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## Integrated models of the combination of EU grant funding and private funding in the energy sector of Ukraine based on Public-Private Partnership

**Abstract:** The post-war reconstruction of the energy sector of Ukraine is a critical issue that requires significant investment in both infrastructure and modernization. However, the limited financing of the public sector is a problem that needs to be addressed. A combination of European Union (EU) grant funding and private funding through public-private partnerships (PPPs) has been suggested as a potential solution to this problem. The relevance of this topic lies in the potential of PPPs to attract resources and experience from both the public and private sectors. This can lead to a more efficient use of resources and can help solve the problems associated with limited public sector funding. In addition, PPPs can provide a framework for sharing risks between the public and private sectors and can help mobilize private sector resources and expertise, which can be critical in post-war recon-

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struction efforts. In addition, a combination of EU grant funding and private funding through PPPs can contribute to broader economic development by promoting investment in the energy sector. This can help stimulate economic growth, create jobs and improve energy security, which is critical for the long-term sustainability of Ukraine's energy sector. Thus, the topic of combined models of uniting EU grant funding and private funding based on public-private partnership for the post-war reconstruction of the energy sector of Ukraine is extremely relevant for solving problems related to limited public sector funding, attracting resources and experience from both public and private sectors as well as promoting the broader economic development of Ukraine.

Keywords: VOSviewer, public-private partnership, post-war recovery Ukraine, energy infrastructure, energy sector

## Introduction

Important for attracting foreign investments is the implementation of the best international practices in national legislation. In this context, there is a need to study the experience of “combined” projects based on public-private partnership and grant funding. A “combined” project is a project that is implemented under a PPPs agreement and that combines state and private funding, where part of the state funding is provided directly in the form of a grant from the EU Structural Funds or other international organizations (Using EU Funds in PPPs 2011; EU Funds in PPPs 2012; Hybrid PPPs 2006; Goldsmith 2008; Geest 2011). Rebuilding destroyed infrastructure, people's homes and businesses is quite a challenge during wartime. Energy infrastructure facilities need to be restored as a priority, and public-private partnership is one of the most convenient tools for implementing a reconstruction plan during both the war and post-war reconstruction. However, the public-private partnership mechanism needs to be adapted to attracting investments for the reconstruction of the destroyed energy infrastructure in Ukraine. Moreover, there are already examples of attracting business and EU grant funds (Public-private partnership; The World Bank; Local economic development 2020; Zapatrina 2017) and the local budget for the reconstruction of social and other infrastructure of Ukraine, which suffered from the war.

The purpose of the study is to bridge the gap between public and private sector funding in the energy sector of Ukraine by researching and developing effective strategies for attracting both European Union grant funding and private investment through public-private partnerships. The study aims to explore how these sources can be strategically combined through public-private partnerships to drive economic development, innovation and sustainable growth in Ukraine's post-war energy sector.

# 1. Literature review

The results of the bibliometric analysis of 2,000 documents published in scientific journals on the scientometric search and analytical platform dimensions showed that scientists from the United States of America, China and Australia were the first to start researching the issue of applying forms of public-private partnership in energy (Fig. 1). Keywords such as “public-private partnership”, “PPPs”, “energy”, “renewable energy” and “sustainable development” were selected for the literature review.

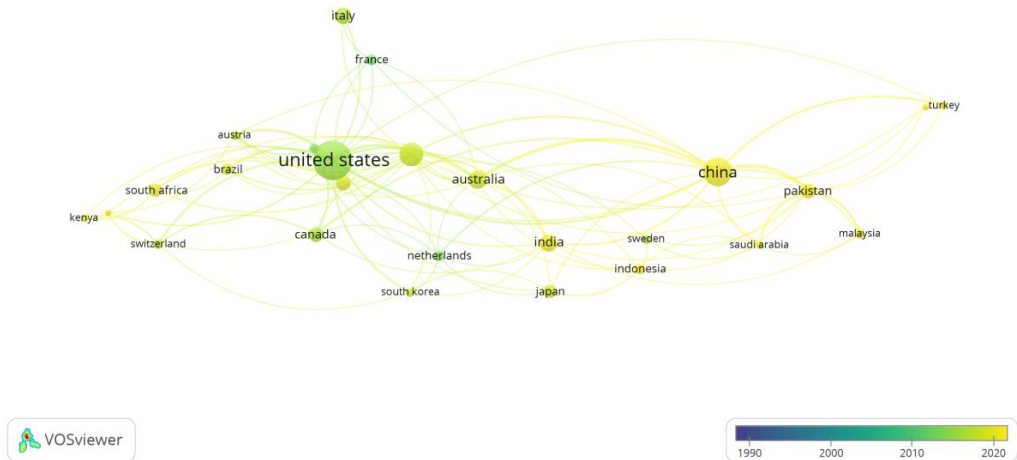


Fig. 1. Visualization map of basic scientific clusters in the study public-private partnership in energy by country

Rys. 1. Wizualizacja podstawowych klastrów naukowych w badaniu partnerstwa publiczno-prywatnego w energetyce według krajów

Using VOSviewer, the meta-analysis results confirmed that the public-private partnership in the energy aspect was studied from the point of view of production modernization and economic growth (red and blue clusters, Fig. 2a) and qualitative characteristics of partnership application (green cluster, Fig. 2a).

In addition, since 2014, scientific communities have been investigating the issue of public-private partnerships for energy development (Fig. 2b). For example, the impact of public-private partnership investments on technological innovation and carbon emissions in different countries has been investigated. The authors of the study (Adebayo et al. 2021) presented results on renewable energy consumption and technological innovation reducing CO<sub>2</sub> emissions, while public-private partnership investments in energy and economic growth increased CO<sub>2</sub> emissions. This study recommends promoting renewable energy consumption by focusing on technological innovation in the East Asia and Pacific regions. Other scientists (Behera and Dash 2017) have examined the relationship between urbanization, energy consumption, foreign direct investment

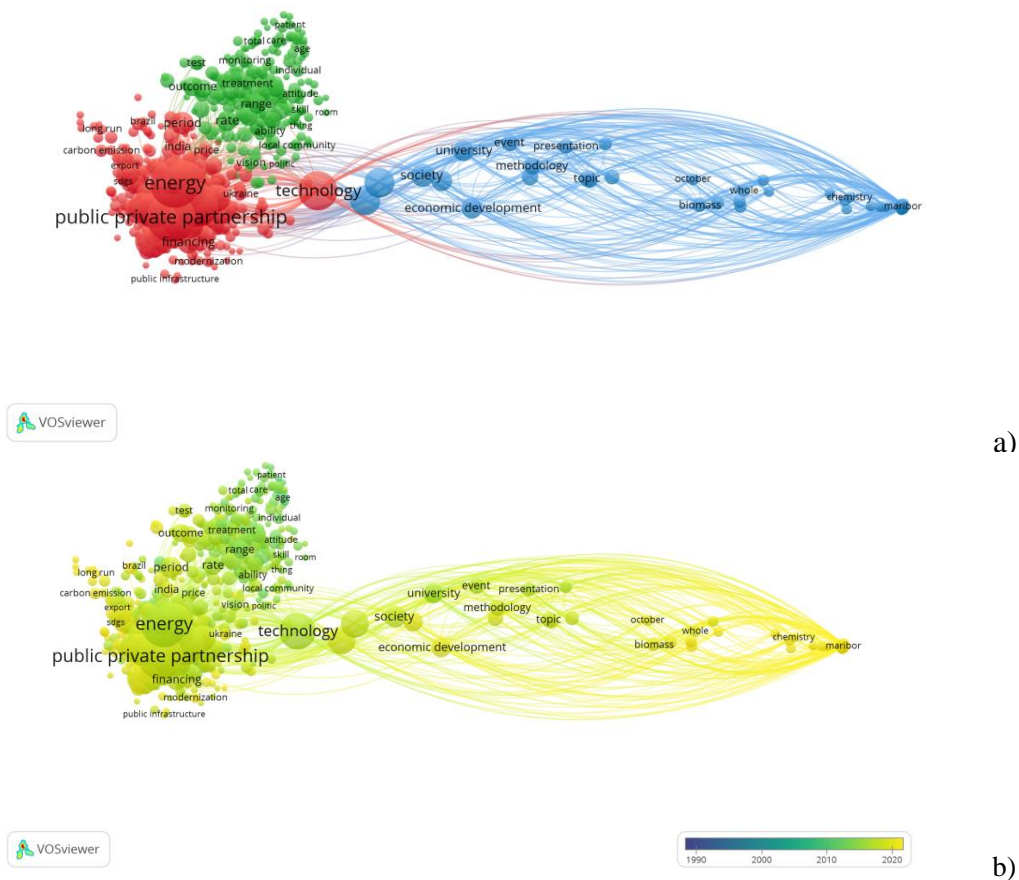


Fig. 2. Visualization map of the main scientific clusters in the study of public-private partnership in energy: (a) commonality analysis; (b) time-lapse visualization

Rys. 2. Wizualizacja głównych klastrów naukowych w badaniu partnerstwa publiczno-prywatnego w energetyce: (a) analiza podobieństw; (b) wizualizacja poklatkowa

and carbon dioxide emissions in seventeen countries of the South and Southeast Asia region during the period 1980–2012; the results showed that primary energy consumption, fossil energy consumption, fuel and foreign direct investment significantly affect CO<sub>2</sub> emissions in the region.

## 1.1. Public-Private Partnership in Pakistan

Scholars (Ning et al. 2023) have examined public-private partnerships in the context of sustainable development in Pakistan and have studied the impact of green innovation, public-private partnerships in energy, energy use, economic development and electricity prices on CO<sub>2</sub> emis-

sions in Pakistan from 1980–2019. The study (Chunling et al. 2021) studied the role of public-private partnership investment in energy in influencing the long-term environmental sustainability of Pakistan from 1992 to 2018. They found a long-term equilibrium relationship between the environmental footprint and public-private partnership investment in energy, technological innovation, economic growth and trade openness.

## 1.2. Public-Private Partnership in China

The authors of other work (Khan et al. 2020) investigated the impact of public-private partnership investments in energy and technological innovation on carbon dioxide emissions in China for the period 1990–2017. Other scholars (Shahbaz et al. 2020) examined the relationship between PPP investment in the energy sector and carbon emissions, given the vital role of technological innovation in China's carbon emissions function. Other authors (Khan et al. 2020) investigated the impact of public-private partnership investment in energy and technological innovation on China's consumption-based carbon emissions in 1990–2017. Other scholars (Cheng et al. 2021a) investigate the impact of public-private partnerships in energy and energy efficiency on CO<sub>2</sub> emissions in China from 1991 to 2017. The results of these studies have revealed a relationship between energy PPP investment, technological innovation, renewable energy consumption, exports, imports and consumption-based carbon emissions, and in the long run, PPP investment and technological innovation drive China's carbon emissions through consumption. The results show that increasing incomes and public-private partnerships have increased China's carbon emissions. Conversely, increased energy productivity, renewable energy sources and technological innovation have a negative impact on CO<sub>2</sub> emissions.

## 1.3. Public-Private Partnership in India

Kirikaleli and Adebayo (2021a) examined the impact of renewable energy consumption and PPP energy investment on carbon dioxide emissions in India in 1990 and 2015, while controlling for technological innovation and economic growth. The authors (Kirikaleli and Adebayo 2021b) studied the long-term and causal effects of financial development and renewable energy consumption on environmental sustainability while controlling for technological innovation and economic growth in a global framework. The work (Zameer et al. 2020) investigated the relationship between innovation, environment and economic growth in the context of the Indian economy from 1985 to 2017. The empirical assessment confirmed the existence of long-term cointegration. Similarly, in the long run, trade openness, energy use and economic growth are found to positively increase CO<sub>2</sub> emissions. By contrast, technological innovation and foreign direct investment negatively increase CO<sub>2</sub> emissions in the long run.

## 1.4. Public-Private Partnership in Brazil

Ahmad and Raza (2020) studied the impact of public-private partnership investments in energy, technological innovation, economic growth, exports and foreign direct investment on CO<sub>2</sub> emissions in Brazil over the period from 1984 to 2018. Akinsola (2022) assessed the impact of public-private partnerships in energy and financial development on Brazil's environmental footprint and considered the role of renewable energy sources and economic growth using data covering the period 1983 to 2017. The results are as follows: first, in the long run, PPP energy investment worsens environmental quality through increased CO<sub>2</sub> emissions, while TI has a significant negative impact on CO<sub>2</sub> emissions. Empirical findings provide policymakers with new ideas for regulating PPP investments in the energy sector to improve environmental quality in Brazil and create a forum to promote public-private partnerships for improving communication that will facilitate collaboration on new initiatives related to environmental technological innovation.

## 1.5. Public-Private Partnership in Bangladesh

Kirikaleli et al. (2022) investigated the impact of public-private partnership investment in energy on CO<sub>2</sub> emissions, taking into account economic growth, foreign direct investment and trade openness for Bangladesh from 1997 to 2019. This study proposes a technical development for a greener procedure for the production and financing of public-private partnerships in green energy. Therefore, as a policy justification, this study suggests investing in the latest technological advances in order to produce environmentally sustainable goods through public-private partnerships.

## 1.6. Public-Private Partnership in the energy sector in the European Union

Public-private partnerships in the EU energy sector involve cooperation between public institutions (government agencies, local authorities, etc.) and private sector companies to jointly plan, develop, finance and manage energy-related projects. These partnerships aim to leverage the strengths of both sectors to address a variety of energy challenges and opportunities. The main goal of PPP implementation in the EU energy sector is to promote sustainable energy development (IFC Advisory Services in Public-Private Partnership 2014), increase energy security (World Bank 2019) and achieve climate goals through the creation of climate-smart infrastructure (Climate Bonds Initiative, Climate Resilience Consulting and World Resources Institute 2019) as well as encouraging private sector participation and investment (European Investment Bank 2022).

## 1.7. Public-Private Partnership in the energy sector of Ukraine

In recent years, studies of public-private partnerships in the energy sector of Ukraine have attracted considerable attention. Scientists are actively studying various models of cooperation between the state and private structures to increase the efficiency of the energy sector, attract investments and promote sustainable development. The study focuses on innovative financing and investment models for energy PPPs in Ukraine. This includes the study of different financing mechanisms, such as project financing, public funds, foreign direct investment and hybrid financing options (Zapatrina 2017). Researchers (Bilous; Public Private Partnership 2019; Agency on Support Public-Private Partnership 2023) have also explored potential incentives and financial instruments in order to attract private sector investment in the energy sector.

The working hypothesis of the study is that a public-private partnership can serve as an effective mechanism for Ukraine to receive funds from the European Union in order to restore its energy sector by attracting the experience, resources and capabilities of the private sector with the assistance of the EU. Cooperation between public and private entities combined with EU financial support has the potential for post-war recovery and accelerated development of energy infrastructure, promoting sustainable practices and increasing energy efficiency in Ukraine, contributing to the country's energy security and overall economic growth.

## 2. Materials and methods

### 2.1. Institutional support for the development of PPPs by international organizations

#### 2.1.1. Grant support Public-Private Partnership through structural EU funds

Grant support public-private partnerships on the part of the EU will play an important role in attracting private business to infrastructure, especially in countries that have recently joined the European Union or are candidates for joining the EU.

Technical help that is performed at the expense of Structural EU funds can be grouped into the following three categories (Using EU Funds in PPPs 2011; Zapatrina 2017; PPIAF):

- ◆ Tools financial engineering (help provided, as a rule, on a revolver basis, and not as an irrevocable grant; provided as part of this categories technical help must be returned as part of the implementation project and again to be used public power for the like goals).

- ◆ Sectoral focused grants which promote pan-European projects interests (help provided in the grant form for support of research or works – most support goes to the poorest European regions).
- ◆ Grants which support EU policy or individual EU members (help provided on a grant basis as co-financing projects public-private partnership; most support goes to the poorest European regions).

Based on the analysis ([Using EU Funds in PPPs 2011](#); [EU Funds in PPPs 2012](#); PPIAF), it is possible highlight general principles granting such support regardless of categories and draw some important conclusions, in particular:

- ◆ Budgetary reasonable support at the expense of EU funds were provided to both the public and private sectors. Additionally, public power was always involved in the process granting such help. In fact, in PPP projects, the beneficiary was supposed to be the beneficiary of the grant public sector which initiates the project and they actually had to dispose of the grant public sector in the form of irreversible grants and vice-versa. In another case, support appeared mainly for development financial mechanisms PPP implementation and structuring projects. At the same time provided to solve a specific task funds necessary return public to the authorities winners of the competition for implementation PPP project with the aim of further use in the preparation of other PPP projects.
- ◆ Budgetary support was provided as a matter of course software professional preparation PPP projects and/or formation mechanisms their implementation, as well as to cover “financial gaps” already directly during the implementation of socially important infrastructure projects.
- ◆ Budgetary support mainly went to the poorest and most disadvantaged modern infrastructure EU countries and had to answer priorities of European politicians.

Note that grants of structural EU funds were not used as “support for life cycle” and focused exclusively on one of the following lower mechanisms:

- ◆ The use of grant funds as a contribution public authority to the PPP project (actually – partial financing capital expenses). There are different opinions about efficiency similar grants from the point of view encouraging the private partner to provide proper quality services and optimization cost works.
- ◆ The use of a parallel grant co-financing that provides divide infrastructure project into two separate projects. When using this, one is a subproject of the mechanism fully financed by the account public sources (including a grant), and the second is a competition for implementation in the form of PPP. In a row cases such mechanism support it turns out very effective, but it requires high coordination actions public authorities and a private partner in implementation project, which is not always the case you can ensure in countries that are developing.
- ◆ The use of the grant as a part funds affordability. This mechanism actually provides creation at the expense of grants certain funds which serve or to pay an availability fee to a private partner, or partial payment for services according to the results implementation project, or rent (if private partner gives the object built by him is leased public authorities).
- ◆ The use of the grant within the limit’s models investment fund. This mechanism provides combination grant funds, public authorities and a private partner in some “investment funds” for the purpose of them use to solve certain tasks important for creation organizational, legal



and financial mechanisms or generally for implementation PPP projects in that or another country, or a specific society significant project similar funds are usually used on a revolving.

### 2.1.2. Consultative support institution Public-Private Infrastructure

Consultative support institution public-private infrastructure (Public-Private Infrastructure Advisory Facility – PPIAF) was created in 1999 under a joint initiative of the governments of Japan and Great Britain. PPIAF performs its activities in the warehouse of the World Bank (The EBRD's).

PPIAF is the only global organization aimed at strengthening the foundations of governments in countries that develop so that they can generate a number of attractive projects. Since 1999, PPIAF has been helping governments develop policy, laws, regulations Acts, institutions and capacity needed for promotion private investments in infrastructure. Clients are national governments and authorities' local self-government, PPP institutions, regulators. For implementation programs, technical assistance PPIAF attracts fund donors.

Technical PPIAF provides assistance in two directions

#### 1. Technical help municipalities (The Sub-National Technical Assistance – SNTA)

This one program aimed at providing help municipalities of development their institutional capacity and creation opportunities regarding their access to financing markets without provision sovereign guarantees for the purpose of improvement infrastructure services as a result of the implementation of such programs should be promoted creditworthiness municipalities, as well as improving the regulatory and legal environment for engagement financing.

#### 2. Technical help with by PPIAF (PPIAF's Technical Assistance)

This one program provides assistance to governments in eliminating the conditions that prevent the participation of private business in infrastructure projects. Mainly like that help is provided low- and middle- income countries, as well as because are in conflict situations, and grouped according to the following directions:

- ◆ formation strategies development infrastructure;
- ◆ development and implementation political, regulatory and institutional reforms;
- ◆ organization measures of carrying out consultations between the parties;
- ◆ strengthening institutional capabilities public authorities;
- ◆ design and implementation pioneers projects.

Except of this, PPIAF provides technical assistance in the form of grants to bridge knowledge gaps in the field of infrastructure development, supporting research and publications on relevant for the world community theme.

PPIAF declares orientation own help primarily on those countries where it is the most in demand and can have biggest effect about 60% of the whole PPIAF support goes to countries in sub-Saharan Africa that are considered the poorest. Help is also provided to countries from average level development, if projects that offered for financing, focused on their transfer experience countries with lower level (The EBRD's).

Priority areas for support are: the development of water supply and drainage systems, management handling household waste, irrigation, transport communications, energy and tele-communications. Advantage is provided those programs that are carried out within the framework of strategies expanding access to infrastructure services for the poorest and at a affordable prices.

#### 2.1.4. Program preparation infrastructure of EBRD projects (IPPF)

Program preparation infrastructure EBRD 's Infrastructure Project Preparation Facility – IPPF) was established by the European Bank for Reconstruction and Development in 2015 with the aim of providing assistance in the preparation of well-structured infrastructure projects in countries that have serious “infrastructural gaps” and are not institutionally ready for them overcoming.

The activities of IPPF are carried out in two directions (has the so-called two windows – two windows):

- ◆ “PPPs window,” within which contribute preparation (structuring) of projects public-private partnership;
- ◆ “Window stable infrastructure,” focused on commercialization investment projects that are implemented public sector.

Providing support within each of these directions, IPPF independently attracts qualified consultants to provide assistance in structuring projects that allows provide their high quality. Help in preparation projects is accompanied organization political dialogues on high levels, conducting examinations projects for bank clients, increase institutional capabilities public authorities on issues infrastructure development and distribution knowledge in society (Álvarez- Herránz et al. 2017; Gielen et al. 2019).

## 2.2. Schemes of a combination of EU grant funding and private investment based Public-Private Partnerships in periods of EU programming from 1994–1999 to 2014–2020

Previous EU funding rules did not include none provisions regarding PPP. Nevertheless, “combined” projects were (and can continue to be) structured in several ways. It is important to understand that these structures were basically adapted to work with mechanisms grant approval and payment funds which were created for ordinary forms of purchases (i.e. payment only advances capital expenses in moderation occurrence of such costs) (PPIAF).

Below are potential one's structures which combine grants with private financing, presented in growing levels of difficulty. Each example is illustrative of certain constraints in the context of public-private partnership.

### 2.2.1. EU grant as a contribution to capital costs in the contract only for construction

EU grant as a contribution to capital costs in the contract only for construction is the simplest structure in view provision of a grant for construction without private financing and with limited transfer of risks to creditors/ investors. The private sector receives operational and operational payments. These payments are not included elements repayment capital.

Thus, long-term operation and maintenance in the second contract is engaged though the private sector, the first contract is unlikely to be a PPP because there is no capital of the private sector, and accordingly receiving long-term efficiency. In addition, potentially problematic interactions can arise between separate contractors and operators, as well as can be problematic due harmonization term purchases by two separate contracts.

### 2.2.2. EU grant as a contribution to capital costs based single contract

EU grant as a contribution to capital costs based of a single contract that covers construction and operation with a private partner responsible for the functions of design, construction and operation (Design, Build and Operate – DBO), but not by granting financing.

This structure is potentially associated with smaller one's risks combination because a single contract commits the private partner to both the design and construction of the asset and for its further operation and maintenance. Payments to the private sector in stages operation cover only operational costs and maintenance costs service is not included none elements reimbursement capital because construction fully financed by the state, private funding is risk-free long-term obligations, which is the main feature of PPP.

### 2.2.3. Parallel financing and funding capital cost based two individual contracts

This funding structure consists of two contracts. The first contract is a design and construction contract, which financed from the national funds and EU funds for the first object infrastructure; the second contract is a contract for design, construction, financing and operation (Design, Build, Finance and Operate – DBFO) that is financed by the private sector for the second facility infrastructure. The second contract also covers exploitation of the first object infrastructure that is financed from the national funds and EU funds.

Split into two contracts simplifies structuring of the grant, since the grant application must be submitted only for the first contract. It also allows the transfer of higher risk to a private partner (since private financing now exposed to risk ineffectiveness to the second contract). However, this structure is more complex than described above because it includes using two individual contracts of different nature and two processes procurement and construction that are performed at the same time (though two contracts can be transferred to one contractor to soften potential problems). Structure may also cause significant risks a combination between two contracts.

#### 2.2.4. Financing parts capital cost based single contract

Financing parts capital cost based of a single contract for design, construction, financing and operation (Design, Build, Finance and Operate – DBFO). This structure in which EU grants are used for financing parts capital expenses, allows use of loan funds for private financing and transfer more high risk to a private partner.

As in previous funding models, it is limited expenses only in period construction (i.e. EU grants are not used at the stage operation). It maybe not so much deterrent factor if level national and grant funding compared to the level of private funding is sufficient small as to attract a sufficient number of private funds for long-term efficiency. However, coordination management and terms PPP process and EU grant application as well can be difficult task.

Trace note that the above models financing has peculiarities in distribution risks to the private sector. In fact, in the previous one software period (2007–2013) grant there was EU funding intended for payment of deposits project according to traditional approaches to procurement. However, the essence of PPP is a payment-based approach to procurement results. If the grant component of the EU project is significant limits one of the fundamental advantages public-private partnership because the level of private financing may or may not exist, or be lower than optimal, thus putting under doubt justification using public-private partnership.

The European PPP Expert Center (EPEC) (*EU Funds in PPPs 2012*) analyzed fifty “combined” PPP projects in thirteen countries, which predicted using grants received from European structural funds or funds cohesion in periods programming from 1994–1999 to 2007–2013. By cost dominated transport projects, but by quantity there were ICT projects the most common. Most of such projects were in France, Slovenia and Greece.

Features implementation of “combined” financing models is: absent flexibility in grant granting procedures; availability certain equal national funding for access to an EU grant; risk return of the grant in case essential changes in the applied tariff politics that will lead to a change in the flow of income in the future; difficulties and uncertainties associated with the unknown level of the grant or “deficit financing” which necessary cover until they are famous the results procurement of PPPs (in the event that the amount of the grant turned out to be less than expected).

In new one’s provisions for software period 2014–2020 was amended to eliminate shortcomings. For comparison with the previous models described above, one of the key changes was granting opportunities for EU grants to co-finance payments acceptable capital expenses but in such a way that the payment to the private partner could be made for the operational period of the project (even if it goes beyond the current software period).

Revised rules for the current software period are significant improvement of conditions and application financial EU support for “combined projects”. Public-private partnership is recognized as a form of implementation projects that can access grants from structural and investment funds of the European Union, and the rules are better adapted to PPP requirements. One of the important changes was the provision of such grants for the support of long-term based payment mechanism results, which are key to many forms of PPP. Others aspects improve include availability alternative and simpler one’s ways definition Sumy grant for projects that bring income

and opportunity get grant approval prior to identifying a private partner. These measures can both accelerate general the process of “combination”, hide and eliminate risks for bodies that carry out procurement and improve conditions support of granting grants.

### 2.3. Research methods

The theoretical and methodological basis of the study is the provision of modern economic theory and the work of Ukrainian and foreign scientists on the problems of public-private partnership in the energy sector.

The main scientific methods used in the research process are systematic and complex with regard to the collection, analysis and interpretation of data, as they are most suitable for the study of such a complex phenomenon as the development of public-private partnerships in the energy sector of Ukraine in the post-war period.

General scientific and special methods of cognition are also applied:

- ◆ structural-logical – to justify the logic and structure of the research, ensuring its integrity and conceptual unity;
- ◆ going from the abstract to the concrete – to assess existing or historical cases where EU grant funding and private funding were combined in energy projects on the basis of public-private partnerships;
- ◆ analysis and synthesis, grouping and comparison – to perform the analysis of public-private partnership in the energy sector, comparing the practice of financing of the energy sector in Ukraine with other EU member states. Based on these comparisons, propose successful strategies and best practices that can be adapted to the Ukrainian context.

Based on the results, develop policy recommendations and guidelines for politicians, regulators and investors to facilitate the effective integration of EU grant funding and private investment through public-private partnerships in the Ukrainian energy sector in the post-war period.

## 3. Results

### “Combined” models of combining EU grant funding and private funding based on Public-Private Partnership in Ukraine

The growing understanding of the need to attract large-scale investments in the energy infrastructure of regions and cities of Ukraine and the awareness of the insufficiency of tra-

ditional budget funds (especially in the conditions of post-war recovery) forces the state to look for alternative mechanisms for financing the necessary infrastructure costs. It is already possible to ascertain the maximum demand for the development of public-private partnership, since it is foreign investors and private businesses who are interested in investing in the post-war reconstruction of Ukraine's energy infrastructure as well as other related sub-sectors of the economy.

The participation of international organizations in the implementation of investment projects on the basis of partnership in post-war Ukraine will contribute to the widespread attraction of funds from commercial banks, foreign and national investors and governments. Such a partnership creates a reliable environment for the project and increases its effectiveness in the conditions of recovery, reconstruction and modernization of the energy sector, when the concentration of resources to solve key tasks is urgently needed.

The most interesting model is the use of an EU grant within the Investment Fund (Fig. 3). In this model, the EU grant and the national fund are combined with private capital in the Investment Fund, which invests in a number of public-private partnership projects. Risk is spread across the entire portfolio. Such funds are already being used for urban regeneration projects in Great Britain (*Hybrid PPPs 2006*). The mechanism for selecting private investors should be fair and transparent. Any conflicts of interest between project investors must be resolved in advance. Given that a public sector investor will have different goals than a private investor seeking maximum financial returns, a risk sharing mechanism should be agreed upon that will reflect the goals of the various parties.

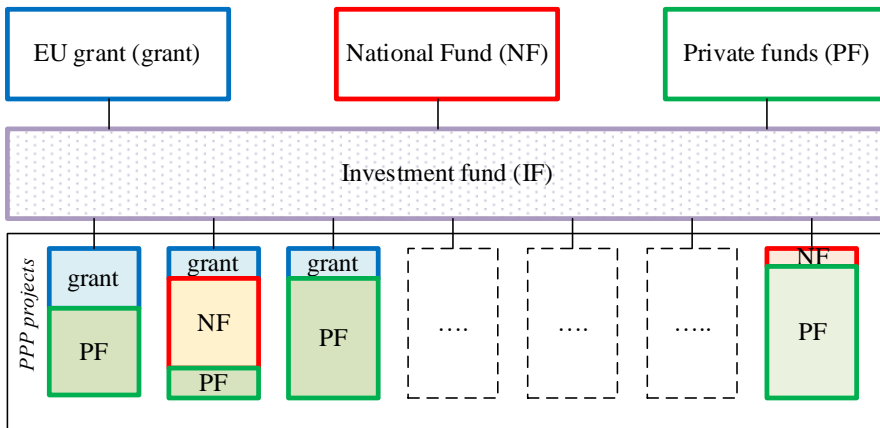


Fig. 3. The structure of EU grant use within the Investment Fund

Rys. 3. Struktura wykorzystania dotacji UE w ramach Funduszu Inwestycyjnego

Therefore, the funds of the Investment Fund are directed to the solution of problematic issues that arise during the preparation and implementation of PPP projects. According to experts

(Using EU Funds in PPPs 2011; EU Funds in PPPs 2012; Zapatrina 2017; PPIAF), it makes sense to reserve similar funds for the prompt resolution of organizational and legal issues. The availability of such an opportunity would allow the significant reduction of transaction costs in the structuring of projects, and in some cases, simply save projects from stopping.

It is also advisable to consider a capital grant (Fig. 4), which consists of financing initial capital investments, thereby reducing either future fees from users or one-time payments from the state authority. The point of the grant is that it increases accessibility. Both France and Italy use this model in conjunction with tendering to determine the minimum amount of subsidy required to implement a project. Most of the previous PPP projects in these countries financed by EU grants used this structure.

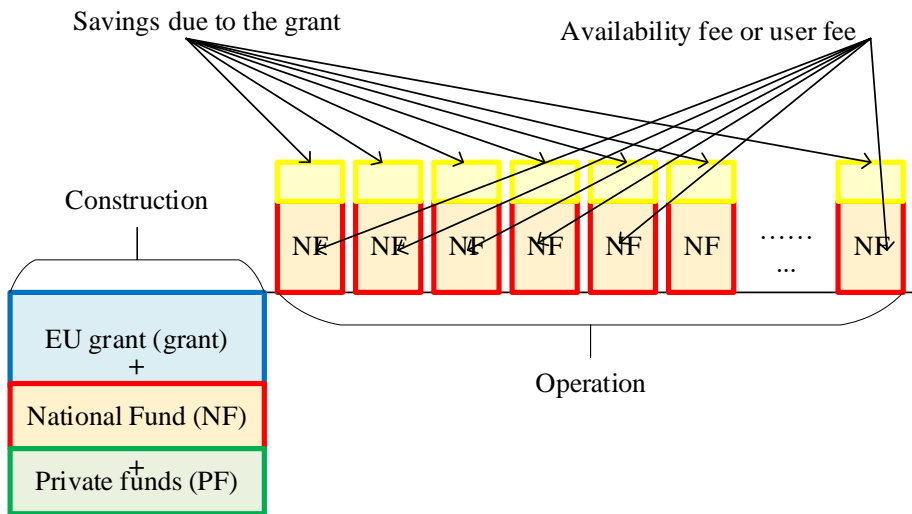


Fig. 4. The structure of the capital grant

Rys. 4. Struktura dotacji kapitałowych

Parallel financing should be used, especially for such projects that require subsidies and can be easily divided into separate contracts (Fig. 5). For example, the subsidizing public body finances the construction of facility A through traditional procurement, but facility B is leased as a concession with responsibility for operation and maintenance. The application of this model depends on the possibility of dividing the entire project into separate contracts without creating excessive operational problems. EU grants simply replace part of the need for the public financing of a project that is traditionally procured using well-tested procedures for determining the cost and disbursement of grant funds.

Using the EU grant as a part of the “affordability” funds – the creation of certain funds at the expense of the grants, which serve to pay accessibility fees to the private partner; partial payment for services in accordance with the results of project implementation; rent (if the private partner leases the facility built by them to the public authority); debt repayment (Fig. 6, 7).

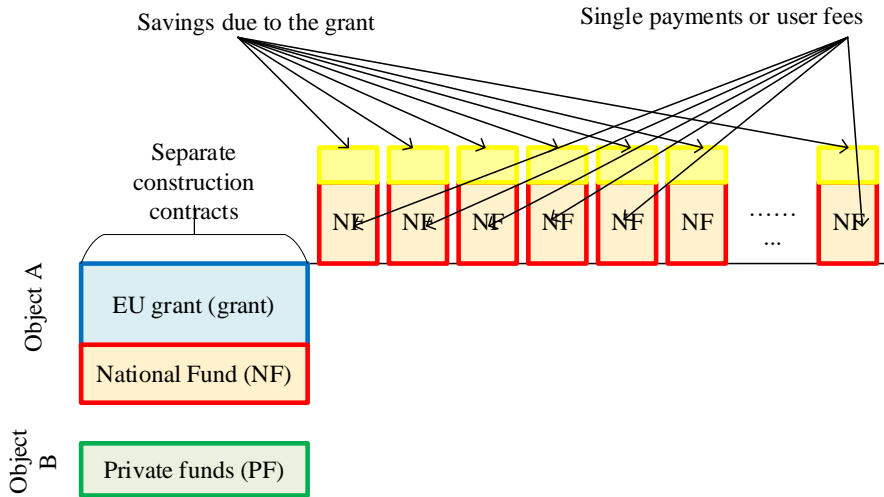


Fig. 5. Structure of parallel financing of the project

Rys. 5. Struktura równoległego finansowania projektu

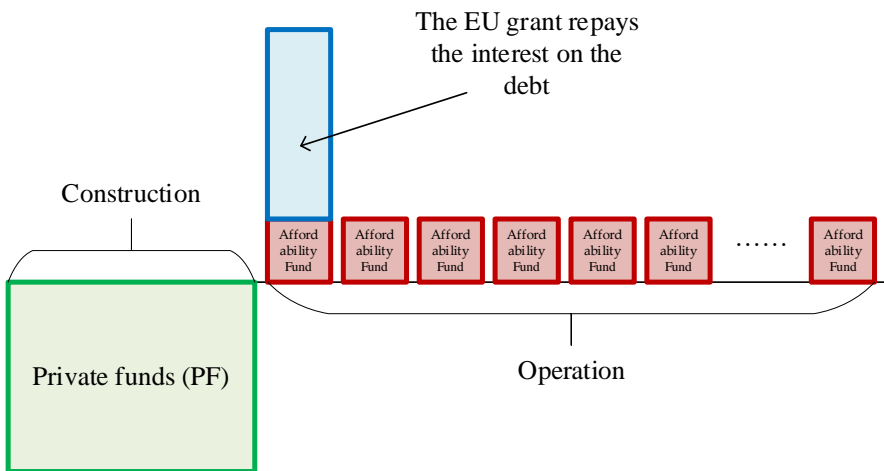


Fig. 6. The structure of subsidizing payments through the "affordability" fund

Rys. 6. Struktura subsydiowania płatności za pośrednictwem funduszu „przystępnościowej”

Based on international and domestic practice, public-private partnership is considered as an investment mechanism for the modernization of the energy sector of Ukraine, which ensures the attraction of private investments in the economy, the improvement of the quality of goods and services provided to consumers, and the growth of the country's competitiveness.



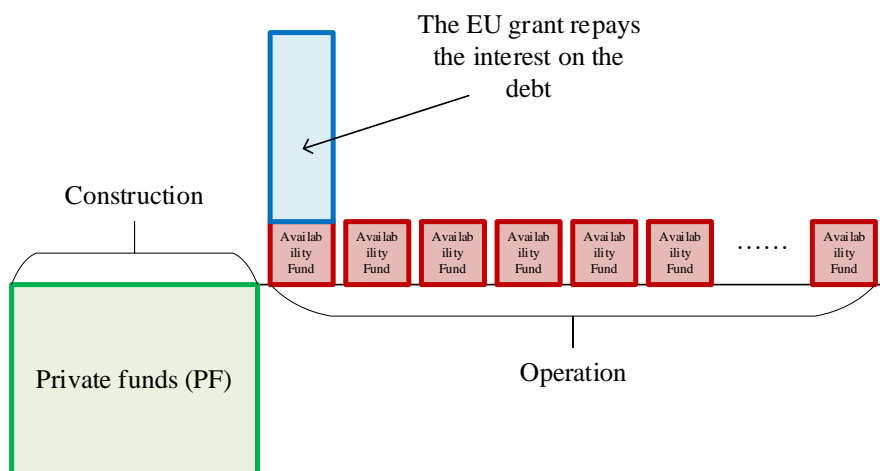


Fig. 7. The structure of debt repayment through the "affordability" fund

Rys. 7. Struktura spłaty zadłużenia za pomocą funduszu „przystępności”

One cannot fail to note the fact that in the conditions of the post-war recovery of the country, public-private partnership can become a powerful incentive for the development of energy infrastructure, the implementation of large-scale socially significant projects and an effective mechanism for the implementation of innovation and investment policy.

The experience of combining public-private partnership with EU funds was studied from both a theoretical and a practical point of view. It is argued that public-private partnerships should be chosen in order to: best use EU grant funds for projects aligned with the policy objectives of the European Union; increase the certainty of costs and time of public procurement; provide better public services to citizens; achieve obvious value for money compared to alternatives.

The analysis of support for the development of public-private partnership at the expense of EU structural funds showed that it will be an important element of promoting the modernization of Ukraine's energy infrastructure with the participation of private business.

Projects combining PPPs with EU funds are subject to both public-private partnership rules and principles for European funds. Certain risks are associated with such "combined" projects (for example, insufficient institutional capacity of the public authorities of the countries that received such support; organizational and institutional "failures" in the management system of the countries that received support; a lack of provisions in national legislation regarding the use of European funds in PPPs implementation; a lack of necessary coordination in the interaction of public institutions involved in the administration of aid from the EU with those engaged in planning and procurement in the PPP sphere) (PPIAF).

In other words, the institutional capacity of the public authorities of the countries that received support from EU funds turned out to be insufficient not only in the field of public-private partnership, but also in the use of EU technical assistance in general.

With the new rules for the 2014–2020 EU programming period, there has been a significant improvement in the conditions and application of EU financial support for “combined” projects. PPPs are now clearly recognized as a form of project implementation that can access grants from European structural and investment funds, and the rules are better adapted to the requirements of public-private partnerships. One important innovation has been the provision of such EU grants to support the long-term performance-based payment mechanisms that underpin many forms of PPPs. Other areas of improvement include the availability of alternative and simpler ways of determining the amount of the grant for profitable projects and the ability to obtain grant approval prior to the identification of a private partner. These measures can both speed up the overall ‘combination’ process and de-risk grant-making authorities.

## 4. Discussion

### 4.1. New opportunities for Public-Private Partnership in the energy sector

A combination of public-private partnership and grant funding from the European Union can be an effective strategy to support the post-war recovery of Ukraine’s energy sector. The war in Ukraine has caused serious damage to the country’s energy infrastructure, and its restoration will require significant investment and expertise. PPP can be a means of attracting investment and experience of the private sector to support the reconstruction of the energy infrastructure of Ukraine (Abdullah and Khadaroo 2020; Buso and Stenger 2018; Cheng et al. 2021b; Cui et al. 2018; FC-World Bank 2014; IFC-World Bank. *Public-Private Partnership Stories* 2014). As a consequence of the partnership with the public sector and the involvement of EU grant funding, PPPs can help to reduce the financial risk associated with energy infrastructure projects (Iloisio and Carraro 2015; Wang and Ma 2021) as well as promoting innovation and sustainable development (Pattberg et al. 2012; Raza et al. 2021; Rosell and Saz-Carranza 2020; Tolstolesova 2021; Vagliasindi 2012a).

It is stated in the literature (Bilous; *Public Private Partnership Guide in Ukraine 2018–2019; The Director of the PPP*) that Ukraine has made progress in developing the legislative framework for PPPs, but more needs to be done to ensure transparency and accountability in the procurement process. The EU’s approach to PPPs is based on the European Commission’s PPP guidelines, which emphasize the need for transparency and competition in the procurement process. Practical studies of PPPs in the energy sector in other countries provide insight into best practices (Vagliasindi 2012b; Vagliasindi 2012c; Vagliasindi 2013; Wang and Cui 2022), which can be applied in Ukraine. For example, the literature states (FC-World Bank 2014) that a successful PPP requires clear project goals, clearly defined risk allocation, and a solid financial structure. PPPs also need to be effectively managed to ensure efficient use of money and effective risk ma-

nagement. Challenges related to PPPs in the Ukrainian energy sector include political instability, corruption and a lack of institutional capacity. PPPs should be designed to address these issues, for example, by involving civil society and promoting transparency in the procurement process. The potential of PPP to contribute to the broader economic development of Ukraine is also an important factor. The PPP has the potential to attract significant EU funding for energy infrastructure projects in Ukraine, but careful planning and effective management will be required to ensure their success.

One of the potential areas of PPPs in the energy sector is renewable energy (Abdouli and Hammami 2017; Ahmad et al. 2020; Álvarez-Herránz and Balsalobre et al. 2017; Alvarez-Herranz and Balsalobre-Lorente et al. 2017; Apergis et al. 2013; Baloch et al. 2019). Ukraine has significant potential for the development of renewable energy, in particular solar, wind and biomass. By combining PPP with EU grant funding, it is possible to develop renewable energy projects (Chishti and Sinha 2022; Danish et al. 2019; Ganda 2018; Ganda 2019; Gielen et al. 2019; Hall 2017; Kaltenbrunner and Paineira 2018; Li et al. 2019; Usman et al. 2021), which are economically and environmentally sustainable (Usman et al. 2020; Tufail et al. 2021; Usman and Hammar 2020; Shahbaz et al. 2015; Stock and Watson 1993; Richter 2012; Rodríguez 2015; Pereira et al. 2012; McCollum et al. 2013). International financing has long been important in the source capital energy sector of Ukraine. Development banks will play an important role in disclosure investment potential business in the sector renewable sources energy Europe will play important role in recovery of Ukraine as the country moves towards joining the EU.

#### 4.2. The matrix of the basic SWOT analysis of the prerequisites for the combination of EU grant and private financing in the energy sector of Ukraine based on Public-Private Partnership in the post-war period

Prerequisites for the implementation of energy projects using public-private partnership in general in Ukraine in the post-war period can be assessed using the SWOT analysis matrix (Table 1).

In summary, the implementation of integrated models that combine EU grant funding and private funding in the energy sector of Ukraine on the basis of public-private partnerships in the post-war period offers both opportunities and challenges. This highlights the complex dynamics and considerations that must be taken into account when implementing such models to ensure successful energy sector reconstruction and sustainable development. In the context of the post-war reconstruction of the energy sector of Ukraine, it provides a new start and an impetus for cooperation and international support in the implementation of a public-private partnership, which contributes to the reconstruction, modernization and sustainable development of the energy sector in post-war Ukraine.

Table 1. SWOT analysis of the combination of EU grant funding and private investments on the basis of public-private partnership in Ukraine in the post-war period

Tabela 1. Analiza SWOT połączenia dotacji UE i inwestycji prywatnych w oparciu o partnerstwo publiczno-prywatne na Ukrainie w okresie powojennym partnerstwa publiczno-prywatnego na Ukrainie w okresie powojennym

Strengths:	Opportunities:
<p>Possibilities of EU funding for the implementation of sustainable and innovative initiatives in the energy sector of Ukraine.</p> <p>Involvement of the private sector (technical expertise, innovation and operational efficiency of energy projects).</p> <p>Distribution of risks between the public and private sectors in the implementation of energy projects.</p> <p>Mobilization of resources through both EU grants and private investments for the implementation of larger energy projects.</p> <p>Coordination of the energy policy of Ukraine and the EU, contributing to the achievement of the goals of both energy security and sustainable development.</p> <p>Large-scale post-war reconstruction of the energy sector, which contributes to the implementation of integrated PPP financing models.</p> <p>Increased focus on sustainable development and rebuilding in a more environmentally friendly way that meets the goals of EU grant funding and private investment in renewable energy.</p> <p>International support for the recovery of the energy sector, offering political support and incentives to integrate EU grants and private financing to speed up the reconstruction process.</p>	<p>Emphasis on sustainable development, including the development of renewable energy sources, energy efficiency projects and climate-smart infrastructure, helping Ukraine transition to a greener energy landscape.</p> <p>Cooperation with private partners can contribute to the transfer of advanced technologies, know-how and best practices to the Ukrainian energy sector.</p> <p>The combination of EU grants and private investments based on a public-private partnership creates a diversified funding base, reducing dependence on a single source of funding and increasing financial stability.</p> <p>The successful implementation of energy projects can stimulate economic growth through job creation, increased investment and the development of local supply chains.</p>
Weaknesses:	Threats:
<p>Lack of national and regional strategies for the development of public-private partnerships in the energy sector</p> <p>The inconsistency of the legal framework for the development of public-private partnerships, which can potentially cause delays or complications in the implementation of the project.</p> <p>The uncertainty of the regulatory environment in the post-war period, which can create uncertainty for private investors and potentially complicate the integration of funding sources.</p> <p>A lack of awareness among interested stakeholders, which may hinder the application of integrated approaches to financing in the energy sector.</p> <p>A lack of a unified register of energy projects based on public-private partnership.</p>	<p>Political changes and economic instability in Ukraine may affect the stability and continuity of public-private partnerships and project financing.</p> <p>Frequent changes in regulations or uncertainty in political direction can create problems for energy project planning and execution.</p> <p>Fluctuations in energy prices, market demand and technological advances can affect the financial viability of energy projects, affecting both public and private partners.</p> <p>The uncertain and volatile environment during wartime and postwar times may deter private investors from committing to long-term projects, affecting the feasibility of integrated public-private partnership financing models.</p>

Weaknesses:	Threats:
<p>An underdeveloped market for long-term commitments, as implementing PPPs requires long-term commitments from both parties, and sustaining these partnerships over long periods can be difficult if priorities change.</p> <p>Lack of experience in the implementation of energy projects on the basis of public-private partnership, which will lead to skepticism about the effectiveness of public-private partnerships.</p>	<p>Changing priorities and allocation of resources within the government can prevent the implementation of integrated financing models in the energy sector based on public-private partnerships.</p> <p>Over-reliance on external financing may pose a risk if financial commitments are reduced over time.</p> <p>Ensuring transparency and preventing corruption in the management of PPP funds can be a serious challenge.</p> <p>Damage to energy infrastructure can create significant barriers to the implementation of integrated models, requiring significant recovery efforts.</p>

### 4.3. Energy projects in Ukraine based on Public-Private Partnership: risks and prospects

Energy projects in Ukraine, based on public-private partnership, represent a complex interaction of risks and prospects. While political, financial and technological risks pose challenges, the prospects for enhanced energy security, technological innovation, economic growth and sustainable development are compelling arguments for implementing PPPs in the energy sector.

According to the World Bank, PPPs in Ukraine have been implemented in the field of electricity since 1998. Since 2001, the priority sector of investment in PPP projects has been the electric power industry. The majority of investments in PPP projects in Ukraine are made in the power industry, accounting for 70% of all PPP investments in Ukraine (*Private Participation in Infrastructure (PPI) – World Bank Group 2022*).

Increasing investments in energy on the basis of public-private partnership is of crucial importance for the successful implementation of the Energy Strategy of Ukraine, as well as the Paris Agreement on Climate Change of 2015 and the Concept of “green” energy transition of Ukraine by 2050. Despite important reforms already implemented by Ukraine, much remains to be done to support and ensure the effectiveness of energy sector reforms using public-private partnerships (*Agency on Support Public-Private Partnership 2022*).

Ukraine has taken important steps to ensure the proper level of implementation of public-private partnership projects in recent years. Efforts were also made to create an open and transparent environment for attracting foreign and domestic investments in the energy sector of Ukraine by adopting new laws and improving regulations that strengthen and simplify the protection of enterprises operating in the energy sector. To further encourage investment, Ukraine has also implemented significant reforms to improve public-private partnership legislation in line with best European practices.

Integrated models of the combination of EU grant funding and private funding in the energy sector of Ukraine based on public-private partnership can cover electricity generation and sto-

rage systems, combining generating capacity with technologies that facilitate the integration of generated electricity into the network (storage, highly maneuverable capacity), the distribution/supply of electrical energy, and the production of electricity and heat from biomethane/biogas, hydrogen power plants (Agency on Support Public-Private Partnership 2023).

Clear regulatory frameworks for public-private partnerships, active stakeholder engagement, and effective risk management strategies are essential with regard to maximizing the benefits and minimizing the challenges of PPP-based public-private cooperation. Due to the presence of international support and strategic partners, Ukraine can use the experience and resources of the private sector to create a modern and sustainable energy landscape that supports its economic and environmental aspirations.

## Conclusions

When implementing energy projects in many countries of the world, public-private partnerships are becoming increasingly popular. In developing countries (Africa, Asia, Latin America and others) there is an acute problem of energy supply and access to it. In these regions, energy facilities are being created from scratch using new technologies based on renewable energy sources. In European countries, the energy infrastructure was mainly created a long time ago, so public-private partnership projects implemented here are often aimed at its modernization, capacity increase and/or transition to more ecological and efficient technologies. In Ukraine, the mechanism of public-private partnership is considered as one of the main tools for business involvement in the development of clean energy. The few energy projects based on public-private partnership in Ukraine are aimed mainly at the reconstruction of existing facilities and increasing their efficiency. Most of the operated energy facilities require colossal investments in the reconstruction and modernization of fixed assets, the situation was especially aggravated during the war period.

A combination of PPPs and EU grant funding can help address some of the key challenges facing the energy sector. One such example is the high capital costs associated with renewable energy projects that can make them unaffordable for many communities and businesses. By attracting EU grant funding, PPPs can help reduce the financial risk associated with these projects and make them increasingly accessible to a wider range of stakeholders. In addition, the use of PPPs can contribute to the introduction of new technologies and innovative solutions in the energy sector. By combining the experience of the public and private sectors, it is possible to develop projects that are technologically advanced and financially viable. By leveraging the strengths of both the public and private sectors, it is possible to create projects that will bring tangible benefits to society as well as a return on investment for private investors. In summary, combining PPPs with EU grant funding can be a very effective approach to financing and developing energy infrastructure projects. Despite the challenges associated with this approach,

with careful planning and coordination, projects can be created that deliver long-term value to all stakeholders.

In Ukraine, in order to implement integrated models of the combination of EU grant funding and private funding in the energy sector through public-private partnership, it is necessary to develop a clear and systematic legislative and regulatory framework for public-private partnership in the energy sector and align the public-private partnership system with EU standards and recommendations to attract foreign investment and increase confidence. Particular attention should be paid to the involvement of all interested participants in the process of planning and implementation of public-private partnership projects in the energy sector. In addition, first of all, it is necessary to determine PPP energy projects that meet the country's energy goals, climate goals and regional development strategies of Ukraine. In the conditions of war and post-war reconstruction, the question of risk distribution between public and private partners arises. The issue of implementing strategies to reduce the risks of project implementation, such as appropriate insurance mechanisms and guarantees, in order to increase the confidence of investors, becomes especially relevant. It is advisable to develop a typical financial structure that optimally combines EU grant funding, private capital, debt financing and other financial instruments. Regularly evaluating the effectiveness of the integrated financing model achieves the goals of the energy sector and fulfills EU requirements. In addition, a typical integrated financing model must be flexible and adaptable to changing circumstances, such as changes in market conditions, technological advances, and policy changes. Following these recommendations, Ukraine can create a favorable environment for attracting private investments and attracting EU grant funding for the development of the energy sector through a well-structured and effective public-private partnership.

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## Zintegrowane modele łączenia dofinansowania unijnego i prywatnego w sektorze energetycznym Ukrainy w oparciu o partnerstwo publiczno-prywatne

### Streszczenie

Powojenna odbudowa sektora energetycznego Ukrainy jest kwestią krytyczną, wymagającą znacznych inwestycji w infrastrukturę i modernizację. Problemem wymagającym rozwiązania jest jednak ograniczone finansowanie sektora publicznego. Jako potencjalne rozwiązanie tego problemu zaproponowano połączenie dotacji UE i finansowania prywatnego w ramach partnerstwa publiczno-prywatnego (PPP). Istotnym tego tematu polega na potencjale PPP w zakresie przyciągania zasobów i do wiadczenia zarówno z sektora publicznego, jak i prywatnego. Może to prowadzić do bardziej efektywnego wykorzystania zasobów i pomóc w rozwiązywaniu problemów związanych z ograniczonym finansowaniem sektora publicznego. Ponadto PPP mogą zapewnić ramy podziału ryzyka między sektor publiczny i prywatny oraz mogą pomóc w mobilizacji zasobów i wiedzy fachowej sektora prywatnego, co może mieć kluczowe znaczenie w powojennych wysiłkach na rzecz odbudowy. Ponadto połączenie dotacji UE i finansowania prywatnego za pośrednictwem PPP może przyczynić się do szerszego rozwoju gospodarczego poprzez promowanie inwestycji w sektorze energetycznym. Może to pomóc w stymulowaniu wzrostu gospodarczego, tworzeniu miejsc pracy i poprawie bezpieczeństwa energetycznego, co ma kluczowe znaczenie dla długoterminowej stabilności ukraińskiego sektora energetycznego. Zatem temat połączonych modeli łączenia dofinansowania unijnego i prywatnego w oparciu o partnerstwo publiczno-prywatne na rzecz powojennej odbudowy sektora energetycznego Ukrainy jest niezwykle istotny dla rozwiązywania problemów związanych z ograniczonym finansowaniem sektora publicznego, przyciąganiem środków i do wiadczenia zarówno z sektora publicznego, jak i prywatnego, a także i promowanie szerszego rozwoju gospodarczego Ukrainy.

Słowa kluczowe: VOSviewer, partnerstwo publiczno-prywatne, powojenna odbudowa Ukrainy, infrastruktura energetyczna, sektor energetyczny

