Can big data drive the market for residential energy efficiency?

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Abstract

The building sector is fragmented and disaggregated; hence the availability of reliable data on building characteristics, energy use and related socio-economic factors has been challenging. However, European energy efficiency analysts increasingly have access to one major source of building level data: Energy Performance Certificate (EPC) registers.

An EPC certifies how energy efficient a building is and gives it a rating, letting the user be aware of how costly it is to get the right thermal comfort. Data from EPCs, if properly collected, archived, managed and analysed, can provide precious information and complement other sources for decision making on the energy performance of buildings. Much wider access to, and affordability of large scale data handling technologies (the "big data revolution") makes possible the presentation of this data in accessible ways for policy makers and market actors. Intuitive analysis for predictive insight is spreading nowadays, and a number of dedicated services and open platforms are available, even in the energy sector. But to what extent do new data services overcome the barriers to the development of the market for home energy efficiency? The Request2Action (R2A) Intelligent Energy Europe project is being delivered principally by national energy agencies responsible for managing EPC databases. The project aims to drive retrofit action in the residential sector by addressing the knowledge and capacity building barriers making retrofit data available to home-owners, the supply chain and policy makers in new and dynamic ways. This paper focuses on if and how the different market actors respond to the new information being made available. Within the R2A project hundreds of stakeholders in 8 countries collaborated in providing specifications, information and evaluation that are essential to guarantee effectiveness of the data services, according to modern product-service systems (PSS) approach, providing customers value and functionalities to fulfil sustainable goals. Hence a detailed evaluation of the stakeholder response to the big data tools has been developed. Using the quantitative and qualitative data collected, our paper takes into account the value of new data tools in stimulating the retrofit market. Do manufacturers and installers need address-level data about the energy efficiency of homes, or can they find a market without this additional data? How can this data drive a more evidence-based approach to policy making? For home owners, does better data about the comparative energy performance of their home drive higher uptake of financing or incentive programmes?

Introduction

Good data are needed to enable decisions on the energy use in the building stock. To this purpose, the new EU Building Observatory and several EU projects (EPISCOPE, ZEBRA, ENTRANZE) have collected relevant information. In particular the Intelligent Energy Europe (IEE) Request2Action developed new and inedited services in the participating Countries, that can make building energy performance, building features and installation data available to the supply and demand side market actors, thereby driving retrofit action. National and regional energy agencies have access and expertise in EPC data. Through this project agencies have used that expertise to set up

services to provide accurate, trustworthy building performance data improving insight. These services are developed as stand-alone tools or integrated tools within retrofit action websites (R2A Hubs) that will serve as an online market place to connect demand and supply side actors as well as online energy performance monitoring platforms. Such 'one-stop-shops' are particularly recommended, not only as information providers but also as energy renovation facilitators, bringing together all parties needed in the renovation process to ensure quality (I. Artola, K. Rademaekers, 2016).

To this extent, a methodology was developed following the product-service systems (PSS) approach. PSS represents an evolution of traditional generic and standardised services towards targeted and personalised ones, aimed at satisfaction of the users. One of the characteristics of this approach is co-creation with the potential users, in order to attract and retain them as active contributors to the service performance. (G. Vasantha, R. Roy, A. Lelah et al., 2012).

To take forward that co-creation process, the partners, eight energy agencies and a research institute developed, coordinated and facilitated stakeholder engagement at regional and national level. Ad hoc guidelines on mandatory topics to deal with, procedures, and feedback questionnaires were provided to Partners in order to standardise this process getting comparable results. The engagement methodology consisted of six steps, when the consultation strategy and rules have been established, the key interlocutors have been identified, the engagement plan have been defined, engagement sessions organized and performed and the overall process evaluated.

The stakeholders were consulted using qualitative and quantitative research methods to assess how they perceived the value of R2A data service concepts for their businesses and to co-create them. Integration of existing products/services, development of support functions, collection and storage of data from stakeholders, definition of business models, were carried out during the data-services design and development phase.

Stakeholders are engaged again - once the services had been completed – to validate and use the services.

The interaction between the PSS methodologies typical dimensions and the stakeholder engagement methodology can be found in Figure 1.

Stakeholder engagement in the PSS design and development phase was mainly "performed" through two series of workshops (input and integration to and evaluation of the R2A data-services). The evaluation phase is still in course. So far the number of consultation workshops (52) exceeded that established at the beginning of the project (18), proving the interest from stakeholders and the importance of their active participation for the partners.

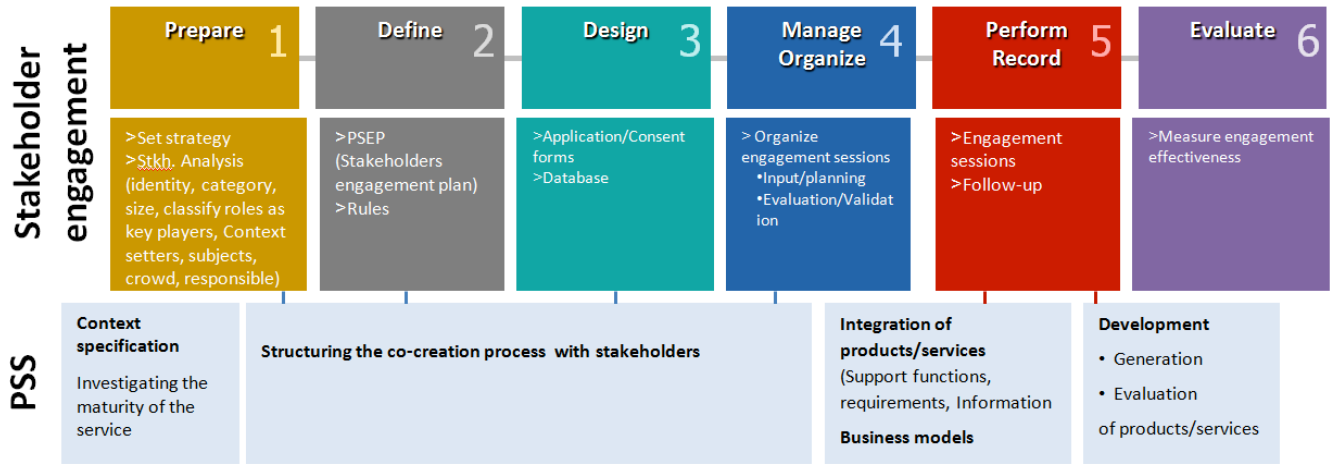

Figure 1. Stakeholder engagement in R2A compared to typical PSS methodology.

Table 1. Stakeholder engagement in R2A data-services development/evaluation.

Stakeholder Engagement (phase 5) in the PSS "design and development"		
Planning / Input Properties derived from customer's value		**Evaluation**
✓ Share and debate existing best practice ✓ **Provide input and specifications**		✓ **Assess, evaluate and validate**
Data tools	Retrofit Hubs	Data tools and Retrofit Hubs
Austria, Italy, Slovakia, the Netherlands, United Kingdom	**Belgium, Greece, Italy, Portugal, United Kingdom**	**Austria, Belgium, Greece, Italy, the Netherlands, Portugal, Slovakia, United Kingdom**
41 WORKSHOPS performed (only 9 were mandatory)		**11 WORKSHOPS performed and others** to be performed by May 2017 (only 9 were mandatory)

The workshops with the stakeholders resulted in specifications, relevant information and feedback to functionalities, outline and presentation of R2A building performance data services, thus guaranteeing their consistence and effectiveness once operating.

Request2Action services: co-creation with stakeholders

Across all countries involved in the R2A Project, 324 stakeholders, including associations and federations that count hundreds members, have been engaged in the R2A data-service development through a PSS co-creation process. Input workshops on building **data-tools** have been attended by some 111 participants and 94 stakeholders. Figure 2 presents the various stakeholders engaged.

16 stakeholders declared they were willing to share data/resources and almost all of them were interested in future workshops on similar topics. Input workshops on **retrofit Hubs** were attended by 273 participants and 230 stakeholders. In both cases 60 % of stakeholders initially engaged declared they find the information useful for their daily work. The evaluation workshops are still on-going and a new appreciation is to be quantified. There was a high appreciation of the way the consultation has been led, notably facilitation, documents, presentations, insight provided by R2A partners. Records and minutes from quite all engagement sessions have been produced and circulated between the participants; some of these reports were published in the partners' websites. Some of the stakeholders signed agreements with R2A partners for the support, use or integration of the services.

Stakeholder engagement contributed to fix key requirements of R2A data-services, replying to the following questions: What EPC information is used to monitor retrofit? What is the added value of using EPC data for planning and decision making? Which additional data are needed and have to be integrated to get wider use of EPC databases? What is the recommended user interface/data format? Are comprehensive renovation one-stop-shops/platforms already in place at local/regional/national level? Which characteristics are needed for effective renovation HUBs?

DATA TOOLS

In these kind of services, basic data (property number, issue date, type of building or components, type of heating and cooling systems, etc.), output of energy performance calculation (heat & cooling demand, hot water heat demand, primary energy demand, CO_2 emissions), technical services characteristics (energy resources including renewable ones, energy and hot water supply, etc.) from EPCs were combined with other data, e.g. from flat census or property registers (cadastres): addresses, geo-coding, building function, construction period, geometry (height, floor area, covered area, number of floors, utilisation units).

The aim was getting added value from use of building data. In different regulatory and market contexts the process led to particular serviced.

In order to monitor building retrofit in **Austria**, available information from different province sources (including regional EPC data) was combined to the klimaaktiv national declaration system, issuing certification of energy efficiency, good design, and execution, material quality and comfort, within the Austrian Federal Climate Initiative. For this purpose AEA agency cooperated with an EPC-software provider and the host of the klimaaktiv platform.

Access to the service, allowing analyses and comparisons all over Austria, is now given to market actors and different provincial governments to uptake holistic and tailor-made expert advice within the klimaaktiv scheme. (Figure 3).

Local authorities (Styria, Salzburg and Carinthia, Vienna), ÖGUT, the Austrian Society for Environment and Technology directing specialist partners under the programme, and research institutes contributed to the coordinated service providing information on existing data, specifications for elimination of redundancies, suggestions on integration requirements of the klimaaktiv standard (e.g. connection between costs and energy efficiency measurements and use of geo-referenced information). The co-creation process resulted in a win-win situation: harmonisation and improved data management and promotion of the standard nationwide.

In order to improve insight on energy performance of the building stock, **Italy** undertook the harmonisation of regional EPC systems through the consultation of managing authorities. A new harmonised system (SIAPE) will produce statistics on raw and aggregated open data, allowing consumer's but also policy makers' awareness. Moreover, interoperability of the EPC registers with other databases has been investigated. To this extent, ENEA mainly collaborated with IlSpa, the Lombardy in-house energy agency that has a long-lasting experience in managing the regional EPC register, - a nearly 2 million EPCs totally open database. This data was already combined with the cadastre of building technical heating systems and the ground source heat pumps cadastre into a wider information

Country	Building owners	Energy Agencies and Advice	Policy makers and Local Authorities	Representatives of tradepeople and professionals	Universities and Research	Investors and developers	Trades people and professionals
AT		4	3	4			1
BE			1			2	50
EL	3		4	13			25
IT	1	11	8	21	1	2	1
PL		6	4	6	4	1	2
PT	1	7	3	10	1	1	
SK	2	2	55	7	3	1	
UK	1	2	2	11			29
NL		1			1	6	

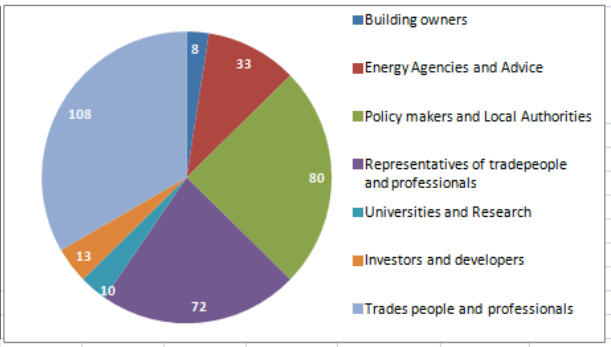

Figure 2. Consistence and distribution of the stakeholders engaged in R2A data-services.

system for energy and environment (SIRENA20) that feeds and updates the regional energy balance, the emission monitoring system and supports energy policies. The brainstorming in the project demonstrated that consistency of EPC data and interaction with other territorial data were missing. Moreover, a simple visualisation allowing user friendly access from local authorities and private actors was needed. Thus, ENEA developed a tool (named DIPENDE) based on integration of EPC data with the national Census and building renovation incentives data, establishing a relationship between estimated energy performance in EPCs, recent systems and materials installation , climatic and social data. The database is made of nearly 70 records on 1,500 municipalities and more than 105,000 data and. The information was aggregated at municipal level and released in tables, graphs, maps. Main specifications settled through the PSS process concerned: interoperability of the datasets that imposed the chosen scale (retrofit and installations is available as an average at municipal level so far), standardization of the analysis and setting up relevant queries and easier-to-interpret categories. The tool will be accessible from the R2A Hub ("Portale4E").

Figure 4 shows some pages of DIPENDE tool.

Other regions are interested in such an insight tool to characterise the building stock, estimate retrofit trends, and select

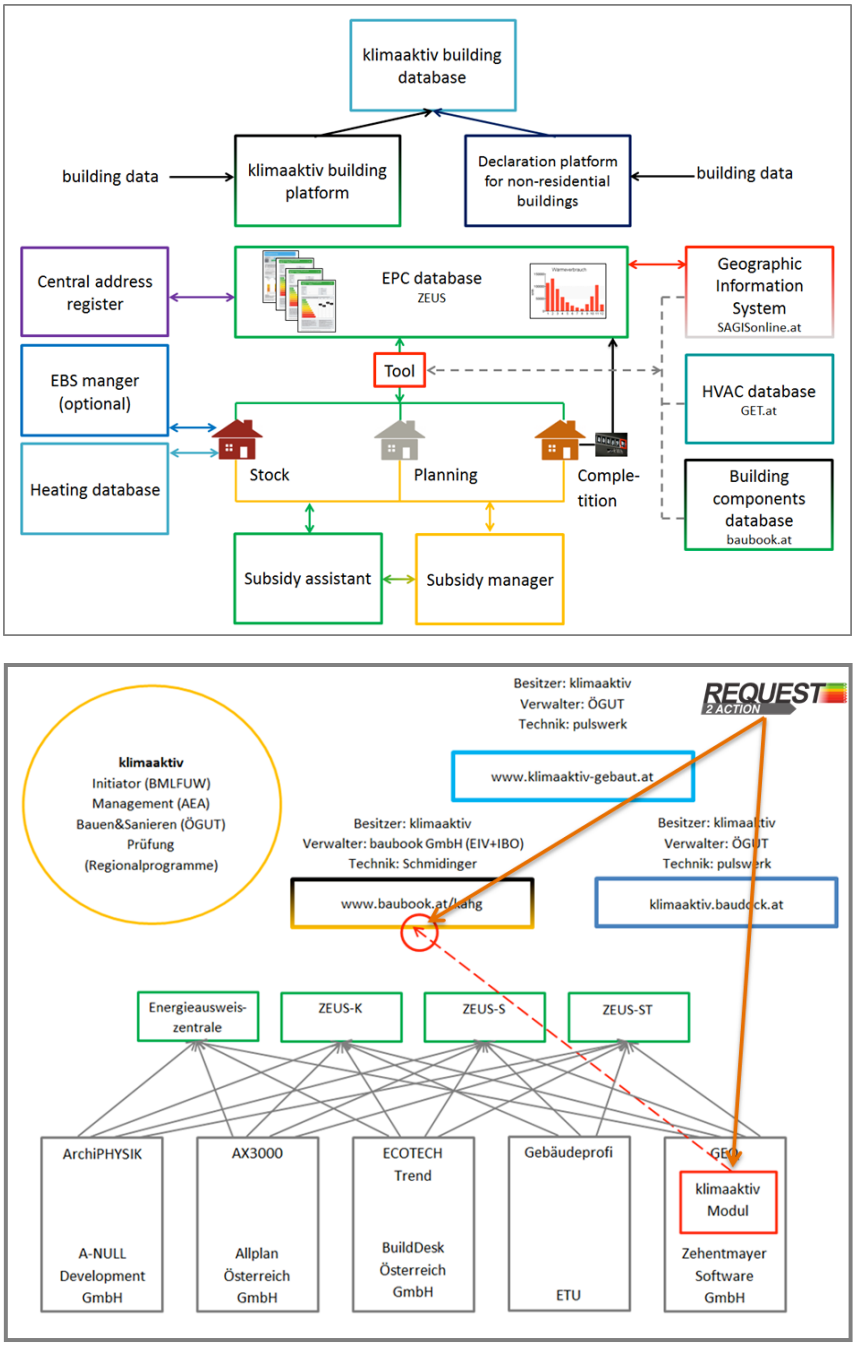

Figure 3. The datasets and tools integration in Austria.

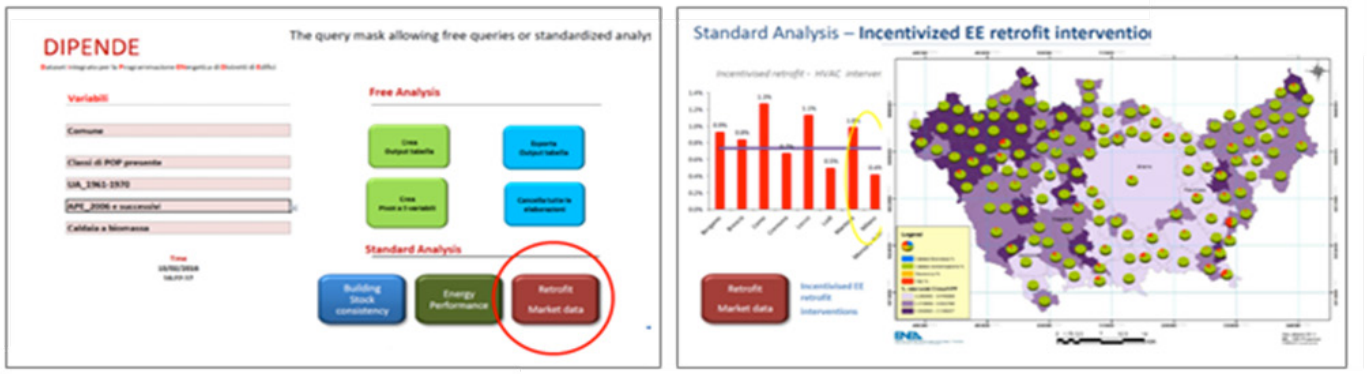

Figure 4. The R2A Integrated data-tool for regional/district energy planning in Italy (named DIPENDE).

priority areas to support renovation strategies. The new regulatory framework (EPBD-related decrees in 2015) can endorse wider application.

Enterprise Agency (RVO) in the **Netherlands** currently supports consortia of local authorities and market actors to improve the performance of dwellings adopting new ways of financing. RVO also manages the central EPC database and is involved in several national revolving funds. Banks and financiers were engaged to explore reputation of the EPC to the aim of providing independent advice to homeowners on how to use their savings to co-finance energy efficiency measures and issue loans. Beyond the present on-line information to the owner, a new "budget planner" on the website was suggested to inform homeowners on available financial products to uptake energy efficiency measures.

The Slovak Innovation and Energy Agency (SIEA) worked with the Union of Towns and Cities of **Slovakia** (UTCS). 55 cities that adhere to the Covenant of Mayors have asked support in developing and handling data on energy performance and building retrofit roadmaps. A detailed questionnaire filled by these municipalities and the following discussion during the Request2Action workshops evidenced specific shortage of information (e.g. energy performance of buildings and their components, number of retrofits or NZEB) that can be solved by using EPC data owned by SIEA.

In the **United Kingdom** (Scotland), the Energy Saving Trust (EST) managing the EPC register for Scotland, already provided data to local authorities. EST adds value to the EPC data by cleansing it, addressing erroneous records and systematic biases in the register and by statistically modelling an EPC value for those properties that do not currently have a real EPC. EPC data are combined with 10 other datasets to create a comprehensive, reliable, up-to-date profile for 100 % of properties in Scotland. Geo-spatial modelling on property type, roof orientation, building size, garden size and other variables have been used as input to feed further analysis (e.g. renewable energy resources potential).

Through an arcGIS geographic information mapping and analytics software the local authorities are able to see at address, community or whole-region level the energy performance of their building stock. As part of the R2A project, EST developed a new service to provide the EPC data to the Scottish supply chain taking advantage from similar techniques to those already used with the local authorities. The data provided enabled companies selling energy services to identify which homes in which area will benefit from different energy saving measures. This new supply chain service has now been integrated into a new Scottish home energy data hub ("the Local Homes Portal") which provides EPC and other data to householders, supply chain actors, local authorities, community groups, researchers and national policy makers. The web maps allow comparing the energy efficiency rating, energy consumption and carbon footprint of their homes to the average home in the same area. The data in the maps is aggregated at the data zone level. This geographical boundary usually contains between 500 and 1,000 homes, identified by the postcode or council, and avoids privacy problems linked to eventual door-to-door selling. Figure 5 shows the Scottish data tool.

During the project workshops different stakeholders gave different views on the proposed services being developed. Supply chain views on the value of the new data services were mixed. Supply chain actors felt that the new data added little to their existing knowledge of the market for their products. At the same time the local authorities have found the maps very valuable. A key issue in Scotland has been the granularity of the data which is determined by the permission to access data for different types of stakeholder given by the Scottish Government. While local authorities are allowed by the government to access data to address (individual building) level, the Government only gave permission for EST to release data to consumers and the supply chain at local community area level (clusters of homes).

RETROFIT HUBS

Comprehensive online services to building owners, investors, suppliers, policy makers on how to act on building renovation, find aggregate demand, display offer, are estimated extremely useful to overcome the awareness and knowledge barriers, judged, together with the financial ones, the main obstacle to a higher renovation rate and depth in Europe (BPIE, 2016). Most of R2A countries had no similar services in place. Results of co-creation of the new services with key actors in the different countries are illustrated below.

In **Belgium** EPC data is not publicly available. To this extent, VITO combined existing housing stock and energy performance data in the **Flanders** with information acquired directly from homeowners. A renovation platform has been developed in consultation with several cities and distribution system operators – DSO (refer to Figure 6). Households accessing the

public website declare the state of their homes and their intentions regarding refurbishment. Cities and DSO can visualize the data in a geo-related map at building level and area level (block, district, city, region, etc) and derive useful statistics using different filters and features.

Involved cities claimed to embed the R2A hub components into their websites. The possibility to visualize other geo-referenced data was requested in order to monitor municipal housing and energy efficiency policy programs (targeted subsidy schemes, priority neighbourhoods, etc.). The platform was evaluated useful to track progress on an annual basis and improve policy making. Data confidentiality was a point of attention which is carefully observed in the private and public sections of the hub.

In **Greece** and **Italy** the R2A hubs were developed as new and unique market places to connect demand and supply side actors as well as a meeting place and advice resource for refurbishment activities, in response to the lack of knowledge from consumers on the potential savings and benefits from energy efficiency in buildings. "EnergyHUB for all" aims at increasing trust and establishing a good reputation for the EPC systems among building owners, tenants, suppliers and other market actors. Information on issued EPCs, energy categories statistics, energy data on type and age of buildings at a regional level is provided (see Figure 7).

In both countries, the hub was welcomed as unique in its kind. A wide range of actors (see Figure 2) have guided the design of the content, layout, and structure of these websites. Most of them evaluated good examples of building energy renovation, innovative energy efficient technologies and access to EPC analytics as priority issues. Initial stakeholder feedback in Italy led to a restyling and further content on nearly zero energy Buildings, deep renovation, and financing.

Manufacturers' associations and service/product suppliers are committing to build durable supporting networks. On return they benefit from visibility and marketing. A Home Energy Check tool, giving advice to the homeowner on the energy performance comparison and potential of their homes, is embedded in both the hubs and is estimated to stimulate 1 % homeowners to take action on renovation.

After a year from the launch (Dec. 2016), "EnergyHUB for All" has more than 6,440 unique visits and 13 official supporters from the building market, government and local authorities, NGOs for sustainable and energy efficient buildings, energy consultants, and the technical press. Six national associations signed agreements with CRES to contribute to technical information and best practices. In the blog area of the Greek Hub, they can also provide advice to homeowners under CRES's auspices. Research institutes, energy magazines, ESCOs are interested in contributing too.

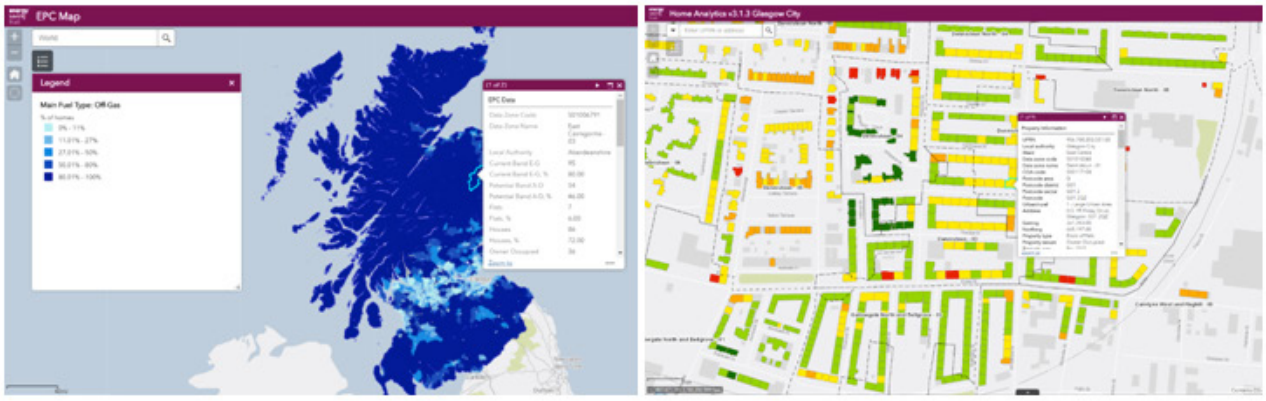

Figure 5. The EPC based data tool in Scotland targeting home owners, local authorities and trades-people.

Figure 6. The public website (for households) and a municipal users' website in Belgium.

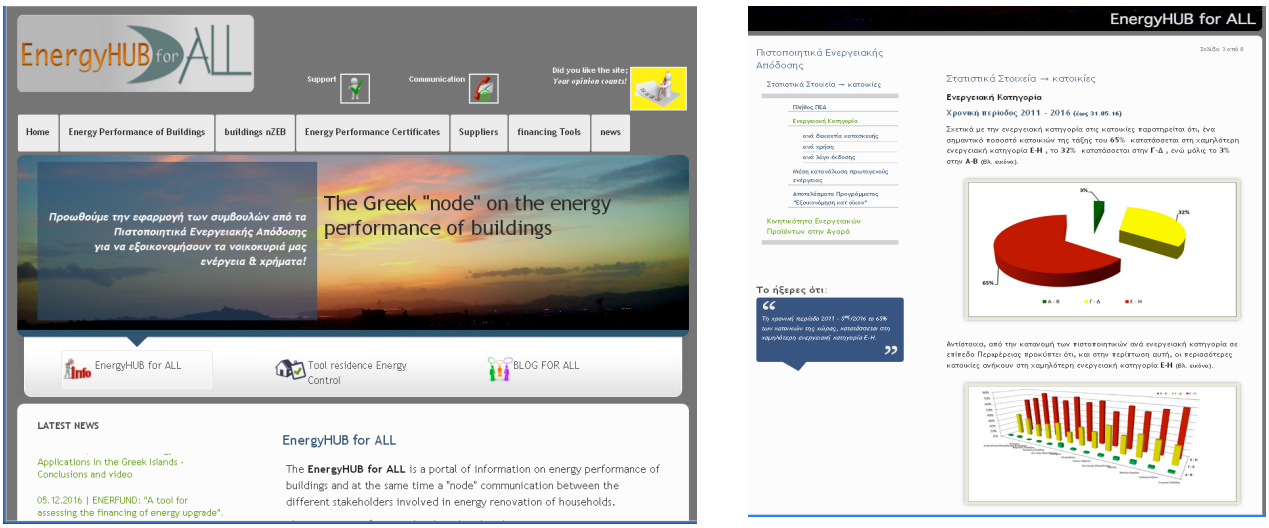

Figure 7. The R2A "EnergyHUB for all" Hub in Greece.

In **Portugal** ADENE manages a central registry with more than 800,000 issued EPCs. The new data service will focus interaction with the homeowner to get an update on new retrofits. A Hub will be created engaging homeowners to report on new retrofit measures in their houses, give feedback on installation quality and to interact with the supply chain. Thus, the hub should improve consumer's trust in service providers and promote the quality of works through marketing of accredited and qualified experts and suppliers, that should guarantee the economic sustainability. The consultation involved key associations from the supply chain, the financial sector (banks, insurances), and consumers' associations. Sector associations and parallel accreditation schemes are presently establishing criteria for the selection of installers/companies to be part of the platform. Installers, manufacturers, banks, companies seem to be willing to assure sustainability of the Hub by paying fees on advertisements. Some municipalities committed in creating an area of access to EPC data, aimed at local energy planning. Consumers could have a role in tracking implementation of retrofit actions, by supplying data through the web, and evaluating construction works and energy experts: a market study conducted through 650 telephone calls to householders confirmed their agreement to register improvements made after the EPC issuing. According to the survey this should preferably be reported by the same expert who updates the EPC. A reduced cost for this update should be guaranteed to promote reporting on the implemented EE measures.

LESSONS LEARNED

In spite of the existing efforts in Europe for collecting and provide access to building data, good quality information is still needed. EPCs are a unique source of data for planning and decision making, but searchable databases and data mapping need to be more accessible and therefore more worthwhile, first of all for policy makers and investors. The rare information currently displayed is the building energy class. Other reliable data on performance of the envelope and of the technical systems, estimated consumptions and building features (type, occupation, owner, age, …) embedded in EPCs should be displayed too. Use of EPCs and integration with other datasets like heating and air conditioning inspection data (EPBD art. 18), governmental buildings data and existing building stock (EED art. 5, 4) is already practiced in a few MS. Integration of different existing datasets (Census, inspections, Cadastre, incentives, gas registers, energy networks, bills, revenue agencies, etc.) could have a wider use but it is technically difficult and costly.

The main limitations are due to regulatory and juridical framework stiffness in ministries and regional governments (EEPPA 2015). Moreover, access to EPC data should be provided in a user-friendly and targeted way. Targeted communication for different stakeholders is extremely important for an effective use. Different solutions were developed within R2A pilots: tables and GIS, web-tools able to inquire databases (IT); maps and GIS (BE, UK Scotland). Indicators derived from EPCs that can link costs and effectiveness of measures are particularly recommended by the stakeholders. The issue of available actual data rather than common EPC calculated data is also a main concern, since guarantees and risk analysis should rely on trustable information.

The private sector would find value in the data to establish marketing and business strategies – but some risks are associated with this, as it was analysed at different levels in R2A countries. Reactions are quite different in countries like Italy and the Netherlands (where market actors independently developed GIS tools from public data) and Scotland (where private sector access to the data was restricted to aggregated data on the decision of the government). Data services developed by the project should be coupled with various services provided by local authorities/cities and by third parties at local level. Data consistency and quality control, interoperability of different databases could be an outstanding barrier as well as privacy issues in the case of data displayed at address level. The neighbourhood or district level have to advantage to overcome this problem. The reliability of information from households, but also from experts, is a main concern in some cases.

EPC data in their raw format are generally incomplete. Raw EPC data are mostly out of date and finally not helpful for local authorities. In order to add value to information embedded in

EPCs further data is needed to attract and deliver supplier obligation funding (e.g. Scottish ECO) and government funding, to pro-actively target fuel poverty, to develop effective long term strategies to tackle building retrofit. Use of statistical modelling is needed to accurately predict energy performance of houses that have no EPC (the majority in EU MS), based on fuel type, floor area, construction. Known datasets at the area level (e.g. Census) can be used to calibrate the address level results.

Access to data service from private entities is often impeded by privacy issues: that is the case for Scotland, where a concern on the impact of making data available to the private sector suggested limiting access only to those organisations contracted central or local governments or registered social landlords to carry out domestic energy efficiency related projects. Datasets, in facts, seem to be used only by the larger organisations where there is a need for strategic planning. On the contrary, most of the supply chain actors are one-man-band installers. Online data-services could even harm competitiveness and development of the market. Quite a different approach was adopted in Lombardy region where the digital agenda implementation made the whole EPC dataset completely public at address level. No complain to date has been registered and the database has been adopted from private associations (e.g. developers) to build up services to their members. Increased integration with less accessible datasets is needed in this case.

Stakeholder consultation suggests that where public authorities do not systematically collect energy data, EPC data disclosure is judged extremely useful to improve knowledge and decision making at urban, district, regional level.

Data cleansing and improved characterisation of the building stock are time and resource consuming tasks need support from agencies, interested in wider analysis.

Conclusions

Wider use of EPC data can help understand the housing stock, monitor EE progress and develop strategy, but it is not a common practice. A European action to provide large data related to current energy performance of a house and possible energy retrofit measures is presented in the current work. This action incorporated the development of databases -containing both known records and modelled data on the whole building stock, - and of web oriented applications/ services, so that they are very easily accessible and can attract more users to support energy efficiency measures. This attempt was reinforced by the contribution of relevant stakeholders through a PSS approach.

When engaging stakeholders in R2A pilot projects, partners initiated, managed, performed and evaluated two-way dialogue seeking understanding and solutions to mutual concern on optimised data on building performance and renovation. A common product service system (PSS) and stakeholder engagement methodology provided a benchmark for the quality and effectiveness of the data-service co-creation process in the different R2A countries. Lessons learned from stakeholder consultations resulted in further refinement and evaluation of these services.

Access to R2A data-service is needed mainly from policy makers at different territorial levels (municipalities, regional governments and agencies) and representative bodies of trades people. For the first ones, the aim is: monitoring, building energy performance code implementation and energy planning. Collecting and integrating data aimed at drafting SEAPs within the Covenant of Mayors initiative appears to be particularly interesting for cities. The address level data is adequate for urban planning while data aggregated at municipal level seem to be advisable for the bigger scale of provincial and regional planning.

Enterprises, distributors, providers, investors could spot areas for potential deal. Larger trades or corporations would access data to expand and develop their business or to provide targeted services to their members. Visualisation of data aggregated at the zone level (e.g. 500–1,000 buildings or postal code, like in UK) is recommendable in this case, in order to avoid door-to-door selling and data privacy concerns. On the contrary, interest from single trades seems to be low: the supply chain, in many EU countries, is dominated by small companies (1–5 persons) who operate in small geographic areas. Their leads are based on words-of-mouth or localised advertising rather than on data analysis.

User-friendly Home Energy Checks (HEC), that, with a very few inputs (average six), can provide house owners and occupants with comparative information and advice can convince households to act on renovation, provided that HEC are linked to available national incentives.

There is a general interest in easy-to-interpret data for decision making on energy performance, as literature confirms. Interfaces/data format (indicators, web-tools, aggregated/address level, GIS (geo-coding)) vary with targets, as explained above.

Meeting platforms matching supply and demand in a one-stop-shop are welcome. Between requirements for data-service based platforms:

- create trust (data on quality and skills of advisors and installers)
- evidence reliability of data and impartiality of the insight
- appealing ad-hoc graphical interface and targeted information
- clear rules for access and data sharing (i.e. clearly distinguishing public and restricted areas)
- reference to other related hubs (e.g. municipal websites)
- display market trends and innovation opportunities

Liaising with key stakeholders also allowed for exchanging international and national best practices focusing market barriers for home energy efficiency. Finally, the performed consultation has the potential – as well as to gather the data we needed for the project - to generate long-lasting networks focused on energy and low-carbon renovation of buildings and using the R2A data-services. Beyond assessment of the value of new data services stakeholders engagement resulted in increased understanding of the market by Partners, further data collection, and in-kind contribution, commitment for collaboration in the development and integration of similar services.

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