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Role of utilities, big data and geo-spatial data in energy transition

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Note by the secretariat

I. Background information

1. Transition to sustainable energy consumption requires action on different scales: from installation of equipment in individual buildings to development of infrastructure at the district, city and regional levels. Some energy solutions are complementary (e.g., a building can be equipped with different types of energy efficient equipment from lighting and household appliances to heating, ventilation and air conditioning systems), while other solutions are alternative (e.g., a building can be heated by an individual heating system or connected to a district heating network).

2. Implementation of energy efficiency and renewable energy solutions involves multitude stakeholders, from energy consumers, installers, facility managers to energy providers, utilities, energy programme administrators and government authorities.

3. Effective coordination between the stakeholders regarding the choice and implementation of technological solutions at different scales is essential for successful achievement of energy and climate policy targets. High quality data is one of the central elements of this coordination.

4. Many countries and cities have started using Big and geo-spatial data and related data management and analysis methods for implementation of sustainable energy projects. Exchange of international experience on the use of Big and geo-spatial data and on application of related data management and analysis methods is of special interest as the respective IT solutions can be easily transferred among different locations. The insights from the case studies can be used as a basis for development of legal and organizational practices in other locations.

II. Examples of applications at different scales

5. Work at the country and regional levels is mainly done by research institutions with the purpose of providing evidence for governments and international organizations. Among the main topics of the respective studies are identification of renewable energy potential, estimation of energy consumption and linking energy demand with sustainable energy supply.

6. Applications at the city and individual building levels are often developed by the private sector (consultancy and engineering companies) for the use by municipal authorities and building owners. These applications allow to perform city planning with regard to energy infrastructure (district heating networks), identify energy efficiency and renewable energy potential by building and consumer, and implement energy management in buildings.

7. An example of the use of geo-spatial data at the regional level is geothermal energy project GEothermie 2020 in the canton of Geneva, Switzerland.[1] Currently in Geneva there is a growing interest in sustainable territorial development, including the management of subsurface resources. One of these resources is geothermal energy. The project GEothermie 2020 focuses on reprocessing old and collecting new data in order to increase geological knowledge on the Greater Geneva Basin for the development of geothermal energy projects. Energy demand data is also evaluated and cross-checked with geothermal resources data to ensure that available resources are in line with the energy needs and territory planning issues. In the context of the GEothermie 2020 project, a new legal framework and a geo-spatial information system GESDEC is currently under development. The future information system should be able to gather all information related to the subsurface resources, answer queries to produce maps and models, guide geothermal project leaders, and assist the cantonal authorities for an optimal management of the subsurface resources in Geneva to guarantee a sustainable expansion of geothermal energy.

8. Energy Mapping project represents an example of application at the city level.[2,3] The project addresses the needs of local governments and final energy consumers in more detailed information on the current and future energy use at the neighbourhood and building levels, as well as on the local energy infrastructure. Energy Mapping process analyses the local energy data, such as types of energy consumption including heating and cooling demand, and energy resources including excess heat and renewable heat assets (geothermal, solar, etc.). The methodology includes the Big data analysis, statistical analysis and visualization on a GIS platform. Actual buildings consultation and various evaluation criteria are used to evaluate buildings' actual energy performance as opposed to theoretical energy performance widely used nowadays in building certification practice. In fact, the gaps between theoretical and actual energy performance are significant in many buildings, often due to a lack of qualified energy management. Energy Mapping allows to address these performance gaps. To evaluate the actual energy performance and to allow comparison with other buildings and energy consumers, normalization of influential factors is performed (including accounting for outside air temperature, heating season duration, shares of hot water consumption, heated areas, etc.). Energy Mapping has been implemented in Vilnius, Lithuania, and in Belgrade,

[1] Favre, Stéphanie. Systèmes d'information pour les données géologiques 2D et 3D: perspectives et limites pour l'analyse du sous-sol genevois et ses ressources. Université de Genève. Thèse, 2018. https://archive-ouverte.unige.ch/unige:102945

[2] Savickas R. Study and assessment of an Actual Energy Consumption Class (AECC) and energy consumption efficiency in Vilnius. Vilnius: Šiluminė technika, 2014, No.1 (No. 58) March, pp. 3–6.

[3] Savickas R. Vilnius – most innovative among Europe Cities in energy sector. Vilnius: Šiluminė technika, 2014, No.4 (No. 61) December, pp. 10-11.

Serbia. Its methodology can be applied in other locations either directly or with adjustments to local specific conditions and requirements.

9. One of the decision-making tools for policy makers is GRIDS energyCity web-based software for territorial energy and climate planning. The 3D platform visualizes all energy-relevant information for cities, municipalities and regions in a bottom-up and user-friendly way at the push of a button. By modelling the real world with a "digital twin", the complex relationships and processes in a sustainable city become transparent and tangible. Thanks to the simulation of scenarios and measures, policy makers are able to take well-informed decisions in highly uncertain circumstances. Once implemented, the policies and measures can be monitored reliably and efficiently over a long period of time. GRIDS energyCity is also a modern internal and external communication platform creating transparency for all stakeholders (residents, politicians, energy suppliers, and companies) and allowing them to participate in the energy transition. The tool is being applied in several cities and municipalities in Switzerland and Germany. It was developed by two Swiss companies in close cooperation with the Energy and Municipal Research Centre (CREM) in Martigny, Switzerland.

10. An example of using Big data and geographic information system (GIS) methods for energy management in buildings is a tool developed by the National Cleaner Production Center (NCPC) in the Russian Federation. NCPC has developed Energy Management Analytics (EMA) system based on the United Nations Industrial Development Organization (UNIDO) approach for energy analysis. EMA is a web application for monitoring of energy efficiency on a day-to-day basis. NCPC works both with industry and cities. As an example, NCPC initiated development and implementation of the "Sustainable City" programme in the city of Astrakhan. The basis for this programme is organization of data collection and analysis of a large number of objects such as municipal schools, hospitals, and residential buildings. For this purpose, NCPC uses dispatching system for data collection and monitoring of technical parameters of the energy users and EMA application for energy analysis.

11. In practice, implementation of sustainable energy projects requires coordination of multiple actors who may often have different objectives. As a result, the operational and decision-making work is done with different IT tools.

12. For example, in Geneva, Switzerland, a local publicly owned utility Services Industriels de Genève (SIG) runs energy programme éco21 in collaboration with the cantonal energy authorities. Éco21 promotes energy efficiency and renewable energy technologies by providing subsidies for final consumers, developing partnership programmes with installers, and running information and awareness campaigns. SIG also collaborated with the local authorities in development of local energy plans at the cantonal and municipal levels. Multiple IT tools have been developed to support this operational and strategic work. In most cases, there has been no possibility to exchange data among the different IT tools, which led to inefficiency of their operation and a lack of the complete picture of all processes. AtlasEco21 project led by éco21 aims at developing solutions for data exchange among the stakeholders via the network of interconnected GIS-based tools. These solutions would allow to ease operational work through automatization of data treatment processes and to support decision-making by energy consumers, contractors, utility, and the local authorities though a more comprehensive picture of the state of the energy system and on sustainable energy projects, implemented and planned.

III. Case study on energy demand model for Switzerland[4]

A. Introduction

13. Swiss Energy Strategy 2050 includes phasing-out of nuclear production, an increase in the share of renewable heat production, including with the use of heat pumps, and the development of electric mobility. Against this background, there is an important pressure on assuring the future sustainable electricity supply. In addition to increasing capacities of renewable electricity supply, efficient use of electricity is recognized as an important driver for the achievement of 2050 energy policy goals.

14. Among the policy mechanisms to promote energy efficiency are energy programmes, provision of subsidies to final consumers, training support for professionals, awareness campaigns, and implementation of other measures to foster market transformation and behavioural change. The design of large scale electricity efficiency programmes requires a detailed knowledge of how the electricity demand of a territory breaks down into various activities and electric appliances.

15. Energy programmes could also be used for demand side management to reduce the demand peaks as well as the need for storage. This is especially important in the context of increasing share of renewable electricity production that is often subject to temporal constraints. Active storage being expensive, a forecast of the electric load curve is a useful input helping to make optimal use of the batteries. On the other hand, indirect storage can be implemented by shifting part of the load (e.g. electric hot water boilers) to a more suitable time when renewable excess electricity is available. Local microgrids connecting producers, consumers and storage units should include efficient real time communication. The estimation of load curves by usage type is a valuable input to estimate the potential of such smart grids.

16. ElectroWhat platform aims to answer the question who consumes where, when and for what use, by simulating load curves per usage type on municipal level for Switzerland.

B. Methodology

17. The annual demand of a municipality is split into three main sectors, each one with its own estimation algorithm. The annual consumption is split into 36 activities and 18 electric appliances such as lighting, refrigerators, TV sets, etc. The next step is transforming the annual demand into estimated load curves using a library of load curve shapes.

18. The estimation of the annual consumption of the industry and services sector is based on the number of working places per General Classification of Economic Activities (NOGA 2008) activity code available in the government statistics database (STATENT). These statistical data are combined with unitary average consumption per working place and NOGA code. For the canton of Geneva, the unitary consumption data are estimated using the total billed electricity per activity. For the remaining Swiss municipalities, the average unitary consumption is calculated using an annual national survey conducted for approximately 12,000 companies. For each activity code, the total annual demand is decomposed into different appliances used for lighting, motor power, heat, etc.

[4] Schneider S. et al., Electro-What: A platform for territorial analysis of electricity consumption, Energy Procedia, Vol. 122, 2017, p. 92-97. https://www.sciencedirect.com/science/article/pii/S1876610217329806

19. The number of collective dwellings is used as an explanatory variable for common appliances and public lighting. This assumption is based on the fact that public lighting (including traffic lights) is linked to urban density. This approximation does not take into account some specificities such as e.g. additional urban highways and tunnels. The priority is given to unitary consumption data calibrated on local ESCO bills to take account of regional differences. For example, there are big differences between various Swiss regions in the use of lighting in the common areas of buildings. In the canton of Geneva, it is mandatory to have the staircase illuminated round the clock. The Geneva energy programme ECO21 promoted low consumption light fixtures with occupancy sensors that switch on only when required. In canton Vaud, the common practice is to have light fixtures with a manual switch.

20. The consumption of the average household is estimated by combining equipment rates, time of use, and average power per main use appliance. The unexplained part is included in the appliance named "other". The main regional difference concerns the equipment rate of electric cookers. A stock model based on sales statistics according to energy efficiency label permits to estimate the average power consumed by a specific device.

21. A library of average load curve shapes per electric appliance type and activity permits to split the annual consumption into monthly estimations. The used shares defining these shapes are based on measured seasonal effects that are particularly pronounced for heating and lighting. Monthly demand is further broken down into daily demand for working and non-working days and finally into hourly demand. The load curve of a particular municipality is estimated by adding up the individual load curves of all activities and all electric appliances.

C. Results and applications

22. The annual estimated consumption of each municipality split into activities and electric appliances will be made available by a web service. The GIS maps will allow to visualize total annual demand for municipalities, annual demand per capita, and decomposition of demand into four main activity sectors. A report will be generated, containing the main indicators enriched with charts illustrating the decomposition of the annual demand into activities and electric appliances. This detailed decomposition of consumption could be downloaded in Excel format for further treatment.

23. The ElectroWhat platform will allow to explore the specificities of consumption of each Swiss municipality. This knowledge can be used to design energy programmes at the municipal, cantonal and national levels.

IV. Preliminary policy implications

A. Data security and availability

24. A legal framework is needed to facilitate development of Open access practices, while assuring personal data protection. Energy systems are becoming more complex and more driven by data and communication technologies. Institutions should ensure the highest standard of cyber security.

25. In view of the growing share of renewable energy supply and a trend towards decentralized energy systems, the use of Blockchain technology could be evaluated for delivering transparent, secure, reliable, and timely data due to validation and recording of direct transactions between peers visible to all network participants.

26. Academic research could contribute to a better understanding on how to generate and use data for sustainable energy projects. This includes transparency of methodologies, improving the availability of long-term observational data sets, and exchange of best practice methods. Long-term datasets including parameters related to markets, growth, energy and the environment, and their interactions with people and businesses are critical in enabling improved understanding and evaluation of policy.

B. Use of energy data for building consumption optimization

27. Energy utility companies serving as district heating producers and suppliers are not motivated to encourage consumers to reduce their energy consumption as consumers have to pay for all energy they have consumed and have been billed for. In standard market conditions, the district heating companies would prefer to sell more energy to consumers as this will provide higher revenues leading to higher profits. Local governments are also not always interested in Energy Mapping and Actual Energy Performance as they often own district heating companies. Therefore, a set of policies and institutional measures are needed to move from selling energy to selling energy services.

28. Among possible solutions are: 1) installation of heat meters in every building; 2) establishment of a national regulatory commission responsible for setting up thermal energy prices where there is a monopoly of supply; 3) the methodology for setting up thermal energy price should be developed not by local municipality, which owns and operates district heating company but by the National Regulator; 4) consumers should have practical tools at their disposal, such as Actual Energy Performance certificates or regularly updated Energy Maps, to be able to check and ideally adjust the level of their energy consumption. Assessment of Actual Energy Performance has to become mandatory.