Template/Example

Measurement and Verification Plan

For Client/Project

(Option B Small Project)

# Document Control

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| Revision No. | Date | Author | Reviewed | Approved |
| 0 | 1 April 2019 | Jack Smith | Jane Smith | John Smith |
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| Facility and Project Overview |
| Stakeholders and Project Team | **Client:** Food Manufacturer**Client Rep:** Plant Manager**Project Manager:** Joe Blogs (Refrigeration Eng)**M&V Specialist:** Jack Smith (independent) |
| Description of the Site/Facility | Location: 123 Smith DriveType: Food Manufacturing Plant* Large refrigeration system to store a frozen food line
* Refrigeration System has a number of compressors controlled be an aging step logic control system.
 |
| Project Description | Replace aging step logic control system with PLC System to regulate the loading and unloading of refrigeration compressors.  |
| M&V Requirements and Key Outcomes | The Plant Manager is required to demonstrate that the ROI will be achieved within 5 years (with 90% probability). |

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| ECM Intent |
| ECM Description: | Upgrade refrigeration control system. |
| Savings achieved by: | Reduce un-necessary run time of compressors. |
| Affected Equipment: | * Step Logic Controlled Refrigeration System
* Consumes 1,240,330 kWh (last 12 month)
 |
| Expected Savings: | 154,000 kWh ($20.000) per annum |

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| IPMVP Option and Measurement Boundary |
| M&V Option: | Option B: All Parameter Measurement |
| Measurement Boundary: | Electrical supply to refrigeration system which powers evaporator and condenser fans, compressors and controls. |
| Interactive Effects: | Nil. |

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| Baseline Definition |
| Period: | A four week period was sufficiently long enough period to observe all operating condition (i.e. production) variances. |
| Energy (and Demand) Data: | Average daily energy consumption of the refrigeration system – recorded via check meter installed prior to baseline period |
| Independent Variables: | 1. Operating hours of Refrigeration system – recorded via electrical sub meter. The daily and weekly hours are expected to be similar for both the baseline and reporting periods.
2. Ambient Air Temp (data from local weather station) – it expected that a linear regression model will be developed to adjust the baseline for variances in cooling degree days.
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| Equipment Inventory  | * 5 x 64 kWe Compressor (total 320 kWe)
* Step Logic Control System
 |
| Static Factors: | * Freezer temperature set point: -12oC
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| Reporting Period |
| Period: | A four week period to match the baseline period. |
| Frequency: | Continuous logging of refrigeration system electrical energy consumption. |
| Measurements: | Electrical energy consumption measured by submeter on supply to refrigeration system. |

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| Basis for Adjustment |
| Conditions | Baseline consumption will be adjusted to Reporting period conditions (i.e. avoided energy use). |
| Routine Adjustments | A baseline model will be developed for changes in ambient air temperature (cooling degree days) and refrigeration system operating hours to adjust the baseline to the reporting period conditions. |
| Non-routine Adjustments | Should any Refrigeration System faults or operating parameter changes (i.e. Freezer Temp set point) be detected during the baseline or reporting periods, then corresponding adjustments with be made. |

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| Calculation Methodology and Analysis Procedure |
| Data Analysis Procedures: | Electrical sub meter kWh data (consumption and demand) will be obtained for the 4 week baseline and reporting periods. The average daily kWh consumption for both periods will be calculated. The Baseline model will be developed for cooling degree days. The model will then be adjusted for the reporting period conditions (i.e. CDD). |
| Savings Calculation Methodology: | Energy Savings are calculated using the following equation:kWhsavings = (average daily kWhbase – average daily kWhreporting) x 365 days ± adjustments |
| Assumptions: | Refrigeration system operates 24 hours 7 days during the Baseline and Reporting Periods. This will be verified via the electrical energy meter data. |

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| Energy Prices |
| Electricity: | Blended rate of 13 cents per kWh to be used for the valuation of all energy savings |

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| Meter Specifications |
| Electrical sub Meter: | Merlin Gerin PM800 kWh |
| Meter Accuracy = ±1%  |
| Meter Reading and Witnessing protocol | Not applicable. |
| Lost measurements record plan | Meter energy data will be uploaded on a weekly basis. Should any data be lost during any given week then the baseline or reporting periods will be extended for a further week to ensure lost data does not impact on the savings assessment. |

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| Monitoring Responsibilities |
| Operational Verification: | Joe Blogs (Project Manager) |
| Collecting Energy Data: | Joe Blogs (Project Manager) |
| Collecting Independent Variable Data: | Jack Smith (M&V Specialist) |
| Collecting Static Factors: | Joe Blogs (Project Manager) |
| Analysing collected data: | Jack Smith (M&V Specialist) |
| Reporting Savings: | Jack Smith (M&V Specialist) |

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| Expected Accuracy |
| Required level of Accuracy and Precision | Results to be reported with 90% probability (confidence) and ±10% precision |
| Metering equipment measurement standard error calculation | $$SE\_{metering}=\frac{meter relative precision∙measured value}{t}$$Where t = t-statistic for infinite sample sizes Energy Meter Accuracy = ±1%.At the required 90% confidence level the Standard Error of measurement by this meter will be calculated as:$$SE\_{metering} =\frac{0.01∙kWh}{1.645}=0.006 kWh\_{}$$Where 1.645 is the t-value @ 90% confidence  |
| Sampling Error Calculation | Number of samples (n) = 28 (7 days x 4 weeks) average daily kWh are being taken for each period.Sampling Standard Error Calculation undertaken as both periods using the following equations: * Sample Mean: $\overline{Y} =\frac{\sum\_{}^{}Y\_{i}}{n}$
* Sample Variance: $s^{2}=\frac{\sum\_{}^{}(Y\_{i}-\overline{Y})^{2}}{n-1}$
* Sample Standard Deviation: $s= \sqrt{s^{2}}$
* Standard Error of Mean: $SE\_{sample} =\frac{s}{\sqrt{n}}$
 |
| Modelling Uncertainty Calculation | The modelling standard error will be calculated once the baseline model has been developed. |
| Savings Assessment Uncertainty Calculation | Savings Assessment Uncertainty Formula:$$SE\_{daily savings}=\sqrt{(SE\_{baseline})^{2}+(SE\_{Reporting })^{2}}$$Where:$$SE\_{baseline}=\sqrt{(SE\_{sampling})^{2}+ (SE\_{Measurement})^{2}+(SE\_{Modelling})^{2}}$$$$SE\_{reporting}=\sqrt{(SE\_{sampling})^{2}+ (SE\_{Measurement})^{2}+(SE\_{Modelling})^{2}}$$To calculate the confidence interval for the estimated savings ($\hat{x}$):* $\hat{x}-t∙SE\left(\hat{x}\right)\leq x\leq \hat{x}+t.SE(\hat{x})$

where:* Absolute Precision $\left(\hat{x}\right)=t∙SE(\hat{x})$
* Relative Precision $\left(\hat{x}\right)=\frac{t∙SE(\hat{x})}{(\hat{x})}$

and: t is the t-value for (n-1) degrees of freedom  |
| M&V Budget |
| M&V Plan | $450 excl GST (3 hours @ $150 per hour) |
| Measurements | $1,440 excl GST (16 hours for electrician) |
| Report | $300 excl GST (2 hours @ $150 per hour)  |
| Total Budget | $2,190 excl GST |

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| Report Format |
|  | The report will include at a minimum the following information:* Project background
* ECM description
* M&V Option chosen for the ECM or project
* Reporting period start and end dates
* M&V activities conducted during the reporting period, including:
* Start and end time for the measurement period
* Energy use data
* Data for independent and static variables
* Description of inspection activities conducted
* Verified saving calculations and methodology
* Provide detailed description of data analysis and methodology
* Provide an updated list of assumptions and source of data used in the calculations
* Provide details of any baseline or saving adjustments including both routine and non-routine adjustments to account for changes
* Provide details of utility costs used to calculate the reported savings
* Clear presentation of verified energy, cost savings and comparison to the proposed savings.
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| Quality Assurance |
| Data gathering quality | CMVP will be analysing and verifying |
| Data errors | Low risk with accurate sub meter data and published weather station data. |
| Missing data | * M&V Plan – authored by CMVP (Jack Smith)
* Baseline and Reporting Power Readings taken by Registered Electrician with calibrated Fluke True RMS power meter
* M&V report prepared by CMVP (Jack Smith) and reviewed/approved by Client Rep (Jane Smith).
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| Verified Savings | CMVP over sight |
| Operation Performance | Project Manager is also the site refrigeration engineer and therefore accountable for operational performance. |