The Building as the Cornerstone of our Future Energy Infrastructure

Outcome of the DYNASTEE SYMPOSIUM in Bilbao, Spain, 10–11 April 2019

HANS BLOEM
DYNASTEE - INIVE
Lozenberg 7, 1932 St-Stevens-Woluwe, Belgium
Corresponding author:
hans.bloem@inive.org

LUK VANDAELE
DYNASTEE - INIVE
Lozenberg 7, 1932 St-Stevens-Woluwe, Belgium

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The DYNASTEE network (www.dynastee.info) took the initiative to organise a symposium, following the 6th Expert meeting of IEA EBC Annex 71 at the University of the Basque Country in Bilbao. The aim of the symposium was to discuss the future role of the building stock in a changing society facing the climate challenges for companies, governments, researchers and most importantly, the citizen. Seven international renowned experts were invited to present their view on the energy transition and the development of an energy infrastructure integrating information and communication technologies and renewable energies in the building stock. In this context the speakers were asked to address the importance of dynamic and real data for reliable assessment. Two IEA EBC Annexes were invited to present the status of their research project. The selected topics for this symposium are related to monitoring, data analysis and modelling, energy standards, the gap between design and real values of energy performance of buildings, renovation of the huge building stock and integration of renewable energy resources. Interesting questions were raised by the audience and discussed by the experts. Will a carbon free society be feasible using innovative technologies? Will the greenhouse gas emissions and final energy consumption be reduced while maintaining the standards of living and working? Are citizens aware and willing to pay? Will it be feasible to adjust the present building stock to the requirements set by the political targets of reducing GHG emissions? Are the variable energy resources like wind and solar power giving the security of energy supply?

In the transition towards a new energy system, based on minimal carbon use and circular economy principles, the building is the cornerstone of the future energy infrastructure. Energy use in European buildings is still around 40% of the total final energy use. Decarbonisation of power and heat are high on the agenda of EU Member States. Present initiatives by governments for a proper energy transition are based on reducing energy consumption, increased use of renewable energy resources and making the energy infrastructure more intelligent measured with the Smart Readiness Indicator, (SRI) as mentioned in the Energy Performance of Buildings Directive (EPBD). Presently, the major part of final energy in buildings is heat. Soon, these needs will be converted more from (renewable) electricity. The energy transition should be a play between governments, industry and end-users.

Often not considered, the citizen should become at the centre of the energy system; from passive consumers to engaged energy customers. For that purpose, digitisation is essential, enabling monitoring and control of optimised energy use for a comfortable living and working environment.

The energy infrastructure needs to address the balancing for energy at different levels (transmission system operator (TSO) and distribution system operator (DSO)). The energy markets play an important role in managing the flows of energy in multi-directions. However, the level of balancing between the building end-user and the climate is not often carefully considered. Also, the energy flow between buildings and the energy networks will become more and more multi-directional. Buildings will have to become flexible and produce energy: electricity that is partly delivered to the grid, and heat that is stored in the building or underground. The near future may see more self-consumption in buildings, including the electricity stored in electric cars. One may conclude that buildings in which presently 40% of final energy is consumed, will take a more prominent position in the energy infrastructure.

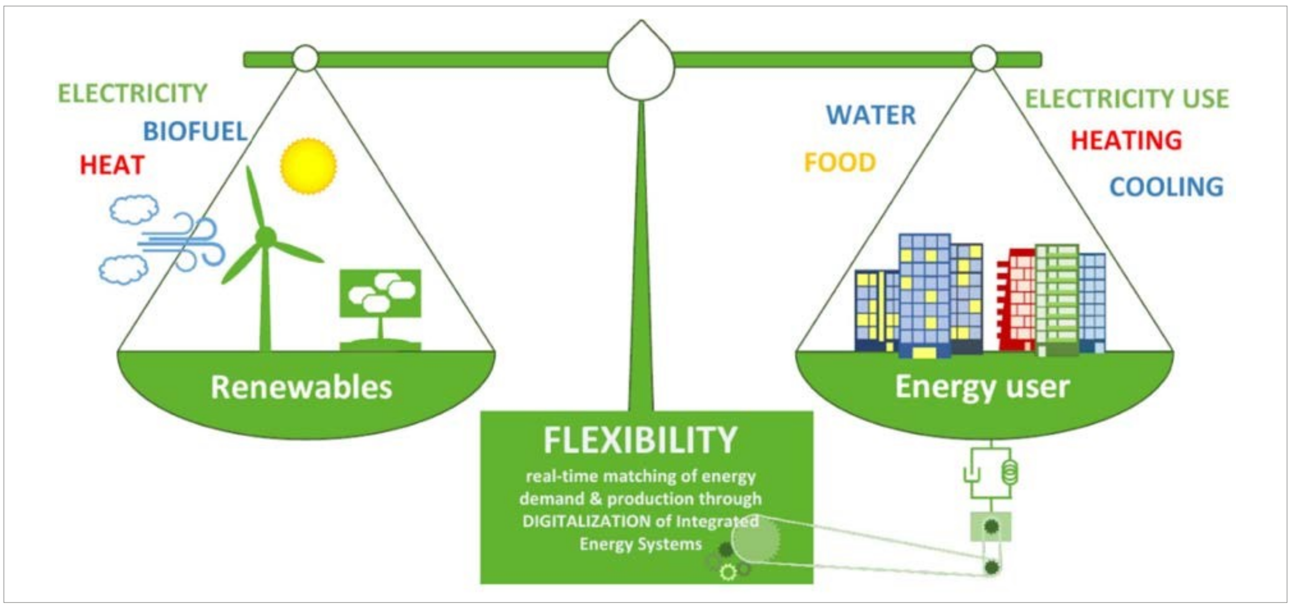

Figure 1. Source: DTU – Flexibility issue.

EPB CENTER

Example of national choices
from EN ISO 52016-1

- Main choice is between hourly and/or monthly method (choice may differ per category of buildings)

A.3 Selection of main method

Table A.2 — Choice between hourly or monthly calculation method (see 5.2)

Type of object and/or application	.....[b]	.....[b]
Description	Choice [a]	Choice [a]
Only hourly method allowed	Yes/No	Yes/No
Only monthly method allowed	Yes/No	Yes/No
Both methods are allowed	Yes/No	Yes/No

[a] Only one Yes per column possible.

[b] Add more columns if needed to differentiate between type of object, type of building or space, type of application or type of assessment. Use the list of identifiers from ISO 52000-1:2017, Tables A.2 to A.7 (normative template, with informative default choices in Tables B.2 to B.7).

Figure 2. Source: EPB Center – Example of national choices.

Summary of presentations and forum discussion

Energy standards and modelling techniques

Recently the EPB Directive 2010/31/EC, has been revised (2018) and related energy standards are updated (CEN/ISO). The use of EPB-standards for calculating energy performance, as well as for energy performance certification and the inspection of heating systems and boilers, ventilation and air-conditioning systems will be harmonised and have a positive impact for energy saving solutions. The EPB Center supports the implementation of these standards in national regulations. The modular structure of the set of EPB standards offers flexibility for specific applications at national and regional level by means of the national Annex. The assessment of the energy performance of a building, as required by the EPBD, is related to a single building (or building unit) and requires an energy performance certificate, expressed in primary energy. The EPBD links directly to standards for calculation as well as measurements when it concerns performance assessment. The EPBD addresses new, as well as renovated buildings. The EPB Directive mentions in article 2:

The 'energy performance of a building' means the **calculated** *or* **measured** *amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting.*

Figure 3. Source: CityGML – Building Level of Detail.

Figure 4. Source: CARTIF – CityFied project.

Developments of a third, more **holistic** assessment approach are presented in several projects, based on administrative data and the application of reference buildings (which are measured on-site for that purpose). Whereas the EPBD deals with *individual* buildings, buildings have to be considered as part of urban areas or cities and will have a more important place when energy demand and production is concerned. The Energy Efficiency Directive (EED) addresses this issue also. Several international projects are studying the urban area in terms of infrastructure (roads, underground, water, etc.) as well as energy (production and load). Modelling software is developed in a very sophisticated way and uses modern techniques for planning and assessment. CityGML is regarded as a very powerful IT environment to develop the necessary software tools putting the building in the urban environment while taking advantage of innovative technological developments. As an example, the Sumstad project presented a dynamic model for heating and cooling demand at district level.

However, the major part of the energy standards are calculation techniques that are based on mathematical models and these are by definition, a simplification of reality. Validation of these models requires measured data and specific analysis techniques.

Renovation of buildings is key to meet the EU's energy efficiency targets. Recent revisions of the Energy Efficiency Directive and the Energy Performance of Buildings Directive address this issue. Much of the European building stock is in need of renovation (estimated about 50% of 210 million buildings) however, both relevant Directives define 'renovation' in an ambiguous way. The EED defines 'deep renovations' in a very broad way, as "renovations which lead to a refurbishment that reduces both the delivered and the final energy consumption of a building by a significant percentage compared with the pre-renovation levels leading to a very high energy performance". Renovation of the existing building stock requires a proper performance assessment in order to agree on feasible energy saving measures. The question remains always: why and when to renovate. To justify energetical and economic measures, practical and reliable methods have to be developed. Most of the measures are focussing on reduction of energy demand as well as optimising the efficiency of energy systems. However, as made clear during the presentation on the European CITyFiED project, the users – citizens – should always be involved in the decision-making process in order to understand and value the retrofitting actions and the RES integration, which is becoming more common. To this end, specific indicators are needed to justify renovation at district or urban level, which are clear, understandable to citizens, and useful to the performance evaluation.

Discussions are ongoing on the issue of the *gap* between designed and actual performance of buildings. Questions are put on the table in order to understand and reduce this *gap*. It may lead to the important question whether building simulation is ready to deal with present development in the building energy sector as well with recently reviewed standards.

Monitoring, metering and experimental measurements

To analyse and compare existing methods for the assessment of the energy performance of buildings, *dynamic measured data* from metering and in-situ measurements are required. The question if energy saving measures work in reality can only be answered when measurements are performed. The ENEDI research group of the University of the Basque Country carries out testing on building construction products and elements in laboratory as well as outdoors under real weather conditions in the LCCE laboratory. The University of Salford presented their test laboratory in which real buildings can be tested under controlled climate conditions. The new laboratory will open in 2021 and can test four homes, with and without occupants, in which modern appliances and innovative information technology can be applied to study the demand and supply of energy to the grid. In that context note that governments have emphasised that renewable electricity resources will have a prominent part in the energy transition, in the transport as well as the building sector. In practice this may result in movable and variable sources of electrical energy that may or may not be connected to the building by means of batteries (or other solutions). The Electric Vehicle (full electric, hybrid or other types) will take a more prominent position in our society for several reasons. Future buildings may therefore be equipped with electrical storage facilities and the new EH 2.0 laboratory in Salford will be equipped for testing these new conditions.

Figure 5. Source: LCCE laboratory, Basque Government. Outdoor testing.

Figure 6. Source: Salford University – EH2.0 Indoor testing.

The IEA EBC Annex 71 project presented the development of reliable methods for energy performance assessment based on in-situ measurements. Quantifying the actual performance of buildings can only be effectively realised by optimized in-situ measurements combined with dynamic data analysis techniques. Two approaches may be distinguished:

1) Co-Heating measurements on site (CEN TC89 WG13 is developing a standard) that requires specific conditions for testing in a limited period of time.

2) Metering data of electricity, gas, heat, water (regular readings with intervals ranging from a few minutes up to daily values). The roll-out of new intelligent metering equipment is at full speed in most EU countries. The advantage of metering data is that a growing amount of data is coming available and hence an improved accuracy is feasible. In order to split building related energy use from occupant energy consumption a combined statistical and dynamic method is investigated for the analysis of time series. *Validation* of the selected methods with measured data from field experiments or from metering readings (e.g. electricity, heat, gas and water) is required.

These collected data may be linked with different data sources (Internet of Things) and analysis tools to manage new domestic devices and building comfort in an energy efficient way. The Argonne National Laboratory presented the Waggle platform, an urban sensor project (Array of Things) providing environmental air quality data, to understand particular urban and environmental phenomena. The collected, huge amount of data in the cloud from a wide range of sensors, including image data, can be analyzed with advanced models and study urban mobility energy, building energy systems and building energy losses using thermal imaging and climate data.

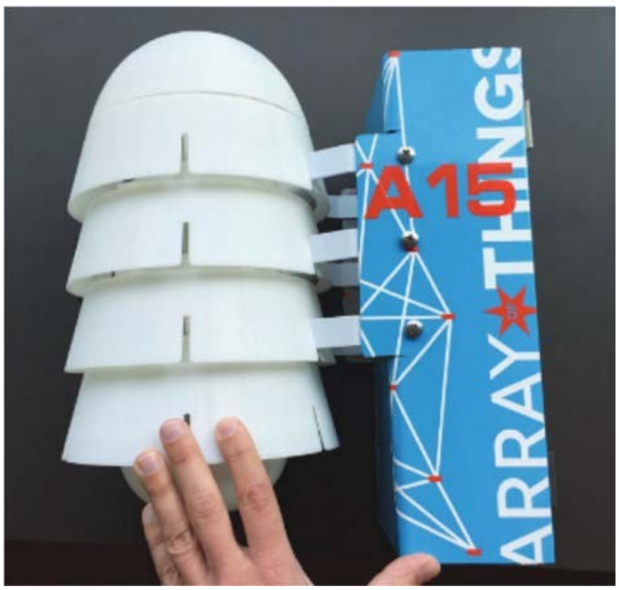

Figure 7. Source: ANL – Array of Things.

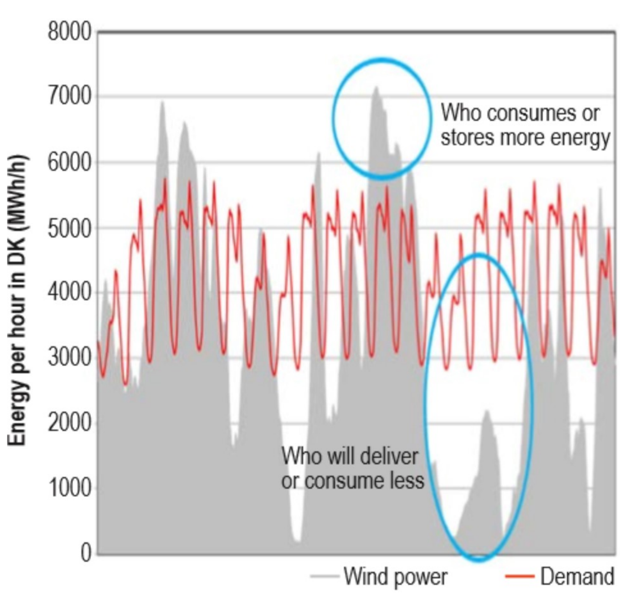

Figure 8. Source: DTI – Integration of wind energy; supply – demand.

Integration of renewable energy resources

Important to notice is the trend to move from one building performance assessment (EPBD) to district or urban levels (EED and RED) and hence the integration issue in the energy infrastructure. One of the highly interesting projects is the Danish CITIES project that covers the complex issues of applying Information Technology for the Integration of Energy Systems, in particular the variable renewable resources such as solar and wind electricity. The *Danish* government has set an ambitious target of weaning *Denmark* off *fossil fuels* by 2050. District Heat is a major component that contributes to the aim of reaching a fossil free society, through renewable energy. In addition, Denmark is one of the world's most digitalised countries. The CITIES project plays an important role in introducing the building flexibility (IEA EBC Annex 67). The Flexibility Index implies that it will be possible to design buildings, districts and cities such that they are optimized towards the local characteristics of the renewable energy resources. Results have been used on an international level to define the concepts of flexibility for smart energy systems.

Conclusions

In a final panel discussion with lively interaction with the audience, it was stressed that there is no conflict between energy efficiency and emission reductions, that flexibility and energy efficiency as a whole are more efficient on a larger urban scale, that energy poverty is an issue and energy solutions should be inclusive for all citizens. Pricing of energy and CO_2 is an important instrument. And the massive use of sensors should take account for the acceptance by the users and the own energy use. Finally, there should be a balance between investments in energy efficiency of the building and the energy system based on renewable resources.

The symposium discussed several aspects of the energy transition and challenges that may be faced. The need for real measurements to give evidence for justifying renovation, to make integration of renewable energies feasible and to manage the balance of energy demand and supply at the building and urban level. The very interesting presentations highlighted the innovations and strategies that the future energy infrastructure may see using the building stock as an essential part of the energy transition. ■

Speakers and Presentations of the DYNASTEE Symposium, 10-11 April 2019, Bilbao, Spain, please see www.dynastee.info for overview and download of all presentations.