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Sessione POSTER

Organizzazione — con la collaborazione di

Geothermal hybrid plants

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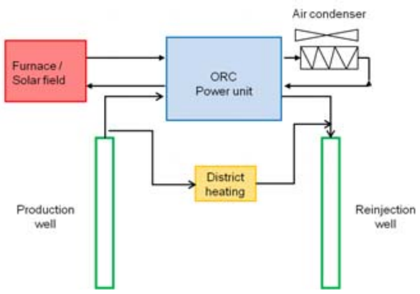
Introduction

Environmental concern and limited availability of fossil fuels push towards renewable sources. Among these, geothermal energy is a high potential source, with particular positive features: it is indigenous and it allows electricity generation with low or no environmental impact and continuous operation. In addition to the well known huge potential of EGS systems, an interesting potential exists for the liquid dominated sources, which are broadly distributed all over the world and do not require particular efforts in reservoir enhancement and management. However, liquid dominated sources are often characterized by rather low temperatures, thus allowing only limited electric conversion efficiencies: this disadvantage may be overcome by coupling the geothermal source to another, higher temperature, renewable energy source. Different situations exist according to the features of the second source, which can be characterized by continuous availability, like a residual fuel source, or intermittent availability, like solar energy.

Concept and basic scheme



The concept of coupling the geothermal source to a higher temperature heat source is conducted by considering two different secondary sources: (i) biomass and (ii) the solar source. In both the cases ORC technology is selected for power generation, as represented in figure. Synthetic oil is used as heat transfer medium between the biomass-fired furnace (in the first case) or the solar field (in the second case) and the power unit. From a thermodynamic point of view, the ORC plant operates by means of a thermodynamic cycle working between two variable temperature heat sources, the synthetic oil and the geothermal fluid, both charged with heat introduction, and the ambient, charged with heat rejection. The selection of a proper thermodynamic cycle that conveniently matches the thermal sources and the choice of the operating parameters is crucial in order to have good overall plant performance.

Calculations were carried out with reference to the following sites and operating conditions:

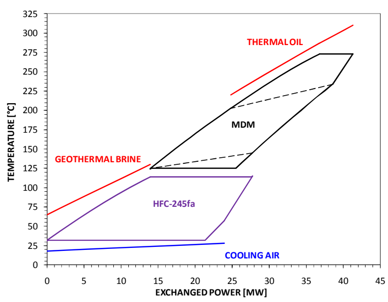
- biomass source: Munich area (Molasse basin, Germany); the plant generates electric power all over the year and thermal power according to seasonal demand;
- solar source: Imperial Valley (USA), S. Diego (USA), Pisa (Italy) and Palermo (Italy); the plant generates electric power only

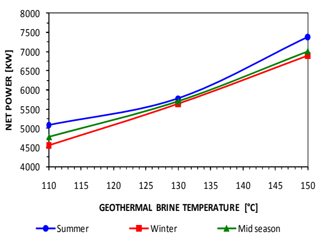
Plant components are sized for the on design condition (summer, only electric generation, for the first case; only geothermal source for the second case); all other operating conditions are calculated as off design, with proper component performance.

Hybrid geothermal biomass plant

Performance evaluation

A cascades cycle is selected with MDM, regenerative, top cycle and R245fa bottom cycle. Synthetic oil loop temperatures are assigned and correspond to common values for biomass plants; influence of the geothermal fluid temperature is investigated by means of a parametric analysis.





Basic assumptions:
$m_{geoth\ fl}$ = 44 - 71.4 kg/s
$T_{geoth\ fl}$ = parameter, 110-150 °C
$T_{reinject\ (minimum)}$ = 65 °C

$m_{th\ oil}$ = 75 kg/s
$T_{th\ oil}$ = 310-220 °C

Thermal power:
winter = 8 MW
mid season = 4 MW

Results
Net power plant, first and second law efficiencies are evaluated
Calculated η_{II} = 0.54 - 0.61

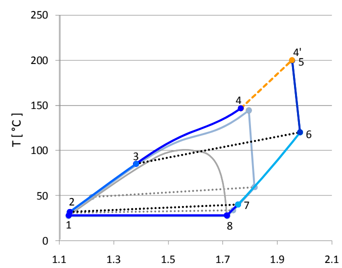
Comparison with separate plant performance, on design condition

Heat source	Geoth. fluid	Synthetic oil
ORC Net power, kW	987	3508
Down hole pump consumption, kW	132	-
Total net power, separate cycles, kW	4363	
Total net power, cascaded cycle, kW	5800	

Hybrid geothermal solar plant

Performance evaluation

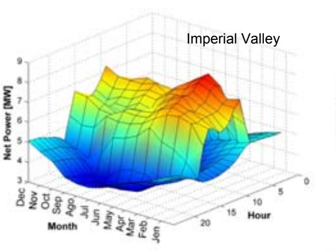
A supercritical R134a cycle is selected; geothermal fluid temperature is assigned; synthetic oil loop temperatures, which affect the solar field thermal efficiency, the auxiliary consumption and the cycle maximum temperature (and therefore efficiency) are optimized. Calculations are carried on an hour by hour basis

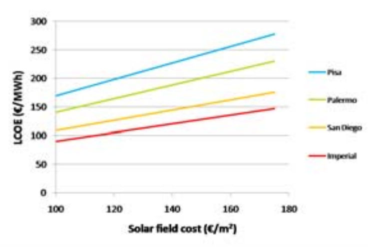


Basic assumptions:
$m_{geoth\ fl}$ = 100 kg/s
$T_{geoth\ fl}$ = 150 °C
$T_{reinject\ (minimum)}$ = 70 °C

Solar field: parabolic trough
Reflector surface: 60000 m^2

Results
Additional electric power produced and cost of the additional electricity generated are evaluated





Conclusions

Performance analysis has shown that results attainable with optimized hybrid plants are of great interest. For hybrid geothermal-biomass case, the net power produced is higher than with conventional separate plants and evaluated second law efficiencies are also noteworthy in all operating conditions. Moreover, combined power and heat scheme can improve global plant economics. For hybrid geothermal-solar case, the net power produced is increased significantly, and the cost of the additional energy produced is lower than for stand alone solar plants. It is also remarkable that additional electricity generation occurs during peak hours.

References

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