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# Thermolib

The Key to Thermal Management in Simulink®

Introduction and Applications in the Power Plant Sector

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© EUtech Scientific Engineering GmbH Dennewartstrasse 25-27, 52068 Aachen, Germany www.eutech-scientific.de Phone:+49/241/963-2380 Fax:+49/241/963-2389

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# Introduction

# Introduction

## Thermolib is ...

... modeling thermodynamic systems in Simulink.

... simulation for control.

... Model-Based Design.

... completion of physical modeling toolchain – engineering thermodynamics.

EUtech Scientific Engineering GmbH is a MathWorks Connections Partner.

# Introduction

## Industries

# Introduction

## Fields of Application

- Thermodynamic processes (cooling/heating circuits)
- Thermal Power Plants
- Process Industries
- µ-CHPs Systems
- Fuel Cells
- Heat-engines
- HVAC systems

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# Features & Benefits

# Features & Benefits

## Key Features

- Based on the fundamental principles of engineering thermodynamics
- Thermodynamic state and state change calculations including real gas modeling
- Component blocks including heat exchangers, reactors, pumps, turbines, and valves
- Equilibrium and reaction chemistry
- Customizable and extendable thermophysical database and IAPWS-IF97 water and steam properties
- MATLAB command-line functions for thermodynamic calculations and plots

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## Benefits of Thermolib

- Customer can concentrate on his core business
  - Consistent basic thermodynamic already implemented
  - Ready-to-use components
- Intuitive process design
  - Flow sheet orientated
- Cost and project time reduction
  - Model Based Design allows earlier error detection
- Risk free safety analysis
- Continuous development and support
  - Compatible with latest MATLAB® version
  - Support via on-site assistance, training, web sessions, e-mail, phone

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# Examples – Power Plant Sector

Please note: Demo models marked with * are not included in the scope of supply of the Thermolib-Basic License

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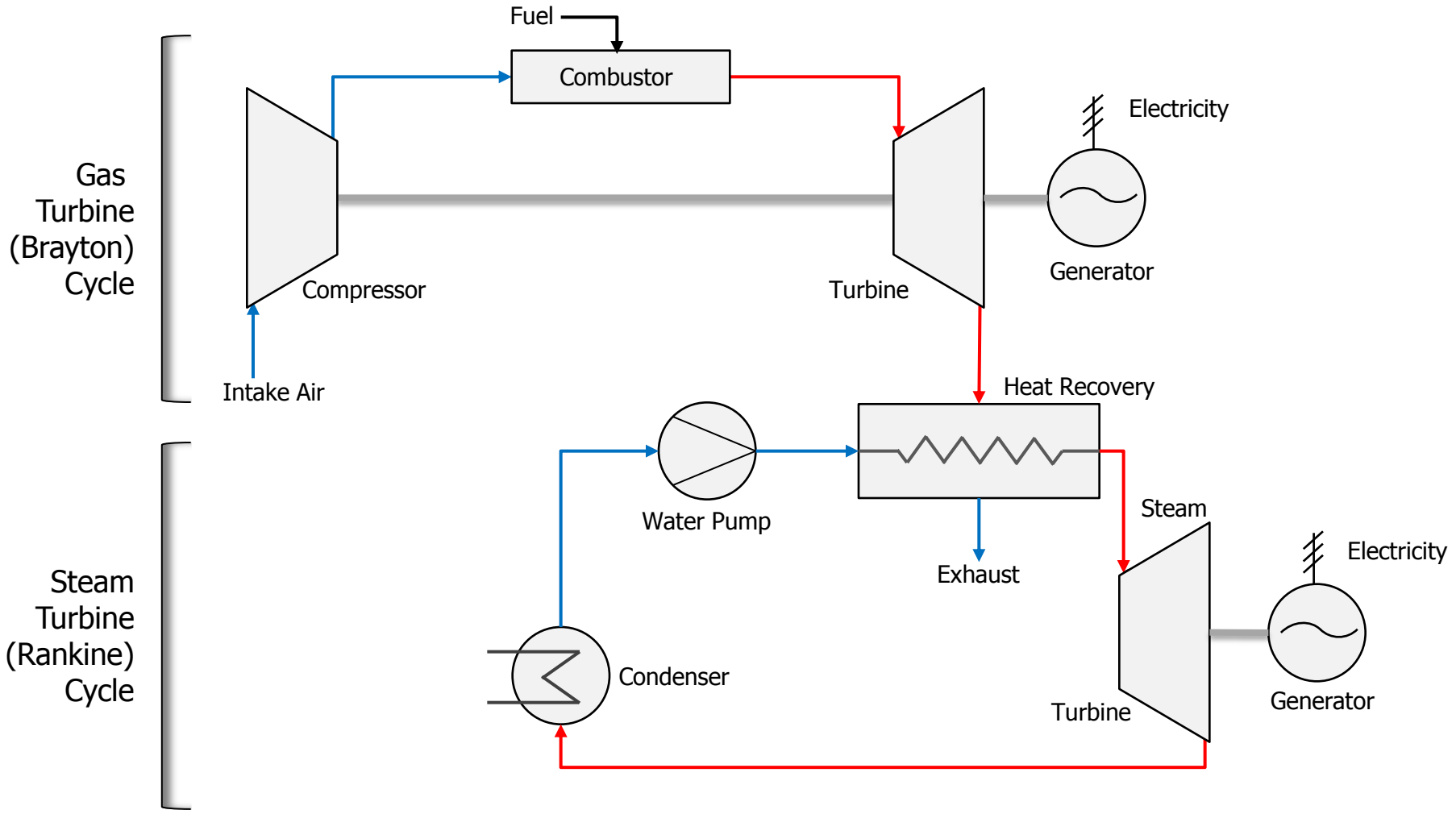
# Example – Combined Cycle Power Plant

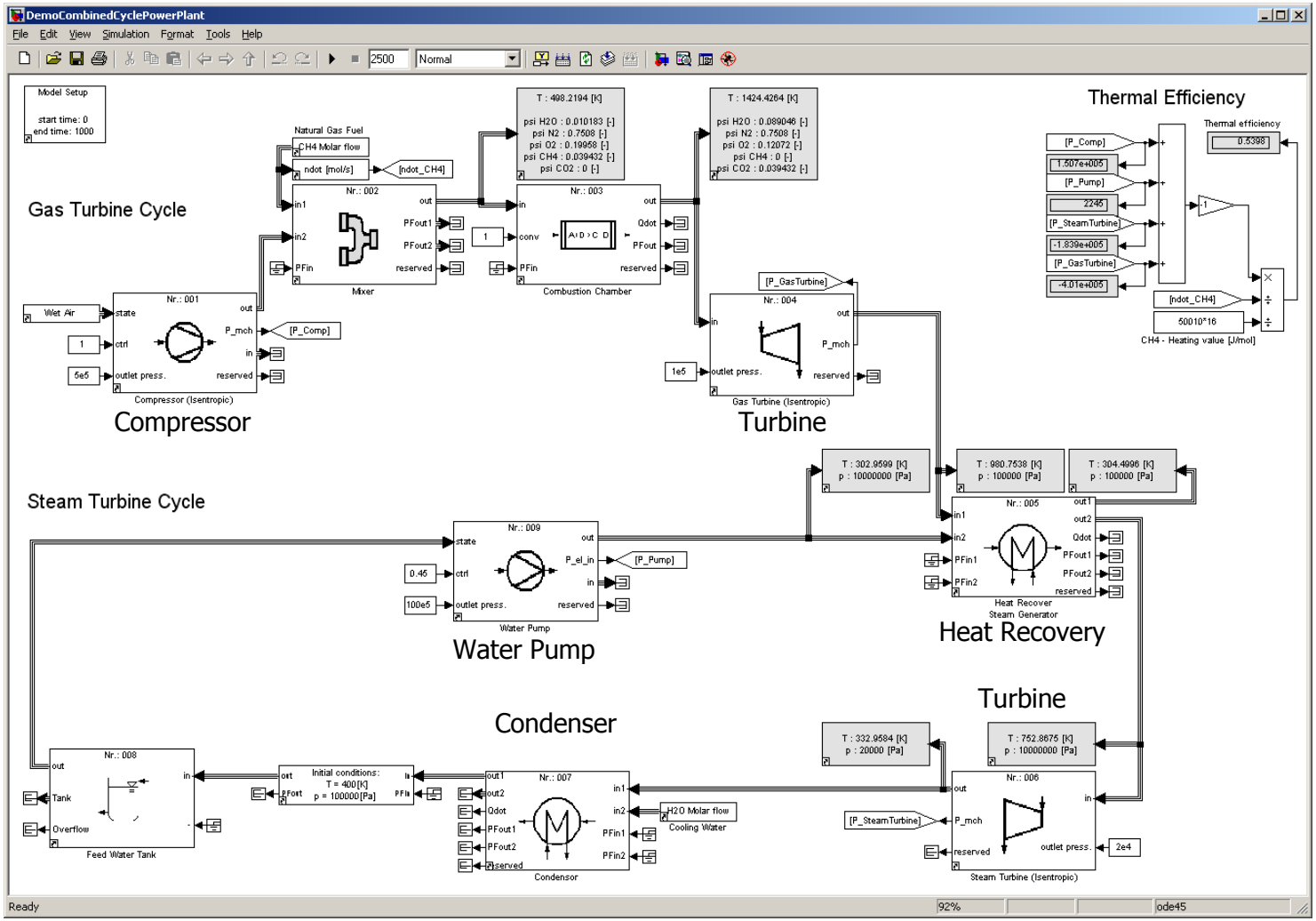
# Example – Combined Cycle Power Plant

## Flow scheme



# Example – Combined Cycle Power Plant

## Simulink Model with Thermolib blocks




DemoCombinedCyclePowerPlant.mdl

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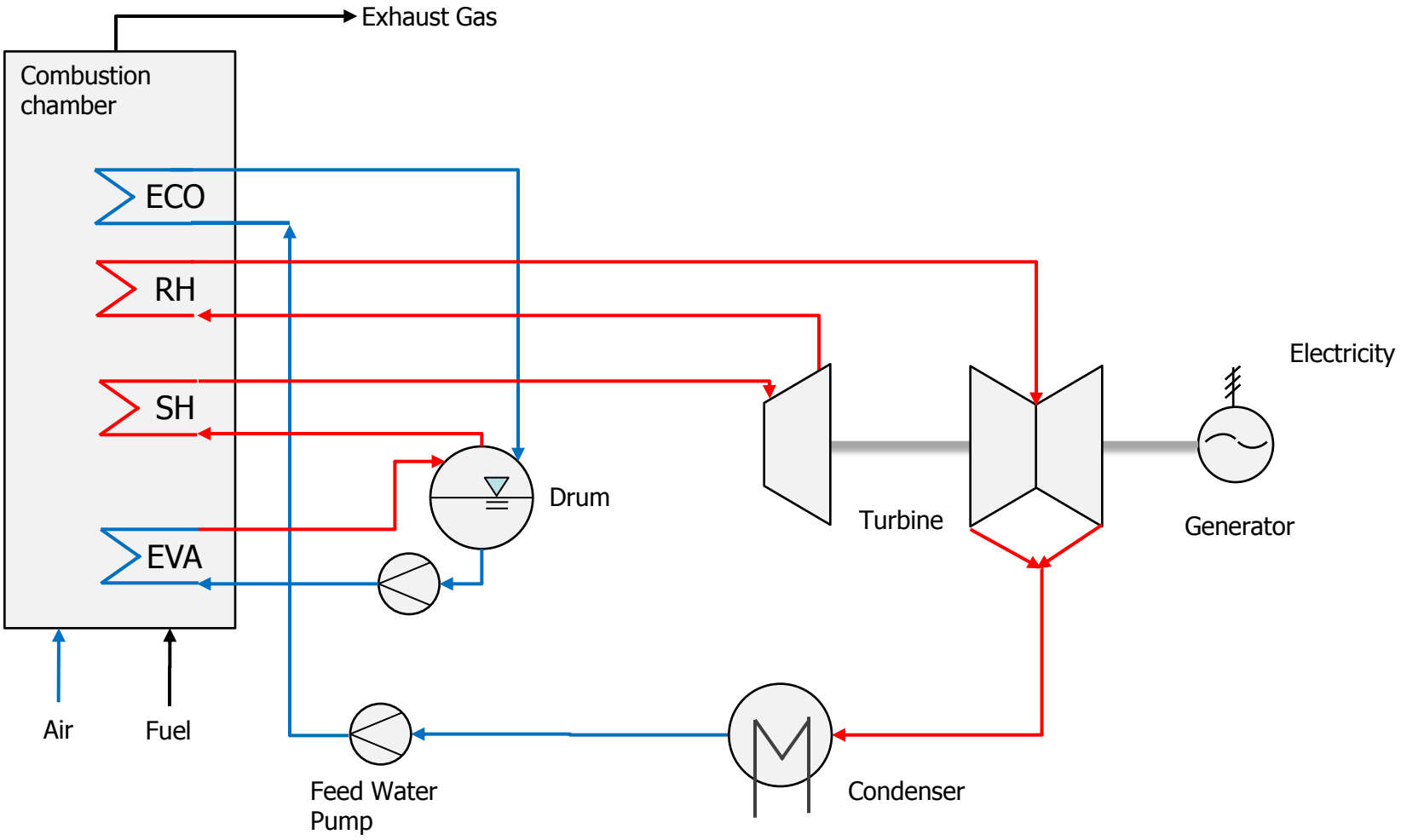
# Example – Forced Circulation Boiler

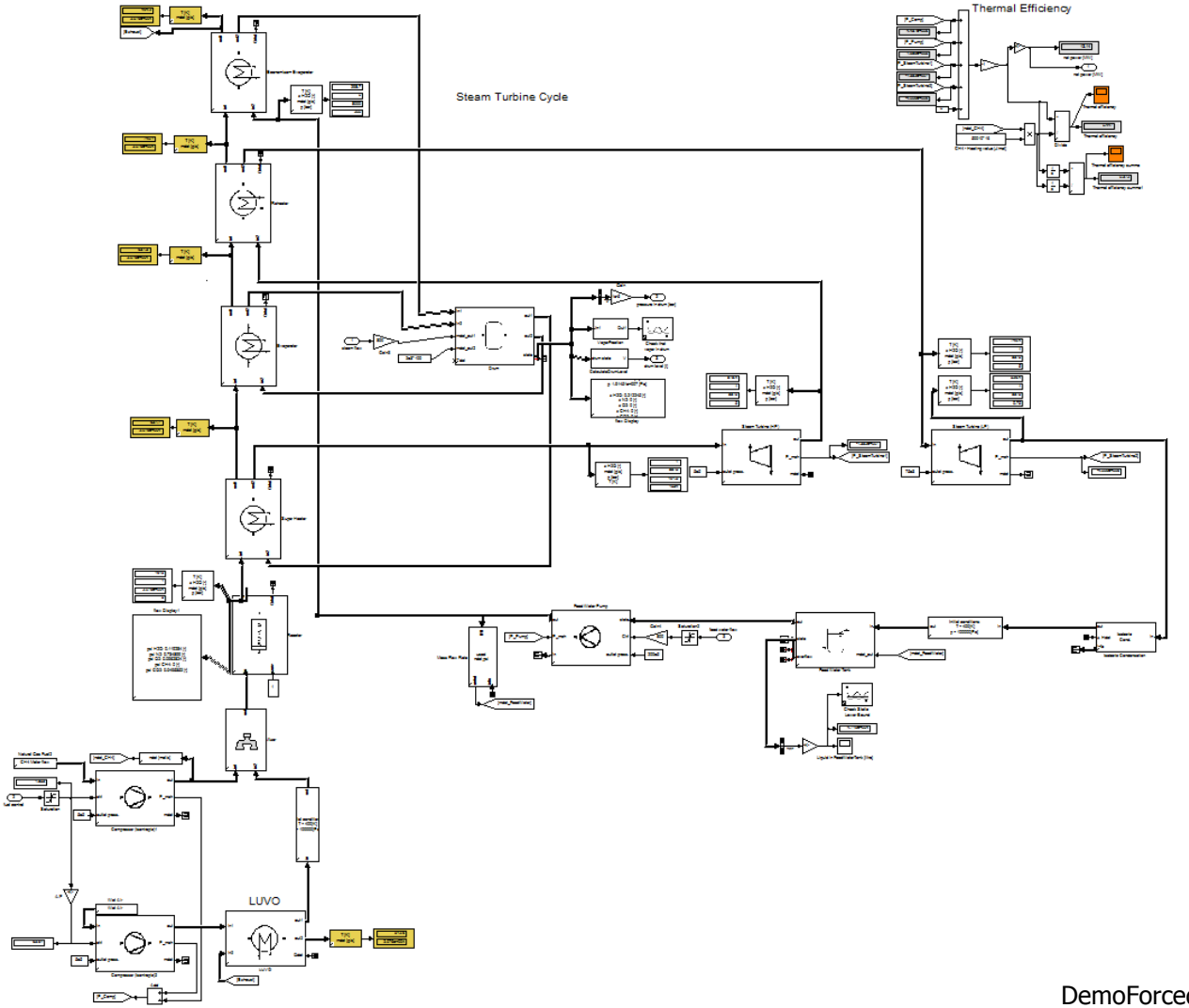
# Example – Forced Circulation Boiler

## Flow scheme



# Example – Forced Circulation Boiler

## Simulink implementation using Thermolib




DemoForcedCirculationBoiler.mdl*

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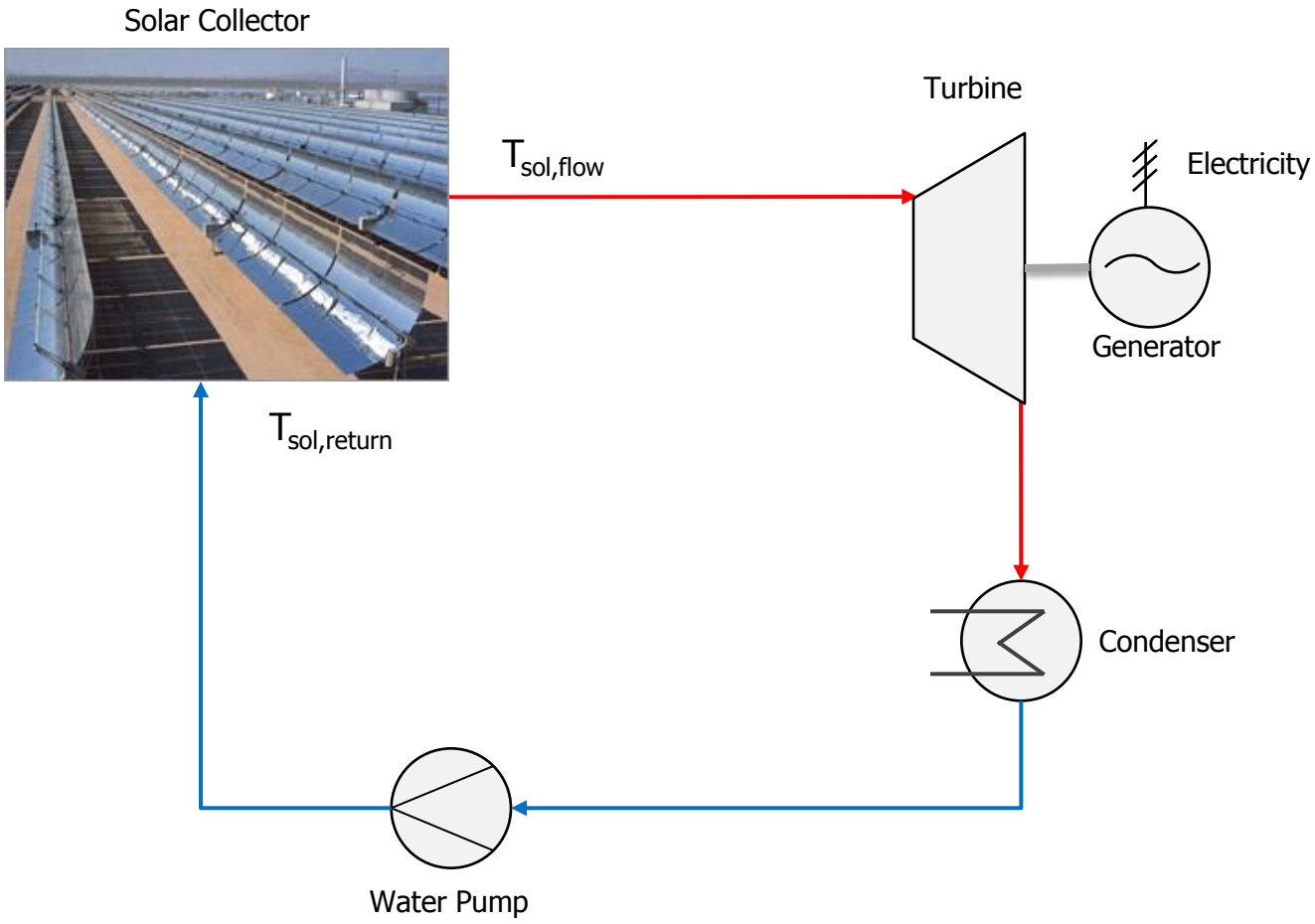
# Example – Solar Thermal Plant

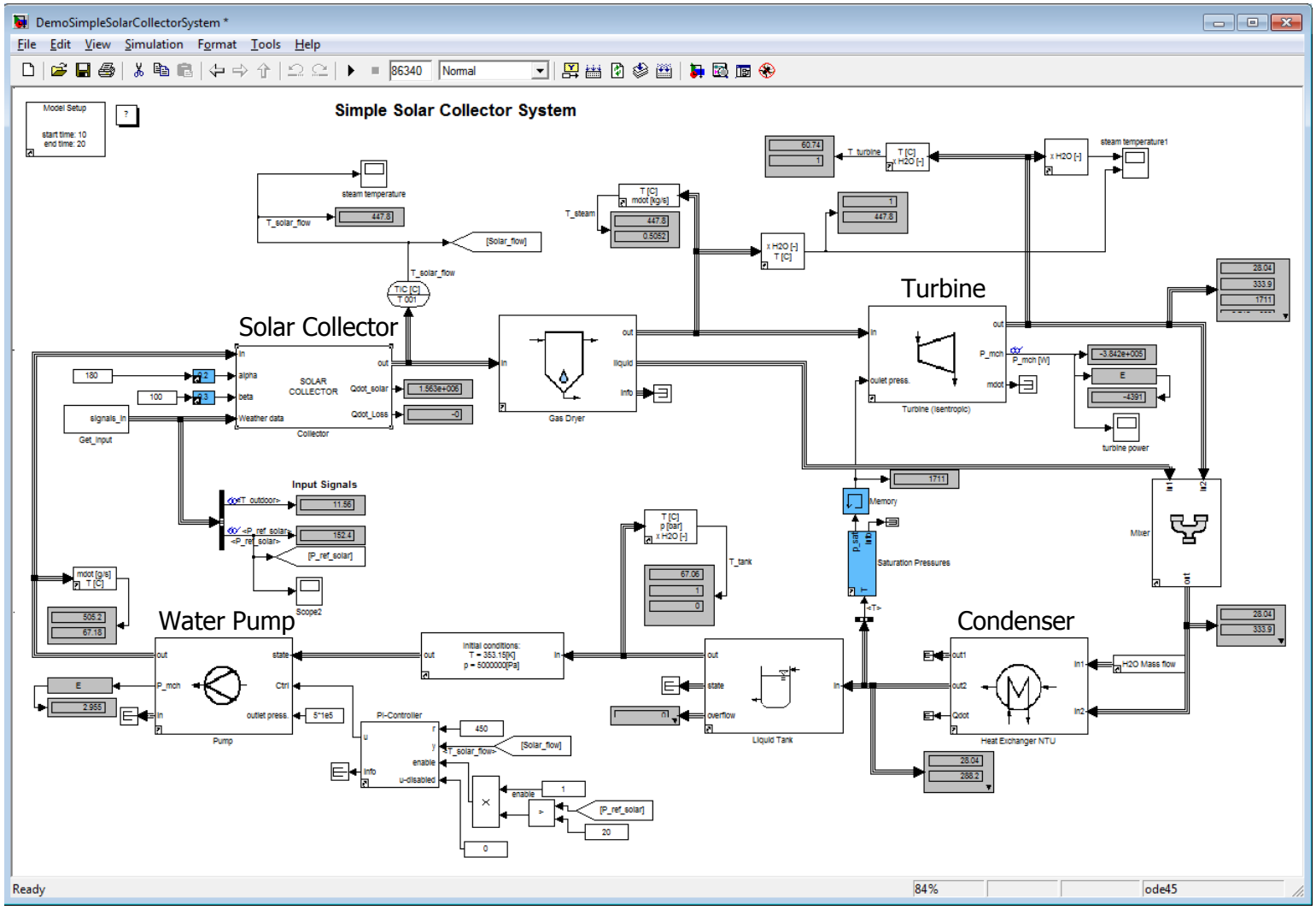
# Example – Solar Thermal Plant

## Flow scheme



# Example – Solar Thermal Plant

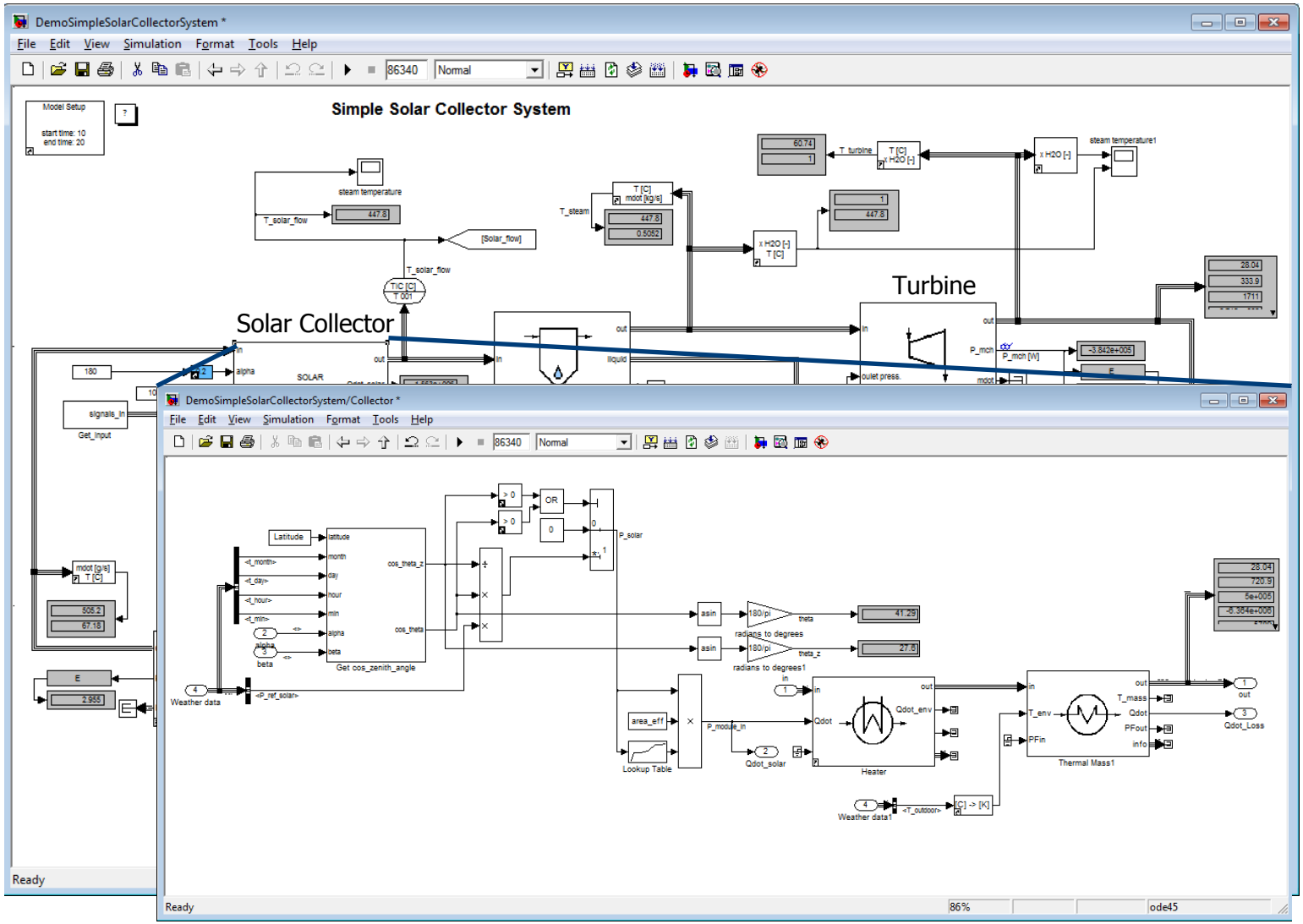
## Simulink Model with Thermolib blocks




DemoSimpleSolarCollectorSystem.mdl

# Example – Solar Thermal Plant

## Simulink Model with Thermolib blocks



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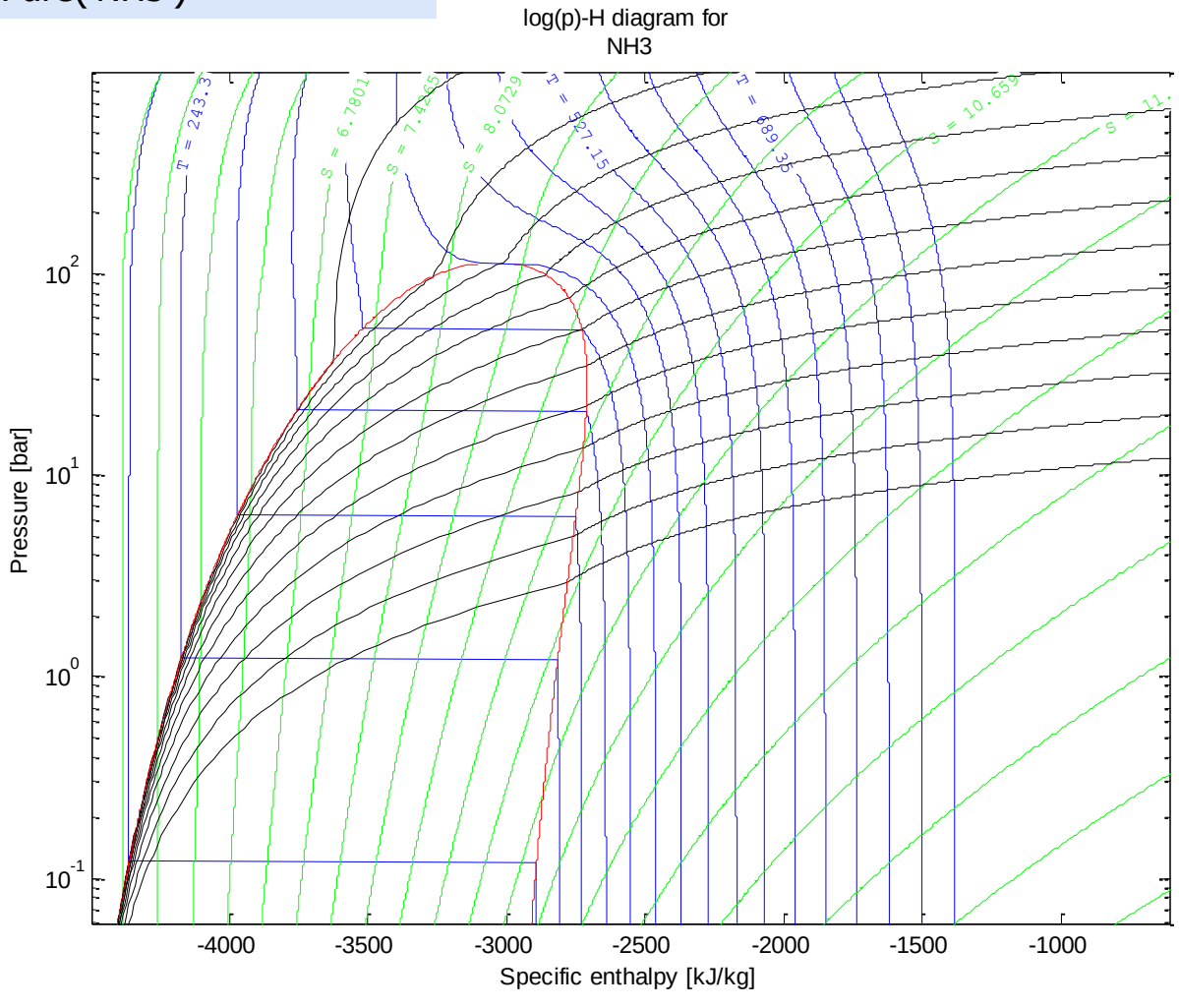
# Example – Species Diagrams

# Example – Species Diagrams

## Species Diagrams

```
>>th_PlotLogPHPure('NH3')
```



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# Example – Command Line Functions

# Command Line Functions

## Compression of Air

Defining the initial state:

```
initial_state = th_TpState(
    'ndot',1000/28.85,
    'T',300,
    'p',1e5,
    'psi',[0.21; 0.79],
    'species',{'O2','N2'},
    'MediaData',SMediaData);

initial_state =

     ndot: 34.6620
        T: 300
        p: 100000
     Hdot: 1.8711e+003
     Sdot: 6.8945e+003
     Gdot: -2.0665e+006
    Cpdot: 1.0115e+003
        x: [2x1 double]
      psi: [2x1 double]
```

A massflow of 1kg/s of Air (21% O2, 79% N2) At 300K and 1bar

Result is a struct containing the defined state

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## Compression of Air

Calculate isentropic compression first:

```
isentropic_compression = th_SpState(
    'ndot',1000/28.85,
    'Sdot',initial_state.Sdot,
    'p',10e5,
    'psi',[0.21; 0.79],
    'species',{'O2','N2'},
    'MediaData',SMediaData);
```

Isentropic State Change

Compression by 9 bar

Calculate final state with isentropic efficiency

```
final_state = th_HpState(
    'ndot',1000/28.85,
    'Hdot',initial_state.Hdot + (isentropic_compression.Hdot -
       initial_state.Hdot) / 0.85,
    'p',10e5,
    'T_initial', isentropic_compression.T,
    'psi',[0.21; 0.79],
    'species',{'O2','N2'},
    'MediaData',SMediaData);
```

Final enthalpy calculation with isentropic efficiency of 85%

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# User Story

# User Story

## Market Driven Waste-to-Energy Production

"Using the Thermolib toolbox enables us to develop model predictive controllers for complex systems, such as thermal power plants. It brings together extended control methods like planning under uncertainty and learning from the field of artificial intelligence and thermodynamic simulations."

Dr. Bastian Migge, ETH Zurich, Institute of Machine Tools and Manufacturing

"Power plant simulation with Thermolib reduces the effort to set up realistic, plant-specific simulations in order to test and continuously improve controllers with the simulation-in-the-loop approach."

Christian Baltensperger, ABB Switzerland Ltd., Power Systems

Read More

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# Summary

# Summary

## Thermolib allows you to...

- Concentrate on your core business
- Enjoy the intuitive process design
- Reduce your costs and project time
- Benefit from continuous development and support

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# www.thermolib.de