INTEGRATED SOLAR COMBINED CYCLE POWER PLANT

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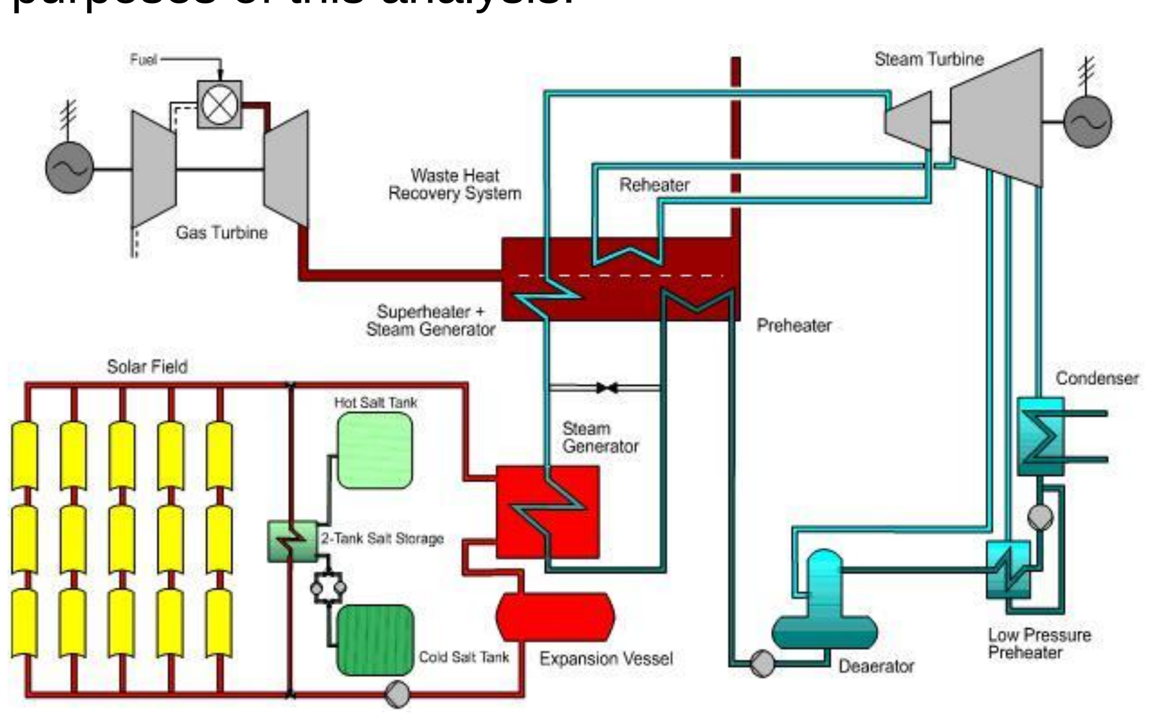
Abstract

An Integrated Solar Combined Cycle (ISCC) power plant uses a combination of a Concentrated Solar Power (CSP) plant and a Natural-Gas fired Combined Cycle (NGCC) power plant to generate power. Three different modes of the ISCC are analyzed in this study; namely the stand-alone NGCC plant (night time), power boosting mode (same fuel input as the NGCC night time mode during the day) and cost saving mode (same power0 output as the NGCC night time mode) which use solar energy to generate part of its output. The results obtained from this analysis are then compared to determine the feasibility of this design.

Introduction

With the world facing a dwindling supply of conventional energy sources and alarming climatic changes, a power plant model with reduced emissions and increased efficiency is the need of the hour. Also, with the currently dwindling prices of natural gas and the urgent need to use renewable energy, it makes sense to invest in this power plant.

•Combination of NGCC and CSP.
•An ISCC system adds thermal energy harnessed from a solar field into heat recovery steam generators (HSRG) in a NGCC plant.
•A NGCC plant is taken as the reference.
•NGCC is modified by coupling it with CSP.
•The ISCC plant is analyzed in power boosting as well as in fuel saving mode.
•A thorough exergy analysis is carried out, followed by an economic analysis to verify if the power plant is economically viable.
•Palm Springs was chosen as the location for purposes of this analysis.



Courtesy: www.flagsol.com

Results

Parameter	Unit	Night Mode (Baseline)	Day Mode (Power boosting)	Day Mode (Cost saving)
Natural Gas Flow Rate	**[mol/s]**	**300**	**300**	**260**
Air Flow Rate	[mol/s]	6996	6996	6063.2
Solar thermal fluid flow rate	[mol/s]	N.A.	1880	1880
Rankine Water flow rate	[mol/s]	2565	2995	2687.5
Coolant Water flow rate	[mol/s]	80000	80000	80000
Solar Split fraction to reheat	[-]	N.A.	0.25	0.22
Exergy Input from natural gas	[MW]	251.93	251.93	218.34
Exergy Input from solar energy	[MW]	N.A.	63.33	63.33
Total Exergy input	[MW]	251.93	315.26	281.67
Natural Gas exergy input fraction	[%]	100	80	77.5
Solar exergy input fraction	[%]	0	20	22.5
Power Output	**[MW]**	**114.13**	**129.71**	**114.13**
Solar power output fraction	[%]	N.A.	12	13.5
Efficiency (Exergy based)	**[%]**	**45.3**	**41.14**	**40.52**

Methodology

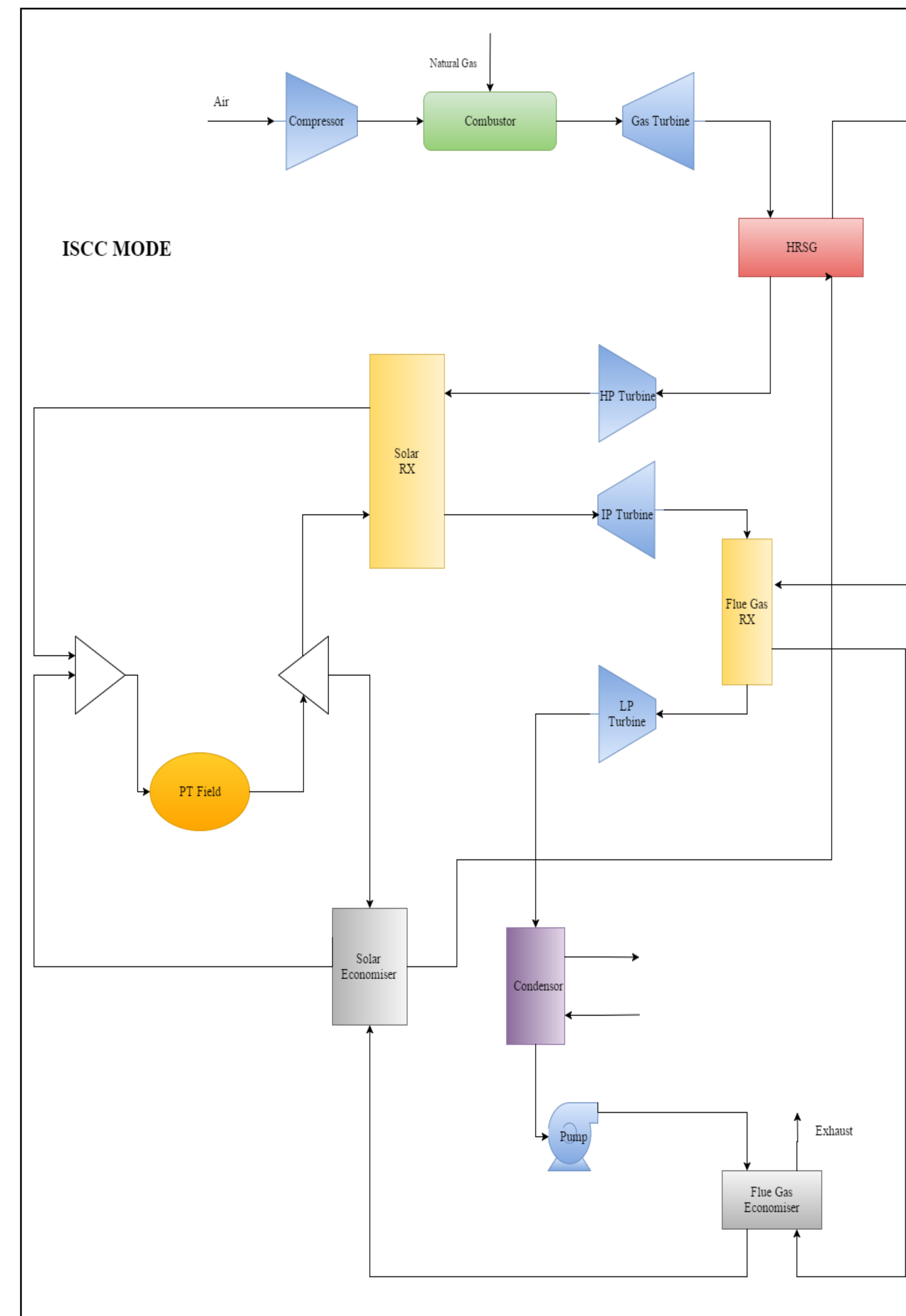
Thermodynamic Analysis

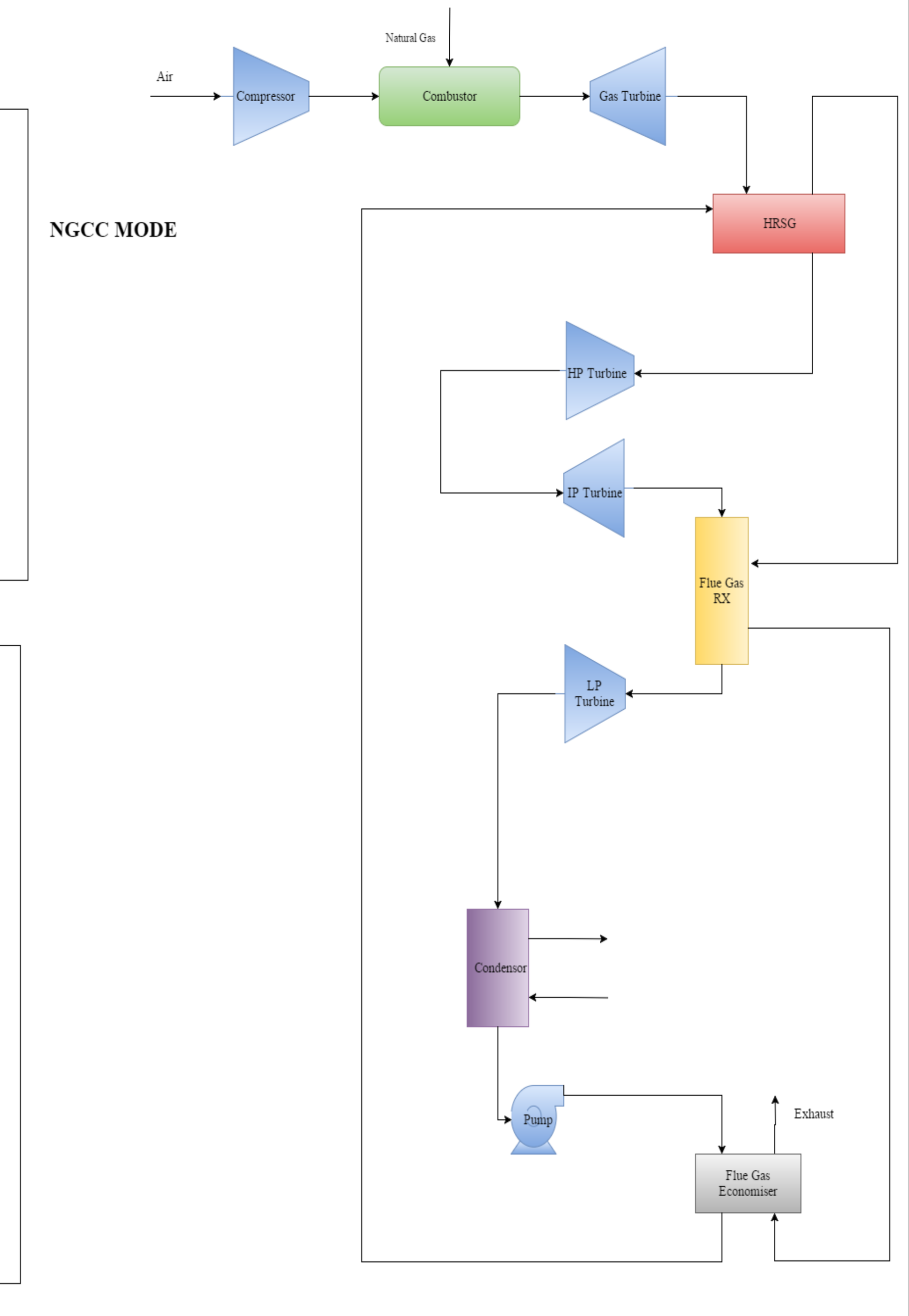
•Pressure drop across heat exchangers is negligible.
•The ratio of fuel to air was assumed to be 1:23.32 by mole.
•Air enters the Brayton cycle at 298 K and 1 bar.
•Fuel enters the Brayton cycle at 298 K and 25 bar.
•The solar thermal fluid enters at the solar fluid heater at a pressure of 200 bar and temperature of 566 K and leaves at the same pressure and 665 K.
•Capacity of the power plant and the optimization criteria were fixed.
•Number of Reheats, regenerations and pressure ratio of turbines were fixed.
•A working model in COCO Simulator for both modes was set up.

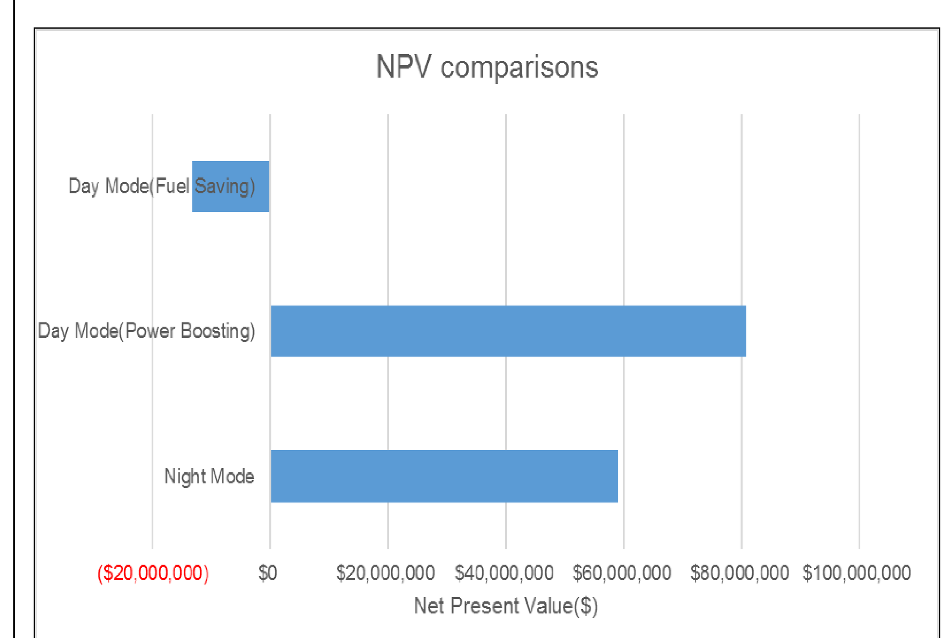
Economic Analysis

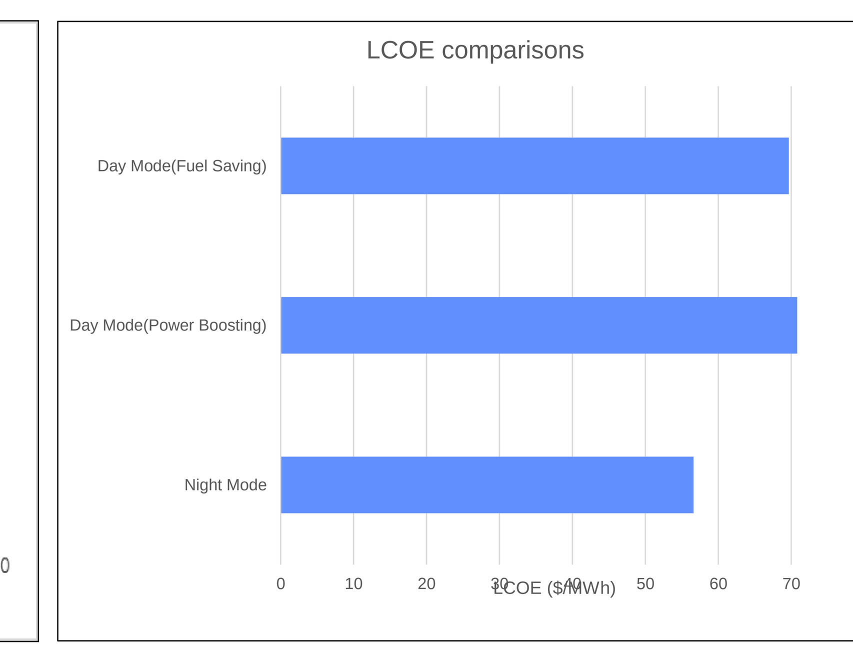
Important Assumptions:

- Lifetime for the power plant is assumed to be 32 years including 2 years of construction. The real discount rate is assumed to be 7%.
- The NGCC and CSP capacity factor is assumed to be 75% and 15% respectively for the year 3. In year 4, this factor increases to 80% and 20% respectively and from year 5 onwards, the capacity factor is fixed at 85% and 25% respectively.
- The sale price of electricity for the NGCC is taken as $65/MWh and $80/MWh for the ISCC configuration.
- Capital cost of the fields, the area, and the installation and component costs were found. Operation & Management cost, and the the fuel cost were found.
- NPV, IRR and LCOE for all modes were calculated.









Solar energy can be better harnessed if used in combination with a NGCC power plant rather than a stand-alone solar power plant.

Selected References

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