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FINANCIAL MODELS IN THE ENERGY SECTOR

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Abstract. Undoubtedly, in the last decade, a serious change has been observed in the energy sector from the main point of change in the main energy sources. Simultaneously, there is an accelerating transfer from fossil fuel raw materials (oil, coal) to renewable sources (solar energy, wind energy). Following the change in policies regarding the energy sources used, it is necessary to use and/or adapt existing financial models in the energy sector to address the new economic and social challenges. In addition, these models play a central role in decision-making processes, from large-scale investments in energy infrastructure to strategic planning for the transition to renewable sources. Accordingly, the main goal of this study is to analyse specific models that could be applied in the energy sector towards a clean energy transition.

Keywords: green energy models; financial modes; energy transition
JEL: G23, O16, Q49

Introduction

The transition to a climate-neutral economy represents a fundamental transformation of modern economic models aimed at achieving sustainable development and minimizing environmental impacts. This process requires the integration of environmental, social, and economic aspects into the policies and strategies of countries and international organizations. The European Union (EU) plays a leading role in this transition through initiatives such as the European Green Deal, which sets ambitious goals to achieve climate neutrality by 2050. These goals include reducing greenhouse gas emissions, promoting renewable energy sources, and improving energy efficiency in the building sector.

In the context of Bulgaria, the transition to a carbon-neutral economy represents a significant challenge, especially given the country's dependence on the coal industry and the need for a socially just transition in the affected regions. As Zinoviev & Nikolov (2022) note, the significance of the transition to a carbon-neutral economy and the potential for Europe and the Balkans are key factors for the region's sustainable development.

The European context in the transition to a neutral economy

Within the contemporary institutional finance theory, we could find rise of the "green finance" theory. This concept is based on the market failure of the energy transition model, which aims to enhance the provision of environmental public goods (Stern, 2022). Following Lu et al. (2025) based on public definitions, green finances refer to the usage of different financial instruments that support environmental improvement, climatic change mitigation, and resource-efficient utilization. Therefore, green finances are at the core of the financial push-up of energy-saving initiatives and forthcoming clean energy projects.

The transition to a climate-neutral economy is a strategic priority for the European Union (EU), which aims to become the first climate-neutral continent by 2050. This ambition is set out in the European Green Deal, a comprehensive sustainable development strategy aimed at reducing greenhouse gas emissions, promoting the circular economy, and protecting biodiversity. /EC, European Climate Law. In addition, in July 2021, the EU adopted the European Climate Law, which makes the objective of achieving climate neutrality by 2050 legally binding. The law also sets an interim target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. This legislation ensures that all EU policies contribute to achieving these objectives and that all sectors of the economy and society participate in the transition. Despite its ambitious targets, the EU faces several challenges in implementing climate policies. Some member states are concerned about the economic consequences of strict measures and are pushing for the weakening of certain policies. For example, Denmark has warned of growing pressure on the EU to weaken its climate laws, with some countries wanting to review the ban on the sale of new combustion cars until 2035 and delay the introduction of new carbon markets.

In 2019, Bulgaria presented its Integrated National Energy and Climate Plan (INPEC) for 2020 – 2030. This document outlines the country's strategic goals in the field of energy and climate, including the following: Reducing the use of coal as an energy source is essential; Expansion of nuclear capacity; Increasing investments in renewable energy sources (RES), such as solar, geothermal energy, and biofuels; and Improving the energy efficiency of buildings and promoting low-carbon transportation. Accordingly, the 2030 goals include: Achieving a 27.1% share of RES in the final energy consumption; and Improving energy efficiency by reducing primary and final energy consumption is also important.

The transition to climate neutrality in Bulgaria has significant regional dimensions, especially in areas with a high concentration of the coal industry. This transition not only transforms the energy sector but also has a profound impact on the local economies, employment, and social structure of the affected regions. The regions of Stara Zagora, Pernik, and Kyustendil are among the most affected by the transition to a low-carbon economy, as they are home to the

main coal-fired power plants and mines. The closure or transformation of these facilities leads to job loss and economic instability. To address these challenges, Bulgaria has developed Territorial Just Transition Plans (TJTPs) for the regions. These plans envisage investments in new economic activities, retraining of the workforce, and improvement of infrastructure, with the aim of creating sustainable jobs and economic recovery. The transition to a climate-neutral economy is not just a technological transformation but also a structural change in economic and social models. As part of the European Union, Bulgaria is bound by ambitious goals but also faces significant challenges. At the same time, these challenges open up opportunities for sustainable growth, modernization of the economy, and improvement of the quality of life.

– Coal dependence: Bulgaria is among the last countries in the EU that continues to rely heavily on coal-fired power generation. Coal provides approximately 40% of the country's electricity (CEER, 2023), making decarbonization a serious challenge. In addition to technical and financial aspects, the issue also has a social dimension; entire regions such as Stara Zagora, Pernik, and Bobov Dol are economically dependent on the mining industry.

– Limited administrative and expert capacity: At the national and local levels, there is often a lack of trained personnel capable of planning and managing green projects (Petkova, 2022). This leads to **slow absorption of European funds**, insufficient impact assessment, and low efficiency in project implementation.

– Weak digitalization and innovation activity: According to the EU Competitiveness Report (2023)[1], Bulgaria ranks among the lowest in innovation and digital transformation. This limits the opportunities for building smart energy infrastructure, circular business models, and automated production, which are the foundations of the green economy.

– Insufficient public support: Sociological surveys show that **approximately 40% of Bulgarians are unfamiliar with the Green Deal** (Alpha Research). A lack of understanding leads to resistance to measures such as energy efficiency, carbon taxes, and transport reforms.

The transition to a climate-neutral economy requires not only political will but also well-designed financial and technological instruments. These mechanisms are key to mobilizing investment, innovation, and the accelerated deployment of low-carbon technologies, especially in sectors such as energy, transport, and industry (European Commission, 2020).

Financial and technological mechanisms to support the transition to a neutral economy

A key financial mechanism at the European level is the Just Transition Mechanism, which aims to support the most affected regions in the EU. Bulgaria will receive approximately EUR 1.2 billion under the Just Transition Fund (JTF)[2],

intended for the development of new economic activities in coal-dependent regions (Ministry of Energy, 2023). Additionally, the National Recovery and Resilience Plan (NRRP) includes a package of investments worth over BGN 10 billion, a significant part of which is aimed at the "Green Transition"–energy efficiency, renewables, and modernization of the electricity grid. National instruments, such as the Security of the Electricity System Fund and the National Trust Ecofund, also participate in financing energy efficiency projects, especially in public buildings and households[3].

The transition to neutrality cannot occur without the active participation of the private sector. In this context, green bonds, sustainable banking, and environmentally sound investment funds (ESG funds) are becoming increasingly important. According to a report by the European Investment Bank (EIB, 2020), over 30% of corporate investments in Central and Eastern Europe are focused on decarbonization and green technologies. Scientific and technological advancements play a crucial role in achieving climate neutrality. The overall effects of different green finances are not sufficiently studied as most of the green financial programs are on-the-way. Additionally, green financing instruments include: green credit, green securities, green insurance, and green investment (Ren et al., 2020; Mngumi et al., 2022, Lu et al., 2025). The leading green technologies include: High-efficiency photovoltaic and wind installations; Smart electricity grids and digitalized demand management; Hydrogen energy as an intermediate step towards decarbonization of transport and industry; and Carbon capture technologies (CCUS) for industrial emissions (IEA 2023).

When using different mechanisms to finance the energy-neutral transition, it is necessary to achieve a balance between the fairness and efficiency of the transition. One of the main principles of the transition is **fairness, that is,** leaving no one behind. For Bulgaria, this means that: retraining and social support for workers in the mining industry; promoting the transformation of small and medium-sized enterprises; and protecting energy-poor households through targeted subsidies. Simultaneously, the transformation must be **cost-effective** to generate growth, increase competitiveness, and reduce external dependence on fossil fuels.

Financial instruments for the transition to a circular energy system

Seven different green instruments could be found in Bulgaria for stimulating green energy transition for regional competitiveness development (Delchev, 2024).

Public-Private Partnerships (PPP)

Public-private partnerships (PPPs) are collaborations between public institutions and private companies to finance, develop, and manage projects of public interest. In the context of the transition to a circular energy system, PPPs play a key role in mobilizing capital and expertise for the implementation of large-scale infrastructure projects, such as renewable energy installations, waste-to-energy systems, and

district heating networks designed according to the principles of the circular economy.

The public sector typically provides regulatory support, access to land, and partial financing, whereas the private sector contributes technical expertise, operational efficiency, and innovation. A key advantage of this model is the risk-sharing mechanism, in which financial and operational risks are distributed among partners according to their capabilities. For example, governments may assume political or regulatory risks, whereas private entities manage construction and operational risks. However, PPPs are complex to design and implement. They often involve long-term contracts that require careful negotiation to ensure value for money and to clearly define performance indicators. Furthermore, if not transparently accounted for, they can lead to hidden public debt. Successful PPPs require strong institutional capacity, transparent procurement procedures, and robust legal frameworks that balance public accountability and incentives for the private sector.

In circular energy systems, PPPs are increasingly used to finance anaerobic digestion plants, biomass-fired combined heat and power plants, and circular urban infrastructure, such as eco-industrial parks, where energy and material flows are optimized among multiple users. The model encourages long-term investment and systematic planning, both of which are essential for a successful transition to circularity.

Green bonds / Climate bonds

Green bonds are debt securities that raise capital for environmental or climate-related projects, including those supporting the circular economy. Issued by governments, corporations, or development banks, these bonds offer investors predictable returns while ensuring that their capital contributes to sustainable development. A specialized category, climate bonds, focuses on projects that reduce greenhouse gas emissions and increase climate resilience. In energy systems, green bonds increasingly finance projects such as solar and wind farms, bioenergy facilities, and energy-efficient renovations, all of which are central to circular economy models that emphasize renewables and resource regeneration. They also support infrastructure for energy reuse or waste-to-energy, consistent with the principles of decarbonization and circularity of the economy.

To promote transparency and prevent "greenwashing," green bonds typically adhere to standards such as the Green Bond Principles (GBP) and Climate Bond Standard (CBS). These frameworks require issuers to disclose fund allocation, account for environmental impacts, and undergo independent verification. Despite their advantages, green bonds face certain challenges, including high issuance costs, complex due diligence procedures, and a still-developing secondary market. Nevertheless, they remain a powerful financial instrument for mobilizing institutional capital, increasingly aligned with environmental, social, and governance (ESG) principles.

Energy Performance Contracting (EPC)

Energy Performance Contracting (EPC) is a financing mechanism in which an external provider, usually an energy service company (ESCO), implements energy-saving measures and is repaid through the cost savings achieved over time. This model is particularly suitable for integrating circular economy principles into energy systems, as it incentivizes energy efficiency improvements, waste heat recovery, and other resource optimization strategies without requiring significant upfront investments from the end user. In an EPC, the ESCO typically conducts an energy audit, designs and installs efficiency or reuse technologies, and guarantees a minimum level of energy savings. The client – for example, an industrial enterprise, municipality, or building operator – repays the ESCO from the savings achieved over the term of the contract, which is typically between 5 and 15 years. If the savings do not reach the guaranteed level, the ESCO covers the difference by assuming the financial risk.

EPCs are well-suited for circular energy systems because they prioritize performance and value generation over raw-energy consumption. Examples include financing systems for recovering waste heat in industrial processes and implementing smart energy management platforms that minimize energy losses during production. These interventions not only reduce costs but also close energy loops, which are key elements of circularity. The success of EPCs depends on precise measurement and verification of savings. They are generally more viable for large-scale or multisite projects, as small applications may not generate sufficient returns to justify the costs. Despite these limitations, EPCs are essential for driving energy efficiency and circularity while minimizing financial risks to the end user.

Pay as you save (PAYS) / Funding through the account

The Pay-As-You-Save (PAYS) model, also known as bill financing, allows customers to finance energy efficiency or renewable energy improvements through their utility bills. The model addresses a key barrier to energy system upgrades – high initial capital costs – by matching payments to monthly energy savings resulting from improvements. In this model, a utility company or third party funds the initial cost of an improvement, such as the installation of energy-efficient equipment or waste heat recovery systems. The customer then pays for the cost through a surcharge on their utility bill, which is structured to be less than or equal to the monthly energy savings.

The Pay-As-You-Save (PAYS) model is an innovative financing scheme in which customers repay energy efficiency investments through their utility bills. A special feature of this model is that the repayment obligation is tied to the property or meter itself, rather than to a specific tenant or owner. This facilitates investments in rental and commercial properties, as the financial responsibility is transferred when the user changes the property. The PAYS supports the principles of the

circular economy by incentivizing long-term investments in energy efficiency and energy reuse systems without consumers bearing the full financial risk. The model is particularly effective in energy-intensive industries and in the residential and commercial sectors, where high capital costs hinder infrastructure renovation.

One of the main advantages of PAYS is its inclusive nature; even consumers with limited access to credit can benefit. Tying repayment to the monthly bill creates a positive relationship between consumption, responsibility, and benefits. However, successful implementation depends on a stable regulatory framework and cooperation with the energy companies. In the absence of such conditions, implementing this model may be difficult. Despite these challenges, PAYS is emerging as a promising mechanism for promoting decentralized circular energy solutions, especially when combined with government incentives or support programs.

Circular investment funds (public or venture)

Circular investment funds, both managed by public institutions (e.g., under the European Green Deal) and private ones (including venture capital), play a key role in accelerating the development and deployment of innovative energy systems that are consistent with the principles of the circular economy. These funds finance technologies and business models that decouple economic growth from resource use by promoting energy efficiency, reuse, and the integration of renewables. Typically, such funds support start-ups or pilot projects that would have difficulty obtaining traditional financing because of high risk or uncertain returns. The investment portfolio may include companies developing circular battery technologies, artificial intelligence-based energy monitoring systems, waste-to-energy technologies, and solutions for reusing components from renewable energy systems (e.g., obsolete wind turbine blades).

In addition to capital, circular funds often provide strategic mentoring, market access, and connectivity to innovation ecosystems. Many use blended financing, a combination of public funds (to bear the initial risk) and private capital (to scale innovation). This is particularly effective in emerging markets and sectors with technological risks. Challenges include long payback times, technical complexity, and the need for cross-sector expertise. Furthermore, measuring the impact and defining clear circularity metrics remain an evolving area. However, these funds are essential for channeling 'patient capital' towards innovations that support closed loops, energy recovery, and decarbonization.

Feed-in tariffs and premiums tied to circular results

Feed-in tariffs (FiTs) and Feed – in Premiums (FiPs) are public policy instruments designed to incentivize the production of renewable energy through long-term power purchase agreements at fixed or preferential prices. While traditionally applied to wind, solar, and biomass energy, these mechanisms are increasingly being adapted to the circular economy by incorporating circularity indicators. In this model,

energy producers, especially small and medium-sized enterprises, receive a fixed payment for each kilowatt-hour of energy produced from circular sources, such as biogas from waste, synthetic fuels from captured CO_2, or electricity from waste heat. If criteria for the source are introduced (e.g., energy from waste streams), these financial instruments can directly promote circular behavior in the energy sector.

Feed-in tariffs reduce the risk for investors, increase the predictability of returns, and facilitate project financing, especially in decentralized or innovative systems. They also create demand for circular technologies at an early stage of the product lifecycle. Implementation challenges include the need for flexible regulation, the risk of market distortions, and the need to phase out subsidies. Integrating circularity criteria requires complex regulatory designs and robust monitoring mechanisms. However, well-designed buy-back schemes that focus on circularity can be an effective financial tool to combine energy transformation with circular economy goals.

Incentives for industrial symbiosis and tax breaks for circularity

Industrial symbiosis involves the exchange of energy, materials, water and by-products between different industrial enterprises in order to increase efficiency and reduce environmental impact. Financial models supporting symbiosis – such as tax breaks, subsidies or public grants – are emerging as strategic tools for creating circular energy systems at the industrial or regional level. Circular economy tax breaks reward companies that engage in energy exchange, invest in waste heat capture and utilization facilities, or replace primary raw materials with recycled ones. Such breaks can offset capital costs and improve the profitability of projects that have high initial investments but significant long-term benefits.

Additional instruments include performance-based subsidies for the development of eco-industrial parks, shared energy platforms or cross-sector energy networks. These models require coordination, trust and transparency between actors – elements that financial incentives can support. Challenges include the complexity of measurement and verification, the need for interagency cooperation, and the risk of abuse in the absence of rigorous criteria. However, targeted incentives for industrial symbiosis have been shown to increase systemic energy efficiency and stimulate innovation.

According to the research, summary of given above four green finance instrument is given at next Table 1.

Table 1. Comparison of Circular-Energy Financing and Policy Instrument

Criterion / Instrument	Core Concept	Main Actors	Role in Circular Energy Systems	Financing Logic	Advantages	Limitations / Challenges	Best Suited For	Circularity Mechanisms
Public–Private Partnerships (PPP)	Collaboration between public sector and private companies to finance and operate public-interest infrastructure	Governments + private firms	Enables large-scale circular infrastructure (eco-industrial parks, anaerobic digestion, biomass CHP)	Shared public–private capital with risk allocation	Brings expertise, capital and risk-sharing	Contractual complexity; risk of hidden debt; governance burden	Large circular infrastructure projects	Co-planning of infrastructures with optimized resource flows
Green Bonds / Climate Bonds	Debt securities financing environmental / climate-aligned projects	Governments, corporates, development banks + investors	Mobilises capital for circular renewable and waste-to-energy infrastructure	Borrowing via bonds with earmarked sustainable use of proceeds	Mobilises institutional capital aligned with sustainability	High issuance & verification costs; evolving secondary market	Large-scale renewable and circular-energy investments	Financing energy regeneration & decarbonization
Energy Performance Contracting (EPC)	ESCO implements efficiency measures and is repaid via achieved savings	ESCO + industrial/ public clients	Supports energy efficiency, waste heat recovery and resource optimization	Third-party financing recovered from energy savings	No upfront investment for end user; performance guaranteed	High M&V requirements; less viable for small projects	Municipalities, industrial and building sectors	Reduces energy waste and closes energy loops
Pay-As-You-Save (PAYS)	Customers repay energy improvements through utility bills	Utility companies / third-party investor + energy users	Encourages energy efficiency and reuse without upfront cost for consumers	Utility-bill-based repayment tied to the property/meter	Inclusive and accessible, even for users without credit	Requires stable regulation and cooperation from utilities	Residential, commercial & industrial users facing high capital barriers	Links consumption reduction to financial benefit
Circular Investment Funds	Public or private (often VC) funds financing circular innovation	Public investment funds + private venture capital	Accelerates innovation and deployment of circular energy technologies	Blended capital + high-risk investments	Enables scaling of high-risk innovations; ecosystem support	Long payback times; complex technologies; impact metrics evolving	Start-ups, pilot projects and emerging circular technologies	Supports scale-up of technologies decoupling growth from resource use
Feed-in Tariffs / Feed-in Premiums (with Circular Criteria)	Long-term power purchase agreements at fixed / premium prices for circular-energy production	Governments + energy producers	Creates demand and reduces risk for circular energy production	Subsidized / premium price per generated circular energy unit	Predictable revenue; reduces investment risk for SMEs	Requires complex regulatory design; risk of market distortions	SMEs and innovative producers using circular-energy sources	Rewards production from circular energy sources (waste, CO_2 fuels, heat reuse)

Criterion / Instrument	Core Concept	Main Actors	Role in Circular Energy Systems	Financing Logic	Advantages	Limitations / Challenges	Best Suited For	Circularity Mechanisms
Incentives for Industrial Symbiosis & Tax Breaks for Circularity	Financial incentives (tax breaks, subsidies) to promote exchange of energy, materials and by-products between industries	Governments + industrial stakeholders	Stimulates energy and material exchange and resource sharing across industrial networks	Tax reductions, grants, performance-based subsidies	Supports systemic efficiency & innovation in industrial clusters	Verification complexity; interagency coordination; risk of abuse	Eco-industrial parks, energy-intensive sectors, regional symbiosis	Enables cross-sector exchange of energy & materials, reducing total resource input

Conclusion

The transition to a climate-neutral economy represents one of the greatest challenges and opportunities of the 21st century. At the heart of this transformation is the need to rethink the way we produce, use and recover resources – especially in the energy sector, which is among the main sources of carbon emissions. This is where the principles of the circular economy and innovative financial models play a key role. They not only enable a more efficient use of resources, but also enable new business models where sustainability and economic viability go hand in hand. Unfortunately, the most of Bulgarian companies as SMEs could not use green finances and that have to find innovative financial instruments as crowdfunding and stocks (Yordanov, 2019; Petkov, 2025 and others).

The circular economy in the energy sector means closing energy and material flows through reuse, recycling, waste energy recovery and the use of decentralized renewable sources. In this context, financial instruments become the main mechanism for the implementation of circular projects, which often require high initial investments, long payback periods and innovative technologies. For this reason, there is an urgent need for adapted financing models that create conditions for the participation of different actors – including small and medium-sized enterprises, municipalities, consumers with limited access to credit and venture capitalists. The financial mechanisms examined – such as the Pay-As-You-Save (PAYS) model, circular investment funds, feed-in tariffs, and incentives for industrial symbiosis – show the diversity of approaches that can accelerate the deployment of sustainable energy solutions. The PAYS model, for example, offers an accessible and inclusive form of financing, where the consumer does not bear the initial investment risk, but pays for the improvements through their utility bills. This is particularly valuable in areas with high energy poverty or low access to credit. On the other hand, circular investment funds – both public and venture – allow the mobilization of long-term capital in areas with high innovation potential, but also with an increased degree

of market uncertainty. They support not only financially but also strategically the development of new technologies, such as the reuse of energy components, artificial intelligence for energy efficiency or the reuse of waste products as an energy resource.

Additionally, policy instruments such as feed-in tariffs and circular economy premiums provide certainty for investors and create a stable framework for the uptake of alternative energy sources. They can stimulate not only renewable energy production, but also the use of secondary raw materials, waste heat or waste from industrial processes as energy inputs. Financial incentives for industrial symbiosis are also key – they encourage cooperation between different industries and the formation of "closed loops" within industrial zones. Despite the potential of these models, there are challenges that should not be overlooked. These include the complexity of measuring circular outcomes, the need for cross-sectoral collaboration, and the need for a robust regulatory and institutional framework. The success of implementing these tools depends on the joint efforts of governments, financial institutions, business, and civil society. Following, according to Stoyanov (2024) green finances have to be improved in the regulatory frameworks of EU member states as the uniform green finance regulations could facilitate cross-border green energy projects.

In conclusion, financial models that support circular principles in the energy sector not only facilitate the transition to more sustainable energy production and consumption, but also create the basis for a more just and inclusive economy. They are an indispensable element of the overall transformation towards a climate-neutral future – a future in which resources are used efficiently, the energy system is decentralized and sustainable, and innovation moves in sync with nature and social needs. Ultimately, these green financial instruments not only support the shift toward cleaner energy systems but also help competitiveness without missing the management of green energy finance's risk (Biolcheva & Beleliev, 2021).

NOTES

1. https://commission.europa.eu/topics/competitiveness/draghi-report_en
2. JTF launch green energy project financing in Stara Zagora, Pernik and Kyustendil Region in 2025. The call has just ended in Nov.2025
3. https://www.ecofund-bg.org/

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