RENEWABLE ENERGY SOLUTIONS FOR FINANCING OF RENOVATION OF CONDOMINIUM HOUSING

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Abstract. Research background: Importance of the energy consumption in the urban structures is getting increasing attention in the context of exhausting of non-renewable sources of energy and the global warming prospective. Therefore, both energy saving and renewable energy options within the built environment are considered to mitigate the looming global negative changes. The concept of Positive Energy Districts (PED) is getting increasing popularity among researchers and urban practitioners. Positive Energy Districts and Neighborhoods are an integral part of comprehensive approaches towards sustainable urbanization including technology, spatial, regulatory, financial, legal, social and economic aspects.

Purpose: Worldwide pilot developments are exploring the concept of PED as urban neighborhood with annual net zero energy import and net zero CO_2 emissions by integration between buildings, the residents and the energy, mobility and ICT systems. The purpose of the paper is focused on the investigating the potential of use the concept by integrating of renewable energy sources in apartment housing estates. The phenomenon of prevailing large scale multistory mass housing estates is taking place in almost all Eastern European countries. It leads to threefold problem of low living standard, low energy efficiency and deterioration of housing in such estates. The use of PED concept for such housing estates could have the potential to solve the problem by integrating of RES within the multistory housing. For the purpose it is instrumental to investigate the local specifics, pros and cons for the case of Bulgaria in regard to housing technologies and legislation climate conditions and residents mentality etc.

Methods: Analysis of the potential of use of mass large scale condominium housing to be used for integration of RES. Analysis of potential viable options for use of funds from produced energy for refurbishment of multistory apartment buildings and the related institutional and legal provisions that would be necessary.

Findings and novelty: The lack of proper maintenance and management of large scale condominium housing is a common problem in post-Soviet Eastern European countries starting from the very beginning of occupation of such apartment buildings. After the political and economic changes in 90-ies of last century the problem worsened in the context of missing legislation and financing that has led to systemic and permanent process of deterioration of such housing. Another weak point of such buildings is the extremely high extent of energy inefficiency leading to increasing issue of energy poverty for the residents of condominium apartments. The paper

investigates the potential to convert the problems into opportunities by integration of renewable energy sources into industrially built mass multistory apartment housing using the funds from produced RES energy to fund condominium apartment buildings renovation.
Keywords: sustainable architecture; LCCA, renewable energy; payback period
JEL: Q01, Q42, R11, R21, R31, R58

1. The concept of Positive Energy District (PED)

As known buildings account for 40% of energy consumption in the EU, transformation of the built environment is a key step in the climate neutral strategy. Europe has made significant progress at building level innovations by the development of the concept of Nearly Zero-Energy Buildings (NZEBs). The further step aims at establishing citywide transformation with the pioneering concept of Positive Energy Districts (PEDs), which is based on the idea of the smart cities. The concept of PED-s is in the phase of shaping, it still needs to be refined, advanced, demonstrated, implemented and replicated (Aghamolaei et al., 2018).

Transformation of the building sector is one of the main challenges that Europe is facing and the largescale deployment of NZEBs is seen as one of the essential means. The recasted Energy Performance of Buildings Directive EPBD 2010/31/EU[1] makes NZEBs a standard for new buildings by end of 2020. In order to fulfil this requirement, Member States need to develop policies and measures to stimulate the uptake of NZEBs. According to an assessment by the Joint Research Centre (JRC) of the European Commission (EC), progress can be seen in many Member States in developing the NZEB concept (European Commission: Joint Research Centre, 2016).

In order Europe to be climate neutral by 2050 there is a need for commitments beyond NZEBs. It demands scaling up of efforts from the building level to the district and eventually city level. The Strategic Energy Technology Plan (SET Plan) of the EC aims to accelerate the development and deployment of the most impactful technologies in the EU's transformation to a low-carbon energy system by coordinating research and innovation efforts amongst EU countries, companies, research institutions, and the EU itself. In June 2018, the SET Plan on Action 3.2 “Smart Cities and Communities” was endorsed by the EC. The main objective is to develop integrated and innovative solutions for the planning, deployment, and replication of Positive Energy Districts (PEDs). According to the SET Plan Action 3.2 document, 100 PEDs are expected to be in concrete planning, construction or operation, synergistically connected to the energy system in Europe by 2025.

JPI Urban Europe (JPIUE) hosts the program “Positive Energy Districts and Neighborhoods for Sustainable Urban Development”, which aims to

[1] Energy Performance of Buildings Directive EPBD 2010/31/EU, European Union, 2010.

coordinate efforts of stakeholders from research and innovation funding networks, cities, industry, research institutions and citizen organizations[1]. Europe is poised to enable transitions towards a climate neutral economy and the concept of PEDs will be introduced in the energy planning of many cities and communities in the coming years (Koutra, Becue & Gallas, 2018). Active management will allow for balancing and optimization, peak shaving, load shifting, demand response and reduced limitation of RES, and district-level self-consumption of electricity and thermal energy. A Positive Energy District pairs built environment, sustainable production and consumption, and mobility to reduce energy use and greenhouse gas emissions and to create added value and incentives for the consumer. Furthermore, implementation has to come with a high and affordable standard of living for its inhabitants. Urban development is moving from single building solutions to Positive Energy Districts and neighborhoods and similar innovative concepts to reach the European energy and climate targets. As an integral part of comprehensive sustainable urbanization strategies including societal, social, economic, cultural aspects and the involvement of citizens, establishing Positive Energy Districts shift the focus from the individual positive energy building to positive energy blocks towards neighborhoods and thus a new level of impact on sustainable urban development and the energy transition process.

The planning, deployment and replication of PEDs requires an innovation model with active involvement of different stakeholders. Cities will take a leading role in integrating PEDs in their long-term urban strategies (Droege, 2018). Industries will play a vital role as providers of efficient and clean energy solutions. Energy consumers will become prosumers and take part in energy trading. Investors will develop new models for cooperative innovation and participatory funding. Researchers will create methods to support the planning, implementation, monitoring and evaluation of PEDs as well as strengthen capacity building of suitable experts. The strategic vision towards 100 PEDs by 2025 is clear and inspiring. The main challenge so far is to establish an open innovation model that can drive Europe towards this goal (Appio, Lima & Parou, 2018].

2. The program "Positive Energy Districts and Neighborhoods for Sustainable Urban Development"

The Program has been developed as a cooperation of 20 European countries, the European Commission and different stakeholder groups with the intention of establishing a transnational, intergovernmental initiative for planning and replication of Positive Energy Districts and neighborhoods (fig.1). In order to boost urban energy transition, the program coordinated by

[1] Available at: https://jpi-urbaneurope.eu/ped/

JPI Urban Europe involves stakeholders from research and innovation funding networks, cities, industry, research and citizen organizations[1].

In order to become a successful model, implementation processes will have to tackle a range of challenges (fig.2), consider regional differences within Europe and provide open experimental space for smart innovative solutions. A circular pathway (fig.3) of monitoring, experimenting, developing guidelines and replication provides the framework for mainstreaming urban solutions of energy transition within the years to come. Finally, yet importantly, success of implementation will strongly depend on citizen acceptance and therefore will have to account for affordability and an actual improvement of quality of life for the citizens.

Figure 1. Current member states of the Programme on Positive Energy Districts and Neighbourhoods (https://jpi-urbaneurope.eu/wp-content/uploads/2019/09/PEN-Leaflet-190924.pdf)

[1] Available at: https://jpi-urbaneurope.eu/wp-content/uploads/2019/09/PEN-Leaflet-190924.pdf

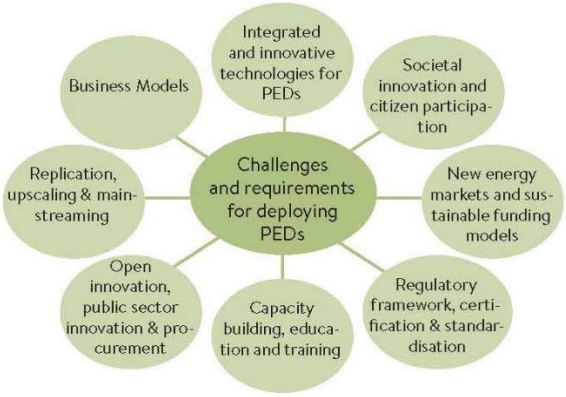

Figure 2. Key challenges and needs for deploying PEDs (https://jpi-urbaneurope.eu/wp-content/uploads/2019/09/PEN-Leaflet-190924.pdf)

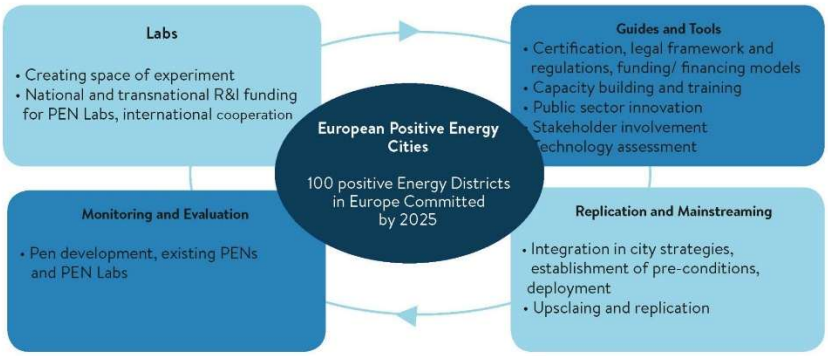

Figure 3. Circular pathway (https://jpi-urbaneurope.eu/wp-content/uploads/2019/09/PEN-Leaflet-190924.pdf)

Municipalities and urban actors play a key role in achieving energy and climate targets. By creating the pre-conditions cities and communities are the driving forces behind establishing Positive Energy Districts and Neighborhoods. European cities are already very active in integrating strategies of sustainable urbanization – the Program on Positive Energy Districts and Neighborhoods offers partnership and support for cities in doing the next step of sustainable urban development and becoming frontrunners in the field of energy transition. Being part of the problem means being part of the solution: cities consume two thirds of energy supply and 70% of CO2-emissions come from urban environments. The program offers an intense dialogue with cities and other stakeholders on urban transition – together we will develop feasible and socially sound pathways for creating livable urban neighborhoods meeting the challenges of the 21st century.

3. PEDs towards climate neutrality: transforming existing housing neighborhoods

With the formulation of the European Green Deal and the Mission on Climate-Neutral and Smart Cities, the European Commission has set ambitious goals regarding climate change adaptation and the energy transition. For European urban areas this implies also a strong focus on existing housing estates and therefore needs of innovative retrofitting and redesign strategies towards Positive Energy Districts. European Union developed a "renovation wave" strategy and action plan with particular measures to enhance renovation activity. Aggregated, urban level approach, such as Positive Energy Districts concept is an essential piece of the EU's renovation wave strategy thanks to the economies of scale of combining single projects into district-wide approaches (Bruck, Diaz Ruano & Auer, 2022). The three PED pillars are energy efficiency, renewable energy generation and energy flexibility, implying also a high standard of living.

The case of Eastern Europe seems even much more complicated. The high priority of the ambitious goal for climate neutrality of built environment requires intensive and continuous efforts to reconcile this goal with the existing realities in this region, concerning large housing estates, consisting mostly of mass multistory apartment buildings, erected by industrial ways (large panel etc.). The situation is further exacerbated by the distorted tenure structure of mass housing with homeownership exceeding more than 90% of apartments in some countries (Bulgaria, Romania etc.). The large scale multistory mass housing estates has prevailing share in almost all Eastern European big cities. It leads to threefold problem of low living standard, low energy efficiency and deterioration of housing in such estates. The use of PED concept for transforming of such housing estates could have the potential to solve the problem by integrating of RES within the existing housing structures. For the purpose it is instrumental to investigate the local specifics including technology, climate, regulatory, financial and social aspects.

4. The potential of integration of RES in mass large scale multistory condominium housing

4.1. Solar Cities Project

The project team informs citizens, businesses, and public institutions on the potential of their properties – especially unused roof spaces – for generating solar energy. For this purpose, the team develops a digital platform that provides helpful information: how many PVs can be installed and where, how much energy they can potentially generate, how high is the required investment, and how long will it take for investment return? Additionally, the project team targets potential investors and offers them detailed guidelines on processes and requirements for PV installation. This is supplemented by

dedicated units in both town administrations, who provide administrative support to potential investors. A series of events and trainings targets representatives of local and state administrations, of small and medium enterprises, of homeowner associations, public building managers, and residents of multi-family apartment buildings. These aim to further spread knowledge and to pave the way for joint projects between city administration, businesses, and citizens/energy cooperatives. With these measures, the project team aims to kick-start the broad installation of PVs in the region, thus contributing to its energy transformation and creating an example to follow for other municipalities in the region. Considering the meteorological conditions in Bulgarian cities, solar power is the most promising source of renewable energy for them. Businesses in particular are capitalizing on this and investing in photovoltaic systems. For many private homeowners, weighing up this kind of investment is often more difficult. 'Personally, I've always wondered about the cost of photovoltaic systems in apartments. I was keen to know how much of your energy consumption they would cover, but I couldn't get hold of the information,' says Ivaylo Trendafilov from Burgas Municipality. Now, these questions can be answered. Trendafilov works for the energy office in Burgas, one of the first to open in Bulgaria and part of the EUKI-funded project 'Unlocking the Solar Potential of Burgas and Sofia', also known as 'Solar Cities'. Another energy office opened in Sofia.

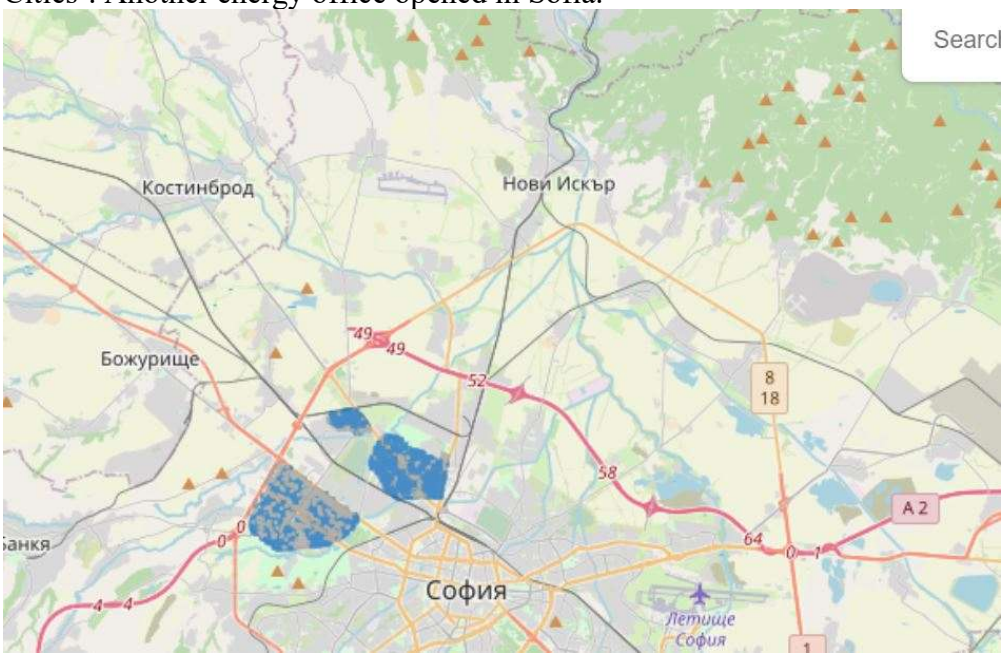

Figure 4. Localization of the investigated housing estates in Sofia (https://sofia.solarcities.bg)

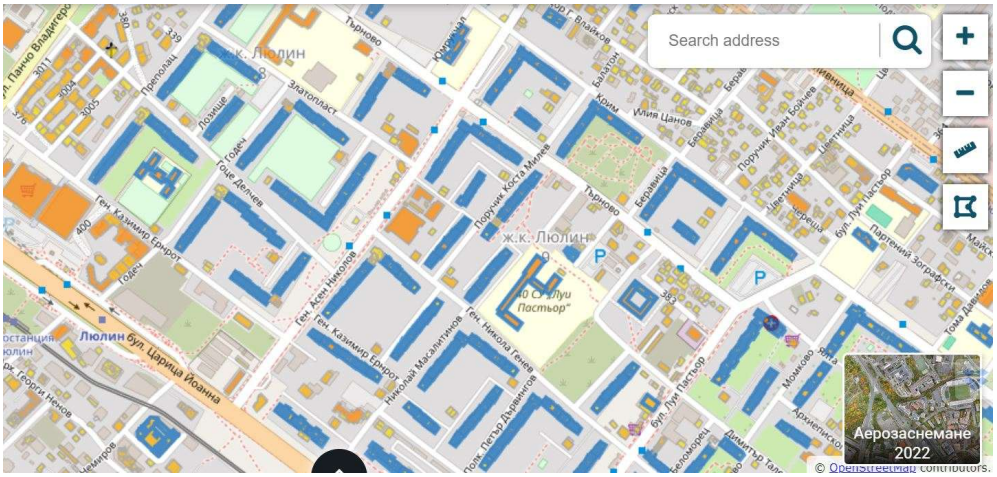

Figure 5. Map of Lulin housing estate in Sofia with the buildings roofs studied (https://sofia.solarcities.bg/)

4.2. Pilots in Sofia and Burgas

The offices opened at a really good time, as a program had been launched for sustainable energy renovation of multi-family residential buildings in Bulgaria that entailed a complex application process for citizens. In these one-stop shops, officers explain the programme's requirements and citizens receive support with filling out the paperwork. 3200 people have already come through the doors of the office in central Burgas since it opened in 2022 to find out about the national programme and smart methods of installing solar panels. Another of the project's accomplishments are accurate solar maps produced from drone footage that focus on public buildings and apartments. These maps are available online at burgas.solarcities.bg and sofia.solarcities.bg. 'A total of 5700 buildings were mapped in three residential districts of Sofia. 2800 of these buildings were identified as offering the most potential. The map provides very detailed information, including feasibility studies for installing panels on each building and data on how much energy can be produced,' explained Tsonka Harizanova from Sofia Municipality. The metropolitan municipality organised two information days for citizens and businesses (an open-air one and one at its own premises), along with two training events (one for employees of municipal administrations and one for citizens and businesses in the pilot districts). The 500 or so attendees showed great interest in the opportunities offered by the project. At a two-day exhibition for renewable energy sources in Burgas mid-October 2023, 20 representatives of photovoltaic installers, charging stations operators or automobile companies showed their products to interested businesses and citizens. They also participated in information sessions dedicated to the benefits of photovoltaic installations, solutions for generating and storing solar

energy as well as the status and perspectives of an electronic vehicle charging infrastructure in Bulgaria.[1]

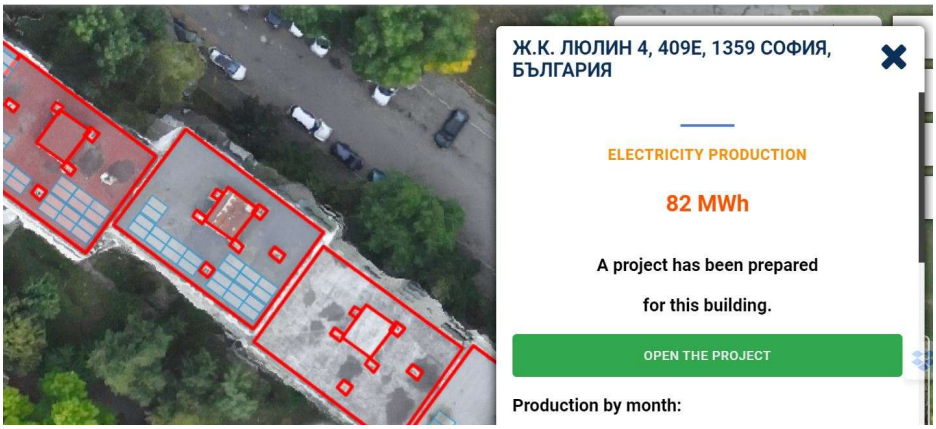

Figure 6. Aerial view of the building roof with PHV technical proposal (https://sofia.solarcities.bg/)

5. How to empower the potential of deployment of RES within mass housing condominium estates

5.1. Existing situation

Energy inefficiency of the housing in Eastern Europe and related fuel poverty is a problem of momentous importance but it could also be viewed as an opportunity for reshaping of the housing sector through innovative housing initiatives in energy retrofit of condominium housing. Such an approach uses financial and management tools based on energy saving-oriented housing retrofit (Georgiev, 2017). The region comprises of 11 EU member states that joined the EU from 2004 to 2013. Due to process of forced urbanization during the rule of communist governments in Eastern Europe, about half of the existing housing stock in these countries was constructed between 1960 and 1990 of the twentieth century. During this time, new housing construction was consisting predominantly of pre-fabricated large-scale multifamily housing apartment blocks built in cities with little or no consideration of energy efficiency. For example, this type of housing represents about 70% of the existing housing stock in Bucharest and 45% in Sofia (United Nations, 2013).

During the time of the centrally planned economy until 1989, the planning, development and construction of new housing were almost fully implemented by the state within the frame of the five year 'socio-economic development plans'. A limited and distorted private sector activity existed in the so-called 'individual' and 'cooperative' housing construction. That share of housing supply, in addition to being a minor, was the subject of inequality

[1] Available at: https://www.euki.de/en/euki-projects/burgas-sofia/

in terms of access to financing, subsidies and building materials supply, compared to the state housing development. According to the prevailing in this period doctrine of the centrally planned economy, all the parameters of the dwellings to be built – quantitative, qualitative, financial, etc. – were also determined in a centralized way through housing planning in the framework of five-year development plans (Georgiev 2017).

The quick mass privatization of high-rise apartment buildings left many Eastern European countries without an adequate regulatory framework for management and maintenance of these newly formed condominiums, as pointed out by various researchers (Lujanen, 2010; Tsenkova, 2005; Georgiev, 2017). In addition, new homeowners had few resources to manage and maintain their newly acquired apartments as well as the adjacent common areas of the buildings. As a result, after the transfer of ownership, the housing stock in many countries from the region is ageing prematurely and deteriorating following the low quality of construction works and used materials, lack of funds and proper maintenance. Due to the above-mentioned reasons, combined with the inherited from the socialist past low construction quality and lack of management, high rise apartment buildings in Eastern Europe are in general extremely energy inefficient (United Nations, 2013).

5.2 Potential solutions by use of building integrated RES

Nowadays we are facing the growing interest and rapid expansion of the pilot developments that are exploring the concept of PED worldwide within urban neighborhoods by integration between buildings, the residents and the energy through ICT systems. Regardless the variety of existing problems in functioning of large scale multistory housing estates in Eastern European countries and in Bulgaria in particular there are some opportunities to turn the problems into solutions. There is a certain huge but unexplored yet potential of integrating of renewable energy sources in apartment condominium housing estates. The recent pilot projects in Sofia and Burgas investigated the technical aspects of installing, operating and the energy capacity of having photovoltaic panels on the flat roofs of multistory condominium housing buildings. However, despite the promising prospective, the most problematic issues regarding financing, ownership structure, participating institutions and operation of Photovoltaic panels still remain unclear. The prospective solutions could be seen in finding of ESCO type cooperation between homeowners associations and financing/operating party that most likely will be local energy distribution (utility) companies. Some legal provisions need to be created in order to ensure both party interests. Well-designed ESCO type contract will ensure not only financing of RES installation on the apartment buildings flat roof but even implementation in advance of energy saving building renovation

measures, that will be repaid from the produced energy by RES with certain period of time, stipulated in the ESCO contract.

Conclusion

The major obstacles for large scale energy efficient renovation of multistory condominium apartment housing have always been dispersed ownership structure over the buildings and the lack of sufficient funding. By use of the potential of building integrated RES in ESCO based cooperation with energy distribution (utility) companies we could overcome both of them:

- by channeling the untapped resource form produced energy towards building renovation
- by regulating the homeowners rights and obligations through unifying role of ESCO contract

In addition, we will still need creation of necessary legal provisions in order to ensure both party interests during the longer term project relations.

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