Greenest
A BREATH OF FRESH AIR

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SAVINGS VERIFIED UTILISING IPMVP

International Performance
Measurement & Verification Protocol

(Option B)

Goals

The overall aim of this test is to prove the energy savings achieved through the installation of appropriate Energy Saving Devices (ESDs), whilst maintaining the required cooling performance.

The success of the trial will be appraised against the specific energy saving goals and the ability to maintain temperature performance of the customer's refrigeration compressors.

Site & Test Installation

Greenest undertakes a detailed evaluation of the customer's site and equipment during a technical site survey. This section would clearly identify the equipment to be included in the evaluation.

Test Methodology

Tests will adhere to the *International Performance of Measurement & Verification Protocol (IPMVP) Option B:* Retrofit Isolation - All Parameter Measurement, where the performance of a single Energy Conservation Measure (ECM) can be measured independently of the rest of the facility. Testing will be performed using an alternate week ON / week OFF strategy to establish the variance in energy usage attributable to the Greenest installation.

Test Boundary

Energy usage of a cooling system is dependent on several factors, such as cooling demand and system efficiency, both of which may vary independent of the installation of the energy saving device. Therefore, undertaking reliable and accurate monitoring and verification relies on establishing the factors that affect energy usage and managing them appropriately during the test. The test boundary technique has been used to identify the system under test, the factors that affect the system and then how this test will handle those factors. Items wholly within the test boundary are

Chart Showing The Daily kWh Usage of Freezer 1 & Freezer 2

classified as constants, which are to be kept consistent through-out the test. Items that come across the test boundary are classified as variables, which need to be measured and accounted for in the results.
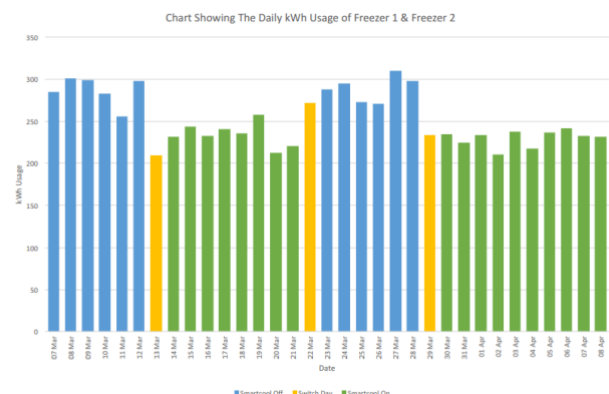
Constants

Parameters that can be maintained at a uniform level throughout the period of the test are considered constants. However, it is not assumed that these factors will remain constant. If possible, they will still be measured or observed, to ensure that they do remain consistent. For this test, the constant factors and the monitoring methods are as follows:
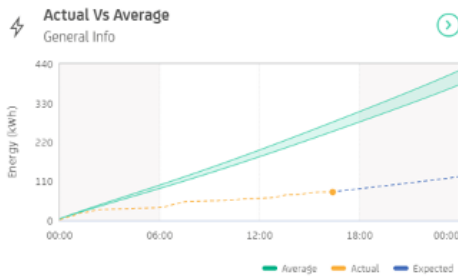
1) System Settings & Set-Points – Monitored using a combination of available data including the customer's own monitoring data on system operating temperatures and pressures, observing work done to the system during the test and awareness of any changes made to the system during the test.

2) System Maintenance, Repairs & Alterations – Greenest will monitor work being undertaken on the refrigeration systems by engaging with the customer's maintenance team and observing the equipment during the trial.

3) Building Heating, Ventilation & Air-conditioning – Greenest will monitor the temperature and performance of the system using available data that can include the customer's own building management system data, additional temperature loggers installed in the controlled space, observations made during the test by Greenest or any system maintenance personnel.

A change to the Constant parameters may impact the validity and accuracy of the trial. Any changes observed or required during the trial this must be reported to the Project Manager leading the trial so that appropriate control action can be taken. All control action's will be discussed and agreed between Greenest and the customer but may involve, restarting the trail, extending the trial, excluding certain time periods from the results or other appropriate actions.

Independent Variables

Factors that affect energy usage of the system which cannot be maintained as constants through the trial they are considered as independent variables. These factors are measured throughout the trial and then accounted for within the analysis of results. The independent variables of this test and the measurement method are as follows:

1) Ambient Temperature – Weather station data the Panoramic Power / Centrica Energy Insights platform
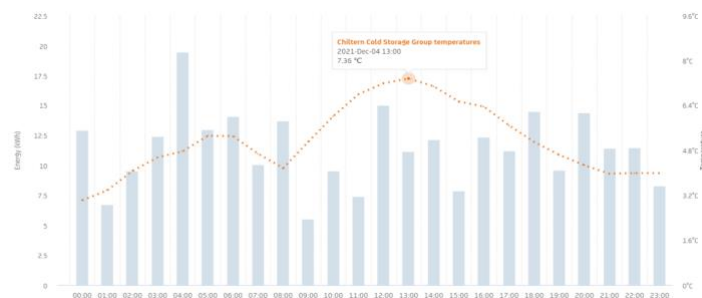
2) Trading Patterns – This is assumed to follow a consistent weekly pattern, so variability is to be accounted for by considering the weekday of the energy usage within the analysis, specifically by splitting the analysis by weekday as described below. Exceptional trading events, such as holiday/seasonal trading days, power cuts etc. are to be excluded by omitting this data from the results.

Measurement of Energy Usage

Energy usage is the dependent variable and will be measured by energy metering using measuring devices. The energy measuring device will be fitted so that it records only the energy used by the compressor under test. The energy measuring device will be installed and removed by a qualified Greenest technician. The energy measuring device will at 1-minute intervals measure voltage, 3-phase current, which will be used to calculate kW and kWh. Data will be downloaded from the energy measuring device as a .csv file, a copy of which will be retained by Greenest indefinitely.

If possible, the customer will make available the previous 1-year of energy data from the systems under test. This data will be used to produce a historic energy baseline, which will be compared against the data collected during the trial to ensure that the test accurately reflects the regular energy usage of these packs.

Other Required Measurements

Controlled space temperatures will be measured by temperature energy measuring devices or by the customer's own building management system. These will be reviewed during and after the trial to ensure that all controlled space on the systems under test maintained the temperatures required by the customer.

Data Analysis

On completion of the trial analysis of the raw data is required to produce an accurate, coherent, and reliable result. All the raw data will be made available upon request, if either party wishes to undertake further analysis. The following techniques will be used to analyse the data:
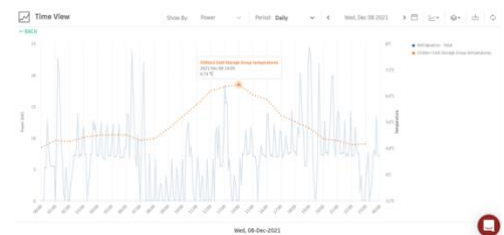
1) Daily Summary – Irrespective of how the data is collected or recorded, it will be summarised into daily totals or averages for ease of evaluation and analysis.

2) Discarded Data – Sections of data (not less than a single day) may be removed from the analysis if it has been affected by known inconsistencies or is anomalous to the rest of the data set. Discarded data may include days/periods where constants were known to have been not uniform i.e. temporary set-point change, or the 'switch' days where the ESD is switch OFF/ON. All discarded days along with the reason for removing will be listed in the main section of the results.

3) Regression Analysis – The relationship between the energy usage and the Independent Variables will be established by analysing separately for ON days and OFF days, so that the effect of the independent variables on energy usage is known for both cases. The quality of the relationship identified will comply with the International Monitoring and Verification protocol (option B).

4) Split Analysis by Operational – As operational hours and product volume is not easily and accurately measurable, it cannot be accounted for within a regression analysis. However, it can be accounted for by undertaking the

regression analysis separately for days of similar operational hours and product volume, particularly where this is a regular weekly pattern. Once the split analysis is complete, the results can be re combined to give an average % or daily kWh saving (i.e. weighted to the number of days in the split).

Summary of Test Factors

Factor	Type	Measurement Method	Analysis Method
Energy Usage	Primary	Panoramic Power/Centric Energy Insights	Regression Analysis, result reviewed against trial goals.
Ambient Temperature	Independent Variable	Panoramic Power uses Open Weather service to get data into PowerRadar. https:home.openweathermap.org/subscriptions Data is collected once per hour, location is based on site coordinates.	Regression Analysis
Trading Variations	Independent Variable	Trading hours and footfall assumed to be constant over a consistent weekly cycle.	Split Analysis by weekday & Discarded data
System Settings & Setpoints	Constant	Customer system temperature monitoring data, third party logger temperature data, monitoring of maintenance to the system, on-site observation and measurement , engagement with system maintainer.	N/A
System Maintenance, Repairs & Alterations	Constant	Monitoring or maintenance to the system, on-site observation and measurement, engagement with system maintainer	N/A
Building Controls, Heating, Ventilation & Airconditioning	Constant	Customer controlled space temperature data, third party temperature logger data, monitoring of maintenance to the system, on-site observation and measurement, engagement with system maintainer.	N/A

Required Steps

1) Installation - Install the measuring devices and Energy Saving Device components that are required for the existing refrigeration systems, as outlined in the Greenest proposal previously made to the customer. Additional baseline data will be collected prior to the start of the test.

2) Full Test 4 weeks duration - After the installation and commissioning is complete and Greenest's technical representative is satisfied with the operation of the system, the test will begin. The test will run for a four-week period with the Energy saving measuring devices switching from Bypass mode (OFF) to Run mode (ON) after the completion of Week 1. While in Bypass, the ESM will have no effect on the operation of the customer's refrigeration system.

Proposed Test Period

Task	Period	Date
Smartcool Installation and Data Logger Fitting	Day 0	
Week 1 – Test OFF	Day 1-7	
Site Visit & Data Collection	Day 7	
Week 2 Test ON	Day 7 - 14	
Site Visit & Data Collection	Day 14	
Week 3 Test OFF	Day 14-21	
Site Visit & Data Collection	Day 21	
Week 4 – Test ON	Day 21 - 28	
Site Visit & Data Collection	Day 28	

Proof of Savings

At the conclusion of the test period a comparison of the temperature and kWh data will be created, and a savings report will be presented. The report will provide details of any financial and environmental benefits and outline the cost effectiveness of the installation of the ECO3 and/or ESM units. The M&V test will be considered successful if the projected savings based on trial data are 90% or more of the kWh figure quoted in the 'Goals'.