SAM

SUB ATMOSPHERIC MODULE

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SAM - Objective

- Increasing the Electricity Generation Efficiency of the OCN TS-450 Turbogenerator in view of the rising Natural Gas prices.

- Attaining the goal of 36+ % HHV Electric Generation Efficiency set by the US DOE by 2010.

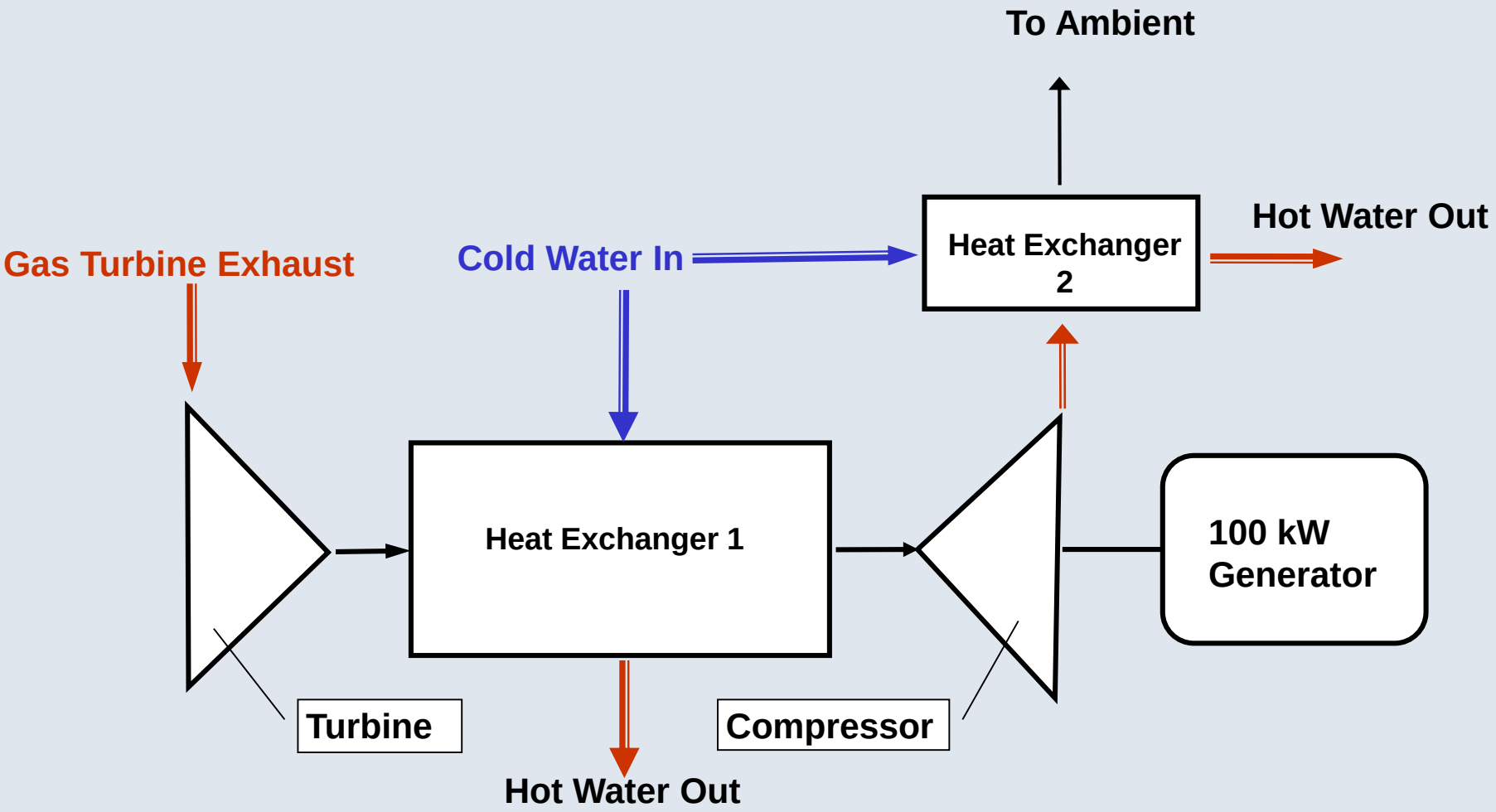
SAM - Description

Two packaging solutions result in the same total system performance:

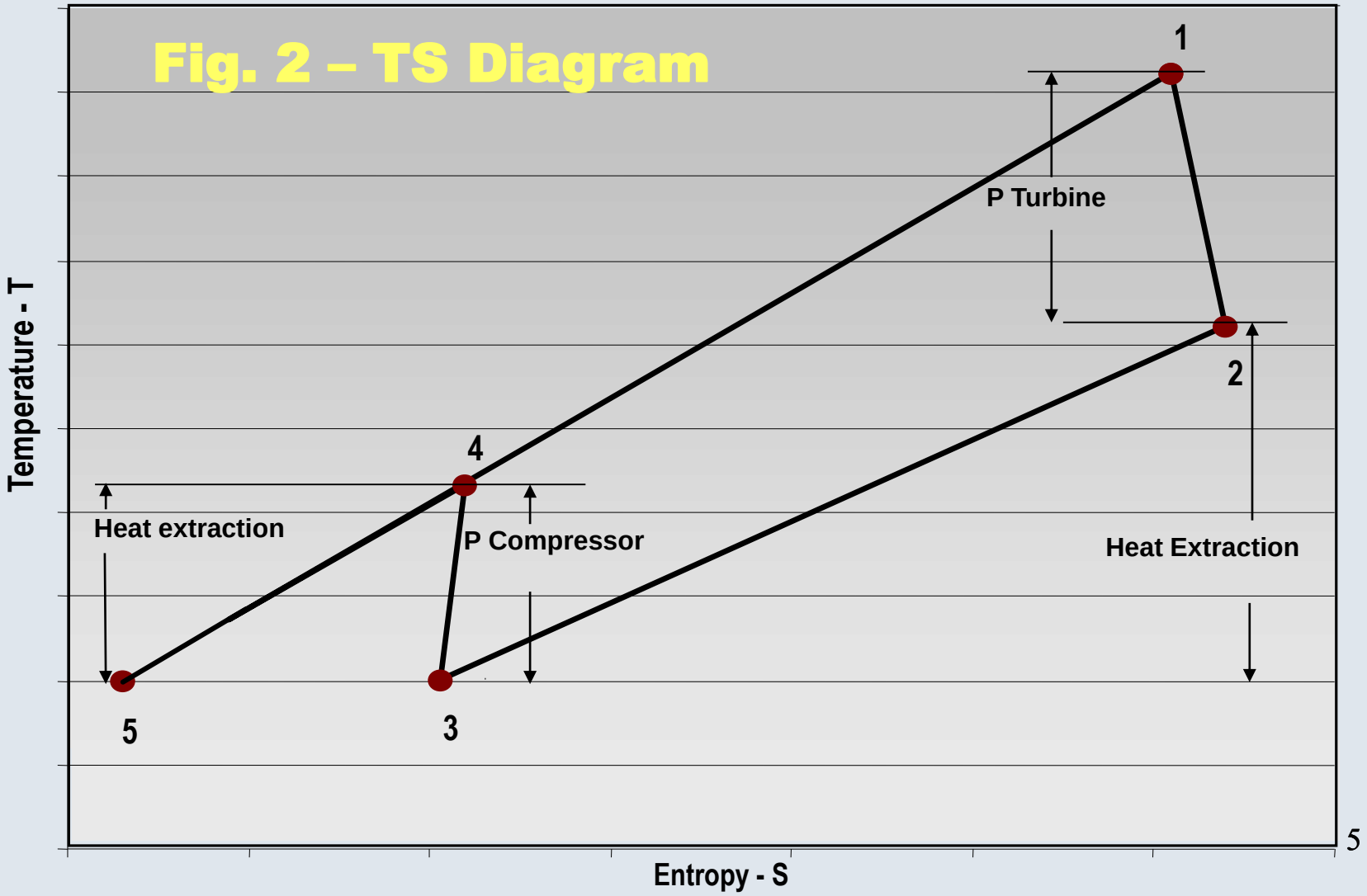
- A separate unit added to the OCN TG-450 turbogenerator connected to its exhaust duct, driving an high speed 100 kW alternator (Fig. 1)

- An integral stage to the basic OCN TG-450 gas turbine driving a common alternator. (Fig. 4)

Fig. 1 – Separate SAM Unit



Technical Concept



OPTIMUM CYCLE PRESSURE RATIO (see Fig 3)

- A parametric analysis has been done to find the expansion pressure ratio which results in maximum power gain.
- For each pressure ratio the compressor and turbine efficiencies have been re-calculated.
- Following analysis for two (2) values of heat exchanger relative pressure drop (ΔP/P), the optimum cycle pressure ratio of three (3) was

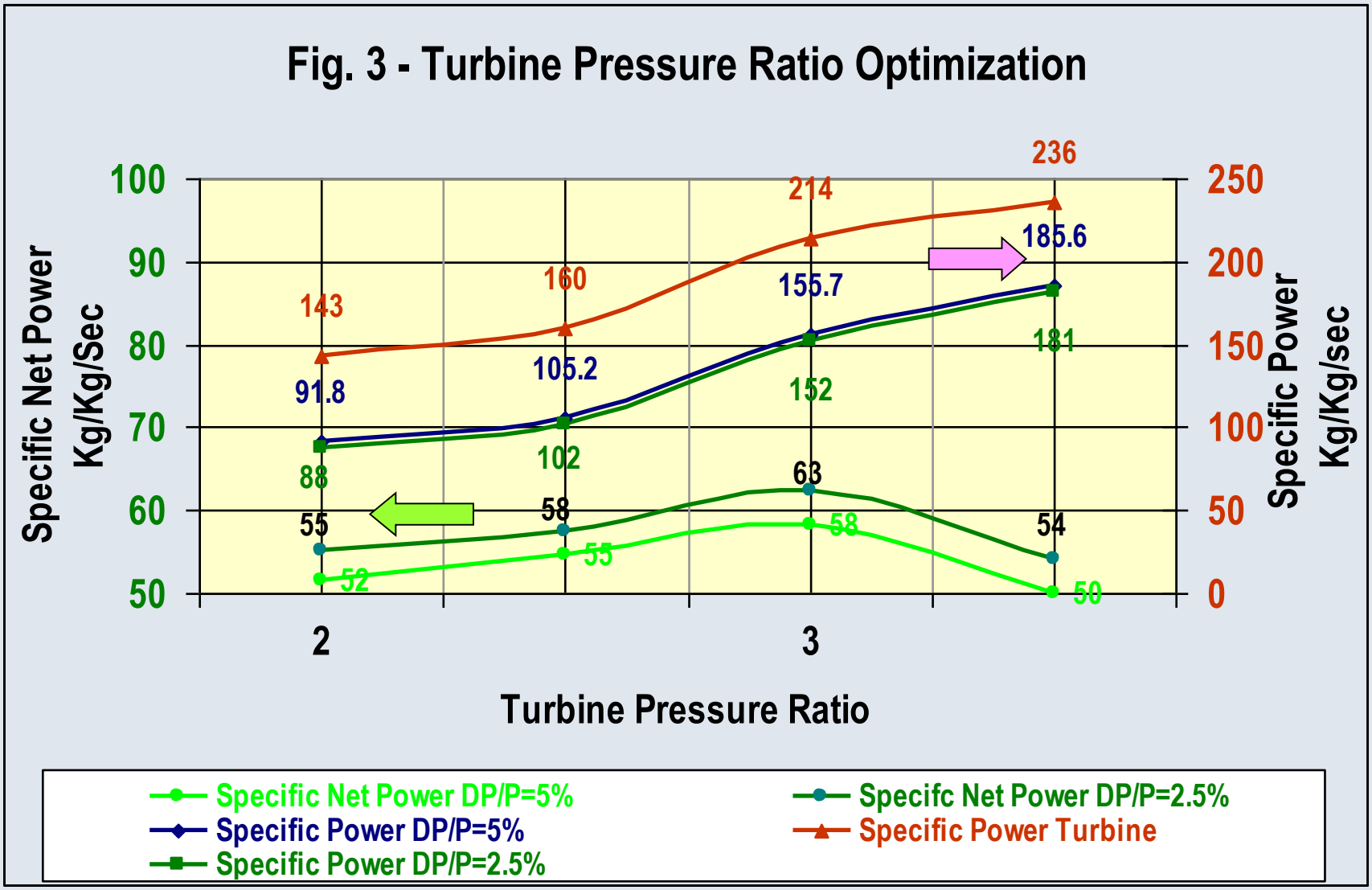


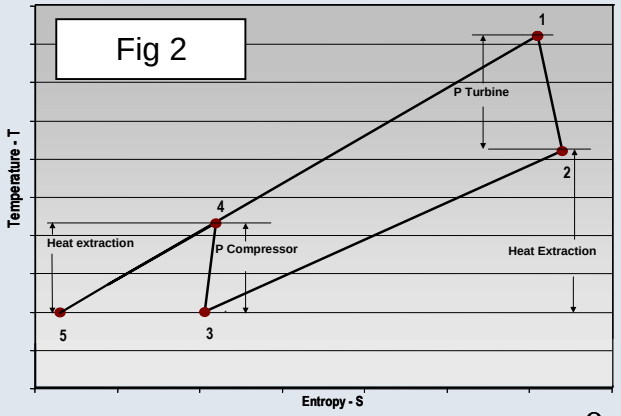
Fig. 3 - Turbine Pressure Ratio Optimization
Specific Net Power Kg/Kg/Sec
Specific Power Kg/Kg/sec
Turbine Pressure Ratio
100
90
80
70
60
50
250
200
150
100
50
0
2
3
143
160
214
236
91.8
105.2
155.7
185.6
88
102
152
181
55
58
63
54
52
55
58
50
Specific Net Power DP/P=5%
Specifc Net Power DP/P=2.5%
Specific Power DP/P=5%
Specific Power Turbine
Specific Power DP/P=2.5%

Thermodynamic Cycle (Fig. 2)

Point 1- Point 2

- The exhaust gas (mass flow of 1.534 Kg/sec and a temperature of 874 ^{o}K) expands through a turbine from ambient pressure to 0.344 kg/cm^2 cooled to a temperature of 680 ^{o}K.

- Turbine efficiency - 89.5%
  Expansion energy - 330 kW

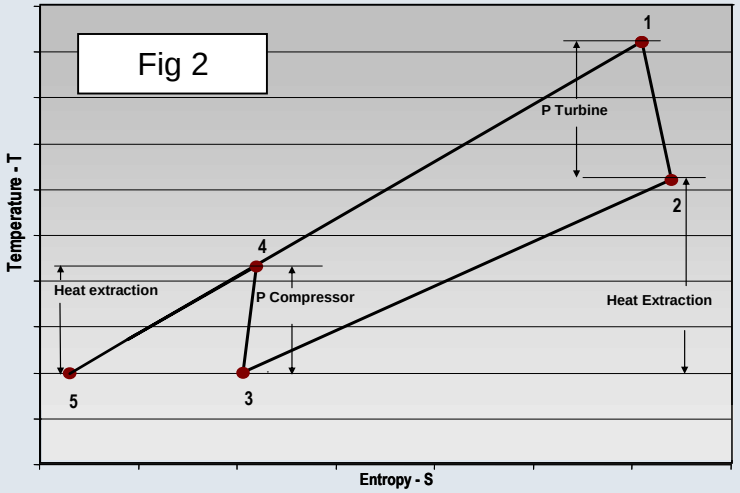


Thermodynamic Cycle

Point 2 - Point 3

- The gas is cooled in a heat-exchanger with water at 290 ^{o}K to a temperature of 330 ^{o}K at a pressure of 0.331 kg/cm^{2}.

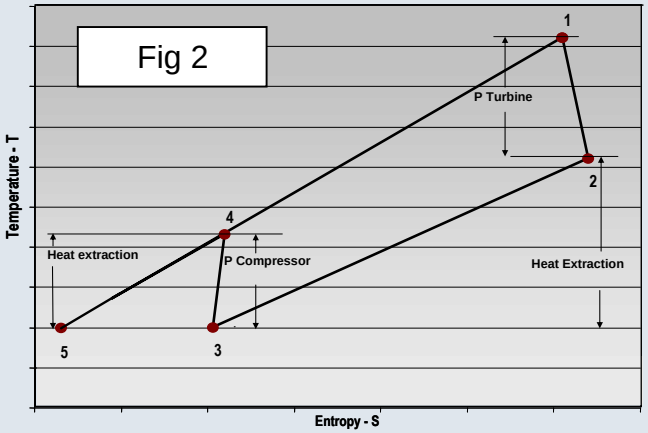
- Heat Exchanger Efficiency - 90%.
  Heat energy - 576 kW



Thermodynamic Cycle

Point 3 - Point 4

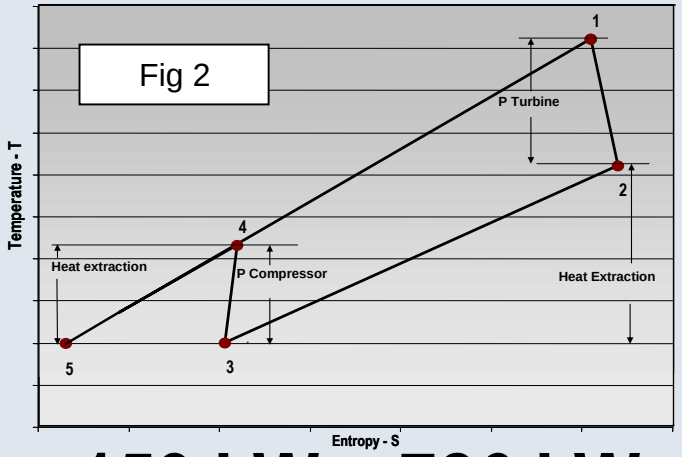
- The gas is compressed to a pressure of 1.054 kg/cm2 and a temperature of 469 oK.
- Compressor efficiency - 84%
  Compression energy - 223 kW
- Net mechanical energy –
  (326 kW – 223 kW) = 103 kW
- Net electric energy -103 kW x 0.97 = 100 kW.



Thermodynamic Cycle

Point 4 - Point 5

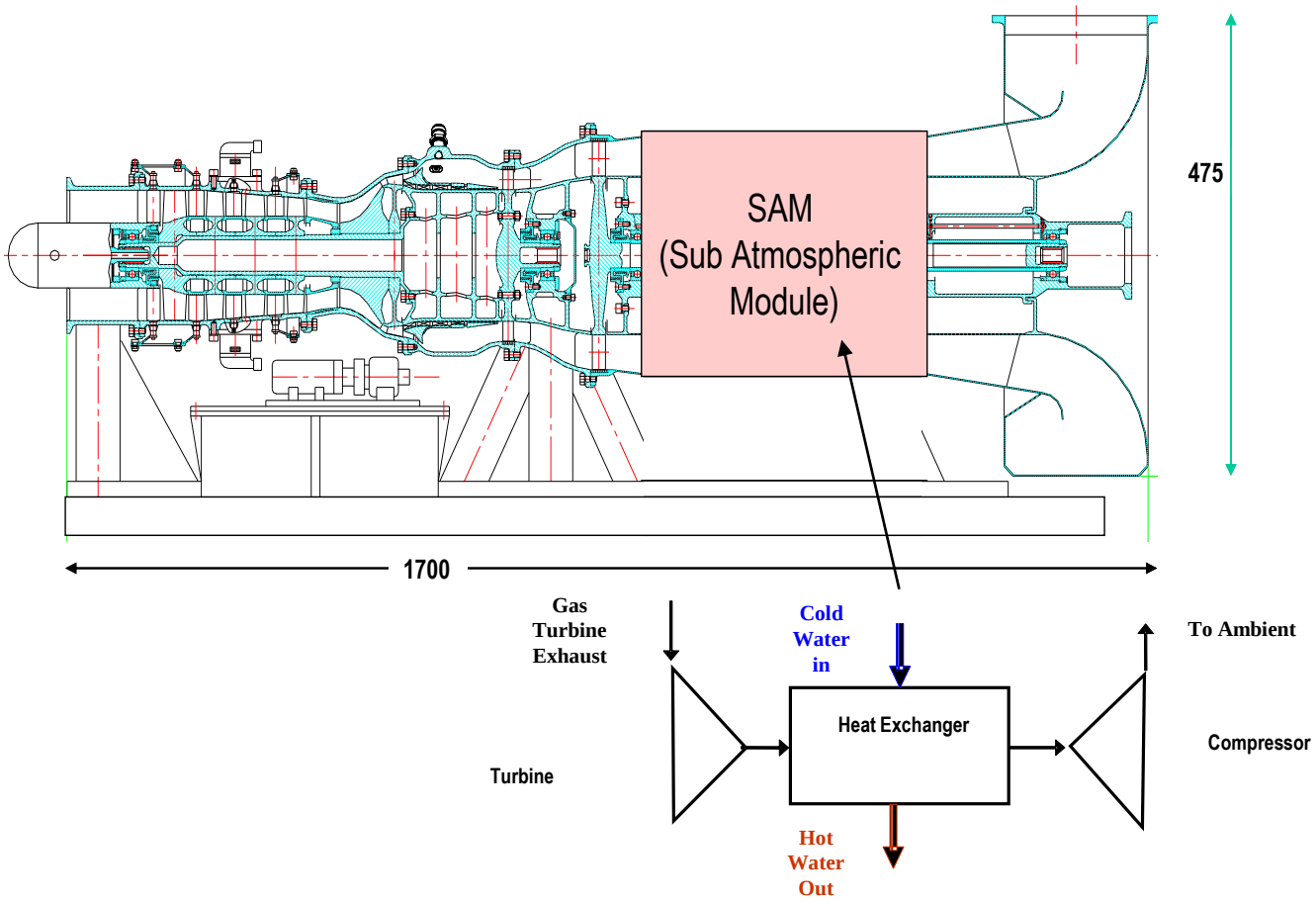
- The gas is cooled through a secondary heat exchanger by water at 290 ^{o}K to 326 ^{o}K .
- Heat exchanger efficiency - 80%.
  Heat energy 153 kW.



- Total heat energy - 573 kW + 153 kW = 726 kW.

Fig. 4 – Integrated SAM Unit

540 kW OCN Turbo Shaft Engine
(Including SAM Module)



Main components

An axial stainless steel (AISI 304) turbine; 500 mm max. diameter.

A water/gas finned tube heat exchanger.

A centrifugal compressor made of stainless steel (AISI 304) with radial diffuser - 630 mm max. diameter, driven at 26000 rpm.

A secondary water/gas finned tube heat exchanger.

Total weight - (water weight excluded) - 350 kg.

Performance

The OCN TG 450 + SAM performance:

- The fuel energy input is 1513 kW
- TG 450 engine electric output is 450 kW and 92 kW are added by the SAM
- The electrical efficiency (HHV) is thus – (450 + 92)/1513 = 36%
- Total thermal efficiency 39.4%

Performance

The OCN TG 450 + SAM performance (continued):

…

- The combined energy output is 1271 kW: 542 kW electrical (OCN -450 kW + SAM -92 kW) and 726 kW of heat energy.

- The total cogeneration efficiency is - 1271 / 1513 = 84 %

Performance Summary

- 542 kW electrical energy at 39.4% thermal efficiency or 36 % electric efficiency.
- 726 kW hot water energy assignable at different proportions to heating and cooling to suit the specific client requirements.

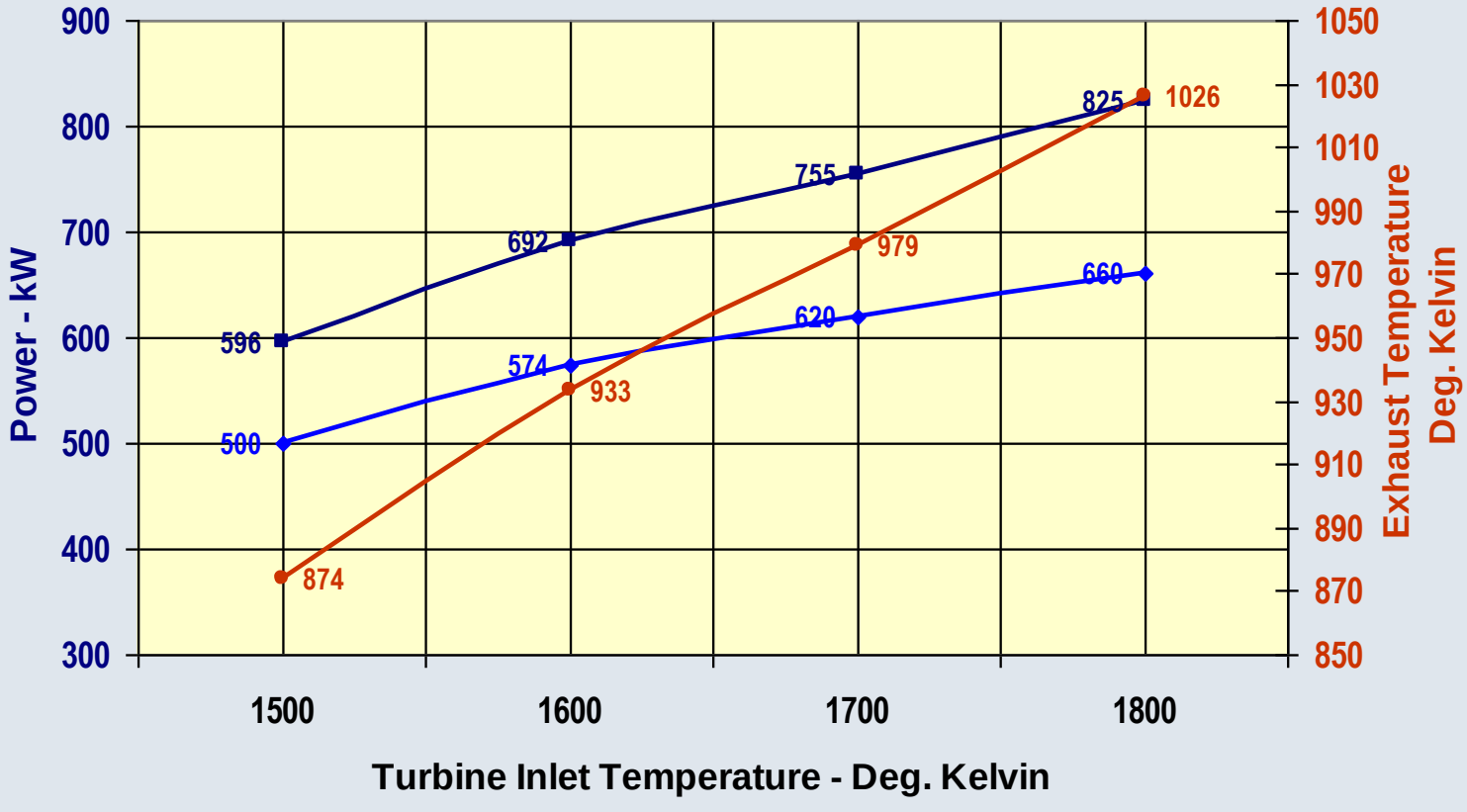
Growth Potential

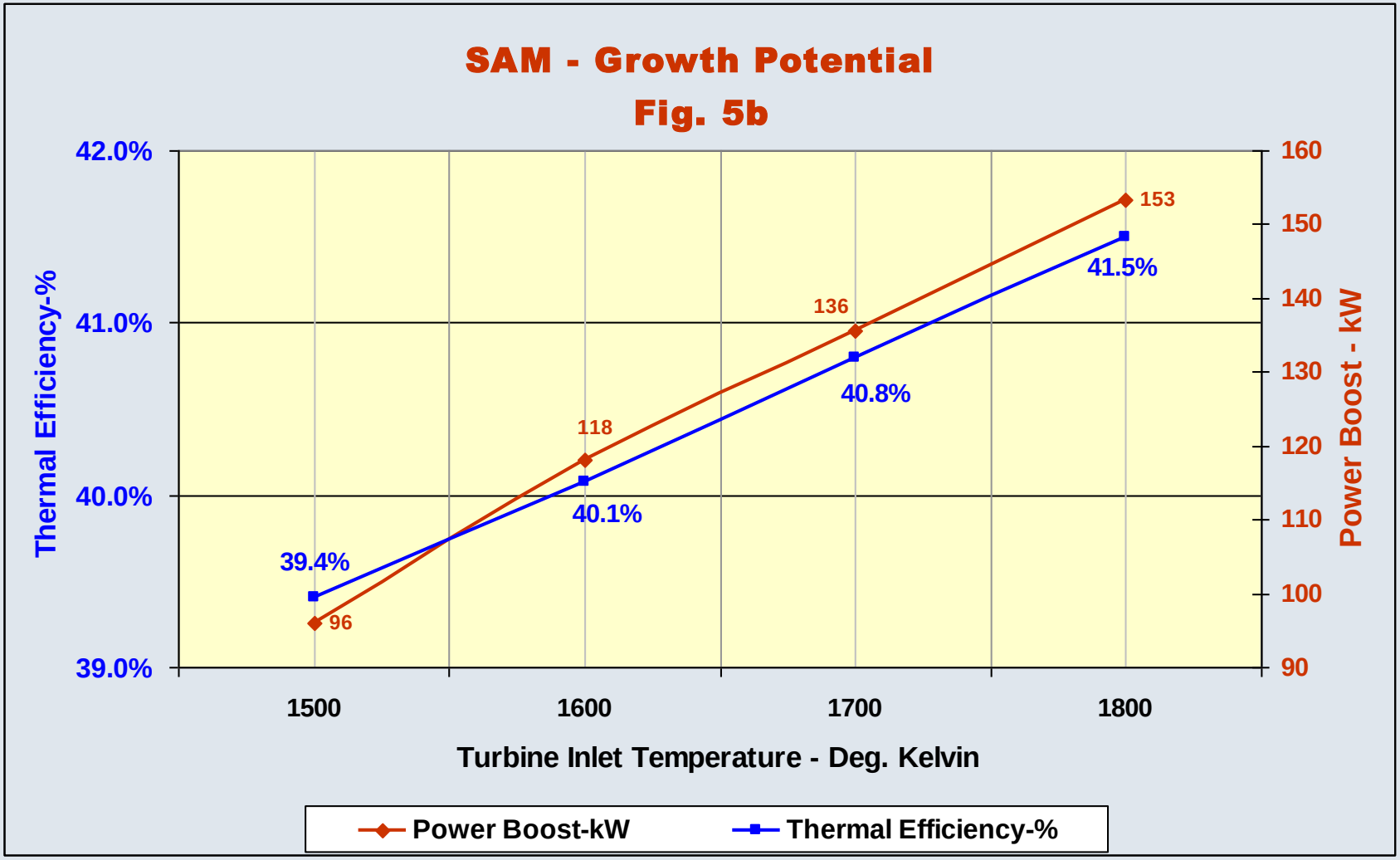
The SAM contribution to the combined power increases with increase of the turbine inlet temperature.

Fig.5 presents this improvement potential

SAM - Growth Potential

Fig. 5a




SAM - Growth Potential
Fig. 5b
42.0%
41.0%
40.0%
39.0%
Thermal Efficiency-%
160
150
140
130
120
110
100
90
Power Boost - kW
153
136
118
96
41.5%
40.8%
40.1%
39.4%
1500
1600
1700
1800
Turbine Inlet Temperature - Deg. Kelvin
Power Boost-kW
Thermal Efficiency-%

conclusions

The SAM add on is a cost effective method to achieve high performance superior to future advanced IC engines.

The OCN SAM CCHP configuration provides high electric efficiency combined with high heat energy utilization.

The above features present a system superior to any IC or Gas Turbine performance for CCHP systems.