Working groups on “modelling of NHES”

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How to study NHES?

Techno-economic assessment of NHES

. Technical feasibility
    . New process system to be studied (e.g., performance)
    . **Dynamic exchange of interconnected energy streams (steam, electricity, hydrogen, …)**
    . Monitoring of process and data for real-time decision (control)

. Economic feasibility
    . Impact of new structure of costs (capital and operational)
    . Assessment of plant revenues in new market (heat and H2)
    . Optimization of cost at system-level

+ Unit sizing, dispatch optimization, resource assessment, infrastructure requirements, development of new policies

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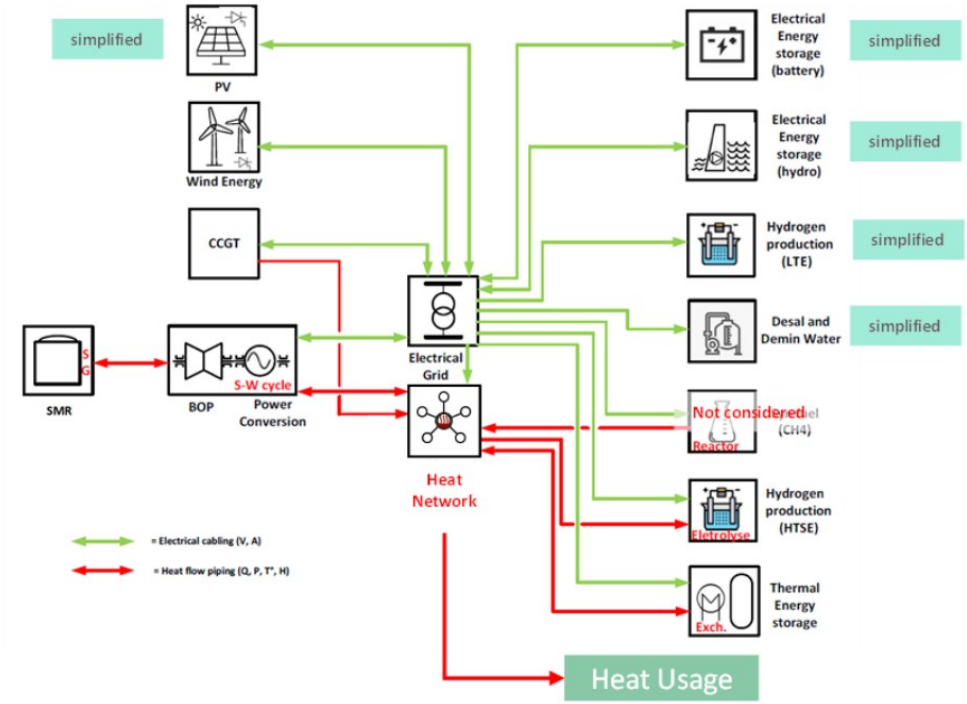
How to study NHES?



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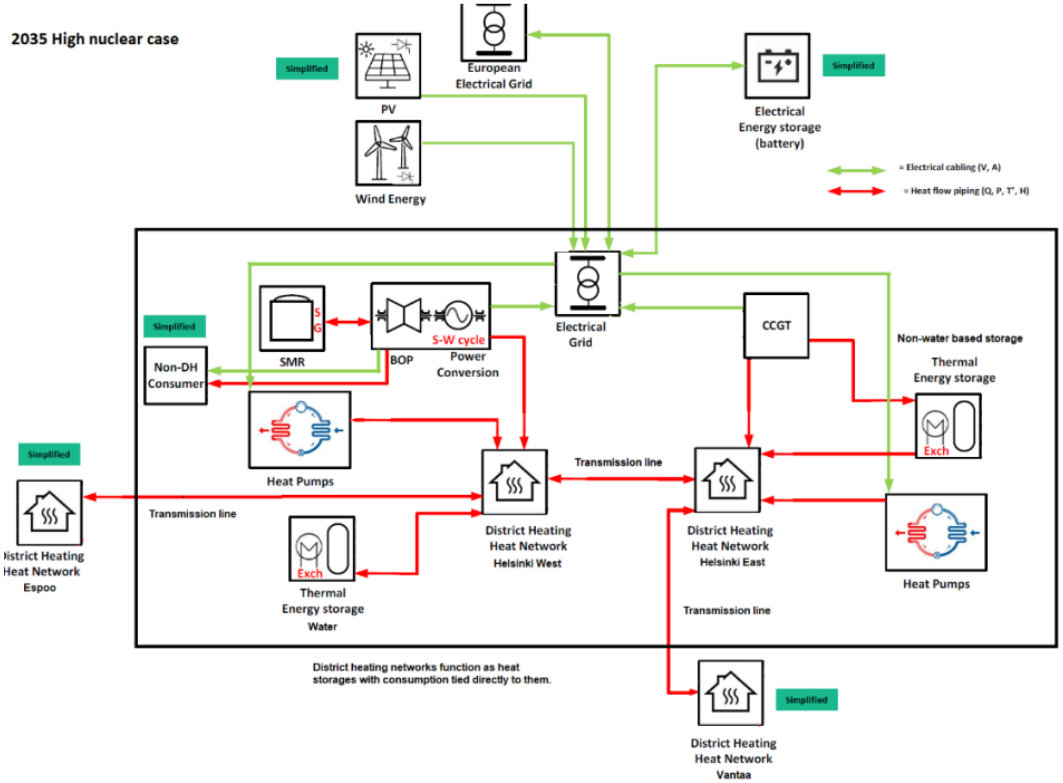

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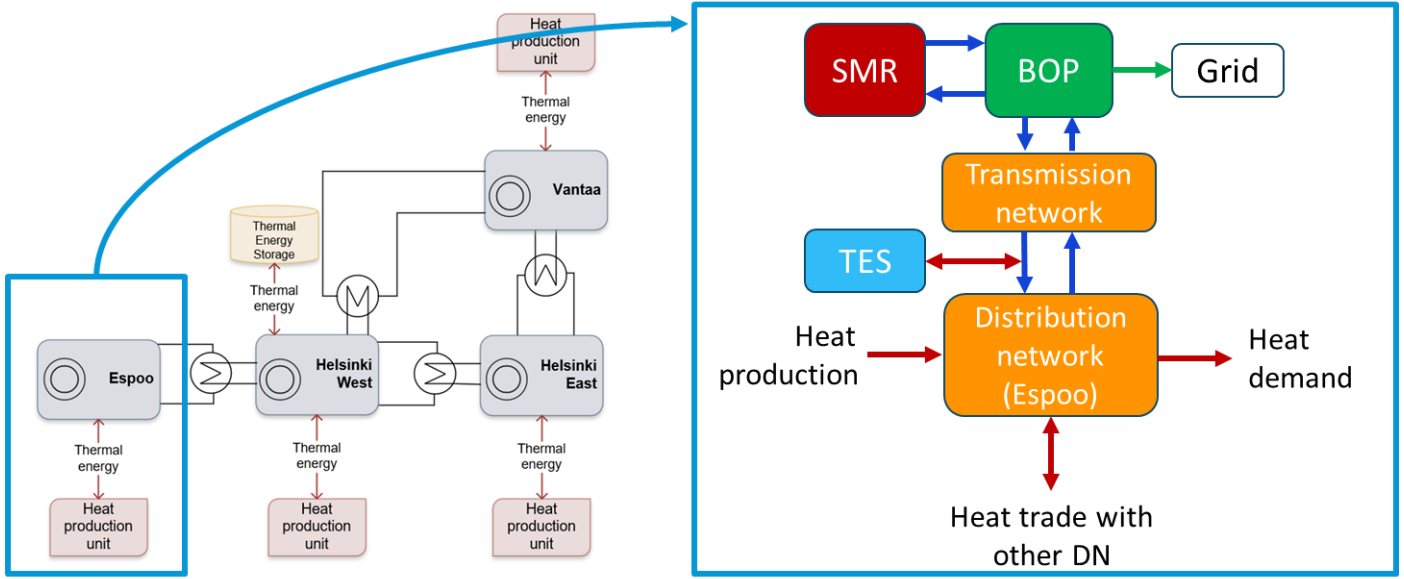

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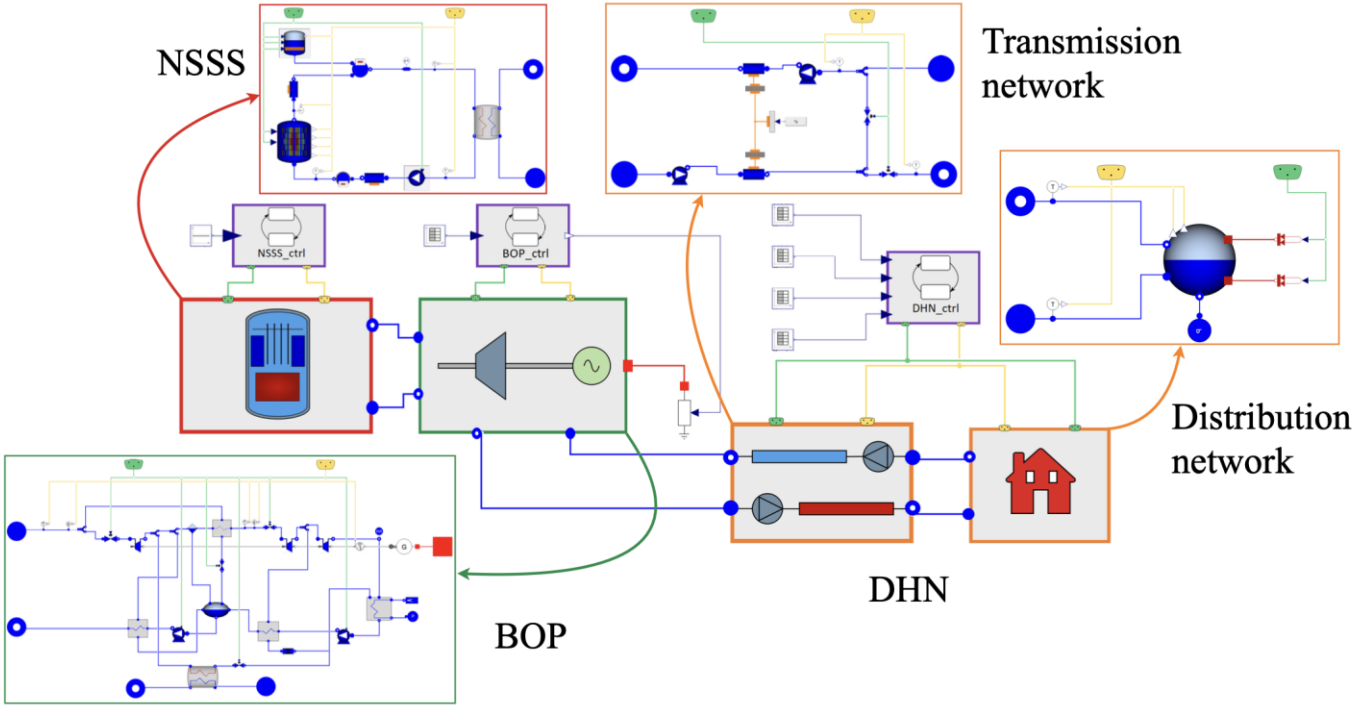

Introduction to Modelica

Modelling options

- Data-driven, needs input-output info
- Model-based, requires physics knowledge

Equation-based Object-Oriented modelling is the natural choice for the model-based simulation

Modelica is a modelling language

https://modelica.org/

MODELICA

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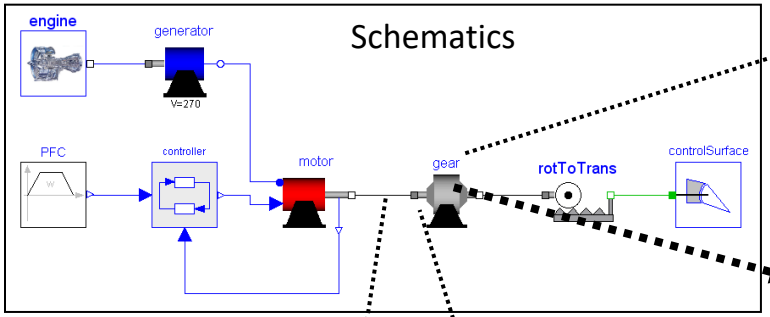
Introduction to Modelica

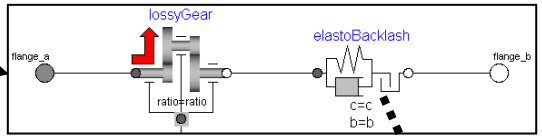


Ref. 2

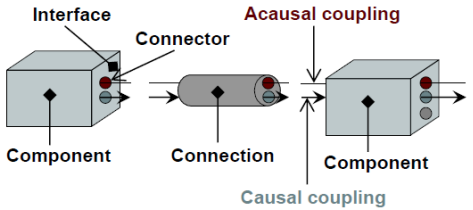
Component/device

Connection

Connector




```
equation
        0 = flange_a.tau + flange_b.tau;
  phi_rel = flange_b.phi - flange_a.phi;
    w_rel = der(phi_rel);
      ...
```



Ref. 3

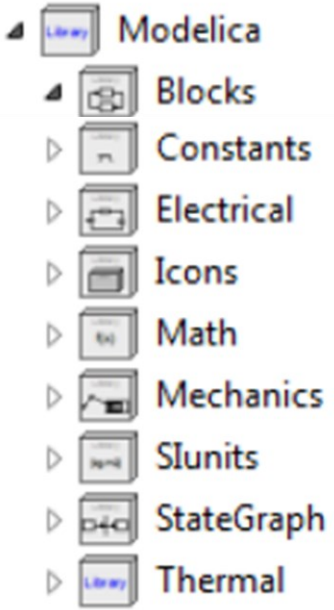
. Each Icon represents a physical component (electrical resistance, pipe, turbine, ...)

. A connection line represents the actual physical coupling (wire, fluid flow, heat flow, ...)

. Variable at the interface describe interaction with other components

. A component consists of connected sub-components and is described by equations

Introduction to Modelica



Ref. 3

Modelica Standard Library

- **Blocks** Library for basic input/output control blocks
- **Constants** Mathematical constants nature
- **Electrical** Library for electrical models
- **Icons** Icon definitions
- **Fluid** 1-dim Flow in networks of vessels, pipes, …
- **Math** Mathematical functions
- **Magnetic** Magnetic – for magnetic applications
- **Mechanics** Library for mechanical systems
- **Media** Media models for liquids and gases
- **SIunits** Type definitions based on SI units
- **Stategraph** Hierarchical state machines
- **Thermal** Components for thermal systems
- **Utilities** Utility functions especially for scripting

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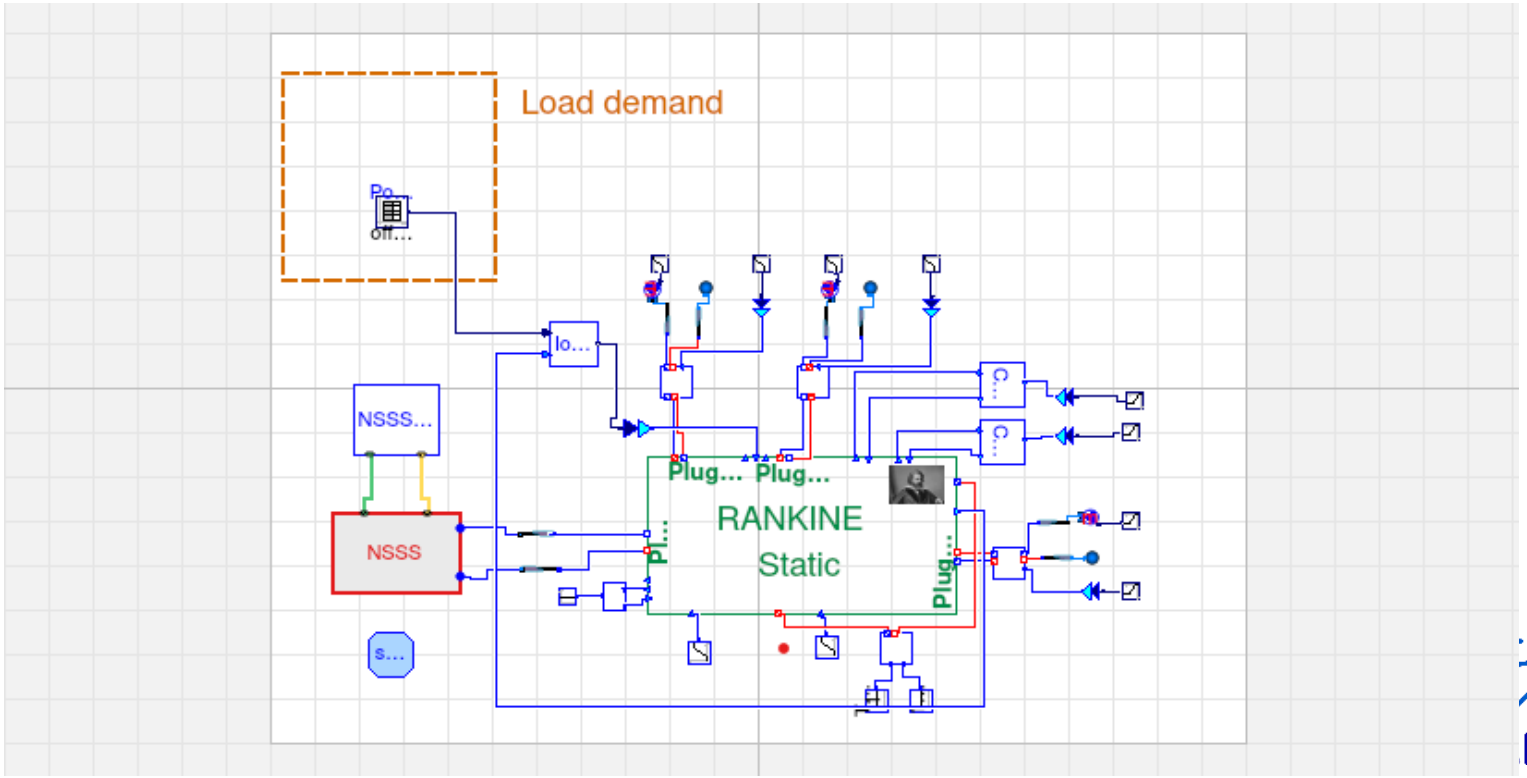
TANDEM library

Working groups

Assigment 1 – Load following capability



Assigment 1 – Load following capability

- Simulate the reactors at constant power and check the main variables in NSSS (thermal power, temperatures, mass flow rates,…) and BoP (electrical power, temperatures, pressures, mass flow rates,…)

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- Modify the power profile, e.g., with a 10% ramp down
    - check how the reactor is controlled
    - check how (and if) the main variables have changed

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- Consider to perform load following to avoid RES (solar) curtailment. Make hypothesis about the solar daily power curve and adjust the power of the reactor accordingly
    - check how the reactor is controlled
    - check how (and if) the main variables have changed

References

1. P. Fritzson, 2014. Principles of Object Oriented Modeling and Simulation with Modelica 3.3. A Cyber-Physical Approach. Wiley-IEEE Press, 2014, 1250 pages
2. M. Otter. Modelica Overview. https://modelica.org/education/educational-material/lecture-material/english.html
3. P. Fritzson, A. Pop, 2020, Introduction to Object Object-Oriented Modeling and Simulation with Modelica and OpenModelica. Tutorial 2020-02-04. https://www.openmodelica.org/images/M_images/200204-ModelicaTutorial-slides-PeterFritzson-AdrianPop-MODPROD2020.pdf

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