

Solar Enablement Initiative

State Estimation Algorithm Project

Project Progress Report

June 2019

Report to
Energy Networks Australia

June 2019

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1. Introduction

The SEI Project aims to support distribution network operators in their processes for assessing the impact of proposed PV embedded generation systems in their networks. This is achieved by providing them with a better understanding of the operational conditions of their networks through the implementation of a State Estimation Algorithm (SEA). The SEA uses existing network and measurement data as well as existing static data characterising the structure and nature of the supplied customer base within the networks. These results are passed on to a semi-automated power-flow analysis based simulation tool in which the likely impact of the additional PV system is assessed.

Phase 4 of the SEI Project commenced in December 2018 and is the last phase before the project conclusion in December 2019. The key priorities in Phase 4 have been:

- migrating the analysis tool functionality into the dashboard environment;
- providing designated project partners with access to the estimator and analysis tool for
 - testing and feedback of the functionality developed;
 - training of the system.
- testing, refining and interfacing the real time deployment of the estimator, to publish export limit signals.

1.1. Purpose

The purpose of this report is to document the progress of the SEI Project, providing an updated summary of the current state estimation execution approach and key technical achievements. It is a continuation of the Update Report that was produced for Milestone 3. This report focuses on the technical areas of implementation achieved in Phase 4, with the identification of some of the key activities planned for the next phase in the project.

1.2. Scope

The scope of this report includes any technical content related to the application of the State Estimator, as applied to the three DNSP's networks and any major project events or progress during Phase 4.

1.3. Audience

The intended audience of this report is any party interested in the technical aspects of the implementation of the State Estimator and a general update on the projects progress.

2. Report Overview

This report is provided as a continuation and update following on from the Update Report from Milestone 3.

The structure of the report is similar to the Milestone 3 report, with Sections 3 – 7 covering the functional parts of the State Estimator such as

- Financial and personnel update;
- measurement data;
- data management;
- the SEA; and
- the dashboard.

Section 10 cover the key results to date in Phase 4 of the project.

3. Financial Update

The financial tables are provided in Appendix A. The project is running within budget and is forecast to be completed within budget.

3.1. Budget alteration request

The SEI project has requested ARENA to approve reallocation some of the budget that was intended for NSP partner physical servers. The NSP partners requested the a cloud deployment rather than physical servers and the increased computational requirements of the estimations, network models and applications that we are running and to purchase something similar to what we have been using so far. The proposed budget reallocation is summarised below.

Table 3-1 Budget reallocation

	Current Budget*	Proposed Budget	Diff
Equipment and Licences	\$49,634.00	\$69,505.00	-\$19,871.00
Servers for each DNSP	\$85,000.00	\$65,129.00	\$19,871.00

The cloud deployment (on AWS) is forecast to cost significantly less than the physical servers. Final written approval from ARENA is pending.

4. Integration with NSP Partners

ASC meeting 8 approved the SEI Integration Plan that will integrate the SEI Project Outcomes with each of the three partner DNSP's systems at Energy Queensland, TasNetworks, and United Energy. This phase will include demonstrating, refining and handing over the SEI state estimation and network analysis systems as well as training DNSP staff in its use in their business environments.

These activities will to be undertaken from March to August 2019, leaving the final three months September to November 2019 for final reporting, knowledge sharing, project wrap-up and closure. The SEI Project must be fully completed and closed by 5th December 2019.

The approved Integration Plan has now been endorsed the three DNSP's and comprises the following components (see Appendix B for the flow chart):

1. NSP consultation to demonstrate the SEI network analysis tool and to present, discuss and refine the Integration Plan for each Partner DNSP. These meetings occurred at the end of February and early March 2019. **COMPLETED**
2. Development, comprising feedback, refinements and early access to selected users at each partner DNSP. **IN PROGRESS**
3. Monthly teleconferences providing further co-ordination of feedback, updates and demonstrations (these may be in person if required). **IN PROGRESS**
4. Feedback on the demonstrations including suggested refinements, usage options and case studies. **FIRST PHASE COMPLETED AND DOCUMENTED**
5. Integration possibilities including identifying targeted users and suggestions for integration into each DNSP's existing systems and processes. **IN PROGRESS**
6. Further face-to-face presentations, demonstrations, case studies and final feedback from each DNSP. **SCHEDULED**
7. Documentation including user manuals and other documentation. **IN PROGRESS**
8. Training on a one-on-one basis of selected DNSP staff. **YET TO COMMENCE**
9. Hand-over of final State Estimator and Analysis Tool and User manuals. **AT PROJECT COMPLETION**
10. Plan for ongoing support and services. **DISCUSSIONS INITIATED BY DNM**

Each of the DNSPs now have access to the Dashboard and Analysis tool on their own AWS server. The SEI team have provided a short primer training course and worksheets to each of the DNSP partners and are awaiting feedback.

5. Staffing Update

Since the previous ASC meeting the following five staff changes have occurred:

- (a) QUT's Aaron Lei Liu replaced Mehdi Sahfehi in March (who left to take up a job in industry)
- (b) Resignation of Jack Terry, effective on 17th May 2019, (to re-join industry). Options for a replacement are being investigated.
- (c) Unavailability of Gian Morosini, annual leave for 5 weeks from end May, part-time availability thereafter (to re-join industry).
- (d) Antionne Olivier from 24th June, a French engineering student to assist with the Integration plan documentation

Going forward the SEI Project Team is:

1. SEI ASC Chair, Knowledge Sharing Assistant, SEI Participant Liaison Officer: Simon Bartlett working ~ 15% FTE part time.
2. SEI Team Leader, Dr Olav Krause, allocated 60% to SEI, 20% to ARC LV State Estimation, 20% to ENA Network Sensing.
3. ENERGEX Project Manager Deepthi Yogiswara - 30% allocation to SEI–
4. SEI Project Director & Research Officer, Gian-Marco Morosini on a reducing part-time basis from July onwards.
5. SEI Research Officer, Jack Terry departing 17th May 2019 – seeking replacement.
6. SEI Software Developer and Testing; Andre Gebers, commenced 1st Jan 2018.
7. SEI Computer Programmer; Dendi Pambudi, commenced 1st Jan 2018.
8. SEI Research Officer, Automated Network Analysis – Aaron Lei Liu from QUT commenced March 2019.
9. SEI Technical Assistant – Antoine Oliver to commence 24th June 2019

6. Measurement Data

One of the core inputs to the State Estimator is the actual measurement data received from each of the DNSP's. As with the size and number of nodes in each of the NSP's networks, there is a significant range in the nature and extent of data available for performing state estimation runs.

Since the last milestone report, significant work has been undertaken in restructuring the backend database to facilitate the application of measurements in a more flexible and robust manner. This section provides an overview of some of the key functionality that now exists in terms of the application of measurements in the estimator.

6.1. Characteristics

6.1.1. Device Type

All measurement devices are associated with a particular device type. This describes how the measurement should be applied in the network i.e. whether it is a branch or nodal measurement.

This is because transformer measurements must be treated slightly differently, as they interface to elements external to the network.

6.1.2. Device Class

All measurement devices are associated with a particular device class. Each device class contains sufficient details to be used as a template for instantiating and applying a particular measurement at a given location. The measurements will be applied according to the specifications in the Device Class table.

Depending on the availability and nature of measurements available for a device class, some measurement points will need to be transformed to comply with the specification of the device class. Measurement points that cannot be transformed will not be applied in the estimator and the user should be warned.

6.1.3. Measurement Point Class

Each measurement point type is associated with a particular measurement point class. These relate to the actual measurement values that are stored prior to application in the estimator. Importantly, more than one measurement device class can use the same measurement point class.

6.2. Measurement Application Flexibility

In the data collection and development phase, it was identified that available measurements provide data in a variety of structures, with a variety of schemes, units, references, symmetry and sign conventions. This implementation attempts to take in these factors (that should be determined and stored by the DNSP), and use these to appropriately calculate and apply measurements in the estimator input system.

6.2.1. Application Type

In the collection of data, it was identified that measurement devices record and report values for certain metrics in one of three ways, which would affect the way that the measurement values should be applied in the estimator. Measurement can either be applied as:

- Total - The measurement device reports a single total value for a parameter over the phases.
- Individual – The measurement device reports individual values for a parameter for each of the phases.
- Average - a measurement device may report multiple or a single values for a given parameter that are averaged and applied across all three phases.

6.2.2. Phase Reference

Across the measurement datasets received, it has been identified that measurement devices report back parameter values with a variety of phase references. Measurement device classes have been assigned with three phase reference parameters that define how power and voltage measurements should be applied.

6.2.3. Symmetry

Symmetry is used to manage the application of two phase measurements where there are two options for the application of measurements. A measurement device that measures only two phases, where the PowerVreference is “Phase” can be classified as “Symmetrical” or “Asymmetrical”.

6.2.4. Units

All measurement points are stored with their units, which are used in the scaling of the measurements by factors of 1000 that correspond to the unit prefix

6.2.5. Point Inversion

Point Inversion provides the capability for certain signed parameters to be applied with a multiplication of -1 in the measurement application stage. This might be useful in instances where the phase angle convention of a device is non-standard, where the CTs have been put on backwards,

or where the network model describing the directionality of a device is inconsistent with the reported values.

6.2.6. Service Status

Service status provides capability for measurement devices to be removed from service for particular time frames. This might be required where a measurement has been physically removed from service, or is malfunctioning and providing bad values.

6.2.7. Phasing

. Measurement phasing allows the phasing of measurements to be reassigned to any arbitrary combination based on known associations or associations determined through calibration. With three measurements, there are six possible phase association combinations, of which any measurements may be mapped to. These are current, positive rotation, negative rotation, AB swap, BC swap, AC swap.

7. State Estimator

Documentation of the State Estimator is ongoing and is planned to correlate with migration of the underlying core functions to more efficient platforms and languages throughout the project. A summary of the progress on the SEA during phase 4 of the project has been separated into performance improvements and additions of functionality, and are presented below.

7.1. Performance

The performance of the State Estimator has dramatically improved in the current phase of the project.

At the conclusion of Phase 3 of the project in December 2018, single solution iterations of the largest test feeder, 33271 (Bruny Island), have reduced from 20 min to down to 400 ms. However, as a result of the computationally intensive Kron reduction calculation, the total estimation solve time was approximately 5 minutes.

Performance improvements that have been applied since the last milestone submission include:

- Implementation of Functional Input Groups that reduce the computation time associated with Jacobian row generation;
- Implementation of Basic Linear Algebra Subprograms (BLAS) to replace LAPACK function calls in many of the time intensive matrix computations;
- Implementation of Intel Math Kernel Library (MKL) to perform the calculation of these BLAS functions.

As a result of these performance improvements, feeder 33271 (Bruny Island), now solves in approximately 47 seconds, including data read in, kron reduction, a 7 iteration solve, and report generation.

7.2. Functionality

Functionality that has been added to the State Estimator since the last milestone submission includes:

- Capability to determine output uncertainty calculated from input uncertainty values.
- Capability for the estimator to be run locally on the same code base as that deployed on the server. This includes:
 - Specifications of particular networks and time steps;
 - Collection of input data from the database;
 - JSON output and JSON read in;
 - Retention of the kron reduced network for subsequent time steps;
 - Definition of arguments alter options in the estimator execution.

Additionally, prototype functionality has been added to develop constraint systems from defined network limits and then perform optimisation on these systems.

7.2.1. Uncertainty Analysis

All parameters in the real world contain inherent uncertainty. As all data used as inputs to the state estimator contains inherent uncertainty, so too does the outputs (estimated states). For the operation of distribution networks, the distribution network operator must have an understanding of the degree of uncertainty associated with estimated network parameters, to ensure that the network resides within specified limits for the required percentage of time.

Functionality has been added to take in the uncertainty associated with each of the inputs and then mathematically determine what the uncertainty associated with any of the output parameters is. This includes:

- nodal voltages and power injections; and
- branch power and current flows.

Initially, the computation time for uncertainty analysis was approximately 1 minute for SFC12A, with an estimation solve time of 1 second. However, the implementation of the BLAS subroutines has now reduced the total time for estimation solve and uncertainty analysis is approximately 1.5 seconds.

This is sufficiently fast that it is likely to be possible for uncertainty analysis to be left switched on for real time execution of the state estimator.

7.2.2. Constraints and Optimisation

In both the real time and offline aspects of the project, the capability to determine the impact of additional PV export into the network is required. This can then be used to determine the maximum allowable PV that may be connected without exceeding defined network limits.

The constraint generation and network optimisation has been developed to meet this requirement, such that it is suitable for both offline and real time implementations. At the conclusion of the estimation run (or as a part of setup for real time execution), the user would be presented with the option to undertake constraint generation and optimisation as an additional application in the dashboard environment.

The key inputs to the constraint generation and optimisation are:

- controllable parameters;
- network constraints.

The ability to consider a number operational constraints has been defined, with capability for the user to define the operational limits for each. Additional constraints (such as reverse power flow at the zone substation) may be added based on user feedback. These constraints are:

- Steady state voltage, medium voltage;
- Steady state voltage, low voltage;
- Voltage delta, medium voltage;
- Voltage delta, low voltage;
- Thermal limits, lines;
- Thermal limits, transformers.

Network constraints by default will be applied to all relevant network elements, however functionality will be added to support the ability for

- constraints to be blinded out at particular nodes/elements;
- scaling factors to be applied to particular limits in the network.

This may be particularly useful for scenario analysis, to determine the impact of making particular changes to the network.

The second input to the constraint system generation and optimisation is the definition of the controllable parameters connected at different locations in the network. A controllable parameter is something that can be provided by a distributed energy resource (DER), which may or may not be dispatchable i.e. real and reactive power. For non-dispatchable technologies, such as a PV system, the controllable aspect relates to the maximum allowable export at that location.

A constraint system is developed from the set of network constraints and the set of controllable parameters, which as a set of equations contains the allowable combinations of all controllable parameters such that no network limits are violated.

The constraint system may then be passed into an optimisation function, to find the combination of DER that finds the global maximum/minimum value of some objective function. This might relate to the total allowable import/export of PV generation in a network, or the total value of energy or some other defined function.

The constraint system and optimisation has been set up to function independently of each other, to support a future in which the optimisation is performed by a third party.

At this stage:

- a prototype of the constraint system builder and optimiser has been developed and tested;
- a database architecture has been developed that contains all relevant input data for constraint system development and optimisation.

7.3. Next Steps

The next activities in enhancing the estimator functionality and performance are to:

- implement functionality to plot uncertainty envelope for estimated parameters;
- generalise the code that generates the constraint system;
- develop a front end interface
 - that takes in user inputs and populates values in relevant tables in the database;
 - displays results from the optimisation.

- implement functionality to take data out of the database and generate the constraint system.

8. Analysis Tool

One of the key outcomes of the SEI Project is the development of a semi-automated analysis tool that can help DNSPs improve their Medium Voltage (MV) PV connection assessment processes. The ultimate aim is to increase solar PV penetration levels and reduce solar PV connection costs for customers.

The development of the analysis tool began in Phase 3 culminating at Milestone 3 with a working prototype that can be used to identify the maximum generation that can be installed (hosting capacity) at a particular point on a feeder.

The analysis tool currently uses a script that utilises and automates the Sincal power flow engine and models based on outputs from the State Estimator. This version has been provided to the NSPs.

The next version of the Tool will be entirely self-contained in the SEI dashboard and not require Sincal. This deployment is well into development and testing has begun on local machines.

9. Real-time Deployment

The real-time deployment (RTD) of the State Estimator is one of the two key outputs of the SEI Project. It is required to run state estimations in real-time on the SFC12A feeder in the Energex network.

Once the RTD is established the next phase is to broadcast a maximum allowable export signal to a connected customer to allow it to safely export power to the grid based on the present network condition and constraints developed in real-time from the estimator results.

There have been minor improvements to the real time implementation of the state estimator.

In the final week of May, the customer in Springfield has signed the Network Connection Contract Variation Letter. The site is now permitted to export based around the limits determined through the Dynamic PV Export Trial.

Next Steps:

- Sign Trial Agreement with the Installer (completed a first pass review already)
- Update the Springfield Feeder Model in Real Time
- Update the real time estimator to fix the random PI connection problems we have experienced

First Stage – Using transformer monitor data

Set broad PV export limits for a day at a time – i.e. 20%, 50%, 80%, 100%

Installer to enter these values into the inverter manually (but remotely)

Second Stage – Using SE Output & Constraint/Envelope Calculation

Update the PV Export limit automatically, based on the SE output

The automation associated with the Second Stage described above which is being established for the Cleveland site (which is still proceeding) may not be achieved at Springfield. Depending on the cost and complexity of converting the site to integrate a controller to read PV export limits from the designated website and transfer them into the inverter in near real time (e.g. every 5 mins) the customer and installer may decide this is too complex and costly.

9.1. Next Steps

The key next step in the real time deployment is to integrate the constraint system and optimisation functionality. With the constraint system running immediately after each estimation run time step, the current network state can be analysed to determine the maximum PV that may be exported in the next time step.

10. State Estimation Results to Date

Since the last milestone submission, measurement are now available for Bridgewater 48182, for which measurements were previously not available. A brief overview of the feeder is provided, including a description of the measurement coverage, for the purposes of state estimation.

As with previous reports, the results provided are comparisons between the estimated values, and measured values from a device that has not been used as an input to the state estimation (where those values are unsuitable for use in state estimation).

One of the new visualisation tools now available for presentation of results a node graph of estimated states with:

- Nodes coloured by the magnitude of the voltage;
- Branches coloured by the magnitude of the branch apparent power flow.

10.1. 48182 – TasNetworks

10.1.1. Overview

48182 is a rural feeder supplied from Bridgewater Terminal substation that runs from the suburb of Bridgewater up the Tasmanian midlands just north of Kempton. There are 363 distribution transformers on the feeder ranging in size from 5 kVA up to 750 kVA. A significant percentage of the load connected to the feeder is through single-phase transformers with two-phase secondary voltage supply.

One of the key differences between Bridgewater is the presence of two step voltage regulators installed on the feeder to regulate the MV voltage at two locations. One of these voltage regulators is installed in an open delta configuration, similar to the unit installed on 33271. However, the other regulator is installed in a closed delta configuration, with three tanks providing regulation of the three line to line voltages.

The effect of the voltage regulation can be observed in Figure 10-6, with two locations in the feeder in which the voltage magnitude is boosted

10.1.2. Measurement Coverage

A number of additional measurement devices have been installed on 48182. To date, three new transformer monitors have been installed that provide 3 phase active power (P), reactive power (Q) and voltage (V) measurements for use as inputs to the State Estimator. A fourth unit has also been purchased, but has not yet been installed as it is experiencing technical issues. These are currently being investigated and expected to be addressed and rectified in the next few weeks.

The vast majority of energy consumption on the feeder is residential, with a small amount of commercial and industrial customers. Approximately 3% of energy consumed by residential customers groups is measured, less than 1% of energy consumed by commercial customer being measured, and no coverage of industrial customers.

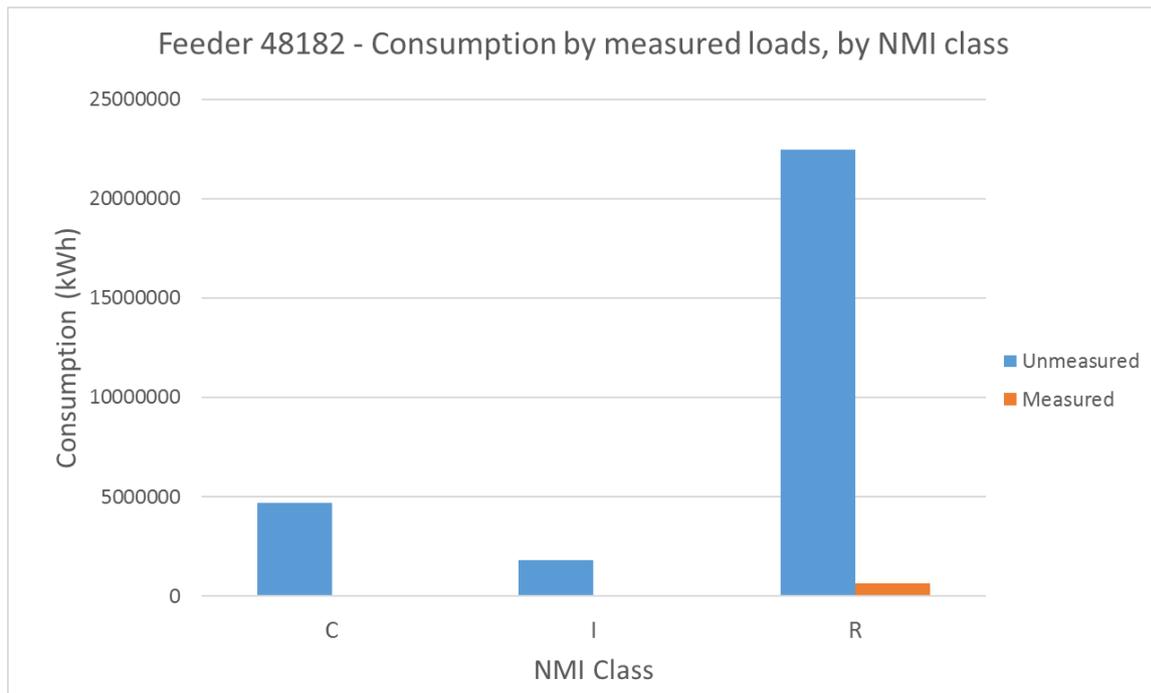


Figure 10-1: Measurement coverage of loads by energy consumption on 48182, by NMI class.

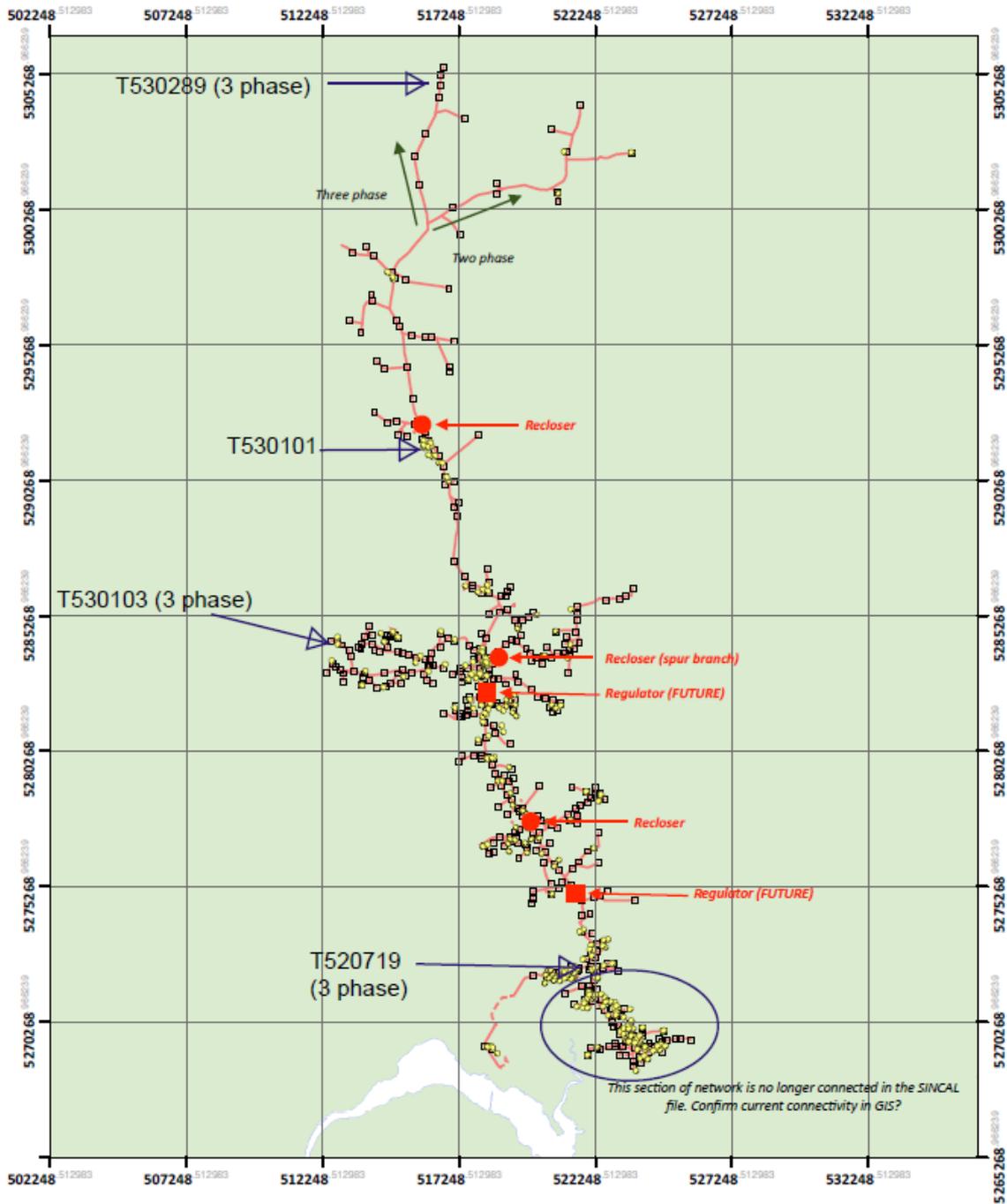


Figure 10-2: Location of measurements installed on Bridgewater 48182.

10.1.3. Results

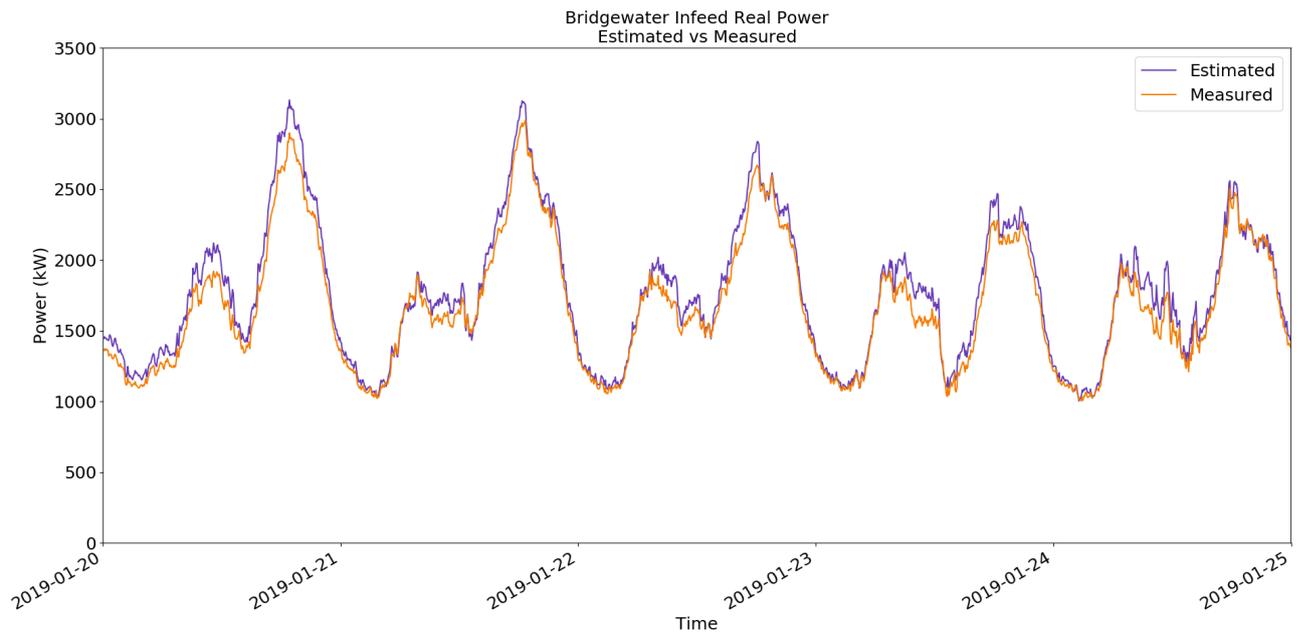


Figure 10-3: Estimated and measured real power on 48182

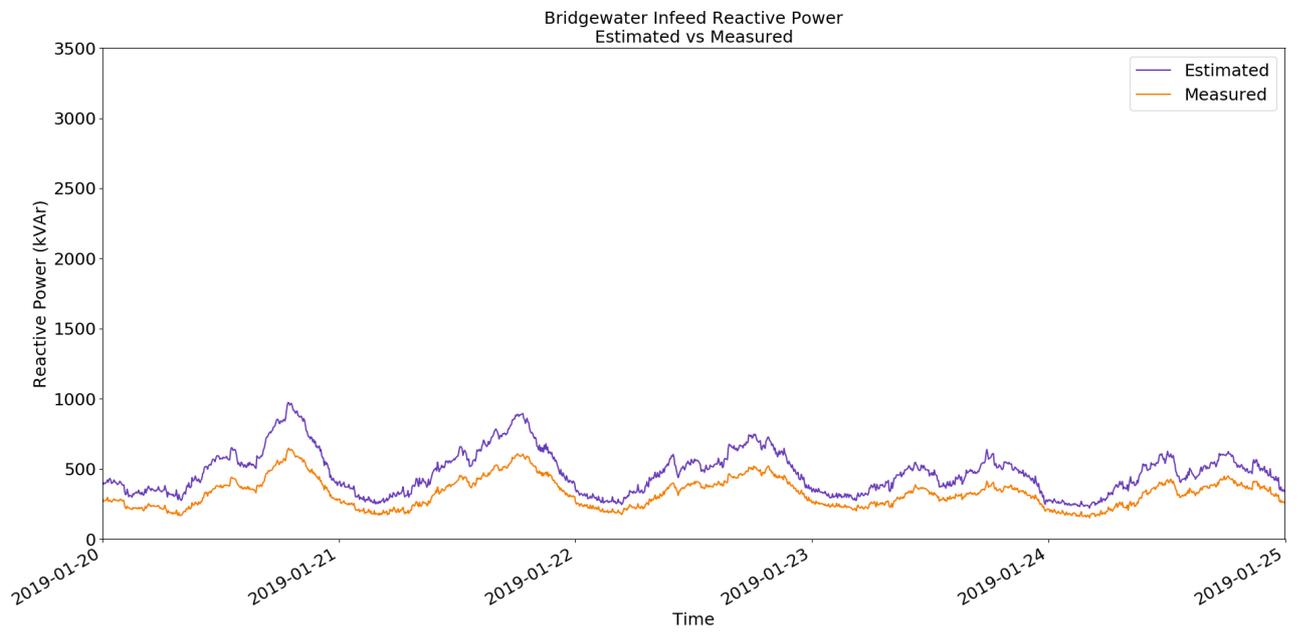


Figure 10-4: Estimated and measured reactive power on 48182

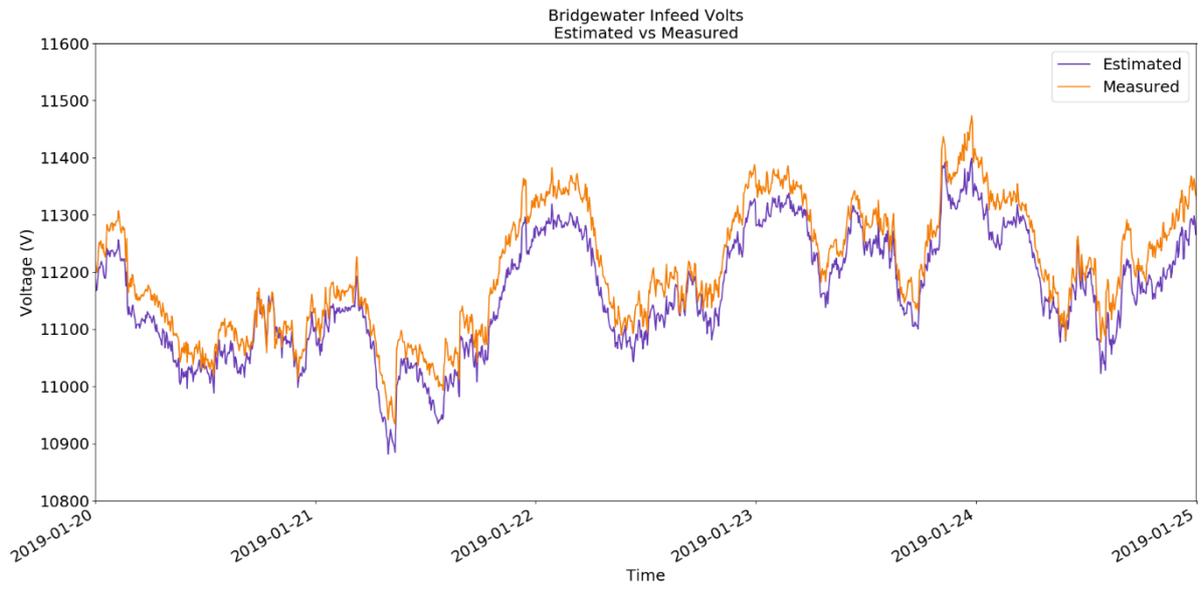


Figure 10-5: Estimated and measured voltage on 48182

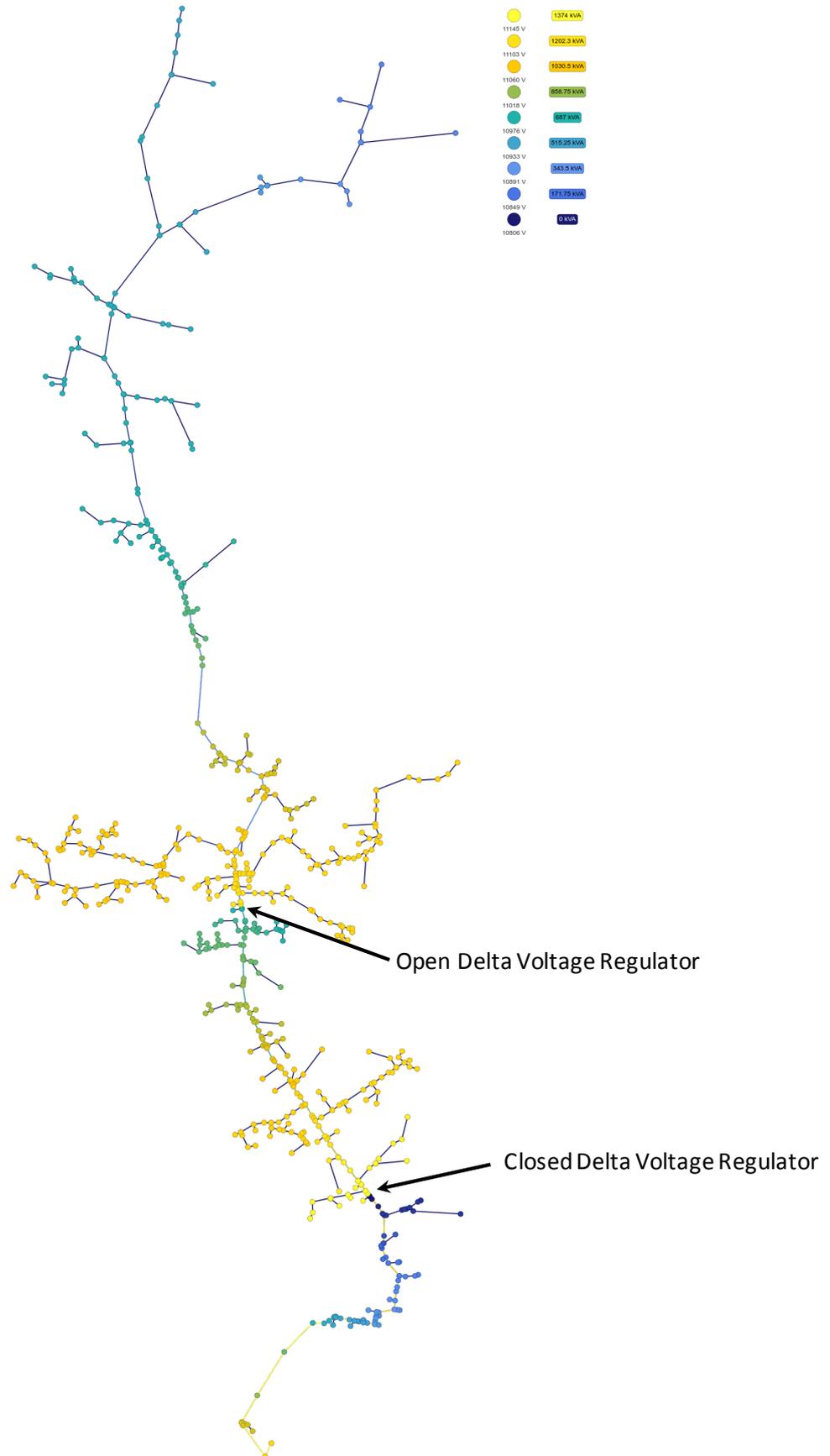


Figure 10-6: Network node graph coloured by estimated voltages and branch power flows.

10.1.4. Estimation Health

The estimation runs on 48182 are relatively healthy, with no instances of non-convergence over a 7 day estimation run period. However, the iteration count sometimes increases into the double digits, which indicates that there may be an issue with the input data or configuration.

Additionally, the histogram of voltage residuals shows up some slight biases between various measurements of voltage throughout the feeder. Some further investigation is required to identify the source of this conflict between the voltage measurements.

10.2. General Discussion

State estimation has been successfully applied to all eight nominated by the three DNSP project partners for the offline analysis and real time implementations of the estimator. In particular, the estimator has now successfully been applied to TasNetworks' feeder 48182 that has even more transformers and lower measurement coverage than 33271.

11. Key next steps

The progress of the SEI Project to date has been as planned and is on target based on the deliverables required and expectation from ARENA.

The key next steps in the project are to:

- Move the Analysis Tool to the server side to break the dependence on Sincal
- Develop the UI and analysis tool based on customer feedback.
- Create the documentation and User Manuals for the Dashboard and Analysis Tool and API.
- Arrange face to face training sessions with the NSPs
- Progress the Real time estimation to sending export limits to the customer.

Appendix A – Financial Tables

Reported expenditure (on an accrual basis) to end March 2019.

Collaborator	Category	Financial Year 2018/2019				Life to date 31/03/2019			
		Budget	Actual	Variance	%	Budget	Actual	Variance	%
	INCOME								
ARENA	ARENA Cash	\$400,000	\$400,000	\$0	-	\$990,000	\$990,000	\$0	0%
UQ	Recipient Cash	\$0	\$0	\$0	-	\$0	\$0	\$0	-
ENA	Partner Cash	\$75,000	\$75,000	\$0	-	\$150,000	\$150,000	\$0	0%
API	Partner Cash	\$75,000	\$75,000	\$0	-	\$150,000	\$150,000	\$0	0%
Springfield Land Corp	Partner Cash	\$30,000	\$30,000	\$0	-	\$60,000	\$60,000	\$0	0%
Interest on Recipient Cash	Interest	\$0	\$2,728	\$2,728	-	\$0	\$3,939	\$3,939	-
	TOTAL INCOME	\$580,000	\$582,728	\$2,728	0%	\$1,350,000	\$1,353,939	\$3,939	0%
	EXPENDITURE								
Expenditure of ARENA Grant Funds	Salaries	\$365,658		\$365,658	100%	\$795,823	\$787,337	\$8,486	1%
	Olav Krause (buy out)	\$26,959		\$26,959	100%	\$74,923	\$74,923	\$0	0%
	Equipment	\$36,926		\$36,926	100%	\$60,309	\$27,936	\$32,373	54%
	Materials	\$0		\$0	-	\$0	\$0	\$0	-
	Subcontract	\$0		\$0	-	\$0	\$0	\$0	-
	Travel	\$28,581		\$28,581	100%	\$62,928	\$40,662	\$22,266	35%
	Other	\$297		\$297	-	\$2,401	\$5,232	-\$2,831	-118%
	TOTAL	\$458,421	\$0	\$458,421	100%	\$996,384	\$936,090	\$60,295	6%
	TOTAL INCOME	\$580,000	\$582,728	\$2,728	-	\$1,350,000	\$1,353,939	\$3,939	0%
	TOTAL EXPENDITURE	\$458,421	\$0	\$458,421	100%	\$996,384	\$936,090	\$60,295	6%
	Surplus/Deficit	\$121,579	\$582,728	\$461,148	379%	\$353,616	\$417,850	\$64,234	18%

Forecast expenditure for the remainder of the project

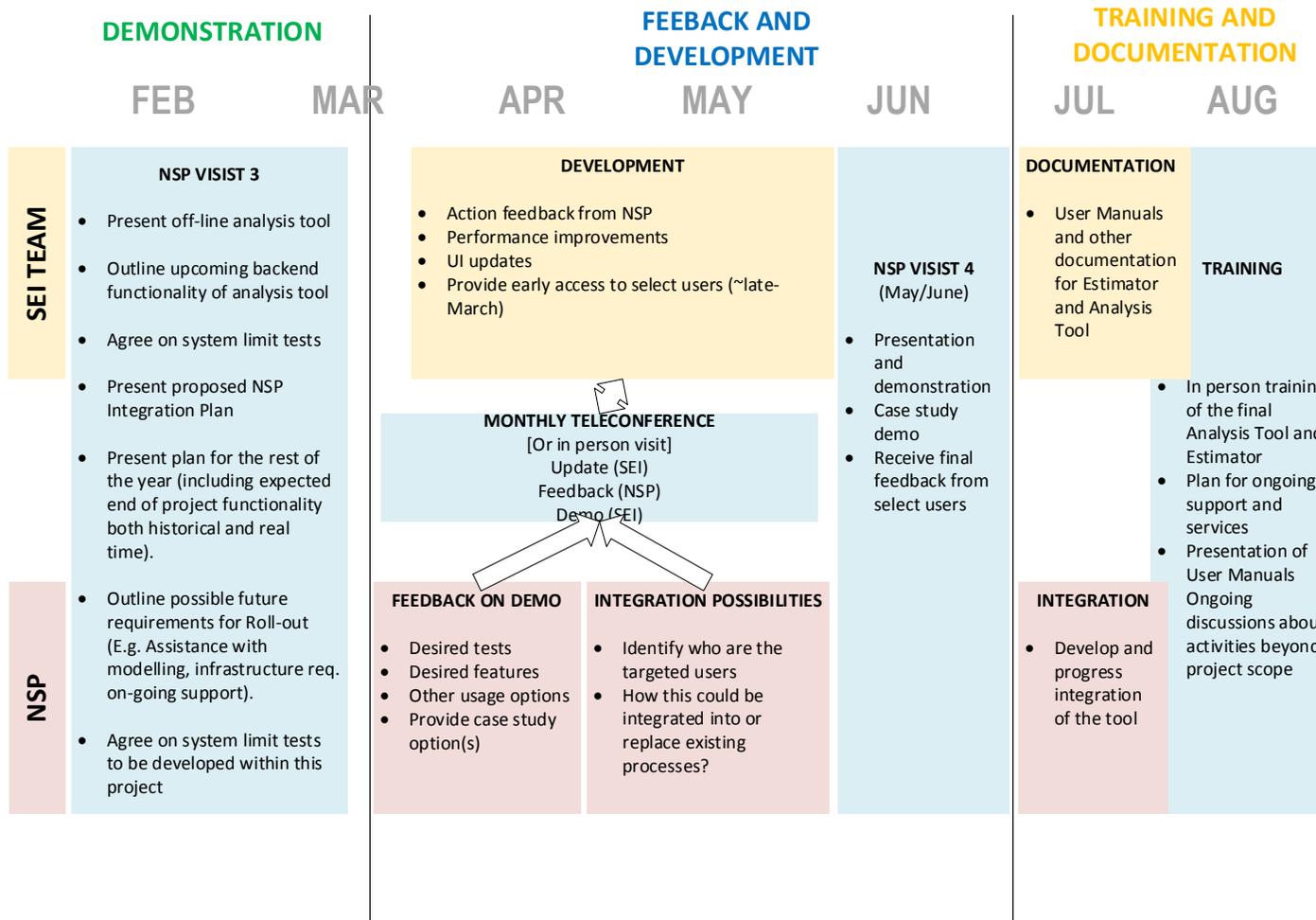
Collaborator	Category	Remaining Actual	Total Budget	Remaining Budget	Forecast Remaining	Surplus
	INCOME					
ARENA	ARENA Cash	\$200,000	\$1,190,000	\$200,000	\$200,000	\$0
UQ	Recipient Cash	\$0	\$0	\$0	\$0	\$0
ENA	Partner Cash	\$0	\$150,000	\$0	\$0	\$0
API	Partner Cash	\$0	\$150,000	\$0	\$0	\$0
Springfield Land Corp	Partner Cash	\$0	\$60,000	\$0	\$0	\$0
Interest on Recipient Cash	Interest	-\$3,939	\$0	\$0	\$0	\$0
	TOTAL INCOME	\$196,061	\$1,550,000	\$200,000	\$200,000	\$0
	EXPENDITURE					
Expenditure of ARENA Grant Funds	Salaries	\$396,556	\$1,183,893	\$388,070	\$281,313	\$115,244
	Olav Krause (buy out)	\$40,541	\$115,464	\$40,541	\$37,350	\$3,191
	Equipment	\$109,089	\$137,025	\$76,716	\$50,000	\$59,089
	Materials	\$0	\$0	\$0		\$0
	Subcontract	\$0	\$0	\$0		\$0
	Travel	\$69,338	\$110,000	\$47,072	\$25,000	\$44,338
	Other (AWS)	\$13,530	\$18,762	\$16,361	\$25,000	-\$11,470
	TOTAL	\$629,055	\$1,565,144	\$568,760	\$418,663	\$210,392

Reported In-kind expenditure to end March 2019

Collaborator	Category	Financial Year 2017/2018				Life to date 31/03/2019			
		Budget	Actual	Variance	%	Budget	Actual	Variance	%
Recipient UQ (in-kind)	All	\$ 37,500	\$ 37,500	\$ -	0%	\$ 93,000	\$ 93,000	\$ -	0%
Energex (in-kind)	All	\$ 75,000	\$ 75,000	\$ -	0%	\$ 187,000	\$ 187,000	\$ -	0%
United Energy (in-kind)	All	\$ 42,500	\$ 42,500	\$ -	0%	\$ 106,000	\$ 106,000	\$ -	0%
Tasnetworks (in-kind)	All	\$ 30,000	\$ 30,000	\$ -	0%	\$ 75,000	\$ 75,000	\$ -	0%
QUT (in-kind)	All	\$ 27,500	\$ 27,500	\$ -	0%	\$ 68,000	\$ 68,000	\$ -	0%
API (in-kind)	All	\$ 7,500	\$ 7,500	\$ -	0%	\$ 19,000	\$ 19,000	\$ -	0%
ENA (in-kind)	All	\$ 7,500	\$ 7,500	\$ -	0%	\$ 19,000	\$ 19,000	\$ -	0%
Springfield Land Corp (in-kind)	All	\$ 75,000	\$ 75,000	\$ -	0%	\$ 187,000	\$ 187,000	\$ -	0%
Aurecon (in-kind)	All	\$ 6,000	\$ 6,000	\$ -	0%	\$ 15,000	\$ 15,000	\$ -	0%
TOTAL PARTNERS	All	\$ 265,000	\$ 265,000	\$ -	0%	\$ 676,000	\$ 676,000	\$ -	0%
TOTAL	All	\$ 308,500	\$ 308,500	\$ -	0%	\$ 769,000	\$ 769,000	\$ -	0%

Note: as agreed with ARENA these figures are based on the contractually agreed in-kind contributions from each partner.

Appendix B



REPORT AUTHOR(S) AND CONTACTS

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