Software Information

- Please check, whether your inputs, the equations applied and the charactersitics are displayed correctly.

- You are welcome to send your feedback via `https://github.com/oemof/tespy/issues`.

- LaTeXpackages required are:

  - graphicx
  - float
  - hyperref
  - booktabs
  - amsmath
  - units
  - cleveref

- To supress these messages, call the model documentation with the keyword draft=False.

TESPy Version:	0.4.2-002 - User's Universe
Commit:	bb88b626@master
CoolProp version:	6.4.0
Python version:	3.8.0 (default, Oct 28 2019, 16:14:01) [GCC 8.3.0]

1 Connections in design mode

1.1 Specified connection parameters

label	m in kg/s (1)	p in bar (2)	T in °C (3)
ambient air:out1_compressor:in1	250.000	1.000	20.000
combustion:out1_gas turbine:in1	-	-	1200.000
economizer:out1_waste heat recovery:in1	-	-	290.000
waste heat recovery:out1_chimney:in1	-	1.000	100.000
superheater:out2_ls cycle closer:in1	-	100.000	550.000
steam turbine:out1_condenser:in1	-	0.800	-
district heating backflow:out1_condenser:in2	-	5.000	60.000
waste heat recovery:out2_district heating feedflow:in1	-	-	90.000

Table 1: Specified connection parameters

1.2 Equations applied

$$0 = \dot{m} - \dot{m}_{\text{spec}} \tag{1}$$

$$0 = p - p_{\text{spec}} \tag{2}$$

$$0 = T\left(p, h\right) - T_{\text{spec}} \tag{3}$$

1.3 Specified fluids

label	Ar (4)	CH4 (5)	CO2 (6)	H2O (7)	N2 (8)	O2 (9)
ambient air:out1_compressor:in1	0.013	0.000	0.000	0.000	0.755	0.231
fuel source:out1_combustion:in2	0.000	0.960	0.040	0.000	0.000	0.000
superheater:out2_ls cycle closer:in1	0.000	0.000	0.000	1.000	0.000	0.000
district heating backflow:out1_condenser:in2	0.000	0.000	0.000	1.000	0.000	0.000

Table 2: Specified fluids

1.4 Equations applied

$$0 = x_{\text{Ar}} - x_{\text{Ar,spec}} \tag{4}$$

$$0 = x_{\text{CH4}} - x_{\text{CH4,spec}} \tag{5}$$

$$0 = x_{\text{CO2}} - x_{\text{CO2,spec}} \tag{6}$$

$$0 = x_{\text{H2O}} - x_{\text{H2O,spec}} \tag{7}$$

$$0 = x_{\text{N2}} - x_{\text{N2,spec}} \tag{8}$$

$$0 = x_{\text{O2}} - x_{\text{O2,spec}} \tag{9}$$

1.5 Referenced values for mass flow

label	reference	factor in -	delta in kg/s
evaporator:out2_drum:in2	drum:out2_superheater:in2	4	0

<div align="center">Table 3: Referenced values for mass flow</div>

1.6 Equation applied

$$0 = \text{value} - \text{value}_{\text{ref}} \cdot \text{factor} + \text{delta} \tag{10}$$

1.7 Referenced values for temperature

label	reference	factor in -	delta in °C
fuel source:out1_combustion:in2	ambient air:out1_compressor:in1	1	0

<div align="center">Table 4: Referenced values for temperature</div>

1.8 Equation applied

$$0 = \text{value} - \text{value}_{\text{ref}} \cdot \text{factor} + \text{delta} \tag{11}$$

2 User defined equations in design mode

3 Components in design mode

3.1 Components of type Compressor

3.1.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \ \forall i \in [1] \tag{12}$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \ \forall fl \in \text{network fluids}, \forall i \in [1] \tag{13}$$

3.1.2 Inputs specified

label	eta_s (14)	pr (15)
compressor	0.910	14.000

<div align="center">Table 5: Parameters of components of type Compressor</div>

3.1.3 Equations applied

$$0 = -\left(h_{\text{out}} - h_{\text{in}}\right) \cdot \eta_{\text{s}} + \left(h_{\text{out,s}} - h_{\text{in}}\right) \tag{14}$$

$$0 = p_{\text{in},1} \cdot pr - p_{\text{out},1} \tag{15}$$

3.2 Components of type CombustionChamber

3.2.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},1} + \dot{m}_{\text{in},2} - \dot{m}_{\text{out},1} \tag{16}$$

$$0 = p_{\text{in},1} - p_{\text{out},1}$$
$$0 = p_{\text{in},1} - p_{\text{in},2} \tag{17}$$

$$\Delta\dot{m}_{\text{fluid}} = \dot{m}_{\text{in},1} \cdot x_{\text{fluid,in},1} + \dot{m}_{\text{in},2} \cdot x_{\text{fluid,in},2} - \dot{m}_{\text{out},1} \cdot x_{\text{fluid,out},1}$$
$$\dot{m}_{\text{fluid,m}} = \frac{\dot{m}_{\text{in},1} \cdot x_{\text{fluid,in},1} + \dot{m}_{\text{in},2} \cdot x_{\text{fluid,in},2}}{M_{\text{fluid}}}$$
$$\dot{m}_{\text{H,m}} = \dot{m}_{\text{CH4,m}} \cdot 4 \tag{18}$$
$$\dot{m}_{\text{C,m}} = \dot{m}_{\text{CH4,m}} \cdot 1$$
$$\dot{m}_{\text{O2,m,stoich}} = \frac{\dot{m}_{\text{H,m}}}{4} + \dot{m}_{\text{C,m}}$$

$$0 = \Delta\dot{m}_{\text{Ar}} \tag{19}$$

$$0 = \Delta\dot{m}_{\text{CH4}} - \dot{m}_{\text{CH4,m}} \cdot M_{\text{CH4}} \tag{20}$$

$$0 = \Delta\dot{m}_{\text{CO2}} + \dot{m}_{\text{C,m}} \cdot M_{\text{CO2}} \tag{21}$$

$$0 = \Delta\dot{m}_{\text{H2O}} + \frac{\dot{m}_{\text{H,m}}}{2} \cdot M_{\text{H2O}} \tag{22}$$

$$0 = \Delta\dot{m}_{\text{N2}} \tag{23}$$

$$0 = \Delta\dot{m}_{\text{O2}} - \dot{m}_{\text{O2,m,stoich}} \cdot M_{\text{O2}} \tag{24}$$

$$0 = \sum_i \dot{m}_{\text{in},i} \cdot (h_{\text{in},i} - h_{\text{in},i,\text{ref}}) - \dot{m}_{\text{out},1} \cdot (h_{\text{out},1} - h_{\text{out},1,\text{ref}})$$
$$+ LHV_{fuel} \cdot \left(\sum_i \dot{m}_{\text{in},i} \cdot x_{fuel,\text{in},i} - \dot{m}_{\text{out},1} \cdot x_{fuel,\text{out},1} \right) \tag{25}$$
$$\forall i \in \text{inlets}$$
$$T_{\text{ref}} = 298.15\,\text{K}\ p_{\text{ref}} = 10^5\,\text{Pa}$$

3.3 Components of type Turbine

3.3.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i}\ \forall i \in [1] \tag{26}$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i}\ \forall fl \in \text{network fluids},\ \forall i \in [1] \tag{27}$$

3.3.2 Inputs specified

label	eta_s (28)
gas turbine	0.880
steam turbine	0.850

Table 6: Parameters of components of type Turbine

3.3.3 Equations applied

$$0 = -(h_{\text{out}} - h_{\text{in}}) + (h_{\text{out,s}} - h_{\text{in}}) \cdot \eta_{\text{s}} \tag{28}$$

3.4 Components of type HeatExchanger

3.4.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \ \forall i \in [1,2] \tag{29}$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \ \forall fl \in \text{network fluids}, \ \forall i \in [1,2] \tag{30}$$

$$0 = \dot{m}_{\text{in},1} \cdot (h_{\text{out},1} - h_{\text{in},1}) + \dot{m}_{\text{in},2} \cdot (h_{\text{out},2} - h_{\text{in},2}) \tag{31}$$

3.4.2 Inputs specified

label	ttd_l (32)	pr1 (33)	pr2 (34)
superheater	-	0.990	0.834
evaporator	25.000	0.990	-
economizer	-	0.990	1.000
waste heat recovery	-	0.990	0.980

Table 7: Parameters of components of type HeatExchanger

3.4.3 Equations applied

$$0 = ttd_{\text{l}} - T_{\text{out},1} + T_{\text{in},2} \tag{32}$$

$$0 = p_{\text{in},1} \cdot pr1 - p_{\text{out},1} \tag{33}$$

$$0 = p_{\text{in},2} \cdot pr2 - p_{\text{out},2} \tag{34}$$

3.5 Components of type Drum

3.5.1 Mandatory constraints

$$0 = \sum \dot{m}_{\text{in},i} - \sum \dot{m}_{\text{out},j} \ \forall i \in \text{inlets}, \forall j \in \text{outlets} \tag{35}$$

$$0 = x_{fl,\text{in},1} - x_{fl,\text{out},j} \ \forall fl \in \text{network fluids}, \ \forall j \in \text{outlets} \tag{36}$$

$$0 = \sum_i (\dot{m}_{\text{in},i} \cdot h_{\text{in},i}) - \sum_j (\dot{m}_{\text{out},j} \cdot h_{\text{out},j}) \ \forall i \in \text{inlets} \ \forall j \in \text{outlets} \tag{37}$$

$$0 = p_{\text{in},1} - p_{\text{in},i} \; \forall i \in \text{inlets} \setminus \{1\}$$
$$0 = p_{\text{in},1} - p_{\text{out},j} \; \forall j \in \text{outlets} \tag{38}$$

$$0 = h_{\text{out},1} - h\left(p_{\text{out},1}, x = 0\right)$$
$$0 = h_{\text{out},2} - h\left(p_{\text{out},2}, x = 1\right) \tag{39}$$

3.6 Components of type CycleCloser

3.6.1 Mandatory constraints

$$0 = p_{\text{in},i} - p_{\text{out},i} \; \forall i \in [1] \tag{40}$$

$$0 = h_{\text{in},i} - h_{\text{out},i} \; \forall i \in [1] \tag{41}$$

3.7 Components of type Condenser

3.7.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \; \forall i \in [1, 2] \tag{42}$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \; \forall fl \in \text{network fluids}, \forall i \in [1, 2] \tag{43}$$

$$0 = \dot{m}_{\text{in},1} \cdot (h_{\text{out},1} - h_{\text{in},1}) + \dot{m}_{\text{in},2} \cdot (h_{\text{out},2} - h_{\text{in},2}) \tag{44}$$

3.7.2 Inputs specified

label	pr1 (45)	pr2 (46)	subcooling (47)
condenser	0.990	0.980	True

Table 8: Parameters of components of type Condenser

3.7.3 Equations applied

$$0 = p_{\text{in},1} \cdot pr1 - p_{\text{out},1} \tag{45}$$

$$0 = p_{\text{in},2} \cdot pr2 - p_{\text{out},2} \tag{46}$$

$$0 = h_{\text{out},1} - h\left(p_{\text{out},1}, x = 0\right) \tag{47}$$

3.8 Components of type Pump

3.8.1 Mandatory constraints

$$0 = \dot{m}_{\text{in},i} - \dot{m}_{\text{out},i} \; \forall i \in [1] \tag{48}$$

$$0 = x_{fl,\text{in},i} - x_{fl,\text{out},i} \; \forall fl \in \text{network fluids}, \forall i \in [1] \tag{49}$$

3.8.2 Inputs specified

label	eta_s (50)
feed water pump	0.750

Table 9: Parameters of components of type Pump

3.8.3 Equations applied

$$0 = -\left(h_\text{out} - h_\text{in}\right) \cdot \eta_\text{s} + \left(h_\text{out,s} - h_\text{in}\right) \tag{50}$$

4 Busses in design mode

4.1 Bus "power output"

This bus is used for postprocessing only.

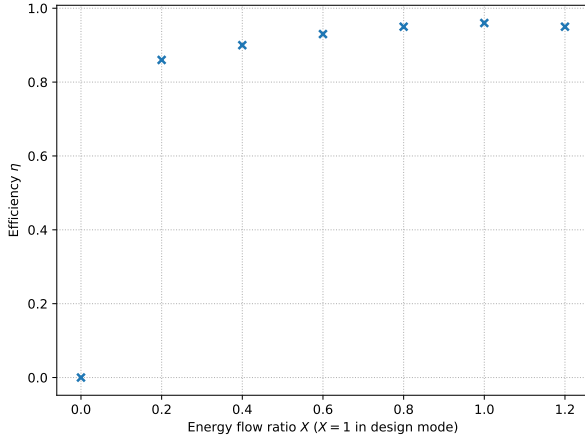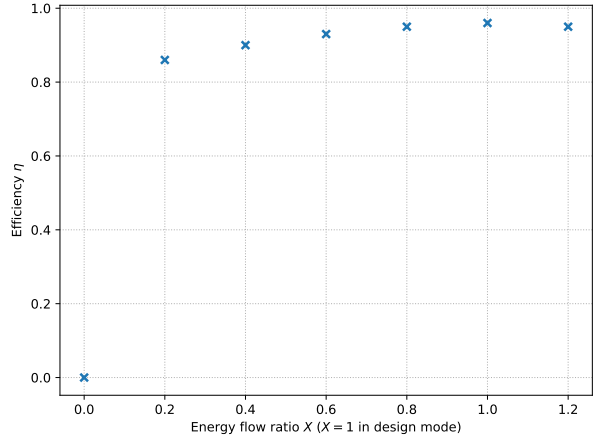| label	$\dot{E}_\text{comp}$	$\dot{E}_\text{bus}$	η
gas turbine	$\dot{m}_\text{in} \cdot \left(h_\text{out} - h_\text{in}\right)$	$\dot{E}_\text{comp} \cdot \eta$	$f\left(X\right)$ (1)
compressor	$\dot{m}_\text{in} \cdot \left(h_\text{out} - h_\text{in}\right)$	$\frac{\dot{E}_\text{comp}}{\eta}$	$f\left(X\right)$ (2)
steam turbine	$\dot{m}_\text{in} \cdot \left(h_\text{out} - h_\text{in}\right)$	$\dot{E}_\text{comp} \cdot \eta$	$f\left(X\right)$ (1)
feed water pump	$\dot{m}_\text{in} \cdot \left(h_\text{out} - h_\text{in}\right)$	$\frac{\dot{E}_\text{comp}}{\eta}$	$f\left(X\right)$ (2)

Table 10: power output

Figure 1: Bus efficiency characteristic

Figure 2: Bus efficiency characteristic

4.2 Bus "heat output"

This bus is used for postprocessing only.

label	$\dot{E}_{\text{comp}}$	$\dot{E}_{\text{bus}}$	η
condenser	$\dot{m}_{\text{in,1}} \cdot (h_{\text{out,1}} - h_{\text{in,1}})$	$\dot{E}_{\text{comp}} \cdot \eta$	1.000
waste heat recovery	$\dot{m}_{\text{in,1}} \cdot (h_{\text{out,1}} - h_{\text{in,1}})$	$\dot{E}_{\text{comp}} \cdot \eta$	1.000

Table 11: heat output

4.3 Bus "heat input"

This bus is used for postprocessing only.

label	$\dot{E}_{\text{comp}}$	$\dot{E}_{\text{bus}}$	η
combustion	$LHV_{\text{fuel}} \cdot \left[\sum_i \left(\dot{m}_{\text{in,}i} \cdot x_{\text{fuel,in,}i} \right) - \dot{m}_{\text{out,1}} \cdot x_{\text{fuel,out,1}} \right]$	$\dot{E}_{\text{comp}} \cdot \eta$	1.000

Table 12: heat input