University of New South Wales Sydney:

Prototyping a Photoluminescence Imaging Tool for Testing of Fielded Solar Modules

LESSONS LEARNT REPORT

Project Details

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Reporting Period	Start: 13th July 2020 (budget release) End: 31st March 2021 (extended deadline due to COVID-19 impacts and delay in budget release)

This Project received funding from ARENA as part of ARENAs Advancing Renewables Program.

Executive Summary

The ARENA funding was used to take a technology that was proven in the lab (Outdoor Photoluminescence Imaging; O-PL) into its target field of use, PL imaging of field-deployed solar panels on utility scale solar farms.

This was achieved by designing and building a fully functioning alpha-prototype outdoor PL imaging system that was subsequently tested and improved on three distinctly different solar power plants in NSW.

The project was completed successfully and substantial additional further technological advances beyond the scope of the project were accomplished based on the experience gained in the project and via the respective field trips.

Having a highly functioning and efficient team was critical for the project success.

Key Learnings

Lesson learnt No. 1: Delay in budget release

Category: Logistical

Objective: Finish project on time

Detail: Substantial delays were caused early in the project when we tried to execute an agreement with our commercial partner (PV Evolution Labs, US) who were increasingly concerned with the economic uncertainty that the just unfolding COVID-19 crisis brought upon them. Eventually, they pulled out of the project because of the circumstances which had changed rapidly and detrimentally for them. Some additional delays were caused by administrative processing on UNSW side (UNSW are increasingly under financial pressure and this naturally impacts processing efficiency). Ultimately the budget release was substantially later (July 2020) than the intended project start date (Jan 2020).

Communication with ARENA was very constructive and both sides agreed to extend the project finish date by 3 months backwards which greatly relieved the time pressure and allowed us to complete the project more thoroughly and successfully than we would have otherwise been able to.
Generally, it is probably unrealistic to assume very fast completion of all the administrative processes that need to happen prior to budget release and it might be a good thing to build such expected delays into the project right from the start.

Lesson learnt: Maybe best to increase the project time right from the start by a few months since one always needs to “expect the unexpected” (delay).

Lesson learnt No. 2: Project partner dropped out

Category: Risk

Objective: Delivery of prototype imaging tool to project partner

Detail: At the beginning of the project we struggled to get an agreement in place with our high-profile project partner PV Evolution Labs in the US. The COVID-19 crisis was just unfolding, and they saw themselves commercially exposed to many negative implications including substantial loss of revenue. Eventually, they concluded that with this changed situation they are no longer in a position to be partner in this project and to make very substantial cash and in-kind contributions. A situation had arisen that was very difficult for us to navigate.

As soon as this negative outcome was clear we communicated it with ARENA and after some considerations they concluded that the project is still viable without the project partner. The funding agreement (including milestones) was amended to account for this substantial change in circumstances and, very fortunately, the project could still go ahead.
We are very grateful for ARENA's help in this crisis and believe that ultimately the outcome was even better than we had hoped. In essence, not having to build and deliver a second tool to our partner we had time and attention available to develop two very substantial technological advancements that make the technology commercially much more appealing due to an increased ease of use of the technology and much improved imaging throughput.

Lesson learnt: Communicate project difficulties with ARENA as early as possible such that an emerging project crisis can be constructively managed and, ideally, avoided.

It's life after all - nothing ever goes perfectly as planned. However, some flexibility can really pay off in the end and lead to better than anticipated outcomes.

Lesson learnt No. 3: Managing PV plant field trips

Category: Risk/Social

Objective: Access to field testing site for alpha-prototype inspection system

Detail: An essential part of our project was to test the developed alpha-prototype tool in its "natural habitat", ie. on fully operational utility scale PV power plants. At some stage of the project, we came to realise that it is not actually as easy as we thought to get access to suitable solar power plants for testing even being immersed in very extended industry networks via our School of Photovoltaic and Renewable Energy Engineering at UNSW Sydney. This is the case because solar farms are commercial enterprises and those involved in managing and running them have no direct benefit from us coming to their solar farm. However, they still need to spend resources (mostly time of personnel) to accommodate for us.

Eventually we managed to get access to three large scale solar power plants in NSW which was achieved via our extended networks (UNSW alumni contacted via LinkedIn; UNSW Knowledge Exchange; Sunraysia solar farm contacts within UNSW). We were extremely lucky to have these networks since it would otherwise have been much more difficult to accomplish this aspect of the project.

Lesson learnt: It really pays off to be well connected and to have and foster good relationships on all levels. In the end, this can be the critical element in whether something can happen, or not.

Fig. 1: Our first field trip was possible only due to our UNSW alumni connections. Yang-Yang, a UNSW alumni, now working at HCB Solar was instantly happy to help us after we contacted him on :LinkedIn. The picture shows Raghavi, Germain and Oliver with Logan Haggerston (yellow jacket), Yang Yang's colleague at the Summerhill solar farm which is managed by HCB Solar.

Lesson learnt No. 4: Technological development of the project

Category: Technical/Commercial

Objective: Development of the technology

Detail: A typical question that came up when we spoke to personnel at the solar farms we visited was: "How many solar panels can you image per hour (or day)?".

This was kind of unexpected since we thought that people working on solar farms would be very interested in the technical details of our technology and the (quite remarkable) images we can take with it.

Through these experiences we realised that people who are tasked with running a solar farm have many day-to-day challenges that they need to deal with. If they are eventually asked to pay money for a service then it is very relevant to them that the service is delivered in a timely manner and that the result is a substantial volume of image data.

Partly resulting from this experience, partly due to our technological curiosity, we eventually developed two further technological advancements of our outdoor imaging technology that will enable substantially easier and faster imaging of PV panels on solar farms. According to our experience we believe that this will greatly be embraced by the industry.

As a result, one provisional patent was filed in the course of the project and another one is currently considered for filing. Both patents give this technology a much higher chance of commercial success, an avenue that we are currently considering.

Lesson learnt: There can be a substantial gap between research (and technological excitement) and the realities in the commercial world. The experiences gained in the project and via our field trips helped us to understand this better and to subsequently tailor our technology to be much fitter for purpose in the commercial world, in essence, to reduce the gap between research and commercial reality.

Lesson learnt No. 5: Speedy technological development

Category: Technical/Risk

Objective: Efficient development of technology (software and hardware)

Detail: The project duration was only 1 year, which is a very challenging time frame considering that we did not operate from a commercial but a university environment. The substantial technology development as was needed for this project, necessitated so-called "rapid prototyping" and going through product cycles in a very efficient way, something universities are not necessarily designed for. We navigated these challenges via several routes:

- We purchased small items (electronic parts etc.) privately and got them reimbursed later. This sped up project cycles from potentially weeks to several days. A downside of this approach is substantially increased admin work (claiming of parts etc.) on our side.
- We engaged professional services where needed. For instance, many parts we needed could be laser cut from aluminium sheets. While we have this capability, in principle, at UNSW – it was substantially faster (probably cheaper as well) to simply order the parts from a company in Sydney that specialises in this as a service. Delivery was usually well below a week after placement of an order.
- We hired a software professional to develop our custom LabView software in accordance with our needs and specifications. This was done throughout the project duration since several iteration cycles were made to keep improving the functionality and ease of use of the software. The outcome was very rapid development of robust and fit-for-purpose software. Additional benefits of engaging a professional are the learning experiences from thousands of hours of that person that were flowing into the project (eg. an optimised user interface design) which made the software better than we had intended it to be in the first place.

Lessons learnt: When operating from a university environment and on a short duration project that includes technology development one needs to engage in effective and creative problem solving in order to enable "rapid prototyping" (or as close as one can get to it), an area universities are not necessarily designed for. Engaging external professionals can be very helpful and eventually not only save time but potentially also money while even increasing the quality of the final product.

Lesson learnt No. 6: Make sure you are also having a good time together

Category: Social

Objective: Successful overall project delivery

Detail: Human beings are not machines. We critically rely on positive social interaction in order to function well and to perform at the peak of our capability. Therefore, we cannot just assume that everyone feels positively connected and embedded in the project. For instance, when preparing for field trips our gear had to be in the best shape possible – this was at times quite stressful and working overtime was routinely required in those periods. But then, going onto the solar farm together was a really rewarding experience.

Lesson learnt: We all need positive interactions to connect with each other and to perform well. Plan those into the project. The time and effort invested will have very fruitful returns and when the going gets tough, it is those shared positive experiences that get you through.

Lesson learnt No. 7: Team matters – more than anything

Category: Technical/Social

Objective: Technology development and timely project delivery

Detail: The project we embarked on was very challenging given the various technological and organisational hurdles we encountered. It seems trivial, but the team that is working on a project is probably the number one factor making a particular project a success – or not. A flawless team spirit of mutual support, and mutually complementing skills as well as social engagement skills and "team enthusiasm" are all critical elements of this.

Our particular project has been a "challenging joy" to execute which was intimately related to the people working on it. This concerns the people directly working on the project, mainly Germain Rey, Mattias Juhl and Oliver Kunz as well as many others like our group leader (Prof. Thorsten Trupke), the entire PL group at UNSW (who had to put up with the incredible mess we sometime made in the labs whenever we "worked on technology") and also many external parties (the "extended team") such as ARENA, UNSW Design Centre, our lab development team, to name a few. Trust is a vital component for team success, and trust needs to grow. It pays off to take some time and effort to consciously grow it.

Lesson learnt: Choose your team wisely – it is probably the most important ingredient to success.

Fig. 2: Picture from our last field trip to the Sunraysia Solar Farm. Three of the people working at the farm were present with us. After the trip we debriefed with the Sunraysia site manager, Joaquin Munoz on our experiences and future collaborative opportunities.

Lesson learnt No. 8: Engaging with international experts

Category: Technical/Commercial/Regulatory

Objective: Joining a team of global experts in solar power plant monitoring

Detail: In the context of our outdoor PL work we became aware of the global report "Qualification of PV Power Plants Using Mobile Test Equipment" by the International Energy Agency Photovoltaic Power System Program (IEA-PVPS). We approached them and were presented with the opportunity to add a section to the report on our outdoor PL imaging technology. The chapter we added is called "Outdoor Photoluminescence Imaging of Field-Deployed PV Modules" and the full report is now available online. This was a chance to get to know experts in the field and to contribute to a high-profile global report that is widely referred to in both industry and academia. It also allowed us to work hand in hand with the team from Solarzentrum Stuttgart who are using a very similar technology to ours commercially, i.e. the so called DaySy system.
While the time invested in this was not anticipated from the start we believe that the international networks and the profile our work will be getting as a result will be well worth it.

Lesson learnt: If the opportunity arises join forces with international experts in the field and publish with them together in journals or via other avenues.

Summary of lessons learnt

Like in any intensive project, We learnt a lot. This project has seen substantial challenges in many areas. Funding was certainly not excessive and time for execution was rather limited, our one and only

commercial partner pulled out and we operated in an environment not designed for rapid prototyping of technology.

A highly efficient team, great networks, external professional support, outstanding support from ARENA, were all some of the essential components for the final success of this project.

One thing stood out: It really pays off to take some time and effort to grow the team (spirit) – We believe that if you do, then the team – and its outcomes – will far exceed the sum of its parts.

Implications for future projects

Despite having difficulties in executing the project due to the loss of an important project partner we were able to fully fulfil the core requirements (design, building and testing of an outdoor PL system) and even managed to substantially advance the technology in use beyond the scope of the project.
The release of funding was delayed due to admin processes and this delayed the project on top of additional challenges we faced due to the multi-faceted implications of the COVID-19 crisis.

ARENA was extremely helpful and supportive in all this and without their goodwill we would not have been able to complete the project and take our technology to a level where it is very significantly closer to a commercial application.

Based on what we have learnt in this project it seems that future projects could benefit from "some level of flexibility" being built into the project since research is never fully predictable and we are living in times of very rapid and unpredictable change. Maybe it is also a wise thing to allow a little more time for project execution than you think you will need to allow for unexpected challenges that will inevitably happen.

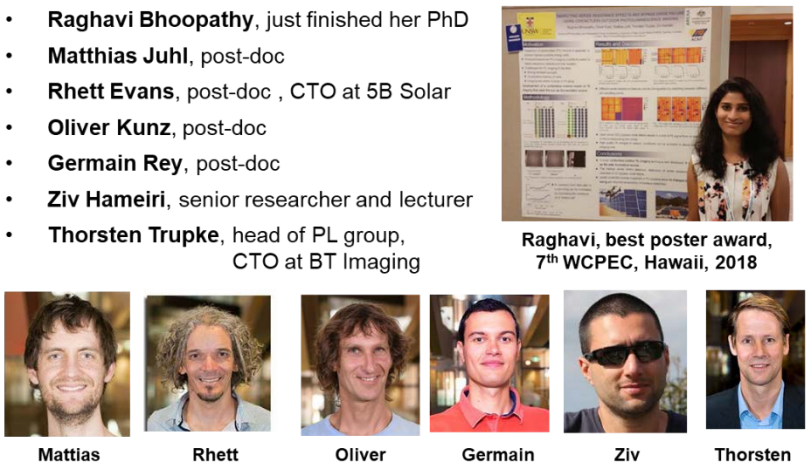

Fig. 3: *Team matters*: Our UNSW team having worked on outdoor PL imaging since 2017. Each of the people pictured have vitally contributed to the opportunity this project offered to us – either directly by working on the project, or by laying the foundations to it.