D2EPC

Building performance assessment towards Next generation EPCs

DEMO CONSULTANTS

Analysis of cost and economic indicators for EPCs

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D^2EPC project / DEMO Consultants B.V.

Session 4: Monetizing buildings' energy performance, the use of life cycle costing indicators

D^2EPC indicators

- D^2EPC objective: the enhancement of EPCs through a novel set of indicators, aiming to simplify the understanding of buildings energy performance and to present a more comprehensive overview of the actual energy performance of buildings
- Novel set of Indicators:
  - Smart Readiness Indicators
  - Human comfort & wellbeing Indicators
  - Energy performance & LCA Indicators
  - Financial Indicators

Financial indicators objectives

- Establishment of simplified indicators which will enhance the user-friendliness of the building certificate

- Development of a set of financial indicators based on the well-established concept of whole life cycle costing

- Interpretation of the individual elements of buildings energy performance as a monetary normalized values

- Enable the employment of EPCs for the financial assessment of buildings energy upgrade measures

Approach

Literature review

- IEA EBC Annex 56
- ISO 15686-5
- EN 15643
- EN 16627:2015
- D1.3
- Level(s) scheme

Methodology

- Definition of financial KPI
- Integration into D^2EPC
- Calculation of the financial indicators

Development of guidelines for D^2EPC integration

- FRC building
- Measured data
- Example

Literature review

- IEA EBC Annex 56 - Cost-Effective Energy & CO_2 Emissions Optimization in Building Renovation
  - promotion of nearly-zero energy / emission levels in the renovation of the existing building stock, cost-effective optimization of the building
- ISO 15686-5 - Buildings and constructed assets – Service life planning – Part 5: Life-cycle costing
  - requirements and guidelines for performing Life-cycle cost analysis, a methodology for the economic evaluation of a cost of an asset over a period, decision-making through a comparison between alternatives
- EN 15643-2021 - Sustainability of construction works – Assessment of buildings
  - principles and requirements for the assessment of the economic performance of buildings taking into account the technical characteristics and functionality of a building
- EN 16627:2015 - Sustainability of construction works - Assessment of economic performance of buildings - Calculation methods
  - calculation rules for assessing the economic performance of new and existing buildings (LCC & Life Cycle Economic Balance
- D1.3 Aspects of Next Generation EPC's definition
  - D^2EPC project proposes additional indicators that display the environmental performance of buildings for their introduction in the next-generation EPCs
- Level(s) scheme
  - assess and report on the sustainability performance of buildings across their entire life cycle, the "Cost, value, and risk indicator" is intended to track and quantify the beneficial impact of increased sustainability performance

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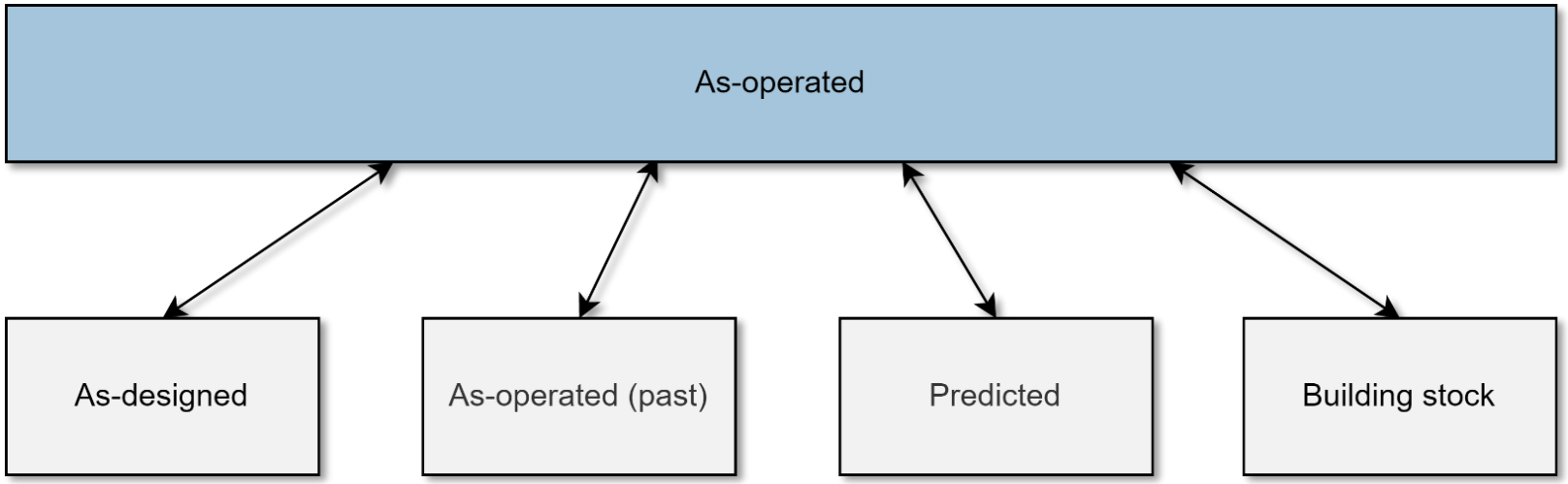
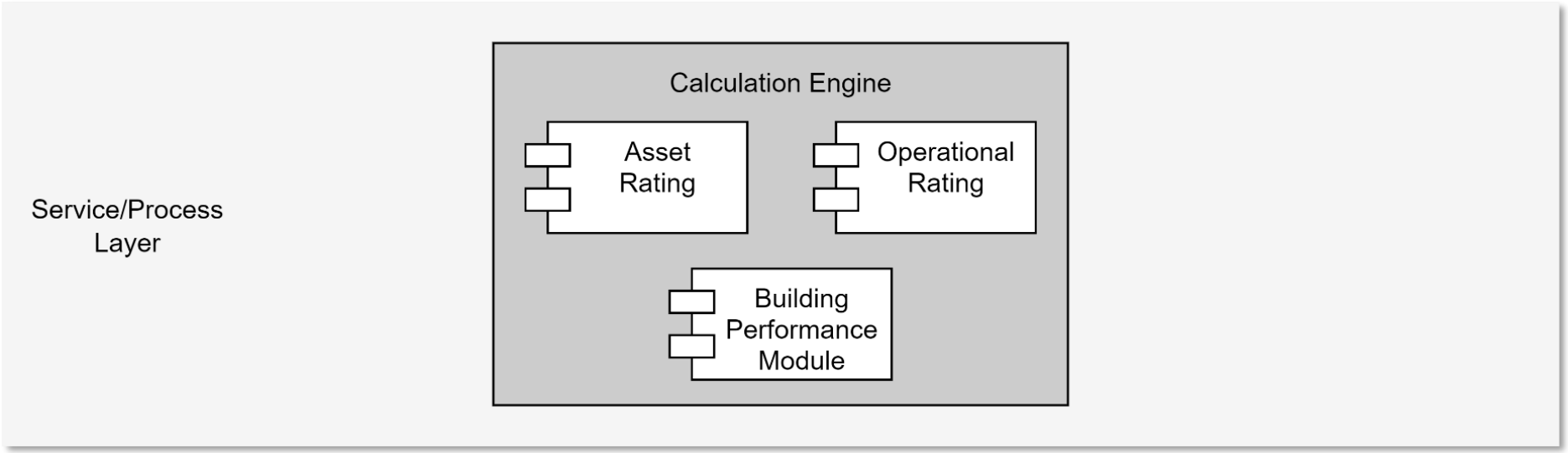
Methodology – definition of financial KPIs

- Provide users with a real-time image of the monetized performance of the building
- Allow users to allocate the performance of their building. The focus of the comparison is user behaviors and his awareness of energy use rather than the improvement of the building's systems and envelope.
- Financial indicators will not affect the energy class of the building, they will be presented as additional information for the user.



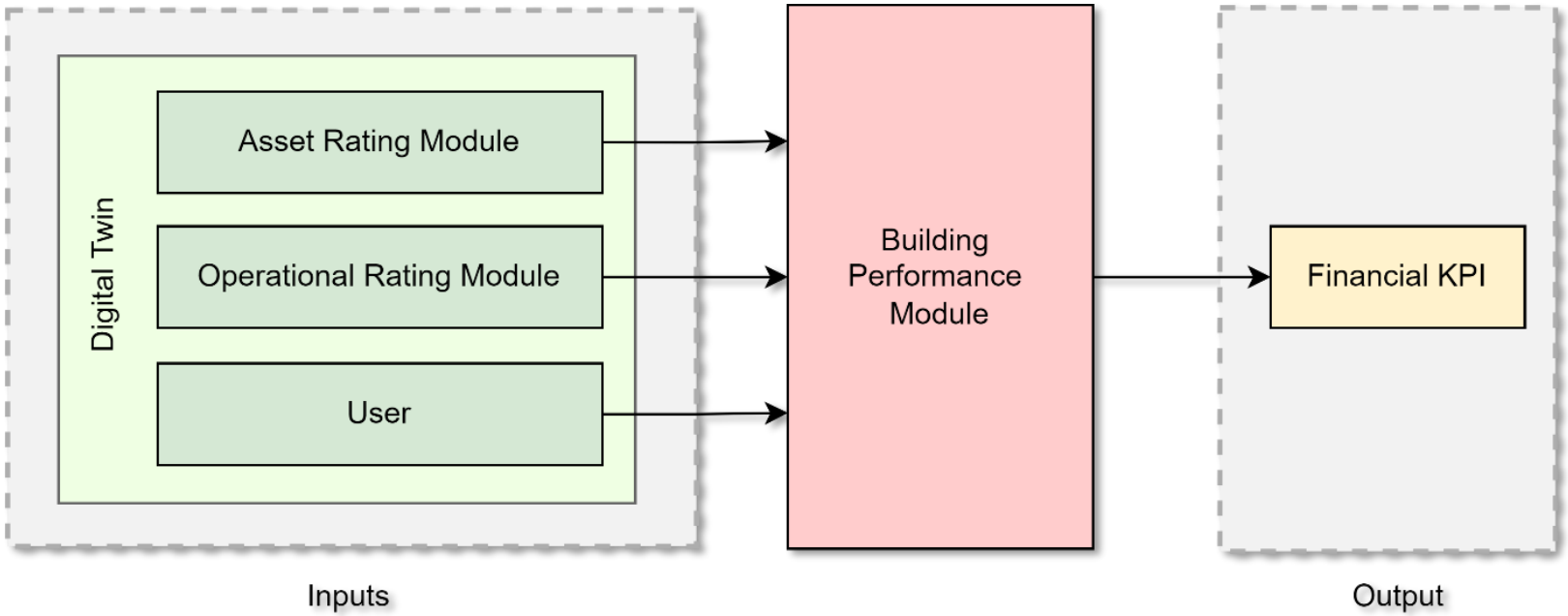
Methodology – integration into D^2EPC

- D^2EPC Framework Architecture
- Service/Process Layer
- Calculation Engine – responsible for calculations to assess asset and operational performance
- Building Performance Module – responsible for KPIs calculations



Methodology – integration into D^2EPC

- Inputs are based on BIM literacy (Digital Twin)
  - Asset Rating Module
  - Operational Rating Module
  - User

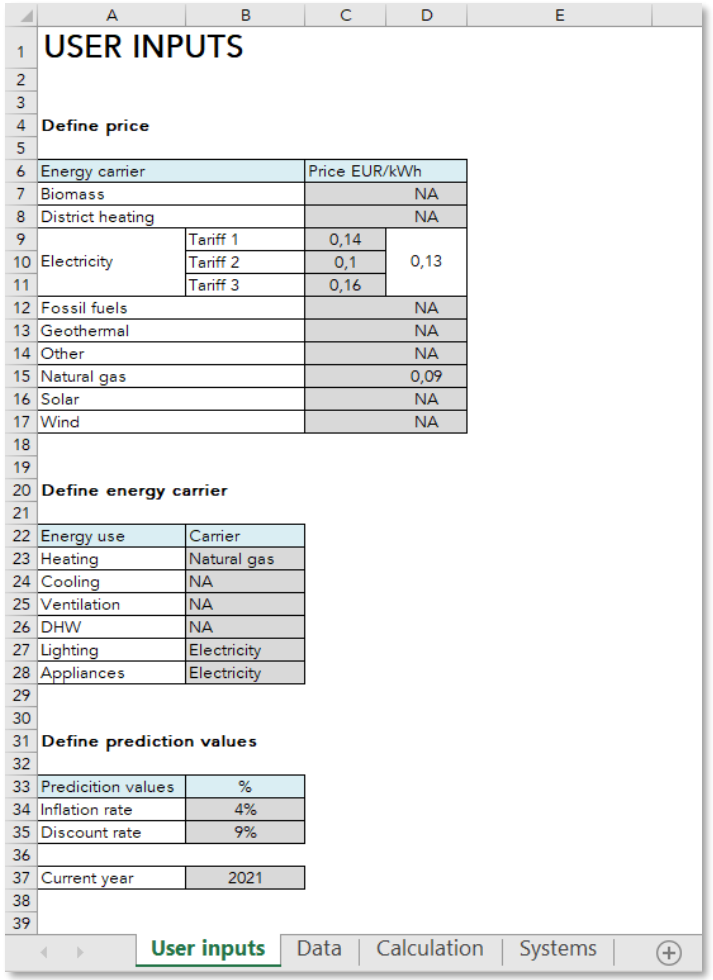


Methodology – calculation

Inputs

Operational utility costs: costs of fuel for heating, cooling, power, lighting, ~~water~~, and ~~sewerage costs~~

- Asset Rating Module
  - as-designed energy consumption
- Operational Rating Module
  - as-operated energy consumption
- User
  - price of the energy carrier (more accurate results, different tariffs approach),
  - energy carrier per energy use,
  - average expected inflation and discount rate (different per country),
  - building systems' information – if not retrieved from the BIM model (installation date & price, life span, maintenance schedule & price)



USER INPUTS

Define price

Energy carrier		Price EUR/kWh	
Biomass			NA
District heating			NA
Electricity	Tariff 1	0,14	0,13
	Tariff 2	0,1	
	Tariff 3	0,16	
Fossil fuels			NA
Geothermal			NA
Other			NA
Natural gas			0,09
Solar			NA
Wind			NA

Define energy carrier

Energy use	Carrier
Heating	Natural gas
Cooling	NA
Ventilation	NA
DHW	NA
Lighting	Electricity
Appliances	Electricity

Define prediction values

Predicition values	%
Inflation rate	4%
Discount rate	9%
Current year	2021

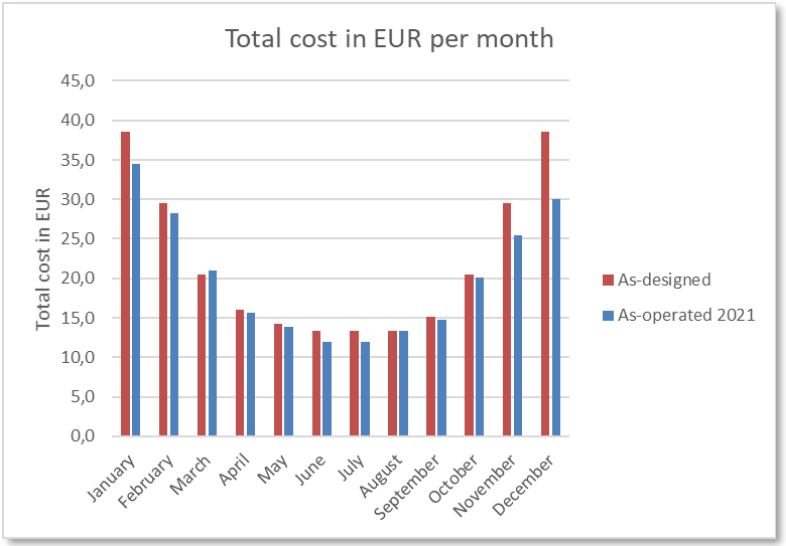
User inputs | Data | Calculation | Systems

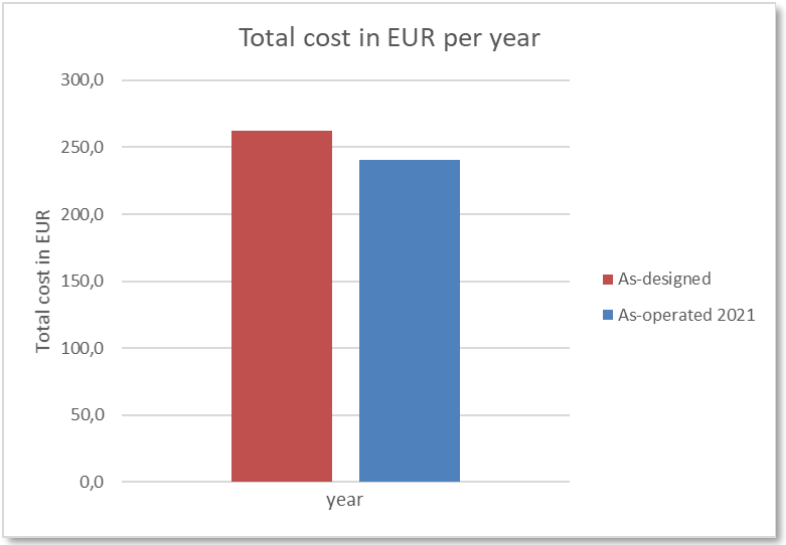
Methodology – calculation

As-designed & As-operated model

Multiplying the energy consumption with the energy price

- As-operated model
  - Cost in EUR per month per energy use
  - Cost in EUR per month per energy carrier
  - Total cost in EUR per month*
  - Total cost in EUR per year*
  - Total cost in EUR per square meter
- As-designed model
  - Total cost in EUR per month
  - Total cost in EUR per year
  - Total cost in EUR per square meter





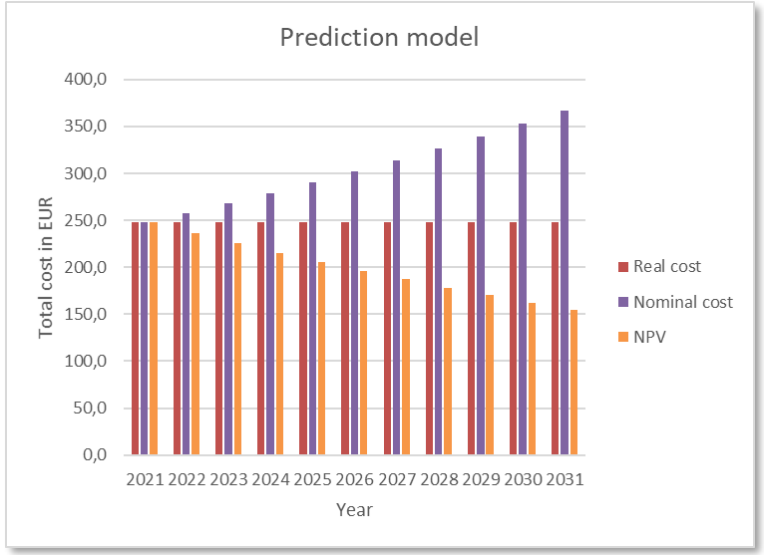
*The as-operated yearly cost in EUR is a true reflection of the monetarized energy use in the building, although it does not match the bills that the residents receive because the additional costs and taxes are omitted.

Methodology – calculation

Prediction model

Tries to evaluate the future costs, based on the inflation rate and discount factor provided by the user

- Real cost
  - which is adjusted for inflation, meaning that it can be compared as if the prices have not changed on average
- Nominal cost
  - which has not been adjusted to inflation and therefore reflects the effect of inflation
- Net Present Value (NPV)
  - which represents the future price in today's value, that is determined with the discount rate



The comparison between the three values is an approximation and aims to illustrate to the user the impact of time on the value of money they will be paying for the energy use in their building.

Methodology – calculation

Building stock

Future exploitation:

- presenting the monetized energy use on an expanded, larger scale, i.e., the comparison with the building stock. By filtering buildings based on the pre-defined criteria (such as building use, building systems, climate and location), the user could evaluate the performance of their building by not just comparing it to their own (past or designed) performance but similar buildings as well.

Methodology – calculation

Expected costs for building systems

Summing up the expected costs for the maintenance and replacement of the systems in the next few years

SYSTEMS

Information from the IFC

list of all the HVAC systems
when were they installed
what is their price
what is their life expectancy
how often should the maintenance be performed
what is the price for maintenance

Systems	Installed in	Price	System life expectancy	Maintenance occurance	Maintenance cost	Replacement in	Maintenance in
Heat pump	2018	5000	10	2	500	2028	2020, 2022, 2024, 2026
Ventilation system	2018	3000	8	2	200	2026	2020, 2022, 2024
Electric heater	2018	200	3	0	0	2021	

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Replacement	200					3000		5000				
Maintenance		700		700		500						
Expected yearly costs	**200**	**700**	**0**	**700**	**0**	**3500**	**0**	**5000**	**0**	**0**	**0**	**0**

User inputs | Data | Calculation | Systems

Methodology – calculation

D^2EPC financial KPIs

Indicator name	Indicator description	Units
As-operated costs	The “as-operated cost” indicator presents the following costs to the user: - Cost per month per energy use - Cost per month per energy carrier - Total cost per month - Total cost per year - Total cost per square meter	EUR
As-designed costs	The “as-designed cost” indicator presents the following costs to the user: - Total cost per month - Total cost per year - Total cost per square meter	EUR
Total cost comparison (graphically presented)	The “total cost comparison” indicator is comparing the as-designed and as-operated cost, namely the total costs per each month and total costs for the whole year. - Total cost comparison per month - Total cost comparison per year	EUR
Predicted costs	The “predicted costs” indicator presents the real cost, the nominal cost, and the Net Present Value for the next 10 years	EUR
Expected costs for building systems	The “expected costs for building systems” are an estimation of the costs that the use can expect for the replacement and maintenance of building systems	EUR

Approach

Literature review → Methodology → Development of guidelines for D^2EPC integration

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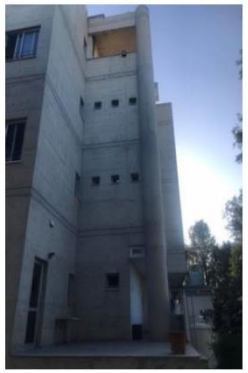
Development of guidelines for D^2EPC integration

Frederick University demonstration case

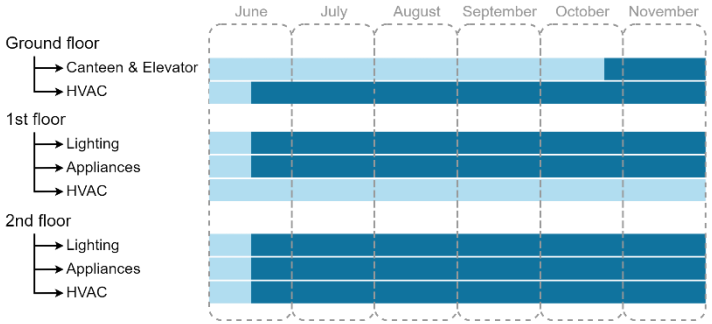


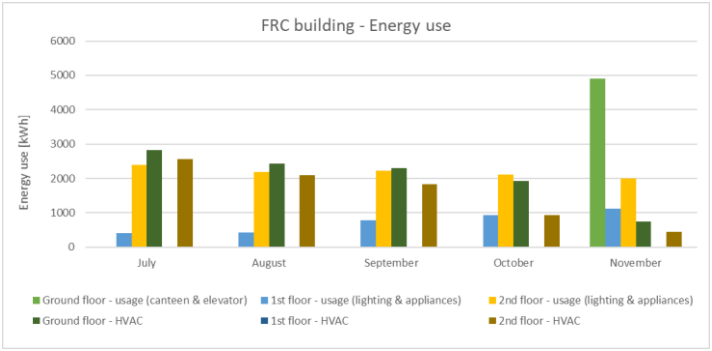
- 30 input meter data loggers
- 45 input meter core data loggers
- 3 zone monitoring and remote sensors for CO_2, T, RH
- measurements started in the middle of June 2021

Development of guidelines for D^2EPC integration

Frederick University demonstration case

Floor	Item			Measurements
Ground floor	Usage			- Canteen - Elevator
1st floor	Usage	1st floor total lights	Lecture Theatre Large Lights	- Lecture Theatre L LIGHTS1 m11 - Lecture Theatre L LIGHTS2 m13 - Lecture Theatre L LIGHTS3 g13 - Lecture Theatre L LIGHTS4 g14
			Lecture Theatre Small N Lights	- Lecture Theatre N LIGHTS1 k6 - Lecture Theatre N LIGHTS2 m8
			Lecture Theatre Small S Lights	- Lecture Theatre S LIGHTS1 m6 - Lecture Theatre S LIGHTS2 k11
			Utilities	- Lecture Corridor LIGHTS k7 - Utilities South LIGHTS g11 - Utilities North LIGHTS k13
				- 1st floor sockets
2nd floor	Usage	Lights total POWER		- Lights OFFICE 1 - Lights OFFICE 2 - Lights OFFICE 2 - Lights UTILITIES 1 - Lights MEETING ROOM - Lights OFFICE 12 - Lights OFFICE 6 - Lights PRINCIPAL OFFICE - Lights CORRIDOR - Lights OFFICE 10 - Lights OFFICE 5 - Lights OFFICE 3 - Lights OFFICE 7 - Lights OFFICE 11 - Lights UTILITIES 2 - Lights UTILITIES 3 - Lights OFFICE 4 - Lights OFFICE P1 - Lights OFFICE 8
				- 2nd Floor Sockets
Roof	Usage			- Power EVRV-G3| - Power EVRV-G2| - Power EVRV-G1| - Power VRV-2F2| - Power VRV-2F1|





- currently available data is not sufficient for the initial calculation of the KPI
- analysis of the available data from the FRC building was beneficial, provided an overview of what kind of data can be retrieved
- the proposed methodology was adjusted to better fit the purpose

Development of guidelines for D^2EPC integration

Example

As-operated 2021

Energy use	Energy carrier	Price	2021 January	February	March	April	May	June	July	August	September	October	November	December
Heating	Natural gas	0,09	250	180	100	40	20	0	0	15	30	90	150	200
Cooling	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
Ventilation	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
Lighting	Electricity	0,13	40	40	40	40	40	40	40	40	40	40	40	40
Appliances	Electricity	0,13	50	50	50	50	50	50	50	50	50	50	50	50

Cost in EUR per energy use	2021 January	February	March	April	May	June	July	August	September	October	November	December
Heating	22,50	16,20	9,00	3,60	1,80	0,00	0,00	1,35	2,70	8,10	13,50	18,00
Cooling												
Ventilation												
Lighting	5,33	5,33	5,33	5,33	5,33	5,33	5,33	5,33	5,33	5,33	5,33	5,33
Appliances	6,67	6,67	6,67	6,67	6,67	6,67	6,67	6,67	6,67	6,67	6,67	6,67

Cost in EUR per energy carrier	2021 January	February	March	April	May	June	July	August	September	October	November	December
Natural gas	22,5	16,2	9	3,6	1,8	0	0	1,35	2,7	8,1	13,5	18
Electricity	12	12	12	12	12	12	12	12	12	12	12	12

Total cost in EUR per month	34,5	28,2	21,0	15,6	13,8	12,0	12,0	13,4	14,7	20,1	25,5	30,0
Total cost in EUR per year	240,8											
Total cost in EUR per sqm	0,46	0,38	0,28	0,21	0,18	0,16	0,16	0,18	0,20	0,27	0,34	0,40

As-designed

Energy consumption	Energy carrier	Price	2021 January	February	March	April	May	June	July	August	September	October	November	December
Heating	Natural gas	0,09	280	180	80	30	10	0	0	0	20	80	180	280
Cooling	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
DHW	NA	NA	20	20	20	20	20	20	20	20	20	20	20	20
Lighting	Electricity	0,13	100	100	100	100	100	100	100	100	100	100	100	100

Cost in EUR	2021 January	February	March	April	May	June	July	August	September	October	November	December
Heating	25,20	16,20	7,20	2,70	0,90	0,00	0,00	0,00	1,80	7,20	16,20	25,20
Cooling												
DHW												
Lighting	13,33	13,33	13,33	13,33	13,33	13,33	13,33	13,33	13,33	13,33	13,33	13,33

Total cost in EUR per month	38,5	29,5	20,5	16,0	14,2	13,3	13,3	13,3	15,1	20,5	29,5	38,5
Total cost in EUR per year	262,6											
Total cost in EUR per sqm	0,51	0,39	0,27	0,21	0,19	0,18	0,18	0,18	0,20	0,27	0,39	0,51

As-predicted

as-operated + inflation rate + discount factor to the price

As-operated total cost in EUR per year 248,0

Year		Real cost	inflation rate		Nominal cost	discount rate		NPV
2021	0	248,0			248,0			247,95
2022	1	248,0	4%	1,04	257,9	9%	1,09	236,58
2023	2	248,0	4%	1,08	268,2	9%	1,19	225,72
2024	3	248,0	4%	1,12	278,9	9%	1,30	215,37
2025	4	248,0	4%	1,17	290,1	9%	1,41	205,49
2026	5	248,0	4%	1,22	301,7	9%	1,54	196,06
2027	6	248,0	4%	1,27	313,7	9%	1,68	187,07
2028	7	248,0	4%	1,32	326,3	9%	1,83	178,49
2029	8	248,0	4%	1,37	339,3	9%	1,99	170,30
2030	9	248,0	4%	1,42	352,9	9%	2,17	162,49
2031	10	248,0	4%	1,48	367,0	9%	2,37	155,04

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Sum up

Aim: to investigate the possibilities of integrating financial KPIs into new generation EPCs which will raise user awareness and provide additional information and thus improve the existing EPCs

User-friendly: The financial KPIs allow the user to better understand his energy consumption as it is translated into monetary values. Such interpretation can be clearer and more understandable, considering that tenants operate with money on a daily basis

Outcome: User can compare the monetary value of actual consumption with the monetary values of design consumption, can get an overview of predicted costs based on the inflation and discount rate and get an estimation of future costs, related to the building systems

Conclusions

Current EPCs:

- already include information about the monetary value of energy consumption
- based on the design values
- yearly values
- number of people it considers is an average
- it does not include the energy use of household appliances

Financial KPIs within the D^2EPC project:

- monetized values of energy consumption based on the monitored/operational use
- insight into monthly values
- reflect the actual consumption, including the household appliances and with no need to estimate the number of people
- additionally: information about predicted and estimated future values

Thank you!

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