Malaysian Journal of Sustainable Environment
Vol.8.No.1 (2021) 91-104
doi: https://doi.org/10.24191/myse.v8i2.13239

ISSUES IMPEDING QUALITY INSPECTION OF A SOLAR FARM CONSTRUCTION

Hafizah Mohd Latif[1], Noor Sahidah Samsudin[2] & Faris Anwar Hussin[3]
[1,2,3]*Department of Building, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus, Seri Iskandar, 32610 Perak, Malaysia*

hafiz017@uitm.edu.my
noorsahidah@uitm.edu.my
Received: 12 October 2020
Accepted: 30 November 2020
Published: 30 June 2021

ABSTRACT

The quality inspection of a solar farm construction is essential in ensuring that the structural base to receive photovoltaic modules is built as planned. The aim of this exploratory paper is to discover issues that could impede an effective quality inspection. The evidence suggests that unethical behaviour of the site personnel is the major factor, apart from poor drainage system and poor documentation management, which have impeded the delivery of quality. Unethical behaviour and the racism issues, which were unexpected would be fruitful areas for further studies. The potential solar investor and related stakeholders shall consider the above issues in future for a more sustainable lifecycle.

Keywords: *QA/QC process, Quality Inspections issues, Solar farm construction; Unethical behaviour*

INTRODUCTION

Solar farms are in the limelight in the efforts of minimising environmental impact while maximizing clean energy output. Evidently, the capacity of photovoltaic usage expands rapidly every three to four years, which now provides about 3% of the world's electricity (Brunisholz, 2019). Malaysia has shown interest in photovoltaic by harvesting solar energy in several large successful projects. In addition to changing the electric generation of the world, the development of solar farming transforms the experience of the construction industry. It is widely known that the failure to overview issues that can occur during the construction phase may not only contribute to delays, but also can have an impact on the cost and quality of the project. A successful solar project is an intensely comprehensive process with strict guidelines and challenges that requires detailed quality and safety approach. However, most of the research on construction quality focuses on elements such as product or service quality (e.g.: Forsythe, 2016), the quality management (e.g.: García-Bernal & García-Casarejos, 2020) or quality environment and safety (e.g.: Soni & Trivedi, 2020). On the other hand, to increase the performance of solar harvesting, numerous research have been carried out on its technology (e.g.: Kodali & John, 2020), the economy (e.g.: Tillmann et al., 2020) and geographical considerations (e.g.: Watson & Hudson, 2015). However, there is a need for empirical research to identify what actually happens during the quality inspection tasks of solar project construction. By doing this, investors and contractors are therefore able to reduce risks. There is no doubt that the performance and reliability of photovoltaic modules and systems are topics that are attracting more attention every day from various stakeholders. However, in recent time, it should also come in combination with the project quality and sustainability. Through an extensive quality sitework inspection, a high-quality and sustainable solar farm can be certainly achieved. The aim of this paper is to discover issues that could impede an effective quality inspection at a solar farm construction in Malaysia.

LITERATURE REVIEW

The overall growth of Malaysia is reflected in its large rise of electricity consumption (see: CEIC data, 2020). This increase in demand leads to

Malaysia generating more electricity from diverse sources, including solar. Schemes introduced by Tenaga National Berhad (TNB) have shown greater extent of organisations and individuals in investing and supporting the solar energy generation in Malaysia (see: Integrated Annual Report 2019, 2019). Hence, more solar farms that incorporate the large-scale solar photovoltaic panels are expected to generate clean electricity to be fed into the TNB grid. In conjunction to this, potential solar farm investors, whom most probably do not have sufficient knowledge on construction, would be lulled into complacency that they are doing the right process for the first time. Tian (2013) reported installation of solar at a school and affirmed that due to the experience of the contractor and responsibilities they carried out during the construction phase, the tight budget for the project did not disbursed for it to be successful. This suggests that the investors and contractors shall reap immense benefits from educating themselves on the quality performance standards and plans.

Today, many projects have adopted the Quality assurance (QA) and Quality control (QC) guidelines, which involve detailed processes and tests. The failure to incorporate QA/QC results in construction defects and reduces sustainability (Assaf et al., 1996; Tayeh et al., 2020). Among issues related to quality practices at site are misconception of quality, poor performance of vendors/subcontractors, lacked clarity of engineering specifications, poor management/ coordination and communication, large volume of work, time constraints and insufficient experience (Burati Jr et al., 1991). Although extensive research has been carried out on quality management system, there has been little qualitative analysis of its execution. Thus, it is interesting to explore the ways in which each issue as above occurred at site. Understanding the issues could help stakeholders to mitigate identified risks during the construction stage and have a durable and sustainable solar farm. As Manghani (2011) points out, sound quality system can have positive effects such as client satisfaction, improvement of business opportunities, elimination of waste and correction. Considering construction of solar farm is an expensive operation and required to adhere to strict regulations, it is best to provide adequate measures and assurances instead of wasting time and money on rectification works. While it is agreed that people make mistakes, the probability of rectifications can be minimised if sufficient effort is made to control them. Hence, this paper attempts to provide overview of quality issues of a solar farm for the investors and contractors to learn from.

Whilst there are many components and processes involve in the scope of construction, the focus of this study is limited to issues pertaining to quality inspection only of a solar farm civil work package in Malaysia.

METHODOLOGY

This exploratory study has been carried out at 47MWAC Capacity Solar Photovoltaic Energy Generating Facility located in Malaysia. Although the collected data was rich, this paper condenses only the key points of quality inspection of the solar farm construction. Hence, the methods of construction work and tests, the safety and health inspections as well as the detail explanation of the quality management plan are not described herein. Data was collected through two methods for the research. First was the participatory observation, which was carried out from 5 August 2019 until 20 December 2019 which focused on the methods of construction work and issues related to quality management system on the field. The observation was recorded in the observation diary. The second method was the unstructured interviews carried out simultaneously with the observation to gain a deeper understanding of the issues involved. Among the site workers interviewed were the QA/QC engineers and Project Engineer and the interviews took place at the site office. Each interview typically lasted for 30 minutes to one hour and written in a notebook as recording was not allowed. The details of the project, companies involved and their personnel are kept minimum and anonymised as part of the research protocol. Data were analysed using thematic analysis in Microsoft Words with colour coding based on the pre-determined themes, which include "understanding of quality, performance of site workers, clarity of specifications, management processes, volume of work, time constraints and experience". During the analysis, other themes or sub-themes emerged which led to a more meaningful contribution in discovering issues that could impede an effective quality inspection at a solar farm construction in Malaysia.

RESULTS AND DISCUSSIONS

The site selected as the case study was one of the biggest solar projects in Malaysia with 96,000 photovoltaic units installed in the total area of 124

acres and contract value of RM17,000,000. During the construction of the solar farm, a series of inspections were carried out before, during and after the completion of works. Three QA/QC engineers were assigned to ensure the quality of materials and services of the solar farm construction. One engineer was appointed under the main contractor (named herein as the QA/QC: main-con) and two others were under the client (the QA/QC: client). This shows that the client was very concerned about the quality management. All QA/QC engineers overseen the materials ordered, involved in every stage of the construction of civil and structural elements and ensured the completed works were done as planned. Accordingly, the implementation of the QA/QC inspections involved the issuance of three key documents known as the Request for Inspection (RFI), Non-Conformance Report (NCR) and Inspection Testing Plan (ITP). The documents helped the QA/QC engineers to carry out proper inspection in reporting and documentation.

The RFI was a formal paper-based document that provided the views of construction works as planned and adhered to requirements. It required signatures of the QA/QC engineers to indicate that the quality of respective works was acceptable. RFI can only be processed once both sides of QA/QC engineers were satisfied and had signed the form before a report was prepared for the client. The QA/QC: client were more thorough in the inspection process to ensure that the works complied with the plans and guidelines. The client was looking at the best possible way to control their cost within the budget without compromising the quality of the construction. On the other hand, the main concern of the contractor was more on the time and cost. It was found in the qualitative study by Bowen et al. (2002) that clients perceived project quality to be more important than time performance as opposed to the contractors and consultants, however, the reasons behind the different perceptions were uncertain. Due to subjectivity of the phrase 'minimum requirement of quality' from the client and contractor perspectives, the QA/QC engineers had different views as to the level of acceptance for RFI approval. Although the QA/QC: main-con inspected new items, working platforms activities, soil tests, concrete tests and solar farm structural elements and given his approval, there were some instances where his decisions were out-slashed by the QA/QC: client, based on field inspection. The QA/QC: client expected high level of quality for the money that they have invested in and for the sustainability of the solar farm in the future. The contractor, nevertheless, had to meet the deadline to

avoid any incurring additional cost. Thus, the contractor would accept low-quality work for some minor tasks, otherwise the progress might be delayed without a time extension. Looking at both perspectives, the client had the right to not approve the RFI in ensuring high quality. At the same time, the QA/QC: main-con also wanted to deliver quality tasks but his challenges in handling unreliable labourers, supervisors and unpredicted weather were among some factors that impeded the process. The quality of the works under the contractor, however, can be called into question since works carried out were just on the surface and not following the method statement. For example, the QC/QC: client issued a Quality Incident Reporting after they detected that the geotextile material had no over-lapping at certain working platform and that the water detained in the excavated area was not pumped out before backfilling. This indicates unethical conduct, poor supervisory performance and unreliable sub-contractors at the site, which can be seen by client as the red flag for current progress and future projects. The QA/QC engineers from both sides and related site personnel held a meeting to decide on the actions that should be taken. Such major rectification required progress to be halted and rescheduled which resulted in the financial loss borne by the contractor. Apart from what have been detected, it was observed that the depth of excavation at certain areas was lesser than as planned, the overlapping of geotextile underneath the ground was insufficient and each of the backfill soil layer was not compacted at every 300mm as according to the specification. This unethical work conduct shows the character of the sub-contractor in carrying out their works or the main contractor in supervision. Although the QA/QC engineers were dedicated in doing their job by ensuring quality control, the unethical conduct of sub-contractors and poor supervisory were not easily identified due to the huge size of the project in question.

The QA/QC: main-con sometimes had arguments about the work process and conflicts such as delay of inspections and approval from the QA/QC: client due to quality misconception. Not only that, the QA/QC: main-con also received pressure especially from the Project Director to speed up the inspection/ construction works, although the time and other resources given to him were limited. For example, only one 4x4 car was provided by the contractor for the site use. As a result, the QA/QC engineers and other site personnel had to wait for their turn to use the car to carry out their duty in the large site area. This has slowed down the work of the QA/QC

engineers in carrying out inspection works at the site. In order not to delay their tasks, the QA/QC: main-con as well as other site personnel had to use their own vehicle and absorbed the cost for any damage. Furthermore, the progress of the project was affected due to constant rainfall. The drainage system at the site was not properly channelled to the nearest river, which has caused several occasions of floods. As Lebel (2020) observed, many solar projects have failed to properly plan and manage storm water runoff during construction, which resulted in unwanted consequences. Moreover, the drainage system has often been overlooked at the site. To make matters worse, the contractor also had a high turnover of workers. The labourers had once gone on strike due to unpaid wages. Their wages were cut by the Project Director, who assumed that the labourers came late to the site and went back early as they wanted. However, the labours did their job accordingly but were not given a punch card or any other system to measure their working hours. A police report was made against the Project Director and the contractor. Their salary was then paid but slower than as promised. Making decisions without sufficient knowledge had disrupted the construction progress and caused dissatisfaction among the workers. This confirms the findings of Haupt & Whiteman (2004) that senior management commitment and involvement is critical for effective quality management, and thus they must provide and lend continuous support for quality programs to be successful.

In addition, a few workers of a certain ethnic minority (at the site) have also faced racism and discrimination at the hands of the Project Director, which is an unexpected finding. This has adversely affected the emotions of the workers, which can lead to poor work performance, health and quality of life. Racism has grown into a research subject in the construction field (e.g.: Dunn et al., 2011; Monteiro, 2018). This issue seems relevant here and is an area which is worthy of being further explored in future research on how racism among site personnel can influence the quality of inspection in the construction industry. As a result of all the above issues, the QA/ QC: main-con and a few other workers had resigned and refused to continue their work contract. Due to the decreased number of site personnel, other remaining employees were given more tasks or a wider job scope to ensure work is completed on time while safeguarding the interests of the company. But the senior management did not hire new employees because the project had only two months remaining for completion. As a result, the site Quantity

Surveyor was assigned to carry out the duty of the QA/QC: main-con. However, she was not able to understand most of the works related to quality inspections and had to constantly contact the previous QA/QC: main-con. The incompetency of workers and multi-tasking approach as found by Latif (2014) resulted in poor work standards and lack of accountability. Similarly, in consequence, it was informed that the performance of the quality inspections by the contractor had reduced. However, data on how and what have been affected were not available as the data collection period has ended during this time.

In quality inspection process, all RFIs were attached together with the ITP, a document that described the approach to testing of materials or construction works at the solar farm. An ITP is a guideline or plan designed to ensure that the QA/QC engineers can work as according to plan, specifications and standards. The ITP included earthworks, cable trench works, internal road works, drainage works, survey works, piling works, gabion and stone pitching perimeter fencing, concrete plinths and retaining wall. Through proper inspections, many items ordered from the suppliers were detected as not being delivered as requested. For example, the QA/QC: main-con inspected that the c-channel connectors were delivered in the wrong size, many honeycombs, and damaged U-ditch at the working platform. Based on the ITP and RFI, an NCR was issued when any non-conformance work was discovered such as completed works did not meet the specifications or when elements were not built according to the drawings. NCR detailed the problems, solutions and any corrective changes carried out. It was found that NCRs have led to delays in work progress, required additional resources to correct the situations and raised pressure on the contractor. Even when some of the rectification works were minor, the process of NRCs took some time until they were approved. This created pressure for the site personnel of the contractor. Notwithstanding that, the contractor responded with corrective actions to solve NRCs issues to avoid further losses. However, again, the ethical standard of the main contractor/ sub-contractors was questioned since some rectification works have just been performed on the surface. This highlights an important issue in having a deeper understanding about the way in which the behaviour and performance of subcontractors can influence quality.

The RFI, ITP and NCR required quite a number of document

attachments and paperwork, which sometimes was challenging to prepare. On average, about 3cm thickness of RFI documents needed to be printed and attached together with ITP for submission. Most of the documents were redundant. Furthermore, three copies were required for each NCR; one is for the record of the client, one is for the contractor and one was placed at the guard house for the reference of the Project Director/ Senior Management. Moreover, signatures from the QA/QC engineers and Project Manager were needed on these three copies. Besides that, inquiring signatures from three personnel (which was later changed by the client to four personnel) was troublesome to the contractor. This was not only a waste of time, papers and energy, but it was a tedious process for all the QA/QC engineers as they had many other tasks to complete. Apart from the RFI, ITP and NCR, the QA/QC engineers had to wait for the Permit to Work for risky tasks. The QA/QC engineers had to prepare what needed to carry out and ensure that inspections had commenced before, during and after the execution of each task. Although the Permit to Work is related to Health and Safety Management, it was essential in achieving the quality of tasks. It is to note here that two site offices were built on the site, one is for the main contractor and the other one is for the client. Delivery of documents to the client normally was made by hand and left with the clerk when the respective personnel was not around. There were at least two incidents whereby the client misplaced the Permit to Work documents and lost them. This had wasted the contractor's time to prepare a new one and delayed the inspection works. The contractor's personnel then decided to scan all documents before the next submission. Indeed, the reliance on the overall paper system was a tedious job.

The dynamic issues in quality inspection appear to be complex in the context of this study as depicted in Figure 1. The key players influencing inspection process are capitalised and embolden. However, the dashed line indicates that the top management at the site has an indirect link to influence the quality of the tasks. On the other hand, the solid line suggests the concepts that are directly linked. Meanwhile the boxes display the influencing factors, whereas findings that are not boxed denote the outcomes.

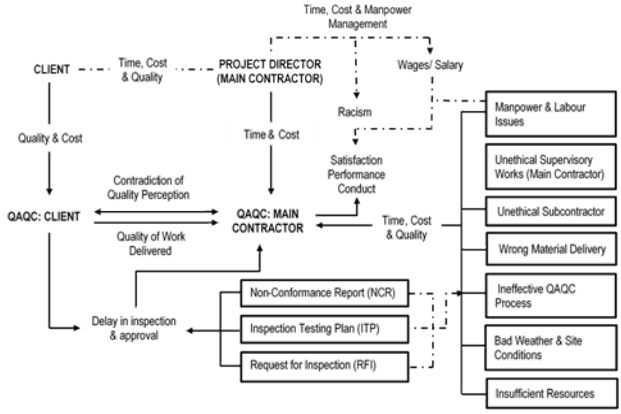

Figure 1. The factors influencing the quality inspections
(Source: Author)

CONCLUSION

Once a solar project is initiated, the quality management and safety plans of the construction are considered first before the solar system is installed. This paper highlights the issues that could impede an effective quality inspection during the construction of civil works package of a solar farm in Malaysia. It was found that the paper-based quality documentation was a lengthy, costly and non-eco-friendly process which required signing, scanning, distributing, searching, filing and archiving a lot of paper. Furthermore, the results show that the decisions made at the top without adequate knowledge, attitudes and resource allocation not only distressed the quality inspections and progress, but also created an unpleasant work environment at the site. Moreover the senior management focused less on the overall goal of the client in completing the project with the quality in mind, but more on the time and cost. The mistreatment of workers which involved cutting their wages, giving them more responsibilities that were not within their job scope and also racism by the senior management were deemed unethical, lacked integrity and ultimately led to the dissatisfaction of the workers and high turnover of the employees. This study strengthens the idea that having QAQC from both the client and contractor is crucial in ensuring quality although their perceptions differ. The QAQC process fosters a quality consciousness especially among the personnel who were given the

responsibility. The client's QA/QC engineers were important for their quality judgement, inspections and solar lifecycle sustainability to avoid future problems. However, the client needs to identify the minimum acceptable level of quality for each work, perhaps before it was constructed to avoid conflicts. In conjunction to this, the data suggests that the site supervisors should support the quality delivery as they were expected to provide daily real-time constructive feedback on performance of the sub-contractors and workers. Moreover, the sub-contractors had deliberately concealed mistakes or defects and poor-quality works, which have raised doubts about the ethical standards of the project. This issue lays the foundation for future research on how supervision (as well as the issue of racism) can hinder quality delivery by the sub-contractors. Although this study focuses on quality inspections of a solar farm project, the findings may well have a bearing on unethical conducts and poor performance of the sub-contractors, senior management, site supervisors and labourers that have jeopardised the quality. The main limitation of this study, which could be addressed in future research is that quality inspection requires careful observations with a longitudinal effect and full access to all the quality management processes. This can add more value to the underlying mechanisms of the problems. The issues exhibited in this paper enable the researcher, investors and contractors to understand and identify the issues at an early stage which are definitely worth investing the time and resources.

ACKNOWLEDGEMENT

This paper and the research behind it would not have been possible without the permission of access to data and the help of certain individuals at the solar farm site.

REFERENCES

A Assaf, S., Al-Hammad, A.-M., & Al-Shihah, M. (1996). Effects of faulty design and construction on building maintenance. *Journal of Performance of Constructed Facilities, 10*(4), 171–174.

Bowen, P., Cattel, K., Hall, K., Edwards, P., & Pearl, R. (2002). Perceptions of time, cost and quality management on building projects. Construction Economics and Building, 2(2),

48–56.

Brunisholz, M. J. (2019). IEA PVPS Annual Report 2019 (p. 121). *Solar Power Europe (SPE)*, formerly known as EPIA. https://iea-pvps.org/wp-content/uploads/2020/05/IEA-PVPS-AR-2019-1.pdf

Burati Jr, J. L., Matthews, M. F., & Kalidindi, S. N. (1991). Quality management in construction industry. *Journal of Construction Engineering and Management, 117*(2), 341–359.

CEIC data. (2020). *Malaysia Electricity Consumption Economic Indicators.* https://www.ceicdata.com/en/malaysia/electricity-generation-and-consumption/electricity-consumption.

Dunn, K., Loosemore, M., Phua, F., & Ozguc, U. (2011). Everyday Ethnic Diversity and Racism on Australian Construction Sites. International *Journal of Diversity in Organisations, Communities & Nations, 10*(6).

Forsythe, P. J. (2016). *Construction service quality and satisfaction for a targeted housing customer*. Engineering, Construction and Architectural Management.

García-Bernal, J., & García-Casarejos, N. (2020). Determinants in the adoption of total quality management (tqm) in the construction sector: A management perspective. *Journal of Construction, 15*(2), 28–36.

Haupt, T. C., & Whiteman, D. E. (2004). Inhibiting factors of implementing total quality management on construction sites. The TQM Magazine.

Integrated Annual Report (2019). *Building Relationships Creating Value*. Tenaga National Berhad.

Kodali, R. K., & John, J. (2020). *Smart Monitoring of Solar Panels Using AWS*. 422–427.

Latif, H. M. (2014). *Case studies of Malaysian contractors" bidding process: Ethical principles and practices* [Thesis (Ph.D.), University of Reading].

Lebel, C. Y. (2020). Solar and Stormwater: Plan Better to Avoid Me. *Natural Resources & Environment, 34*(3), 50–52.

Manghani, K. (2011). Quality assurance: Importance of systems and standard operating procedures. *Perspectives in Clinical Research, 2*(1), 34–37.

Monteiro, B. (2018). *On "Race", Racism And "Class Racism*": Research Notes On Portuguese Migrants In The Construction Industry. 113–127.

Soni, A., & Trivedi, M. (2020). Determination of Quality and Safety in Construction Project consisting Multi-Mode Activities. 8(VII), 1422–1431.

Tayeh, B. A., Maqsoom, A., Aisheh, Y. I. A., Almanassra, M., Salahuddin, H., & Qureshi, M. I. (2020). Factors affecting defects occurrence in the construction stage of residential buildings in Gaza Strip. *SN Applied Sciences, 2*(2), 1–12.

Tian, J. (2013). Going Solar Atop School Buildings. School Administrator; *Arlington, 70*(10), 12–13.

Tillmann, P., Jäger, K., & Becker, C. (2020). Minimising the levelised cost of electricity for bifacial solar panel arrays using Bayesian optimisation. *Sustainable Energy & Fuels, 4*(1), 254–264.

Watson, J. J., & Hudson, M. D. (2015). Regional Scale wind farm and solar farm suitability assessment using GIS-assisted multi-criteria evaluation. *Landscape and Urban Planning*, 138, 20–31