

REQUEST FOR PROPOSAL

RUSTENBURG GIRLS HIGH SCHOOL SOLAR PROJECT



Request for Proposal

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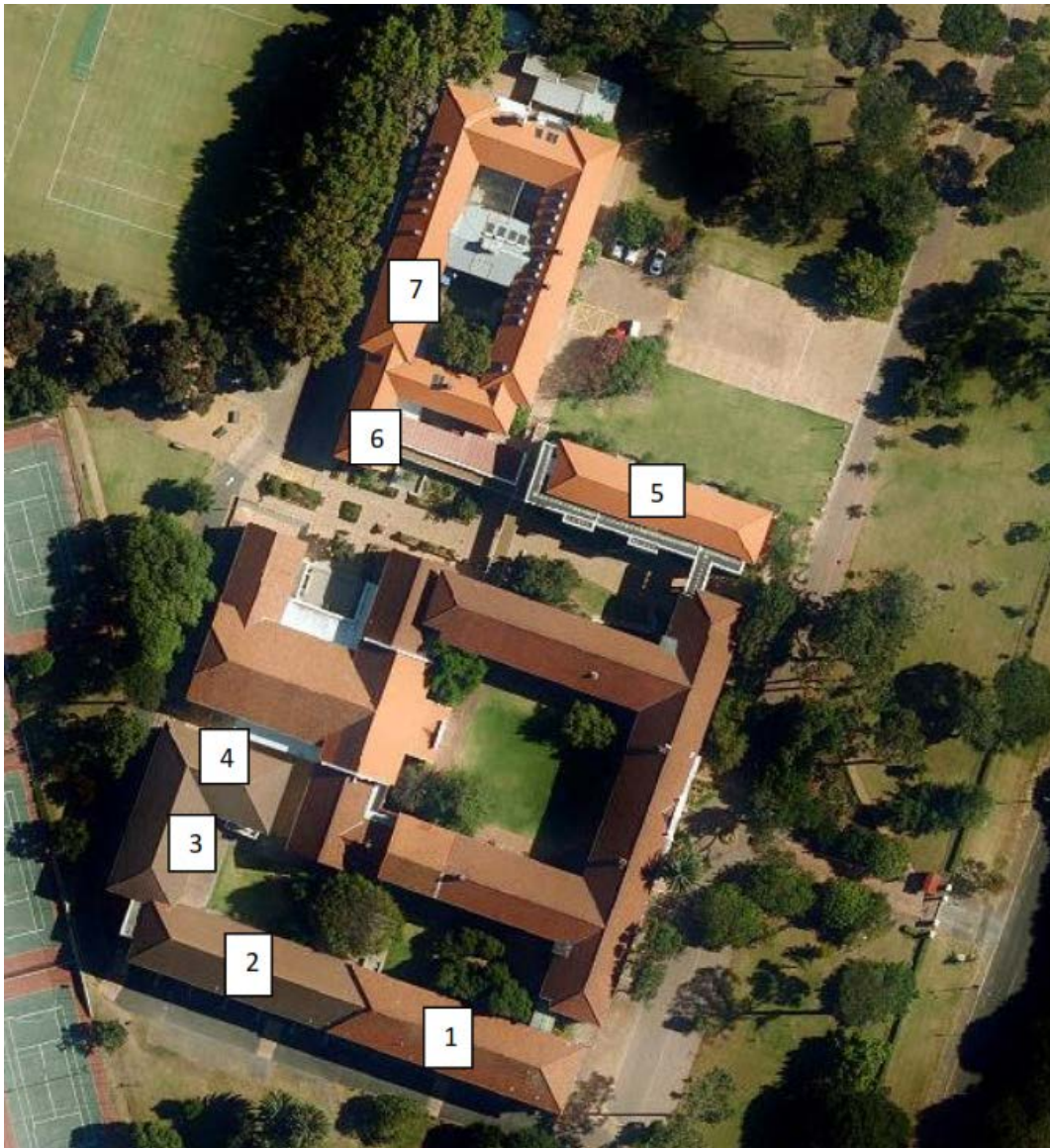
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1 Objective

In line with our long-term objective to become carbon neutral and more self-sufficient, Rustenburg Girls High School (RGHS) is looking to install a roof-top solar PV system at the school to supplement its on-site electricity consumption.

While taking note of the on-site limitations regarding available roof areas the school would like to maximise the possible PV system installation by installing arrays on multiple buildings.



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2 Invitation to Contractors

Suppliers are invited to provide a proposal for a solution, including system design, supply of materials, installation, testing, commissioning, and all relevant permit applications. The contractor is also to supply a proposal for the maintenance, performance monitoring and warranty management of the installed system. Proposals shall be based on an outright capital purchase of the system, with separate line items for maintenance, insurance and warranty management (priced per annum).

The contractor is expected to demonstrate and ensure full compliance with all relevant local standards and by-laws associated with Solar PV and small-scale embedded generation (SSEG) systems within the City of Cape Town municipal jurisdiction.

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3 Contractor Qualifications

The following factors will be considered when evaluating the suitability of contractors for this project:

- Track Record within the City of Cape Town for Small Scale Embedded Generation (SSEG)
- Local in-house capability for long-term support and maintenance
- SAPVIA PV GreenCard registered

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4 Tender Process

4.1 School Contact Person

The contact person for this project is:

Name:	Craig Leith
Mobile:	0677 867 004
Office:	021 686 4066
Email:	leithc@rghs.org.za

All queries relating to this RFP must be directed in writing (email) through this contact. Clarifications will be shared with all invited contractors.

4.2 Proposal Submission

Proposals are to encompass the following:

- Description of system and layout
- System design/yield report (e.g. Helioscope)
- Technical data sheets and documentation

Final proposal and all supporting documents must be submitted in hard copy format by 17h00 on **Monday 9 May 2022** for proposal submissions at the School, addressed as follows:

***For Attention: Ms S. Ebrahim
Rustenburg Girls' High School
44 Campground Road, Rondebosch
7700***

(Please refer to section **Project Schedule**).

4.3 Proposal Evaluation

Proposals will be evaluated based on the written submissions and on the criteria as laid out in this document. A short-list of contractors will be selected and notified for further discussion within three weeks of proposal submission closing date. Contractors who are not shortlisted will be informed in writing.

4.4 Site Visits to Reference Projects

Short listed contractors will be required to show one of a reference project of similar size as a means to demonstrate their work practices.

Attendees will be appointed representatives of RGHS.

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4.5 *Presentation to RGHS Board for Approval*

Based on the written submissions and site visits, a report with recommendations will be compiled by the appointed RGHS representative. The report will be presented to the RGHS School Governing Body for consideration and approval.

4.6 *Contract Award*

The RGHS Board will make the final decision on whether to proceed with this project and with which contractor. The successful contractor will be contacted to plan for the start of installation. Unsuccessful contractors will be informed in writing. **The Contract Award is subject to the final approval of the MEC for Education and the Western Cape Education Department.**

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5 Project Schedule

The following table shows the expected programme schedule for the approval and execution of this project, which will commence when the tender goes out, namely **Monday 28 March 2022**.

Activity	Date
Tender is open, including 2 weeks for site visit (by appointment only)	6 weeks
Evaluation of proposals and selection of successful tender	2 weeks
Drafting of contract	2 weeks
Ordering of materials	2 – 3 months
Construction and installation	3 months
Commissioning, performance testing and final handover	1 – 2 months

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6 System Sizing and Design

The following table lists the basic system requirements to be considered.

System Type	Grid-tied (non-residential SSEG)
Installation Type	Fixed Rooftop (multiple roofs)
PV Generation Capacity (AC)	Approx. 140 kWp (limited by roof areas)
Battery Backup systems	Optional battery backup systems will be considered for: • Admin/IT • the Hostel and • the headmaster's residence
Location	Rustenburg Girls High School, Rondebosch
Supply Utility	City of Cape Town
Existing Tariff	Small Power User 1 High Consumption
Proposed New Tariff	Non-Residential SSEG
Existing Annual Consumption	500,000 kWh
Utility Circuit Breaker Size (3ph)	630A – dedicated transformer

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7 Technical Requirements

The following section covers the salient aspects of importance in this project. These aspects should be seen as the minimum requirement and not an exhaustive list of requirements.

7.1 *Applicable Standards*

This project falls within the authority of City of Cape Town municipality. The system must be designed and installed according to the City of Cape Town's "**REQUIREMENTS FOR SMALL-SCALE EMBEDDED GENERATION**", which is available on their website. This document stipulates all significant requirements and references the applicable national and international standards.

NRS 097-2-1: 2017 is the applicable national standard.

7.2 *Modular Design*

It is expected that the RGHS may wish to expand the capacity of this system in future. All proposals must take this into consideration and provide for a modular approach to the design of the system.

7.3 *PV Panel Selection*

PV panels using Mono-Crystalline Silicon with a 30yr performance warranty will be the preferred choice for this project. Panels which have been designed to eliminate PID as well as frame and mount structure corrosion will also be given preference. Panels being proposed must be certified as compliant with **IEC 61215: 2016**.

7.4 *Rooftop PV Installation Considerations*

A structural engineering report is made available. The contractor shall develop a design for a new photovoltaic system at Rustenburg Girls High School (RGHS) taking into consideration the limitations as stipulated in the structural engineering report.

All DC cabling shall be protected by means of UV stabilized conduit (not exposed to direct sunlight) or stainless-steel / galvanized steel piping where it is exposed to the sun or potential physical damage. This includes on the roof, under the PV panels, as well as the cable routes between the PV panels and the inverter/s. All DC cabling passing through roof spaces, where exposed wood trusses are located, will be routed through stainless-steel / galvanized steel piping to further reduce the risk of fire in these vulnerable spaces. Contractors may propose a means of protecting the DC cables which is equivalent or better. Loose or unprotected DC cables will not be accepted anywhere on this project.

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A shading analysis shall be provided to demonstrate that there will be no adverse effects due to shading (between 07h00 and 17h00 during the summer and 09h00 and 15h00 during Winter).

7.5 Electrical Installation

Only material approved for use in South Africa will be allowed. This includes circuit breakers, fuses, fuse holders, DC isolators, wiring and cabling etc. All equipment must meet or exceed the SABS standards for use within South Africa. The onus will be on the contractor to prove that such equipment is compliant by means of appropriate test certificates provided by reputable, independent test and certification authorities.

7.6 Power Optimisation

The Solar system shall include maximum power point tracking (MPPT) to ensure that the PV panels are optimally utilised. All panels in any given array/string must be mounted with the same inclination and orientation.

7.7 Inverters

Only inverters and equipment listed on the City of Cape Town website may be used for this project.

Moreover, the installation needs to comply with all technical requirements as per **NRS 097-2-1: 2017**.

7.8 Utility Connection

The contractor, once appointed, will be expected to liaise with the City of Cape Town and complete all necessary forms. An ECSA-registered professional engineer will be required to sign off upon completion of commissioning to enable final registration with and approval by City of Cape Town.

7.9 Performance Monitoring System

System monitoring via the manufacturer's portal (or alternative) is required giving access to graphs and displays for public viewing as well as regular reporting (monthly, annual).

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8 Proposal Format

8.1 Cover Page

Each proposal must have a cover page which includes the following information:

Project Name	Rustenburg Girls' High School Solar Project
Organisation name	
Primary address	
Contact person: Name Phone Number Email	

8.2 Company Background and Qualifications

8.2.1 Track Record

Track Record within the City of Cape Town for Small Scale Embedded Generation (SSEG):

Company history and registration

details. List of Non-residential

SSEG's > 20kVA.

Reference list of all other rooftop installations in City of Cape Town or Western Cape surrounds.

3 Recent projects (<5yrs) indicating name, system installed capacity, system performance vs design/expected performance since new, PV Panel Technology used.

3 older projects (>5yrs) indicating name, system installed capacity, system performance vs design/expected performance since new, PV Panel Technology used. All reference projects must be independently verifiable.

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8.2.2 Local Inhouse Capability

Local presence and in-house qualifications for:

- Site analysis, including:
 - Load Profile measurement,
 - shading analysis and
 - orientation optimisation
- System design
- Installation using qualified staff, trained to the relevant local/international standards and best practices
- Applicable Health and Safety training
- Commissioning and professional sign-off
- System performance monitoring
- Annual maintenance and warranty handling

8.3 Compliance to Technical Requirements

The contractor shall provide detailed descriptions with photographs (from their own projects) and other supporting documents showing how they intend to comply with the technical requirements listed in section 7 hereof.

This will include, but not be limited to the following items:

- Details of **site survey** and proposed **roof location for installation** and orientation of the solar panels
- **Load profile** (measurements and) analysis.
- **Specifications** of the solar panel, inverters, and all other accessories. The specifications should include make, model, country of manufacture and warranty period. Supporting certificates and data sheets must be provided.
- Preference will be given to **Tier 1 suppliers**.
- **Mounting type** with specific reference to the roofing installed at RGHS. Protection of system from **animals and birds** where applicable.
- Frame and mounting system **corrosion mitigation** methodology.
- **DC cable management**

8.4 System Proposal and Performance

Single line diagram of the PV system including the above system specifications

Energy simulations with AC kWh output after accounting for panel efficiency corrected for local conditions, inverter efficiency, wiring losses and other losses. Local conditions to be accounted for include, expected operating cell temperature, irradiance levels, etc.

- Over the performance warranty period of the solar panels
- on a monthly basis for first year
- on a monthly basis for the 10th year
- on a monthly basis at the end of the performance warranty period for the solar panel

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PV Panel **performance degradation factor** (% reduction per annum)

Specific production (kWh/kWp/Year)

- o Over the performance warranty of the solar panel (Average)
- o For the first year
- o For the 10th year

Expected “**Self-Consumption**” ratio (% Self Consumption) for each month. This can be done with the aid of measured load profile data or the data as provided in this RFP.

Performance guarantee of the system. The kWh generated and period for which this guarantee is applicable should be stated clearly.

8.5 System Cost Proposal

The following information regarding the system cost is to be provided.

- **Total Capital Cost** (Excluding VAT)
- **Bill of Materials** with component costs and labour costs.
- **Outsourced costs**
- Estimated costs for **CoCT requirements (as applicable)**
- **Maintenance cost** per annum (as proposed by the contractor).
This can be based on % of capital value. It will be assumed that this cost will increase at CPI annually.

8.6 Energy Savings

Evaluation of proposals will be based on energy (kWh) savings viewed per year over the life of the system. This is made up of two components:

Self-consumption of PV-generated energy and
PV-generated energy exported to the utility.

While the contractor is free to translate this into “Rand-savings”, all proposals will be evaluated using the same economic assumptions, such as electricity price escalation, inflation and interest.

8.7 Input Data

8.7.1 Electricity Consumption

For this proposal, the RGHS’s approx. monthly electricity consumption is shown in the table below. This can be split approx. 60:40 between day and night consumption:

MONTHS	Total
Jan	32 501
Feb	39 662
Mar	38 144

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Apr	36 625
May	41 675
Jun	50 254
Jul	35 247
Aug	55 789
Sep	55 085
Oct	37 466
Nov	42 637
Dec	36 312
Year	501 397

8.7.2 Load Profile

The load can be assumed to be constant for night-time and relatively flat (constant) for day- time between 07h30 and 15h00.

The load profile should be verified by means of the 30-min metering data from City of Cape Town or direct measurements.

8.8 Risks During Construction

This project is for a high school which comes with significant inherent public safety risks. The contractor is required to demonstrate that they have a full appreciation for what it takes to mitigate all risks associated with this type of site.

8.8.1 Risks the Client should know about.

The contractor needs to state upfront what it requires to enable a safe work environment, such as lay-down areas, access control (out of bounds areas), space for cranes or scaffolding and buildings being worked on to be vacant or not. Installation during a school holiday when there are few people on site, will be preferred.

8.8.2 Hazard Identification and Risk Mitigation Plan.

The contractor is expected to provide a baseline (generic) Risk Assessment, as an example, to demonstrate that they understand the risks associated with installing PV systems in public spaces. Once the contractor is appointed, they will need to provide a site specific Risk Assessment for this project before they may proceed with work on site.

8.9 System Performance Guarantee and Retention

The decision to invest in Solar PV is based largely on expected yields and energy savings and hence financial savings. This means that there needs to be a performance guarantee upon which this investment decision can be based.

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An amount of **10%** of contract value (Incl. VAT) will be held back until the RGHS is satisfied that the system will deliver according to the proposed yield values.

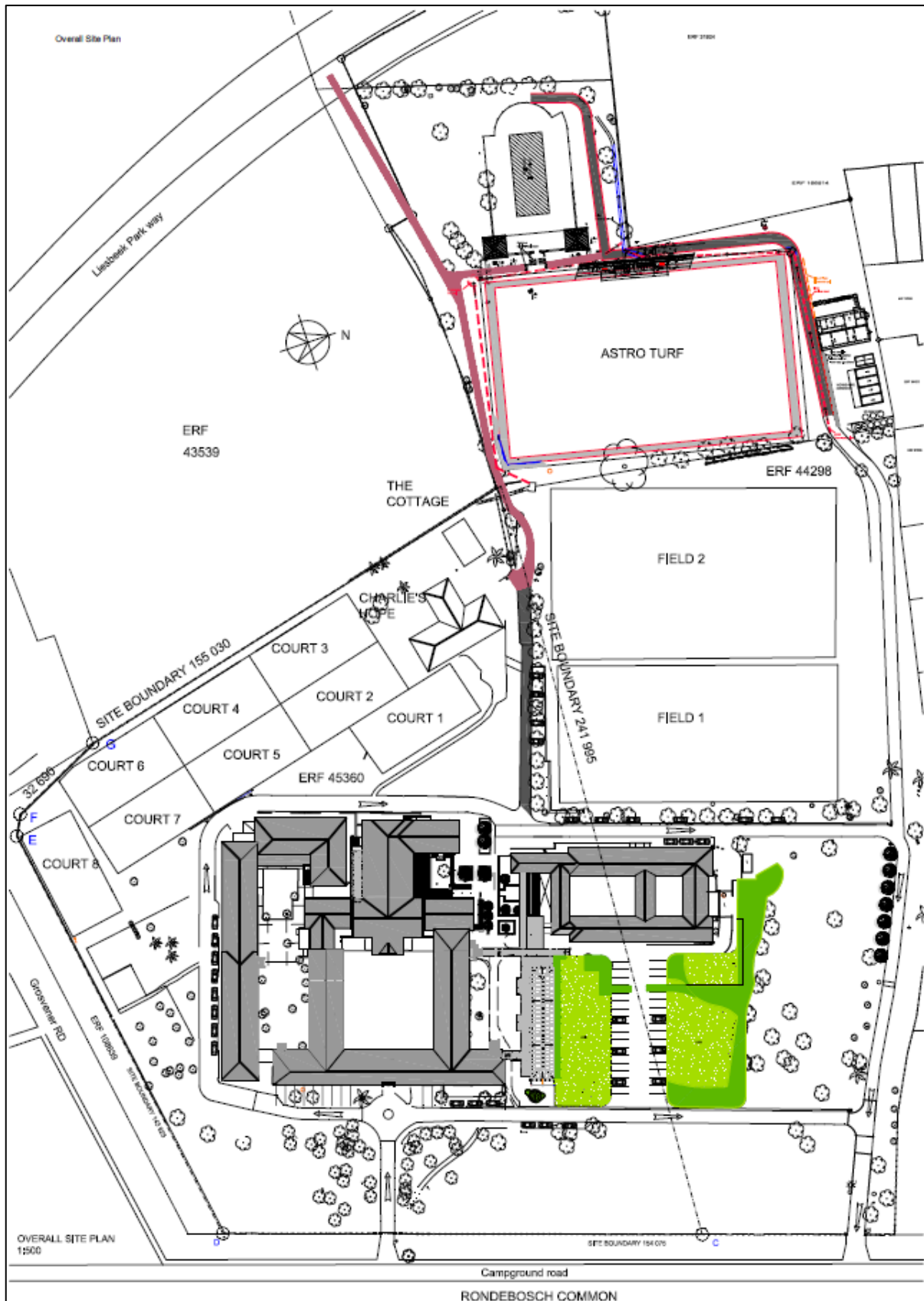
It is understood that solar irradiance conditions vary with weather and climatic variations. It is thus not possible to guarantee an exact yield in any given year. It is, however, possible to select a number of days where irradiance and other conditions are known, where the system's output can be measured against the design expectation.

The contractor shall propose a schedule of calibrated measurements, over a period not exceeding three months, to demonstrate that the system produces the promised energy savings.

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9 Appendices – Reference Documents

9.1 Property layout – see below (included in Feasibility Report by RED).



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Location for PV inverters

Inverters convert the DC current coming from the solar PV modules to AC current for use in the grid. Due to the distributed nature of the proposed system multiple inverters will be required. These will ideally be located as close to the sub distribution boards, they will be tied-in to, while keeping the DC cable runs as short as possible.

9.2 Report - Structural Engineer

See below

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9.3 30-min metering data (City of Cape Town) – see below:

Summary of consumption / load data

For the study, 30-minute interval data for the time January 2019 to March 2020 was obtained from the City of Cape Town electricity department. We used the full-year data January to December 2019 for our analysis.

In summary:

Summary figures: 1 Jan 2019 - 31 Dec 2019; all days of the week

Total over period	
Energy	509 600,1593 kWh

Daily energy	
Maximum	2 332,8743 kWh on Wed, 17 Jul 2019
Average	1 396,1648 kWh
Minimum	588,0120 kWh on Sun, 17 Mar 2019

Half-hourly energy	
Maximum	77,3753 kWh on Mon, 29 Jul 2019 between 18:30 and 19:00
Average	29,0868 kWh
Minimum	0,0000 kWh on Thu, 12 Dec 2019 between 18:00 and 18:30

Half-hourly power	
Maximum	154,751 kW on Mon, 29 Jul 2019 between 18:30 and 19:00
Average	58,174 kW
Minimum	0,000 kW on Thu, 12 Dec 2019 between 18:00 and 18:30



Prepared for:
Rustenburg Girls' High School



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RUSTENBURG GIRLS' HIGH SCHOOL ROOFTOP SOLAR PHOTOVOLTAIC PROJECT

STRUCTURAL ASSESSMENT REPORT

FINAL REPORT
REVISION 00

JUNE 2020



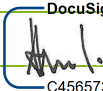
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DATE:	June 2020		
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REVIEWED BY:	Nicholas Poxon	Pr Eng (Structural)	
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	Rustenburg Girls' High School	Mhlanga Nombewu	

RECORD OF REVISIONS

REV. NO.	STATUS	DESCRIPTION OF REVISION	REV. DATE
00	Final	Formal issue to RGHS	04/06/2020

EXECUTIVE SUMMARY

Rustenburg Girls' High School (RGHS) intends to install a rooftop solar photovoltaic (PV) system on various structures at the school. In March 2020, Mr Mhlanga Nombewu of RGHS approached Delta Built Environment Consultants (Delta BEC) to conduct structural assessments of most roof structures across the school to establish whether they are able to accommodate the additional loads from the PV modules.

All structures were assessed at the main building complex and the headmaster's house between 16 and 18 March 2020. For the purposes of the assessment, it was assumed that the additional dead load imposed by the solar PV system is 20 kg/m².

SUMMARY OF FINDINGS

Main buildings: None of the main building structures comply with regulations and are at risk of failing in some cases. We do not recommend installing solar PV modules onto any roof unless the structures are fully analysed, repaired, strengthened and certified by a professional engineer. A19 roof certificates would then need to be issued for each building.

The absence of A19 roof certificates may have insurance implications.

Although installing PV modules might be possible on certain roofs and could even reduce the live load factors of those roofs depending on the configuration of the PV modules, we cannot conclusively determine this without performing thorough investigations, including detailed measurements and analyses of the structures. Given how these structures were constructed by skilled carpenters without following formal engineering designs that were produced by professional engineers, an analysis of each structure would take several weeks and would be extremely costly. We do not recommend this course of action as the detailed investigations are likely to conclude that all the structures are uncompliant and must either be replaced or repaired at significant cost.

We recommend that the roof structures are replaced entirely.

However, a solar PV installation is probably possible without any repairs or modifications on the Maths and Science Building roof (referred to as Roof 15 in this report). This structure should be analysed in further detail to confirm this, the cost of which is around R10 000.00 for the analysis, and a further R3 000.00 for subsequent inspection and certification of possible remedial action. Should a detailed investigation find that a PV installation is possible, a system with a nameplate rating of approximately 15 kWp can be installed at a cost of around R215 000.00, excluding VAT, with an annual energy saving of around 24 640 kWh.

Headmaster's house: These roofs are also not suitable for solar PV as the roofs are not compliant with regulations and have been modified such that they are at risk of failing. However, it is possible to undertake remedial action to resolve the immediate dangerous issues to make them compliant and possibly even suitable for a solar PV installation.

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GLOSSARY OF TERMS AND ABBREVIATIONS

A19 certificate	A certificate issued by a registered professional person to accept responsibility for the design, inspection and certification of a roof structure, as required by the National Building Regulations (SANS 10400)
Delta BEC	Delta Built Environment Consultants (Pty) Ltd
ECSA	Engineering Council of South Africa
kWp	Kilowatt-peak
PAR	Planed All Round
PV	Photovoltaic
RGHS	Rustenburg Girls' High School
SANS	South African National Standards
Wp	Watt-peak

1 INTRODUCTION

1.1 BACKGROUND

Rustenburg Girls' High School (RGHS) intends to install a rooftop solar photovoltaic (PV) system on various structures at the school. In March 2020, Mr Mhlanga Nombewu of RGHS approached Delta Built Environment Consultants (Delta BEC) to conduct structural assessments of most roof structures across the school to establish whether they are able to accommodate the additional loads from the PV modules.

Delta BEC appointed Mr Richard Cooper to assess the structures. The structures were assessed between 16 and 18 March 2020, and an assessment report was sent to Delta BEC's structural engineer for review (Nicholas Poxon). Mr Cooper and Mr Poxon are both professionally registered with the Engineering Council of South Africa:

- Richard Cooper: ECSA Pr Tech Eng 8670245; and
- Nicholas Poxon: ECSA Pr Eng 20190651.

For the purposes of the assessment, it was assumed that the additional dead load imposed by the solar PV system is 20 kg/m².

1.2 PURPOSE OF REPORT

This report summarises the findings on the structural assessment of individual existing timber roof structures of the school, with the intention to visually establish the structural integrity of the timber roof structures in order to install solar PV modules onto the top of the roof surfaces.

1.3 STRUCTURE OF REPORT

The report comprises the following sections:

- Section 2: School Buildings;
- Section 3: Headmaster's House;
- Section 4: Solar PV Potential; and
- Section 5: Conclusion.

2 SCHOOL BUILDINGS

2.1 GENERAL OBSERVATIONS

The buildings appear to have been built in the early 1930s. The design calculations, detailed drawings and A19 certificates are not available.

Access into the roof voids was difficult due to the limited access points and the firewalls which were built to separate the different roof areas. This made some of the roof voids inaccessible without removing roof tiles or ceilings.

Access from one roof void to another via small openings between trusses was also difficult and dangerous due to high dust levels and exposed electrical wires.

The timber and workmanship is generally very good. In most cases, the timber joints are bolted and nailed. However, none of the roof structures have been designed according to sound structural engineering principles and do not comply with today's standards and regulations.

Most of the roofs have cement tiles on battens and only a few structures have plastic underlays and insulation.

2.2 ROOF NUMBERING

The following sections provide information about the different roof types. Each roof type has been numbered according to the image below.

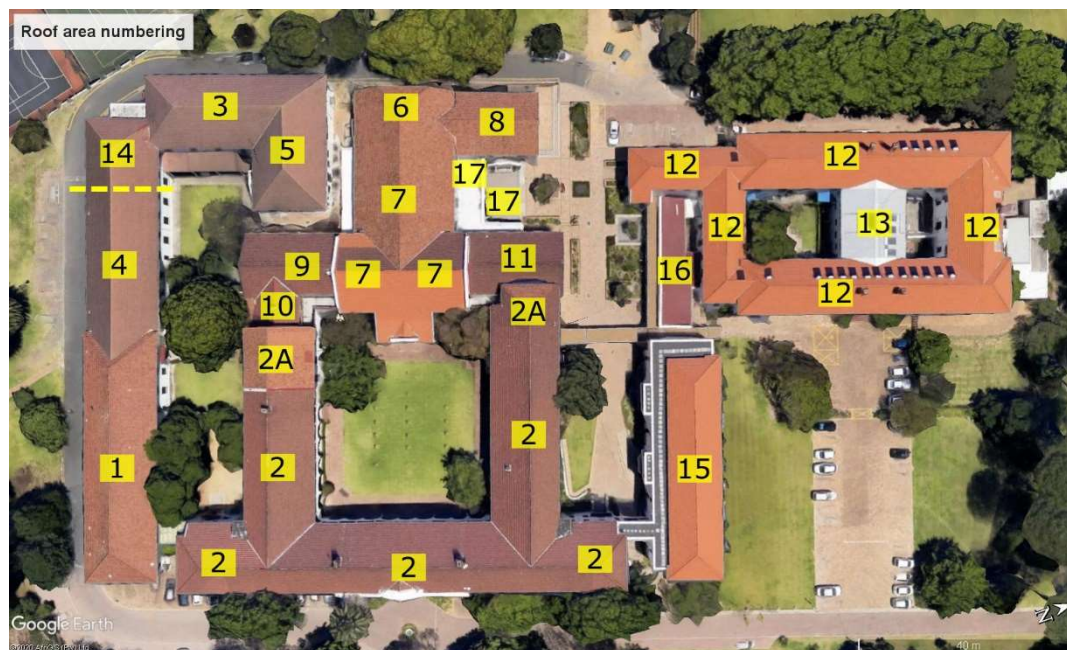


Figure 2-1: Roof numbers

2.3 ROOF 1

Timber structure with cement tiles

The timber structure consists of rough cut, double pitched trusses constructed with ungraded timber. The trusses are tiled and have a pitch of approximately 40 degrees, with large spans resulting in very high apex points and extremely long web and chord members.

The trusses are generally in good condition given their age. They are nailed and bolted at most nodal joints. They are supported near the heel ends of the trusses and inside classroom passage walls.

The supports at the heel ends of the trusses are midway between the last web node and the heel. The truss configuration does not allow for a support at this point, introducing a bending moment into a tie/strut.

Due to the extremely long web and bottom chord members, the effective lengths are unacceptable and require additional bracing and web/bottom chord runners.

The rafters require bracing.

The interconnecting trusses and mono trusses require hangers.

The general truss member configuration does not triangulate correctly to transfer forces correctly through nodal points.

2.4 ROOF 2

Timber structure with cement tiles

The timber structure consists of rough cut, double pitched trusses constructed with ungraded timber. The trusses are tiled and have a pitch of approximately 40 degrees, with large spans resulting in very high apex points and extremely long web and chord members.

The trusses are generally in good condition given their age. However, there are a number of joints that are nailed only.

The following is required:

- Runners for web and bottom chords;
- Web, bottom chord and rafter bracing; and
- Hangers for interconnecting trusses and mono trusses.

The general truss member configuration does not triangulate correctly to transfer forces through nodal points and onto supports.

Trusses are not suitably fixed to the substantial wall plates with hoop iron straps. In some cases, certain trusses are not fixed at all. The wall plates are sparsely and randomly fixed to the top of walls with anchor bolts.

Multi-ply truss girders are not correctly bolted or nailed together.

2.5 ROOF 2A

Timber structure with cement tiles

The short roof sections (Roof type 2A) could not be accessed due to the firewalls that separate Roof 2A from Roof 2. They can only be accessed by removing roof tiles or opening ceilings. However, it is assumed that the roof structures are similar to the adjacent Roof 2 structures.

2.6 ROOF 3

Timber structure with cement tiles

This roof structure is considerably newer than the other roofs and the trusses were prefabricated using graded, planed all round (PAR) timber. The possibility exists that there may be design and layout drawings from the original truss manufacturers, but unfortunately the erection of the roof structure is not compliant.

The roof structure incorporates a piggyback truss design which requires the trusses to be correctly strapped to each other. Rafter bracing has been installed in the wrong position and is spliced with a major dogleg joint, rendering the bracing completely ineffective.

Timber structures have been built through the fire walls and do not comply with fire regulations. T-type web bracing has been incorrectly fixed to web members, and the multi-ply girders are not correctly bolted and nailed together.

The following is required:

- Bottom chord bracing; and
- Hurricane clip or equivalent fixing of rafters passing over the truncated girder top cords.

2.7 ROOF 4

Timber structure with cement tiles

This roof structure is considerably newer than the other roofs. The trusses were prefabricated using graded, planed all round (PAR) timber. The possibility exists that there may be design and layout drawings from the original truss manufacturers. However, the erection of the roof structure is not compliant.

The roof structure incorporates a piggyback truss design which requires the trusses to be correctly strapped to each other. This has not been done.

Timber structures have been built through the fire walls and do not comply with fire regulations. The multi-ply girders are not correctly bolted and nailed together. Hoop iron straps are to be fixed and correctly nailed to trusses.

The following is required:

- Rafter, bottom chord and web bracing;
- Bottom chord and web runners; and
- Hangers for interconnecting trusses and mono trusses.

2.8 ROOF 5

Timber structure with cement tiles

There are signs that remedial work was done on this roof structure. However, some of the web members have not been braced and hoop iron straps have not been nailed to trusses. Timber structures have been built through the fire walls.

2.9 ROOF 6

Timber structure with cement tiles

This roof covers the **stage area of the main hall**.

This is a very old structure, but the timber is generally in a good condition.

The timber has nailed joints.

The winged areas on the sides of this roof area are not accessible. Based on visual observations made from a distance, it appears that the deflection of the rafters has exceeded permissible limits. Some trusses were excessively laterally bowed. The battens supporting the roof tiles are in extremely poor condition and broken in places. The configuration of hip truss webs is not suitable and has not been triangulated. The trusses are not tied to walls.

The following is required:

- Runners for web and bottom chords; and
- Web, bottom chord and rafter bracing.

2.10 ROOF 7

Steel structure with cement tiles

This roof covers the **main hall and adjacent areas**.

This is a very old structure, but the trusses are in a very good condition.

The primary structure comprises riveted structural steel trusses at approximately 4-metre centres. The roof tiles are supported on battens that are then supported on secondary timber rafters that are, in turn, supported on timber beams, similar to purlins on a sheeted roof.

Based on visual observations, the purlins appear to span around 4 metres. This is unlikely to satisfy the maximum allowable deflection limits or stress limits. The

purlins are also used to support the very heavy ceiling structure, catwalks in the ceiling void, stage lighting and other such equipment.

2.11 ROOF 8

Timber structure with cement tiles

Most of the truss members are bolted together but some are nailed.

There are broken web members. The bottom chords of every truss have been extensively notched away at mid span, thereby reducing the cross-sectional area by approximately 50%. The trusses supporting several geysers in this area are not adequately strengthened. Hoop iron straps have not been nailed to trusses.

The following is required:

- Rafter, bottom chord and web bracing; and
- Bottom chord and web runners.

2.12 ROOF 9

Timber structure with cement tiles

This roof covers the **media centre**.

The trusses are heavy-duty, exposed Vierendeel timber trusses with a centre-to-centre spacing of about 3 metres. They are in excellent condition.

As is the case with the Main Hall roofs (Roof 7), the roof tiles are supported on battens that are then supported on secondary timber rafters that are, in turn, supported on timber beams, similar to purlins on a sheeted roof. These purlins span around 3 metres. This is unlikely to satisfy the maximum allowable deflection limits.

2.13 ROOF 10

Timber structure with cement tiles

This roof covers the **media centre extension**.

This section of the roof has conventional trusses with fully-bolted members. It is adequately strapped to the walls.

2.14 ROOF 11

Timber structure with cement tiles

This roof covers the **drama centre**.

The roof construction is identical to the media centre main roof (Roof 9). The issues observed in this roof are the same as the issues in the media centre.

2.15 ROOF 12

Timber structure with cement tiles

These roofs of the perimeter buildings are very old. The roof insulation is in very good condition and is fixed to the underside of the battens and above the truss top chords. The timber is also in very good condition. The trusses are bolted and nailed. However, there are many issues with this roof that could result in failure.

The top, bottom and web members of some trusses have been cut away.

Trusses supporting all the geysers are not adequately strengthened.

Runners for web and bottom chords are required.

Web, bottom chord and rafter bracing is required.

Trusses are not tied to walls.

Hoop iron straps have not been nailed to the trusses.

The trusses are not suitably fixed to the substantial wall plates with hoop iron straps and these wall plates are sparsely and randomly fixed to the top of walls with anchor bolts.

The supports at the heel ends of the trusses are midway between the last web node and the heel. The truss configuration does not allow for a support at this point, thus introducing a bending moment into a tie/strut.

Trusses are randomly supported at points on the trusses that are not designed for support.

The roof structures have numerous connections of additional members, acting as beams, struts and ties. These members are nailed at random wherever it was convenient during their construction. These point load applications are stressing members in ways that the structures are not designed to accommodate.

The general truss member configuration does not triangulate correctly through nodal points to transfer forces accordingly.

There are various timber beams with large spans, unrestrained and supporting large roof areas.

These beams are spanning in the region of 8 metres. This is unlikely to satisfy the maximum allowable deflection limits.

These beams have also been notched at mid span.

2.16 ROOF 13

Timber structure with metal roof sheeting

This is a shallow double-pitched roof of approximately 17 degrees. Purlins have been installed incorrectly about the Y-Y axis instead of the X-X axis. The general truss member configuration does not triangulate correctly through nodal points to transfer forces accordingly.

The following is required:

- Bottom chord runners and bracing; and
- Rafter bracing.

The top chords of trusses appear to be excessively long between nodal points and have visible deflection.

2.17 ROOF 14

Timber structure with cement tiles

The supports at the heel ends of the trusses are midway between the last web node, and the heel and the truss configuration does not allow for a support at this point, thus introducing a bending moment into a tie/strut.

The following is required:

- Runners for web and bottom chords; and
- Web, bottom chord and rafter bracing.

2.18 ROOF 15

Timber structure with cement tiles

This roof covers the **maths and science block**.

This is one of the most recently built roofs and has been very well designed, built and erected. It is almost completely compliant.

There are only a few issues:

- The runners and bracing must be correctly nailed to trusses;
- The hoop iron straps must be nailed to the trusses; and
- Some straps are missing completely.

2.19 ROOF 16

Timber structure with metal roof sheeting

This is a shallow mono-pitched roof of approximately 10 degrees. There is no access into this roof other than by removing roof sheets or opening ceilings.

However, because the roof appears to be in good condition with relatively short spans, we climbed onto the roof and carried out a resonance bounce test at strategic points on the roof to check for possible deflection and resonance.

This is not a very accurate assessment, but nothing untoward was observed.

2.20 ROOF 17

Flat concrete roof slab

These roofs are waterproofed on screed, on concrete roof slabs and are not subject to issues of latticed frame construction.

Due to the small surface area of the roof, it was not assessed further for potential solar PV installations. Should RGHS require this roof to be assessed in greater detail, we will be happy to provide a fee proposal for a more detailed assessment.

3 HEADMASTER'S HOUSE

3.1 OVERVIEW

The headmaster's house comprises the main house and an outbuilding, both of which have timber roof structures. The design calculations, detailed drawings and A19 certificates for these structures are not available.

3.2 MAIN HOUSE

The roof structure is relatively new, and the roof trusses are all prefabricated and manufactured in a truss plant using standard nail plate connectors and graded PAR timber.

It is evident that there were probably design and layout drawings from the original truss manufacturers. However, the erection of the roof structure is not compliant due to the roof erectors not having sufficient knowledge or experience to erect the structures to the required standards and regulations. It also suggests that the recent structures have not been inspected and certified by a registered engineer.

There are some serious issues with this roof structure that must be addressed as a matter of urgency to ensure that the roof structure does not fail in the foreseeable future. The primary reason for this is that some strategic members of the girder trusses have been cut away to allow access for other facilities such as geysers.

Other areas of non-compliance include:

- Two-ply trusses are not reel-pitch nailed;
- The trusses are not reinforced to support geysers;
- Blocks are required at valley trusses;
- Valley truss bottom chord supports;
- Hurricane clips at truncated girders;
- Hoop iron straps must be nailed to trusses;
- Bottom chord runners and bracing are required; and
- Hanger brackets must be nailed to trusses.

3.3 OUTBUILDING

The roof structure is generally compliant. The only item that requires attention is the hoop iron straps which must be nailed to the trusses.

4 SOLAR PV POTENTIAL

We do not recommend installing solar PV on any roof except possibly the maths and science block (Roof 15). This structure must be measured and analysed in greater detail before a conclusive recommendation can be made about Roof 15. We have included a cost estimate for the detailed investigation in Section 5. However, our provisional opinion is that a solar PV installation is probably possible on Roof 15. Should this be the case, the following sections provide a high-level calculation of the potential cost and energy yield of a PV installation on this roof.

4.1 ROOF 15 PV SIZING

The following image shows a Google Earth composite aerial image of Roof 15.

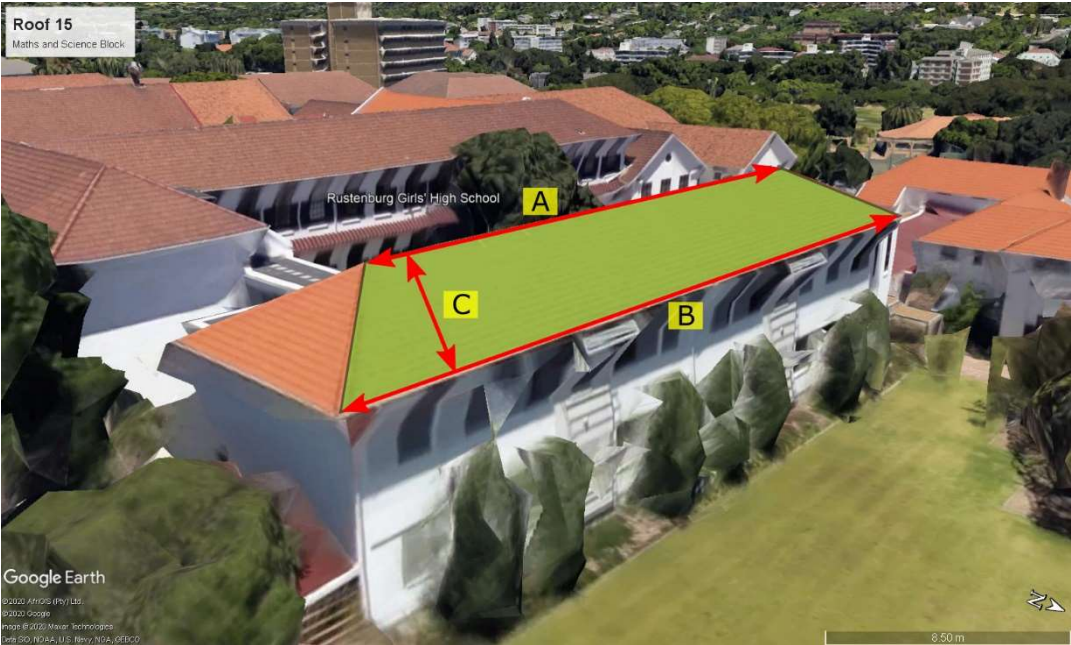


Figure 4-1: Roof 15 Google Earth composite aerial image

The roof’s tilt and orientation are perfect for a PV installation as its orientation is very close to true north while its 30-degree tilt is optimal for maximum year-round energy production. Based on Google Earth satellite and composite aerial images, there appears to be no significant shading of Roof 15. The following table shows measurements that were taken from Google Earth.

Table 4-1: Roof 15 Google Earth distance measurements

KEY	DESCRIPTION	MEASUREMENT
A	Ridge	28.3 m
B	Eave	37.1 m
C	Rafter length: ridge to eave	4.85 m
Pitch	Approximate roof pitch relative to the ground plane	30°
Orientation	Approximate roof orientation relative to true north	20°

These measurements suggest that up to 44 PV modules can be installed on this roof, assuming 72-cell modules are used (Figure 4-2). Such modules are typically 2 metres wide and 1 metre tall, and typically have an output of 350 watt-peak (Wp) per module.

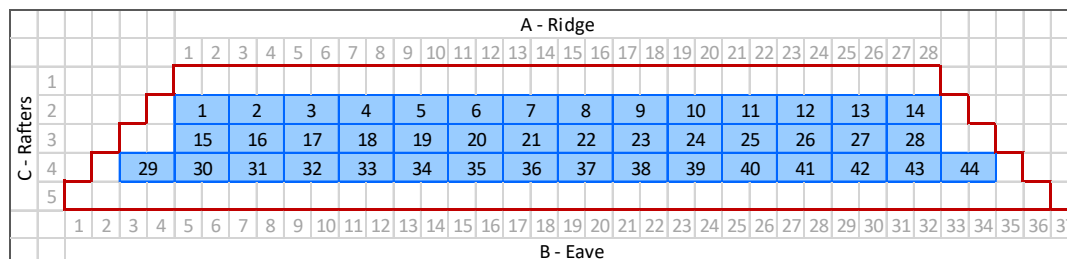


Figure 4-2: Approximate number of 350 Wp, 72-cell PV modules on Roof 15

With this configuration, the total nameplate power of the PV system is 15.4 kilowatt-peak (kWp), i.e. 44 modules x 350 Wp = 15 400 Wp. The following table summarises the cost and energy yield of the system. These calculations do not present a full financial model or feasibility analysis, but rather serve to provide a broad overview of the cost and performance of a PV system on Roof 15.

Table 4-2: Roof 15 PV system cost and energy yield

PARAMETER	UNIT	VALUE	CALCULATION
ROOF GEOMETRY			
Total roof area	m ²	158.6	A
Usable roof area for PV modules	m ²	88.0	B = E x G
Orientation	°	30°	C
Pitch	°	20°	D
PV MODULES			
Module area	m ²	2.0	E
Module nameplate rating	Wp	350.0	F
SYSTEM SIZING			
Number of modules installed on roof	No.	44.0	G
Total nameplate rating of system	kWp	15.4	H = F x G
Assumed specific yield after losses	kWh/kWp	1 600.0	J
Total energy output after losses	kWh/year	24 640.0	K = H x J
SYSTEM COSTS			
Assumed installation cost per watt-peak	R/Wp	14.00	L
Total installation cost	R	215 600.00	M = H x L x 1000
Assumed RGHS tariff type	Large User LV (TOU)		N
Assumed average RGHS energy cost	R/kWh	1.50	P
Assumed annual energy cost savings	R/year	36 960.00	R = K x P

5 CONCLUSION

5.1 SUMMARY

None of the structures comply with regulations and are at risk of failing in some cases (Headmaster's House and Roof 12). We do not recommend installing solar PV modules on any roof unless the structures are fully analysed, repaired, strengthened and certified by a professional engineer. A19 roof certificates would then need to be issued for each building.

The absence of A19 roof certificates may have insurance implications.

Although installing PV modules might be possible on certain roofs and could even reduce the live load factors of those roofs depending on the configuration of the PV modules, we cannot conclusively determine this without performing thorough investigations, including detailed measurements and design verifications of the structures. Given how these structures were constructed by skilled carpenters without following formal engineering designs that were produced by professional engineers, an analysis of each structure would take several weeks and would be extremely costly. We do not recommend this course of action as the detailed investigations are likely to conclude that all the structures are uncompliant and must either be replaced or repaired at significant cost.

We recommend that the roof structures are replaced entirely, pending approval from the relevant heritage council (Heritage Western Cape, www.hwc.org.za). If the roof structures are replaced entirely, the existing roof tiles can be retained to preserve the historic appearance of the buildings. This will invariably result in damage to some roof tiles during the installation of the new structure, but it may be possible to procure nearly identical tiles that were retained from demolition projects in the past. If not, tiles on smaller roofs could be replaced with new tiles, and the old tiles extracted from those roofs could be used to replace damaged tiles on other roofs.

5.2 SCHOOL BUILDING COMPLEX

The age of the timber structures and the manner in which they were built and erected presents significant risks to the school, both in terms of the safety to human life and also the cost and disruptions related the repairs that are required. Fundamental design principles were not adhered to in almost every structure. Although some of the more recent structures appear to have been designed properly, the roof erectors installing those structures were not sufficiently qualified and experienced to erect the roofs to the required standards. It also suggests that the recent structures have not been inspected and certified by a registered professional engineer.

The maths and science block (Roof 15) is the only roof structure that has been well designed and erected.

There is nothing to suggest that the roof structures would fail due to the additional load of solar panels, but the structures are far from compliant and each of the existing structures would have to be independently measured up and thoroughly analysed. Remedial actions would need to be implemented, and drawings and inspections must be done to ensure that the roofs are compliant. A19 certificates to be issued.

Another consideration that must not be forgotten is the fact that most of these buildings appear to be around 90 years old and are highly likely to be classed as Heritage Buildings.

5.3 HEADMASTER'S HOUSE

These roofs are unsuitable for solar PV installations. However, it is possible to undertake remedial action to resolve the immediate dangerous issues and make them compliant and subsequently suitable to accommodate solar PV modules.

However, this would all be subject to a full design check, remedial instructions, inspections and A19 certification.

5.4 DETAILED ASSESSMENTS

The Maths and Science Block (Roof 15) is the only roof that has been well designed and erected, based on visual inspections. In order to formally confirm this, a detailed measurement and design analysis must be performed, whereafter an A19 certificate must be issued pending any remedial works that may be required.

Our budgetary estimate for the detailed measurements and design analysis is **R10 000.00, excluding VAT**. Should the roof subsequently be found not to comply with regulations, an additional follow-up inspection would cost around **R3 000.00, excluding VAT** to inspect and certify the roof after any remedial work has been completed.