HYDRO POWER LIBRARY

Overview

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AGENDA

- ❑ About Hydro Power Library
- ❑ Key Benefits
- ❑ Key Capabilities
- ❑ Key Applications
- ❑ Library Contents
- ❑ Modelon Compatibility

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ABOUT HYDRO POWER LIBRARY?

- Hydro Power Library is designed to be an effective tool for
  - Commissioning
  - Testing of new control strategies
  - Improve plant operation
  - Development and verification of new designs
  - Analysis of waterway dynamics
  - Failure investigation

- Reduces the risk of unexpected events and minimizing costly tests done on the actual plant

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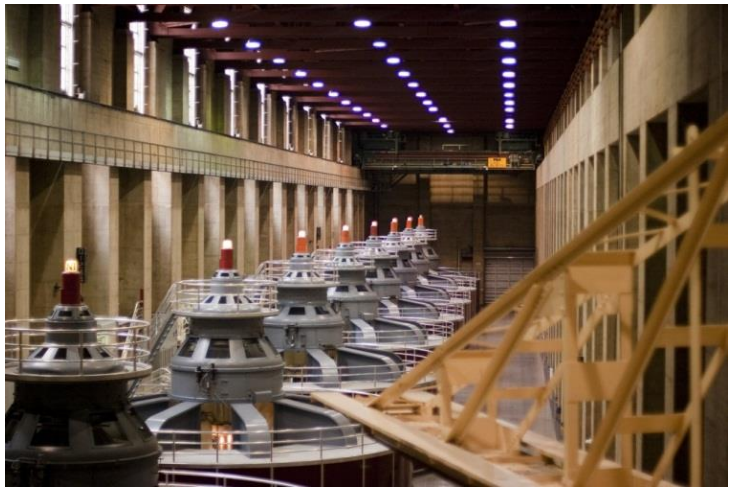
KEY BENEFITS

- Complete environment for verification of plant concepts and control strategies
- Get quick feedback with fast and robust simulations
- Accurate physics-based models capable of predicting water-hammer effects and give insight of the waterway dynamics
- Easy integration of hydraulic and electrical models
- Safely plan and execute commissioning tests by first practice in a safe-virtual environment
- Estimate the opening and closing rates of guide vanes based on pressure transient analysis to react more quickly to critical disturbances



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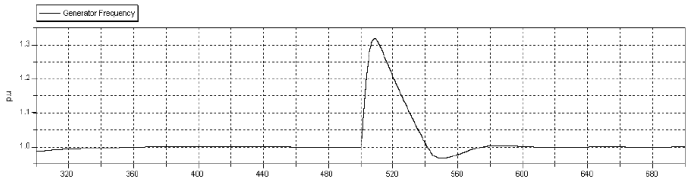
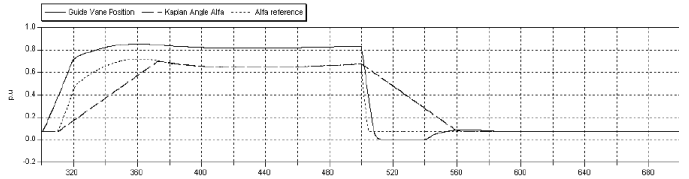
KEY CAPABILITIES

- Full plant model simulation including grid synchronization and control system
- Support for dynamic and steady-state simulation
- Component and system studies
- Interface compatible with Electrical Power Library to use for detailed electrical grid studies
- Identification of objectives for the water level control
- Analysis of extreme working conditions of the plant, such as load rejection
- Advanced analysis and prediction of dynamics when several hydro power plants are connected in cascade.



Generator frequency at load rejection



Guide vane position, Kaplan angle and angle reference

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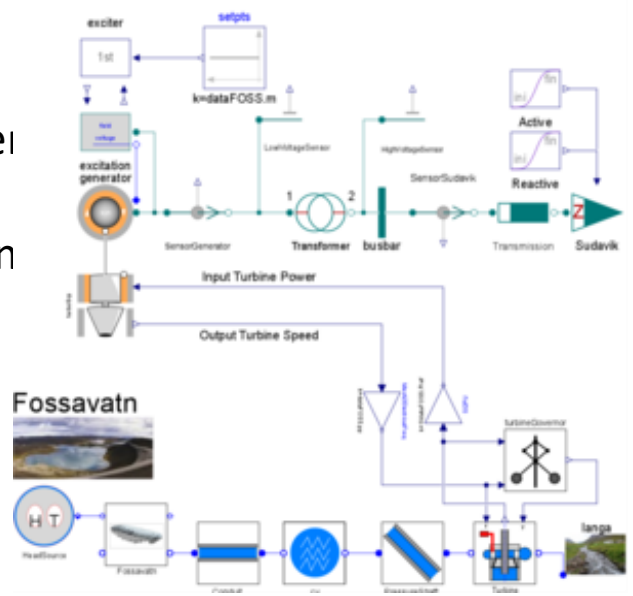
KEY APPLICATIONS

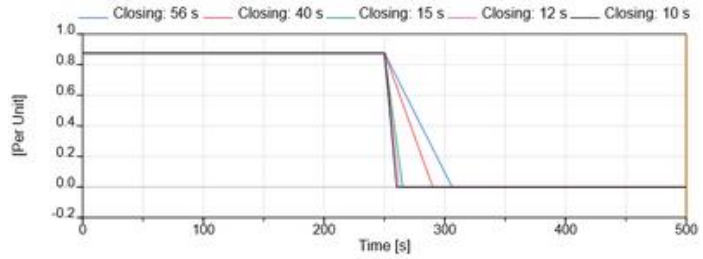
CASE STUDY

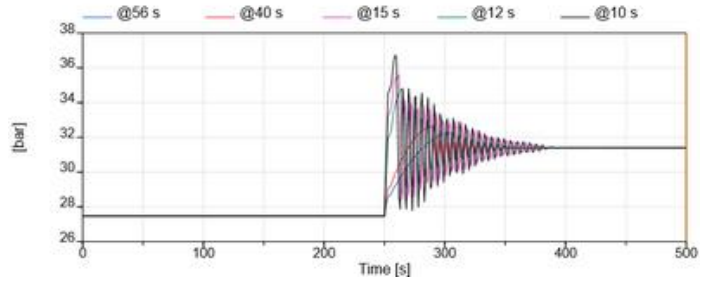
Stabilizing Hydro Power for the Electrical Grid

Objective

Using Modelon's Hydro and Electric Power Library, engineer set out to improve the understanding of Iceland's Fossarvirkjun power plant by investigating load rejection an exploring worst-case scenarios during complete plant shutdowns.







Results

- Electrical grid that is better prepared to handle disturbances and safety critical scenarios
- Improved operation, enabling faster reactions to critical disturbances

In collaboration with:

Modelon VERKÍS USN

CASE STUDY

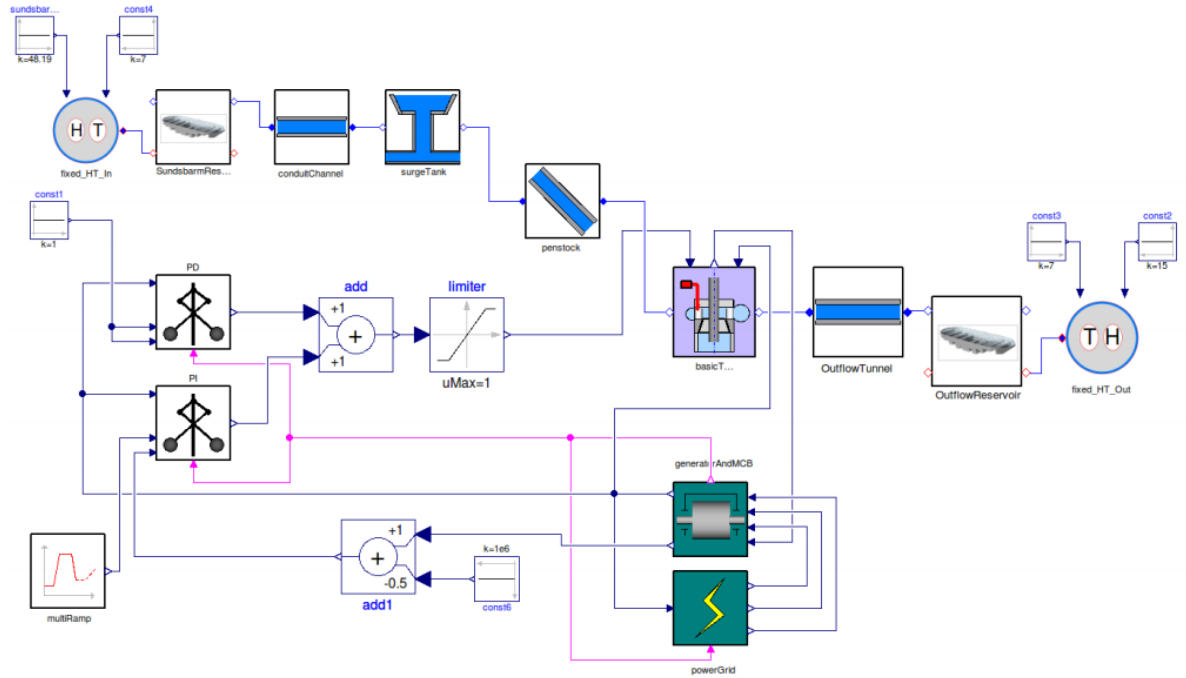
Optimization of Scheduled Production Deviation

Objective

Using Modelon's Hydro Power Library, researchers set out to decrease the deviations from the scheduled production in Sundsbarm in Norway. Deviations have a negative economic impact as overproduction leads to low price on excess power and underproduction may be fined.

Results

- Identification of critical causes for production deviations.
- Suggested new control strategy: Model Predictive Control based on the plant model to improve safety and control performance.



In collaboration with:

Modelon

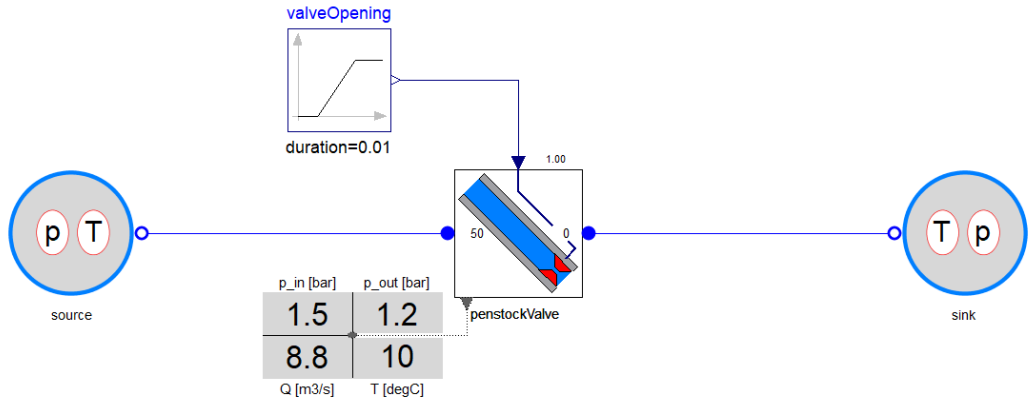
USN Skagerak Energi

CASE STUDY

Hydro Power Plant Design and Extension

Typical customer concerns addressed by the library

1. Does the new control implementation function correctly, so that it can be safely commissioned?
2. Can the guide vane closing time be reduced without exceeding pressure limits?
3. What will the pressure rise and consequences be if a safety valve malfunctions?
4. Nominal plant data are available from a tender call. How does the future plant behave at part loads and during transients?
5. What would be the economic gain of a design change based on data for a typical year?
6. How will the controller react on dynamic load changes?



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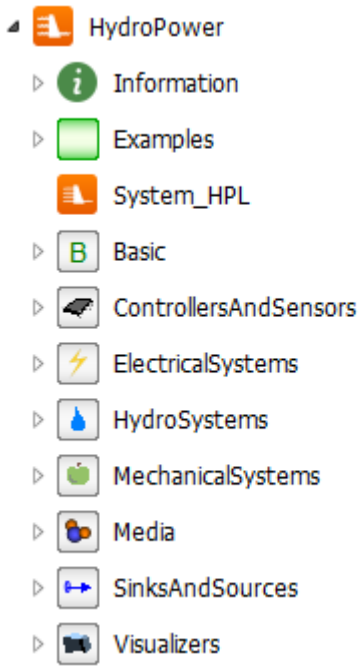
LIBRARY CONTENTS

LIBRARY CONTENTS

- More than 100 components, covering all important aspects of hydro plant modeling
- The library includes:
  - Examples displaying typical use-cases and capabilities
  - Hydro system components including pipe and reservoir models
  - Mechanical components
  - Electrical components to model the grid
  - Control models



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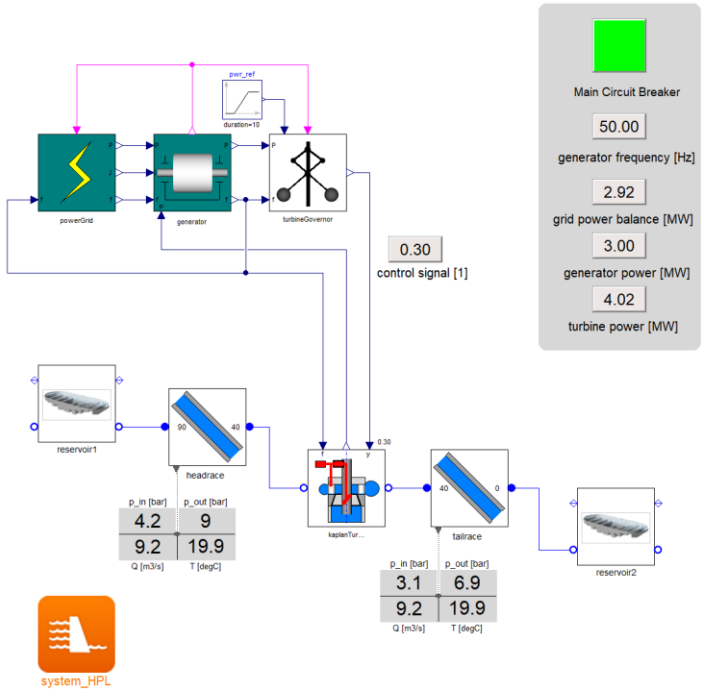
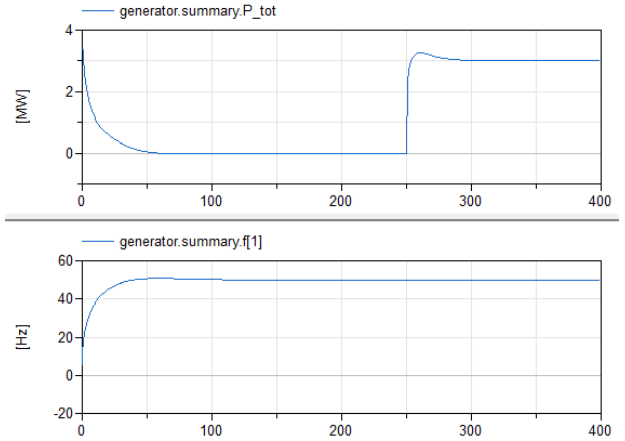
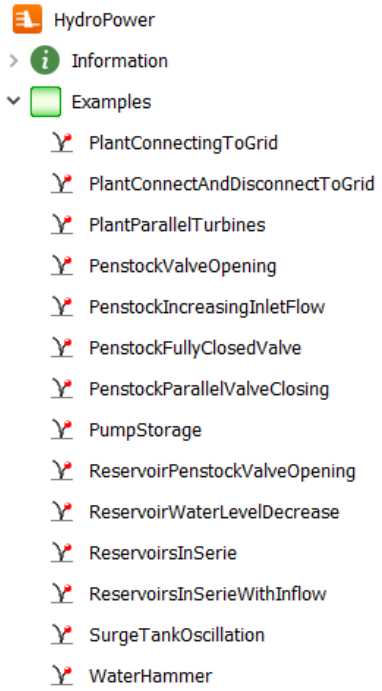
LIBRARY CONTENTS

- Examples – Plant connecting to grid
  - Will there be a smooth transition at grid synchronization?

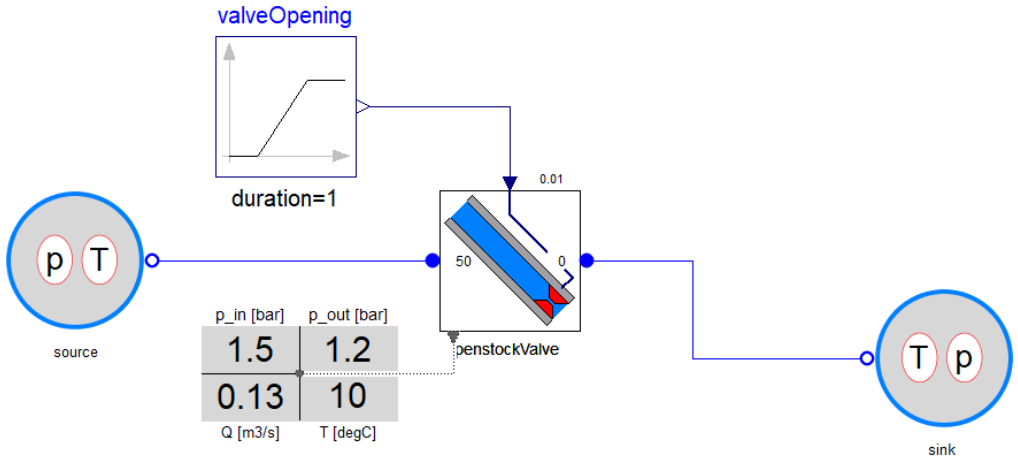


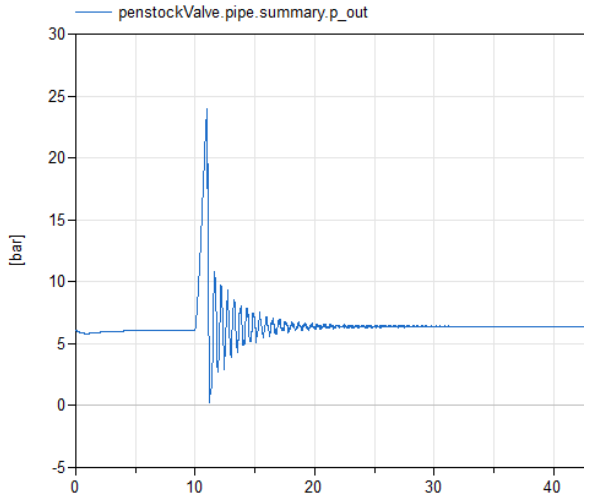




LIBRARY CONTENTS

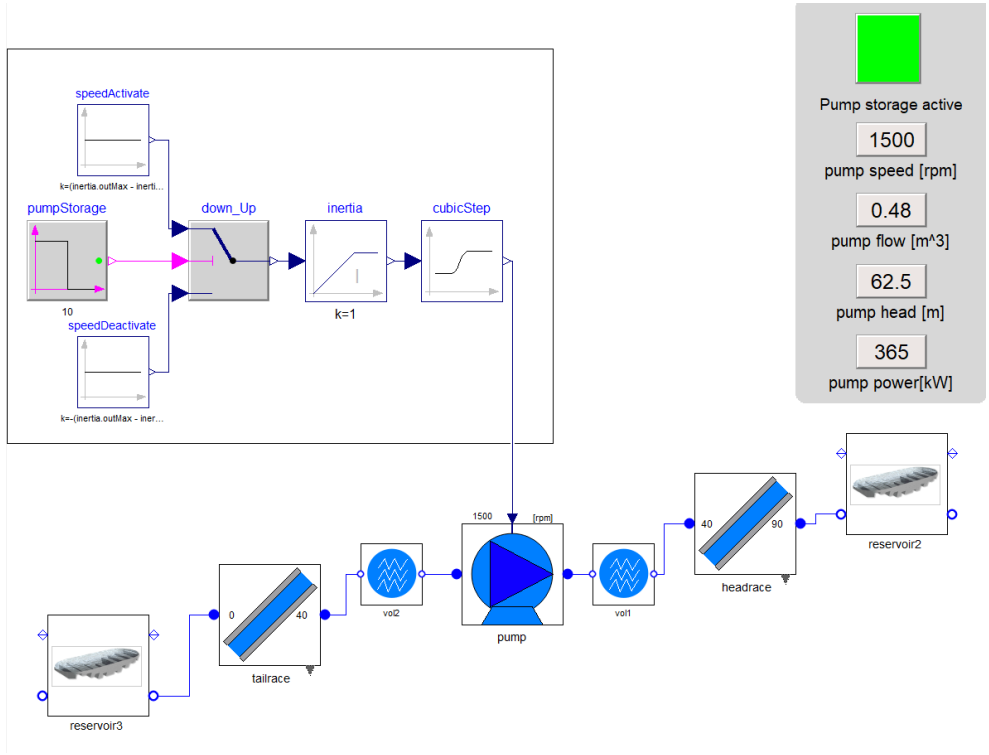
- Examples – Water hammer effect
  - Will the pressure exceed damaging levels during an emergency shutdown?

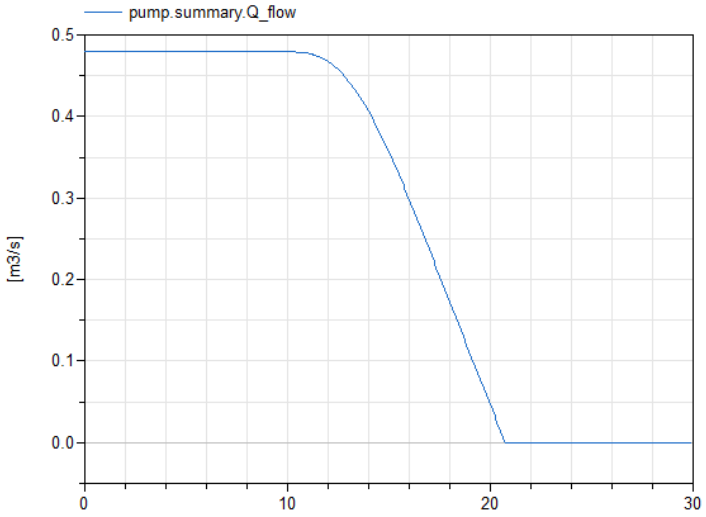




LIBRARY CONTENTS

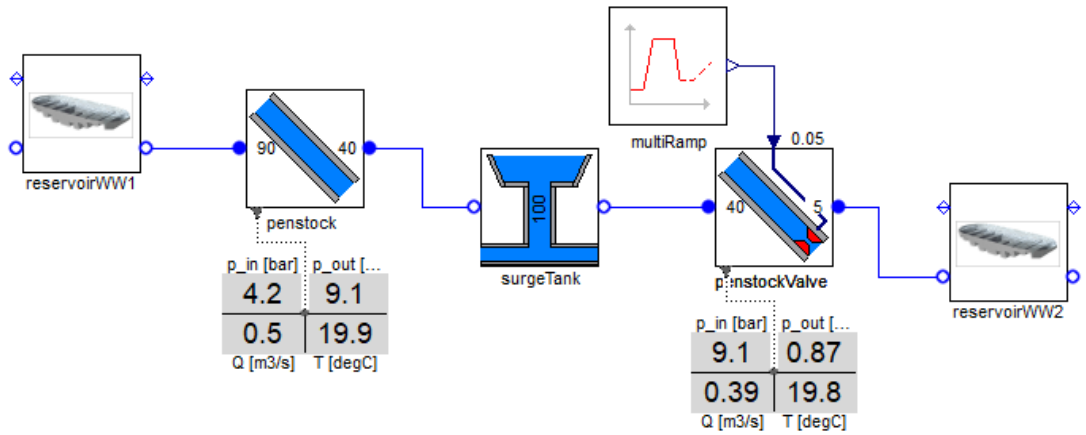
- Examples – Pump storage
  - Investigate strategies for pump storage

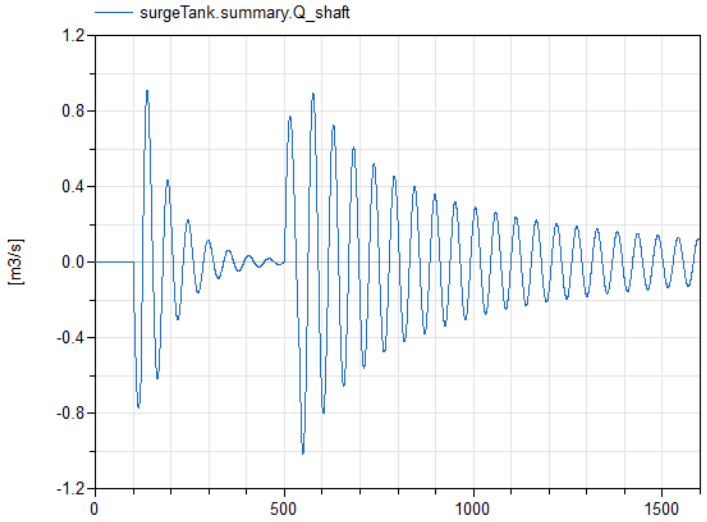




LIBRARY CONTENTS

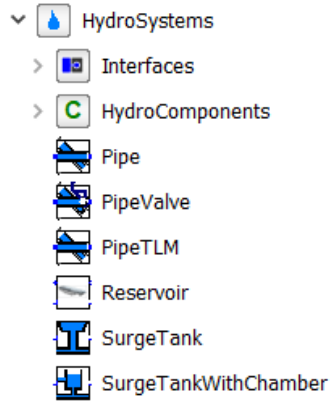
- Examples – Surge tank oscillations
  - How to dimension surge tank, valves and closing times to avoid long oscillation times and high pressure?

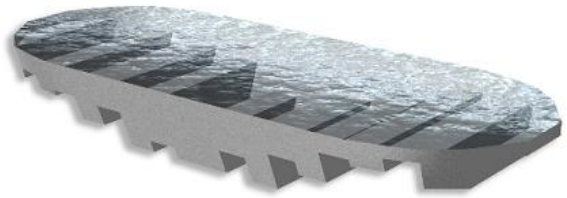




LIBRARY CONTENTS

- Hydro system
  - Pipes capable of simulating pressure transients and water inertia
    - 1D – discretized pipe
    - TLM (transmission-line-model) for fast simulation of longer pipes
  - Reservoir
    - Can predict the water level while tuning the water level control system and studying the dynamics involved for cascaded hydro power plants





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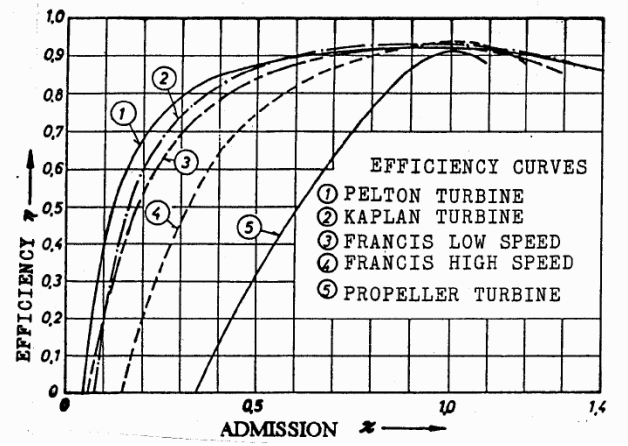
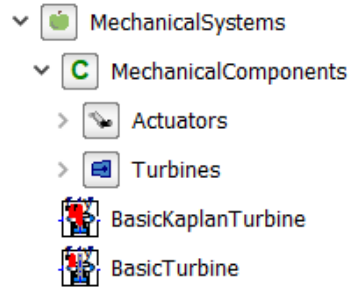
LIBRARY CONTENTS

- Mechanical system
  - Parameterized using efficiency and flow data available from manufacturers
  - Transfer function based actuator models (possible to increase fidelity level using physics-based hydraulics models)

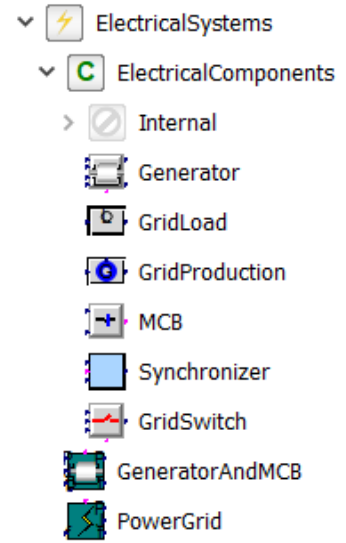




LIBRARY CONTENTS

- Power grid load and production units can be enabled and disabled during simulation
  - Support for resistive and frequency depend loads
- Possible to combine with Electric Power Library for more detailed grid studies

- Main circuit breaker
  - Enables power plant simulation in different modes
    - running under no load
    - synchronization phase
    - connected to the grid



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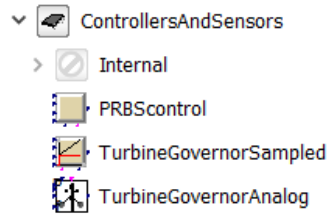
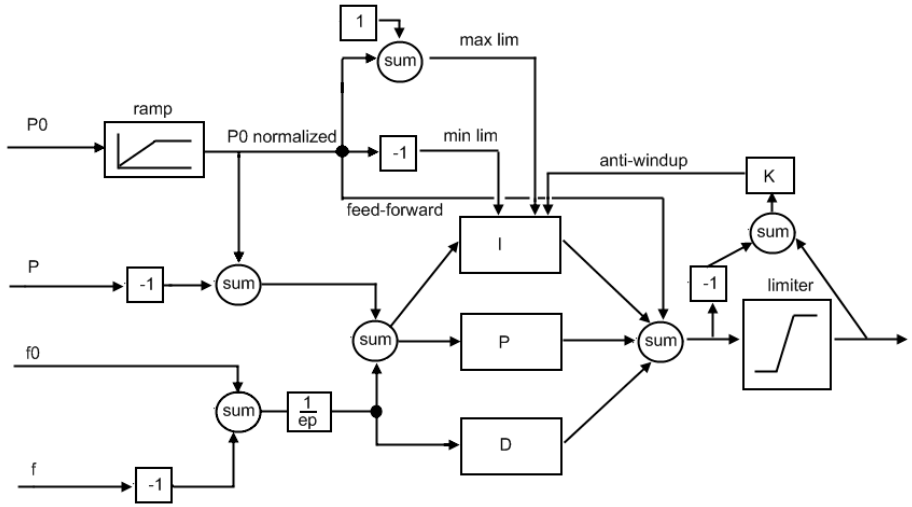
LIBRARY CONTENTS

- Turbine governor
  - PID structure with a feed-forward part including droop control
  - Default controller may be replaced with more sophisticated model based methods such as Model Predictive Control.





LIBRARY CONTENTS

- System component
  - System-wide settings
  - Transient or steady-state initialization
  - Disable thermal effects for speed-up
  - Default parameters for pipe roughness and tube elasticity

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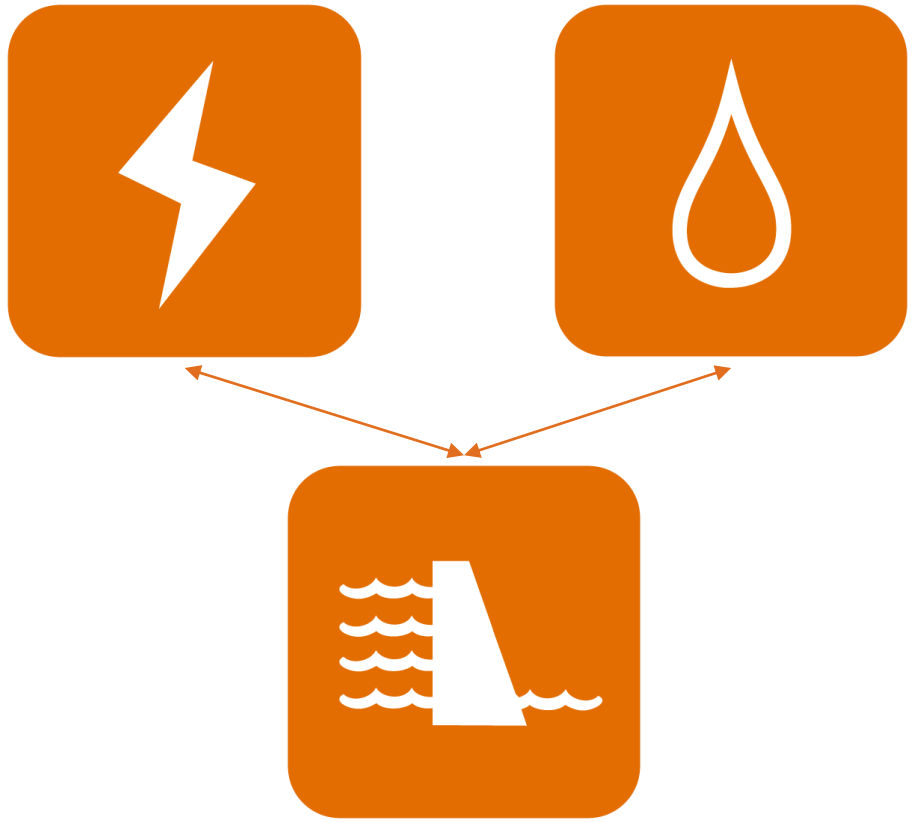
MODELON COMPATIBILITY

RECOMMENDED MODELON LIBRARY COMPATIBILITY

- Electric Power Library
- Hydraulics Library



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LATEST RELEASE

RELEASE:2021.2

Enhancements

- Version 2.13 is updated for use with Modelon Base Library 3.7