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SOLAR THERMAL ENERGY RESEARCH GROUP

Design and Performance Analysis of an Air-Cooled Parabolic Trough Power Plant under Tamanrasset Climatological Conditions

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Introduction

- Over the last years the economy of Algeria has negatively been affected by changes in oil prices (from 108 $ to 35 $).

- The price of electricity in Algeria is one of the lowest in the world at 0.03 USD/kWh which is due to the biggest share of the cost being covered by subsidies.

- The latter factors pushed the Algerian government to take austerity measures to mitigate the deficit in the budget.

- The government decided to open the doors to the development and utilization of renewable energy resources.

ALGERIA

Area: 2,381,741km^2 (Water % negligible)

Population: 40 million inhabitant

GDP (2016): 181.71 billion dollars

Electricity and gas coverage: 99% and 50%

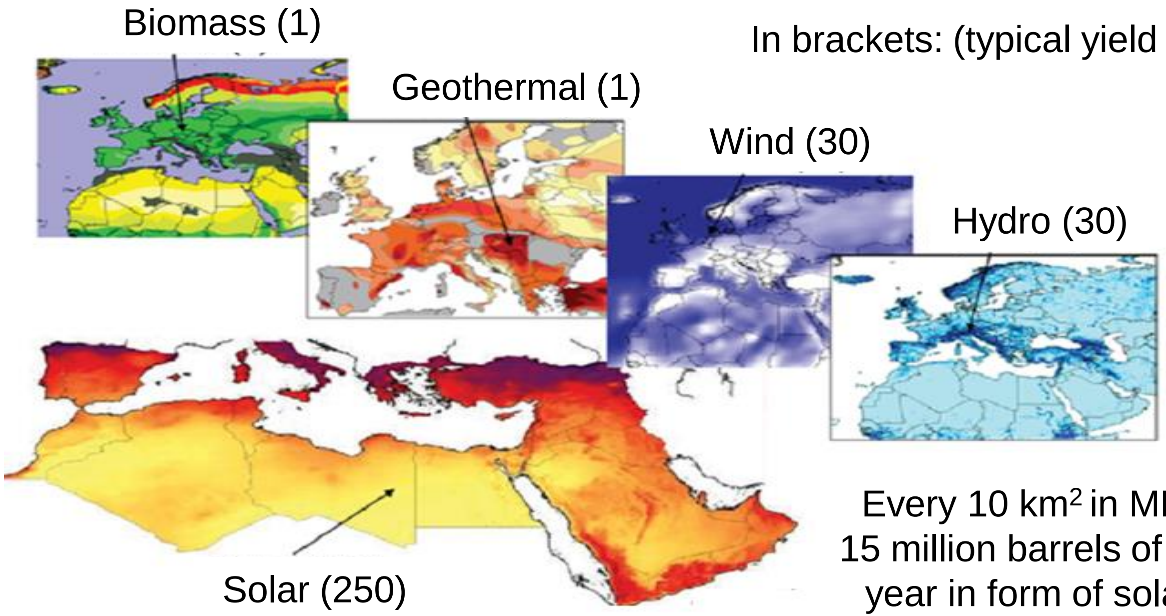
Economy: based on hydrocarbons with

- ❖ 10th largest gas reserve
- ❖ 6th largest gas producer
- ❖ 16th in oil reserves
- ❖ 90% of export earning

Figure 1 Map showing geographical position of Algeria

Renewable energy resources

In brackets: (typical yield in GWh/ km^2 y)



Every 10 km^2 in MENA yield 15 million barrels of fuel oil per year in form of solar energy

Figure 2 Typically electrical yield per area and year of renewable energies in good and very good location (arrow) in western Europe middle East and North Africa (Source DLR)

Renewable energy program

Encouraged by its commitment to the international community to fight against global warming and promoting renewable energies Algeria has drawn a roadmap to reach an installed capacity of 22,000 MW in 2030

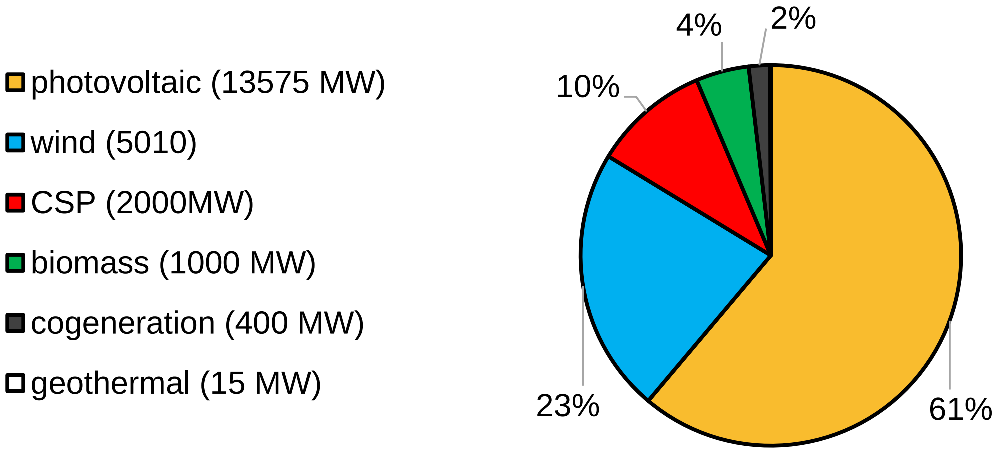
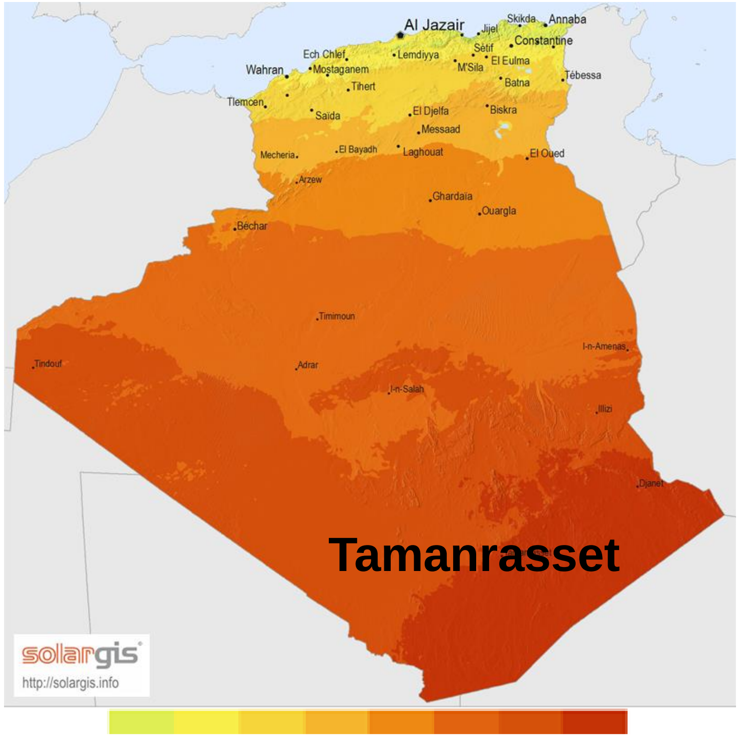


Figure 3: Installed power capacity from renewables in 2030 (CDER).

Solar potential and case study (Tamanrasset)



Tamanrasset:

- latitude of 22°.47, longitude 5°31 E altitude of 1377m
- Area: 619360 km²
- Average temperature: 30°C exceeding 38°C in summer
- direct normal irradiation exceeding 2691 KWh/m²/year
- 90% of the population has access to the grid where the remaining use standalone PV installations
- Only 11 % of the population has access to gas

Load profile of the province

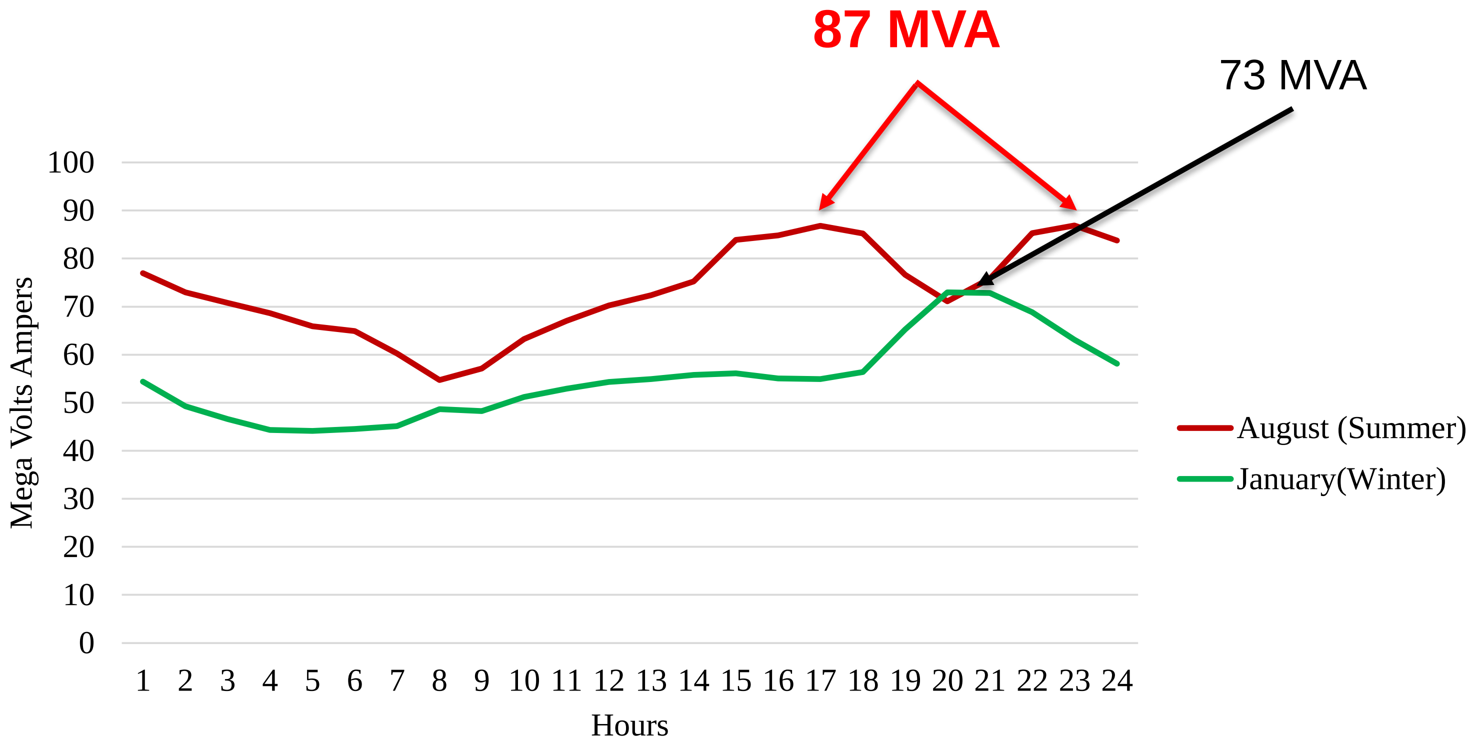


Figure 5:Load profile of Tamanrasset

Methodology

Weather file data generation using Meteonorm

Design of 100MW parabolic trough power plant with a solar multiple of 2 with the optimum TES

Determination of key economical parameters

Environment impact of the power plant (CO_2 emissions)

Energy Production

	Solar efficiency	Capacity factor
Dry cooling	14.5%	44.6%
Evaporative cooling	15.3%	48.3%

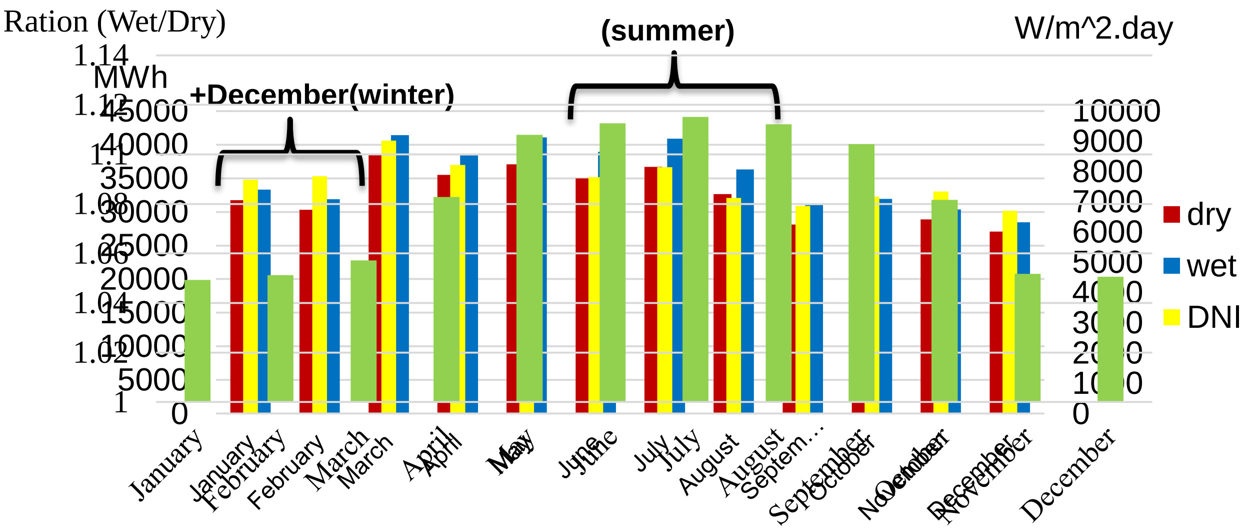


Figure 6: Monthly energy production for 1 year
Figure 7: Ratio of energy produced by wet and dry cooled power plant

Water consumption

	Amount (m³) per year
Dry cooling	126,755
Wet cooling	1,477,865

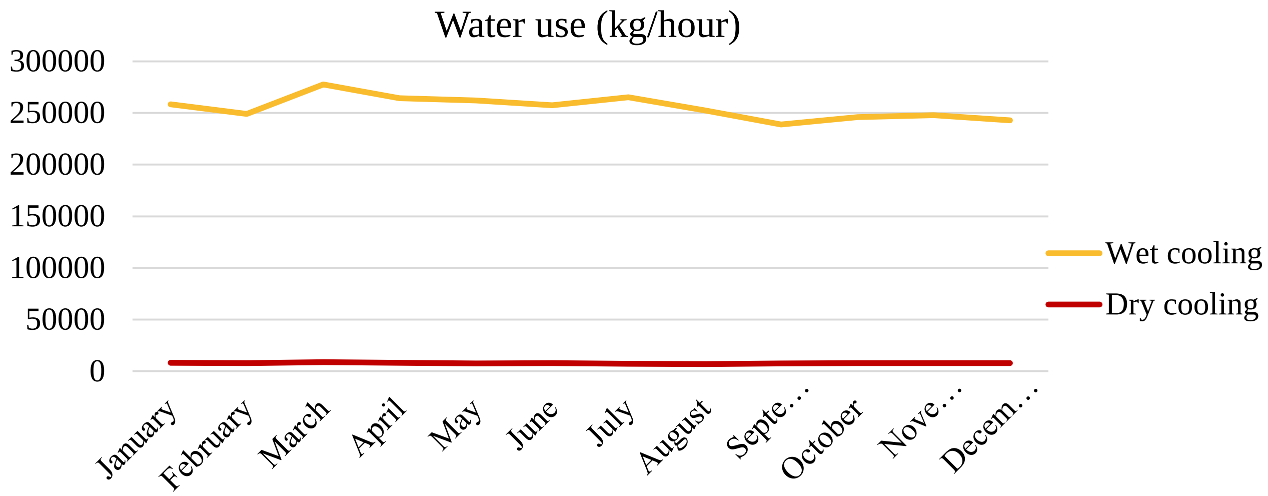


Figure 8: Power plant water usage

January electricity supply

	Covered demand
Power plant	78%
National grid	22%

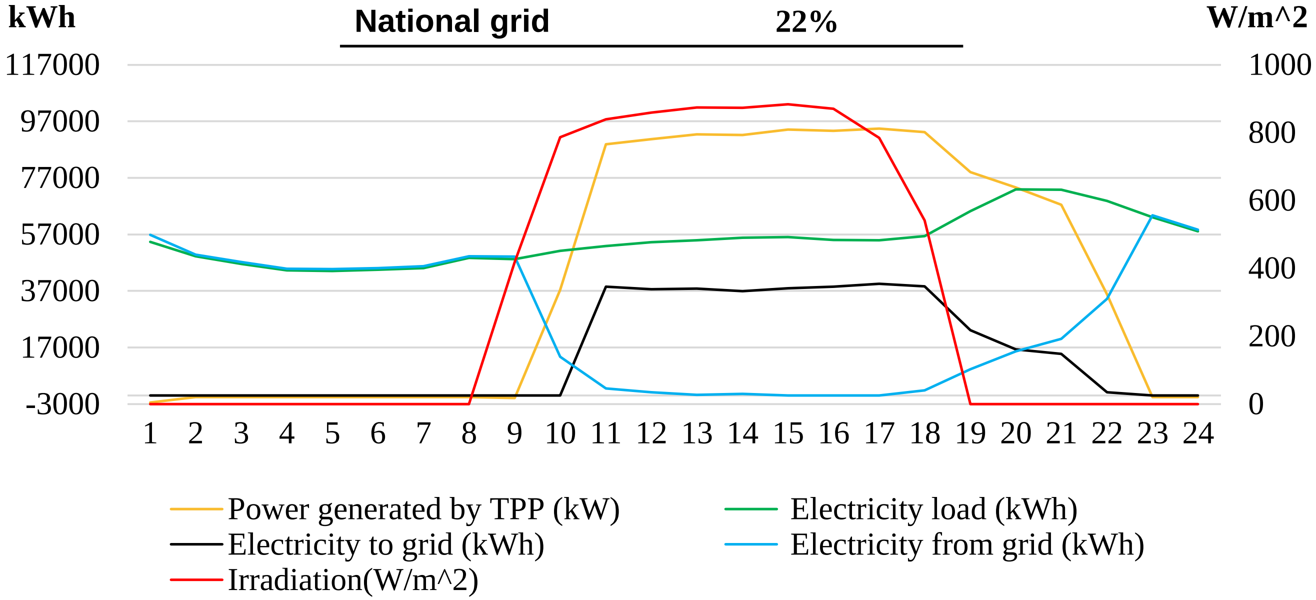


Figure 9: January (winter) electricity supply

August electricity supply

	Covered demand
Power plant	**60%**
National grid	**40%**

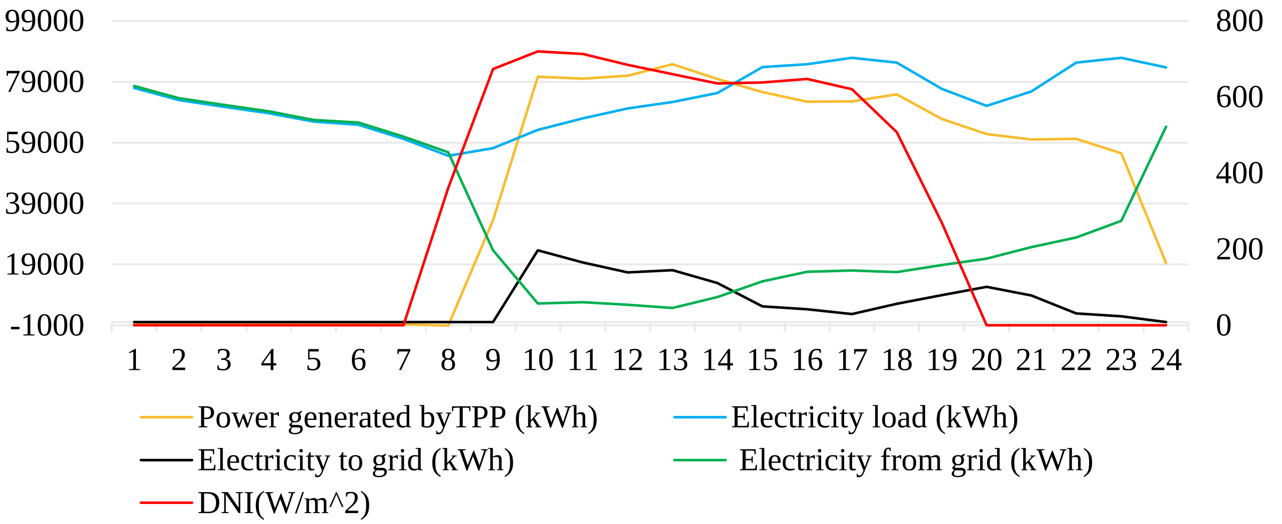


Figure 10: August (summer) electricity supply

Backup charging and discharging

	Load covered during the night
January	91%
August	64%

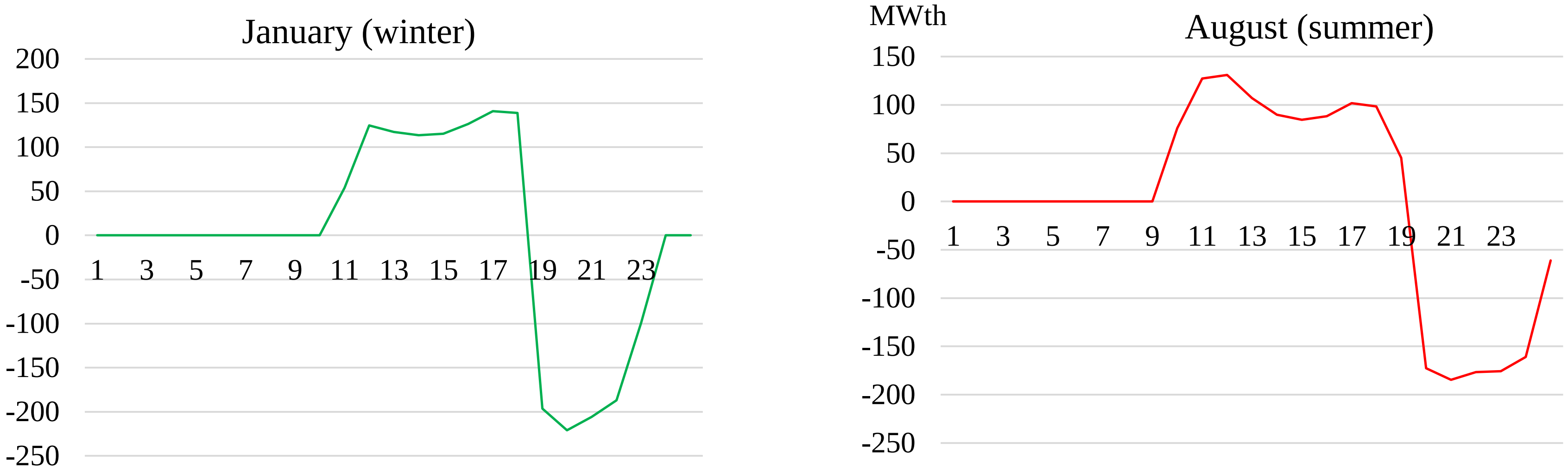


Figure 11: Charging and discharging of the TES

Economic analysis

The levelized cost of electricity was found 0.089 $/kWh with a payback period of 6.39 years and benefit-cost ratio of 1.5.

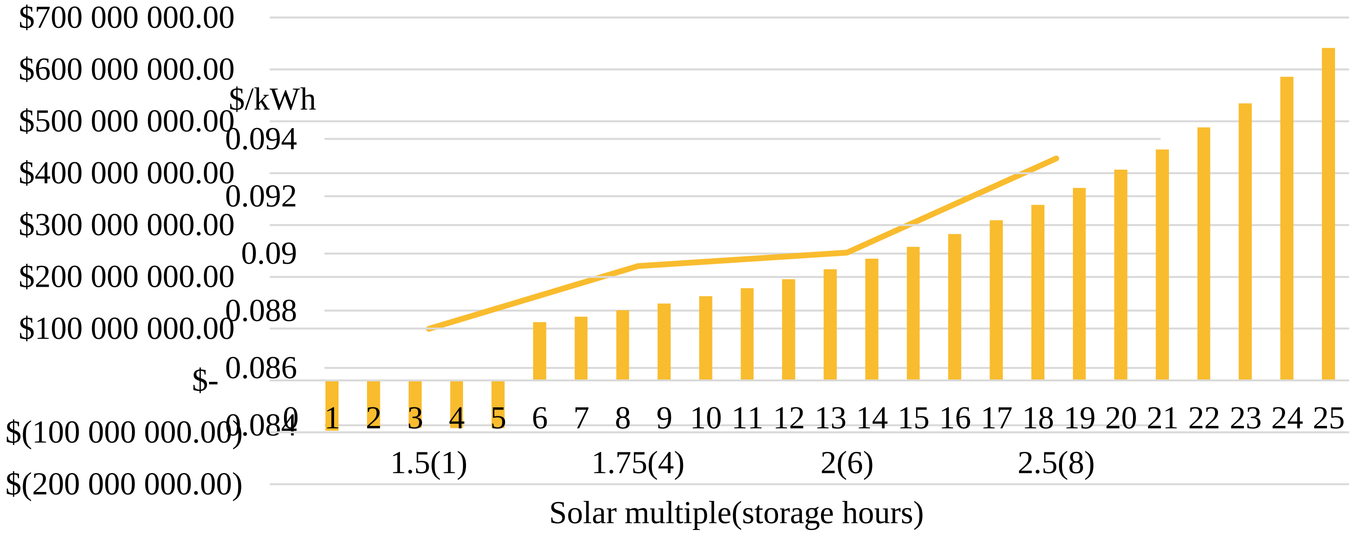


Figure 13: Solar multiple and storage hours effect on LCOE

Figure 12: Cash flow analysis

CO_2 gas emission

It was found that for the same energy generated for one year the combined cycle power plant can produce almost 2 million tons of CO_2 per year

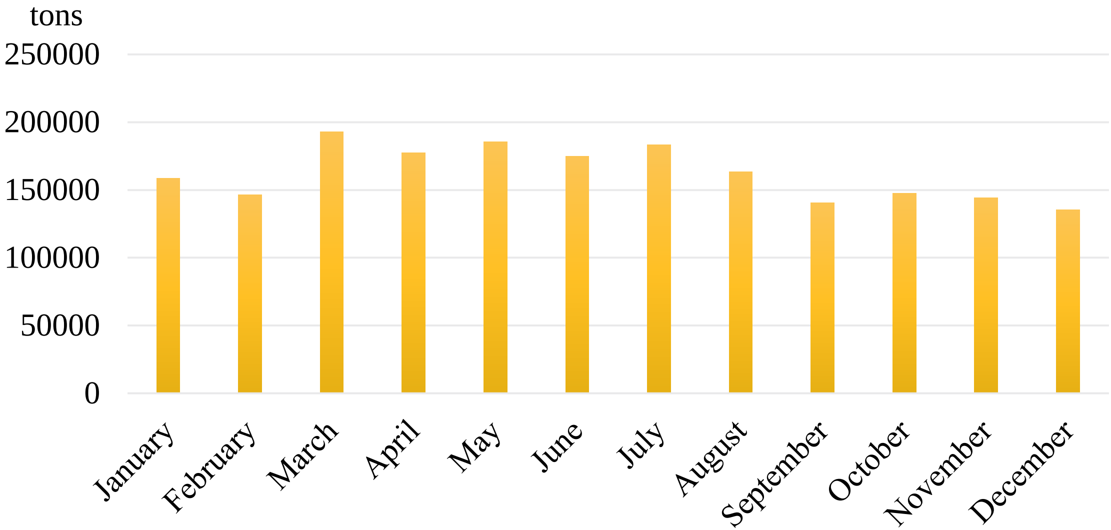


Figure 14: August electricity supply

Conclusion

- For regions where water is a challenge, use of air cooled condensers is the most viable choice.

- Parabolic trough technology can play a very important role to meet the growing electricity demand and mitigate climate change.

- The low Levelized Cost Of Electricity can foster the government's support more the implementation of CSP technologies.


THANK YOU