DIRECTORATE GENERAL FOR NEIGHBOURHOOD AND ENLARGEMENT NEGOTIATIONS – DG NEAR

Short Term High Quality Studies to Support Activities under the Eastern Partnership

HIQSTEP PROJECT

STUDY ON THE EFFECT OF THE PLACEMENT OF SOLAR PANELS ON BUILDINGS TO INCREASE ENERGY SECURITY AND ENERGY EFFICIENCY AND DEVELOP CLEAN ENERGY IN THE EASTERN PARTNERSHIP COUNTRIES

EXECUTIVE SUMMARY

March 2018

List of abbreviations

AM	Armenia
ANRE	The National Regulatory Authority for Energy in Moldova
AREA	Azerbaijan State Agency on Alternative and Renewable Energy Sources
AZ	Azerbaijan
BY	Belarus
CBA	Cost Benefit Analysis
CEER	Council of European Energy Regulators
DANIDA	Danish International Development Agency
DGPV	Distributed Generation from Photovoltaics
DISCO	Distribution Company
DSO	Distribution System Operator
EaP	Eastern Partnership
EBGL	Electricity Balancing Guideline
EC	European Commission
ECT	Energy Community Treaty
EU	European Union
EUD	EU Delegation
FiP	Feed in Premium
FiT	Feed in Tariff
GE	Georgia
GEDF	Georgian Energy Development Fund
GWNERC	Georgian Water and Energy Regulatory Commission
HiQSTEP	Short term high quality studies to support activities under the Eastern Partnership
IRR	Internal Rate of Return
LCOE	Levelised Cost of Energy
MD	Moldova
MS	Member State
NM	Net Metering
PV	Photovoltaic(s)
R2E2	Armenia Renewable Resources and Energy Efficiency Fund
RES	Renewable Energy Sources
ROO	Renewable Obligation Order
SAEEE	State Agency on Energy Efficiency and Energy Saving of Ukraine
SPE	Solar Power Europe
STL	Study Team Leader
T&D	Transmission and Distribution
TOR	Terms of Reference
TSO	Transmission System Operator
TYNDP	Ten Year Network Development Plan
UA	Ukraine
WACC	Weighted Average Cost of Capital

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1 Introduction

The present report summarises the results of five components of the Study of the Effect of the Placement of Solar PVs on Buildings in the EaP Countries" carried in the framework of the EU-funded project "High Quality Studies to Support Activities under the Eastern Partnership - HiQSTEP" (EuropeAid/132574/C/SER/Multi), which covered all six Eastern Partner Countries, namely Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine.

The Study was implemented by a Study Team headed by Mr. Nikos Tourlis, Study Team Leader and Grid Expert; and composed of: Mr. Vassilis Papandreou – Energy Expert, Coordinator of Component 1; Mr. Matteo Leonardi – Energy Expert, Coordinator of Component 2; Prof. Agis Papadopoulos – Solar Energy Expert, Coordinator of Component 3; Prof. Petros Patias - Rural and Surveying Engineering Expert; Ms. Chiara Candelise – Energy Expert, Coordinator of Components 4 & 5; Mr. Armen Gharibyan - Local Energy Expert Armenia; Mr. Jahangir Efandiyev - Local Energy Expert Azerbaijan; Mr. Andrei Malochka - Local Energy Expert Belarus; Ms. Nino Maghradze – Local Energy Expert Georgia; Mr. Andrei Sula – Local Energy Expert Moldova; and Mr. Kostiantyn Gura - Local Energy Expert Ukraine.

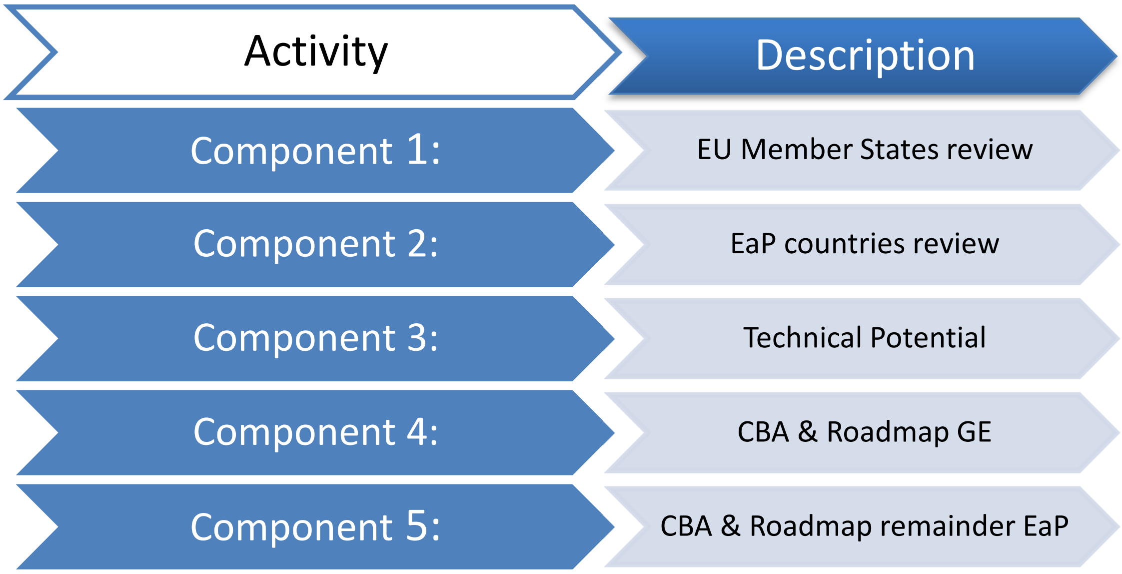
The overall objective of the study is to address the effect of the placement of solar panels on buildings in Eastern Partner countries for the purpose of increasing energy security and energy efficiency and developing clean energy sources.
The specific objectives of the study are the following:

- To present EU policies, rules, regulations, tools and schemes towards the promotion of solar panels on buildings;
- To assess existing policies, rules, regulations and tools towards promotion of solar panels on buildings in the six Eastern Partner countries;
- To develop cost-benefit analysis for the staged development of building PVs in all Eastern Partner countries;
- To formulate recommendations on how to enhance PV penetration in the six Eastern Partners;
- To quantify the impact of building PV penetration to the overall energy mix and on the energy security of each country and to quantify the impact of PV generated energy to greenhouse gas emission reduction.

The Buildings' Solar PV Study comprises, five deliverables each one of them describing the results of a set of five components as it is illustrated below in Figure 1 below.

The study commenced in September 2016 and was completed in November 2017. During its course of implementation two missions took place in the Eastern Partner Countries; the first on selected countries for the purposes of data collection for Components 2 & 3 in February 2017 and the last one for the verification of data and information as well as for the discussion of preliminary conclusions in September 2017. The last mission involved all six Eastern Partner countries. In addition, the study team has made use of the opportunity provided by the Eastern Partnership Platform 3: Energy Security meetings in December 2016 and June 2017 to update on the study's progress.

Figure 1: The structure of the Building's Solar PV Study



2 EU Member States review

As a first step, a compendium of information has been developed on building-PVs, based on the experienced gained in the EU. Component 1: "Review of EU Experience with Solar PV on Buildings" had to answer first what are key drivers for PV market development, e.g. solar resources, proper supporting framework and what does the building PV market segment represent and, furthermore, what are the dynamics in the overall PV market. Of course, the undisputed key driver for all PV development around the world seems to be the dramatic reduction of installation costs, which in turn is mostly led by the PV modules' price drop.

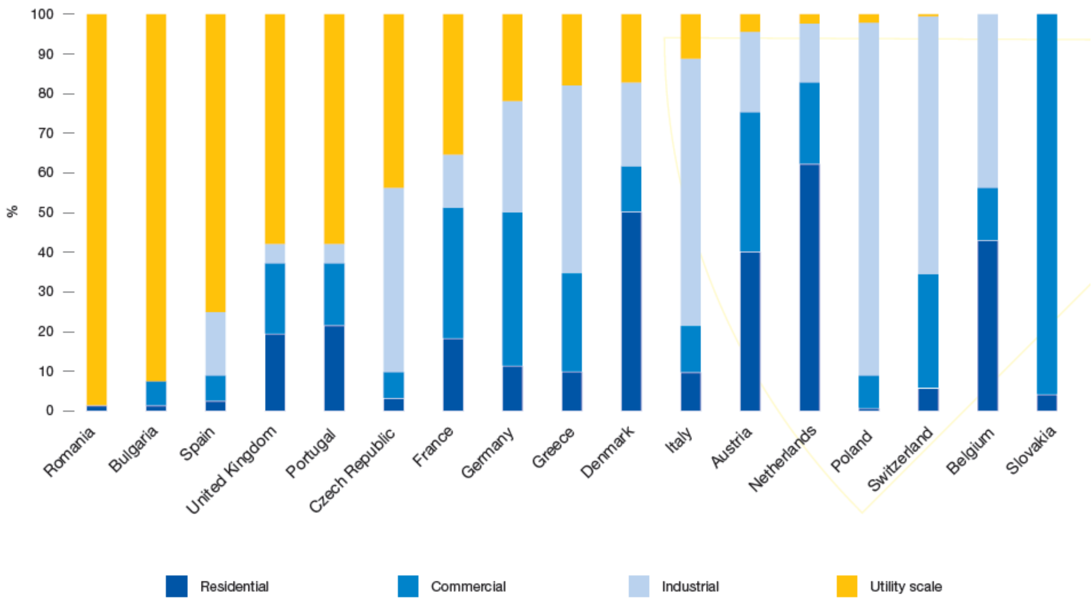
The review of the EU status quo suggests that the geographical distribution of PV installed capacity does not line up with the "maximum irradiation" logic. With the exception of Italy, Greece and Malta total installed capacity per inhabitant is greater in central and northern Member States[1], highlighting the importance of non-technical aspects that influence the deployment of the technology, such as support policies and financial incentives, overall economic conditions, public awareness, etc.

The segmentation of PV installations, illustrated in Figure 2~~Figure 2~~ below, provides an overview of the different approaches of MS towards PV deployment. Although the categorisation merely refers to systems' capacity segmentation, rather than the actual distinction between the referred categories (see reference note no.2), residential (merely rooftop) PV systems constitute a small portion of total installed capacity in most MS where large deployment of the technology has occurred(e.g. Spain, Germany and Greece) indicating the existence of a favourable framework

[1] https://www.eurobserv-er.org/photovoltaic-barometer-2017/

for large scale installations. On the other hand, smaller and more densely populated MS like the Netherlands, Denmark, Belgium and Austria have targeted mainly small-scale building-PV systems with quite remarkable results.

Figure 2: EU PV cumulative capacity segmentation in 2014 (SPE, Global Market Outlook 2016[2])

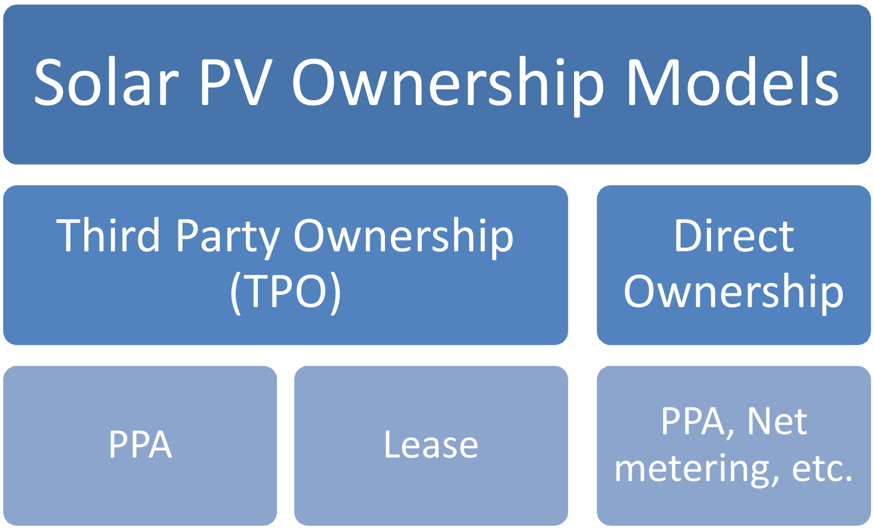


Whether building-attached or building-integrated, PVs in buildings are quite different from ground-mounted systems in several ways. The opportunity of self-generation has always been a consideration for solar PV in buildings and it is getting greater attention as the grid electricity price rises and the cost of electricity storage becomes competitive. Moving towards nearly Zero Energy Buildings (nZEB) inevitably leads to the consideration of on-site RES production and solar PV is perhaps the most attractive, low-noise, no-moving parts and no-emissions electricity generation technology that can be deployed in the urban environment. All these conditions as well as the very fact that the installation area of these systems is by definition the built environment a number of different business models has emerged. Figure 3~~Figure 3~~ below presents a taxonomy of the ownership models of building PVs and their compatibility with the most frequent revenue stream options.

Many policy makers and regulators have developed a framework that considers the technical, economic and environmental aspects pertinent to solar PV in buildings. However, the general directions in the supporting mechanisms are often harmonised with the overall RES support scheme adopted in each country.

Figure 3: A building PV ownership model taxonomy (own illustration)

[2] Note: The categorisation is as follows: residential-systems below or equal to 10 kWp, commercial-systems with a capacity between 10 and 250 kWp, industrial- systems with a capacity above 250 kWp, utility scale- systems with a capacity above 1000 kWp and built on the ground



In addition, Component 1 report touches briefly upon the following points, with respect to the impact of RES and in particular of building applied PV systems on the electricity grids and markets:

- PV integration at a decentralised and small scale implies connection at distribution network level, but the higher the penetration rate, the higher the impact on transmission system;
- Distribution is likely to experience hosting capacity issues which in turn relate - in order of significance - with voltage rise at feeder level, reverse power flows and transformer capacity saturation;
- Transmission is likely to experience increased decentralised PV generation as residual load, grid congestion and an increased need for reserves;
- Electricity markets at large may experience displacement of low-cost generation in the merit-order (due to mandatory offtake of PV generation), forecasting errors and - consequently - price spikes in the intra-day and balancing markets.

Further to the regional review of EU practices specific Country-Cases reviews (i.e. Germany, Greece, Italy, Netherlands, UK) have been developed using a uniform set of criteria comprising: licensing, grid connection, support scheme, project financing, ownership and business models. In addition, the review also included some Pilot Programmes which can further be categorised as:

- National Programmes
  - Germany 100,000 roofs
  - Italy (10,000 roofs, conto energia, tax rebates, mandatory schemes, etc.)
  - Greece (Rooftop FiT programme)
- Local initiatives
  - UK (Bristol community energy funds)
  - Germany (Stuttgart “intracting” programme)
  - Switzerland (Solar exchange – Lausanne)

3 Eastern Partner Countries' review

Based on the findings of Component 1 report, the respective Component 2: "Review of EaP Experience with Solar PV on Buildings" report compares the current market framework for building-PVs in the studied countries with a favourable and adequate one able to *increase energy security, energy efficiency and develop clean energy with the placement of solar panels on buildings*.

The country assessment and the gap analysis, using selected EU countries as benchmark to develop a favourable policy and market for PV rooftop dissemination, has showed a different situation (with some degree of divergence) per Eastern Party country with reference to energy policies to promote building-PVs infrastructure.

The main common feature of all six countries is **the low level of electricity prices**, both at wholesale and retail side, compared to EU countries. Although significant differences can be found among the target countries, with Azerbaijan having the lowest electricity prices and Moldova the highest, wholesale and retail prices are generally not adequate to sustain the PV market in the absence of further incentives. One common feature of Eastern Partner countries' electricity price structure is the limited amount of taxes and levies on final prices. Taxes and levies, which build up a significant share of EU electricity end-use prices, make PV generation less attractive for end-users, compared to most significant EU countries' experiences, even in presence of net metering schemes. Block tariffs (which are in use in most Eastern Partner countries) providing higher electricity rates for higher consumption levels, can be considered advantageous for distributed PV systems in net metering mode. Still, even the highest block price levels appear not to be high enough to achieve a reasonable investment payback.

Electricity prices are the facet of the overall market structure and in general terms of the underlying economic indicators of the country. Electricity markets in turn are not yet fully liberalized in Eastern Partner countries. Whereas this should not be taken necessarily as a barrier for the penetration of building PVs, all experiences of successful supporting building PV programmes in EU countries to this date have followed the liberalization reform. Energy Community Contracting Parties (CPs) have embraced a reform trajectory in respect of their energy markets. This however may not be the case for the remainder countries in which the process will be, most likely, slower or not exactly compliant to the EU acquis.

General economic context

The current economic situation in the Eastern Partner countries showing a low GDP per capita and still high percentages of energy poverty indicators (in some countries connected with high domestic electricity consumption level), suggests that the path towards full cost reflectivity of electricity prices will not be an easy and fast one.

On the contrary, most countries are in need of increasing investments in the electricity sector and current electricity prices will likely be adjusted, in order to achieve the necessary improvements. This comprises be a mid to long-term prospect in favour of PV installation.

Overall, at present, electricity prices cause a significant gap for the development of a specific building-PV policy on the model embraced in EU countries. Building PVs in all Eastern Partner countries are in need of financial support to fill the gap between the total production cost from a PV installation and the current electricity price level; **The higher the gap the higher the need of support**.

RES and PV deployment target

Ukraine and Moldova have introduced a RES development target and a trajectory compliant with EU Directive 28/2009/EC and are in process of introducing policy instruments coherent with the mandatory targets, whilst other countries are far from establishing a direct link between the policy targets and the relevant regulation and policy mechanisms. In the case of Georgia, a national target is still missing.

In all countries, with the exception of Ukraine, the gap consists in the fact that energy legislation does not incorporate in a coherent manner the identified development targets. The targets are established but the development of policies and mechanisms to achieve it, are lagging behind.

Support mechanisms

All countries have some mechanisms in place to promote renewables but they are not always effective. They appear to be insufficient in terms of prices, or in terms of supporting secondary legislation able to deliver the expected capacity. With reference to PV policies, none of the countries has a single legal instrument specifically dedicated to the development of the PVs segment; consequently, PV-related legislative framework is mostly scattered among energy policy legislation and regulation. In some cases, the main RES legislation does not include the PVs segment, and rarely the building PVs segment finds a specific place in national policies.

Regulatory aspects

In the regulatory dimension important gaps have emerged. The development of secondary legislation and regulation, as experienced in EU countries goes together with the implementation of favourable RES and PV supporting policies. The absence or inconsistency of supporting policy implies a weak definition of regulatory mechanism, aimed at facilitating distributed generation and development of building PV solutions. Again, Ukraine is the most advanced country, also in this respect, although some gaps may be found in this area as well.

In the regulatory dimension two countries, namely Azerbaijan and Belarus, are still found without an independent regulatory authority. Whereas the institution of a regulatory authority does not imply a favourable approach to RES or PV development per se, regulation does play an important role in filling the gaps which may jeopardize PV development in term of third party access and transparency of rules.

Grid issues

Grid connection and access (preferably on a dispatch priority) still face implementation challenges in the Eastern Partner countries. Thought the aforementioned principles are widely accepted the absence or lack of details in the connection arrangements and the use of negotiated third party access rules is evident in most countries. Curtailment rules and regulatory provisions for its gradual reduction are either not adopted or not clearly enforced

Balancing does not represent an issue connected with the development of building-PVs capacity, yet. Connection restriction capacity restriction rules, which in turn are not established via hosting capacity studies by the relevant network operators, are foreseen either on the basis of the contracted capacity of the (consumption) connection point or as a function of the operators’ area peak demand.

Licensing

With reference to the licencing and authorization procedure, some gaps are still found in Ukraine and Moldova regarding the establishment of a “one stop shop” licencing procedure to have the building-PVs system approved within a single authorization procedure.

Whereas most selected countries have introduced some facilitation on licencing the authorization procedure, this still needs to be tested in practice and in particular on whether the procedures are sufficient to handle a large number of applications. The limited experience in terms of the number of installed systems is not enough to be able to identify the specific barrier at local level. In addition, in most countries, the systems installed have managed to work out their own authorisation procedures, but those are not traceable as a transparent procedure encompassing all subsidiarity levels.

Conclusions

The incomplete regulatory framework represents an evident gap for a sound building-PVs market development where the growth of the PV sector is the outcome of private initiatives based on favourable economic incentives and transparent procedures. Pursuant to the barriers synopsis presented above in this section, some conclusions arising from the gap analysis may be grouped in the following areas:

Economic context: all Eastern Partner countries have limited GPD level, this combined with low end-users electricity price, further reduce the economic resource availability to support incentive schemes in the electricity sector without significant support from external financial institutions. Other priorities, such as relevant share of households recorded in energy poverty conditions, are also found.

Energy policy: with the exception of Ukraine and Moldova, implementing EU Directive 28/2009/EC, little policy commitment is found to support RES development. Within RES sector, negligible commitment is found to support the building PV sub-sector. Ukraine is an exception. Lack of policy commitment plays an important role as building PV, referring to the distributed generation domain, need specific policy and regulatory provisions to flourish. A good policy to promote RES may not equal to a favourable policy for building PV solutions.

Electricity prices: as anticipated the gap between end-user prices and technology costs is a main barrier in all selected countries. Supporting mechanisms are needed, at least in the short term, to develop building PV. This links with the economic variable.

Electricity market structure: only EC signatories are going toward the reform of the electricity market. In other countries different model of electricity market structures exist. Markets are not fully liberalized. This may restrict third party participation in PV capacity development.

In terms of the **regulatory context** it can be argued - as it is often observed – that without strong policy commitment, regulation alone will not be able to develop a complete favourable legal framework for penetration of building PV. Significant gap(s) in the regulatory dimension represent(s) a barrier for building PV. Connection rules and authorization procedures are hardly defined for small PV systems. To date the existing, very limited in number, installations have not emerged as the result of a harmonised and transparent procedure, which is readily available to be adopted by other independent developers.

Finally, the **solar resource potential**, though not the one and only determinant of the attractiveness of PV technology, needs to be taken into consideration when policy support costs need to be assessed. Inevitably the development of the PV sector will be more expensive in countries where the resource endowment is relatively low. Annual expected specific production (in kWh) may fall below 1000kWh in significant area of the Northern Eastern Partner countries, Belarus and Moldova and to some extent Ukraine.

4 Eastern Partner Countries' building-PVs potential

As the deliverable of the third component of the study the Component 3: "Quantification of the potential of building-PVs in Georgia and the rest of the Eastern Partner countries" report comprises an assessment of technical potential of PV in buildings for selected cities in all six Eastern Partner Countries. Whereas the selection of cities for Georgia was provided for in the study's ToR, to include Tbilisi, Batumi, Rustavi and Kutaisi, the selection of representative cities for the remaining countries was based on a set of criteria. These included: the size of the city, which in all cases was best represented by the national capital, the resource endowment, the data/information availability as well as the participation of the municipalities to the Covenant of Mayors initiative.

The technical potential assessment presented in this report comprises two major stages in terms of its development. First it was the collection, verification and analysis of surface data i.e. the derivation of areas in each city's built environment on which the installation of PVs would be possible. Then, the second part of the assessment uses this gross area in order to come up with reasonable estimates on the PV capacities that would be able to be installed on the buildings. This step involves a series of constraints relative to the roofs' inclination, orientation, already captured roof space and shading obstructions. Although it is discussed from a planner's point of view, we have deliberately not included grid constraints in this stage of the technical potential's assessment. Grid impact with respect to distributed generation brings both benefits and costs, which were eventually dealt with in the Cost-Benefit Analysis part of the study. Having the capacities defined, an annual simulation for the derivation of the specific annual yield is used in order to estimate the annual energy yield based on the estimated capacities. In view of the requirements of the Cost-Benefit Analyses, carried out in the next component, capacity and energy figures are presented for two market segments. Due to their characteristics these market segments are (a) small residential systems and (b) bigger systems on bigger buildings which include multi-family apartment buildings, commercial and industrial premises.

The methodology to estimate the solar potential in urban environment, such as of the cities selected, comprises two main work phases:

i) The first includes the use of available geographical data, such as GIS, aerial and satellite to calculate the total building rooftop areas per city. Based on available data regarding the total number of buildings, a mean building rooftop area can be also approximated.

ii) The second includes a more detailed and complex elaboration of the above results of the building rooftop areas to deduce the actual building rooftop areas that are suitable for photovoltaic installations. Then, a series of solar simulation scenarios are examined to estimate the annual potential solar energy that can be generated on a city's level, with respect to technological, economic and policy parameters, as discussed in Component 2 report. Still, given the fact that PVs are still of negligible importance in electricity mix of the countries considered, it is reasonable to assume that technological parameters will be the key factor for the determination of the potential in the short- to medium termed future.

Regarding the second phase, since complex urban environments present various building block densities and miscellaneous building elevations as well as limited available rooftop construction data about most of the urban regions, the difficulties involved in the solar potential assessment are significant. In addition, the lack of available data about urban layouts, prevent an effective and valid reliable statistical approach of the actually suitable built areas for photovoltaics.

Therefore, in the present study a quantitative, empirical methodology approach is used, which compensates the lack of available data, wherever this is the case, in the selected cities. In particular, the methodology applied comprises three separate tasks:

i) The first task includes the building roofs' classification according to their shape, i.e. flat and pitched roofs. This allows the separate assessment of the roofs' solar suitability, which is for obvious technical reasons different.

ii) The second task includes the estimation of the unavailable rooftop areas occupied by various obstacles, such as staircase wells, parapets and other structural elements as well as their shading, in order to determine the available solar potential

iii) The third and final task comprises the estimation of the potential PV capacities based on the PV technology utilized and the simulations to estimate the annual solar energy production and the potential electricity consumption savings.

The potential for PV capacity and the respective electricity production, are based on the assumptions that (a) state of the art Mono-Si panels are used, (b) that the whole solar potential of flat roofs can be utilized and (c) that the whole solar potential of the sloped roofs is utilized (subject to the aforementioned constrains) are presented below.

Two different segment potentials have been considered, representing the two major markets that can be detected, based on the buildings' typology and on technical, legal and practical differentiations:

Segment A:

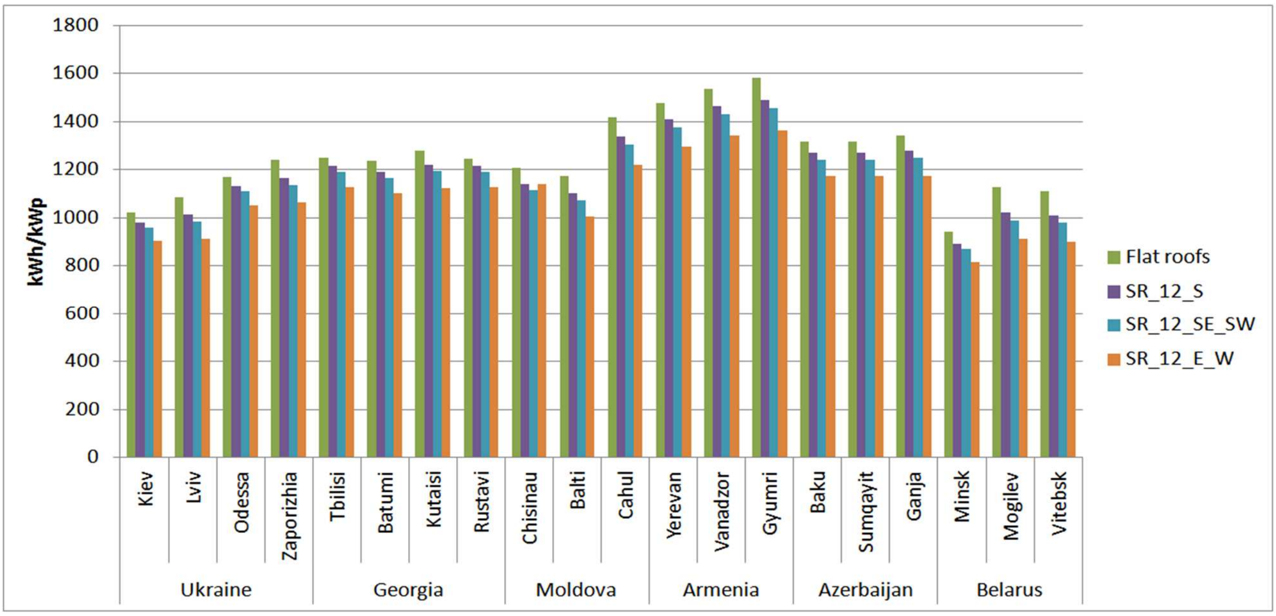
It consists of the small domestic applications, which are as a rule the small single-family houses, with a sloped roof. In those one can apply up to 10 kWp, as a rule between 3 and 8, depending on the size of the houses, on the type of the roof (pitched or hipped) and on its orientation.

Segment B:

This segment consists of the bigger applications, namely of commercial/industrial buildings, of big multifamily blocks and of public buildings, all featuring flat roofs, which can accommodate 50 to 200kWp PV systems.

The aggregated results for the solar energy production for all cities in the six countries and for flat and sloped roofs are depicted in Figure 4~~Figure 4~~ below:

Figure 4: Solar energy production for all orientation-inclination scenarios in all examined cities



5 Eastern Partner Countries' building-PVs programme development

The purpose of Components 4 and 5 of the study was to develop and undertake a cost benefit analysis of different scenarios, allowing for a staged building-PVs installation programme, accounting for different levels of PV penetration and policy support in the Eastern Partner Countries. Georgia is discussed explicitly in Component 4, whilst the other Eastern Partner Countries (Armenia, Azerbaijan, Belarus, Moldova and Ukraine) are collectively discussed in Component 5 of the study.

5.1 Defining the maximum quantities per market segment over the period 2018-2030

Staged building-PV deployment scenarios for Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine are developed, based on the total installation potential for building-PVs as estimated for each country in Component 3 report of this study. This potential has been estimated in terms of MWp of rooftop PV systems which can be installed on suitable building roofs for major cities in each country. Estimates are developed for two main typologies of buildings: 1. Single family houses, characterized by sloped roofs; 2. Large buildings, characterized by flat roofs. A constraint factor of 80% has been applied to the overall total PV capacity of single family houses/sloped roof building type, to take into account significant restrictions to the PV installation potential due to the limited bearing capacity of the roofs, the lack of adequate structural support and the difficulty in ensuring effective water tightness, but also the difficulties pertinent to access to finance which are most frequent for this specific market segment. In other words, the constrained capacity potential cannot exceed 20% of the total capacity estimated.

5.2 Selection of the applicable support schemes

In a context of quite mature RES markets, the current EU policy framework is progressively reducing FiT scheme support, in favour of more 'market based' policy support tools, such as Feed in Premium or quota and auction based mechanisms. Nonetheless, in the context of the Eastern Partner countries, characterized by only nascent electricity market and limited experience in an emerging PV (including building-PV) sector, we consider and analyse the implementation of policy support instrument similar to those already implemented in other European countries at the early stages of their PV sector development, in particular:

- Capital based support;
- Production based support, in the form of: net metering and Feed in Tariff scheme (FiT)

Feed in Premium[3] (FiP) was not considered in the analysis since the current design of the electricity markets in the region does not allow to elicit clear price signals (e.g. wholesale price), therefore also not allowing a proper definition of premium tariffs.

In the process of developing scenarios for building-PV penetration in Eastern Partner cities, the level of support plays a crucial role, by engaging a "more-for-more" principle which assumes a progressive increase of policy support through the implementation of:

- Net metering (NM) scheme, which is already in place in most of the countries
- Capital grants, defined as a percentage of the initial building-PV investment cost;
- Feed in Tariff scheme (FiT) offering a specified generation tariff for the total PV electricity generated, over a 20 years' timeframe.

The respective levels of support, i.e. the capital grant, as a percentage of the initial investment cost, and the tariff offered under FiT scheme are calculated through an investment appraisal analysis, which optimizes policy support in order to achieve returns on the investment sufficient to incentivise end-users to invest in PV systems.

5.3 Scenario building

In order to develop scenarios for building-PVs deployment in the selected Eastern Partner cities, we have firstly calculated a progressive deployment of the estimated maximum total capacity potential from 2018 up to 2030 for each market segment, taking into account the constraint factor of 80% applied to the overall total PV capacity of single family houses/sloped roof building type, as described in section 5.1.

Then, with a view to account for progressive maturity of the PV market in the region, we assumed a staged implementation, implying an S-shaped learning curve i.e. initial slower deployment and a faster uptake at later stages; in particular we assumed that:

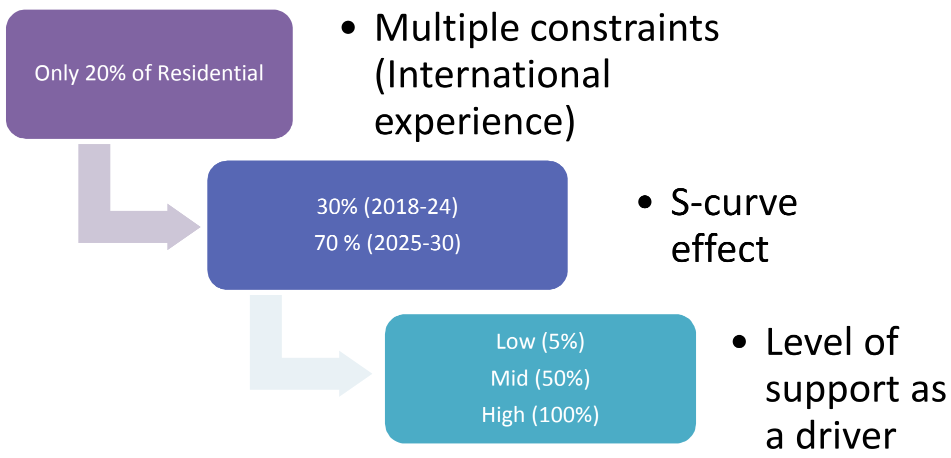
- 30% of the total potential will be deployed in the first half of the period (2018-2024),
- and the remaining 70% deployed between 2025 and 2030.

Finally, we use the end-user analysis described briefly in section 5.4, in order to first evaluate the efficacy of the existing support scheme and then to determine the level of support (i.e. level of capital grant or level of FiT) required to make the building-PVs attractive for their prospective investors.

The overall process of scenario building comprising its distinct stage explained above is presented in Figure 5 below:

Figure 5: An overview of the scenario building process

[3] Support schemes in general including the Feed in Premium scheme are elaborated in the "Review of EU Experience with Solar PV in buildings" (Component 1) report of this study



5.4 End-user analysis

The end-user analysis is an investment appraisal of building-PV systems for the two market segments assumed: the residential and the non-residential sector.

A typical financial cash flow analysis of each investment type has been conducted, in order to identify the specific investment's Internal Rate of Return (IRR). The aim is to understand the economics of current building-PV policy framework and to estimate the level of policy support, in terms of FiT or capital grant levels, necessary to achieve adequate investment returns, which may properly incentivise the deployment of building-PV both in the residential and non-residential market segments.

The analysis has been conducted for the five-year period assumed, i.e. 2018-2022, so as to provide the necessary inputs, in terms of the level of policy support, to the cost benefits analysis of the policy measures implemented under the defined building-PV deployment Scenarios. Investment appraisal has been done for both residential and the non-residential market segment and for the three deployment and policy scenarios, so as to complete the final step of Scenario Building, which involves a more-for-more principle[4]. It should be noted that, given the existing regulations and policy objectives, in the case of Azerbaijan and Belarus the development scenarios include a 1000 rooftop pilot programme and the staged development under the quota, respectively.

Based on the analysis, the NM scheme seems rather uneconomical in the case of **Armenia** and significant grant support would be necessary for both residential and non-residential systems in both scenarios. For **Azerbaijan** the analysis indicated rather high levels of FiT for a 1000 rooftop-PV program[5]. For **Belarus** a FiT scheme for the established 25 MW PV Pilot Program was analysed indicating that current support in the country is, at-least price-wise, sufficient. For **Georgia** the analysis showed that under current conditions the technology is not suitable for net metering or self-consumption schemes alone. Results indicate that significant support either in the form of capital grants or in the form of FiT shall be leveraged in order to make investments in the sector attractive. For **Moldova** the assumption regarding the evolution of electricity end user prices results in the NM scheme becoming relatively profitable for the non-residential case in three years' time and in four years for the residential case (average 20yr LV tariff of 0,182€/kWh).

[4] More capacity achieved for more policy support resources committed.

[5] Based on the underlying assumptions the differences between residential and non-residential systems are low, as only small scale systems were analyzed for both cases, thus lacking the economies of scale factor. In this case FiT levels for non-residential seem slightly higher due to the inclusion of taxation, despite the relatively better financing conditions.

However, if further deployment should be reached through an increased IRR of 15%, additional grants would be required. Concerning the FiT scheme the analysis indicates relatively high FiT levels compared to other countries mainly due to lower productivity of the PV systems. Finally in **Ukraine** the analysis indicates that at current and future end user tariffs the NM scheme requires substantial grants in order to become economically meaningful. Moreover, the current FiT scheme was initially analysed resulting in negative IRR levels for the underlying investment assumptions of small scale systems. Hence a new scheme without the current provisions for FiT payment until 2031 (and wholesale tariffs thereafter) was analysed resulting in higher than current (162€/MWh) FiT levels.

5.5 CBA and programme planning

The cost benefit analysis provides aggregated results at system's level, i.e. from the 'social planner's point of view, which in turn reflect on the programmes the Eastern Partner countries shall adopt, in order to promote building-PVs. The target future building-PV penetration scenarios, assuming different levels of deployment over the 2018-2022 period of the total building-PV potential, estimated for each city and in each country comprise:

- a High Scenario which assumes that the total potential is actually achieved (to 100%);
- a Medium Scenario which assumes a 50% deployment.

For each of those scenarios we have assumed two alternative potential building-PV policy support measures:

- The addition to the currently available net metering scheme (which in most cases renders building-PV investment not attractive enough to incentivise investment in both market segments) of a capital grant support scheme in order to achieve an internal rate of return (IRR) of building-PV investments at least equal to the estimated IRR, or
- the implementation of a FiT scheme for tariff levels which would make the investment profitable enough (resulting in the same IRR level as above), which would also provide a stable financial framework and increased levels of confidence among investors.

The main difference between High and Medium Scenarios is the assumed IRR (5% higher under the High Scenarios), implying that higher investment profitability would incentivise higher deployment levels.

For Belarus and Azerbaijan we have assumed the implementation of a specific FiT based policy support programme with the target of respectively 25MW and 5MW of building-PV installed over the 5 years period (i.e. 2018-2022).

For each country and scenario, we have calculated:

- the cost of policy measures assumed using figures of FiT and capital grants, estimated by the end-user analysis.
- The potential economic impact of the implementation of the FiT scheme on electricity consumers.
- The quantifiable environmental and social benefits, namely the value of CO_2 emissions' reductions achieved and the number of jobs created by the implementation of building-PV capacity under different scenarios.

It is worthwhile to highlight, that the current level of awareness and the state of the mandate on network operators, allowed for a qualitative discussion on grid impacts expected by the adoption of the proposed development scenarios. Though the quantity of the new variable generation expected to be introduced to the national generation mix is minimal, the network operators (both TSOs and DSOs) need to gradually prepare for this development and align their operations respectively.

5.6 Conclusions and recommendations

One of the main conclusions derived from the Solar Study of the HiQSTEP project, is that PVs in urban areas can play a significant part in the development of the Eastern Partner countries electricity markets towards a more competitive, flexible and sustainable direction. Considering that the PV sector in the region is a niche market, being still in its infancy, and having the experience from a series of EU markets in mind, it becomes clear that this cannot happen without a strategic plan, which would be implemented by means of specific policies and measures. The present study suggests the implementation of specific policy support programmes tailored on building-PV deployment, to serve as pilots to open or, in particular in the case of Ukraine to scale up, the market and allow PV system costs to decrease and the value chain to be created, thanks to a progressive deployment, market expansion and experience.

The main conclusions and takeaways from end user and cost and benefit analysis of the above scenarios include the following:

- The end user analysis has indicated that in most Eastern Partner Countries, financial attractiveness of building-PV investments is low under the current RES and specifically PV policy support framework, due to the adoption of net metering schemes which in turn reward prospective building PV developers based on the existing relatively low end-user electricity prices. On these grounds a substantial market uptake of building PVs based on their financial attractiveness shall not be anticipated. Moldova may potentially differentiate from such an estimate given the evolution of electricity end-user prices which may render building-PV feasible in the next 3 to 4 years. The FiT scheme in Belarus would also be in a position to support a market uptake in building PV if only the legally-imposed quota and ownership limitations were alleviated. However, such an action may aggravate the adverse effects of electrical energy surpluses the Belarus's system is likely to demonstrate in the near future. .
- Additional support will be needed to make building-PV systems financially attractive and hence attractive for the end user, always keeping in mind the stage of development at which the electricity markets of those countries are. The support policies that seemed most suitable and were analysed are: capital grants and FiT schemes.

However, this additional support comes at a cost which is not always justifiable if one considers the possible energy mix alternatives on a short-term horizon. Nevertheless, the policy decision of developing distributed generation usually relates with the overall ambition for a decarbonisation of the electricity system, which is translated into a high level of RES penetration. It is therefore recommended that building-PVs' development is viewed in the wider context of decarbonisation, decentralisation and digitisation of the future energy system.

From the study's results emerges clearly, that building-PVs can play a significant, although not dominant, role in the energy balances of most Eastern Partner countries. Either driven by security of supply or by supply diversification based on cleaner, indigenous energy sources, Armenia, Azerbaijan, Georgia, Moldova and Ukraine should look further into distributed PV generation However, the broad market uptake of building-PVs is not a self-initiated development, as the example of the most advanced PV markets shows. Targeted policies are needed, with careful quantification of their costs and benefits, so as to have a solid validation. Furthermore, a similarly careful determination of the stakeholders' role is needed to allocate costs and benefits in an effective, yet also socially bearable way.

Taking into account the key issues common to all six Eastern Partner Countries addressed in this study, the following actions can be proposed for an effective promotion of building-PV:

- Organisational innovation[6] is instrumental for the design and implementation of an appropriate programme for the development of building-PVs. Given that the proposed programme is expected to be led by a national public institution, organisational innovation shall be regarded as the process of ensuring project aggregation and financing solutions minimising transaction costs and engaging the (international and/or private) finance community. It also has to include the removal of legal, administrative and other market barriers for bringing the specific investment pipeline to a financial close, possibly following the proposed staged development, if they are in agreement the plans of the partner financing institutions. This calls for regulatory and administrative actions, which can only be undertaken by national competent authorities. The Ministries responsible for energy and the national RES/EE agencies, where relevant, are the key stakeholders, although it obviously also will have to act as a focal point for other authorities – both at central government and local level - as well.

- Access to improved financing is of an utmost importance for the development of building-PV programmes. In our view, engaging with the IFIs is crucial in order to increase financing, for instance by exploring the possibility of, or the extent to which, aggregation and standardisation of financeable solutions is feasible. In this line of approach, the present report can act as the introductory study on which the IFIs may base their own assessments and eventually come up with their own specific solutions.

- When it comes to the specific policy tools required, a Feed-in-Tariff appears to be the most appropriate instrument, since it will reduce investment risks and provide the necessary basis for the engagement of financing institutions.

- FiT schemes could be financed by means of a RES levy, thereby the cost would be charged and passed on to the final electricity consumers. However, care should be taken in designing and implementing the scheme to avoid excessive burden on end-users and adverse social redistribution effects (possible measures are proposed, see also discussion in Section 4.2.2 and 4.3 of Component 4:“Programme development for building-PVs based on a Cost-Benefit Analysis: Georgia” report of this study).

- The implementation of capital grant schemes (or alternatively soft loan schemes) in conjunction with FiT schemes might help final end users to overcome access to capital barrier, thus facilitating investments and guaranteeing higher levels of building-PV deployment.

- Capital grant and soft loan schemes could be financed through specific International/Multilateral Financing Institutions' programmes, due to both their relatively small total cost and the fact that their cost burden is limited to a few years, compared to FiT which require longer term commitment.

[6] http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Organisational_innovation

- It would also be appropriate to promote building-PVs via other policy mechanisms such as obligation to install building-PVs in new building development, as a percentage of the expected final electricity consumption due to the new buildings. This will scale up building PV market, on the basis of an obligation and not as, an incentive thus reducing the long term policy's cost.

- The integration of building-PVs in the electrical systems of the countries considered is a further area where further work has to be carried out, as there are significant problems that have to be tackled, in order to maximize the benefits of distributed generation and reduce the impact of adding non-dispatchable generation in the urban environment, with its highly stochastic demand. There are structural and organizational issues, like the cooperation of the TSOs, the DSOs and the market actors, that should be addressed – and this is a discussion by no means limited to the Eastern Partnership Countries, as it an ongoing one also in many EU countries.

- Furthermore, as it emerged from Components 4 and 5 of the study, more explicit, quantitative assessments of the various costs and benefits comprising the impact of building-PVs integration to the local distribution grids are also needed, as no studies on the intermittency analysis are available for the Eastern Partner countries. Hence, the aspects of hosting capacity on a national and city's level should be considered, along with the generation displacement on an hourly level, by means of dispatch simulation. Those aspects have eventually to be linked to the costs of balancing the transmission systems and planning the development of infrastructure, to be able to cover future RES projects, admittedly building-PVs being not the major cause of concern.