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Solar Energy Simulations in Historical Districts for Retrofitting and Evidence-Based Decision Making: Data Challenges for Low Carbon Cities in the EU Neighbourhood & Accession Countries

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1 ABSTRACT

Transformation of cities to low carbon cities is a global policy priority that attracts a wide range of actors, including policymakers, local governments, scientists as well as associated technology companies. On the other hand, the geographic, climatic, and structural variations across cities are high not only at the global level but also in sub-continental regions. Besides, the cities also contain highly varied districts with respect to their built environment, land use, microclimatic conditions, and geographical and topological features, where some type of districts may require similar solutions adopted in other cities rather than the district's own city. Historical districts constitute a particular category from this perspective, where retrofitting and application of smart energy systems and energy-efficient solutions depend on different issues than in other districts.

Historical districts have unique problems with respect to the adoption of smart and energy-efficient technologies. While positive carbon districts imply energy production at the site, low carbon districts instead focus on decreasing energy usage and carbon footprints. The selection of the appropriate basic strategy at the district level relies on sound scientific assessment. The assessment should be able to evaluate whether the district is capable of locally producing positive energy outputs without significantly altering or destroying the historical characteristics and ongoing or proposed socio-economic functions. As an example, assessment of the application of solar energy panels in historic neighbourhoods require building based modelling approaches for: a) understanding whether solar energy panels may function within a required technical operation range in built environments; b) if the energy produced locally may be distributed to other buildings in the district; c) if historical buildings can safely accommodate solar energy panels and associated infrastructure; d) if energy storage is necessary and if buildings possess suitable interior spaces for safe storage of electric energy.

All these categories of assessment require standardised, rich, transmissible data on various properties of the interior and exterior of existing buildings, of open spaces, and of existing infrastructure. Often, historical neighbourhoods consist of a large number of buildings and extensions which have been subject to an unknown number of interventions over time with varying quality. It is highly unlikely that any existing databases could provide the basis for the extraction of relevant information, as in the past the purposes of such data collectiond did not involve objectives regarding energy efficiency or positive energy potentials. On the other hand, it would be costly and technically challenging to collect all such data from the site by traditional surveys. This problem is exacerbated as many cities now face sudden policy pressures to apply sustainable energy action plans at short notice. All these issues force the stakeholders to seek effective solutions for collecting data, structuring of data and conducting integrated-holistic retrofit simulations in historical districts that provide the evidence-based information for the selection of the suitable technological approach and strategic choices to transform historical cities into low carbon cities. In addition, such simulations might enable a healthier assessment of making use of carbon credits and other incentives in line with such strategies and interventions.

This paper discusses the general situation of historical districts and their assessment as positive or low energy districts, in the context of EU Neighbourhood countries. As a first step, the paper evaluates the regulatory framework regarding the UNDP Sustainable Development Goals, global climate change, EU Energy Policy, cultural heritage preservation, retrofitting in historical districts, and research-policy connections. Next, the paper surveys the literature associated with the data problems in the simulation of the application of sustainable energy systems and provides a critical evaluation of the general case of historical districts. Third, the paper explores the situation of data assets in the EU, its neighbourhood and Turkey, with

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a particular emphasis on building level data about buildings in historic districts. The paper discusses alternative approaches to effective data collection and joining strategies that would serve for different levels of PV solar energy simulations in historical districts. The paper concludes by providing a research agenda on PV Solar Energy simulations in historical districts for improving relationships between scientific research and policies addressing Climate Change.

Keywords: positive energy district, European Neighborhood Countries, retrofitting, simulation, solar energy

2 APPLICATION OF SUSTAINABLE ENERGY SYSTEMS IN CITIES: POLICY, LEGAL ISSUES AND IMPORTANT FACTORS IN HISTORIC DISTRICTS

The transformation of cities to low carbon cities is a global policy priority today. By the year 2018, 4.2 billion people lived in cities and this number will rise to more than 6.5 billion people by 2050. Cities occupy only 3% of the Earth's land but account for 60 to 80 percent of energy consumption and at least 70 percent of carbon emissions.[1] It is expected that the Earth could be 3–5 C warmer than pre-industrial levels by 2100, if current trends are not changed, making sustaining life in Earth extremely difficult. 195 countries in 2015 signed the Paris Agreement to challenge this threat.

2.1 Global and Continental Policy Targets on Climate Change

2030 of the United Nations Development Programme's 11th Sustainable Development Goal is about Sustainable Cities and Communities. The programme sets targets on reducing the adverse per capita environmental impact of cities, paying special attention to air quality and waste management, increasing the number of cities adopting and implementing integrated policies and plans for resource efficiency and adaptation to climate change, supporting positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning, and building sustainable and resilient buildings utilising local materials. The programme claims that a rapid reversal of the current upward trend in greenhouse gas (GHG) emissions, and an eventual halving of global GHG emissions by midcentury is necessary.[2]

The European energy and climate change policy was adopted by the European Union in 2008. One of the five pillars of this policy was increasing renewable energy usage, by tripling the usage to reach 20% by the year 2020. The Lisbon Treaty that entered into force in 2009 gave new powers to Europe and to EU citizens to act in several policy areas such as the areas of energy, climate change and scientific research. These policies shaped the design of the Europe 2020 Initiative that was launched in 2010, aiming at smart, sustainable and inclusive growth in the EU. EU's Roadmap to a Low Carbon Economy in 2050 sets 80-95% of the reduction of GHG emissions. A cost-effective and gradual transition to such an economic system requires almost halving current GHG emissions by the year 2030 compared to 1990. The European Environment Agency's (EEA) latest 'State of the Environment' report warns that Europe will not achieve its 2030 goals without urgent action. While targets on renewable energy for the year 2020 were largely on track, the situation was dire for the year 2030 and beyond (Martin et al., 2015). In line with this situation, one of the three thematic priorities in the Seventh Environment Action Programme (7th EAP), is to turn the EU into a resource-efficient, green and competitive low-carbon economy. In addition, the Horizon 2020 programme now has a specific focus on low carbon cities and positive energy districts, aiming at the development and diffusion of associated technologies.

With the Treaty of Lisbon, fighting climate change at an international level has become a specific objective of EU environmental policy (da Graça Carvalho, 2012).

[1] Sustainable Development Goals of UNDP for 2030: 11th Goal - Sustainable Cities and Communities- targets: Accessed by 30th Jan. 2020. https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-11-sustainable-cities-and-communities.html#targets

[2] IPCC Secretariat/World Meteorological Organisation/United Nations Environment Programme: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press; 2007.

2.2 Building Ties Between Research and Policy to Improve Impact of Interventions Regarding Renewable Energy Systems in the EU Neighbourhood Countries

Within this context, successful diffusion of renewable energy systems in the EU Neighbourhood Countries and Accession Countries like Turkey becomes an important issue not only for these countries but also for the EU. These countries have structural and economic problems that slow the transition and increase costs of GHG emissions reduction, despite their geographical advantages in renewable energies, such as solar energy. Built areas and particularly historical districts of the cities in the EU Neighbourhood pose unique challenges in the diffusion of renewable energy systems. The costs and benefits of such transformation are not clear which, in turn, drags interventions and applications below the desired rates. That is why improving the information base for costs and benefits of solar energy applications in built areas is important for improving the effectiveness of policies targeting the diffusion of renewable energy systems in these countries.

Informing policy-making through scientific research improves the efficiency and effectiveness of policies. Translation of scientific evidence into the language and information type that is useful and relevant to policymakers is difficult due to possible conflict between different types of evidence, differences in values that drive scientific inquiry and policymaking, and different paces of the scientific world and the policy world. In addition, science and policy communities are often cognitively disconnected, leading to frustrations and feedback problems (Bogenschneider and Corbett,2006). Establishing strong ties between research and policymaking is a supported practice through the 6th and 7th EU Framework Programmes and Horizon 2020 to help solve real-world problems (COM, 2011), (Sinozic et al., 2015).

The development of policies for the successful deployment of PV systems in the urban environment, including financing schemes, utility planning or accommodating grid capacity, critically depends on the assessment of the local potential which is determined by local realities, meteorological data, reference technologies and economic factors (Wittmann et al., 1997). Solar energy simulations have become crucial scientific assessment tools for the creation of valuable scientific evidence that could improve the effectiveness of policies at multiple spatial scales, given that they are provided with data and information as discussed above. However, the status of the required building level data assets for urban areas is not clear in the EU Neighbourhood countries. In addition, the amount of information and data required for historical districts is higher, as is discussed below.

From this perspective, the evaluation of Turkey's building and district level data assets for the utilisation of solar energy simulations provides important opportunities for the identification of important obstacles against building links between research and policy practice. Although being an Accession country to the EU, Turkey shares a common history and similar socio-economic features with many other European Neighbourhood countries, as well as similar geographic features, that have played a role in the development of both historical and contemporary urban settlements. This makes it an ideal case for such evaluations. In this paper, we focus on historical districts as they pose interesting and unique legal, cultural, economic and technical challenges for solar energy simulations in built areas.

2.3 Energy efficiency regulations and heritage protection

Following the adoption of the Kyoto Protocol in 1997, the European Union approved regulations to lessen the energy consumption in existing residential buildings including residential built heritage. Major actions have been taken by the European Environment Agency by Energy Performance Building Directives (EPBD). Directive 2002/91/EC mentions energy efficiency in buildings both new and existing with major renovations, and their energy performance calculations. (DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings, o. J.) Directive 2010/31/EU stresses over the issues of historic buildings over the minimum energy performance requirements. (Directive 2010/31/EU on the energy performance of buildings (recast) - 19 May 2010 | Build Up, o. J.) (Jurošević & Grytli, 2016)

Historic districts require the sustainable and proper implementation of energy retrofitting. The decision making process has to consider the utilisation of proper tools and technologies for a smooth and respectful change. Complexity in historic districts in terms of energy systems requires a multiscale perspective approach for retrofit. The EFFESUS project (Energy Efficiency for EU Historic Districts Sustainability) developed a system for the selection of the most appropriate strategies. (Jurošević & Grytli, 2016) (Egusquiza & Izkara, 2016)

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Local and international legal challenges (Directive 2010/31/EU on the energy performance of buildings (recast) - 19 May 2010 | Build Up, o. J.) and the local requirements need to be elaborated by all the stakeholders for better implementation of sustainable energy systems. Innovative approaches proposed by some European research projects[3] need to be further improved for current energy efficiency requirements.

Interventions targeting energy efficiency in historic districts do not have proper regulations and protocols for data collection and the design process. This situation creates ambiguity about data requirements for the interventions in historic districts. Italian GBC (Green Building Council) implemented a Historic Building Protocol into LEED standards to solve this issue. This protocol is compatible with LEED standards and guidelines and it allows innovative designs and suitable material selection while also taking into account the preservation of cultural heritage.

The financial concerns challenge the regulation and application of the energy efficiency systems in accession countries and EU Neighbourhood countries, unlike some of the European countries that provided incentives both for Public Administrations and private citizens.[4]

Turkey started to take measures by delivering the new energy efficiency standard TS 825 (Thermal Insulation Requirements for Buildings) in 2000 and the Directive on Building Energy Performance (BEP-TR) sets lower limits[5] for the building envelope (Şahin et al., 2015). The BEP-TR covers existing and new buildings. Clause 2/c, of BEP-TR states that retrofits in historical districts is to be done in harmony with the official authorities without compromising the heritage value of the buildings, reflecting the Energy Performance of Buildings Directive (EPBD) (Directive 2010/31/EU on the energy performance of buildings (recast) - 19 May 2010 | Build Up, o. J.). However, BEP-TR does not include any further instructions regarding the proposed interventions for historic buildings. A non-governmental agency in Turkey, Turkish Green Buildings Council (ÇEDBİK) has established the B.E.S.T. (Ecological and sustainable design for buildings) certificate system only for new residential buildings. However, it might be useful to develop a special certificate system for new and historical buildings in historical districts.

Another issue is the choice of appropriate strategies at the district level for large-scale and rapid transformation of cities in line with the 11th SDG while taking into account other goals regarding cultural heritage preservation. Currently, it is very difficult to assess whether a low carbon policy focusing on decreasing energy usage by multiple interventions to historic districts is more suitable than a positive energy policy which rather focuses on on-site production of renewable energies via application of systems like PV panels. These two policy options would rely on highly varying technological interventions both at building and at the district levels to be effective and efficient. As a consequence, simulation approaches and methods utilised could be quite different. In both cases, simulation approaches have to take into account the historical value and socio-economic functions in these districts. Simulation-based assessment of solar energy technology applications in historical neighbourhoods may use building-based modelling techniques, taking into account various factors or standards such as operational range, storage, and safe accommodation of solar energy panels, the condition of the associated infrastructure and components of the buildings. In order to produce district-level information to feed policy decisions, the simulations also have to be able to represent the highly varying features of historical buildings which could be subject to non-standard interventions. These issues are likely to be more important in countries where regulations are weaker and users prefer ad-hoc interventions to historic buildings.

[3] [ENCULT Project, Efficient Energy for EU Cultural Heritage. Seven Framework Program (FP7-EeB.ENV.2010)] [SECHURBA Project (2008). Sustainable Energy Communities in Historic Urban Areas. Intelligent Energy Europe IEE-07-695 SECHURBA]- [SuRHiB Project (2011). Development of Technical and Architectural Guidelines for Solar System Integration in Historical Buildings, supported by CCEM- Retrofit, WP-7. SFOE [2009-2012]-[SOLNUC Project (2007): PV and Solar Collectors in Historical Centers. University of Applied Sciences and Arts of Southern Switzerland(SUPSI) by order of DT, Ufficio della Natura e del Paesaggio, Consiglio di Stato del Canton Ticino].

[4] As an example, Ministerial decree in Italy provides such incentives [Ministerial Decree 16/02/2016. Aggiornamento della disciplina per l'incentivazione di interventi di piccole dimensioni per l'incremento dell'efficienza energetica e per la produzione di energia termica da fonti rinnovabili.].

[5] [TS825-Thermal Insulation Requirements in Buildings (Recast), TurkishStandard, Turkish Standards Institute, May 2008, Available: http://www.mmo.org.tr/resimler/dosya ekler/cf3e258fbdf3eb7 ek.pdf (in Turkish),(accessed: 20.02.2014).] [Directive on Building Energy Performance (BEP Directive), Off. Gaz., Issue:27075, 5 December 2008]

There are various legal restrictions regarding historic districts and buildings in Turkey; both exterior and interior alterations require approval from the pertaining preservation board according to Law no. 5366 and Law no. 2863.[6] Proposed alterations have to be in compliance with local preservation laws for designated conservation areas and registered historical buildings, where restrictions may arise not only due to the attributes of buildings themselves but also due to their relationship with neighbouring parcels. Some partially collapsed or heavily damaged historic and cultural heritage structures are allowed to be reconstructed and put in use by the law, but there still exist uncertainties regarding the appropriateness of applications (Kaplan, 2017). The situation of applications targeting low carbon emissions or positive energy objectives is unclear, leading to a waste of opportunities arising in such reconstruction works. If conservation policies and associated laws could be connected by policies targeting the Climate Change and renewable energies, through scientific information based on evidence, the probability of effective implementation of appropriate technologies would likely increase.

3 DATA REQUIREMENTS FOR BUILDING BASED SOLAR ENERGY SIMULATIONS IN HISTORIC DISTRICTS

For new and existing buildings both at building and district levels, the primary aim is to achieve a reduced carbon footprint level and improve comfort conditions. The desired alterations in historical districts require necessary permits from the preservation boards. Buildings in historic districts require specific micro-climatic conditions, therefore, balance is essential between the occupants and the requirements of the building, the final use of the building's desired energy performance and comfort level (Del et al., 2010). New buildings and retrofitted buildings require specific approaches for window frames, opaque surfaces, and claddings, efficient thermal or passive solar techniques to reduce energy consumption of the building at the beginning of the design stage. (López & Frontini, 2014)

Directive 2010/31/EU of the European Parliament for retrofit of the historic buildings require an original approach to each building. However, the costs of such works could be extremely high, depending on the needs to collect primary data and establish relationships between different data sets which may not be compatible. A mid-level solution could be to develop common models feeding on joint databases that could provide adequate information for the purposes of solar energy retrofit applications in such districts. This might also improve building bridges between appropriate policy options such as positive energy districts and cultural heritage preservation, which might help closing the potential gaps at strategic levels and contribute to the sustainable development targets.

3.1 Solar Energy Technology & Alternative Simulation Options

Densification of cities increased the significance of solar technology and their proper integration and application to historical buildings (López & Frontini, 2014). Solar energy technology is basically categorised under two options, one as solar thermal technologies, and the other is solar photovoltaic (PV) panels as a passive solar heat system to produce electricity. There are examples of building integrated active systems, like building integrated solar batteries, solar collectors, both solar battery and collectors. On the other hand, there are roof or façade integrated solar systems (Özeler Kanan, 2012). However, visual concerns of solar thermal technology systems within historic districts may potentially create problems, so PV systems are a better choice. The solar potential of a district can be addressed at various levels in terms of resource, technical, economic, and market potential (Bódis et al., 2019). Evaluation of the solar potential requires data like the amount of solar radiation, usable sunlight, environmental parameters, efficient surface area, technical performance of the system, sustainability criteria, technology cost, and legal issues (Bódis et al., 2019).

The assessment of solar potential depends on the method used. Currently used methods are classified as low, medium, and high-level methods based on the utilised statistical, spatial, and detailed spatial and solar irradiation data. The low-level methods use aggregated statistical data, medium level methods use the spatial data derived from the geographic information system (GIS) and light detection and ranging (LiDAR) methods, and the high-level methods use detailed spatial data along with the solar radiation analysis (Bódis et al., 2019) (Castellanos et al., 2017)

[6] Law no. 5366: Yıpranan Tarihi ve Kültürel Taşınmaz Varlıkların Yenilenerek Korunması ve Yaşatılarak Kullanılması Hakkında Kanun, Law no. 2863: Kültür ve Tabiat Varlıklarını Koruma Kanunu

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Low-level methods	Example: population density as a proxy for the building/rooftop area. Assumption: homogeneity of the data throughout the area. Concern: limited reliability, ignores local interactions of buildings, ignores the design differences of buildings. Suitable: for homogenous districts.
Medium level methods	Feature: spatial data allows heterogenisation of the aggregated statistical data. Benefits: Better reliability. Concern: ignores local interaction of buildings. Suitable: for districts with a low building design heterogeneity
High-level methods	Feature: Highly reliable in estimating the performance of PV Solar Energy systems on buildings. Advanced methods to collect microdata and the detailed spatial information takes into account local interactions, design differences, rooftop slopes. Suitable: for heterogeneously developed mixed-use districts or historic districts.

Table 1: Features and uses of different methods according to their level of complexity.

3.2 Critical evaluation of simulation models for integrated solar energy retrofitting in historic districts

Transforming a historic district into a positive energy (historic) district requires the effective utilisation of renewable energy systems locally, such as PV solar systems. The prior simulation of the PV systems may help local governments to choose whether it is better to pursue a positive energy district or go for a different strategy like being a low carbon district by employing other technological and organisational solutions.

Especially historical districts in EU Neighbourhood countries face challenges in the assessment of potentials with respect to local application of renewable energy systems. Historical neighbourhoods in general consist of a large number of buildings and extensions which have been subject to an unknown number of interventions with varying quality, in countries where regulations are weak and social change are strong. Many of these interventions severely alter the structural properties of the buildings, but the resulting changes in the structural properties of buildings often remain completely unrecorded.

While at first glance, the above mentioned high-level simulation methods seem to be appropriate to assess PV solar system utilisation in historical district contexts, in reality, it may be almost impossible to employ them due to their expansive reliance on micro-level building data which is not available. On the other hand, low-level methods lack the ability to capture the heterogeneity of the districts which eventually increases the risk of successful implementation of PV solar systems. Even though this line of thinking leads us towards medium level methods, there are other issues that have to be taken into account;

(a) How detailed the available spatial data sets are,

(b) Whether existing spatial data will provide the desired level of representation of the heterogeneity of the historic district,

(c) Whether aggregated statistical data on socio-economic activities makes sense for modelling objectives.

Based on the International Energy Agency (IEA) PV rooftop potential is calculated by the use of rooftop area per capita, population density, solar insolation, total city population, rooftop PV system efficiency, and performance ratio and orientation factor. Some of the data like population density, rooftop PV system efficiency and population can be obtained as statistical data for historic districts. GIS data is available for most districts, but data collected by LiDAR methods are not readily available for every district.

Roof structural system, building use category, multiple ownerships are also important factors for the selection of the methods in the determination of the solar potential. Some multiple-owner estates are not registered despite being located in the historic district. Any kind of intervention and/or retrofit for the buildings in historic districts requires compliance with rules and regulations of the conservation boards. Multiple ownership in some states and especially in historic districts are important issues to get necessary permits from the owners even if there are no preservation rules and regulations.

4 EXISTING DATA STRUCTURES IN THE EU, ITS NEIGHBOURHOOD, AND TURKEY

4.1 Data structures in the EU with respect to solar energy simulation

EU and its southern and southeast Mediterranean neighbours' collaboration resulted in the Mediterranean Solar Plan (MSP) to promote solar energy production in North Africa. Morocco is one of the examples of the EU Neighbourhood countries within MSP which is expected to provide increased green energy production and employment by means of the new green energy trade scheme, that was put in effect with EU 2009/ 28 Directive (Tahri et al., 2015).

Infrastructure for spatial information in Europe (INSPIRE) was initiated in 2007. The INSPIRE Directive aims to create a European Union spatial data infrastructure for the purposes of EU environmental policies or activities which may have an impact on the environment. This European Spatial Data Infrastructure will enable the sharing of environmental spatial information among public sector organisations, facilitate public access to spatial information across Europe and assist in policy-making across boundaries.

4.2 Evaluation of the data structure in Turkey as a representative country of the EU neighbourhood.

Parallel to the INSPIRE directive, Turkey as one of the EU accession country which started the implementation of a geographical Information system based on building an inventory registry in several municipalities (Toybıyık, 2017)(Toybıyık, 2017). Turkey's national geographical information system-based (TUCBS) thematic building data includes both the BuildingsExtended2D requirements from INSPIRE and the local city information system (KBS) in 3D detail classification.

Besides, there have been many municipalities which have used geographical information systems to implement a cultural heritage inventory (Kudde et al., 2019; Savran et al., 2017). Inventory projects for cultural and historical assets are well-formed databases and they may be extended even more to encompass the required data for solar energy utilisation in historical districts. Besides, these databases have to be integrated with the TUCBS. Thematic building data in TUCBS inventory can be useful for building scale solar energy estimation, however, the calculations of solar capacity at district level may require further assessment of local solar obstructions. Therefore, TUCBS data may be extended with the help of aerial mapping of the district with the utilisation of methods like LiDAR. This information may be integrated into the TUCBS database. With that the medium-level methods will be attainable. To the best of our knowledge, LiDAR data for Istanbul is available prior to 2013 (Kayı & Erdoğan, 2015). However, it is not certain if the data from different LiDAR applications elsewhere in Turkey are compatible with each other.

For the overall energy performance evaluation, the energy demand of the historic district also depends on envelope materials. In the reconstruction and retrofitting of historic buildings, a current database on the environmental performance of materials would be useful. In this context, there is a database called TurCoMDat[7], about the environmental performance of building materials based on the international norms and standards produced in Turkey. The database may be extended by the addition of data on materials specifically designed for retrofit use for the historic districts. Utilisation of both energy demand determination with the help of building envelope data and calculated solar potential enables to deduce an appropriate strategy for the energy efficiency system.

5 CONCLUSION

In this paper, we have briefly discussed the possible ways of utilisation of PV Solar Energy simulations in built-up areas as it is an important issue for informing policies regarding the Climate Change and international role of the EU. We have focused on the specific case of Turkey as a representative country of the EU Neighbourhood, and the subject of historic districts as a special case where diffusion of innovation faces significant challenges.

Although the paper is the product of ongoing research, it provides some perspectives on the development level of building-level databases and their utilisation for PV Solar Energy simulations in historical districts in the EU Neighborhood context, assuming that Turkey is a good representative. To the best of our knowledge, it is likely that up-to-date LiDAR data for wide-scale use is not cırrently available in the EU Neighbourhood countries. Due to their unique features historical districts might need advanced LiDAR data and building envelope data available at the district level so as to facilitate high-level simulation methods.

High-level simulation methods may help practitioners to obtain a fine-tuned balance between energy efficiency and the historical heritage conservation priorities that would be crucial in the decision of appropriate strategy between low carbon and positive energy district, However, it could be possible to use medium level simulation methods in historical districts in some cities which have collected LiDAR data. We believe that even medium-level simulation methods applied to historical districts might improve the

[7] https://turcomdat.com

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provision of evidence-based information to feed policies targeting Climate Change in the EU Neighborhood countries, which could reduce stress to meet sustainable development targets set by various international, national and local actors.

For the case of Turkey, the rise in the number of studies focusing on building level data inventories seem to be increasing, while modelling capabilities seem to be developing depending on the limited data available. There are also significant efforts to avoid coordination pitfalls and waste of resources due to thematically and geographically duplicated works.

A relevant research agenda might focus on at least three subjects. First, approaches have to be developed, which enable joint use of existing building data structures in modelling works for PV Solar Energy. This might still provide benefits as the costs and benefits of choosing alternative strategies would be assessed better than it can be done today. Second, cultural heritage inventory data collection efforts by various local governments and other public bodies should be coordinated and subject to standards so that they take into account the data needs of medium or higher level PV solar energy simulations, depending on their budget. Third, hybrid approaches that use strengths of sampling and high-level methods have to be developed to open an alternative path for the production of scientific evidence for policy making. Alternative approaches may provide opportunities for faster development of simulation capabilities in the overall region, conditional on the capability in the EU Neighborhood to establish research partnerships aiming at establishing stronger ties between research and policy making to help solve real-world problems associated with Climate Change.

6 REFERENCES

Bódis, K., Kougias, I., Jäger-Waldau, A., Taylor, N., & Szabó, S. (2019). A high-resolution geospatial assessment of the rooftop solar photovoltaic potential in the European Union. Renewable and Sustainable Energy Reviews, 114(August), 109309. https://doi.org/10.1016/j.rser.2019.109309

Castellanos, S., Sunter, D. A., & Kammen, D. M. (2017). Rooftop solar photovoltaic potential in cities: How scalable are assessment approaches? Environmental Research Letters, 12(12). https://doi.org/10.1088/1748-9326/aa7857

da Graça Carvalho, M. (2012). EU energy and climate change strategy. Energy, 40(1), 19–22. https://doi.org/10.1016/J.ENERGY.2012.01.012

Del, D., Fratelli, M., Claudio, S., Ornaghi, S. G., Ciccarelli, E., Furuli, G., Minotti, S. S., Berti, F., Fabrizio, N., Zipoli, A., & Pagliarulo, A. (2010). Conservazione degli edifici e delle opere d ' arte a cura di. 1–110.

DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings. (o. J.).

Directive 2010/31/EU on the energy performance of buildings (recast) - 19 May 2010 | Build Up. (o. J.). 21 Jan 2020 www.buildup.eu/en/practices/publications/directive-201031eu-energy-performance-buildings-recast-19-may-2010

Egusquiza, A., & Izkara, J. L. (2016). Facilitating historic districts energy retrofitting through a comprehensive multiscale framework and its implementation in the EFFESUS DSS. 2nd International Conference on Energy Efficiency and Comfort of Historic Buildings, 59–67.

Jurošević, S., & Grytli, E. R. (2016). Energy efficiency retrofit of historic buildings: concepts, approaches and interventions. 2nd International Conference on Energy Efficiency and Comfort of Historic Buildings, 296–300.

Kaplan, O. (2017). 5366 Sayılı Kanun Kapsamında Yenileme Alanlarında Gerçekleştirilen Kentsel Dönüşüm Süreci Üzerine Bir Deneme. Hacettepe HFD, 7(2), 275–304.

Kayı, A., & Erdoğan, M. (2015). OPTECH HA-500 ve RIEGL LMS-Q1560 ile Gerçekleştirilen LIDAR Test Sonuçları SEMI-AUTOMATIC EXTRACTION OF FEATURES FROM DIGITAL IMAGERY View project Göktürk-2 Satellite Project View project. 153, 42–46. https://www.researchgate.net/publication/316279744

Kudde, E., Erdogan, I., & Ilze, I. (2019). Inventory project for the cultural assets of istanbul: A model for digitization of cultural heritage. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 42(2/W11), 693–697. https://doi.org/10.5194/isprs-Archives-XLII-2-W11-693-2019

López, C. S. P., & Frontini, F. (2014). Energy Efficiency and Renewable Solar Energy Integration in Heritage Historic Buildings. Energy Procedia, 48, 1493–1502. https://doi.org/10.1016/J.EGYPRO.2014.02.169

Martin, J., Henrichs, T., & Eea. (2015). The European Environment: State and Outlook 2015: Synthesis. In European Environment. https://doi.org/10.2800/45773

Özeler Kanan, N. (2012). TARİHİ YapilardaEnerji Kazanci Sağlamak Amaciyla Çati Ve CepheBütünleşikAktiSistemlerin Kullanimi. 6. Ulusal Çatı & Cephe Sempozyumu.

Şahin, C. D., Arsan, Z. D., Tunçoku, S. S., Broström, T., & Akkurt, G. G. (2015). A transdisciplinary approach on the energy efficient retrofitting of a historic building in the Aegean Region of Turkey. Energy and Buildings, 96, 128–139. https://doi.org/10.1016/j.enbuild.2015.03.018

Savran, D., Tuna, G., Macİt, F., & Daş, R. (2017). Coğrafi bilgi sistemleri kullanılarak taşınmaz kültür envanterinin hazırlanması : Kırklareli ili örneği. 0(284), 147–157.

Sinozic, T., Baypinar, M. B., Bergman, E. M., Hornyak, M., Kruzslicz, F., & Varga, A. (2015). A Policy Research Method Case-Study: Generating and Extracting Evidence-based Policy Inferences from a large EC Framework Programme Project.

Tahri, M., Hakdaoui, M., & Maanan, M. (2015). The evaluation of solar farm locations applying Geographic Information System and Multi-Criteria Decision-Making methods: Case study in southern Morocco. Renewable and Sustainable Energy Reviews, 51, 1354–1362. https://doi.org/10.1016/j.rser.2015.07.054

Toybıyık, S. S. (2017). Coğrafi tabanlı Türkiye bina envanterinin oluşturulması.