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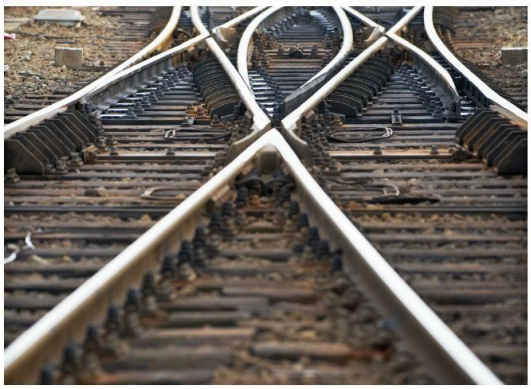


# Location data for buildings related energy efficiency policies

*European Union Location Framework (EULF) Project Feasibility Study*

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**Abstract**

**Based on the priority currently given by the European Union to the energy efficiency topic through its Energy Union Package, this feasibility study has focused on the role of location data in support of energy efficiency policies, taking into account the requirements of INSPIRE, EPBD and EED Directives, as well as the CoM initiative. The EU Member States are already due to implement such Directives according to different roadmaps, but there are benefits to be gained from a coherent and consistent approach. Moreover, data is not always available in consistent form and with good quality. The monitoring and reporting requirements set by the CoM need real data and models, that can be used and that should work consistently across different administrative levels. The analysis reported in this document support these statement, showing that there is lack of data quality and reliability. These aspects might hinder the effective application of the energy efficiency policies at the municipal, district and national level. Geospatial technologies in general and accurate location data in particular can support this field, because they can significantly support efficient processes related to data collection, elaboration and communication to be executed in all the phases of energy efficiency policies life cycle; and effective decision-making. INSPIRE has a role to play as it can provide common data models and common data access rules adopted by all EU MS and a roadmap to provide interoperable datasets of high relevance with energy efficiency. The study has identified areas of development and analysis that can be useful to fill the recognised "data gap", and proposed an initial pilot activity as a start-up project to investigate concretely these ideas with a limited number of pilot cities.**

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ABBREVIATIONS

| Acronym | Description |
|---|---|
| BEI | Baseline Emission Inventory |
| CEN | Comité Européen de Normalisation |
| CO2 | Carbon Dioxide |
| CoM | Covenant of Mayors |
| EP | Energy Performance |
| EPBD | Energy Performance of Buildings Directive |
| EED | Energy Efficiency Directive |
| EU | European Union |
| EULF | European Union Location Framework |
| FTE | Full Time Equivalent |
| GML | Geography Markup Language |
| IES | Institute of Environment and Sustainability |
| IET | Institute for Energy and Transportation |
| INSPIRE | Infrastructure for Spatial Inforation in Europe |
| IR | Implementing Rule |
| ISA | Interoperability Solutions for Public Administrations |
| ISO | International Organisation for Standardisation |
| JRC | Joint Research Centre |
| LA | Local Authority |
| MS | Member State |
| NACE | Nomenclature Statistique des Activités Economiques dans la Communauté Européenne |
| NEAP | National Energy Efficiency Action Plan |
| OGC | Open Geospatial Consortium |
| SEAP | Sustainable Energy Action Plan |
| SME | Small Medium Enterprise |
| TG | Technical Guidelines |
| TWG | Thematic Working Group |
| UML | Unified Modelling Language |
| UN | United Nations |
| WFS | Web Feature Service |
| WMO | World Meteorological Organisation |
| WMS | Web Map Service |
| XMI | XML Metadata Interchange |
| XML | eXtensible Markup Language |
| XSL | Extensible Stylesheet Language |

## 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 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

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)
3 More details about the EULF project are provided in the following section
4 http://inspire.ec.europa.eu/

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:

- 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:

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

    - 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.

# 1 INTRODUCTION

Energy is among the priorities defined in the Commission's New Start for Europe strategy[6] and energy efficiency plays a significant role in several European Directives and initiatives[7] moving toward the Energy and Climate targets for 2020. Among the initiatives, it is worth mentioning the Covenant of Mayors, signed voluntarily by more than 6000 European Mayors[8], who commit to reductions in $CO_2$ emissions in their municipalities of at least 20% by 2020. Buildings are responsible for approximately 40% of the primary energy consumption in Europe and there is a vital need to improve energy efficiency through policies and innovative solutions.

Reliable data, at national and at local level, are necessary in all the phases of the policy life cycle, from planning to implementation and monitoring. Obtaining this data for effective monitoring of progress against targets is a key challenge. In particular, the data requirements set by the energy efficiency policy instruments explicitly require data accuracy at local level.

Valuable support to satisfying these data needs can be provided by the INSPIRE Directive (2007/2/EC)[9]: INSPIRE is the reference directive for spatial data, establishing an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment, such as energy policies. The INSPIRE Directive is well-timed as it is due to be operational by 2020, when MS have to report about data which are of interest for energy efficiency[10].

Based on this background, the "Location data for energy efficiency policies" feasibility study aims to verify the potential for an effective application of spatial data to support the monitoring requirements of the different EU energy efficiency policies and initiatives, which include data from different sources and at different scales (building, district and national).

To achieve this aim, three objectives have been set:

- to investigate how INSPIRE can contribute to harmonise and combine several data requirements coming from different energy policy instruments, in order to simplify the reporting and monitoring commitments of Member States and local authorities;
- to investigate how INSPIRE can facilitate and integrate the collection, elaboration, access to and sharing of meaningful data required from different sources to serve the many needs of the energy efficiency policy making process, at all stages, including planning and implementation, at local level;
- to outline a methodological approach and a set of tools based on location data, which will initially support the monitoring needs related to energy efficiency policies at local level and then the whole policy life-cycle.

[6] http://ec.europa.eu/priorities/energy-union/index_en.htm
[7] More details about are provided in the section 2
[8] 6,453 Signatories (June 26th 2015)
[9] http://inspire.ec.europa.eu/
[10] More details about INSPIRE data themes of interest for energy efficiency are provided in section 5

The feasibility study has been commissioned by the European Union Location Framework (EULF) project[11], which is led by the European Commission Joint Research Centre and is part of the Interoperability Solutions for Public Administrations (ISA) Programme[12], run by DG Informatics (DIGIT). The EULF is a framework of recommendations, guidance and actions to improve the way location information is used in all public services across Europe, targeting benefits for businesses, citizens and government in key areas of EU activity, such as Transport and Energy policy, and the Digital Single Market. The EULF builds on the spatial data infrastructure for Europe being implemented by INSPIRE.

The project has carried out a 'state-of-play' survey on location-enabling e-government and used this in preparing an EULF Strategic Vision, with focus areas on 'policy and strategy alignment', 'e-government integration', 'standardisation and interoperability', 'return on investment' and 'effective governance and partnerships'. An initial EULF Blueprint 'package' has been developed, with recommendations and actions in the different focus areas and detailed guidance on key topics such as 'Public Procurement of Geospatial Technologies' and 'Architecture and Standards for SDI and e-Government'

This feasibility study addresses key aspects of the EULF, including alignment of policies, efficiency in meeting policy requirements, interoperable standards-based solutions, re-use of best practices, and better integration of public sector and private sector activities.

The report is structured into seven main sections.

1. *Introduction*

   The context, scope and objectives of the feasibility study.

2. *European Energy Efficiency Policies*

   An overview of the main European energy efficiency policies.

3. *Energy and Location: State of the Art*

   An overview of existing European projects and initiatives dealing with both energy and location, and presents the results of a survey on the actual and foreseen use of location data related to energy policies.

4. *A Methodology to Support Energy Efficiency Implementation and Monitoring*

   A description of the proposed methodology for the use of location data to support the different energy efficiency policy reporting requirements.

5. *The Role of INSPIRE*

   Taking into account the data requirements of energy efficiency policies outlined in the proposed methodology, this section includes:

   a) an analysis to identify the candidate INSPIRE data themes that will be used to support the energy related data requirements;

   b) a summary of the initial mapping of the data required by the Energy Performance of Buildings Directive (EPBD), the Energy Efficiency Directive (EED) and the Covenant of Mayors (CoM) and the

[11] Information about the EULF, including links to publications and key events, can be found at http://ec.europa.eu/isa/actions/02-interoperability-architecture/2-13action_en.htm

[12] Information about ISA is available at http://ec.europa.eu/isa/ and at http://ec.europa.eu/isa/library/isa-work-programme/index_en.htm

corresponding elements present in the data models of the INSPIRE candidate data themes.

6. *Energy Pilot Outline*

   An outline of a possible Energy pilot, based on the needs and gaps recognised in the previous analyses, including examples of use cases that could be supported.

7. *Conclusions*

   In this section the main conclusions of this feasibility study are reported.

The report is completed by an Annex documents containing the following:

- Annex I: "Detailed data requirements", containing the outcomes of the initial mapping exercise between the INSPIRE Building data model and the EPDB and CoM data requirements;
- Annex II: "Projects and initiatives dealing with energy and location", containing a description of the fourteen projects and initiatives dealing with "energy and location" inventoried during the study;
- Annex III: "Results of the online survey", containing the results of the online stakeholder survey on the actual and foreseen use of location data related to energy policies;
- Annex IV: "Data and methodologies for energy performance of buildings", containing a description of a methodology to assess energy performance of buildings.

# 2 EUROPEAN ENERGY EFFICIENCY POLICIES

Both the Energy Roadmap 2050[13] adopted by the European Commission in 2010 and the 2030 policy framework for climate and energy[14] proposed by the European Commission in 2014 reinforce a political commitment to very high energy savings, with the aim to achieve a more competitive, secure and sustainable European energy system. Increased energy efficiency is vital to achieve the challenging goals set for the future, and particularly the target of at least 27% reduction in the final energy consumption in 2030, compared to expected energy consumption for 2030. In addition, energy efficiency constitutes one of the five dimensions of the **European Commission's Energy Union Package[15],** designed to enhance energy security, sustainability and competitiveness.

European energy policy is reflected in several directives; the current study focuses on two main directives concerning the efficient use of energy in the building sector (Directive 2010/31/EU Energy Performance of Buildings) and in the national energy systems (Directive 2012/27/EU Energy Efficiency Directive). A further important initiative considered in the study is the Covenant of Mayors,[16] a mainstream European movement involving local and regional authorities, voluntarily committing to increase energy efficiency and use of renewable energy sources in their territories. The Covenant signatories aim to meet or exceed the European Union 20% CO2 reduction objective by 2020 February 2015. Over 6000 local authorities to date have signed the Covenant, a total of c. 160m inhabitants in the EU-28, and c. 186m million inhabitants in the whole initiative.

Buildings are responsible for approximately 40% of the primary energy consumption in Europe and there is a vital need to improve energy efficiency through policies and innovative solutions. Therefore, the data requirements set by the **Energy Performance of Buildings Directive** (EPBD) explicitly call for data accuracy at building level and, where necessary, in terms of building units.

It is noteworthy that under the EPBD timetable, new standards for certification and inspection have to be in place by 2015, and by 2018 new buildings have to be nearly zero-energy. The new building-related standards have to take into account the INSPIRE Directive (to be implemented by 2020 by Member States), and to involve national institutions (e.g. cadastre) as well as construction and utility organisations.

The **Energy Efficiency Directive** (EED) explicitly requires Member States to ensure that obligated parties (energy distributers and/or retail energy sales companies) provide on request:

- aggregated statistical information on their final customers;
- current information on final customers' consumption, including, where applicable, load profiles, costumer segmentation and geographical location of customers, while preserving the integrity and confidentiality of private and commercially sensitive information in compliance with applicable Union law.

[13] http://ec.europa.eu/clima/policies/roadmap/index_en.htm
[14] http://ec.europa.eu/clima/policies/2030/index_en.htm
[15] http://ec.europa.eu/priorities/energy-union/index_en.htm
[16] http://www.covenantofmayors.eu/index_en.html

Finally, reliable and accurate data are of high importance for the Sustainable Energy Action Plans of **Covenant of Mayors** signatories.

Effective implementation and monitoring of energy efficiency policies requires that Member States and local authorities report about 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 rely on aggregated and approximated values (for example, local authorities may rely on national data when local data are not available) for planning and monitoring progress toward the targets.

Table 1 describes and compares key features of EPBD, EED and CoM, with relevance to the scope of the study.

*Table 1: Key features of main energy efficiency policies relevant to the study*

| | EPBD | EED | CoM |
|---|---|---|---|
| *Data reporting level* | Building / Building Unit | District | Urban |
| *Data aggregation level* | National (various statistics plus national reporting) | National (various statistics plus national reporting) | Sectors, groups of municipalities |
| *Scope* | Energy efficiency<br>(Buildings, Building Units) | Energy efficiency<br>(Buildings) | Energy efficiency<br>(Buildings, Transport, Waste, Water, Public lighting) |
| *Use* | Residential, commercial, public | Residential, commercial, public | Residential, commercial, public |
| *Coverage* | National | National | Only "urban" areas |
| *Countries* | EU | EU | EU + other countries |
| *Source of data* | Public authorities (INSPIRE, Cadastres)<br>Utilities<br>Building owners<br>Building designers, constructors<br>MS auditors | Energy distribution companies<br>Energy retailers | Local and regional governments (not just municipalities)<br>Energy Service Companies<br>Statistical offices |
| *Method of data collection* | Empirical (top down)<br>Measured or calculated (bottom up) | Measured, anonymised and aggregated | Measured or calculated |
| *What is being measured* | Energy performance | Consumption data translated to efficiency<br>"ratio of input to output energy" | Consumption translated to emissions |
| *Requirement* | Mandated | Mandated | Voluntary |
| *Reference to INSPIRE* | Yes | No | Yes |
| *Issues* | Lack of data | Lack of data<br>Imprecise specifications<br>'Districts' not related to standard administrative units (NUTS) | Lack of data<br>Imprecise specifications |
| *Key dates / targets* | New building stock to be near zero energy in 2018<br>EPBD finishes in 2020 | Energy distributers/sales companies have to achieve 1.5% energy savings annually<br>3% of public buildings must be renovated annually | Beyond 2020 targets (at least 20% C02 reduction by 2020) |
| *Planning instrument* | Yes | National Energy Efficiency Action Plans (NEAP) | Sustainable Energy Action Plans (SEAP) |

# 3 ENERGY AND LOCATION: STATE OF THE ART

This section gives an overview of existing projects and initiatives in Europe related to energy efficiency and the use of location data and summarises the results of a survey undertaken by this study on the actual and foreseen use of location data related to energy efficiency policies, addressing organisations making use of location data in the energy context.

## 3.1 Projects and initiatives related to "Energy and Location"

The following table presents some relevant initiatives dealing with energy efficiency and the use of location data. Even though the list is not exhaustive, fourteen examples have been explored and analysed in order to find out possible elements that could be used in IT solutions to support the energy efficiency policies under consideration. More details about the projects and initiatives are available in Annex II.

*Table 2: Relevant projects and initiatives dealing with energy and location.*

| Initiative | Web link | Relevant for |
|---|---|---|
| BPIE Data Hub | www.buildingsdata.eu | Download of statistics on buildings at national level |
| BUILD UP | www.buildup.eu | Buildings Data Community |
| CERISE-SG | www.cerise-project.nl | Energy Information Broker |
| EMPOWERING | iee-empowering.eu | Link to energy use real data |
| ENERGIE LABEL ATLAS | energielabelatlas.nl | Energy performance estimation at building level for all buildings in NL |
| ENERGY-REGION | www.energy-region.eu | Detailed information on conventional and unconventional energy plants or installations |
| GEOSMARTCITY | www.geosmartcity.eu | Open data portal on buildings' energy-related info |
| HEAT | www.saveheat.co | VGI[17] tool to identify roof material |
| MESHARTILITY | www.meshartility.eu | Solutions and tools for the exchange of energy data between energy utilities and local authorities |
| SEAP ALPS | seap-alps.eu | Methodologies, tools, training platform for SEAP |
| SEMANCO | semanco-project.eu | Ontology for energy performance of buildings |
| SUNSHINE | www.sunshineproject.eu | CityGML Energy ADE |
| U.S. Department of Energy "Building Energy Data Exchange | bedes.lbl.gov | Cross-domain standard for the exchange of buildings energy data |
| U.S. Department of Energy "Building Performance Database" | bpd.lbl.gov | Collection of actual data about real buildings |

[17] Volunteered geographic information

The initiatives listed above are relevant for this study due to their objectives related to the geographical dimension of energy efficiency. Some of them are focused on data collection, mainly at national level (key statistical data related to policies) based on building stock inventories and energy performance certificates. Among those working on data collection, only two (SEAP ALPS and MESHARTILITY) are strictly related to the Covenant of Mayors, even if they are not considering spatial information.

Sometimes, data and tools are also made available through community portals like BUILDUP where interesting references to best practices are described, as well as examples of (open) datasets about energy certificates and properties of actual buildings (Ireland), or data about the capacity of installations and generated energy, their technological characteristics, equipment, purpose of utilisation, etc.

A limited number of initiatives make an explicit reference to INSPIRE or other geo-standards, and only one (GEOSMARTCITY) is also focusing on the opportunity for opening "energy-related" harmonised spatial data.

Similarly, few initiatives are defining ontologies, conceptual standards, use cases, activity descriptions and, in particular, terms and attributes for describing spatial features (regions, cities, neighbourhoods and buildings), energy consumption, CO2 emission indicators, as well as climate and socio-economic factors that influence energy consumption.

The spatial dimension is considered in tools for 3D modelling and visualisation, and by initiatives providing simple maps to visualise data about energy consumption from smart meters.

The increasing interest in smart metering and smart grid data has been found in some examples (CERISE-SG and EMPOWERING), with information about energy consumption taken from utilities' readers and/or bills, and used to inform consumers and help them reduce their energy consumption.

Only the US Department of Energy Building Performance Database is devoted to the collection of actual data from existing buildings. Detailed information about buildings are collected through various channels, and used to perform benchmarking and analysis at supra and sub-urban scales.

A detailed and robust analysis of similar initiatives would be beneficial in order to assemble a structured best practice catalogue: what is provided in this study is an initial list of initiatives, but a more detailed and structured catalogue would be valuable as a follow on activity.

In general, all the fourteen projects and initiatives highlight the need for energy-related data exchange, either considering the energy need (performance) of buildings or actual energy consumption. However, the factors below need to be considered in solutions to support the policies covered in this study:

- information about buildings and energy-related data are usually presented for statistical analysis and benchmarking at national or regional level;
- in all the initiatives, data are not derived from actual (real) buildings registers, nor do they have a direct geographical dimension;

- apart from one initiative, the need for collecting harmonised data from distributed (national) data infrastructures is not considered;
- even if data requirements from local authorities are considered by some projects, evident references to the use of spatial data are missing, and usually the access to more detailed data is restricted or hampered;
- spatial data are often seen as ancillary, mainly for visualisation purposes;
- methodologies are usually not provided for effective use of harmonised spatial data in use cases related to urban energy planning;
- projects dealing with the estimation of energy performance in urban areas do not clearly describe the characteristics of buildings and building units considered in the calculation;
- even if some projects consider the location of users/customers in providing neighbourhood analysis, this is only done by using addresses (users in the same building); furthermore neither daily climatic conditions or the physical characteristics of buildings are considered in relation to energy consumption;
- a holistic approach is generally missing: pilot projects are only taking into account "buildings" per-se, while other energy-related data themes are not considered;
- only one initiative is focused on INSPIRE-harmonised spatial datasets and there is no initiative proposing a mapping of the data requirements between the energy directives and the INSPIRE Directive.

## 3.2 On-line survey on "Energy and Location"

In November 2014 an online survey was launched by the EC-JRC on "Energy and Location"[18]. The key objective of this survey was to collect information on the actual and foreseen use of location data related to energy policies. The questionnaire was set up to gather not only descriptive information on the current situation but also to collect information on projects and initiatives dealing with both "energy" and "location". The survey consisted of the following parts:

- General information about respondents
- Actual and potential use of geodata, barriers in accessing data
- Awareness of different European Directives related to the Energy policies and spatial information
- Energy and location

The questionnaire re-used the methodology already adopted in the smeSpire project[19]. The web platform was EUSurvey[20], funded by the ISA programme.

The survey mainly targeted experts involved in energy and GeoICT activities: the attendees of the international workshop "Benchmarking Energy Sustainability of Cities"[21]

[18] Available at http://ec.europa.eu/eusurvey/runner/EULF_EnergyAndLocation
[19] The smeSpire project (www.smespire.eu) built up a community of more than 600 organisations, mainly private SMEs, working on Geo-ICT
[20] https://ec.europa.eu/eusurvey/home/welcome
[21] http://iet.jrc.ec.europa.eu/energyefficiency/workshop/benchmarking-energy-sustainability-cities

organised by the JRC-IET were directly involved in the survey, together with Geo-ICT experts invited through the smeSpire community.

The link of the survey was also disseminated through web channels (e.g. ISA [22], INSPIRE[23], smeSpire[24] web sites, fora, social networks, ...) as well as via mailing lists.

As of February 2015, the number of submitted questionnaires was 72; detailed statistics of the survey are available in Annex II. Below is a brief analysis of the responses.

More than two-thirds of the respondents are from Italy (38%): this share is in line with the high involvement of Italian stakeholders in the Covenant of Mayors, with more than half of all signatories represented by Italian municipalities.

An interesting finding is the balance of public bodies (44%) and private companies (38%, mainly SMEs) participating in the survey, with the remaining 18% represented by NGOs and other organisations.

60% of respondents are from small organisations (less than 50 FTE[25] employees) and 40% from larger organisations (more than 250 FTEs).

Respondents work mainly at local/regional (39%) or national level (28%), but more than one-fifth (22%) of them are already involved in activities at European level or outside EU (10%).

Only 11% of the respondents are from the "Electricity, gas, steam and air conditioning supply" sector (NACE classification): 17% are from "ICT", and another 15% from "Professional, scientific and technical activities".

The large majority of respondents (81%) are already working with geographic data, with buildings (65%), energy resources (56%), land use (44%) and utility/governmental services (40%) being the most important data themes.

It is noteworthy that about 42% of the respondents are "producers" of geodata, with many of these producers also involved in the modelling (53%) and/or in the processing/analysis of data (60%).

Notwithstanding the high ratio of geodata users, only a few of them are familiar with geodata standards (50% are aware of OGC WMS), and standards for access and exchange of geodata in interoperable encoding are relatively unknown (WFS 35%, GML 29%).

Half of respondents (49%) are aware of the INSPIRE Directive, with very few respondents (16%) very or extremely familiar with the Regulations and Technical Guidelines.

The main barrier encountered in getting geodata (or preventing the innovative use) is the lack of open and reusable data (69%).

The large majority of respondents (89%) are currently involved in some activities related to energy.

[22] http://ec.europa.eu/isa/news/2014/isa-survey-on-energy-and-location_en.htm
[23] http://inspire.ec.europa.eu/index.cfm/newsid/11681
[24] http://www.smespire.eu/eulf-survey-on-energy-and-location/
[25] Full Time Equivalent

Among these respondents, half are directly involved in activities related to the Energy Performance of Buildings Directive (Directive 2010/31), the Energy Efficiency Directive (Directive 2012/27) or the Energy from Renewable Sources Directive (Directive 2009/28).

Interestingly, 59% of them are involved in the Covenant of Mayors initiative.

Respondents are mainly involved in activities dealing directly with public buildings (67%) and residential buildings (54%), with energy savings measures (58%) as principal objectives.

Principal barriers when working in the energy field are the 'lack of detailed data about local energy consumption' (e.g. buildings, transport, public lighting, ...), 'lack of energy geodata' (e.g. data about energy with spatial dimension) and 'lack of information on energy performance of buildings'. This is maybe the reason why 56% of respondents are not familiar with "energy density maps".

Respondents considered that energy geodata could be very useful in real time monitoring of energy consumption and emissions at city level (60%) and for improving sustainable energy planning (69%), and that "energy geodata" could facilitate the monitoring of the Energy Performance of Buildings Directive (72%) and of the Energy Efficiency Directive (75%).

Finally even though the final number of responses was not as high as expected, this is compensated by the skills of respondents involved and the quality of the submitted replies.

Furthermore, it is worth noting that the importance of linking geospatial and energy has been also considered in two other similar surveys launched in 2014:

- "Open Geospatial Data for Energy Access", by the World Bank Group and the European Space Agency[26]
- "Energy Maps", by the smeSpire, Sunshine and GeoSmartCity projects[27], which with more than 110 respondents in 45 days highlighted the importance of "mapping energy" to help urban planning and energy regulations, to improve information and training and facilitate the coordination of local policies.

[26] http://goo.gl/forms/OY1bE5vFE6
[27] http://193.205.215.100/GT/limesurvey/index.php?sid=89353&lang=en

# 4 A METHODOLOGY TO SUPPORT ENERGY EFFICIENCY IMPLEMENTATION AND MONITORING

As outlined in section 2, "European Energy Efficiency Policies", policy-makers need accurate and reliable data and tools for the effective implementation and monitoring of energy efficiency policies. This section introduces a proposal for a methodological approach based on the use of location data to support implementation and reporting of energy efficiency policies (see *Figure 1*).

The proposed approach aims at making use of location data 1) to support policy-makers in reporting and monitoring of energy policies and initiatives and 2) to harmonise the monitoring and reporting of energy efficiency policies at different scales.

Such a methodology may support not only the reporting for energy related policies at national level (e.g. EPBD, EED) and local energy planning (e.g. developing and monitoring action plans for CoM signatories), but also the whole policy life-cycle (e.g. local planning, implementation of measures for efficient renovation of buildings).

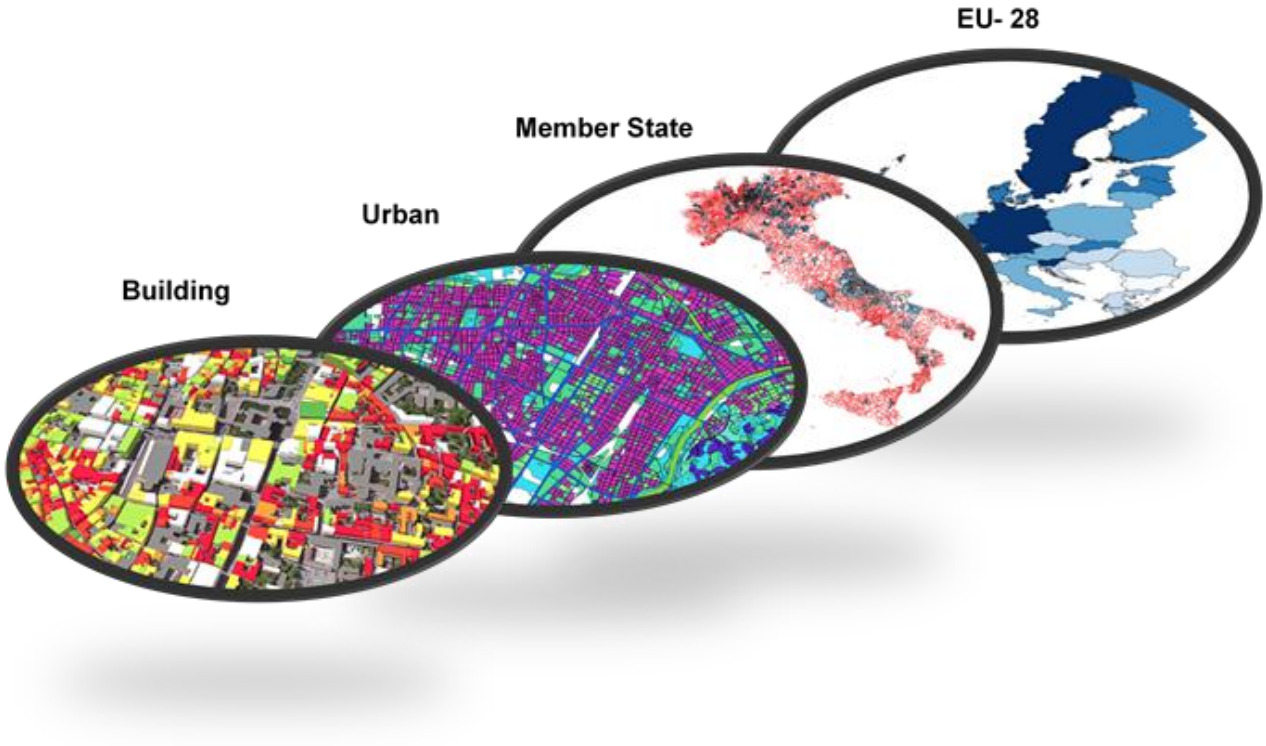


*Figure 1: The methodology addresses the different scales in the application of energy efficiency policies*

The approach is based on three key components:

*Data*: Firstly, the data related to the monitoring and reporting under the energy efficiency policies are identified, with particular attention to their structure. Reporting under the energy efficiency policies (e.g. EPBD, EED) is not necessarily formalised with

specific data models, and plain text may be sufficient to fulfil the reporting obligations. Moreover a top-down approach is typically adopted by public authorities, with no attempt to ensure consistency with data at local level.

*Methodologies*: Based on the data available at local level and compliant with the INSPIRE Directive, methodologies will be developed to devise the parameters needed for monitoring of the energy policies:

- The first step will be the calculation of energy performance at building level, when no energy label or energy performance certificate are available, and in line with the calculation methods provided in the EPBD;
- From the building level, the methodology will describe the scaling up at urban level and it will enable assessments to be made of energy needs in groups of buildings, districts and cities. For example, this would allow monitoring of the building related measures described in their Sustainable Energy Action Plans by the signatories of the CoM;
- A further scale-up step will take the assessments of the energy savings at urban level and aggregates them, in order to assess their contribution to the national targets set up under the EED.

*Tools*: A set of tools is needed for the practical implementation of the methodologies and ultimately to support a better, evidence-based, policy-making process. This will include data models, geodatabases, visualisation instruments, data exchange protocols, data sharing mechanisms, web services, a cookbook for implementers, training materials, demonstrators, etc.

Some inputs for the development of applicable methodologies are given in the following paragraphs. A pilot implementation will be needed to define the detailed methodologies, based on an assessment of data from different sources.

### 4.1 Building level: Energy Performance of Buildings

There is a need to provide local authorities with reliable energy performance data at building level to build and update a robust inventory of local energy performance of buildings data not only based on statistical indicators, and to generate policy support tools such as energy density maps (see Figure 2) or dashboards of indicators.

The methodology should follow the common general framework set out in Annex I of the EPBD and refer to the EPBD related CEN overarching standard EN 15603. The proposed approach will involve a simplified estimation of energy performance at building level, when no energy label or energy performance certificate are available, in line with the calculation methods provided in the EPBD.

It is anticipated that the assessment of the energy performance of buildings will draw on data and calculations from different sources. Figure 3 below shows a top-down and bottom-up approach for making the assessments. The top-down approach starts from administrative building data coming from the cadastre and other sources, whilst the bottom-up approach starts from the calculation method based on CEN standards.

*Figure 2: Atlas of Energy Performance of Buildings- Ferrara*[28]

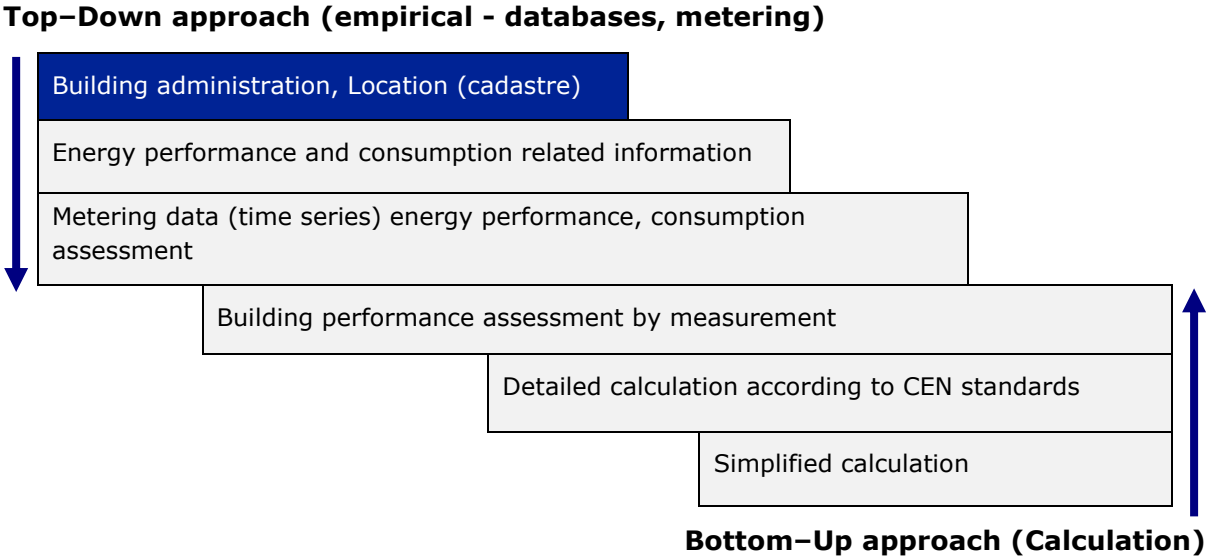


*Figure 3: Top-down and bottom-up approaches in assessing energy performance of buildings*

A detailed description of the methodology can be found in the Annex IV to this report "Data and Methodologies for Energy Performance of Buildings".

## 4.2 District level: Energy Efficiency Directive

Article 7 of the Energy Efficiency Directive calls for MS to set up an energy efficiency obligation scheme, under which the obligated parties (energy distributers and/or retail energy sales companies) have to achieve energy savings of 1.5% per year.

Once a year, MS are required to publish the energy savings achieved by each obligated party (Article 8). MS ensure that obligated parties provide on request:

[28] Source: sunshine project: http://www.sunshineproject.eu/

- Aggregated statistical information on their final customers;
- Current information on final customers' consumption, including where applicable, load profiles, customer segmentation and geographical location of customers, while preserving the integrity and confidentiality of private and commercially sensitive information in compliance with applicable Union law.

One of the features that will be developed in the pilot study is the elaboration of location based indicators at district level according to article 7 and 8 of the EED. Maps representing district indicators will be produced, similar to the one in Figure 4, where the colour intensity is related to the amount of yearly energy intensity.

*Figure 4: District Level: Energy Efficiency Indicators*

### 4.3 Urban level: Covenant of Mayors

The Sustainable Energy Action Plans (SEAPs) are the key documents in which the Covenant of Mayors (CoM) signatories outline how they intend to reach their CO2 reduction target by 2020. SEAPs define the activities and measures set up to achieve the targets, together with time frames and assigned responsibilities.

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*". In the SEAPs the data collection process and the data sources should be well documented and publicly available, so that the process is made transparent and stakeholders can be confident with the inventory of emissions. Data should be relevant to the particular situation of the local authority, i.e. based on energy consumption / production data, mobility data etc. within the territory of the local authority, and

estimates based on national or regional averages are not considered appropriate as they would not capture the efforts made by the local authority to reach its CO2 targets[29].

In all of this, the collection of reliable data with an acceptable level of accuracy is one of the most difficult tasks in designing, implementing and monitoring a SEAP. The majority of CoM signatories (88%) are small municipalities with less than 50,000 inhabitants and they often encounter many obstacles in getting data about energy consumption at the right level of detail.

One of the features that will be developed in the pilot study is the production of maps like the one represented in Figure 5 with the administrative borders of cities (LAU 1 or 2). The blue shapes represent CoM signatories in Italy, and the colour intensity is related to the amount of yearly energy consumption per capita [expressed in MWh/cap].

The mapping of CoM signatories, along with energy and emissions indicators, will be developed in the pilot study. This will allow local authorities to rely on high quality and local data to better inform the planning of energy efficiency measures.

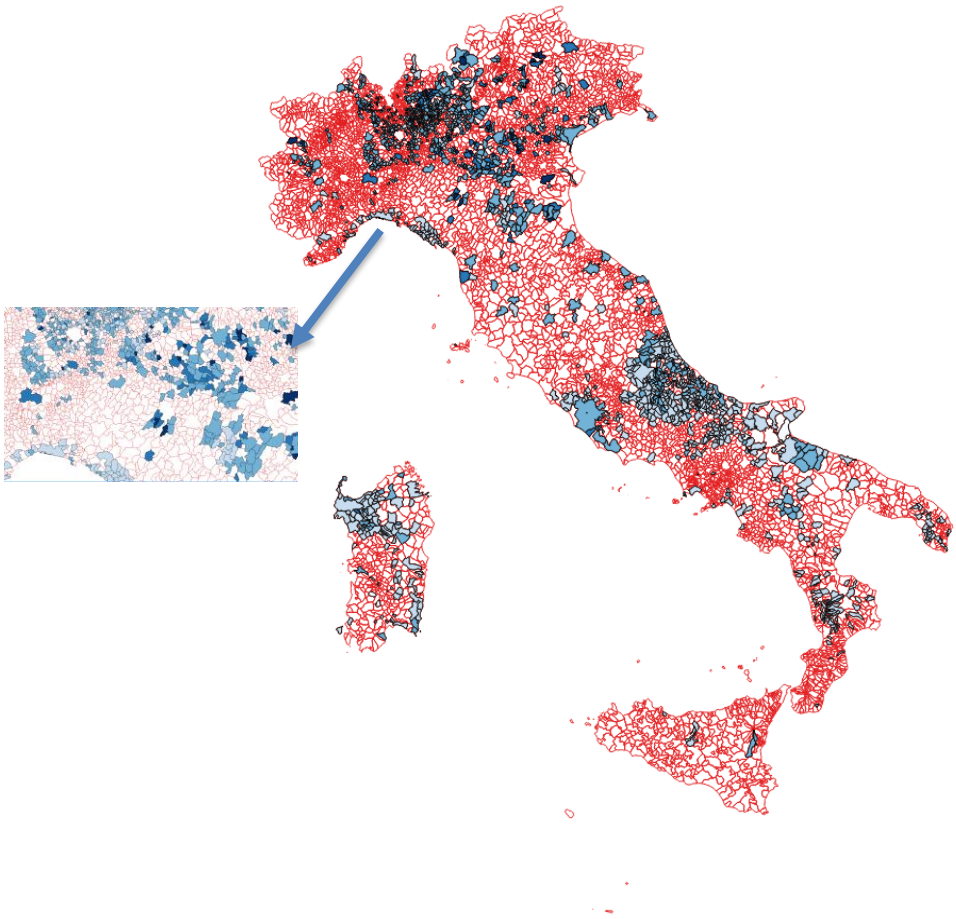

*Figure 5: Urban Level: Covenant of Mayors signatories in Italy as of mid May 2014*
*(the colour intensity is related to the amount of yearly energy consumption per capita [MWh/cap])*

[29] SEAP guidelines (EU, 2010b, p.9)

## 4.4 National level: Energy Efficiency Directive

The Energy Efficiency Directive requires Member States to ensure an annual renovation of central government buildings of 3% (Article 5.1) and to encourage public bodies including regional and local government to adopt energy efficiency plans (Article 5.7).

For these purposes MS are required to establish an inventory that contains data on the floor area and the energy performance or relevant energy data of public buildings affected by the application of the Energy Efficiency Directive (Article 5.5).

One of the features that will be developed in the pilot study is the elaboration of location based indicators on energy savings at MS level, using the scaling up methodology from the building level to the national level. Maps with the administrative borders of MS (NUTS 1) will be produced, similar to the one represented in Figure 6, where the colour intensity is related to the amount of yearly energy consumption per capita [expressed in MWh/cap].

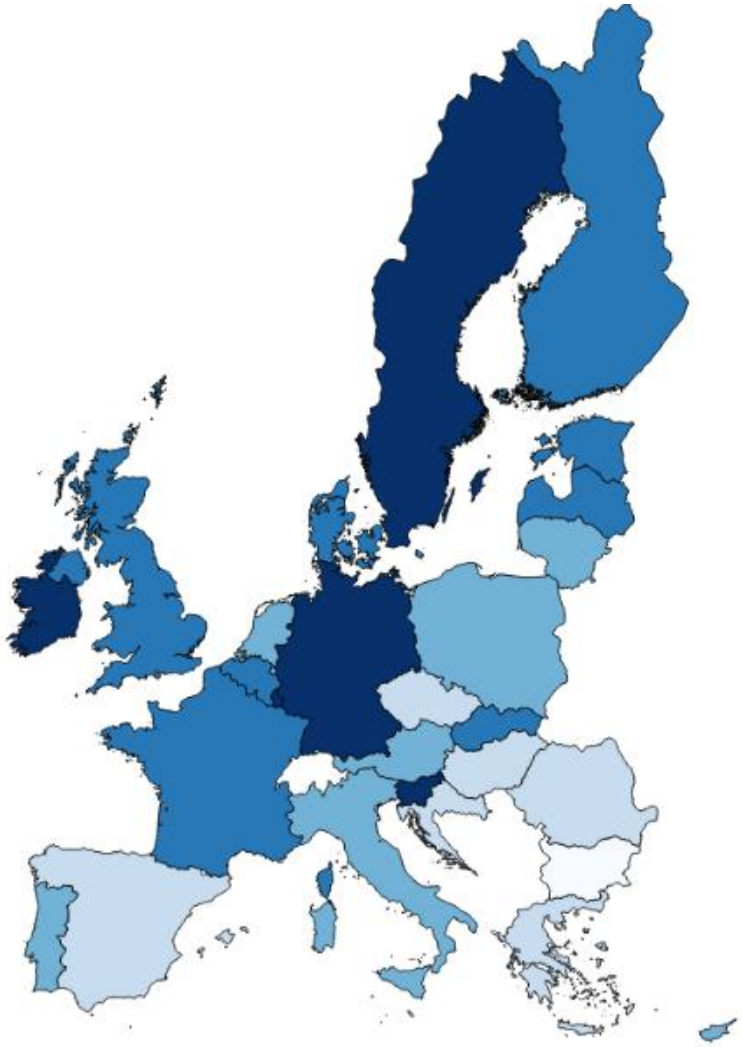

*Figure 6: National Level: Energy Efficiency Indicators*
(colour intensity is related to the amount of yearly energy consumption per capita [MWh/cap])

### 4.5 Conceptual Architecture to Support the Methodology

The proposed architecture to support these requirements is depicted in *Figure 7*. Such an architecture will be developed as a demonstrator within the proposed pilot study. It will rely on INSPIRE compliant datasets and draw in additional data from different sources, tools will be developed to provide the different services and features, and the demonstrator will be hosted in a web portal (e.g. the Energy Efficiency web portal under development in the Renewables and Energy Efficiency unit).

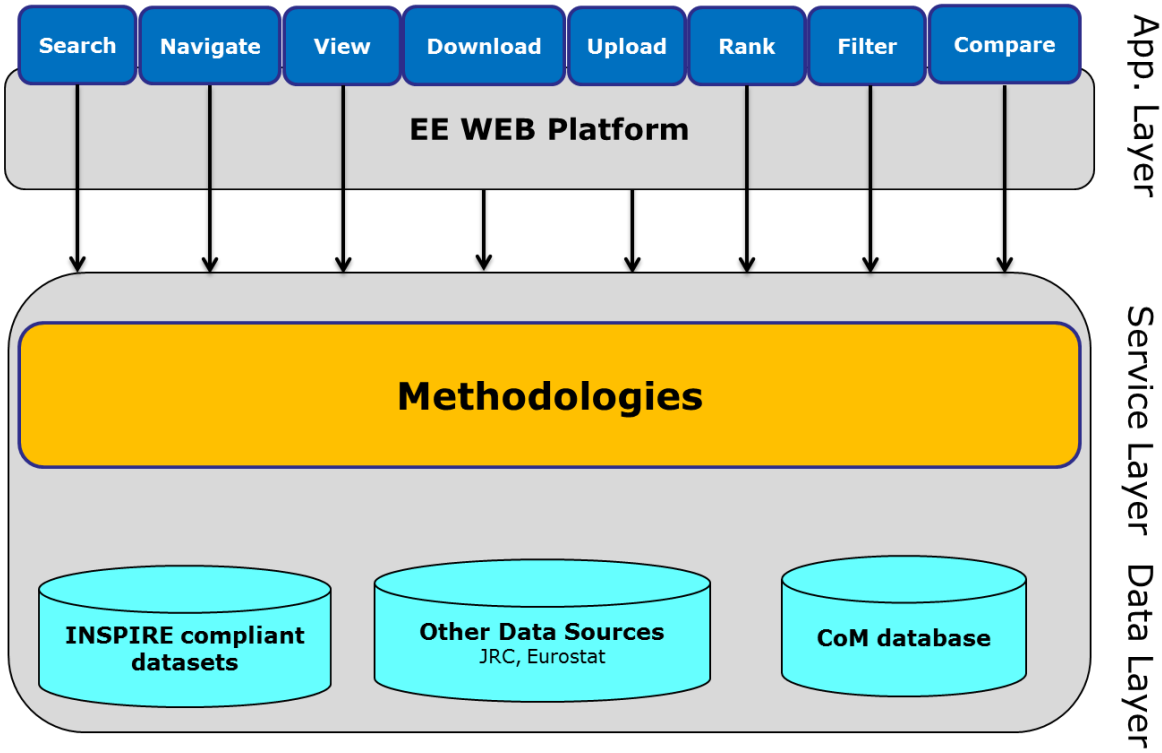


*Figure 7: Conceptual architecture to support the methodology*

## 5 THE ROLE OF INSPIRE IN ENERGY EFFICIENCY AND LOCATION

This section addresses the "data" component referred to in the previous section, where an overview of the data requirements coming from EPBD, CoM and EED has been provided. The following activities have been carried out to investigate the possibility of using the INSPIRE data models to address the energy efficiency needs:

- a fit-for-purpose analysis to identify the candidate INSPIRE data themes that will be used to match the energy related data requirements;
- an initial mapping exercise between the elements of the data models required by EPBD, EED and CoM and the corresponding elements present in the data models of the INSPIRE Building data theme.

## 5.1 INSPIRE candidate data themes

The INSPIRE Directive "establishes an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment". INSPIRE defines binding Implementing Rules (Commission Regulations) and non-binding Technical Guidelines for the interchange of spatial data through interoperable data models and services. Among the 34 spatial data themes addressed by the Directive[30], the following are directly or indirectly related to "Energy Efficiency and Location":

- Buildings
- Addresses
- Cadastral parcels
- Utility and governmental services
- Production and industrial facilities
- Energy resources
- Atmospheric conditions
- Land Cover
- Statistical Units
- Population Distribution

The Regulations (Implementing Rules) do not require any specific encoding or formats, but define the minimum core to be considered for each INSPIRE data theme. At the same time, INSPIRE strongly encourages the implementation of the data models through Technical Guidelines defining "how" data should be structured and encoded, by using well-known and vendor-neutral standards. INSPIRE Data Specifications are described in various ways: Technical Guidelines are comprehensive documents (one for each of the 34 data themes) with formal descriptions of data requirements, based on UML diagrams (mainly class diagrams). Data models are also available on the INSPIRE web site[31] as UML interchange format (XMI), GML Application Schemas and XML/XLS Mapping Tables.

Mapping tables provide a comprehensive yet simple tool to represent INSPIRE data requirements for the aforementioned themes related to "energy". The detailed lists of classes, attributes, and constraints for the Building data model are available in Annex I. These are based on mapping tables available on the INSPIRE web site[32]. Below is a description of the candidate data themes and the main aspects of their data models, in relation to the data requirements described in section 4.

[30] http://inspire.ec.europa.eu/index.cfm/pageid/2/list/7

[31] http://inspire.ec.europa.eu/index.cfm/pageid/2/list/datamodels
As stated in the web site above, this distribution combines the data models contained in the amendment to the Implementing Rules and the extended data models contained in the data specification Technical Guidelines (but not in the IRs). Please note that the extended data models not included in the IRs should be considered as draft and therefore be used with caution.

[32] http://inspire.ec.europa.eu/data-model/approved/r4618/mapping/

### *5.1.1 Buildings*

The "Buildings" theme includes the following application schemas (INSPIRE Technical Guidelines "Buildings" 3.0. pp.29,30):

- **BuildingsBase**, describing the concepts that are common to all other Buildings application schemas; it contains mainly the core normative semantics of theme Buildings
- **Buildings2D,** describing the 2D geometric representation of the spatial object types defined in Buildings Base application schema, namely buildings and building parts; it inherits from the common semantics of Buildings base
- **Buildings3D,** describing the 3D geometric representation of the spatial object types defined in Buildings Base application schema, namely buildings and building parts; it inherits from the common semantics of Buildings base
- **BuildingsExtendedBase,** describing the additional semantics that should be used to extend normative profiles, whatever the chosen geometric representation (2D or 3D) is.
- **BuildingsExtended2D,** describing the 2D geometric representation of the additional spatial object types (namely installations, other constructions, building units); it inherits both from the common semantics of <Buildings ExtendedBase> and of the 2D geometric representation of buildings and building parts.
- **BuildingsExtended3D,** describing both the 3D geometric representation of the additional spatial object types (namely installations, other constructions, building units) and the additional concepts that should be used to provide more detailed information about buildings and associated objects, when represented by 3D data (walls, roofs, openings, room, textures, …); it inherits both from the common semantics of <Buildings ExtendedBase> and of the 3D geometric representation of buildings and building parts.

The tables included in Annex I contain the list of detailed properties defined in the **BuildingsExtended2D** mapping tables.

The types of objects that are of main interest for the scope of the first mapping exercise are Buildings, Building Parts and Installations.

### *5.1.2 Addresses and Cadastral parcels*

In the "Buildings" theme, the objects representing "buildings" and "buildings units" include associations to other feature types defined in two other INSPIRE data themes: Addresses and Cadastral Parcels. Most buildings can be identified (geocoded) by one or more addresses (adapted from the INSPIRE Registry[33]). An address is an identification of the fixed location of a property. The full address is a hierarchy consisting of components such as geographic names, with an increasing level of detail, e.g. town, then street name, then house number or name. It may also include a post code or other postal descriptors. The address may include a path of access but this depends on the function of the address (INSPIRE TWG-AD, 2014, p.15).

In the INSPIRE context, cadastral parcels should be forming a partition of national territory (INSPIRE TWG-CP, 2014, p.13). A cadastral parcel should be considered as a

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

single area of Earth surface (land and/or water) with property rights and unique ownership[34] defined by national law (adapted from UN ECE 2004 and WG-CPI, 2006).

Both addresses and cadastral parcels are often used to reference data about energy consumption and/or energy performance.

### *5.1.3 Utility and governmental services*

According to the INSPIRE Directive, the Utility and Governmental Services theme "*Includes utility facilities such as sewage, waste management, energy supply and water supply, administrative and social governmental services such as public administrations, civil protection sites, schools and hospitals*" (INSPIRE TWG-US, 2013, p.13). This theme has been divided into three sub-themes, one of which deals with "Utility networks".

Utility services and networks include the physical constructions for transport of defined utility products (namely pipelines for transport of oil, gas, chemicals, water, sewage and thermal products), transmission lines and cables (included those for transmission of electricity, phone and cable-TV signals) and other network elements for encasing pipes and cases (e.g. ducts, poles and towers). All kinds of transmission utility systems have nodes (e.g. pump stations), and they are linked to facilities for production and treatment of different kinds of utility products. These major production and treatment sites are described in the "Production and industrial facilities" theme.

Six important types of utility networks are distinguished, namely Electricity Network, Oil, Gas & Chemicals Network, Sewer Network, Telecommunications Network, Thermal Network and Water Network. They have been designed to describe data in a structured model with only the most basic characteristics, but adhering to the node-arc-node concept (taken from the "Network" concept in the INSPIRE Generic Conceptual Model), respectively for the six types of utility networks (electricity, oil-gas-chemicals, water, sewer, thermal and telecommunications).

Three types of utility networks are relevant to this study, namely, Thermal networks, Electricity networks, and Oil, gas, chemicals networks.

### *5.1.4 Production and industrial facilities*

According to the description of the data theme available on the INSPIRE website[35], "… the "Production and Industrial Facilities" theme comprises information about industrial facilities and activities of production (focusing on extraction, transformation or storage of resources, including energy production) and the main related environmental issues. In the relevant Data Specification (INSPIRE TWG-PF, 2013), a more detailed description says that: "… *The overall set of activities considered within the Production and Industrial Facilities theme spans from extraction of resources, to their transformation in products or by-products, and their storage. … Transformation of resources should be seen both as transformation of one resource or product into another, or as transformation into energy, thus including power generation plants within the scope of this theme* …".

The elements of the ProductionAndIndustrialFacilitiesExt.xsd application schema will have to be analysed to match the data requirements coming from tables B.2, B.3 and

[34] By unique ownership is meant that the ownership is held by one or several joint owners for the whole parcel.

[35] http://inspire.ec.europa.eu/index.cfm/pageid/2/list/7

B.4 of the SEAP for Local renewable electricity plants, Local electricity production plants and Local heat/cold production plants.

### *5.1.5 Energy Resources*

In the INSPIRE context, "Energy resources" are features defining an inferred or observable spatial extent of a resource that can be, or has been, used as a source of energy (INSPIRE, TWG-ER, 2013, p.13). The data specification for Energy Resources provides the mechanism to exchange and compare energy resources related information defined within a spatial context.

Energy resources are commonly divided into two main types: Primary and Secondary energy. Primary energy is either extracted or captured directly from natural resources (such as coal, crude oil, wind or solar radiation) whereas Secondary energy (Energy Carriers) is the result of a conversion of primary or secondary energy types. Electricity is one of the most common secondary energy types, being transformed from various primary energy sources such as coal, oil, natural gas, and wind. Although within the INSPIRE context only Primary Energy Resources are considered, links to secondary energy are allowed for through the connection via statistics.

A more detailed analysis of EnergyStatistics application schema is recommended and a cross-check will have to be done between the relevant elements of the Data Specification on Energy Resources and the relevant elements of the Data Specification on Production and Industrial Facilities, in order to ensure consistency and reduce multiplicities where cross-theme interrelationships exist[36].

### *5.1.6 Atmospheric conditions and Meteorological geographical features*

The INSPIRE "Atmospheric Conditions" and "Meteorological Features" themes are covered together in one Data Specification. These themes provide basic concepts and data models for environmental protection related activities requiring information on atmospheric conditions like weather, climate and air quality. The two themes are defined as follows:

- **Atmospheric conditions**: physical conditions in the atmosphere. Includes spatial data based on measurements, on models or on a combination thereof and includes measurements locations;
- **Meteorological geographical features**: weather conditions and their measurements: precipitation, temperature, evapotranspiration, wind speed and direction.

A detailed fit-for-purpose analysis will identify the elements of the relevant application schemas needed to match the climatic zones data requirements present in the energy efficiency policies.

### *5.1.7 Land cover*

The application schemas of the Land Cover data theme are candidate target data models to harmonise several input datasets to be used in the energy pilot workflows. In

[36] Page 7 of INSPIRE Data Specification on Energy Resources http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_ER_v3.0.pdf

particular, the flexibility of the LandCoverNomenclature data type available in both Raster and Vector application schemas of the Land Cover data specification can facilitate the harmonisation of several thematic layers, such as Urban Atlas and other datasets based on urban areas related classification schemes.

#### *5.1.8 Statistical Units and Population Distribution*

The combined use of the data models of these two themes will facilitate harmonisation of datasets consisting of indicators. The Population Distribution theme deals with datasets of statistical information describing how some phenomena regarding human population are spread within some part of the 2D space. The theme has no direct spatial features, and only contains attributes supporting the description of population phenomena related to statistical units. Population data is linked to spatial objects (statistical units) through their common identifier, e.g. NUTS codes.

In addition, regarding the genericity of its range of applications, the Executive Summary of the Data Specification on Population Distribution states that: "There are many different kinds of statistical data about human population: about people, dwellings, people at their work place, etc. This document does not intend to provide specifications for all these. Common characteristics have been extracted and represented into a generic data model. Using the data model described in this specification, all statistical data regularly organized in tables or data cubes can be provided in the INSPIRE framework."

### 5.2 Initial mapping exercise

An initial mapping exercise has been carried out between the building related elements of the data models required by EPBD and CoM and the corresponding elements present in the INSPIRE data specification on Buildings. Details of the mapping are provided in Annex I.

The main outcome of this mapping exercise is that the building-related data models required by EPBD and CoM are semantically richer than the data models under INSPIRE. For instance, *Figure 8* shows the UML representation of the element of the INSPIRE Buildings Base Extended data model (Feature Type BuildingAndBuildingUnitInfo) which deals with energy related aspects.

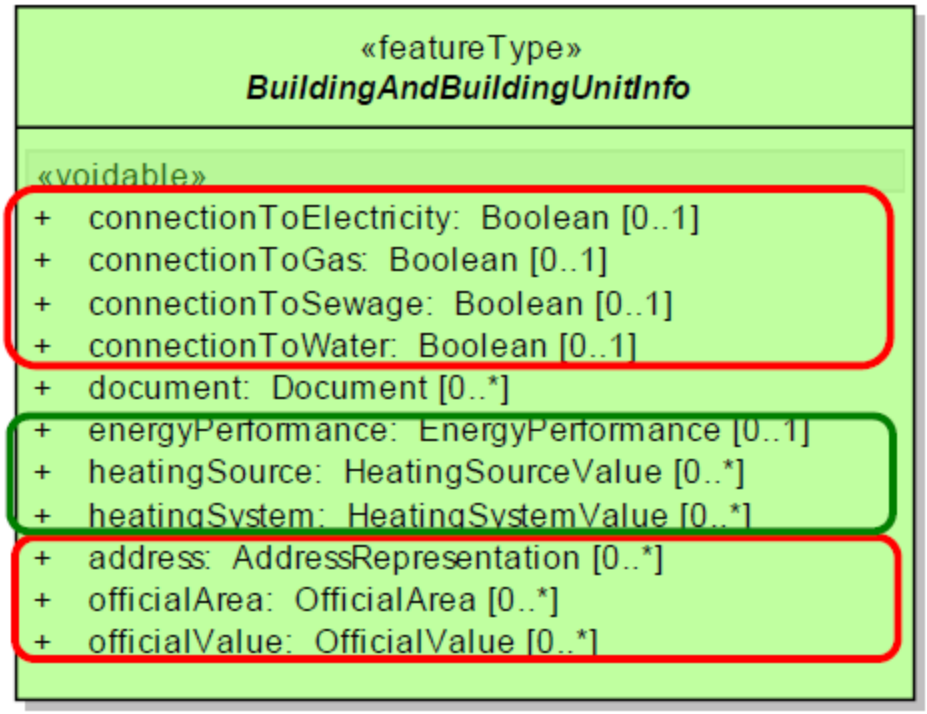


*Figure 8: INSPIRE Feature Type BuildingAndBuildingUnitInfo*

It is evident that:

- there are 4 boolean attributes which can be used just to store the information if the building (or building unit) is connected or not to the different networks (electricity, gas, sewage, water)[37];
- there is one attribute (energyPerformance) which can be used to store the information related to the energy label;
- there is one attribute (heatingSource) which can be used to store the information related to the source of energy used for heating (i.e. electricity, naturalGas, etc.);
- there is one attribute (heatingSystem) which can be used to store the information related to the system of heating (i.e. stove, central heating, heat pump, etc.).

Conversely, there are additional attributes required by the EN 15603 standard (on which the EPBD data modelling requirements are based), like "Energy need" for heating, cooling, ventilation, air conditioning, domestic hot water, lighting, appliances, which do not match with any attribute existing in the current INSPIRE data model for buildings.

In general, because not all the elements of the data models required by EPBD and CoM have a corresponding element in the applicable INSPIRE data model, these elements with a missing correspondence with INSPIRE need to be further analysed in order to proper address an extension of the existing applicable INSPIRE data models. It is also worth highlighting that the extension of an existing INSPIRE data model is subject to

[37] It is worth noting the absence of a similar boolean attribute to identify buildings connected to district heating network

precise rules and conditions, set to ensure that it does not break the interoperability of harmonised data and services[38].

# 6 ENERGY PILOT OUTLINE

Based on the outcomes of this feasibility study, this section provides an outline for a possible EULF pilot on energy efficiency. As mentioned in the introduction, the main aim of the feasibility study is to verify that geolocation can increase the quality and the reliability of the data available to local and national policy-makers and help the alignment between the data requirements addressed by different energy related policies.

The sections below describe first the objectives of the pilot, then details about the possible approach to be followed and finally propose examples of possible use cases the pilot should support.

## 6.1 Aims

The aims of the EULF Pilot Project on "Location data for energy efficiency policies" include the following:

a) To support local authorities (e.g. Covenant of Mayors signatories) to enhance the energy efficiency policy-making process (from planning to implementation and monitoring), improving the quality of data they use (particularly time series local data).

b) To develop a methodology and to provide local authorities with tools to build and update a robust inventory of reliable local energy performance of buildings data (not only based on statistical indicators), to generate energy density maps, a dashboard of indicators and changes over time of energy performance.

c) To provide local authorities with tools to share data of better quality related to energy consumption, which can be used by citizens and businesses, including energy saving companies.

d) To put in place harmonised data flows to support energy related initiatives at local level (e.g. the CoM) and to align them with the national energy efficiency planning obligations (set by the Energy Efficiency Directive or the Renewable Energy Directive).

e) To provide more effective scientific and technical support to European energy efficiency policy-making process, particularly in relation to the collection and use of high quality and reliable data for reporting and monitoring.

f) To provide a real example of how INSPIRE can better serve data collection, collation and sharing among different stakeholders. This may include developing a formal definition of an extension of the INSPIRE data specification on Buildings and other data themes related to energy efficiency.

g) To provide a best practice case study for the EULF and contribute to implement and test its guidelines where appropriate.

[38] INSPIRE Generic Conceptual Model - http://inspire.ec.europa.eu/documents/Data_Specifications/D2.5_v3.4.pdf

The pilot should involve a representative set of cities, all of which are CoM signatories and are already involved in SEAP monitoring activities. In particular, efforts should be spent to identify candidate cities for which the data needed (as identified in the present feasibility study) are available and possibly already conformant to the requirements of the INSPIRE Directive.

In terms of time frame and geographical scale, the involvement of 2-3 cities in the short term (Phase 1), expanding to 5-6 in the medium term (Phase 2), belonging to different countries is envisaged. An international workshop could be beneficial both for the selection of interested cities and for the dissemination of the ideas originated with this feasibility study to a wider audience.

## 6.2 Approach

A possible approach to design and deploy the pilot could be based on the steps schematized in the following Figure 9.


*Figure 9: Possible pilot implementation steps*

The process to select the partner-cities will have to start in parallel to step 1 and they will have to be deeply involved in steps from 1 to 4 and in step 6.

A physical workshop will have to be organized with the partner-cities as soon as possible.

Steps 3 and 4 will have to focus on:

- output to be produced
- functionalities of the demonstrator
- assessment methodologies to be applied to produce the desired output
- data flows to be managed by the demonstrator
- data sources to be used into the data flows
- data harmonization steps to be carried out

Step 6 should include cost-benefit analysis, better if by means of quantitative indicators.

With reference to the proposed approach, different scenarios can be envisaged for the pilot design and deployment, each of them characterized by different costs and benefits.

The main criteria characterizing the scenarios are listed below and in the following Table 3 an estimation of the related costs and benefits are provided:

- the number of cities to be involved;
- the heterogeneity of the source datasets, similar in scope;
- the level of complexity of the web-based tools to be used by the demonstrator.

Having more cities involved in the pilot would give the possibility to obtain feedback from a bigger sample, having as a drawback the need to invest more resources for

coordination and technical support. Similarly, selecting datasets from a variety of heterogeneous sources would entail an increased effort to harmonise a higher number of datasets, while improving the re-usability of the data harmonisation approach. Having a high level of complexity of the web-based tools to be used by the demonstrator would increase its exploitation but more resources are needed for designing and implementation.

Therefore, depending on the available resources, it could be decided to choose to let one of these criteria be higher than the others, or start with a limited amount of cities, sources and level of complexity, to follow up with the a richer and more complex demo afterwards.

*Table 3: Criteria characterizing the scenarios*

| Criterion | Costs | Benefits |
|---|---|---|
| Number of cities to be involved | Increased effort to handle more cities | Increased feedback coming from testing the use cases in more cities |
| Heterogeneity of the source datasets (similar in scope) | Increased effort to harmonize a higher number of heterogeneous datasets | Increased re-usability of the data harmonization approach |
| Level of complexity of the web-based tools to be used by the demonstrator | Increased effort to design and implement more complex web-based tools | Increased exploitation of the demonstrator |

### 6.3 Examples of Use Cases

In this section five possible use cases are presented, that the Pilot should develop and test, highlighting how the whole energy efficiency policies life-cycle can be supported. In the pilot project a thorough revision of these examples, following the approach described in the previous section, together with a detailed formal description of the use cases, will be done.

**Use Case 1** assumes that a local public administration relies on a default dataset for energy performance of buildings (e.g. based on national or local statistics). In this case, the dataset can be improved with data relevant to the physical structure of the buildings, obtained from diverse data sources or collected in-situ.

**Use Case 2** aims at improving the quality of the estimation of energy consumption at building level (and the corresponding CO2 emissions) to improve the quality and the level of details of the Baseline Emissions Inventory (BEI) for buildings. In this case, the use of actual energy consumption data at building level allows to improve the estimated energy consumptions at building level based on a default energy performance label.

**Use Case 3** assumes that a local public administration wants to update the energy performance labelling default dataset using the data contained in the energy performance certificates available and to create a web service showing the buildings having an energy performance certificate.

**Use Case 4** aims at contributing to the national energy efficiency targets using location in data relevant to energy efficiency policies at urban level. In this case, the datasets dealt with in the previous use cases, combined with other urban planning related

datasets, can facilitate to set priorities and financial incentives for the refurbishment of a target buildings stock at urban level as a contribution to national renovation targets.

**Use Case 5** aims at supporting the CoM signatories to prepare and monitor the Emission Inventory, as the main pillars of their Sustainable Energy Action Plans. In this case, in addition to the datasets dealt with in the previous use cases, also data related to the energy production will have to be considered.

# 7 CONCLUSIONS

Based on the priority currently given by the European Union to the energy efficiency topic through its Energy Union Package, this feasibility study has focused on the role of location data in support of energy efficiency policies, taking into account the requirements of INSPIRE, EPBD and EED Directives, as well as of the CoM initiative.

The EU Member States are already due to implement such Directives according to different roadmaps, but there are benefits to be gained from a coherent and consistent approach. Moreover, data is not always available in consistent form and with good quality. The monitoring and reporting requirements set by the CoM need real data and models, that can be used and that should work consistently across different administrative levels. On the other hand, the more than 6000 signatories to the CoM should be supported by few reusable solutions, instead of being left to set up thousands of ad-hoc planning, monitoring and reporting tools.

The analysis reported in this document support these statement, showing that there is lack of data quality and reliability, especially at the building level, that it is costly to collect such data and that the energy consumption data at the building level are generally not available because they are commercially sensitive. These aspects might hinder the effective implementation of the energy efficiency policies at the municipal, district and national level.

In fact, it is generally agreed that, for a better implementation and monitoring of energy efficiency policies, precise and reliable data as well as robust and evidence-based tools would be strategic. For example, the development of tools for assessing the energy performance of buildings at urban scale would strongly support the implementation of the Energy Performance of Buildings Directive.

A methodological approach for the use of location data for the monitoring of energy efficiency policies has been provided, clarifying the role of three key components (data, assessment methodology, tools) and their interrelationships and showing how they can support the whole life cycle of the energy efficiency policies. It has been highlighted the need to develop a robust assessment methodology to scale-up energy efficiency data from building level to district, city and national level, and to develop a set of tools supporting the implementation of the methodologies.

Geospatial technologies in general and accurate location data in particular can support this field, because they can significantly support efficient processes related to data collection, elaboration and communication to be executed in all the phases of energy efficiency policies life cycle and effective decision-making. The INSPIRE Directive has a role to play for its relevance in data and services harmonisation and coordination of thematic expertise at the European level. It can provide common data models and common data access rules adopted by all EU MS and a roadmap to provide interoperable datasets of high relevance with energy efficiency.

The study has identified areas of development and analysis that can be useful to fill the recognised "data gap", and proposed an initial pilot activity as a start-up project to investigate concretely these ideas with a limited number of pilot cities. Next steps would include an international workshop to call for interested cities, and to understand their level of maturity in the implementation of energy efficiency policy, to assign them to different use cases and choose the most appropriate scenario to meet their needs.

## LINKS TO RELEVANT BIBLIOGRAPHY

Agenzia delle Entrate (AdE). (2011). Gli immobili in Italia. Retrieved March 3rd, 2015, from http://wwwt.agenziaentrate.gov.it/mt/comunicazione/Gli%20immobili%20in%20Italia%202011/Gli%20immobili%20in%20Italia%202011%20-%20capitolo%201.pdf

Bloem H. (2013). "The future for standardisation in the building sector; Assessment of high energy performance buildings" in Workshop on High Performance Buildings - Design and Evaluation Methodologies. Retrieved March 3rd, 2015, from http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/events/High-Performance-Buildings-June-2013/Papers/session3/36_pap_bloem_futurestandardisationegrbld.pdf

Building Performance Institute Europe (BPIE). (2011). Europe's Buildings under the Microscope. Retrieved March 3rd, 2015, from http://www.bpie.eu/uploads/lib/document/attachment/21/LR_EU_B_under_microscope_study.pdf

Coalition for Energy Savings. (2014). Annex A: Timeline of the Energy Efficiency Directive obligations. Retrieved March 3rd, 2015, from http://eedguidebook.energycoalition.eu/annexes.html#B

Comitato Termotecnico Italiano (CTI). (2014). Attuazione della certificazione energetica degli edifici in Italia. Retrieved March 3rd, 2015, from http://www.cti2000.eu/app/download/8284443385/Sintesi+rapporto+CE+2014.pdf?t=1419258442

Energy Information Administration (EIA). (2013). International Energy Outlook. Retrieved July 26th, 2014, from http://www.eia.gov/forecasts/ieo/excel/ieotab_1.xls

European Commission (EC). (2007). Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). Retrieved March 3rd, 2015, from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:108:0001:0014:EN:PDF

European Commission (EC). (2010). Mandate to CEN, CENELEC and ETSI for the elaboration and adoption of standards for a methodology calculating the integrated energy performance of buildings and promoting the energy efficiency of buildings, in accordance with the terms set in the recast of the Directive on the energy performance of buildings (2010/31/EU). Retrieved March 3rd, 2015, from ftp://ftp.cencenelec.eu/CENELEC/EuropeanMandates/M_480.pdf

European Commission (EC). (2013a). European Union Location Framework Strategic Vision. Retrieved March 3rd, 2015, from http://ec.europa.eu/isa/actions/documents/isa-2.13_eulf-strategic-vision-lite-v0-3_final_en.pdf

European Commission (EC). (2013b). The Covenant of Mayors in Figures. 5-Year Assessment. Retrieved March 3rd, 2015, from http://www.covenantofmayors.eu/IMG/pdf/com_in_figures_jrc.pdf

European Commission (EC). (2015). Establishment of a European Union Location Framework (EULF). Retrieved March 3rd, 2015, from http://ec.europa.eu/isa/actions/02-interoperability-architecture/2-13action_en.htm

European Union (EU). (2006). Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC. Retrieved March 3rd, 2015, from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0032&from=EN

European Union (EU). (2010a). Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast). Retrieved March 3rd, 2015, from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF

European Union (EU). (2010b). How to develop a Sustainable Energy Action Plan. Retrieved March 3rd, 2015, from http://www.eumayors.eu/IMG/pdf/seap_guidelines_en.pdf

European Union (EU). (2012). Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. Retrieved July 26th, 2015, from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0027&from=EN

European Union (EU). (2014). Energy Performance of Buildings. Retrieved July 26th, 2015, from http://europa.eu/legislation_summaries/internal_market/single_market_for_goods/construction/en0021_en.htm

INSPIRE Thematic Working Group Addresses (TWG-AD). (2014). D2.8.I.5 Data Specification on Addresses – Technical Guidelines. Retrieved March 3rd, 2015, from http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_AD_v3.1.pdf

INSPIRE Thematic Working Group Atmospheric Conditions and Meteorological Geographical Features (TWG-AC-MF). (2013). D2.8.III.13-14Data Specification on Atmospheric Conditions and Meteorological Geographical Features – Technical Guidelines. Retrieved March 3rd, 2015, from http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_AC-MF_v3.0.pdf

INSPIRE Thematic Working Group Buildings (TWG-BU). (2013). D2.8.III.2 INSPIRE Data Specification on Buildings – Technical Guidelines. Retrieved March 3rd, 2015, from http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_BU_v3.0.pdf

INSPIRE Thematic Working Group Cadastral Parcels (TWG-CP). (2014). D2.8.I.6Data Specification on Cadastral Parcels – Technical Guidelines. Retrieved March 3rd, 2015, from http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_CP_v3.1.pdf

INSPIRE Thematic Working Group Energy Resources (TWG-ER). (2013). D2.8.III.20 Data Specification on Energy Resources – Technical Guidelines. Retrieved March 3rd, 2015, from

http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_ER_v3.0.pdf

INSPIRE Thematic Working Group Production and Industrial Facilities (TWG-PF). (2013). D2.8.III.8 Data Specification on Production and Industrial Facilities – Technical Guidelines. Retrieved March 3rd, 2015, from http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_PF_v3.0.pdf

INSPIRE Thematic Working Group Utilities and Governmental Services (TWG-US). (2013). D2.8.III.6 Data Specification on Utility and Government Services – Technical Guidelines. Retrieved March 3rd, 2015, from http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_US_v3.0.pdf

Junker J.C. (2014). My Priorities. Retrieved March 3rd, 2015, from http://juncker.epp.eu/my-priorities

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