 More information on solar potential of the EU using PVGIS tools: Photovoltaic Geographical Information System (PVGIS), available at: <https://ec.europa.eu/jrc/en/pvgis>

are specific challenges related to the distribution of the solar radiation throughout the year, as most radiation is available during the summer months and only a limited amount during the winter (Good et al., 2014). However, the economic situation (and sometimes even the overvaluation of solar system benefits) and technological advances significantly support the installation of solar systems; however, all this requires flexibility of the regulatory framework and targeted incentives. Numerous research studies and reviews provide evidence that the use of renewable energy sources, especially in rural areas, affects the development of the local energy value chain (more on this in: Benedek et al., 2018). In addition, they provide various socio-economic and environmental benefits: (1) Employment of local population and increase in their purchasing power, (2) mitigation of the negative demographic trends, (3) diversification of rural economic activities, (4) increase in social cohesion and use of endogenous resources, (5) mitigation of negative impacts of climate change, and creation of a healthier environment through the use of clean energy technologies.

4. PREREQUISITES FOR A SOLAR ENERGY MODEL

To develop a solar energy model that will support rural and regional development, three key factors need to be determined: (1) The number of solar hours and the amount of solar radiation that ensures electricity generation, (2) electricity consumption in a particular micro-region, and (3) the price of such an investment in that micro-region (the main constraints and advantages are listed in Table 3). The number of solar hours and the amount of solar radiation varies across the European continent – it is higher in the south and lower in the north. The intensity of radiation in the northern part of the continent is less than 600 kWh/m², while in the southern part it is above 2,200 kWh/m² (Photovoltaic Geographical Information System, 2017). In addition, it is necessary to analyse the consumption of micro-areas. Indicators are generally available through electricity distributors, unless they are classified, as is increasingly the case in the EU due to data protection rules. The next step is the analysis of infrastructure (spatial) capacity. It is important to note that the present study does not encourage the installation of solar panels on agricultural/forest land, but only on the roofs of existing buildings that are the consumers of such energy. In that context, public buildings have a great potential as they can install larger PV power stations; however, they are also greater consumers of electricity. In addition to public buildings, private households or company facilities are also considered.

Table 3: Main constraints and factors determining the overall applicability of PV systems

Criteria	Description
Constraints	Protected and sensitive natural areas
	Built-up areas, wetlands, water bodies and forests
Sustainability factors	Intensity of solar radiation
	Topographic parameters (slope, aspect, elevation)
	Potential population and its segmentation
	Proximity to roads
	Proximity to the electricity grid

Source: Authors based on the conclusions and findings by: Perpiña et al., 2016

Public-private partnership would accelerate the implementation of such an energy model and would enable citizens and legal entities to gain access to free or significantly cheaper electricity (depending on the size of the installed power station). In addition to analysing the amount of energy consumed, energy price, investment costs, and the intensity of solar radiation, it is necessary to determine the financing model. A major part of the investment can be co-funded by different EU funds.

Given the simplicity of investment implementation (in contrast to the complexity of previous ones), current capacity, and the often conflicting political will at the local and national level, it is necessary to provide an alternative model which would rely on households, i.e. houses with a roof area larger than 140 square meters. This potential “energy New Deal” could improve the standard of living and the way people live in rural areas, raise the birth rate, boost domestic industry, ensure renewable energy development, reduce CO₂ emissions by households that, which, according to all parameters, are the largest consumers of energy and thus the largest generators of CO₂, as well as facilitate sustainable growth and development of underdeveloped areas. The default value would be a solar power plant with a capacity of 10 + 5 kW (which annually produces 17,400 kWh of electricity and whose retail price is HRK 181,380). Based on the data on the level of development of local self-government units in the Republic of Croatia, collected by the Ministry of Regional Development and EU, the rural areas in Croatia are less developed, as can be seen from the 2018 values of the development index and indicators for calculating the development index. The lower standard of living both causes and results in inferior living conditions, which this model aims to change.

The indicators for a 15 kW solar power plant, which produces more than 17,400 kWh of electricity per year, show that one household can generate a surplus of approximately 12,600 kWh of electricity on an annual basis. Such surpluses open up new possibilities: They could be used for heating, feeding into the distribution network to prevent system collapse, financing the network maintenance, building a storage system for excess energy, etc. However, unlike the previous model of investing in publicly-owned solar power plants, this model requires some regulatory changes. One of these would involve the adaptation of the electricity purchase and sale system in which one kWh of electricity generated in this system would have the same value as one kWh of electricity bought by such a household from a network distributor. This would allow for the redistribution of electricity as shown in Table 4.

Table 4: Redistribution of generated electricity (in kWh) in a household power plant with installed capacity of 15 kW

Annual consumption	Redistribution of generated electricity (kWh)
Standard use electricity consumption– public lighting and facilities	4.800
Electricity consumption for heating	4.000
Annual grid and system maintenance	3.345
Savings delivered to the grid	5.255
TOTAL	17.400

Source: Authors

In addition to regulatory changes needed for the implementation of the household solar power plant investment/construction model, some additional technical adjustments need to be made to the system. For the distribution network to function, these solar power plants need to be upgraded. In this particular case, it would mean upgrading the solar power plant with a 4.7 kWh lithium battery that would accumulate unused electricity during the day and absorb it for potential consumption during the night when the amount of electricity generated is not sufficient to meet the demand (annual consumption of 4,800 kWh incurs a cost of just over 4,000 HRK, which in this case would mean additional savings for the household). In this way, households would not disturb the stability of the network, and the surplus energy distributed into the network system would not significantly affect it. The investment value of such solar power plants would increase by slightly more than 17%, given that the value of the lithium battery is about 37,500 HRK (more on the value in: Kantej, 2017). Such a system of power plant operation (on-grid and off-grid) would eliminate technical difficulties and provide citizens with a free energy from a source that is both independent and sustainable. The significant increase in academic and professional research in this area points to many noteworthy possibilities (more on this can be found in research by, e.g. Akinyele et al., 2017, Song et al., 2017, Podder and Khan, 2016, and Gurung and Qiao, 2018, who wrote about the key advantages and disadvantages of batteries). What are the advantages of such a system? Having a free source of energy throughout the year would save a household more than 9,000 HRK/year on electricity and heating. In addition to that, these solar power plants would generate annual energy surplus that could be used for activities as the ones proposed in Table 4. The redistribution of electricity would contribute to the following:

- 1) Household energy needs would be met in full and, as a result, an individual household would save more than 9,000 HRK/year (which is better than all the previous tax measures and reliefs for an average Croatian household⁵).
- 2) The value of energy generated would also be used to maintain the network and power plants, thus making the system sustainable.
- 3) Savings would be made that would provide enough money over 25 years to co-finance the replacement of the existing system with a new one. Such households would not generate CO₂ emissions as they would be using a clean energy source, which is not the case for buildings that are undergoing energy efficiency upgrade (refurbishing the building envelope). To illustrate, the value of the complete upgrade of the building envelope for a building of 100 square meters equals the value of one solar power plant of 10 kW (the amount varies depending on the condition of the building, material quality and region, and the cost of works). The difference between these two investments is in the consumption of energy products - households that have upgraded to energy efficient building envelope still use energy from the grid, incur energy

costs and generate CO₂ emissions, while households with a solar system of 15 kW are completely energy independent, have no expenditures for energy, and do not generate CO₂ emissions. This clearly indicates that the model of investing in household solar power plants in rural areas is far more cost-effective and environmentally friendly than the model of upgrading the building envelope.

Why such a comparison? The funds of the Program for energy efficiency upgrade of family houses for the period 2014-2020 with a detailed plan for the period 2014-2016 and a detailed plan for the period 2019-2020) that have been spent so far on upgrading building envelopes could have been repurposed for installing solar power plants on the roofs of the houses. As in the case of energy performance upgrade of houses, the government could start applying for EU grants and receive funding support of up to 80% of project costs. In this particular case, to install solar power plants on 50,000 households, the government would have to invest 1,313,280,000.00 HRK (12% of the total value of the investment at a minimum). It could commit to investing more to ease the financial burden on the citizens as well as local self-government units, which could also co-finance the installation in rural areas. This measure and the amount would cover about 5% of the population of the Republic of Croatia and, in the long run, would certainly mean more for citizens in terms of savings they would make than some other energy efficiency measures. Specifically, in addition to the savings on utility costs, which is also an important pro-natal measure, the savings achieved by delivering electricity to the system using the model 1 for 1 kWh would also provide other benefits. Through the system of energy cards, households would be able to monitor their electricity consumption and generation at all times. This would allow the surplus of electricity generated to be used for other purposes, e.g. energy independent households could be encouraged to purchase electric vehicles. This would enable them to be more mobile (which is important for rural areas, and save money on fuel as well, given that charging such vehicles using an energy card would be completely free (which would result in additional annual savings for households). The use of electric vehicles would also reduce CO₂ emissions. The savings could also be used for upgrading the energy efficiency of buildings, but also for the replacement of the existing system with a new one. If the savings are achieved, the government could stimulate households with an additional kilowatt-hour per each kWh of electricity generated and delivered to the network to encourage them not to be wasteful in consumption. Such a policy would without doubt motivate people to stay in rural areas, provide economic and social benefits for the local population, thus improving their living conditions. It would also reduce CO₂ emissions and air pollution, which is crucial for the two predominant activities in rural areas – tourism and agriculture.

What are the benefits for the state? First and foremost, this is a large investment wave which, according to estimates and analyses, would amount to more than 14 billion HRK. As it involves predominantly new technologies and the metalworking industry, this could also be a new 'rescue' project or a development driver for industries, such as the shipbuilding and metalworking industry. To address the twin challenge of energy efficiency and affordability,

5 Average annual consumption per household obtained on the basis of the analysis of the tabular presentation of energy (heat and electricity) consumption in the document of the Ministry of Environmental Protection and Energy entitled *Energija u Hrvatskoj 2017. - godišnji energetski pregled*, available at: http://www.eihp.hr/wpcontent/uploads/2019/03/Energija2017_final.pdf, 19 January 2020

EU Member States and the EU as a whole need to engage in a 'renovation wave' of public and private buildings. Although increasing renovation rates is a challenge, renovation lowers energy bills, and can reduce energy poverty. As noted earlier, it can also boost the construction sector and is a significant opportunity to support SMEs and local jobs (COM, 2019, p. 640; COM, 2018, p. 773). The amounts mentioned would without doubt encourage the education sector to take a proactive role in re-skilling and up-skilling of the workforce, thus helping them acquire the skills necessary in the field of renewable energy sources. The additional funds available to contractors would encourage new research (which would in turn trigger a new investment cycle). Through this type of investment, the state would soon recoup the invested funds (the stated price includes VAT that would be returned to the state budget, which is why the part of the investment that the state would finance would be negligible when the entire cycle from the initial investment to the return on investment is completed). In addition, the state would reduce the risk of paying penalties and fines for lack of investment in renewable energy sources and would be closer to achieving the goals set in the Europe 2030 strategy⁶ (as well as the ones set in the Europe 2020 strategy). Moreover, it would motivate young people to stay not only in Croatia but also in its less developed regions which would be covered by this measure, as well as support the development of new technology-based industry. Finally, it would support the economy through an investment wave in energy based on the installation of solar power plants similar to investments in public infrastructure made across the United States in the 1930s as part of the New Deal⁷. Considering the problematic state budget and a relatively rigid banking system in terms of credit lines, the focus must be on policies that affect private financing. This, as Butikofer (2014) points out, can be achieved through:

- 1) Tax policy (environmental taxation),
- 2) Creating new markets and directing finances - which will affect the creation of a whole new class of entrepreneurs, and
- 3) Innovative models of loans and partnerships (more on this in: Butikofer, 2014). The stages of integration are presented in Figure 1.

5. CONCLUSION

Living standard and energy consumption are inextricably linked: Without energy, there is no food, no mobility, no heating, no industrial processes, no computers (Verley and Demailly, 2013). It is therefore not surprising that EU Member States have identified key mechanisms for national policies to boost the production of renewable energy, such as:

- 1) Feed-in tariffs (FIT) and feed-in premiums (FIP),
- 2) Quota obligations with tradable green certificates,
- 3) Loan guarantees,
- 4) Soft loans,
- 5) Investment grants,
- 6) Tax incentives, and
- 7) Tendering schemes (Fruhmman and Tuerk, 2014).

In some cases, examined by the European Court of Auditors (ECA), it was found that components for solar panels or wind turbines could revive existing production facilities that had not been previously used for power generation (ECA, 2018). For example, in Bulgaria, more than 90% of renewable energy projects approved in the 2007-2013 period related to solar energy which also benefitted from attractive feed-in tariffs (FIT), a financial incentive that supports renewable energy production. However, other targets had been seriously neglected and emphasis will have to be placed on new forms of incentives (ECA, 2018). Nevertheless, we should not neglect the assessment that solar panels will contribute to the growth of the share of renewable energy in total power generation by about 0.21% (total renewable energy sources 0.7%) for the period 2015-2050. As a result, for example, renewable energy generation capacity will increase eightfold, from around 2,000 GW to 16,000 GW, including solar (7,122 GW) and wind (5,445 GW) power in the period 2015-2050 (Gielen et al., 2019, p. 44). In this context, it is important to mention the framework that supports the European New Deal, which includes:

Figure 1: Six phases of VRE integration and four pillars of flexibility

Phase 6			Peer-to-peer trading	Long-term storage
Phase 5	Advanced plant design	Advanced technology to increase stability	Commercial and residential	Medium-term storage
Phase 4	Flexibility from VRE			Battery storage
Phase 3		Special protection schemes	Large industrial	Reservoir hydro
Phase 2	Plant retrofits	Improved grid infrastructure		
Phase 1	Phases 1 and 2 can usually be managed through existing resources and operational practices			
	Power plants	Grids	DSR	Storage

Source: Authors, adapted from: IEA, 2019

- 1) Taxation,
- 2) Energy Union and climate action,
- 3) EU budget and sustainable finance,
- 4) Local action,
- 5) Research and innovation,
- 6) Industrial strategy and circular economy,
- 7) Free but fair trade,
- 8) The social pillar,
- 9) Digital single market, and
- 10) Competition policy and state aid (COM (2018) 773).

Seetharaman et al. (2019) emphasise the need for a strong political and regulatory framework that supports and promotes a continued focus on renewable energy. It is interesting to note that it takes 25 years to transform an industrial sector and the entire value chain. To achieve the goals for 2050, decisions and actions need to be taken in the next 5 years (COM (2019) 640). Energy is the future, and the fact that it is reasonably priced today does not mean that it will remain so in the future. Countries with long-term development plans are investing in systems that guarantee independence and better control over the resources for which there is a growing need. If such plans give rise to opportunities to achieve demographic targets and support the development of underdeveloped regions, this creates new value and provides a foundation for a better future for the country and all of its inhabitants.

Over the past decades, we have witnessed a significant increase in energy consumption, in particular in the consumption of non-renewable energy sources, which has led to increased environmental pollution. Living in such conditions in a county/region that is also affected by negative demographic trends (high emigration rate and high negative natural population growth), high unemployment rate, negative economic trends, and low income is a challenge in itself. If high energy consumption and high prices of energy generating products are added into that equation, one must give serious and careful thought to energy dependence. All of these issues make the lagging regions a suitable context for research into the role of renewable energy sources in revitalizing the economy and demography of rural areas. Energy efficiency will always require considerable initial, up-front investments, while the benefits are accrued gradually, with outcomes dispersed across the private and public sectors (Payne et al., 2015; Yadav et al., 2019). Nevertheless, one should not neglect the failure of distributive justice principles within the energy sector that is as an almost impenetrable barrier reinforced by traditional power generation and distribution systems (more on this in: Yadav et al., 2019). There are several major reasons why investor interest is relatively low: (1) Long recoupment cycle of such an investment, especially if it is not subsidized, (2) short infrastructure life and (3) disposal at end-of-life. As previously pointed out, a key element of the presented energy model is co-financing (mainly from EU funds) of the construction of solar power plants that can be installed on existing infrastructure in less developed regions. It should be noted that the European Union is energy dependent on certain countries; although not numerous, they are also its main competitors in all fields (politics, economy, energy). In addition, considering the fact that energy imported by the EU comes from or goes through regions and countries that are politically unstable

or hotbeds of numerous conflicts, it is clear why it is necessary to invest in new forms of power plants, and why it is necessary to develop an energy model that will eliminate most potential energy-related and economic problems.

REFERENCES

- Akinyele, D., Belikov, J., Levron, Y. (2017), Battery storage technologies for electrical applications: Impact in stand-alone photovoltaic systems. *Energies*, 10, 1760.
- Benedek, J., Sebestyén, T.T., Bartók, B. (2018), Evaluation of renewable energy sources in peripheral areas and renewable energy-based rural development. *Renewable and Sustainable Energy Reviews*, 90, 516-535.
- Breyer, C., Bogdanov, D., Gulagi, A., Aghahosseini, A., Barbosa, L.S.N., Koskinen, O., Barasa, M., Caldera, U., Afanasyeva, S., Child, M., Farfan, J., Vainikka, P. (2017), On the role of solar photovoltaics in global energy transition scenarios. *Research and Applications*, 25(8), 727-745.
- Madsen, D.N., Hansen, J.P. (2019), Outlook of solar energy in Europe based on economic growth characteristics. *Renewable and Sustainable Energy Reviews*, 114, 109306.
- Butikofer, R. (2014), Financing a Green Industrial Transformation, Taming the Financial Giants, Vol. 7. Available from: <http://www.greeneuropeanjournal.eu/financing-green-industrial-transformation>.
- Castillo, C.P., Silva, F.B., Lavallo, C. (2016), An assessment of the regional potential for solar power generation in EU-28. *Energy Policy*, 88, 86-99.
- Castellazzi, B., Biberacher, M., Hausl, S. (2016), Energy supply for buildings with focus on solar power in the urban context-an interactive web-tool for citizens. *Energy Procedia*, 97, 156-163.
- Cini, V., Drvenkar, N., Čandrić-Dankoš, I. (2017), Energy efficiency projects of budget beneficiaries and its impact on regional economy. In: 20th International Scientific Conference Economic and Social Development, Prague. p402-416.
- Collina, T.Z., Poff, E. (2009), The Green New Deal: Energizing the U.S. Economy, Friedrich Ebert Stiftung, United Nations Environment Programme, 2012. Available from: <https://www.library.fes.de/pdf-files/bueros/usa/06873.pdf>.
- COM. (2018), A Clean Planet for All: A European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy. Available from: <https://www.eur-lex.europa.eu/legal-content/en/txt/?uri=celex:52018dc0773>.
- COM. (2019), The European Green Deal. Available from: https://www.ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf.
- Cunliff, C., Hart, M. (2019), Global Energy Innovation Index: National Contributions to the Global Clean Energy Innovation System. Available from: <http://www.2.itif.org/2019-global-energy-innovation-index.pdf>.
- Dribssa, E., Coglian, E., Lavagno, E., Petrarca, S. (1999), A modification of the Heliosat method to improve its performance. *Solar Energy*, 65, 369-377.
- Drvenkar, N., Marošević, K. (2014), The Green Industry and the Regional Competitiveness, Zbornik Radova VII Međunarodnog Simpozija: 7th International Conference An Enterprise Odyssey: Leadership, Innovation and Development for Responsible Economy, Faculty of Economics and Business. Croatia, Zadar: University of Zagreb.
- ECA. (2018), Renewable Energy for Sustainable Rural Development: Significant Potential Synergies, but Mostly Unrealised, Special Report No. 5. Available from: https://www.eca.europa.eu/lists/ecadocuments/sr18_05/sr_renewable_energy_en.pdf.
- Eurostat. (2020), Renewable Energy Statistics. Available from: <https://>

- www.ec.europa.eu/eurostat/statistics-explained/index.php/renewable_energy_statistics.
- Fruhmann, C., Tuerk, A. (2014), Renewable Energy Support Policies in Europe. Climate Policy Info Hub. Available from: <http://www.climatepolicyinfocenter.eu/renewable-energy-support-policies-europe>.
- Gielen, D., Boshell, F., Saygin, D., Bazilian, M., Wagner, N., Gorini, R. (2019), The role of renewable energy in the global energy transformation. *Energy Strategy Reviews*, 24, 38-50.
- Good, C.S., Lobaccaro, G., Harklau, S. (2014), Optimization of solar energy potential for buildings in urban areas-a Norwegian case study. *Energy Procedia*, 58, 166-171.
- Gurung, A., Qiao, Q. (2018), Solar charging batteries: Advances, challenges, and opportunities. *Joule*, 2, 1217-1230.
- Hsu, A., Rosengarten, C., Weinfurter, A., Xie, Y. (2017), Renewable Energy and Energy Efficiency in Developing Countries: Contributions to Reducing Global Emissions, United Nations Environment Programme, Third Report.
- Huld, T., Salis, E., Pozza, A., Herrmann, W., Muellejans, H. (2016), Photovoltaic energy rating data sets for Europe. *Solar Energy*, 133, 349-362.
- IEA. (2019), Solar Energy: Mapping the Road Ahead. Paris: IEA. Available from: <https://www.iea.org/reports/solar-energy-mapping-the-road-ahead>.
- IPCC, editor. (2014). Climate Change 2014-Mitigation of Climate Change, Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available from: <https://www.ipcc.ch/report/ar5/wg3>.
- Jenniches, S. (2018), Assessing the regional economic impacts of renewable energy sources-a literature review. *Renewable and Sustainable Reviews*, 93, 35-51.
- Jakovac, P., Vlahinić-Lenz, N. (2016), Energija i Ekonomija u Republici Hrvatskoj: Makroekonomski Učinci Proizvodnje i Potrošnje Električne Energije, Ekonomski Fakultet Sveučilišta u Rijeci. Available from: https://www.bib.irb.hr/datoteka/839101.jakovac_vlahini_lenz_-_energija_i_ekonomija_u_republici_hrvatskoj.pdf.
- Janessen, R., Staniaszek, D. (2012), How Many Jobs? A Survey of the Employment Effects of Investment in Energy Efficiency of Buildings, The Energy Efficiency Industrial Forum. Available from: <https://www.euroace.org/wp-content/uploads/2016/10/2012-how-many-jobs.pdf>.
- Jenniches, S. (2018), Assessing the regional economic impacts of renewable energy sources-a literature review. *Renewable and Sustainable Reviews*, 93, 35-51.
- Kabira, E., Kumarb, P., Kumarc, S., Adelodund, A., Kim, K. (2017), Solar Energy: Potential and Future Prospects. Available from: <https://www.sciencedirect.com/science/article/pii/S1364032117313485>.
- Kantej, L. (2017), Procjena Mogućnosti Korištenja Baterijskih Spremnika za Kućanstva uz Fotonaponske Sustave, Geotehnički Fakultet, Varaždin.
- Landsberg, H.H. (1974), Low-cost, abundant energy: Paradise lost? *Science*, 184(4134), 247-253.
- Madsen, D.N., Hansen, J.P. (2019), Outlook of solar energy in Europe based on economic growth characteristics. *Renewable and Sustainable Energy Reviews*, 114, 109306.
- Madsen, D.N., Hansen, J.P. (2019), Outlook of solar energy in Europe based on economic growth characteristics. *Renewable and Sustainable Energy Reviews*, 114, 109306.
- Munari, P.M., Roecker, C. (2019), Criteria and policies to master the visual impact of solar systems in urban environments: The LESO-QSV method. *Solar Energy*, 184, 672-687.
- Munawwar, S., Ghedira, H. (2014), A review of renewable energy and solar industry growth in the GCC region. *Energy Procedia*, 57, 3191-3202.
- Oberle, B., Bringezu, S., Hatfeld-Dodds, S., Hellweg, S., Schandl, H., Clement, J., Cabernard, L., Che, N., Chen, D., Droz-Georget, H., Ekins, P., Fischer-Kowalski, M., Flörke, M., Frank, S., Froemelt, A., Geschke, A., Haupt, M., Havlik, P., Hüfner, R., Lenzen, M., Lieber, M., Liu, B., Lu, Y., Lutter, S., Mehr, J., Miatto, A., Newth, D., Oberschelp, C., Obersteiner, M., Pfister, S., Piccoli, E., Schaldach, R., Schüngel, J., Sonderegger, T., Sudheshwar, A., Tanikawa, H., van der Voet, E., Walker, C., West, J., Wang, Z., Zhu, B. (2019), Global Resources Outlook 2019: Natural Resources for the Future We want, United Nations Environment Programme. Available from: https://www.resourcepanel.org/sites/default/files/documents/document/media/unep_252_global_resource_outlook_2019_web.pdf.
- Paduos, S., Corrado, V. (2017), Cost-optimal approach to transform the public buildings into nZEBs: An European cross-country comparison. *Energy Procedia*, 140, 314-324.
- Paul, M., Fremstad, A., Mason, J.W. (2019), Decarbonizing the US Economy. Pathways toward a Green New Deal, A Roosevelt Institute. Available from: https://www.rooseveltinstitute.org/wp-content/uploads/2019/06/roosevelt-institute_green-new-deal_digital-final.pdf.
- Payne, J., Weatherall, D., Downy, F. (2015), Capturing the Multiple Benefits of Energy Efficiency in Practice: The UK Example, Energy Saving Trust, ECEEE Summer Study Proceedings. p229-238. Available from: https://www.energysavingtrust.org.uk/sites/default/files/reports/1-424-15_payne.pdf.
- Perpiña, C.C., Batista e Silva, F., Lavalle, C. (2016), An assessment of the regional potential for solar power generation in EU-28. *Energy Policy*, 88, 86-99.
- Photovoltaic Geographical Information System. (2017), PVGIS Tools, EU Science Hub, The European Commission's science and Knowledge Service. Available from: <https://www.ec.europa.eu/jrc/en/pvgis>.
- Podder, S., Khan, Z.R. (2016), Comparison of lead acid and Li-ion battery in solar home system of Bangladesh. In: 5th International Conference on Informatics, Electronics and Vision (ICIEV). p434-438.
- Rawat, D., Sauni, P. (2015), Importance and prospects of renewable energy: Emerging issues in India. *International Journal of Art and Humanity Science*, 2(4), 11-18.
- Seetharaman, A., Moorthy, K., Patwa, N., Saravan, Gupta, Y. (2019), Breaking barriers in deployment of renewable energy. *Heliyon*, 5, e01166.
- Rigollier, C., Lefèvre, M., Cros, S., Wald, L. (2002), Heliosat 2: An Improved Method for the Mapping of the Solar Radiation from Meteosat Imagery. Dublin, Ireland: EUMETSAT Meteorological Satellite Conference. p585-592. Available from: <https://www.hal-mines-paristech.archives-ouvertes.fr/hal-00465571/document>.
- Rigollier, C., Lefèvre, M., Wald, L. (2004), The method Heliosat-2 for deriving shortwave solar radiation from satellite images. *Solar Energy*, 77, 159-169.
- Rozentale, L., Lauka, D., Blumberga, D. (2018), Accelerating power generation with solar panels. Case in Latvia. *Energy Procedia*, 147, 600-606.
- Ruiz, P.C., Nijs, W., Tarvydas, D., Sgobbi, A., Zucker, A., Pilli, R., Jonsson, K., Camia, A., Thiel, C., Hoyer-Klick, C., Dalla, L.F., Kober, T., Badger, J., Volker, P., Elbersen, B., Brosowski, A., Thrän, D. (2019), ENSPRESO-an open, EU-28 wide, transparent and coherent database of wind, solar and biomass energy potentials. *Energy Strategy Reviews*, 26, 1-12.
- Seetharaman, A., Moorthy, K., Patwa, N., Saravan, A.S., Gupta, Y. (2019), Breaking barriers in deployment of renewable energy. *Heliyon*, 5, e01166.
- Song, M., Lee, S., Kim, D., Lee, C., Jeong, J., Seo, J., Kim, H., Song, D.I., Kim, D., Kim, Y. (2017), Charging characteristics of lithium ion battery using semi-solar modules of polymer: Fullerene solar cells. *Energies*, 10, 1886.

- Šúri, M., Batista e Silva, F., Lavalle, C. (2007), Potential of solar electricity generation in the European Union member states and candidate countries. *Solar Energy*, 81, 1295-1305.
- Talaei, M., Mahdavejad, M., Zarkesh, A., Haghighi, H.M. (2017), A review on interaction of innovative building envelope technologies and solar energy gain. *Energy Procedia*, 141, 24-28.
- Verley, P., Demailly, D. (2013), The Aspirations of the Green Industrial Revolution: A Historical Perspective, *Industry in a Post-Industrial Society*, Vol. 6. Available from: <http://www.greeneuropeanjournal.eu/green-industrial-revolution>.
- Yadav, P., Davies, P.J., Sarkodie, S.A. (2019), The prospects of decentralised solar energy home systems in rural communities: User experience, determinants, and impact of free solar power on the energy poverty cycle. *Energy Strategy Reviews*, 26, 100424.