Compressor Intercooling and Staging — Report

DOCUMENT

Plant / project	**Example Plant**
Equipment tag / system	**C-101**
Calculation / document no.	**CALC-IC-001**
Revision	**0**
Prepared by	**Your name**
Checked by	**—**
Date	**07-Nov-2026**

Calculation basis

Mixture: Natural gas (typical pipeline) · Polytropic · From temperature limit · Peng–Robinson real-gas states from the PlantCalcKit fluid library; equal pressure ratio in every stage, gas returned to cooling-water inlet + approach after each stage; intercooler pressure loss 2.0 %

Status

✓ Inputs OK · ℹ️ 10 default value(s) in use: intercooler approach, cooling-water temperature rise, pressure loss per intercooler, stage efficiency, mechanical efficiency, highest pressure ratio per stage, operating time, energy price, driver and drive-train efficiency, cooling-water temperature step for the what-if

KEY INPUTS

Input	Unit	Value used
Suction pressure (stage 1 inlet)	bar a	5.000
Suction temperature (stage 1 inlet)	°C	35.0
Final discharge pressure (last stage outlet)	bar a	60.000
Mass flow	kg/h	25,000
Allowable discharge temperature per stage	°C	150.0
Cooling-water inlet temperature	°C	30.0
Intercooler approach (gas out − water in)	K	10.0
Cooling-water temperature rise	K	10.0
Pressure loss per intercooler (% of its inlet pressure)	%	2.0
Stage efficiency (polytropic)	%	80.0
Mechanical efficiency (gas power ÷ shaft power)	%	97.0
Highest pressure ratio per stage (machine limit)	—	4.00
Operating time	h/yr	8,000
Energy price (USD per unit shown)	per MWh	80.00
Driver and drive-train efficiency	%	95.0

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RESULTS — SELECTED DESIGN

Result	Unit	Value
Number of stages	—	3
Overall pressure ratio (final ÷ suction, absolute)	—	12.000
Pressure ratio per stage (equal)	—	2.320
Highest stage discharge temperature	°C	119.0
Mass flow	kg/h	25,000
Compressibility Z at suction	—	0.9884
Density at suction	kg/m³	3.533
Gas power, all stages	kW	3,453
Shaft power (gas power ÷ mechanical efficiency)	kW	3,560
Specific energy per standard volume (shaft)	kWh/1000 Sm³	108.07
Single-stage gas power for the same duty	kW	4,211
Power saved by intercooling vs single stage	kW	758
Power saved, % of single-stage power	%	18.0
Isothermal efficiency	%	68.1
Total intercooler duty	kW	2,404
Total cooling-water flow	m³/h	208.1
Annual energy saved at the driver	MWh/yr	6,580
Annual value of the energy saved	USD/yr	526,366

NUMBER OF STAGES — COMPARISON

Item	Unit	1 stage	2 stages	3 stages	4 stages	5 stages	6 stages
Pressure ratio per stage	—	12.000	3.499	2.320	1.890	1.671	1.539
Highest stage discharge temperature	°C	282.2	159.8	119.0	99.0	87.2	79.5
Gas power, all stages	kW	4,211	3,628	3,453	3,378	3,343	3,329
Shaft power	kW	4,341	3,741	3,560	3,483	3,447	3,431
Power saved vs one stage	kW	0	582	758	833	867	882
Power saved vs one stage	%	0.0	13.8	18.0	19.8	20.6	20.9
Total intercooler duty	kW	0	1,836	2,404	2,683	2,856	2,977
Total cooling-water flow	m³/h	0.0	159.0	208.1	232.2	247.2	257.7
Meets both limits?		⚠ too hot	⚠ too hot	✓ yes	✓ yes	✓ yes	✓ yes

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STAGE BY STAGE

Item	Unit	Stage 1	Stage 2	Stage 3
Suction pressure	bar a	5.000	11.370	25.857
Discharge pressure	bar a	11.602	26.384	60.000
Pressure ratio	—	2.320	2.320	2.320
Suction temperature	°C	35.0	40.0	40.0
Discharge temperature	°C	111.5	117.8	119.0
Margin to the allowable discharge temperature	K	38.5	32.2	31.0
Gas power of the stage	kW	1,159	1,162	1,131
Specific work (enthalpy rise)	kJ/kg	166.9	167.4	162.9
Intercooler gas outlet temperature	°C	40.0	40.0	
Intercooler duty (after the stage)	kW	1,132	1,272	
Cooling-water flow	m³/h	98.0	110.1	
Hot-end difference (gas in − water out)	K	71.5	77.8	
Log-mean temperature difference	K	31.3	33.1	
Required UA of the intercooler	kW/K	36.20	38.48	

WHAT-IF — COOLING-WATER INLET TEMPERATURE

Case	Step	Water inlet	Cooler gas outlet	Gas power	Change	Change, %	Annual cost change
Cooling water -10.0 K	-10.0	20.0	30.0	**3,379**	-73	-2.1	-50,875
Cooling water -5.0 K	-5.0	25.0	35.0	**3,416**	-37	-1.1	-25,437
Now (base case)	0.0	30.0	40.0	**3,453**	0	0.0	0
Cooling water +5.0 K	+5.0	35.0	45.0	**3,489**	+37	+1.1	+25,437
Cooling water +10.0 K	+10.0	40.0	50.0	**3,526**	+73	+2.1	+50,875

FINDINGS AND RECOMMENDATIONS

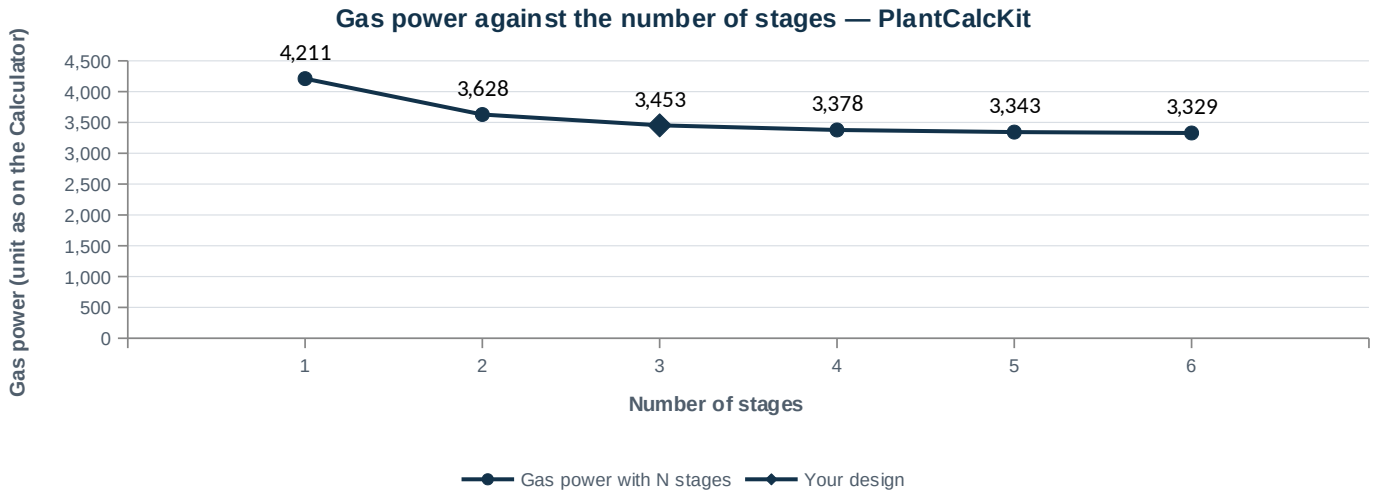
◆ **Opportunity**

Intercooling saves 758 kW (18.0 %) against one stage, about 6,580 MWh a year at the driver, worth 526,366 a year at the price entered; it needs 208 m³/h of cooling water.

ℹ️ **Note**

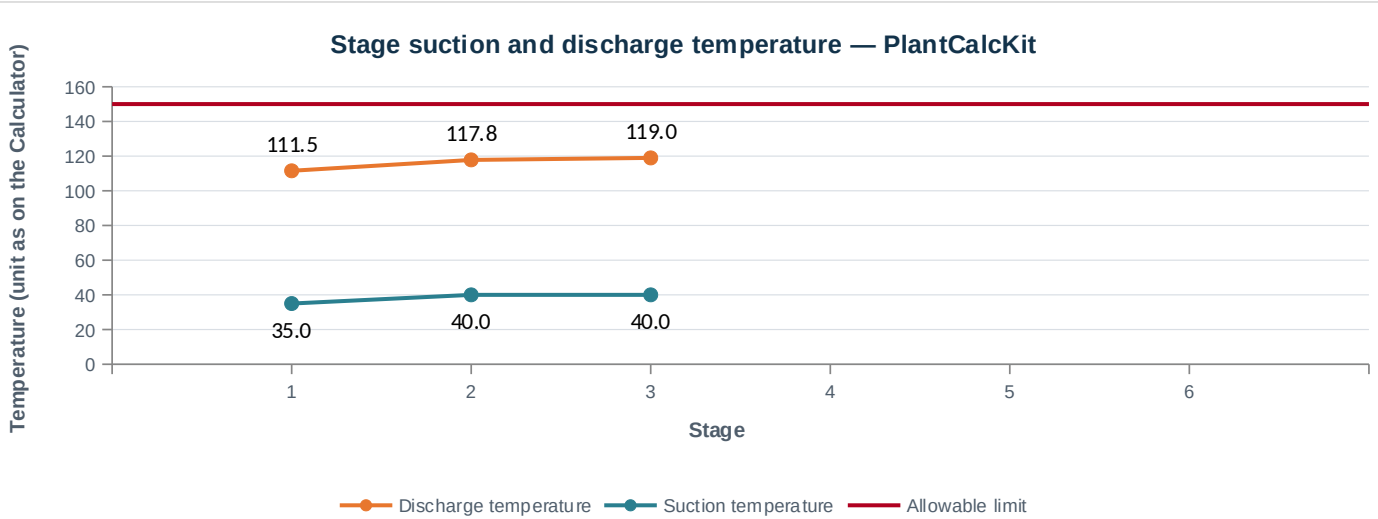
One more stage would change the gas power by 75 kW (2.2 %) and add an intercooler: diminishing returns.

CHARTS



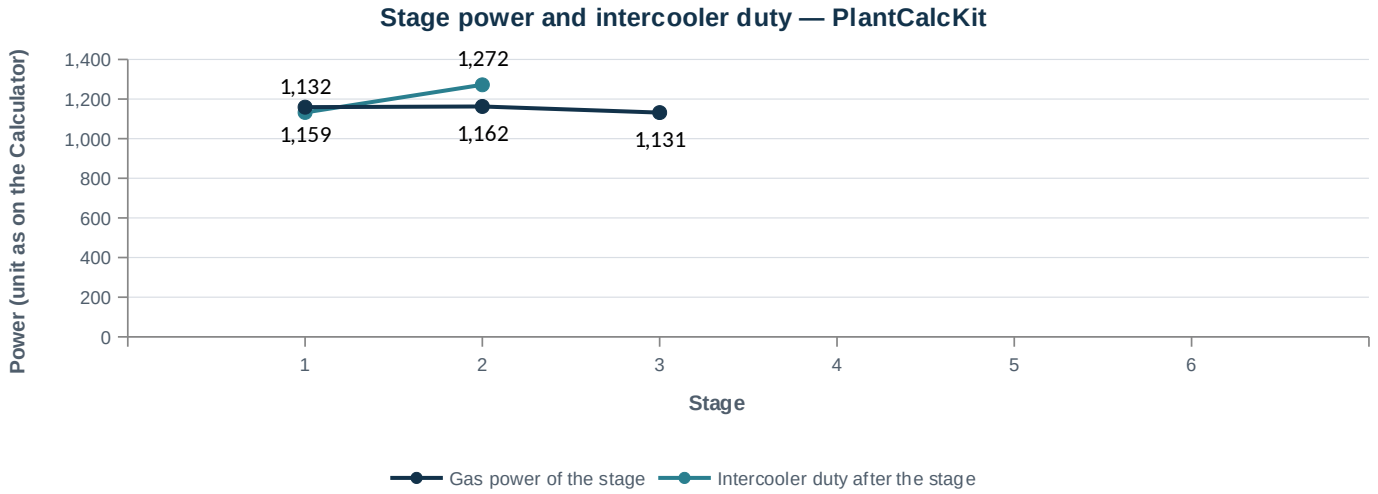
Observations — power against stages

[Write your observations here]



Observations — temperatures

[Write your observations here]



Observations — stage loads

[Write your observations here]

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