CONTAINER ROLL OUT SOLAR SYSTEM

PUBLIC REPORT

ARENA Funding Agreement G00908

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INTRODUCTION

1. The Australian Renewable Energy Agency (ARENA) awarded funding to ECLIPS to contribute to the development of ECLIPS' Container Roll-Out Solar System (CROSS). CROSS is a factory assembled, relocatable ground mount solar PV array that can be stacked seven high for shipping and loaded into standard 20ft and 40ft ISO shipping containers. The CROSS are fitted with heavy duty rollers on one end that enable easy loading and unloading of the stacked units through the doors of a shipping container using a forklift. The CROSS design is based on ECLIPS' patented Container Roll-Out Warehousing System (CROWS™), which is an intermodal logistics platform used to provide high payload mezzanine layering in shipping containers. The CROSS replicates the logistics efficiencies of CROWS in the delivery of relocatable solar array solutions.

2. ECLIPS have successfully completed the development and test of the CROSS, which culminated in a live setup demonstration to industry in Canberra on 12 April 2018. This report provides an overview of the Project and includes information relevant to industry partners and energy users who are considering relocatable solar PV applications.

PROJECT OBJECTIVE

3. The primary objective of this Project was to conduct the analysis and planning, detailed design, fabrication and testing of the CROSS. Achievement of this objective enabled ECLIPS to progress the CROSS concept from Technology Readiness Level 6 to Level 7, and Commercial Readiness from Level 2 to 3+.

COMPANY BACKGROUND

4. ECLIPS is an Australian owned systems engineering company that designs and fabricates purpose-built permanent and deployable buildings and logistics platforms using shipping containers and derivatives. Based in Canberra, ECLIPS primarily services the Defence, Government, Mining and Resource sectors within Australia and internationally.

5. ECLIPS has evolved over the years, and gone through a couple name changes, however its focus has remained on specialised deployable infrastructure and logistics platforms. ECLIPS has delivered a number of hybrid power solutions, including remote solutions delivered to the Department of Defence shown in Figure 1. Despite providing several of these solutions, ECLIPS' primary operating model is to sell or lease its products, such as CROSS, to power and energy providers who are responsible for the overall power solution to a project. When required, ECLIPS can provide a full turn-key hybrid power solution to customers.

Figure 1 – Remote Hybrid Power for Defence Range Facility

PROJECT OVERVIEW

6. The CROSS Project was a Design, Development, Test and Evaluation (DDT&E) project that was originally aimed at servicing customers with temporary power demands in challenging environments, such as humanitarian agencies, Defence, and remote mining camps. One of ECLIPS' early objectives was to provide rapidly deployable utility scale PV generators to improve the self-sufficiency of Defence's deployed forward operating bases. Diesel consumption related to the provision of electricity can account for up to 70% of deployed military fuel usage and is a significant operating cost driver. More importantly, deploying CROSS to forward operating bases would also reduce the frequency of convoys for fuel resupply, which reduces the threat to soldiers in contested environments. These same logistics efficiencies and benefits are transferrable to commercial and utility customers in remote areas of Australia.

7. Prior to signing the Funding Agreement (Agreement) with ARENA, ECLIPS had completed Preliminary Design of a relocatable solar array. ECLIPS sought funding from ARENA to finalise the design and fabricate and test the prototype solutions.

8. The main highlights of the Project included:

   a. Final selection of configuration variants from options identified in Concept and Preliminary Design Stages;

   b. Detailed Design of the CROSS;

   c. Engagement and initial quoting from Contract Manufacturers;

   d. Structural Certification of CROSS20 and CROSS40 for use in Wind Regions A to D of AS/NZS1170.2:2011;

   e. Fabrication of the CROSS, including two 20ft and two 40ft configurations (CROSS20 and CROSS40). This validated that the design was manufacturable;

   f. Delivery of CROSS units to Canberra;

g. Successful test and evaluation against the Functional Performance Specification;

h. Evaluation of the CROSS against a range of target customer project requirements;

i. Identification of future product development roadmap, based primarily on design-for-cost;

j. Identification of a competitive product price range per watt for various projects; and

k. CROSS Demonstration Day conducted in Canberra on 12 April 2018.

CONTRACT DETAILS

9. Contract details related to the ARENA Funding Agreement are summarised in Table 1.

Table 1: Funding Agreement Contract Details

Contracting Entity Details	
Recipient Name	ECLIPS Pty Ltd
Subcontractors	ECLIPS Logistics Pty Ltd
ECLIPS Contact Name	Matt Hanlon Project Manager M: 0448 049 198 E: matth@eclips.engineering
Activity Title	Container Roll-Out Solar System
Activity Number	G00908
Total Project Value	$719,911
ARENA Funding Amount	$289,725
ECLIPS Contribution	$444,130
Activity Period	21 July 2017 – 30 April 2018 (does not include internal Research and Development project reaching Preliminary Design)

PRODUCT DEVELOPMENT AND DESIGN CONSIDERATIONS

10. Two possible configuration variants for a relocatable solar array were identified during the Preliminary Design Stage. The first design was the Containerised Roll-Out Warehousing System – Photovoltaic (CROWS-PV), which was named as a variant to ECLIPS' existing CROWS™ product. The CROSS was the second design option. The CROWS-PV variant identified in Figure 2 was the preferred solution at the completion of PDR, however both variants were analysed during the Detailed Design Stage.

During the analysis process, the CROSS variants detailed at Figure 3 and Figure 4 was identified as a superior solution, primarily due to:

a. lower purchase price per Watt,

b. increased power density per shipping container,

c. improved manufacturability, and

d. easier to setup and packup.

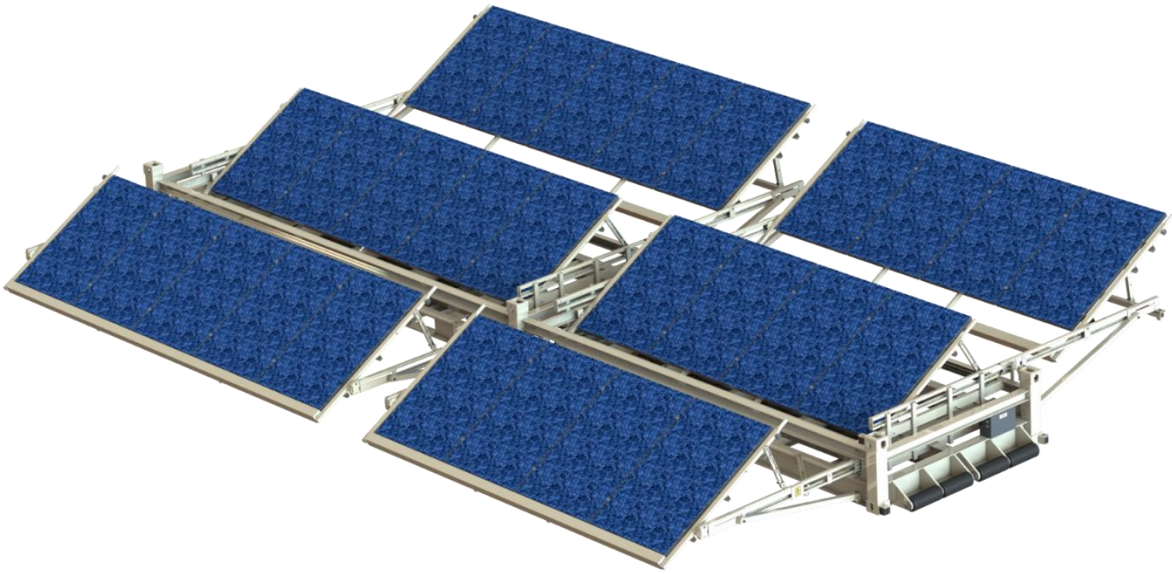

Figure 2 – 40ft CROWS-PV

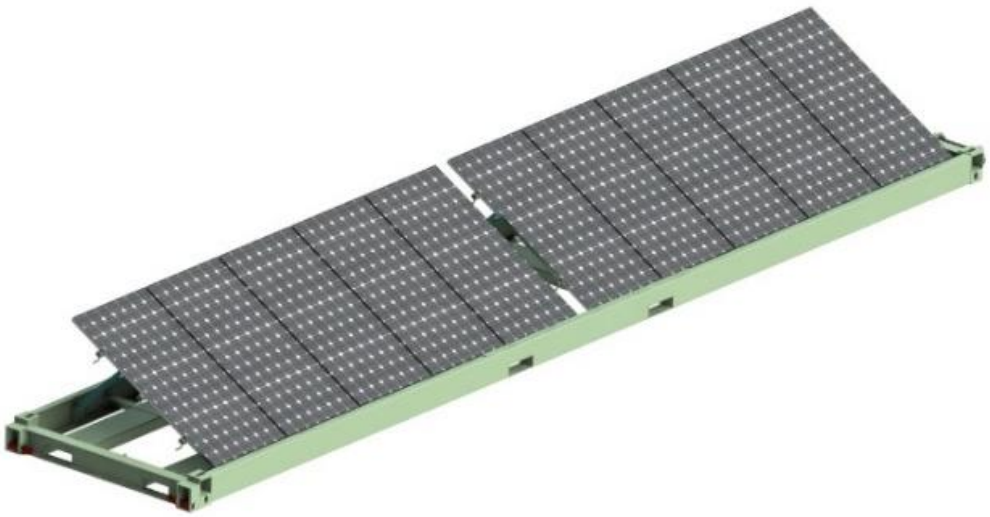

Figure 3 – CROSS40

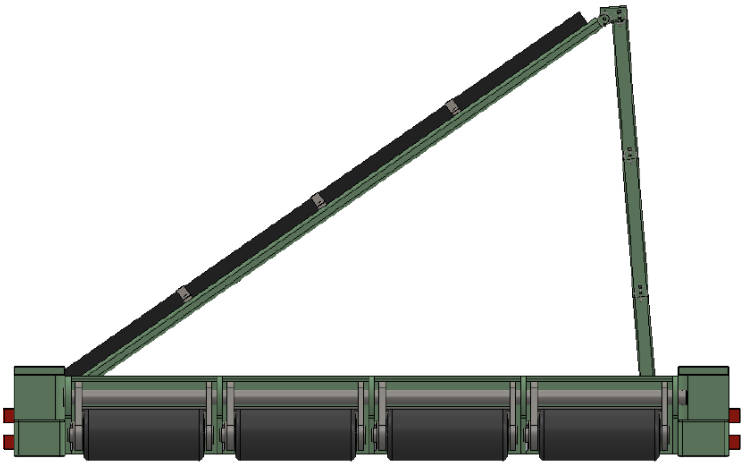

Figure 4 – CROSS end view showing rollers

11. The main technical and analytical activities conducted during ECLIPS' Concurrent Engineering approach to Detailed Design are summarised below:

    a. Review of Functional Performance Specification (FPS). Following interaction with potential customers during the Preliminary Design Stage, the FPS was narrowed down to target the Essential performance requirements for a deployable solar array. Some of the FPS items were reassessed for criticality following other analysis activities listed in this section.

    b. Design Calculations. Design calculations were conducted for the shortlisted configuration variants that were identified during the PDR Stage. The outcomes of the analysis activities formed the basis for the structural design of the array framework. ECLIPS also used previous Design Calculations from its CROWS™ development for comparative analysis to shape the structural design. Examples of inputs to the Design Calculations included:

    c. Stacking/nesting mass of CROSS in transport mode;

    d. AS/NZS 1170.2:2011 Wind Region loads on the deployed structure;

    e. Material Handling Equipment requirements for individual and nested CROSS units;

    f. Ground restraint options and interfaces;

    g. Clean Energy Council (CEC) and Clean Energy Regulator (CER) requirements to ensure the CROSS could be certified to enable Small-scale Technology Certificates and Large-Scale Generation Certificates;

    h. Other requirements listed in:

        i. AS/NZS 5033:2014 Installation and Safety Requirements for photovoltaic arrays;

        ii. AS4509 Stand-alone power systems.

    i. Finite Element Analysis (FEA). Using the Finite Element Modelling capability within ANSYS, ECLIPS modelled the shortlisted configuration variants that were identified during the PDR Stage. The Design Calculation inputs were used as a basis for the designs that were then modelled through FEA. The primary outcomes of the FEA included analytical information on the structural integrity of the variant solutions being considered.

j. Safety and Risk in Design Analysis. Safety and Risk in Design is continuously reviewed throughout the design process. During the Detailed Design Stage, particularly attention was focused on the Human Machine Interface and related actions of the mechanical structure and electrical circuits. In addition to updating design to avoid or reduce crush/pinch injuries from moving components during setup and packup, ECLIPS updated the design to meet guidance in Model Work Health and Safety Regulations (2016) released by Safe Work Australia, relating to lifting and reaching actions associated with Hazardous Manual Tasks.

k. Design for Cost (DfC) Analysis. DfC is a design method which involves the analysis and evaluation of a product's life cycle cost (LCC), then modification of the design to reduce the LCC. The main criteria under the DfC Analysis was the product purchase price per Watt. The outcomes of this analysis were the main driving factor in selecting the final configuration option to take to DDR.

l. Design for Manufacture (DfM) Analysis. DfM is the process of designing a product for ease of manufacturing, including criteria such as:

   i. Fabrication tolerances;
   ii. Production throughput;
   iii. Requirement for specialist jigs and assemblies;
   iv. Contract Manufacturer capabilities;
   v. Minimisation of specialist parts and components; and
   vi. Testability of finished solution.

m. The complex design of the original CROWS-PV design required many unique components and Level C critical welds during the production process, which was adding cost and risk, and reducing production throughput. The CROSS is much simpler to manufacture and represents less risk in the quotes received by Contract Manufacturers for fabrication.

n. Assessment and Selection of Design Options. Following the *Design for X* (DfX) analysis on the variant options, ECLIPS formally scored each variant to select the candidate it would take through DDR. The main selection criteria included:

   i. Cost per Watt,
   ii. Risk in cost price,
   iii. Land area power density (W/m^2),
   iv. Supportability / Maintainability,
   v. Can be fabricated by multiple Contract Manufacturers,
   vi. Power output per unit,
   vii. Power output per shipping container (standard and high cube),
   viii. Human Machine Interface factors,
   ix. User safety risk,
   x. Setup time per Watt,
   xi. Ease to setup and packup (tools, steps, labour, and Material Handling Equipment),
   xii. Design risk,
   xiii. Electrical circuit integration, and

xiv. Testability.

o. Each of the criteria listed above were given a weighting, based on criticality of the requirement identified in the FPS, and other factors supporting the business case. The weightings ranged from 1 – "Desirable" through to 5 – "Major Positive Distinguisher". The variants were then scored by technical, management and sales staff within the business. Scoring options were from 1 – "Marginal" to 4 – "Excellent". The scores were then multiplied by the weightings and summed across all participants. The result was that CROSS was the clear preference to take to DDR. The metrics-based approach to selecting the best variant provided ECLIPS owners confidence in its own investment.

p. Structural Engineering Assessment. ECLIPS engaged an external, independent structural engineering company to complete the structural certification of the design. This was conducted in two phases:

i. *Phase 1 - Wind Action Analysis*. The CROSS 3D CAD model and drawings were issued to the structural engineering company to calculate the wind loads exerted on the CROSS during 10, 20 and 30-degree deployments in various Wind Regions. The report provided by the independent structural engineers validated the Design Calculations and FEA performed by ECLIPS engineers. The main outcome is that the CROSS has been structurally designed to withstand wind pressure up to 7.5kPa, and the Region D Resultant Wind Pressure (worst case) calculated by the structural engineers is 5.667kPa. Based on the external analysis, the Design Calculations ECLIPS based its design upon exceed the Region D requirements. ECLIPS aimed to withstand 7.5kPa of wind pressure as that is what the SunPower E20-435-COM PV Modules are rated to. A copy of the structural engineering report for Wind Action Analysis can be provided on request. This activity was a critical entry requirement for DDR; and

ii. *Phase 2 – Structural Certification*. Structural certification of the design occurred post DDR based on the final production pack. This ensured that the permanent modifications conducted during the fabrication process were accounted for in the certification.

q. Completion of Detailed Design and Detailed Design Review. Following the completion of the analytical inputs to design, the CROSS 3D model and drawings were finalised, and design documentation completed. This included a Draft Fabrication Specification and Non-Destructive Test Plan to provide to the Contract Manufacturer.

12. ECLIPS followed its methodical systems engineering approach for the development of the CROSS. At times, and Agile approach was used to fill the gaps in the Functional Performance Specification, and where trade-offs were required to help reduce cost, ECLIPS spoke to its customers to help determine criticality of certain functions. This Agile approach was critical in shaping the decision to move from a CROWS-PV design to the CROSS, which better reflects what customers are asking for.

13. Throughout the design process, ECLIPS considered that the relevant Australian Standards were sufficient to guide the technical specifications, however Industry may benefit from better clarity in AS/NZS1170.2:2011 in terms of requirements for Ground Mount PV Arrays.

COMMERCIAL CONSIDERATIONS

14. 55% of all enquiries ECLIPS have received regarding CROSS quotes are from customers requiring full turn-key technical solutions, including installation and commissioning. Less than half of those have requested Power Purchase Agreements. Since the Demonstration Day, most enquiries have come from project integrators who are interested in buying the product, rather than buying power. It is too soon for ECLIPS to draw any long-term conclusions from these enquiries, however it is important to be able to offer full turn-key technical solutions to appeal to a wider range of clients, as customers want a single point of contact for contractual and technical issues associated with the delivery of power to their projects, regardless of the size. For larger project tenders and proposals, ECLIPS have partnered with established power providers who will act as the Prime Contractor.

15. ECLIPS has been approached by several power finance companies who are willing to offer project finance. Of note, power finance companies like the CROSS because it can be easily repossessed and redeployed to another project site, which helps to manage finance risks. ECLIPS also offer leasing arrangements for CROSS to help customers deal with balancing Capital Expenditure and Operational Expenditure. To date, this has not influenced customers either way as they often include the Capital Expenditure for power in their overall project finance arrangements.

16. The CROSS reduces technical and commercial risks associated with the provision of power to project sites. Offering factory-assembled PV arrays and containerised Balance of Circuit (BoC) reduces schedule and budget risks associated with performing larger scale civil works, along with the associated labour resource and management issues.

17. Recognition of PV Module warranties on a relocatable PV array has previously been a concern to ECLIPS' customers. SunPower provide warranty for their PV Modules when fitted to the CROSS. As ECLIPS do not control SunPower's warranty document, the current warranty statement is not attached, as warranty terms and conditions change from time to time. For up to date warranty conditions, interested parties should contact SunPower directly.

18. Additional commercial considerations regarding cost and pricing are described in this report under the *Analysis of the Activity* section.

INTEGRATION CONSIDERATIONS

19. CROSS can be integrated into any solar PV or hybrid power solution the same as other traditional PV arrays. The standard offering of CROSS includes PV modules and wiring connected to a DC isolator. Connection to CROSS simply involves connecting solar cables from the DC isolator to the inverter. When designing solutions with relocatable requirements, ECLIPS offer containerised BoC that includes inverters, control systems and energy storage as required.

20. The mobility characteristics of the containerised BoC are important for relocatable systems. If the mobility performance characteristics of the associated containerised BoC are not at the same level of the CROSS, many of the advantages of a relocatable system are lost. Although many Commercial-off-the-Shelf BoC solutions are fitted to modified shipping containers, this does not always mean the containers can be relocated without disassembling the fitted components, especially batteries. In this regard, key considerations include:

    a. Restraining internal loads: inverters and batteries are heavy and must be adequately restrained to prevent damage or injury when in motion. Documents

such as the National Load Restraint Guidelines should be considered when designing containerised BoC;

b. Environmental Controls: including temperature and humidity. The performance of batteries, particularly Lithium Ion, seriously degrade in high operating temperatures, and safety limits on charging systems often prevent charging once the batteries reach a certain operating temperature. When installed inside a shipping container, these operating temperature limits can be reached very quickly, even with modified ventilation. Active air conditioning is often the only way to adequately manage this, which needs to be considered in the power budget for system design;

c. Material Handling Equipment (MHE): consideration needs to be given to the type of MHE available throughout the supply chain, including the use of tilt trays to load and unload containers; and

d. Warranty Provisions: When fitting BoC components to a container designed for relocation, system integrators must consult equipment manufacturers to determine the impact on warranties.

ANALYSIS OF THE ACTIVITY

Achievement of Outcomes

21. ECLIPS successfully completed all outcomes and deliverables under the Agreement. Eight major Outcomes are detailed in the Agreement. ECLIPS' results against those Outcomes are described below.

Outcome 1 – Fabrication of CROSS

22. This outcome involved the fabrication of 2 x CROSS20 and 2 x CROSS40 units. All four units were successfully manufactured and delivered to Canberra in February 2018. The CROSS units are fitted with SunPower E21-435-COM PV modules. The CROSS20 has an output of 2175 W, and the CROSS40 has an output of 4350 W. With up to seven CROSS units per standard shipping container, over 30 kW of power can be shipped in a 40 ft container, and 15 kW per 20 ft container. Photos of the completed CROSS20 and CROSS40 units are shown in Figure 5 and Figure 6.

23. ECLIPS use Contract Manufacturers in Australia and China. The CROSS steel framework was fabricated in China. ECLIPS uses its Australian full-time engineers and production staff to supervise all fabrication activities, including those conducted in China. The attendance and involvement of ECLIPS staff during the fabrication process is critical is ensuring the quality standards required for all its products. Supervision also helps to manage cost of fabrication and deal with issues as they arise. ECLIPS also use the services of an independent Chinese engineering consultancy business to perform quality inspections during all stages of fabrication, including sampling of materials, welds, and functional performance. The independent Chinese engineer represents excellent value for money and can deal with the cultural and language barriers better than Australian staff. ECLIPS has a long-term relationship built on trust with its Chinese engineering consultancy, which is essential in ensuring quality outcomes.

24. ECLIPS follow this process for all its fabrication projects, which is a key differentiator to other equipment manufacturers who outsource fabrication to Chinese companies. In ECLIPS' experience, Chinese fabricators can be highly skilled and represent excellent value for money, however best results regarding quality and form are achieved when a company representative attends and participates in the fabrication process.

Figure 5 - CROSS20 units deployed at 30 degrees

Figure 6 - CROSS40 units deployed at 30 degrees

Outcome 2 – Production Price Point

25. Outcome 2 required ECLIPS to determine the production price point for production quantities of CROSS. This outcome was successfully achieved. Interested parties requiring pricing information on the CROSS should contact ECLIPS, as pricing and CROSS configuration options vary.

26. Many of the projects ECLIPS has submitted proposals and quotes for do not have requirements for frequent relocation of the arrays. Such projects may include landfill sites or areas with difficult topology that prevent traditional pole mount arrays requiring ground penetration and concreting. Given this, ECLIPS have developed a basic CROSS design for a lower cost that retains the logistics performance characteristics. One difference in the low-cost CROSS version is that the torsion springs that provide integrated mechanical assistance for raising and lowering the array have been removed. This means separate Mechanical Handling Equipment (MHE), such as a forklift or PALFINGER crane, may be required to raise and lower the arrays. This is unlikely to be an issue for projects that don't involve frequent relocation of the CROSS and where customers are attracted to CROSS due to its logistics benefits and ability to surface mount a PV installation without significant ground penetration or civil works.

Outcome 3 – Price Comparison

27. Outcome 3 is focussed on comparing the cost of CROSS against traditionally mounted fixed arrays and other temporary power solutions. In conducting this task, the first action was to establish a benchmark for price comparison. It is not common for businesses to publicise the fully installed price or the Levelised Cost of Energy for their PV systems, and many of those that do may not include all costs associated with secondary cost drivers that can be shared across other areas of a project, such as:

    a. logistics,

    b. civil works;

    c. installation;

    d. project management,

    e. finance;

    f. maintenance and support, and

    g. disposal costs.

28. The main input for establishing a common benchmark was from potential customers who have tendered CROSS based solutions across a range of Australian projects. Based on feedback from ECLIPS' customers and partners, a competitive target price point was established for the CROSS which would make it price competitive. Feedback from industry was reasonably consistent in this regard, however inclusions/exclusions varied significantly.

29. In determining the target price point, ECLIPS spoke to customers with at least one of the following requirements:

    a. Relocation of PV arrays (low frequency);

    b. Remote sites with challenging or expensive supply chains;

    c. Landfill sites where soil penetration for ground restraints was not permissible;

    d. Difficult topology such as surface rock or environmental constraints that prevented traditional pole mount arrays that require ground penetration.

30. None of the projects used to determine the target price had a requirement for frequent relocation of the PV arrays. Customers with such requirements are generally will to pay a higher price for a durable solution that maintains warranty following frequent relocation.

31. The other source of data that provided an input for the pricing benchmark was the study *Analysis of cost of medium-scale solar PV in Australia*, commissioned by ARENA, performed by Ekistica. The study, published in December 2017, provided cost data on a small number of projects over the previous two years that ranged in size between 500-1000 kW. Of the four ground-mount projects analysed, the average turn-key price for fixed-tilt systems was AS$2.28 per watt. The prices cited in the study were based on published data by the source and reflected economies-of-scale associated with conducting multiple projects and buying components in bulk. Each of these examples also included PV modules on the lower end of the cost spectrum. There was no data regarding any costs absorbed in other project costs, such as civil works. The sites were all within 150-200 km of a major capital City. The study did not identify any requirements for relocatable PV solutions.

32. Based on the established price benchmarks and targets, ECLIPS assess that a single relocation of CROSS is required to achieve cost benefit over two traditional pole-mount fixed array sites. There are many variables that will affect the results of the cost break-even point, but the most important factor in determining the type of solution is the problems it solves and the value it provides to the customer. CROSS are not designed to compete with traditional pole mount solutions that are suitable for simple projects and sites with a life of 25 years. Cost benchmarking has been important for ECLIPS to filter the projects it should tender for, as it's an obvious conclusion that customers will not purchase CROSS when a traditional solution with a lower turn-key will suffice.

33. ECLIPS also investigated the comparison costs against traditional diesel generators, however the variables associated with such scenarios make it difficult to establish a relevant benchmark. In some circumstances within Australia, diesel rebates for primary producers and resources sectors mean that even with Small-Scale Technology Certificates for solar PV, it is generally cheaper to use diesel generators if fuel resupply is reliable and low cost. ECLIPS identified a range of diesel costs from AS$0.80/L (with rebates) up to in excess of AS$100/L for remote locations in the Middle East and Africa. The high range examples are influenced by the cost of security and logistics for convoys or the requirement to use air transport for resupply. In other examples within the South-East Pacific regions, diesel replenishment is very irregular and may even be barged in on seasonal rivers. In these circumstances, power availability was a more important factor than cost. In other situations, such as small projects like remote water bore sites, the cost of diesel was not the major factor in selecting power sources, instead it was the long-term reliability of power and downtime following generator failure that drove customers to a PV solution. Based on these findings and observations, a direct comparison cost with diesel generators was not established for the scenarios suitable for CROSS.

Outcome 4 – Fabricate and fit-out the CROSS with solar PV

34. This Outcome was linked to the final fit out of the CROSS. ECLIPS have installed SunPower E21-435-COM PV modules on the CROSS. Five modules are fitted per CROSS20, and ten per CROSS40. The modules are wired to DC isolators, and earthing is conducted through the steel frame. The completed CROSS units were designed in accordance with:

    a. AS/NZS 3000:2007 Wiring Rules;

    b. AS/NZS 5033:2014 Installation of Photovoltaic PV arrays;

c. AS 4777:2016 Grid Connection of Energy Systems via Inverters;

d. AS 1768:2007 Lightning protection; and

e. AS 1170.2:2011 Structural design actions—Wind actions.

35. As part of ECLIPS' Verification and Validation activities, an independent Clean Energy Council Accredited Designer and Installer inspected and certified the CROSS units against the top three listed standards. An independent structural engineering company certified compliance of the CROSS for installation in Wind Regions A-D of AS/NZS 1170.2:2011. Project certification against the Lightning Protection standard is site specific, however the CEC Designer signed off that the CROSS was compliant with the standard as a sub-system.

Outcome 5 – Transportability

36. The original specification and Agreement Outcome required three of the CROWS-PV units be stacked inside a High Cube ISO shipping container. The final CROSS design allows up to seven units to be stacked, interconnected via twist locks through the corner castings, and be loaded into 20 ft and 40 ft shipping containers.

37. Figure 7 shows seven units stacked inside a standard ISO shipping container, with sufficient clearance to lift the end and roll out the stacked units. Only two of each configuration were fabricated under the Agreement, so the successful validation result was by analysis.

38. CROSS can also be loaded directly onto trailers and flatbed truck with twist locks using an existing ECLIPS adapter plate to connect the CROSS to the ISO footprint. This means CROSS can be removed from containers before reaching the project site and unloaded into position individually using sideloaders, PALFINGER cranes or forklift.

Figure 7 - CROSS20 stacked seven high inside shipping container

Figure 8 - CROSS units loaded and transported by tilt trays

Figure 9 - CROSS40 in shipping container during transportability testing

Outcome 6 – Loading and Handling

39. This Outcome required demonstration of rapid handling by standard intermodal mechanical handling equipment, such as a forklift, for the loading, unloading and redeployment of CROSS. During the formal Test and Evaluation phase of the Project, the CROSS have been loaded into and out of shipping containers with a range of forklifts types. Containers have been loaded and unloaded on container ships and trucks by forklifts, cranes, side loaders and tilt trays.

40. A shipping container can be unloaded from a truck/trailer in less than a minute using a forklift, and within a couple minutes using a side loader. A forklift can remove the CROSS20 and CROSS40 stacks in less than two minutes. CROSS are then individually unstacked and moved by forklift to the desired installation location. Demonstration of this successful Outcome was conducted during the CROSS Demonstration Day on 12 April 2018.

Figure 10 - CROSS20 in shipping container being unloaded by forklift

Figure 11 - CROSS40 in shipping container being unloaded by side loader

Figure 12 - CROSS20 units being unloaded from containers using forklift

Figure 13 - CROSS20 units being moved into position for setup

Outcome 7 – Setup Times

41. Outcome 7 specified that the CROSS would take less than:
    a. 15 minutes to setup a CROSS20 by two people once unloaded; and
    b. 30 minutes to setup a CROSS40 by two people once unloaded.
42. The test was performed several times and included deployments of 10/20/30degrees. The average achieved results for this performance criteria was:
    a. CROSS20 – less than 1 minute; and
    b. CROSS40 – less than 1 minute.
43. Although the test was performed by two people to measure performance against the target Outcome, it is safer and easier to complete the task using three people. The CROSS User Manual recommends three people are used to setup the CROSS.

Outcome 8 – Validate the Scale of the Temporary Power Market

44. This Outcome was set to ensure that there is a strong commercial business case for a relocatable PV power product. ECLIPS have responded to multiple customer enquiries and requests for quote over the last 12 months, including several sole source engagements where the customer could not find other solutions that met their requirements.
45. Around 70 percent of the enquiries related to projects where there is a shorter deployment period than 7-10 years, requiring relocation to another site during or at the end of that term. An additional 20 percent related to sites with challenging supply chains or site conditions that prevent ground penetration associated with traditional pole mount arrays. The interest received in ECLIPS' relocatable PV system has

validated the scale of the temporary power market, and further identified projects that may not be temporary, but still be relevant for CROSS due to its rugged free-standing structure.

Project Achievements

Successful Design, Development, Test and Evaluation Project (DDT&E)

46. This project represents a successful DDT&E approach to product development and project delivery. ECLIPS has mature and effective systems engineering and project management procedures, which helped ensure the project was delivered on schedule. Following the systems engineering approach, including the concurrent engineering practices related to “Design for X”, enabled ECLIPS to critically analyse the technical and commercial benefits and challenges of the original CROWS-PV design, and adjust accordingly. This ensured the most affordable and capable product was developed that met the Functional Performance Specification.

Achievement of Initial Target Price

47. ECLIPS have established a competitive price point for relocatable solutions. Following feedback from customers and industry partners, ECLIPS also completed the design for a basic CROSS version which is targeted towards customers that do not require frequent relocation of the CROSS. The basic version remains a factory assembled, roll out PV array, but the main difference is that lifting of the arrays into the 10/20/30 degree deployment angles requires assistance through MHE, as it does not include the inbuilt torsion springs (can also be done using more people). ECLIPS are continuing to drive the price down through competitive quoting amongst contract manufacturers and selection of common steel I-Beams and other materials.

Manufacturability

48. The Design for Manufacture and Design for Cost analysis undertaken significantly influenced the design changes throughout the project. Using lessons learnt from designing and fabricating similar products, including the CROWS™, ECLIPS was able to generate a production pack for the Contract Manufacturer that required very little change during fabrication. The test and acceptance procedures enabled effective quality assurance of the product.

Ease of Setup

49. The achieved test results significantly exceeded original targets for setup time. This was due to a priority focus on the Human Machine Interface aspects during the design process. The design evolution ensured an efficient process for setting up the CROSS which will enable small teams to quickly setup utility scales of CROSS.

Customer Interest

50. Prior to announcing the CROSS Demonstration Day, ECLIPS had taken a passive approach to CROSS sales, and did not advertise the product on its website or actively seek potential projects. This was due to an understandable reluctance by customers to buy a product that was yet to be built or tested. Since the successful Demonstration Day event, ECLIPS have been encouraged by the amount of interest and quote requests from industry. This has reinforced that the CROSS fills a niche in the market of relocatable solar PV power.

Technology Convergence

51. The end rollers for CROSS base frame are background IP from ECLIPS' patented CROWS™ product (Figure 14), which was designed to support complex supply chains within the Oil and Gas sector. The CROWS™ (and CROSS) design was also influenced by ECLIPS' ISO 1C Flatrack (Figure 15), which was designed for military customers. ECLIPS have previously designed, fabricated and delivered over 10,000 special-to-purpose logistics platforms to Resources and Defence sector clients. Using lessons learnt in deploying plant and equipment to these projects, and new requirements identified from engaging with the energy sector, ECLIPS sought to address the common logistics challenges to the supply of renewable power. The CROSS represents a technology convergence in logistics products across the Defence, Mining, Oil& Gas and Energy sectors.

Figure 14 - ECLIPS' patented Container Roll Out Warehousing System (CROWS™)

Figure 15 - ECLIPS' ISO 1C Flatrack delivered to the Australian Army

KNOWLEDGE SHARING

Knowledge Sharing Activities

52. Three main areas for knowledge sharing were specified in the Agreement, including:
    a. Test Report;
    b. Onsite demonstration to industry;
    c. Public Report (this report); and

Test Report

53. ECLIPS completed a detailed Verification Cross Reference Matrix to trace functional requirements all the way through to achieved test results. The CROSS passed all formal testing. The Test Report was submitted to ARENA but is not part of the publicly released information. Parties interested in discussing CROSS test results should contact ECLIPS directly.

Onsite Demonstration to Industry

54. ECLIPS conducted a comprehensive demonstration of the CROSS on 12 April 2018 that was attended by representatives from Government, Defence, mining, oil and gas, and energy sectors. The demonstration activity included:
    a. Static demonstration of a CROSS40 setup;
    b. Project briefing on the products and some project findings;
    c. Live demonstration of CROSS being delivered, unloaded and setup; and
    d. Opportunity for attendees to inspect and ask questions on the product and the project.

Published Material and Media Activities

55. Over the course of this Project, ECLIPS have published a range of material and technical data for the CROSS, including:

a. CROSS Datasheet (Attachment A);

b. Published articles, including:

i. South East Region of Renewable Energy Excellence(SERREE) (SERREE_CROSS_Article);

ii. Jane's 360 (Janes_CROSS_Article); and

iii. Defence Connect (Defence_Connect_CROSS_Article);

56. In additional to publications by ECLIPS, a wide variety of media outlets reported on the Demonstration Day and the launch of the CROSS.

LESSONS LEARNT

57. The Lessons Learnt Register is included as Attachment B to this report.

CONCLUSION

58. ECLIPS successfully achieved the Project Objectives and Outcomes listed in the Funding Agreement. The iteration in design from the original CROWS-PV design to the CROSS design has resulted in marked improvements in the overall capability, including commercial viability. This Project has also proven the viability of the technical solution, which was successfully demonstrated to industry on 12 April 2018.

59. During the Project, ECLIPS engaged with clients to get a good understanding of a competitive price for a relocatable solution. ECLIPS also identified that a couple configuration variants of the CROSS may be required. One that supports customers with a requirement for frequent relocation, and another basic version that retains the logistics benefits, but has some functionality removed to support customers that only wish to relocate a very small number of times over the life of the CROSS.

60. ECLIPS' next step for CROSS involves large scale deployments of CROSS on project sites. ECLIPS and is actively looking for partners and customers with suitable projects. Further information on ECLIPS and the CROSS can be found at www.eclips.engineering.

ATTACHMENTS

A	CROSS Product Datasheet
B	CROSS Project Lessons Learnt

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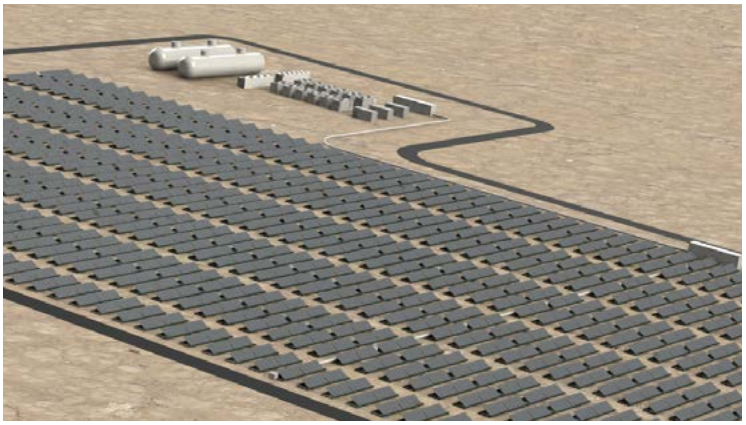
Container Roll-Out Solar System (CROSS)

PRODUCT FEATURES AND BENEFITS

- CROSS is a factory assembled, relocatable solar power array providing up to 2175 W of power per 20 ft unit (CROSS20) and 4350 W of power per 40 ft unit (CROSS40).
- CROSS is delivered fully assembled and can be rolled out of a shipping container and setup in minutes. The PV array is spring assisted, meaning no special tools are required during setup.
- CROSS are inter-connectable with corner twistlocks and can be stacked up to seven high in an ISO shipping container during transportation or storage. CROSS is a modular solution suitable for projects up to utility scale and can be deployed without any ground penetration for anchoring.
- CROSS include heavy duty rollers on one end enabling them to be rolled in or out of shipping containers for quick and easy deployment.
- The PV array can be setup at 0°, 10°, 20° and 30° angles. Additional angles can be requested when ordered.
- CROSS comes pre-wired to a DC isolator and ready for connection to an inverter.
- CROSS is structurally certified for installation in AS/NZS 1170.2:2011 Wind Regions A to D.

Container Roll-Out Solar System (CROSS)

ECLP-101723_v1-1



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Container Roll-Out Solar System (CROSS)

Container Roll-Out Solar System (CROSS)

CROSS20 SPECIFICATIONS

Dimensions folded (Transport Mode)	Length	Width	Height
mm	5825	2296	310
ft in	19' 1 3/8"	7' 6 3/8"	1' 0 1/4"

Dimensions deployed with panels at 30°	Length	Width	Height
mm	5825	2296	1335
ft in	19' 1 3/8"	7' 6 3/8"	4' 4 1/2"

CROSS20	SPECIFICATION
Nominal Power P_{Max}	2175 W
Number of PV Modules	5
Maximum PV Module dimensions	2067 mm x 1046 mm
Cables	PV1F rated, 4.0 mm²
Connectors	MC4
Gross Mass	1350 kg
Complies with	AS/NZS 1170.2 AS/NZS 5033 AS/NZS 3000 AS 4100

CROSS40 SPECIFICATIONS

Dimensions folded (Transport Mode)	Length	Width	Height
mm	11,924	2296	310
ft in	39' 1 1/2"	7' 6 3/8"	1' 0 1/4"

Dimensions deployed with panels at 30°	Length	Width	Height
mm	11,924	2296	1335
ft in	39' 1 1/2"	7' 6 3/8"	4' 4 1/2"

CROSS40	SPECIFICATION
Nominal Power P_{Max}	4350 W
Number of PV Modules	10
Maximum PV Module dimensions	2067 mm x 1046 mm
Cables	PV1F rated, 4.0 mm²
Connectors	MC4
Gross Mass	2350 kg
Complies with	AS/NZS 1170.2 AS/NZS 5033 AS/NZS 3000 AS 4100

ISO 9001
www.intlcert.com

ALL DIMENSIONS AND WEIGHTS ARE NOMINAL AND SUBJECT TO MINOR VARIATIONS THAT MAY OCCUR DURING THE MANUFACTURING PROCESS

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ATTACHMENT B - LESSONS LEARNT REGISTER

SERIAL	CATEGORY	DESCRIPTION	IMPACT	RECOMMENDATION	SUITABLE FOR PUBLIC DISSEMINATION
1	Requirements	Although the CROSS can be rapidly deployed and relocated, ECLIPS's partner companies and suppliers of Balance of Circuit (BoC) components, such as batteries, may not be as easy to relocate in their existing container solutions. Generally, batteries need to be uninstalled from racks before containers are transported offsite.	Partner selection and customer business case.	Based on project requirements, partner companies modify BoC solutions, including Energy Storage Systems (ESS) to enable transportation without major batteries and components being removing and repackaged.	Yes
2	Business Case	Some ECLIPS customers have requested ESS/BoC components be integrated into the CROSS or added to a skid below the CROSS. The cost is currently prohibitive for small quantities, and COTS ESS containers may be more cost effective (assuming ESS has same mobility characteristics).	Expense to develop customer ESS skids that can connect to a CROSS seems higher than COTS ESS container.	Enclosed ESS container with air-conditioning (where required) remains most cost-effective and scalable solution for BoC components. This assumes ESS containers can be moved without major repackaging of batteries.	Yes

SERIAL	CATEGORY	DESCRIPTION	IMPACT	RECOMMENDATION	SUITABLE FOR PUBLIC DISSEMINATION
3	Business Case	Further effort is required to enable comparative assessment of costs including LCOE between CROSS and traditional fixed array solutions. The main report details modelled costs for CROSS, including delivery. Some users have compared solutions based on purchase price per watt, which is a Capital expense, and ignore relocation expenses, as this is an Operating expense, and has little bearing on a procurement project.	Even when CROSS represents a lower LCOE, users may select traditional systems.	ECLIPS to better communicate the business case for relocatable solutions to clients, including LCOE that incorporates multiple moves.	Yes
4	Business Case	ECLIPS have received interest from power financiers due to the ability to repossess the asset.	CROSS may improve viability of customer business cases when seeking project finance.	ECLIPS to develop partnerships with power financiers to reduce risks to clients associated with project finance.	Yes

SERIAL	CATEGORY	DESCRIPTION	IMPACT	RECOMMENDATION	SUITABLE FOR PUBLIC DISSEMINATION
5	Business Case	CROSS has appealed to some Government organisations providing or funding power to remote indigenous communities due to the ability to easily increase/decrease the size of the supported system. This reduces the risk of Government Agencies being left with stranded assets if the circumstances in those communities change.	Easy relocation and modular design offers product differentiation, and reduces obstacles / barriers in the uptake of renewable energy.	ECLIPS to discuss CROSS with Government and Power companies providing power to remote communities.	Yes