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Simulation model of Parabolic Trough Power Plants on Direct Steam Generation and Integrated Solar Combined Cycle System in Algeria

BOUMEDJIREK Mohammed,MERABET Abderrezak

Mechanical Engineering Department, Renewable energy laboratory and Sustainable Development University of the Brothers Mentouri (Constantine)Algeria
boumed185@gmail.com
abderrezak_67@yahoo.fr

MICHEL Feidt , MERICHE Imad eddine
University Lorraine LEMTA ENSEM - 2 Avenue de la Forèt de Haye BP 90161 54505 Vandoeuvre CEDEX . France
Mechanical Engineering Department, Renewable energy laboratory and sustainable development.University of the Brothers Mentouri (Constantine)
Michel.Feidt@univ-lorraine.fr,
imad-113@ live.fr

***Abstract* — Parabolic trough power plants have several concepts for production energy, these concepts are developed by Solar Electric Generating System (SEGS) and Direct Solar Steam (DISS) project for research and development, the SEGS is developed the integrated solar combined cycle system (ISCCS), however in recent years the DISS project with direct steam generation (DSG) technology proves the evaluation from the cost, the process control and the easy erection in construction.**

There are many studies developed in the solar hybrid power plants system for ISCCS and DSG, in this paper will be evaluated these models of solar hybrid system compound a natural gas combined-cycle backup for solar thermal energy , taken into account the thermodynamic analyses and techno-economic assessment for each concept of the ISCCS and DSG plants .

These models evaluated in this work will be simulated with TRNSYS program and SAM System Advisor Model. This analysis was conducted to get the performance in these concepts and shows the lower levelized energy cost (LEC), so to increase to the electricity net efficiency in solar contribution of the power plants.

***Keywords: combined, energy, generation, heat, performance, solar*.**

I. INTRODUCTION

The economic boom in developing countries particularly China and India with the continuous increase in world population as well as increase in consumption energy this major factors that have boosted energy demands and prices[1].But the availability for this energy and result for height consumption in the future is the major stress in energy security environmental ,so for this reason all researchesand developments concern to develop the sustainable energy system and increase the low carbon technology in renewable energy.

The renewable energyin concentrating solar power now is the result for more than fifty years for researches and development at universities laboratories, and scientists experimented with ways to produce electricity via concentrate the solar ray, it because it is diffused in the nature under mild form, so it necessity to concentrate these rays to get the high temperature and pressure for the electrical productions. Many concepts for concentrate the solar ray is developed, but parabolic trough is the technology which is commercialized.

The solar energy concentrates is developed with areas strongly sunny. Algeria among this area is like shows the geographical map.

Algeria is oil state and has a large solar radiation from largest desert in 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 operational since 2011[2].

The solar power stations with parabolic trough collectors currently account for 94% of the power stations in activity. It is also the technology privileged for the majority of power stations [3]. This study work is based on parabolic trough system.

The parabolic trough system were implemented for several concentrated solar power CSP technologies actually two concepts for Produce solar to electricity the integrated solar combined cycle system ISCCS and direct steam generation DSG, proving the easy way for the best performance until now the parabolic trough have several concept in hybridization.

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Nomenclature

A	area (m^2)
C	concentrationratio
DNI	direct normal irradiation (W/m^2)
h	enthalpy (kJ/kg)
h’	specific enthalpy(kJ/kg)
LHV	lower heating value (MJ/kg)
Q	heat energy (MWth)
s	entropy(KJ/kg)
T	temperature (K)
U	heat transfer coefficient (W/m^2 K)
ṁ	mass flow rate (kg/s)

Acronyms

A_1	annual insurance
BOP	balance of plant
CSP	concentrated solar power
DISS	direct solar steam
E	annual energy production
EF	annual expense for fuel cost
FCR	fixed charge rate
HRSG	heat recovery steam generator
HTF	heat transfer fluid
I	installed capital cost
ISCCS	integrated solar combined cycle system
Kd	real debt interest
LEC	levelized electricity cost
PTR	parabolic trough receiver
SAM	system advisor model
NEAL	new energy Algeria
SEGS	solar electric generating system
SGT	siemens gas turbines
SST	siemens steam turbines
TRNSYS	transient system simulation program

Greek symbols

η	efficiency
α	absorption coefficient
ρ	reflection coefficient
σ	stefan–boltzmann constant

Subscripts

a	absorber
b	boiler
ccs	combined cycle system
col	collector
el	electric
e_{stage}	isentropic efficiency
f	multiplication coefficient
ff	fossil fuelled
sol	solar
m	ambient
n	lifetime of the plants
r	aperture

II. HYBRIDIZATION SYSTEM IN SOLAR ENERGY

Hybridization is means the combination of different energy conversion technologies in one system, is the combination between solar-fossil hybrid concept is called integrated solar combined cycle (ISCC), where the solar-produced steam is superheated through a waste heat recoveryheat exchanger by making use of the heat energy of gas turbine exhaust gas [4].This combination is one factor of development in concentrated power plants due no stability in production at the day and the night.

Therefore hybrid system is the weakness of solar energy because is a discontinuous production, for this reason 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 [5].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 in the near and mid-terms [6].

The integrated solar combined cycle integrates the solar thermal cycle into the combined cycle power block as shown in “Fig. 2” [7].Using a two-pressure heat recovery boiler, the solar saturated steam is fed into high-pressure steam line of power bloc at the entrance to the superheating -section. Several hybrid systems using gas as another energy source are developed [8].

Other work [9] reported that retrofitting the natural gas combined-cycle through replacing duct burner capacity with solar input can provide economic values when compared to a standalone solar plant.

III. Technology Of Parabolic Trough Power Plants

Recent technology of commercial parabolic trough power plants have different concepts, the ISCCS use synthetic oil (Therminol VP-1) as working fluid for transformation the heat to heat recovery steam generator (HRSG) from collector receivers in solar field.Another process without syntheticoil it the direct steam generation (DSG), this concept use steam in the collector receivers to feed the steam turbine. 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 owing to the higher temperatures that can be attained in the collector receivers [10].This last reason is especially important at present, when new commercial absorber tubes, for working at higher temperatures, have been developed [11].

The DSG technology was tested at the DISS test facility in AlmeriaSpain[12]. Currently there is built commercially for the first time with parabolic troughs in Thailand [13].Several of studies are realized the economic potential of DSG technology [14,15].Analyses results showed that live steam parameters of up to 500°C and 120 bar are most promising and could lead to reduction the levelized electricity cost (LEC) about 11% [16].

The kind of power plant is the most method for converting solar thermal energy to electric energy, in this study we compered two models the ISCCS and DSG.

IV. Model For Integrated Solar Combined Cycle System

The integrated solar combined cycle system ISCCS initially proposed by Luz Solar International is a typical hybrid system that integrates solar heat and fossil fuel [17, 18].Solarsystem produce the vapour that is supplier for steam turbine as well as production the electrical energy. The solar gas turbine system is another promising hybrid solar/fossil technology[19,20] , 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 exchangers has heat has production of vapour (HRSG) heat recovery steam generator [21].

The oil cycle thermal is composed from oil heated (Therminol VP-1) in collector recovers of solar parabolic trough, the energy of this recovered oil conducts to generate steam generator via heat solar steam generator HSSG include an economizer, an evaporator and a superheater.

The steam cycle with Rankin type consist a power block, the steam turbine model Siemens SST-900, is supplied by vapour in different pressure levels in stage.

In ISCCS the solar components are supplier to conventional power plant sometimes referred to height temperature; this heat can produce steam of pane in the heat recovery steam generator and can generate low pressure steam that is fed directly into the steam turbine [21].

Annually the solar system cannot generate electricity on its own in system integrated it must operate as a power supplier when the gas turbine is operated. But the system should be designed with solar system without considers worst operate in power plant[22].

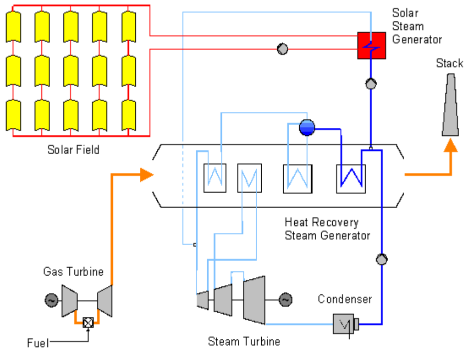

Figure. 1Schematic of the integrated solar combined cycle systems (ISCCS) in conventional configuration, source: Dersch

V. Model For Direct Steam Generation

The collectors of solar thermal power plants are used for generate steam to power in thermodynamic cycle. The steam is generated directly into the absorber tube which is concentrated from sun ray. This concept is called Direct Steam Generation (DSG), so this technique is without Heat Transfer Fluid HTF “Fig.4”.

The concept of DSG is to use water as an HTF in the parabolic trough solar field, so that the solar field preheats, evaporates and superheats the water feed. Accordingly, steam can be expanded at a steam turbine directly[23]. The benefits of this operation strategy are cutting capital and operation costs. Using water as an HTF results in eliminating the use of expensive synthetic oils and eliminating the heat exchanger from the power plant [17].Furthermore the thermal efficiency of the thermal cycle is increased.

Three different operation regimes were tested by the European project DISS. These experimental tests were carried out in southern 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[23].

The description of the recirculation mode explained above is only valid when superheated steam is produced. In case the saturated steam cycle, the collectors after the steam drum are not needed. This is of particular interest for the present work.The step to higher temperatures has been demonstrated by the research project Real DISS with operation of the essential components at 120 bar/500 °C [24].

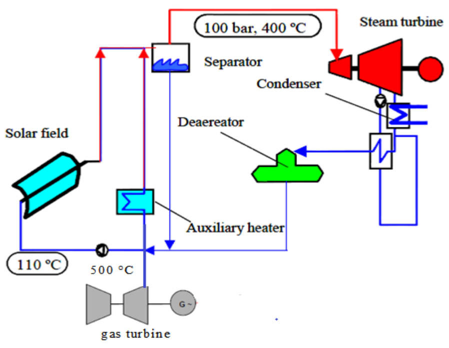

Figure. 2 Schematic of parabolic trough plant with the direct steam generation

This work is divided in two steps for evaluation the hybrid concepts, firstly we determine the effect of efficiency on collector loops via the nature of heat transfer fluid for each model, secondly we presented the major aspect in possibility to use a different reheat configurations in the power cycle, author word the option of extraction steam in the regenerative Rankine power plant to preheat the boiler feedwater for each power block efficiencies.These parameters is analysed and simulated in the commercial software TRNSYS program and SAM System.

VI. Methodology

This paper presents the simulation results and anoverview of evaluation in the performance assessment of DSG and ISCCS in concepts. This work is based on hybrid station (ISCCS) design Hassi R'male [26], with actual operational condition taking 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 site is located at 33°7' latitude and 3°21'longittude, with elevation above the sea level is 750 m. The ambient temperature is varied in cold month on winter period between -10° C and 20°C and on the hot period between 21° C and 50°C in the summer, the solar in hot period with Direct Normal Irradiation DNI can reach 930 W/m^2. The design of the power plant considered air ambient at 0.928 bars and 35°C with relative humidity at 24%.

The solar power plantinclude the solarfield and power block. The power block in conventional combined cycle power plant with two gas turbine on 47 MW SGT-800 in Brayton cycle[27], accumulate with Rankin cycle for an steam turbine on 80 MW SST-900[28]. The power block contains system of heat exchanger from two identical single-pressure HRSGs with supplementary firing and no reheats ,as well as each HRSG is equipped by economizer and evaporator , two super heaters and two duct burners. The solar field for 183120 m^2 comprises 224 parabolic collectors assembled in 56 loops, 4 collectors per loopand the heat transfer fluid HTF is the oil, it runs with PTR-70 receivers.

The analysis presented in this concept for DSG configuration is similar in the power block configuration to Hassi R'male solar power plant design .It referred for solar size initially sized to produce 50 MWth, although this figure will be varied in some results series. Geometrical and optical parameters of a collector loop were taken from[25].

TABLE I. THE PARAMETERS FOR EACH CONCEPT DSG AND ISCCS

Production	ISCCS	DSG
Gas turbine		
Ambient temperature	35°C	35°C
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
Net output power	47 MW	47MW
Thermal efficiency	35%	35%
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
Full output capacity	80 MW	80 MW
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	183120 m^2
Heat transfer fluid	oil	steam/water
The receivers type	PTR-70	PTR- 80
Outlet steam temperature	-	550 °C
Outlet receivers pressure	93bars	120 bars
Outlet HTF temperature	392°C	-
HTF mass flow rate	205 kg/s	-
Pressure losses in HTF side	2 bars	
Water/steam mass flow rate		55 kg/s
Pressure loss in tube steam		0.5bars

VII. Model Of Simulation

In order to evaluate the model of simulation, we have selected the ISCCS plant in design for process actual of Hassi R'mmel "Fig.5" it composed of: solar field, gas turbine, steam turbine and system of heat exchanger include HRSG this components are described below.

The solar field with 183120 m^2 area and 56 loops for each loop, and one axis involves 6 collectors from type of LS-3. This axis isaligned on thenorth south line and tracking the sun from east to west. The receiver's type is PTR-70.

Two gas turbineunits on 47 MW SGT-800 to provide a necessary flexibility in the operation in the night, day and cloudy day.

The steam turbine unit on 80 MW SST-900 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.

Several configurations in the concept of the ISCCS plant, component design and system operation are proposed by [30].In this work the power plant is the integrated between Brayton cycle and Rankin cycle with parabolic trough system.The design parameters of the each solar power plants are summarized in Table I.

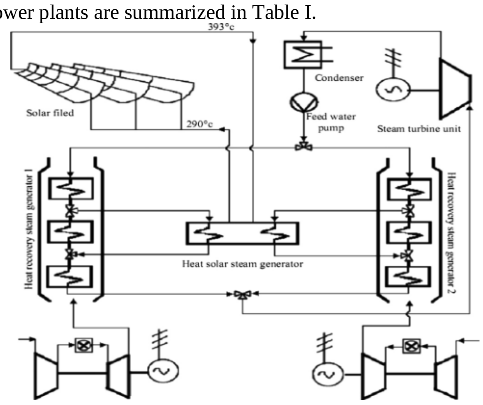

Figure. 3 HTF-ISCCS of Hassi R'mmel power plant with simple pressure level [30].

The DSG power plant will be proposed for validation and comparative. We consider the DSG plant basically similar to ISCCS plant in area of solar field, gas turbine and steam turbine without the HRSG system. These power plants are modeled and simulated in two commercial codes the SAM [31]and the TRNSYS [32]with a model library STEC developed by DLR, was used to model the solar components.

The fossil fuel power plants have quite stable power flows and in working conditions and stable efficiencies, but parabolic trough power plants are operated under changing operation conditions, with fluctuating power flows and fluctuating efficiencies: the Sun position implies different optical efficiencies for annual production. Other word the receivers generate different thermal losses in parabolic trough.

VIII. Efficiency Of Collector Receiver For Solar Field

The DSG plant use thePTR-80 receivers because the 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 the world wide in this step we choose Algeria area with Tamanrasset city , other worth the area of Tamanrasset is the hot area in Algeria with direct normal irradiation 2600 kWh/m^2/ year .

The data for weather condition from Meteonorm is a comprehensive climatologically database from the TRNSYS, is for solar energy applications at every location on the globe.

The simulation model for the parabolic trough collectors using water-steam as heat transfer fluid, has already been developed and validated in other work[33].Another model for the parabolic trough, their cycle is activated in a central water boiler heated by the oil coming from the solar field [34].

The efficiency of collector$\eta_{col}$is given by the Hottel-Whillier Bliss equation[22], it was defined as;

$$\eta_{col} = \frac{Q_{col,net}}{DNI \cdot A_{col}} \quad (1)$$

$Q_{col,net}$(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;

$$Q_{col,net} = [[DNI \cdot f\rho\alpha] - [U_A\,(T_b - T_m)/C] - [\varepsilon\sigma(T_b^4 - T_m^4)/C]] \cdot A_{col} \quad (2)$$

Whereη_{col} is the collector efficiency;*DNI*(kWth) is the incident direct normalirradiation 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^{2}K^4).
- C = A_r/A_a = 60 is the concentration ratio with A_r aperture area and A_a absorber area [35].
- The factor f is a multiplication coefficient to reduce the $\eta_{col}$of series parallel connected collectors as its efficiency is smaller than that for single collector where $0.85<f<0.95$ [36].

Collector efficiency is an important parameter which directly influences the thermodynamic performances of a solar thermal power plant, so in order to evaluate these performances we determine the efficiency of collector loops.

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

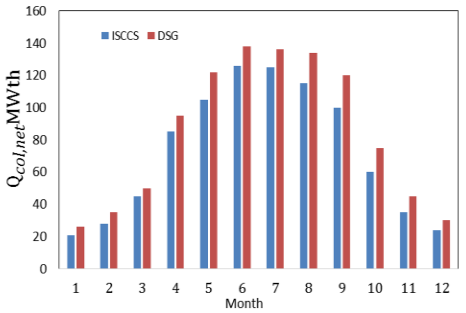

Figure.4 The monthly power of solar field output in DSG and ISCCS

For different months in each power plants, there are a variations in solar field performance, the solar field output $Q_{col,net}$increase according the solar radiation in each month until season of the summer when is reached the peak , due a high radiation and the solar field decrease when the summer it over , as well as there are a variations between the DSG and the ISCCS due a heat transfer fluid .The DSG use water like as a heat transfer fluid and it reached 500 C° , while the ISCCS use oil (Therminol VP-1) as like as heat transfer fluid and it reached 400 C° , so the water is better than the oil in the solar concentrating technologies.

Secondly we determine the increase effect of direct normal irradiation (DNI) in the efficiency of collector loop ηcol for each integrated power plant and the results of simulation are set out the following graph "Fig.5".

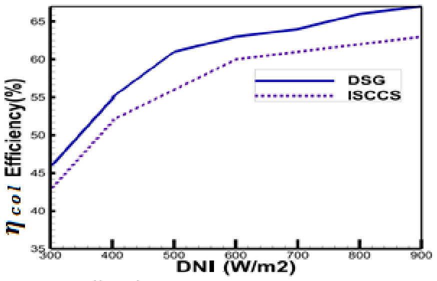

Figure.5 The effect of direct normal radiation in DSG and ISCCS

The receiver tube in DSG systems include only water in high temperature the water will be steam but in ISCCS the receiver include only HTF, so the steam is more efficiency than the oil in heat transfer. For this reason oil and steam have a variation inefficiency*ηcol* for same direct normal irradiation DNI, therefore the DSG is more efficiency than the ISCCS, as well as the HTF is make a loss for heat because is a long cycle of generation and is not use direct generation, while in the DSG use direct system generation therefore the losses of efficiency in the HTF system, this losses is from the fluid in receiver tube not from collector loop.

Coupling the process between the solar field and the power block, and the power block with the electricity grid in both concepts for the ISCCS and the DSG, it is necessary an auxiliary fossil-fired boiler via gas turbine [37].There is several reasons to take into account the coupling systems and not only one, the first reasons is the integrated with gas turbine for assures annual generation power at night or in cloud day.

IX. Efficiency For Combined Cycle System

The simulation results of the DSG configurations in different extractions will be compared with reference configuration in ISCCS power plant

The following model is evaluation for analysing the efficiency of the solar integration system in the DSG configuration. It can be summarized as follows: with the steam temperature and pressure at the turbine stage inlet, the steam specific enthalpy h_{in} and specific entropy s_{in}.

The thermodynamic process in a steam turbine is an isentropic transformation;$s_{in} = s_{out}$. The ideal outlet steam specific enthalpy h_{out} can be obtained from steam tables because the outlet steam pressure Pout and steam entropy s_{out} are known.

In steam turbine the ideal work generated in the stage is the ideal specific enthalpy change, $\Delta h$is the difference between the inlet enthalpy $h_{in}$and the outlet enthalpy hout. $\Delta h = h_{in} - h_{out}$

Thenonreversible process the real specific enthalpy change $\Delta h'$, considering the type of nonreversible losses, the real work generated in the stage, is $\Delta h' = e_{stage}\Delta h$

$e_{stage}$is defined as the isentropic efficiency of the stage, and the value can be inquired or calculated by design instructions.

The power in steam turbine is the real power output Wout in the stage on function of the steam flow rate and the real enthalpy change $\Delta h'$ and is defined as; $W_{out} = F_{in}\Delta h'$

The real outlet steam enthalpy of the stage is h'_{out} which is the difference of the inlet enthalpy h_{in} and the real enthalpy change$\Delta h'$ and is defined as;$h'_{out} = h_{in} - \Delta h'$

These analyse presented that the nonreversible process is a real operation in cycle power plants, for decrease these losses from nonreversible process it will be addition an extraction process .The results above show that the collector efficiency for DSG is better than the ISCCS, we choose the DSGconcept forextraction the solar steam and their effect in cycle efficiencyfor nonreversible process.

X. Solar Extraction In Power Cycle

The extraction in steam turbine have the affects in steamflowrate , decrease the power output if there is extraction and vice versa. In DSG combined cycle the solar heat is used to replace the steam extraction point from the steam turbine to parabolic trough.If the poor or no solar radiation available ,the output of solar collector does not required parameters for replacing the extraction steam, it will be replace by gas turbine boiler.

In this step the extractions locations for the heat in this configuration are divided into three scenarios under to their reheat system configuration: the first one(scenario A) is the configuration with extraction from the HP turbine , the output steam leaving the solar field is directly feed the turbine stages hence the heat will be extract from steam turbine , the second configuration (scenario B)with extractions the steam from the HP and LP turbine stages to preheat feedwater that feed the parabolic trough .The final scenario (scenario C) indirect reheat which include the extraction of steam fraction from parabolic trough before the HP turbine, this fraction is connected in a heat exchanger and used to reheat the steam leaving the before the HP turbine from the live steam. The simulation of these scenarios we get the results and is showed in the followingchart “Fig. 6”.

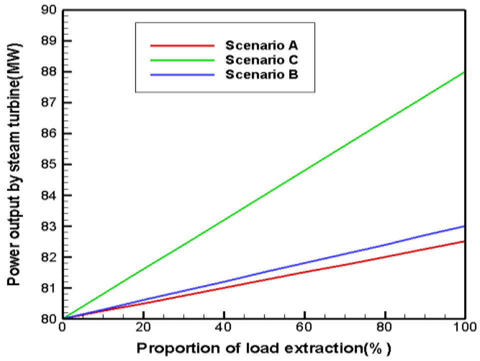

Figure. 6 Output steam turbine in extraction mode.

According these simulation the output power for the turbine stage is varied in each configuration. In scenario A ,the extraction from HP steam turbine so the power output is less than the scenario B ,is caused by the low temperature in the feed water which connected the parabolic trough .It can be seen in the scenario C the extractions is caused by solar heat not from steam turbine , the output power plant in this case is the higher 88 MW for all configurations with increasing 8 MW in output .Extraction the heat from steam turbine decrease their power output bydecrease the outlet enthalpy h_{out}.The Extraction of the solar heat increase the output steam turbine.

XI. THE EFFICIENCY A OF ISCCS AND DSG PLANT

Two configurations in concept of DSG and ISCCS systems have been analyzed the HTF in ISCCS and water in DSG, the same parabolic trough field about 183120 m^2 but the concept without gas turbine. Firstly the modeling results are presented with tow last configuration.

For plant design and technologies (DSG and ISCCS) the total aperture area of the solar field was assumed equal to *Aap* =183120 m^2, the total solar power production is:

$$Q_{sol\text{-}el}=Q_{ccs}-\dot{m}_{ff}*LHV_{ff} \quad (4)$$

Where:

- Q_{ccs} is the thermal energy of output the combined cycle system(kWth).
- $\dot{m}_{ff}$ 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.

For evaluate the cycle efficiency, we needs to evaluate the electric power coming from the solar source and determined the thermal energy of the cycle, so this fraction between solar and combined cycle is the solar-to-electric efficiency are defined as:

$$\eta_{sol-el} = \frac{Q_{sol-el}}{DNI * A_{col}} \quad (5)$$

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 analyzed in day light when the sunrise until sunset and (table 2) shows the overall annual power production. For simplify the calculation, taken into account the daily light in power plant operation, the electricity production period must be considered and we have taken the average value all every month in one- year for annual production. The cycle of each power plant is analyzed and simulates the solar-to-electric efficiency of the DSG and ISCCS is shown in the following chart.

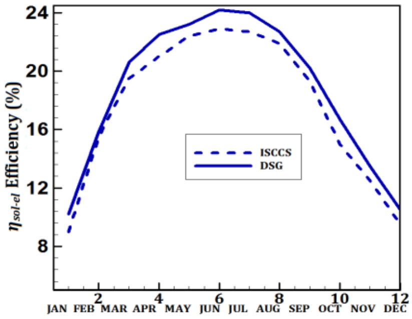

Figure. 7Themonthly efficiency powersolar-to-electric

Commentaire [s1]:

The several behaviour of the analyzed 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 5 % more than ISCCS, this variation is from losses in receiver tube . Conversely in winter the efficiency decays of the solar energy in both concept DSG and ISCCS, with less than 3% of difference between them in efficiency and DSG concept keep their efficacy despite the lower DNA in winter. The heat losses depending on the heat transfer fluid, it looks evident that the DSG efficiency better than the ISCCS due from losses in the HRSG, so this losses decrease the efficiency of the in the ISCCS, except in the hottest months of the year but in winter this loses decrease.

The average daily efficiency and the natural gas consumption are depending on the daily operation in each concept, were assumed to operate only in daylight hours. The annual electricity production and annual natural gas consumption have been calculated in Table2taking into account the monthly percentage of clear cloudy and overcast days.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 II).

TABLE II.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	30 MW	36 MW
Annual gas consumption	20845.43 m^3	12548.67 m^3
Gas percentage in electricity at day light	13.6%	8.7%

XII. 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 , this analysis conducted to assess the efficiency of solar cycle and thermal cycle in both concepts , each concept has their own process in power generation but the target is the best efficiency.

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 now use complex heat transfer system in the process while the goal of erection is the height performance ,so the result in this study indicate that the DSG plant in annual production is 4 % higher than the ISCCS plant with each parameter, same design and area condition of Algeria desert .The DSG concept allowed to choose several mode extraction, the simulation results showed that extraction the solar heat is the best performance in any mode of extraction .We conclude that the ISCCS have more losses so less efficiency in solar to electric performance.

These results are a detail performance of the parabolic trough solar thermal power plants. They will conducted to choose the economically concept. The parabolic trough technology is under development, other word decrease the cost for this technology in future. This step is remained a critical point in the development of solar parabolic trough plant.

XIII. REFERENCE

[1] International Energy Agency. World Energy Outlook. www.worldenergyoutlook.org.Accessed on October 2013.

[2] David. Kearney & Associates.Vashon, Washington, NationalRenewable Energy Laboratory (NREL).Subcontract And Reviewed By Guidelines(April 2009, December 2010).

[3] Syndicat des énergies renouvelablesLes fiches d'informations sur l'énergie solaire thermodynamique,Principle of operation of thermodynamic,www.enr.fr. Accessed on May2010.

[4] Allani Y. CO2 mitigation through the use of hybrid solar-combined cycles. Energy Conversion Management(1997), 38, S661–S7.

[5] Kuenstle, K, Lezuo, A., Reiter, K. Solar powered combined cycle. Proceedings of the Power Gen Europe '94, Cologne,1994 17–19May.

[6] Steinmann, W.-D., Eck, M., Direct solar steam generation in parabolic troughs. Proceedings of the 10th Solar PACES International Symposium on Solar Thermal Concentrating Technologies, Sydney2000., pp. 107–112.

[7] Steinfeld A, Palumbo R. solar thermochemical process technologies. Encyclopaedia Phys Sci Techno(2001),15,237–56.

[8] Dersch J, Geyer M, Herrmann U, Jones S, et al. Trough integration into power plants – a study on the performance and economy of integrated solar combined cycle systems. Energy(2004),29,947–59.

[9] McMahan A, Zervos N. Integrating steam generation from concentrating solar thermal collectors to displace duct burner fuel in combined cycle power plants. In: Power-Gen International 2009. Las Vegas.

[10] Montes, M.J. et al.ThermoFluid Dynamic Model and Comparative Analysis of Parabolic Trough Collectors Using Oil, Water/Steam or Molten Salt as Heat Transfer Fluids. In Proceedings of 14th InternationalSolarPACES Symposium on Solar Thermal Concentrating Technologies,Las Vegas, USA(2008).

[11] Benz, N. et al. Advances in Receiver Technology for ParabolicTroughs. Proceedingsof 14th International SolarPACES Symposium on Solar Thermal Concentrating Technologies, Las Vegas, USA(2008) .

[12] Zarza E., Valenzuela L., et al.Direct Steam Generation in Parabolic Troughs: Final Results and Conclusions of the DISS Project. Energy(2004) , 29 (5), 635-644.

[13] Krüger D. Krüger J., et al.Kanchanaburi Solar Thermal Power Plant with Direct SteamGeneration – Layout. Proceedings of the 16th CSP SolarPACES Symposium, Perpignan, France(2010)..

[14] Eck M., Benz N., et al.The Potential of Direct Steam Generation in Parabolic Troughs - Results ofthe German Project DIVA. Proceedings of the 14th Biennial CSP SolarPACES Symposium, LasVegas, USA (2008).

[15] Price H., Lupfert E., et al. Advances in Parabolic Trough Solar Power Technology. Journal of Solar Energy Engineering,(2002) 124(2), 109-125.

[16] Zarza E.) DISS Phase II Final Report. EU Contract No (2002). JOR3-CT98-0277.

[17] Feldhoff J. F., Benitez D., et al.Economic Potential of Solar Thermal Power Plants With Direct Steam Generation Compared With HTF Plants. Journal of Solar Energy Engineering (2010) , 132(4), 041001-9.

[18] Horn .M, Führing .H, Rheinländer .J. EconomicAnalysis of Integrated Solar Combined Cycle Power Plants: aSample Case: The Economic Feasibility of an ISCCS Power Plant in Egypt. Energy(2004) ,29 ,935-945

[19] Johansson .TB, et al., editors. Renewable Energy, Sources for Fuels and Electricity. Washington, DC: Island Press (1993) , P. 234-5.

[20] Kelly, B., Herrmann, U., Hale, M.J. Optimization Studies for Integrated Solar Combined Cycle Systems. Proceedings Of Solar Forum 2001 - Solar Energy: The Power To Choose, Washington.

[21] Status Report on Solar Trough Power Plants. Sponsored by the German Federal Minister for Education, Science, Research and Technology under Contract No (1996). 0329660.P 40, 56.

[22] Solar Engineering of Thermal Process. Wiliam A.Bickman. John A.Duffie (2013). Simulation in solar process design.

[23] Eck, M. and Hirsch, T. Dynamics and control of parabolic trough collector loops with direct steam generation, Solar Energy (February 2007), 81(2), 268-279.

[24] Eck, M., Eickhoff, M., Feldhoff, J. F., et al.Direct Steam Generation in parabolic troughs at 500°C - First results of the REAL-DISS project, 17th Solar PACES, Granada, Spain(2011).

[25] Montes MJ, Rovira A, Muñoz M, Martínez-Val JM. Performance Analysis of anIntegrated Solar Combined Cycle Using Direct Steam, Applied Energy(September 2011), 88(9), 3228–3238.

[26] Fouad Khaldi, Energy and exergy analysis of the first hybrid solar-gas power plant in Algeria. Proceedings of ECOS 2012 -

The 25th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems June 26-29, 2012, Perugia, Italy.
[27] Shukin S., Annerfeldt M.et al . Siemens SGT-800 industrial gas turbine enhanced to 47MW. Design modifications and operation experience. Power forLand, Sea and Air GT2008; 2008 Jun 9-13; Berlin, Germany. Proceedings of ASME: 65-70.
[28] Steam turbines for solar thermal power plants. Siemens AG(2008). Order No. E50001-W410- A105-V1-4A00. Available at <http://www.siemens.com/ energy> [accessed 12.6.2011].
[29] O. Behar, A. Khellaf, K .Mohammedi, S .Ait-KaciaReview of Integrated Solar Combined Cycle System (ISCCS) with a Parabolic Trough Technology, Renewable and Sustainable Energy Reviews.(November 2014), 39, 223–250.
[30] Behar Omar, Kellaf Abdallah, Mohamedia Kamal, Belhamel Maiouf .Instantaneous performance of the first integrated solar combined cycle system in Algeria. Energy Procedia.(2011) , 6,185–93.
[31] Solar Advisor Model (SAM) software .User guide version 2016.03.14. National Renewable Energy Laboratory.
[32] Trnsys 17. (2010) <http://sel.me.wisc.edu/trnsys/>.
[33] Montes MJ, Abánades A, Martínez-Val JM. Performance of a direct steam generation solar thermal power plant for electricity production as a function of the solar multiple. Solar Energy(2009), 83,679–89.
[34] Frier, S.D., Cohen, G.E., Cable, R.G., An overview of the KramerJunction parabolic trough solar electric system. In: Proceeding of ANZSES 36th Annual Conference Christchurch, New Zealand, (1998) ,547–554.
[35] Steinmann, W.-D., Eck, M., Direct solar steam generation in parabolic troughs. Proceedings of the 10th Solar PACES International Symposium on Solar Thermal Concentrating Technologies, Sydney(2000), pp. 107–112.
[36] Kleeman, M., Meliss, M., Regenerative Energiequellen. Springer, Berlin, Heidelberg(1988).
[37] Yang YP, Yan Q, Zhai R, et al.An efficient way to use medium-or-low temperature solar heat for power generation-integration into conventional power plant. Appl Therm Eng(2011) , 31,157–62.
[38] Bejan, A., Tsatsaronis, G., Moran, MThermal Design and Optimization. Wiley, New York. (1996).
[39] Enermodal Engineering. Marbek Resource Consultants Ltd.Cost Reduction Study for Solar Thermal Power Plants. World Bank, Washington, DC(1999).