Co-Simulation of Socio-Technical Energy Systems: An Interdisciplinary Design Process

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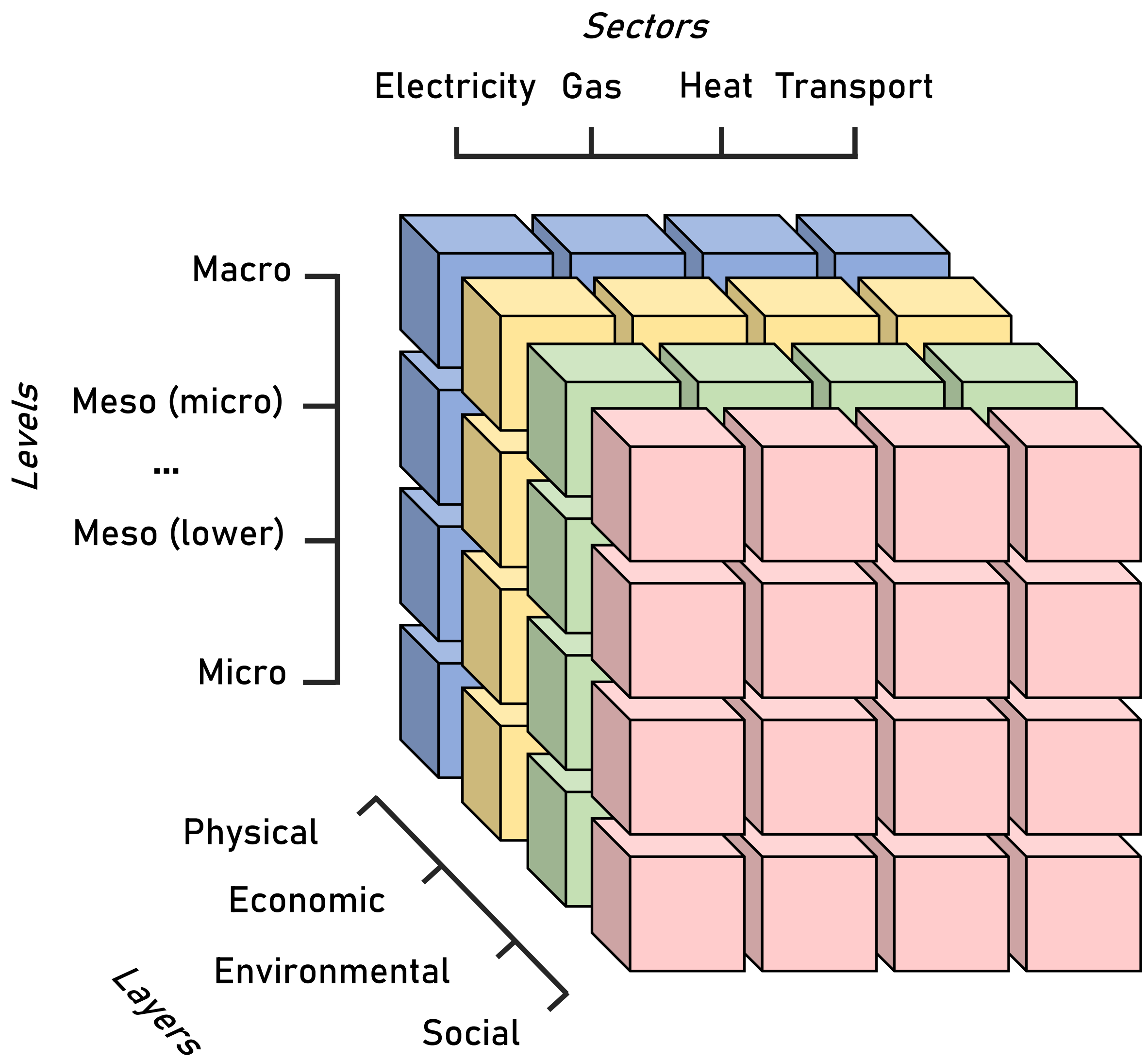
Energy Transition & Modeling

Complex & Interconnected System
- Sector coupling
- Energy-climate dependencies
- Human component

Models often
- Address particular problem
- Address part of energy system
- Use reductionist mathematical approach

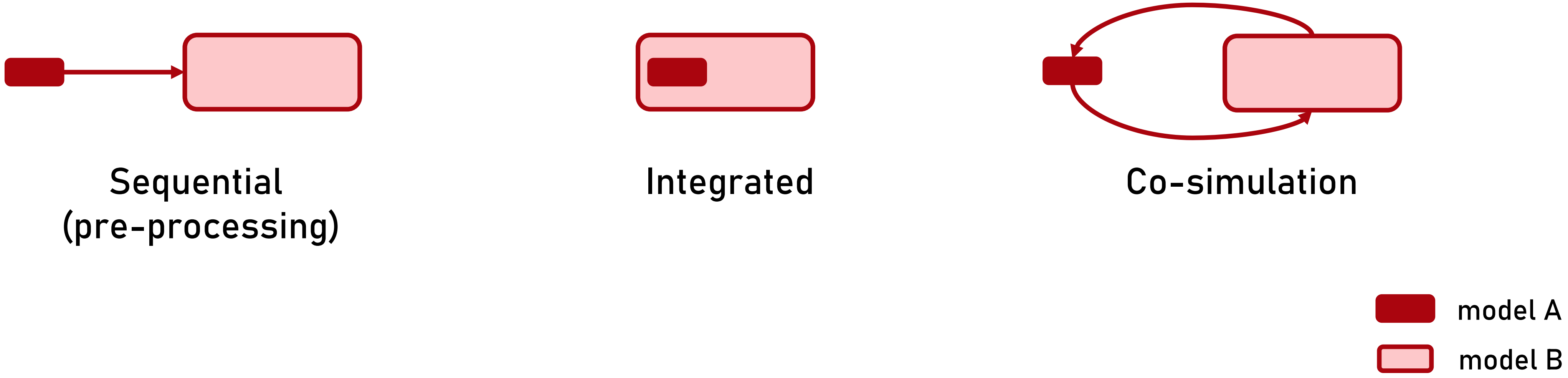
Gaps
- More “realistic” models
- Interdisciplinary collaborations

A solution, not “the” solution
→ Co-Simulation



Co-simulation

A co-simulation encompasses a set of coupled and cooperating simulators, whose dynamic interconnections and interdependencies are established through data interfaces. Thus, the simulators can operate simultaneously and represent independent units with individual step sizes.



Co-simulation

advantages

- Model repurposing
- Scenario definition
- Scenarios expandability
- Interdisciplinary collaboration

challenges

- Model coupling
- Multi-level validation
- Tracking data flows
- Data comparability and transferability

Research questions

1. How can we effectively build socio-technical co-simulation scenarios to explore the energy transition?

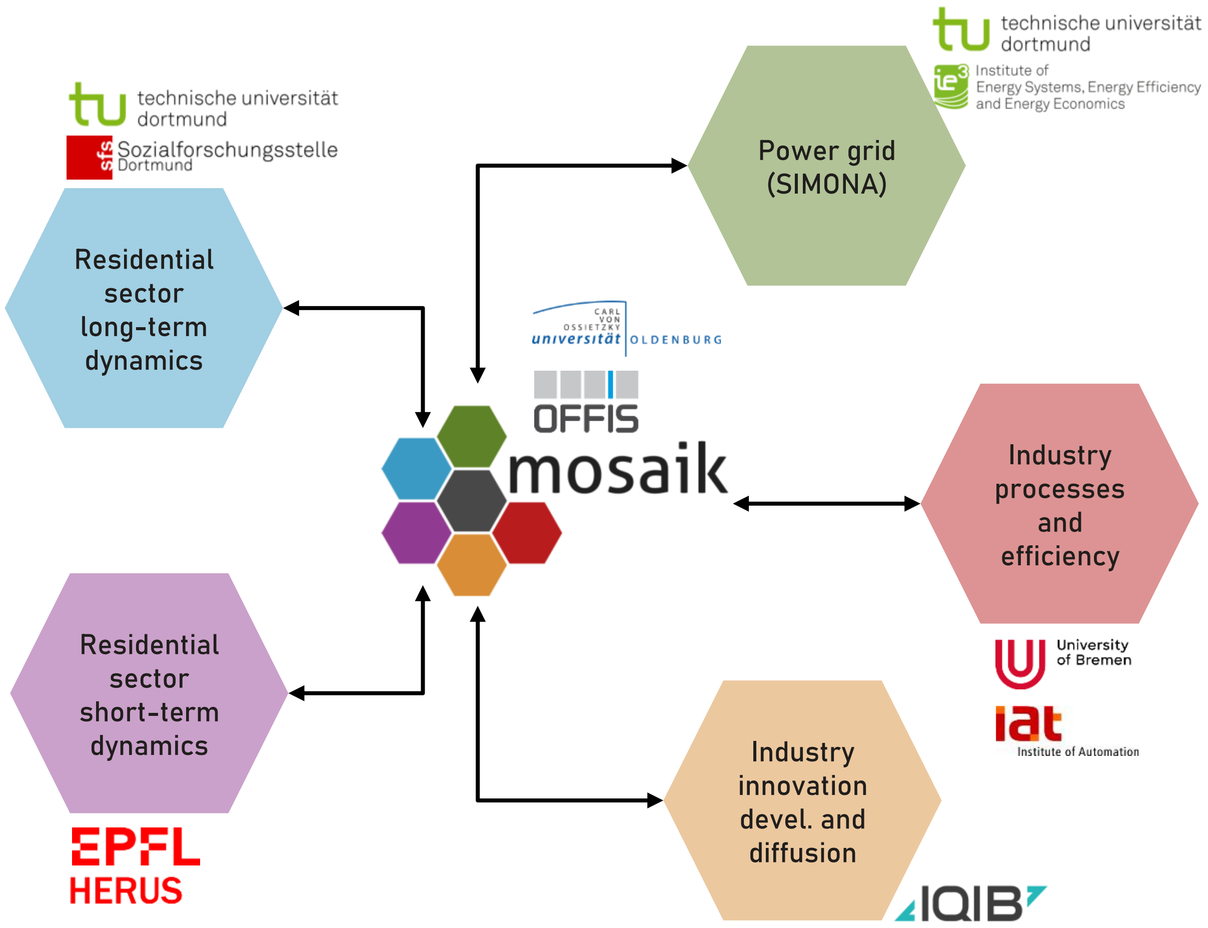
2. How to navigate the complexity of co-simulation scenarios in simulation and analysis?

MoMeEnT project

MoMeEnT
Modeling the socio-technical | Multi-level architecture of the | Energy system and its | Transfor-mation

Full name: Modelling the socio-technical multi-level architecture of the energy system and its transformation

Project objective: develop a policy design support tool which is able to examine different dimensions (i.e. technical and social) of the transformation of the multi-level energy system.



Methodology

Starting point: Interdisciplinary group with independently developed models analyzing diverse dynamics of the energy system.

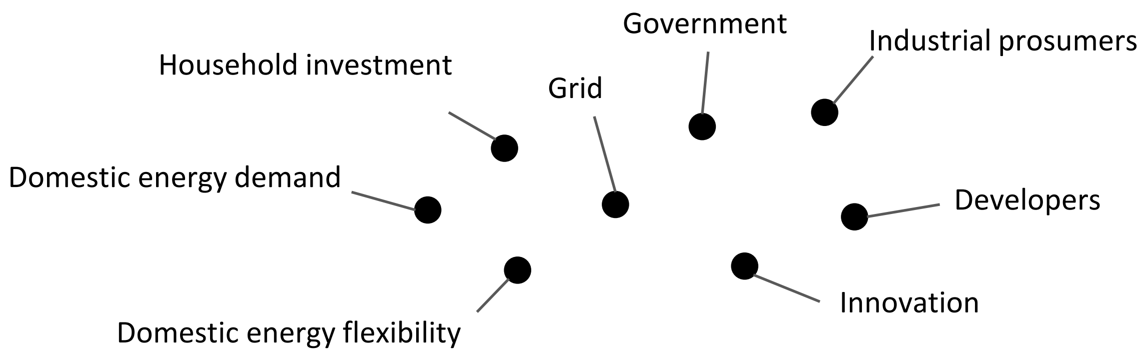
1 Information model

2 Modularization

3 Co-simulation

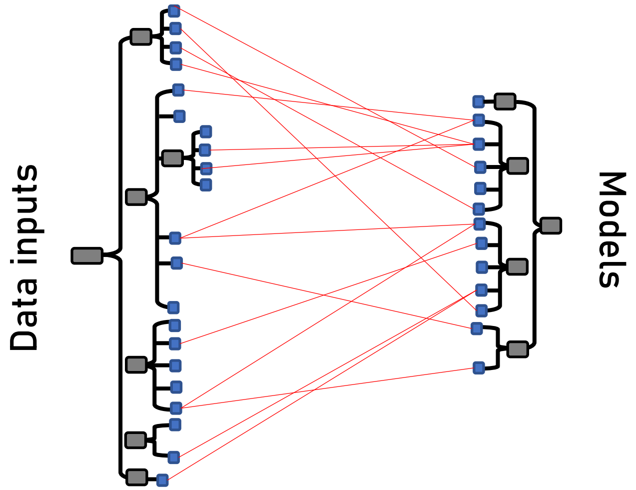
Goal: to explore the transition dynamics of the energy system through a socio-technical lens.

Information model



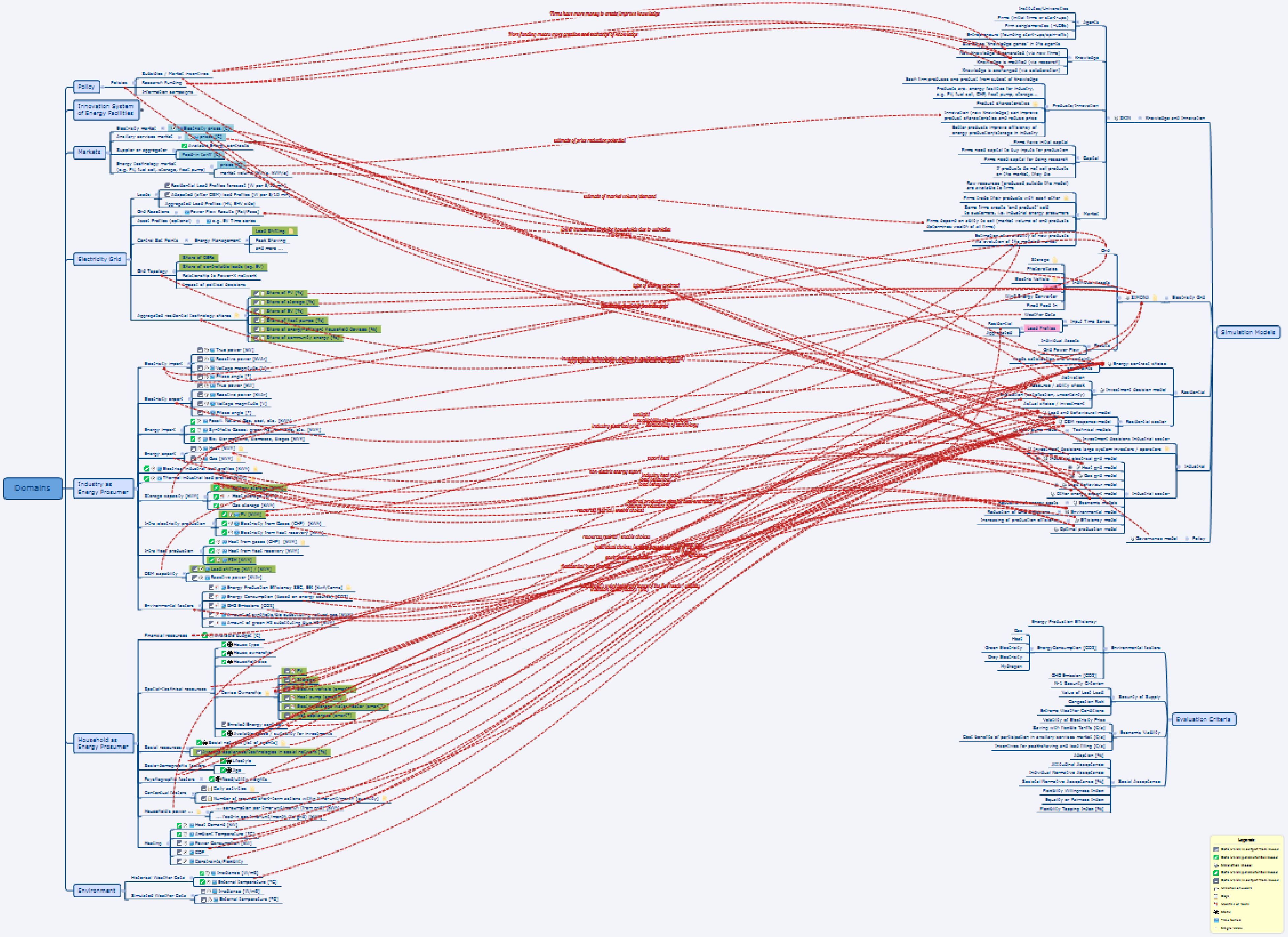
Objective: to provide a framework to describe the data flows between different models.

Mind map: easy-to-use tool for collaborative and interdisciplinary brainstorming without requiring in-depth familiarization with special modeling tools.



Data model: to transform the mind map in an ontology-based machine readable format and to allow querying on its content.

- Data dependencies and attributes
- Data sharing across models
- Missing/overlapping models

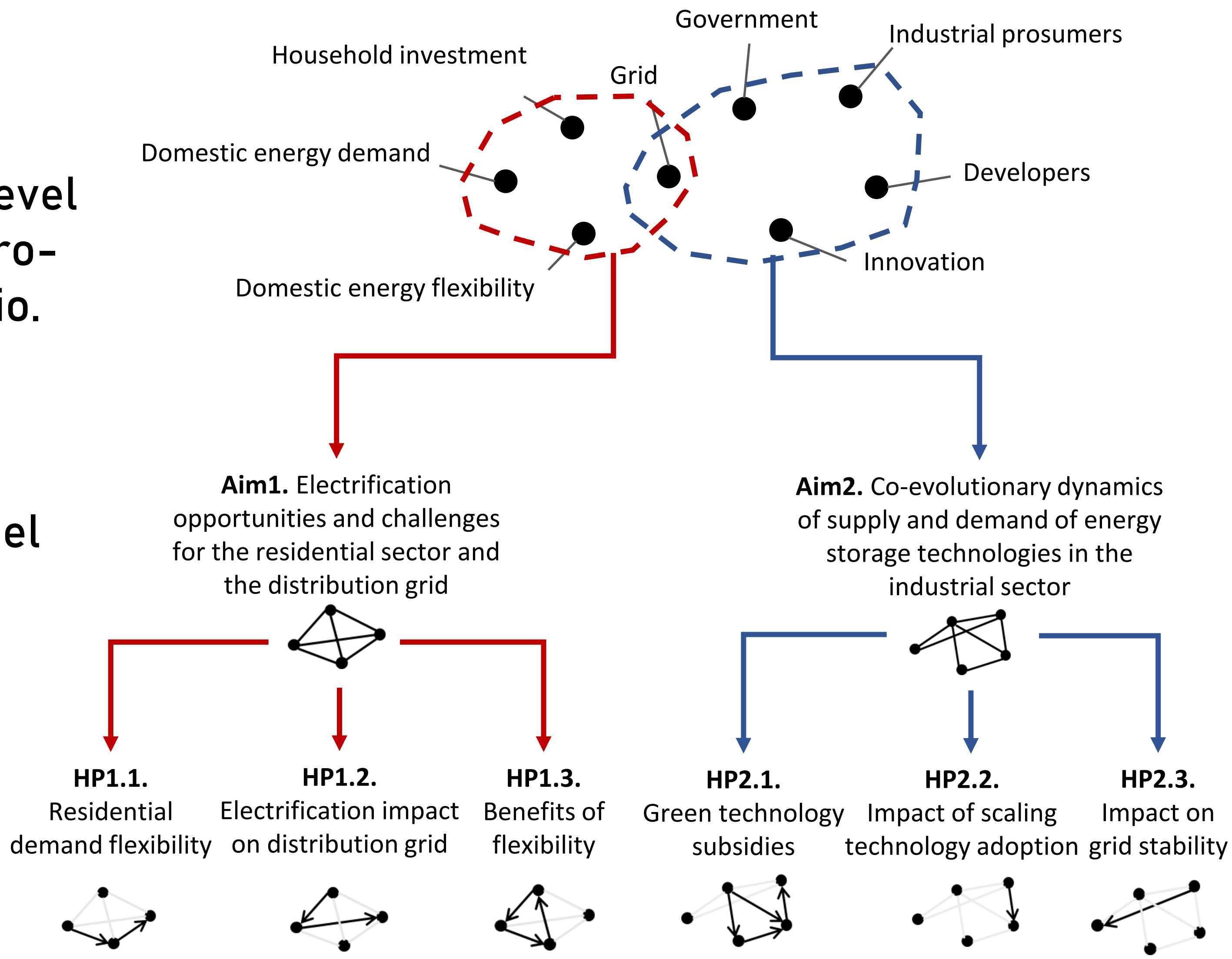

Domains
Policy
Innovation System of Energy Facilities
Markets
Electricity Grid
Industry as Energy Prosumer
Household as Energy Prosumer
Environment
Simulation Models
Evaluation Criteria

Modularization

Objective: to validate both the micro-level of individual sub-models and the macro-level of the coupled system or scenario.

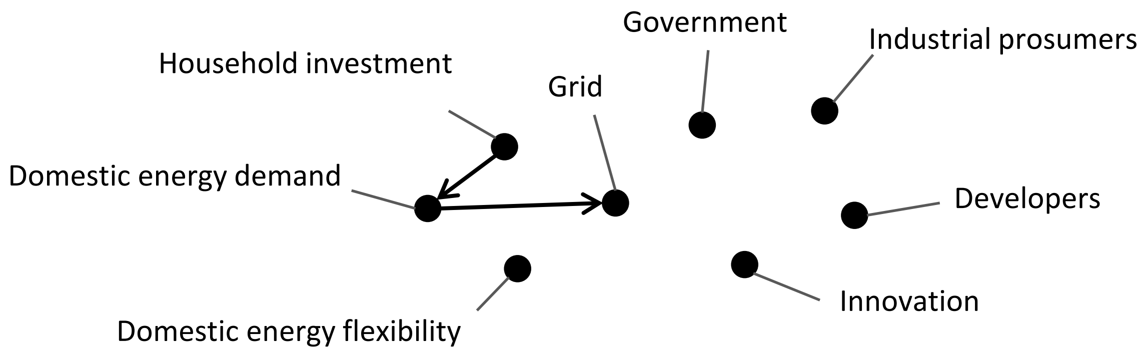
Meso-level: to describe a complex simulation scenario with multiple model couplings and analysis boundaries.

Micro-level: sub-scenario with limited number of couplings and higher analytical focus.



Co-simulation

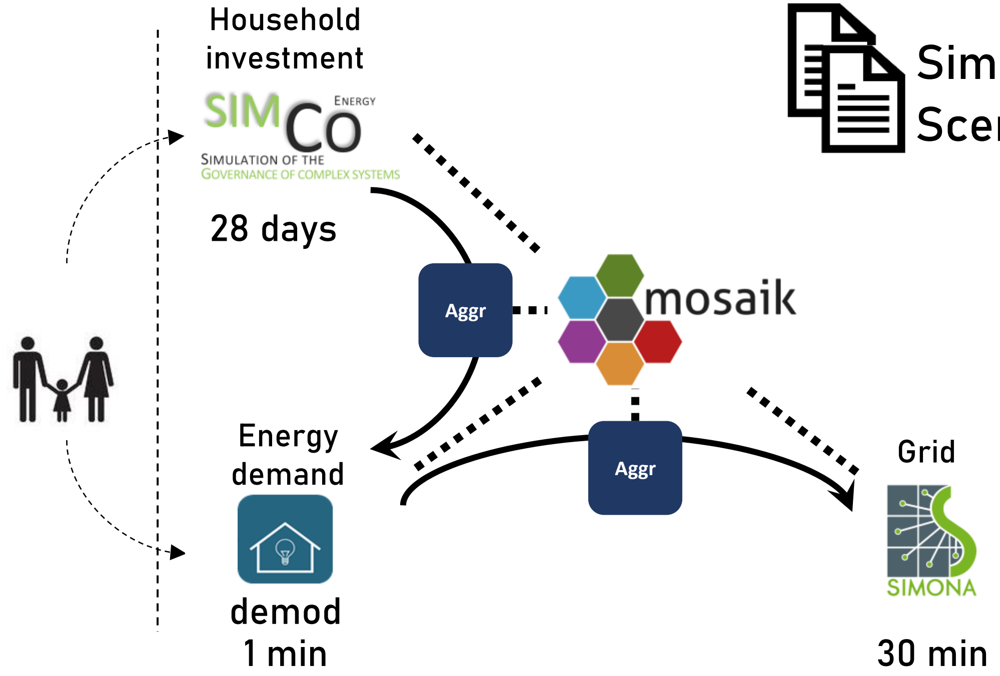
Objective: to quantitatively assess the hypotheses and aims; to generate insights for policy making.



Coupling: consistent initialization of models and data flows coupling based on spatio-temporal granularity.

Challenges:

- plausible simulation scenarios
- data and model consistency
- adapting the data format



Simulation API
Scenario API

Conclusions

- Co-simulation enables the development of interdisciplinary modeling ecosystems with profound insights across the different disciplines.
- The interdisciplinary effort consists of a thorough exploration and unambiguous specification of the research questions, the purpose of the simulator and the operational hypotheses.
- Modelers still require a conceptual understanding of distinct simulators beyond the technical specifications of the interfaces.
- Model validation challenges can be reduced (but not avoided) through a problem modularization approach.

Current status and next steps

- All the simulators mentioned above are able to interpret each other's data and communicate via mosaik.
- We are working on creating a meaningful electricity distribution grid with its components to explore the different co-simulation scenarios.
- The models developed and used in this project will be documented and partly made available open source.

Thank you!

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