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Utilizing PV System for Auxiliary Energy Demand in Conventional Power Plant

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Abstract

The purpose of this study is to investigate the utilization of PV feeding system for auxiliary energy demand in the conventional power plants. A 573 MW tri-fuel power plant in Jordan IPP3 the largest internal combustion engine (ICE) power plant in the world is the case study to evaluate the energy economy aspects of PV feeding system and its effects on the monthly payments for this energy. All relevant computations will be performed in order to end up with reasonable, feasible and applicable results. The auxiliary energy demand of this power plant while no operation is covered from the national transmission grid which results in around 48 MWh imported energy on daily basis taking in mind no operation case. Therefore, such PV system will have a noticeable impact over the productivity of the whole plant as well as raising the money spent for fuel upon the reduction of the heat rate. The PV system is sized to have a capacity of 2 MWp planned to be utilized during the day time. Considering the imported energy benefit, the corresponding pay-back period will through the 5th year where is expected to be accomplished during the 7th year when it comes to the heat rate improvement. The prominent fact to be mentioned here that the pay-back period upon either imported energy benefit of heat rate improvement is calculated separately.

Keywords: *Energy, Auxiliary, Imported.*

1. Introduction

Thermal power plants play a main role in the worldwide power generation production. However, utilizing these facilities efficiently, productively and feasibly is a major vision throughout the comprehensive generation process. One of the most crucial factors to evaluate the performance of thermal power plant is the thermal efficiency which is completely related to the heat rate associated with the energy conversion process. Electricity is generated by several different processes, each using different raw resources and involving different methods which convert falling water, solar energy, geothermal heat, or “fuel” to electricity. Most of the energy use in the generation of electricity occurs in thermal power plants when heat is converted into mechanical energy for turning electric generators [1].

Among all performance improvement strategies and implemented actions, the plant’s auxiliary energy usage has a reasonable footprint. Auxiliary systems are a major part of a power generation plant. Their main purpose is to keep the power plant using a minimum of input energy to achieve maximum output and reliability. These systems feed the need of the plant’s auxiliary equipment’s in power generation process during both operation and shutting down situations. The thermal power stations, has the drawback of inductive loads with, the motorized pumps and fans, air conditioning system, starting air units and plant’s demand for lighting, etc.

Moreover, the usage of auxiliary energy will increase the difference between the gross and net energy outputs and hence affecting the plant’s heat rate. The plant efficiency is the first priority among all power plant management aspects. Therefore, research and development are kept to propose power generation facilities methods. When utilities design a power plant, there are many design trade-offs between efficiency and cost. However, auxiliaries are oversized in such a way they can meet the design requirements. Some of these auxiliaries are operating at full output whenever the plant is in generation process where some

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of them particularly pumping systems and fans are modulated mechanically by means of valves and dampers.

Different counter measures are applied to lessen the impact of local electricity usage such as optimum motors sizing, utilizing variable frequency drives, increasing plant capacity with power factor improvements in addition to turbines performance improving. The independent power plant IPP3 is located at Al-Manakher, approximately 30 km east of Amman and owned by Asia Electric Power Company AAEPC. KEPCO KPS the operation and maintenance company for this plant is utilizing dual fuel diesel engine generator technology based on tri-fuel operation availability. The demand for maximum energy conservation and efficiency enhancing has become a persistent need trough the operation and management of thermal power plants. In 2008-2009, Electric power Research Institute EPRI developed a methodology to assess the costs and benefits of potential maintenance improvements to coal-fired power plants, and refined the methodology to assess the net annual benefit of potential capital improvements to these plants. EPRI's studies were applied to a 500-MW power plant aiming to evaluate the feasibility of various actions to be taken including the heat rate improvement, reduction in auxiliary loads. The reasonability of such studies is based upon their financial benefits that can be achieved. An EPRI study in 2010 identified cost-effective capital modifications and adjustments to plant operating procedures to improve heat rate during through multi proposed actions. Some of them are listed below:

- Variable-speed drives for main cycle and auxiliary equipment. Variable-speed drives reduce auxiliary power consumption of rotating equipment, thus increasing plant net output. The amount of savings available with variable-speed operation can vary widely. Variable speed drives are expensive and can be difficult to justify for older plants with limited remaining life [1].
- Performance monitoring: several tools are available to display relevant parameters with respect to plant efficiency at various loads. These tools can be optimized to enable operators to prioritize corrective actions, thereby improving cycling efficiency [1].
- Where multiple fans are operating in parallel, plant efficiency at low loads and under ramping conditions can be maintained and improved by the proper selection of startup/shutdown procedures. Depending on the load scenario, this measure will allow auxiliary load reductions by operating fewer fans, but can increase maintenance and reliability risks [1].

Currently, Wartsila, the diesel engine manufacturer plans to install PV system as a cogeneration facility to the 250 MW installed power plant, IPP4-Jordan, owned by AES Jordan. The PV system is set to be 46 MW in capacity and connected to the 132 kV national grid through the same step up transformers of the engines. This will reduce the need for operating the engines during the day time.

The benefits of photovoltaic hybrid systems are (a) improved reliability and energy services, (b) reduced emissions and pollution, (c) provide continues power supply, (d) increased operational life, and (e) reduced cost, and more efficient use of power [10]. A photovoltaic diesel hybrid has been installed and operated successfully at the middle and top stations of the Langkawi Cable Car resort facilities [10]. The operational concept of the hybrid system is that solar will be the first choice of supplying load and excess energy produced will be stored in battery [10]. Diesel generator set will be a secondary source of energy [10].

Anyhow, Ineffective control systems and equipment optimization leading to uncompetitive levelized cost of energy are the main challenges for the development of hybrid energy systems, both grid-connected and off-grid [11].

But a collaboration like Northern Power and MCM should see the development of cutting-edge solutions delivering the lowest operating cost of micro-grids for effective optimization of renewable technologies and turnkey deployment for grid-connected as well as island and remote applications [11]. The partnership intends to address opportunities across the globe and incorporate the most effective and productive technologies both for generation (wind, solar and other) as well as storage (batteries and mechanical energy storage systems (ESS)), and control and software overlays [11].

2. Objective and Methodology

This paper illustrates and investigates the effect of using of PV feeding system to cover the station energy demand aiming to improve the productivity and efficiency of the plant as well.

The imported energy tariff is 133JOD/MWh in the day time while it's 109JOD/MWh in the night period.

On daily basis, considering shutting down situation, the station demand of energy is around 48 MWh fed either locally as a portion of the generated energy while there is exporting of energy or from the national transmission grid in the stand by case. However, the total of imported energy along identified period is strongly depending on the plant load factor, sometimes referred as capacity factor, as the imported energy from the transmission grid will be definitely zero in case the station is in operation mode.

The payback period of such feeding system is evaluated and calculated upon the reduction of the monthly imported energy bill and increasing the money gained from fuel resulted as per heat rate reduction.

The net heat rate (kJ/kWh) represents the total heat content of the fuel consumed (based on the lower heating value, LHV) divided by the net energy generation. The net energy generation is represented by the gross generation minus the electricity consumed internally by the plant (e.g., fuel feed systems, boiler feed pumps, pollution control devices, heat recovery equipment, and other auxiliary loads); whereas gross generation for a unit represents the total amount of electric energy as measured at the generator terminal.

The total gross generation splits into exported and auxiliary energies with usual percentages. To illustrate, figure 1 shows how much the auxiliary energy accounts from the total gross generation in usual situations.

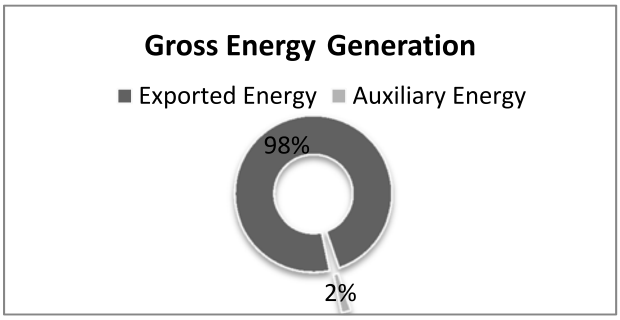

Fig. 1: Gross energy generation distribution

A noticeable improvement in heat rate can often be accomplished through the commitment to optimum and recommended operating procedures.

3. Plant's Key Performance Indicators

Generally, generation Performance Indicators are usually related to the plant's availability, heat rate, thermal efficiency, and environmental impact of a generation plant or unit. The boosting of the overall performance for the plant and corresponding economic analysis are approximated for any suggested method in order to end up with the feasibility and applicability over these items. The plant load factor of a power plant is the ratio of the actual energy output of the plant over a period of time to its potential output if it had operated at the installed capacity the entire time period. Plant load factor varies greatly upon the type of power plants and it is calculated according to the following formula

$$\text{Plant Load Factor (\%)}=\frac{\text{Produced Energy (MWh)}}{\text{Capacity (MW)*Time (hour)}} \quad (1)$$

The Heat rate is the common measure of power plant generation efficiency. It can be described as the energy input to a system, usually in kJ, divided by the energy generated, in kWh. Mathematically:

$$\text{Heat rate}\left(\frac{\text{kJ}}{\text{kWh}}\right)=\frac{\text{Fuel Burnt (kJ)}}{\text{Produced Energy (kWh)}} \quad (2)$$

The fuel burnt refers to the fuel used in the generation process either way it is burnt internally in the combustion engine or it is burnt to maintain the plant's availability like the steam generation through the boilers. A common way to express the fuel consumption when calculating the heat rate is to reflect its amount by the heat supposed to be the result through burning 1 Kg of fuel by using the lower heat value LHV (kJ/Kg) which represents the calorific value of the fuel used so the amount of heat that the fuel supposed to extract can be calculated by:

$$\text{Fuel burnt (kJ)=Fuel amount (Kg)*Fuel LHV}\left(\frac{\text{kJ}}{\text{Kg}}\right) \quad (3)$$

A reduction in heat rate implies that will be a reduction in the quantity of fuel required to produce certain Kilowatt-hours. This difference in the burnt amount of the fuel is commonly expressed in GJ considering the LHV of the fuel used in generation so most power plants have a target or guaranteed heat rate that they are attempting to accomplish.

If the actual heat rate does not match the target, the difference between the actual and desired heat rate is the heat rate deviation.

Whenever the actual heat rate is less than the guaranteed value based on the heat rate schedules agreed in the power purchase agreement (PPA), the heat rate deviation will be in negative which implies that the plant's owner company will gain a proportional amount of money accordingly base on the LHV of the fuel. Considering the installation of the proposed PV feeding system, the corresponding single line diagram can be illustrated in figure 2. Energy flow before using the PV system will be summarized through the following equation:

$$A=B+C \quad (4)$$

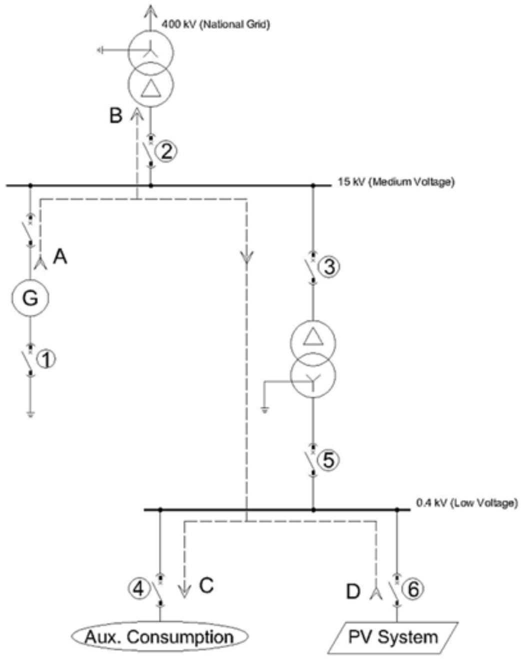

Fig. 2: Energy Flow

Where A represents the gross energy generated by the diesel engine generator technology, B is the part of generated energy which is exported to the transmission grid. C shows the energy consumption through the station various loads fed locally through the medium voltage bus 15KV. Consequently, the heat rate will be affected as it includes only the produced energy to the 400-KV grid as the produced energy to be used in heat rate calculations in this case is the energy represented by B.

This paper, as mentioned previously, proposes the utilizing of PV feeding system to cover the local energy demand in the power plant. In other words, to utilize the gross energy generation more than it was by exporting the whole generated energy. Basically, the term C can now be excluded from the equation (4) which implies that the heat rate will decrease due to the increase in the exported energy. Reduction of the heat rate means more money will be paid for the corresponding heat rate deviation.

On the other hand, while there is no operating for the internal combustion engines, the station will import its needs of energy from the national grid. This imported energy tariff is given in the following equation: Imported energy bill = Day time imported energy * 133JOD/KWh + Night time imported energy *109JOD/KWh. Therefore, the reduction of the heat rate plays an essential role in enhancing the productivity of the power plant. Another term used to indicate the performance of the power plant is the thermal efficiency which considered a leading tool to evaluate the generation process carrying out. Generally, the power plant efficiency η is the ratio between useful electricity output from the generating unit, in a specific time unit, and the energy value of the fuel used in producing this electricity output over the same time period. The thermal efficiency for thermal power plants can be calculated as follows:

$$\text{Thermal Efficiency (\%)}=\frac{3600}{\text{Heat rate (kJ/kWh)}} \tag{5}$$

With that in mind, its noticeable here that if the efficiency is increased when the corresponding heat rate is reduced. Therefore, indicating a better running for the plant. To summarize, the suggested PV system will enhance the productivity of the plant by both cancellation of the imported energy bill from the monthly invoicing and through increasing the money spent for heat rate deviation from the guaranteed value.

4. PV System Design Considerations

Photovoltaic is method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing photovoltaic materials. Materials presently used for PV include mono-crystalline silicon, silicon, amorphous, cadmium telluride and copper indium gallium selenide/sulfide.

Mainly, two types of systems are used when installing the PV systems; grid-connected systems and stand-alone systems. A grid-connected energy system is an independent electricity generation power system that is connected to an electricity transmission and distribution system (GRID). They are ideal for locations close to grid. Two types can be distinguished of grid-connected systems. In the first type the main priority is to meet the local needs for electricity and any excess generation will be fed into the grid, and when there is shortage electricity it can be drawn from the grid. In the second type it is an utility scale, wherein grid connected PV power stations are managed by the utilities in the same way as large electric power plants. Electricity will be fed to grid without taking any consideration of local electricity needs. Stand-alone systems produce power independently of the utility grid (OFF- GRID). Also known as remote area power supply (RAPS). They are ideal for remotest location where the grid is not reachable and there is no other source of electricity.

Two types can be distinguished of stand-alone systems; direct-coupled system without batteries and stand-alone system with batteries. In the direct-coupled system without batteries solar panels were connected directly to the dc load. In the other option battery banks are generally used with charge controller to store energy when there is a surplus available and to provide it when it is required. They are often the most cost-effective choice for applications far from the utility grid. Examples are lighthouses and other remote stations, auxiliary power units for emergency services or military applications, and manufacturing facilities using delicate electronics. The main disadvantages of Stand-Alone systems are the low capacity factor, surplus battery cost and the finite capacity to store electricity forcing to throw away the extra energy generated (Waste Energy).Even though both Grid - Connected and Stand – Alone are useful in their own right, choosing between GC or SA system depends on number of factors. Some of the most important factors are accessibility, climate change benefits, and economic feasibility and load factors.

For example, the extension of the grid in some remote areas is prohibitively expensive. In such locations Stand Alone systems are inevitable choices even though excess power cannot be fed back to the grid and the system needs additional costs on storage batteries in case of wind and solar PV. Knowing that grid acts as an infinite storage unit facilitating continuous operation. Therefore it is important to study the necessary and sufficient conditions under which the Grid - Connected and Stand – Alone become feasible. The sizing for on-grid systems is carried out through the peak hour's approach in which the main components that should be taken into consideration and sized are the Solar panels, and inverter. Solar panels are chosen depending on the power rating needed, area available, and ambient temperature. Sizing the inverter requires knowing the output power of the solar system installed. Arranging the modules will depend on the inverter specifications, by knowing the MPPT (Maximum power point tracking) voltage range, maximum DC voltage input, and number of DC inputs. Temperature effect on the output of the PV modules should be taken into consideration; output voltage depends on ambient temperature of cells.

The matching inverter for the same system should never be lower than the total watt of appliances and the inverter's input voltage must have the same nominal voltage as the battery bank. Inverter size should be 25-30 % bigger than total Watts of appliances because in some cases the inverter should be capable to handle the surge current during starting. Finding the required number of PV cells on a stand-alone system that should be installed is more complicated than an on-grid system and it can be calculated as the following: The climate of site location is represented by Peak Sun Hours (PSH) which is selected according to the location and application. For Amman, the month with the lowest PSH is December with 3.9h/day at 32° tilt angle (optimum latitude tilt). The sequence will be listed as follows:

1- Divide the kWh at the inverter DC side on both the battery efficiency and the charge controller efficiency

2- Calculate the total Watt-peak rating needed for PV modules by divide the total Watt-hours per day needed from the PV modules by PSH to find the total peak power of the PV array

3- Multiply the calculated watt peaks by a specific safety factor to compensate the degradation in the power of the PV modules over years

4- Calculate the number of PV panels for the system by divide the total Watt-peak rating by the rated output Watt-peak of the selected PV module

The solar charge controller is typically rated for amperage and Voltage capacities. Sizing of controller depends on the total PV output current which is delivered to the controller; automatically relies on the configuration (series or parallel) of the PV panel. The idea of using the PV has more than one way to utilize; it can be used to cover all the daily demand for the station needs of energy. On the other hand, it can be utilized to cover a portion of the station energy consumption such that the feasibility of the installed system depends on the plant load factor scenarios and the periods during which the station is experiencing generation of energy.

Due to the variable energy supply and demands there are no reliable values to count on sizing the Photovoltaic System. For that reason, in IPP3 case study PV system assumes covering nearly 20% of the imported energy on the mentioned daily basis based on worst case scenario; shutting down. Cancellation of the battery bank comes due to the high cost and the relatively short life-spam of the batteries. Therefore, it is not feasible and economically reasonable to install the battery bank as a storage system. Depending on meteorological data in Jordan, there is an average of 3602 hours of sunlight per year (of a possible 4383) with an average of 9:51 of sunlight per day. It is sunny 82.2% of daylight hours and the remaining 17.8% of daylight hours are likely cloudy or with shade, haze or low sun intensity.

PV system generates the maximum power point (MPP) within an average period of five hours per day. Therefore, energy can be calculated roughly by multiplying the system capacity (kW) with the MPP period (Hours). When PV system capacity is 2 MWp and the meteorological data gives a period of 5 hours operating in MPP per day then the PV system generate about 10 MWh per day which mean it covers 20.8% in the worst case of IPP3 energy demand. These facts are illustrated in table 1. Hence, the cost of the PV system to be taken into account when evaluating the pay-back period will be taken under the assumption that 950JOD serves as the cost of 1kWp. Therefore, the proposed size of the PV system will be 2MWp.

As stated earlier, the feasibility of the PV feeding system comes from two main categories; the imported energy tariff deduction and the heat rate deviation from the guaranteed one. Hence, in order to evaluate the system benefit and reasonability these money-saving aspects have to be verified using the proper calculations. Based on the suggested PV system size, the plant will import less energy that of the previous situation. With no energy producing during the day (the period during which the PV system can produce energy), the installed PV system is supposed to cover a total of 10 MWh on daily basis followed by saving of 1330JOD resulted after the applying of the imported energy day time tariff.

On the other hand, utilizing the PV system to feed the station while there is energy being exported to the transmission grid, the heat rate associated within this period will be reduced due to exporting all output energy to the transmission grid rather than using a part of it to feed the station. Hence, the heat rate will be enhanced by saving the corresponding amount of fuel used to cover the station energy demand at that instant.

5. Feasibility Assessment

The feasibility analysis of the PV system installation can be evaluated via determination of the benefits resulting from the heat rate reduction and the imported energy deduction based. The benefit comes from the deduction of imported energy is calculated in the previous section which is 1330JOD under the assumption of no generation. Therefore, the resultant monthly money saving considering the same assumption will be 399000JOD and 478800JOD annually. The plant load factor may be misleading for the number of hours through which the plant is in operating condition as it's depending on the number of operating units and the time they spend while producing energy until the shutting down situation. So the heat rate reduction calculations shall be applied based on normalized situations. Another term to be normalized is the lower heat value for the heavy fuel oil used in the combustion process to be taken into the calculations. A heating value of 40500kJ/Kg will be used in the heat rate reduction evaluation.

As it has been shown in the previous section, the PV system generation among one day will be 10MWh. The fuel associated in feeding this amount of energy to the local loads in the plant will be saved. Consequently, the heat rate will be reduced and thus deviates from the guaranteed value. The heat rate deviation from the guaranteed value, as agreed in the power purchase agreement PPA, associated with the fuel saving can be forecasted taking in mind that 10MWh of energy corresponds to 2000 Kg of fuel as the generation facility is supposed to consume on average.

Therefore, the heat rate will deviate from the previous system value at the same operating conditions. This deviation should be reflected as a difference in the heating value associated in the generation of thermal energy which expressed in GJ.

Table 1. PV system facts

IPP3 local energy demand (MWh/Day)	48
Avg. Period of MPP (Hours/Day)	5
PV System Capacity (MWp)	2
PV System Generation (MWh/Day)	10
PV System Coverage (%)	20.8

Usually, the benefit resulted from GJ deviation is taken to be 11 JOD/GJ after a series of site condition correction factors applying. In our case, the amount of fuel can be then expressed in GJ by the application of equation 3 so a deviation of 81GJ is associated in this fuel saving. The gain upon 81GJ saving can be easily found by just multiplying the GJ deviation by its pre-agreed cost. The gain under these circumstances will be 891JOD and 26730 on daily and monthly basis respectively where it will reach 320760JOD annually. The pay-back period serves as a leading evaluation of the idea feasibility and reasonability as well. It completely related to the PV system initial cost and the yearly money gain. The cash flow associated with both imported energy deduction and heat rate gain is illustrated among 25 years taking in mind that the PV system yield degrades by 0.8% annually.

Table 2 shows the forecasted statistics of the imported energy deduction. A negative cash flow indicates the gain of the relevant benefit. The annual PV system yield is expected to behave as in the table according to the pre-mentioned 0.8% degradation factor. Correspondingly, the annual PV energy gain varies and the gain accumulated year by year to conduct the cash flow. The pay-back period upon this advantage is set to be obtained within the 5th operational year as the cash flow turns from positive into negative. However, ensuring a higher degradation factor will result in better figures. The annual PV energy gain refers to the day-time imported energy tariff, 133JOD/MWh. The night –time imported energy can be covered by means of battery banks installation. However, the pay-back period will differ in such situation.

Consequently, the following table illustrates the potential fuel incentive to be paid upon the heat rate enhancing. Fixing the heat rate deviation gain to be 11JOD/GJ, the annual heat rate gain is calculated and thus accumulated. Applying the same degradation factor, 0.8%, the installed PV system will return its cost back within 7 years upon just inclusion of the heat rate issue. To clarify, the first year PV system yield to be 3600 MWh. This amount of energy requires around 720,000 kg of fuel in order to be produced, this amount of fuel corresponds 29160 GJ when applying equation 3. Applying the heat rate deviation incentive mentioned earlier could result in 320760 JOD gain by the end of the first operational year. Same approach was followed up among the whole period to complete the anticipation of such benefit.

Table 2: Cash flow, Imported Energy Benefit

Year	Annual PV system yield (MWh)	Annual PV energy gain (JOD)	Annual Accumulative PV system gain (JOD)	Cash flow
1	3600	478800	478800	1421200
2	3571.2	474969.6	953769.6	946230.4
3	3542.63	471169.84	1424939.4	475060.56
4	3514.29	467400.48	1892339.9	7660.07
5	3486.18	463661.28	2356001.2	-456001.21
6	3458.29	459951.99	2815953.2	-915953.2
7	3430.62	456272.37	3272225.6	-1372225.6
8	3403.17	452622.2	3724847.8	-1824847.8
9	3375.95	449001.22	4173849	-2273849
10	3348.94	445409.21	4619258.2	-2719258.2
11	3322.15	441845.93	5061104.1	-3161104.1
12	3295.57	438311.17	5499415.3	-3599415.3
13	3269.21	434804.68	5934220	-4034220
14	3243.05	431326.24	6365546.2	-4465546.2
15	3217.11	427875.63	6793421.8	-4893421.8
16	3191.37	424452.63	7217874.5	-5317874.5
17	3165.84	421057	7638931.5	-5738931.5
18	3140.52	417688.55	8056620	-6156620
19	3115.39	414347.04	8470967.1	-6570967.1
20	3090.47	411032.26	8881999.3	-6981999.3
21	3065.74	407744.01	9289743.3	-7389743.3
22	3041.22	404482.05	9694225.4	-7794225.4
23	3016.89	401246.2	10095472	-8195471.6
24	2992.75	398036.23	10493508	-8593507.8
25	2968.81	394851.94	10888360	-8988359.8

Table 3: Cash flow, heat rate improvement

Year	Annual PV system yield (MWh)	Annual heat rate gain (JOD)	Accumulative heat rate gain (JOD)	Cash flow
1	3600.00	320760.00	320760.00	1579240.00
2	3571.20	318193.92	638953.92	1261046.08
3	3542.63	315648.37	954602.29	945397.71
4	3514.29	313123.18	1267725.47	632274.53
5	3486.18	310618.20	1578343.67	321656.33
6	3458.29	308133.25	1886476.92	13523.08
7	3430.62	305668.18	2192145.10	-292145.10
8	3403.17	303222.84	2495367.94	-595367.94
9	3375.95	300797.06	2796165.00	-896165.00
10	3348.94	298390.68	3094555.68	-1194555.68
11	3322.15	296003.55	3390559.23	-1490559.23
12	3295.57	293635.53	3684194.76	-1784194.76
13	3269.21	291286.44	3975481.20	-2075481.20
14	3243.05	288956.15	4264437.35	-2364437.35
15	3217.11	286644.50	4551081.85	-2651081.85
16	3191.37	284351.35	4835433.20	-2935433.20
17	3165.84	282076.53	5117509.73	-3217509.73
18	3140.52	279819.92	5397329.65	-3497329.65
19	3115.39	277581.36	5674911.02	-3774911.02
20	3090.47	275360.71	5950271.73	-4050271.73
21	3065.74	273157.83	6223429.55	-4323429.55
22	3041.22	270972.56	6494402.12	-4594402.12
23	3016.89	268804.78	6763206.90	-4863206.90
24	2992.75	266654.34	7029861.25	-5129861.25
25	2968.81	264521.11	7294382.36	-5394382.36

6. Conclusion

The feasibility assessment showed that the suggested PV feeding system has a significant production improvement upon the reduction of the imported energy from the transmission grid and the heat rate improvement so it worth to be investigated more to end up with a reasonable production enhancing by means of co-generation facility.

The 20.8% covering of the needed imported and the reduction in the heat rate will be pilot results for further studies to be implemented in such a way to achieve the common target represented in the improvement of the power plants production. Anyhow, the implemented idea can be performed on different power plant scales on different targets and scenarios with the ability to forecast the obtained feasibility.

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