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Utility Regulation and Competition Office

10/2/18

ENTROPY 5-MW SOLAR PV POST PROJECT REVIEW

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EXECUTIVE SUMMARY

Entropy Cayman Solar Limited (“Entropy”), has established a 6.335 MW_(dc), 5 MW_{peak} capacity utility-scale grid-connected solar photovoltaic (PV) power plant at Block 43A Parcel 346 in Bodden Town, Grand Cayman, which is the first of its scale in the Cayman Islands. The project was built at a cost of [REDACTED] [REDACTED] delivered 6 months behind schedule when the plant was fully commissioned in June 2017. Upon completion of the project, the Bodden Town facility was the largest and only utility-scale solar power plant in the Cayman Islands. At the time of writing this PIR, the PV plant has demonstrated over 1 year of successful operations.

The project was initiated by Caribbean Utilities Co. Ltd., (CUC) (a wholly-owned subsidiary of Fortis Inc.) with an original objective in its 2011 Expressions of Interest (EOI) for 13MW of renewable energy. The EOI was subsequently revised to 5MW_{ac} after the two winning bidders were unable to fulfill the requirements of the contractual term sheet. Entropy was selected, a term sheet was signed in October 2013 and entered into a power purchase agreement (PPA) and Interconnection Agreement (IA) with CUC in 2015 which was approved by the then Electricity Regulatory Authority (ERA). The PPA was granted for 25 years and Entropy committed to build and maintain the PV plant for this period.

The levelized cost of this solar PV energy (LCOE) is expected to be approximately CI\$0.16 cents per kWh over the 25-year life of the PPA. Data from completed utility-scale solar projects in the Caribbean post the Entropy project, show that the average price has fallen by 33% since 2012, changing from US\$0.30 per kWh in 2012 to US\$0.20 per kWh in 2016.

The project has, among other indicators, successfully commissioned 5 MW_{ac} of renewable solar power, delivered actual energy production of 9.4 GW-hours (GWh) of clean electricity annually, avoided over 4.2 tons of greenhouse gas (GHG) emissions annually, employed over 40 people during construction and operations, and purchased over [REDACTED] of local goods and services during construction.

The project attracted media attention as it demonstrated the financial viability and sustainability of solar technology in the region.

The project’s environmental, social, health, and safety performance is considered very good. The project has met Cayman Islands country laws and regulations and complies with the actual power quality and performance standards required by the contract with CUC. However, the renewable energy production and associated benefits are slightly less than estimated levels, but above minimum levels.

Overall, the project is considered successful, financially sound, environmentally sustainable, and has met all of its development objectives. This project is consistent with Cayman Islands National Energy Policy (NEP) goals to have 70% of total electricity power generated from renewable energy by 2037. Hence, it is essential to evaluate and document the first utility-scale grid-connected solar power plant installed in the Cayman Islands.

In this Post Implementation Review (PIR) report, the performance of the stakeholders in completing this project and the lessons learned are discussed and will be used to inform future projects of this nature. The main lessons and recommendations OfReg can draw from the project are that it should:

- 1) Continue to promote utility-scale solar PV power generation as it is expected that non-firm renewables will continue to be price competitive with diesel-fired thermal;
- 2) Ensure that approved projects provide least cost electricity rates for consumers;
- 3) Utilise experience gained to inform decision-making on renewable energy projects;
- 4) Ensure that knowledge transfer occurs in order to develop local expertise;
- 5) Follow up to confirm that licence terms and conditions e.g. reporting requirements are adhered to;
- 6) Recommend charging a fee for new generation licences issued to Independent Power Producers (IPPs); and
- 7) Develop and institutionalise a pre-defined process and procedure for dealing with renewable energy solicitations.

INTRODUCTION

As of December 2012, Grand Cayman had 151.22 megawatts (MW) of installed fossil fuel power generation capacity operated by CUC. The country's electricity production depends heavily on diesel fuel with 84% of the imported amount being used for power generation. The Cayman Islands has abundant renewable energy opportunities primarily from solar and to a lesser extent wind and Ocean Thermal Energy Conversion (OTEC.) The NEP recognises that exploiting these clean, local sources of renewable energy can help boost Cayman's energy security, save foreign exchange, and protect the country from global price fluctuations in energy markets.

The Bodden Town solar plant was expected to generate approximately 11,120 megawatt hours (MWh) of clean, non-firm renewable electricity annually. Therefore, on an annual basis, the Bodden Town solar plant will produce enough electricity to meet the needs of approximately 800 average Grand Cayman homes.

The solar plant is estimated to reduce greenhouse gas (GHG) emissions by over 4.2 tonnes of CO₂ equivalent per annum, assuming a rate of 0.55 tonnes per MWh of electricity.

The genesis of this project was the issuance by CUC of a Request for Expressions of Interest dated August 24, 2011 for the financing, construction, ownership and operation of renewable energy generation facilities. CUC received 53 proposals for a total of 380 MW of renewable energy (RE) from 31 companies. From these CUC shortlisted 20 projects from 9 companies totaling 158 MW which included 31.4 MW of wind power from 6 projects at prices ranging from CI\$0.13 to CI\$0.23 per kWh, and 126.6 MW of solar PV from 14 projects at prices ranging from CI\$0.18 to CI\$0.24 per kWh.

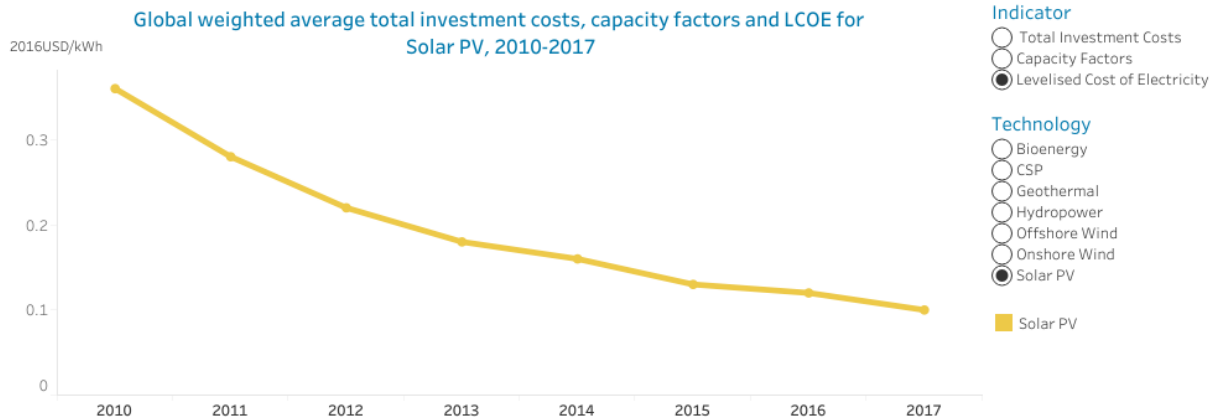
As of October 2011, the average fuel cost (including import duty) was approximately CI\$0.24/kWh. In addition, consumers paid a base rate energy charge of approximately CI\$0.1039/kWh over and above the fuel cost. It should be noted that in 2013, Jamaica approved a project at US\$0.0854 cents/kWh however, it was difficult to draw a comparison between the two projects as there were different deliverables, terms and conditions and concessions for the Jamaica project.

Since this was the first renewable energy project Power Purchase Agreement (PPA) for all parties, there was not an established procedure to be followed at the time of the initial EOI/solicitation. Essentially, the process was developed/refined enroute. This resulted in an extended timeframe to conduct sufficient due diligence reviews and approvals. The process followed is shown below:

1. EOI issued by CUC;
2. Proposal evaluation and recommendation of winning proposal issued by CUC;
3. ERA (now OfReg) review and approval of winning proposal;
4. Development and execution of term sheet – CUC;
5. ERA review/approval of term sheet;
6. Development and execution of interconnection study agreement by CUC;
7. Performance of interconnection study by CUC;
8. Development and negotiation of PPA and Interconnection Agreement (IA) by CUC;
9. Production of Independent Power Producers (IPP) Generation Licence by ERA;
10. ERA – review and approval of PPA, IA & Generation Licence;
11. ERA – commission of independent review of PPA;
12. Execution of PPA and IA by CUC & Entropy (IPP);
13. Project financing – Entropy;
14. Permitting – C.I. Government (CIG);
15. Entropy - Engineering, Procurement Contract for renewable energy facility;
16. Entropy - Engineering, Procurement Contract for interconnection facilities; and
17. Entropy – 5MW_{ac} plant Commercial Operation.

Two shortlisted bidders emerged from CUC's technical and financial evaluation namely; Lanco Solar who proposed to provide 5 MW_{ac} of solar power and New Generation Power (NGP), who proposed to provide 3 MW_{ac} of wind generation and 5 MW of solar generation. However, during the process of developing the interconnection study, Lanco Solar informed CUC that it was closing its Caribbean operations and served notice to terminate its agreement with CUC. CUC subsequently selected the next highest ranked bidder, International Electric Power LLC (IEP), and signed a Term Sheet (TS) with that company on October 22, 2013 and an Interconnection Study Agreement (ISA) on January 23, 2014. Following the signing of a TS and ISA with NGP, that contract terminated on May 24, 2014 because the project had not met the schedule as outlined in the ISA and TS. On June 27, 2014, IEP subsequently transferred all rights under the TS and ISA for this project to an affiliate of Entropy Cayman Solar Limited ("Entropy"). In 2014, CUC ultimately submitted a recommendation for Entropy's single 5 MW_{ac} solar PV facility to the former Electricity Regulatory Authority (ERA).

Following a comprehensive review conducted by its consultant ICF, the ERA in 2015 approved a Power Purchase Agreement (PPA) proposed by CUC for a 5-megawatt (5MW_{ac}) plant to be built by Entropy in the district of Bodden Town at the 20-acre site registered as Block 43A Parcel 346 and granted an electricity generation licence to Entropy Cayman Solar Limited. The PPA was projected to provide renewable energy at a competitive initial price of CI\$0.1428 cents per kilowatt hour (kWh). The levelized cost of this energy (LCOE) was projected to be approximately CI\$0.16 cents per kWh over the 25-year life of the PPA. This amount is slightly higher than the IRENA weighted average LCOE for utility-scale solar PV projects installed in 2016 in Central America, the Caribbean and South America which was US\$0.13/kWh. Figure 1 refers.



Solar photovoltaic (PV) modules are more than 80% cheaper than in 2009. The cost of electricity from solar PV fell by almost three-quarters in 2010-2017 and continues to decline. Focussing on the global weighted average trends for new utility-scale solar PV projects by year, the LCOE reduction of 73% between 2010 and 2017 is put in context. By far the main driver has been the reduction in total installed costs for utility-scale solar PV, with a 68% reduction in total installed costs between 2010 and 2017. The global weighted average total installed cost for utility-scale solar PV fell from USD 4 394/kW in 2010 to USD 1 388/kW in 2017, with a 5th and 95th percentile of USD 898/kW and USD 3 754/kW.

Source: IRENA (2018), Renewable Power Generation Costs in 2017, International Renewable Energy Agency, Abu Dhabi.
<http://www.irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017>



Figure 1 Global levelized cost of electricity for utility-scale renewable power generation technologies, 2010-2017

CUC engaged Entropy as the PV plant supplier and Entropy employed Entropy Solar Integrators, LLC (“ESI”) a sister company, as the engineering, procurement and construction (EPC) contractor for the project. Entropy/ESI built the station using 21,690 poly-crystalline photovoltaic (solar) modules each with a DC-rated capacity of 305 watts which are connected to CUC’s Bodden Town 13kV substation. The solar PV collector system consists of 5 x 1 MW solar arrays, each connected to their own individually protected, 1 MVA padmount transformer through 165 x 30 kW inverters. The electricity produced by the project is sold under the power purchase agreement (PPA) to CUC.

The contractual PPA and IA estimates versus actuals are shown in Table 1 below:

Requirement	Estimate	Actual
1. Renewable energy capacity.	5 MW _{ac}	5 MW _{ac} (100% of plan).
2. Energy p.a. in year 1 of operation.	11.1 GWh	9.4 GWh (84% of plan).

3. Minimum energy p.a. in year 1 of operation	8.9 GWh	9.4 GWh (105% of plan).
4. Commercial operation date.	December, 2016	June 2017 (6 months after plan).
5. Power quality & other contractual requirements.	As per specifications	As per specifications (as per plan).

Table 1 Project Estimates vs. Actuals

Entropy also hired ReNew Solar Development Limited, a local company in December 2016 to maintain the facilities for a 1-year period post-construction with continuous and automatic renewal of the operations and maintenance (O&M) contract for one-year periods.

Construction of the Bodden Town solar plant commenced in February 2017 and was completed at the end of May 2017. The plant began actual commercial operation in June 2017, 6 months after plan, due to defaults by both parties.

The solar PV power plant was officially opened during a ceremony at the site in June 2017. Generation from the plant commenced late April 2017 and full commercial operation (5 MW_{ac}) was achieved in June 2017.

OBJECTIVE

To benefit future large-scale solar plant and other renewable energy (RE) developments in the Cayman Islands, this Post Implementation Review (PIR) report covers topics ranging from the project's purpose, financing, planning, approvals and logistics to procurement, construction and grid connection. The report evaluates each of these topics specifically to:

1. Determine if the project fully met the business need it was intended to address.
2. Ascertain if greater benefits can be derived.
3. Ensure that lessons learned are not forgotten.

For staff and organisations that will be working on similar projects in the future, it is important to learn as many lessons as possible.

The report also outlines the benefits of the 5-MW_{ac} solar PV plant installation. For stakeholders, it makes sense to ensure that all desired benefits have been achieved, and to understand what additional benefits can be realised.

BENEFITS

The project helped illustrate the feasibility of utility-scale solar PV power generation in the Cayman Islands, encouraged economic and industry development in Bodden Town, provided research infrastructure, and developed Caymanian intellectual property in solar power generation.

The benefits include:

1. Reduced GHG emissions;
2. Reduction in fossil fuel utilisation;
3. Renewable energy production;
4. Stable energy prices for the energy supplied under contract;
5. Maintenance of CUC's grid power quality and reliability.

The above-mentioned benefits were achieved but the renewable energy production and associated benefits are marginally below the estimated levels, but above the minimum specified levels.

In addition, CUC and Entropy estimate that over 40 construction jobs were created by the project. Approximately 4 permanent local jobs were also created to support ongoing plant operations at the site. During construction, Entropy was able to utilise local content in plant procurement and construction through sourcing local materials.

Local opportunities provided during plant construction included:

1. Civil engineering and site preparation
2. Post, racking, and module installation
3. Medium voltage power system works
4. Construction and supervision roles
5. Administration and construction support roles

Importantly, the Entropy project promoted industry development by transferring skills and experience to the local labour markets, as well as helping to identify supply chains that benefit the local solar industry. These developments should help drive down the cost of the next generation of large-scale local solar PV projects.

KEY DOCUMENTS REVIEWED

- Power Purchase Agreement (PPA)
- Interconnection Agreement (IA)
- Operation and Maintenance (O&M) Contract
- Financial projections

INTERVIEWEES:

- ERA: Louis Boucher, Charles Farrington
- CUC: Letitia Lawrence, David Watler
- Entropy: Sarah Armstrong

GAP ANALYSIS

A gap analysis was conducted to obtain answers to the following questions:-

- How closely does the project results match the original objectives?
- Expected deliverables – were they delivered to an acceptable level of budget, quality, and time objectives or that an acceptable substitute was provided.
- How were gaps (if any) closed/could be closed?

CUC's original objective per its 2011 Expression of Interest (EOI) was for 13 MW of renewable energy. However, this was revised to 5MW after the two winning bidders were unable to fulfill the requirements of the contractual term sheet. Entropy (the next lowest bidder), was selected and entered into a contract to produce the deliverables shown in Table 1 above.

Both Entropy and CUC have agreed that the expected deliverables were provided to an acceptable level of budget and quality.

The time objectives were not met due to defaults by both parties – CUC underestimated the construction and logistics costs of the interconnection facility which resulted in budget overruns and Entropy did not meet the commercial delivery date due to financing and equipment delivery delays. The parties have subsequently agreed on a solution for liquidated damages and costs offsets.

Since this was the first utility-scale renewable solar PV energy project, and with both parties defaulting, the process duration was imperfect. CUC has advised that it has subsequently established additional process improvements and has now implemented internal standards and studies which it believes would expedite the process in the future. OfReg has also been determining and establishing regulatory standards and process improvements to expedite future RE projects.

ACHIEVEMENT OF PROJECT GOALS

The IA & PPA contained power quality and other contractual requirements that Entropy had to meet. The following questions were posed about aspects of the project to determine if these had been adhered to:-

- Is the plant functioning as expected?
- Is it fit for purpose?
- Are personnel adequately trained and supported? Are there sufficiently enough skilled people in place to maintain the plant?
- Are the necessary controls and systems in place, and are they working properly?
- What routine activities are needed to support the project's success?
- If there are problems, how will these be addressed?

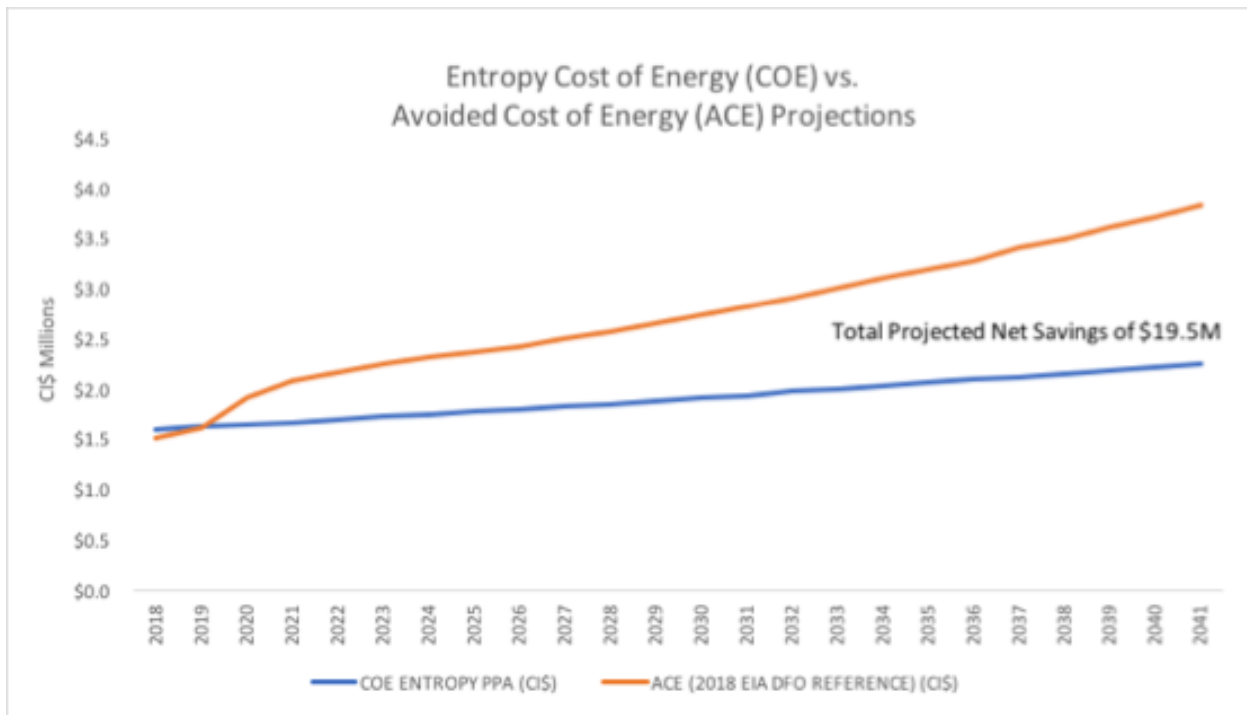
Both CUC and Entropy have agreed that the plant is functioning as expected, is fit for purpose, the necessary controls and systems are in place and are working properly. The actual energy production was less than estimated due to unfavourable weather conditions, [REDACTED]. Generally, the plant has produced as expected, given the actual solar irradiance.

As mentioned earlier, Entropy has contracted with ReNew Solar Development Limited to maintain the facilities for a 1-year period post-construction with automatic renewals on an annual basis. ReNew has supported the system thus far and has sufficient skilled and trained staff to maintain the plant.

Both the IA and PPA contain procedures to handle technical and contractual issues in order to address any problems that arose. The ERA addressed regulatory issues in the Generation Licence.

SATISFACTION OF STAKEHOLDERS

Both CUC and Entropy have confirmed that the end-user’s needs have been met and that they are satisfied with the project’s outcomes. The effect on CUC and consumers has been a reduction in fuel costs which is a direct pass-through to consumers. Although the solar plant does not substantially decrease fuel costs, it still contributes to the overall goal of ensuring that consumers pay the least cost for their energy needs. The plant also contributes to the National Energy Policy’s goals of increasing the amount of electricity produced by renewable energy facilities.



OfReg has not to date received any complaints or dissatisfaction by consumers or other stakeholders about the project. OfReg has also not received any complaints from residents in the vicinity of the plant.

PROJECT’S COSTS AND BENEFITS

Entropy has stated that the final costs to implement the project were: [REDACTED]. There are liquidated damages to be offset against interconnection costs with CUC, the latter being [REDACTED].

Entropy has forecasted annual operating costs of [REDACTED] p.a. for the first 12 months for the plant.

Both parties are satisfied that the costs compare favourably with the expected benefits, given that it was the first project of its kind to be done in the Cayman Islands. There

were unavoidable upfront costs such as the ERA having to incur legal costs to produce an assignment agreement to enable Entropy to obtain local financing and costs for an independent third-party review of the IA, ISA, PPA, etc., documents that would not necessarily apply, or cost less in future projects. OfReg will need to pay attention to these areas for future projects to ensure their success.

And from a financial viewpoint, Entropy [REDACTED]

AREAS OF FURTHER DEVELOPMENT

As previously mentioned, most of the expected benefits were achieved and the execution of the project has provided some insight as to what to expect for future projects and how/what is needed to achieve them.

There may be opportunities for further training and coaching that will maximize results, and these should be explored by CUC/OfReg. This could incorporate changes the system's design which could deliver even more value over the lifetime of the renewable energy resource.

LESSONS LEARNED

This project review seeks to garner lessons by examining how well were the projects deliverables, timescales and costs determined, what went wrong, why did these things go wrong, and how could these problems be avoided in the future. It also looks at what went well and needs to be learned from, and what were the unknowns that may have increased implementation risks.

CUC advised that not having a pre-defined process and historical experience with utility-scale renewable energy solar plant projects nor the required review and due diligence procedures contributed to the implementation risk. Delays were also incurred in the procurement of major materials, especially solar panels which had limited availability at the time, and this drove the construction timeline. There were also unknowns with the foreign bidders since many had not conducted business in the Cayman Islands before. Moreover, the industry was immature with respect to experienced and qualified renewable energy providers than currently. These issues played a part in:-

- Late delivery – plant not being commercially operable until 6 months after projected date.
- Geographical issues – siting e.g. settling of panels, dust accumulation on panels post implementation, etc.

Observations

Most bidders had relevant experience but mainly in more mature developed markets. However, since the project was the first of its kind in the Cayman Islands, none had experience constructing a “utility-scale Solar PV system near a quarry site”. As such there were inefficiencies due to the level of “new development” required for documentation, processes and procedures.

Other lessons learned include:-

- Using corrective activity to get the benefits we want e.g.
 - Amending the regulatory framework to allow multinational IPPs to build, own and operate renewable energy projects;
 - The need to structure the same programme for energy storage projects to encourage these for eventual development of a strong storage market.
 - The need to encourage innovation/new technology.
- For future projects (both positive and negative);
 - EPC contracts should have non-performance penalties;
 - PPAs and IAs should be structured such that the costs of non-performance are not passed through to Consumers but are borne appropriately by the T&D licensee and/or the provider as the case may be;
 - Greater due diligence on companies' ability to execute;
 - IPPs should pay Generation Licence fees. There was no opportunity to charge Entropy a generation licence fee as this option was not available under the licensing framework.
- Catering for unknowns;
 - Better forecasts are required to ensure that the estimated and actual performance objectives are closely matched;
 - During implementation, project management reports should be provided to OfReg;
 - Appropriate risk management tools should be employed to mitigate project risk. There is no evidence of a project risk analysis framework being used.
- Monitoring;
 - No executed copy of IA on file. The ERA did not follow up on ensuring that all of the required documents were acquired and stored for the project. Consequently, there is no signed/executed copy of the Interconnection Agreement on file. This has subsequently been requested from Entropy.
 - No monthly reports were requested/submitted per Generation Licence – This was not done by OfReg until recently.

Implications for Future Projects

If a contractor lacks the experience in comparable jurisdictions and environment, additional selection criteria should be required prior to contract award together with additional planning and project management during construction.

Knowledge Gap

As the solar PV industry in Cayman matures and more contractors/suppliers become experienced, there will be a greater opportunity for projects. However, there are still a very limited number of contractors in the utility-scale solar industry with the appropriate experience. This naturally affects project risk, cost, schedule and in turn, the project's likelihood of meeting its targets. One means of potentially bridging this gap and reducing project risk is for OfReg to require a commitment from both parties to a knowledge transfer provision in future renewable energy projects.

RECOMMENDATIONS

The recommendations emanating from the PIR are as follows:

- 1) OfReg should continue to promote utility-scale solar PV power generation as it is expected that non-firm renewables will continue to be price competitive with diesel-fired thermal;
- 2) Verify that appropriate due diligence has been done on bidders/providers ability to execute and that appropriate risk management tools are used to mitigate risk;
- 3) Ensure that approved projects provide least cost electricity rates for consumers;
- 4) Utilise experience gained to inform decision-making on renewable energy projects;
- 5) Ensure that knowledge transfer occurs in order to develop local expertise;
- 6) Follow up to confirm that licence terms and conditions e.g. reporting requirements are adhered to;
- 7) Scrutinise PPAs and other agreements to ensure that consumers do not bear the cost of non-performance as a pass-through by the Licensee;
- 8) Recommend that an appropriate fee be charged for new generation licences issued to Independent Power Producers (IPPs);
- 9) Develop and institutionalise a pre-defined process and procedure for dealing with renewable energy solicitations;
- 10) Conduct Post Implementation Reviews (PIRs) of projects to determine their outcomes.

This project will naturally lead to future renewable energy projects, which will build on the success and benefits already achieved, so it is crucial that OfReg has established tools and procedures for renewable energy solicitations that will streamline the process. The implementation and commissioning of the Bodden Town Solar Project has proven that a utility-scale solar PV system can be successfully integrated with a Licensee's utilities transmission and distribution system. This has provided the industry with a reference case for future renewable energy projects.

The stakeholders (primarily contractors and suppliers) involved with the project will have a greater degree of experience that can be transferred to other projects. However, the industry as a whole can now use this solution knowing that it is a feasible renewable energy source.

For future utility-scale PV projects it is instructive to note that the latest International Renewable Energy Agency (IRENA) report shows that the global weighted average levelized cost of electricity (LCOE) of utility-scale solar PV is US\$0.10/kWh for new projects commissioned in 2017.) Increasingly, this technology is competing head-to-head with conventional power sources. OfReg will therefore encourage more renewable energy plants to supply power to the grid.