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Performance of Solar Contribution in Hybrid Parabolic trough Power Plants on Solar Extraction System in Algeria

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A B S T R A C T

Parabolic trough power plants have been developed on several concepts for production of renewable energy in integrated solar combined cycle system (ISCCS) and direct steam generation (DSG). Each concept has their characteristic due to solar energy configuration. Recently, technology for Solar aided power generation (SAPG) is appeared for optimization of these concepts by solar contribution system in hybrid power plants. The aim of this work is thermodynamic analysis on solar hybrid power plants system for ISCCS and DSG concepts. For these concepts, we evaluated the main differences in solar efficiency to electrical power. The solar aided power generation was proposed for evaluating the solar contribution in DSG concept. The study shows that the share of solar contribution in DSG concept is high, for the best method on thermal solar extraction in the DSG concept. Therefore, the optimum value of solar extraction is to preheat the feed water in the heater.These models were evaluated in this work which is simulated on TRNSYS software and System Advisor Model (SAM). The analysis in performance of hybrid concepts and solar contribution in new DSG concept can be evaluated. It was found the best method is solar contribution in the solar hybrid power plants.

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INTRODUCTION

The renewable energy in concentrating solar power is the result of more than fifty years of research and development at universities' laboratories level. Scientists have experimented new approaches to produce electricity via concentrating on solar rays. The rays are diffused in the nature under mild form, so it necessity to concentrate these rays to get high temperature and pressure for electrical power productions. Many concepts for concentration of solar ray were developed. Finally, parabolic trough is the commercial technology.

Algeria is oil state and has a large solar radiation from largest desert in the world. So the New Energy Algeria (NEAL)– has programmed many power projects. The first project is the hybrid natural gas/solar power plant in Hassi R'male at 420 km south of Algiers is in operation since 2011 [1].

The solar power stations with parabolic trough collectors currently account for 94% of the power stations in operartion. It is also the technology privileged for the majority of power stations [2]. The parabolic trough systems were implemented for several concentrated solar power (CSP) technologies; actually two concepts for converting solar to electricity first one is the integrated solar combined cycle system (ISCCS) and second is the direct steam generation (DSG) .Until now the parabolic trough have several concepts in hybridization to increase their efficiency and continuous generation in dark .

Hybridization means the combination of different energy conversion technologies in one system. Combination between solar-fossil hybrid concept is called integrated solar combined cycle (ISCC), where the solar-produced steam is superheated through a waste heat recovery heat exchanger by the use of heat energy of gas turbine exhaust gas [3]. Therefore, discontinuous

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production is the weakness of hybrid system in solar energy; to address this issue, the burner in the exhaust gas turbine may serve as back-up firing when solar power is not available but total plant capacity is demanded [4]. Other target for improving the economics of the solar thermal energy systems is the consideration of efficiently utilizing solar energy and reducing emission of the greenhouse gases [5].

Hybridization is not enough to improve efficiency, the solar contribution is the first factor in their development. The solar contribution evaluation methods based on second law of thermodynamics and thermoeconomic theory were proposed [6]. The evaluated solar contribution in a SAPG system based on exergy analysis ,instead of determination of the share of solar thermal in output cycle efficiency. They proposed a new evaluation method of SAPG system based on the exergy analysis and the characteristics of exergy flows crossing the boundary of the system. They showed with this evaluation method, the contribution proportion of solar energy in a SAPG system can be determined [7].
The integrated solar combined cycle system (ISCCS) initially proposed by Luz Solar International (see Fig. 1) is a typical hybrid system that integrates solar heat and fossil fuel [8]. Solar system produce the vapour that is needed for steam turbine for production of electrical energy. The solar gas turbine system is another promising hybrid solar/fossil technology [9, 10]. This cycle is composed from two gas turbines SGT-800 has open cycle of Brayton type, whose waste thermal heat of gases is recovered in a system of heat exchangers, which is producing vapour in heat recovery steam generator (HRSG) [11].

This concept is called Direct Steam Generation (DSG), so this technique is without Heat Transfer Fluid (HTF) shown in Fig. 2. Direct steam generation is considered a very promising option to increase the efficiency of parabolic trough systems, not only because there is no need of a heat exchanger between the solar field and the power block; but also to the high temperatures can be attained in the collector receivers [12]. This last reason is especially important at present, when new commercial absorber tubes, for working at higher temperatures, have been developed [13].
The DSG technology was tested at the DISS test facility in Almeria Spain [14]. Currently, DSG is built commercially for the first time with parabolic troughs in Thailand [15]. Several studies are realized the economic potential of DSG technology [16, 17]. Results showed that live steam parameters of up to 500°C and 120 bar are the most promising and could lead to reduction of levelized electricity cost (LEC) about 11% [18]. Use of water as an HTF results in elimination of use of expensive synthetic oils and also eliminating the heat exchanger from the power plant [19].

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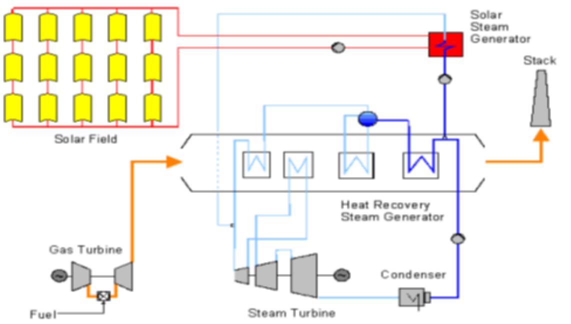

Figure 1. Schematic of the integrated solar combined cycle systems (ISCCS) in conventional configuration, source: Dersch.

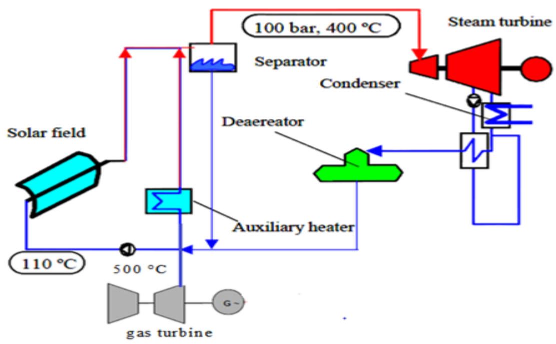

Figure 2. Schematic of parabolic trough plant with the direct steam generation.

Different operation regimes were tested by the European project DISS. These experimental tests were carried out in southern part of Spain, in real solar radiation conditions and have proven the trough capability to generate steam with good conditions for the Rankin cycle operation. The three operation strategies are once-trough, injection system and recirculation system are described in literature [21].

MATERIAL AND METHODS

This work is divided in two parts. At first, we evaluated the simulation of solar hybrid power plants in DSG system compared to ISCCS for validation of the results. Secondly, we evaluated the model of hybrid power plants

DSG on different cycle of steam parameters in several configurations for solar contribution.

The target is to simulate and analyse thermodynamic model similar to ISCCS design [22], which is the base of this work. The SAM and TRNSYS software are used to build the concept for each models of hybrid power plants including the gas turbine, steam turbine, HRSG and solar components. Finally, we evaluate the best parameters in output electricity production by featuring this concept in solar contribution.

Model of solar hybrid power plants

The model selected for simulation based on hybrid station (ISCCS) design Hassi R'male [22] which includes Heat Transfer Fluid (HTF) , with actual operational condition takes into account the weather and the region. This reference plant is located at the south of Algeria in Hassi R'male, province of Laghouat at about 500 km from Algiers. The solar in hot period with Direct Normal irradiation (DNI) can reach to 930 W/m2 .

The solar power plant include the solar field and power block. The power block in conventional combined cycle power plant with two gas turbine on 47 MW SGT-800 in Brayton cycle [22], incorporated with Rankin cycle for a steam turbine on SST-900 [24]. The solar field for 183120 m2 comprises 224 parabolic collectors assembled in 56 loops, 4 collectors per loop and the HTF is the oil, it runs with PTR-70 receivers .

These power plants are modelled and simulated in two commercial codes the SAM [26] and the TRNSYS [27] with a model library STEC developed by DLR; which was used to model the solar components. The design parameters of the each solar power plants are summarized in Table 1.

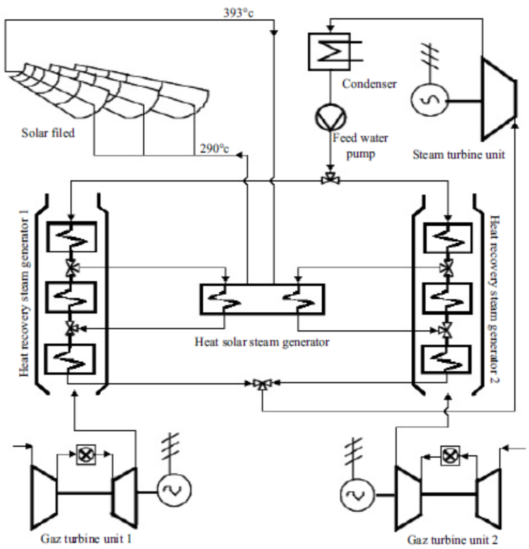

Figure 3. HTF-ISCCS of Hassi R'mmel power plant with simple pressure level [22].

Configuration of the DSG concept in solar contribution system

The component of new concept DSG proposed in configuration is similar to the solar hybrid power plants of Hassi R'male, without Solar Steam Generator and include the receivers for parabolic trough kind PTR-80. This concept is referred for validation of results in solar size initially to produce 200 MW [38].

Two gas turbine units on 47 MW SGT-800 to provide a necessary flexibility in the operation in the night and cloudy day [23]. The steam turbine on SST-900 [24] and the system of heat exchanger include concept that are two heat recovery steam generator (HRSG) to generate steam and gas-boiled for thermodynamic cycle [25].

Table 1. The parameters for each concept DSGand ISCCS

Production	ISCCS	DSG
Gas turbine		
Ambient temperature	35°C	35°
Compressor pressure ratio	20.2	20.2
Compressor isentropic efficiency	0.88	0.88
Inlet turbine temperature	1200°C	1200°C
Turbine isentropic efficiency	0.88	0.88
Exhaust mass flow rate	120, 20 kg/s	120,20kg/s
Exhaust temperature	550 °C	550°C
LHV of natural gas	45778 kJ/kg	45778 kJ/kg
Gas natural mass flow rate	2.46kg/s	2.46 kg/s
Steam turbine		
Inlet steam temperature	500°C	550°C
Inlet steam pressure	83 bars	120 bars
Steam mass flow rate	70 kg/s	70 kg/s
Condensate temperature	52°C	52°C
Isentropic efficiency	0.9	0.9
HRSG		
Fuel mass flow rate	0.66 kg/s	0.66 kg/s
Approach temperature	25°C	25°C
Pressure losses	16 bars	16 bars
Inlet water temperature	60°C	60°C
Thermal efficiency	98.50%	98.50%
Solar Steam Generator		
Inlet water temperature	195°C	-
Inlet water pressure	90 bars	-
Water/steam mass flow rate	22.60 kg/s	-
Pressure losses	5.8 bars	-
Thermal efficiency	98 %	
Parabolic trough		
Area collector	183120 m^2	
Heat transfer fluid		
The receivers type	PTR-70	
Outlet steam temperature	550°C	-
Outlet receivers pressure		
Outlet HTF temperature	392°C	-
HTF mass flow rate	205 kg/s	-
Water/steam mass flow rate	55 kg/s	

The new model of DSG concept proposed include the grid of solar field in receivers PTR-80 which is composed of two parts preheater and superheated; these parts load the water or steam ,the model is presented in Fig. 4 . In the new DSG concept, liquid water from the deaerator is pumped to the proper pressure levels for to feed the feed water heater, at same times preheated on

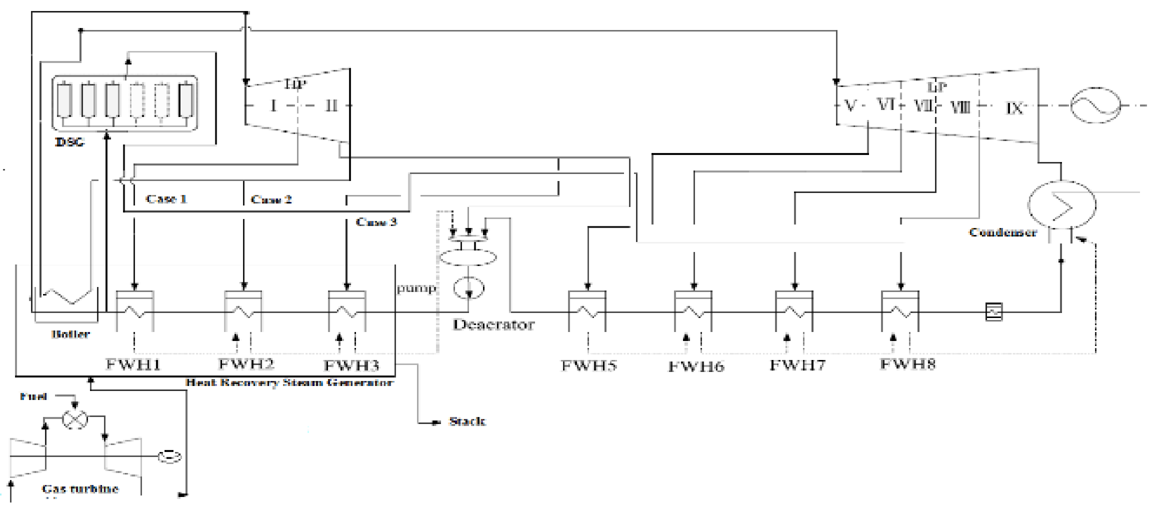

Figure 4. Schematic diagram of a solar contribution on DSG concept, in which solar thermal energy used to preheat the feed water heater.

the first DSG solar field in the saturated case, and then vaporized in the second DSG solar field in superheated case (the solar field is not described in diagram below). When wet steam produced from the solar collectors it separated in a vacuum , the liquid returns to the solar fields, saturated steam is superheated by the gas turbine exhaust gas in HRSG before heading to the steam turbine. After high-pressure stage turbine, the steam returns to HRSG, to be reheated and feeds the next stage steam turbine.

The new DSG concept in configurations for simulation are presented in subsystems, each subsystem include extraction point from solar field to heat the feedwater which is fed the DSG solar filed . In this new concept DSG the feedwater is heated by solar thermal energy carried from parabolic trough; but there is a large loss of exergy. The exergy loss in the heaters can be reduced by increasing the number of extraction stages (and feedwater heaters), so we simulate the best approach for extraction in order to get the best performance efficiency.

Analyses for combined cycle system

The following model is evaluation for thermodynamic analyse of the solar integration system in each configuration. We use the first law of thermodynamics energy balance form should be used for control volume [28]:

$$\frac{dE_{cv}}{dt} = \sum \dot{m}_i \left(h_i + \frac{v_i^2}{2} + gz_i\right) - \sum \dot{m}_o \left(h_o + \frac{v_o^2}{2} + gz_o\right) + \dot{Q}_{cv} - \dot{w}_{cv} \quad (1)$$

The thermodynamic process in a steam turbine is an isentropic transformation. The ideal outlet steam specific enthalpy can be obtained from steam tables because the outlet steam pressure and steam entropy are known. For exergy balance in a control volume, the following equation has been used [28]:

$$\sum_r \dot{Q}_r + \sum \dot{m}_i \left(h_i + \frac{v_i^2}{2} + gz_i\right) = \frac{dE_{cs}}{dt} + \sum \dot{m}_o \left(h_o + \frac{v_o^2}{2} + gz_o\right) + \dot{W} \quad (2)$$

The control volume for irreversibility explanation, in the following equation is used [30]:

$$\dot{I}_{cv} = \left(\sum \dot{m}_i \psi_i - \sum \dot{m}_o \psi_o\right) + \sum (1 - \frac{T_o}{T})\dot{Q}_{cv} - \dot{W}_{cv} \quad (3)$$

In exergy calculation of all cycle equipment, we should calculate all exergy flows. The exergy calculation for single-phase flows such as water or steam flow is easily carried out. For this action following relevance is used [28]:

$$\psi = (h - h_0) - T_0(s - s_0) \quad (4)$$

For transferred exergy by heat [30]:

$$\psi_Q = Q(1 - \frac{T_0}{T} \quad (5)$$

Efficiency of collector receiver for solar field

The DSG plant use the PTR-80 receivers because of higher temperature and pressure (550C° and 120 bars) in recirculation mode as well as to minimize pressure drop over the collector loop.

The ISCCS plant use the PTR-70 receivers are commercialized in worldwide. At this step, we have chosen Algeria area with Tamanrasset city , other worth the area of Tamanrasset is the hot area in Algeria with direct normal irradiation 2600 kWh/m2/ year .

The simulation model for the parabolic trough collectors using water-steam as heat transfer fluid, has already been developed and validated in other work [31]. Another model for the parabolic trough, their cycle is activated in a central water boiler heated by the oil coming from the solar field [30].

The efficiency of collector η_{col} is given by the Hottel-Whillier Bliss equation [11], it is defined as;

$$\eta_{col} = \frac{Q_{col,net}}{DNI \ \cdot A_{col}} \tag{6}$$

Qcol,net (kWth) is the net heat gain per collector loop is the energy balance applied to the troughs; it allows the calculation of the thermal power transferred to the fluid as a function of the impinging Direct Normal Irradiation (DNI) on the tube is defined as follows;

$$Q_{col,net} = [[DNI \cdot f\rho\alpha] - [U_A\,(T_b - T_m)/ C] - [\varepsilon\sigma(T_b^4 - T_m^4)/C]] \cdot A_{col} \tag{7}$$

where ηcol is the collector efficiency; DNI (kWth) is the incident direct normal irradiation to the collector aperture area.

- A_{col} (m^2) is the total collector area of the solar field.
- ρ is the reflection coefficient of mirror 0.85.
- α is the absorption coefficient of pipe 0.96.
- U_A is the heat transmission index of the absorber 8W/m^2 K.
- T_b is the absorber temperature (K).
- T_m is the ambient temperature (K).
- ε is the emission coefficient of the absorber 0.15, σ is the Stefan–Boltzmann constant (5.67∗10^{-8}/m^2K^4).
- C = A_r/A_a = 60 is the concentration ratio with A_r aperture area and A_a absorber area [32].
- The factor f is a multiplication coefficient to reduce the η_{col} of series parallel connected collectors as its efficiency is smaller than that for single collector where 0.85<f<0.95 [33].

Efficiency of isccs and dsg power plant

The solar thermal energy of the cycle concept of DSG and ISCCS systems is defined as follows**:**

$$Q_{sol-el} = Q_{ccs} - \dot{m}_{ff} * LHV_{ff} \tag{8}$$

where:

Q_{ccs} is the thermal energy of output the combined cycle system (kWth).(m) ̇_ff is the mass flow rate of the fuel consumed in the gas turbine. 〖LHV〗_ff is the fuel's lower heating value from gas turbine.

To evaluate the cycle efficiency, we need to evaluate the electric power coming from the solar source and determine the thermal energy of the cycle, so this fraction between solar and combined cycle is the solar-to-electrical efficiency are defined as follows:

$$\eta_{sol-el} = \frac{Q_{sol-el}}{DNI \, * \, A_{col}} \tag{9}$$

All previous work estimated that the coal-fired power plants are operating in the regenerative Rankine cycle. In a typical regenerative Rankine cycle power plant, some steam is extracted from the turbine to preheat the boiler feedwater, which can increase the overall thermal efficiency of the plant [34]. When the extracted steam partly or totally replaced by solar thermal energy carried by heat transfer fluid to preheat the feedwater, this operation is solar contribution in hybrid power plant.

Analyses the solar contribution in dsg concept

The solar aided power generation (SAPG) concept, is to use solar thermal energy to replace the bled-off steam in regenerative Rankine power cycle. This extracted bled off steam is normally used to preheat feed water entering the boiler; it has the effect of increasing the thermal efficiency of the cycle [35, 36].

$$\eta_{th} = \frac{W_{net}}{Q_{ff} + \ Q_{sol,net}} = \frac{W_{net}}{m_{ff} * LHV + Q_{sol,net}} \tag{10}$$

where Wnet is the system's total net power output including both from gas turbine and steam turbines, Qf is the thermal energy provided from the fuel which is equal to the mass flow rate of the fuel mff consumed multiplies the fuel's lower heating value (LHV), Qsol,net is the absorbed solar heat by water/steam.

The exergy efficiency is also calculated for the system performance evaluation. Assuming that methane's chemical exergy is approximately equal to 1.04 times its LHV, and the solar thermal exergy corresponds to the maximal work availability between solar collector temperature (Tsol) and ambient temperature (T0), so the definition of system exergy efficiency is given as follows [37] :

$$\eta_{ex} = \frac{W_{net}}{Q_{ff,ex} + Q_{sol,net}\left(1 - \frac{T_0}{T_{sol}}\right)} = \frac{W_{net}}{1.04 m_{ff} * LHV + Q_{sol,net}\left(1 - \frac{T_0}{T_{sol}}\right)} \tag{11}$$

The steam cycle thermal efficiency ηsteam is defined as the ratio of steam turbine power output Wsteam to the total thermal input to the steam cycle from solar field Qsol and gas turbine exhaust Qexh:

$$\eta_{steam} = \frac{W_{steam}}{Q_{sol,net}+Q_{exh}} \quad (12)$$

The contribution of the solar heat in the total heating load can be measured by its share in the system's total heat input:

$$X_{sol} = \frac{Q_{sol,net}}{Q_{ff} + Q_{sol,net}} = \frac{Q_{sol,net}}{m_{ff} * LHV + Q_{sol,net}} \quad (13)$$

The fossil fuel could be saved if the plant's power output remains unchanged as the same as the reference CCGT plant. The fossil fuel saving levels in comparison with the reference CCGT plant, for the same amount of electricity generated, is termed as the fossil fuel saving ratio:

$$SR_f = \frac{Q_{ccs}-Q_f}{Q_{ccs}} \quad (14)$$

RESULTS AND DISCUSSION

Analyses the performance in hybrid concept model

Firstly we calculate the total annual net heat gain per collector loop, other word the heat output by solar collector in each concept for the power plant introduced in Fig. 4.

For different months in each power plants, there are variations in solar field performance, the solar field output Qcol,net increase according the solar radiation in each month until season of the summer when it has reached to the peak, due a high radiation and the solar field decrease when the summer is over, as well as there are variations between the DSG and the ISCCS due a heat transfer fluid. In the annual simulation for one years the output of solar field is varied in each concept. The DSG concept use water like as a heat transfer fluid and it has reached to 500 C° and 120 bar, the peak value of output solar field at midday is 138 MWth, while the ISCCS use oil (Therminol VP-1) as like as heat transfer fluid and it has reached to 400 C° and the peak value at midday is 124 MWth.

We determine the increase effect of the direct normal irradiation (DNI) in the efficiency of collector loop η_{col} for each integrated power plant and the results of simulation are presented in Fig. 5.

The receiver tube efficiency increase when the DNI increase. The DSG systems include only steam in high temperature, but in ISCCS the receiver include only oil, thereby the steam is more efficiency than the oil in heat transfer, the steam reach to the efficiency for 67%, but the oil concept cannot be reached to 63% (see Fig. 6). For this reason oil and steam have variation in efficiencies η_{col} . It can be seen that the ISCCS reaches to the value of 400 C° and 80 bar, this characteristic is from the propriety chemical, while in the DSG concept the values reached is 500C° and 120 bar. Therefore the efficiency in the HTF system is less than DSG concept is depending from the heat transfer fluids in receiver tube.

The ISCCS and DSG plants has been taken into account one-year period to determine the annual performance for both concepts, as well as this simulation is analysed in day light when the sunrise until sunset. Table 2 shows the overall annual power production. The cycle of each power plant is analysed and simulates the solar-to-electric efficiency of the DSG and ISCCS is shown in the following chart.

The several behaviour of the analysed solar collector technologies is evident in the first estimation. The simulation explain that the DSG and ISCCS are able to have a very high efficiency in summer months ,due to high percent of DNI in this months ,whilst efficiency of DSG is 6 % more than ISCCS, this variation is from the kind of heat transfer fluid in receiver tube .

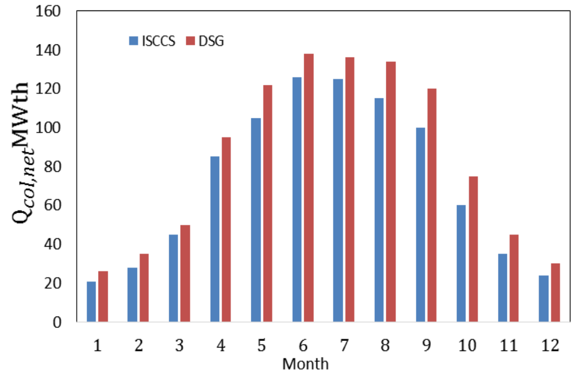

Figure 5. The monthly power of solar field output in DSG and ISCCS

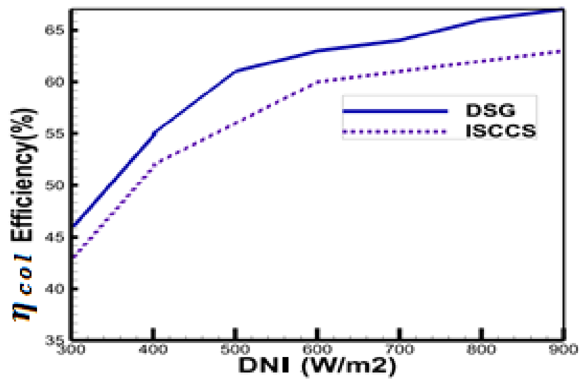

Figure 6. The effect of direct normal radiation in DSG and ISCCS

Conversely in winter the efficiency decays of the solar energy in both concept DSG and ISCCS, this variation lead to decrease in solar to electric efficiency, with less than 3% of difference between each concept (see Fig. 7).

The annual electricity production and annual natural gas consumption have been calculated in Table2 taking into account the monthly percentage of clear cloudy and overcast days.

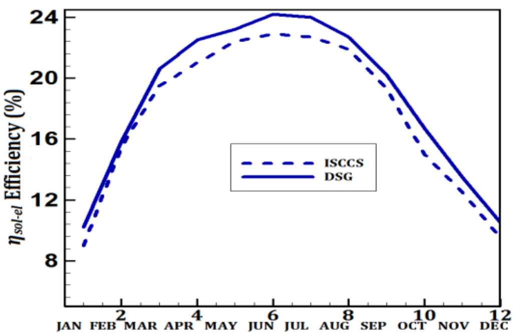

Figure 7. The monthly efficiency power solar-to-electric

TABLE 2. The production solar combined system plant performance

Plant type	ISCCS plant	DSG plant
Gas turbine	47 MW	47 MW
Steam turbine	80 MW	80MW
Parabolic trough	30MW	36MW
Annual gas consumptio	20845.43 m^3	12548.67 m^3
Gas percentage in electricity at day light	13.6%	8.7%

When comparing the ISCCS and the DSG plant, it can be concluded that DSG work better than ISCCS this behaviour due of cloudy and overcast day, so the gas turbine is operated for balance the shortage in heat losses as well as more fuel consumption (Table 2).

Analyse the performance for solar contribution in DSG concept

Previous work in the hybrid power plants based on evaluation of the HTF for solar contribution when the oil is the HTF. In this study, for analyse the DSG concept we take on compete the water and steam in DSG system. The new model proposed is validated according to literature [38]. We assumed that the DSG concept for simulation, that the cycle include two stage steam turbine in three extraction point from solar field to heat the feedwater.

The extraction steam is from solar thermal energy carried by parabolic trough, including steam or vapour saturated for to preheat the feedwater shown in Fig. 4. We assumed the amount of steam in every extraction point from parabolic trough is the same with high-pressure (superheated solar field). So, sufficient heat to raise the feedwater temperature (FWH 1, FWH 2, FWH 3) ,every extraction is one case, the first one scenario case 1 is the configuration with extraction from the superheated solar field, the output steam leaving the solar field is directly preheat the feed water FWH1. The second configuration case 2 with extractions the steam from the superheated solar field to preheat feed water FWH2 .

The final scenario case 3 which include the extraction of steam from parabolic trough to preheat the FWH3. Therefore, there are three cases for the model analysed.

Firstly we determined the best case in analyse thermodynamic for all parameters, secondly we compared the solar contribution on best case simulated to the best case results given in literature [38]. According the analyses and simulation of the model in each case on the TRNSYS software, the results are in the table below. The results of this simulation showed the best share of solar contribution in the hybrid power plant, when we preheat the feed water we decrease losses of solar thermal energy, despite the legend decrease in thermal efficiency. Case 1 is the best way to preheat the feed water with X_{sol}=29.2%, almost the best approach to preheat the last feed water near the boiler (see Fig. 8).

Finally we compared the best concept simulated when we used the new DSG concept in effect of solar contribution to the results reported in literature [38].

The solar contribution is varied in each concept, it can be seen that the new DSG concept have a large share solar in electric production, with the effect of best way for to reheat the feed water and decrease the losses. The annual solar to power efficiency in each concept increase when the solar collector area increase until a peak value 29% in the efficiency and 170000 m^2 of solar collector area ,than the efficiency decrease when the solar collector area increase due for more losses to collect all collector area in parabolic trough (see Fig. 9).

The new concept DSG has high output solar thermal energy it can be reached to 118GWh , but the reference HTF concept not exceeded the value 114GWh in same collector area to new DSG concept . Hence, more solar collector area more solar output and more losses. Furthermore the DSG concept show their performance in the solar contribution.

According to these simulation of the solar contribution in new DSG concept proposed, the output power increase when we preheat the last feed water from the superheated

TABLE 3. Performance for solar contribution

Items	Case1	Case2	Case3
Solar heat input, $Q_{sol,net}$ (MW)	96	84	73
Solar thermal share, X_{sol} (%)	29.2	26.5	24
Fossil fuel saving ratio, *SRf* (%)	29.5	26.7	24.2
Net power output, W_{net} (MW)	168	164	160
System thermal efficiency, η_{th} (%)	51.2	51.8	52.4
Steam cycle thermal efficiency η_{steam}(%)	26.5	26.2	26.
System exergy efficiency η_{ex} (%)	52.1	52.9	53.3

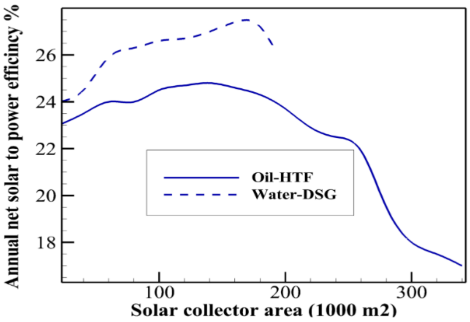

Figure 8. The annual net solar to power efficiency in solar contribution method

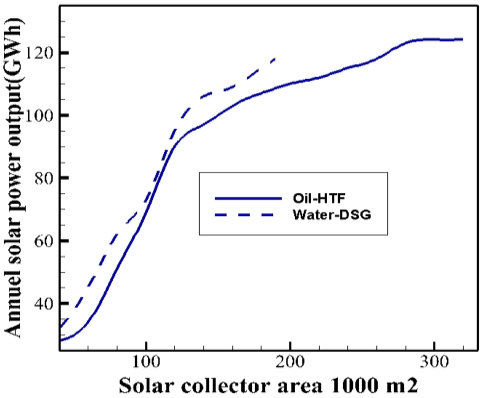

Figure 9. The annual solar power output in solar contribution methode

parabolic trough ,other words to heat the last feed water it mean less losses in heat and short way to feed the steam turbine . Furthermore the best approach to increase efficiency is to decrease the losses.

CONCLUSION

The influence of the solar on the annual performance of direct steam generation and integrated solar combined cycle system is detailed whose system analysis has been performed .The DSG plants proves the height efficiency after the development of new receiver as well as solve the trouble for pressure drop in recirculation mode, and the ISCCS plant until recent use of complex heat transfer system in the process and low efficiency. Therefore, the result in this study indicate that ;the DSG plant in annual production is 4 % higher than the ISCCS power plant in same design and area condition of Algeria desert .

The DSG concept in solar contribution mode with the simulated results showed that; the extraction of solar thermal to preheat the last feed water behind the boiler, is the best performance compared to HTF concept .The efficiency of solar production has reached 29%.We conclude that the effect of solar contribution is to decrease losses of energy. Therefore, increase efficiency in solar to electric performance .

These results are a detail performance of the parabolic trough solar thermal power plants in the DSG and HTF. This work is not taken into the economic study. This step is remained a critical point in the development of solar parabolic trough plant.

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Persian Abstract

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چکیده

نیروگاههای پارابولیک بر روی چندین مفاهیم برای تولید انرژی تجدید پذیر در سیستم ترکیبی جامد خورشیدی (ISCCS) و تولید بخار مستقیم (DSG) توسعه یافته است. هر مفهوم به دلیل پیکربندی انرژی خورشیدی، ویژگی خاصی دارد. به تازگی، تکنولوژی تولید انرژی خورشیدی (SAPG) برای بهینه سازی این مفاهیم با استفاده از سیستم پاداش خورشیدی در نیروگاه های هیبریدی ظاهر می شود. هدف از این کار تجزیه و تحلیل ترمودینامیکی در سیستم نیروگاه های هیبریدی خورشیدی برای مفاهیم ISCCS و DSG است. برای این مفاهیم، تفاوت عمده ای را در بازده خورشیدی به قدرت الکتریکی ارزیابی کردیم. تولید انرژی خورشیدی به منظور ارزیابی مشارکت خورشیدی در مفهوم DSG پیشنهاد شد. این مطالعه نشان می دهد که سهم انرژی خورشیدی در مفهوم DSG برای بهترین روش در استخراج خورشیدی خورشیدی در مفهوم DSG بالا است. بنابراین، مقدار مطلوب استخراج خورشیدی، پیش گرم کردن آب خوراک در بخاری است. این مدل ها در این کار مورد بررسی قرار گرفتند که در نرم افزار TRNSYS و مدل مشاور (SAM) شبیه سازی شده است. تجزیه و تحلیل در عملکرد مفاهیم هیبرید و مشارکت خورشیدی در مفهوم جدید DSG می تواند مورد بررسی قرار گیرد. بهترین روش این بود که کمک خورشیدی در نیروگاه های هیبریدی خورشیدی باشد.