Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 69 (2015) 1431 – 1440

Energy Procedia

International Conference on Concentrating Solar Power and Chemical Energy Systems, SolarPACES 2014

The South African REIPPP two-tier CSP tariff: Implications for a proposed hybrid CSP peaking system

C.Silinga[a]*, P. Gauché[b], J. Rudman[b] and T. Cebecauer[c]

[a]*Centre for Renewable and Sustainable Energy Studies, Faculty of Engineering, Stellenbosch University, Private Bag X1 Matieland, 7602, South Africa*

[b]*Solar Thermal Energy Research Group, Dept of Mechanical and Mechatronic Engineering, Stellenbosch University, Private Bag X1 Matieland, 7602, South Africa*

[c]*GeoModel Solar, Bratislava, Slovakia*

Abstract

We proposed a case for a short term CSP peaking system of plants for South Africa in a previous study. A virtual hybrid system including planned Open Cycle Gas Turbines and a spatial-size optimized fleet of CSP plants suggests a number of benefits. A progressive rollout exceeding 3,000 MW of CSP in 15 years: mitigates cost of capital; incrementally reduces fuel dependency; leads to a local CSP learning rate; adds reserve margin; and leads to a lower system LCOE.

In this paper, we study the effect that the two tier tariff introduced in the Independent Power Producer programme of the Department of Energy has on a 3,300 MW capacity of CSP plants that is proposed as a peaking CSP system. We use the same spatial-temporal analysis approach as conducted in the earlier study.

Two scenarios are developed and presented in this study in order to determine the implications of the two-tier tariff structure. The profitability – Levelized Profit of Energy of the CSP system is used as criteria for validation. Scenario 1 is based on the previous peaking CSP study load profile. It shows that the two-tier tariff structure generates 29 % less revenue than the fixed tariff. Scenario 2 is based on the re-optimized energy delivery from CSP system. This scenario shows that re-optimized energy delivery approach of CSP system makes the CSP system more profitable under the two-tier tariff structure.

Peer review by the scientific conference committee of SolarPACES 2014 under responsibility of PSE AG

Keywords: Concentrating Solar Power (CSP), Peaking CSP system, Levelized Cost of Energy (LCOE), Levelized Cost of Profit (LPOE)

* Corresponding author. Tel.: +27 (0)21 808 3605; fax: +27 (0)21 883 8153.
E-mail address: cebo@sun.ac.za

Peer review by the scientific conference committee of SolarPACES 2014 under responsibility of PSE AG
doi:10.1016/j.egypro.2015.03.119

1. Introduction

In a previous study, "Scenario for a South African peaking system", here in referred to as "peaking CSP study" we proposed a case for a short term CSP peaking system of plants for South Africa [4]. A virtual hybrid system including planned Open Cycle Gas Turbines (OCGT) and a spatial-size optimized fleet of CSP plants suggests a number of benefits. A progressive rollout exceeding 3,000 MW of CSP in 15 years: mitigates cost of capital; incrementally reduces fuel dependency; leads to a local CSP learning rate; adds reserve margin; and leads to a lower system LCOE. One of the findings/recommendations from the study was that the CSP plant has a potential to be utilized to deliver peak period energy in South Africa. Also, the CSP plant should be utilized in such a way that its dispatchability potential is realized.

In 2010, the Department of Energy (DoE) released the Integrated Resource Plan (IRP2010), which is a policy document that states the energy sources that will be used and new capacity that will be built for electricity generation in South Africa from 2010 – 2030 [1]. The IRP (2010 – 2013) proposed that a capacity of 1 200 MW CSP should be built in this period. The IRP was revised in 2013, released for public comment. The draft IRP proposes that the CSP capacity should be increased from the original 1 200 MW to 3 300 MW.

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) is a programme designed by the DoE that implements the renewable energy allocations of the IRP in SA. In 2013, the REIPPP programme changed the tariff structure of the CSP to a two-tier tariff structure to allow CSP plants to deliver peak energy.

In this paper, we study the effect that the two-tier tariff structure, introduced in the Independent Power Producer (IPP) programme of the DoE has on a fleet of CSP plants. In the previous study, we used the national load demand to assume the peak load in order to determine the dispatchability potential of the CSP plants, and to answer the following question: is the operation of CSP plants based on time variable feasible in South Africa? The answer was yes. The question at hand now is; will the two-tier tariff structure make the CSP system more profitable in South Africa? We use the same spatial-temporal analysis approach as conducted in the earlier study.

The following section of this study gives the background of this study. Subsequent sections describe the previous work on the scenarios for a peaking CSP system, current work on the tariff based operation of the CSP system. Final sections present the results and conclusions of the current work.

Nomenclature

E_t	electricity generation in year t	M_t	O&M expenditure in year t
EI_t	energy income in year t	n	life time of the system
F_t	fuel expenditure in year t	r	discount rate
I_t	investment in year t		

2. Background

The REIPPPP is responsible for allocating capacity for various renewable energy technologies. The IPPs submit bids for the systems that they intend to build depending on the capacity allocation [2]. Table 1 shows the CSP projects of the IPPs that are developed under the REIPPPP. These are projects from the first, second and third bidding rounds.

Table 1 IPP projects for the REIPPPP [2].

Name of Plant	Bidding round	Type of Plant	Capacity (MW)	Energy Storage (hours)
KaXu Solar One	1 (single tariff)	Parabolic Trough	100	3
KHI Solar	1 (single tariff)	Central Receiver	50	2
Bokpoort	2 (single tariff)	Parabolic Trough	50	9
Xina	3 (two-tier tariff)	Parabolic Trough	100	5
Ilanga	3 (two-tier tariff)	Parabolic Trough	100	4.5

For the first and second bidding rounds, the REIPPPP allocated a capacity of 200 MW to CSP. During the first bidding round, projects totalling up to 150 MW was awarded to CSP. The second bidding round awarded the remaining 50 MW to CSP. The tariffs for the first and second bidding rounds were capped at 2 850 ZAR/MWh. During round three, a further 200 MW capacity was allocated to CSP. The new tariff structure for CSP was introduced for CSP during the third round and is determined as follows: 1 650 ZAR/MWh for off-peak generation – 4:00 am to 4:29 pm, 9:30 pm to 10:29 pm and a multiplier of 2.7 for generating during peak hours – 4:30 pm to 9:29 pm. The tariff for the night time – 10:00 pm to 4:59 am is 0.00 ZAR/MWh. The third round tariff structure promotes the dispatchability of CSP plants. Also, it raises a question: what is the optimum operation method of the CSP plant in order to deliver optimum energy value?

In 2012 we conducted a study about the dispatchability potential of CSP plants. The study investigated the feasibility of utilizing CSP plants as peaking plants in South Africa. In that study we proposed a fleet of CSP system with the total capacity of 3 300 MW [4]. At that point in time, the REIPPPP in South Africa was based on the fixed tariff structure. The study established that the current CSP capacity allocation of 1 200 MW in the IRP in not sufficient [1]. The most significant findings of the study was that the CSP can guarantee dispatchable energy and can deliver energy at competitive costs. Also, that the CSP plant has a potential to be utilized to deliver peak period energy in South Africa in a short term.

The IRP is undergoing revision. The draft IRP update was released during the last quarter of 2013 for comment. According to the DoE, the final IRP will be submitted to cabinet for approval in 2014 [3]. The draft IRP proposes that CSP capacity should be increased from the initial 1 200 MW capacity to 3 300 MW (coincidentally the same capacity as the CSP peaking study but unrelated).

This is the context that informed the undertaking of this study. In this work, several scenarios are investigated in order to evaluate possible benefits and drawbacks of the two-tier tariff structure on a distributed CSP peaking system for South Africa. The technical model that was used for the peaking study will be adapted for this study [4].

3. Previous work

The “Scenario for a South African peaking system” study [4] focused of the dispatchability potential of the CSP systems. This was done by modeling a contemporary central receiver system using a model developed by Gauche [5], [6]. The criteria that were used to validate the study were the energy costs and guarantee of energy from CSP system. The energy costs of the OCGT were compared to the energy costs of the peaking CSP system.

The study investigated three scenarios; scenario 1 – OCGT scenario, scenario 2 – CSP system scenario with the option of electricity buy back. The concept of electricity buy-back considers arbitrage by buying electricity from the grid to charge the thermal storage. Scenario 3 – the virtual hybrid system of CSP system and the OCGT system. The OCGT system scenario considered the OCGT system which is currently used as a peaking system in South Africa. The LCOE of the OCGT system was then used as a measure of the feasibility of peaking CSP.

The CSP and electricity buy-back scenario consider the proposed CSP system and the purchase of electricity to heat thermal storage. The electricity buy-back concept has been studied before [7] and [8].

The model assumed that during the periods where the CSP plants are unable to deliver peak energy, electricity would be purchased from the grid to heat up the molten salt based on weather prediction. Electricity would be purchased during low tariff periods and sent to the grid during high tariff periods. The proposed CSP system had a LCOE of 1.89 ZAR/kWh, Fulfilment coefficient of 0.82 and Curtailment coefficient of 0.06. When considering the electricity buy-back, the LCOE of the combined system increased to 3.00 ZAR/kWh.

The virtual hybrid system where the CSP is used with the OCGT system had a combined LCOE of 2.52 ZAR/kWh. Figure 1 shows the fuel sensitivity of scenario 1 and scenario 3. Due to lower capacity of the OCGT when used with the CSP, the LCOE increased to 5.30 ZAR/kWh. Figure 1 which is derived from the peaking CSP study has different values from the original figure. Figure 1 below assumes zero inflation, hence the OCGT LCOE starts at 3.69 ZAR/kWh as compared to the 5.00 ZAR/kWh in the peaking CSP study which assumes 5 % inflation in diesel costs.

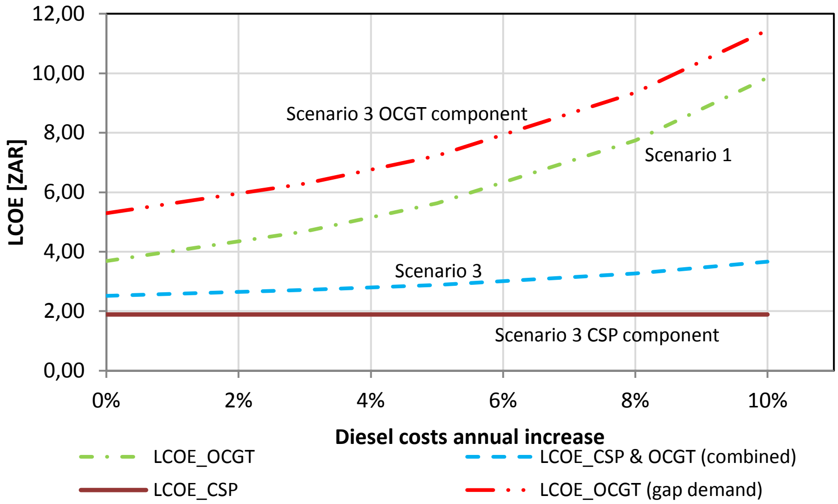

Figure. 1. LCOE fuel sensitivity of the OCGT system

3.1. Model description

This study consists of the technical model and financial model. The CSP technical model that is used in this study is a systematic model of a CSP tower system. It is the same model that was used for the peaking CSP system [4] [5] and [6]. The average hourly solar resource data is used as inputs to evaluate the plant performance. This type of modeling evaluates the plant performance by considering the optical to thermal energy conversion. The key inputs for the modeling purposes are: the DNI solar resource, the solar field configuration, ambient temperature, wind speed and the receiver operating temperatures. The model aims to generally replicate the Gemasolar plant with the understanding that it is a real plant proving the ability to dispatch [9].

The first requirement of the plant model is the continuous determination of sun position. The solar time, which is based on the angular motion of the sun across the sky, is derived and it contains standard time, longitudinal corrections and the equation of time. From the solar time, the hour angle which is the conversion of solar time into angle is derived. After that the zenith angle and the azimuth angles are derived.

These angles provide the incidence ray to the heliostat module and the receiver atop of the tower provides the reflected incidence target. The implementation of the position of the sun as well as the remaining model description has been documented by Gauché [5].

The thermal energy from the receiver is sent to the Thermal Energy Storage (TES) and it is delivered to the turbine’s steam generator during the peak period.

The commercially available TES show a round trip efficiency of 95 % [10]. This gives an average loss of 5 %/24 hours or 0.2 %/hour. The model for this study assumes a 90 % round trip efficiency for the TES. This gives an average loss of 10 %/24 hours or 0.5 %/hour.

The model is more conservative in a sense that it assumes more losses than what is recorded for commercially available TES. The model assumes a TES charge efficiency of 95 %.

In order to determine the performance of the steam turbine, a theoretical Chambadal-Novikov, modified Carnot efficiency is used. This has been because no specific turbine is selected for this study. The high temperature reservoir is the hot salt temperature and the low temperature reservoir is the ambient temperature, assuming dry cooling is used.

4. Current work

The current study is a continuation of the previous proposed peaking CSP study, specifically focusing on the energy delivery from CSP without the option of electricity buy back or virtual hybrid. In that study, three interrelated plant parameters were considered in order to determine the optimal CSP system; storage capacity, solar field and the turbine capacity. The focus of the study was on the design of the CSP system by considering the lowest LCOE of the system. In this paper we study the implications of the two-tier tariff structure on the proposed CSP system. Specifically, the previously proposed CSP system is optimized to deliver energy based of tariff structure in order to maximise profit. The concept of optimization of time variable operation of CSP plants for electricity generation has been investigated before [7]. The focus of that was to investigate the potential of the CSP plant to generate electricity based on fluctuating electricity prices.

The idea of considering the electricity buy-back for the peaking CSP study was to guarantee peak energy from the CSP system. However, it has not been considered for the current study. We acknowledge that it might have more value and might make economic sense to consider it for the two-tier tariff structure, provided that the law allows it.

4.1. LCOE

Levelized Cost of Energy (LCOE) is used to determine the energy generation costs of the CSP system in this study. Utilizing the LCOE to compare the different energy generation technologies is adequate because it allows for technology comparison based on the weighted average costs basis. The LCOE does not capture the daily fluctuations in demand and supply, which are seen as true value of energy [11]. However, the LCOE allows different technologies to be compared or equated based on average costs basis [11].

The definition of LCOE is shown by equation (1) and is commonly used in the electricity sector. It is adapted from the IRENA report on RE systems costs analysis [12]. The capital costs expenditure costs and the operation and maintenance costs for the CSP system is obtained from the SANDIA report on CSP tower costs reduction plan [13]. The LCOE model assumes 8 % interest rate on the loan and 10 % discount rate. The predicted lifetime of the energy systems is 30 years.

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \qquad (1)$$

4.2. LPOE

The emphasis on the peaking CSP study was on the energy generation costs of the modelled energy systems. The LCOE of the energy systems was used as criteria to determine the feasibility of the CSP system. In this study, the focus is on the energy profit of the CSP system.

This is done in order to determine the implications of the two-tier tariff structure on the proposed CSP system by establishing the profitable configuration. The Levelized Profit of Energy (LPOE) is used to determine the feasibility of the CSP system. The definition of the LPOE is shown in equation (2). This concept considers the total income from the CSP plant over the life time of the plant, and the total capital and operational costs of the CSP plant over the lifetime of the plant. These parameters are levelized by factoring the time value of money and the loan discount rate of 10 %.

$$LPOE = \frac{\sum_{t=1}^{n} \frac{EI_t}{(1+r)^t} - \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \tag{2}$$

4.3. Scenario 1(peaking CSP system)

The proposed peaking CSP system was optimised for the lowest LCOE. The load demand was assumed from the South African national load demand. This was done by taking 90 % of the daily maximum hourly demand as base load or mid-merit limit. Anything above that was considered to be peak load. This made it easier to determine the fulfilment and the curtailment of the CSP system. In this study, we consider the same load demand and the proposed CSP system to determine the implications of the fixed tariff and the two-tier-tariff. The criterion used is the income generated by the peaking CSP system based on these tariff structures. The analysis shows that the two-tier tariff structure generates 29 % less income as compared to the single tariff under identical operating conditions, when the load demand is not optimized for the two-tier tariff. This is remarkable given the large drop in the base tariff structure, the complete lack of revenue for 8 hours of the day and no re-optimization for maximizing revenue in the direct comparison.

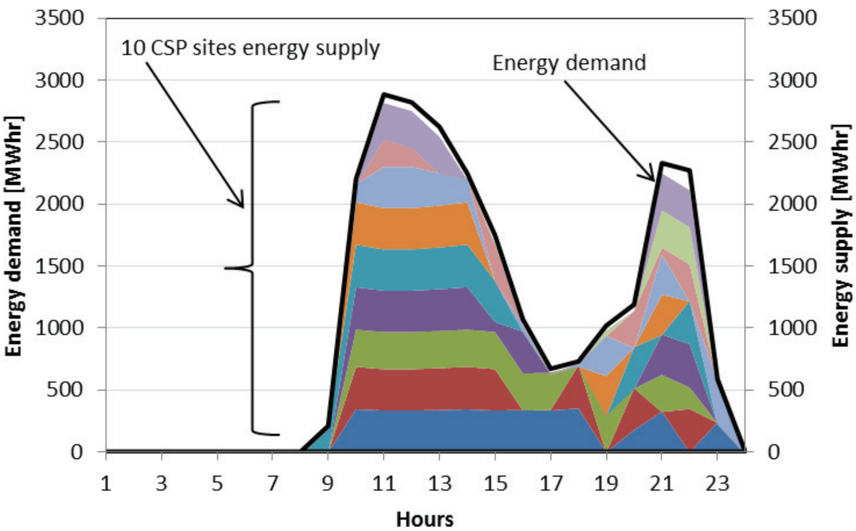

Figure. 2. Peaking CSP system load profile and energy supply operational configuration

The peaking CSP study considered the electricity buy-back concept. However, for this analysis, only the energy generated form the CSP system was considered. Figure 2 shows the assumed load profile of the peaking CSP study and the energy delivery from 10 CSP plants. Even though Figure. 2 shows one-day operation of the CSP system, however, it is clear that the high tariff periods for the two-tier tariff do not coincide with the highest load demand.

This results in more energy being sent to the grid during standard tariff period. In order to maximise the profit of energy from the CSP system, the energy generation of the CSP system needed to be optimised to deliver energy during high tariff periods.

4.4. Scenario 2 (re-optimized energy generation)

The CSP operation in this scenario is re-optimized for the new two-tier tariff structure. This scenario analysis looks at the potential of CSP system to be profitable and the best operational method in order to maximise profit. The re-optimized operation of the CSP system is analysed to establish profitability of the CSP system based on the two tariff structures; fixed tariff and the two-tier tariff structure. The two-tier tariff structure consists of the two periods, the standard and the peak period.

For the two-tier tariff structure, the CSP system operation is optimized for the highest paying tariff. The CSP plants deliver minimal or no energy during the standard period and deliver maximum energy during the peak period. During standard periods, CSP plants are operated at part load in order to allow for charging the thermal energy storage tank during hours of low demand and discharging during hours of high demand to take advantage of the two-tier tariff structure. Figure 3 illustrates the two-tariff structures and the two energy generation operation of the CSP system. Non-optimized energy generation operation, in this case, the CSP plants would be operated at full capacity all the time, irrespective of the tariff period. Optimized energy generation operation, the CSP system is re-optimised for the higher tariff during this time. During the day (standard tariff period), the CSP is operated at part load and it is operated at full capacity during the peak period. The energy generation operation does not mean the load demand, however, it is the operation that the CSP system – proposed energy delivery. Part load in this case means running part of CSP fleet (operating some CSP plants while other CSP plants are charging the storage) rather than part load on each plant. This results in a flat load profile that coincides with the two-tier tariff structure.

For this study, the proposed peaking CSP capacity is modelled. In this case, the optimization of CSP energy generation implies that only the storage sizes are changed. The optimization is not a comprehensive optimization of the configuration of CSP plants. The turbine size and the solar fields are kept the same as per the peaking CSP study.

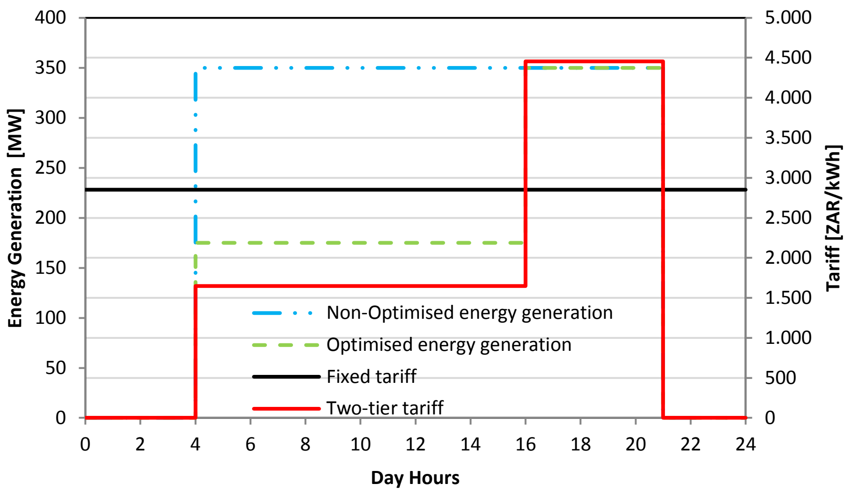

Figure. 3. Optimised and non-optimised energy generation and the two different tariff structures

5. Key results

The first consideration was to look at how the part load plant operation affects the LCOE of the CSP system. Few factors affect the LCOE of the proposed peaking CSP system. The first is the storage capacity that is altered which affects the capital expenditure.

Secondly, due to part load operation – reduced daytime energy generation, fewer energy is generated which slightly increases the LCOE. When the CSP system is not optimized to deliver energy based on the two-tier tariff, and not operated at part load during the standard tariff period, the 4 hour storage size looks feasible, with the lowest LCOE. This is due to the fact that there is no incentive to store energy during the day when the standard tariff applies. Only excess energy is stored and delivered during the evening. The analysis shows that the LCOE ranges between 1.64 ZAR/kWh – 2.86 ZAR/kWh for various storage configurations. For part load operation, the LCOE ranges between 1.64 ZAR/kWh – 2.07 ZAR/kWh. This is based on the part load ratio of between 1.0 – 0.2. For the part load operation, a bigger storage is required and the 4 hours storage has the highest LCOE.

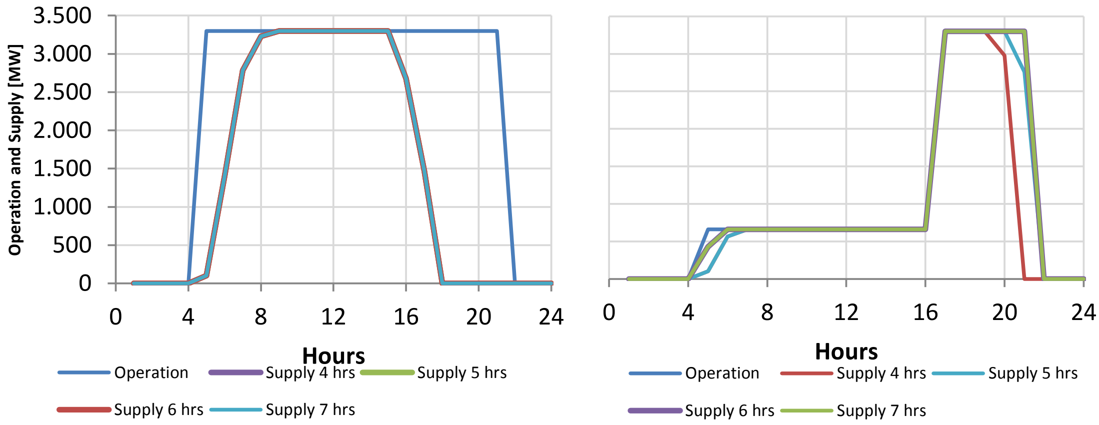

Figure. 4. (a - left and b - right) energy delivery operation and the energy supply of CSP system at full load (a) and part load (b)

The Figure. 4 (a and b) shows the energy delivery operation of the CSP plants and the energy supply based on various energy storage configurations. The energy delivery operation indicates how the CSP system would be operated to maximise profit. The energy supply shows the energy that is delivered by the CSP system and how much of the evening peak is missed due to energy generation during the day. Figure. 4 (a) shows the operation at full speed and (b) shows the operation at part load – 20 %.

During the full speed operation, energy is delivered to the grid during the day, based on the availability of the solar resource. Limited amount of energy is stored and delivered to the grid during peak hour. During full speed operation, the CSP system with all various storage systems follows the same profile. In this operation, the storage configuration does not make a difference because the turbine is operated at full speed. This operation does not yield to high profit. However, more energy is generated and sent to the grid as compared to the part load operation.

When CSP plant is operated at part load by reducing energy generation during the day, the bigger storage sizes make profit. Figure. 4 (b) shows the operation of the CSP system at part load and the energy supply of the CSP system based on various storage configurations. When the CSP system is operated at 20 % part load, the energy delivery coincides with the two-tier tariff structure.

Figure. 5 shows the LPOE based on various storage size. For the 4 hour storage system, the CSP system is at a break-even point with no profit generation when not operating at part load. The rest of the storage sizes are not profitable at full speed/load operation. However, the part load operation of the CSP plant makes it profitable.

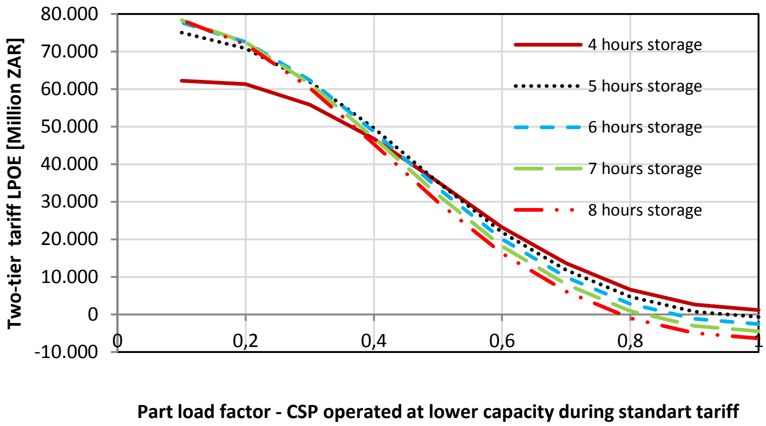

Figure. 5. Two-tier tariff LPOE sensitivity

The full load yields to higher amounts of energy being delivered to the grid. This energy is sent to the grid during standard tariff period and some is sent to the grid during peak period. However, due to limited amount of energy being sent to the grid during peak period, this operation results in low profit. The part load operation yields less energy delivered to the grid. However, it results in high profit. Energy is stored during the day and delivered to the grid during peak period. Figure. 6 shows the energy supply of part load and full load operation which results in curtailment at lower part load operation and in less energy being sent to the grid.

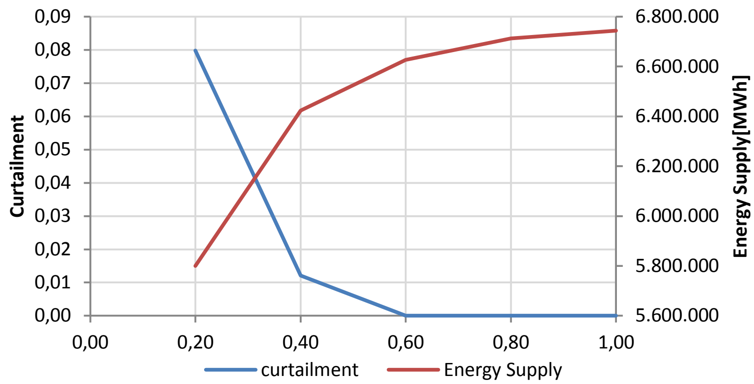

Figure. 6. Energy supply and curtailment for different energy delivery operations.

6. Discussion

The analysis of the CSP system reveals that it would be economically feasible to operate it under the two-tier tariff. Profitability of a CSP system is possible through part load operation. Also, what is revealed by the analysis is that there is a potential for designing the CSP plant to maximise profit from both the two-tier tariff and the fixed tariff. When looking at the re-optimized energy generation of the proposed peaking CSP system capacity, the two-tier tariff generates 2 % more profit when operated at 20 % part load as compared to the fixed tariff. This means the same CSP system capacity can be profitable and adaptable to different tariff structures. The study shows that the CSP system is able to deliver peak period energy while remaining profitable with both tariff structures. The current two-tier tariff structure is not seasonal, it would be interesting to see the implications of the seasonal two-tier tariff structure.

7. Conclusion

A study on implications of the two-tier tariff structure on the proposed peaking CSP system has been conducted. Two sets of scenarios have been developed and presented to determine the profitable tariff structure. The first scenario is based on the peaking CSP study load profile. The analysis shows that the re-optimised CSP operational configuration makes it feasible for the two-tier tariff structure. This is done by operating the CSP system at part load. Part load operation means running part of the fleet rather than part load on each plant. When considering the proposed peaking CSP system and operating in on part load, the LCOE increases from 1.64 ZAR/kWh to 2.07 ZAR/kWh for 20 % part load operation. However, for the same part load operation, the LPOE increases to ZAR 72 467.00 Mio from ZAR -3 062.00 Mio. At 20 % part load, the two-tier tariff generates 2 % more profit than the fixed tariff. This analysis reveals that the proposed peaking CSP capacity, with 7 hours storage capacity can be profitable under the two-tier tariff structure. It is thus possible to maximize the profitability and feasibility of different CSP system designs by balancing the load of the CSP plant with specific storage capacity according to the determined tariff structure. The study shows that the proposed peaking CSP system can deliver peak period energy and it is still profitable and reduces the national energy costs.

Acknowledgements

The authors would like to thank Centre for the Renewable and Sustainable Energy Studies (CRSES) and the Solar Thermal Research Group (STERG) at Stellenbosch University for funding the resources to perform this work and present it at SolarPACES. SolarGIS data © 2012 was generously supplied by GeoModel Solar s.r.o. making it possible to complete this project. The advice and support from Prof Wikus van Niekerk (CRSES).

References

[1] IRP 2010. Integrated Resource Plan for electricity 2010 - 2030. Government Gazette, Republic of South Africa; 2011.
[2] Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). Department of Energy, Republic of South Africa. http://www.ipprenewables.co.za/
[3] Draft IRP 2013. Integrated Resource Plan 2010 Update. Department of Energy, Republic of South Africa. 25 March 2014, [Online]. Available: http://www.energy.gov.za/files/irp_frame.html
[4] C. Silinga and P. Gauché. (2013). Scenarios for a South African peaking CSP system in the short term. SolarPACES. Las Vegas, USA 2013.
[5] P. Gauché, et.al (2011). Modeling Methodology for Macro Decision Making – Emphasis on the Central Receiver Type, SolarPACES. Granada, Spain 2011.
[6] P. Gauché, et. al. (2012). Modeling dispatchability potential of CSP in South Africa. SASEC 2012. May 2012.
[7] E. Lizarraga-Garcia, et.al (2013). Optimal operation of a solar-thermal power plant with energy storage and electricity buy-back from grid. Energy, vol. 51, pp. 61–70, Mar. 2013.
[8] C. Kost, et.al (2013). Concentrating solar power plant investment and operation decisions under different price and support mechanisms. Energy Policy, vol. 61, pp. 238–248, Oct. 2013.
[9] J. I. Burgaleta. Gemasolar Thermosolar Plant. NREL Concentrating Solar Power Projects - Gemasolar Thermosolar; 2011
[10] P. Denholm and M. Mehos. Enabling Greater Penetration of Solar Power via the Use of CSP with Thermal Energy Storage; 2011.
[11] C. D. Kost, T. Schegl, J. Thomsen, S. Nold, and J. Mayer. Levelized Cost of Electricity Renewable Energies; 2012.
[12] IRENA. Renewable Energy Technologies: cost analysis series. International renewable Energy Agency; 2012
[13] G. J. Kolb, C. K. Ho, T. R. Mancini, and J. A. Gary. Power Tower Technology Roadmap and Cost Reduction Plan: SANDIA report. 2011.
[14] GeoModel. SolarGIS data © 2012 GeoModel Solar s.r.o; 2010.
[15] Eskom, source unknown, 2012.