



Digitisation of building operations and integration in the energy performance certification process: the D²EPC framework

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Main highlights

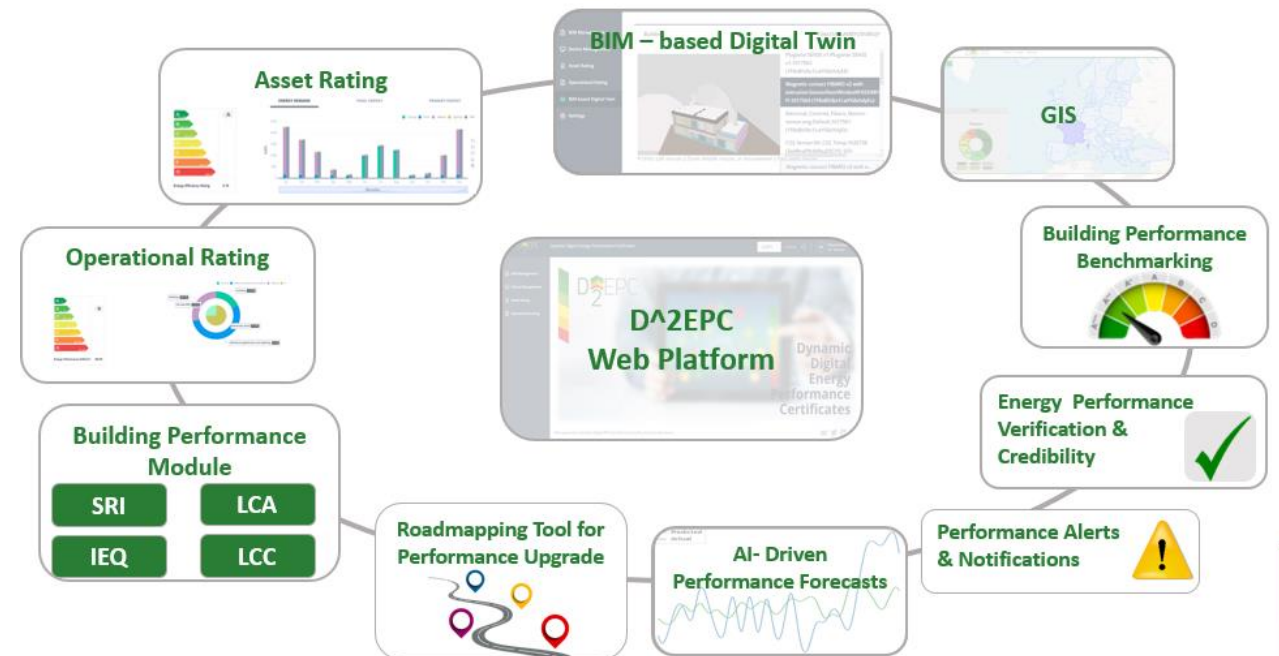
- D²EPC in a nutshell
- The BIM-oriented and digital twin-enabled approach
- The real-data EPC calculation
- The enhancement of the EPC through the introduction of various building performance indicators
- The holistic digital solution for dynamic issuance of the next generation EPCs and the provision of added value services & tools

D²EPC Objectives

- The introduction and establishment of the concept of the **dynamic EPC** (dEPC), an **operational certificate** to be **calculated** and **issued** on a **regular** basis.
- The definition of the **drawbacks** and **discrepancies** of the current EPC scheme, as well as the update of EU standards on the **classification** requirements of **buildings**.
- The **enhancement** of EPCs through a **novel set of indicators** which cover **environmental, financial, human** comfort and technical aspects of **new** and **existing** buildings, aiming to simplify the understanding of buildings energy performance and to present a more comprehensive overview of the **actual energy performance** of buildings.
- The integration of **actual operational data** from buildings into **the EPCs**.
- The integration of **smart readiness rationale** into the building's **energy performance assessment** and **certification**.
- Intelligent **operational digital platform** for dynamic **EPCs issuance** and actual **building performance monitoring** and improvement, **validated** and **demonstrated** under realistic conditions.

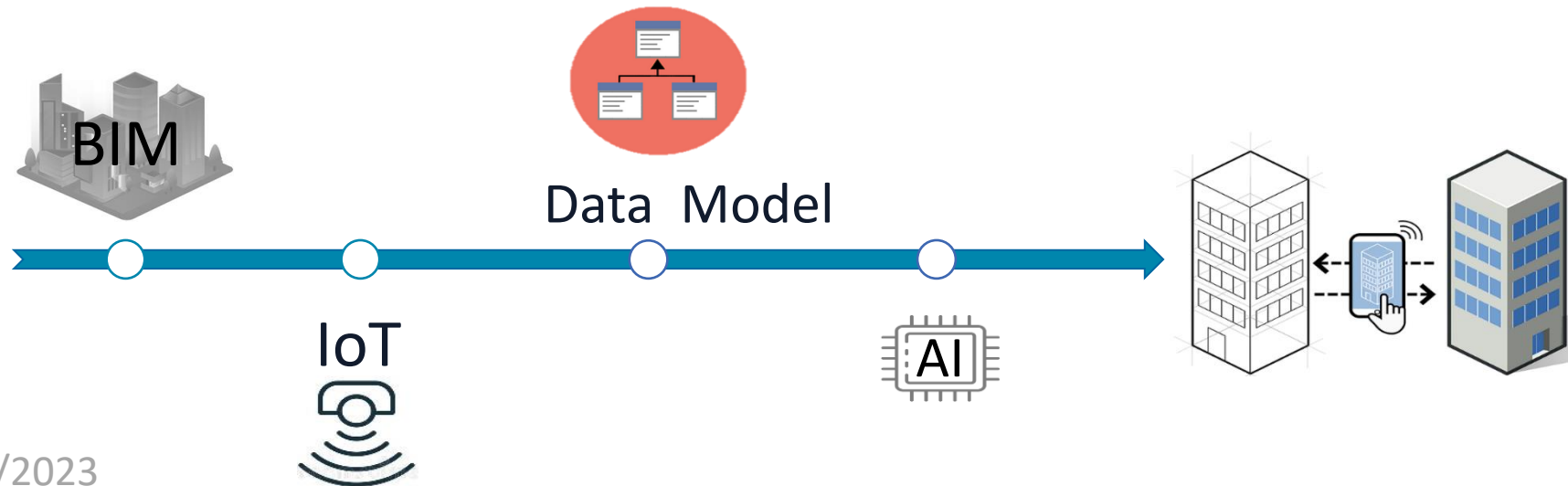
D²EPC at a glance

- Building Documentation
 - BIM / IoT / Web APIs
- BIM-based **Digital Twin**
 - Near real time asset monitoring
 - Building info integration
- Enhanced multi-parameter assessment
 - **As-designed/ As-Operated** energy rating
 - Extended KPIs (**smartness, sustainability, human comfort, financial**)
- Improved **AI-driven** assessment recommendations and added-value services
- Delivery of **Dynamic Energy Performance Certificates**
 - Infrastructure and operational classification for buildings
 - Added value district/ neighborhood information through **GIS**

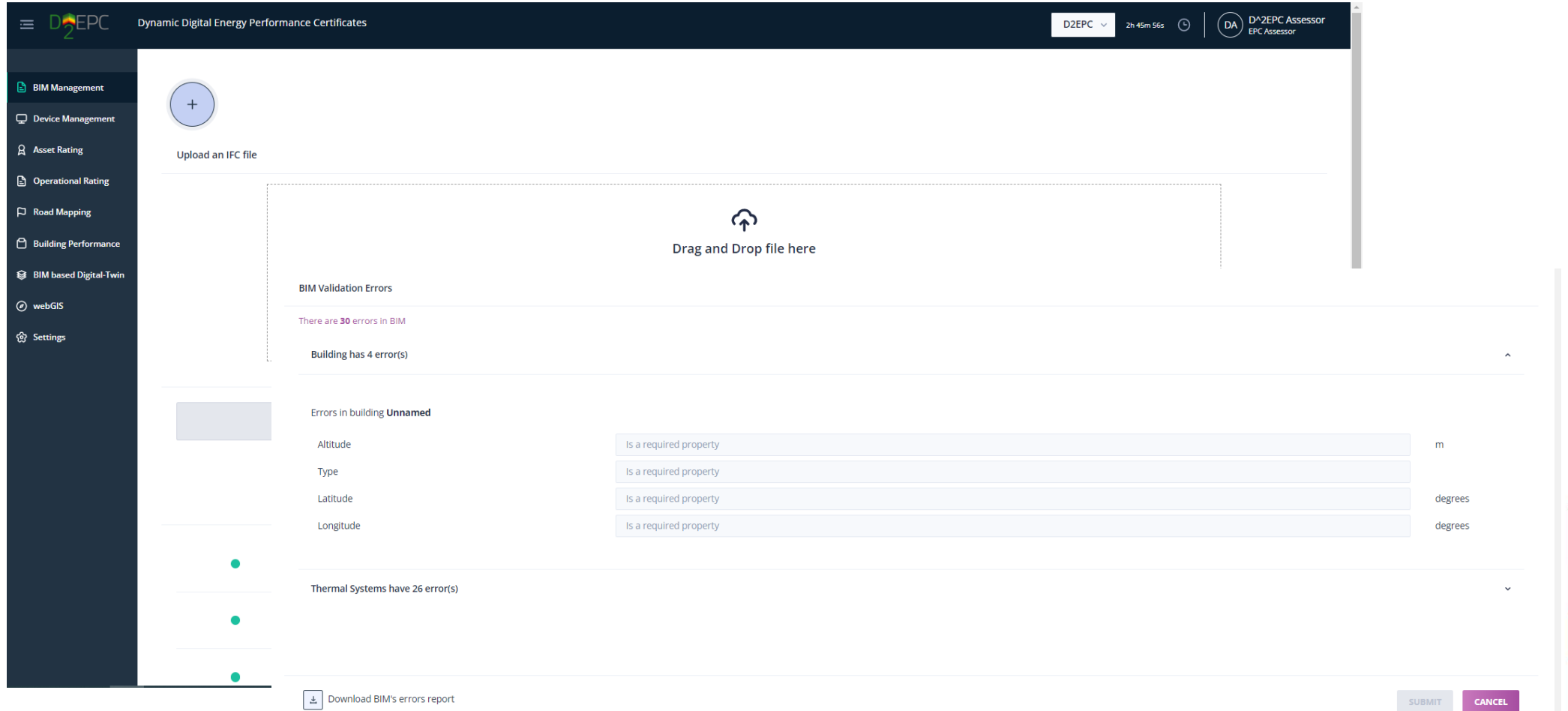


BIM-centric information extraction

- The **D^2EPC solution** leverages the utilization of **BIM files** towards simplifying the EPC-related data collection
- The extracted information is semantically enriched to consider **additional attributes** as well as **real-time data streams** for building sensing and metering equipment, defining a new **building data model**
- Coupling the data model with energy performance simulation and AI-based functionalities forms the **Building Digital Twin**



From BIM to Digital Twin: The D²EPC approach



The screenshot displays the D²EPC web application interface. The top navigation bar includes the D²EPC logo, the text "Dynamic Digital Energy Performance Certificates", a "D2EPC" dropdown menu, a timer showing "2h 45m 56s", and a "DA D²EPC Assessor EPC Assessor" profile icon.

The left sidebar contains a menu with the following items: BIM Management, Device Management, Asset Rating, Operational Rating, Road Mapping, Building Performance, BIM based Digital-Twin, webGIS, and Settings.

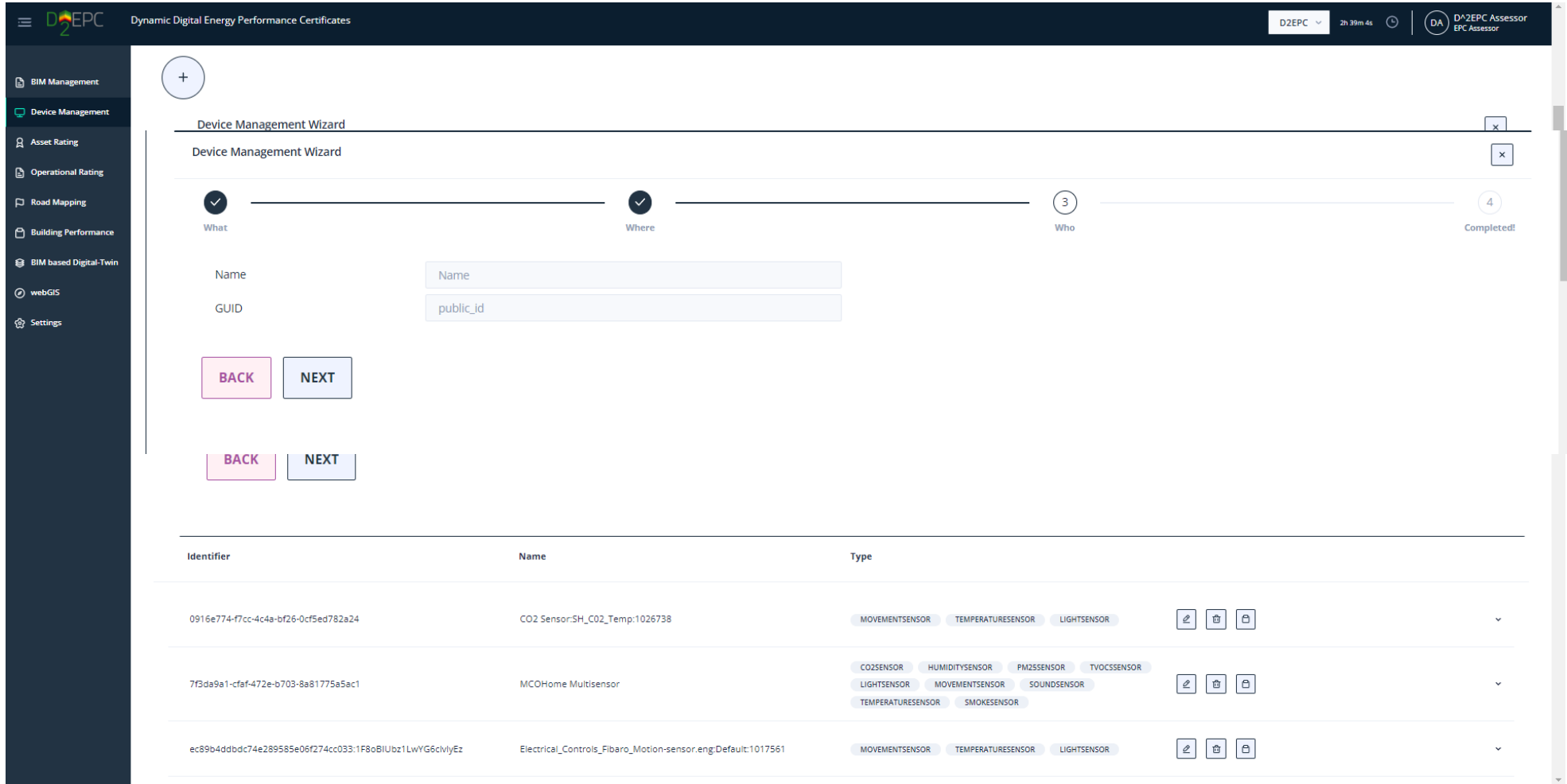
The main content area features an "Upload an IFC file" section with a plus icon and a dashed box for file upload. Below this, a "BIM Validation Errors" section indicates "There are 30 errors in BIM" and "Building has 4 error(s)".

The "Errors in building Unnamed" section lists the following errors:

Altitude	Is a required property	m
Type	Is a required property	
Latitude	Is a required property	degrees
Longitude	Is a required property	degrees

Below the table, it states "Thermal Systems have 26 error(s)". At the bottom of the interface, there is a "Download BIM's errors report" button and "SUBMIT" and "CANCEL" buttons.



From BIM to Digital Twin: The D²EPC approach












The screenshot shows the D²EPC interface with a sidebar menu on the left containing: BIM Management, Device Management, Asset Rating, Operational Rating, Road Mapping, Building Performance, BIM based Digital-Twin, webGIS, and Settings. The main content area displays the 'Device Management Wizard' with a progress bar showing four steps: 'What' (checked), 'Where' (checked), 'Who' (3), and 'Completed!' (4). Below the progress bar are input fields for 'Name' (containing 'Name') and 'GUID' (containing 'public_id'), followed by 'BACK' and 'NEXT' buttons. A second set of 'BACK' and 'NEXT' buttons is also visible. Below the wizard is a table of sensors:

Identifier	Name	Type	Actions
0916e774-f7cc-4c4a-bf26-0cf5ed782a24	CO2 Sensor:SH_CO2_Temp:1026738	MOVEMENTSENSOR TEMPERATURESENSOR LIGHTSENSOR	[Edit] [Delete] [Lock]
7f5da9a1-cfaf-472e-b703-8a81775a5ac1	MCOHome Multisensor	CO2SENSOR HUMIDITYSENSOR PM25SENSOR TVOCSENSOR LIGHTSENSOR MOVEMENTSENSOR SOUNDSSENSOR TEMPERATURESENSOR SMOKESENSOR	[Edit] [Delete] [Lock]
ec89b4ddbdc74e289585e06f274cc033:1F8oBIUzb1LwYG6civlyEz	Electrical_Controls_Fibaro_Motion-sensor.eng:Default:1017561	MOVEMENTSENSOR TEMPERATURESENSOR LIGHTSENSOR	[Edit] [Delete] [Lock]

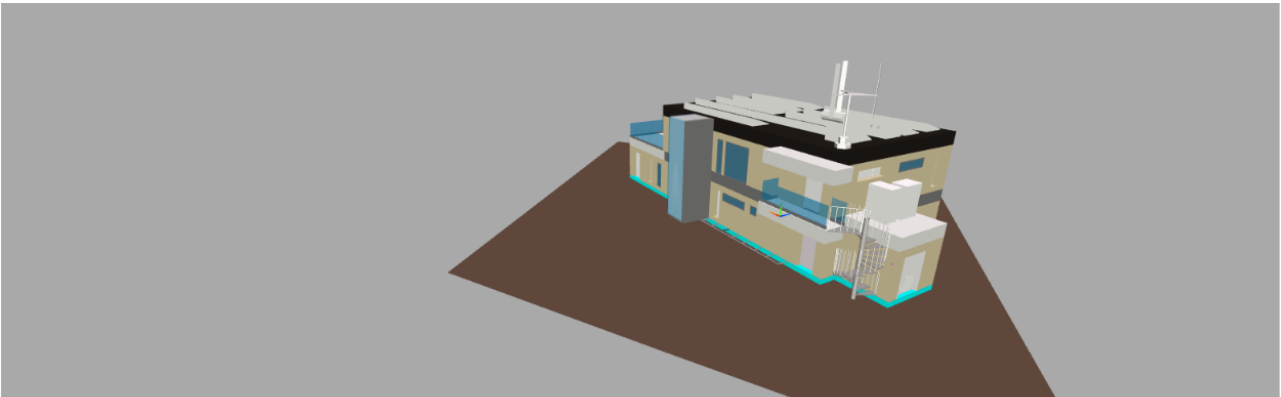
From BIM to Digital Twin: The D²EPC approach

 Dynamic Digital Energy Performance Certificates
D2EPC 2h 57m 20s  DA D²EPC Assessor EPC Assessor

-  BIM Management
-  Device Management
-  Asset Rating
-  Operational Rating
-  Road Mapping
-  Building Performance
-  BIM based Digital-Twin
-  webGIS
-  Settings

Select Building

CS1 - nZEB Smart House DIH



* Orbit: Left mouse | Zoom: Middle mouse, or mousewheel | Pan: Right mouse

The **ENERGYMETER** named "Energy_Meter:Energy_PCC:1023878" (ID="2w48yaPS+6tRw2QCjY5z4I") is selected.

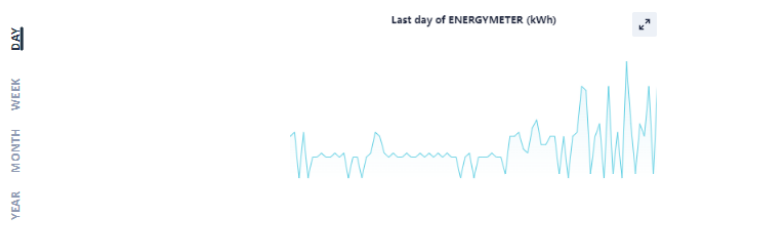
Also, is one of the **3 Meters** of the BIM

Some of its attributes are:

- Device Id**
- Energy Carrier**
- Energy Service**
- Type**
- Name**
- Refers To** 1F8oBIUbz1LwYG6clvlyFY,1F8oBIUbz1LwYG6clvlyFZ,1F8

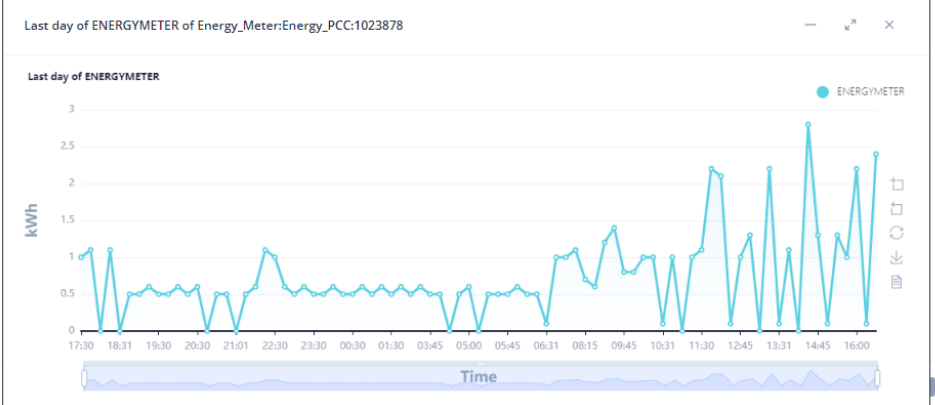
Last day of ENERGYMETER (kWh)

DAY
YEAR MONTH WEEK



Last day of ENERGYMETER of Energy_Meter:Energy_PCC:1023878

Last day of ENERGYMETER
ENERGYMETER



Next-generation Dynamic Digital EPCs for Enhanced Quality and User Awareness

Asset & Operational Rating

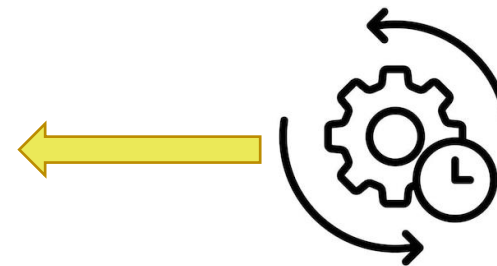
Asset Rating Module

- Based on the overarching standards:
ISO 52000-1, 52003-1, 52010-1,
52016-1, 52018-1
- quasi-steady-state monthly calculation
 - Energy Demand → Delivered Energy → Primary Energy
- Energy performance comparison with Reference building
 - Adoption of national values

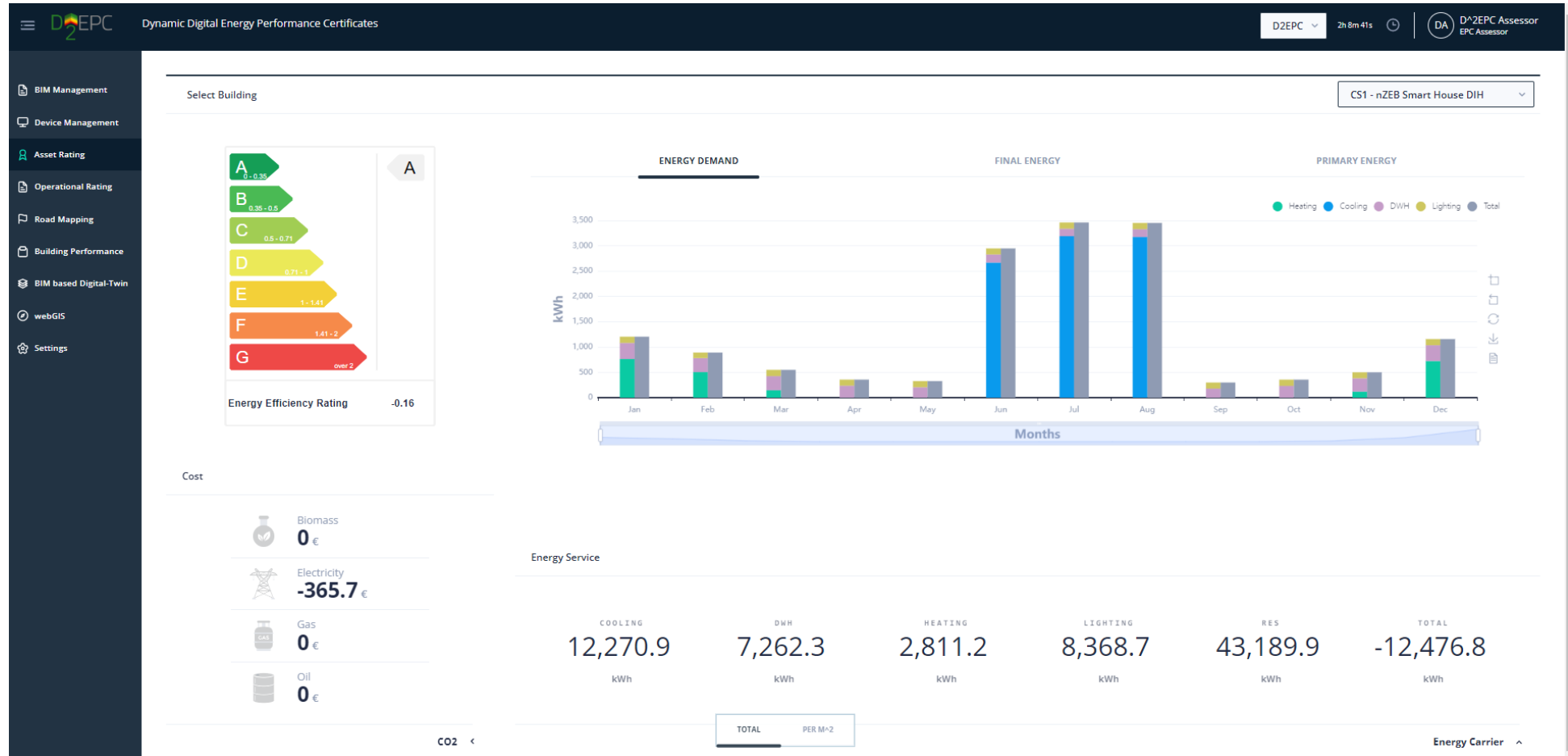


Operational Rating Module

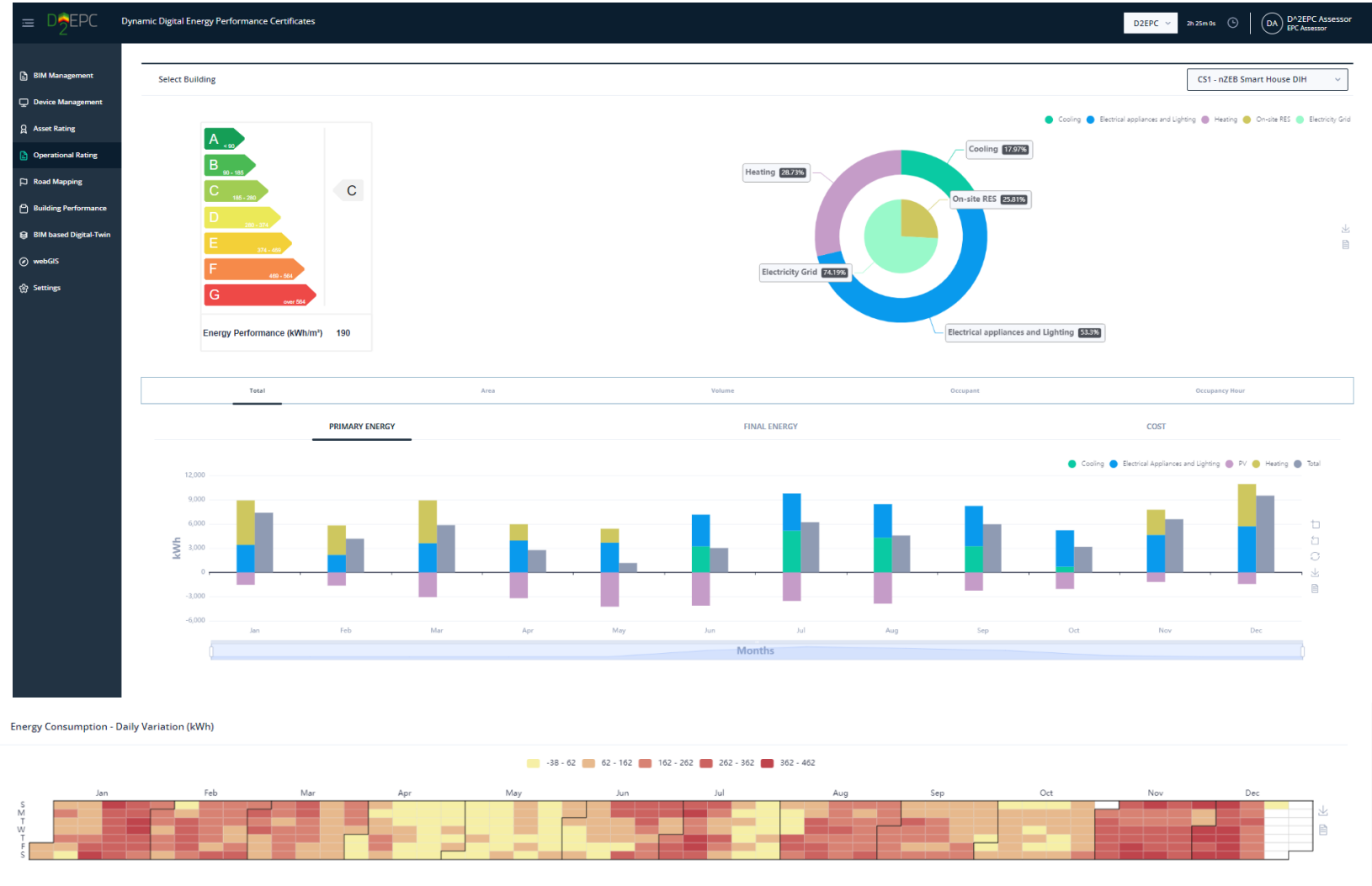
- Lack of a Common EU- based approach
 - D²EPC proposed methodology
- Total indicators: 26
- Operational Rating Indicators:
 - Delivered Energy / Primary Energy
 - Cost (calculated)
 - CO₂ emissions
 - Energy Class [A-G]



Asset rating: BIM-based EPC assessment

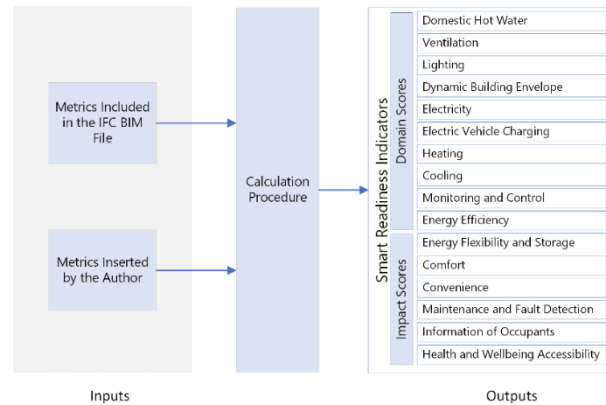


Operational rating: real data-based EPC assessment

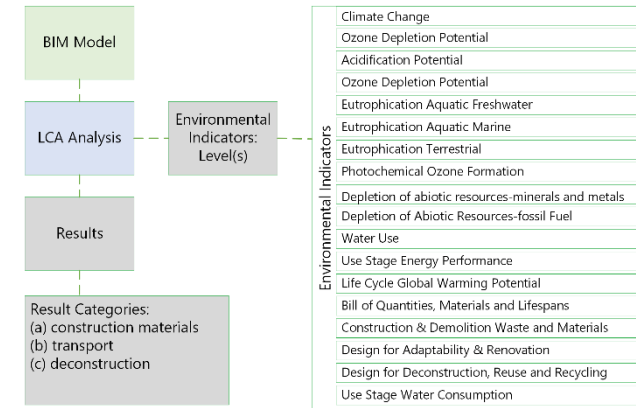


Enhancing the EPC: set of indicators

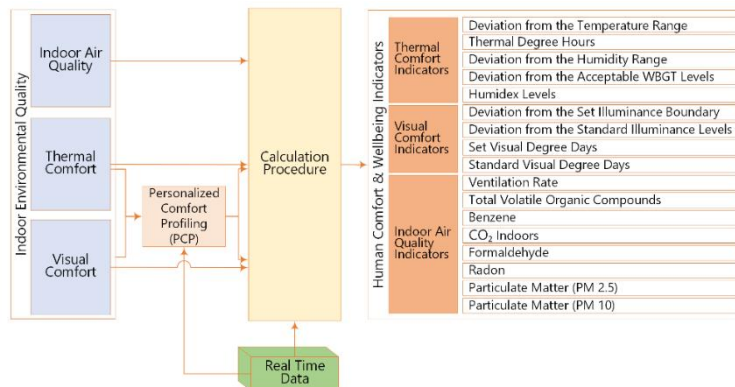
Smart Readiness Indicator



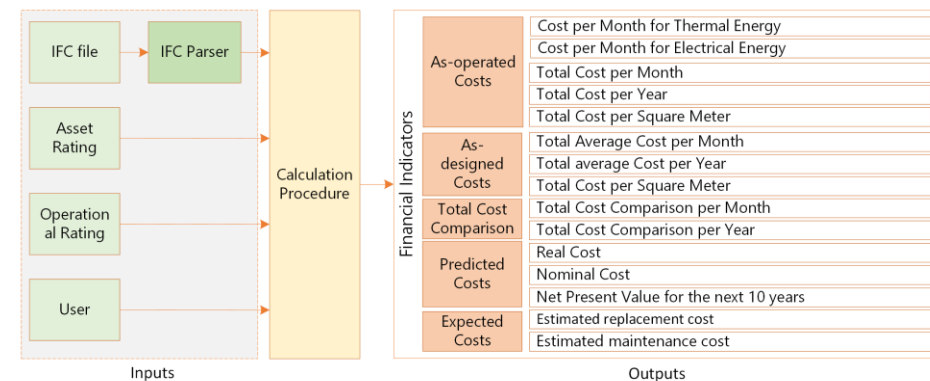
Life Cycle Assessment



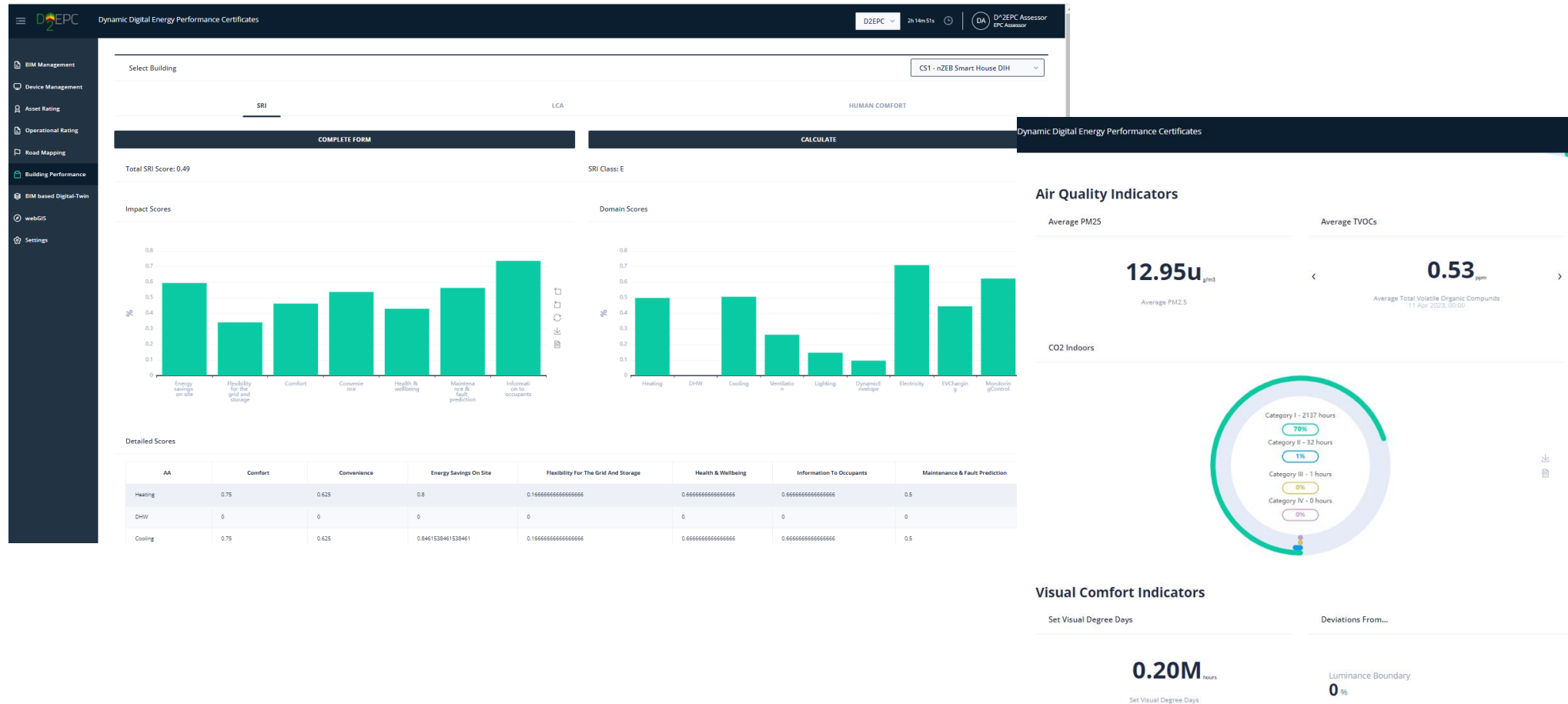
Indoor Environmental Quality



Life Cycle Cost



Enhancing the EPC: set of indicators



Dynamic Digital Energy Performance Certificates

Select Building: CS1 - nZEB Smart House DIH

SRI | LCA | HUMAN COMFORT

COMPLETE FORM | CALCULATE

Total SRI Score: 0.49 | SRI Class: E

Air Quality Indicators

Average PM2.5: **12.95** $\mu\text{g}/\text{m}^3$ (Average PM2.5)

Average TVOCs: **0.53** ppm (Average Total Volatile Organic Compounds)

Visual Comfort Indicators

Set Visual Degree Days: **0.20M** hours (Set Visual Degree Days)

Luminance Boundary: **0** %

AA	Comfort	Convenience	Energy Savings On Site	Flexibility For The Grid And Storage	Health & Wellbeing	Information To Occupants	Maintenance & Fault Prediction
Heating	0.75	0.625	0.8	0.16666666666666666	0.6666666666666666	0.6666666666666666	0.5
DHW	0	0	0	0	0	0	0
Cooling	0.75	0.625	0.8481538461538461	0.16666666666666666	0.6666666666666666	0.6666666666666666	0.5

Enhancing the EPC: added-value services suite

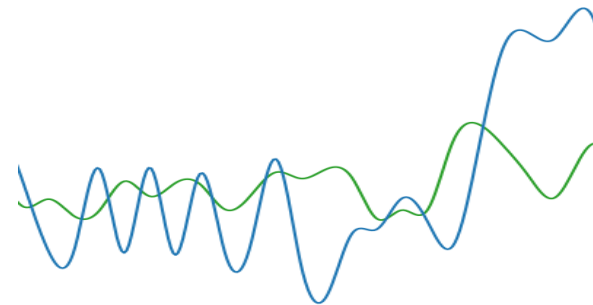
Roadmapping Tool for Performance Upgrade

- Asset Diagnosis
 - Envelope
 - Technical Systems
- Multiple strategic scenarios generation
- Result: “Building Renovation Roadmap”

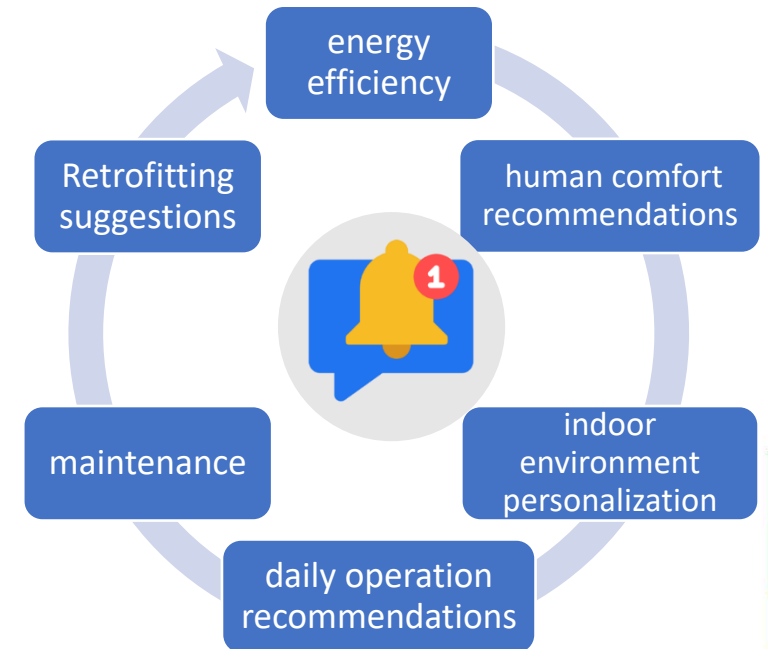


AI- Driven Performance Forecasts

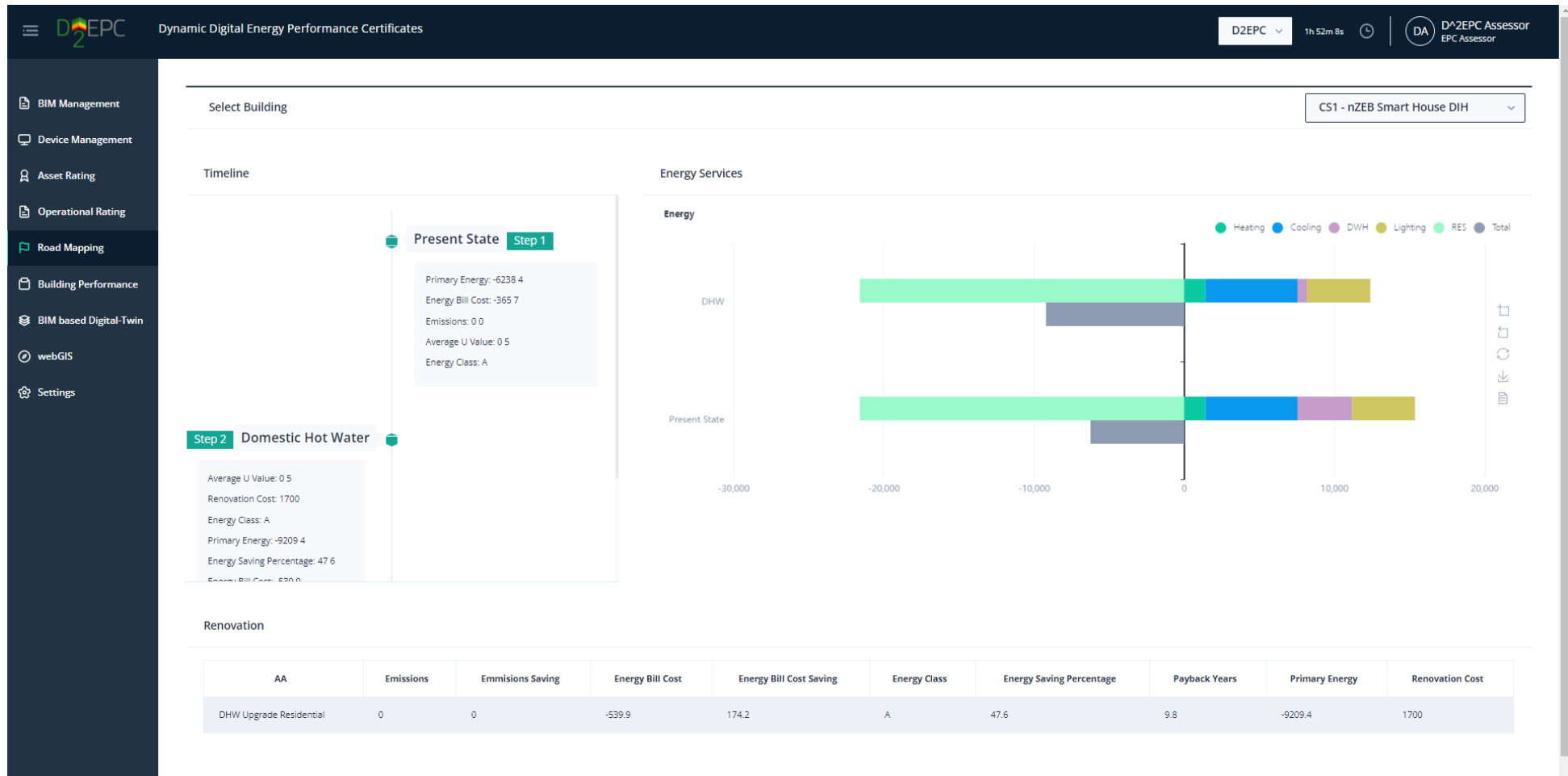
- Building long-term energy consumption forecasting
- Pattern identification
- Recommendations:
 - Energy efficiency
 - Human comfort



Performance Alerts & Notifications



Supporting the decision-making on building renovation: Roadmapping tool



Extended dEPCs Applications Toolkit

Building Performance Benchmarking

- Infrastructure and operational classification for buildings
- Percentile ranking within specified groups (e.g. location, building type)
- Insight extraction from D²EPC certification results correlation
- Path indication for performance improvements



15/06/2023

Energy Performance Verification & Credibility

- Data stream reliability insurance
 - series of quality checks
 - overall quality monitoring with a set of performance indicators
- Status monitoring of the deployed IoT infrastructure
- Alerting mechanism for device malfunctions or poor data quality
- Credibility user interface






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