Department of Climate Change, Energy, the Environment and Water

Measurement and verification demonstration project

Food manufacturer: Appendix C measurement and verification (M&V) plan

November 2023

Acknowledgment of Country The Department of Climate Change, Energy, the Environment and Water acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Contents

Appendix C: M&V plan

This measurement and verification (M&V) plan was prepared by the M&V practitioner prior the Implementation of the energy efficiency measures (EEMs), and it details the methods, procedures, analyses, and reporting that will be conducted throughout the measurement periods to determine, verify, and report energy savings for the energy efficiency upgrades that took place at a supermarket.

This document was prepared while ensuring that the requirements of EVO 10000 – 1:2022, IPMVP Core Concepts 2022, chapter 13, are met.

1. M&V plan authorisation

Site name	Bravo Food Company
Site address	Smith Street, Smithville, NSW
Date of this plan	16 November 2019[1]
International Performance Measurement and Verification Protocol (IPMVP®) version being followed	IPMVP Core Concepts 2022[2]

The signatures below indicate acceptance and adoption of this plan.

Organisation that prepared the M&V plan (M&V practitioner)

Person responsible	Loretta Liu
Title	M&V Officer
Organisation	Compliance and Audits Pty Ltd
Signature of approval and acceptance	Loretta Liu
Date	16 November 2019

[1] While the data reflects an earlier period, the current version (as of the date of publication of this example M&V plan) of the ESS and VEU legislation has been applied (where these schemes are referenced).

[2] INTERNATIONAL PERFORMANCE MEASUREMENT AND VERIFICATION PROTOCOL (IPMVP®), *CORE CONCEPTS*, MARCH 2022, EVO 10000 – 1:2022

Third party quality assurance

Person responsible	Sarah Cando
Title	M&V Quality Officer
Organisation	Quality Assessors Pty Ltd
Signature of approval and acceptance	Sarah Cando
Date	16 November 2019

Energy user

Person responsible	Md. Akbar Hussain
Title	Production Manager
Organisation	Bravo Food Company
Signature of approval and acceptance	Md. Akbar Hussain
Date	16 November 2019

2. Facility and project overview

Site Name	Bravo Food Company
Site address	Smith Street, Smithville, NSW
Brief description of the site operation	Food manufacturer producing dehydrated foods.
Energy Efficiency Measures (EEMs)	1. The burners on the gas dryer were replaced with new, more efficient burners 2. Variable speed drives (VSDs) were fitted to the burner fans 3. The sensors and controls for the burners and fans were upgraded
Energy audit report / other analysis used to develop the project	The two energy efficiency measures (EEMs) were identified in an energy audit performed by Earnest ESCO (report not available).

3. Intent of the energy efficiency measures

<table>
<tr><th>EEM</th><th>Burner upgrade</th><th>VSDs on burner fans</th><th>Upgrades to burner and fan sensors and controls</th></tr>
<tr><td>Description of measure</td><td>The burners on the gas dryer will be replaced with new, more efficient, burners.</td><td>VSDs will be fitted to the burner fans. Previously they operated at constant speed.</td><td>Sensors and controls will be upgraded or added to enable fan speed to modulate giving a constant percentage of excess air to the combustion process.</td></tr>
<tr><td>How the measure will save energy, demand, or other resources</td><td colspan="3">The dryer removes moisture from the incoming “wet” food to produce a final dehydrated product. Food is dried in a batch process across several rooms, all supplied by the one dryer. The burners heat air coming into the dryer, with the hot air then de-hydrating the moist food. The moisture from the food is transferred to the hot air, with the moist air then vented outside.

The dryer currently has four 1,170 kW burners, with a total capacity of 4,680 kW. The burners are staged depending on the demand for heat. The existing burners are non-modulating high fire/low fire burners. Air is supplied through constant volume fans.

The proposed EEMs are to:
1. Install one 1,600 kW burner, two 1,000 kW burners, and one 600 kW burner, with a total capacity of 4,200 kW, with burners being capable of modulating down to 30% load.
2. Install VSDs on the burner fans.
3. Enable more efficient combustion by reducing the amount of excess air when burners are modulated.
4. Install sensors to ensure that the amount of excess air is closely controlled.

This upgrade enables better staging of the amount of heat supplied to the dryer, with smoother burner staging possible with the burners modulating down to 30%.</td></tr>
</table>

	By being able to better regulate the amount of heat and air supplied: • More even drying of products can be provided. • Stop/start burner losses are minimised. • Combustion efficiency is improved, by reducing the amount of excess air in part load conditions.		
EEM	Burner upgrade	VSDs on burner fans	Upgrades to burner and fan sensors and controls
EEMs impact on operational factors (e.g., temperature set points, hours of operation, etc.) and if the measure will correct operational deficiencies	There will be no impact on operational factors. The upgrade may provide more consistent drying and improved product quality.		
Affected equipment inventory	The dryer burners.	The fans supplying the dryers.	The sensors and controls fitted to the dryer to control burner and fan operation.
Form of energy saved	Gas	Electricity	Electricity and gas
Expected annual energy savings	Electricity: 300 MWh Gas: 4,000 GJ		
Expected annual energy cost savings	Electricity: $63,000 Gas: $43,000 Total: $106,000		
Expected annual energy savings (% of site energy)	Electricity: 1.1% Gas: 2.7% Overall: 2.1%		
Expected annual non-energy cost savings	None (ignore any potential savings from improved product quality)		

Expected total annual cost savings	Electricity: $63,000 Gas: $43,000 Total: $106,000
Expected annual GHG savings (t CO2-e) [3]	Scope 1 Gas savings: 206 Scope 2 Electricity savings: 237 Total scope 1 and 2 savings: 443

These savings estimates were provided by Earnest ESCO, the energy service provider who conducted the energy audit for the site.

4. Selected IPMVP option and measurement boundary

Energy source	Electricity	Gas
IPMVP option	Option B Retrofit isolation: All parameter measurement	Option B Retrofit isolation: All parameter measurement
Measurement boundary	The dyer burners, fans and controls.	The dryer burners.
Interactive effects and their calculated impact on savings	There are no interactive effects – i.e., changes to gas or electricity consumption within the measurement boundary are not expected to have any impact on energy use outside the boundary.	

5. Baseline measurement period, energy consumption and conditions

Identification of baseline measurement period

Energy source	Electricity	Gas
Start date	30 May 2019	30 May 2019

[3] Based on the emissions factors in the National Greenhouse Accounts Factors of August 2021 for the financial year 2019 of 0.79 kg CO2-e/kWh and 51.53 kg CO2-e/GJ for electricity and natural gas respectively.

Energy source	Electricity	Gas
End date	8 November 2019	8 November 2019
Measurement frequency	Daily	Daily
Total number of measurements	163	163
Baseline energy use and demand data	Baseline electricity data was collected from the submeter supplying the burners, fans and controls. It is included in Appendix C2, along with data for the selected independent variables.	Baseline gas data was collected from the submeter supplying the burners. It is included in Appendix C2, along with data for the selected independent variables.

Independent variable data / Energy influencing variable data

Energy source	Electricity	Gas
Independent variables selected	kg of dried product	Square root of kg of dried product
Independent variables rejected	Weather related data: demonstrated no correlation. Days of the week as binary variables: Including Monday, Saturday and Sunday as binary variables improved the CV_{RMSE} of the model, and these variables had acceptable t-statistics. However, days of the week were rejected as it was not possible to identify a satisfactory explanation as to why these variables would influence electricity usage of the burner, fans and controls.	Weather related data: demonstrated no correlation.

Energy source	Electricity	Gas
Independent variable data	This is shown in Appendix C2	This is shown in Appendix C2
Plots showing the relationship between the independent variables and energy usage	As shown below this table	As shown below this table

Static factors / Operating conditions

Potential static factor for each energy source	Included in this M&V plan? (Electricity)	Included in this M&V plan? (Gas)
Available dryer volume Value = 600 m^3	Yes	Yes
Dried product target moisture content Value = 9%	Yes	Yes
Equipment nameplate data (to identify changes to existing electricity-using equipment)	Yes Fan motor nameplate data. Four identical fan motors: TECO 245 kW motors, 4 pole, IE class 2 motors, model number TC105785.	N/A
Planned changes that are likely to occur during the reporting period	None planned	None planned

Figure 1 and Figure 2 below show the relationship between the independent variables and energy use.

Figure 1 Electricity consumption (MWh) versus square root of production (kg)

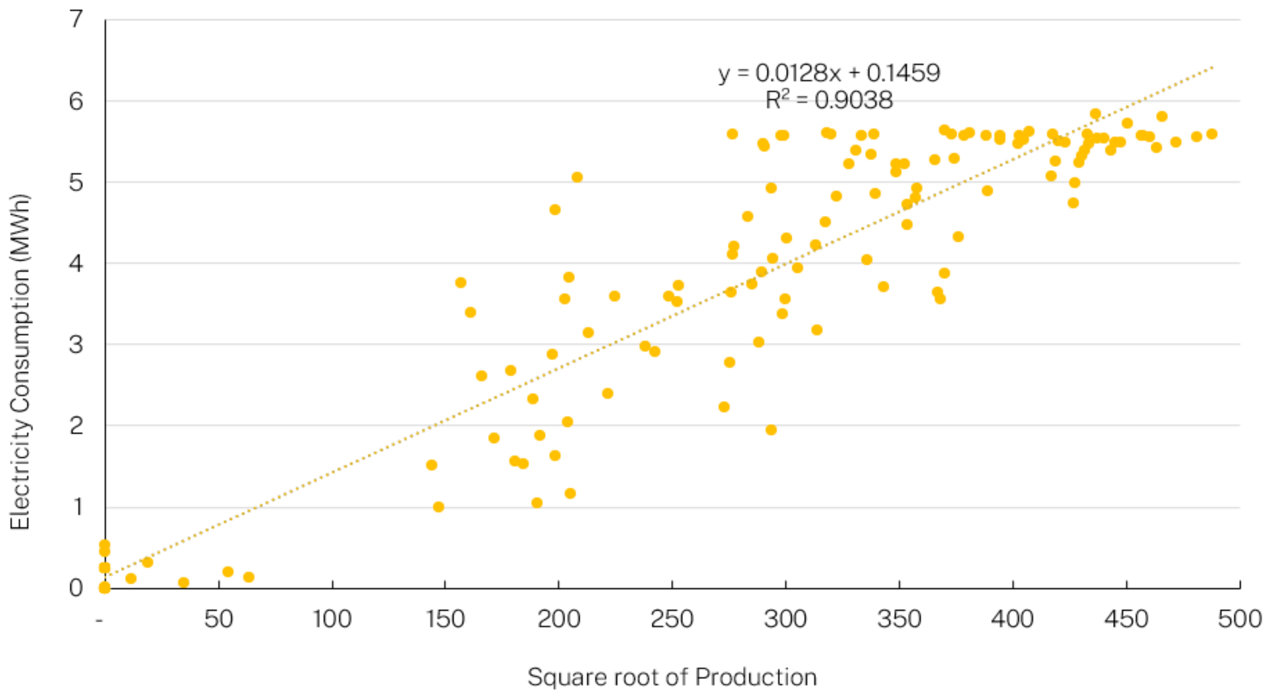
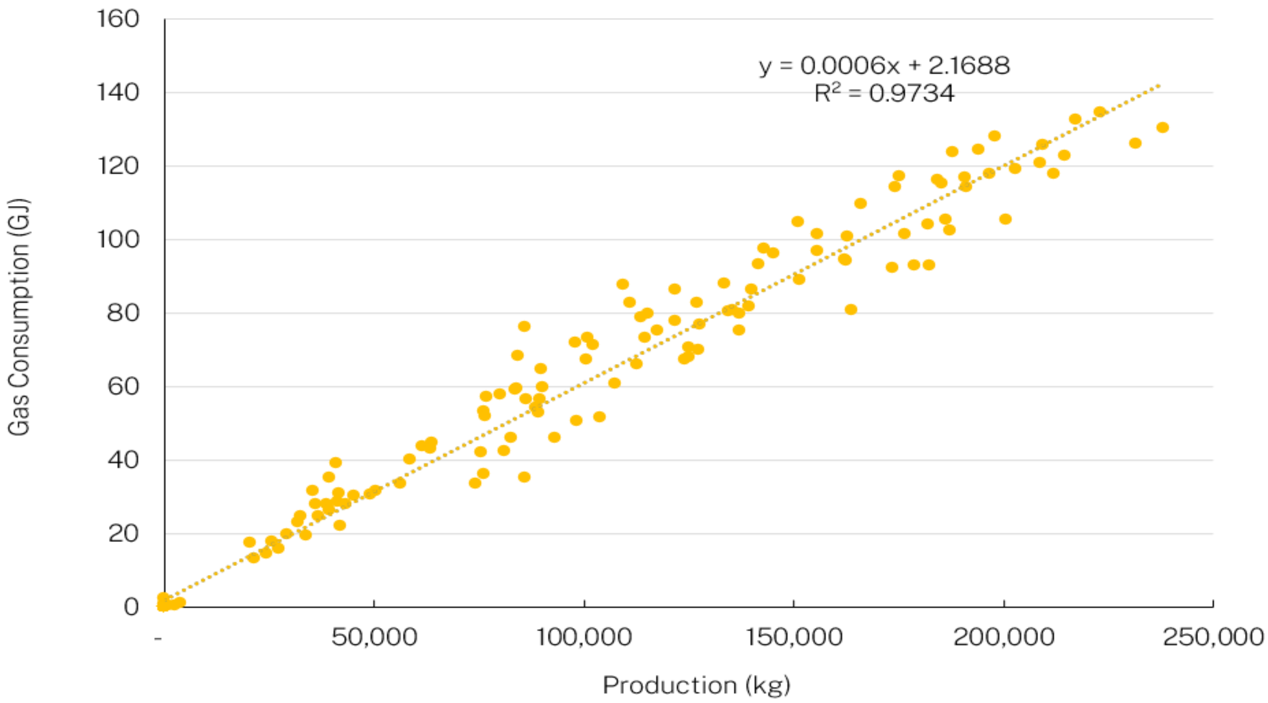


Figure 2 Gas consumption (GJ) versus production (kg)



6. Operational verification requirements

Operational verification activities to be undertaken include validating that:

- the new burners modulate

- the fan speed modulates
- the SCADA system is showing a constant percentage of excess air across a range of operating conditions
- the fans and burners modulate in accordance with the kg of production.

Additionally, 3 months after the commissioning of the EEMs, the energy savings will be determined to verify if the savings are approximately as expected.

Loretta Liu, the M&V Officer from Compliance and Audits Pty Ltd, will be responsible for verification activities.

Every 3 months, Loretta Liu will contact the production manager to discuss if there are any changes to static factors. However, prior to this quarterly call with the production manager, Loretta Liu will determine avoided energy use in the preceding 3 months. If there are any unexpected trends this will be discussed with the production manager, and if needed, additional verification visits will be undertaken. Each M&V report will detail any verification activities undertaken.

There are no plans to undertake additional site verification inspections. However, where there are significant unexpected and unexplained variations in savings, a site inspection will take place to verify proper operation of the EEMs.

7. Reporting period(s)

Parameter	Value
Length of reporting period	12 months
Number of reports	10
Frequency of reports	Every 12 months
Date first report will be provided	Within one or two months after the end of the first 12-month reporting period. It is expected that implementation of the EEMs will be completed by the end of November 2019, with the reporting period expected to commence on 1 December 2019. So, the first report should be issued in January 2021.

8. Basis for adjustment

Adjustment	Description
Basis for adjustment	Savings will be reported as normalised savings. The normal year will be considered the calendar year of 2020.
Static factor adjustments	Where changes in static factors have been identified the IPMVP Non-Routine Adjustments Guide[4] will be followed to make non-routine adjustments. *Note: The NSW Energy Savings Scheme (ESS) and Victorian Energy Upgrades (VEU) legislation have different requirements, as shown in the box below.*
Baseline adjustments due to issues in the baseline period	No baseline equipment problems or code compliance issues occurred in the baseline period that need to be addressed.

Box 1 Static factor adjustments according to the ESS and VEU

ESS	VEU
The PIAM&V method application requirements for non-routine events and adjustments describes how to account for events that affect energy consumption and are not modelled by any of the Independent Variables or the Site Constants	Only changes whose root sources is COVID can be treated as non-routine events and must be undertaken in accordance with the document Accounting for COVID-19 under Victorian Energy Upgrades Measurement & Verification Projects.

[4] IPMVP APPLICATION GUIDE ON NON-ROUTINE EVENTS & ADJUSTMENTS, INTERNATIONAL PERFORMANCE MEASUREMENT AND VERIFICATION PROTOCOL®, October 2020, EVO 10400 – 1:2020

9. Calculation method and analysis procedure

9.1. Baseline energy use

Baseline models of gas and electricity consumption are established via regression analysis using the excel function 'LINEST':

Daily gas consumption (GJ) = 2.1688 + 0.00058966 x kg production

Equation 1 Baseline gas regression model

Daily electricity consumption (MWh) = 0.14588 + 0.012837 x $\sqrt{(kg\ Production)}$

Equation 2 Baseline electricity regression model

The model statistics, including the range of the independent variables, t-statistics, CV_{RMSE}, and R^2 are shown in Tables 1 to 4.

Table 1 Gas baseline model statistical test results

Statistical test	Value	IPMVP recommendation	Acceptable?
Expected values error	0.000%	< 0.005%	Yes
Adjusted R^2	0.97	> 0.75	Yes
CV_{RMSE}	0.14	< 0.2	Yes

Table 2 Electricity baseline model statistical test results

Statistical test	Value	IPMVP recommendation	Acceptable?
Expected values error	0.000%	< 0.005%	Yes
Adjusted R^2	0.90	> 0.75	Yes
CV_{RMSE}	0.22	< 0.2	See discussion below.

Table 3 Gas baseline model coefficients, t-statistics, and range of independent variables.

Parameter	Intercept	kg of dry product

Coefficient	2.168	0.0006
t-statistic	2.57	76.73
t-statistic acceptable? (> |2|)	N/A	Yes
Minimum value	N/A	0
Maximum value	N/A	238042

Table 4 Electricity baseline model coefficients, t-statistics, and range of independent variables.

Parameter	Intercept	Square root of kg of dry product
Coefficient	0.145	0.013
t-statistic	1.53	38.76
t-statistic acceptable? (> |2|)	N/A	Yes
Minimum value	N/A	0
Maximum value	N/A	487.89

The box below shows the minimum statistical requirements in the ESS and VEU.

Box 2 Regression model statistical requirements according to the ESS and VEU

ESS	VEU
Table A22 of Schedule A in the ESS Rule stipulates the statistical requirements: • t-statistics must be > |2| • CVRMSE must be less than 0.25 if R2 is > 0.5, and < 0.1 when R2 is < 0.5	The VEU has no legislated statistical requirements.

The electricity model's CV_{RMSE} was slightly greater than 0.2, however, all parties agreed to accept this, noting that:

- the M&V practitioner and production manager had not been able to identify any other variable that could explain the difference between actual and predicted energy consumption.

- it had been clearly established that weather variables were not suitable independent variables.
- including the weekdays of Monday, Saturday and Sunday as binary independent variables did improve the model and reduced the CV_{RMSE} to less than 0.2. However, it was not possible to come up with a satisfactory explanation as to why these variables would influence electricity usage of the dryer.
- this would result in a higher uncertainty of savings.

Figure 3 and Figure 4 show plots of actual energy and predicted energy use in the baseline period. It shows that the gas and electricity models are a very good predictor of energy usage.

Figure 3 Gas Baseline actual and predicted consumption.

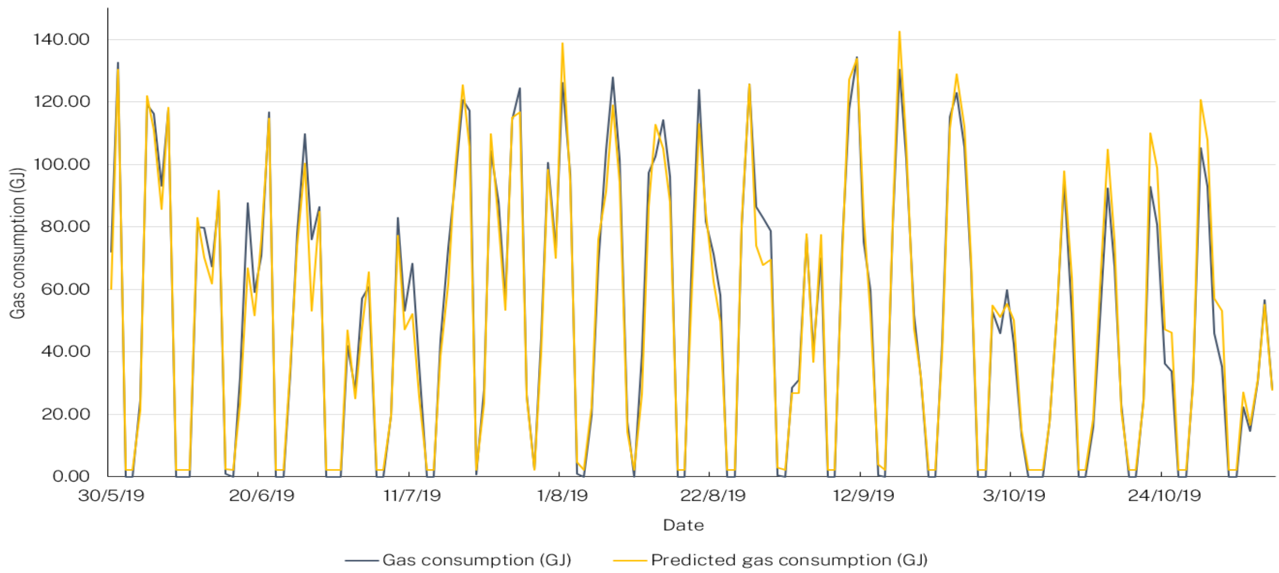
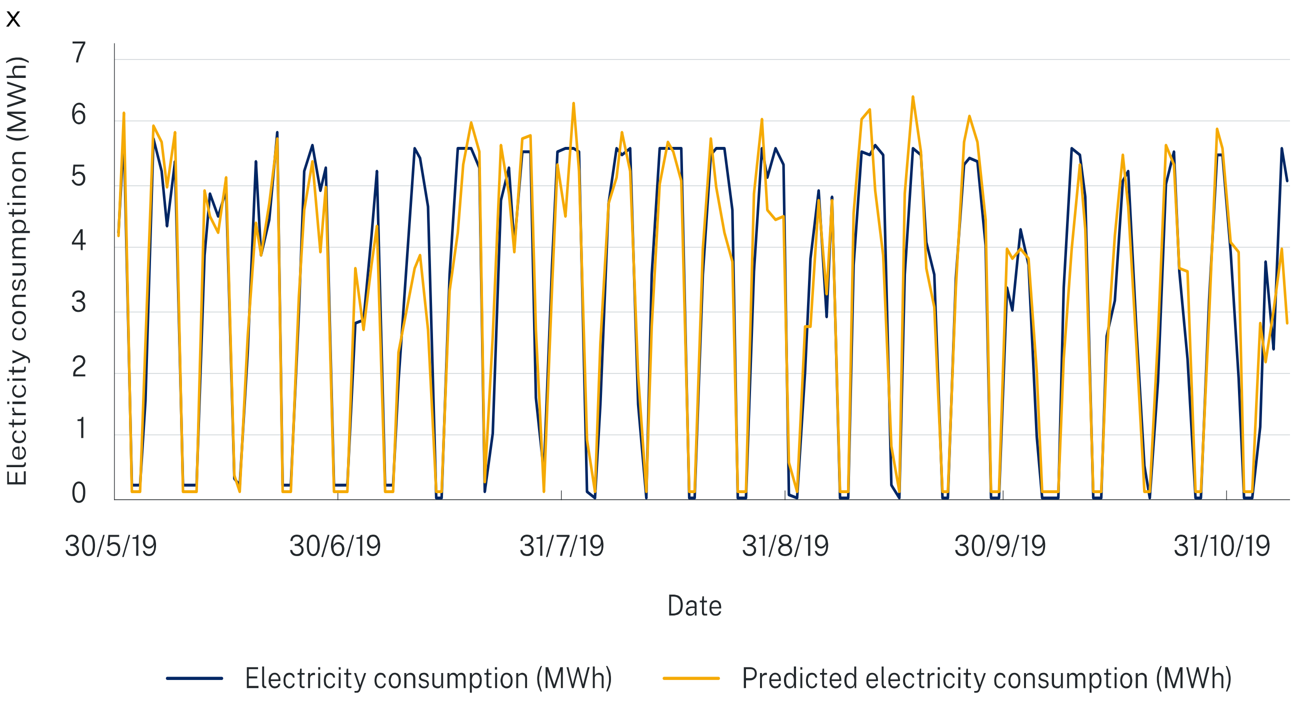


Figure 4 Electricity Baseline actual and predicted electricity consumption.



9.2. Calculation of savings

The adjusted baseline energy consumption will be determined by applying the independent variables in the normal year to the baseline energy models.

The adjusted reporting period energy use will be determined by applying the independent variables in the normal year to the reporting period energy models (to be developed for each reporting period).

Normalised savings for any reporting period will be determined by subtracting the adjusted reporting period energy from the adjusted baseline period energy. As mentioned earlier, the 2020 calendar year will be used as the normal year.

9.3. Uncertainty determination

Uncertainty will be determined by combining the sources of uncertainty as outlined in Uncertainty Assessment for IPMVP.[5]

The sources of uncertainty are:

- The baseline model uncertainty

[5] UNCERTAINTY ASSESSMENT FOR IPMVP, INTERNATIONAL PERFORMANCE MEASUREMENT AND VERIFICATION PROTOCOL®, July 2019, EVO 10100 – 1:2019

- The baseline metering uncertainty
- The reporting period model uncertainty
- The reporting period metering uncertainty

There is no sampling uncertainty.

The error of the daily gas and electricity models has been adjusted to take into account the autocorrelation that exists for both models.

Meter error is based on the accuracy of the meters used.

The electricity meter installed is an Allen Bradley, PowerMonitor 1000 (1408-TR2A-ENT)[6] with a EN62053-21:2003 Class 1 accuracy. This corresponds to an accuracy of ±1% at full load and with a power factor of 1, with accuracy deteriorating at lower loads and with a lower power factor.

Details of the current transformers (CTs) used by the meter have not been determined, so it is not possible to know the loading conditions (as a percent of full load). Therefore, by undertaking a conservative approach, and assuming that the CTs are appropriately sized, it is assumed that the meter accuracy is ± 2% of reading at a 95% confidence level.

The gas meter installed is a Endress+Hauser, Proline t-mass 65 (65F80-AK2AG1AAABCA)[7]. This is a thermal mass flow rate meter – needing no compensation for temperature or pressure. It has an error of ± 1.5% of reading for flow rates between 10% to 100% of the maximum design mass flow rate of 2,030 kg/hr. This corresponds to a daily maximum flow rate of 2,439 GJ/day, assuming constant full load (101.6 GJ/hr).
Data is converted to MJ assuming a higher heating value (HHV) of 50.071 MJ/kg.

Note that the actual HHV is not static and varies over time based on the mix of gases in the natural gas supplied to the site. However, as the HHV is not measured at any point, a simplifying assumption is that the HHV is constant at 50.071 MJ/kg. Typically, the HHV of natural gas could vary by up to 5% across a month.[8]

Based on the actual maximum daily gas consumption in the baseline period of 134 GJ/day, (but noting that the average hourly gas consumption is higher than this because the plant doesn't operate 24/7), the meter is likely to be measuring gas flow rates which, most of the time, are less than 25% of the maximum mass flow rate – which would still correspond to an accuracy of ±1.5% of reading

6 https://media.distributordatasolutions.com/Rockwell/files/File_PowerMonitor_1000_1408-IN001_EN_1.pdf

7 https://www.endress.com/en/field-instruments-overview/flow-measurement-product-overview/t-mass-65f-thermal-mass-flowmeter?t.tabId=product-overview

8 Based on hourly measurements of heating value in the Victorian gas network.

Considering that there is also an error associated with the HHV of the gas, it is assumed that the gas meter has an error of ±5% at a 95% confidence level.

Baseline model uncertainty taking into account autocorrelation is shown in Table 5 below.

Table 5 - Baseline model uncertainty, accounting for autocorrelation

Error	Gas	Electricity
Baseline model standard error percent	1.6%	2.2%
Baseline submeter standard error*	0.20%	0.08%
Baseline overall standard error	1.6%	2.2%

* Note: In accordance with the IPMVP principle of being conservative, the baseline error is based on the number of observations in the baseline period, and not the number of observations in the normal year.

10. Savings

10.1. Expected savings summary

The expected energy, cost and GHG savings are shown in Table 6 below.

Table 6 Expected savings

Expected savings	Gas	Electricity	Total
Energy savings	4,000 GJ	300 MWh	1,400 MWh
Cost savings	$43,000	$63,000	$106,000
GHG savings (t CO_2-e)	206	237	443

10.2. Energy cost savings

Electricity is supplied at an average rate of $0.21/kWh. Gas is supplied at an average cost of $10.70/GJ.

It has been agreed that an average rate will be used for determining savings, rather than differentiated time-of-use tariffs or demand charges. This is to simplify the delivery of M&V and valuing of savings.

In the reporting periods, savings will be valued at the current average costs with no escalation. The monetary value of savings will be determined by multiplying the normalised savings, in GJ and kWh, by the gas and electricity tariffs respectively.

10.3. Non-energy cost savings

There are no expected non-energy cost savings.

10.4. Greenhouse gas emissions factors

The baseline GHG emissions factor is based on the 2018/2019 financial year emissions factors published in the National Greenhouse Accounts Factors, August 2021.

It includes scope 1 emissions for gas and scope 2 emissions for electricity:

- Gas scope 1 emissions factor: 51.53 kg CO_2-e/GJ
- Electricity scope 2 emissions factor: 0.79 kg CO_2-e/kWh

In savings reports, the most recent published emissions factor, from the National Greenhouse Accounts Factors, for the year in which most of the savings occur, will apply. The emissions factor is to include both scope 2 and scope 3 emissions.

The valuing of savings is treated differently in the ESS & VEU, as shown in the box below.

Box 3 Valuing savings according to the ESS and VEU

ESS	VEU
Financial savings: The ESS has no requirements for savings to be assigned a monetary value. The number of ESCs created is based on the amount of energy saved, applying various factors in accordance with the scheme legislation and as calculated in the case study off which this M&V plan is based. Greenhouse gas savings: The ESS has no requirements for savings to be assigned a GHG savings value.	**Financial savings:** The VEU has no requirements for savings to be assigned a monetary value. The number of VEECs created is based on the amount of energy saved, applying various factors in accordance with the M&V Specifications and as calculated in the case study, off which this M&V plan is based. **Greenhouse gas savings:** The VEU M&V Specifications base the number of VEECs created on the GHG savings, which are determined by applying an emissions factor stipulated in the legislation to the amount of energy saved.

11. Metering details

Sub-meters will be used when determining savings. Data from the meters is collected by the site SCADA system.

Table 7 Energy meters

Energy source	Meter make and model	Configured energy measurement units	Meter serial number
Electricity	Allen Bradley, PowerMonitor 1000 (1408-TR2A-ENT)[9]	kWh	E98487749
Gas	Endress+Hauser, Proline t-mass 65 (65F80-AK2AG1AAABCA)[10]	MJ	N8774884

Both meters were installed in accordance with the manufacturer's requirements.

A hand-held single phase current meter, and a voltage meter, were used to take spot measurements and to verify that the electricity meter was properly installed.

For the electricity meter, no in-situ calibration was needed.

It was not practical to calibrate the gas meter in situ. As a thermal mass flow meter, the parameters of the average composition of the gas supplied to the site were entered in accordance with the gas utility's advice, corresponding to a higher heating value of 50.071 MJ/kg.

The production data is measured by a scale used to weigh the product as it is packaged after being dehydrated. It is also collected by the site SCADA systems.

12. Monitoring and reporting responsibilities

12.1. Responsibility Matrix

Table 8 below shows the different parties responsible for undertaking the various tasks as part of the M&V process.

9 https://media.distributordatasolutions.com/Rockwell/files/File_PowerMonitor_1000_1408-IN001_EN_1.pdf

10 https://www.endress.com/en/field-instruments-overview/flow-measurement-product-overview/t-mass-65f-thermal-mass-flowmeter?t.tabId=product-overview

Table 8 Responsibility matrix

Task	Collect	Analyse	Review	Archive	Report
Energy Data	Energy user	M&V practitioner	M&V practitioner	M&V practitioner	Energy user
Independent Variables	Energy user	M&V practitioner	M&V practitioner	M&V practitioner	Energy user
Management of measurement equipment and specifications	Energy user	Energy user	Energy user	Energy user	Energy user
Static factors / changes to static factors	Energy user	M&V practitioner	M&V practitioner	M&V practitioner	Energy user
Operational verification and periodic verification inspections	M&V practitioner	M&V practitioner	M&V practitioner	M&V practitioner	M&V practitioner
Preparation of M&V reports	M&V practitioner	M&V practitioner	M&V practitioner	M&V practitioner	M&V practitioner

12.2. Names of the individuals responsible

M&V practitioner: Loretta Liu
Energy user: Sarah Cando

13. Expected accuracy

13.1. Sources of uncertainty

Energy source	Gas	Electricity
Modelling standard uncertainty (allowing for autocorrelation)	1.6%	2.2%
Measurement standard uncertainty	0.20%	0.08%
Sampling uncertainty	As no sampling is undertaken, there is no sampling uncertainty.	
Estimation errors	No estimates are undertaken, so there is no estimation uncertainty.	
Overall baseline standard uncertainty	1.6%	2.2%

13.2. Uncertainty calculations

Energy source	Gas	Electricity
Expected accuracy of the reported energy savings	Assuming the reporting model has the same error as the baseline model, the expected normalised savings are expected to have a standard uncertainty of 296 GJ. This is calculated as follows: Based on the gas consumption across the 163 days in the baseline period, annual baseline gas consumption of the burners is 18,659 GJ. The standard error is 1.6%, giving a standard baseline error of 296 GJ. Assuming the reporting model has the same error as the baseline model, the expected normalised savings are expected to have a standard uncertainty of plus/minus √2 x baseline error = √2 x 296 GJ = 419 GJ	Assuming the reporting model has the same error as the baseline model, the expected normalised savings are expected to have a standard uncertainty of 35.4 MWh. This is calculated as follows: Based on the electricity consumption across the 163 days in the baseline period, annual baseline electricity consumption of the burners, fans and controls is 1,157 MWh. The standard error is 2.2%, giving a standard baseline error of 25 MWh. Assuming the reporting model has the same error as the baseline model, the expected normalised savings are expected to have a standard uncertainty of plus/minus √2 x baseline error = √2 x 25 MWh = 35.4 MWh

Energy source	Gas	Electricity
Uncertainty in relation to savings	The expected savings are 4,000 GJ. The expected standard uncertainty as a percent of expected energy savings = 419/4,000 = 10.5%. The IPMVP recommendation that savings be at least twice the standard error is highly likely to be achieved.	The expected savings are 300 MWh. The expected standard uncertainty as a percent of expected energy savings = 35.4/300 = 11.8%. The IPMVP recommendation that savings be at least twice the standard error is highly likely to be achieved.
Energy source	Gas	Electricity

Energy source	Gas	Electricity
Uncertainty in the savings report(s)	Uncertainty in the savings reports will be determined by combining the baseline error with the reporting error. These two errors are combined in quadrature, as shown below. $$Savings\ standard\ uncertainty = \sqrt{\mathrm{SE(Baseline)}^2 + \mathrm{SE(Reporting)}^2}$$ Equation 3 Formula for calculating savings standard uncertainty Where SE(Baseline) is the Standard Error of the baseline, and SE(Reporting) is the Standard Error of the reporting period. The savings uncertainty at the desired confidence level will be determined by multiplying the savings standard uncertainty resulting from equation 3 by the t value. To determine the t value for the 12 months period, the Degrees of Freedom (DoF) must be calculated as follows: DoF = N (number of observations) – 1 – Number of Independent Variables DoF = 365 – 1 – 1 = 362 (assuming that there are no observations excluded due to missing data). This produces a t-value of 1.649 based on Table 1 of the Uncertainty Assessment for IPMVP. Therefore, the savings uncertainty at the 90% confidence level, using the t value of 1.649 can be calculated following equation 4 below. (Assuming no observations excluded due to missing data). $$Savings\ uncertainty\ at\ the\ 90\%\ confidence\ level = 1.649 \times \sqrt{\mathrm{SE(Baseline)}^2 + \mathrm{SE(Reporting)}^2}$$ Equation 4 Formula for determining savings uncertainty at the 90% confidence level	

14. M&V Budget

14.1. M&V Establishment budget

The M&V establishment budget is $35,000, of which $25,000 is for metering expenses.

14.2. M&V Reporting budget

Table 9 M&V Reporting budget

Parameter	Value
Cost of each M&V report	$4,000
Number of reports	10
Subtotal M&V reporting cost (over 10 years)	$40,000
Annual verification costs	$3,000
Number of years of verification	1 (during first year only)
Subtotal verification costs	$3,000
Total M&V reporting and verification costs	$43,000
Annual reporting and verification cost as a percentage of the estimated annual savings	First year: $\frac{\$7,000}{\$106,000}$ = 7% Second and subsequent year: $\frac{\$4,000}{\$106,000}$ = 4%

Note: These costs do not include the costs of independent quality assurance.

15. M&V report format

The M&V report will be prepared using the template in Appendix C1.

M&V reports will be prepared annually. They will be supplied directly to the energy user.

There is no planned independent review of the M&V reports.

16. Quality assurance

The following procedure will be used to ensure the quality of the energy saving calculations and all other related activities in determining the savings:

Verification inspections to ensure that the EEM continues to operate as intended:

- There will be one verification inspection to verify that the EEMs are operating as designed following deployment of the EEMs.
- No other site verification activities are scheduled, however, should quarterly analysis of avoided energy usage identify any loss of inspected savings, additional verification activities may be undertaken. These are not included in the annual reporting budget.

Lost and missing data:

- Where there is missing electricity consumption or weather data, any day in which observations are missing will be excluded from any of the energy models.

Review requirements:

- This M&V plan will be verified by a third-party reviewer.
- There is no plan for independent review of savings reports.

17. References

- UNCERTAINTY ASSESSMENT FOR IPMVP, INTERNATIONAL PERFORMANCE MEASUREMENT AND VERIFICATION PROTOCOL®, July 2019, EVO 10100 – 1:2019 (Uncertainty Assessment for IPMVP)
- INTERNATIONAL PERFORMANCE MEASUREMENT AND VERIFICATION PROTOCOL (IPMVP®), *CORE CONCEPTS*, MARCH 2022, EVO 10000 – 1:2022 (IPMVP Core Concepts)

18. List of appendices

Appendix C1. M&V report template

Appendix C2. Baseline energy and independent variable data

Appendix C3. Energy audit – not provided due to commercial confidentiality

19. Appendix C1 – M&V report template

19.1. Overview of the M&V report

19.1.1 M&V report authorisation

Site name	
Date of this M&V Report	
Name and date of the authorised M&V plan being followed	
IPMVP version being followed	IPMVP Core Concepts 2022

The signatures below indicate acceptance and adoption of this report.

19.1.2 Organisation that prepared the report

Person responsible	
Title	
Organisation	
Signature of approval and acceptance	
Date	

19.1.3 Third party quality assurance

Person responsible	
Title	
Organisation	
Signature of approval and acceptance	
Date	

19.1.4 Energy User

Person responsible	
Title	

Person responsible
Organisation
Signature of approval and acceptance
Date

19.1.5 M&V report distribution

[List who the report is being distributed to]

19.2. Project background

M&V option
EEM description
Reporting period start date
Reporting period end date
Frequency of M&V reports

19.3. M&V Data Collection Activities

Reporting period start time
Reporting period end time
Energy and key parameter data
Independent variable data
Static factor data
Description of inspection/operational verification activities conducted and findings

19.4. Savings Calculation and Methodology

19.4.1. Method overview

[Give an overview of the savings calculation method]

19.4.2. Method details

[Describe how the savings are calculated, including calculation details. Include the following information:

- reporting period data
- reporting regression model
- tests of regression model
- identification of the normal year
- values of independent variables in the normal year
- assessment of the range of independent variables in the baseline and the reporting period models as compared to their range in the normal year.]

19.4.3. Assumptions used in calculations

[List any assumptions made]

19.4.4. Non-routine adjustments

[Describe the baseline adjustments]

19.5. Verified savings

19.5.1. Verified savings calculations

[Insert from the calculation spreadsheet the tables of calculations. Show energy, cost and GHG savings. Graph the adjusted baseline and adjusted reporting energy in the normal year]

19.5.2. Uncertainty

[List sources of uncertainty]

[State calculated uncertainty, including any calculations]

19.5.3. Utility costs used to calculate the reported savings

[Table the utility costs used in the savings calculation]

19.5.4. Greenhouse gas emissions factors used to report savings

[Table the emissions factors used in the savings calculation]

19.6. Verified energy and cost savings compared with those estimated in the M&V plan

[Table showing verified energy, cost and GHG savings compared with those estimated from the M&V plan]

20. Appendix C2 – Baseline data

Table 10 Baseline energy and independent variables data

Date	Gas consumption (GJ)	Electricity consumption (MWh)	Production (kg)	Square root of production
30/05/2019	71.86	4.230	98,026	313
31/05/2019	132.65	5.808	217,416	466
1/06/2019	0.00	0.240	-	-
2/06/2019	0.00	0.240	-	-
3/06/2019	24.55	1.563	32,623	181
4/06/2019	119.23	5.725	202,931	450
5/06/2019	116.18	5.235	184,592	430
6/06/2019	93.15	4.321	141,698	376
7/06/2019	117.71	5.393	196,769	444
8/06/2019	0.00	0.240	-	-
9/06/2019	0.00	0.240	-	-
10/06/2019	0.00	0.240	-	-
11/06/2019	79.81	3.867	137,077	370
12/06/2019	79.72	4.862	115,338	340
13/06/2019	67.31	4.503	100,912	318
14/06/2019	88.83	4.890	151,444	389
15/06/2019	0.82	0.313	351	19
16/06/2019	0.00	0.240	-	-
17/06/2019	31.71	2.322	35,574	189
18/06/2019	87.70	5.380	109,546	331
19/06/2019	59.13	3.886	83,693	289
20/06/2019	70.68	4.471	125,093	354

Date	Gas consumption (GJ)	Electricity consumption (MWh)	Production (kg)	Square root of production
21/06/2019	116.66	5.835	190,907	437
22/06/2019	0.00	0.240	-	-
23/06/2019	0.00	0.240	-	-
24/06/2019	33.47	2.977	56,642	238
25/06/2019	77.86	5.228	121,762	349
26/06/2019	109.64	5.618	166,185	408
27/06/2019	76.02	4.920	86,182	294
28/06/2019	86.30	5.287	140,307	375
29/06/2019	0.00	0.240	-	-
30/06/2019	0.00	0.241	-	-
1/07/2019	0.00	0.240	-	-
2/07/2019	41.93	2.779	75,794	275
3/07/2019	27.86	2.868	38,807	197
4/07/2019	56.98	4.210	76,860	277
5/07/2019	60.67	5.227	107,477	328
6/07/2019	0.00	0.241	-	-
7/07/2019	0.00	0.240	-	-
8/07/2019	19.73	1.849	29,524	172
10/07/2019	82.83	5.592	76,405	276
11/07/2019	53.08	5.435	84,473	291
12/07/2019	68.14	4.647	39,504	199
13/07/2019	35.34	0.000	-	-
14/07/2019	0.00	0.000	-	-
15/07/2019	0.00	3.583	61,753	249
16/07/2019	43.66	5.598	101,175	318

Date	Gas consumption (GJ)	Electricity consumption (MWh)	Production (kg)	Square root of production
17/07/2019	73.23	5.576	162,635	403
18/07/2019	94.19	5.572	209,005	457
19/07/2019	120.58	5.257	175,312	419
20/07/2019	117.12	0.117	142	12
21/07/2019	0.71	1.041	36,243	190
22/07/2019	27.89	4.744	182,161	427
23/07/2019	104.12	5.272	133,804	366
24/07/2019	87.93	4.060	86,578	294
25/07/2019	56.63	5.541	191,108	437
26/07/2019	114.27	5.533	194,043	441
27/07/2019	124.28	1.622	39,422	199
28/07/2019	26.31	0.451	-	-
29/07/2019	2.48	3.724	63,837	253
30/07/2019	44.61	5.533	162,901	404
31/07/2019	100.59	5.582	114,845	339
1/08/2019	73.21	5.556	231,762	481
2/08/2019	126.08	5.514	155,713	395
3/08/2019	96.86	0.133	4,007	63
4/08/2019	0.96	0.000	-	-
5/08/2019	0.00	1.528	34,074	185
6/08/2019	19.45	4.724	125,134	354
7/08/2019	68.09	5.573	151,080	389
8/08/2019	104.60	5.490	198,122	445
9/08/2019	127.82	5.576	155,669	395
10/08/2019	101.41	1.512	20,817	144

Date	Gas consumption (GJ)	Electricity consumption (MWh)	Production (kg)	Square root of production
11/08/2019	17.59	0.000	-	-
12/08/2019	0.00	3.557	41,164	203
13/08/2019	39.25	5.575	143,230	378
14/08/2019	97.38	5.582	187,464	433
15/08/2019	102.43	5.594	174,298	417
16/08/2019	114.24	5.600	145,455	381
17/08/2019	96.17	0.000	-	-
18/08/2019	0.00	0.000	-	-
19/08/2019	0.00	3.560	90,090	300
20/08/2019	64.80	5.465	187,919	433
21/08/2019	123.76	5.588	139,486	373
22/08/2019	81.75	5.581	102,364	320
23/08/2019	71.32	4.577	80,322	283
24/08/2019	57.92	0.000	-	-
25/08/2019	0.00	0.000	-	-
26/08/2019	0.00	3.643	134,731	367
27/08/2019	80.26	5.569	209,432	458
28/08/2019	125.69	5.116	121,762	349
29/08/2019	86.31	5.575	111,151	333
30/08/2019	82.77	5.339	113,924	338
31/08/2019	78.71	0.060	1,200	35
1/09/2019	0.37	0.000	-	-
2/09/2019	0.00	2.047	41,586	204
3/09/2019	28.47	3.817	41,805	204
4/09/2019	30.90	4.919	127,895	358

Date	Gas consumption (GJ)	Electricity consumption (MWh)	Production (kg)	Square root of production
5/09/2019	76.73	2.913	58,697	242
6/09/2019	40.06	4.801	127,524	357
7/09/2019	70.00	0.000	-	-
8/09/2019	0.00	0.000	-	-
9/09/2019	0.00	3.708	117,854	343
10/09/2019	75.22	5.549	211,952	460
11/09/2019	117.73	5.490	223,092	472
12/09/2019	134.33	5.637	137,207	370
13/09/2019	75.11	5.478	84,180	290
14/09/2019	59.55	0.203	2,928	54
15/09/2019	0.46	0.000	-	-
16/09/2019	0.00	3.555	135,747	368
17/09/2019	80.65	5.581	238,042	488
18/09/2019	130.37	5.501	176,505	420
19/09/2019	101.41	4.111	76,606	277
20/09/2019	51.76	3.587	50,532	225
21/09/2019	31.59	0.000	-	-
22/09/2019	0.00	0.008	-	-
23/09/2019	0.00	3.531	63,532	252
24/09/2019	42.99	5.317	185,423	431
25/09/2019	115.16	5.415	214,767	463
26/09/2019	122.76	5.383	186,364	432
27/09/2019	105.40	4.036	112,956	336
28/09/2019	66.07	0.001	-	-
29/09/2019	0.00	0.000	-	-

Date	Gas consumption (GJ)	Electricity consumption (MWh)	Production (kg)	Square root of production
30/09/2019	0.00	3.381	89,217	299
1/10/2019	52.74	3.021	82,947	288
2/10/2019	45.90	4.302	90,291	300
3/10/2019	59.89	3.737	81,308	285
4/10/2019	42.33	1.002	21,669	147
5/10/2019	13.34	0.000	-	-
6/10/2019	0.00	0.001	-	-
7/10/2019	0.00	0.000	-	-
8/10/2019	0.00	3.384	25,980	161
9/10/2019	17.78	5.567	88,814	298
10/10/2019	54.29	5.472	162,153	403
11/10/2019	94.46	4.822	103,895	322
12/10/2019	51.68	0.000	-	-
13/10/2019	0.00	0.000	-	-
14/10/2019	0.00	2.615	27,577	166
15/10/2019	15.86	3.176	98,518	314
16/10/2019	50.51	5.064	173,835	417
17/10/2019	92.29	5.229	124,048	352
18/10/2019	67.20	2.671	32,030	179
19/10/2019	23.12	0.537	-	-
20/10/2019	0.00	0.000	-	-
21/10/2019	0.00	1.869	36,882	192
22/10/2019	24.83	4.993	182,603	427
23/10/2019	92.70	5.521	163,874	405
24/10/2019	80.66	3.641	76,375	276

Date	Gas consumption (GJ)	Electricity consumption (MWh)	Production (kg)	Square root of production
25/10/2019	36.16	2.229	74,430	273
26/10/2019	33.58	0.000	-	-
27/10/2019	0.00	0.000	-	-
28/10/2019	0.00	3.138	45,468	213
29/10/2019	30.25	5.487	200,703	448
30/10/2019	105.33	5.484	179,008	423
31/10/2019	92.70	3.936	93,173	305
1/11/2019	45.97	1.943	86,267	294
2/11/2019	35.17	0.000	-	-
3/11/2019	0.00	0.000	-	-
4/11/2019	0.00	1.158	42,044	205
5/11/2019	22.21	3.757	24,573	157
6/11/2019	14.46	2.392	49,235	222
7/11/2019	30.64	5.567	89,653	299
8/11/2019	56.62	5.056	43,489	209

21. Appendix C3 – Energy audit

- Not provided due to commercial confidentiality

For more information about the Energy Security Safeguard

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Email: sustainability@environment.nsw.gov.au