THERMAL POWER LIBRARY

Overview

Modelon

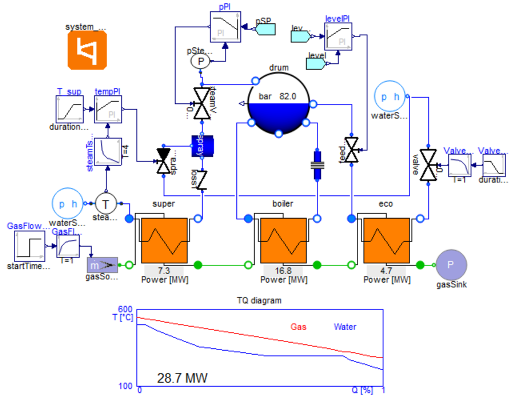
AGENDA

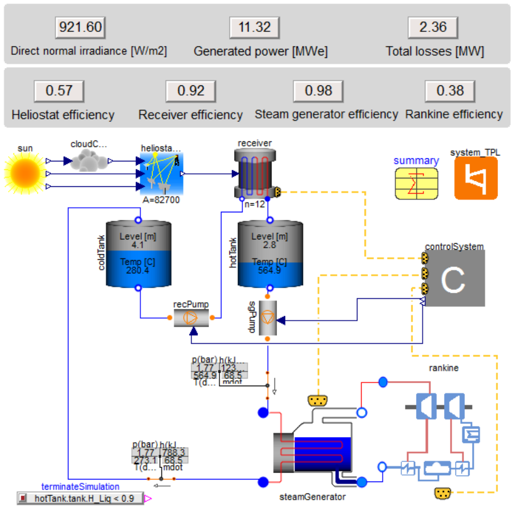
- ❑ About Thermal Power Library
- ❑ Key Benefits
- ❑ Key Capabilities
- ❑ Key Applications
- ❑ Library Contents
- ❑ Modelon Compatibility
- ❑ Latest Release

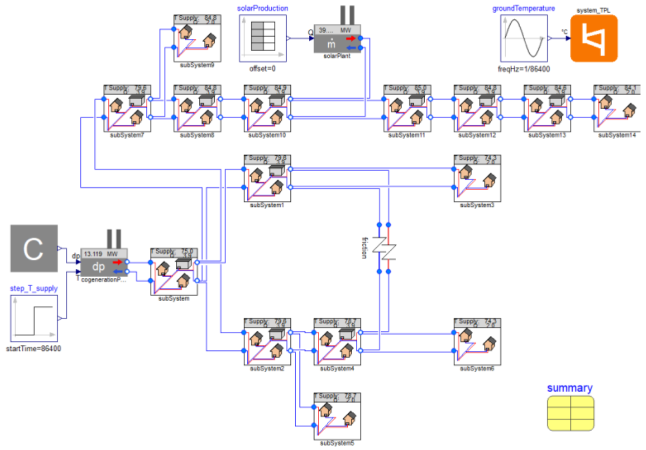
ABOUT THERMAL POWER LIBRARY

- Comprehensive modeling, simulation, and optimization framework for thermal power systems, including district heating networks.

- Covering new and traditional energy sources including:
  - Concentrated solar
  - Gas and coal
  - Waste
  - Nuclear







PURPOSE

- Simulation of thermal power plants and district heating systems for
  - Process design
  - New plant concept evaluation
  - Requirement verification
  - Analysis of plant dynamics
  - Controller design and tuning
  - Commissioning
  - Lifetime calculation
- Optimal operation of plants and district heating systems
  - Start-up optimization of power plants
  - Short-term production planning for district heating systems

KEY BENEFITS

- Rapid model development using pre-configurable templates and numerically efficient models & fluids
- Ready to apply out of the box, accurate and robust models with a large set of correlations
- Easy to share and re-use models during the entire design cycle thanks to flexible fidelity
- Ability to simulate start-up sequences, standard and emergency scenarios or design plant-wide control strategies

KEY CAPABILITIES

- Wide support of technologies including solar, gas, waste, coal and nuclear
- Large set of components and fluid models
- Detailed geometry vs data based correlations
- Complex geometry-based and simpler efficiency-based heat exchanger models
- Fast steam/water and flue-gas properties
  - IF97 water/steam implementation with analytical derivatives
- Fluid and models capable of gradient-based optimization
- Integration with Modelon carbon capture plant library
- Heat exchanger dimensioning using dynamic models
- Easy control design with autotuner and inverse models

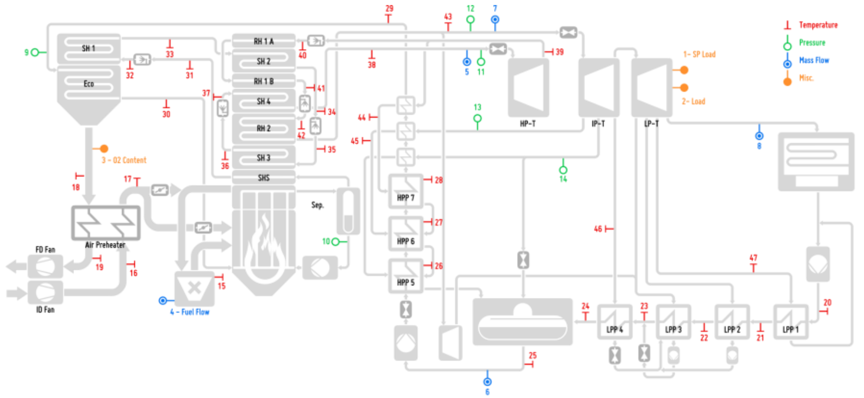
KEY APPLICATIONS

CASE STUDY

Improving Power Plant Operation

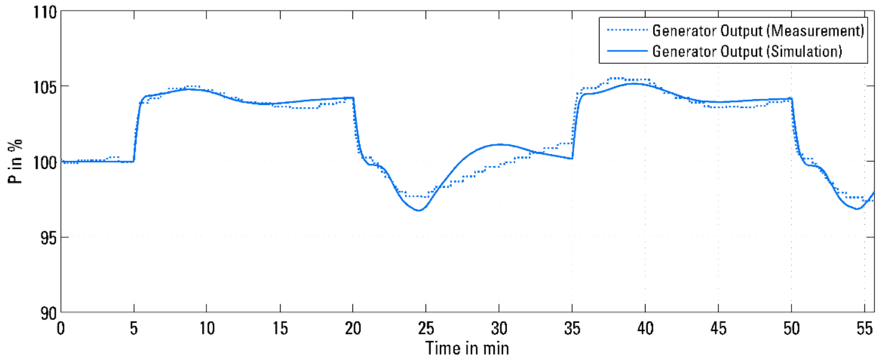
Objective

Using Modelon’s Thermal Power Library researchers set out to improve the flexibility of one of Germany’s largest thermal power plants – integrating a higher number of renewable energy sources.



Results

- Validated model using experimental data
- Control reserve assessment
- Estimation of the mechanical and thermal stress
- Improved primary control reserve
- Experimental verification of the improved controller
- Minimal life time consumption of critical components



In collaboration with:

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Universität Rostock

Traditio et Innovatio

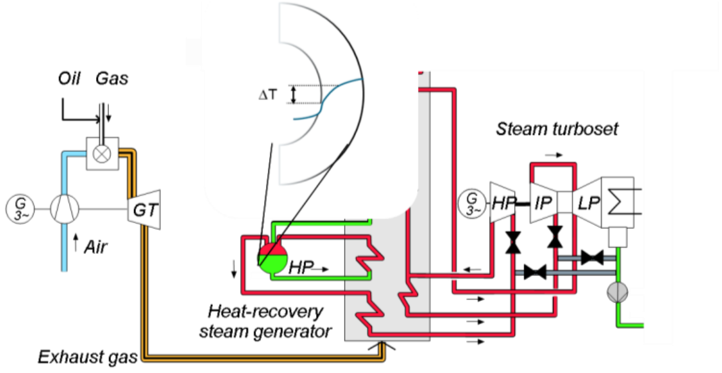
VATTENFALL

CASE STUDY

Optimized Start-up of a Gas Combined Cycle and a Coal Fired Power Plant

Objective

Improve plant flexibility by reducing start-up time. Power output is maximized while keeping stress level under threshold limits using optimization techniques.



Results

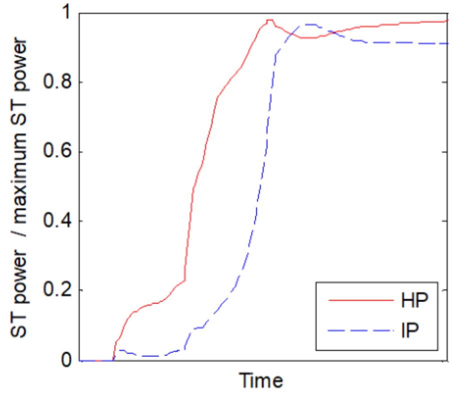
- Better economy with maximized power output.
- Improved life-time with temperature gradients constraints

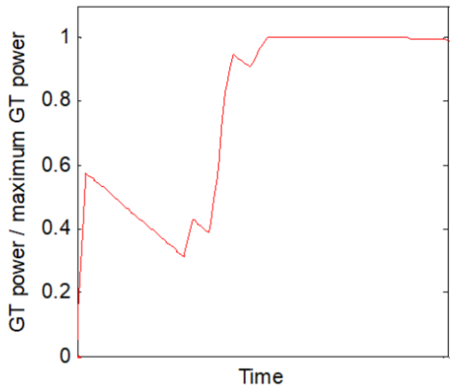
Coal-fired plant

30% Faster startup

70% Reduced oil consumption

35% Less CO2 emissions





OPTIMICA Compiler Toolkit

Modelon

In collaboration with:

SIEMENS

VATTENFALL

CASE STUDY

Platform for Microgrid Design and Operation

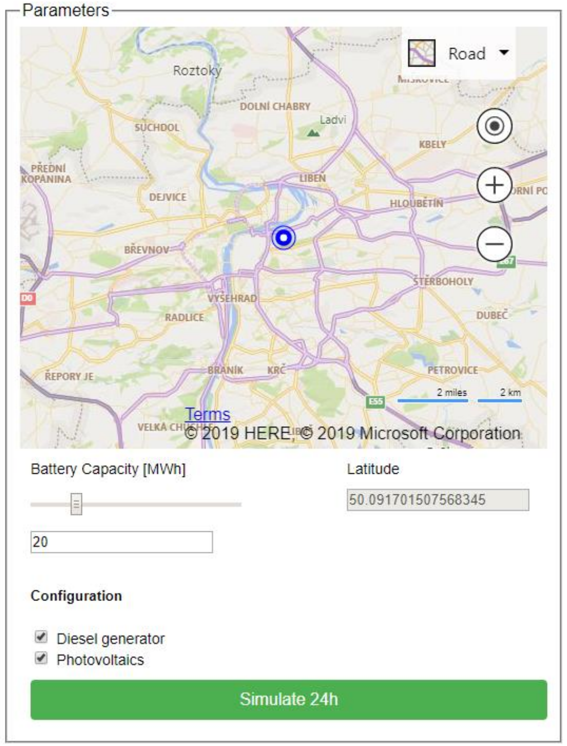
Objective

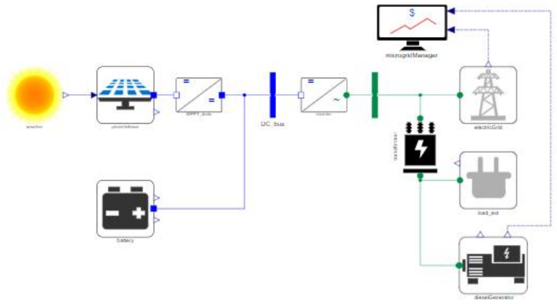
Build, size, configure and control microgrid based on its geographic location balancing the power flow depending on the amount of energy produced by the renewable resources.

Results

Two different use cases:

- Peak shaving optimization to reduce cost with limited power consumption during high loads
- Economy dispatch finding the optimal operation of the microgrid components with the resulting economic cost





	Producers [kWh]		Consumers [kWh]		Economy
PV	1102	Load	2400	Cost	$329
DieselGen	960	Grid	-1115	Diesel	120 L
Battery	-720				

Battery SoC [%]	53.6

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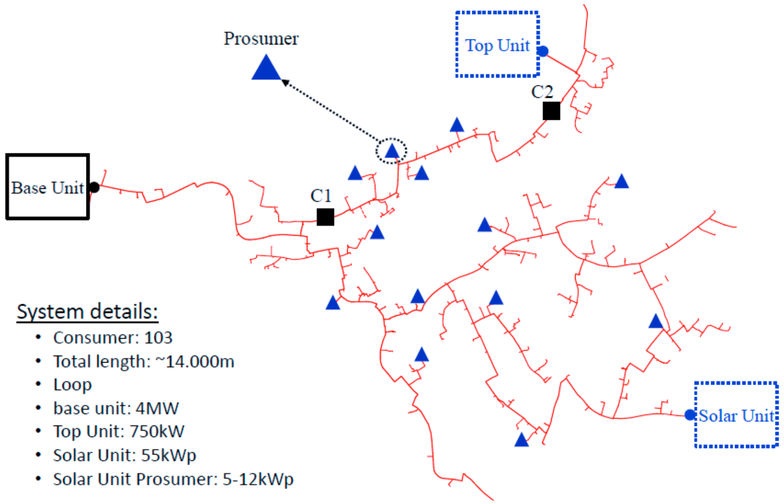
CASE STUDY

Upgrade to 4th Generation District Heating Systems

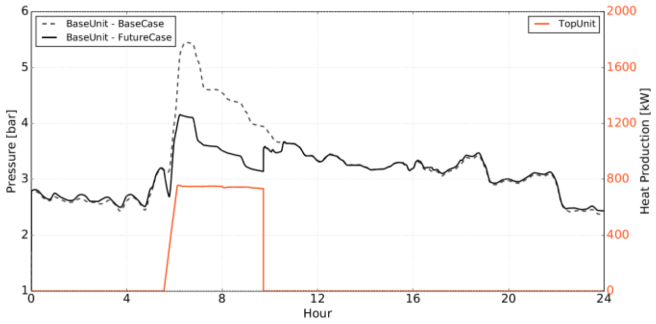
Objective

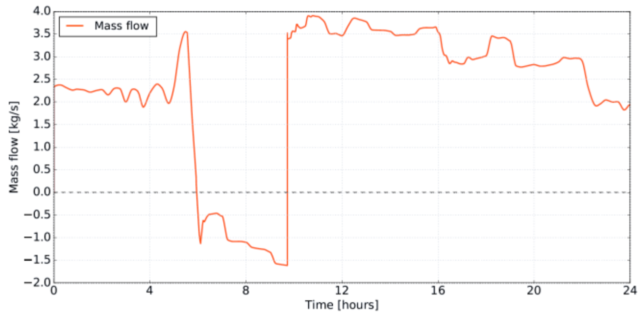
Assess the impact of an upgrade of an existing heating network when renewables with volatile production and prosumers are introduced throughout the network.

Results



System details:
- Consumer: 103
- Total length: ~14.000m
- Loop
- base unit: 4MW
- Top Unit: 750kW
- Solar Unit: 55kWp
- Solar Unit Prosumer: 5-12kWp





- Operation at lower pressure with distributed production units
- Prediction of local pressure transients and back-flows
- Design and verification of advanced control strategy

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CASE STUDY

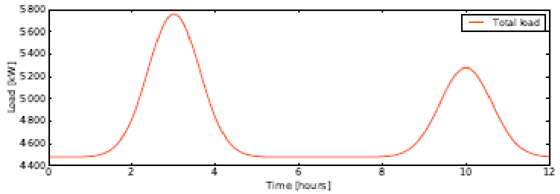
Optimal Production Planning of District Heating Systems

Objective

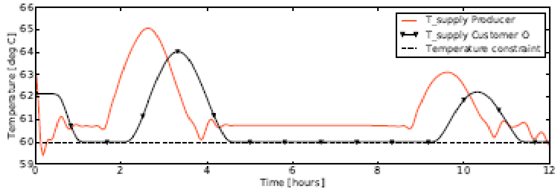
Optimize the operation of district heating networks to minimize cost while satisfying constraints from network capacity and customer demand

Results

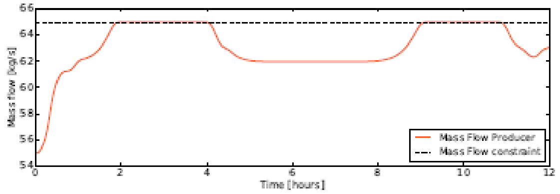
- Maximal flowrate and minimal supply temperature for low cost operation
- Peak shaving by exploiting heat storage in network
- Transport delay and heat loss accurately accounted for



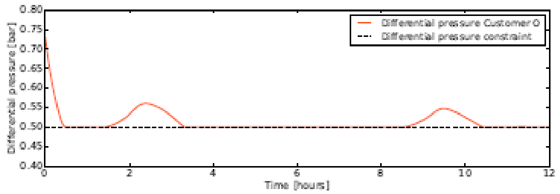
Total customer load



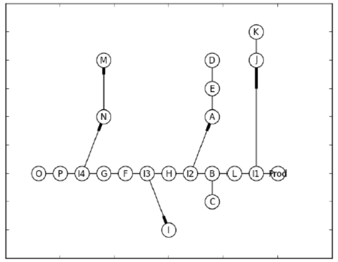
Production unit and Customer O feed water temperature and temperature constraint

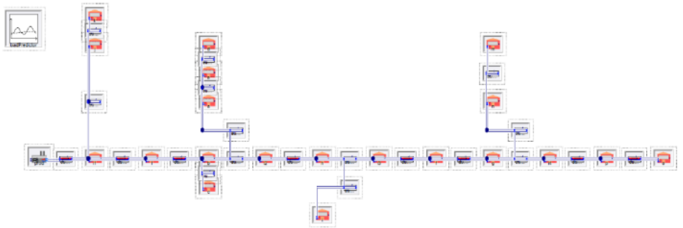


Production unit mass flow and mass flow constraint



Customer O differential pressure and differential pressure constraint



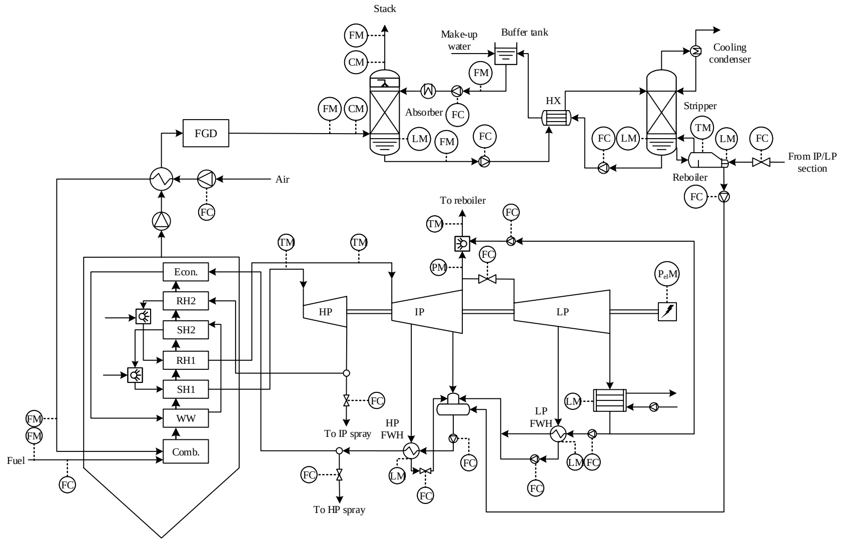


CASE STUDY

Operation of a CO2 Absorption Process Integrated in a Coal-Fired Power Plant

Objective

Investigate new operating requirements and implementation of new technologies.

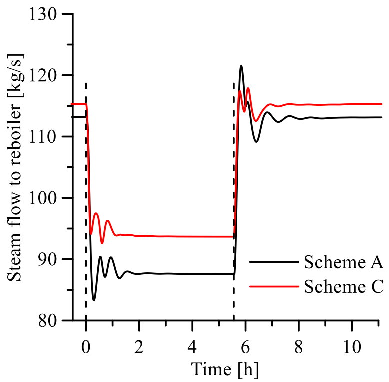


Results

- CO_2-absorption process does not significantly affect the load-following capabilities of the power plant in terms of power output
- When steam availability is varying, power output can be increased at the expense of increased CO_2 emissions.

In collaboration with:

CHALMERS



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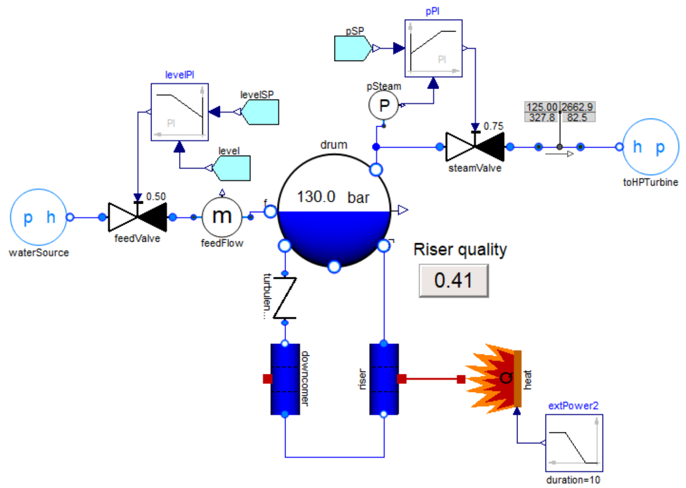
CASE STUDY

Thermal Power Plant Design and Extension

Typical customer concerns addressed by the library

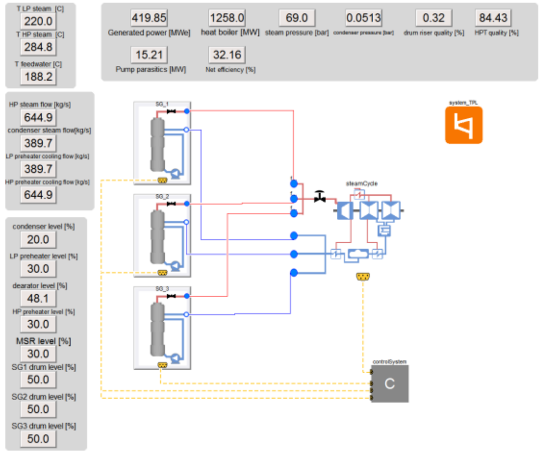
1. Is my drum well-dimensioned? Can it be properly controlled?
2. A new heat/steam customer is to be connected to my plant. What is the impact on the plant control and efficiency?
3. Nominal plant data are available from a tender call. How does the future plant behave at part loads and during transients?
4. What would be the economic gain of a design change based on data for a typical year?
5. What is the minimum size of the bleed valve to be able to control the pressure in the feedwater tank?

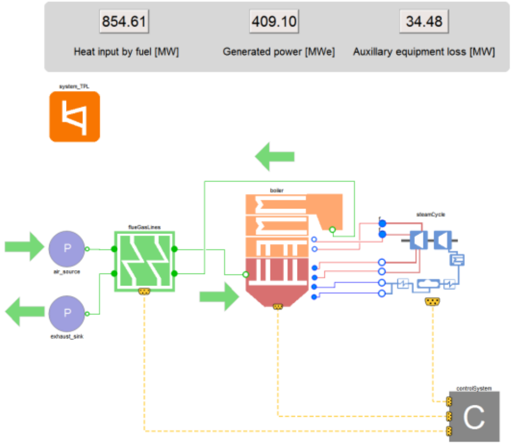


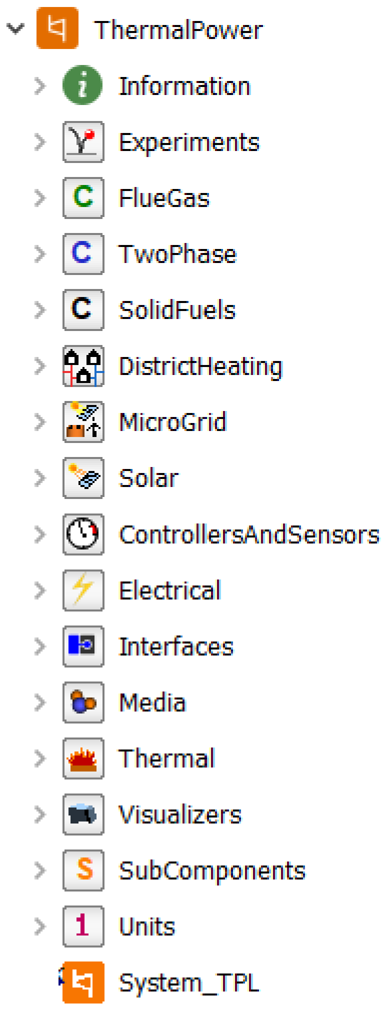
LIBRARY CONTENTS

LIBRARY CONTENTS

- Examples
  - Conventional and renewable energy applications: nuclear, gas, microgrid, district heating, coal, district heating and design

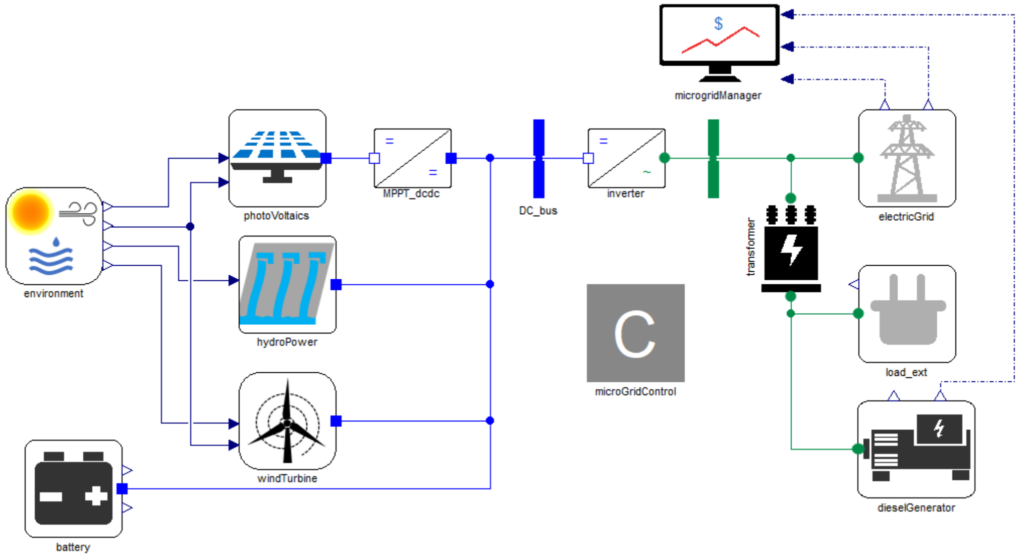


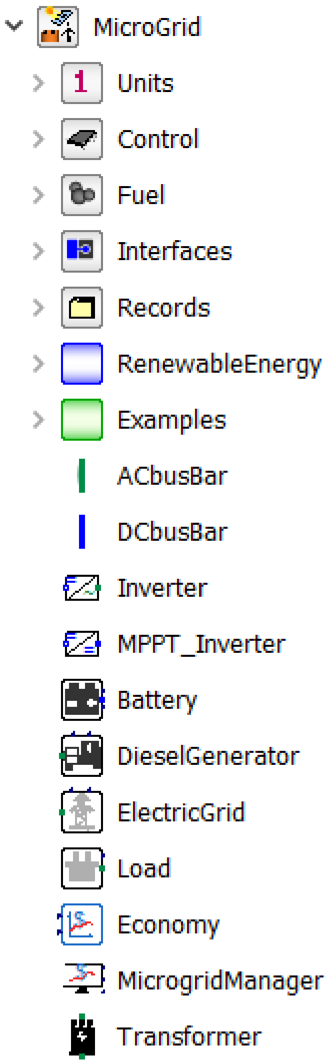




LIBRARY CONTENTS

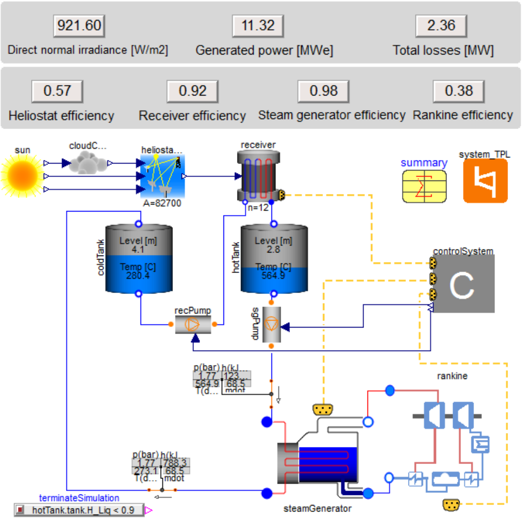
- Microgrid
  - Dynamic simulation including both consumers and producers sources
  - Control system balances the power flow depending on the amount of energy produced by the renewable resources

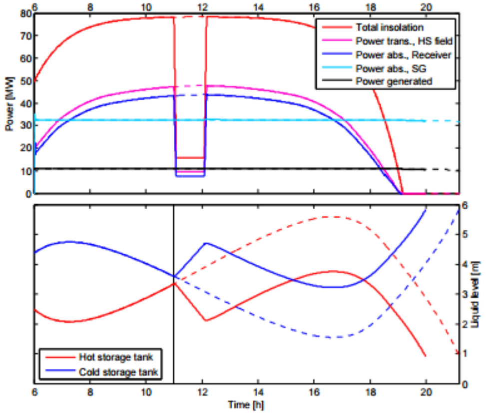


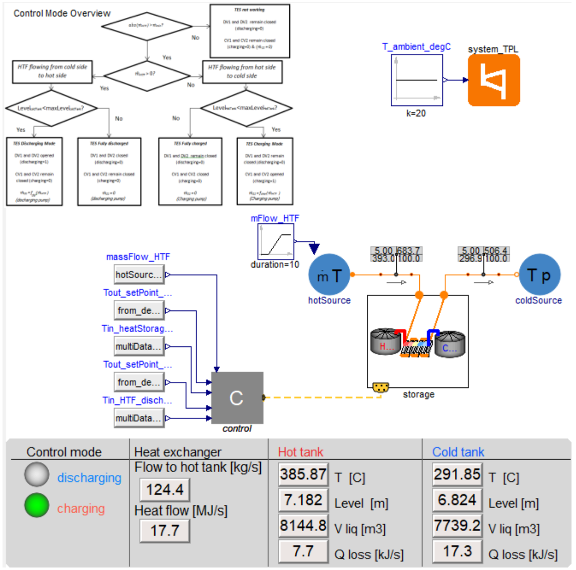


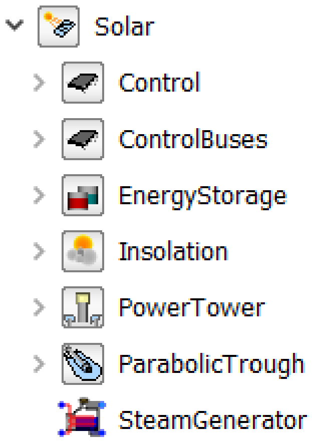
LIBRARY CONTENTS

- Solar
  - Support for parabolic trough, power tower
  - Energy storage using molten salt



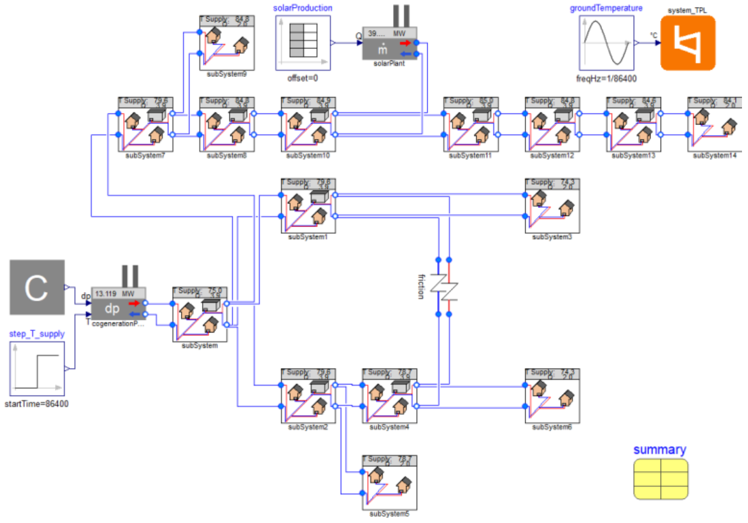


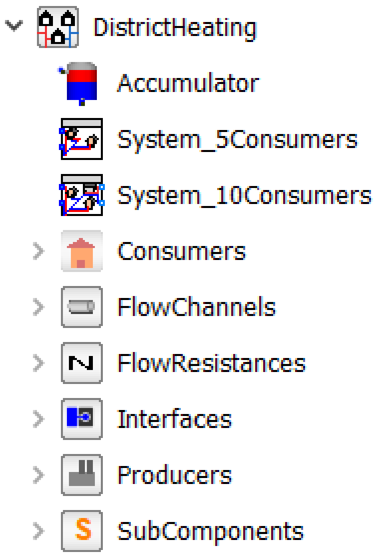




LIBRARY CONTENTS

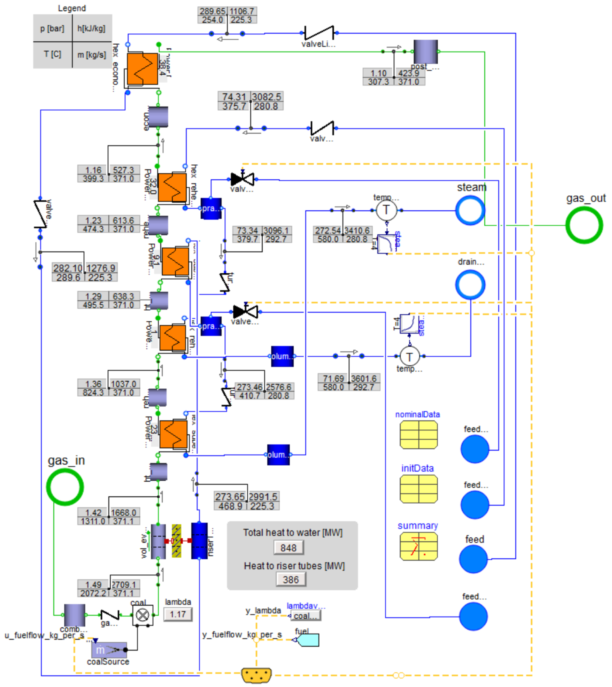
- District heating
  - Non-linear physics based models with transport delays
  - Scalable simulation to several hundred customers
  - Fast simulation of transient scenarios
  - Production planning using dynamic optimization

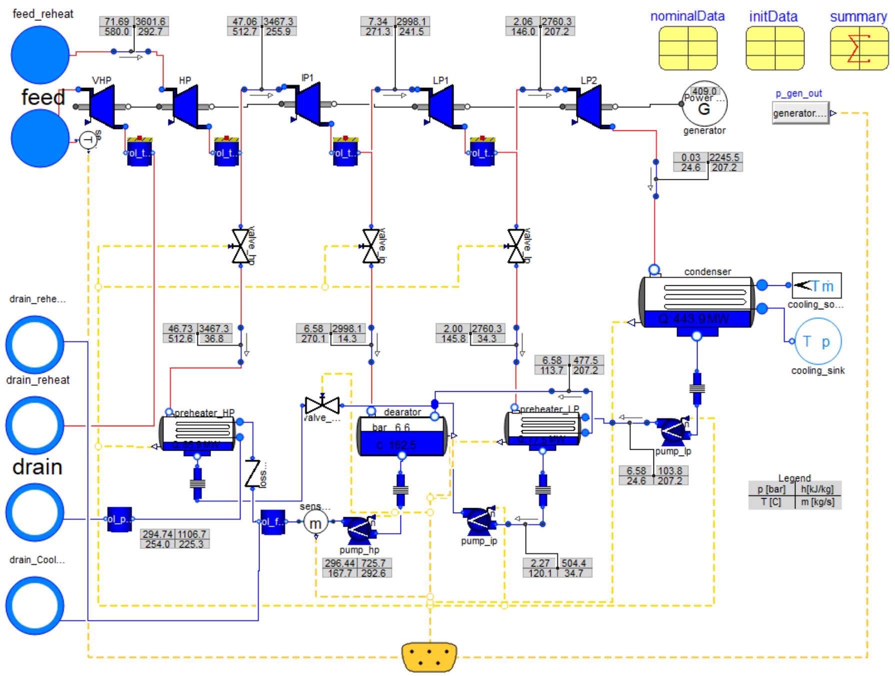




LIBRARY CONTENTS

- TwoPhase
  - Liquid, vapor and 2-phase components
  - Steam and water but also refrigerant capable

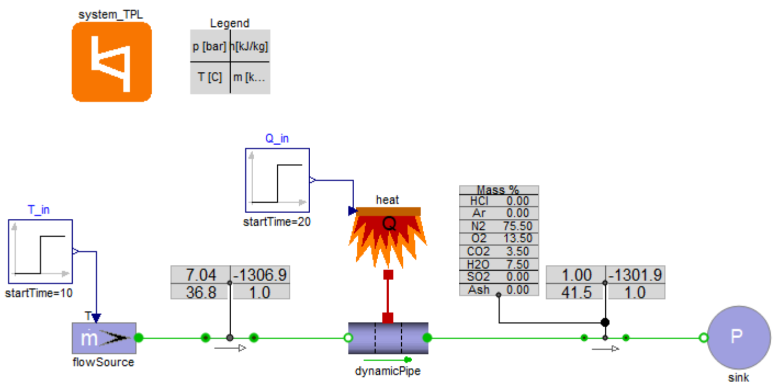


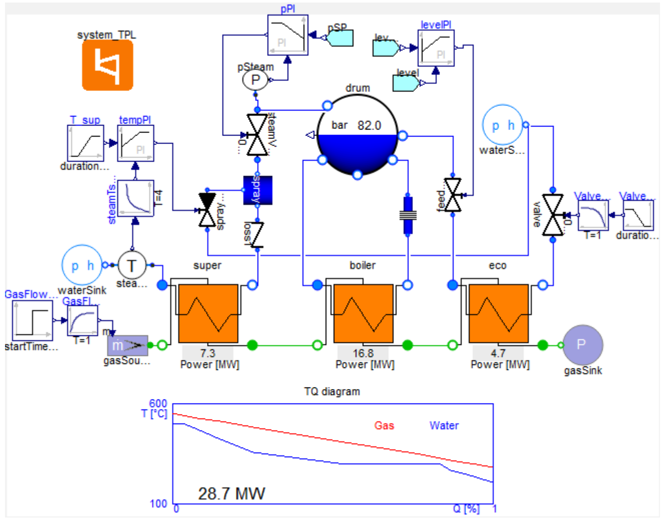


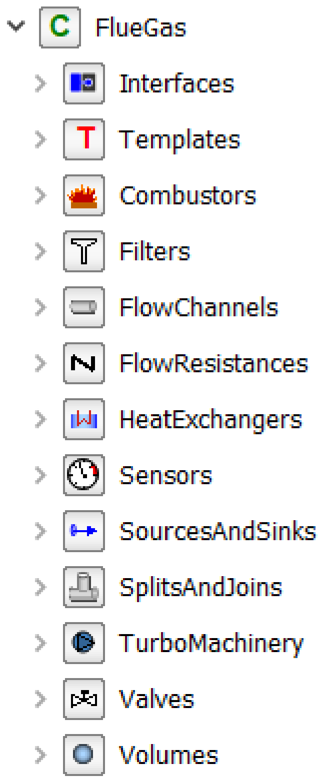
- TwoPhase
  - Interfaces
  - Templates
  - Records
  - Deaerator
  - Drum
  - Condensers
  - FlowChannels
  - FlowResistances
  - HeatExchangers
  - Sensors
  - Separators
  - SourcesAndSinks
  - SplitsAndJoins
  - TurboMachinery
  - Valves
  - Volumes
  - Examples

LIBRARY CONTENTS

- FlueGas (gas mixtures)
  - Pipes, valves, volumes, combustor, fan ...
  - Efficient lumped pressure discretization in pipes

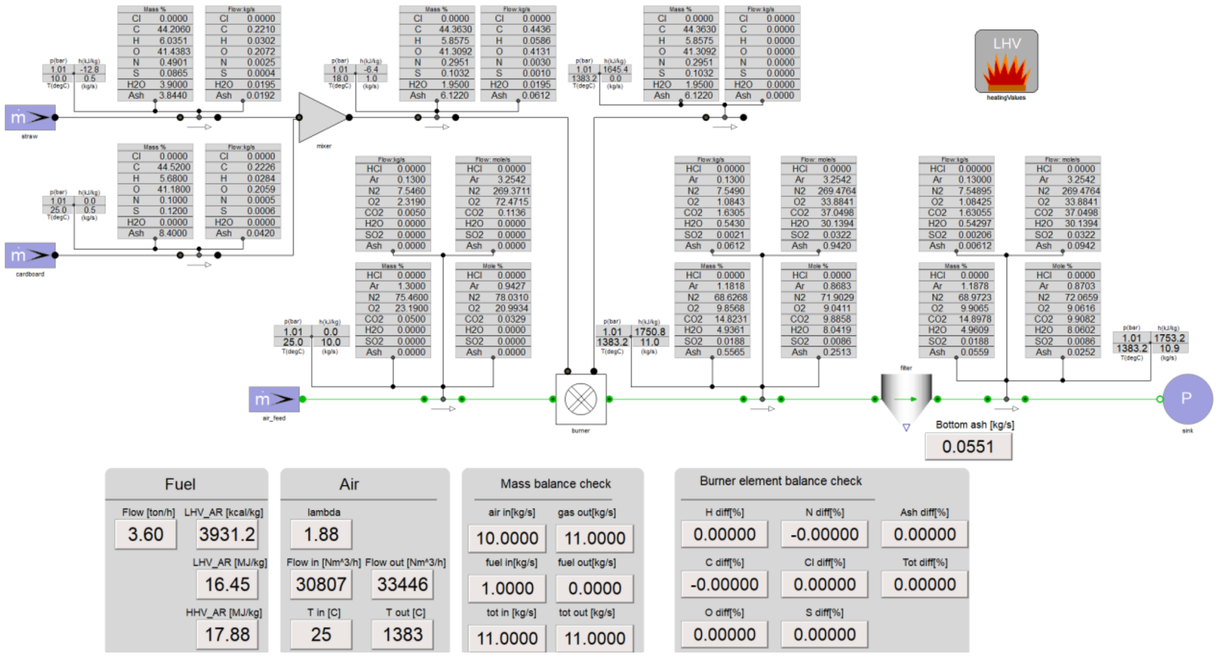


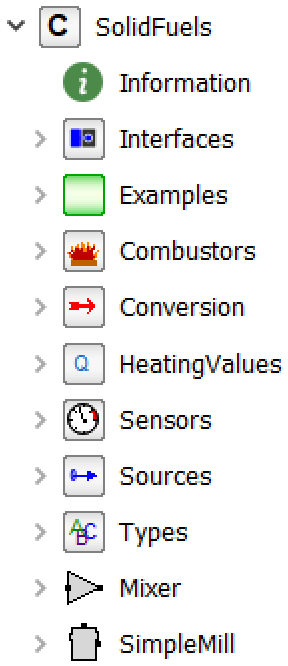




LIBRARY CONTENTS

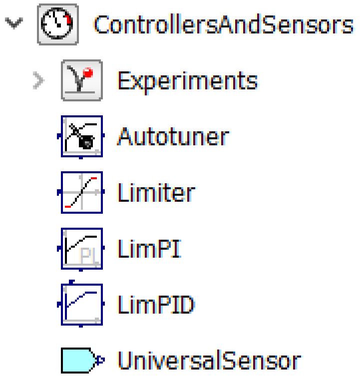
- SolidFuels
  - Combustors, sources, transport, heating values calculator
  - Quickly create fuel mixtures

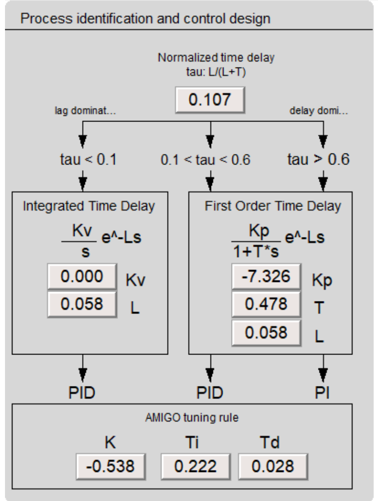


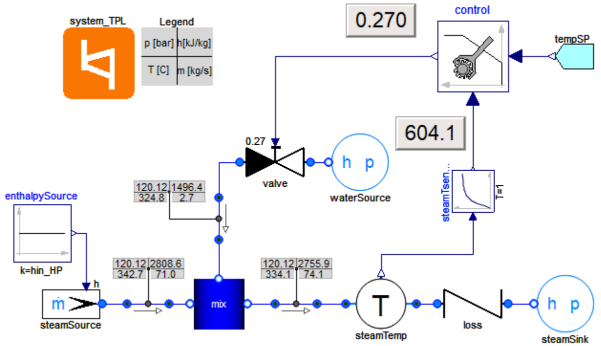


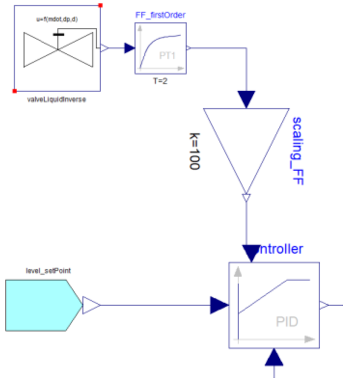
LIBRARY CONTENTS

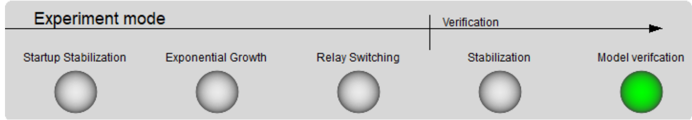
- Control
  - Templates for automatic control design and verification
  - PID controller, autotuner, inverse models for feedforward action





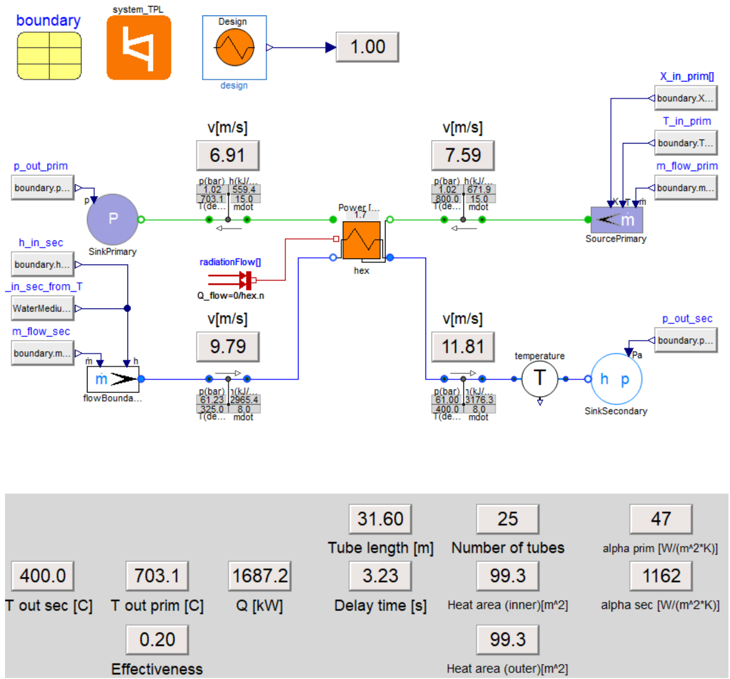


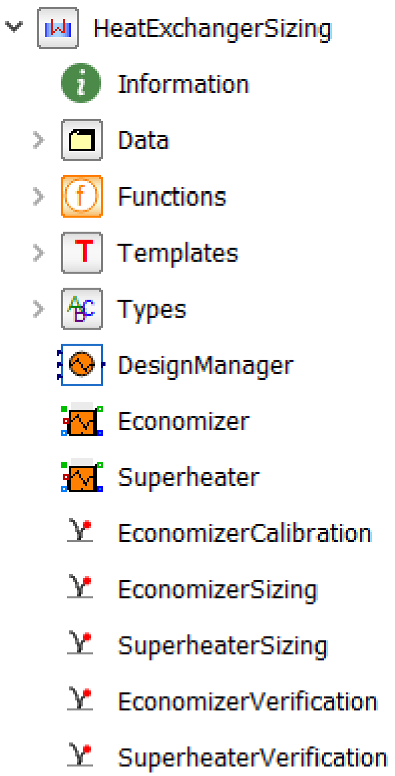




LIBRARY CONTENTS

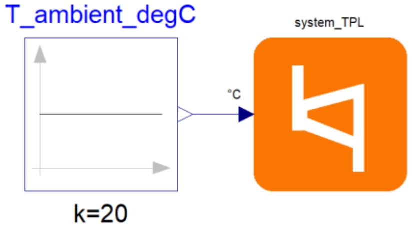
- Heat exchanger dimensioning
  - Using dynamic models (can be integrated directly into a system)
  - Support of various design modes (temperature, heatflow..)





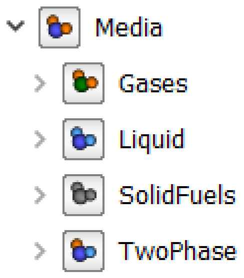
LIBRARY CONTENTS

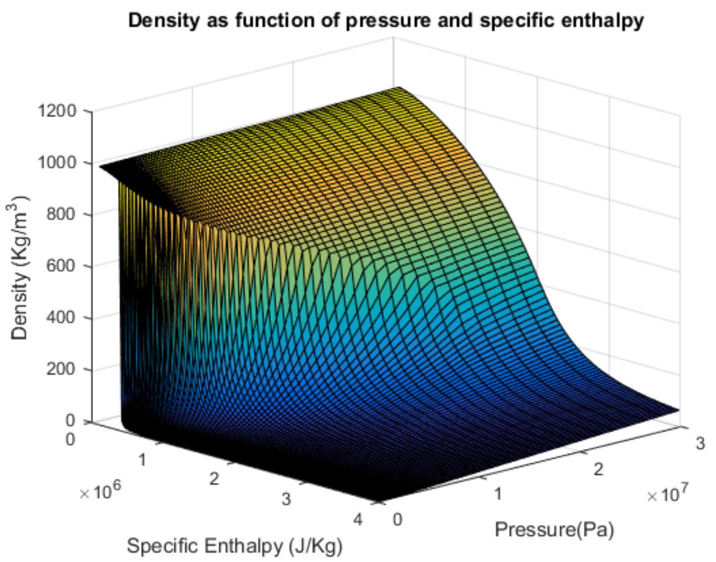
- System component
  - System wide settings (ambient pressure and temperature)
  - Automatic system summation:
    - Fluid mass, volume and energy
    - Wall mass and energy
    - Power consumption of auxiliary components

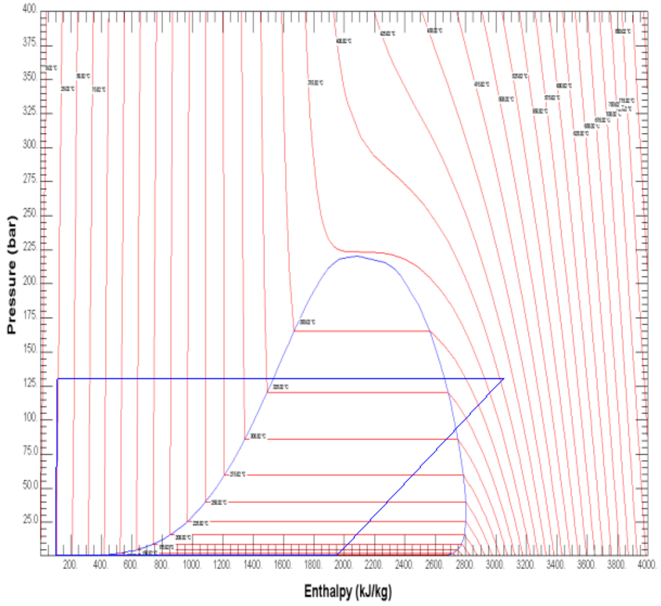


LIBRARY CONTENTS

- Media
  - Gas mixtures, liquids, fuel and two-phase
  - Efficient and optimization capable
  - Fast and robust IF97 water/steam implementation with analytic derivatives





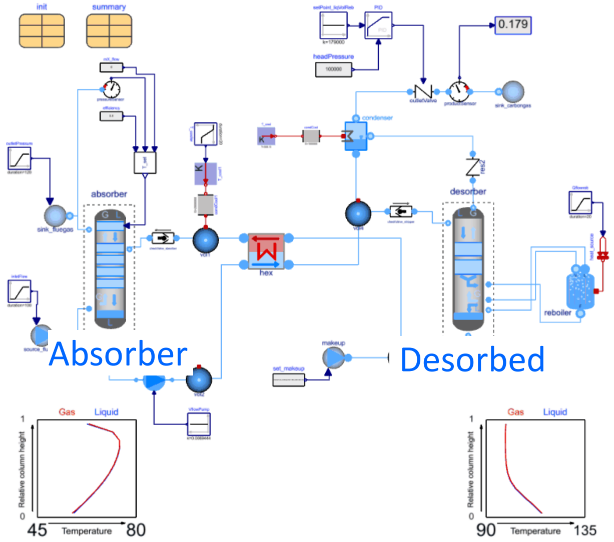


LATEST RELEASE

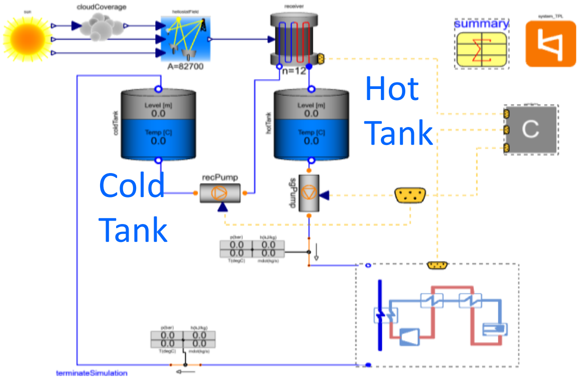
RELEASE: 2021.2

New Features

- Thermal Power Library enhanced by a CO_2 storage separation process for gas-liquid contactors containing models for carbon separation from fuel gas with an absorption process and adsorption process



- New detailed photovoltaic models with connection to the electrical grid

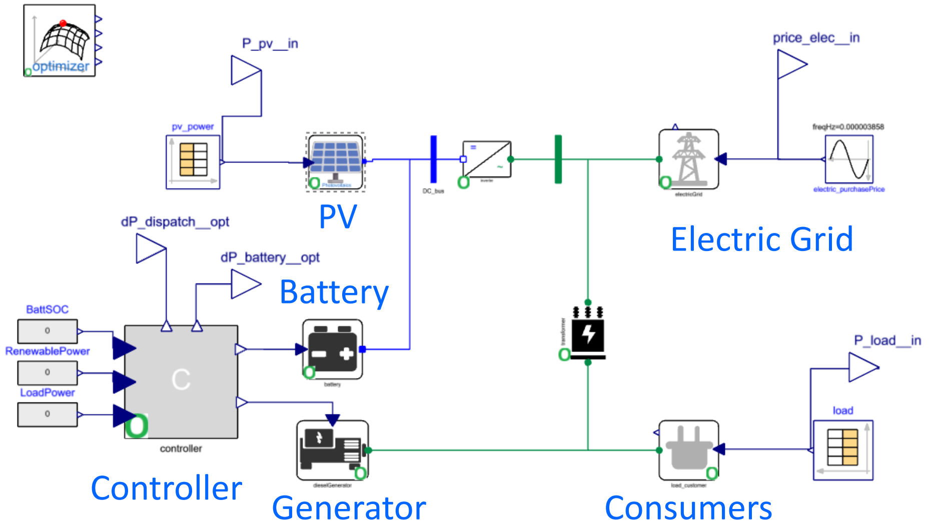


- Solar Power Tower with Supercritical CO_2 -based Recompression Brayton Cycle example has been developed. This is an example of a central receiver concentrated solar power system, based on a model of the 12.5 MW Solar Two test facility

RELEASE: 2021.2

Enhancements

- Significantly improved microgrid in the Thermal Power Library with various control and dynamic optimization options
  - Economic Dispatch
  - Peak Shaving
  - Demand Charge Reduction
  - PV Sizing
  - Generator Sizing



RELEASE: 2021.2

Enhancements

- Geometry parameters S_t and S_l of Fins are no longer evaluated
- Improved the start attributes of the HeatExchangerDimensioningBase template
- Replaced all type of absolute pressures from SI.Pressure to SI.AbsolutePressure, since SI.AbsolutePressure is a better usage