

The role of digitalisation in ESCO service models

Application of blockchain technology in Serbian market for energy efficiency

A Master's Thesis submitted for the degree of
“Master of Science”

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Affidavit

I, **STEFAN MEDAK, MSC**, hereby declare

1. that I am the sole author of the present Master's Thesis, "THE ROLE OF DIGITALISATION IN ESCO SERVICE MODELS - APPLICATION OF BLOCKCHAIN TECHNOLOGY IN SERBIAN MARKET FOR ENERGY EFFICIENCY", 71 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted the topic of this Master's Thesis or parts of it in any form for assessment as an examination paper, either in Austria or abroad.

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Abstract

A transition is happening within the energy sector from traditionally centralised, analogue fossil fuel based systems to a new concept of decarbonisation, decentralisation and digitalisation (the 3Ds). The energy sector is struggling with the integration of distributed renewable energy sources, and the development of new technologies will dictate the extent to which the transition will be possible. So called distributed ledger technology - blockchain is seen as one of the solutions to enhance the energy transition.

The key sectors where strategic changes have to be made in order to reach the Paris Agreement objectives are energy and energy efficiency, where Energy Services Company (ESCO) model as a financing mechanism could play a crucial role. Around 50 % of final energy consumption in Southeast Europe is attributed to the consumption in buildings. It is estimated that energy savings from 20 % to 40 % could be achieved only by improving energy efficiency in that sector. An overall digital upgrade could contribute with additional 15-25 %.

The purpose of this thesis is to validate whether blockchain technology could support the implementation of energy conservation measures through ESCO business models in the Serbian market for energy efficiency. A theoretical decision framework is proposed to test the concept of energy performance contracting supported by blockchain. Secondly, the thesis analyses the main barriers in deploying ESCO financing in Serbia to meet the national goals of increased energy efficiency.

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1 Introduction

In December 2015 the 21st Conference of Parties was held in Paris within the United Nations framework convention on climate. 197 countries to date have ratified the Paris agreement and made commitments to reduce and limit the emissions of greenhouse gases through a variety of measures including, among other, significant deployment of renewable technology systems and improvement in energy efficiency compatible with each country's national capabilities and circumstances. The agreement is projected to slow down the rate of greenhouse gas emissions, with a goal of limiting the rise in global temperature comparing to 1990 levels to below 2 °C, or ideally below 1,5 °C by 2050 (World Bank's Climate Change Group 2018, p. 6). However, even with these measures, prognosis for reaching net zero emissions by the mid of the century is not so optimistic. The Paris agreement objectives can only be met if far-reaching changes in key energy sectors are made and increased efforts in technological development, with the application of the same, are made.

In the last two decades we are witnessing a transition within the energy sector from traditionally centralised, analogue systems, primarily based on fossil fuel generation and transmission to a new setup made on decarbonisation, decentralisation and digitalisation (the 3Ds) efforts. The energy sector is struggling with the integration of distributed renewable energy sources, and the development of new technologies will dictate the extent to which the transition will be possible. So called distributed ledger technology - blockchain is seen as one of the solutions to enhance the energy transition. As a digital, decentralised network made of computers distributed all over the world, blockchain offers new prospects for increased security and transparency through its cryptographic encryption protection (Aoun 2020, p. 24). Equally important, peer-to-peer (P2P) networks with decentralised authority concept are paving the way for eliminating traditional intermediaries such as banks, thus reducing transaction costs associated with implementation of projects. Alongside with other digital opportunities, such as internet of things (IoT), new emerging technologies are acting as enablers for the creation of a decentralised and digitalised energy system by bringing significant changes to the sector (Khatoon et al. 2019, p. 3).

If looking at the sustainable development goal no. 7 that sets the goal of doubling the global rate of improvement in energy efficiency by 2030, the key sectors where strategic changes have to be made in order to reach the Paris agreement objectives

are energy and energy efficiency. Energy services company (ESCO) model could play a key role as a financing mechanism for promoting energy efficiency.

Many countries have recognised the importance of developing finance mechanisms for supporting green projects, but most of them are encountering significant barriers when it comes to reliable policy and implementation frameworks. Prevalence of untrusted and inefficient third-party measurement and verification systems is yet another issue. When encountered with business environments where trust is not supported by reliable and strong legal and regulatory frameworks, potential investors tend to look for more developed markets. Usually, risk is closely related to trust and lack of trust is often considered the main barrier for enabling investments in the energy sector in emerging markets.

Therefore, reducing the risk could be a key enabler for increasing investments in energy conservation measures in developing countries. It is also worth considering that developing countries have the highest potential when it comes to energy efficiency investments (Krofak 2019, p. 51). Serbia is one of those countries.

ESCO and digital technologies come hand in hand in bringing full potential and impact of energy efficiency measures, especially in developing countries. By increasing trust and lowering transaction costs, blockchain is seen as a technology to further promote ESCO business. Scaling up of the advanced technology application in the energy efficiency sector hasn't been achieved in Serbia or the Western Balkans region so far. Therefore, this thesis will try to give an overview of the current status of ESCO market in Serbia and possibilities of scaling it up through blockchain technology.

1.1 Motivation and objective of the Master Thesis

Serbia is one of five Western Balkan countries that has ratified the Paris Agreement. The Western Balkan Countries include Albania, Bosnia and Herzegovina, Montenegro, North Macedonia and Serbia. Albania, North Macedonia, Montenegro, and Serbia are EU membership candidates, Bosnia and Herzegovina is a potential membership candidate. By ratifying the agreement on 25 July 2017, national government of Serbia has committed to take action and ensure the global average temperature increase will remain well below 2 °C, but will also pursue efforts towards limiting the global warming to 1,5 °C. Bilateral relations and EU accession

negotiations reflect climate neutrality and obliges Serbia to already start taking action in transforming its policies accordingly.

The Western Balkans is one of the European regions most heavily affected by the impact of climate change and this trend is expected to continue. Depending on the global effort in emissions reduction, temperature increase is expected to exceed even 5 °C by the end of the century (European Commission 2020a, p. 10). Figure 1 shows that air pollution in the Western Balkans is one of the highest in Europe, which has a direct impact on people's health. Even though very high concentrations of particulate matter pollution are mainly due to emissions from industrial installations, significant share comes from wood and coal fired stoves and boilers and from burning domestic waste for domestic heating. To understand this impact, equivalent to sulphur dioxide emissions from 250 coal fired power plants in the EU is emitted from 16 similar plants in the Western Balkans region (European Commission 2020a, p. 10). It becomes obvious that far reaching changes have to be made to the way we live our lives today in order to achieve climate neutrality by 2050.

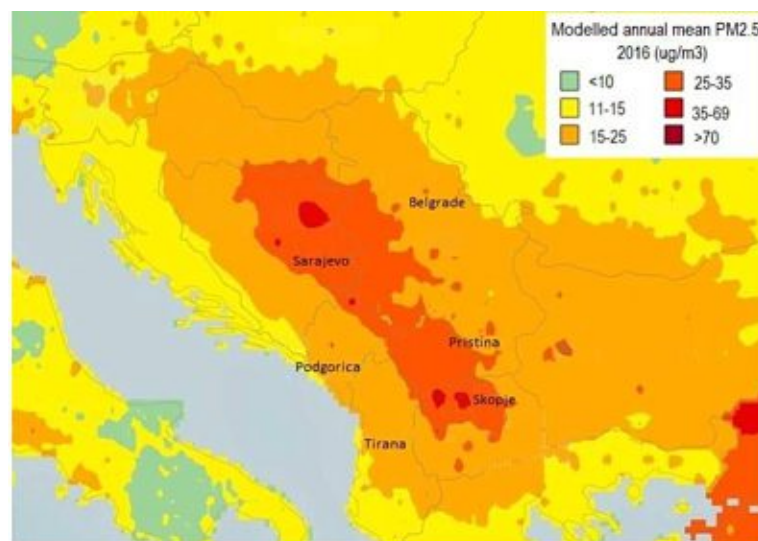


Figure 1: Modelled annual mean concentration of PM_{2.5} in the WB region, 2016 (European Commission 2020b, p. 9)

Energy plays a key role for social-economic development, with its availability and reliability strongly influencing production and consumption habits of the population. Harmful environmental and climate impacts and high energy costs come as a result of poor energy efficiency and high energy intensity. Energy intensity is often used on a national level as an aggregate measure of energy efficiency. It is defined as units of energy consumed to produce a unit of GDP and can be related to energy productivity.

Whenever there is a reduction in energy intensity, each unit of consumed energy is generating more units of GDP.

In the European Union there is a consensus to develop a sustainable energy system made of renewable and clean energy. But not only the supply side of the market should be stimulated with investments, demand side must also be addressed and energy consumption made efficient. It is broadly adopted that to decrease import dependency and increase security of energy supply, energy consumption has to be reduced. In other words, investing in measures to reduce energy intensity improves national security (Fagernæs 2016, pp. 14–15). Energy consumption in South Eastern Europe (SEE) region for decades has been characterised by high energy intensity, with significantly higher rates than the EU (Figure 2).

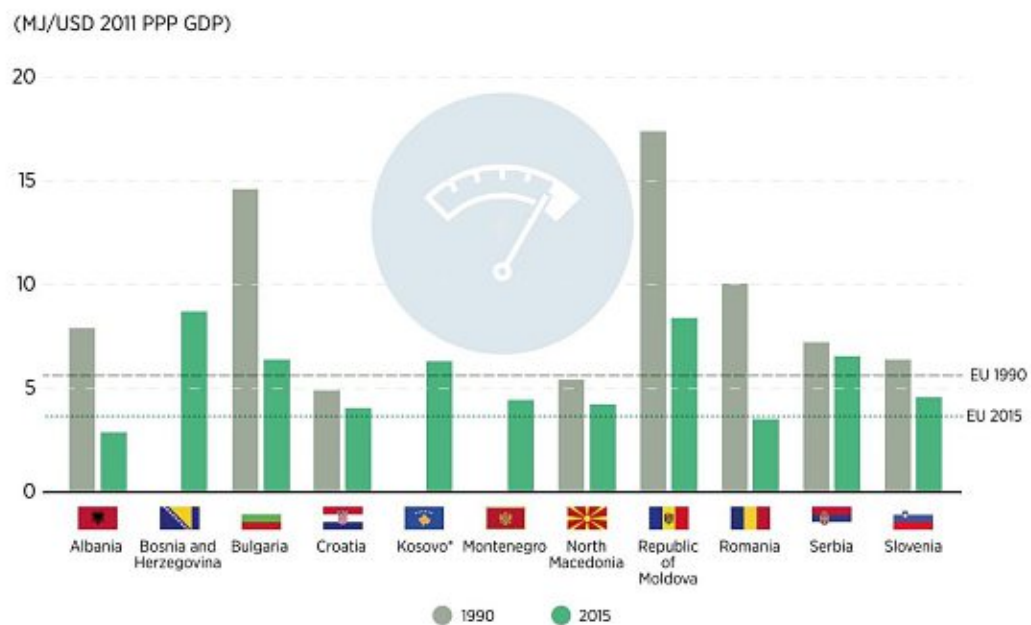


Figure 2: Energy intensity, SEE, 1990 and 2015 (Bianco 2019, p. 118)

In the SEE region the highest potential for energy savings lies in improving energy efficiency in the buildings sector. This potential remains untapped and is much higher than in many other countries in transition because of unmaintained, large stock of old industrial equipment and buildings, and many financial, market and legal barriers (EBRD 2012, p. project-support/why-EnPC).

Around 50 % of final energy consumption in SEE can be attributed to the consumption in buildings. Estimated energy savings in the range between 20 % and 40 % could be achieved only by improving energy efficiency in buildings, 35-40 % in the public sector

and 10-35 % in the residential sector. For those SEE countries not being part of the EU, the so-called Western Balkan Countries, national energy efficiency targets and legislation is based on the frameworks of the Energy Community (Bianco 2019, p. 118). Energy Community Secretariat has concluded through a regional market assessment that potential for energy savings in the Western Balkan Countries amounts to 6.162 GWh or 343,2 MEUR (Bertoldi et al. 2018, p. 24).

Lack of technical knowledge on the decision making levels and lack of financing options are often seen as main barriers to scaling up implementation of energy efficiency projects. To overcome some of the existing barriers, often used financial instrument in reaching higher renovation rates in both public and private buildings is the energy service contracting (ESCO) mechanism and energy service providers. ESCOs can provide exactly these services to its clients, know-how and favourable financing (European Commission 2/13/2020, p. 1). On the other hand, the public sector can enhance the implementation and growth of the ESCO market through enabling strong demand for services and creating favourable conditions for investing in energy efficiency projects. Governments should have the leading role in promoting energy efficiency by adopting regulatory frameworks and legislative policy to eliminate barriers to public procurement of ESCO services. Understandable procurement rules, regulations and procedures and provision of affordable financing would help build trust between the energy contracting parties in the public sector (Bertoldi et al. 2018, p. 14).

In addition to energy saving potential of ESCOs, it is estimated that overall digital upgrade could improve energy efficiency in buildings by 15-25 %. (European Commission 2020b, p. 5).

We are witnessing a profound transformation of our daily life through digital technologies as it affects our way of working, the way we travel, communicate and relate to each other. Digital communication with social media and e-commerce are steadily changing our world. Electronic devices generate an increasing amount of data, which, if used correctly, can lead to a completely new way of living and comfort. However, those benefits come with costs and risks, because people don't feel safe anymore nor to be in control of their personal data. Therefore, a true digital transformation has to come from people and businesses trusting that their online and offline activity is secure (European Commission 2020c, p. 1). New advances in technology through digitalisation and deployment of sustainable and clean energy

solutions are paving the way for new innovation opportunities in the whole energy sector, as well as in energy efficiency sector (Krofak 2019, p. 18).

Among the barriers that constrain the investments in the energy conservation measures, regulatory, financial and informational are most important to consider. Financing the investments is often constrained with lack of access to capital, high investment and transaction costs. As a consequence, level of investments in energy efficiency is not as high as it is supposed to be in order to reach the goal set out by the Paris Agreement of limiting global average temperature increase to below 2 °C. Instead, current investment levels should be doubled by 2025 in order to stay on track for reaching the climate neutrality goals (Schletz et al. 2020a, pp. 1–2). Adoption of energy conservation measures is critical, because most of global greenhouse gas emission reductions is expected to come from the energy efficiency savings.

An example of the informational barrier is the shortage of comprehensive technologies for measurement and verification (M&V) of energy savings and underutilisation of increasing amount of collected data, which lead to lack of credible information. Due to unavailability of credible information investments in energy conservation measures become limited and so does the development of policies. When information is not available or not trustworthy, investments are perceived as risky and with low return by financial institutions. Technologies like blockchain could help to tackle these barriers, by creating transparency and reducing transaction cost for implementation of energy conservation measures for energy efficiency improvement. It is sometimes proposed that blockchain technology could change complex and time consuming traditional governance models and create innovative models for interactions. Energy systems are becoming more complex with distributed energy producers and increasing number of participants, thus, control and management is becoming more challenging for traditional centralised governance models. Advanced communication and data exchange models are required to deal with this increasing complexity (Schletz et al. 2020a, pp. 1–2).

Three main areas of application in the energy sector are seen as relevant for blockchain technology: innovative energy trading systems (e.g. peer-to-peer energy trading), distributed accounting and trading platform for energy efficiency certificates, and support for decentralised financing mechanisms for ESCOs (Schletz et al. 2020a, pp. 1–2).

1.2 Objective of the thesis

The purpose of this thesis is to validate whether blockchain technology could support the implementation of energy conservation measures through ESCO business models in the Serbian market for energy efficiency. Building on the findings resulting from the research made by Krofak 2019, where evidence was provided to confirm that blockchain should be considered as the underlying technology for successful implementation of energy performance contracting (EPC) in developing countries, in this thesis the proposed theoretical framework was applied to test the concept of energy performance contracting supported by blockchain on a concrete market conditions and specifics energy efficiency market in Serbia.

Second, the thesis will analyse the main barriers in deploying ESCO financing in Serbia to meet the national goals of increased energy efficiency.

1.3 Research questions

The central research questions of this thesis:

- How can digitalisation help in reducing transaction costs of ESCO models with blockchain and smart meter technologies?
- How can measurement and verification of energy savings be improved by digitalisation?
- How can technology help in development of ESCO market in Serbia?

1.4 Methodology and Structure of the Master Thesis

After this introductory chapter describing the motivation and objective of the master thesis, chapter 2 will provide relevant background information. Current stage of the ESCO market in Serbia is presented together with the main barriers for further ESCO business development. In-depth analysis and overview of the legislative basis and main policy drivers for the topics described in this thesis is given. Chapters 3 and 4 reflect the theoretical background and literature study. Chapter 3 includes the definition and concept of energy contracting services in general with an overview of well-established business models. Thorough analysis of transaction costs and measurement and verification methods for energy performance contracting (EPC)

projects is made. Chapter 4 covers the description of blockchain and smart contract technologies, supplemented by a brief overview of another emerging technology, Internet of Things (IoT) with smart metering. In chapter 5 the potential of integration of blockchain technology within energy contracting services is discussed and suitability of blockchain application in EPC projects is evaluated through a specific question-based decision framework. Finally, conclusions of the research are discussed in the chapter 6.

2 Background information

Objective of the Paris agreement is to reach carbon neutrality of the society by the year 2050. The estimation is that for developing countries total of 6 trillion USD is needed for the investment in green infrastructure and 500 billion USD annually for the mitigation of carbon emissions (Krofak 2019, p. 12). It will require significant changes in the regulatory frameworks and increased investments for project implementation in sectors where potential of energy savings is the greatest. As a response to these changes, financial institutions are designing new financing instruments and products, for example green bond certificates. But with these instruments requirements such as resource efficiency are emerging as well, because resource and energy efficiency are seen as key areas in reaching the carbon neutrality objectives.

A measure of the way how energy is being used is energy efficiency. It is a preservation of energy by reducing consumption, for example by consuming less. However, by introducing new technologies or more efficient processes the amount of consumed energy will be reduced, while the level of provided service will be maintained the same. According to Fagernæs, *“the cleanest and cheapest kilowatt is the one never produced”* (Fagernæs 2016, p. 13). Another definition says, energy efficiency means that the usefulness from using one unit of energy remains constant, while the input for the production of that unit is reduced. So, if one kWh of input energy can produce more output, and by that increase the usefulness, energy efficiency is improved (Fagernæs 2016, p. 13).

One of the main drivers for the increasing number of energy efficiency investments is the energy price. Increasing energy price across Europe at a steady pace has somewhat improved the prevalence of energy efficiency investments, but the unutilised potential is still great.

For the Western Balkans countries to fulfil the goals of the Paris Agreement it is necessary to align EU international frameworks with domestic policies. For example, in the UN 2030 sustainable development agenda, 17 sustainable development goals (SDGs) were defined to clear way for implementing carbon neutrality projects. In the SDG agenda energy efficiency is defined as SDG No. 7 with the primary goal of doubling the energy efficiency improvement by 2030 globally. Key targets defined in the set 2030 strategy are 40 % reduction in greenhouse gas emissions comparing to levels in 2020, increase of the renewable energy share to 32 % and improvement in

energy efficiency 32,5 % (Krofak 2019, pp. 10–11). However, current pace of development is slow and if the trend continues the goals will hardly be reached. This is especially evident in the energy efficiency in buildings sector.

The agenda clearly sets out the goal of improving energy efficiency as one with the critical impact given the available potential. But even though this potential is immense, there is a notable difference between the available project investments and availability of projects opportunities. Investments are usually lacking. And in some countries where financial barriers are not existent, development of energy efficiency projects is not as fast as expected. In those cases, weak regulatory frameworks are the main barriers for project developments (Krofak 2019, p. 11).

The building and housing sector is seen as important one for energy efficiency improvement by the EU and major financial institutions because of its great potential. With 40 % share in European energy consumption from buildings and 36 % of its greenhouse gas emissions, it is evident that this sector offers significant opportunities for energy savings (Krofak 2019, p. 13). Countries like Serbia are no exception, but relatively undeveloped regulatory framework doesn't support more significant investments. Although some progress has been made in the last 10 years to support the regulatory framework development, it is still evidently slow and long process.

Financial institutions like European investment bank (EIB) are supporting building renovation investments through different financing schemes and specialised funds to promote energy efficiency. In terms of financing, what needs to be considered as a critical factor is that in non-EU countries there is still an underdeveloped financial environment for energy efficiency investments. Usually, credit lines are provided under most favourable conditions by multilateral development banks. These are offered as direct financing of energy efficiency measures in the public sector, like public lighting, schools or hospitals. Alternatively, international financial institutions are offering credit lines through local banks, which are targeting energy efficiency measures implementation in the private sector. The problem is that, in developing countries these transactions and processes are still exposed to certain risks for the investors and the final consumers (Krofak 2019, pp. 13–14). Because of this risk financing options for energy efficiency projects are becoming more expensive and number of investments isn't increasing as it should be. As a result potential energy savings aren't realised.

Figure 3 shows the typical financing options for energy efficiency projects in the EU. The chart shows most common type of financing is self-financing, followed by debt financing.

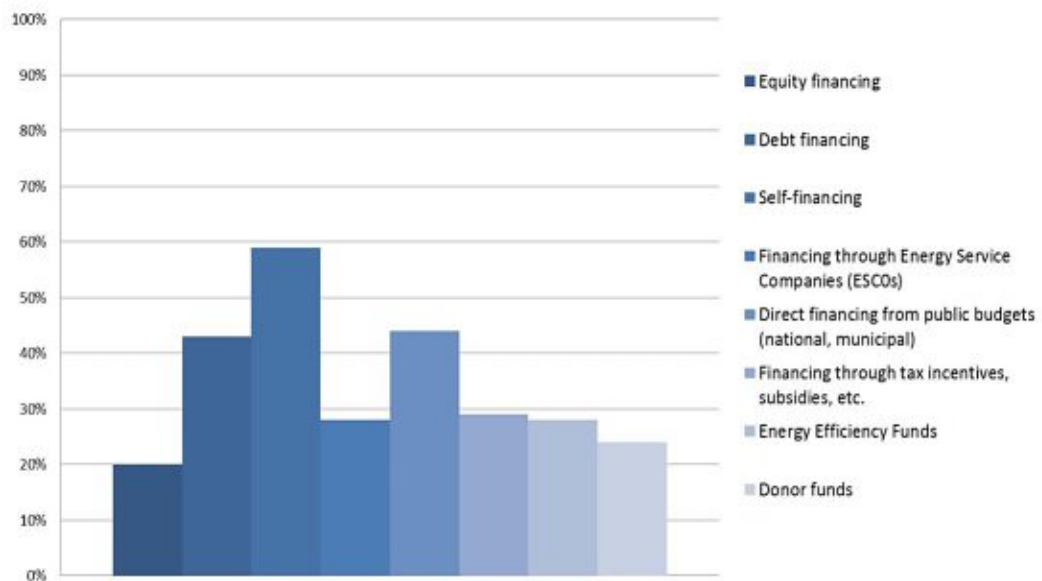


Figure 3: Most widely used types of financing for energy efficiency projects- all countries.
(Krofak 2019, p. 15)

It is the same situation in East European countries as shown in Figure 4. However, after self-financing and debt financing there is a noticeably higher degree of donor financing and much lower degree of funding through the ESCOs.

Because ESCO business models usually involve more participants where high level of trust is required, to implement the models developed regulatory system is required that protects all of them. In developing economies, lack of awareness and required know-how are still some of the main barriers faced by local financial institutions and private investors. As a result, conditions for the loan repayment are much worse there. Considering these increased risks, there are noticeable differences in the way energy efficiency projects are financed in East European countries comparing to the EU, as shown in Figure 3 and Figure 4 (Krofak 2019, p. 16). Countries like Serbia have a weak regulatory framework and energy efficiency projects are mostly financed from donor financing or from public budget and specialised energy efficiency funds.

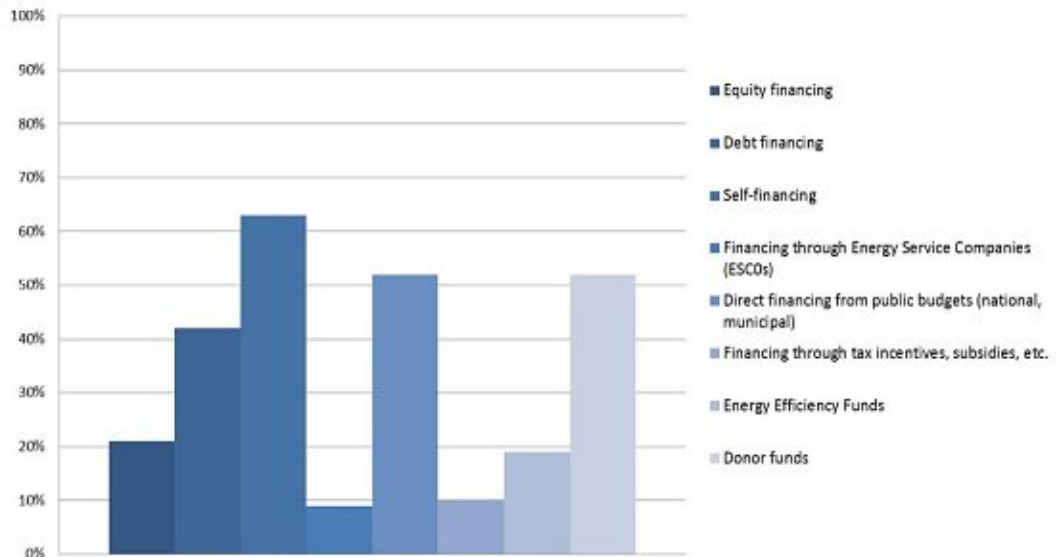


Figure 4: Most widely used types of financing for energy efficiency projects Eastern Europe, Caucasus, Central Asia, Russian Federation (Krofak 2019, p. 15)

These differences can be explained by examining the main factors that enable increased viability of energy investments in Figure 5.

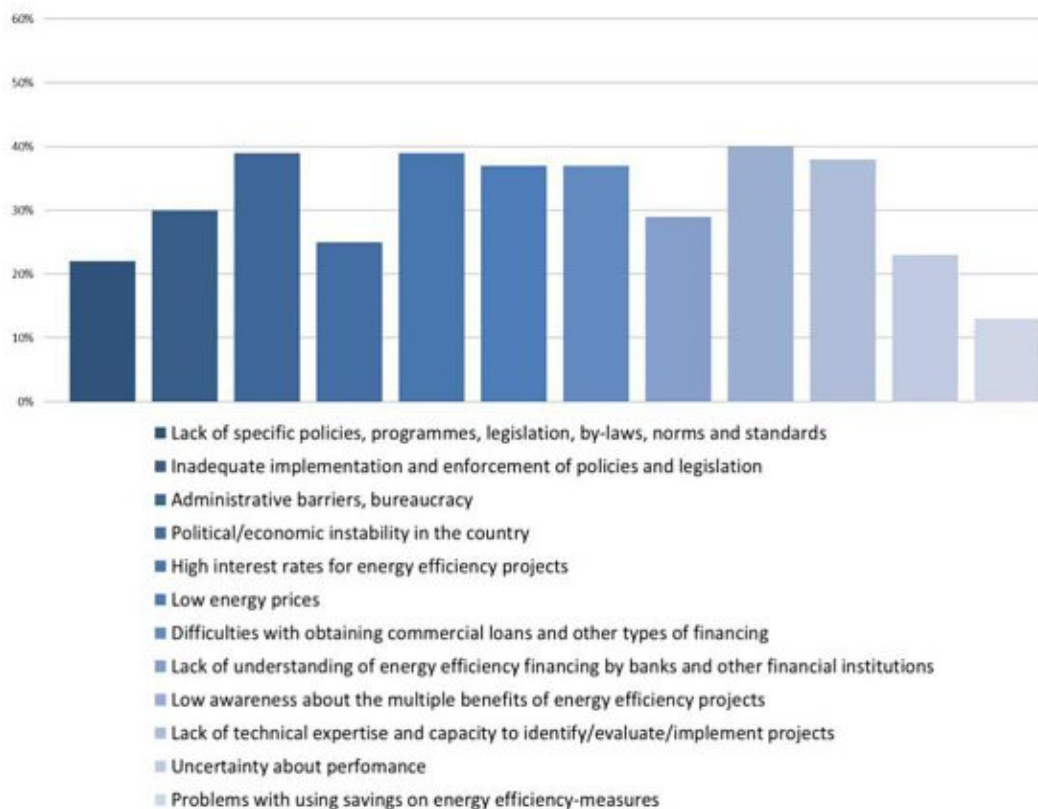


Figure 5: Main factors that can lead to increased energy investment viability (Krofak 2019, p. 17)

Investments in energy efficiency project are directly hindered by the lack of high quality regulatory framework. And generally investments in energy efficiency projects are viewed by the financial institutions as not too favourable and more risky compared to other business projects. Projects in the public sectors where loans are to be repaid from generated saving are considered to be more favourable than those in the private sector, but only by a bit. It is expected that advance technological solutions, like blockchain could help overcome these barriers. Blockchain might have the capacity to address reformed energy systems that are becoming more complex and decentralised, with more participants and possible actions, in managing and controlling them smarter (Krofak 2019, p. 18).

2.1 ESCO market in Serbia - market and legislative background

The market and legislative background chapter will give an overview of those factors and directives that promote improvement of energy efficiency through energy contracting services and the barriers that hinder it.

EU Commission is set to enable digital transformation in Europe in the next five years with the help of digital solutions for the overall benefit of the society (European Commission 2020c, p. 2). One of key actions of an objective set out by the EU Commission to promote technology that works for the people, is to build and deploy cutting-edge joint digital capacities in the areas of AI and blockchain, among others. This is in line with the strategy to develop a clear framework for the promotion of digitally enabled interactions within society with focus on trustworthiness, which is the essential process for the success of digital transformation. Europe is set to become a leader in adoption and standardisation of new generation of technologies like blockchain, in order to boost the productivity of markets as well as companies of all sizes in any sector (European Commission 2020c, p. 2).

The Western Balkans countries – Albania, Bosnia and Herzegovina, Montenegro, North Macedonia and Serbia have signed the digital agenda with the EU Commission for the Western Balkan region in 2018. By accepting the agenda, countries have embraced common objectives and committed to increase cybersecurity, trust and digitalisation of industry to enable all sectors to benefit from digital innovations (European Commission 6/25/2018, p. 1).

As a contracting party of the Energy community treaty, together with Albania, Bosnia and Herzegovina, Montenegro, Moldova, North Macedonia and Ukraine, Serbia has to transpose the third energy package and adopt the EU acquis on energy efficiency and renewable energy. This includes the transposition of provisions for the promotion of energy services in the EU member states, namely the energy service directive ESD 2006/32/EC, and from October 2017 also the Energy efficiency directive EED 2012/27/EU. The contracting parties to the treaty are obliged to make the transposition of Article 6 of the ESD and of Article 18 of EED. Besides, the parties committed to prepare and submit national energy efficiency action plans (NEEAPs) to energy community secretariat once in every two years. Among other, these action plans are supposed help the development of policies to promote energy services and ESCOs at the national level. In the period from 2014 progress has been made in Serbia regarding the transposition of the EU legislation for energy efficiency. Energy performance contracting (EPC) was integrated in the laws of energy efficiency (Bertoldi et al. 2018, p. 7).

According to the treaty, one of the key aspects for improving energy efficiency in public municipal buildings is the application of municipal energy planning. Local authorities should develop local energy efficiency action plans and sustainable energy action plan for the improvement of energy efficiency. In order to implement the measures defined in the action plans, financial support from the national government or from the private sector by energy service companies ESCOs is needed. In this way promotion of the ESCO market is stimulated, investments in energy efficiency improvement are supported (Bertoldi et al. 2018, p. 14).

For the development of the ESCO market, legal frameworks for energy efficiency and the ESCO are of crucial importance. Ministry of Mining & Energy defines measures to support implementation of the energy performance of buildings directive EPBD 2010/31/EU through ESCO mechanism. In the action plan, potentials for energy savings in each energy sector were calculated and presented with possible types of financing. ESCO mechanism was suggested as one of the means for financing implementation of energy conservation measures for the following sectors:

- in public and commercial sector: improvement of energy efficiency of buildings in public and commercial sectors, modernisation of public lighting systems in local municipalities, introduction of energy management systems in public and commercial sectors.
- Introduction of energy management system in the industry sector.

- Reconstruction of the district heating systems and reconstruction and modernisation of heating plants.

The interest of ESCOs to invest in energy efficiency projects in the industrial sector is very low. This is because the sector in the Western Balkan countries is relatively small, energy saving potential is limited and, therefore, it is not in focus of governmental policies. So the ESCO market in the industrial sector in the least developed, even though technologies that most companies are operating with are obsolete and their energy consumption is high.

Full transposition of the EU acquis for energy efficiency is essential for all contracting parties of the Energy community treaty and for energy services it can be done by integrating the ESCO legal frameworks into energy laws or energy efficiency laws. Alternatively, ESCOs can be regulated separately, like it is the case in Serbia.

Implementation of ESCO mechanism in the Serbia is supported through the regional energy efficiency programme (REEP) for the Western Balkans countries founded by the EBRD. More about the REEP in Chapter 2.1.4. Through the REEP, legal conditions for the application of the EPC contracts model for projects in the public sector's buildings and municipality street lighting was made in 2015. Besides the support for the improvement of the legal framework, the programme provides technical assistance for project identification, tender preparation and supervision of projects' implementation. Tenders for the improvement of street lighting efficiency based on EPC were announced in dozens of Serbian municipalities to date. The EBRD has allocated 50 MEUR to be used through ESCO financing for the improvement of energy efficiency in the public sector (Bertoldi et al. 2018, p. 54).

Despite these visible efforts of the government and increasing interest of private companies in providing energy services, ESCO market in Serbia is still in a preliminary phase. Most notably, the public sector is showing progress in preparing and announcing energy service tenders. Since the adoption of the framework, there are several active ESCO companies on the market, mainly domestic companies or subsidiaries of regional or international energy service companies with limited technical and financial capabilities. Sun Energy Balkan, Eltec Petrol, Resalta (previously GGE) are some of the registered subsidiaries of international companies that are already active in implementing of energy efficiency projects based on ESCO concept. Among a few local companies is ESCO – Energy Saving Company Belgrade that provides services in the private sector. There are also a number of technology

supplier companies, like Philips, GE, Minel-Schreder and Siemens, that are becoming more active in the ESCO market (Bertoldi et al. 2018, p. 52). Usually main obstacles that prevent these companies from accessing financing are their limited assets and weak balance sheets; then the perception of commercial financing institutions that energy efficiency projects come with a high risk and unfamiliarity of those institutions with the technical due diligence capabilities to appraise such projects. For these reasons, tendering process for energy contracting services in overall is still scaling up very slow, unlike in Western Europe and North America.

The market could benefit from increased number of international ESCOs that can bring their business experience and help develop the ESCO market on all energy sectors by increasing competition. Sun Energy Balkan, a subsidiary of Dutch ESCO, is mainly targeting small scale projects for heating and cooling of residential buildings in the private sector in Serbia and already has implemented four energy efficiency projects. For two new residential building projects in Belgrade heating and cooling to 16 and 48 apartments is provided through the use of near-to-surface geothermal energy to cover 80 % of the demand. In this way, energy costs of the residents for both heating and cooling and paid with amount that would be normally used only for heating (Bertoldi et al. 2018, p. 53).

Another real case example of the implementation of ESCO projects is a heating plant in city Šabac in western Serbia. The project is based on public private partnership, where a city's utility company applies for a credit from EU bank for reconstruction and development (EBRD) in the amount of 2,5 MEUR though EPC business model for improvement of thermal insulation of 40 residential buildings with the repayment period of 12 years. If this example would be take further to other residential blocks in Šabac, or other cities in Serbia, it is estimated that energy efficiency in the residential sector in Serbia could improve by 70 %. But most ESCO project in Serbia are related to improving energy efficiency in public buildings and public lighting. For example, in 2020 national government called municipalities to apply for grants in the amount of 366.000 EUR for improvement of energy efficiency in public buildings and lighting. Usually underdeveloped municipalities are given priority when allocating grants. Each municipality can apply for one project, and projects normally include improvement of thermal insulation of the building walls, roof and floors, HVAC, internal lights and heating, including installation of solar thermal collector and advance control and energy management devices.

Besides the EBRD financing through REEP programme, there are many international financial institutions and various funds and donors in Serbia that are ready to support the improvement of energy efficiency with favourable credit lines (Ministry of Mining & Energy 2017, p. 69). Public, and especially private sector are highly reliant on these funds.

2.1.1 Barriers for the ESCO business in Serbia

Market barriers

Market barriers for the ESCO businesses in the non-EU countries are manifold. Lack of trust between the clients and ESCOs, understanding for ESCO concept by public administration responsible for public tendering and procurement for public tenders, and lack of standard contracting models are identified as the main market barriers in the Western Balkan countries for the advancement of ESCO services in the public sector.

Some of the reasons behind this lack of trust by the clients in ESCOs are: diverse ESCO offers in the market, shortage of competition, general lack of know-how of clients, ESCOs and financial institutions, non-existence reference cases and lack of standardised systems for M&V of energy savings. In Serbia and in the region fear of corruption is also a reason for the lack of trust (Bertoldi and Boza-Kiss 2017, p. 353).

With the introduction of standardised tender documents and procedures and standardised EPC contracts model in 2015, long procedures for the preparation of public tendering of energy services in Serbia was reduced, resulting in lower transaction costs and increased trust by the clients (Bertoldi et al. 2018, p. 17). Nevertheless, even though a legal framework for ESCOs is in place, it can still be significantly improved in the following areas:

- Public procurement of energy services;
- Investment in energy efficiency in municipalities;
- Energy efficiency in buildings (residential, public and commercial);
- Monitoring and measurement of energy consumption in residential, public and commercial buildings;
- Energy auditing and energy management in the industrial and service sector (public and commercial);

- Creation of homeowner associations as legal entities in the residential sector;
- Maintenance of multi-apartment buildings.

Lack of umbrella organisation / association of ESCOs and low energy prices are significantly hindering the development of the ESCO market in Serbia and the region. Prices of electricity, district heating and natural gas in the residential sector in Serbia are heavily subsidised by the government and are still below the real market prices. As a consequence, EPC contracts have to be concluded with a very long payback period, sometimes exceeding 10 years, which makes energy efficiency investments less attractive.

A common barrier in the residential sector in Serbia is high transaction cost for small size projects. Since 89,6 % of the total number of buildings in Serbia are single family houses, it make is very complex to implement energy efficiency measures to such a fragmented structure of building stock, with so many private clients and projects of small size (Bertoldi et al. 2018, p. 24). Resulting high transaction costs are turning away potential energy conservation investments in the residential sector. Solution to deal with the fragmented structure of the building stock is to bundle several buildings into one project, which is usually possible where the owner of the residential buildings is the state or local authority. In this case, the buildings with similar characteristics and construction period can be categorised accordingly and same energy conservation measures applied. This would significantly reduce transaction cost.

Complex ownership structure of buildings, low to non-existent creditworthiness of Homeowner associations (HOAs) and usually long payback periods are often perceived as high risk operations by commercial banks and they easily become reluctant to issuing loans for the residential sector, or it is issued with very high interest rates (Bertoldi et al. 2018, p. 25).

Homeowner associations

Homeowner associations (HOAs) are legal entities whose creation, although implemented into the legislation of Serbia, in practice is not applied so much. Benefits of having an HOA in a multi-family building is that, in theory, it can apply for credit lines from commercial banks and step into contract with energy service providers, like ESCO. But in Serbia HOA are not creditworthy and, therefore, cannot borrow money. HOAs can ensure fair distribution of any energy efficiency benefits across all homeowners, but decision making process is complicated, as 51 % of the total

number of homeowners in multi-family building in Serbia have to agree before making an investment for an energy upgrade. As a result of these barriers ESCOs have no other option, but to consider dealing with multiple homeowners instead of a single HOA, which implies higher transaction costs and increased complexity of the projects, or not to invest at all. Usually the latter is the case (Bertoldi et al. 2018, p. 25).

Monitoring and measurement of energy consumption

To enhance the preparation of pre-feasibility and to scale up investment with higher accuracy, improving quality as well as quantity of energy data is essential. This is possible by introducing energy management systems (EMS) and energy auditing in the public, industrial and commercial sectors as well as measurement of energy consumption in the residential sector. In Serbia and other contracting countries of the Energy Community from October 2017 the transposition of the Energy Efficiency Directive was brought into force, meaning that the legislation is enforcing the introduction of EMS, energy managers and mandatory energy audits for larger enterprises and the public sector. However, measurement and monitoring of energy consumption in the residential sector is still an issue in Serbia and improvement in this field would be important for enhancing the implementation of ESCO models, because reliable and useful energy data would be produced. Consumption based billing for heating was adopted in some newly built multi apartment buildings, but large scale application is missing, especially in the existing buildings constructed during the second half of the 20th century. Consumption of energy for heating is usually measured at one point, in the heating substation and divided per apartments per square meter in each building. As a consequence, there is a lack of motivation for residents to save energy and to invest in energy efficiency, because there are no tangible results and benefits to them. (Bertoldi et al. 2018, p. 24). District heating companies could finance the purchase of metering devices, or it can be financed through state funds. Then introduction of heat metering and consumption based billing in individual apartments could boost the energy efficiency measures, as consumers would be more aware of their consumption and would be motivated to save their energy costs. Achieved cost savings can use to create cash flows or funds to be used for the repayment of energy efficiency loans.

Measurement and verification of energy savings

Results of achieved energy savings from implemented energy conservation measures by an ESCO are determined by measurement and verification methods (M&V). These results, however, are not always met, or at least an ESCO and its clients do not always agree on them, which causes disputes, often with financial implications for the both sides. These disputes can be avoided by introducing credible methods, based on international protocols and standards. Besides, using credible M&V would enable transparency that can be beneficial for the correct implementation and long term operation of ESCO projects. In Serbia national methodologies for M&V of energy savings were prepared and adopted through the national energy efficiency action plan (Bertoldi et al. 2018, p. 18).

Financial barriers

In Serbia, energy service companies usually use their own equity for financing projects, which is obviously difficult to sustain on the long run, especially for smaller size ESCOs, because of limited liquidity. Main financial barriers for the development of energy services and ESCO market in Serbia are lack of energy efficiency funds for funding energy contracting services and limited understanding of commercial banks about the ESCO business model. With a typical energy efficiency fund, loans are provided to entities in the public sector for covering the initial investment costs of energy efficiency projects, but ESCO projects can be funded as well. The energy efficiency fund in Serbia was authorised by the energy efficiency law in 2013 and created as a line item in the state budget in 2014 as an efficient mean for collection and placement of assets for financing projects, programmes and activities for more efficient energy use. The assets are supposed to be allocated to either public or private entities through public tenders (Ministry of Mining & Energy 2021., p. 1). Ministry of Mining & Energy manages the fund for the purpose of financing energy efficiency projects in municipalities, but financing ESCO project hasn't become praxis yet. Also considered as a key financial barrier, limited knowledge of commercial banks about the EPC contracts and benefits from energy and financial savings is reported in all Western Balkan countries. Furthermore, commercial banks are usually lacking know how and have no capacity for preparation and evaluation of ESCO based energy efficiency projects (Bertoldi et al. 2018, p. 12). So usually very high interest rates for the repayment of energy efficiency loans are offered, which turns away investors. On the other, homeowners are also unfamiliar with the concept of an energy

contracting company and the benefits it brings through the implementation of energy efficiency projects, which hinders the development of the market. General information and rising awareness of the public is essential in this regards, which can be made thorough organising campaigns and public education on ESCO concept and energy efficiency. Dedicated websites could gather relevant information about financing programs and incentives and offer advice to HOAs. Such undertakings can attract investments in energy efficiency project in the private sector and would reduce transaction cost for their implementation.

Furthermore, residential sector is not the focus of state incentives. State financing and incentives, like tax reductions for energy efficient equipment and materials, are good mechanisms for promotion of investments in energy conservation measures in residential buildings, as costs for preparation of technical documentation for building renovation and energy audits (examples of transaction costs) can be covered from state funds or grants created for this purpose. However, in Serbia special initiatives and funds are only available for the public sector.

2.1.2 The EU Green Deal

The European Green deal present a set of policies and measures that aims to transform the EU into a climate neutral society by 2050, where there are no net emissions of greenhouse gases and where economic growth is decoupled from resource use. The Commission also stated that digitalisation will be the key driver for activities in this area and that actually a double transition is happening – green and digital (European Commission 2019, p. 4). Figure 6 shows main elements of the European green deal, where Building and renovating in an energy and resource and efficient way is one them.

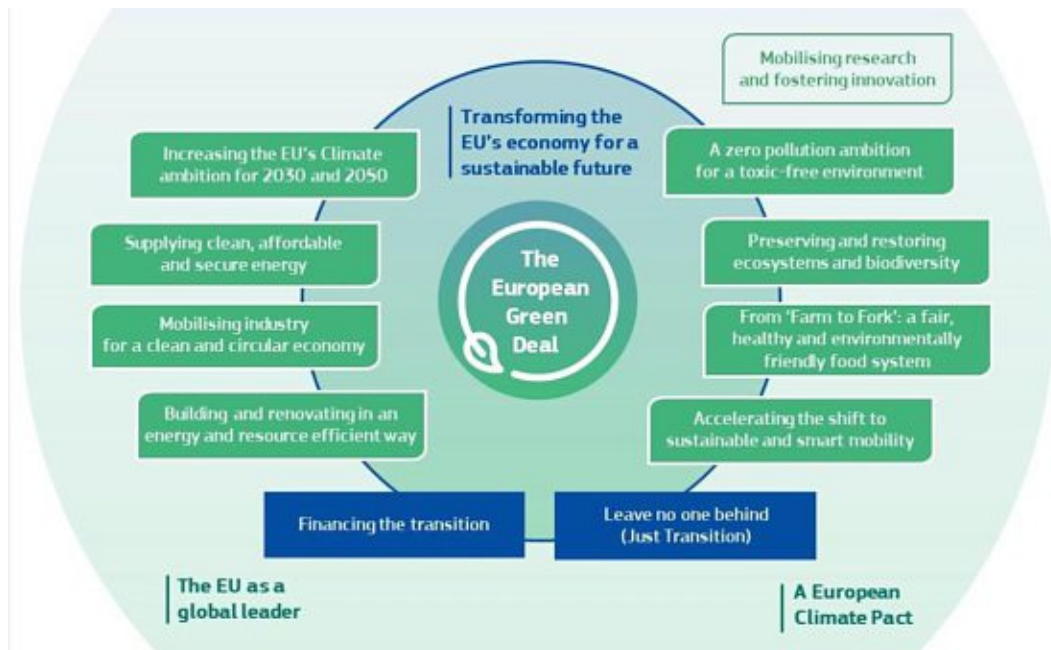


Figure 6: The European Green Deal elements (European Commission 2019, p. 3)

Promotion of and investment in digital transformation and tools are crucial enablers of the transition. Blockchain technology, alongside with artificial intelligence (AI) and internet of things (IoT), is seen as an essential enabler for reaching the sustainability goals of the Green deal in many different sectors (European Commission 2019, p. 4).

According to the EU Commission, the EU green deal will be effective only if the countries that surround it also take efficient measures for the energy transition at the early stage. This especially applies to the Western Balkan countries because of their European perspective. Consequently, as foreseen in the EU Green deal, the Commission presented a Green Agenda for the Western Balkans (European Commission 2020a, p. 10).

The Western Balkan leaders have gathered in Sofia on 10th November 2020 to present an Economic and Investment Plan for the Western Balkans and endorse the Green Agenda for this region. By endorsing the Agenda, countries made commitment to take actions in five broad areas covered in the Green deal, so called five pillars, including introduction of taxes to CO₂ emissions and market model for incitement of renewable energy and total abolishment of coal subsidies.

Five pillars are:

- 1) Decarbonisation through climate, energy, mobility;
- 2) Depollution of air, water and soil;

- 3) Circular economy;
- 4) Farming and food production and
- 5) Protecting biodiversity.

Climate, energy, mobility is the key pillar that prioritises energy efficiency improvement in all sectors, support for private and public buildings renovation schemas and appropriate financing and full enforcement of the EPBD 2010/31/EU (adapted under the EnC framework). It was agreed that the Regional Cooperation Council (RCC) will be coordinating the implementation of the declaration. (Nikčević 2020, p. 2).

The Energy Community (EnC) was founded in October 2005 by a treaty signed in Athens to become operational in July 2006. Contracting parties of the EnC are Albania, Bosnia and Herzegovina, Georgia, North Macedonia, the Republic of Moldova, Montenegro, Serbia and Ukraine. The EnC was founded with the objective to bring together the EU and its SEE neighbours, the Black Sea region and beyond, to create an integrated pan-European energy market on the basis of a common legally binding framework. By signing the treaty, all contracting parties committed to implement EU energy legislation, known as the *acquis communautaire*. The *acquis* covers the areas of electricity, energy efficiency, gas, environment, emergency oil supply, statistics and infrastructure regulation, and it's constantly updated in parallel to ongoing EU regulation. In the main focus of the EnC are stable market and regulatory framework for continuous development of power generation and grids, establishing just conditions for energy trading between countries, providing increased security of supply and increased deployment of renewable energy technologies and energy efficiency. For the Western Balkan region, the EnC has taken the role of the leading promoter of rules and standards for the clean energy transition (Bianco 2019, p. 27). For the Western Balkan countries it means making strong commitments in making fundamental reforms for economic integration of the *acquis* to have a common regional market with a goal of creating a region that would be more attractive for investment in the field of energy. Besides, the parties took an obligation to regularly report on their success of harmonising legislation with EU directives (European Commission 2020a, p. 2).

Through the Economic and Investment Plan for the Western Balkans, EU Commission has proposed to mobilise up to 9 billion EUR of the Instrument for Pre-Accession (IPA) III funding for the period between 2021 and 2027 to ensure economic development of the region to bring it closer to the EU. Main areas for investment are

sustainable transport and twin green and digital transition. Part of the Economic and Investment Plan for the Western Balkans are Guidelines for the implementation of the Green Agenda for the region that define the five pillar activities from the Green deal. The Guidelines bring suggestions of measures and activities that the EU and the Western Balkan countries should adapt together.

The investment package will be deployed through the Western Balkans Investment Framework (WBIF), including Western Balkans Enterprise Development and Innovation Facility (WB EDIF) as a private sector platform and the Western Balkans Guarantee Facility, together with the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD), International Financial Institutions (IFIs), the Western Balkans governments, bilateral donors and private investors (European Commission 2020a, p. 6).

Apart from the 9 billion EUR investment package to the region, the EU also provides guarantees that can reduce the cost of financing and investment risk in both private and public sectors. Guarantees are expected to mobilise approx. 20 billion EUR of investments for the next decade through the Western Balkans Guarantee Facility (European Commission 2020a, p. 6).

2.1.3 Law on efficient use of energy

Energy Services Company – ESCO concept was for the first time explicitly defined in the Law on efficient use of energy published in the Official Gazette of Republic of Serbia number 25/2013 where the rules for energy performance contracting (EPC) were set out in line with the EU acquis, creating a legal framework for the deployment of energy efficiency projects. On May 8th 2015 under the Law on efficient use of energy, a secondary legislation was adapted that included a rulebook ‘determining model contract for energy services for implementation of energy efficiency improvement measures for public sector users’ to promote investments in energy efficiency. With the legislation came two ESCO model contract templates for energy efficiency investments in public buildings and in public street lighting. The legislation allowed ESCO companies as private entities to enter into public private partnership with a public partner, like municipality, the government or a public company, and provide services of installation and management of energy conservation measures on a long term basis. The contract templates were based on the EPC model, allowing the private partner (the ESCO company) to make the repayment of the investment

through energy savings achieved, therefore, not creating public debt (Ministry of Mining & Energy 2017, p. 46).

Three main contractual periods were foreseen by the model contract templates for the ESCO agreement:

- 1) Preparatory period, including evaluation of the energy consumption and habits of the consumer and design of the energy conservation measures;
- 2) Implementation period, including implementation of energy conservation measures by a private partner on the property of a public partner;
- 3) Guarantee period, where the energy and financial savings are monitored, verified and achieved as a result of the implemented measures (Bertoldi et al. 2018, pp. 52–53).

The ESCO model contract also defines a detailed guidelines of methodology for calculating the energy and financial savings for all energy efficiency measures through a so called measurement and verification (M&V) plan. Formulas for calculation include a method for comparing operational expenses that would incur in case conservation measures were not implemented with the operational expenses after the implementation of the measures during the guarantee period. The M&V plan is prepared based on the principles of International Performance Measurement and Verification Protocol – IPMVP (Ministry of Mining & Energy 2017, p. 45).

2.1.4 The Regional Energy Efficiency Programme (REEP) for the Western Balkans

The Regional Energy Efficiency Programme (REEP) was established in June 2012 by EBRD (assisted by GFA Consulting group, Econoler and CMS Serbia) with a 23,35 MEUR grant from WBIF to provide a combination of technical assistance, policy support and financing instruments to help private and public organisations finance their energy efficiency investments and unleash the potential of the Western Balkans countries to benefit from the increased use of renewable energy and energy efficiency measures.

EBRD is a European bank that cooperates with larger banks on the market and is focused on supporting public authorities to prepare ESCO energy efficiency projects. Its credit lines are accessible in the whole region through local commercial banks, without categorising and favouring countries. Decisions on credit allocation are based

on the principle first come – first serve. When financing municipalities, EBRD promotes the concept of cooperation with an ESCO, trains public employees, gives technical assistance for development of the framework and the concept for the structure of public private partnership between the two sectors (Ministry of Mining & Energy 2017, p. 71).

REEP approach of support to public authorities is built on the following pillars:

- 1) technical assistance to central or local government to identify, prepare and implement EPC projects and to support capacity building of ESCO clients, i.e. public authorities, including technical assessment of buildings and monitoring of achieved energy savings;
- 2) policy support in terms of preparing EPC contract templates and related tender procedures to enable regulatory frameworks to promote energy efficiency investments and assistance to amend legislation where needed;
- 3) offering financing instruments for specific renewable energy and energy efficiency investments, including support in designing a structure that combines private finance for EPC with European or other public funds, with estimates of benefits of those measures in terms of energy savings and reduction of emissions. REEP is targeting public sector buildings, like hospitals, schools, town halls and public services, like street lighting (EBRD 2012, p. about).

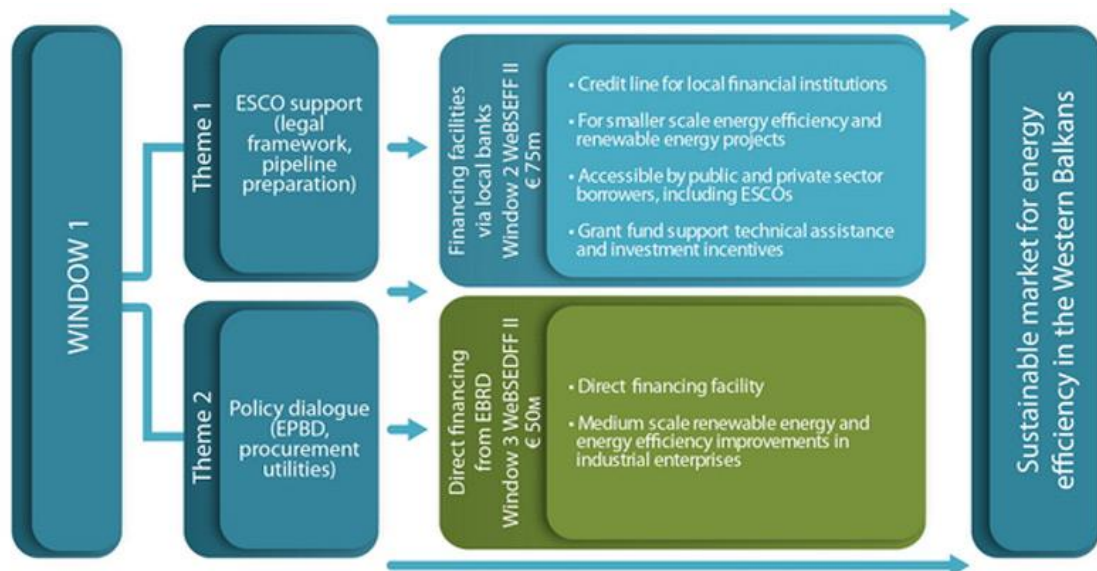


Figure 7: The REEP structure (EBRD 2012, p. about)

Figure 7 outlines the structure of the REEP with its three complementary windows.

So called 'Policy dialogue and project preparation support' is the window 1 with two sub-thematic areas: ESCO support and Policy dialogue. The aim is to provide technical assistance with the amount of 6 billion EUR to establish policy dialogue with the authorities in the region to help them set up regulatory frameworks, remove barriers that hinder the development and help the ESCO market to emerge.

Window 2 provides credit lines to local financial institutions to be used by private and public sector investors. The amount of 92 MEUR credit line is offered through Western Balkans Sustainable Energy Financing Facility (WeBSEFF) II and is aimed to support smaller scale renewable energy and energy efficiency projects.

A total of 50 MEUR is allocated by the EBRD in a direct financing facility window 3 through Western Balkans Direct Sustainable Energy Financing Facility (WeBSEDF) fund. Area of investment is in industrial sector for medium scale energy efficiency and renewable energy investments (EBRD 2012, p. about).

Since its founding and announcement of EPC model contracts, REEP has supported the preparation of street lighting ESCO projects in more than 35 Serbian municipalities so far.

3 Energy contracting services

3.1 Definition

Bleyl-Androschin 2009, p. 9 gives a definition of an ESCO like the following:

„Energy Contracting - also labelled as ESCO or Energy Service - is a comprehensive energy service concept to execute energy efficiency projects in buildings or production facilities according to minimized project cycle cost. An Energy Service Company (ESCO) implements a customized energy service package (consisting of planning, building, operation & maintenance, optimization, fuel purchase, (co-financing, user behaviour ...). The ESCO provides guarantees for all-inclusive cost and results and takes over commercial and technical implementation and operation risks over the whole project term of typically 10 to 15 years” (Bleyl-Androschin 2009, p. 9).

Instead of buying final energy, like electricity or gas, customers of ESCO concept are actually paying for certain benefits or services that come as a result from the use of the energy. They are paying the lowest cost for the comfort that comes from, for example, air conditioned or warmed up space, or its illumination. ESCO concept doesn't favour any specific energy carrier or technology, but instead is a flexible tool with a goal of satisfying a building owner's needs by addressing its energy demand in most efficient way with a minimised lifecycle cost.

As mentioned in definition above, ESCO takes over the project implementation risks. It does so by taking over the role of a coordinator for the implementation of energy conservation measures and by providing the energy service to its customers at turn-key, all-inclusive prices. The resulting outcome of these activities is provision of either useful energy through an energy supply contracting (ESC) model or energy savings through energy performance contracting (EPC) model. There are certain environmental benefits as well that are associated with the achieved energy and emission savings, which are making the ESCO model more appealing.

According to (Fagernæs 2016, p. 35), energy services provided through ESCO include:

- “Energy efficiency analysis, audits and management;
- Project design, implementation, operation and maintenance (O&M);

- *Monitoring and evaluation of savings;*
- *Property/ facility management;*
- *Provision of services and equipment (space heating/ cooling, lighting, etc.);*
- *Advice and training.”* (Fagernæs 2016, p. 18)

The ESCO model is a very useful instrument for improving energy efficiency, but without an adequate policies in place it can't do much difference to the energy sector. The most hindering factor to scaling up the ESCO business is limited access to finance. Only one in every ten of all ESCOs raises capital for energy contracting through external financing, as lending institutions seem hesitant to finance such projects because of high perceived transaction costs (Schletz et al. 2020a, p. 11). High transaction costs are also the reason why smaller projects like residential buildings are usually not interesting for ESCO businesses. Besides, complicated decision making process in multi-family buildings, more frequent and direct interaction with the homeowners, general lack of trust and low creditworthiness are making individual residential project least popular. (Bertoldi and Boza-Kiss 2017, p. 350)

One of the main factors driving the scale of investments in the energy efficiency is the energy price. When the energy prices and related taxes are rising, so is the interest and importance of energy efficiency. Another driver of the ESCO market is information and communication technology, especially the development of smart technology and its use in building energy management (Bertoldi and Boza-Kiss 2017, p. 352).

3.2 Energy-Contracting business models

Figure 8 shows scope of different energy contracting business models. In general there are three main models on the developed markets today. These are energy supply contracting (ESC), energy performance contracting (EPC) and integrated energy contracting (IEC) as a combination of the former two. Each model has its pros and cons that will be described in detail in the following chapters.

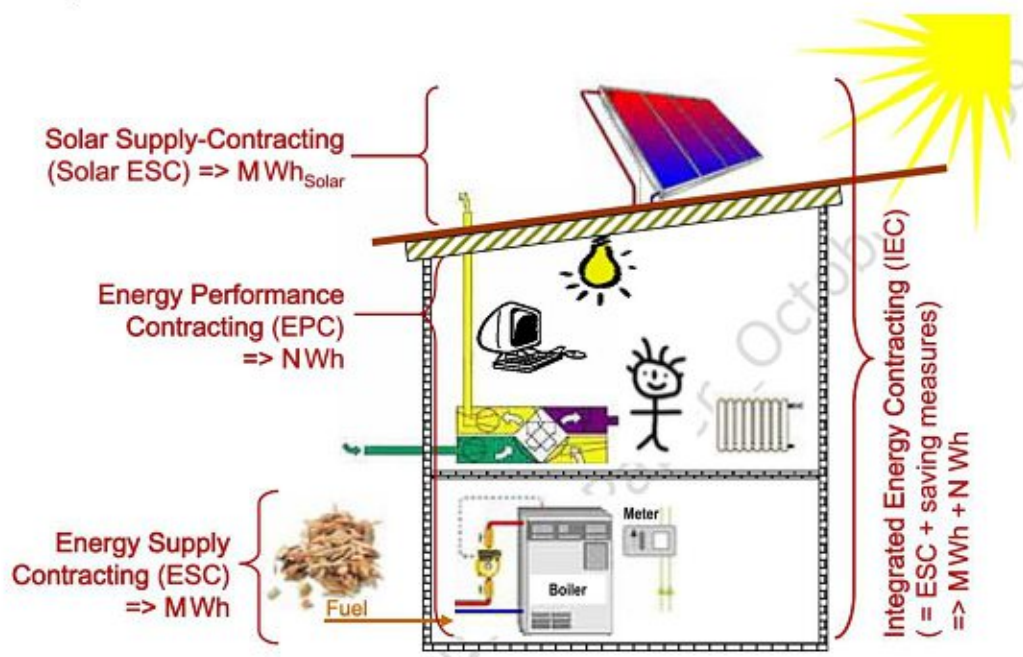


Figure 8: Scope of services of different ESCo models (Bleyl-Androschin 2009, p. 12)

ESC (including Solar ESC) focuses on selling units of useful energy, without taking into consideration the consumer side, like efficient energy use. EPC model implements measures for achieving energy savings through which capital investment for the energy conservation measures is repaid. IEC model combines the former two, which includes the provision of useful energy with the help of renewable technology, while reduction of consumption is addressed as well.

3.3 Energy Supply Contracting (ESC)

Energy supply contracting implies a contract through which useful energy, like heat, steam or compressed air is supplied and measured in kilowatt-hours (kWh). Through a standard ESC model it is possible to make improvements only on the efficiency of the energy conversion from final to useful energy, which is basically confined by the walls of the boiler room (Figure 8). The measurement of the supplied energy is made on a meter in the boilers room of the facility. That's why energy efficiency measures provided by this model are within a scope limited to the energy supply side. Comparable model for this type of service is a district heating supply contract.

The scale of this improvement depends on the type of equipment and measures used to replace an old, inefficient installation. Whether it's a new condensing boiler, variable

frequency mode pumps or just by performing regular O&M activities, the maximum range of the energy gains is up to 20 %. Scale of accompanying emission reductions can be more significant if more sustainable, renewable technology is used, like solar or combined heat and power (CHP) (Bleyl-Androschin 2009, p. 11).

One German survey showed that ESC projects were dominating the ESCO market ten years ago, with its application in all building sectors, such as residential housing, commercial, industry and public buildings (Bleyl-Androschin 2009, p. 10). Another market survey (Bleyl-Androschin 2009, p. 10) resulted in specifying a lower threshold for ESC projects in the residential sector in terms of transaction costs criteria. It showed that projects with system nominal capacity of 100 kW_{th}, corresponding to energy cost of approx. 20000 EUR per year, is the minimum project size under which it's doesn't payoff to develop a project because of high transaction costs.

In general, ESC projects, being limited to the supply side, have great energy saving potential through other contracting models.

3.4 Energy Performance Contracting (EPC)

In the energy efficiency directive (EED, 2012/27/EU), the European Commission defined the EPC as:

“ [A]contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings.” (Fagernæs 2016, p. 18)

For reducing final energy consumption, energy performance contracting (EPC) model, unlike the ESC, has in focus deployment of energy conservation measures on the demand side. The scope of application is extended to cover entire customer's facility (building or factory) with typical measures being energy management and controls, replacing technical equipment (e.g. HVAC technologies or lighting), changing behaviour of the building occupants or improving building insulation. The business model is based on selling negawatt hours (NWh) or energy savings compared to a predefined baseline (Bleyl-Androschin 2009, p. 10).

The term negawatts was first used by Lovins in 1985 in his study of the US electricity market and the potential for energy savings. He described negawatts as energy savings resulting from implemented measures for reducing electricity demand for the production of services that people actually need: heating, cooling, ventilation, hot food, cold drinks and so on (Fagernæs 2016, p. 13).

Measurement and verification of the energy savings starts with determining customer's facility historical energy consumption by creating a model for the baseline period. So called 'baseline' is specified in each EPC contract and is used as a basis for calculating the actually achieved energy savings. Baseline is the action of calculating the value of average consumption and is determined prior to implementation of the measures by the ESCO contractor. Historical data for the calculation should be collected for a longer period of at least three previous years (OEGUT Austrian Society for Environment and Technology 2020.). During the guarantee period, actual adjusted consumption, with the implemented measures, is compared to the baseline and energy savings are calculated as a difference between the two. The consumption is adjusted to account for the factors that are outside of the influence of the ESCO contractor, like occupancy of the facility, price changes and climate. The adjustment formulas should be specified in the contract. Savings are usually calculated on a monthly and invoicing made on a yearly basis (Aoun 2020, p. 26).

Since its introduction in Europe in 1995, energy performance contracting (EPC) model is credited for achieving guaranteed energy savings of between 20 % and 25 %, with a relatively low market share of 10 %, mostly in the public sector (Bleyl-Androschin 2009, p. 4). ESC models were predominantly in use before, but the popularity of EPC model for energy efficiency improvement in buildings has grown significantly in the last couple of years.

In a typical EPC scheme, ESCO contractors fully finance the present cost of implementation of energy efficiency measures, while the customer doesn't have to participate with any upfront costs. The investment is then repaid by the customer to the ESCO from the future savings incurred (Schletz et al. 2020a, p. 11). Two types of EPC contracts are used: contracts with shared savings and with guaranteed savings.

Figure 9 shows the concept of the contract with the shared savings, with benefits to the customer, the share of savings for ESCO to provide the service and refinance the investment, and the operational costs.

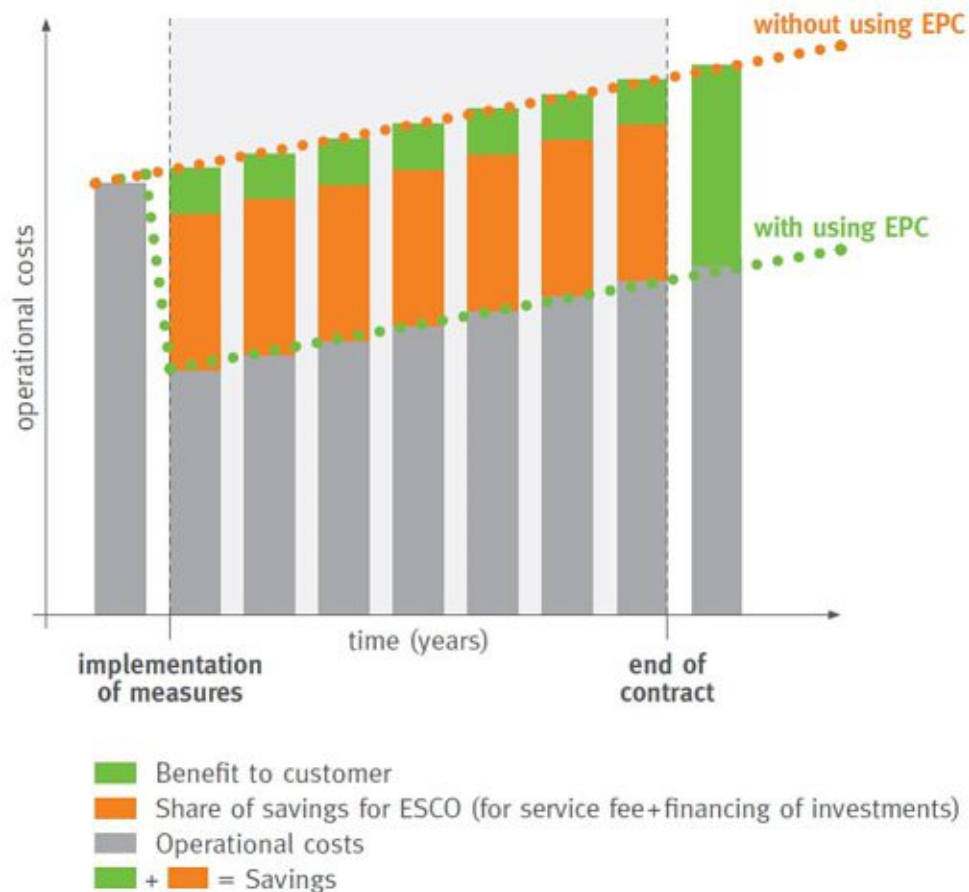


Figure 9: Benefit, savings and operational costs during the lifespan of an EPC - shared savings (Fagernæs 2016, p. 25)

Through a shared savings scheme, the investment for energy efficiency measures is financed by the ESCO (or a third party), who is then paid by the customer over the project course with the agreed share of the future cost savings. Immediately after implementing the measures operational costs are reduced and the benefits for the customer are reflected in partial cost savings, while the larger share is used to pay the ESCO service fee and refinance the investment. Full benefits of the savings are realised by the customer after the contract expiry and repayment of the investment.

Under a guaranteed savings scheme, the host (or a third party) finances the capital investment for the energy conservation measures. Design and achieved performance of the improvements during the project life are financially guaranteed by the ESCO, who also accepts all associated risks. When the savings are not met, the ESCO has the responsibility to reimburse the difference between the actual and negotiated savings to the customer. Because under this type of contract the customer assumes

the investment risk it is not so common in the developing markets and, therefore it is not in use in Serbia.

Every EPC project is specifically tailored for each customer, therefore high transaction costs incur. However, following development stages are valid for a typical EPC project (Aoun 2020, p. 25):

- a) Customer's energy consumption and costs are determined through a preliminary analysis, so are the ways of maximising energy savings;
- b) A detailed energy analysis is undertaken to estimate energy savings and investment costs;
- c) Selection of energy conservation measures is made;
- d) New equipment is installed and selected measures implemented;
- e) In the guarantee period, achieved savings are determined with periodic M&V methods.

EPC challenges

Following problems are identified as main obstacles for deployment and general aversion for the EPC business model (Bleyl-Androschin 2009, p. 13):

1. Problems related to calculation of energy savings. Achieved negawatt hours after implementation of energy conservation measures are relative value, determined indirectly as a difference between the baseline and actual consumption. Problem is that the baseline is not easy to determine with required accuracy, usually because of unavailability of historic data on consumption. Besides, once determined it is not a constant value, but varies with weather and with the energy price. Also, change of building occupants behaviour or the production process, or construction adaptations may lead to varying energy loads. As a result, consumption or the baseline has to be adjusted to be comparable with the other to get reliable savings. These determinations and corrections are causing higher transaction costs and affect the level of trust between the contracting parties.
2. M&V of the savings are increasing continually over the project course and are reducing the potential of the future savings to pay back the initial energy conservation investment.
3. Total savings potential is not utilised unless building's thermal insulation is included as one of the improvement measure, which is usually not the case.

4. All associated risks that ESCO is taking over for implementation of the project are accounted for as the safety surcharges resulting in higher service cost for the customer. Risks that usually are accounted for are those associated with the EPC savings guarantee, change of occupants' behaviour and possibly increased energy consumption or inaccurate calculation of the savings and the baseline.

Also a challenge to a broader implementation and operation of the EPC business model is that a high number of stakeholders is involved, out of which every single one has its own records of project parameters, including energy baseline, capital and operational expenses and level of achieved energy savings. These records are not always identical during comparison when payment is due and, therefore, disputes between the stakeholders can arise. It is seen that advanced technology application, like blockchain could help reduce the complexity of the model and address the challenges of EPC contracts application (Khatoon et al. 2019, p. 4).

Other problem is the project size. In order to absorb very high transaction costs, annual energy baseline of 100000 EUR and above is determined as a minimum threshold for considering implementation of an EPC model being worthwhile (Bleyl-Androschin 2009, p. 11). To address this challenge, blockchain based technology – smart contract has the potential to scale up investments in energy efficiency and increase the total amount of energy saved by allowing ESCOs to undertake the development of smaller projects through reducing the transaction costs. With the help of smart contracts, costs and time needed for setting up and administering an EPC can be substantially reduced.

EPC in Serbia

EPC model contracts were developed and promoted in the energy efficiency sector in Serbia through the REEP programme, which was mentioned more in the chapter 2.1.4. Through the programme sectors including public buildings, schools, hospitals, town halls and street lighting are targeted.

EPC concept is suitable for the application not only because ESCO finances the investment and frees up the public sector's capacity, but because it is a well-established and recognised commercial mechanism in Europe. That allows access for EU structural funds for supporting financing and project development.

EPC is seen as an appropriate instrument for energy improvements in the public sectors because of characteristic under-investment in the service equipment for heating, lighting, air conditioning and ventilation, and the building structure itself, which results in significant energy inefficiencies. Average payback of the investment for the energy efficient building services equipment can be made from the future savings through the EPC contract in less than 10 years (EBRD 2012, p. project-support/why-EnPC).

3.5 Integrated Energy-Contracting (IEC)

As it is the case with the EPC, the scope of integrated energy contracting (IEC) model covers the whole facility (building or factory). The IEC model combines the objectives of the ESC and the EPC models like shown in the Figure 8. Figure 10 shows a table summarising the properties of the two mentioned ESCO models.

	ESC	EPC
End-use markets	Public institutions, residential, commerce, industry	Public institutions (including universities, hospitals, leisure facilities)
Project Size: Minimum Energy Cost Baseline	> 20,000 €/a	> 100,000 €/a (ESP Berlin: 1,88 Mio €/a)
Efficiency potentials	15 – 20 % => limited scope of service	20 – 25 % (up to 30 – 50 %)
Share in ESCo market (in Germany 2008)	85 – 90 %	10 – 15 %
Business model / Performance measurement	Useful energy (MWh)	Energy savings („NWh“) => Baseline problems => High transaction cost

Figure 10: ESC vs. EPC: Summary of typical market properties (Bleyle-Androschin 2013, p. 6)

The structure of the IEC model is designed in a way that reduction of energy consumption is addressed first through implementing measures in building technologies for heating, ventilation, etc., as well as building's envelope including thermal insulation of the floors, roof and walls, energy management, and by dealing with the behaviour of the occupants. Second, measures to cover the remaining demand for useful energy is addressed on the supply side in the most efficient way, preferably by deploying renewable energy technologies (Bleyle-Androschin 2013, p. 8).

The IEC business model is primarily based on the well-established ESC model, while its service is broaden to include the energy savings potential of the whole facility. A

novelty is that, instead of individual M&V methods like in the EPC, for verification of correct performance and operation of energy conservation measures the use of quality assurance instruments (QAI) is promoted. QAIs represent simplified M&V procedures that are used with an objective to reduce high transaction costs and make the model less complex, therefore, more accessible to smaller size projects (Bleyl-Androschin 2009, p. 19). Instead of using EPC baselining methods, IEC model brings simplification by directly measuring the supply of useful energy, while the quantification of negawatts or energy savings is made through QAIs. In order to reduce high expenses related to common M&V methods and to reduce the ESCO's risk related to adjusting the baseline, QAI are introduced as periodic tests for the verification of performance and functionality of energy efficiency measures (Figure 11), without the need to validate their exact quantitative outcome over the whole contract term (Bleyl-Androschin 2013, p. 10).

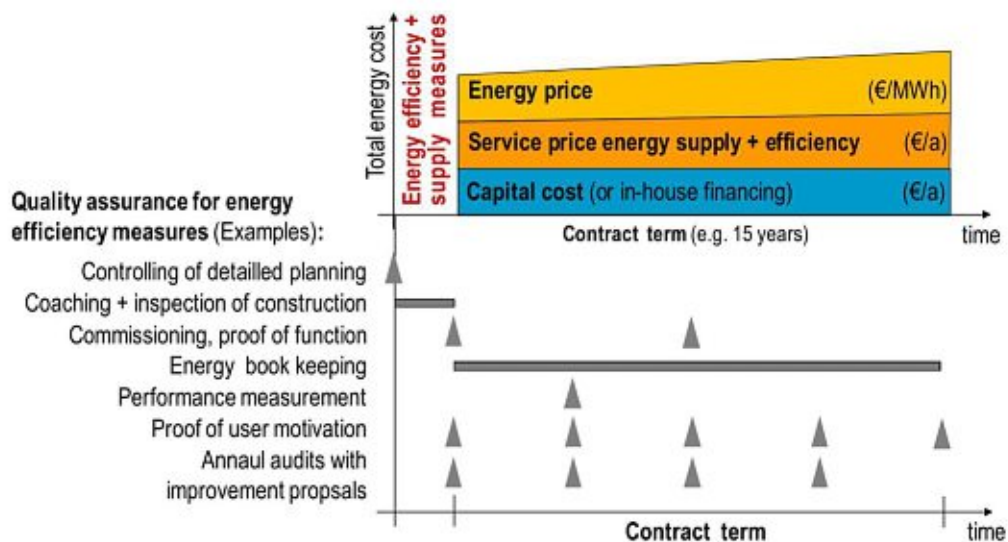


Figure 11: IEC business model: Sample quality assurance instruments as substitute for savings measurements (Bleyl-Androschin 2013, p. 10)

The ESCO is still in a role of a general contractor, responsible for designing, installing and ensuring correct performance of the energy service measures, while taking over all the costs and risks. Like it the ESC model, the customer pays the ESCO variable fee for the supply of useful energy depending on the actual consumption, but also a fixed fee for the service fee that includes quality assurance, O&M costs, accounted risks and profit. Financing can be also included, but not it's necessarily the case. (Bleyl-Androschin 2013, p. 9).

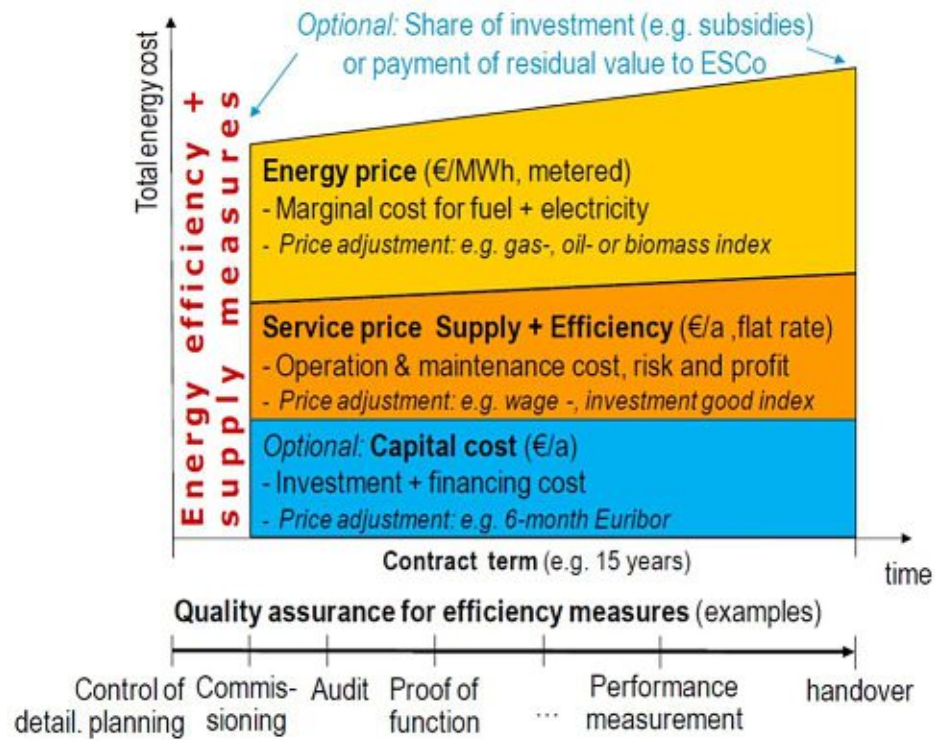


Figure 12: Integrated Energy-Contracting Business Model with Quality Assurance (Bleyl-Androschin 2013, p. 9)

3.6 Risks of Energy Performance Contracting (EPC) services

EPC barriers and risks can be divided into four categories: legislative, economic (including market and financial), measurement and verification, and operational, as shown in Figure 13.



Figure 13: EPC limitations, barriers and risks. (Aoun 2020, p. 28)

Legislative barriers and risks

Major legislative risk for the implementation of EPC projects is country's policy instability, because such projects are usually implemented over a longer course of time. In general, market for energy efficiency is greatly affected by the country's planning and economic, regional and industrial development. When a country has a stable political system and consistent governmental policies, the development of EPC market is promising.

Like the absence of legislation to make the implementation of energy conservation measures obligatory limits the development of the EPC market, so does the lack of governmental incentives (e.g. tax reliefs and credits).

In the case where incentives are available and enabling legislation existent, additional barriers can be made by long administrative and permitting procedures (Aoun 2020, p. 28).

Economic barriers and risks

Two main sub-categories of economic barriers and risks are market and financial.

- Market risk include market uncertainties, energy/ material / equipment / labour costs, client demand, demand charges and industry competition. Risk of variations of energy costs and demand charges is usually borne by both contracting parties, except in the guaranteed savings scheme where ESCO takes all the risks. The ESCO usually takes the risks related to varying material / equipment / labour costs.
- Financial risks are those risks related to EPC project financing mechanisms, whether it's self-financing or third-party financing.
 - Under the self-financing scheme, upfront investment for the implementation of energy efficiency measures is provided by the customer, while the performance risk and projected energy savings are guaranteed by the ESCO.
 - In the case of a third-party financing, the ESCO or the customer borrows money for project development from a financing institution like commercial bank, government or similar.

Inflation and varying interest rates during the project lifetime remain the two main economic factors associated with financial risks. Moreover, lack of awareness of third-

party financing institutions about EPC projects and related risks is also a financial barrier, because it can lead to higher interest rates (Aoun 2020, p. 29).

Barriers and risks associated with measurement & verification

The key risk for EPC project implementation related to measurement and verification is an inappropriately developed M&V plan. Having a poor plan could result in unavailability of relevant data, general lack of clarity on how activities are performed, or encountering difficulties with follow-up assessments because of inadequate resources. Undeveloped plan or inaccurate metering can misrepresent the actual performance of the implemented conservation measures.

New technologies will help improve current M&V methods. Technologies that weren't available when the IPMVP was first established in the end of the last century, like now expanding blockchain or IoT, will be used for developing newer M&V plans to improve verification and monitoring of operational savings and emission reductions (Aoun 2020, p. 29).

Operational barriers and risks

Operational risks include risks associated with the design, construction, commissioning, O&M and management of an EPC project with related technical and human factors.

Inaccurate designs may be a result of lack of historical data on the facility, incomplete surveys or even design faults. Such risk may lead to inaccurate energy baselining and wrong estimates of energy savings from the proposed measures, which would significantly affect the success of EPC project.

Technology risks are related to unsuitable equipment, poor system performance or sizing. Because ESCO takes the responsibility for these risks, correct equipment selection and proper system design is crucial.

Management risks are associated with the lack of experience among the responsible ESCO contractor personnel, which can lead to management failures and not meeting set project objectives.

Human risks include change of behaviour of building occupants, the way facility is operated or any other deviation from the activities that are approved in the M&V plan (Aoun 2020, p. 30).

Another operational risk is associated with payments. Payments in EPC projects are related to achieved and verified energy savings by the ESCO during the contract term. When the savings are equal to greater from the guaranteed amount in the specific operational period, ESCO is paid by the customer. Otherwise, deductions apply when the savings are less than planned. Invoicing periods can be made on monthly, quarterly or annual basis, depending on the agreement between the parties. An ESCO has to account the risk that the customer may go out of business and will not be able to fulfil its payment responsibilities. Such complex administrative procedures causes higher operational and transaction costs, which also reduces the level of trust among the parties. That's why present EPC models are normally based on traditional payment methods that include third-party intermediaries like banks. Downside of this approach is that particularly high transaction and commission fees are charged by these intermediaries. Furthermore, long processing times of payments complicates the interaction between the parties (Aoun 2020, pp. 30–31).

Blockchain and smart contract technology

Some of the many barriers and risks mentioned above can be overcome by increasing awareness of the stakeholders or by creating a comprehensive M&V plan. Legislative and economic barriers are outside of control of parties involved, but, for example, design, construction and management barriers can be mitigated. To all other barriers associated with trust between the parties, human factor risks, complexity of payment procedures with many stakeholders, delays and high transaction costs, blockchain and smart contracts technology can provide a platform for resolving these challenges (Aoun 2020, p. 34).

3.7 Financing options of Energy-Contracting services

Development of energy efficiency in the SEE region is highly dependent on the support measures like financing. Financing of long-term loans is offered by development finance institutions (DFIs) through dedicated funds, usually channelled by commercial banks. To support the agenda for energy efficiency, 150 million USD was provided from 2007 to 2016 by DFIs in the Western Balkans region (Bianco 2019, p. 119). Different funds were created for disbursing such amounts from a number of DFIs (KfW, the World Bank, EBRD, EU, etc.) to support local projects in residential, commercial and industrial sectors. The three most significant vehicles for supporting

energy efficiency projects in the SEE are Green Growth Fund (GGF), Energy Efficiency Financing Facility (EEFF) and Regional Energy Efficiency Programme (REEP) (chapter 2.1.4).

Way of financing is very project specific. In general, financing of the investment can be made by the customer, by the ESCO from its own funds or through third-party financing. Under the financing arrangement for the EPC, where either the ESCO or the customer borrows money for the implementation of the measures, the loan is supported by the energy savings guarantee contract with the ESCO. Under the financing arrangement the customer is completely isolated from financial risk associated with the performance of the EPC energy efficiency system, and his balance sheet is not showing the investment. These are the main benefits of such an agreement (Fagernæs 2016, p. 24).

Figure 14 outlines the process of financing EPC projects.

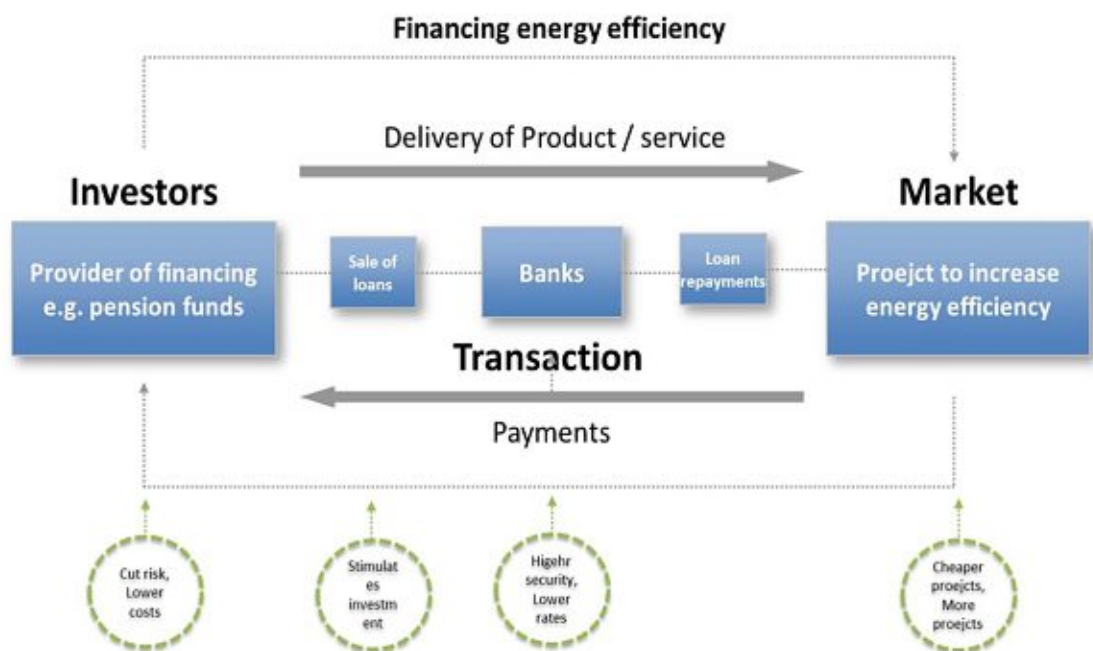


Figure 14: Process of financing energy efficiency projects through energy performance contracting (Krofak 2019, p. 20)

3.8 Transaction costs

Transaction costs are showing up at different stages of the project and are very project specific. Fagernæs 2016, p. 19 showed that an average share of transaction costs in total project cost for an ESCO are in the range between 2 and 40 %, depending on

the case. The higher the share the more expensive the service ESCO charges to the customer, as transaction costs are directly reflected in the energy service price. Even though transaction costs are never the same for two different project, some common attributes can be drawn:

- From every exchange on the market some degree of transaction costs always arise;
- Transaction costs can be quite high; and
- They are among the main drivers for the demand of energy efficiency services.

The scale of transaction costs varies from project to project. It was found that comparison and generalisations are difficult, because of methodological differences. According to Fagernæs, *“the exact size of transaction costs still remain rather unclear, partly because there is no common method for evaluating them and including them in decision making.”* (Fagernæs 2016, p. 35)

Different sources of transaction costs for ESCO projects are illustrated in Figure 15, where as the main identified sources are search for information, contracts negotiation, and M&V procedures (Fagernæs 2016, pp. 19–20). Other variables that are not shown on the chart, but can substantially affect the size of transaction costs for energy efficiency projects are problems with agreeing on baselines and number of intermediaries involved in the investment.

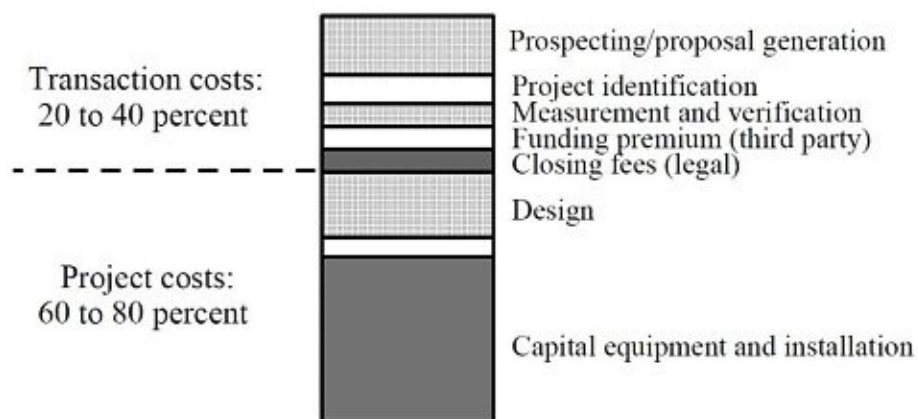


Figure 15: Distribution of costs associated with ESCO projects (Fagernæs 2016, p. 20)

The stages at which transaction costs can erupt in energy efficiency projects, in the broadest sense, can be divided into:

1. Costs that arise before the transaction is realised, so called ex ante transaction costs, and
2. Costs after the transaction takes place, or ex post transaction costs.

Hence, the transaction costs are: *“the costs of arranging a contract ex ante and monitoring and enforcing it ex post, as opposed to production costs.”* (Fagernæs 2016, p. 28).

Ex ante transaction costs of EPC projects are made up from the following sources:

- Prospecting – search for information, identification and contact with potential customers that are willing to take part in energy efficiency improvement programs.
- Project identification – defining the scope of the project by analysing customer’s assets and identification of types of energy efficiency measures for maximum financial returns. This includes analysis of historical energy consumption data and energy audits.
- Packaging and closing – refers to closing the best deal (that attracts capital) and negotiating the contractual terms, including division of responsibilities and risks (and savings) among the parties. Legal fees, making of proposal, definition of preliminary M&V procedures are all constituting transaction costs at this stage.
- Funding – because of perceived risks of EPC projects by the banks, access to capital is offered at particularly high discount rates, with estimates for energy efficiency project in the range of 20 % to 25 %, in extreme cases as high as 50 %. Public sector customers are generally seen as more trustworthy in terms of repayment risk, and the discount rates are lower.
- Design, engineering and specification – at this stage plans and costs are finalised, equipment for the implementation of the measures has been specified. Final M&V plan for the calculation of energy savings is created. Having available standardised calculation models can substantially reduce transaction costs and increase trustworthiness between the parties.
- Construction and implementation – is usually done by third-party sub-contractors managed by the ESCO that, in that case, is in the role of a general contractor.

Ex post transaction costs can occur from operations for monitoring and verification of energy savings, but also from a lack of trust.

- Measurement and verification - Operations begin right after commissioning of the measures, so does the need to verify the guaranteed savings. ESCO makes the operations by itself, or hires a professional company to do it instead. Using standardised measurement and verification procedures makes creation of future energy savings projections much easier to model and reduces transaction costs.
- When there is lack of involvement of the customer in the early stages of the planning or other misunderstanding it usually lowers the level of trust in the operational stage and requires higher degree of M&V, which increases transaction costs (Fagernæs 2016, pp. 20–22)

In a narrower sense, transaction costs can be divided in seven project stages. These can be organised into a value chain, as it is illustrated in Figure 16.

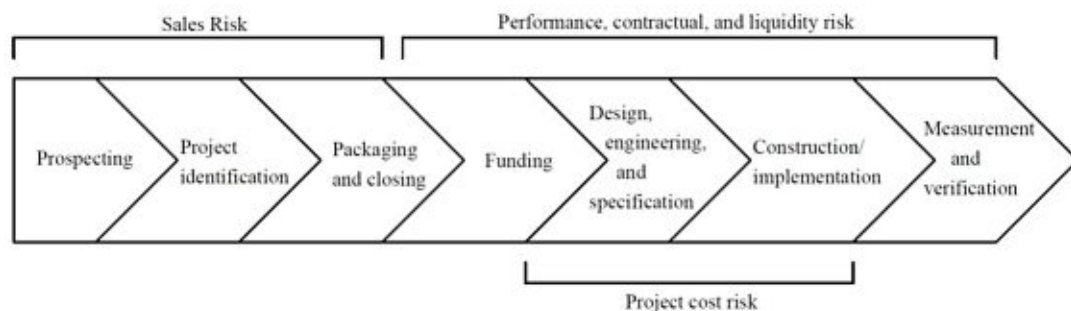


Figure 16: The value chain of an energy efficiency project and related risks (Fagernæs 2016, p. 20)

It was found that the scale of transaction costs is constituted from uncertainties of the outcomes from all seven stages of the energy efficiency value chain. Therefore, all individual stages had to be classified under a specific project risk category of an ESCO project:

- Sales risk is associated with the project implementation in the beginning when ESCO has no guarantee that the contract will be signed;
- ESCO has to account for the risk that estimated project costs will be exceeded by the actual costs;
- Constituted as a performance risk, ESCO assumes the possibility that projected energy savings will be lower than planned;
- Contractual and liquidity risks are associated with the possibility that the customer will back down about the contract or will become unable to financially meet his obligations. These risk would prevent the ESCO to provide the

energy service needed to payback the investment (Fagernæs 2016, pp. 25–26).

Among the most common practices for reducing the scale of transaction costs is the introduction of standardisation into EPC contracts, like it was implemented through the REEP program in Serbia that helped create the ESCO market. It was also found that the duration of the contract has an effect to the scale of transaction costs. The longer the contract the more positive effect on trust between the ESCO and the customer it has, thus, the transaction costs are reduced. Any intention to cheat would affect future earnings, therefore there is less incentive for misconduct (Fagernæs 2016, p. 26).

Other known strategies for reducing transaction costs include rising awareness of the public interested in undertaking implementation of energy efficiency measures, and bundling several buildings into single projects. The latter is possible in old buildings that show similar characteristics, usually when those were built in blocks at around same time and similar construction design. This helps reduce the quantity of the projects developed, but is common only for public or state owned buildings. By rising awareness, an increased level of information can enable more informed choices to be made by potential customers (Bertoldi et al. 2018, pp. 25–26).

3.9 Measurement and verification

Energy savings, representing the absence of energy consumed, cannot be directly measured. Instead, M&V methods are a crucial instrument for the assessment of the performance of the implemented energy efficiency measures in EPC projects. According to Aoun, *“M&V is the process of planning, measuring, collecting and analysing data to verify and report energy savings within an individual facility resulting from the implementation energy conservation measures”*. (Aoun 2020, p. 26)

An essential document of an EPC contract is an M&V protocol. It is important for the customer that relies on the savings to realise his financial goals and ESCO, who is guaranteeing for the savings.

The key for the success in energy efficiency projects always was securing financing. Unavoidable elements for securing funding are the availability of high quality measurement practices and verifiability of the results, as these will provide higher

level confidence that energy conservation measures will yield sufficient savings for loan repayment. The European Commission recommends that the International Performance Measurement and Verification Protocol (IPMVP) protocols are to be used for making M&V plans. Serbia has adopted these recommendation in its own policies (European Commission 2021.).

4 Blockchain and other emerging technologies

Blockchain is a platform that puts together various new technologies to make a trusted database, which enables parties to interact between each other directly and transact without an authoritative third party. Blockchain can break the structure of centralised transaction systems by removing the traditional single point of control over the whole ledger. Internet of Things (IoT) and machine learning technologies can make data collection automated, and verification of data and error identification improved (Schletz et al. 2020a, p. 3). Distribution and synchronisation of the trusting data is automated with blockchain through a network of users, resulting in a temper-proof and immutable log.

Integration of these new technologies is made possible through smart contracts, a particularly important part of the blockchain platform. It enables an automated execution of the contract when predetermined requirements are met in a manner of an 'if, then...' statement. Smart contracts can increase transparency and ensure responsibility by automatically and continuously implementing regulations and methodologies. Such an automation could make cost reductions and allow a smoother transfer of information by eliminating intermediary parties, like auditors and verifiers (Schletz et al. 2020a, p. 3).

By uniting digital technologies like cryptography, digital databases and peer-to-peer (P2P) networks blockchain could bring radical changes to the energy sector. Its feature associated with the increased levels of trust is crucial for the development of the ESCO market, either by addressing the complex M&V methods or the factors that are not in the control of the ESCO, e.g. occupancy of the facility, change of operational habits, unpredictable weather, but directly influence the projected performance. In business arrangements like ESCO that involves a number of participants and is affected by so many different factors, matter of trust is essential (Krofak 2019, pp. 48–49).

4.1 Blockchain technology

Blockchain is a digital, decentralised network made of world-wide distributed computers called nodes. Each of the nodes receives a copy of a transaction once it is made and attached to a chain of previous transactions or blocks. Every block in the

chain holds information about a single entry - transaction that is validated by special nodes called miners and uploaded to the blockchain when a consensus is reached.

Laurence gives a following definition: “A *blockchain* is a *data structure* that makes it possible to create a *digital ledger of data* and share it among a *network of independent parties*. “ (Laurence 2017, p. 7)

When data is recorded in a blockchain, it's extremely difficult to change or remove it. When someone wants to add a record to a blockchain, also called a *transaction* or an *entry*, users in the network who have validation control verify the proposed transaction. This is where things get tricky because every blockchain has a slightly different spin on how this should work and who can validate a transaction. (Laurence 2017, p. 8)

Blockchains are characterised by immutability of the transaction log. Whenever transaction is made and added to the blockchain, it is almost impossible to change it. A transaction (an entry) is added by the user to a blockchain and is recorded only after verification by the miners. The consensus algorithms are not always the same for every blockchain and it's difficult to generalise who can verify the transaction (Laurence 2017, p. 12).

According to Laurence 2017, p. 8, there are three types of blockchains:

- Public blockchain – large distributed networks that are open without restrictions to every user. It is an open-source platform maintained by its community, example is Bitcoin.
- Permissioned blockchain – still a large distributed network with individual participants whose roles within it are controlled. Platform can be an open-source, but it's not necessarily the case. Example is Ripple.
- Private blockchain – is a smaller network where membership of users is strictly controlled. This type is preferred among association with trusted members where confidential information is exchanged.

On Figure 17 it is illustrated how a typical blockchain works and how a transaction is created.

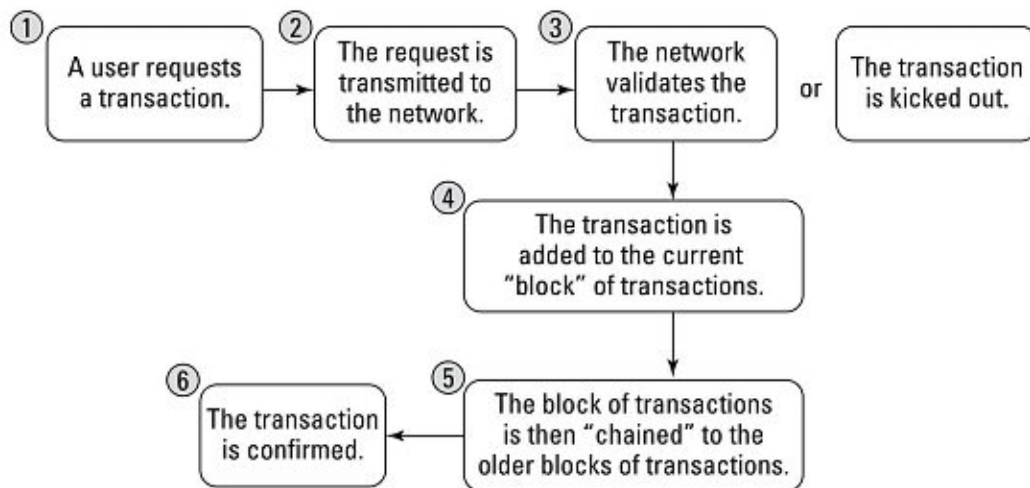


Figure 17: How blockchains works (Laurence 2017, p. 13)

One of the main features of the blockchain technology is the removal of a centralised authority and switch to a peer-to-peer transactions. All types of blockchains allow its users to manage the digital ledger securely, not needed a centralised authority to enforce the rules (Laurence 2017, p. 8). Figure 18 illustrates the difference of two types of transactions:

- a) peer-to-peer, which is a typical blockchain transaction; and
- b) transaction via a traditional centralised authority, represented with a trusted intermediary

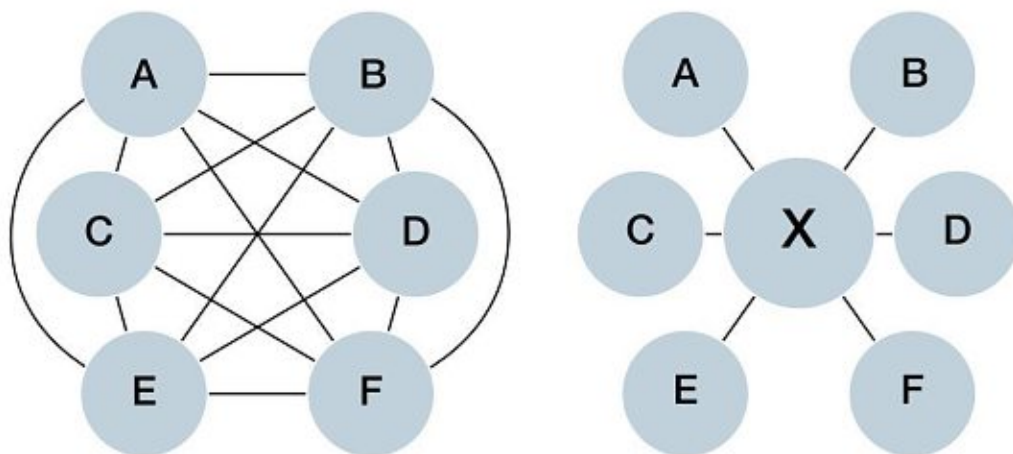


Figure 18: Peer-to-Peer vs. Centralized Authority (World Bank's Climate Change Group 2018, p. 15)

Smart contracts

Smart contracts are used within the blockchain systems for verified automation. These are protocols that activate and deploy predefined commands when a certain condition is met. Smart contract are created based on 'if true, then...' statements that are operational on blockchain and are activated autonomously once the particular conditions are fulfilled. Smart contracts are designed to independently and consistently implement rules and methodologies that assures transparency and responsibility (Schletz et al. 2020b, p. 4). They play an important role in the development of the energy efficiency market by supporting the digitalisation of measurement, reporting and verification processes of the energy savings and related payments.

4.2 IoT and smart metering

Internet of Things

IoT represents a platform that allows continuous communication and data sharing between sensors and devices in a smart environment without interruptions and gaps. With the broader introduction of various wireless technologies, IoT emerged as a revolutionary technology backed by the Internet. New intelligent systems with the word 'smart' in it are seeing some kind of IoT integration, smart buildings, smart transportation, smart energy and so on (Mohsen Marjani et al. 2017, p. 5248). Smart electronic devices for daily life operations, such as air conditioners, water heaters and refrigerators are becoming interconnected on the IoT platform with the possibility of remote control through the Internet. These devices communicate between each other and to central controlling devices for collecting different sorts of data for numerous applications.

Smart metering

Smart metering is one of the applications of IoT that produces data from various sources, like smart grids. A smart meter is an electronic device used to monitor and record electricity consumption and send the data to the control centre. The collected smart meter data is analysed, historical patterns and trends are established and used

for assisting the decision making processes in forecasting of electricity consumption (Mohsen Marjani et al. 2017, p. 5254).

5 Integration of Blockchain into energy contracting services

Following suggested blockchain use in the literature, in this chapter ESCO energy performance contracting concept for financing of energy efficiency measures in Serbian market use case is tested for feasibility of blockchain technology implementation and possible design is outlined. General purpose of the described model is scaling up energy efficiency investments in the buildings sector.

Integration of blockchain and smart contracts within the EPC setup is evaluated in the thesis. Instead of the actual technical implementation, what is emphasised is the assessment of the value drivers and value proposition of the mentioned technologies. In general, data collected from the implemented energy efficiency measures, energy savings calculation, management of payments and penalties are all pulled through the digital platform and, once the contract requirements are fulfilled, payments or penalties between untrusted parties are executed automatically by smart contracts. The transactions are made nearly instantly, in so-called real time, at lower costs because of non-existent commission fees for removed trusted third-party, like a bank (Aoun 2020, p. 24).

The EPC business model is conceptualised on the energy savings that are calculated throughout the contract term, and usually invoiced on a monthly basis. To determine the amount of savings that are actually achieved M&V methods are used. To complete a transaction, it is typical for an EPC projects to have many stakeholders involved, from the specialised ESCO service provider company, to final customer users who want to implement the energy efficiency measures, providers of financing and possibly an energy supplier, like gas or district heating company. Every stakeholder keeps track of the actual consumption and related costs for a specific customer and has its own records. As a consequence there is a high probability of differences in records between these stakeholders. Administrative process becomes complex, which incur high costs of operation and transaction fees

Blockchain and smart contracts trading platform can be a solution to connect several applications and integrate all these records in a single, immutable ledger to increase the transparency in project life-cycle and trust between the participants, thus lower the chance of disagreements and disputes between them. It would also reduce the redundancy of data and so would the related transaction costs. Blockchain based

energy efficiency application could scale up and promote faster development in the sector. Such a framework could also address the particular risk of regulatory and policy change that is one the key barriers in developing countries. Blockchain based EPC framework would be immune to these changes (Krofak 2019, p. 51).

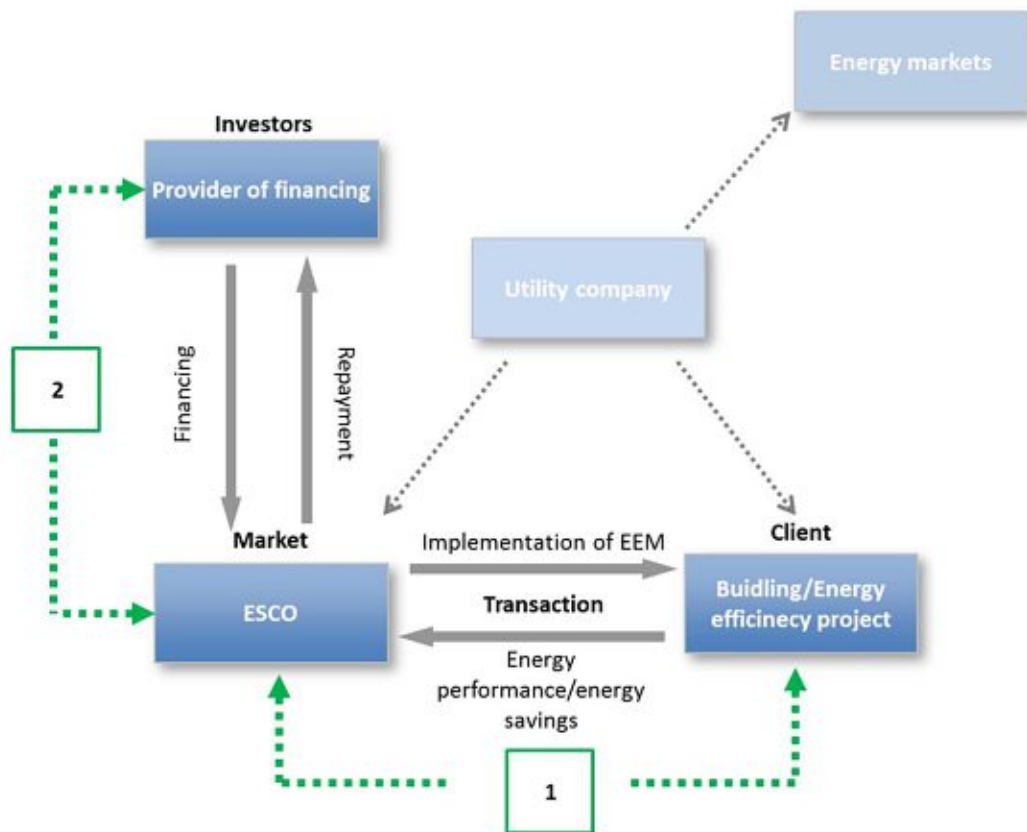


Figure 19: Framework for implementing blockchain supported energy performance contracting for energy efficiency investments (Krofak 2019, p. 48)

Krofak suggested a structure of the framework for implementing blockchain in the EPC model for transactions management, as shown in Figure 19.

Points 1 and 2 indicate where blockchain technology is applicable. The point number 1 says that technology is appropriate for the track of energy savings that are achieved with the implementation of energy conservation measures and managing transactions between the ESCO and the customer. Tracking is made by collecting the data through trusted devices like energy meters, which is done automatically; parameters such as temperatures and occupancy also considered.

In a typical setup, financing of the investment is supported by a third-party. Management and recording of transactions between the financing institution and the

ESCO can be made on the blockchain platforms. This is indicated with point number 2 in Figure 19. Actual energy savings are calculated on monthly or annual bases and then compared with the projected baseline for that period. The baseline is an average state of energy consumption of the customer for a long-term historical period, at least three years, before the measures were installed.

Transactions in such a blockchain based framework would be executed in the following steps (Krofak 2019, pp. 48–50):

- a. Initial copy of the ledges containing address of the first block with all the balances is shared among all the nodes in the network before transaction is initiated between the ESCO and the financing institution.
- b. A pair of keys, one public and one private, is assigned to every stakeholders.
- c. Recoding of energy savings is initiated and associated transactions are executed. The information about the actual energy consumption is not saved on the blockchain, but instead only energy savings is recorded on the blockchain as external data. This is important for data flow constrictions on the blockchain that is limited.
- d. Following the contract terms and conditions, transaction are being executed.

To evaluate the feasibility of a blockchain application, an eight-step decision framework, developed by Schletz et al., is applied in this thesis through a row of consecutive questions that is described in the following chapter.

5.1 Blockchain decision framework

It is important to note that blockchain is not a universal cure for every use case. Evaluation of its application has to carefully made, because of certain trade-offs and associated costs that will emerge, which have to be taken into consideration. For example, compared to traditional databases with a centralised structure, blockchain technology has a much slower updating and development processes. In general, benefits of applying decentralised and automated system should outweigh its deficiency for a specific case use. Several 'fit' considerations were integrated into a decision framework developed by Schletz et al. to make it possible to evaluate the characteristics of a considered mechanism.

The decision frameworks is made of eight consecutive classifiers in the form of questions to test the applicability of blockchain. General suitability of a blockchain is

assessed with the first three questions. Performance requirements are assessed by the following three questions, while the last two are related to choosing of the best type of blockchain based on desired governance and data accessibility (Schletz et al. 2020b, p. 5).

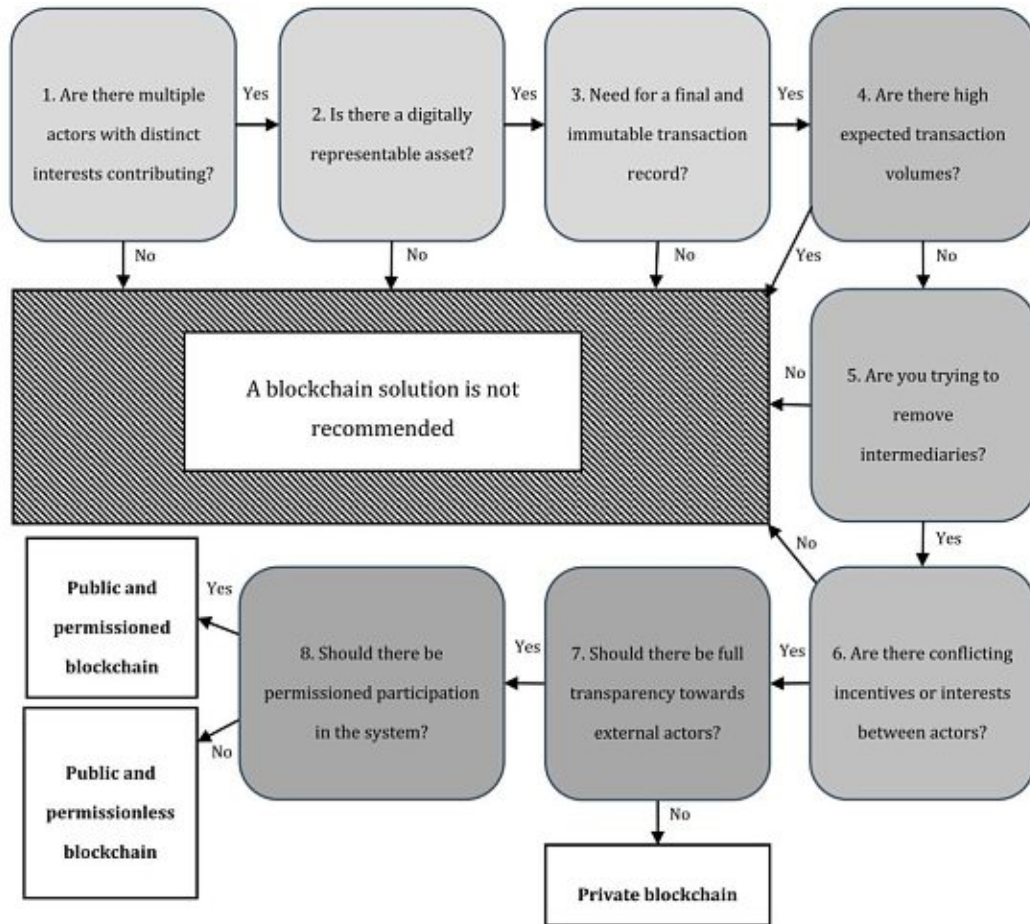


Figure 20: Blockchain decision framework (Schletz et al. 2020b, p. 6)

1. Are there multiple actors contributing? - Yes

In typical EPC projects there are at least two actors. Blockchain based transactions are always concluded with a consensus between nodes on a decentralised network (Schletz et al. 2020b, p. 6). This consensus is achieved in any case, whether there is conflicting data or participants that don't trust each other, single state of the ledger has to be maintained at all times. Certainly being one of the most important contributions of blockchain technology is the removal of risk of failure at single, centralised points and asymmetry of the information.

2. Is there a digitally representable asset? – Yes

In energy performance contracting, achieved energy savings are measured in kWh. Energy meter devices are used to record actual energy consumption that is represented on blockchain in a digital form as an asset, while more advanced smart meters can record and report the readings automatically (Krofak 2019, p. 45). These are an ideal base for executing smart contract based transactions.

3. Is there a need for a final and immutable record? - Yes

The history of made transactions on blockchain is immutable. Every single transaction is recorded in a block, and all blocks are linked in a chain in successive order. Tractability of transactions is possible from the initiation of the project until the final transaction. Tampering with any of the blocks in the chain would mean changing the hash record of all succeeding blocks, which makes altering of information of transactions in an earlier stages almost impossible (Schletz et al. 2020b, p. 7). This characteristic of impossibility of data change is especially significant for the auditing processes in energy performance contracting services. Any attempt of cheating can be traceable to the very beginnings of transacting and linked to any actor involved. Smart contracts are executing rules from the contract based on preconditions written in a computer code. A final state is used as an input for smart contract execution.

4. Are there expected high transaction volumes? – No

For the EPC projects, transactions are usually executed on a monthly or annual bases (Krofak 2019, p. 49). That is suitable for a blockchain system, considering that, unlike centralised databases, the platform is designed for processing limiting amount of data, which is one of the challenges of the technology. Peak is estimated at approx. 1,2 billion per year or 36 transactions per second (Schletz et al. 2020b, p. 8). This capacity is much more than expected number of transaction in an EPC project.

5. Is there an attempt to remove intermediaries? – Yes

To reduce transaction and administrative costs for various fees and commissions for third-party centralised authorities and scale up the investments in energy efficiency projects, these intermediaries have to be removed. Removing intermediaries can also reduce the risk of system failure on a single points of central authority. Energy savings are calculated as energy not used, or as a difference between the baseline consumption before the implementation of the

energy efficiency measures and the actual consumption after the measures. In the operation phase, it is crucial to have a high quality M&V plan that defines the procedures how the savings are measured and calculated. Transaction costs for M&V can be significantly reduced by eliminating the external verifiers and frequency of verifications during the contract term (Krofak 2019, p. 45). IoT and AI blockchain based technologies can improve M&V procedures by introducing automation in data collection directly from the source (e.g. smart meters) or remotely and recording processes (Schletz et al. 2020b, p. 8).

6. Are there conflicting incentives/ interests between the actors? – Yes

The actors in the EPC know each other, but since the execution of transactions is related to savings actually achieved (and these are sometimes dependant on the outside factors not in the control of the actors) there is a strong need for increased transparency and high level of trust.

7. Should there be full transparency toward external actors? – No

There are no strict requirements that EPC related transactions should be made public. Since the transactions are of interest only for the active participants in the EPC, keeping them private is generally a better option. This makes a private, permissioned blockchain the most suitable type (Krofak 2019, p. 47).

8. Not applicable in this use case.

6 Conclusions

This thesis gives an overview of the current state of the ESCO market in Serbia with a discussion how EPC business model can be further enhanced by blockchain with smart contracts and other emerging technologies like IoT and AI. The thesis outlines the market barriers and challenges that are limiting fast paced growth and scaling up of the investments in the energy efficiency sector.

Serbia is one of the countries in the Western Balkans that is most affected by air pollution caused by combustion of fossil fuels mainly for the purpose of heating. Improving energy efficiency in the buildings sector is seen as key contributor to reducing the level of emission and meeting the Paris agreement targets. The ESCO concept, as a financial instrument for providing investments in the energy efficiency sector, is currently developed only for the public sector and public lighting in Serbia through the energy performance contracting model. General lack of awareness and lack of public incentive is hindering the improvement of energy efficiency in the residential and private sector. Particularly high transaction costs are limiting the application of the ESCO concept to bigger projects only.

Digitalisation and introduction of new technologies is seen as a way to increase the reliability of M&V methods and reduce high transaction costs. That would allow project developers to target smaller projects as well. Enhancing transparency and increasing automation would result from a blockchain application. As a consequence, information asymmetry would be reduced substantially and increased trust could lower the transaction costs even further, as there would be less chance of fraudulent behaviour because of immutable transaction logs.

Most blockchain applications are still currently only in an infant stage. And even though it does carry high potential for improvements in the energy sector, it is not a single solution for all carbon related market issues. The lack of real case studies is limiting this thesis to a conceptual overview of possible benefits and restrictions of blockchain application in the energy efficiency projects.

The results of the thesis show that the research in this field can be broaden in several ways. For future research, the scope can be extended to evaluate the structure and quantify the size of transaction costs for energy performance contracting projects in more depth. That would allow for more accurate estimation of the benefits of blockchain technology in this specific case.

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List of abbreviations

€	Euro
€/a	euro per annum
°C	degree Celsius
3D	decarbonisation, decentralisation and digitalisation
AI	artificial intelligence
CHP	combined heat and power
CMS	CMS Reich-Rohrwig Hainz global law firm
CO ₂	Carbon dioxide
DFI	development finance institution
EBRD	European bank for reconstruction and development
EC	European Commission
EED	energy efficiency directive
EEFF	Energy Efficiency Financing Facility
EIB	European Investment Bank
EMS	energy management system
EnC	Energy Community
EPBD	energy performance of buildings directive
EPC	energy performance contracting
ESC	energy supply contracting
ESCO	energy services company
ESD	energy services directive
EU	European Union
EUR	Euro
GDP	Gross domestic product
GE	General Electric
GFA	Gesellschaft für Agrarprojekte in Übersee
GGE	Gorenje, Geoplin and Energetika – an ESCO company
GGF	Green Growth Fund
GWh	Gigawatt-hour
HOA	Homeowner association
HVAC	heating, ventilation, and air conditioning
IEC	integrated energy contracting
IFI	International Financial Institution
IoT	internet of things
IPA	The Instrument for Pre-Accession
IPMVP	International Performance Measurement and Verification Protocol
kWh	kilowatt-hour
kW _{th}	kilowatt thermal
M&V	measurement and verification

m ³	cubic meter
MEUR	million euros
Mio	million
MJ	Megajoule
MWh	Megawatt-hour
NEEAP	national energy efficiency action plan
NWh	Negawatt hours
O&M	operation and maintenance
OEGUT	Österreichische Gesellschaft für Umwelt und Technik
P2P	peer-to-peer
PM	particulate matter
PPP	purchasing power parity
QAI	quality assurance instruments
RCC	Regional Cooperation Council
REEP	regional energy efficiency programme
SDG	sustainable development goal
SEE	Southeast Europe
UN	United Nations
US	United States (of America)
USD	United States Dollar
WB	Western Balkans
WB EDIF	Western Balkans Enterprise Development and Innovation Facility
WBIF	The Western Balkans Investment Framework
WeBSEDF	Western Balkans Direct Sustainable Energy Financing Facility
WeBSEFF	Western Balkans Sustainable Energy Financing Facility
µg	microgram

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