CHALLENGES AND SUCCESSES OF OWN BUILD RENEWABLE ENERGY PLANTS: A CASE STUDY IN THE CITY OF CAPE TOWN ON ATLANTIS 10MW GROUND-MOUNTED SOLAR PHOTOVOLTAIC PLANT

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1 Abstract

This paper aims to explore both the challenges and successes that were experienced by different parties during the development of what is commonly called 'own build' renewable energy (RE) plants. These 'own build' plants refer to the RE plants that are developed, executed, operated and maintained by the City of Cape Town (CCT). This is an in-depth case study of those challenges and successes experienced on one of the CCT's own build plants, Atlantis 10MW ground-mounted solar photovoltaic (PV) plant (Atlantis PV). The specific challenges were grouped into various categories to determine the commonalities and the effectiveness of any responses to those particular challenges and further to establish the efficiency of the response in light of the challenge. In the same vein, the successes were analysed to determine what contributed to making it a success. The results of the study can form a basis for decision-making or learning opportunity for municipalities when exploring own build RE models or other RE projects.

Index Terms – Renewable, Energy, Solar PV, Facility, Procurement, Utility

2 Introduction

According to [1] one of the most famous buildings, the Sydney Opera House was a pioneer in respect to the structural design and construction of its roof, yet in terms of costs and time spent from a project management perspective it proved to be a failure. In the end if one analyses the current usage and benefits of the building and compare it with its intended use, the Sydney Opera House is an obvious success. So too, the benefits of building and implementing renewable energy solutions may appear to be a disaster in terms of the Municipalities and their normal undertakings but the benefits in light of the increased and frequency of load shedding in South Africa gives credence to the changes to legislation in the energy sector, which allows local government / municipalities to find alternative energy solutions [2] [3]. This hold true for municipalities moving beyond their current boundaries by developing, executing, operating and maintaining RE generation facilities as in the case of City of Cape Town. The CCT approach taken on this utility scale RE project was that of developer and off-taker, thus the scope was to develop, design, build, operate and maintain Atlantis PV, which will be connected to a CCT owned 33kV substation. The project development phase, including all permits and land acquisition were completed by the time this paper was written. The CCT relevant supply chain management (SCM) processes are being followed for the appointment of an Engineering Procurement Construction (EPC) contractor to achieve financial close. The case study provides an insight into the challenges and successes experienced at Atlantis PV from a local government perspective. The focus is on the project development phase, which includes the scoping, feasibility, conceptual design and procurement. The paper starts by providing background information about Atlantis PV in chapter 3, followed by a literature review in chapter 4. Chapter 5 covers the challenges and successes experienced and how it was addressed or enhanced. Finally, chapter 6 presents concluding remarks and recommendations for successful development of own build RE projects.

3 Background Information

3.1 About Atlantis PV

The site where the Atlantis PV is situated is approximately 57 kilometres outside the central business district of Cape Town. It is in Wesfleur a suburb in Atlantis, located between a residentially zoned area and an area zoned for industrial use. Currently the land where it will be built is a vacant lot that is being used by the locals for illegal dumping.

The expected power generated by Atlantis PV will initially be 7.7MWp or 7MWac with the possibility to increase the output to 11.5MWp or 10MWac and include a battery energy storage system (BESS). The grid connection will be at 33kV and connected directly to the CCT local electrical network at a nearby substation.

3.1.1 Site Information

Figure 1, shows the location of Atlantis PV that is a greenfield site and approximately 33 hectares in size. The site is relatively flat with some low dunes. After screening a number of sites, this site was ranked the most feasible for the construction of the solar PV. The selection criteria considered whether the land was CCT owned, vacant, not reserve for other purpose, within CCT electricity supply area and within 2km of an existing electrical infrastructure.

Figure 1 Location of Atlantis Solar PV Plant

3.1.2 Justification

Increasing pressure is being placed on countries internationally and nationally, to reduce their reliance on fossil fuels, such as oil and coal, which contribute towards greenhouse gases being emitted into the atmosphere and thus negatively contributing to climate change. RE resources such, as wind and solar PV energy are two of the most popular technologies after hydropower currently being implemented as alternative sources of energy at a global scale [4].

The need and desirability of Atlantis PV and the reasons why CCT has embarked on RE programme was demonstrated in the following main areas:

- Diversifying the CCT energy mix in order to achieve security of electricity supply, where over the last few years, South Africa has been adversely impacted by interruptions in the supply of electricity [2].
- Protection of CCT customers against the impact of further foreseen electricity tariff increases.
- Assisting the CCT in its efforts to mitigate climate change [5].
- Stimulation of the green economy where there is a high potential for new business opportunities and job creation [6].

3.1.3 Technical information

The CCT is the project developer and off-taker. Therefore, CCT performed and completed the full project development phase, including development of tender specifications for the appointment of an EPC contractor. After an initial operation and maintenance (O&M) period by the appointed EPC contractor, Atlantis PV will be handed over to CCT.

Table 1 below shows a breakdown of the how the scope was split between CCT and the EPC contractor.

City of Cape Town	EPC Contractor
•Site screening & selection of preferred site •Development (Feasibility & Conceptual Design) •Financing	•Detail Design •Procurement •Construction •Commissioning •Operation & Maintenance (O&M) for an initial period of 18 months

Table 1 Scope Split of Atlantis PV

The preferred technology selected was solar PV because of its ease of permitting, energy yield per area and levellised cost of energy [7]. Atlantis PV will be a fixed tilt ground mounted system. Figure 2 below is a single line diagram that shows the configuration and connection of the equipment. The solar PV modules will be connected via string inverters and the output will be connected to an onsite substation to step up the voltage to 33kV. The power will be evacuated via underground cables to a CCT substation.

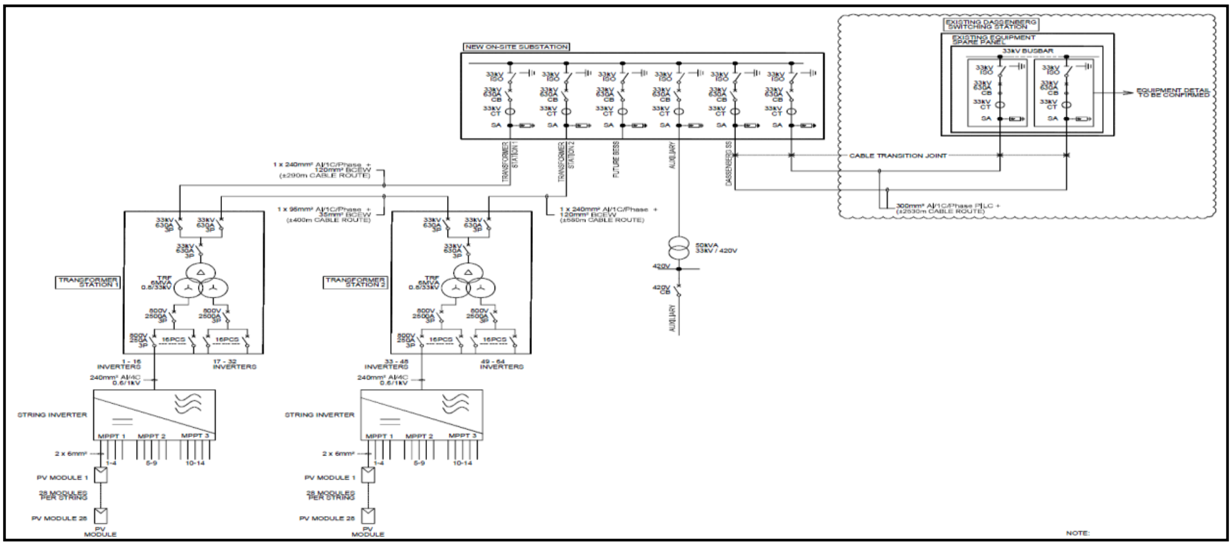

Figure 2 Atlantis PV Single Line Diagram

4 Literature Review

Most provinces in South Africa receives and an abundant of sunshine per day, with 2 500 hours per year and approximately 4.5 to 6.6 kWh/m^2 of radiation level [7]. Solar energy is a renewable energy source that can be obtained from sunlight, which make solar power generation ideal. In solar power generation, electricity is generated by converting the sun's solar radiation.

In Figure 3, it can be seen how electricity is generated using PV Solar cells. These cells consists of doped semiconductor material that is sandwiched between front and back contacts and covered in a layer of glass. These captures the solar radiation to produce DC current. The intensity of solar radiation (i.e. irradiances express by W/m^2) will determine the magnitude of the PVs output [8].

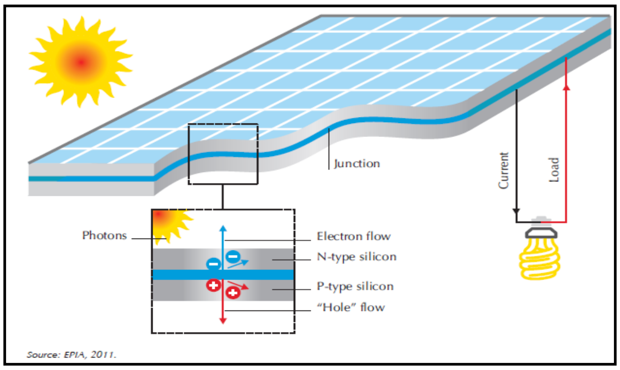

Figure 3 Electricity Generation from PV

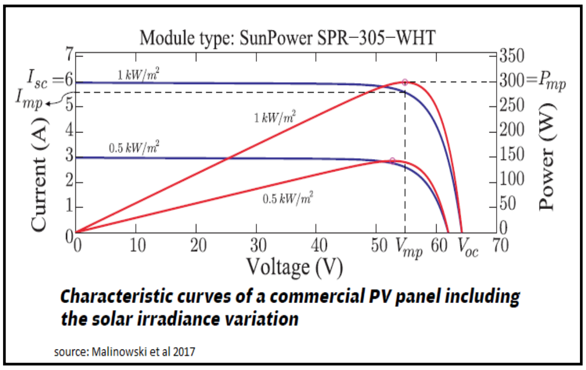

Figure 4 Characteristic curves of PV panel

PV arrays are multiple solar cells that are connected in series and/or parallel configurations to achieve desired output voltage (V) and current (I). It can be seen from Figure 4 above that the VI characteristic changes as the irradiance changes [9]. One can thus conclude that PV array output varies as a function of day light hours and temperature. Therefore, to achieve the highest possible efficiency, the PV cell must operate at maximum power point (MPPT).

Power Electronics plays a vital role in converting the DC output of the PV array for synchronization with the power grid.

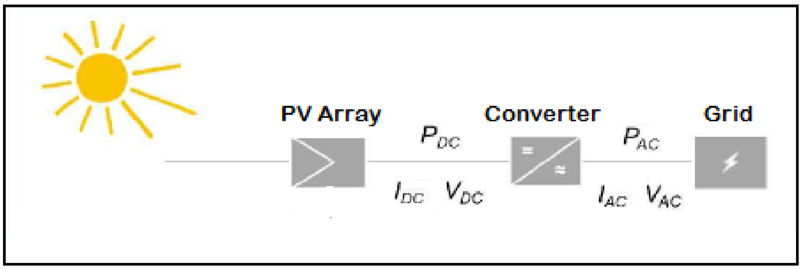

Figure 5 Solar PV system connected to the Grid

5 Case Study

As stated in the introduction, only the challenges and successes experienced during project development are discussed in the case study. The challenges and successes were categorised into the following categories;

Challenges	Successes
Business Case	Site Selection
Financial	Permitting
Procurement	Project Management
Legal & Regulatory	Technology
Technical Considerations	

Table 2 Challenges and Successes categories

5.1 Challenges

5.1.1 Business Case

Providing basic services and housing is local government's main priorities and the Integrated Development Plan (IDP) further supports this [10]. Thus redirecting budgets to pursue utility scale RE programme becomes difficult to justify. Justification for Atlantis PV was one of the major challenges

faced at the initiation stage. It was argued that the same energy could be purchased from Independent Power Producer so why should the CCT take the risks associated with building, operating and maintaining its own RE plants.
Below are some of the key questions raised during evaluation of the business case:

- How does the project align to IDP or any other strategic plans?
- What are the financial benefits associated own build versus IPP procurement?
- Are there socio-economic benefits that may be derived from both own build and IPP procurement?
- While the project will be developed on City-owned land, did the analysis take into account some sort of measure for the opportunity cost of using the land for this purpose?

Response
The initial business case addressed the questions partly but still lacked definitive answers and many of the socio-economic benefits were excluded, as it could not be monetised. In order to fully address these valid questions it was necessary to develop a comprehensive strategic case and perform a socio cost benefit analysis (SCBA).

5.1.2 Financial

During the first half of 2022, a price shock in the market was experienced causing a major shift from initial cost estimate. This lead to an increased in costs of 50%, which triggered concerns around affordability of the project and whether or not it was still financially feasible.

Response
Given the budgetary constraints, an option analysis was performed to ascertain the best way to deal with the excessive increase in project costs. The options that were identied are listed below:

- Option 1 - Reduce to 7.7MWp with the option to increase 11.5MWp with BESS.
- Option 2 - Obtain Additional Funding base on Latest Estimate.
- Option 3 - Appoint IPP, lease land & Sign PPA.
- Option 4 - Defer for 24 months until price recovery.
- Option 5 - Cancel project.
- Option 6 - Test market & withdraw if tender is higher than budgeted amount.

In order to decide between the options above, a set of criteria was identified to evaluate the various options. The criteria included:

- Estimated Capex and Opex costs,
- Risks associated a particular option,
- Estimated commercial operating date (COD),
- Financial benefits and the impacts.

Utilising the criteria above, option 1, 3 and 6 ranked the highest. These were presented to the relevant investment committees where it was decided that option 1 is the favourable option out of the three.

5.1.3 Procurement

The contracting strategy selected for the execution of Atlantis PV was EPC lump sum, which was chosen because of the advantages associated with it and it exposes the CCT to the least amount of risks. To support the contracting strategy, Atlantis PV was identified as the most appropriate project to pilot the NEC4 design, build and operate (DBO) form of contract.
Up to now, the most common type of contracting strategy utilised in the CCT was multiple bid contracts. This means, one would typically appoint a consulted to develop the conceptual and detail designs with bill of quantities (BOQ) and bill of materials (BOM), followed by the appointed of a construction contractor to build and commission the assets. Atlantis PV challenges the status quo by not only utilising a completely new type of contracting strategy in the CCT but also a new form of contract. Many internal governance challenges had to be resolved by the project team before the project was ready to test the

market with a fully developed tender document. These challenges and responses are listed in the table 3 below:

Challenges	Responses
The form of contract has no tender template	A task team consisting of various functional department developed a new CCT NEC4 DBO template specifically for Atlantis PV. This template had to be vetted by CCT legal team and approved by SCM.
Supply chain management (SCM) practitioners did not understand EPC lump sum contracting strategy	Specialised training was arranged and SCM formed part of the task team responsible for the development of the new NEC4 DBO tender template.
The CCT project management governance framework is aligned to a project process that uses multiple bid contracts, where detailed designs must be approved before tenders may be advertised.	The contracting strategy was formally presented to the relevant committees to obtain permission.
In terms of regulation 8(2) of Preferential Procurement Regulations 2017, "*An organ of state must, in the case of designated sector, advertise the invitation to tender with a specific condition that only locally produced goods or locally manufactured goods"* The requirement of Annexure C, a list of products/items must be included as part of the declaration. This is normally based on the BOM included in the tender specification. With EPC contracts, there is no BOM included in the tender specifications because the detailed design is required to compile a BOM. Since the detailed design is only done after the EPC tender is awarded, a functional specification forms part of the tender specification. This makes the completion of Annexure C; section C8 & C9 difficult, as the list of items is not available. Only the designated sectors are know at this stage.	Given this issue of not being able to compile a BOM, clarification was required from the Department of trade and industry (dtic) indicating whether one of the 2 options proposed below will be acceptable to ensure compliance with relevant legislation. Option 1(preferred): The CCT only puts down the designated sectors that will be applicable in Annexure C, column C9. As such, the tenderers will complete Annexure C as per pre-qualification criteria. No risks are considered to be incurred with this option as all designated sectors would be identified and listed and will cover all possible design options Option 2: The CCT can compile a generic BOM that makes provision for the various design options. In this scenario, the Tenderer will complete Annexure C as per the standard pre-qualification criteria. The risk with this option is that some of the items might not be listed after the detailed design has been completed by EPC contractor. In which case, the knock-on implication could be invalidation of the contract entered into.

Table 3 Challenges and Responses of EPC contracting strategy

It is common practice for an EPC contractor to perform the O&M for an initial period of 24 months after the COD as this is the period where most of the plant performance issues are experienced [11]. This was the initial intent that the EPC contractor appointed for Atlantis PV be responsible for the O&M period of 24 months. This meant following section 33 (S33) of the Municipal Finance Management Act (MFMA) approval process as the CCT would be committed to more than three financial years.

Challenge

Since Atlantis PV was identified as a mayoral priority project (MPP), the project team identified and optimised opportunities for the acceleration of governance processes to complete the required scope of works in as short a time as possible, without exposing the CCT to undue risk.

Response

The project team identified three potential options for the acceleration of project timelines. These were

- **Option 1 -** Retain the existing EPC contracting strategy, while removing the need for S33 approval and compressing the SCM related timelines. The S33 requirement would be overcome through the reduction of the O&M period from 24 months to 18 months and the placement of a separate O&M contract to maintain the power plant after the EPC contract has concluded.

- **Option 2 -** Engage the market for separate engineering design and construction contractors (i.e. multiple bid contracts) while only placing the construction contract once the detailed engineering design has been completed.
- **Option 3 -** Engage the market for separate engineering design and construction contractors, and issuing the tender for the construction contract before the detailed engineering design has been completed. This will require engagement with the market for engineering design through an existing (transversal) contract.

The above options all have related risks that must be taken into account when deciding on the optimal manner in which to proceed. These risks are summarised below:

<table>
<tr><th>Option 1
EPC without S33</th><th>Option 2
Detail Design included on Tender specs</th><th>Option 3
Concept Design only included on Tender specs</th></tr>
<tr><td rowspan="4">Design delays might affect the construction commencement date</td><td>Delay in finalisation of Designs by the consultant will affect the Construction tender timeline</td><td>Delay in finalisation of Designs by the consultant will affect the Construction tender timeline</td></tr>
<tr><td>Difficult to enforce accountability for poor Plant performance due to separate contracts for design and construction</td><td>Contractor might under estimate price and/or timeline due to not having detail designs, therefore fail to complete the project on time</td></tr>
<tr><td rowspan="2">Existing Consultant contract might need to be extended to accommodate duration of construction quality assurance/design liability</td><td>Difficult to enforce accountability for poor Plant performance due separate contracts for design and construction</td></tr>
<tr><td>Existing Consultant contract might need to be extended to accommodate duration of construction quality assurance/ design liability</td></tr>
<tr><td></td><td></td><td>Contract value may be over inflated to compensate for uncertainty in detail design that will be submitted after award of construction tender</td></tr>
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Table 4 Procurement strategy options

The above analysis highlights the additional risks incurred by the pursuit of Option 2 and 3. The risks relate not only to the potential for heightened expenditure due to inflated prices due to incomplete detailed designs, but also the risk of an inability to accurately assign accountability for inadequate benefit realisation post-commissioning, therefore option 1, EPC without S33 was selected.

Challenge

Atlantis PV tender had to be cancelled after only receiving one bid, which was found non-responsive. In order to determine the root cause the CCT Demand Management department was requested to investigate and make recommendations on the following:

- Obtain reasons why majority of tenderers did not submit a bid.
- Determine if local content requirement was met as per dtic-designated sectors.
- Perform a market analysis of possible solar PV EPC contractors to deliver plants between 1 to 10MW

The investigation by Demand Management revealed that 212 prospective tenderers requested the tender but only 52 purchased the document. The 212 prospective tenderers were contacted to provide clarification with respect to lack of response to the tender. Number of responses received by the stipulated due date were 29, which equates to a response rate of 13.68%. The investigation highlighted the following areas of concern:

- Functionality Criteria
- CIDB grading
- ISO certification
- Insufficient time and voluminous documentation

Response
Based on the investigation the following recommendation was made:

Functionality Criteria – Separate track record in terms of design, construction and operation with different points e.g. 25, 50, 25. This way it will be easier for bidders to form JVs - Engineering Consulting partners with a construction companies. The minimum score will also be reduced from 70% to 60%.

CIDB grading - Unfortunately this is a statutory requirement but based on the revised functionality criteria above breakdown bidders will be able to form JVs in order to meet the required CIDB grading.

ISO certification **–** This is not statutory requirement and was evaluated as part of functionality and not eligibility. It was, however, removed but it provided an assurance that the contractors comply with best practice when doing designs based on the high risk of the project. It only constituted 5% of functionality, which is immaterial.

Insufficient time and voluminous documentation was addressed by extending the advertisement period to over 60 days.

After the amendments were made and the tender was re-advertised, five submissions were received. At the time of writing this paper, the tenders were being evaluated. This confirms that the changes made improved the submission rate.

5.1.4 Technical considerations

A decision was made to evaluate the technical and engineering related to Atlantis PV as if it was an external application requesting permission to connect to the CCT electrical network. The main reason was to ensure that the plant is built to enable the complete outsourcing and ring fence the generation part. This meant that all requirements applicable to external parties would also apply to Atlantis PV. One key technical aspect that had to be changed was the switchgear rooms. Two switchgear rooms were required and had to be physically separated and the fenced. Each switch room must have its own entrance/exit doors. This is required to separate the switchgear dedicated to Atlantis PV and the switchgear dedicated for the grid connection.

5.2 Successes

5.2.1 Site Selection

To find suitable and available land within municipal boundaries are scarce, that was the reason that site selection is considered a success. Over 30 land parcels were screened before selecting the highest rank land parcel. The CCT well established geospatial information system (GIS) databases that enabled the identification of available land parcels, which contributed to a smooth site selection process. Thus, a key success factor in the site selection process is having access to well-maintained GIS databases and engaging with internal functional departments to understand future land needs.

5.2.2 Permitting

Atlantis PV required an environmental authorisation (EA), land use approvals (LUMS), conveyancing and water authorisation (GA). The EA followed a basic assessment process, which was obtained without any objections during the public participation process and appeals period. It is also well known that there is a high possibility that applications may experience delays once it is submitted to the relevant competent authorities for review. The success of obtaining all required permits with no delays could be attributed to the following factors;

- Well defined scope with a basic design. This will ensure that all permitting requirements are documented.
- Early start of the approval process to account for possible delays.
- If possible, engage proactively with the relevant competent authorities. This will create awareness, build relationships and pre-empt possible bottlenecks.
- Appointment of an experienced profession team.

5.2.3 Project Management

The CCT has adopted a standard project life cycle as shown in Figure 6 to manage the risks associated with project planning and execution. At each stage gate, a committee will review information like strategic, technical, financial, operational and commercial before the project can advance to the next stage. These stage gates control the process and serve as quality checkpoints, outlining the activities that must be completed or reviewed or key decisions that must be made before the project can advance to the next stage of development.

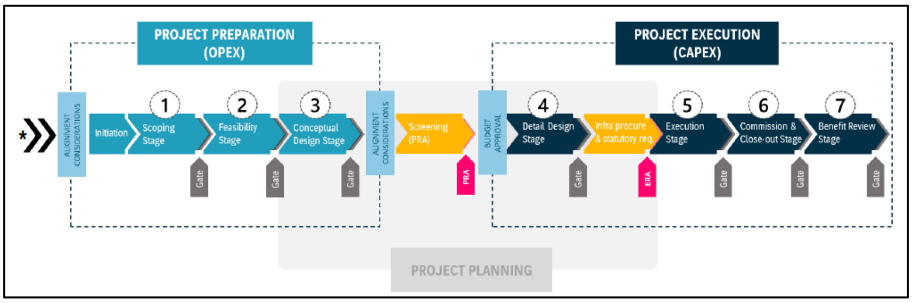

Figure 6 CCT Project Life Cycle

Atlantis PV has completed all stages within Project preparation and currently in detail design within Project execution. The utilisation of a predictive project life cycle has ensured robust decision making on critical aspects of the project. It has also promoted the use of project management best practices and ensure the project core team performs detailed planning before advancing to the next stage. To contribute towards the success of these types of projects within a municipal environment it is recommended that a project management governance framework be implemented.

5.2.4 Technology

As part of deciding which RE, technology was most suitable a wide array factors needs to be considered. Some of these factors could include location, availability of RE resources, environmental factors and LCOE. To assist in the decision making process, a multi criteria decision-making (MCDM) method was used for Atlantis PV. The criteria is shown in table 5 below.

Criteria	Comment	Weighting (1 - 10)	Score (Solar PV) (1-10)	Score (Wind) (1-10)	Weighted Score (Solar PV)	Weighted Score (Wind)
Ease of permitting	Ease of getting EA; acceptability to residents; risk of appeals; foreseen noise, traffic, flora and fauna impact	3	8	3	24	9
Energy Yield per Area	Energy density; more kWh per area used	2	5	2	10	4
Higher Capacity Factors	Ability to run power plant for longer periods	1	2	3	2	3
Levelised Cost	LCOE over life of plant; considers upgrades; benchmarked (Lazard)	3	9	7	27	21
Localisation Impact	Ability to create and sustain local jobs and economic impact	1	4	3	4	3
Final Score		10			**67**	**40**

Table 5 Atlantis PV Multi Criteria Decision-Making results

Based on a CSIR study for the CCT called, Electricity pathways for the City of Cape Town both solar and wind energy resources are available at the identified location. This is why it was important to develop a MCDM to decide which of the two energy resources to select. As one can see from the table 5 above the solar PV scored higher that than wind because of the ease of permitting, energy yield per area and LCOE. The success in making an informed decision on the best alternative is significantly increased with the use of a MCDM method.

6 Conclusion

In conclusion, the case study has shown that the undertaking by a municipality to develop own build utility scale RE plants comes with more challenges than successes. In particular, the procurement phase stands out as having to overcome the most challenges. The reasons for this are twofold. On one hand the local government supply chain management processes does not support an EPC contracting strategy and on the other hand, not knowing the RE market conditions at the time of the tender can contribute towards the challenges. The key takeaway from the successes is that formal reviews at the end of each stage will contribute towards the overall success of project and improve the readiness for the development of the next stage. A follow up paper will be written about the challenges and successes experience during the detail design, construction, commission and O&M of Atlantis PV.

7 Acknowledgements

City of Cape Town for enabling the resources used to undertake this work.

8 References

[1] C. G.-O. MARTIN, “The Sidney Opera House construction: A case of project management failure,” ESCUELA DE ORGANIZACIÓN INDUSTRIAL, 28 August 2023. [Online]. Available: https://www.eoi.es/blogs/cristinagarcia-ochoa/2012/01/14/the-sidney-opera-house-construction-a-case-of-project-management-failure/. [Accessed 28 August 2023].

[2] T. Janse van Rensburg and K. Morema , “South African Reserve Bank Occasional Bulletin of Economic Notes OBEN/23/01,” South African Reserve Bank, Pretoria, 2023.

[3] E. Buraimoh, A. A. Adebiyi, O. J. Ayamolowo and I. E. Davidson, “South Africa Electricity Supply System: The Past, Present and The Future,” in *2020 IEEE PES/IAS PowerAfrica*, Nairobi, Kenya, 2020.

[4] “International Renewable Energy Agency,” [Online]. Available: https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation/Technologies. [Accessed 28 August 2023].

[5] “City of Cape Town,” 28 August 2023. [Online]. Available: extension://elhekieabhbkpmcefcoobjddigjcaadp/https://resource.capetown.gov.za/documentcentre/Documents/City%20strategies%2C%20plans%20and%20frameworks/Climate_Change_Strategy.pdf. [Accessed 28 August 2023].

[6] K. Hagreaves, A. Joseph, T. Belinda and O. Oludolapo, “Renewable Energy Adoption and Integration in South Africa: An Overview,” in *12th International Conference on Clean and Green Energy (ICCGE 2023)*, Xiamen, China, 2023.

[7] Akinbami, M. Olusola, O. R. Samuel and M. O. Bodunrin, “The state of renewable energy development in South Africa: An overview,” *Alexandria Engineering Journal,* vol. 60, p. 5077–5093, 2021.

[8] “Solar Energy Perspectives,” IEA, United States, 2012.

[9] M. Malinowski, M. Leon and H. Abu-Rub, “Solar Photovoltaic and Thermal Energy Systems: Current Technology and Future Trends,” *Proceeding of the IEEE,* vol. 105, pp. 2132-2146, 2017.

[10] CCT, “Integrated Development Plan,” City of Cape Town, Cape Town, 2022.

[11] Engineering Procurement Construction Best Practice Guideline, Brussels: SolarPower Europe, 2020.