LOW CARBON LIVING CRC

RP3033, RP3033u2 WGV Living Lab

Performance Monitoring Design Report

Authors	Dr Josh Byrne, Dr Richard Hosking & Moiz Syed
Title	WGV Living Lab - Performance Monitoring Design Report
Date	July 2019
Version	For Distribution - Rev 1
Preferred Citation	Byrne. J, Hosking. R & Syed. M (2019), WGV Performance Monitoring Design Report, Curtin University Sustainability Policy Institute (CUSP), Curtin University, Perth Western Australia.

Acknowledgements

This report forms part of the research project RP3033 Mainstreaming Low Carbon Residential Precincts – the WGV Living Lab, which was funded by the CRC for Low Carbon Living Ltd, supported by the Cooperative Research Centres program, an Australian Government initiative.

The research team acknowledges the valuable support provided by the following project collaborators:

- Balance Utility Solutions
- Infinite Energy
- Outpost Central
- Water Corporation
- Josh Byrne & Associates

Project Partners

Curtin University | LANDCORP | JOSH BYRNE & ASSOCIATES | City of Fremantle

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

Contents

Introduction

WGV Living Lab

WGV is a 2.2ha residential infill development in White Gum Valley delivered by the Western Australian State Government Developer, LandCorp. Consisting of four multi-residential sites, one group housing site and 23 detached residential sites (refer Appendix 1), WGV will eventually accommodate up to 100 dwellings and around 250 people. Civil works commenced at WGV in 2014, with construction of the first buildings starting later the same year. As of July 2019, WGV is approximately 60% built out and occupied.

WGV incorporates a number of innovative urban design, technology and governance initiatives that are the subject of several research projects being led by Curtin University in collaboration with government and industry partners. The development is described as a 'Living Lab' where concepts, technologies and practices can be tested in a real-life setting. Central to this research has been the establishment of monitoring capabilities to enable the collection of data on energy, water and other parameters in an organised and reliable way. This Report provides an overview of these data collection activities, including system design, equipment, data flow and access/utilisation.

Figure 1: WGV by LandCorp (2018).

Scope of Monitoring Activities

There is a range of performance monitoring activities at WGV fulfilling different purposes. Some activities are long term, for example where monitoring is required for service provision and end-user billing. Others are likely to be shorter term such as data collection for research purposes. In many cases, the equipment deployed to meet the needs of one activity is utilised to fulfil another for efficiency. A summary of the main monitoring activities is provided below:

- Equipment performance assessment by system managers and/or service providers such as strata scale solar energy systems, or the management of the community bore non-drinking water scheme (long term).
- Internal billing of residents for energy and water use by apartment building strata managers, or billing agents (long term).
- Resident feedback on energy and water use via data dashboards (short to medium term).
- Accessing performance data by researchers and industry (short to medium term).

Details on the WGV metering architecture, equipment and data management systems is provided in the following sections.

WGV Metering Architecture, Systems & Equipment

The scale of WGV, combined with the staged building construction and different property title types (green title, survey-strata title and built-strata title), meant that an adaptive metering architecture was required. Funding for the metering equipment and servicing has come from various sources, such as the head developer (LandCorp) where the meters were considered essential infrastructure items, from strata lot development proponents where equipment was required for billing purpose, and grant funds where equipment was linked to specific research activities.

From the early planning stages of WGV, consideration was given to how the various metering systems would form an integrated schema to enable the systematic collection of certain performance data from all dwellings, along with other required information from services such as the precinct community bore (JBA, 2017), and environmental data such as groundwater levels and stormwater flows into an infiltration basin located adjacent to the site (Byrne et al, 2018). Figure 2 illustrates the metering and data collection architecture for the site.

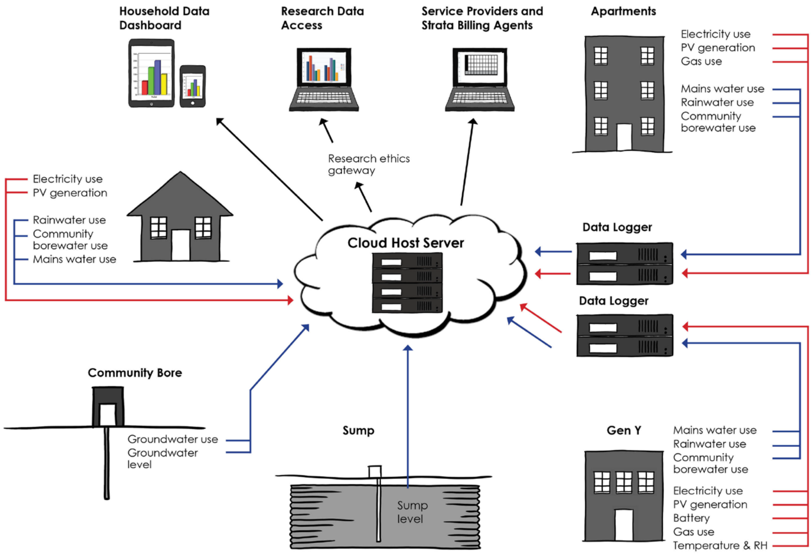

Figure 2: Diagrammatic overview of the WGV data collection architecture.

The following sections describe the specific metering equipment and systems that service the different development sites (multi-residential sites and detached residential sites), as well precinct services such as the community bore, groundwater levels and stormwater basin levels. A schedule of data sources is provided in Appendix 2.

Multi-residential Sites (Apartment Buildings)

The metering architecture and convention is similar for the three apartment buildings currently built at WGV (Gen Y, SHAC and Evermore), with the main difference being the number of apartments and types of common services, and therefore the number meters and interface modules (Schneider SIM 10M) required. Each building has a central data logger (Schneider ComX 510) which records energy and water use data (plus gas, indoor temperature and humidity for Gen Y) from each individual apartment, building common services (e.g. lighting), as well as solar energy generation and storage (via the battery management systems). SHAC and Evermore also have additional meters for monitoring electric vehicle (EV) charging points.

Three types of energy meters are in use. Apartment energy consumption is metered using KMP1-50 energy meters cabled to the data logger or SIM devices using digital connection. Grid import/export is measured using an IEM3255 bidirectional 3 phase meter connected to the logger via Modbus RS485 RTU protocol. Schneider IEM3350 and IEM3255 energy meters are used for monitoring the EV charging points at SHAC and Evermore respectively. All energy meters are NMI compliant so are suitable for billing purposes.

Apartment water use is measured via either Itron TD8 or Elster V100 water meters fitted with cyble sensors and pulse kits respectively, and either cabled to the data logger, or SIM devices using digital connection.

The Gen Y building is serviced by gas (for cook tops and hot water systems), with each apartment having its own gas meter (Ampy 750) which is fitted with a pulse kit and connected to either the data logger or SIM device by digital connection. Each Gen Y apartment also is also fitted with a temperature and humidity sensors (Kimo TH110) in the main living area which use ZigBee wireless communication protocol to communicate with receivers connected to the data logger or SIM devices digitally.

Data is transmitted daily to a cloud hosted server managed by Balance Utility Solutions[1] via each building's internet connection. Current data resolution is set at 15 minute intervals.

A summary of the meters and sensors in use at the WGV apartments is presented below.

Table 1: Meter types for the apartment buildings. Note: PV, battery output and battery state of charge data is sourced via the building battery management systems associated with each building.

Unit	Electricity Meters	Water Meters (submeters)	Gas Meter	Temperature & Relative Humidity Sensors
Gen Y	KMP1-50 (Apartments) IEM3255 (Grid/Overall Load)	Itron TD8 with cyble sensor	Ampy 750 with pulse kit	Kimo TH110
SHAC	KMP1-50 (Apartments) IEM3255 (Grid/Common area) IEM3350 (EV Charger)	Itron TD8 with cyble sensor	NA	NA
Evermore	PMC-220 (Apartments) IEM3255 (Grid/Overall Load) IEM3255 (EV Charger)	Elster V100 with pulse kit	NA	NA

Figure 3 below illustrates the general monitoring arrangement for the WGV apartments.

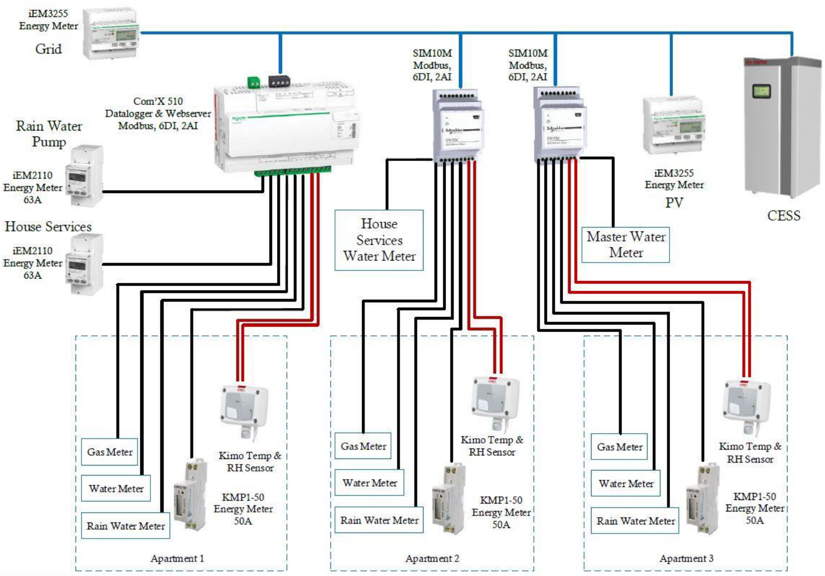

Figure 3: Schematic sensor arrangement for the multi-residential sites (Lot 7 – Gen Y example).

All sites at WGV are serviced by a non-drinking water community bore irrigation scheme which was installed by LandCorp and is now managed by the City of Fremantle. Each lot connection is metred using an Itron TD8 water meter with cyble sensor which is monitored via a standalone battery powered data logger (WASP) with data transmitted daily by 3G to a cloud hosted server managed by a third party service provider (Outpost Central[2]). Each apartment's mains water property meter is also individually logged via this approach. This system is further outlined below.

[1] Balance Utility Solutions: www.balanceservicesgroup.com.au
[2] Outpost Central: www.outpostcentral.com

Detached Residential Sites (Individual Houses)

Energy and water data is collected from the detached residential sites using individual smart meters and data loggers. Energy use, solar generation and import/export data is collected via the property solar inverter and smart meter systems (typically Fronius) that were installed during house construction and supported by the LandCorp Sustainability Package (LandCorp 2015). The devices are connected to the Fronius server as part of the standard installation procedure. Data can then be accessed via the Fronius API. The Fronius inverters can also be programmed to poll data and push to additional server destinations. Both data transfer methods are currently being used for trial purposes, with the data push being sent to a third party server managed by Balance Utility Solutions. Data telemetry for both methods is via the household's internet service and data intervals are set at 5 minutes.

Water use (mains water, rain water and community bore) is metred via Itron TD8 water meters with cyble sensors connected to battery operated data loggers (WASPs) and transmitted daily via 3G network to a third party server managed by Outpost Central. Data is accessed via Outpost Central's API and data intervals are set at 15 minutes.

Community Bore and Stormwater Basin

The community bore has a main meter installed to monitor overall volumes. There are also water level sensors (Mercoid Series SBLT2) installed in the bore hole to monitor groundwater levels and in the stormwater sump to record inflow levels inside the underground drainage cells. Data is collected via a series of separate battery powered data loggers (WASPs) and transmitted daily via 3G network to a cloud hosted server managed by Outpost Central. Data intervals are set at 15 minutes.

Additional submetering is in place to record the balance of groundwater usage between public open space areas and private (on lot) usage, as well as pump energy use, however these are directly connected to the WGV community bore scheme irrigation controller which is managed directly by the Fremantle. Data can be accessed remotely as required.

Data Management & Visualisation

Data Flow Path

Figure 4 shows the data flow path from source to remote server where it is stored, processed and used for various applications such as dashboards and research (see following sections), or made available to third party service providers such as billing agents. As described in previous sections, data is collected from various meters and sensors, logged at the building level, or via individual device loggers, and transmitted either directly, or via a third party platform to a remote server hosted by Balance Utility Solutions running a proprietary database and dashboard application (Schneider Power Monitoring Expert, or PME). PME software provides a number of different applications for data processing, dashboard display and user management services. It also works as a bridging platform between a Structured Query Language (SQL) database and offsite devices.

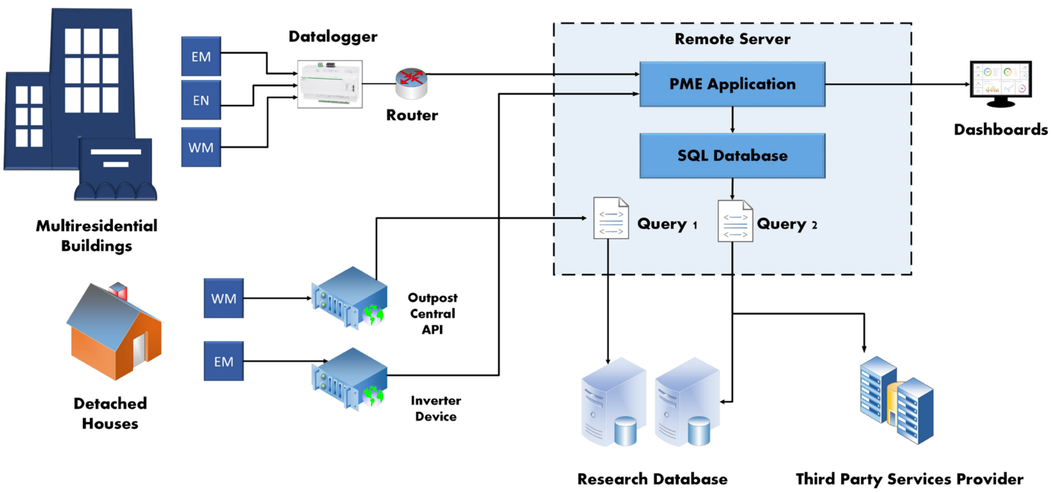

Figure 4: Data flow schematic from field sources to end use.

Data Dashboards

At WGV the PME platform has been used to create 'dashboards' to display real-time data collected from the various sources in a way that makes it easy to visually interpret. The intention is that these dashboards can be used by building strata managers to monitoring common services usage, as well detect leaks and other issues which may otherwise go unnoticed. Likewise, the dashboards enable services providers to check that systems are working as intended. Finally the dashboards can be utilised by residents to monitor their household energy and water use to identify problems with equipment, avoid wastage and potentially reduce the size of their bills.

Each WGV resident is being set up with their own private dashboard. Residents of the apartment buildings also have access to a 'building' level dashboard which provides information about the overall building such as the performance of the shared energy system and energy and water use averages across the apartments. Examples of the dashboards are shown in Figures 5 and 6.

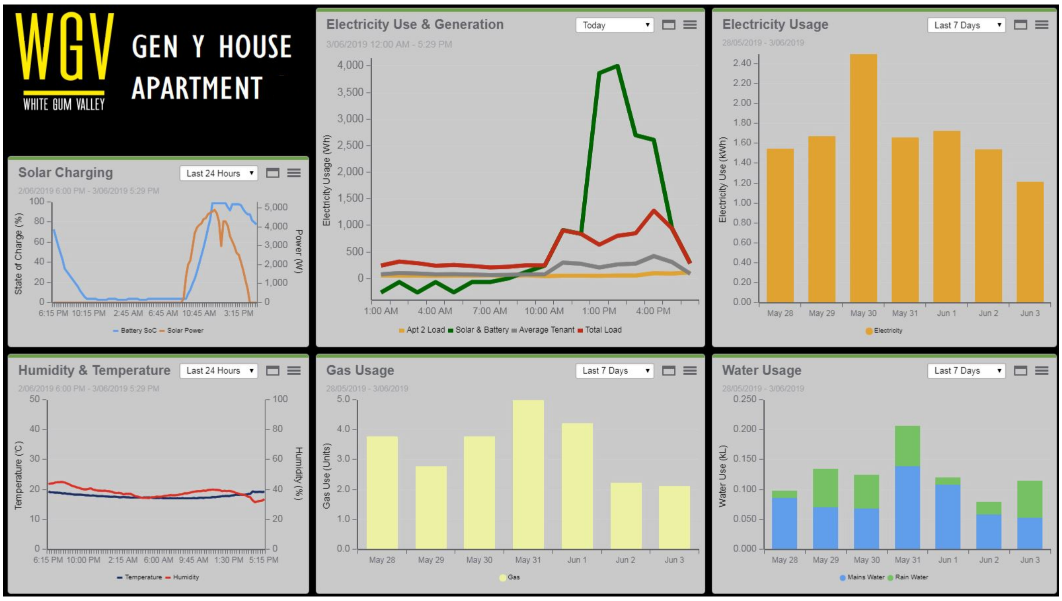

Figure 5: Resident dashboard showing apartment-level data.

Figure 6: Resident dashboard showing building-level data.

WGV Research Database

The monitoring system and the personal dashboards discussed thus far are primarily designed and built to meet the needs of service providers (for management of services and billing) and residents (access to dashboards). In this section the data infrastructure that was designed and developed to suit the requirements of academic research is presented. The research requirements are in many ways similar to the needs of the residents. For example, regular and high precision meter readings benefits both residents and researchers alike, allowing intra-day trends to be observed, which are particularly relevant for detecting and understanding short lived consumption patterns such as cooking. However, the velocity of those individual measurements reaching researcher workflows is less critical. For example residents are likely to be interested in knowing the impact certain actions in real-time (or near real-time). This is reflected in the database requirements below.

Database Requirements

As previously described, data is acquired on multiple channels, across multiple devices, all physically distributed across many sites. For researchers to be productive, complete datasets need to be available spanning the various original data sources through to a single database. This database needs to be easily accessed, and access carefully managed in accordance with the Curtin University research ethics requirements and research participant consent. The specific requirements are listed below:

- There should be a single location that researchers can find all data relating to this wider project.
- Ability for data to be retrieved and utilised in CSV format.
- Data should be grouped and sensibly labelled to enable logical navigation and selective downloading of data.
- Parameters can be set to eliminate spurious data that may result from equipment faults.
- Alerts for major faults should be automated – i.e. transmission breakdowns.
- Able to be queried to extract specific data requirements.
- Deidentified in line with Curtin University Human Research Ethics approvals.
- Controlled access via password protection in line with Curtin University Human Research Ethics approvals.

Data Flow & Integration

Figure 7 below provides an overview of the research data workflow. The workflow is best understood as three distinct phases, each addressing a specific set of requirements. The first phase is ingestion, the second is validation and indexing, and the third is exploration and visualization.

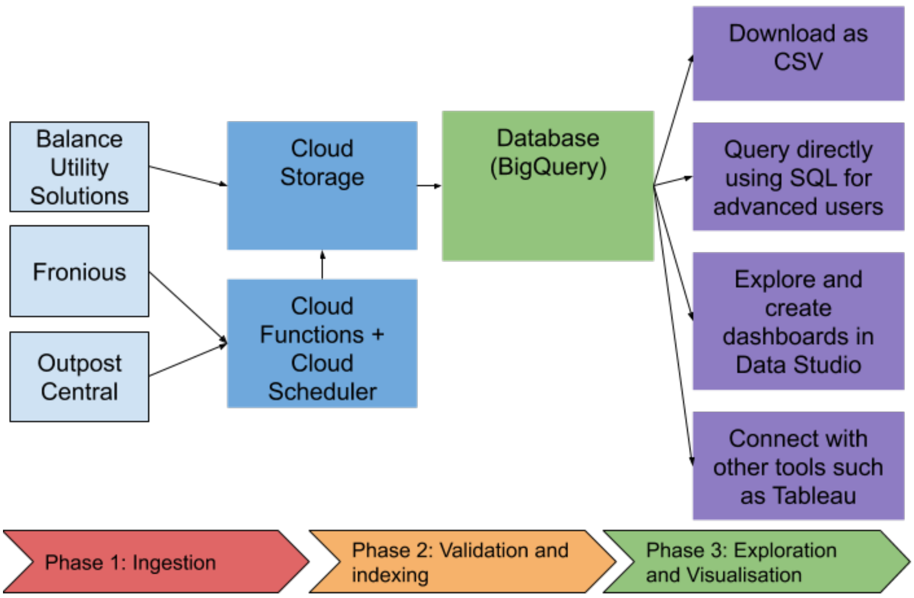

Figure 7: Research data workflow.

Ingestion

The primary goal of this phase is to provide a highly available, secure and low maintenance mechanism for receiving the data from third party sources (Balance Utility Solutions, Fronius and Outpost Central). As outlined in earlier sections, Balance Utility Solutions provides the data for the multi-residential lots, while both energy and water data for the detached lots (and some precinct scale items) is obtained directly from Fronius and Outpost Central respectively. Functionality built in partnership enables data to be 'pushed' from Balance Utility Solutions and 'pulled' from Outpost Central and Fronius (via API). Both of these mechanisms are described below, but first the commonalities across all data feeds are presented.

Whether the data is pushed or pulled, it is always saved to Google Cloud Storage. This service, which is very similar to AWS S3, provides a highly available (the underlying servers will always be available), automatically backed up (no additional overhead to manage), secure (all data is encrypted and has access controls put in place) and elastic (there is no storage limit, nor must disk space be provisioned in advance) location to save all incoming data. The next step for all data is to then be ingested into a Google BigQuery SQL database. The details of this step are described in the following section, and it is here where additional data quality and assurance steps are implemented. The reason to not load the data directly into BigQuery, and to use Cloud Storage as an intermediate step, offers both a second location for the raw data (should any unforeseen issue effect the database, the raw data can be reloaded) and also a staging location that allows additional validation checks (or potentially corrections) to be made to the data before ingestion into the database. The three integrations with the project's data partners are now presented:

Balance Utility Solutions (data is pushed from their servers)

- On Balance Utility Solutions server, a lightweight command line utility was installed that manages the data transfer from their server to a receiving Cloud storage bucket. This utility is able to retry and restart transfers that fail, and importantly encrypts all data in transit.
- With regards to securing access to the receiving storage bucket, Balance Utility Solutions was provided a secure cryptographic key that allows them to upload data. By keeping this key private this ensures that only Balance Utility Solutions is able to upload data. Additionally, this key only allows write access, and does not permit balance to download any data or modify it. This provides an extra level of assurance should the key be lost or stolen.
- Lastly, and as shown in Figure 7, a clean folder structure was initiated for saving data. Data from each location is stored in separate folders, and then further broken down by date. Currently, data is sent every 30min as a CSV file that containing records sampled at 15 minute intervals. This design is flexible though, should there be any issues with the Balance Utility Solutions server, files can be sent that contain records from a much longer period of time.

Fronius and Outpost Central (data is pulled from their servers)

- In contrast to Balance Utility Solutions, code was written for fetching data from both Fronius and Outpost Central. For both, user accounts and private passwords are used for authentication.
- The environment used to run the code are built on two services called Google Cloud Functions and Cloud Scheduler. The later, schedules the data ingestion once a day at a scheduled time. The former spins up a small server (2GB RAM, 1 CPU) for a period of a few minutes. This is the time taken to make a connection to partners servers, and make a request for the water and electricity data from the previous day.
- The data that is returned from Fronius and Outpost Central is then saved into Cloud storage, which at this point the process from this point onwards matches the apartment data that is pushed from Balance Utility Solutions.

Validation & Indexing

This phase is all about maximising the usefulness of the data. This is achieved via three mechanisms: Firstly, validating the schema of the incoming data is correct and the fields all contain sensible values, secondly checking and the number of records expected for the day is within accepted levels and then thirdly, by loading the records not into a managed database (with clearly defined schemas and datatypes), the power of SQL can be utilised by researchers to further interrogate date quality and to address any unforeseen issues. Together, these allow downstream analytics to have a certain trust in the data quality.

The key features of this design include:

- At the end of each day, the data from each site is analysed. Firstly, the schema of the CSV files is compared against a template to ensure the correct fields and number of fields are present. Secondly, the number of total rows is counted. The granularity of data being sent by Balance is at 15min intervals. So, at the end of the day, there should be 96 records for each device or sensor being recorded. (15 minutes x 96 measurements = 24hours worth of measurements).
- Thresholds can then be set, sending an email should the number of records drop below a certain amount, or if the CSV files sent do not match the desired schema.
- Lastly, the entire days data is then ingested into a database called BigQuery. This is a SQL database, where data is stored in rows (individual records with timestamps) and columns (the actual values, with a specific data type, such as energy measured in kWh).

The two main advantages of having data in a database like this are that it enforces the validity of values, that is if the unit being saved is in kWh, any value that is not a floating-point number cannot be saved in that field, and will raise an error that will be investigated; and secondly the data is automatically indexed, that is, is becomes very quick to ask for filtered sets of data, such as between certain dates, fields with values greater than a set amount, or to only return subsets of the data. These affordances enable exploration and visualization which is discussed next.

Exploration & Visualisation

Exploration and visualisation of the data enables researchers to quickly spot trends and issues, as well as present data for reporting and publishing. The four key means for exporting and working with this data are described below:

- At the most basic, data is able to be downloading as a CSV. Allowing researchers to continue using their existing tools. Importantly, access control is enforced on downloading this data, so first a user must be given permission to export the data. More fined grained control of this access (perhaps only certain fields, aggregations, or slices in time) are able to be setup and enforced too. This will be discussed in the following section.
- Dashboards and charts are able to be created using Google Data Studio. Data Studio is designed to work with BigQuery and is fully hosted (no software needs to be downloaded). Reports created in Data Studio work in much the same way as other Google Docs, Sheets and Slides, and allow multiple people to share and work on these dashboards and charts. Importantly, there is a large, global community of users using this tool. Researchers can benefit from the insights and existing documentation.
- The structured data saved in BigQuery can be utilities from a range of other tools. Tableau for example is commonly used, and can easily be connected with BigQuery.
- Lastly the data is able to be queried using SQL which is the defacto standard for relational databases used around the world from large enterprises to research. Complex, or simple, queries can be written to aggregate, filter and sort and classify data. Additionally, a concept called views can be utilised when allowing someone access to the whole dataset is not permitted. A view is able to aggregate data into less granular units (such as daily, rather than 15 minute) or it could hide, or anonymise certain sensitive or personally identifying fields. Like Data Studio, researchers can benefit from a large existing collection of documentation and tutorials.

Examples of Outputs Using Google Data Studio

Figure 8 is a simple stacked bar chart showing the monthly summed energy usage for apartments, plus common services at one of the multi residential sites at WGV, along with the monthly solar energy generation as a running line. Charts like this can be quickly generated to observe trends.

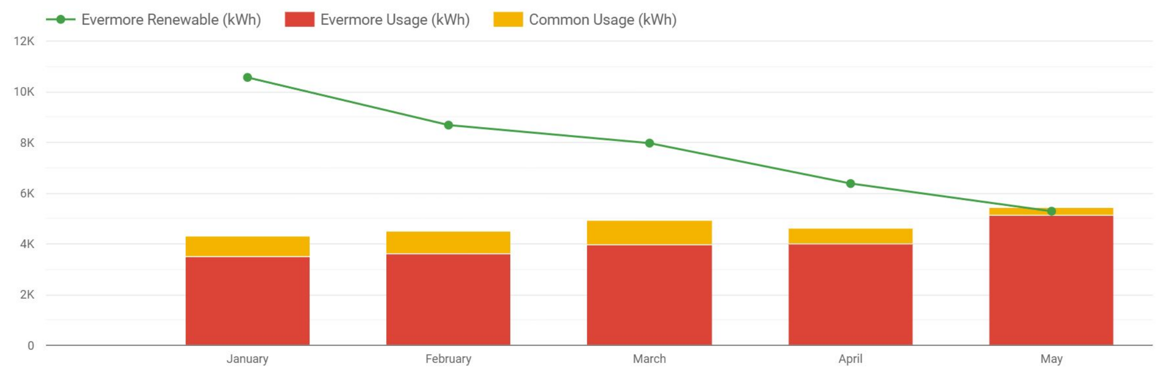

Figure 8: Monthly energy use by sum of apartments and common services, compared with monthly solar generation at Evermore.

Figure 9 shows a heat map table generated to identify outlying values in a particular data set. This is a quick way to identify items of interest, or potential system issues such as the low number of data points received on the 31 May, which can then be investigated.

	timestamp ▾	Record C...	FromGenToGrid	FromGenToConsumer	FromGridToConsumer
1.	May 31, 2019	157	-8,387.9	4,697.21	4,880.7
2.	May 30, 2019	288	-11,301.2	5,482.83	7,067.88
3.	May 29, 2019	288	-16,338.6	6,239.68	7,241.74
4.	May 28, 2019	288	-16,919.4	5,769.14	7,795.47
5.	May 27, 2019	288	-17,210.2	5,654.67	9,919.92
6.	May 26, 2019	288	-17,737.6	5,053.78	9,560.18
7.	May 25, 2019	288	-17,423.25	5,891.63	8,149.35
8.	May 24, 2019	288	-16,040.7	5,448.33	7,491.1
9.	May 23, 2019	288	-8,655.6	4,946.31	10,554.75
10.	May 22, 2019	288	-16,502.2	5,273.69	7,170.3
11.	May 21, 2019	288	-9,849.7	6,307.84	10,674.67
12.	May 20, 2019	288	-13,871.55	5,384.83	10,733.03
13.	May 19, 2019	288	-15,319.25	7,612.04	9,786.07
14.	May 18, 2019	288	-15,615	9,356.11	9,301.4
15.	May 17, 2019	288	-16,283.25	6,708.09	9,496.45
16.	May 16, 2019	288	-4,269	3,804.1	12,218.21
17.	May 15, 2019	288	-12,775	6,106.62	7,627.77
18.	May 14, 2019	288	-18,059.2	5,422.88	6,476.2

Figure 9: Data heat map identifying value outliers.

Security & Data Access

The two key areas of security and access are ensuring only the right people have access to the data, and secondly additional restrictions and deidentification can be applied on data used by authorised users.

The process of ensuring only authorised users can access the data using the following three concepts:

– Permissions: These are based on research ethics approval and research participant consent processes. These permissions define which database tables, or database views are able to been seen or if there is permission to download the data.

– Groups: Groups define certain types of people, and what those types of people should have access to. Such examples would be project researchers such as PhD students who may have research ethics approval for accessing identifiable data, and industry partner who only have permission to access de-identified data. There may also be a group that defines which users have the permission to add users to each group.

– User identities: These can be thought of as login credentials. Once a user has an account, they can be added to one, or more, groups.

The process of deidentifying data is also supported, both with respect to removing fields that identify the property in question, but also for aggregating data across multiple detached lots, or across every unit in an apartment block. Both of these techniques are powered by the concept of database views, which was introduced in the previous section. Views are essentially queries in their own right, as explained with SQL where defined queries can perform aggregation across multiple lots and remove columns that contain identifiable information. From here, permissions to access this view is assigned to a group, which in turn contains certain specified people. This allows some groups of have full access to the data (should that be justified) and other groups to only have access to aggregated data, supported by views. There is no practical limit to the number of views, groups, and users added to these groups.

References

Byrne. J, Green. M & Dallas. S (2018), WSUD Implementation in a Precinct Residential Development: Perth Case Study, Book chapter edited by Sharma. A, Begbie. D & Gardner. T, *Approaches to Water Sensitive Urban Design*, Elsevier, UK.

Josh Byrne & Associates (JBA) (2018), *WGV Community Bore Guide*, Josh Byrne & Associates, Fremantle, Western Australia.

LandCorp (2015), *WGV Design Guidelines*, LandCorp, Perth, Western Australia.

Appendix

1. WGV Estate Plan
2. WGV Data Channel Schedule

Appendix 1

ESTATE PLAN

INNOVATION THROUGH DEMONSTRATION

WGV
WHITE GUM VALLEY

- SINGLE RESIDENTIAL
- APARTMENT SITE
- MAISONETTE SITE
- SEWER LINE AND CONNECTION
- ELECTRICAL SUBSTATION
- ELECTRICAL SUPPLY PILLAR
- WATER CONNECTION
- DESIGNATED CARPORT/GARAGE LOCATION
- CARPORT ONLY PERMITTED (LOT 6)
- RETAINING WALL
- PUBLIC OPEN SPACE

GET IN TOUCH

HAYDEN GROVES 0411 615 582
hayden@dgre.com.au
Dethridge Groves Real Estate

LANDCORP.COM.AU/WGV

LANDCORP

WGV Data Source Schedule by Lot
Version at: 8/07/2019

Appendix 2

Logger (& Telemetry)		Smart Meters & Inverters (Household Internet Sevice)	WASP Loggers (3G)			WASP Loggers (3G) &/or Manual Reads	Building Data Logger (Building Internet)
Lot	**Typology**	**Property Electricty/PV**	**Property Mains Water Meter**	**Property Community Bore Water Meter**	**Rainwater Meter (On Lot)**	**Property Gas Meter**	**Electricity/PV/Battery & Water Sub Metering**
Lot 1	Apartments (24 dwellings)	NA	Elster V300 50mm w/ pulse kit	Elster 25mm V100 pulse capable	NA	NA	Electricity sub metering & source; MW sub metering
Lot 2	Apartments (No. TBA)	TBA	TBA	TBA	TBA	TBA	TBA
Lot 3	SHAC Apartments (12 dwellings)	NA	Elster V100 25mm w/ pulse kit	Elster 25mm V100 pulse capable	NA	NA	Electricity sub metering & source; water sub metering
Lot 4	Attached Dwelling	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	NA	Electricity sub metering
Lot 5	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 6	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 7	Gen Y House (3 dwellings)	NA	Elster V100 25mm w/ pulse kit	Itron TD8 20mm with cyble	Electricity sub metering & source; MW & RW sub metering; Gas; Temp & RH		
Lot 8	Single Residential	Solar Edge	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 9	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 10	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	NA	NA
Lot 11	Group Housing - TBA	TBA	TBA	Elster 25mm V100 pulse capable	TBA	TBA	TBA
Lot 12	Single Residential	TBA	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 13	Single Residential	TBA	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 14	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 15	Single Residential	TBA	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 16	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 17	Single Residential	Solar Edge	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 18	Single Residential	TBA	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 19	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 20	Single Residential	TBA	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 21	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 22	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 23	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 24	Single Residential	TBA	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 25	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	NA	NA
Lot 26	Single Residential	TBA	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 27	Single Residential	TBA	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA
Lot 28	Single Residential	Fronius	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	Itron TD8 20mm with cyble	TBA	NA