

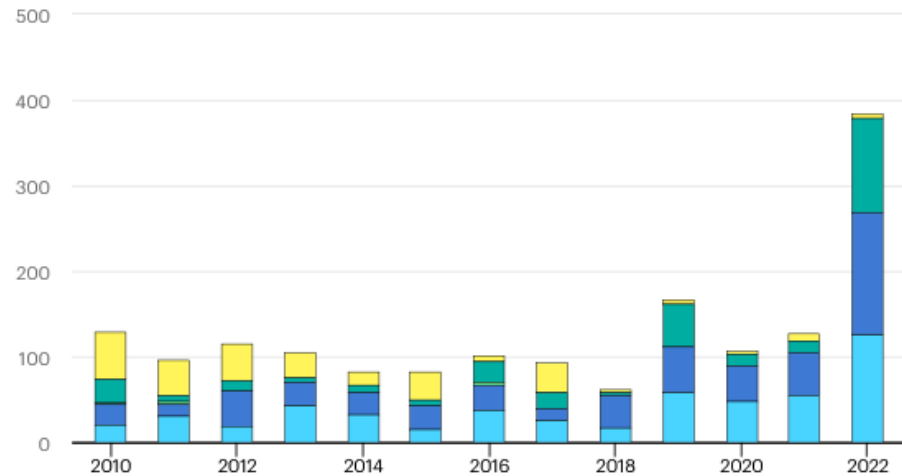
LDAC2025 - Linked Data in Architecture and Construction

Continuous Calculation of Key Performance Indicators for Buildings through an Application Layer Connected to a Knowledge Graph

Motivation & Problem

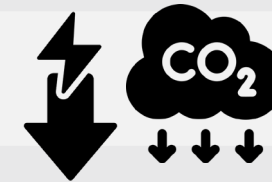
Early-stage venture capital investment in clean energy start-ups developing buildings¹

million USD (2022)



- Building energy management systems, control systems and demand response
- Building design, construction and renovation
- Cooking and appliances
- Heating and cooling
- Lighting

¹International Energy Agency, "Buildings – Energy Systems", IEA, Paris. [Online]. Available: <https://www.iea.org/energy-system/buildings>. [Accesses: May 24, 2025]



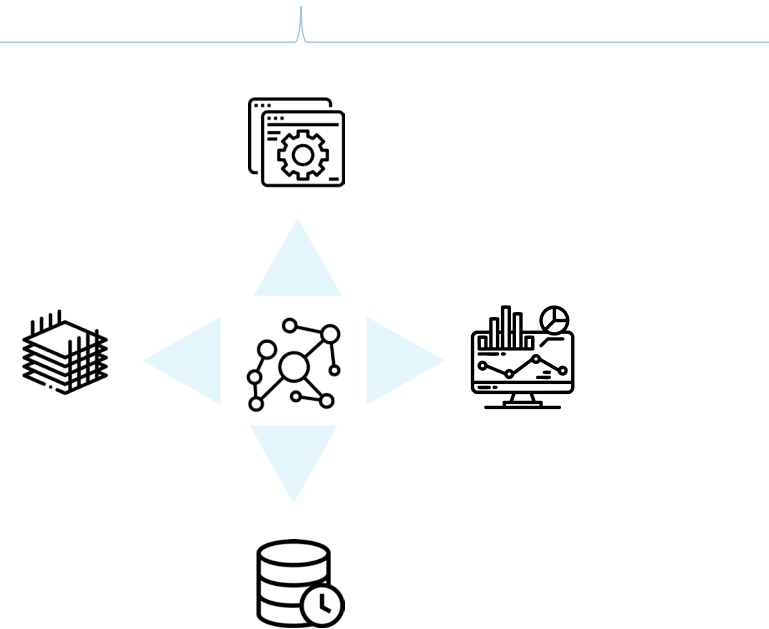
Motivation & Problem

KPI Description and Building Monitoring

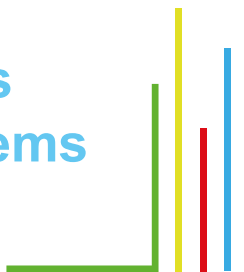
Design & Construction



Operation

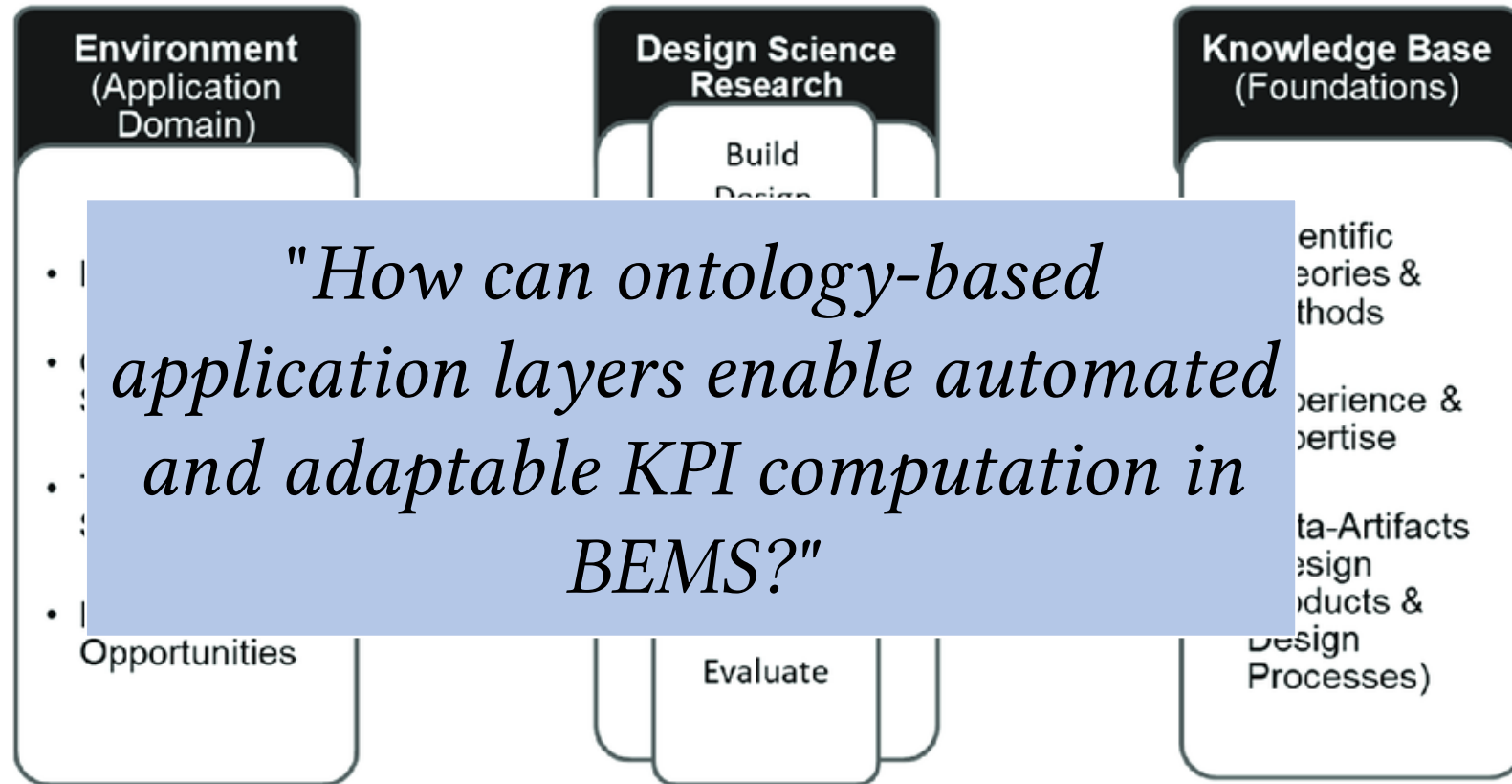


Need to make performance analytics
lighter and easier to adapt across systems



Goal & Methodology

Design Science Research



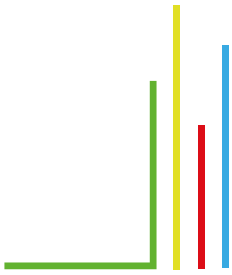
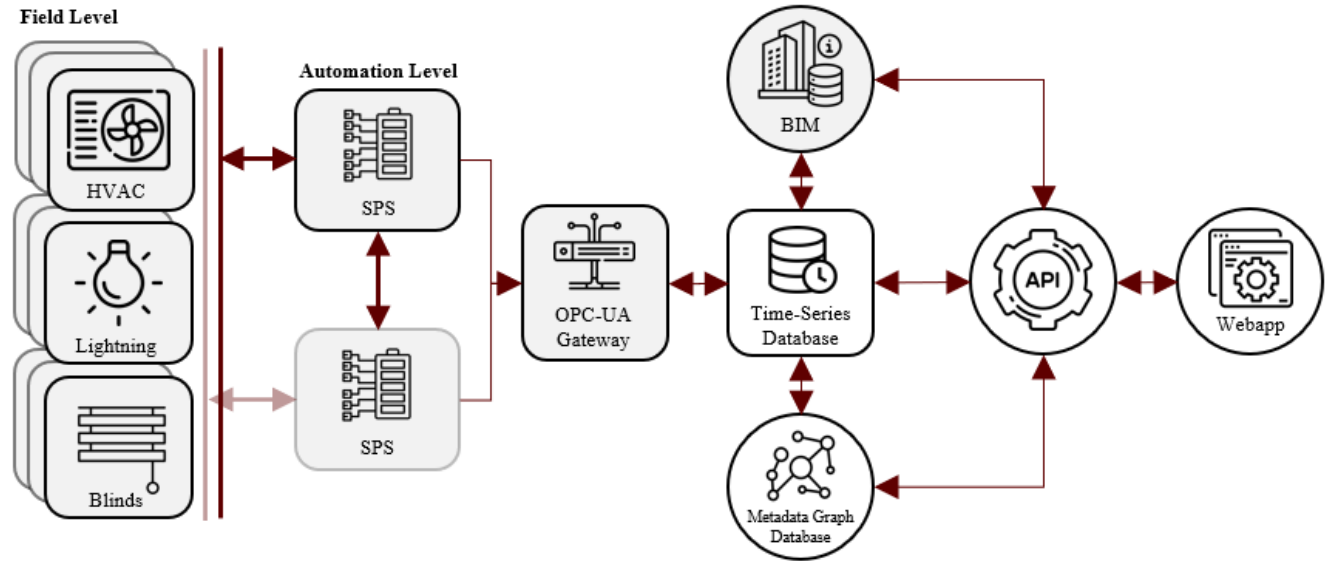
Development & Demonstration

NEST Demonstrator



Source: empa.ch/web/nest/overview

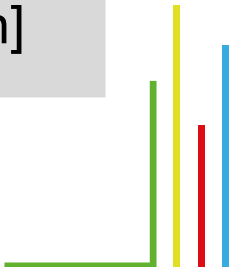
Data Collection



Development & Demonstration

KPI Selection

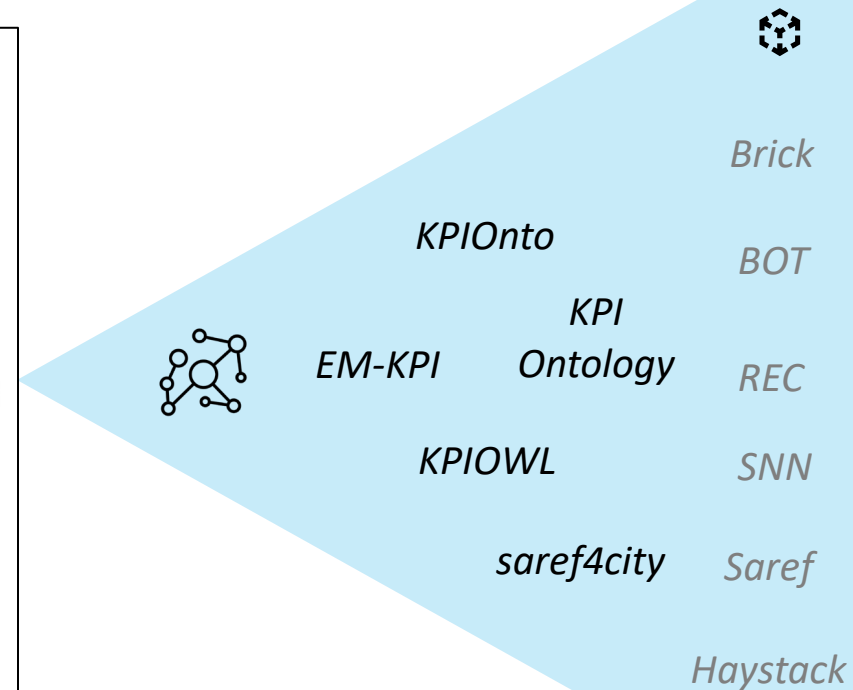
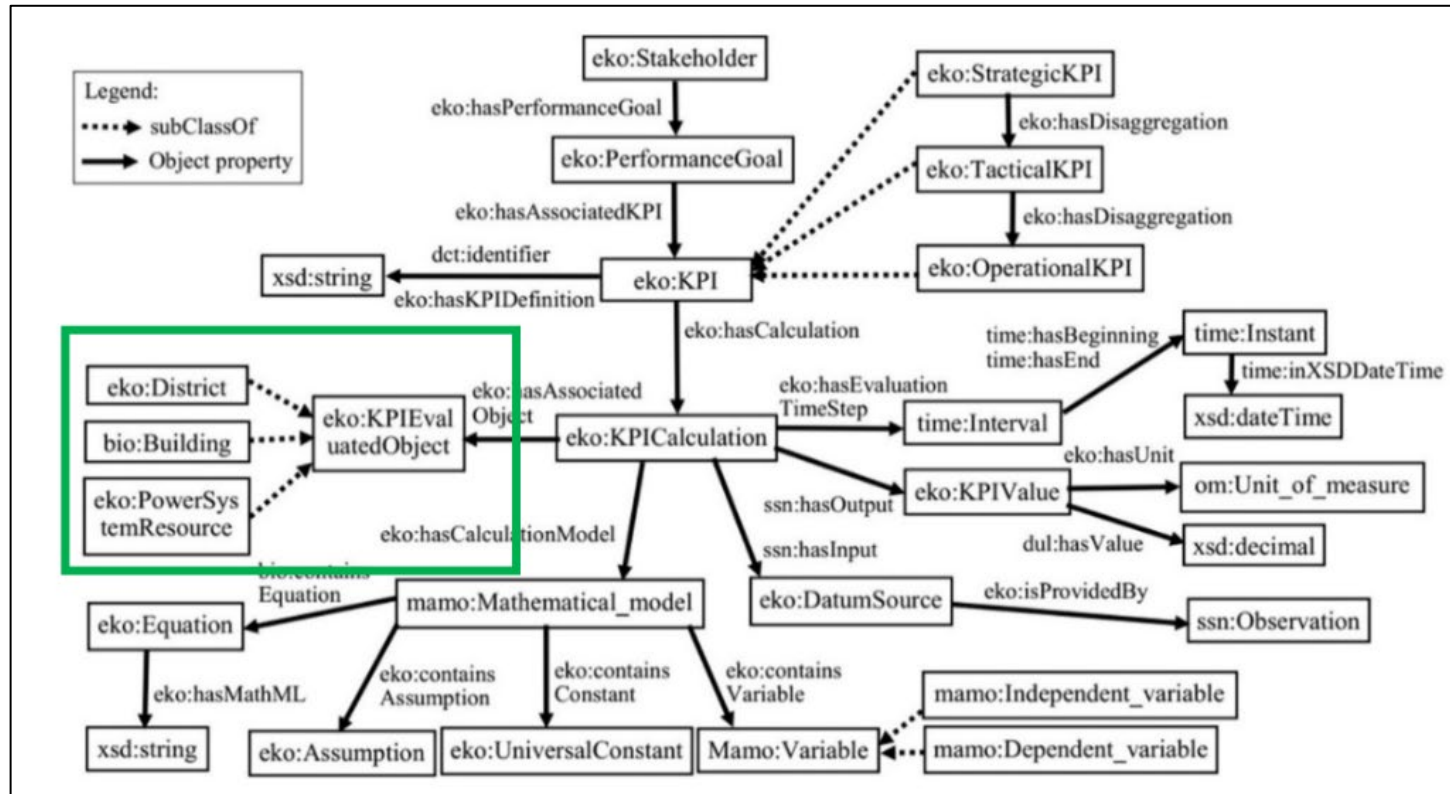
KPI Name	Formula
Energy Consumption	Total Equipment Energy Consumption [kWh]
Energy Consumption Intensity	Total Equipment Energy Consumption / Total Building Area [kWh/m ²]
Space Energy Consumption	Total Building Energy Consumption [kWh]
Space Energy Consumption Intensity	Total Building Energy Consumption / Total Building Area [kWh/m ²]
Peak Power	Max. Equipment Energy Consumption [kWh]



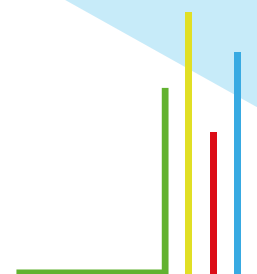
Related Work

Ontologies and semantic Integration of KPIs

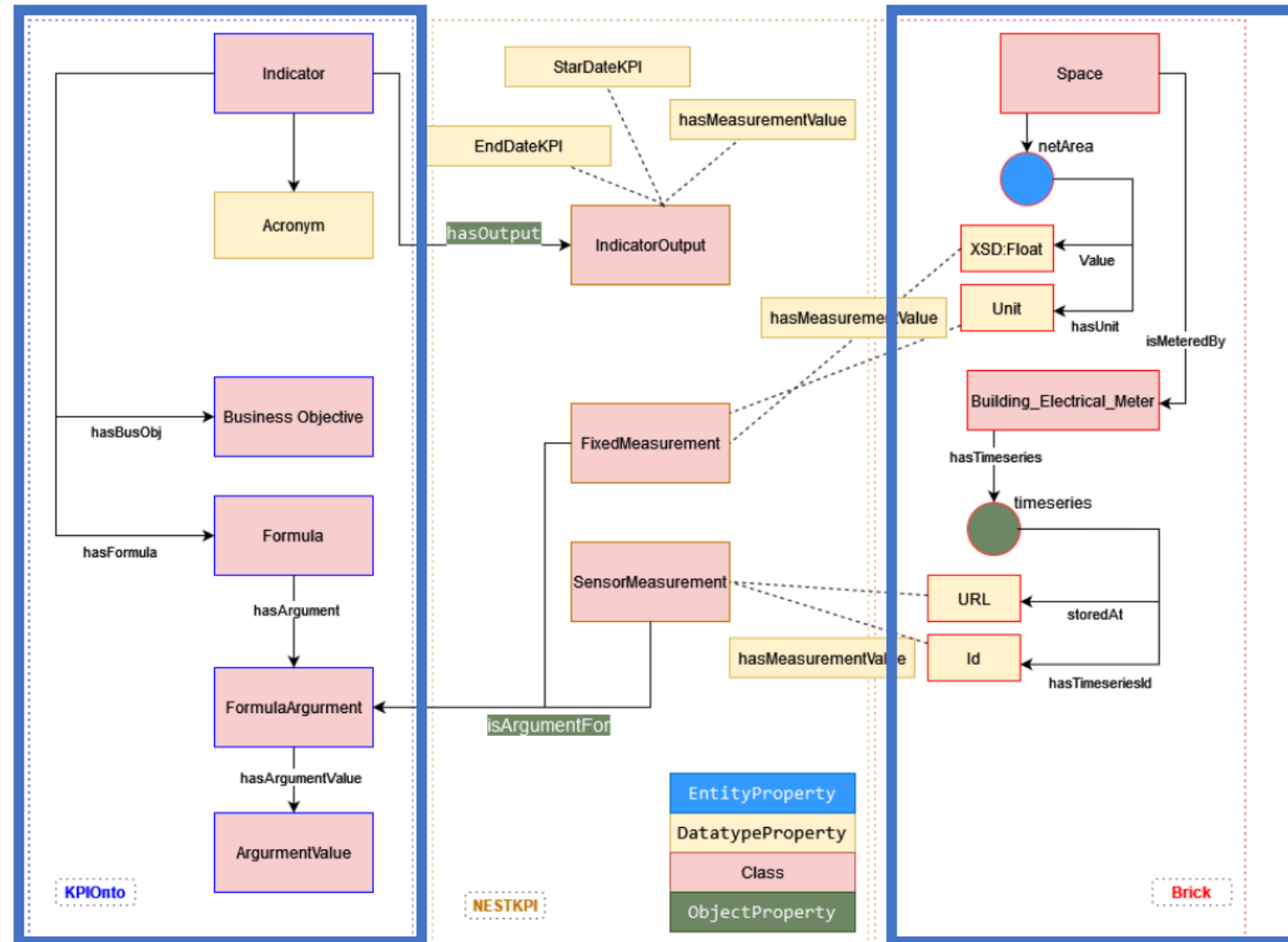
KPI Module of the EM-KPI ontology



L. Yehong, R. Garcia-Castro, N. Mihindukulasooriya, J. O'Donnell, and S. Vega-Sánchez, 'Enhancing energy management at district and building levels via an EM-KPI ontology', Autom. Constr., vol. 99, pp. 152–167, Mar. 2019, doi: 10.1016/j.autcon.2018.12.010



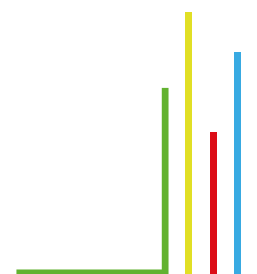
Development First Iteration



KPIOnto

NESTKPI

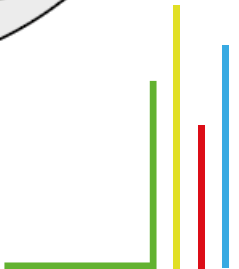
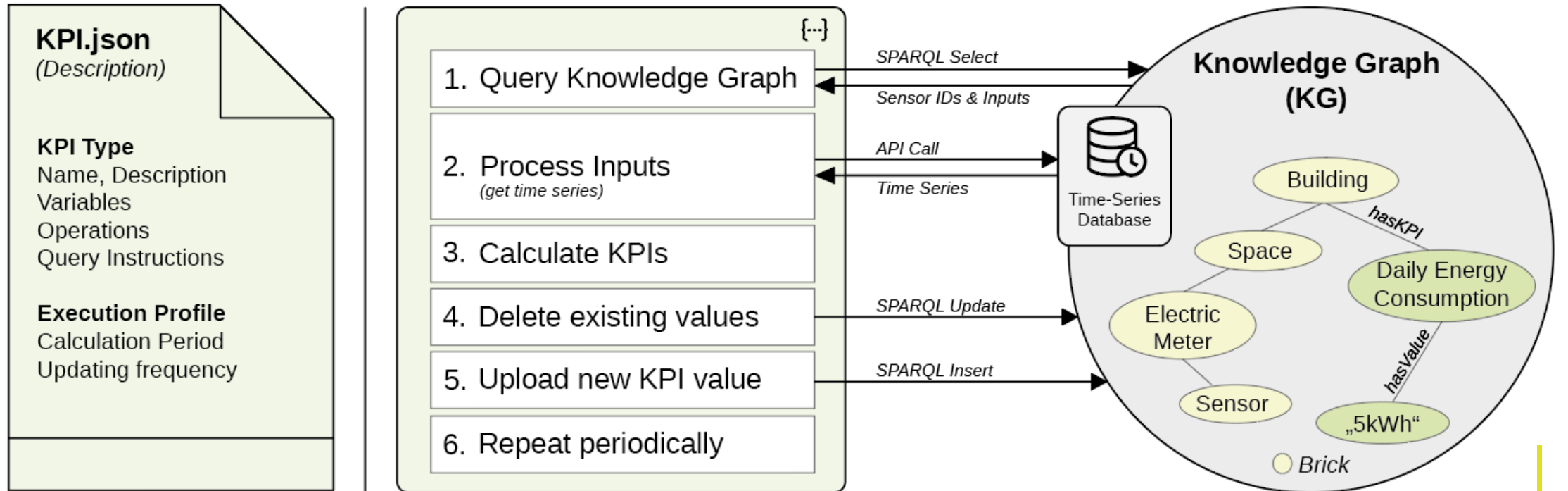
Brick Schema



Development

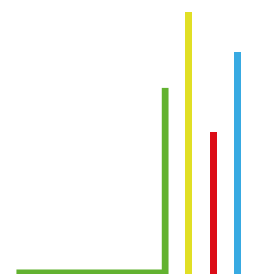
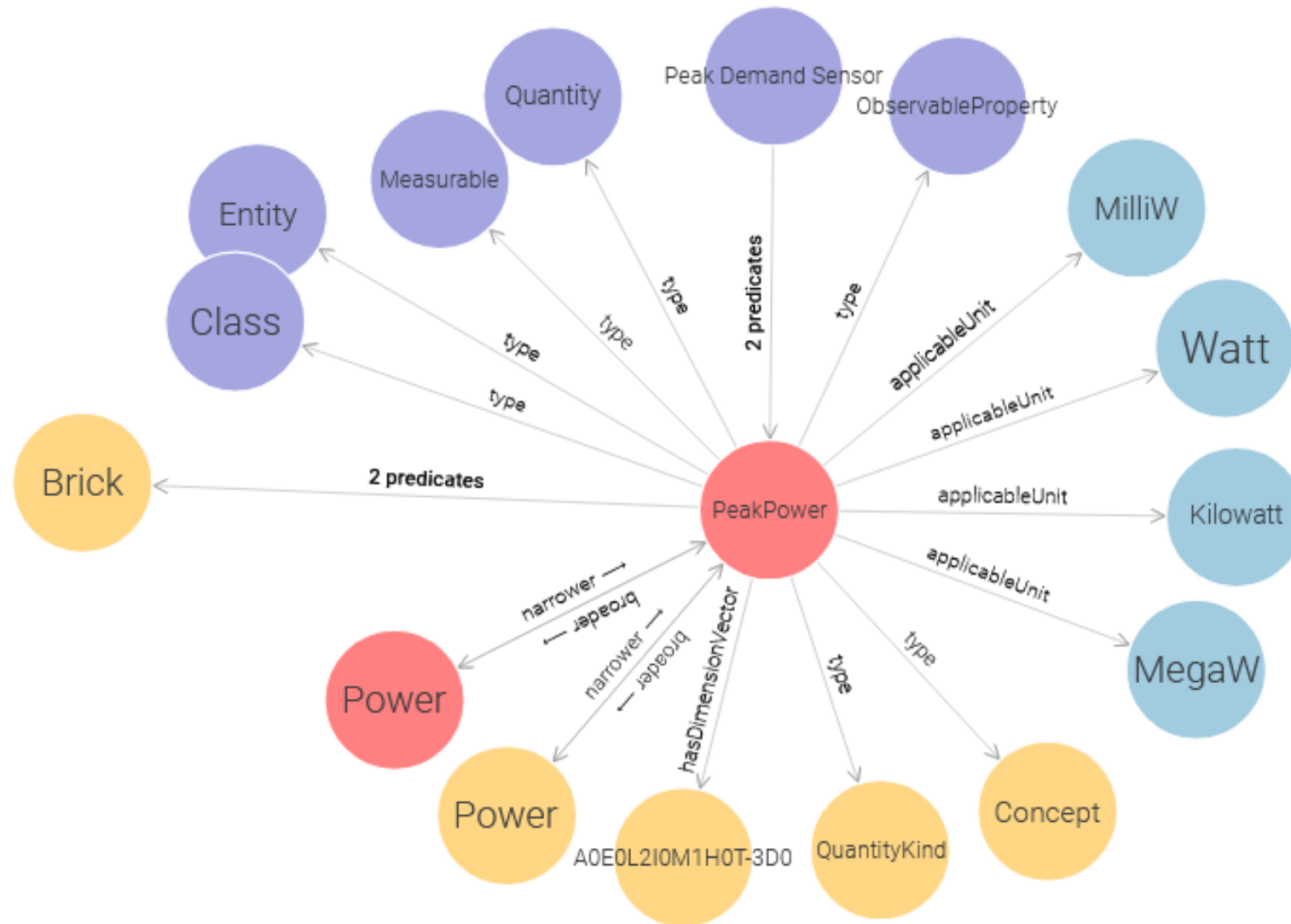
KPI synchronization

KPI synchronization engine



Demonstration

Knowledge Graph (excerpt)



Demonstration

KPI Webapp

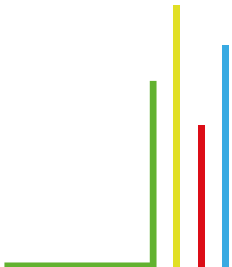
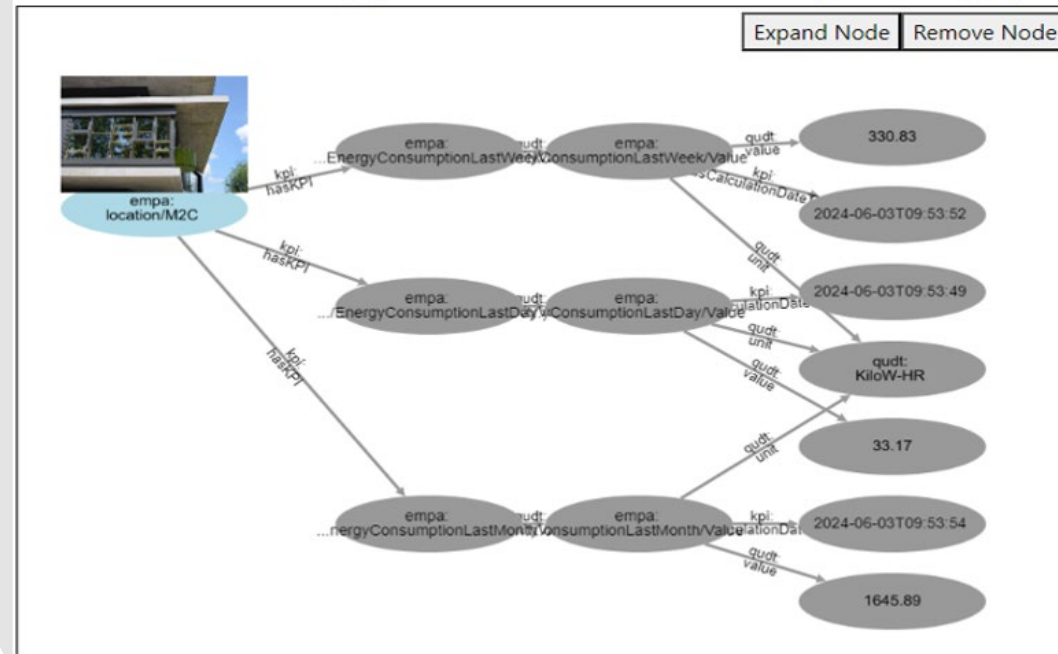
Prototype
Webapp:

1. Select one KPI from the list:

SpaceEnergyConsumptionKPI x ▾

Element	Element_t	unit	LastDay	LastWeek	LastMonth
filter data...					
location/DFAB	Space	KiloW-HR	-6.25	11.29	85.27
location/Hilo	Space	KiloW-HR	20.3	320.74	1413.68
location/M2C	Space	KiloW-HR	33.17	330.83	1645.89

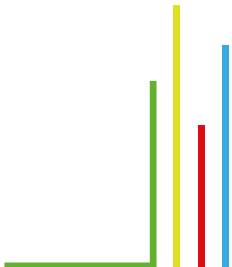
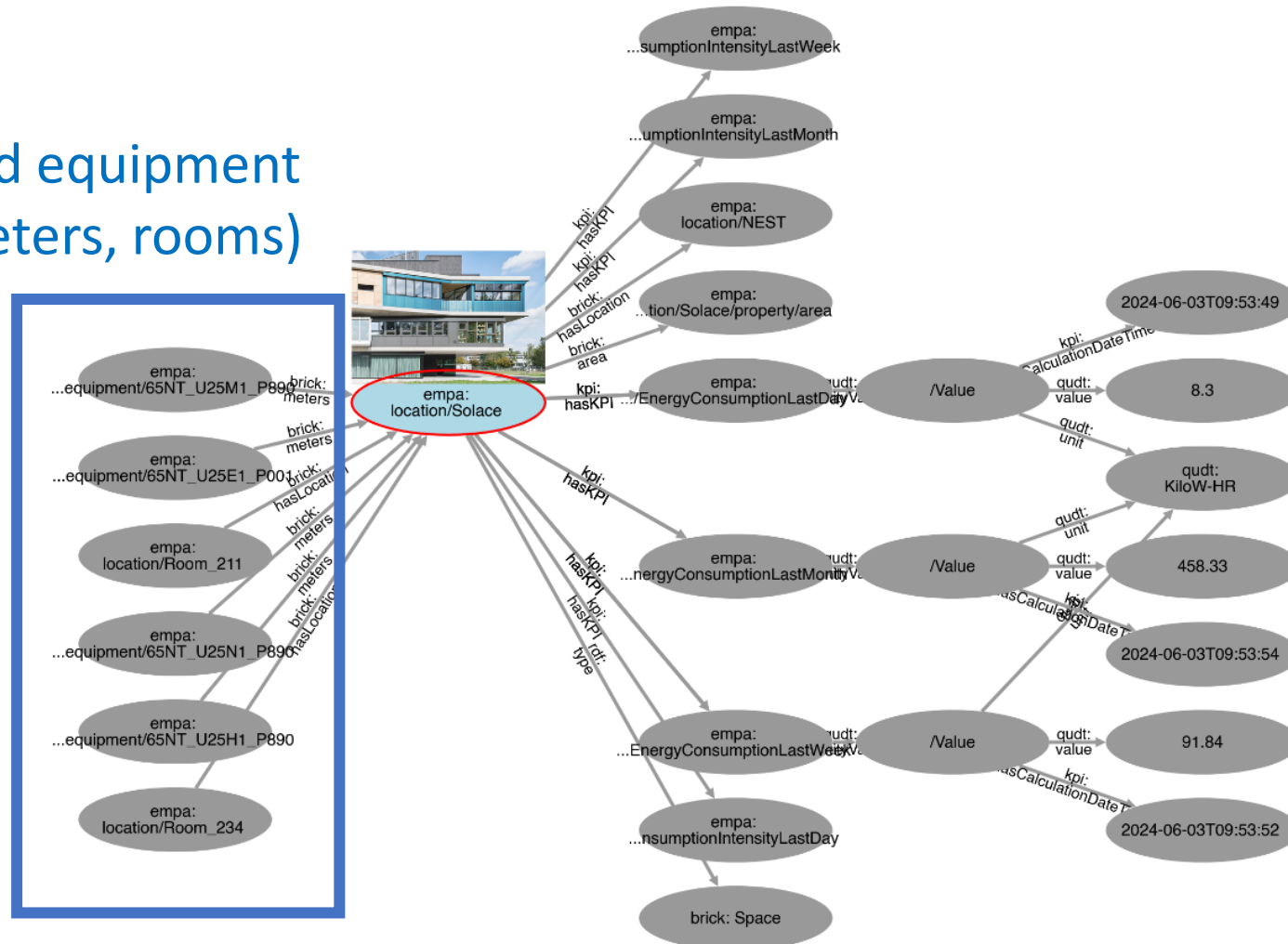
2. Select one element (↑) from the table above and explore the graph



Demonstration

KPI Webapp – Exploring the network

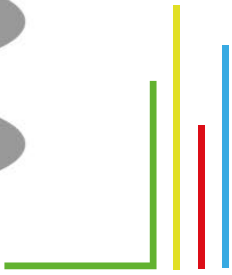
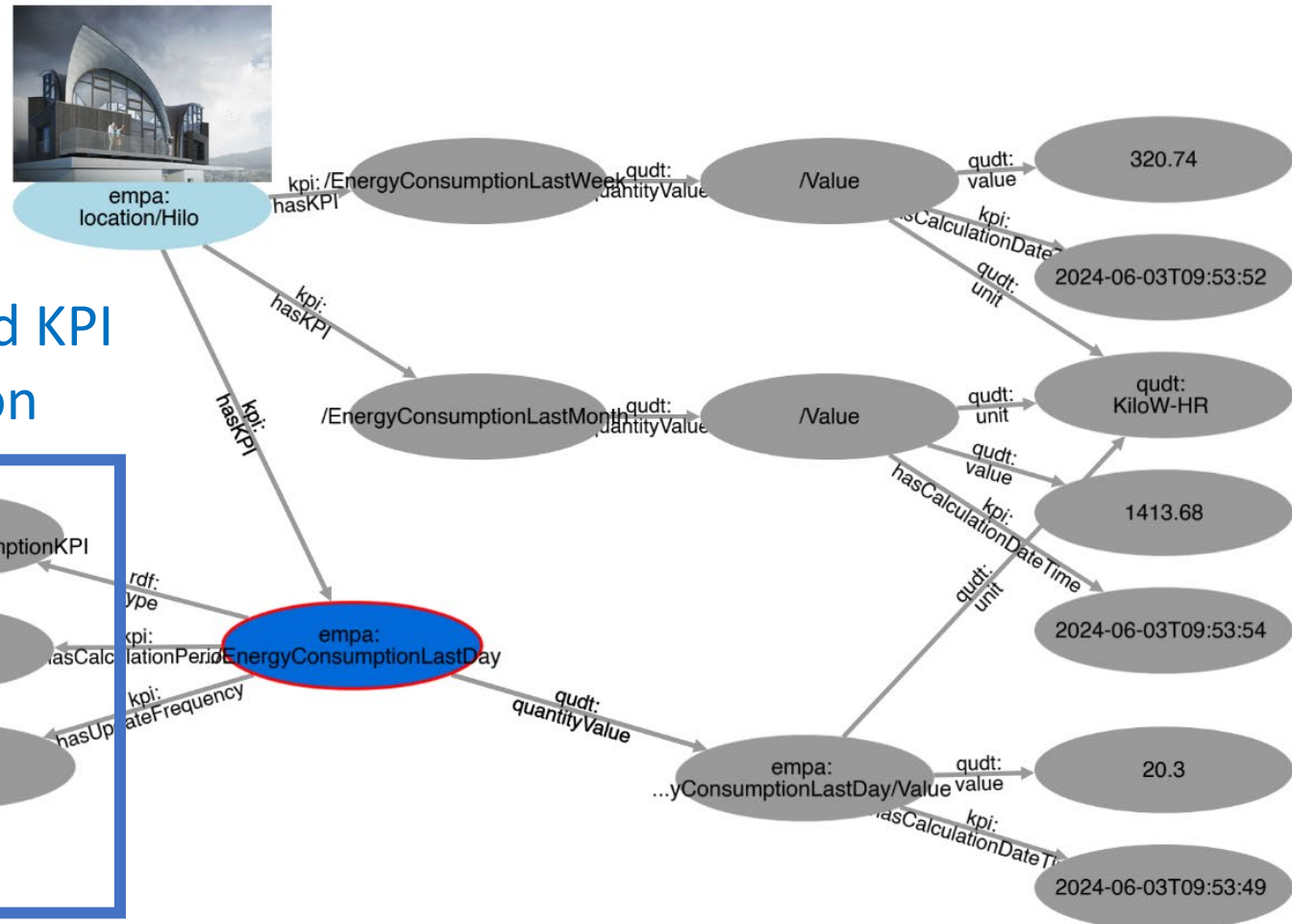
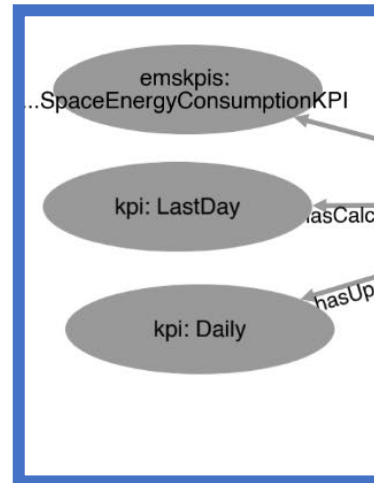
Associated equipment
(smart meters, rooms)



Demonstration

KPI Webapp – Exploring the network

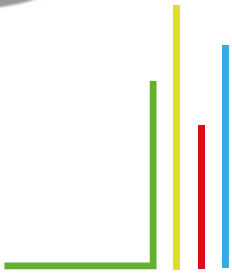
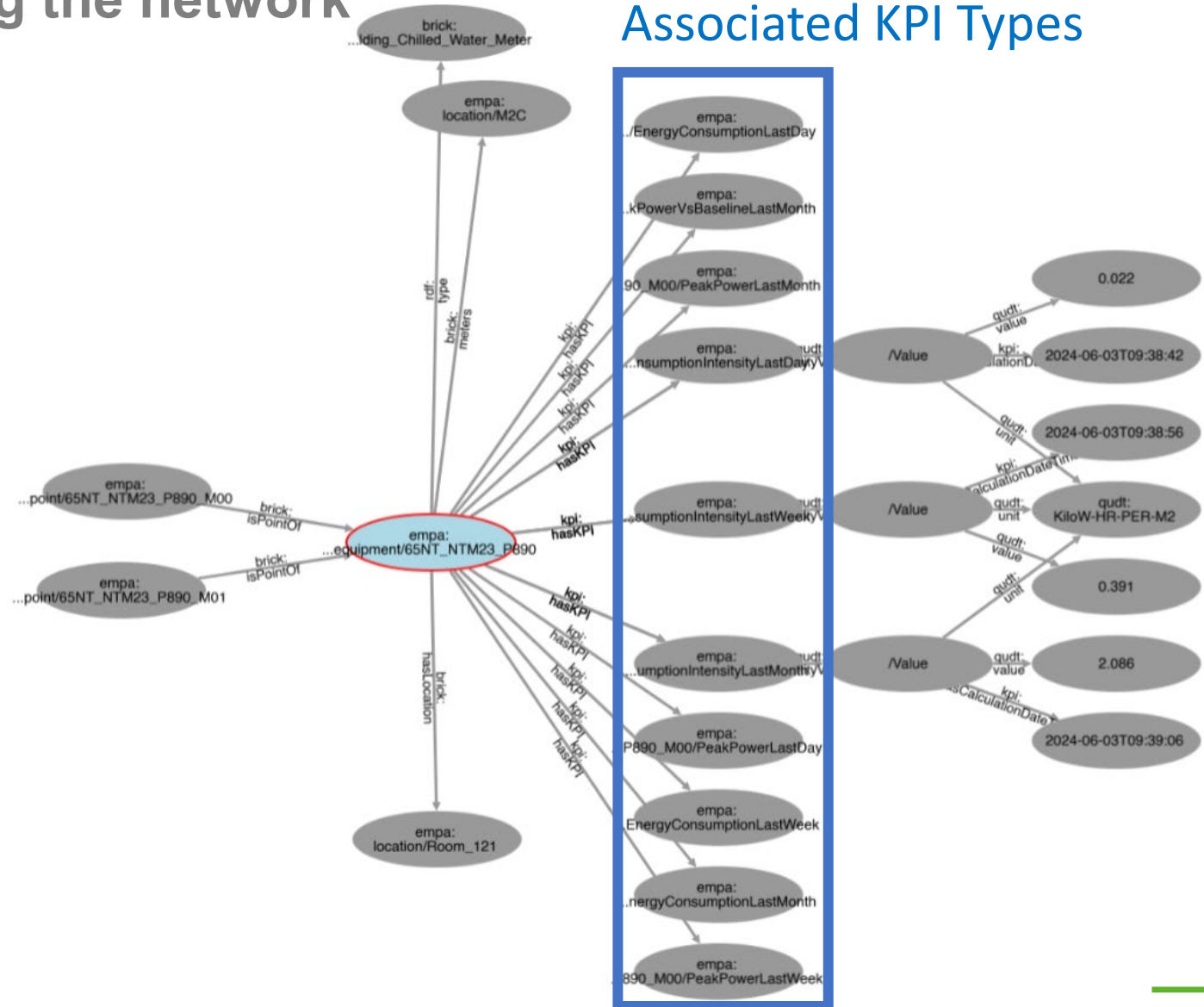
Associated KPI Description



Demonstration

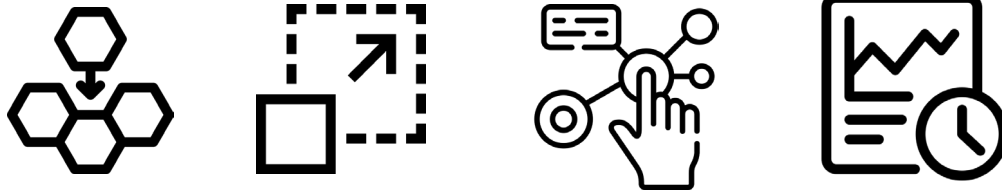
KPI Webapp – Exploring the network

Associated KPI Types

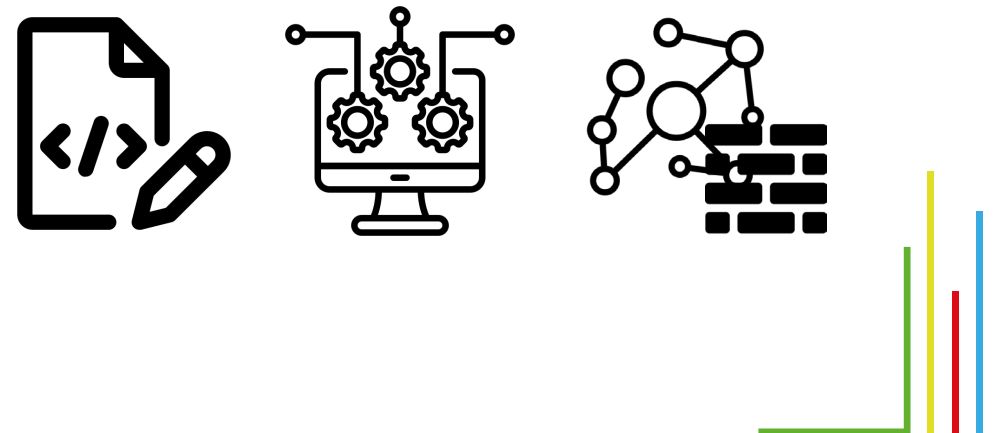


Conclusion

What this work delivers:

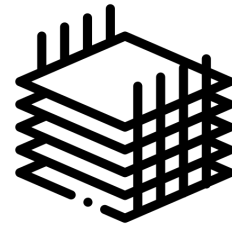


What this work does not cover:

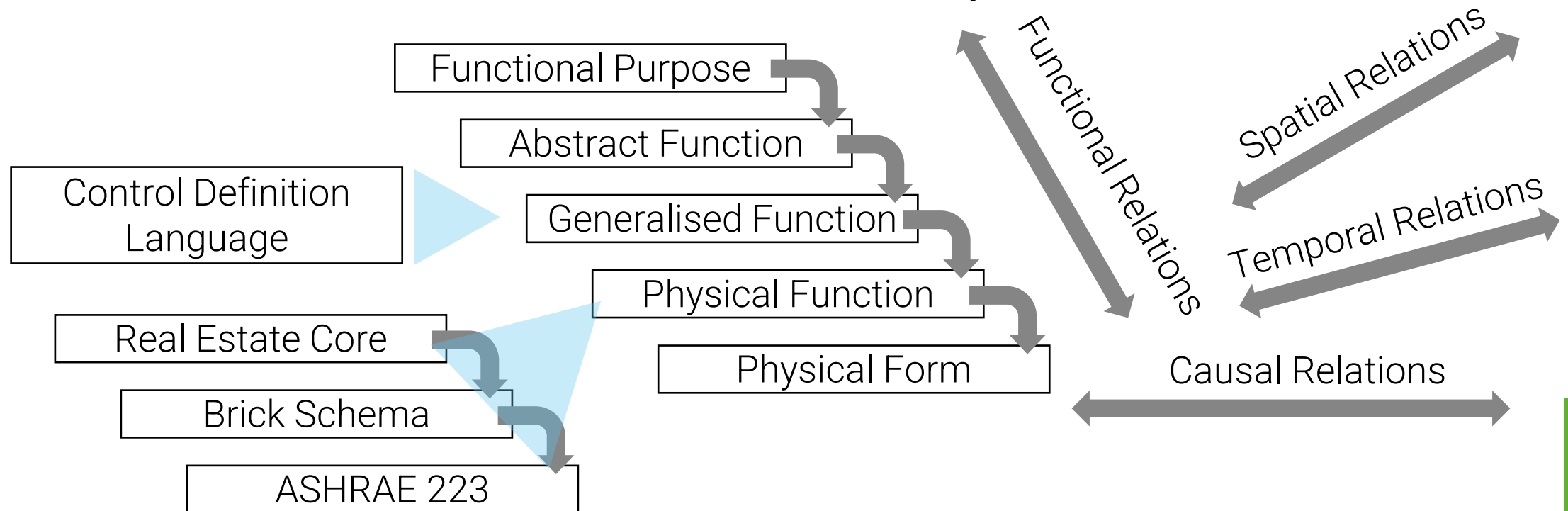


Outlook

Ecological Interface Design

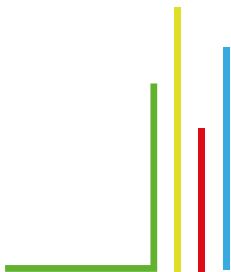
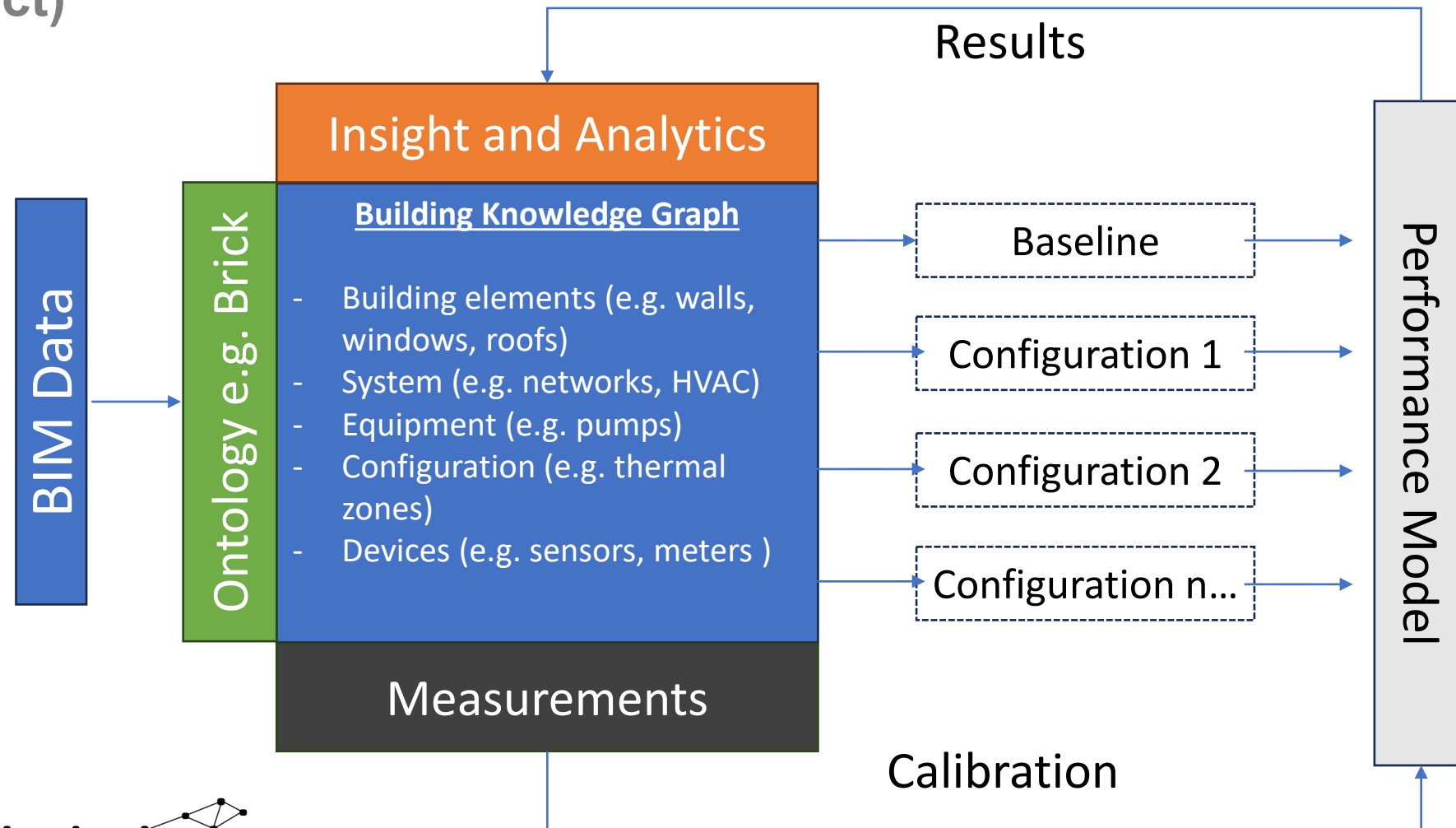


Functional Abstraction Hierarchy



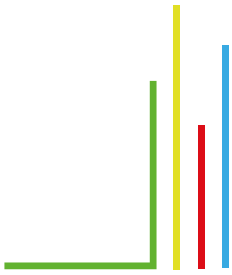
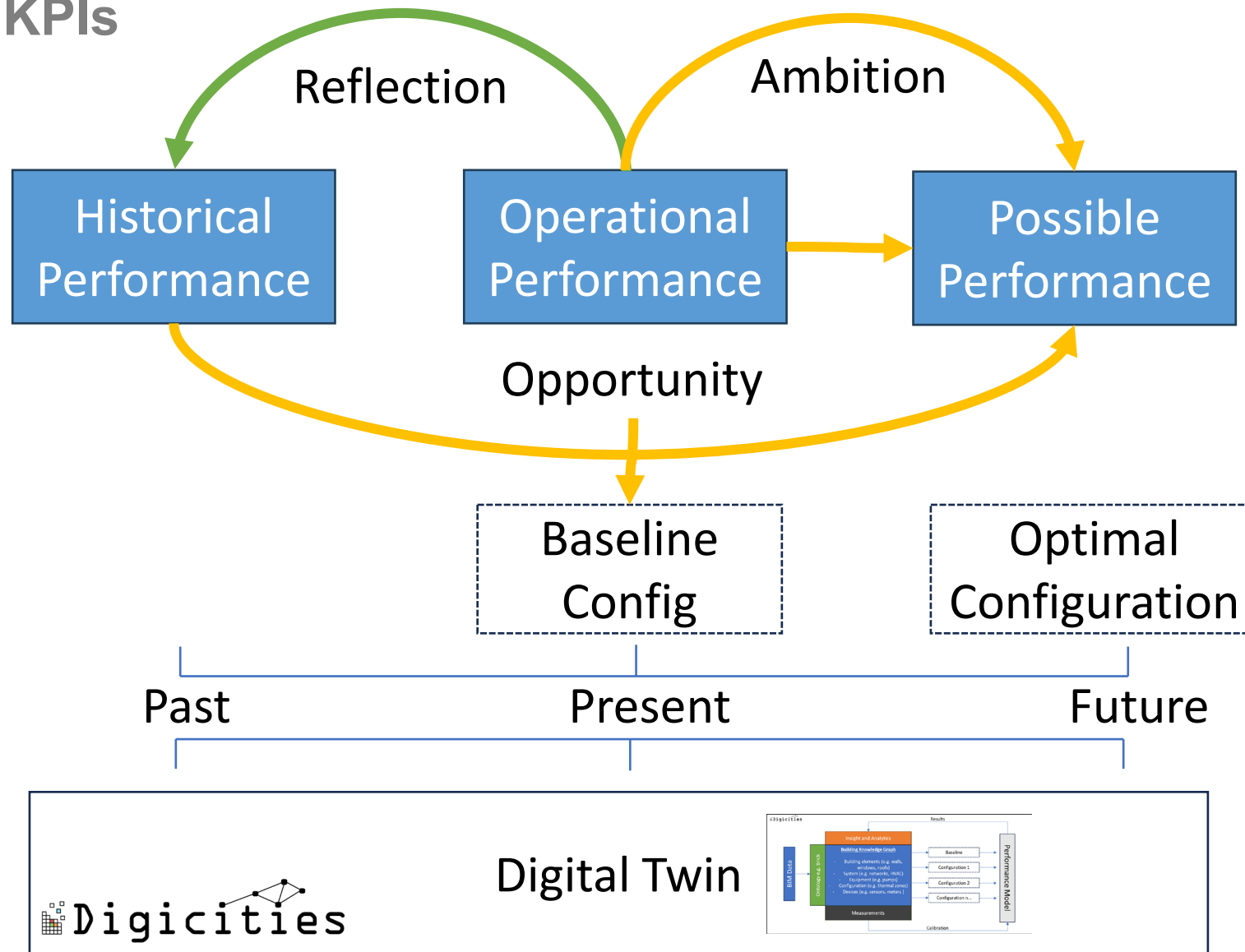
Outlook

Digital Twin Processes (Links to the Digicities project)



Outlook

Temporal KPIs



Obrigado



Empa

Materials Science and Technology

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