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An open endpoint and framework for the development of linked data for building energy systems

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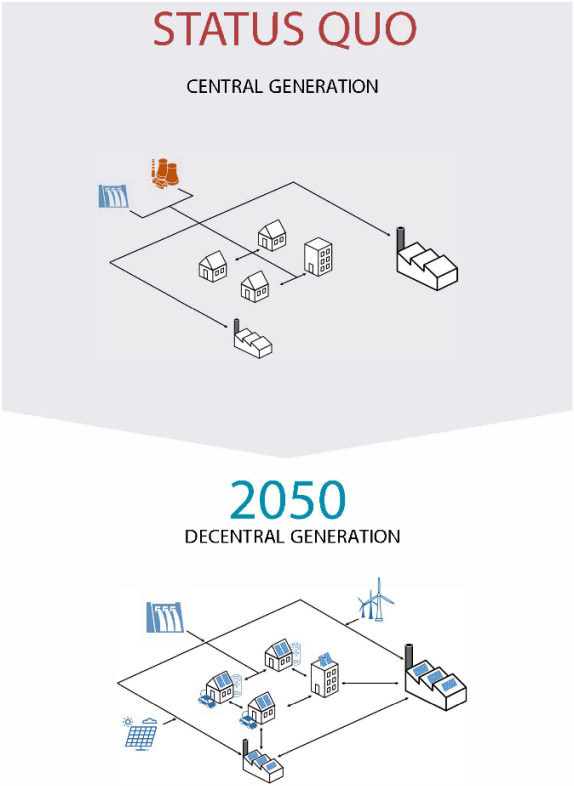
Objectives

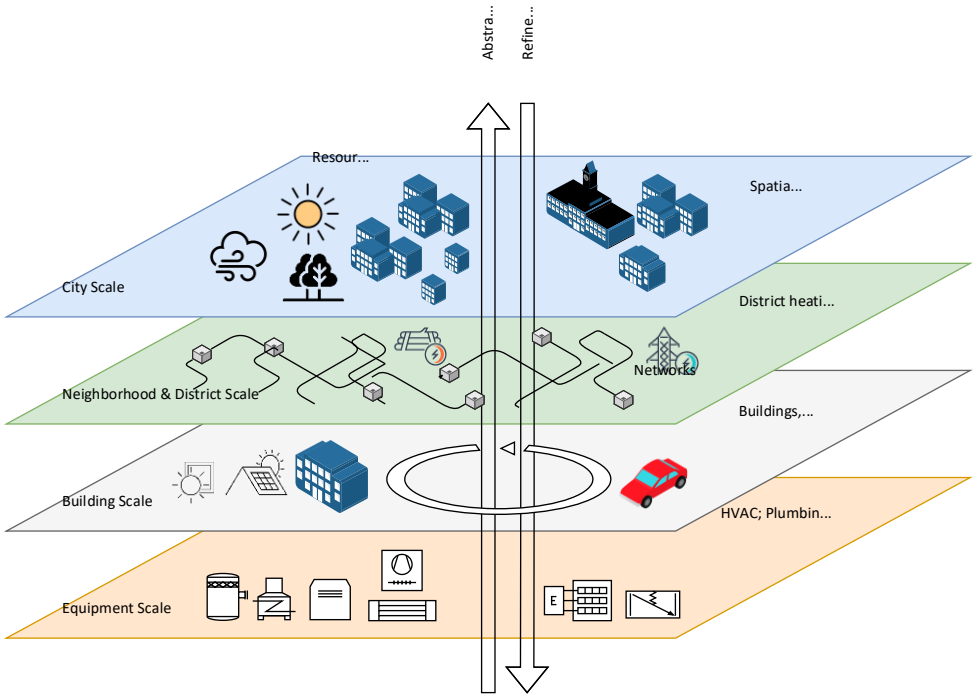
- A cloud-based digital infrastructure to support the reduction of emissions through:
  - Control strategies to reduce energy consumption
  - Integration of decentralized renewables and energy storage
  - Efficient material use and circularity



Moving from a centralised to a decentralised energy system Credit: R Wolter

Roles of linked data

- A linked data graph is a central component to support FAIR data principles including:
  - Data integration and interoperability
  - Discovery and inference
  - Contextual understanding
  - Flexibility in expressivity and representation
  - Transparency and traceability



Visualisation of the data scales encountered in energy planning and operation as interconnected digital layers. Credit: M Sulzer.

NEST/move/ehub demonstrators at Empa

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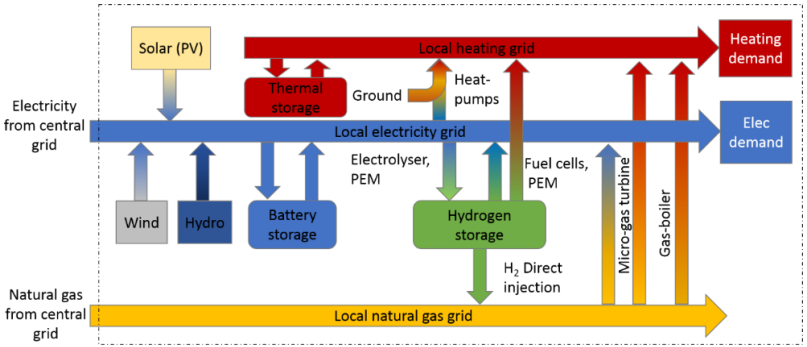
- NEST is a modular research and innovation building
- move is a sustainable mobility demonstrator
- ehub is an energy district of connected demonstrators for the testing and development of energy strategies



6 Heat pumps
3 Thermal buffers
1 Ice storage unit

2 Batteries
7 PV & thermal collectors
1 EV charging station
1 Edge Datacenter

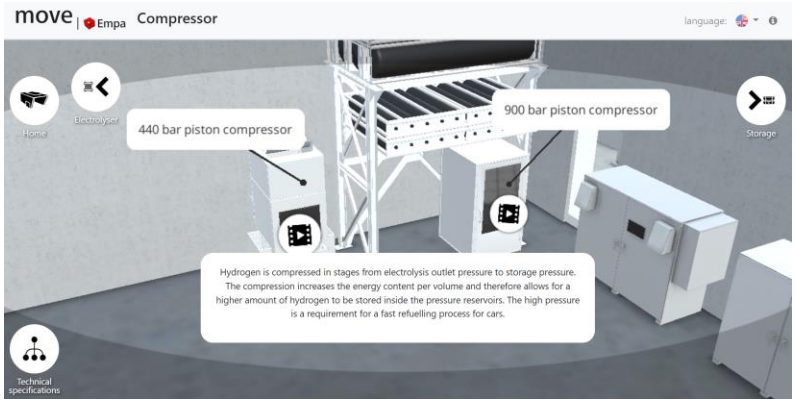
4 Thermal networks
4 Electrical networks

600+ Actors
1'300+ Sensors
10'000+ Datapoints

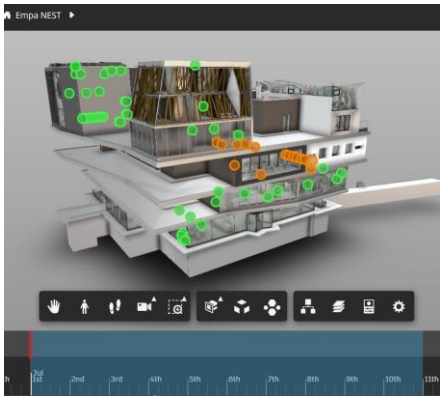
flexible district energy system

dhub

- Digital innovation in the building, energy and mobility sector including:
  - BIM
  - Creation of digital models of existing infrastructure
  - Decision support
  - Virtual and augmented reality
  - Automated data processing



https://move.nestcloud.ch/



https://dasher360.com/share/3Woc9yknY

NEST Cloud Conceptual Architecture

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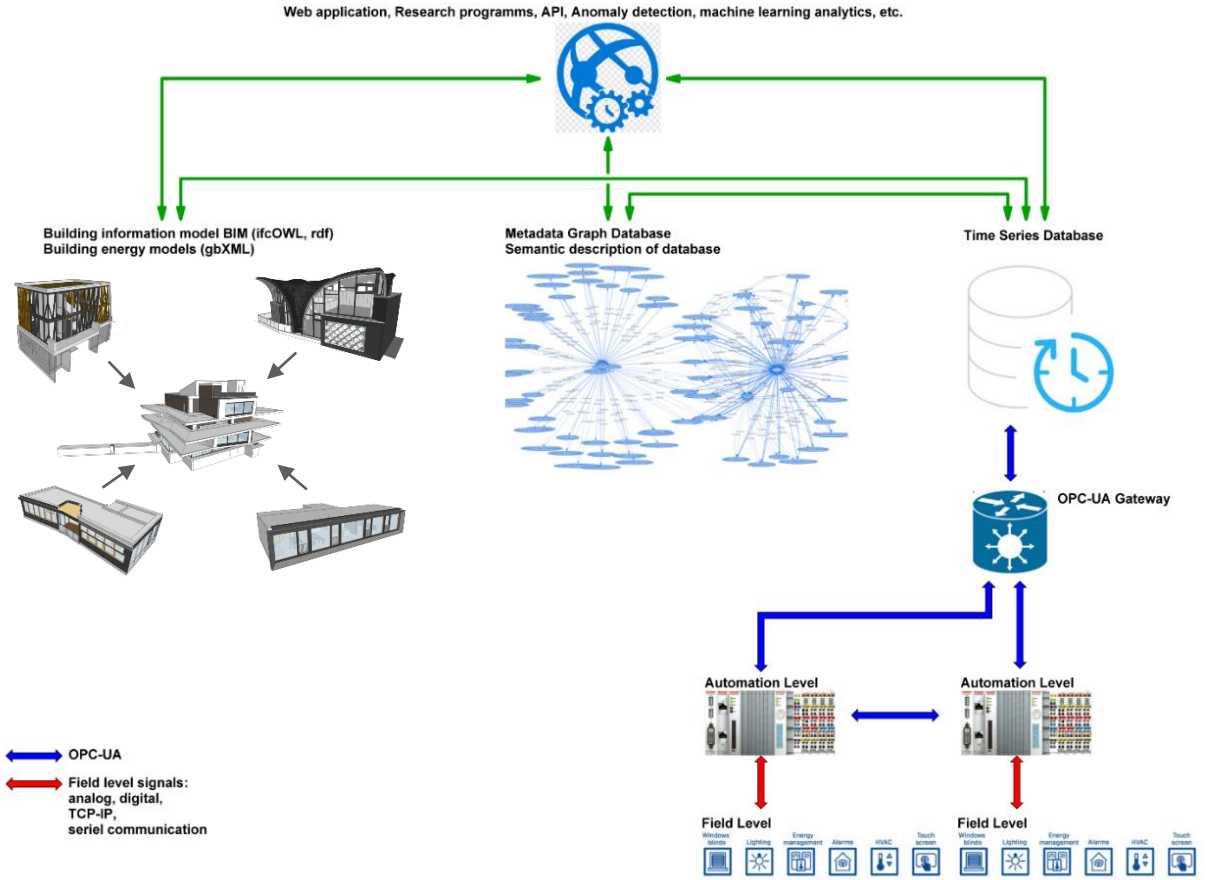
- Our graph database is installed in parallel to a time series database
- The time series database is directly connected to the OPC-UA gateway for control
- Building information models and building energy models are inputs to both the graph and the time series databases



Generating our Brick graph

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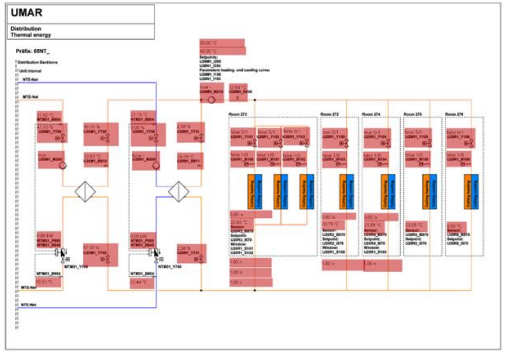
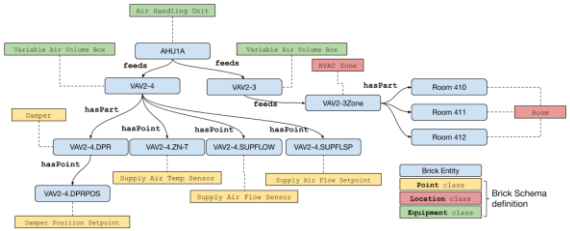
Process:

- Mapping of schematics to Brick classes and properties
- Structured data containing the mapping (csv, dataframe etc)
- SPARQL Generate / rdflib used to generate the triples

Engineering Schematic:

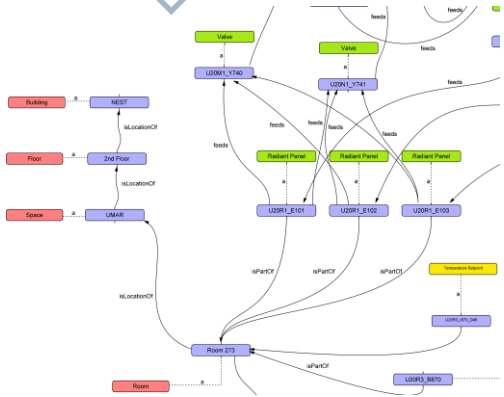


Brick ontology:



Source: https://docs.brickschema.org/intro.html

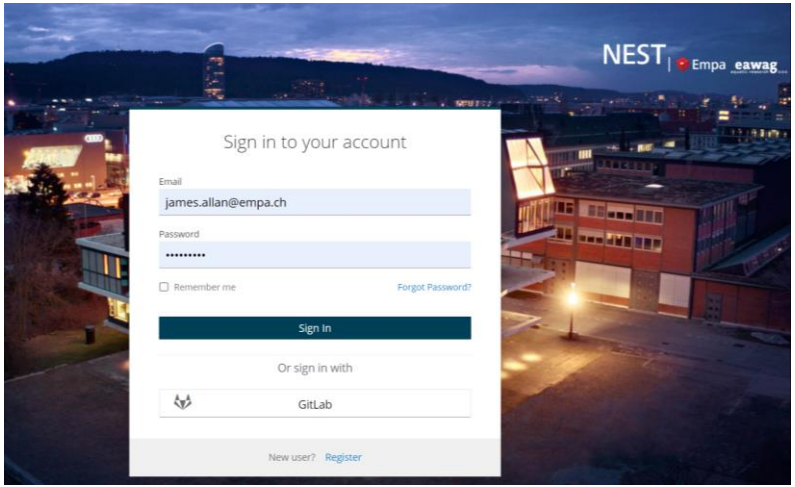
Conceptual Mapping:

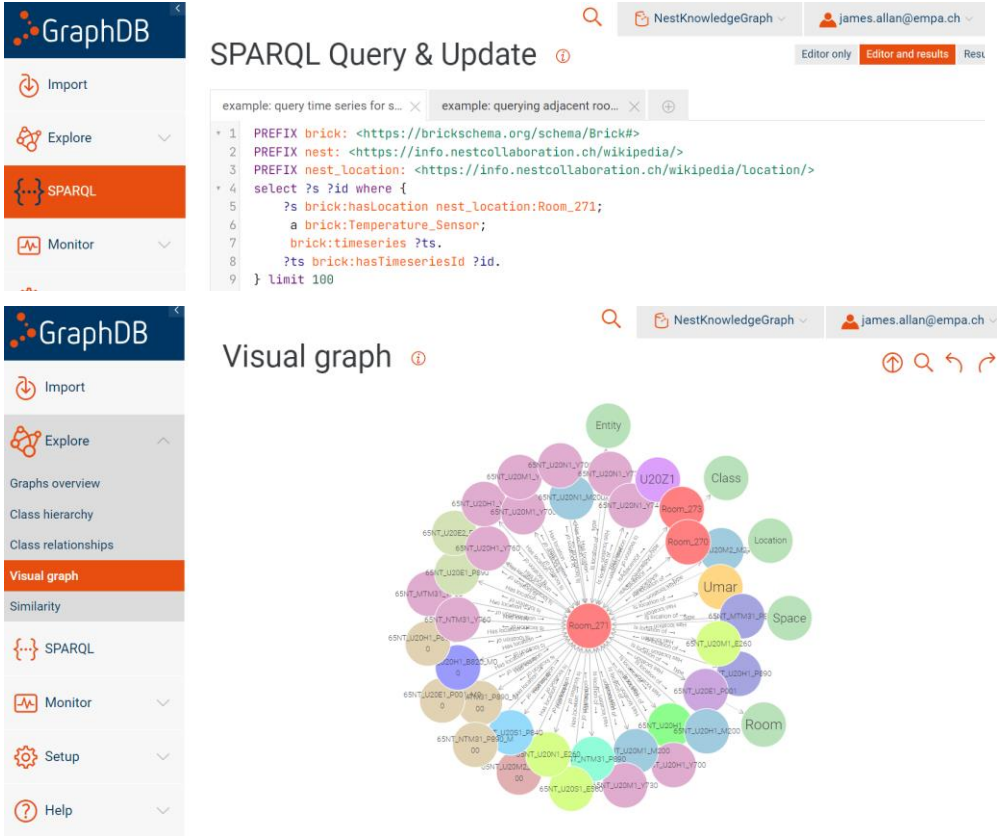


NEST Cloud – Knowledge Graph

The endpoint can be accessed here:
https://graphdb.nestcloud.ch/login

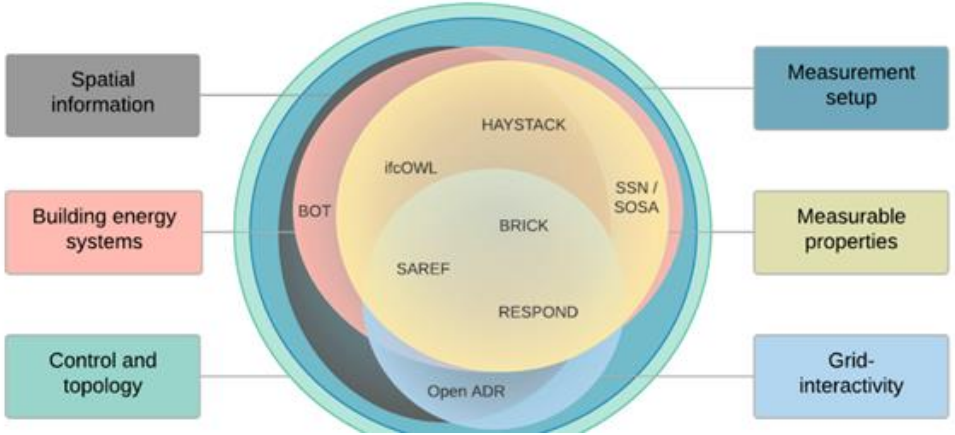
Please get in touch to request access to the beta version.





Challenges faced

- Ontologies (Many, redundancy, versioning, overlaps)
- Manual mapping of systems and sensors is specialist and time consuming
- Necessity of intermediate mapping files
- Conversion tools (Which?)
- Different engineer = different model
- Decision on performance metrics



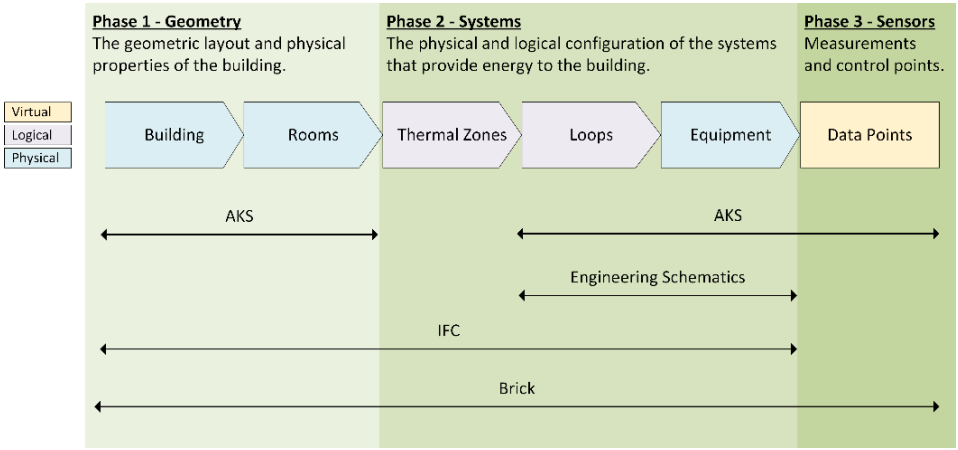
Source: De Andrade Pereira F, Shaw C, Martín-Toral S, L. Hernández J, Sanz Jimeno R, Finn D, et al. Towards semantic interoperability for demand-side management: a review of BIM and BAS ontologies, 2022.

	GUI	CLI, automation	Reuse mappings	Messy data	Virtual graph
OpenRefine + RDF extension	✅	+/-	+/-	✅	
TopBraid Composer (ME)1	✅				
RML-based tools (RML mapper, SDM-RDFizer)		✅	✅		
SPARQL-Generate		✅	✅		
Ontop (RDB only)		✅	✅		✅
Virtuoso (proprietary tool)			✅		✅
Custom code		✅		✅	

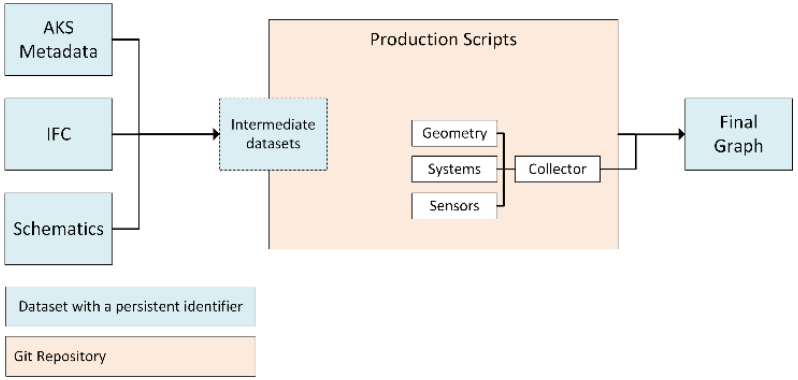
Source: https://fairplus.github.io/the-fair-cookbook/content/recipes/interoperability/rdf-conversion.html

Knowledge graph creation as a framework

- The process of creating a knowledge graph is as important as the contents
- Proposing a sandbox/framework containing persistent versions of the processing scripts and graph serialisation aiming to:
  - Facilitate repeatability
  - Compare the performance of knowledge graphs
  - Refine ontologies to reduce overlap and redundancy
  - Encourage standardisation



Possible framework:



Future work and collaboration

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- Current work with partners from industry and research includes:
  - Knowledge graphs from engineering schematics and BIM
  - Interoperability of BIM and Building Energy Models (BEM)
  - Diagnostic tools
  - Integration of constraints to improve metrics for operation
  - Interface with Digital Twins
- Open to partnerships with researchers and industry to collaborate and work with our data, develop new pipelines and interconnectivity. Please get in touch (james.allan@empa.ch)

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Digital twin process.

Questions/Suggestions

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- Thank you for your attention