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Spatial data for modelling building stock energy needs

Proceedings of the workshop
Ispra, 24-25-26 November 2015

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Table of contents

Workshop on "Spatial data for modelling building stock energy needs"
24-25-26 November 2015_JRC Ispra

Foreword

This Workshop is jointly organised by the Institute for Environment and Sustainability (IES) - Digital Earth and Reference Data Unit and the Institute for Energy and Transport (IET) - Renewable and Energy Efficiency Unit of the European Commission Joint Research Centre.

Institute for Environment and Sustainability
JRC-IES carries out research to understand, monitor and anticipate the complex interactions between human activity and the natural environment, in order to support the development and implementation of policies that protect the global environment and ensure that strategic resources (water, land, forests, food, minerals) are managed in a more sustainable manner for the benefit of present and future generations

Digital Earth and Reference Data Unit
The Digital Earth and Reference Data Unit ensures the overall technical coordination of the INSPIRE Directive (which aims to develop an Infrastructure for Spatial Data Infrastructure in Europe), leads the development of the next-generation of Spatial Date Infrastructures (Digital Earth) and plays a pivotal role in the development of the Global Earth Observation System of Systems.

Institute for Energy and Transport
JRC-IET is doing so by carrying out research in both nuclear and non-nuclear energy domains, with partners from the Member States and beyond. In state-of-the-art experimental facilities, IET carries out key scientific activities in the following fields: renewable energies including solar, photovoltaics and biomass; sustainable & safe nuclear energy for current & future reactor systems; energy infrastructures and security of supply; sustainable transport, fuels and technologies including hydrogen and fuel cells as well as clean fossil fuel; energy techno/economic assessment; bioenergy including biofuels; energy efficiency in buildings, industry, transport and end-use.

Renewable and Energy Efficiency Unit
The Joint Research Centre (JRC) Renewable and Energy Efficiency Unit provides scientific and technical support to the Commission services (DG ENER, DG ENV) for the design, the implementation and the monitoring of the EU energy efficiency policies and programs. Moreover, a number of EU programs are managed directly by the JRC on behalf of DG ENER.
The Unit is linked to several international and national organisations (such as, CEN, ISO, IEC and IEA), research labs and universities operating in the field of energy efficiency. The JRC takes part in several experts network. Improving the efficiency with which energy is consumed by end-users and the energy performance of buildings is a central theme of energy policy within the European Community, since improved energy efficiency meets all three goals of energy policy, namely security of supply, competitiveness and protection of the environment.

Objectives of the workshop

During these days a number of presentations will highlight the challenges that are encountered when running projects or developing method for a proper integration of energy systems in our society, in particular the built environment. Up to 40% of final energy consumption is in the residential and tertiary building sector and has an important energy reduction potential and hence a contribution to reduce the GHG emissions in Europe.

The recent technologies for gathering and elaborating data have to be employed and could contribute importantly to the goal of improving energy usage: "doing more with less" energy.

The main objective of this workshop is to share experience in data collection and methodologies to support energy efficiency policies and scope a possible pilot to establish a harmonised approach supporting EPBD, EED and COM using INSPIRE as a 'location' framework.

The workshop is intended to cover the topics: energy, buildings, location, assessment method and data in relation to European Directives on Energy Efficiency, Energy Performance of Buildings, INSPIRE and the Covenant of Mayors initiative.

Presentations and discussions on selected studies from cities, EU projects on the topic of the development of a methodology for monitoring of public and non-public buildings energy related consumption data (e.g. (electricity, gas, water and other) in order to gain expertise on data-collection and quality for the assessment of energy usage in buildings, urban and regional areas.

The organisers hope for a fruitful workshop and invite all participants to actively take part in the discussions.

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European Union Location Framework – Location data for buildings related energy efficiency policies: Feasibility Study

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EXECUTIVE SUMMARY

Energy efficiency constitutes one of the five dimensions of the European Commission's Energy Union Package [1], designed to enhance energy security, sustainability and competitiveness.

European energy policy is reflected in several Directives; the present document focuses on two main Directives concerning the efficient use of energy in buildings (Directive 2010/31/EU Energy Performance of Buildings - EPBD) and national energy systems (Directive 2012/27/EU Energy Efficiency Directive - EED).

A further important energy policy initiative considered here is the Covenant of Mayors (CoM)[2], a major European movement involving local and regional authorities (more than 6400 signatories as of June 2015). Through this initiative, municipalities in Europe (and outside) voluntarily agree to reduce their CO2 emissions by at least 20% by 2020. Municipalities have to submit a Sustainable Energy Action Plan (SEAP) identifying the measures planned in order to reach the target.

To implement and monitor energy efficiency policies effectively, local authorities and Member States are required to report on baseline scenarios (e.g. the Baseline Emissions Inventories in the Covenant of Mayors initiative) and on progress made at regular intervals (Annual Reports for the Energy Efficiency Directive and the Energy Performance of Buildings Directive and Monitoring Emissions Inventories every two years for the CoM).

Basic reporting tools are available to local authorities and Member States. However, for the time being, they allow the users to input aggregated and approximated values (for example, local authorities may rely on national data when local data are not available) for planning and monitoring progress towards targets.

A common framework for monitoring of energy efficiency policies, with harmonised data from building to district and ending at national level could improve the interoperability of the different directives / initiatives. Within such a framework, geo-referencing all the relevant building data accurately and consistently will significantly improve data quality and

[1] EC COM(2015) 80. "Communication from the Commission to the European Parliament and the Council: Energy Union Package." COM(2015) 80, European Commission, 2015.
[2] (http://www.covenantofmayors.eu/index_en.html)

reliability, enable effective scenario modelling to fill gaps in data, and support the overall policy process.

Furthermore, from a potential market perspective, web-based tools providing access to the energy performance of geo-referenced buildings could improve territorial knowledge, and support, for example, the activities of energy service companies and companies involved in construction / renovation of buildings.

The European Union Location Framework (EULF) [3] project aims to improve the way such 'location information' is used in many different policy areas and in e-government services generally. It does this through a series of recommendations, guidance and actions to promote and deploy best practice. The EULF draws significantly on the legal and technical framework provided by the INSPIRE Directive[4], which started out supporting European environmental policy. INSPIRE is due to be fully operational by 2020, when Member States have to complete actions to publish interoperable data of interest for energy efficiency[5].

In this context, this feasibility study has been initiated within the EULF project, joining efforts from the JRC units H06 (Digital Earth and Reference Data) and F07 (Renewables and Energy Efficiency). It is aimed at verifying how location data can support energy efficiency policies. In particular its specific goal is to evaluate how the framework set by the INSPIRE Directive for the harmonised collection and exchange of location data can serve the needs of policy instruments addressing energy performance of buildings, energy planning in urban areas, and the national energy efficiency plans of Member States.

The study has involved the following activities:

- desk research to identify relevant international "energy and location" projects and initiatives;
- a survey to collect information from different organisations on their actual and potential use of location data relevant to energy policies;
- development of a methodological approach based on location data to support not only the EPBD and other energy efficiency policies (EED and sustainable energy action plans for CoM signatories), but also the whole energy efficiency policy life-cycle (e.g. local planning and the implementation of measures for the efficient renovation of buildings);
- an initial mapping exercise between the EPBD and CoM data requirements and the corresponding data models of the INSPIRE candidate data themes;
- definition of an "energy" pilot project to assess how these different requirements can be satisfied with ICT solutions.

The main conclusions from the feasibility study are as follows:

[3] More details about the EULF project are provided in the following section

[4] http://inspire.ec.europa.eu/

[5] More details about INSPIRE data themes of interest for energy efficiency are provided in section 5

- the different energy efficiency policies involve a diverse range of data requirements to assemble the necessary monitoring against targets at the different administrative levels;
- there is a need for a more harmonised approach to ease the burden for public authorities and support the needs of policy makers. Such an approach needs to bridge the "data gap" identified in this study;
- it is possible to apply a generalised methodology to support different energy efficiency policies using location data as an integrating factor and combining both real and extrapolated data to indicate progress in meeting efficiency targets and help in planning relevant actions;
- geospatial technologies in general and accurate location data in particular can play an important role in the energy efficiency field, significantly increasing:
    - the efficiency of data collection, elaboration and communication processes in all phases of the life cycle of energy efficiency policies;
    - the effectiveness of decisions taken by different stakeholders (policy-makers, technicians, citizens);
- INSPIRE can play an important role through:
    - the provision of common data models and common data access rules adopted by all EU Member States;
    - a roadmap to provide interoperable datasets of high relevance with energy efficiency.
- Various studies have produced technical solutions covering aspects of the overall energy efficiency requirements but none is sufficiently holistic to address the broad needs in a harmonised way and the solutions do not always take advantage of the benefits of location data. Nevertheless, components of these solutions could be considered in such a harmonised approach.
- The methodology and approach require a more detailed assessment in the form of a "proof on concept" pilot, to resolve some of the more detailed questions and provide a demonstrator that can be used in promoting a reusable approach for public authorities and Member States.
- A workshop is needed with key stakeholders to review the assessment and proposed approach and determine interest in participation in the proposed pilot and potential involvement in the future. Invited parties would include the European Commission, Member States policy makers, the Covenant of Mayors, other relevant initiatives, and the energy, ICT and geospatial industries.

Outcome of the Workshop on "Spatial data for modelling building stock energy needs" 24-25-26 November 2015_JRC Ispra

Overall conclusions

The main objective of this workshop was to share experience in data collection and methodologies to support energy efficiency policies and scope a possible pilot. The aim of a pilot project is to establish a harmonised approach supporting European Directives on Energy Efficiency (EED), Energy Performance of Buildings (EPBD) and the Covenant of Mayors (CoM) initiative using INSPIRE as a 'location' framework facilitating a harmonized exchange of data.

The invited experts to the workshop were chosen from different backgrounds, e.g. academic, business, research and government. A number of presentations have highlighted the challenges that are encountered when developing methods for a proper integration of energy systems in our society, in particular the built environment.

Up to 40% of final energy consumption is in the residential and tertiary building sector and has an important energy reduction potential and hence a contribution to reduce the GHG emissions in Europe. Expressed in kWh/m^2 the average of the around 200 million dwellings in EU-28 is 185 kWh/m^2 while the non-residential sector is estimated to consume 280 kWh/m^2.

The recent technologies for gathering real data (metering) and elaborating data have to be employed and could contribute importantly to the goal of improving energy usage: "doing-more-with-less-energy". The obtained information is important for making decision on refurbishment, investing in renovation and managing the energy flows.

The problem of **building definition** was discussed. It became clear that the EPBD, INSPIRE and the construction Eurocodes apply different definitions which is leading to confusing results in the assessment. It is also noted that confusion starts from expressing energy in terms of performance, efficiency and consumption that are related but not the same. This aspect needs more attention when databases will exchange data for calculation purposes. As an example of different definitions can be the fact that the EPBD considers for energy performance assessment the heated spaces of a building whereas a building footprint (INSPIRE) may lead to other dimensions for floor area and hence will have different expressions for the energy consumption expressed in kWh/m^2. Several cases were presented how databases contain building information.

Data availability is seen as a barrier to overcome. The main issue is privacy of data; who decides which data is available and who may have access to the data? Anonymisation is key and some have reported an approach to deal with it. It is clear that Member States (and local governments) are dealing in different ways with this issue.

Several participants mention that end-user involvement in reducing energy consumption comes from motivation by awareness. This requires a simple and clear communication system for which modern information technology (IT) is becoming available. More frequent information is needed than only the regular energy consumption bill. The importance of metering is recognized since it offers actual consumption data.

A **general approach** is difficult to give and the conclusion should be that different methods should be developed that serves different parties. It is therefore important to distinguish at least three actors: policy and decision makers, industry and energy providers and finally the end-

users of energy in the building sector. In other words: end-users are interested in real consumption data and probably to decide for investment in renovation; local or national governments are interested in data for modelling and planning whereas industries and energy providers are interested in innovation of products and energy flow data for management of demand and supply.

A good **method** depends on available information in the data and the requirements for output (which can be a value, a series of data or graphical representation). This will impact the level of detail of the method and the underlying calculation model(s). A stepwise development of a method as is applied for CityGML could be followed for Energy, Buildings and Location. INSPIRE facilitates the data exchange between databases and application software tools, e.g. methods. A layered approach of databases could be an acceptable method.
In that context the issue of scaling has to be placed; the requirements of the EPBD, the EED and CoM are different and implies different although related, methods with specific levels of detail. One may put the question also: what uncertainty is expected for which method? What uncertainty is acceptable at the different level of details required?
It has been emphasized by several experts that **academic support** is essential for the development of methods. Innovative approaches will have to be incorporated in software tools as well as devices for communication and management.

A **pilot study** should focus on issues of: scaling (from building to building stock), data requirements and treatment (including anonymization and uncertainty), connecting databases by conversion and control routines. The list of the use cases that will be considered in the pilot is reported in the summary of session 4, at the end of this document.
The organisers concluded a very successful workshop and have invited all participants to join the proposed informal network to take part in the further discussions and actions.

Giacomo Martirano, Maria Teresa Borzacchiello, Piergiorgio Cipriano, Ray Boguslawski, Francesco Pignatelli, Isabella Maschio, Albana Kona, Hans Bloem

Summary session 1

The audience was welcomed by Heinz Ossenbrink (HoU IET – REE Unit), who explained that energy efficiency is high on the European political agenda, and there is the need to address a series of open issues: how energy policies can be best supported in relation to buildings performance? What is the state of the art in European Member States? What kind of tools and knowledge is available to create an observatory of these issues from the European point of view? Which impact can this have? The time resolution as well as the geographical resolution is very much important in energy performance monitoring. The reasons for the collaboration between the Institute for Energy and Transport and the Institute for Environment and Sustainability can be found in the long history and experience of IES of developing data sharing platforms in the environmental field.
The team composed by Units from both institutes produced a study[6] under the European Union Location Framework[7] project, to investigate the feasibility of a location-based integrated approach to support energy efficiency policies. The objectives of the workshop is to understand current experiences and how their requirements can be best taken into account when developing an infrastructure to manage energy data, in a user friendly manner. The long term vision would be an online map of CO2 emission, with possibility to create energy loss maps, also due to traffic, waste and so on.
Francesco Pignatelli, from IES, explained that the issue of spatial data interoperability has been tackled for the first time at the European level by the INSPIRE Directive, developed in support of environmental policies. After the development of INSPIRE, now the emphasis is on implementation and on reusing the efforts made so far to support other thematic policies, such as energy efficiency.
Hans Bloem provided a historical overview of the collaboration between energy efficiency of buildings and spatial data, started already in 2004 with a project using new satellites to locate cultural points of interest, followed by the INSPIRE Directive in 2007 which was looking more in buildings, and continuing with the reference to INSPIRE in the EPBD and EED Directives. The two units have then worked together at the mentioned feasibility study to prepare a pilot study on data harmonisation at the building level to support Energy Performance of Buildings Directive, Energy Efficiency directive and the Covenant of Mayors initiative.
The chairman of the first session, Ray Boguslawski, explained the ground rules of the workshop, to be active listeners and open to questions.
Giacomo Martirano introduced the EULF feasibility study: *Location Data for Buildings related Energy Efficiency Policies*, distributed to the participants ahead of the workshop. The main objectives of the study were to investigate how to harmonise data flows, to outline a methodological approach supporting the whole energy policy life cycle, at different geographical scales. This has been achieved through desk research on initiatives involving energy efficiency and spatial data, a survey to gain a better understanding on the use of location data in the energy field, and an outline of a methodological approach allowing scaling up performance measures from building to national level. An initial mapping exercise between the energy efficiency Directives requirements and the INSPIRE Directive requirements has been performed as well. The study has recognised the data gaps, in terms of quality and relevance, the existence of different methodologies and the need for convergence of top down and bottom up approaches, through the scaling up concept from the building to the EU-wide level. A pilot has been planned to solve these issues, taking into account the different experiences across Europe, starting from a dedicated workshop.
Giacomo then talked about the role of INSPIRE in the energy pilot: the INSPIRE Data Specifications for buildings is the starting point to model the data at the building level, but to fulfil the requirements of the energy efficiency Directives richer set of attributes is needed. The difference between INSPIRE core schemas (binding for each Member States) and extended schemas (managed by the thematic communities) was explained. The deadline for implementation of INSPIRE for existing datasets (like the buildings ones in most Member States) is 2020[8]. MS will deliver the data produced according to

[6] http://publications.jrc.ec.europa.eu/repository/handle/JRC96946
[7] http://ec.europa.eu/isa/actions/02-interoperability-architecture/2-13action_en.htm
[8] http://inspire.ec.europa.eu/index.cfm/pageid/44

the core schemas and communities of practice can propose extended data models to cover the thematic needs. The adoption of the extended data schema should be approved by the INSPIRE Maintenance and Implementation Group[9], set up to support Member States in the implementation of INSPIRE. In summary, INSPIRE is an opportunity to be taken into account, as it delivers core data models to be used by Member States. In addition, there is the potential to extend these data models, including attributes useful to characterise the energy performance of the building, and this process should be community-driven. However, it is important to not overestimate the role of INSPIRE, but rather see it as an opportunity to facilitate the achievement of the results. Even if at the policy level there is the formal reference of the EPBD and CEN to INSPIRE, at the level of practitioners this is not considered so much. On the other hand, INSPIRE will be implemented fully by 2020: in the meanwhile, some raising awareness of INSPIRE in the energy community is needed (in the audience, 5 persons had never heard of INSPIRE).

Alexander Deliyannis presented "A win-win strategic approach in support of energy-related spatial data collection", highlighting the importance of the right motivation underpinning the provision and sharing of data from different data providers and sources. Motivations and structures for data gathering may indeed differ significantly at the various geographic levels, i.e. building / district / urban / national. For each level there is a list of potential corresponding key actors, taking into account alternative sources of data and stakeholders 'lobbying' a particular category of actors, in order to collect and provide the relevant data.

At the building level, the actors concerned are citizens, consumers, building managers, owners and tenants. Free online tools would provide motivations for entering energy buildings data - at the citizen level. Convenience and empowerment are reasons for the users to provide the information. They can also be stimulated to participate through social aspects and gamification of the tools. However, there are issues of data accessibility, ownership, rights and security.

Neighbourhoods sign the borders between the buildings and the urban environment. There are benefits in considering this geographic scale, in terms of joint procurement of actions, benefits immediate apparent to citizens, improve data granularity to fill the data gaps at the district level (as the latter not defined in NUTS classification).

At the district level, local councils and other local (sub-municipal) formal or informal administration structures, including among others local citizens' associations, can play a significant role in energy data collection, having as an incentive the resolution of energy-related local issues at their own level, and liaising with initiatives at district level the management of open spaces, tree coverage, cool materials, traffic, and even district heating and cooling.

At the urban level, cross-correlation of energy and (external) conditions data among similar districts can support the establishment of relevant benchmarks, highlighting potential issues as well as the potential urban-level solutions, while at the national level, the Member States represent the higher direct interest level where collected data can readily be used to support decision making and interventions leading to higher energy efficiency.

Alexander also mentioned the possibility to link with the Concerted Action EPBD and EED[10], and to include corporations and SMEs and partners of the pilot.

Maarten de Groote presented the BPIE consortium, the Buildings Performance Institute Europe, committed to increasing the energy performance of buildings across Europe. BPIE participated to the recent public consultation ahead of the revision of the EPBD, recognising that there is urgent need for monitoring the energy performance of buildings, and given the impact of Energy performance Certificates (EPCs) on the real estate market, there should a centralised EPC database. In some cases data on EPCs are collected but not available for privacy concerns. BPIE is coordinating a project to support the creation of a European Building Stock Observatory, together with seven main partners and 19 supporting partners to retrieve data from MS. At the beginning of 2016 the official website shall be launched. Main concerns are the gaps on data availability, and for available data they should be verified. The consortium has proposed a methodological framework and list of more than 250 indicators, as attributes to characterise the performance of the building, such as building stock

[9] http://inspire.ec.europa.eu/index.cfm/pageid/5160

[10] http://www.epbd-ca.eu/ , http://www.ca-eed.eu/

characteristics, energy consumption, technical data on energy performance, certification related to building energy performance. Maarten concluded with a set of questions to provoke discussion amongst the audience, on new approaches to collect and stimulate data providers to share their data, on the use of local data sources to scale them up to the national level, and on the opportunity to streamlining and centralising information from local registers and from the utilities.
Steve Evans illustrated an example of building stock model integrated with fine-scale GIS data, deriving from Ordnance Survey (OS, the UK Mapping Agency) and Valuation Office Agency (VOA, advising UK government on taxation and benefits). In order to support their detailed model, Steve's team has proposed a new definition of Self Contained Unit based on the functional use of non-domestic buildings. Starting from the definition of the building unit the developed methodology attributes energy use to individual buildings and makes comparisons between different buildings. The problem they face is that data available from the VOA does not provide the geography (location) and the geometry of the building. This can be overcome by an address matching algorithm, to link the building to its location and from the map to its geometry. Catching the floor space and the footprint of the building is another important factor for modelling building stock, together with 3D information. Sometimes it is possible to estimate the floor space from building volumes, which is risky, but in some cases unavoidable.
All the interventions prompted very interesting questions, spanning from the need of right incentives for data sharing (Sympraxis) and harmonisation (INSPIRE) , the current availability of data (BPIE), and the complexity of using such data to model the real world (UCL). One of the main issues regarded the definition of what a building is. Each different initiative has its own definition, and INSPIRE alike.
The involvement of utilities and their role to give access to metering data was also discussed, especially in relation to the data access conditions and the privacy issues linked to the use of personal consumption data of building owners/tenants.
The importance of having good coverage of Energy Performance Certificates at the building level across Europe was also touched, and if they would be a key data source, they bring serious privacy issues that should be clarified. Moreover, EPCs are not equally defined in all the Member States, and there is the need to adopt a standardised approach across Europe, to facilitate independent control systems and provide a tool to map and monitor the EU building stock[11].

Summary session 2
Claudia Baranzelli presented the LUISA platform (Land-Use-based Integrated Sustainability Assessment Modelling Platform) a GIS-based tool developed by the JRC for territorial impact assessment. The platform is useful for scenario analysis and it can downscale expected impacts from the national to the local level.
Claudia also presented the EREBILAND project, for the modelling of energy resources and energy consumption at local level. The project applies statistical tools to allocate generation and consumption at regional/municipal level. Two cases have been developed: energy needs in the residential sector, downscaling from the national level to the municipal level, and energy production and consumption at the regional level. Data sources include the JRC EU TIMES model and climatic data from the European Environmental Agency.
Roger Antonsson gave a presentation on the Energy Performance Certificate register in Sweden. It is a central database, that experts can access from a web application in order to upload EPCs. A GIS map can be produced displaying EPCs available in Sweden (10x10km). Some open issues are: multiple EPC per single building; individual certificates can't be shown for privacy reasons; data sharing is possible but it has a cost for the user; harmonization of this approach at EU level (for the indoor radon project, a similar map was produced for the JRC. With EPC it's more complex because there is no universal definition in EU); validating the EPC is an open issue too.

[11] For an overview, see http://bpie.eu/wp-content/uploads/2015/10/Energy-Performance-Certificates-EPC-across-the-EU.-A-mapping-of-national-approaches-2014.pdf

At the moment the EPC of 15% of Swedish residential buildings are reported in the Register. The energy performance certification is more often measured than calculated.
Volker Coors illustrated the SimStadt Urban Simulation Platform. It is based on a 3D model of the city that combines large amounts of different types of data. Buildings related data for are well covered, while transport and land use are less complete. The data collections was carried out at Land level (Nuts 1 level), national level and also to some extent at municipality level based on Special Interest Group 3D modelling guidelines, and in line with CityGML data specifications. Two Levels of Details (LoD) have been considered: LoD1 (geometry of the buildings) and LoD2 (including information on roofs and building materials). LoD2 is in line with CityGML data specifications. Access to data is different for different Lands, harmonisation is progressing. Visualisation of buildings is accessible but with a fee. Buildings have a unique ID.
Two use cases were presented: one concerning Heat Demand simulation (the model allows to estimate the heat demand at building level) and another model estimating the PV potential in Ludwigsburg, based on the modelling of solar radiance and shadowing (the model estimates the PV potential of a given area). Based on such use cases, scenarios for the potential for refurbishment can be built.
The main issues are: data availability and improvement of the data model (CityGML ADE Energy was used). For data, a good practice could be: better knowledge of the building, mobile thermal laser scan for the assessment of the building's performance, complemented with metering data for the assessment of energy consumption. Data were finally bought from a private company. Concerning the data, it was confirmed that data privacy is an issue, that census data were used in Ludwigsburg, but in a protected anonymised version, and that only aggregated data can be released. Transport was also modelled, with a model based on fuel consumption. LoD1 can be used, but LoD2 gives better results. If they were involved, building owners would be valuable allies to provide data about their building and energy systems.

Jordi Carbonnell gave a presentation on projects carried out in the Catalonia region to better understand how ICT can improve energy management in buildings, in particular how ICT can help engaging users and proposing services to reduce energy consumption in the residential sector. It was also suggested that opt-out option (for the deployment of ICT devices) is more effective than opt-in.
Another project will be launched in Catalonia, addressing the public stock of buildings and aiming at pointing out different issues as compared to the residential sector.
The Catalan Strategy for Energy Rehabilitation was also presented. It is based on a combination of different layers of data from different databases and sources (cadastral, building certification, energy efficiency measures applied, weather, etc.). For the time being, the data collection was carried out for Catalan governmental buildings, in the next years it will also include tertiary and residential buildings. Conclusions were that it is fundamental to engage the users and that data visualisation is essential for this purpose; public authorities must be involved as well, personal data processing must be compliant with national laws and the use of open source tools is more profitable for reusability and sharing.
Peter Rathje presented in details the project ZeroCarbon deployed in Sonderborg DK. Peter put emphasis on the people's dimension of the project and the need to involve citizens in a mind-set transition. The project has a strong legal structure and it is based on a public-private partnership. It adopts the *trias energetica* approach, addressing 2 dimensions: energy efficiency and renewable sources (the third dimension: fossil fuel is not taken into consideration). It is an integrated, holistic approach based on policy, technical solutions, and participation. The project started in 2007. In 7 years, it reduced CO2 emission by 30%. Now the ambitious target of the master plan is -50% by 2020. Important elements of the approach are: to lead by example (ZERO+ house), to trigger participation from all (a specific programme for families produced 25% reduction in electricity and unexpectedly 45% reduction in water consumption), to challenge energy consumption at home; visiting people proved to be an effective instrument to convince citizens to retrofit (power of discussion); banks and the university were also involved. A Community platform was developed. Collecting the data needed for the annual report was challenging, data collection is not easy. After this first step for the decarbonisation of energy, the project plans to continue with transport and mobility, and food.

A question was raised about the existence of an optimal size of the community for a successful result. The approach needs to be tailored on the type of community and the deep values it shares (e.g. rural or urban). Another question was on possible rebound effect: it was not noted, if people are engaged they become more responsible.

Summary session 3

The third session was introduced and chaired by Giacomo Martirano, and it focused on methodologies, approaches and measurements related to energy demand.

In the first presentation, Hans Bloem started reminding the "big" EU numbers in terms of residential buildings (200 million dwellings, with 75% older than 25 years) and people living in there (more than 500 million); the EU residential building stock consumes about two thirds of the energy mainly for space heating and cooling, while the remaining one third (electricity) is consumed by appliances and light.

Hans also discussed about the definition of "building" and "floor area", being not unique and somehow having different meanings and goals in both EPBD and INSPIRE Directives[12], and the clear need for referencing to unambiguous measurement codes.

Indeed, on Energy Performance (EP) different parties are usually involved with different timings, issues and goals: governments at different levels, industries, and final users play different roles in different times. Furthermore, different organizations are also active on directives and standardization activities (DGs, CEN, UN, Eurostat, …), with different implementation of EPBD varying among Member States.

According to the EPBD, the performance can be either calculated (designed) or measured (also considering climate and other real characteristics), therefore, there are two different ways of expressing EP: top-down (based on simplified calculation) and bottom-up (using databases and metering).

Thanks to new CEN standards under development, in a couple of months probably an harmonized way to express EP will be defined, with a cascading approach on 1) energy savings, 2) increasing efficiency, and 3) use of renewable energy sources.

The overall goal is to minimize energy needs, maximize efficiency of systems, and optimize behaviour of users; indeed, there is strict relation between consumption (behaviour), efficiency (systems required to fulfil requirements) and performance (related to building fabric in a certain country, excluding appliances).

ICT sector is crucial to achieve these objectives: ICT can deliver tools that are vitally needed to collect, process and manage the data and present it in a standardized format; in the near future metering data (electricity, gas and water) will be essential to combine statistical and dynamic methods, bridging the gap between calculation and measurement, and optimizing energy balance. Moreover, hourly consumption data can show occupancy presence and behaviour

Information about "location" is extremely important, since location and climate conditions are directly affecting energy consumption (e.g. wind in DK) and local policies (e.g. incentives for solar and photovoltaic).

One of the main objectives remains the need to cross-reference metering data with cadastral information or other spatial identifiers; the meter is the reference and in the future there will be metering systems (also grouping gas, water and electricity) with reference IDs.

Guglielmina Mutani illustrated the outcomes of Cities on Power project, finished in 2012 and focused on potential energy savings at municipal level, based on use of spatial data at different levels of details, and related to the preparation of local action plans in the Metropolitan area of Torino (50 Municipalities, 1.5 million inhabitants).

Cities on Power project estimated the energy consumption at both building level and municipal level, evaluating the savings potentials in consideration to the improvement of Renewable Energy Sources.

[12] INSPIRE definition: A building is an enclosed construction above and/or underground, used or intended for the shelter of humans, animals or things or for the production of economic goods. A building refers to any structure permanently constructed or erected on its site. http://inspire.ec.europa.eu/featureconcept/Building/
EPBD definition: A building means a roofed construction having walls, for which energy is used to condition the indoor climate. Directive 2010/31/EU

An hybrid approach has been followed, with data at building or building block scale (e.g. age of construction, thermal insulation and heating systems, …) and top-down with statistical models at municipal scale (e.g. data from SEAP used to optimize and validate the bottom-up approach, or number of occupants estimated based on urban regional law and census data for residential sector). An important source of information were also the hourly climatic data as well as hourly consumption data for sample buildings, provided by the Empowering project and used for in-depth study on energy. Using QGIS and other open source libraries (e.g. GRASS, r.sun) solar potential at building level was also estimated and made available on an institutional web portal[13].
Two important outcomes were the importance of construction age as one of the main important variable (with data at buildings block level) and the need for correction factors to be considered at urban scale: context, renovation level, RES distribution, typology of users; demographic factor needed to better understand the spatial variability of the heated and unheated spaces.
To analyse energy savings feasibility, important factors highlighted in the presentation are the age, education, employment, and period of construction; these factors have been used to define a "feasibility index" to find lower and higher feasibility cases. Work has also been undertaken to identify correlation between thermal energy consumption for space heating ad urban variables (also using CitySim and UMI).
The model implemented has also been used in the Enercloud public web database[14] to allow every Municipality to provide energy consumption data about public buildings.

Şiir Kilkis presented two case studies in The Netherlands (TU Delft) and Sweden (KTH Royal Institute of Technology) with similar targets of "Net-Zero Exergy District", producing as much energy at the same grade and quality as consumed on an annual bases. For both cases Şiir explained the use of spatial data for energy, exergy[15] (defined in this study as the quality of energy) and CO2 emissions planning in different scenarios (e.g. increased supply from CHP in summer mode for use of waste heating).
In the case of TU Delft, Şiir highlighted how important is to have good information at building level: for instance, on the Energie Label Atlas web portal[16] only the TU Delft main building is labelled but not the single faculties.
At the building level, data were collected based on the TU Delft Energy Monitor that provides the primary energy consumption, electricity usage, natural gas usage, heat usage, and CO2 emissions of each faculty and building. Indeed, to monitor progress in improving energy performance, TU Delft has decided to make energy supplies on the campus completely public and transparent, on the Energy Monitor website[17], where user can view the current and historic energy consumption for the campus as a whole and at faculty level.
The Energy Monitor provides the CO2 emissions of each building on the campus, with values based on the product of the total delivered energy and the CO2 intensity of the energy mix (buildings are similar, in terms of consumption and fuel, and). On the source side of the energy system, the means of energy conversion and energy production are other essential components for data collection.
On the second case study (Royal Institute of Technology in Stockholm) data for the KTH campus were collected at the building level for a selected number of buildings and at the energy system level. Akademiska Hus is in the process of making building level data available to the university administration based on an Energy Portal.
Data on the monthly purchased electricity of 41 buildings on the main and related campuses is available in the Hus Energy Portal, divided by type of fuel; it is expected to provide building level data on the purchase of thermal energy, including heat and cold from district heating and cooling, which is currently missing.

[13] http://energia.sistemapiemonte.it/ittb-torino
[14] http://www.coopenergy.eu/gp/province-torino-it-enercloud-software
[15] https://en.wikipedia.org/wiki/Exergy
[16] http://energielabelatlas.nl
[17] http://www.energymonitor.tudelft.nl/

Lasse Engbo Christiansen presented a method to split the total energy consumption into "space heating" and "domestic hot water usage" in Sønderborg located in Southern; with data from 1st of March to 1st of April 2010. Time series for an individual house were used, recording uses at high frequency: 10 minute values of total heat load, which is the sum of DHW and space heating.
As more and more data are collected on the energy needs[18] and the actual energy consumption, then it becomes feasible to make more data driven assessments.
The method presented was related to the definition of a threshold for identifying hot water consumption and isolate it from space heating values, using two alternative approaches: ordinary kernel smoother and robust kernel smoother. The latter method seems better as robust kernel reduces the problem of large spikes (affecting the ordinary kernel estimation).
Certainly, the method needs to be applied and tuned using many series with different patterns (e.g. where the DHW and space heating are measured with separated meters) in order to validate the performance more thoroughly. Moreover, parameters like hourly temperature, orientation and speed of wind and others, collected for multiple houses would help better understanding reasons and relations of energy consumptions.
Lasse also highlighted that some challenges were to focus new studies and researches, like the availability of many sensors in same building/room, and the sampling method and variables to be considered, like the rate of sample to be considered, the season and the usage of different energy sources.
Two issues were finally pointed out: privacy and active involvement of citizens. A possible proposal is to have the processing of consumption data at utility level, and then derive and distribute new data with a sufficient level of spatial aggregation.
At the end of this session Albana Kona presented the point of view of local authorities, involved in the preparation and the monitoring of sustainable energy plans, often within the frame of national and sub-national strategies and aiming for ambitious energy efficiency and decarbonisation goals, in the context of the Covenant of Mayors (CoM) initiative.
Small and medium municipalities play a key role: 88% of the signatories of Covenant of Mayor (CoM) are small or medium sized, representing the 56% of the whole EU population.
In the Covenant of Mayors special focus is placed on the data collection required for the Sustainable Energy Action Plans (SEAPs) prepared by CoM signatories, where local and detailed data about energy needs and consumptions are needed at different geographical scales, also with a better knowledge of local energy production (CoM signatories foresee that 29% of the entire demand is will be satisfied by local production).
The INSPIRE Directive is well-timed for CoM as it is due to be operational by 2020, when Member States have to report about different data themes which are also of interest for CoM, with data at different levels "speaking each other".
Albana then illustrated some examples of projects that can be considered as a reference: the European Heat Atlas and the Stratego[19] projects, with a top-down approach, using EU-wide data with spatial aggregation ranging from sub-municipal to regional levels; and the Energie Labels Atlas (already mentioned by Şiir)[20] with a bottom-up approach with data at building data from the cadastre and the Energy Performance Certificates registry.
CoM signatories could be really supported by a EULF energy pilot project putting in place harmonised data flows to support energy related initiatives; practical outcomes of the pilot project would be the improvement of the quality of data used by municipalities, the development of a homogeneous methodology and the implementation of tools for local authorities to build and update a robust inventory of reliable local energy-related data, to be shared and reused by citizens and businesses.

[18] The OIS web portal (Public Information System - https://ois.dk/) is already providing huge amount of information at building unit level
[19] http://stratego-project.eu
[20] http://energielabelatlas.nl

Summary of the Conclusion Session 4

The session 4 started with a summary of all the preceding sessions from the rapporteurs, and the introduction of the proposed EULF pilot project on energy efficiency and location data. The EULF feasibility study pointed towards the need for a pilot to evaluate a potential pan-European approach, based on location data, in supporting energy efficiency policies.

The objective of the EULF pilot project is to support energy efficiency policies and initiatives by an integrated data approach, improving the quality of data and building a robust and harmonised inventory of energy performance data, to improve energy savings, use of renewable energies, and meeting CO2 targets. The workshop aim is to understand current experiences and the thoughts of the experts on the topic, as well as discuss possible use cases that the pilot will implement.

Giacomo presented an outline of the use cases proposed in the feasibility study, here reported with their title for the reader's convenience:

- Use case 1: produce an energy performance accurate labelling dataset at the building level (EPBD)
- Use case 2: support BEI part relevant to buildings, using actual energy consumption data (CoM/EPBD)
- Use case 3: geo-reference and harmonise existing EPC datasets (EPBD)
- Use case 4: support decision makers to set up incentives for the refurbishment of a target building stock at urban level as a contribution for national targets
- Use case 5: to support the whole SEAP (BEI/MEI), focusing on CoM
- Use case 6: support the implementation of regional energy strategy (EPBD, EED and CoM)

Giacomo clarified that the pilot will use the definition of building as in the INSPIRE Thematic Data Specifications[21]. For each use case, there are open questions and more detailed issues to clarify with the community. The workshop participants were very proactive and provided many useful elements to update and refine the use case description, without changing their nature though. The updated version of the brief use case description is available, as annex, in the workshop proceedings.

Based on the facilitated discussions, the following main points can be concluded from the workshop, divided according to the different discussion themes:

USER FOCUS

- Main focus should be the final users, to engage them and make them gain from energy efficiency measures. In particular, households may be seen as producers as well as consumers.
- Main beneficiaries were identified: pilot cities, industry as some business opportunities would be unlocked, consumers' association, the energy savings companies (ESCOs), CoM signatories for benchmarking and using the tools that will be developed
- The challenge of considering the privacy issues and the need to understand how it can be harmonised at the national level was highlighted

DATA AVAILABILITY

- Some data that is available but not accessible (i.e. from the utilities, which may provide on request aggregate data at the dispatch node level). EED will be reviewed and can be influenced in making this option compulsory and not only on request.
- Minimum data requirement for modelling building energy performance would be the geometry (as in Level of Detail 1 of the CityGML model), complemented by the year of construction (TABULA project, deriving energy performance from typology and year of construction of buildings, is available only for 13 countries; BPIE have also conducted case studies deriving energy data from the year of renovation and the building typologies).
- Data about the destination of use and the urban context (actual and planned) are further desired data (and also normally available at the local level)

[21] http://inspire.ec.europa.eu/theme/bu/

- For data collection at the building level it is very important to engage the building owners (example of base labelling to invite users to participate)
- Data from EPC certificates would be good but currently only 3 countries in Europe have EPC registers

IMPORTANCE OF LOCATION

- Location data (including addresses) deemed important: for planning the geographic distribution of funding; to locate the building in the urban context and understand transport distances, but also to assess income levels and environmental characteristics; as a key attribute to merge data coming from different sources; crucial to involve the communities (stakeholder engagement has a very strong territorial; component); as an essential element for interoperability
- INSPIRE has the key role of providing a harmonised data model and guarantee interoperability, through an open protocol

STANDARDS

- Importance of agreeing on a definition of building at a EU level
- CityGML and INSPIRE are considered the standards to be used, considering that INSPIRE Data Specification on Buildings is based on CityGML. CityGML to be preferred for 3D representation

NEXT STEPS

- Most of the participants expressed interest to participate in the pilot activities – mechanism for involvement should be formalised, but in the meanwhile the following candidates were proposed:
    - At the regional level (NUTS3) Ludwigsburg, Stuttgart or Essen in Germany (links to the industry) proposed by Volker Coors
    - Catalonia proposed by Jordi Cipriano
    - Metropolitan City of Turin, proposed by Guglielmina Mutani
    - Sonderberg proposed by Peter Rathje: the activities of the pilot fit with their workplan
- It was also pointed out that all the cities need academic support, that could be provided by KTH or DTU or POLITO or DTE

The workshop was concluded by final remarks from Hans Bloem, informing the participants that as a follow up workshop proceedings will be distributed and an informal network through the European energy efficiency Platform (E3P) under development will be established. In order to start the pilot activities, the interested parties will be contacted to formalise the details of a possible collaboration, on the basis of the ideas exchanged during the workshop.

Workshop on
"Spatial data for modelling building stock energy needs"
24-25-26 November 2015_JRC Ispra

List of participants

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Agenda for the EULF Workshop on

Spatial data for modelling building stock energy needs

Organisers:
JRC Institute for Environment and Sustainability - Digital Earth and Reference Data Unit and JRC Institute for Energy and Transport – Renewable and Energy Efficiency Unit

Workshop Objectives:
To share experience in data collection and methodologies to support energy efficiency policies and scope a possible pilot to establish a harmonized approach supporting EPBD, EED and CoM using INSPIRE as a 'location' framework

Topics:
Covering the topics: energy, buildings, location, assessment method and data in relation to European Directives on Energy Efficiency, Energy Performance of Buildings, INSPIRE and the Covenant of Mayors initiative.
Presentations and discussions on selected studies from cities, EU projects on the topic of the development of a methodology for monitoring of public and non-public buildings energy related consumption data (e.g. (electricity, gas, water and other) in order to gain expertise on data-collection and quality for the assessment of energy usage in buildings, urban and regional areas.

Venue: JRC Ispra, Italy. Meeting room Terra, building 100
Date : 24 - 26 November 2015; in detail the program set-up:

Tuesday 24 November:
Arrival of participants during the morning:
buffet lunch at the JRC from 12:30 onwards

Start of the meeting 14:00 Session 1; Chair: Maria Teresa Borzacchiello, rapporteur: Ray Boguslawski

14:00 Welcome by IET – REE Unit and IES –DERD Unit

14:15 Introduction to the workshop and objectives of the JRC pilot project by Francesco Pignatelli and Hans Bloem

14:30 Giacomo Martirano: introducing the EULF feasibility study; *Location Data for Buildings related Energy Efficiency Policies – The role of INSPRE in the EULF Energy Pilot*

15:00 Alexander Deliyannis – Sympraxis, GR; *A win-win strategic approach in support of energy-related spatial data collection*

15:30 Coffee break

16:00 Maarten de Groote – BPIE, BE; *Data availability on energy consumption in buildings - Overcoming gaps for the European Building Observatory*

16:30 Steve Evans – UCL, UK**;** *Spatial data for modelling building stock energy needs - A UK perspective.*

17:00 summary of the session rapporteur

17:30 Transport to hotels; free evening

Wednesday 25 November

Start of the meeting 9:00 **Session 2;** Chair Albana Kona, rapporteur Isabella Maschio

9:00 Claudia Baranzelli* – JRC, EC*; Data and methods for EU-wide energy-related indicators*

9:30 Jordi Carbonell – CIMNE, ES; *Energy and Location: CIMNE point of view*

10:00 Roger Antonsson – Boverket, SE; *The Swedish EPC register*

10:30 Coffee break

11:00 Volker Coors – UAS Stuttgart, DE; *Simstadt, A new Workflow-Driven Urban Energy Simulation Platform for CityGML City Models*

11:30 Peter Rathje – ProjectZero, DK; *Mobilizing Actors for the Local Energy Transition*

12:00 Summary of the session rapporteur

12:30 lunch break

Start of the meeting 14:00 **Session 3;** Chair Giacomo Martirano, rapporteur: Piergiorgio Cipriano

14:00 Hans Bloem - JRC, EC; *Building Energy Consumption and Location; Big Data handling for Optimized Integration of Energy Systems in the Building Sector.*

14:30 Albana Kona – JRC, EC*; Spatial data for modelling building stock energy needs: Enabling Sustainable Energy Action Plans at local level.*

15:00 Siir Kilkis - KTH, SE; *The Use of Spatial Data for Energy and Exergy Mapping of University Campuses with Implications for a Net-Zero District in Sweden*

15:30 Coffee break

16:00 Lasse Engbo Christiansen – DTU, DK; *Split of total energy consumption into space heating and domestic hot water usage*

16:30 Guglielmina MUTANI – POLITO, IT; *Buildings' energy efficiency and RES potential in urban contexts. Main results of the project Cities on Power.*

17:00 summary of the session rapporteur

17:30 Transport to hotels followed by a social diner in Hotel Lido

Thursday 26 November

Start of the meeting 9:00 **Session 4;** Moderator: Ray Boguslawski

9:00 Summary and points for discussion by the session rapporteurs.

9:45 This part is devoted for making conclusions on the development of a common methodology based on the discussions and topics raised during the sessions.
Defining how the JRC pilot project could be further developed (year 2016)

13:00 End of the meeting and a possibility to join the buffet lunch at the JRC or time for departure from JRC Ispra to train station or airport.

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