



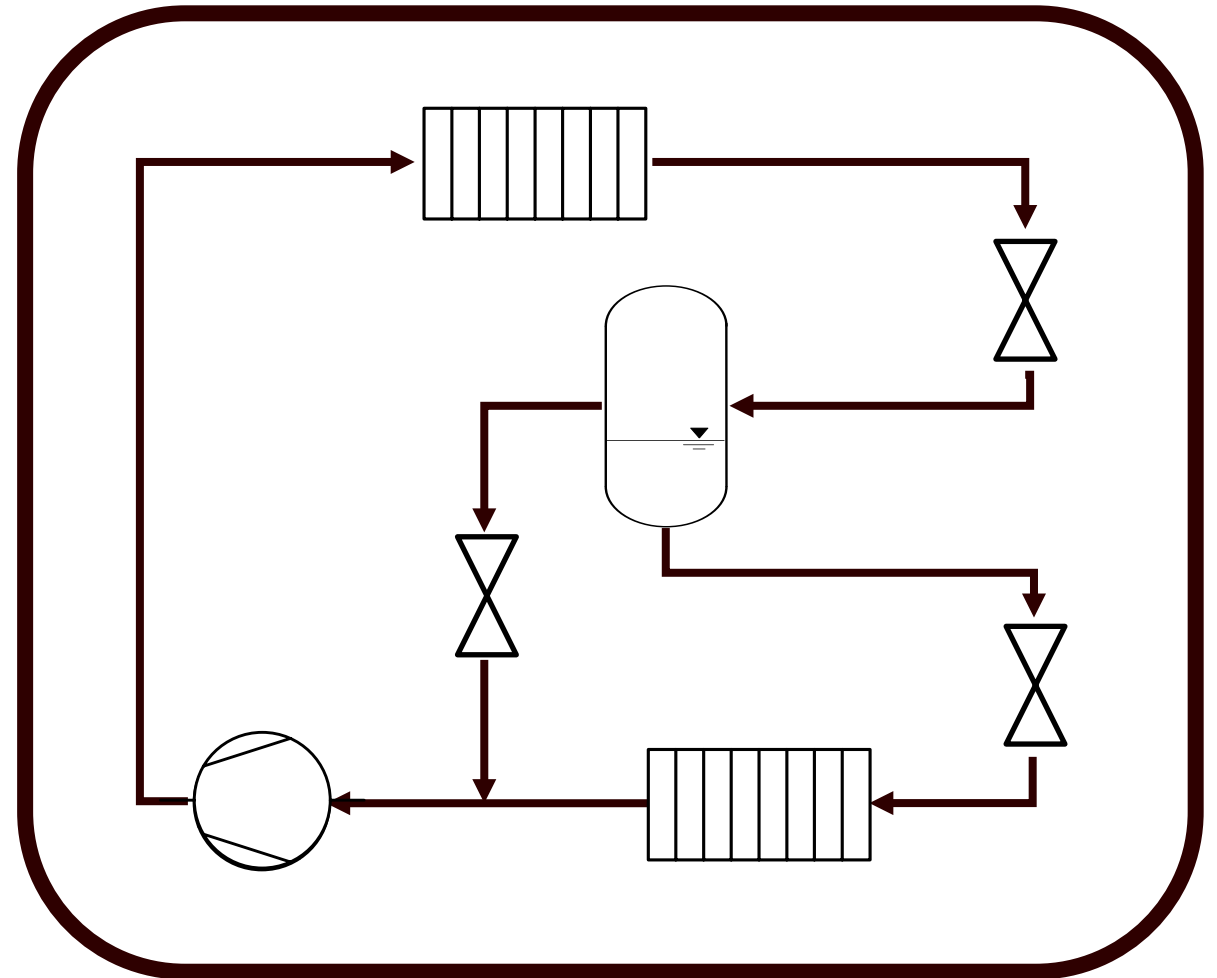
**TEKNOLOGISK
INSTITUT**



**Flexible
steady state
HP model**

What is it?

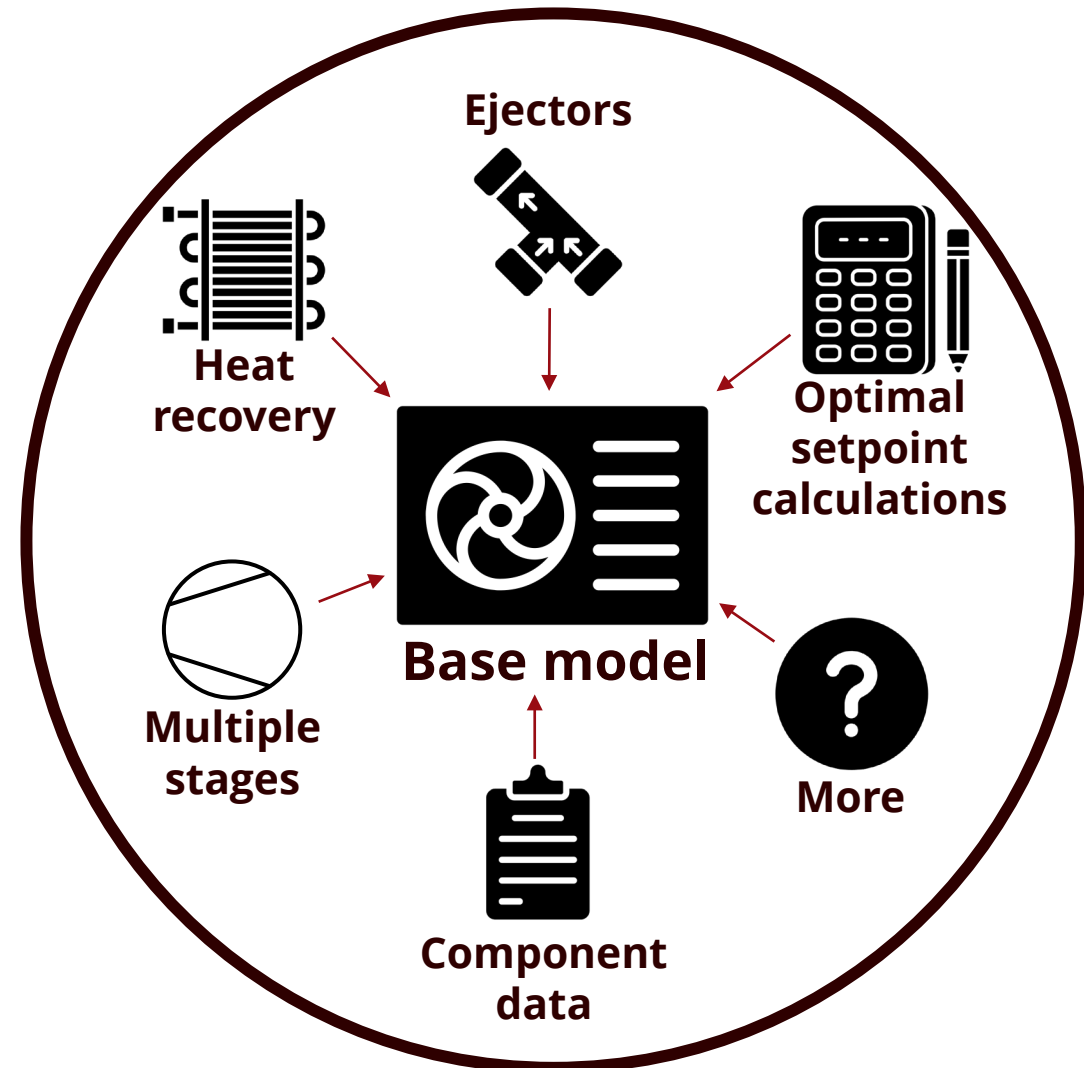
- At the base level is a simple heat pump model
 - Built for CO2 systems, but can be modified to model other refrigerants
 - Steady state
 - Subcritical and transcritical operation
- Written in C#
- Object oriented
 - Based on individual independent components that can be 'dragged and dropped' together



Base CO2 HP model

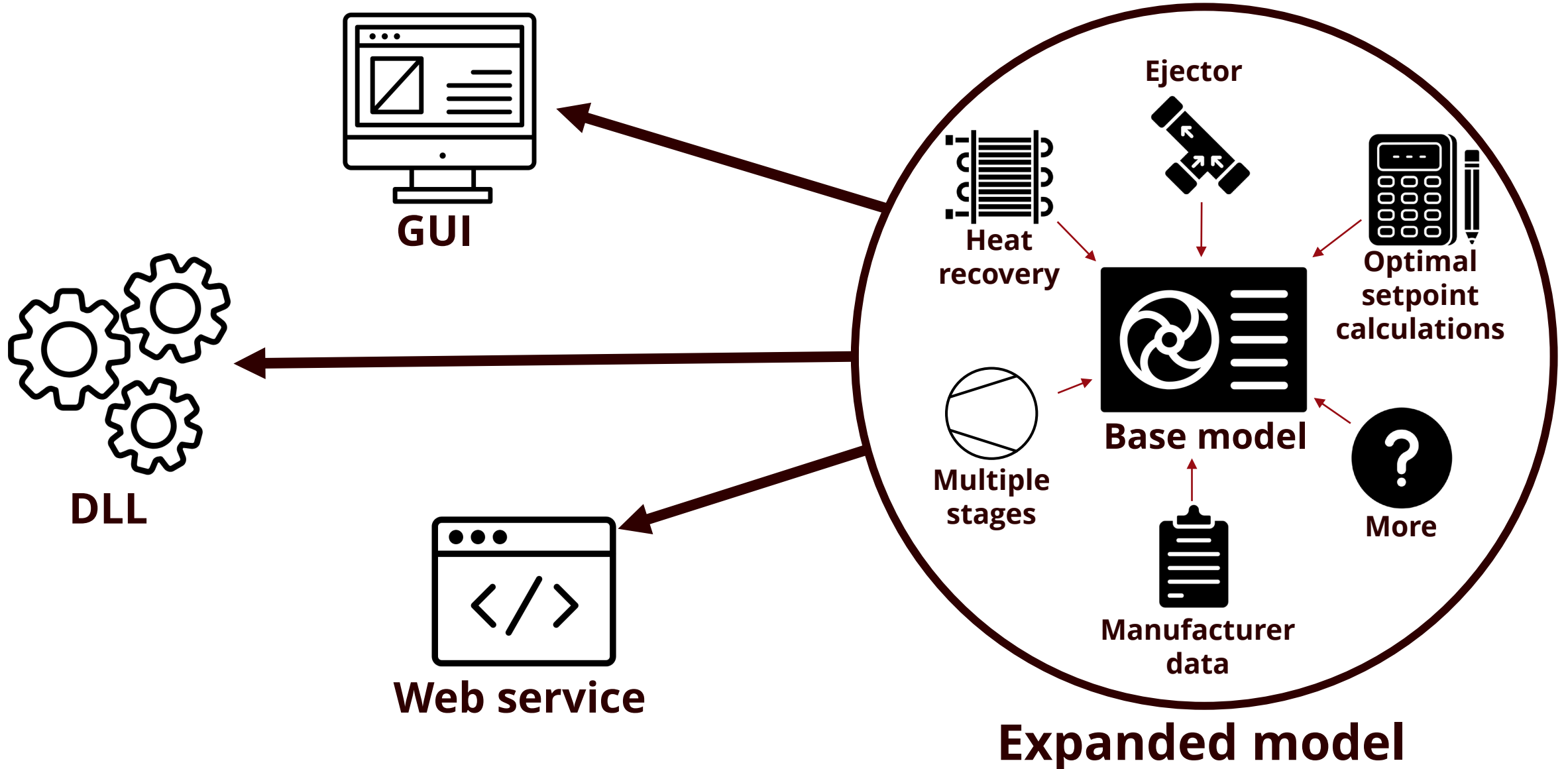
What is it?

- Model can be expanded with advanced features
- Examples
 - Heat recovery
 - Internal heat exchangers
 - HP/LP ejectors
 - Multiple suction stages
 - Integrate external calculation software from component manufacturers (compressors, heat exchangers, ejectors)
 - Calculation of optimal gascooler and receiver pressure setpoints

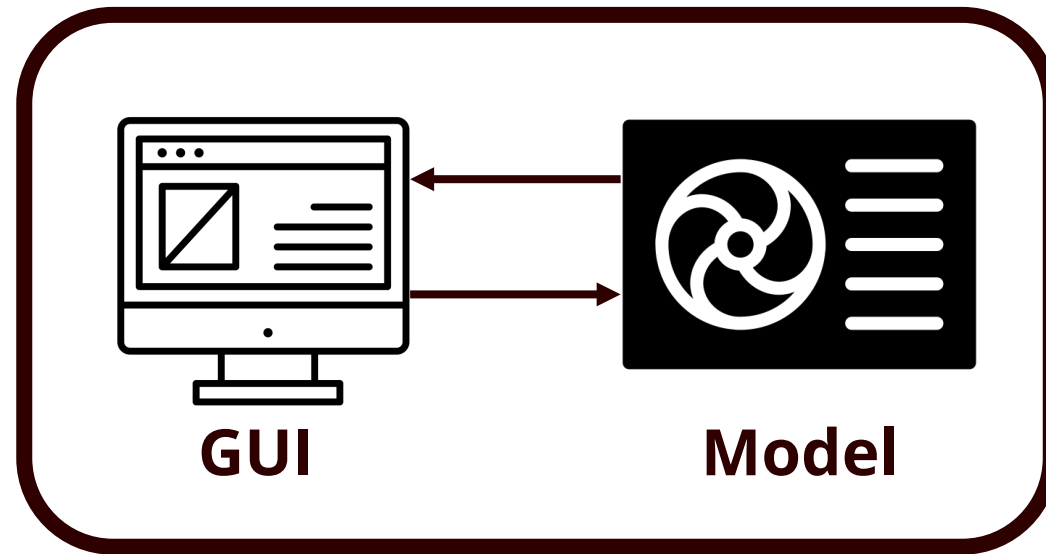


Expanded model

What is it?



Implementations – Custom UI



GUI

Model

C# desktop application

Implementations – Custom UI

- Can be tailored to exactly what is needed
- Includes
 - Report generation
 - Integration with an external system
 - Seasonal calculation
 - Safety valve(s) selection
- Could be extended into a true selection tool

The screenshot displays a software interface for plant design, divided into two main sections: a configuration panel on the left and a process flow diagram on the right.

Configuration Panel (Left):

- File Options:** Plant Design, Details.
- Job Information:** Job name, Client name, Rack Size (7+2x0), Project ID, Country, Sales engineer, File name.
- Calculation Settings:** CALCULATE (F2), MT Suction Groups (1), LT Suction Groups (0), IT Suction Groups (1), dP suction (0.5 bara), High Pressure Side, Gascooler outlet temp. (37.2 °C), Gascooler pressure (105.6 bara), Receiver pressure (35.8 bara), Min. delta P (7.0 bara), Max pressure (63.0 bara).
- Performance Metrics:** Cooling Capacity (1375.8 kW), Power consumption (795.6 kW), COPcool (1.73), COPheat (2.70), Voltage (400V / 50Hz), Current draw (1355.2 A / 1365.2 A), FLA (1908.0 A / 1918.0 A).
- Heat Recovery & Subcooling:** Heat Recovery in common discharge (checked), Capacity rate (100%), Capacity (2149.7 kW), Fluid inlet (36.0 °C), Temp Diff (7.3 Δ°C), Fluid outlet (70.0 °C), PinchPoint (1.5 Δ°C), dT approach (3.0 Δ°C), Heatloss (1%), Subcooling GC return (unchecked), CO2 outlet subcooler (30.0 °C), Subcooler capacity (0 kW).
- MT1 Configuration:** Fixed Cooling Capacity (unchecked), Evaporating temperature (-16.0 °C), Superheat Evaporator (5.0 Δ°C), Superheat Suction line (0.0 Δ°C), Suction to liquid heatexchanger (checked), Efficiency (15%), Temp.MT1 discharge (140.0 °C), Gasbypass to RecCool (60%).
- Compressor Selection:** Brand: Bitzer, Qe Nominal (124.0 kW), FLA (212.0 A), Cooling Capacity (1375.8 kW), Power consumption (581.8 kW), Current draw (991.8 A), COP (1.73).

Process Flow Diagram (Right):

- Components:** Gascooler (0.0 kW, 105.6 bara), IT compressor (151.3 m³/h, 1%, P=213.7 kW), Receiver (35.8 bara), Ejector (0.186 kg/s, 172%), MT compressor (485.8 m³/h, 0%, P=551.8 kW), MT evaporator (1.375 kW, -16.0 °C, 22.2 bara).
- Flow Data:** Mass flow rates (kg/s) and temperatures (°C) are shown at various points in the system, such as 8.300 kg/s at 137.7 °C and 37.2 °C, and 5.535 kg/s at 140.0 °C.
- Legend:** Warnings, YearCalc, Safety Valves, Heat Recovery Diagram.

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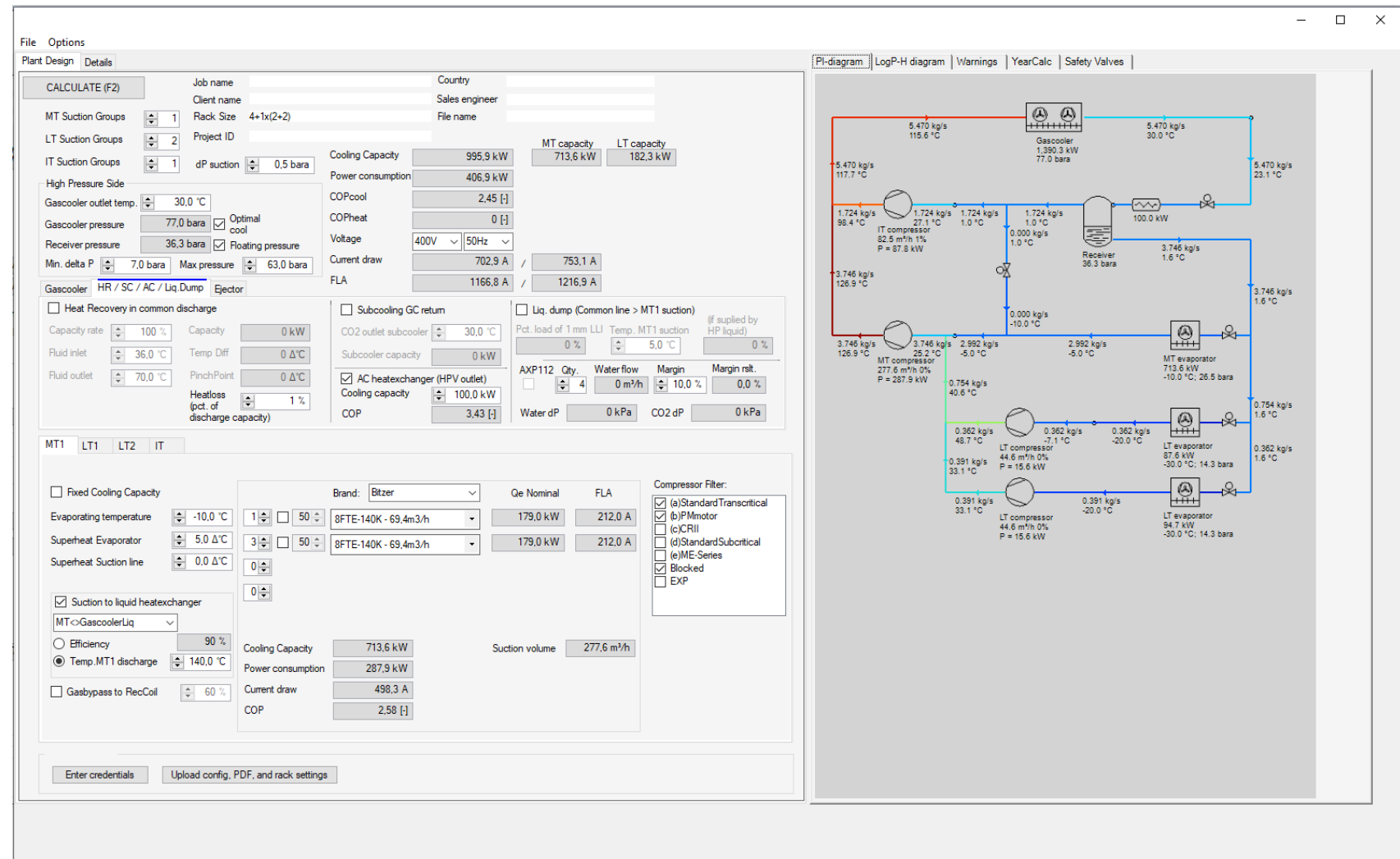
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The screenshot displays a software interface for plant design details, divided into several sections:

- File Options:** Includes tabs for Plant Design and Details.
- Job Information:** Fields for Job name, Client name, Rack Size (7+2x0), Project ID, Country, Sales engineer, and File name.
- Calculation Parameters:** Includes a 'CALCULATE (F2)' button, MT Suction Groups (1), LT Suction Groups (0), IT Suction Groups (1), dP suction (0.5 bara), Cooling Capacity (1375.8 kW), Power consumption (795.6 kW), COPcool (1.73), COPheat (2.70), Voltage (400V/50Hz), Current draw (1355.2 A / 1365.2 A), and FLA (1908.0 A / 1918.0 A).
- High Pressure Side:** Includes Gascooler outlet temp (37.2 °C), Gascooler pressure (105.6 bara), Receiver pressure (35.8 bara), Min. delta P (7.0 bara), and Max pressure (63.0 bara).
- Gascooler Settings:** Includes Heat Recovery in common discharge (checked), Capacity rate (100%), Capacity (2149.7 kW), Fluid inlet (36.0 °C), Temp Diff (7.3 Δ°C), Fluid outlet (70.0 °C), PinchPoint (1.5 Δ°C), dT approach (3.0 Δ°C), and Heatloss (1%).
- Subcooling and Liquefaction:** Includes Subcooling GC return (unchecked), CO2 outlet subcooler (30.0 °C), Subcooler capacity (0 kW), and Liquefaction options (unchecked).
- AC Heat Exchanger:** Includes AC heat exchanger (HPV outlet) (checked), Cooling capacity (0 kW), COP (0.00), and Water flow (54 m³/h).
- Compressor Selection:** A table showing two compressor options (8FTE-140K - 69.4m³/h) with their respective Qe Nominal (124.0 kW) and FLA (212.0 A) values. The 'Compressor Filter' includes options like Standard Transcritical, P/M motor, CR II, Standard Subcritical, ME-Series, Blocked, and EXP.
- MT1 IT Section:** Includes Fixed Cooling Capacity (unchecked), Evaporating temperature (-16.0 °C), Superheat Evaporator (5.0 Δ°C), Superheat Suction line (0.0 Δ°C), Suction to liquid heat exchanger (checked), and Efficiency (15%).
- Summary:** Cooling Capacity (1375.8 kW), Power consumption (581.8 kW), Current draw (991.8 A), COP (1.73), and Suction volume (485.8 m³/h).
- Graph:** A Temperature - [°C] vs Enthalpy - [%] graph showing two curves (blue and red) representing different states or processes.
- Buttons:** 'Enter credentials' and 'Upload config, PDF, and rack settings'.

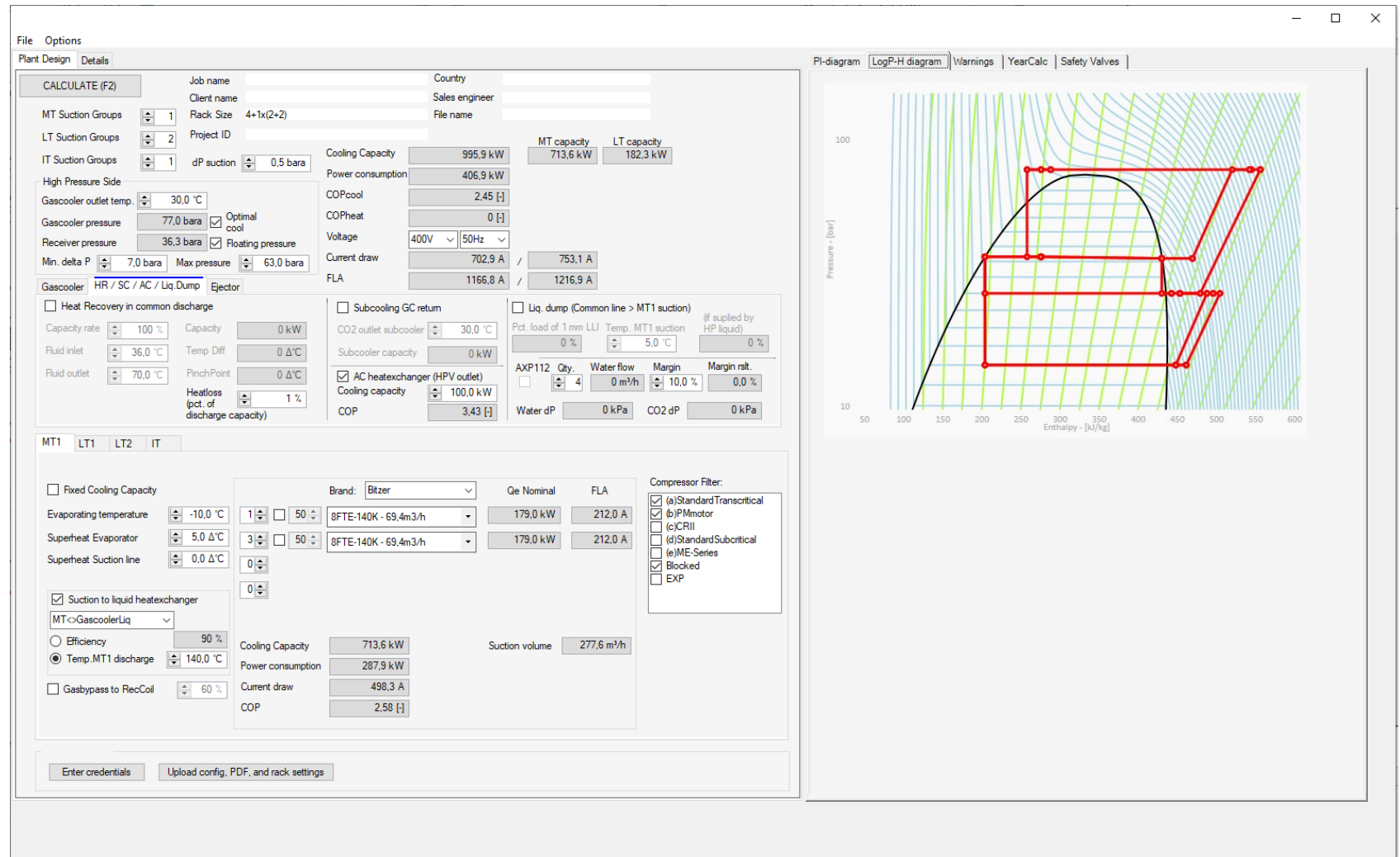
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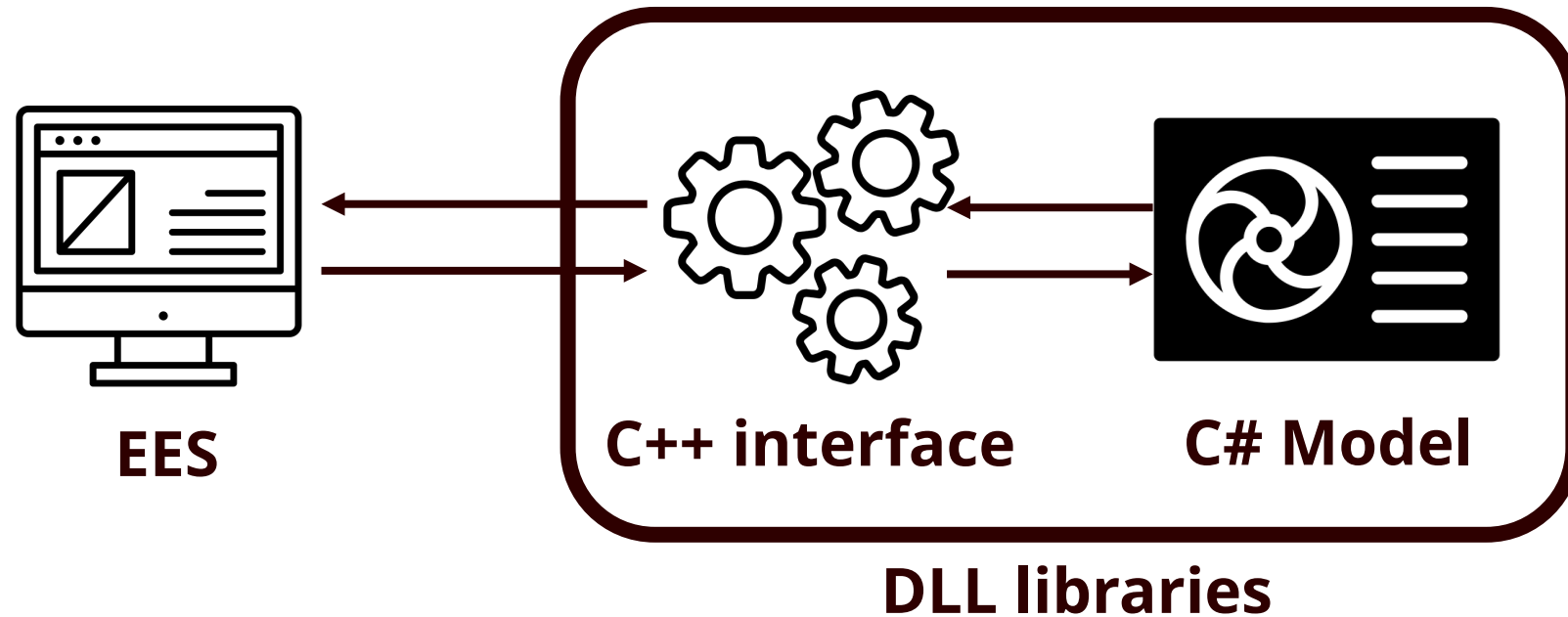


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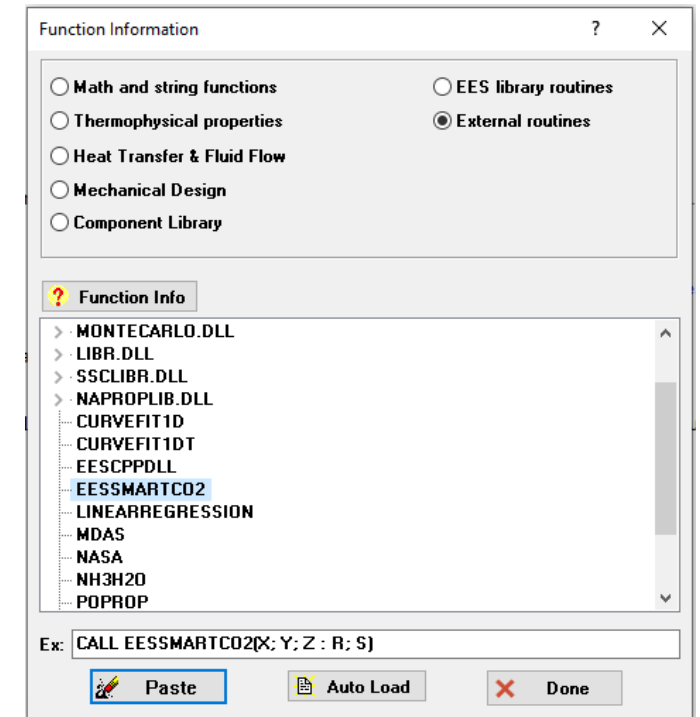
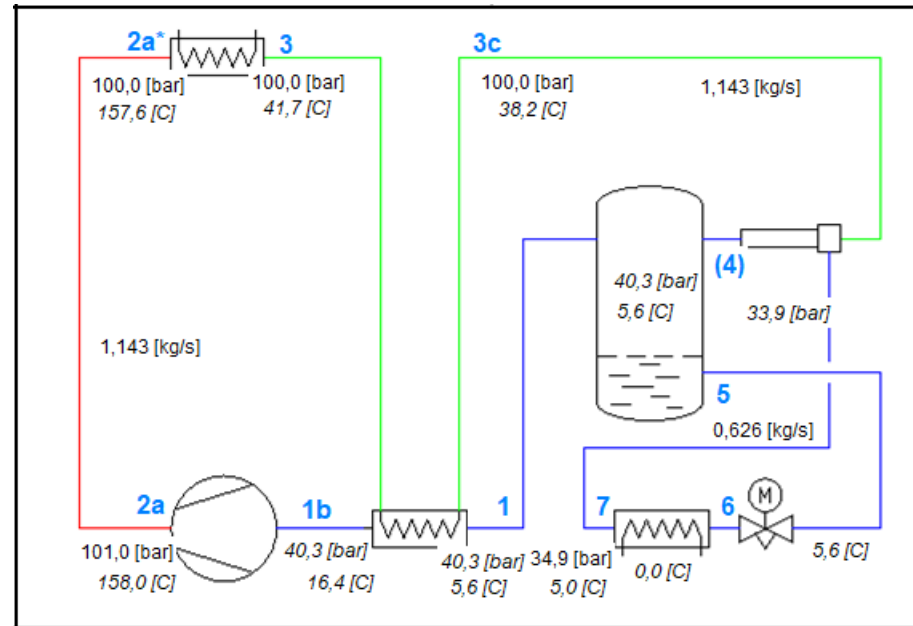


Implementations – EES function

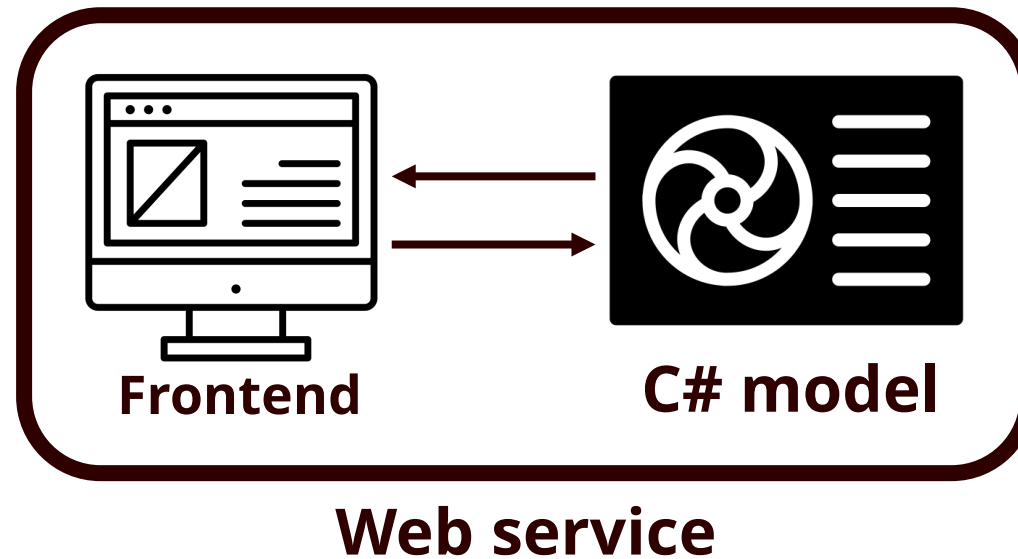


Implementations – EES function

- Callable via EES as an external routine
- Debugging of DLL via EES is possible
- With a similar setup, it is also possible to call the model from other code languages



Implementations - Web service



Implementations – Educational web tool

- Accessed via a browser
- Intuitive graphical user interface suitable for non-experts
- Backend consists of our model



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The screenshot shows a web-based simulation interface. At the top right, there is a 'Menu' button with a hamburger icon. Below it, a navigation bar contains three tabs: 'Aktuel drift' (selected), 'Energiforbrug', and 'Månedlig drift'. The main content area is divided into two sections. On the left, under the heading 'Inputparametre', there is a list of adjustable parameters, each with a slider and a numerical value:

Parameter	Value
Varmepumpens nominelle kapacitet ved 7/35 °C	5 kW
Varmepumpens nominelle vandflow	3 m ³ /h
Udeluftens temperatur	-1 °C
Aktuel varmebehov	7 kW
Fremløbstemperatur	45 °C
Vandflow i procent af Nominel	0 %
Varmetab fra varmpumpens rør til udeluft i % af nominel kapacitet	2 %
Varmetab fra varmpumpens rør til jord i % af nominel kapacitet	2 %
Varmetab fra varmpumpens rør til huset i % af nominel kapacitet	2 %
Beskidt fordampere	0 %
Tilfrosset fordampere	0 %
Kølemiddel mængde	100 %

On the right side of the interface, there is a 3D CAD model of a heat pump unit. A large circular button with a right-pointing arrow and the text 'UDFØR' is positioned in front of the model. The overall design is clean and modern, using a light gray color palette with orange accents for sliders and buttons.

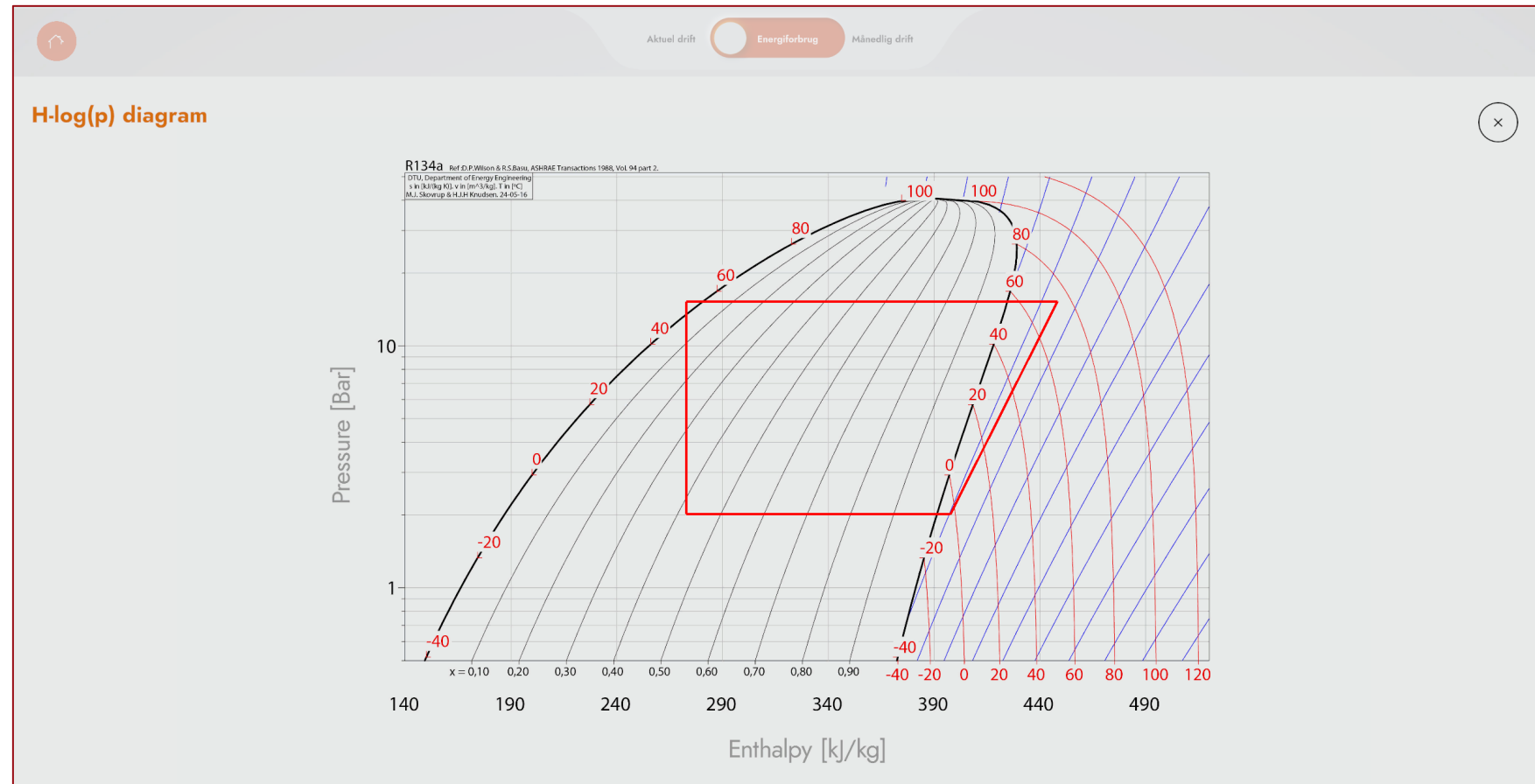
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