

## Lessons Learnt Report

### RayGen Solar Power Plant Demonstration Project

#### Milestone 3A

This Project received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Advancing Renewables Program.

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#### Contents

<b>Lessons Learnt Report: Global Shipping &amp; Logistics .....</b>	<b>2</b>
<b>Lessons Learnt Report: Contract Management .....</b>	<b>3</b>
<b>Lessons Learnt Report: Skills Shortage.....</b>	<b>4</b>
<b>Lessons Learnt Report: Single Source Suppliers .....</b>	<b>5</b>
<b>Lessons Learnt Report: Skill Shortage - Production.....</b>	<b>6</b>
<b>Lessons Learnt Report: 'Peak' generation product.....</b>	<b>7</b>
<b>Lessons Learnt Report: Need for LDES in renewable energy zones .....</b>	<b>8</b>

## Lessons Learnt Report: Global Shipping & Logistics

**Project Name:** *RayGen's Solar Power Plant – Milestone 3A*

<b>Knowledge Category:</b>	Logistical
<b>Knowledge Type:</b>	Risk Management
<b>Technology Type:</b>	Solar Thermal
<b>State/Territory:</b>	Victoria

### Key learning

*The COVID-19 pandemic and global volatility have had wide-reaching impacts on project planning and delivery and in particular, global shipping and logistics.*

*The shipping of key critical equipment, such as turbo expander from Atlas Copco Mafi Trench located in Santa Maria, CA, USA was heavily impacted by global shipping and logistics. This included significantly delayed delivery, revised ship routing via additional ports and continents, and major ship maintenance being performed without notification or transfer to more suitable routing.*

*The lesson learned was that global shipping and logistics remains a significant risk to the project delivery and success.*

### Implications for future projects

*For future projects, additional steps and due diligence are required to help minimise and mitigate the impact of global shipping and logistics. This includes considering local equipment supply where possible, securing early ship allocation and RayGen managing the shipping and logistics with equipment being supplied ex-works.*

### Knowledge gap

*Develop greater understanding of local and global supply chain management.*

### Background

#### Objectives or project requirements

*RayGen has designed Solar Power Plant One (SPP1) for delivery in 2021/2. The purpose of the project is to realise a first of type large-scale, low cost and low risk solar-plus-storage technology for deployment in Australia and internationally. Key equipment, including RayGen's proprietary modules, are manufactured in Australia, with other components sourced internationally.*

#### Process undertaken

*RayGen sourced the ORC turbine out of Santa Maria, CA, with delivery managed by our supplier.*

## Lessons Learnt Report: Contract Management

**Project Name:** *RayGen's Solar Power Plant – Milestone 3A*

<b>Knowledge Category:</b>	Technical
<b>Knowledge Type:</b>	Construction
<b>Technology Type:</b>	Solar Thermal
<b>State/Territory:</b>	Victoria

### Key learning

*The COVID-19 pandemic and global volatility have had wide-reaching impacts on project estimating, forecasting, and commodity pricing.*

*The contractual arrangements with key construction contractors were significantly impacted by logistics, material, and labour price increases during the project execution phase. These price increases were beyond the control of the contractor resulting in some instances of contracts being renegotiated or in some cases re-awarded to new vendors to address these impacts and expedite site works.*

*The lesson learned was that global commodity pricing and availability remains a significant risk to the project delivery and success.*

### Implications for future projects

*For future projects, early completion of design and procurement of equipment and materials coupled with additional contractual measures and a rigorous contractor selection process will help minimise and mitigate the impact of uncontrollable price increases on future projects.*

### Knowledge gap

*Secure relationships with experienced engineering and quantity surveying consultants and/or resources.*

### Background

#### Objectives or project requirements

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#### Process undertaken

*RayGen utilised in house engineering and procurement team to complete the design, procurement, and contractor selection process. The contractual documents were prepared by Melbourne based law firm who specialise in construction contracts and executed by RayGen.*

## Lessons Learnt Report: Skills Shortage

**Project Name:** RayGen's Solar Power Plant – Milestone 3A

<b>Knowledge Category:</b>	Technical
<b>Knowledge Type:</b>	Construction
<b>Technology Type:</b>	Solar Thermal
<b>State/Territory:</b>	Victoria

### Key learning

*Skilled tradespeople are highly sought after in regions outside of capital cities due to remoteness/ small population bases, and limited competition. Large construction projects can often consume all immediate local resources. During the pandemic this became even further constrained due to absenteeism and a short-term lull-to-boom in construction projects.*

*RayGen engaged primarily localised contractors and resource pools to maximise value to the local community, but once the local construction boom occurred the need for resources became highly competitive, and the workforce dwindled for other competing projects.*

*The lesson learned was that engaging with local contractors that have reach to other (e.g. multi-region or city-based contract) resource pools is critical to ensuring a resilient and stable workforce.*

### Implications for future projects

*For future projects, engaging local contractors with ties-to major regional or capital cities as additional support in peak-demand periods will maximise the potential for a stable workforce of skilled tradespeople.*

### Knowledge gap

*Secure relationship with suitable contractors who can support various resourcing options for the project.*

### Background

#### Objectives or project requirements

*RayGen has designed Solar Power Plant One (SPP1) for delivery in 2021/2. The purpose of the project is to realise a first of type large-scale, low cost and low risk solar-plus-storage technology for deployment in Australia and internationally. Key equipment, including RayGen's proprietary modules, are manufactured in Australia, with other components sourced internationally.*

#### Process undertaken

*RayGen utilised an in-house team to complete the contractor selection process with a focus on engaging local contractors for the project.*

## Lessons Learnt Report: Single Source Suppliers

**Project Name:** *RayGen's Solar Power Plant – Milestone 3A*

<b>Knowledge Category:</b>	Technical
<b>Knowledge Type:</b>	Construction
<b>Technology Type:</b>	Solar Thermal
<b>State/Territory:</b>	Victoria

### Key learning

*Specialist services – such as concreting, electrical works – can be limited in regional locations. For certain capabilities, there may be limited or single source supply conditions. Having a single source creates a high-risk dependency for RayGen, especially when there is high demand for that service.*

*The lesson learned was that specialist services remain a significant risk to project delivery and success.*

### Implications for future projects

*For future projects, performing due diligence on local specialist services, and expanding the search to ensure that a minimum of three qualified specialist suppliers are identified. In the event this is not practical, or possible, consideration should be given to developing and/or securing the capabilities internally with RayGen.*

### Knowledge gap

*Develop understanding of specialist suppliers, their capabilities, and locations.*

### Background

#### Objectives or project requirements

*RayGen has designed Solar Power Plant One (SPP1) for delivery in 2021/2. The purpose of the project is to realise a first of type large-scale, low cost and low risk solar-plus-storage technology for deployment in Australia and internationally. Key equipment, including RayGen's proprietary modules, are manufactured in Australia, with other components sourced internationally.*

#### Process undertaken

*RayGen utilised an in-house team to complete the contractor selection process with a focus on engaging local contractors for the project.*

## Lessons Learnt Report: Skill Shortage - Production

**Project Name:** *RayGen’s Solar Power Plant – Phase Three A*

<b>Knowledge Category:</b>	Logistical
<b>Knowledge Type:</b>	Operation and maintenance
<b>Technology Type:</b>	Solar PV
<b>State/Territory:</b>	Victoria

### Key learning

*The COVID-19 pandemic has had a material impact on the labour market. Government policies (closed borders, stimulus packages, limited movement, etc.), have led to a skill and labour shortage. As a result, RayGen’s module production has been impacted at the time when the production team experienced an increase in demand for the PV Ultra modules to meet our internal customers.*

*The complexity of the PV ultra-module manufacturing process across the existing 25 MW manufacturing line, involves the combination of automated machines and repeat, high precision manual tasks to complete a PV module. Along with the known issues that repeat, high precision manual tasks present in productivity, RayGen’s production team faced many challenges in recruiting personnel to meet demand.*

*New hires generally required a learning curve (with an impact on yield) until they were experienced in the requirements of the task.*

### Implications for future projects

*The design for the higher volume 170MW PV Ultra module manufacturing is designed to reduce repetitive, high precision manual tasks. Existing personnel will undergo training and upskilling to operate, maintain and troubleshoot a more automated production process. Staff will have an opportunity to develop broad capability across the manufacturing process. In addition, RayGen will hire staff ahead of production volume, to ensure the workforce has sufficient time for on-boarding and training.*

### Knowledge gap

*Understanding and certainty as to when skill shortage will return to pre-pandemic levels*

### Background

#### Objectives or project requirements

*RayGen has designed Solar Power Plant One (SPP1) for delivery in 2021/2. The purpose of the project is to realise a first of type large-scale, low cost and low risk solar-plus-storage technology for deployment in Australia and internationally.*

#### Process undertaken

*RayGen recruited highly capable production staff to meet production demand.*

## Lessons Learnt Report: ‘Peak’ generation product

**Project Name:** RayGen’s Solar Power Plant – Phase Three A

<b>Knowledge Category:</b>	Financial
<b>Knowledge Type:</b>	Operation and maintenance
<b>Technology Type:</b>	Solar PV
<b>State/Territory:</b>	Victoria

### Key learning

*The market does not have a standard wholesale market product for a dispatchable generator, but existing retail peak / off-peak products provide a relevant proxy. As RayGen has been delivering 50MWh Solar Power Plant One near Mildura, we have simultaneously been developing 3.6GWh Solar Power Plant Two, including a project in South Australia. One advantage of RayGen’s technology is our ability to provide reliable generation during the evening peak. This peak generation (daily evening generation) is in addition to capacity provision, which is typically only incurred when the market price exceeds \$300/MWh.*

*There are standard contracts for capacity, solar generation and LGCs, and there is increasing familiarity with FCAS. There are not, however, standard generation contracts for a dispatchable generator. Attempts have been made to cover this gap, including with the “inverted solar curve” and the four hour daily arbitrage “TB4”. However, these products are not widely accepted by the market, as the “inverted solar curve” covers high value generation (early evening) and very low value generation (rest of time), and the TB4 model (the arbitrage between the eight highest and eight lowest 30min trading periods) is dependent on granular forecasts of the spot market - which offtakers and financiers wish to avoid.*

*There are, however, standard contracts in the retail market that can be a proxy for generation contracts. The retail market has long incentivised customers with tiered pricing for peak and off-peak periods. Peak periods occur in the early evenings (e.g. 4PM-9PM), on weekdays, and often with a longer peak window in summer than winter. RayGen can offer dispatchable generation in a ‘peak’ contract, offering to export at 100% of export capacity for every peak period in the year.*

### Implications for future projects

*RayGen offers ‘peak’ generator contracts – a commitment to generate at 100% of export capacity for every peak period (weekdays ~4PM-9PM) in the year. This is in addition to offering capacity, LGCs and FCAS.*

### Knowledge gap

*Peak generation contracting model.*

### Background

#### Objectives or project requirements

*RayGen has designed Solar Power Plant One (SPP1) for delivery in 2021/2. The purpose of the project is to realise a first of type large-scale, low cost and low risk solar-plus-storage technology for deployment in Australia and internationally.*

#### Process undertaken

*RayGen is in discussion with the market, including RayGen’s investor AGL.*

## Lessons Learnt Report: Need for LDES in renewable energy zones

**Project Name:** *RayGen’s Solar Power Plant – Phase Three A*

<b>Knowledge Category:</b>	Regulatory
<b>Knowledge Type:</b>	Network connections
<b>Technology Type:</b>	Storage
<b>State/Territory:</b>	All

### Key learning

*Most states of Australia have targeted renewable energy development to renewable energy zones (REZs), with dedicated new transmission investment. Australia is not built on a copper plate, and new transmission must bring green power from the regions into cities. New transmission investment will be expensive and require high utilisation to justify the investment. Renewable energy generation, especially solar generation without storage, is low capacity factor and under-utilises new-build transmission infrastructure.*

*Regulators have realised the need for long duration storage in each renewable energy zone, to increase the utilisation of transmission capacity from each REZ to load centres. NSW, for example, has implemented the LTESA program, to incentivise new-build long duration storage and generation.*

*The experience of markets (or regions within markets) that have accelerated deployment of solar without storage have been profound. These markets are experiencing wild swings in pricing, collapsing reliability and severe (>20%) congestion and curtailment. These markets have demonstrated that accelerated deployment of renewable energy generation, especially solar generation, must coincide with accelerated deployment of storage.*

### Implications for future projects

*RayGen should prioritise site development in renewable energy zones in the grid. These zones are well supported by local communities and state regulators, and have a clear demand for the LDES capability RayGen’s storage offers.*

### Knowledge gap

*Need for LDES in REZs.*

### Background

#### Objectives or project requirements

*RayGen has designed Solar Power Plant One (SPP1) for delivery in 2021/2. The purpose of the project is to realise a first of type large-scale, low cost and low risk solar-plus-storage technology for deployment in Australia and internationally.*

#### Process undertaken

*RayGen is delivering the world’s largest next generation storage project, at 50MWh.*