Thermoflex Online

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Bram Kroon

Introduction

- Name Bram Kroon
- Company: Engie
- Department: Energie Nederland (Generation)
- Location Eems & Lelystad Power Plant
- Position: Process Engineer
- Thermoflex Eight Years of experience in Modelling (CCGT and coal fired)

< - Eems:
CCGT 5 x 360 MW

Maxima: ->
CCGT 2 x 440 MW

CONTENTS

The Challenge

- The spark spreads for CCGT’s are small and under pressure
- Actual performance needs to be as close as possible to optimal performance
- Availability needs to be high
- Small deviations in operational data can be an indicator for developing faults
- But the optimal performance of a CCGT is not a fixed number it depends on
  - Load
  - Ambient air temperature
  - Ambient air pressure
  - Cooling water temperature
  - Gas quality
  - Etc.

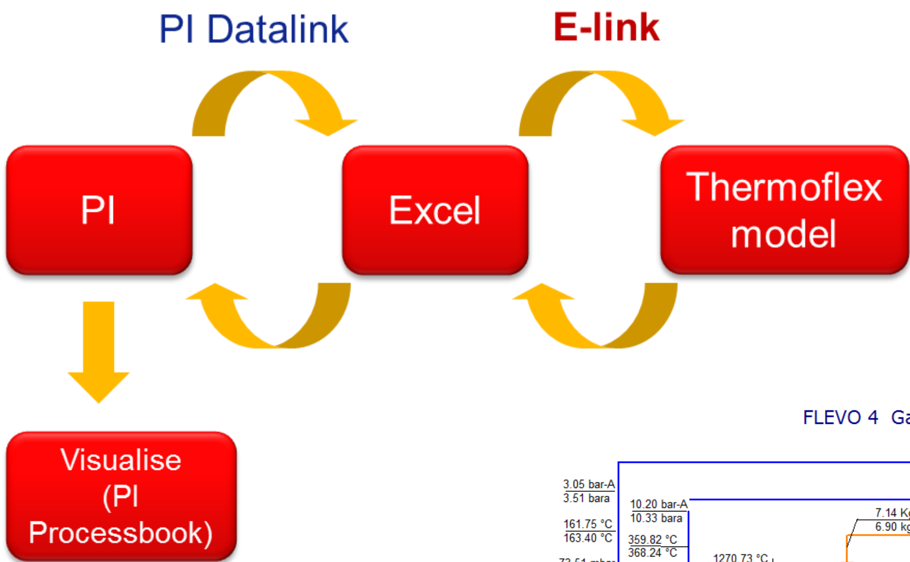
The challenge is how to accurate and reliable monitor the performance

Our solution

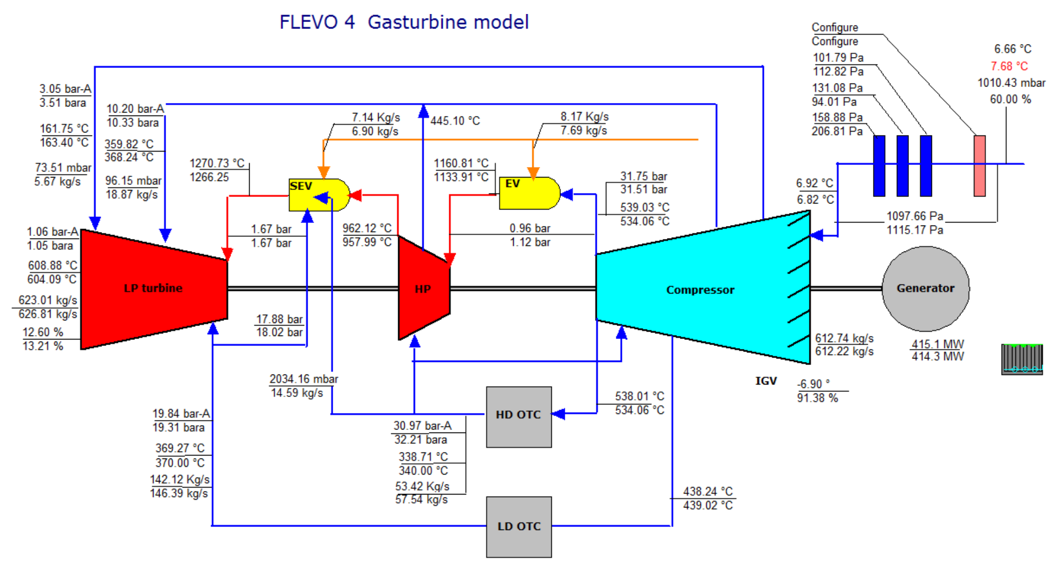
- Use a thermodynamic model that takes all the variables into account
- Make real-time calculations with on-line data
- Model calculated data are written to PI
- Compare the actual measurements with the model calculated results
- Use trends to see the behavior in time more clearly

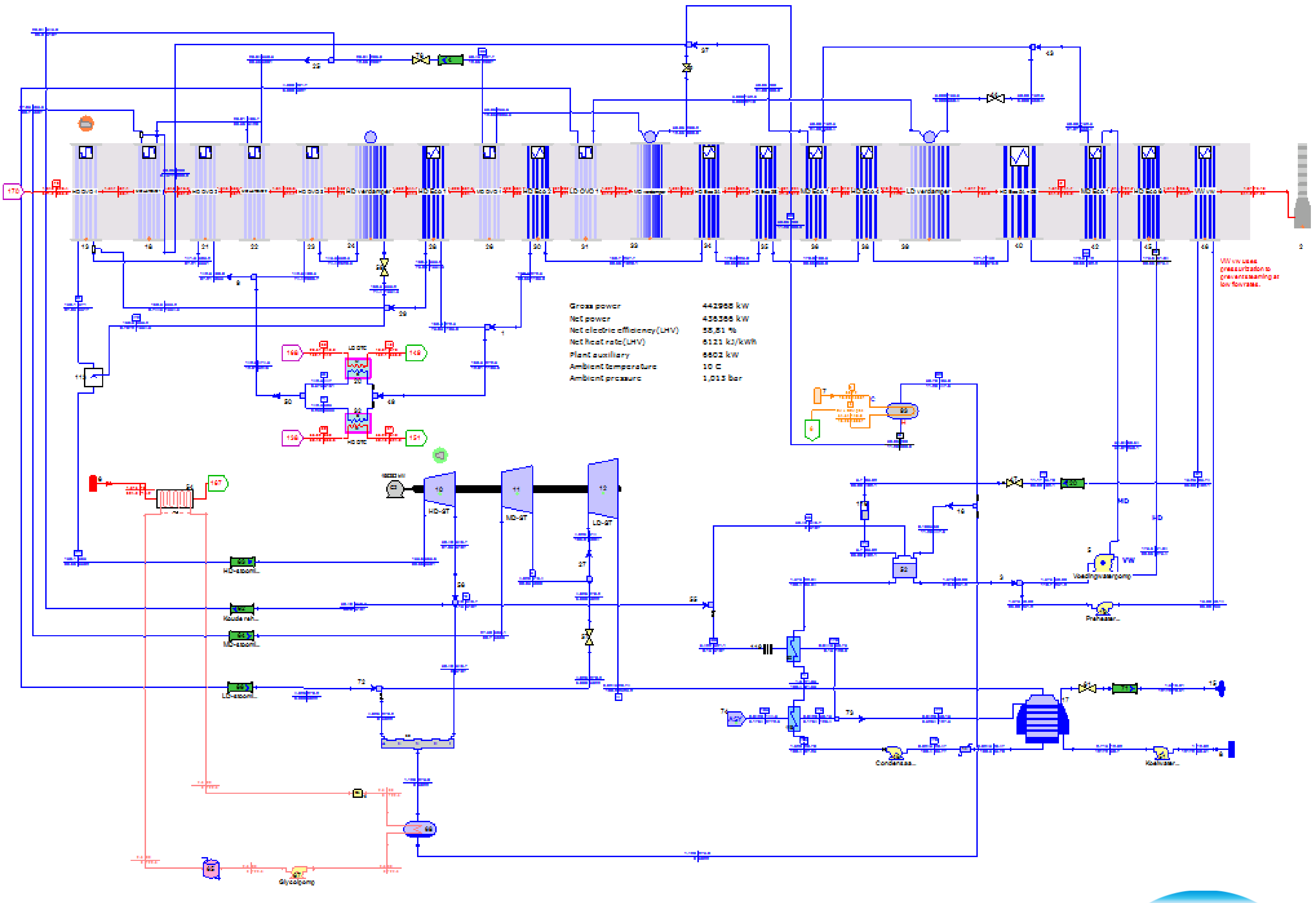
- Advantages:
  - Fuel savings due to early alarming when small performance deviations are detected;
  - Prevent (big) damages by being able to see that a component stays within its operating window

Technology used



- Thermoflex (modeling software)
- PI (Process database)
- Excel and VBA (Data exchange between Thermoflex and PI
- PI processbook (Visualisation)

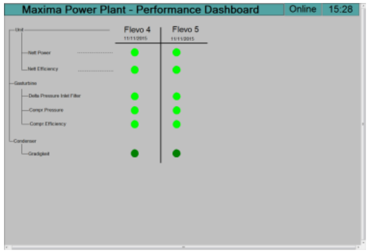




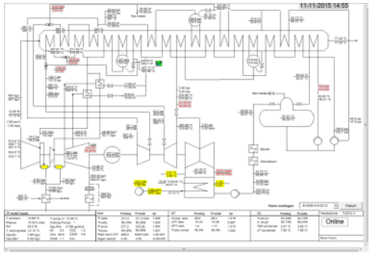
Gross power 442988 kW
Net power 436386 kW
Net electric efficiency(LHV) 58,81 %
Net heat rate(LHV) 6121 kJ/kWh
Plant auxiliary 6602 kW
Ambient temperature 10 C
Ambient pressure 1,013 bar
HD-ST
MD-ST
LD-ST
Voedingswaterpomp
Glycolpomp

Output of the tool (PI Processbook)

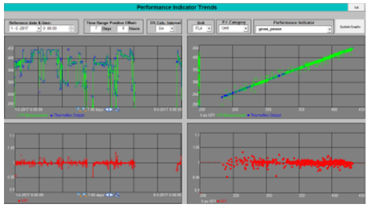
- Dashboard (operators)
  - Most important indicators
  - Alarm when deviation reality/model too high



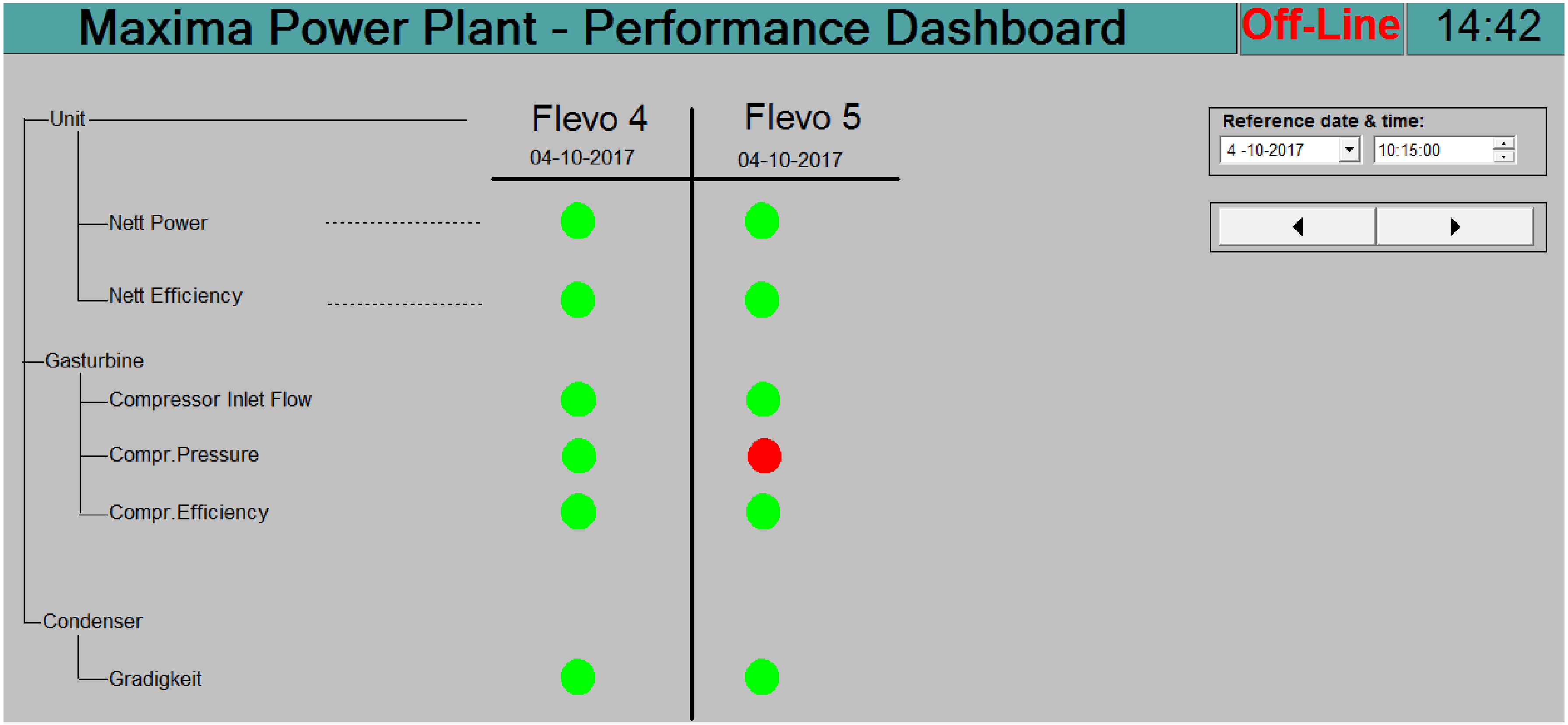
- Heat Balance sheet (process specialist on site)
  - Compare flow, temperature, pressure model and real measurement
  - Alarm when deviation too high



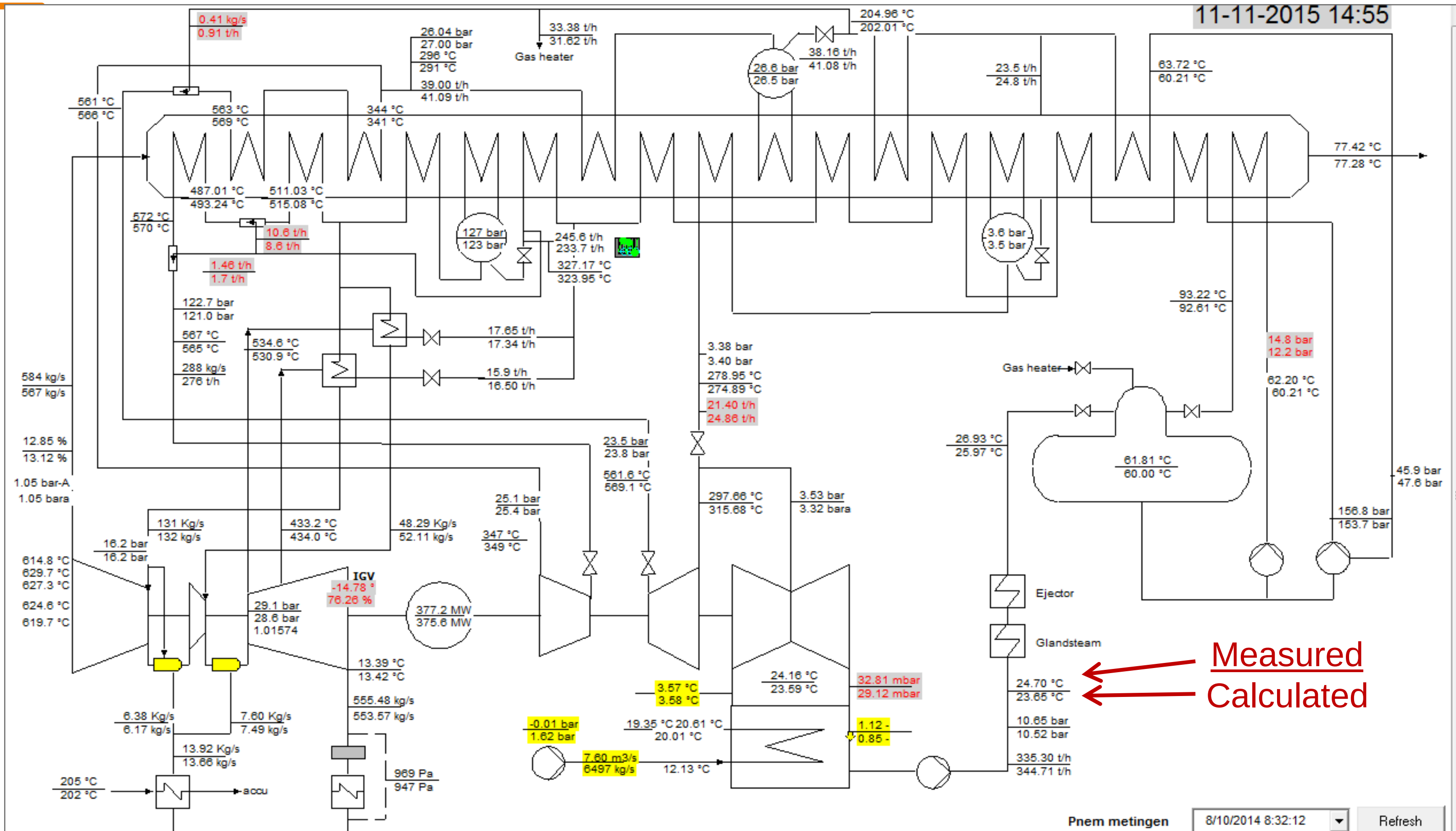
- Trends (process specialist on site / Thermodynamic Expert)
  - Compare measurements, performance indicator over time
  - Analytic tool



High level view: dashboard (Main user: operator)



Second level view: Heat balance sheet, with alarms (Main user: Process responsible on site, thermodynamic expert)



TF model inputs					
T ambiant	13.66 °C	T-compr.in	13.39 °C		
Presure	1019.2 mbar	Cooling Pumps	1		
RH	82.0 %	Gas Rho	0.798 kg/Nm3		
T coolingwater	12.13 °C	N2	2.0	CO2	1.2
Gas EV	7.60 Kg/s	CH4	90.6	C2H6	4.6
Gas SEV	6.38 Kg/s	C3H8	1.1	C4+	

Unit	PI meting	TF model	kpi
P netto	371.0	371.0 MW	1.000
η netto	58.43%	58.28%	1.003
P bruto	377.2	375.58	1.004
η bruto	59.40%	58.99%	1.007
Heat input LHV	635.0	636.6 MW	1.00 MW
Eigen bedrijf	4.49	4.58	-0.09 MW

GT	PI meting	TF model	kpi
Compr. ratio	29.8	29.4	1.016
LPT ratio	15.43	15.49	0.997
HPT ratio	1.8	1.77	1.015
η poly compr.	92.2%	92.2%	1.000

CC	PI meting	TF model
η HP-ST	84.34%	84.13%
η IP-ST	92.73%	92.04%
TDD condenser	3.57 °C	3.58 °C
dT condenser	7.85 °C	7.89 °C

Heatbalance FLEVO 4

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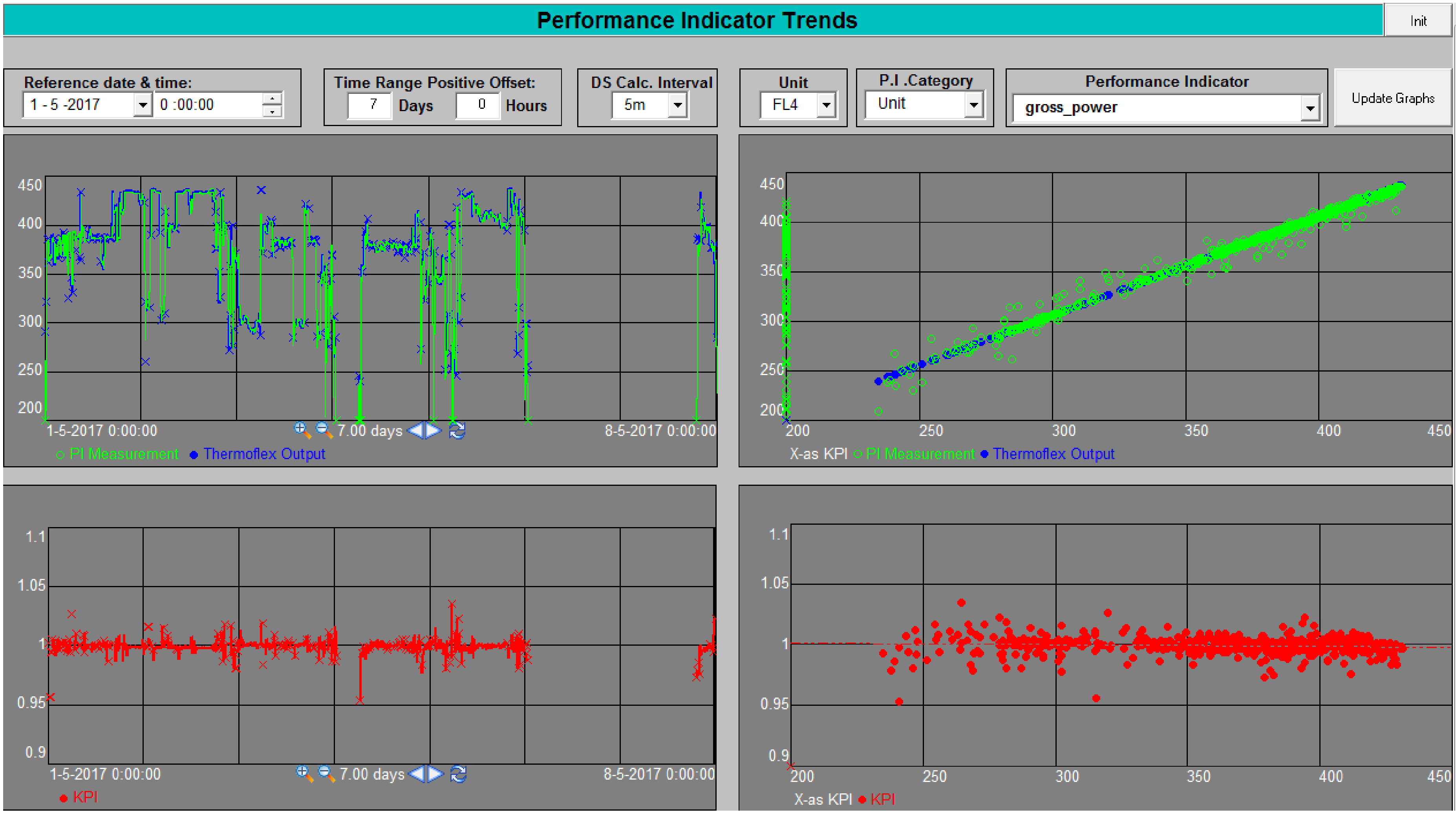
Third level: trends (Main user: thermodynamic expert from EOS, process specialist from site)



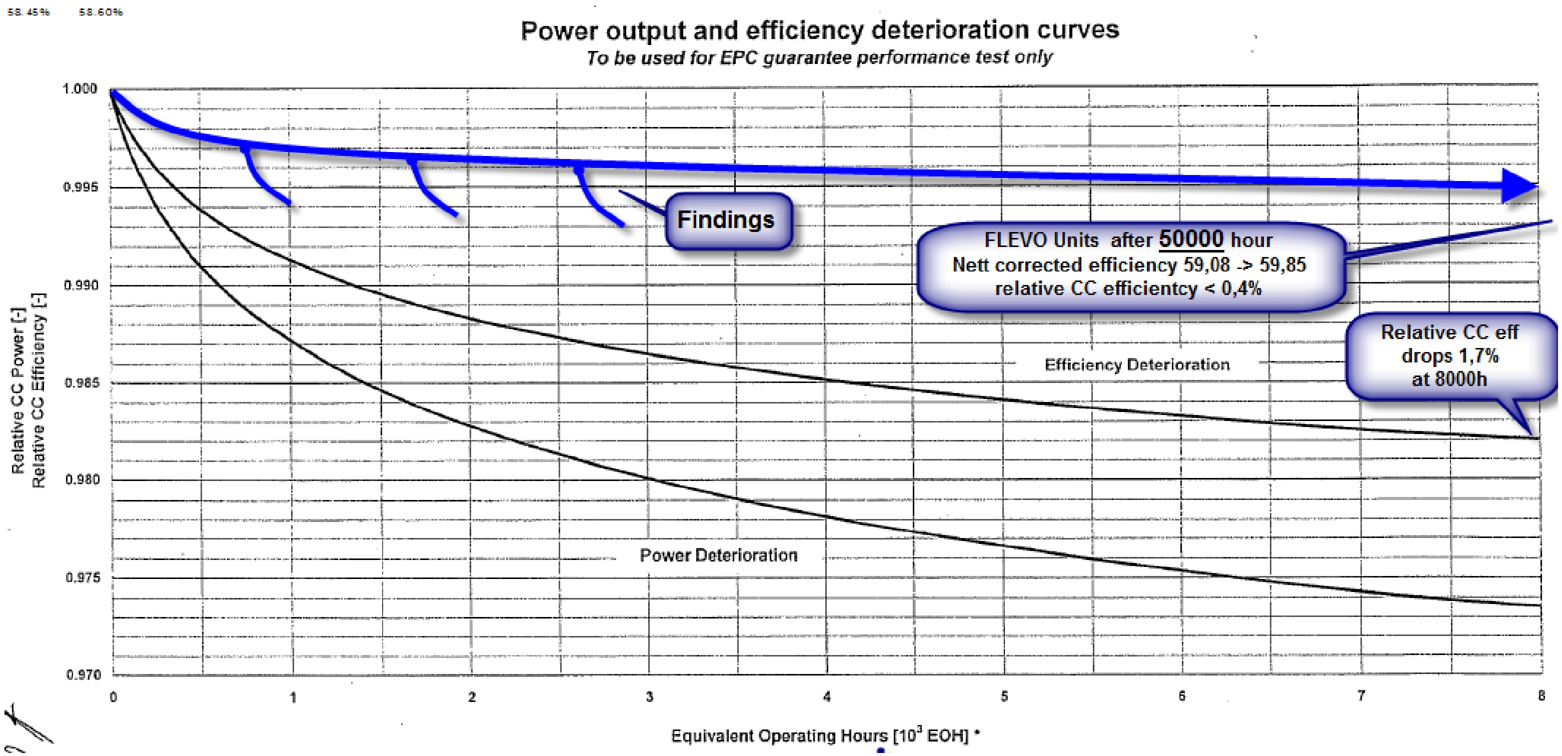
Benefits of Thermodynamic Model (Off-line)

- Knowledge building during model development and discovering faults
  - Measuring failures: Wrong: ranges, calibrations, Pgauge → Pabs, Gas properties, ect.
  - Make real correction curves (ambient T,P,rel%,Tcoolw,LHV, C/H, etc.), (non commercial) It's necessary to know the exact heatrate
  - Findings: Steam temperatures in part load were higher then design temperatures. (creep)
- What if studies
  - Minimum load studies and testing: Pmin 280MW → 110 MW
  - Increase efficiency: Using: inlet air heating , flex load-path, max IGV
  - Reduce home-load: Optimize condenser cooling water flow. Reduce feedwater pressure setpoint.
  - Gas-preheating and building-heating on stack-loss basic design.
  - Basic design study for new desuperheater. (Challenging design of OEM)
  - Optimize control-loops: Developing Energie-balance Feed Forward signals
  - Solving LP-drum-Level instabilities: Increasing minimum pressure IP steam.

Benefits of Thermodynamic Model (On-line)

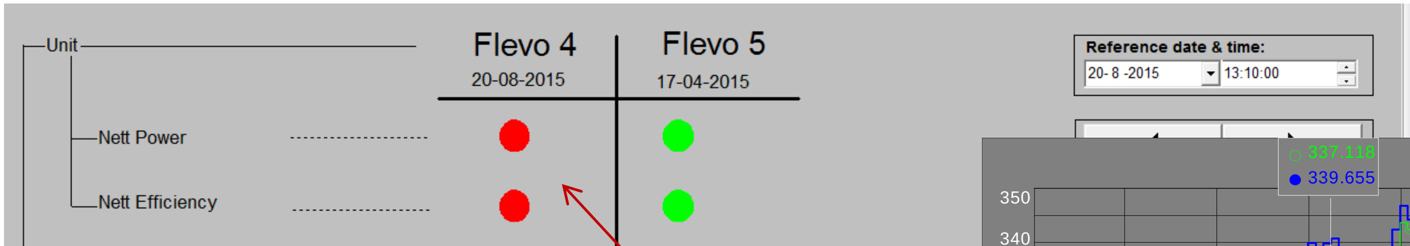
- Detections of small deviations between model and real power plant
  - Drifting measurements, fouling, leakages, performance deviations, parameters changes etc..
  - Examples of found deviations:
    - Lower TIT temperatures after C inspection (retuned by the OEM);
    - Influence of gas composition change on performance;
    - Condenser air in-leakage and condenser fouling;
    - Leaking of a desuperheater attemporation-valve;
    - Leaking draining-valves
    - fouling of compressor and inlet filters;
- On-line saved model data can be used in RCA's
  - to find and analyze deviations afterwards.;
  - or change operations or maintenance instructions.

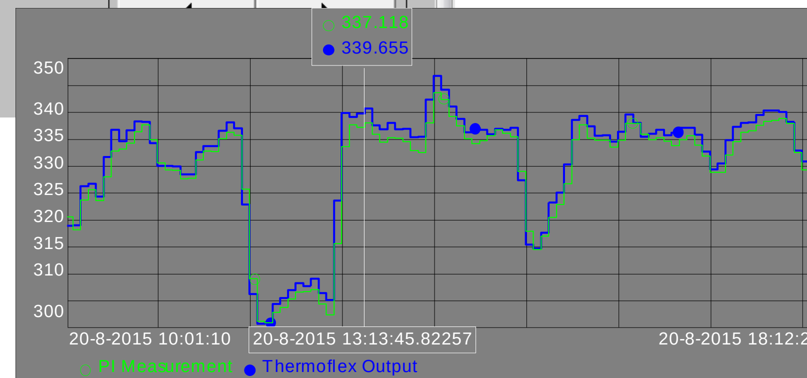
Thermoflex (online) helps to maximize the performance



- The Flevo's drops less then 0,4% in relative efficiency after 50000 EOH
  - According OEM the Relative Efficiency drops 1,7% after 8000 EOH. {not realistic??}
- Full savings since commissioning up to 9M€ (partly contributed by Thermoflex Model)
  - 1,3 % x (50000–8000)hr x ~380MW x ~6100MJ/MWh x ~7€/GJ

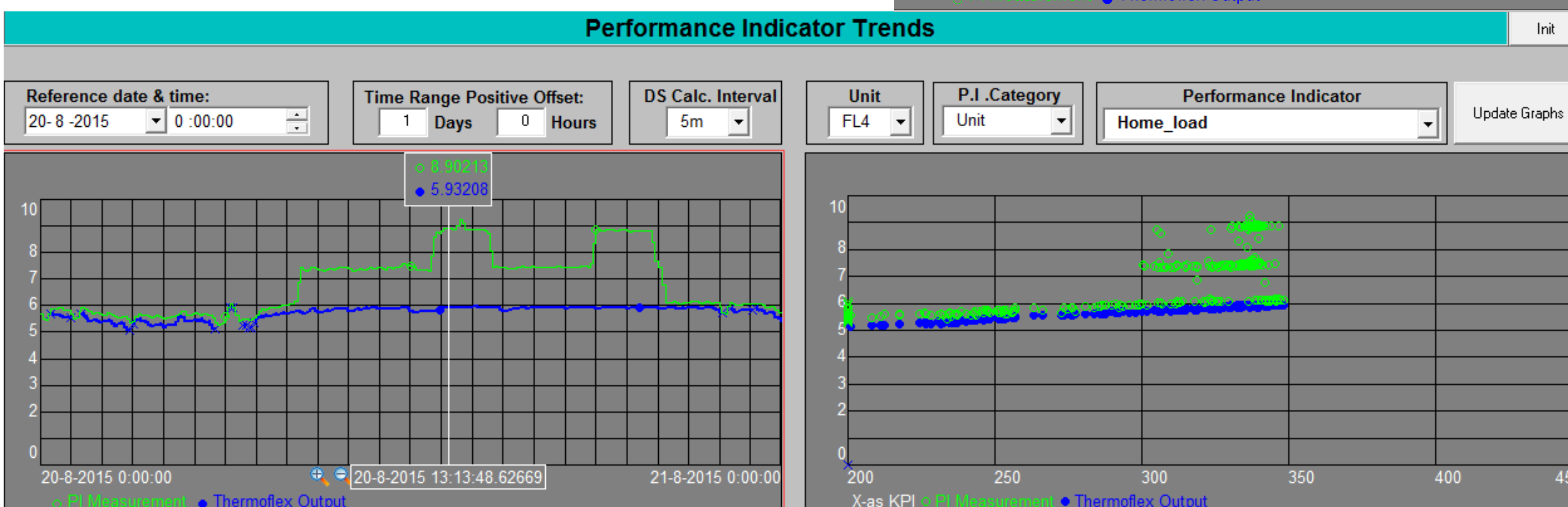
Example of checking errors : Dashboard alarm!! measured power 3MW lower then expect: Increasing home load FL4 -> the model accuracy detects testing coolingwaterpumps FL5





Model accuracy:

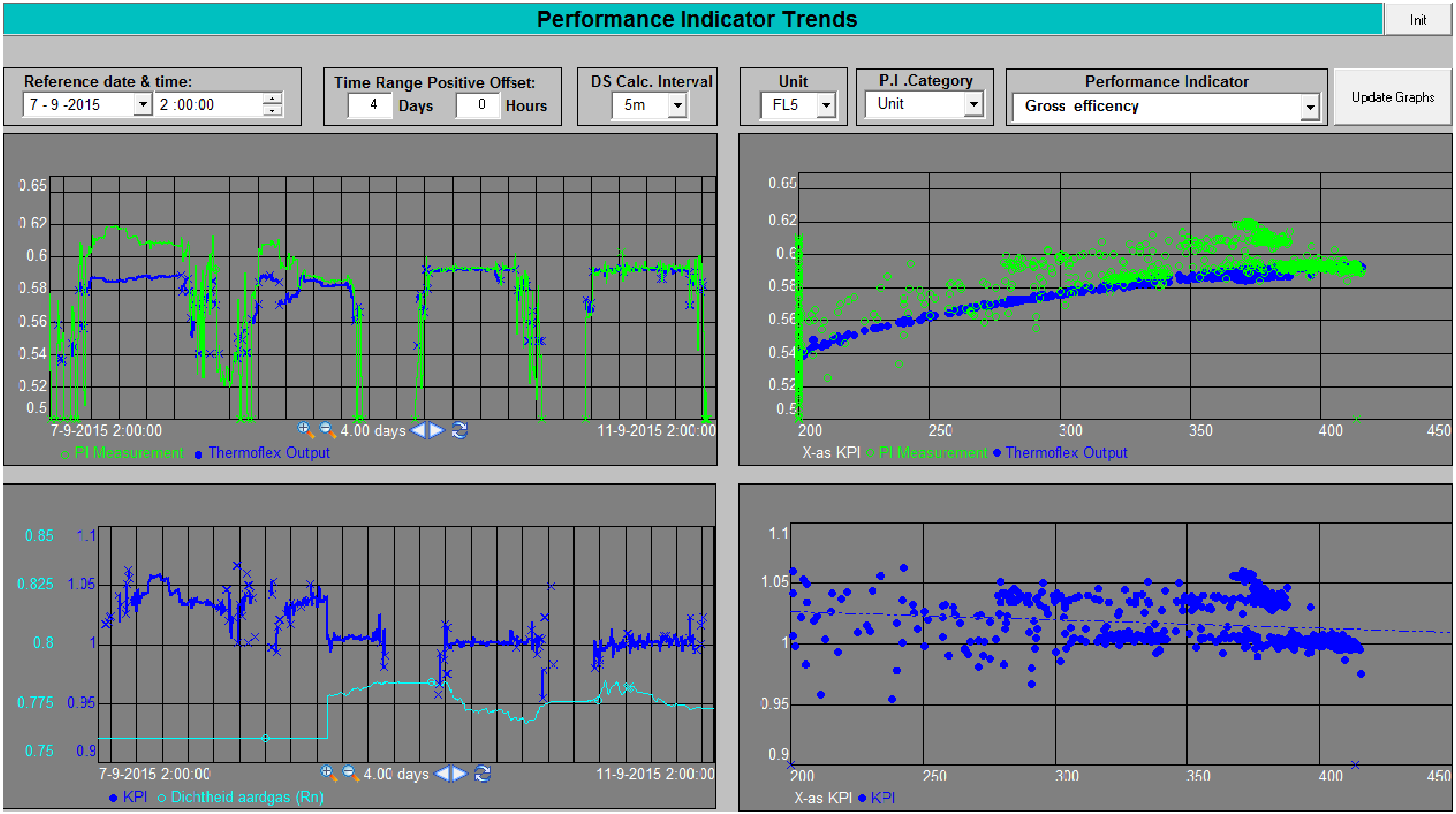
- Load transient (<10MW/min) ± 1,0%
- Stable load ± 0,5%



Example of measurement failure:

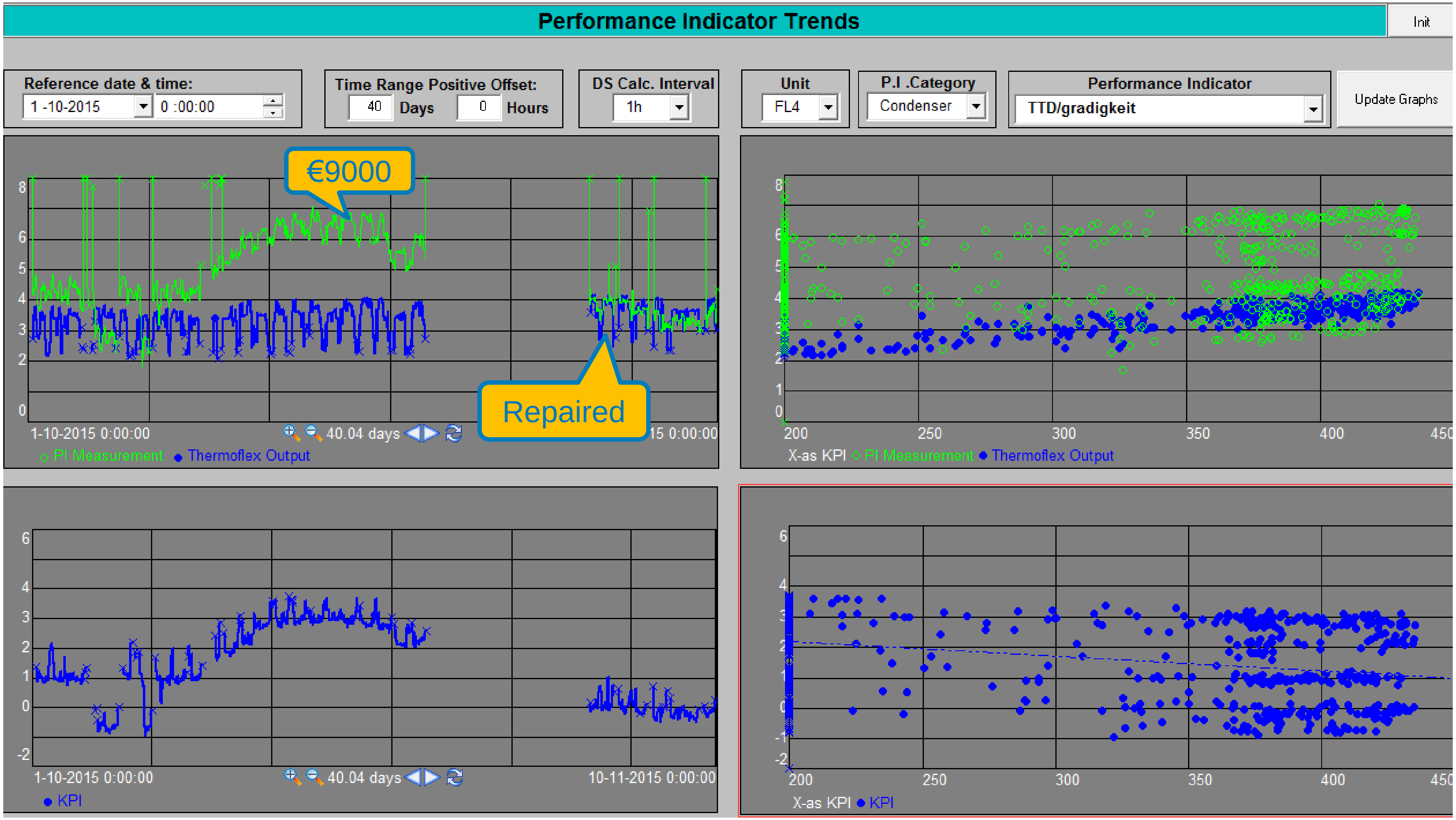
After the mothball period the measured efficiency is too high.

ThermoFlexOnline detected that the gas chromatograph was not working property.



Example of air leaking in condenser :

After condenser repair the Terminal Temperature Difference is back to nominal: dT 3°C -> 1-3MW -> 300000 euro/yr.



Available software

- Steag (software: SR::EPOS;EBSILON). Used mainly on coal fired power plants
- General Physics (software: etaPro).

- Possible Thermoflow (software: thermoflex). They are not active in this market.

- Advantage of combination of PI and Thermoflex / Elink
  - Thermodynamic models of KA26 & GE9FA CCGT's in Thermoflex are available;
  - All Engie power plants have the use op PI Processbook
  - Lot of knowledge of CCGT's in house available also operational experience;
  - Model development costs lower than the market and we keep the knowledge in house

Questions ?

Or if time

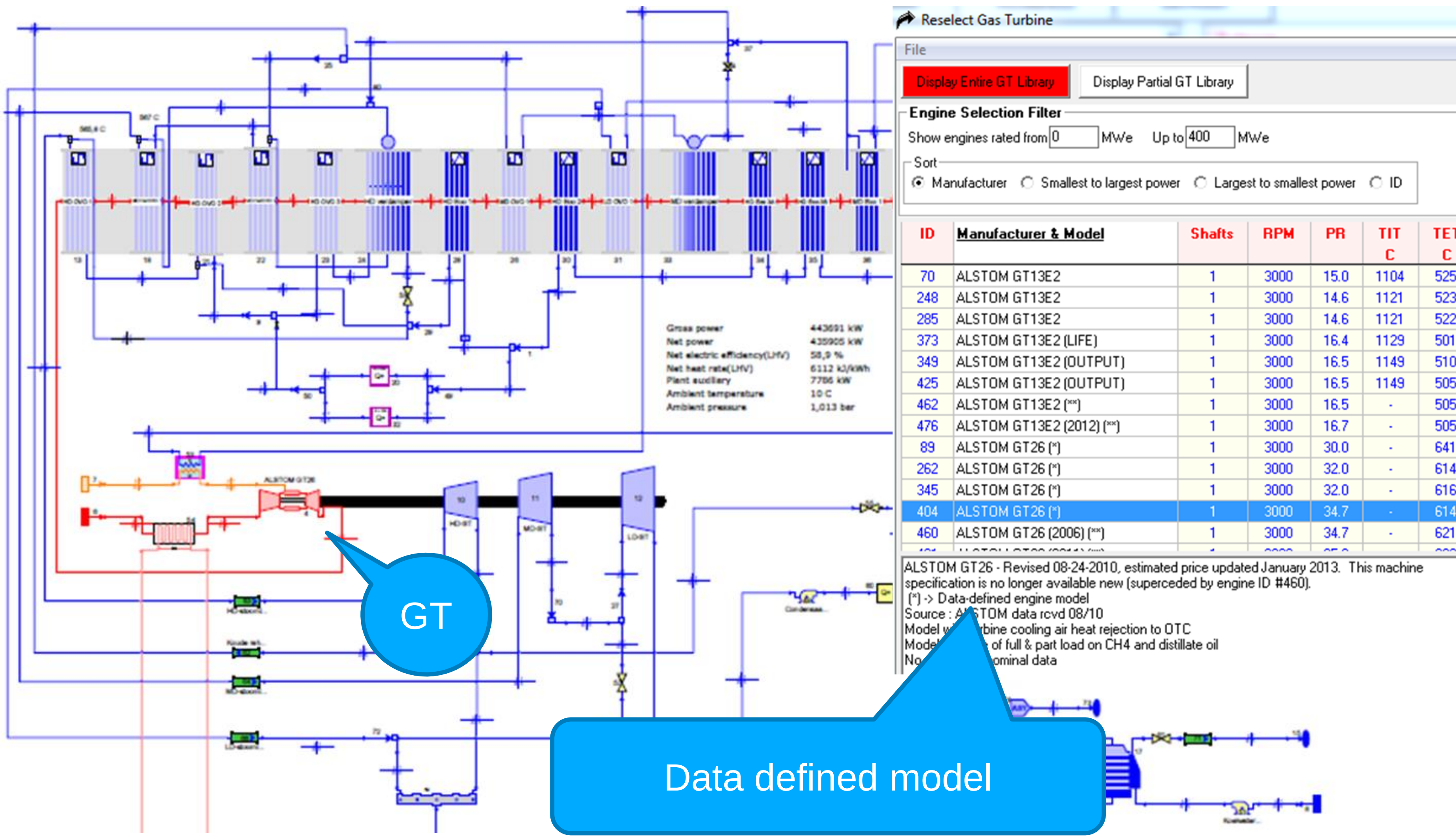
1. Live DEMO

2. ThermoFlex expert subjects

Requirements to build an accurate model

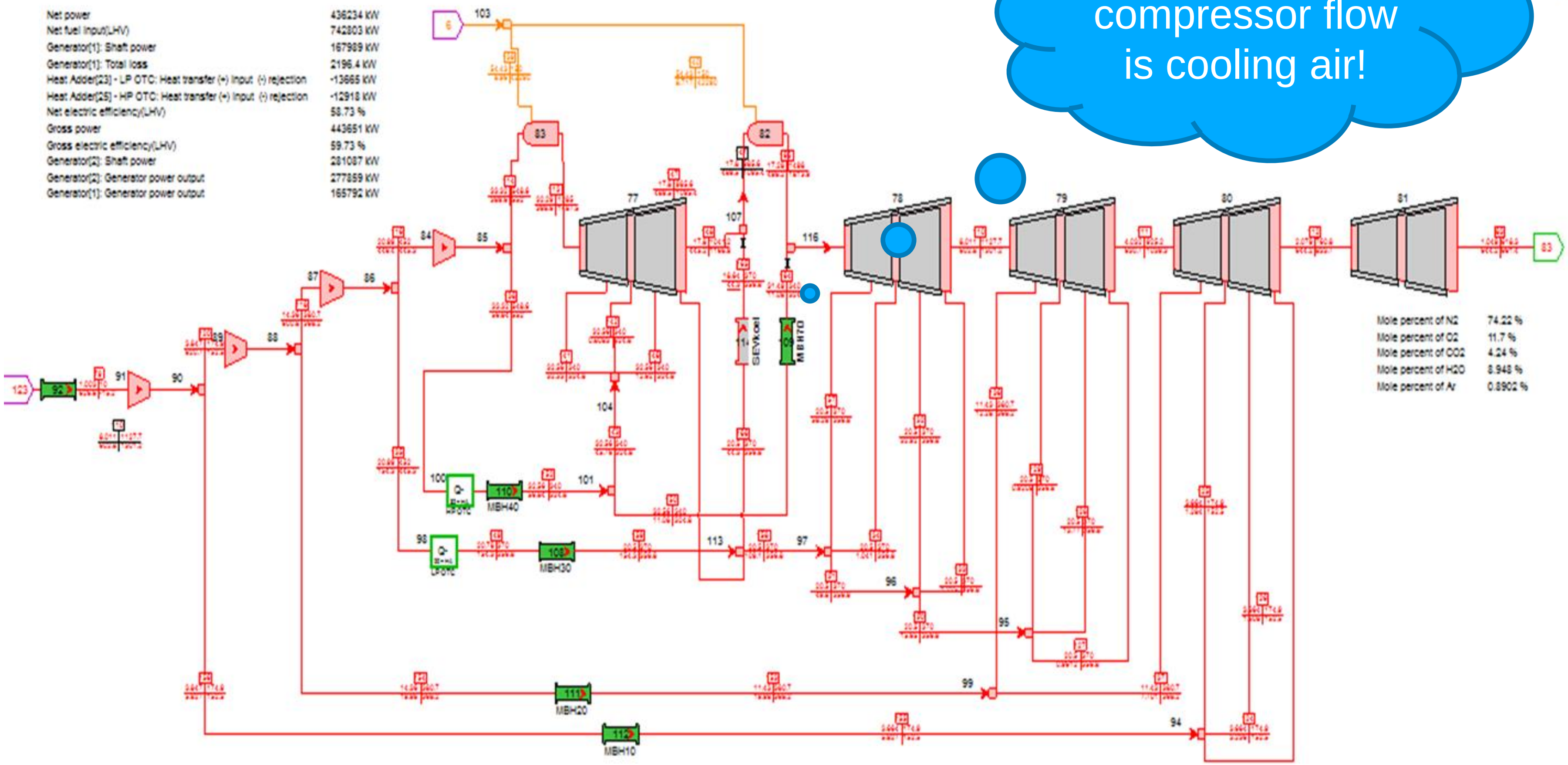
- The design specifications of the plant components:
  - Heat-exchangers, pumps, steam-turbine exhaustloss curves, glandsteam leakages, gas turbine cooling airflows, ect.
- OEM heat balances and correction curves:
  - Only for starting modelling
- Understand the unit control logic’s:
  - gas turbine load path, fixed pressures.
- Check of key measurements and corrections:
  - A control value is not always a physical value. (TAT corrections, TIT calculations, Flow calculations, static heights pressure transmitters)
  - Gas heat input, mass flow and LHV
  - Compressor air mass flow,   Bellmouth calculation

TF standard GT26 has not enough outputs for TFO



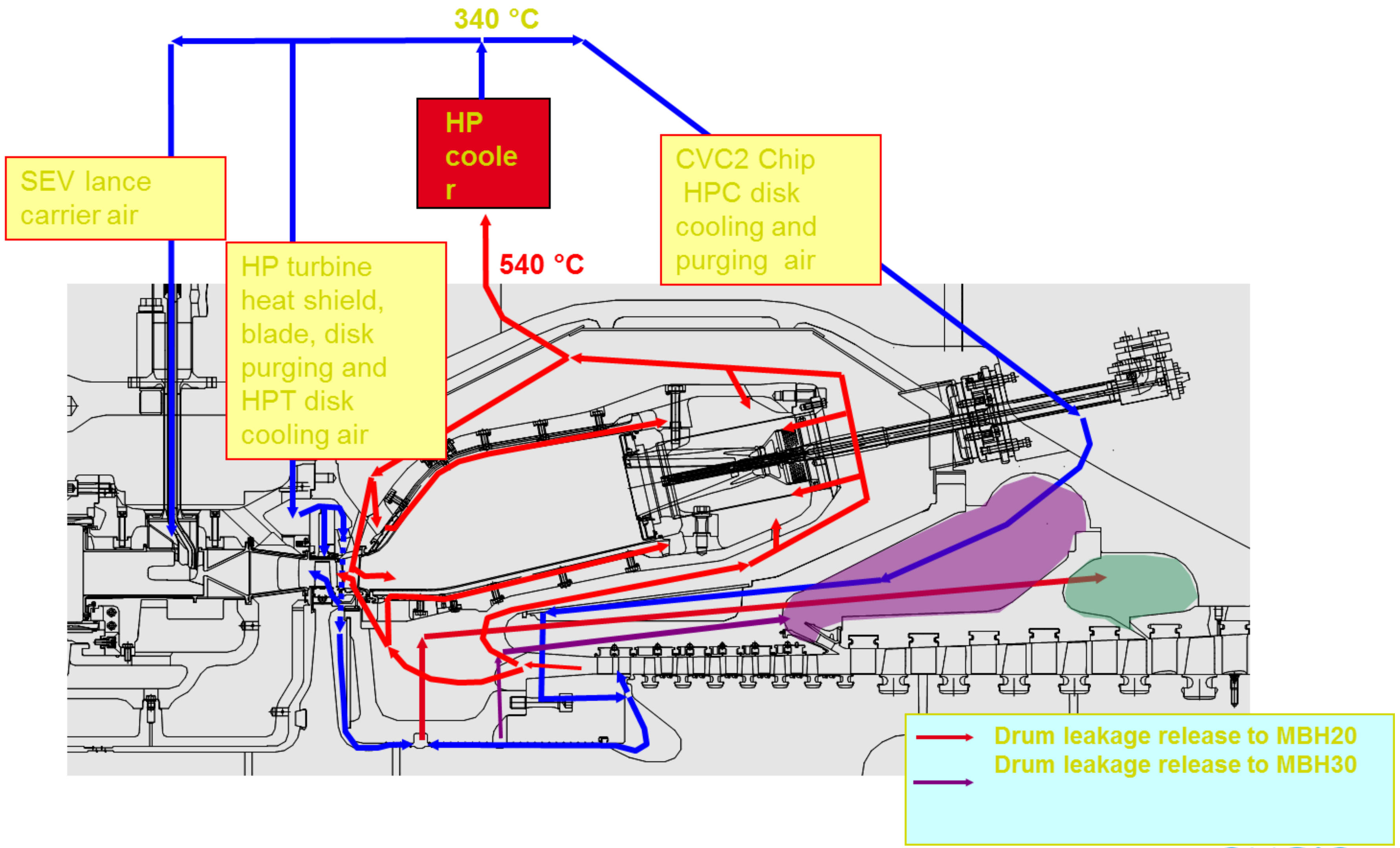
ID	Manufacturer & Model	Shafts	RPM	PR	TIT C	TET C
70	ALSTOM GT13E2	1	3000	15.0	1104	525
248	ALSTOM GT13E2	1	3000	14.6	1121	523
285	ALSTOM GT13E2	1	3000	14.6	1121	522
373	ALSTOM GT13E2 (LIFE)	1	3000	16.4	1129	501
349	ALSTOM GT13E2 (OUTPUT)	1	3000	16.5	1149	510
425	ALSTOM GT13E2 (OUTPUT)	1	3000	16.5	1149	505
462	ALSTOM GT13E2 (**)	1	3000	16.5	-	505
476	ALSTOM GT13E2 (2012) (**)	1	3000	16.7	-	505
89	ALSTOM GT26 (*)	1	3000	30.0	-	641
262	ALSTOM GT26 (*)	1	3000	32.0	-	614
345	ALSTOM GT26 (*)	1	3000	32.0	-	616
404	ALSTOM GT26 (*)	1	3000	34.7	-	614
460	ALSTOM GT26 (2006) (**)	1	3000	34.7	-	621

GT26 Heat balance first design

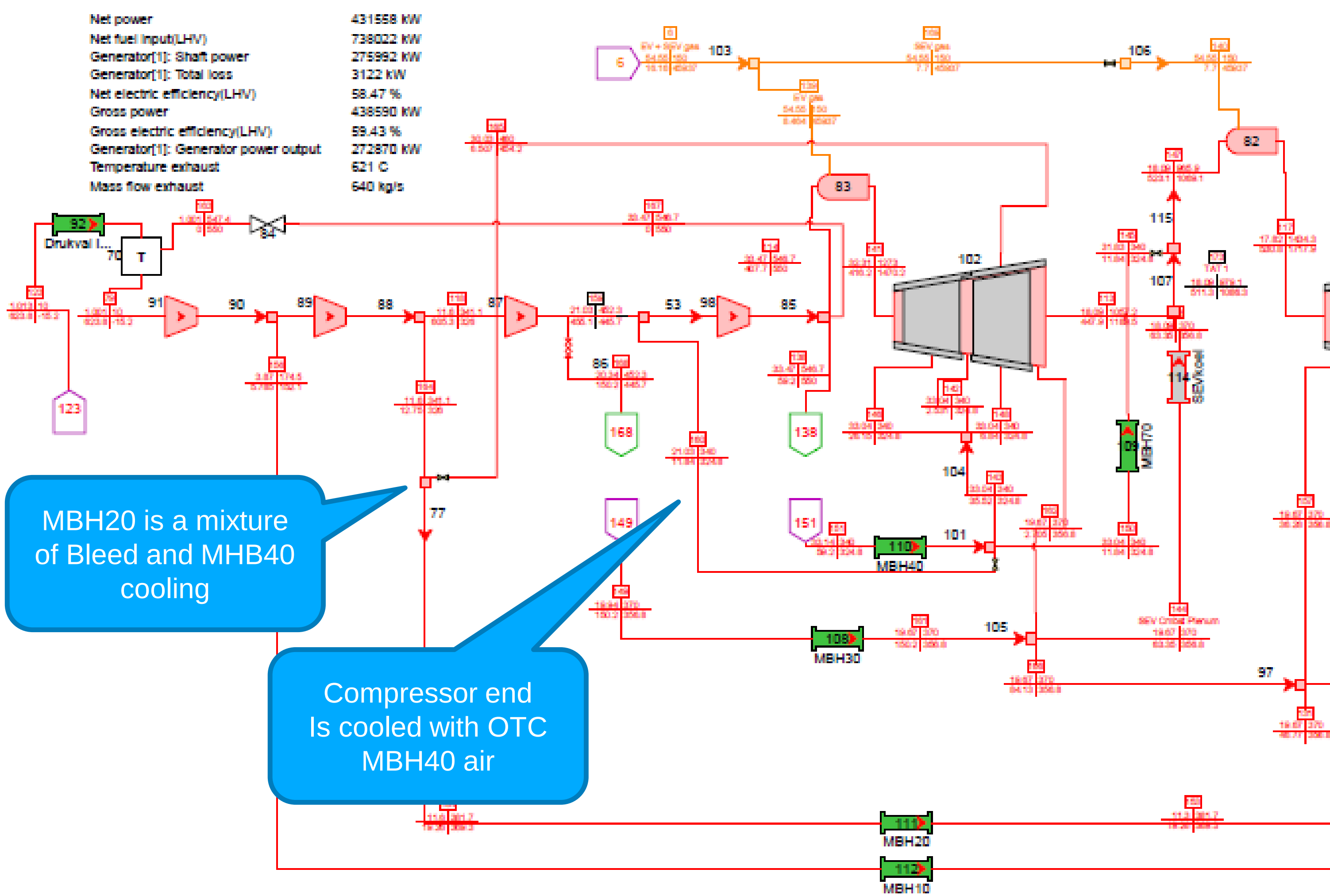


38 % of compressor flow is cooling air!

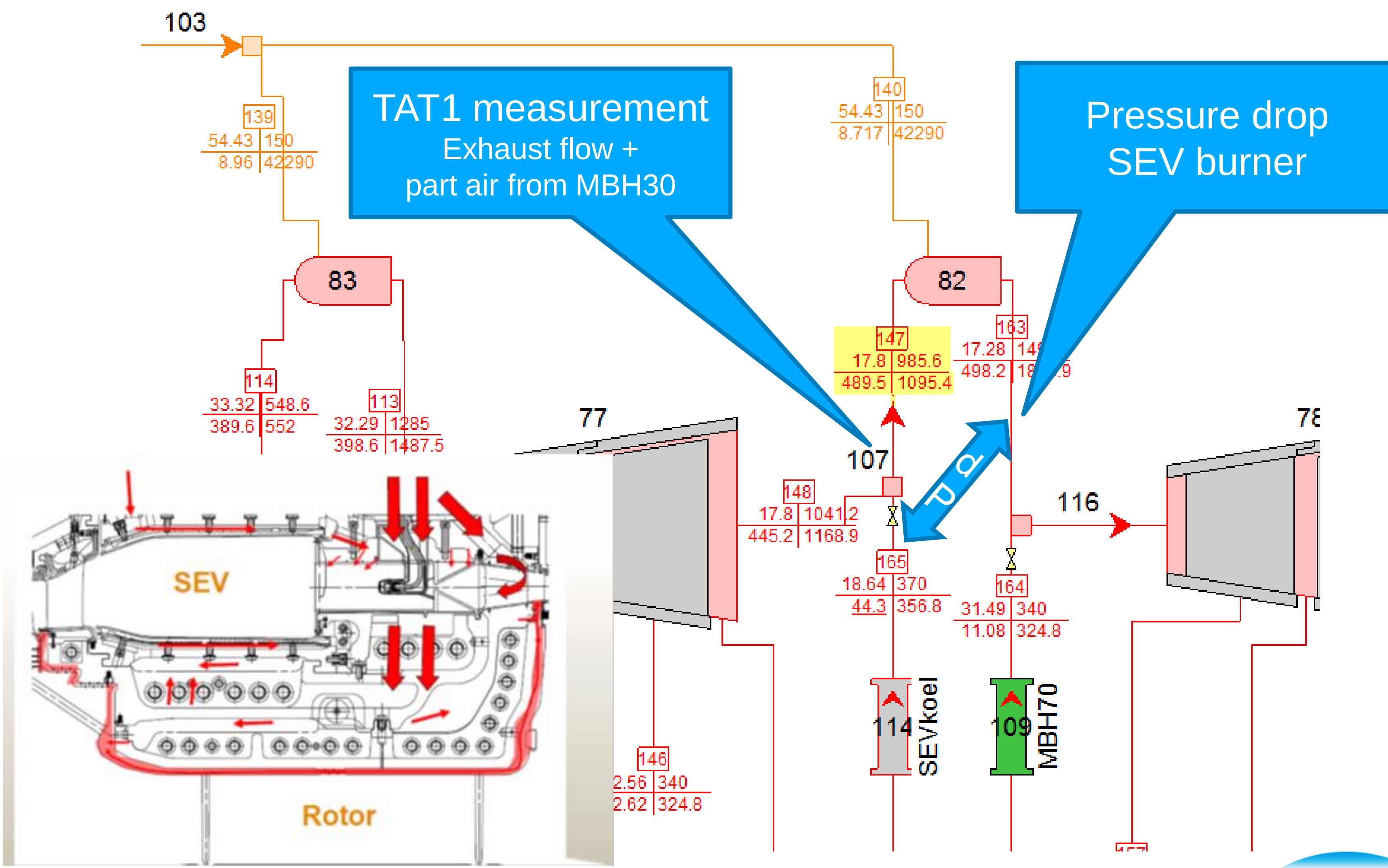
GT26 has a very complex Cooling flow system



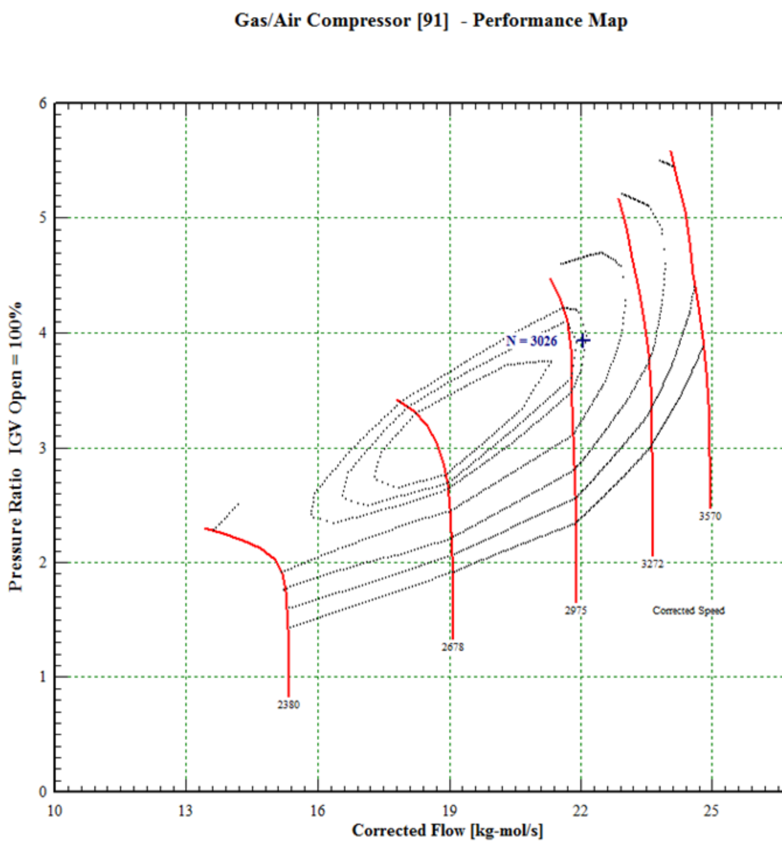
MBH40 Cooling Flow leakages to MBH30 and MBH20

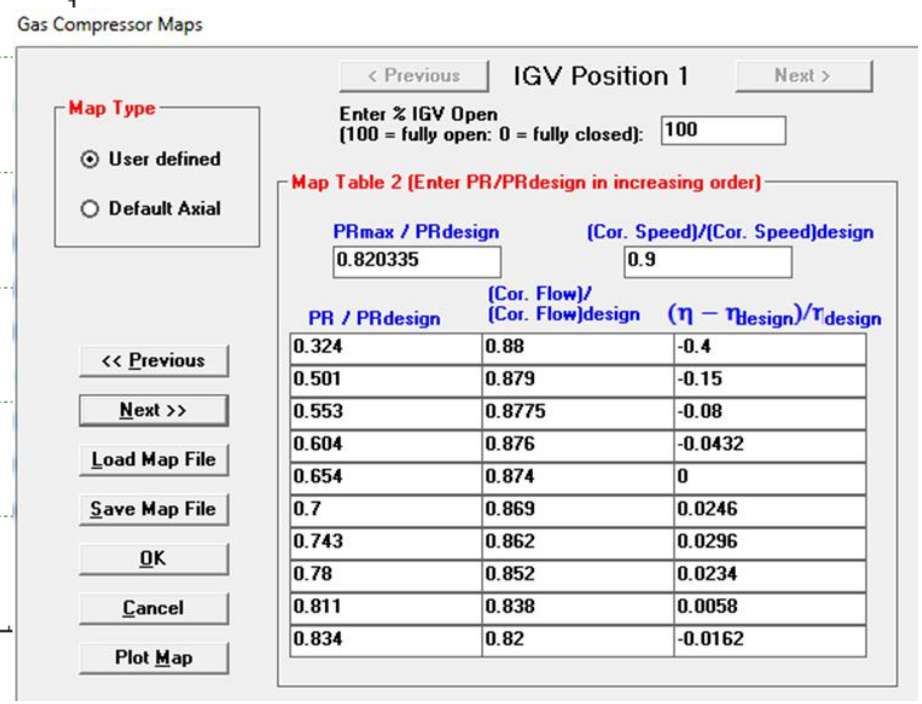


Real: TIT’s, TAT’s and Pressure Ratio’s



Compressor maps not be available from OEM





Gas Compressor Maps

< Previous IGV Position 1 Next >

Map Type
- User defined
- Default Axial

Enter % IGV Open
(100 = fully open: 0 = fully closed): 100

Map Table 2 (Enter PR/PRdesign in increasing order)

PRmax / PRdesign: 0.820335

(Cor. Speed)/(Cor. Speed)design: 0.9

PR / PRdesign	(Cor. Flow)/ (Cor. Flow)design	$(\eta - \eta_{design})/\eta_{design}$
0.324	0.88	-0.4
0.501	0.879	-0.15
0.553	0.8775	-0.08
0.604	0.876	-0.0432
0.654	0.874	0
0.7	0.869	0.0246
0.743	0.862	0.0296
0.78	0.852	0.0234
0.811	0.838	0.0058
0.834	0.82	-0.0162

<< Previous

Next >>

Load Map File

Save Map File

OK

Cancel

Plot Map

4 Compressor maps → 4 x 4 x10 = 160 tables

export PI data → Excel → import in ThermoFlex