# Technical-economic feasibility of solar cathodic protection

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**Abstract.** This paper offerings the technical-economic investigation to evaluate feasibility of solar cathodic protection in Qatar region. The solar cathodic protection is single of the demands of solar energy which is very important to protect oil and gas pipelines from corrosion and also to connect the remote stations to main control room through SCADA and donates to dipping greenhouse gas (GHG) discharges and redeemable energy. The purpose of this study to conduct an assessment of technical-economic feasibility of solar cathodic protection in Qatar, and the opportunity of dipping GHG emissions. Solar cathodic shield connections examination was done by RETScreen software. The result shows the opportunity of substantial energy reserves with solar energy connection in CP. Station Mile 38 (Total yearly provided energy (MWh) = 8) and a significant decrease in GHG (Total yearly net decrease of GHG = 7.7 tCO2, which matches to 17.8 barrels of not expended crude oil).

**Keywords: Technical, Economic, Feasibility, Solar, Cathodic**

## 1. Introduction

At the moment, The State of Qatar hold a vast latent for the expansion of renewable energy funds. The country of the globe captures a plentiful amount of direct sunshine, which in turn creates both wind and solar energy. Drumming into this possible will intensely decrease fossil fuel dependency, and thus generate a cleaner atmosphere and new stages of socio-economic growth. Renewable energy (RE) has lately concerned substantial worldwide consciousness. However, techno-economic viability studies of the RE potentiality in Qatar are indeed actual occasional. It is believed that this papery is timely to report some of Qatar needs to drive onward its energy sector expansion for the drive of refining energy shortage levels in the isolated zone.

Tubes performance an extremely imperative role of transporting gases and liquids completed extensive detachments from their bases to the final clients [1]. Elementary motive for natural gas transference tube accidents, 36% were caused by external rust and 63% were caused by internal oxidation. For natural gas supply pipeline accidents, only approximately 4% of the total accidents were caused by rust, and the majority of those were caused by external oxidisation [2]. Immediate report for occurrences among 1985 and 1994, and stated that rust accounted for 28.5% of pipeline occurrences on natural gas. The similar studied for occurrences among 1986 and 1996, and found out that erosion accounted for 25.1% of pipeline occurrences on dangerous fluid pipelines [3].

In some isolated and desert areas where there are no grid completed electricity, cathodic protection stations are usually motorised with diesel fuelled producers since lengthy grid postponements may not be cost effective. In totalling to great fuel distribution and ingesting costs, maintenance of the generators can also be luxurious in terms of parts and labour time working on the unit. There also apprehensions around ecological contamination using diesel.

Diesels are very important to produce the energy. Photovoltaic knowledge consumes the aptitude to change solar energy keen on electricity overwhelming no fossil fuels, consuming no affecting parts, making no contamination and sound, and permanent for years with slight repairs. The ecological, noise, steadfastness and power obtainability benefits of the PV scheme make it a pretty decision.

Qatar is geologically well located to feat important solar energy. Each square kilometre of terrestrial in the area obtains solar energy corresponding to 1.5 million barrels of crude oil in a year. By a regular daily sunlight hours beyond 9.5 hour/day, little cloud shelter circumstances and plentiful free terrestrial space bargains a countless possible for creation of great scale solar power plants [4].

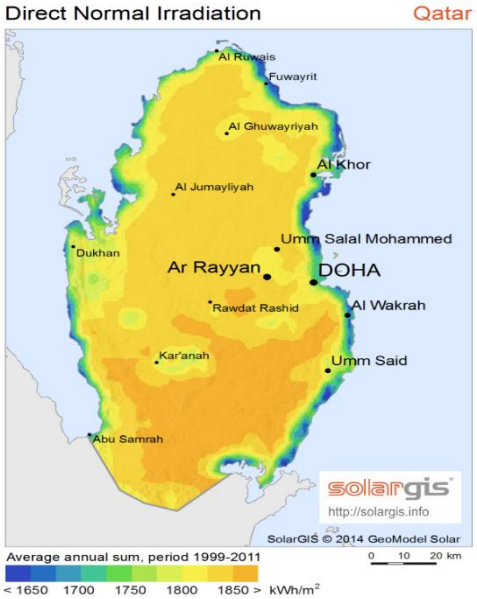


**Figure 1.** Direct Normal Irradiation of Qatar [5]

The average global radiation of 5100 W/m$^2$ with a mean sunshine duration 9.4 hrs/day over Qatar generates 5.5 KWh/m2 of energy per day. In other areas, the generated electricity through solar resources can be used for vital needs of electricity in remote locations such as isolated farms, construction activities and recreational support such as lighting tents etc. [4]. Before the actual deployment of the PV system to the cathodic protection station, it is very important to acquire an estimation the amount of photovoltaic (PV) cells, size of inverters and batteries required and also the cost of production of energy per unit. Software's such as RETScreen enables to replication of rate proficient deployable solar powered cathodic protection places.

## 2. Materials and Methods

Separate PV cathodic shield schemes are planned to activate sovereign of the electric value grid, and are generally intended and sized to source firm DC power to quantity Cathodic Protection station. The model type of separate PV cathodic protection scheme is a direct-coupled scheme, where the DC yield of a PV module is directly associated to a Cathodic Protection Control Unit (CPCU). In direct-coupled schemes, the weight only functions throughout daylight hours. In isolated area which is unobtainable of electrical

supply, which is electrical power is required from the scheme for the duration of the night. Therefore, the packing must be further to the scheme. Normally, batteries are used for energy storage. Several types of batteries can be used such as lead-acid, nickel–cadmium and vanadium batteries. Figure 2 shows the complete scheme cathodic protection at isolated location.

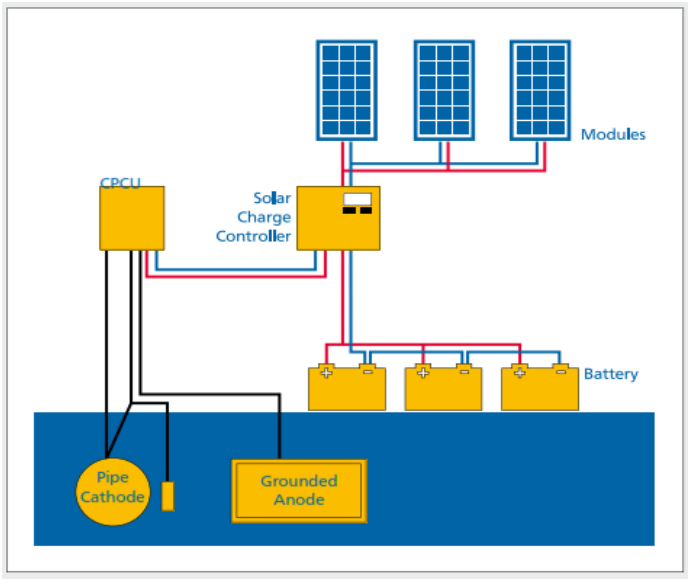


**Figure 2.** Off Grid of PV Cathodic Protection

The RETScreen Clean Energy Management Software is developed in 2016 to measure at the greatest current Clean Energy [6]. In addition, this software provides the dimension and confirmation of the actual presentation of amenities [7]. RETScreen Expert is one combined software stage; exploits full and inclusive models for evaluating projects.. RETScreen assimilates an amount of databases to assist the user, counting a global database of climatic situations gained from more than 6,000 ground-based stations [8]. The software covers widespread combined exercise material, counting an electronic textbook [9]. In recent study in 2018, the authors found the photo electrochemical cathodic protection device for steel based on the SrTiO3-TiO2 composite [10] and Shape-dependent photogenerated cathodic defense by hierarchically nanostructured TiO2 layers [11]. Another authors have contributed in photo electrochemical cathodic shield semiconductor thin layers for metals [12]. This study uses RETScreen Energy Model for determining the economic-technical feasibility.

Table 1 lists the input parameter into RETScreen Energy Model to be calculated in obtaining the technical analysis.

**Table 1.** Input Parameters into RETScreen Energy Model

| Parameter | Value | Remarks |
|---|---|---|
| PV Modules Specification | 37.20% | Characteristics of PV module used for this study (yearly) |
| Inverter Efficiency | 94.1% | From catalogue |
| Battery Efficiency | 90% | Typical battery efficiency |
| Battery Voltage | 24V | Cathodic Protection requirement voltage |
| Battery maximum depth of discharge (DOD) | 75% | Typical DOD for solar system battery |

| Parameter | Value | Remarks |
|---|---|---|
| Battery Storage Capacity | 5280 Ah | Calculated based on an assumed autonomy of 7 days for PV system |
| Charge controller Efficiency | 95% | Typical charge controller efficiency |
| Solar Resource data | 16.53% | obtained from RETSCREEN climate database (module efficiency) |
| Tracking Mode | Fixed | Slope of 35° due south |
| Yearly O&M cost | $1,800 | Minor servicing cost (Quarterly in a year, $ 450 per service, see Table 4.7) |
| Electricity daily base case | 10,456 Wh. | Total energy demanded at site |
| Electricity daily proposed case | 12,024 Wh. | Total energy required from new energy system |
| Days of autonomy | 7 days | QP policy for all solar panel system |
| Generator Capacity | 20 KW | Current CP. Station diesel generator capacity |
| Generator Heat rate | 10,285.7 kJ/kWh | Current generator heat rate |
| Fuel rate | US$ 0.54 per Litre | Current diesel price in state of Qatar |

## 3. RESULTS AND DISCUSSIONS

The areas chosen for the study are Cathodic Protection stations Mile 38 located in Umm Bab which is about 30 Km from Dukhan in the western region of Qatar. The site are located in the middle of desert off the KAHRAMA national electricity grid. Based on RETScreen database, the Solar Radiation data of Umm Bab is not available, the nearest location for weather data is in Dukhan about 20 km away.

The outcomes of the increasing cash flow is exposed in Figure 3. RETScreen produces the standard scenario, without economic provision and allowing for the petroleum cost growth degree is equal with zero.

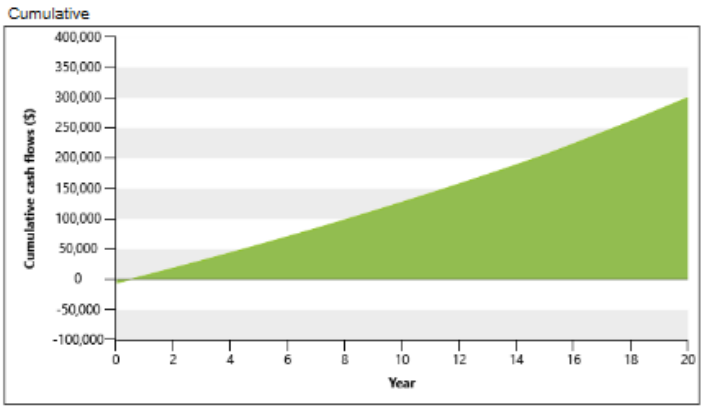


**Figure 3.** Graph of cumulative cash flow (Source: RETScreen)

Figure 3 also shows the technical analysis results of proposed solar cathodic protection for CP. Station Mile 38 in Umm Bab – Qatar. The technical analysis result is simulated in the RETScreen energy model as shown in Table 2. The planned PV scheme had ability to transport a total yearly energy of 8 MWh to the expected load. This signifies more 186.5% of the yearly load requirements of the cathodic protection station. In other word the designed system agreed with the whole yearly energy condition. The model calculates the size issue, which characterises the ratio of the regular power formed by the PV scheme over a year to its rated power volume. The size issue of the system is achieved with 17.9%. This

relates constructively with characteristic standards for photovoltaic scheme with the variety from 5% to 20%.

**Table 2.** Technical Analysis Results of Proposed Solar Cathodic Protection

| | Electricity exported to grid | Electricity export revenue | GHG emission reduction |
|---|---|---|---|
| | MWh | $ | tCO2 |
| Proposed case | 8 | 801 | 3.9 |

Figure 4 shows the RETScreen results to find the total original costs, total yearly costs and total yearly funds and income of the project.

| Costs \| Savings \| Revenue | | | |
|---|---|---|---|
| **Initial costs** | | | |
| Initial cost | 42.7% | $ | 16,896 |
| Inverter | 3.2% | $ | 1,275 |
| Battery Bank | 2.5% | $ | 980 |
| Charge Controller | 2.2% | $ | 888 |
| Total PV System Installation | 49.3% | $ | 19,485 |
| **Total initial costs** | **100%** | $ | **39,524** |
| **Annual costs and debt payments** | | | |
| O&M costs (savings) | | $ | 225 |
| Debt payments - 15 yrs | | $ | 3,038 |
| **Total annual costs** | | **$** | **3,263** |
| **Annual savings and revenue** | | | |
| Diesel Fuel not consumed | | $ | 10,896 |
| Diesel Generator Maintenance Cost | | $ | 1,800 |
| Electricity export revenue | | $ | 801 |
| **Total annual savings and revenue** | | **$** | **13,497** |

**Figure 4**. Print screen from RETScreen - Total costs, savings and revenue of the project

Table 3 lists the financial viability of the project based on the RETScreen result. The study determines a simple pay back of 3 years. The equity payback signifies the span of period that it takes for the projected project to recover its own preliminary asset out of the project cash flows produced. The equity payback deliberates scheme cash flows after its commencement to leverage of the project. The study provides an equity pay back with value of 1.1 years.

**Table 3.** Financial viability of The Project (Source: RETScreen)

| Parameters | Value |
|---|---|
| Pre-tax IRR - equity | 91.1% |
| Pre-tax IRR - assets | 29.2% |
| Simple payback | 3 years |

| Parameters | Value |
|---|---|
| Equity payback | 1.1 years |
| Net present value (NPV) | 120,247 |
| Yearly life cycle investments | 12,242 |
| Benefit-Cost (B-C) | 11.1 |
| Debt service coverage | 4.5 |
| Energy production cost | 10,000 $/kWh |

RETScreen calculates the NPV for the projected PV system. The NPV for the system is US$ 120,247. Positive NPV values are an indicator of a potentially feasible project. In addition, RETSCreen calculates net Benefit-Cost (B-C) ratio, meaning is the ratio of the net benefits to costs of the project. The Benefit-Cost (B-C) ratio for the project is determined with value of 11.1. From the result also found that the ratios superior than 1 are revealing of cost-effective projects. Figure 5 shows the results given by RETScreen in gaining the gross yearly GHG discharge decrease of this study.

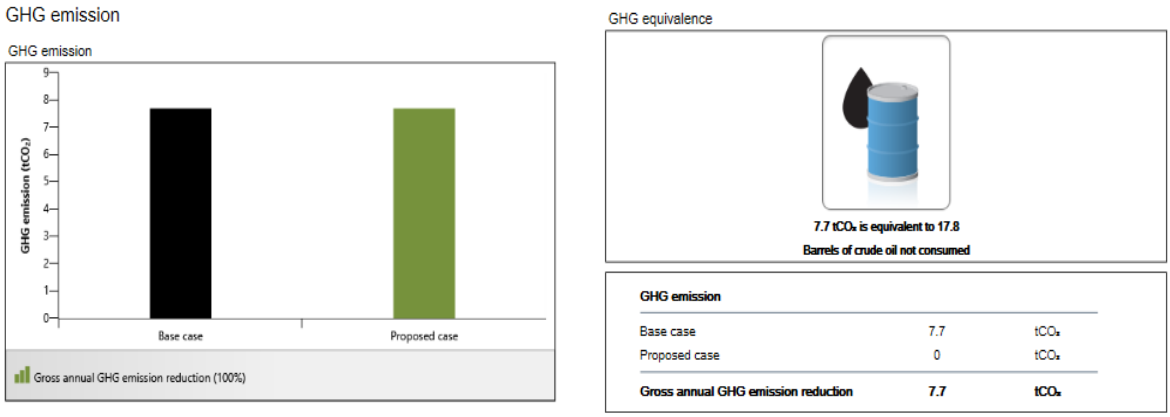


**Figure 5.** Gross Yearly GHG Emission Reduction
(Source: RETScreen)

It is obvious that the solar cathodic protection is increased the cos-effective significantly. The additional portion is the decreasing of CO2 discharges. In this study, net discharges of greenhouse gases are condensed by 7.7 tons of CO2, correspondent (tCO2) which agrees to 17.8 barrels of crude oil not expended. The results of the feasibility study for solar cathodic protection paybacks in CP. Station Mile 38 are potted in Table 4.

**Table 4.** Summary of the consequences gained with the case study in CP. Station M.38

| Total yearly provided energy (MWh) | Total yearly net decrease of GHG (tCO2) | Total oil barrels equivalent (barrels) |
|---|---|---|
| 8 | 7.7 | 17.8 |

(Source: RETScreen)

Table 5 shows that the proposed project in CP. Station Mile 38 is very cost-effective, and there is a substantial redeemable in equally energy savings and plummeting GHG discharges. The benefits of this profitability are on the company and the environment.

## 4. CONCLUSION

This study supports to determine yearly energy formed with 8 MWh for Cathodic Protection Station in Umm Bab area. This energy is determined in corresponding to 0.687876"toe". Additional constraint was found that the effectiveness of clean energy schemes were achieved with total yearly net greenhouse gas emissions. This study shows that this parameter is equal to 7.7 tCO2 or 17.8 barrels of oil not expended.

Based on the RETScreen results, the technical analysis found the designed system encountered the whole yearly energy condition to transport a total yearly energy of 8 MWh to the expected load. Furthermore, the economic analysis found that this project is feasible, and it is proposed to saving in both energy reserves and plummeting GHG discharges.

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