This sample file first appeared in Thermoflow 18 (2008).

Off-design model of a 1x1 9FA combined cycle coupled to a solar thermal steam generator capable of producing partially superheated HP steam. The parabolic trough solar-field heats a thermal oil (Therminol VP-1) which is pumped through a series shell and tube heat exchangers which preheat feedwater, generate steam, and superheat steam. Therminol temperatures are limited to about 400 C thereby requiring final superheating of the steam in the HRSG. The solar generator receives partially preheated feedwater from the HRSG, and returns superheated steam which is mixed with HP steam exiting the first superheater (HPS0). The mixture is superheated to final steam turbine throttle conditions of approximately 550 C.

A duct burner is installed in the HRSG to raise additional steam when the solar generator is unavailable. This configuration is sized for approximately 25% of HP steam generation in the solar generator, and 75% in the HRSG. However, given the variation in solar irradiance coupled with the impact of ambient temperature on gas turbine performance, the solar generator can contribute up to 35% of HP steam at peak summer conditions, and far less than that in winter conditions.

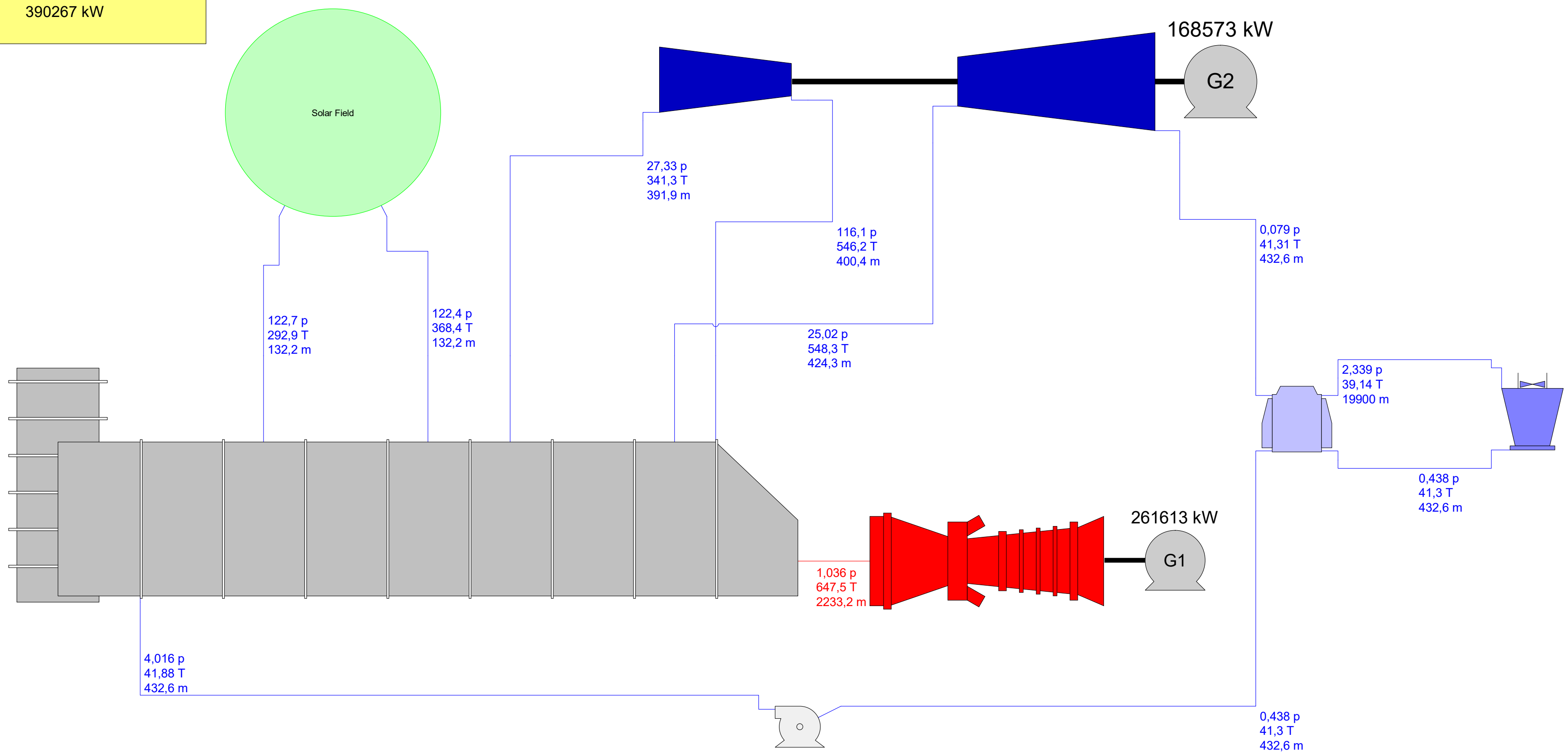
Ambient conditions typical of Seville, Spain are used to configure the solar field. The site latitude is 37 degrees north, and site elevation is 50 m ASL, both important elements in determining the solar irradiance levels.

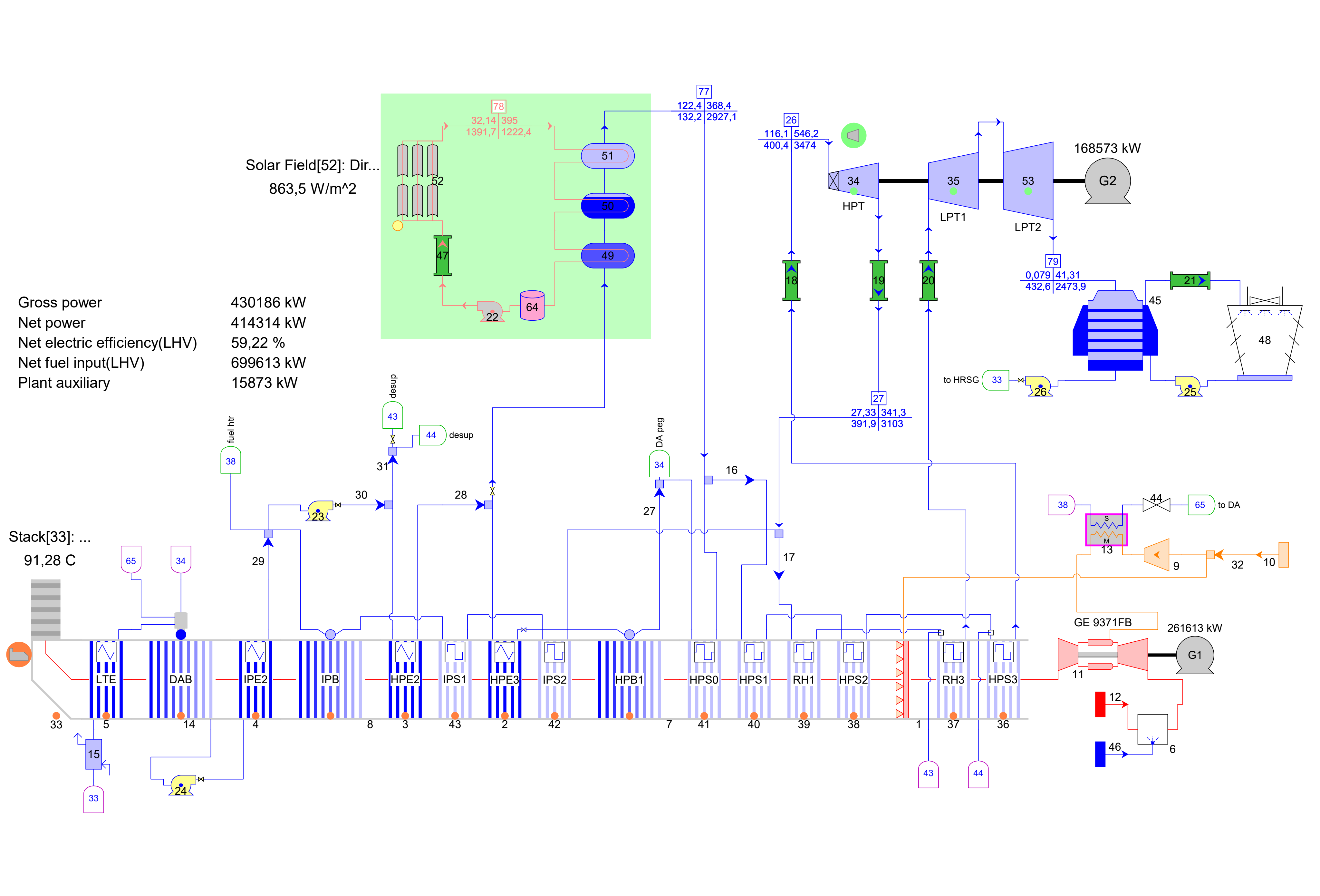
Outputs of icon 52, Solar Field, show the solar field layout. The computed field consists of 68 rows of mirrors on a field of almost 30 hectare. A GT PRO / PEACE model of the combined cycle alone indicates a required land area of about 3.5 hectare, for a combined land area of about 34 hectare. At a summer peak rating of 415 MWnet, the plant occupies less than 0.1 hectare per MW.

Operation at peak summer condition with and without solar field in service indicates the solar field contributes approximately 27.5 MW net power (6.5% of total plant power), and adds about 3.9 percentage points to plant efficiency to make a net LHV 55% efficient combined cycle almost 59% efficient on a net LHV basis. These modest improvements come with little impact on the combined cycle operation due to the limited contribution from the solar system. Solar systems that contribute more of the HP steam generation would have proportionally larger impact on power and efficiency, but come at a price of added complexity for plant design and plant operation in non-solar mode.

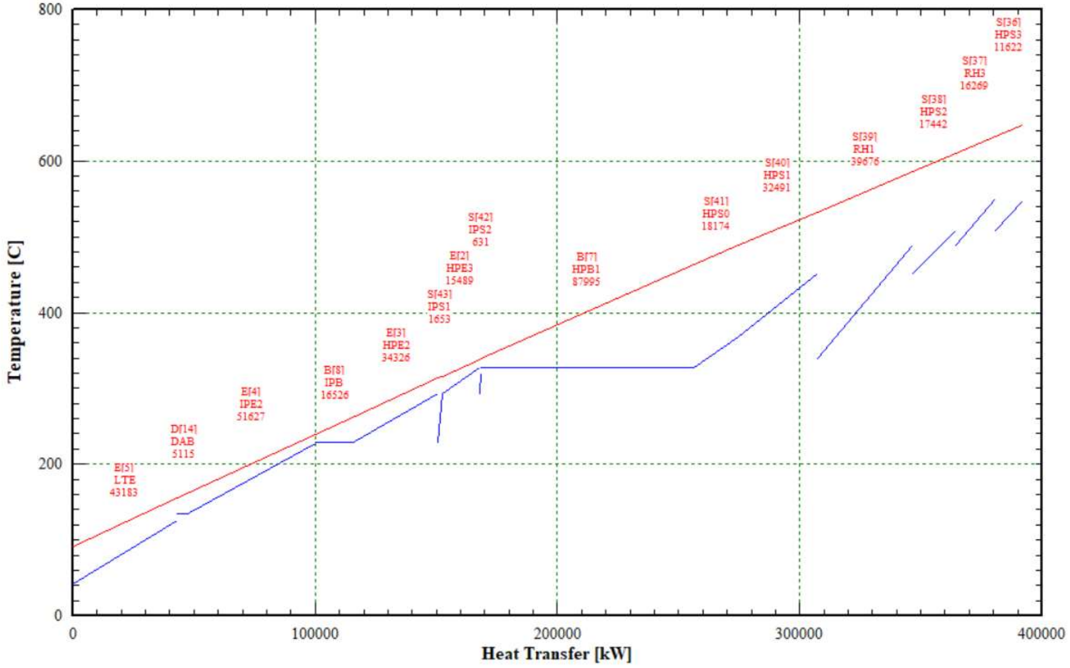
The PowerDraw sheet contains a graphical summary of the plant designed in this model using the PowerDraw feature. This sheet contains no heat balance information and exists for illustrative purposes only.

Net power	414314 kW
Net electric efficiency(LHV)	59,22 %
Net heat rate(LHV)	6079 kJ/kWh
HRSG 1: HRSG efficiency	90,86 %
HRSG 1: Stack gas exit temperature	91,28 C
Solar Field Heat absorbed	59241 kW
HRSG Heat recovered	390267 kW




bar | C
t/h | kJ/kg
Solar Field[52]: Dir...
863,5 W/m^2
Gross power 430186 kW
Net power 414314 kW
Net electric efficiency(LHV) 59,22 %
Net fuel input(LHV) 699613 kW
Plant auxiliary 15873 kW
Stack[33]: ...
91,28 C
78
32,14 | 395
1391,7 | 1222,4
77
122,4 | 368,4
132,2 | 2927,1
26
116,1 | 546,2
400,4 | 3474
27
27,33 | 341,3
391,9 | 3103
79
0,079 | 41,31
432,6 | 2473,9
168573 kW
G2
HPT
LPT1
LPT2
to HRSG
to DA
desup
fuel htr
DA peg
GE 9371FB
261613 kW
G1
LTE
DAB
IPE2
IPB
HPE2
IPS1
HPE3
IPS2
HPB1
HPS0
HPS1
RH1
HPS2
RH3
HPS3

HRSG 1 TQ Diagram



Solar Boiler