Next-Generation Energy Performance Certificates. What novel implementation do we need?


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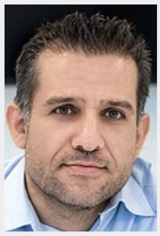
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Abstract: This study performed under the H2020 project "Next-generation Dynamic Digital EPCs for Enhanced Quality and User Awareness (D^2EPC)", aims to analyse the quality and weaknesses of the current EPC schemes and aspires to identify the technical challenges that currently exist, setting the grounds for the next generation dynamic EPCs.

Keywords: EPC, SRI, LCA, BIM, DT, GIS, human comfort, D^2EPC.

The novelty of the dynamic EPC

The aforementioned shortcomings of national EPC schemes urge the development of a holistic framework that will strengthen and improve the quality and application of EPCs. The former can be achieved with the introduction of novel and cost-effective approaches for assessing the energy performance of building envelopes and systems. According to the collected information, the introduction of novel aspects in the certification process and the simplification thereof, the strengthening of its user-friendliness, as well as the conformity with national and European legislations, can be accomplished using a standard collection of indicators based on a specific methodology. All upgrade needs of EPCs can be met by choosing acceptable output indicators supported their automated estimation.

New indicators

The introduction of novel aspects into the energy performance certification process in our project includes three indicators – the smart-readiness level of the buildings (SRI), human comfort-related indicators, and environmental aspects (LCA).

Smart readiness indicator. The scheme for rating the smartness of buildings was presented in 2018 in a revision of the Energy Performance of Buildings Directive (EPBD). It was established that the smart readiness of buildings should be optionally evaluated by the smart readiness indicator (SRI) [1]. According to the EPBD, this indicator reflects the building's ability to adapt to the needs of its occupants and outdoor energy infrastructure, improving its overall energy performance.

To define the smartness of buildings' services, three main functionalities of smart readiness are introduced in the methodology:

- The ability of the building to adapt its energy consumption based on the needs in an energy-efficient way;
- The ability of the building to adapt its operation to occupant's needs;
- The building's flexibility to its overall electricity demand, as well as its ability to participate in demand-response, in relation to the grid.

Within the H2020 D^2EPC project, both SRI and EPC methodologies will be included in the same calculation engine allowing, where possible, to merge these two methodologies to progress the SRI to a higher level.

Human comfort. People in developed countries spend more than 90% of their time in closed environments - buildings and transport [2]. Air quality indoors is 2-5 times lower than outdoors [3]. These values can be even lower if we consider the future effects of climate change (extreme temperatures, heat waves, heavy rainfalls, air pollution). Therefore, significant attention should be paid from researchers, businesses, and standardization organizations to the field of indoor environment quality (IEQ) [4-6].

The main indicators that assess the IEQ of a building and human comfort/wellbeing can be described by an integrated multi-comfort concept that includes indoor air comfort/quality, thermal, visual, and acoustic comfort. The indoor air quality (IAQ) examines how fresh the air is in a building and the concentration in the air of certain pollutants (e.g. CO_2, VOC). Thermal comfort provides a state of satisfaction with the existing thermal environment. Visual comfort ensures that the luminance levels are within acceptable levels. Acoustic comfort creates a comfortable acoustic environment without uncomfortable noise or vibrations.

Within the H2020 D^2EPC project, human comfort / wellbeing parameters will be measured and used in the calculation engine allowing dynamic input for dynamic EPCs.

Life cycle assessment. LCA indicators such as "energy savings", expressed in "embodied energy/m^2" and "carbon reductions", expressed in "carbon dioxide equivalent/m^2", will be included in the dynamic EPCs calculation engine. This will provide to the building design team the option

to improve and optimize the environmental performance of the building, based on changes to be integrated at the initial design stages of the building.

In the D^2EPC project, the LCA Indicators for EPCs will allow maximizing energy saving and carbon reduction of the buildings, introducing this way the aspect of building's sustainability as part of the EPC issuance process. This could speed up the transaction into NZEBs as well as control the building's energy demand, reduce carbon emissions, and enhance public awareness.

The D^2EPC project will propose additional indicators, which will demonstrate the environmental performance of buildings, for their introduction in the next-generation EPCs.

The Introduction of BIM and Digital Twin Concepts for the Next-Generation EPCs

The use of BIM technology helps to improve the collaboration of stakeholders from the design to asset maintenance phases. While BIM delivers static data, Digital Twin (DT) focuses on linking physical objects to their respective digital replicas using periodically updated (dynamic) data flow. The key features of DT are sensing and monitoring, data linkage, Internet of Things (IoT) implementation, simulation, predictions, and controls.

Figure 1 represents the definition of BIM and DT concept regarding the energy efficiency of the building throughout its life cycle stages: plan and design > produce and construct > use and maintain.

It is evident that BIM and DT overlap in the construction phase since BIM can deliver object-based data utilized for the DT.

Introduction of GIS in EPC

In the D^2EPC project and GIS context buildings are described and considered in the concept of BuildingsExtended3D, i.e. with correct geometric dimensions, proportions, scale, but not considering geolocation of a particular building. The use of geospatial technologies and accurate data location could improve the processes related to the data needed to assess the energy performance and needs of buildings and urban areas. In addition, the use of geolocation practices can increase decision-making effectiveness by different stakeholders (policymakers, technicians, citizens).

Introduction of financial schemes

Introducing financial schemes in EPC is suggested in this study. Based on the well-established principle of lifecycle costing, a set of financial indicators could be developed to allow the individual elements of buildings' energy efficiency to be interpreted into standardized

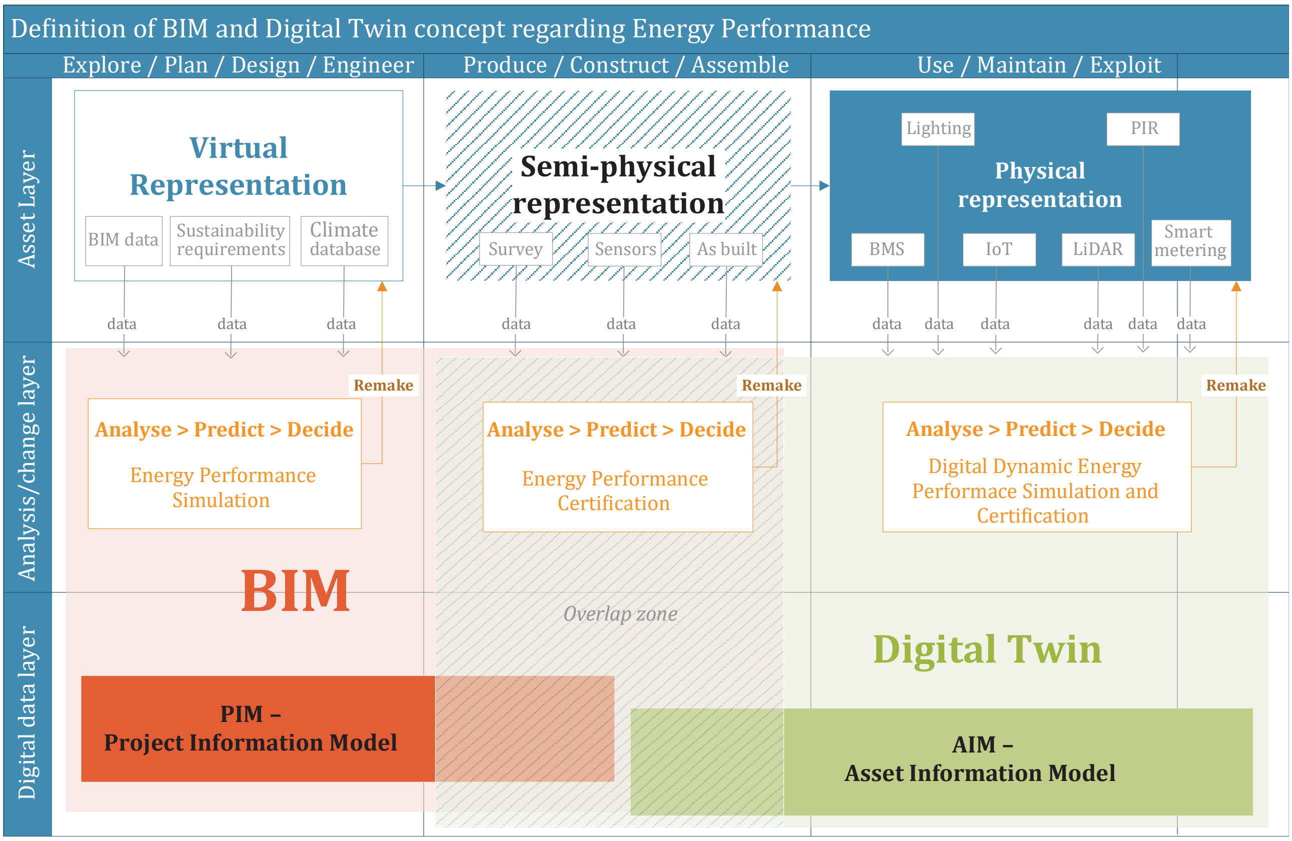

Figure 1. Definition of BIM and DT concept regarding energy performance.

numerical values. The delivery of such indicators could allow the use of EPCs for the financial evaluation of energy upgrading measures for buildings. For example, financial awards (e.g. tax reliefs) should be included if the building owner exceeds new EPC requirements and class. In the opposite case – penalties should be imposed based on the "polluter pays" principle.

D^2EPC System Architecture

A novel methodology for dynamic EPC is being developed within the H2020 D^2EPC project, which introduces the aspects of SRI, occupant comfort, LCA, integration with DT, and GIS systems. Key functionalities of D^2EPC architecture are presented in **Figure 2**.

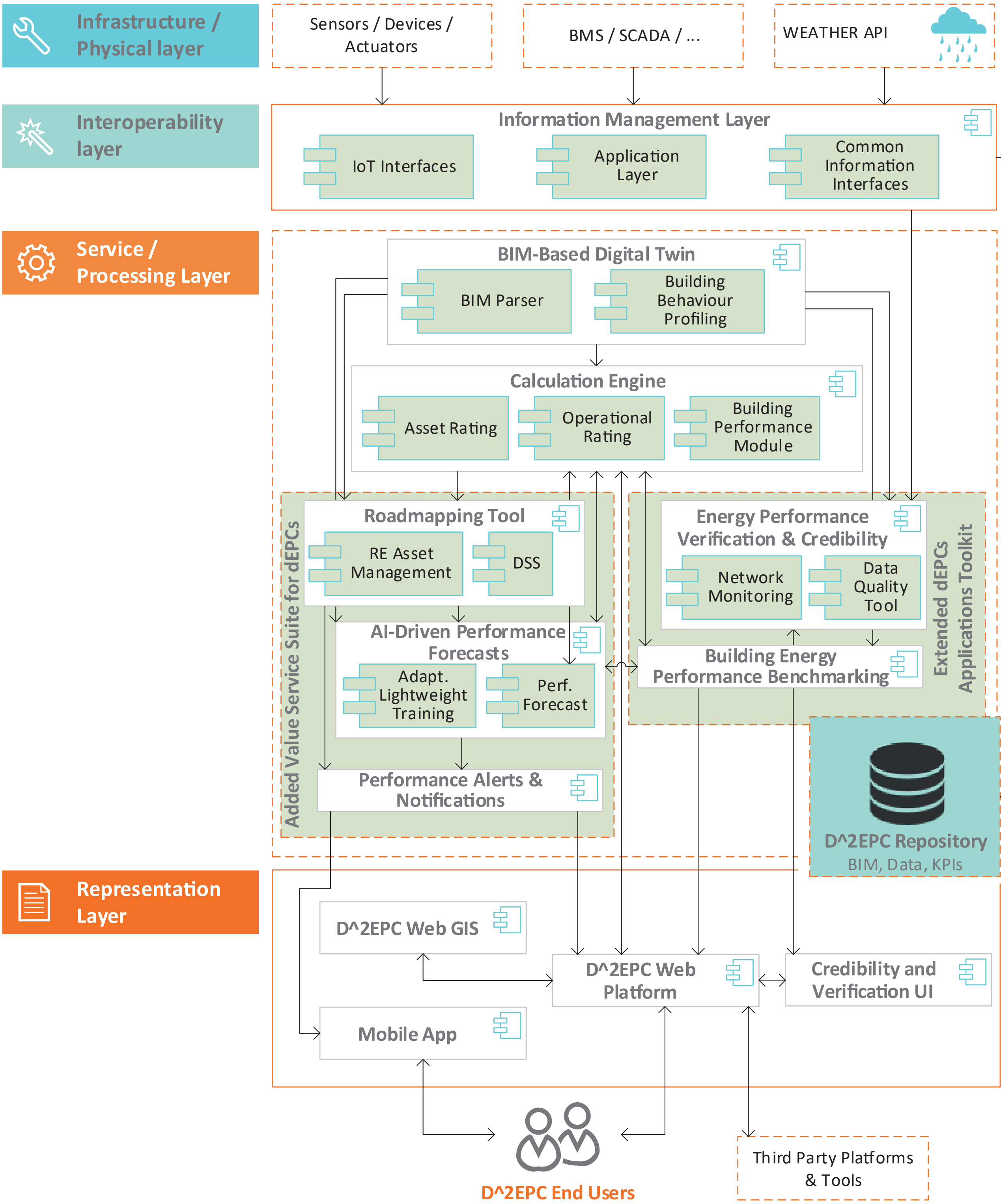

Figure 2. D^2EPC System Architecture. [13]

D^2EPC framework consists of four layers:

- Infrastructure/Physical Layer,
- Interoperability Layer,
- Service/Processing Layer, and
- Representation Layer [7].

Conclusions

New technologies that didn't existed at the time when the current EPCs schemes were developed, enable new approaches towards building energy certification. D^2EPC platform aims to integrate IoT, AI, and other novel technologies to enhance end-user awareness and facilitate a more sustainable life cycle of buildings. Nevertheless, integrating these technologies into a coherent unified tool is still a challenging task. D^2EPC aims to provide a demonstrator platform that will help increase the understanding of European building stock's EPCs. ■

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