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ASSESSING THE ECONOMIC VIABILITY OF CONCENTRATED SOLAR POWER WITH THE NATIONAL ENERGY REGULATOR OF SOUTH AFRICA (NERSA) RENEWABLE ENERGY FEED-IN TARIFF (REFIT) SCHEME

C. Chukwuka; K. A. Folly

Intelligent Power and Energy Systems (IPES) Group

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

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INTRODUCTION

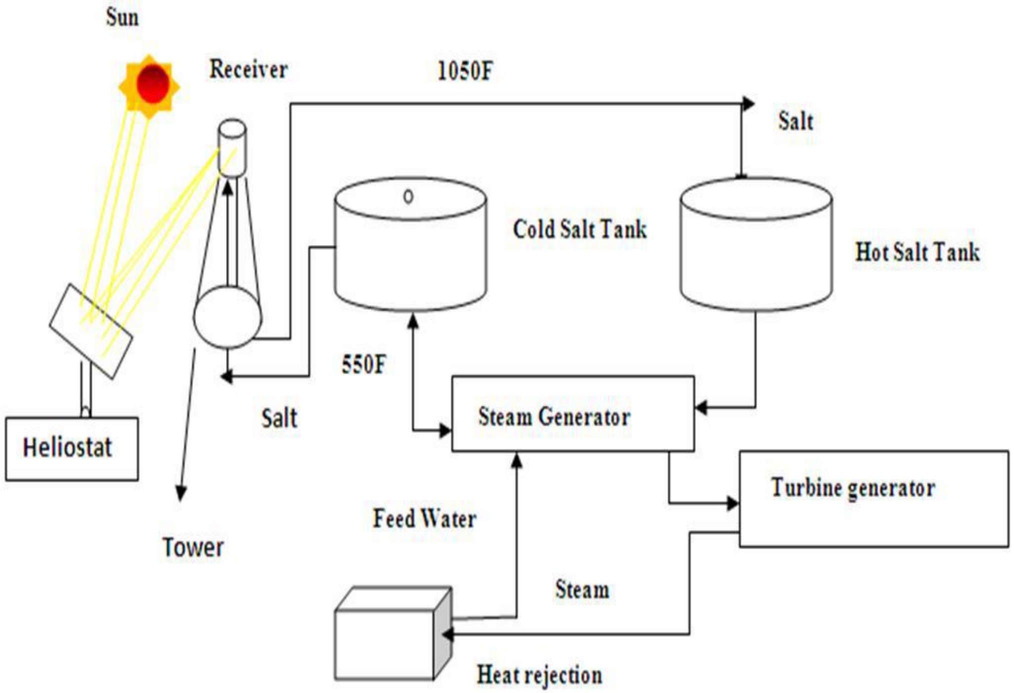


Fig 1: Concentrated Solar power

INTRODUCTION (2)

- The concentrated solar power (CSP) plant produces electricity by focusing the solar flux onto a central receiver. The heat produced is used to drive a steam turbine.
- A typical CSP plant is normally made up of the solar collector, solar receiver, thermal energy storage unit, and the turbine/generator blocks. There are numerous ways these units can be assembled however in order to obtain the optimal set of configuration that would deliver cost effective electricity, a computer simulation method is needed.
- In this work, we carried out an overall system simulation of a molten salt power tower CSP using Systems Advisor Model (SAM)

NERSA REFIT

- The National Energy Regulator of South Africa (NERSA) in March 2009 introduced the Renewable Energy Feed-in Tariff (REFIT)

- REFIT scheme includes technologies such as wind, small hydro, landfill gas, PV, solid biomass, biogas and CSP with and without 6hr storage

- In November 2011, the total renewable energy allocation was increased from 1250MW to 3750MW and the tariffs were revised and reduced between 7.3 to 41.5%

SYSTEMS ADVISOR MODEL (SAM)

- Is a product of the National Renewable Energy Laboratory (NREL) and Sandia National Laboratories first released in 2005.
- Used for technical and financial analysis of renewable energy projects
- SAM accepts inputs such as climate, financials and type of technology and produces outputs such as desired power, cash flow and levelized cost of electricity .

ANALYSIS PERIOD

- The analysis period is the number of years covered by the analysis. This is typically equivalent investment life of the project

- It is the term of the Power Purchase Agreement (PPA) which in this case is 20 years [NERSA pp13, 2011].

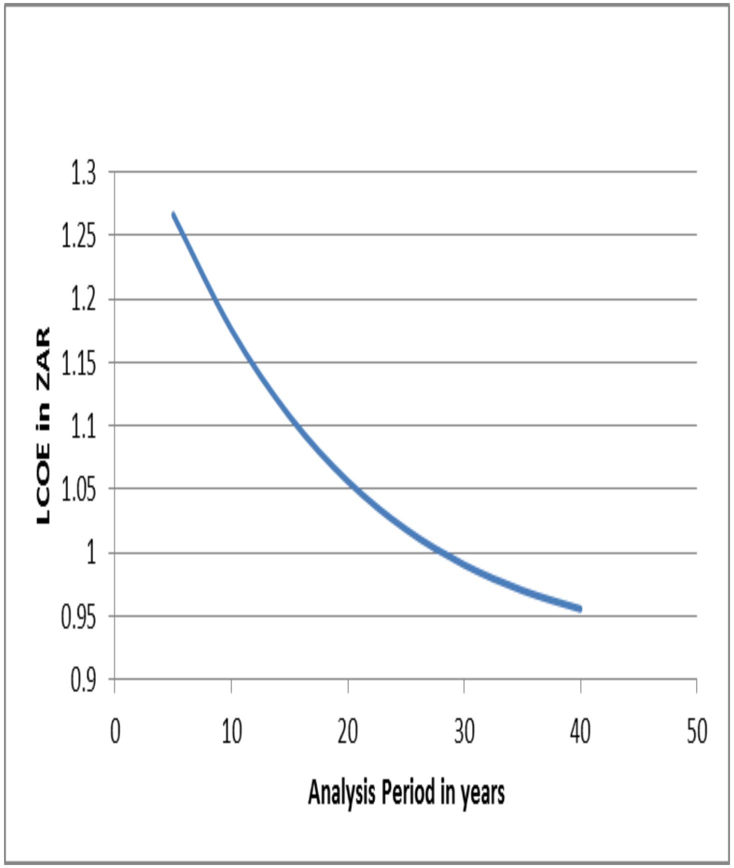


Fig 2: Analysis Period/LCOE

SOLAR MULTIPLE

- Solar Multiple (SM) is the ratio of the receiver`s design thermal output to the power block`s design thermal input.
- For systems with no storage, the solar multiple is equal to one.
- NERSA specifies capacity factor of 40% which corresponds to the solar multiple of 3.2 and thermal storage (TES) of 6 hours as shown in figure 3.
- The capacity factor of a plant is the ratio of the actual amount of energy produced over the maximum energy that it can produce if the plant was to operate at full load hourly round the year (i.e. 8760hrs).

SOLAR MULTIPLE/TES

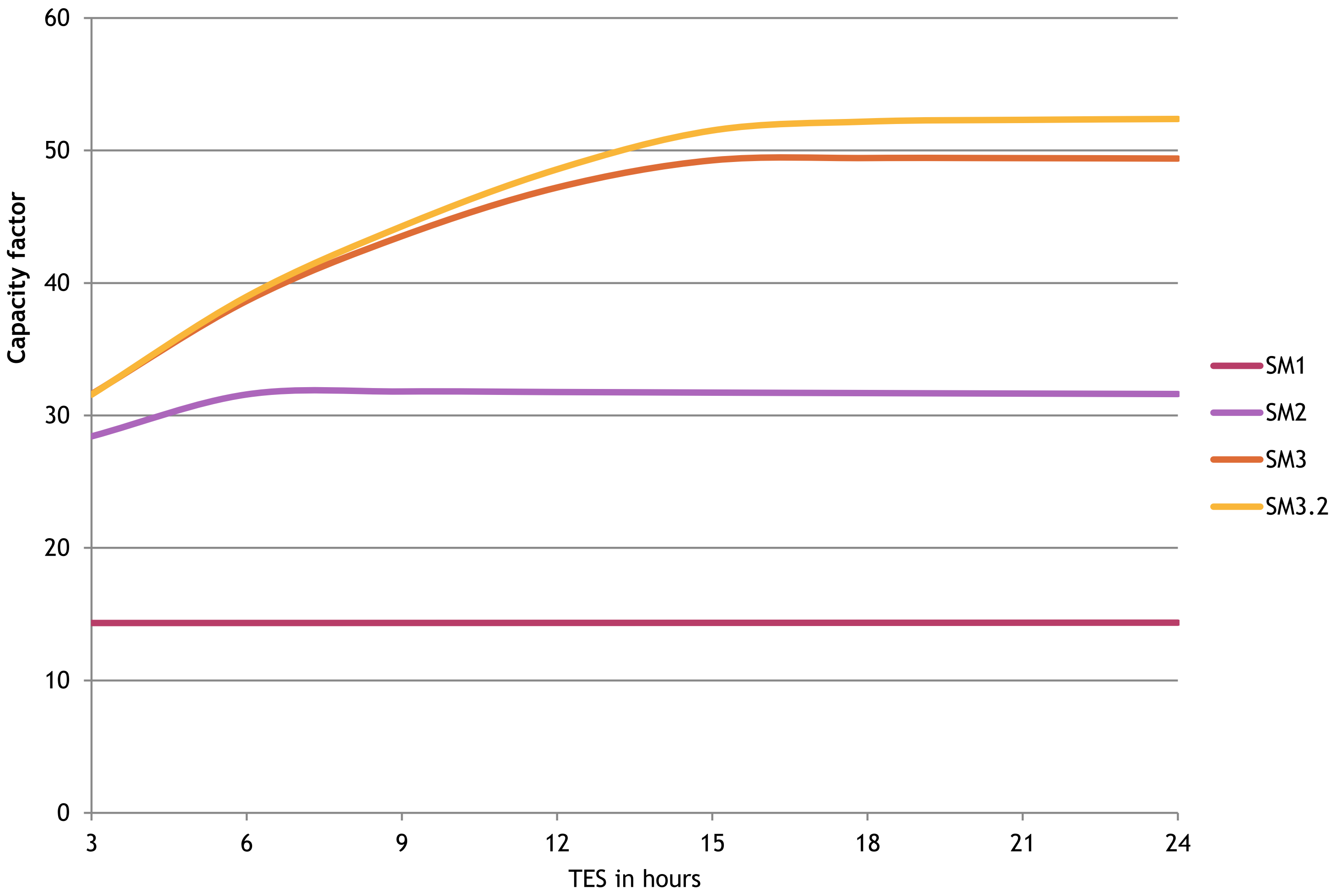
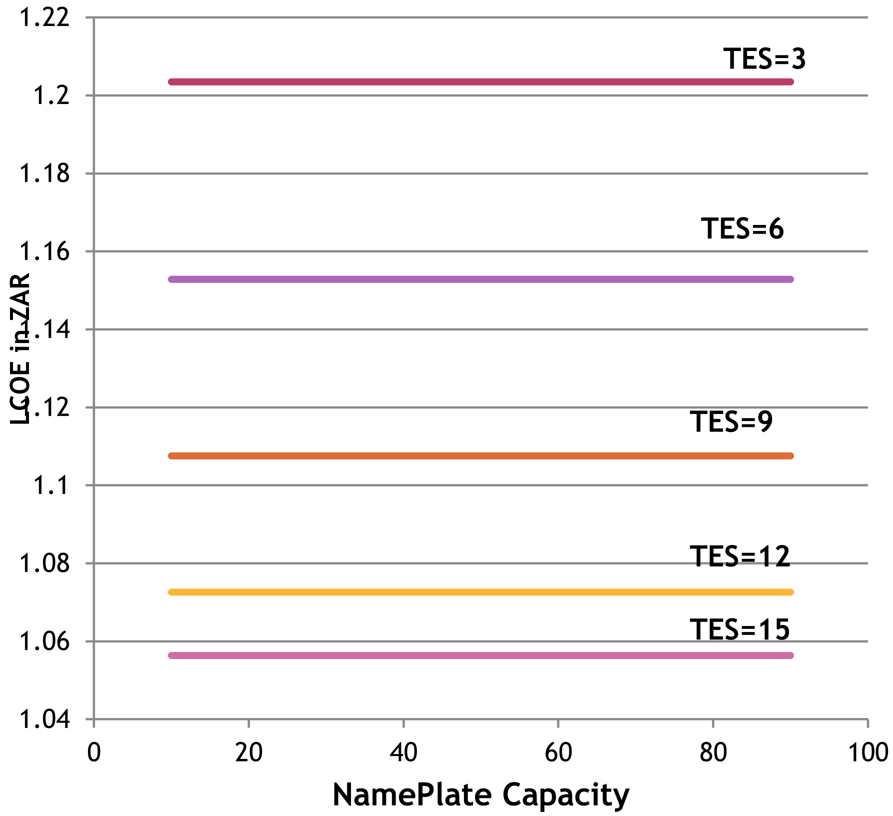


Figure 3: Solar multiple/TES

SENSITIVITY OF LCOE TO NAME PLATE CAPACITY



For plant sizes up to 100MW LCOE shows no significant changes at different TES levels

Figure 4: LCOE/Nameplate Capacity

POWER PURCHASE AGREEMENT(PPA) ESCALATION

Table 1: NERSA Adjustments

CSPCPI adjustments	2011 R/kWh	2012 R/kWh	2013 R/kWh
CAPEX	**1.24**	**1.24**	**1.24**
FOM R/kWh	**0.15**	**0.16**	**0.17**
Fuel R/kWh	**0.0027**	**0.0029**	**0.0030**
VOM	**0.00**	**0.00**	**0.00**
Total	**1.39**	**1.40**	**1.41**

The REFIT or PPA escalation is given by the formula

$$REFIT_{j+1} = Capex_{2011} + (FOM_j + VOM_j + FUEL_j)X\left(1 + RSA_{CPI_j}/100\right)$$

Where:
j = calendar year ≥ 2011
$REFIT_j$= PPA tariff in tear j
$CAPEX_{2011}$ = capital expenditure, Capex, R/kWh
FOM = Fixed Operation and Maintenance in year j, R/kWh
VOM = variable operation and Maintenance in year j, R/kWh
RSA_CPI_j= Actual South Africa CPI for year j

[NERSA pp. 25, 2011]

INPUT DATA

- climate.

Table 2 Climate Data

Location Details	
City	Cape Town
Time zone	GMT+2
Elevation	47m
Latitude	-33.98
Longitude	18.6 deg
Annual Weather Data Information	
Direct Normal Irradiance (DNI) kWh/m2	1923.9
GlobalHorizontalIrradiance kWh/m2	1900.7
Dry-bulb temperature deg C	16.5
Wind speed (m/s)	5.1

OTHER INPUTS

Table 4: Summary of the Inputs

Inputs	values
Climate	Cape Town
Nameplate Capacity	100MW
Inflation Rate	5%
Real discount rate	8%
Loan Term	20
Debt Fraction	70%
Solar Multiple	3.2
Thermal Storage (TES)	15hrs
First year PPA Price	R1.40
PPA Escalation Rate	1.006%
Heat Transfer fluid	Synthetic oil
Condenser type	evaporation
Tax Rate	28%
Loan Rate	6%
Operation and maintenance	R0.16/kWh

RESULTS

Table 5: Results

Metric	Cost
Total Direct Cost	R7,077,000,000
Total Installed Cost	R8,281,000,000
Total Installed Cost per Capacity	R82,560/kW
Net Annual Energy	451,561,665kWh
First year PPA price	R1.39/kWh
LCOE Real	R1.05/kWh
After Tax Net Present value(NPV)	R197,000,000
Gross to Net conversion Factor	0.89
Debt Fraction	70%
Capacity Factor	51.6%
Annual Water Usage	1,217,669m3
Total Land Area	2711.89 acres

SENSITIVITY OF THE LCOE TO THE THERMAL ENERGY STORAGE (TES)

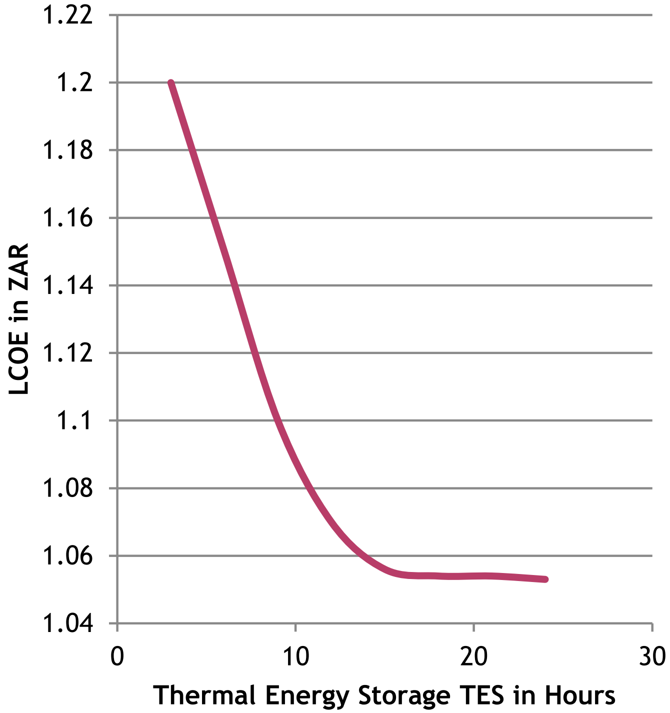


Fig 5: LCOE/TES

Though 6hr storage is suggested by NERSA however the chart in fig 5 shows an optimum storage at 15hr

CONCLUSIONS

- The simulation carried out shows that within the NERSA REFIT tariff scheme CSP is economically viable.
- The size of plant could be scaled between 10 to 100MW without causing a major changes in the LCOE
- For the conditions used in the simulation, the optimal thermal energy storage is 15hrs which indicates that CSP could be used as a base load power plant.

THANK YOU