Scalloway Harbour Data Logging Summary And Analysis:

Development Of Tool And Analysis Of Data From Installed Datalogger

E-Harbours towards sustainable, clean and energetic innovative harbour cities in the North Sea Region

ACKNOWLEDGEMENT

This report has been realised with the support and input of many experts. We thank all those who have provided input and contributions and helped to shape the document. We also tanks The Interreg IVB North Sea Region Program for supporting this project.

EXECUTIVE SUMMARY

This report has been carried out as part of a pan European project called **E-Harbours, E-Logistics in NSR Harbour Cities**, awarded by the Interreg IVB North Sea Region Programme.

The report presents the Pure Data Analysis Tool (PureDAT) developed by Pure Energy Centre. The PureDAT is a must have tool when it comes to analysing energy data. It aims at substantially reducing the time it takes to analyse energy data logged on a given harbour site. In this particular case, the large amount of data collated from the Scalloway harbour has been analysed using the PureDAT. From the PureDAT different analysis displays, a series of recommendations for one of the organization within Scalloway harbour have been derived and are provided in this document-.

In essence, the remote monitoring system that has been installed at Scalloway Harbour has logged many parameters such as electrical consumption, weather data, temperature parameters, oil consumption amongst many others. This resulted in a large amount of data being logged for a period of just over 12 months. In fact, in excess of 15 billion values have been logged and stored electronically. When the logging period ended, these data needed to be analysed.

Because of the share volume of data collated, it was almost impossible to quickly and easily make any meaningful interpretation of the key information contained within the data. As such, it was identified that there is a need for a specialised tool to support a quick and accurate interpretation of the data. Such a tool must have well defined methodologies to assess and process intelligently the information contained in the Scalloway Harbour logged data (and other harbours data if need be).

Unfortunately, it was found that no tools have been developed specifically for an easy post analysis of data logged within a harbour setup. Therefore a tool has been developed by the Pure Energy Centre Team for this particular purpose.

The tool is able to process large amount of data and obtain user friendly diagrams. The tool extracts the data logged from the harbour and produces a number of graphics including a quick one pager summary of the most important parameters that needs the user attention.

Of high interest, this tool has been built so that it can be used in conjunction with any type of data logger output files, and thereby can be used in conjunction with a universal data logging strategy (as developed by the Pure Energy Centre throughout the e-harbour project).

To illustrate the value added of the PureDAT, this report presents an analysis of the Energy Consumption of processing activities of an organisation within Scalloway Harbour. The analysis is based on the information collected on site by means of energy data-loggers, sensors, electricity bills, site assessment and targeted questionnaires and visualised using the Pure Data Analysis Tool.

Finally, this document describes the Energy recommendations derived from the PureDAT

diagrams and that allow achieving the following objectives:

- Maximise Energy savings measures
- Increase uptake of Renewables
- Improve efficiency of the Processing plant activities
- Identify deferrable loads
- Reduce Electricity expenditures

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INTRODUCTION

The implementation of the Universal Energy Monitoring Strategy for Scalloway Harbour has been described in a previous report (report 6). This has provided a comprehensive methodology on how to monitor the energy consumption of processes and activities within a given harbour area.

The Energy strategy suggests using sensors and data loggers for acquiring information on weather condition and energy consumption of processes, where preliminary information (such as electricity bills and reports) are not available or not sufficient to build a complete energy assessment of the harbour. In fact by using monitoring equipment it is possible to reduce some of the uncertainty on how and when the energy is used within a harbour.

As a result of the energy strategy, a series of data loggers have been installed within the harbour area for about 12 months. The dataloggers have logged many parameters such as electrical consumption, weather data, temperature, oil consumption and others. This result in excess of 15 billion values being logged and stored electronically.

The processing of this large amount of data cannot be done manually. It is only possible by using an automatic data analysis tool that provides a quick meaningful interpretation of the process monitored.

Unfortunately there is no such analysis tool currently available on the market and specifically developed for Harbour environment. Therefore, this report described an analysis data tools developed by the Pure Energy Centre.

The tool has been developed by using advanced computer programming language for assessing intelligently large amount of data. It includes a user-friendly graphic interface that provides guidelines on using the tool and provides quick and intuitive output results based on the type of analysis selected.

The tool has been developed with the aim to process output data from different type of data logger. Therefore, it is possible to extend the use of the tool and to apply it to other harbours and other types of dataloggers. Hence the monitoring strategy is applicable universally to other small and medium harbours (and even larger ones).

The information collected on site by means of energy data-loggers, sensors, electricity bills, site assessment and targeted questionnaires and the information obtained by using the Pure Data Analysis Tool have provided a comprehensive picture on how and when energy is used as well as illustrated the performance of the different processes implemented in the harbour.

As result of the information acquired and the analysis conducted, a set of recommendations have been given as guidelines for Harbour stakeholders on achieving the following objectives:

- Identify energy savings measures
- Increase the local generation of energy by means of Renewables Energy.

- Reduce carbon footprint
- Improve efficiency of the Processing plant activities
- Reduce Electricity expenditures.

The results of the analysis are presented in this report for one organisation operating in Scalloway harbour. Due to confidentiality of the information included in this report the name and any reference to the activity conducted by this organisation has not been revealed.

For this reason the organisation described in this report is referred with the generic name "Shetland Business" (SB).

AIMS AND OBJECTIVES

The E-harbours Project as a whole aims to create a lasting change towards sustainable energy logistics for North Sea Region harbour cities. It aims at setting innovative energy standards to create a transformation of the energy network in harbour areas.

This report intends to provide a description of the Pure Data Analysis tool developed by Pure Energy centre for assessing and processing large amount of monitoring data.

In addition the report presents the outcomes and results of the Energy Analysis for the Shetland Business operating in Scalloway Harbour.

The analysis of the energy assessment of Scalloway harbour includes a series of recommendations for the harbour's stakeholders with the aim to support the decision-making process on improving the energy footprint of the harbour.

KEY FINDINGS

1. Large amount of data can be processed and analysed quickly and efficiently.

2. It is possible to extract information from data logged with the use of an automatic Data analysis tool.

3. Most of Energy Data loggers have a common output format.

4. Harbour energy sustainability can be improved by following recommendation provided in this report.

5. Stakeholders can prioritise the investment in a harbour environment by using the report recommendations.

6. The organisation Shetland Business has consumed about 1.2GWh of Energy for its activities in 2012.

7. Due to the high dependence of the market in which Scalloway organisations operate the working days are dictated by external conditions and therefore are not flexible time-wise.

8. The Shetland Business has a recurring behaviour on how electricity is used during each working day.

9. Wind Energy is not suitable for Shetland Business (SB) due to the limited footprint area available in the harbour and due to the high wind turbulence in the vicinity of the SB building.

10. Solar Energy can cover up to a maximum of 17.5% of the total energy consumed by SB using the current SB free roof area.

11. It is possible to reduce the energy consumed during standby periods by isolating unused appliances from the mains power supply.

12. It is possible to reduce the warming up energy consumption period by delaying the switch on of the machines till they are needed.

13. By setting up simple shut-down policy and procedures, it is possible to save about 28MWh of Energy per year.

14. SB consumed 590 MVARh of reactive energy in 2012. The installation of a Power Factor Corrector unit can reduce the cost of electricity bills by £2,100 per year.

15. Shifting the 'cleaning process' to the time just after the fish processing activity has terminated can reduce the energy consumed during the interim period.

THE PURE DATA ANALYSIS TOOL

The Pure Data analysis tool aims to process large amount of energy data in short time and to obtain meaningful information on the energy performance of the process monitored.

The tool has been developed with advanced computer programming with built-in intelligent routines for analysing large amount of data. It then represents the information on energy performance by compact and meaningful format, such as tables, statistics, and graphs.

Most of the conventional energy dataloggers currently available on the market commonly use standard CSV file format when exporting data recorded. The CSV format is a plain-text file with recorded data represented as list of value separated with comma.

The Pure Data analysis tool has been developed with the ability to import data from any type of energy datalogger output as long as the exported data have a CSV file format. This allow to increase the flexibility of the Pure Data Analysis tool and apply it to other field and dataloggers even if they are different from the one used in the Scalloway harbour and described in report 8.

The PureDAT Tool automatically process the data imported and elaborate them to provide the following outcomes:

- **Energy Statistics**: the tool provides a series of statistics on energy consumption, such as total consumption, maximum values, energy cost, etc.
- **Chart Analysis**: the tool allows the user to select a time window within the full logging period and plot graphs on energy, power and current consumed by the process.
- **Chart Exporting**: The tool allows users to export graphs with spread-sheet format. The output file is accessible by using most of spread-sheet software currently available on the web.

A screenshot of the Pure Data Analysis tool is shown in Figure 1.

Data loggers used at Scalloway Harbour have been in the field and monitored the energy consumption of process for 12 months. Each datalogger has monitored the electrical consumption of processes with 5 minutes sampling and produced a summary file for every logging day. An example of logging file exported from the dataloggers is presented in Appendix A.

The logging data contains information on how and when energy is used, some of the parameters monitored at Scalloway Harbour are: Data and time, current, voltage, power factor, frequency, active and reactive power, and others.

The Pure Data analysis tool has the ability to import and process large amount of data. It can import and process more than 1 million monitoring data; this is equivalent to about 10 years of data when a sampling time of 5 minutes is used.

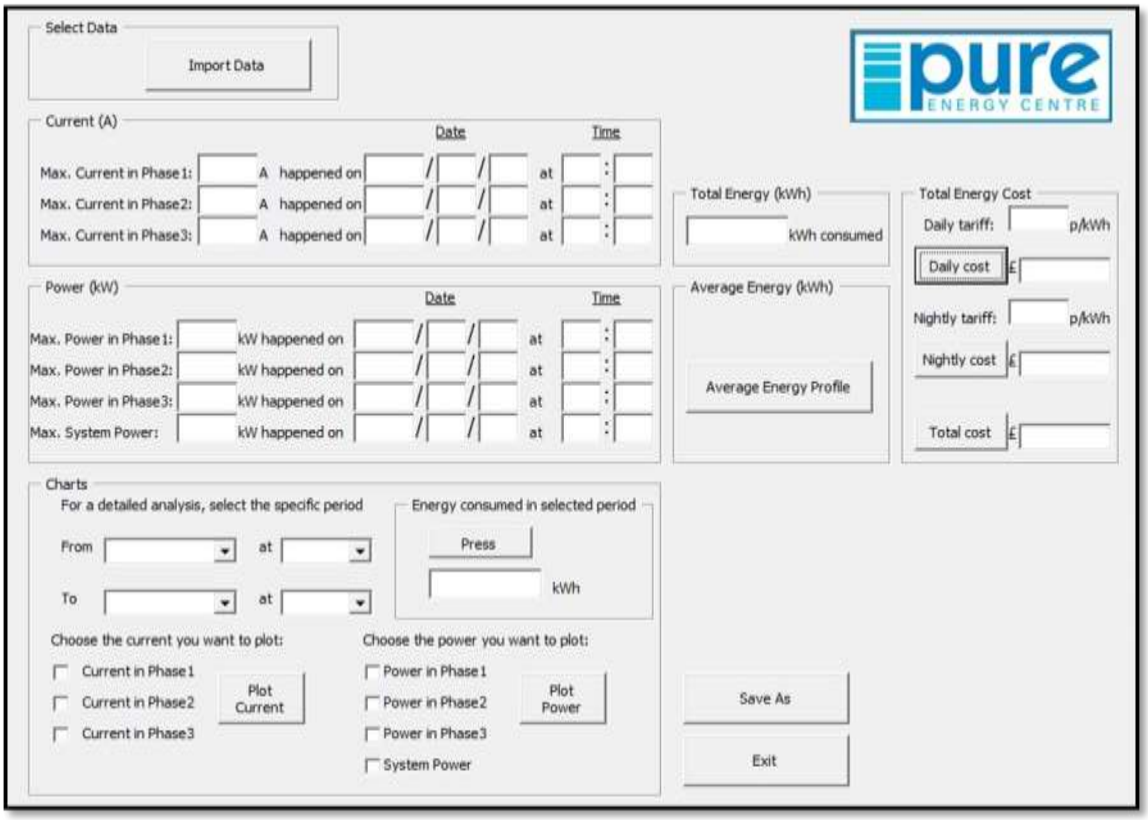

Figure 1. Pure Data Analysis tool mask

FEATURES OF THE PURE DATA ANALYSIS TOOL

The Pure Data Analysis tool is made of five (05) main areas with different functionalities. These are shown in figure 2 with highlighted colours.

- **Import Data**: This section is highlighted in Blue colour. When a user selects the Import button, a mask prompts for selecting the path of the data to be imported in the Pure Data analysis tool. Once the data are imported, the tool automatically elaborates the information.

- **Energy Statistics:** This section is highlighted in red colour. After importing the data, the Pure Data Analysis tool automatically process the information and shows the energy statistics in this section. The tool identifies, within the imported data, the maximum values for current and electrical power for single and three phase systems and records the time and date on when the maximum value has occurred. In addition the total and average energy for the full period is presented.

- **Chart analysis:** This section is highlighted in orange. In this section the user could plot graphs of electrical variables within a desired period. The electrical variables are electrical current and power for both single and three phase systems and the total Energy consumption in the selected given period. The user could select a time window within the full logging period when plotting the electrical variables.

- **Cost Analysis:** This section is highlighted in green colour. If the user inserts the price of electricity for daily and night consumption, the Pure Data Analysis tool is able to provide the cost for the energy consumed during daylight and night hours and the total energy cost in the period monitored.

- **Export data:** This area is highlighted in brown colour. The user is able to export the Chart Analysis by selecting the button "Save As". A mask prompts for a path where to save the analysis.

An example of Chart analysis achieved with the Pure Data Analysis tool is presented in figure 3. It shows the daily average energy consumption for a process monitored within Scalloway Harbour.

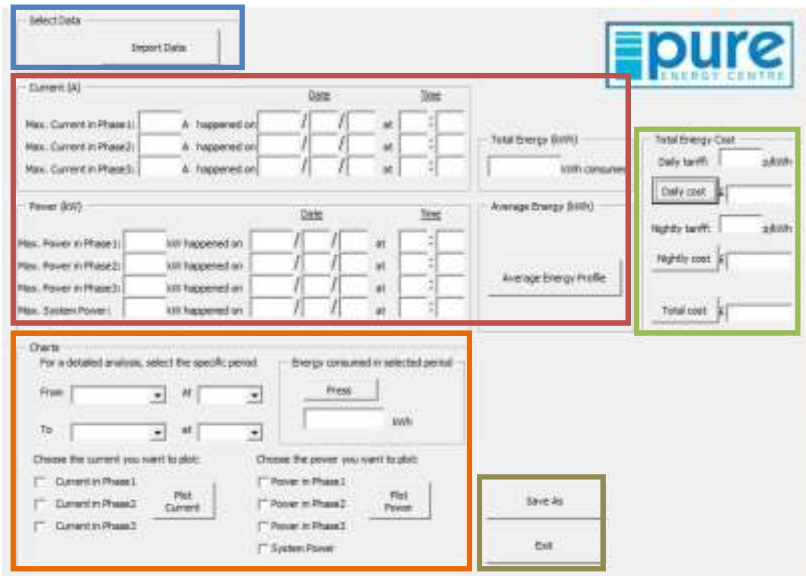

Figure 2. Functionality parts highlighted in the Pure Data analysis tool

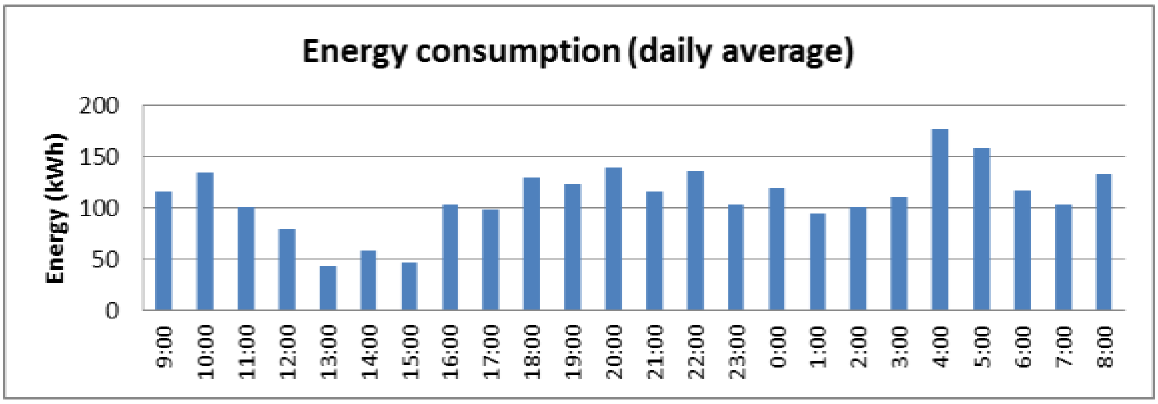

Figure 3. Example of Energy Analysis for a process monitored in Scalloway harbour

ENERGY ANALYSIS AND RECOMMENDATIONS

Shetland Business working activity is unpredictable and not constant all year round. The high dependence upon the fluctuation of landing fish to the market, the logistics constrain and in addition weather unpredictability makes it difficult to predict a steady operation of the plant at the Shetland Business.

A series of electricity Data-loggers have been installed within the plant of Shetland Business for the whole of the year 2012. The aims of the SB monitoring process are as follows:

- Identify the energy consumption behaviours for the plant
- Identify any potential waste of Energy
- Identify equipment not operating efficiently
- Identify flexibility of processes through time
- Potential integration of Renewable Energy

SHETLAND BUSINESS ENERGY USE BEHAVIOUR

It is important to understand the energy behaviour of a plant before one can derive any conclusions, improvements and provide targeted recommendation(s). Therefore, this section describes Shetland Business (SB) energy consumption behaviour.

During 2012, the total energy consumed at the SB plant was in the region of 1,102 MWh. The plant operated for 284 working days. Figure 1 shows the energy consumption of the plant for the year 2012 using PureDAT.

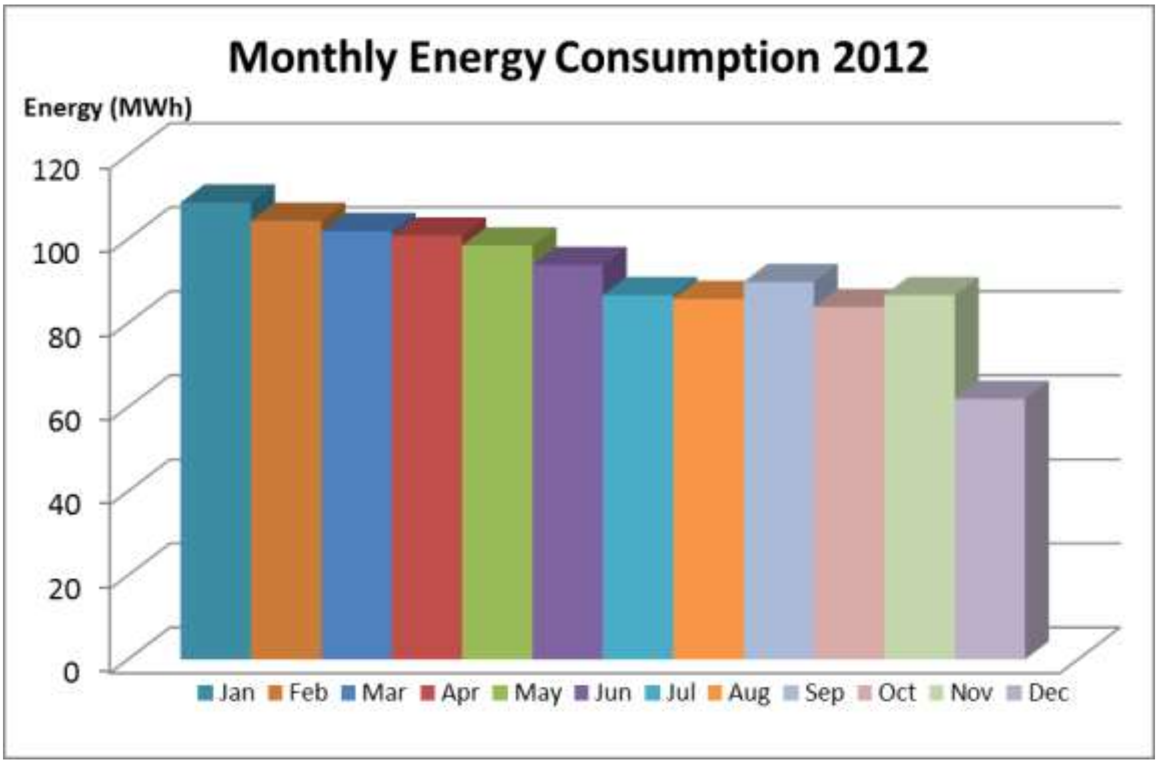

Figure 4. Energy Consumption for the plant at SB during 2012.

The higher energy consumption during the first part of the year (till March) is due to a higher business activity of the organisation.

By looking at the electrical consumption for the full 2012 year, it has been possible to record the working days of 2012. This is summarised in table 1.

Days	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Su	We	Th	Su	Tu	Fr	Su	We	Sa	Mo	Th	Sa
2	Mo	Th	Fr	Mo	We	Sa	Mo	Th	Su	Tu	Fr	Su
3	Tu	Fr	Sa	Tu	Th	Su	Tu	Fr	Mo	We	Sa	Mo
4	We	Sa	Su	We	Fr	Mo	We	Sa	Tu	Th	Su	Tu
5	Th	Su	Mo	Th	Sa	Tu	Th	Su	We	Fr	Mo	We
6	Fr	Mo	Tu	Fr	Su	We	Fr	Mo	Th	Sa	Tu	Th
7	Sa	Tu	We	Sa	Mo	Th	Sa	Tu	Fr	Su	We	Fr
8	Su	We	Th	Su	Tu	Fr	Su	We	Sa	Mo	Th	Sa
9	Mo	Th	Fr	Mo	We	Sa	Mo	Th	Su	Tu	Fr	Su
10	Tu	Fr	Sa	Tu	Th	Su	Tu	Fr	Mo	We	Sa	Mo
11	We	Sa	Su	We	Fr	Mo	We	Sa	Tu	Th	Su	Tu
12	Th	Su	Mo	Th	Sa	Tu	Th	Su	We	Fr	Mo	We
13	Fr	Mo	Tu	Fr	Su	We	Fr	Mo	Th	Sa	Tu	Th
14	Sa	Tu	We	Sa	Mo	Th	Sa	Tu	Fr	Su	We	Fr
15	Su	We	Th	Su	Tu	Fr	Su	We	Sa	Mo	Th	Sa
16	Mo	Th	Fr	Mo	We	Sa	Mo	Th	Su	Tu	Fr	Su
17	Tu	Fr	Sa	Tu	Th	Su	Tu	Fr	Mo	We	Sa	Mo
18	We	Sa	Su	We	Fr	Mo	We	Sa	Tu	Th	Su	Tu
19	Th	Su	Mo	Th	Sa	Tu	Th	Su	We	Fr	Mo	We
20	Fr	Mo	Tu	Fr	Su	We	Fr	Mo	Th	Sa	Tu	Th
21	Sa	Tu	We	Sa	Mo	Th	Sa	Tu	Fr	Su	We	Fr
22	Su	We	Th	Su	Tu	Fr	Su	We	Sa	Mo	Th	Sa
23	Mo	Th	Fr	Mo	We	Sa	Mo	Th	Su	Tu	Fr	Su
24	Tu	Fr	Sa	Tu	Th	Su	Tu	Fr	Mo	We	Sa	Mo
25	We	Sa	Su	We	Fr	Mo	We	Sa	Tu	Th	Su	Tu
26	Th	Su	Mo	Th	Sa	Tu	Th	Su	We	Fr	Mo	We
27	Fr	Mo	Tu	Fr	Su	We	Fr	Mo	Th	Sa	Tu	Th
28	Sa	Tu	We	Sa	Mo	Th	Sa	Tu	Fr	Su	We	Fr
29	Su	We	Th	Su	Tu	Fr	Su	We	Sa	Mo	Th	Sa
30	Mo		Fr	Mo	We	Sa	Mo	Th	Su	Tu	Fr	Su
31	Tu		Sa		Th		Tu	Fr		We		Mo
Total Working days	**23**	**23**	**25**	**26**	**27**	**23**	**24**	**22**	**26**	**27**	**25**	**13**

Table 1. Calendar of working days[1] for SB for the year 2012.

[1] Table Cells with light green background are working days; cells with brown background are not working days, cells with grey colours are not calendars days.

As shown in Table 1, SB working days are neither scheduled nor neatly distributed between the weeks. Due to the high dependence upon external factors within which SB operates, the working days are mainly dictated by external conditions and therefore are not flexible time-wise.

Even if the schedule of the working days is neither predictable nor flexible, by analysing the trend of power consumption for each month, it has been possible to define a routine and repetitive behaviour on how electricity is used during each working day. The profile of electricity used for each working day is mostly cyclical as shown in Figure 2. The electrical consumption presents most of the time a peak from 7.00am to 3.00pm, in the range of 170-230kW. Then a medium consumption, in the mid-afternoons, with a range of 70-100kW. Finally a low power consumption at night surrounding 50kW. Though 50kW may seem low power consumption within the scheme of things, it is still considered as high power consumption when it comes to financial outlays. This requires further investigation and is discussed further in the below sections.

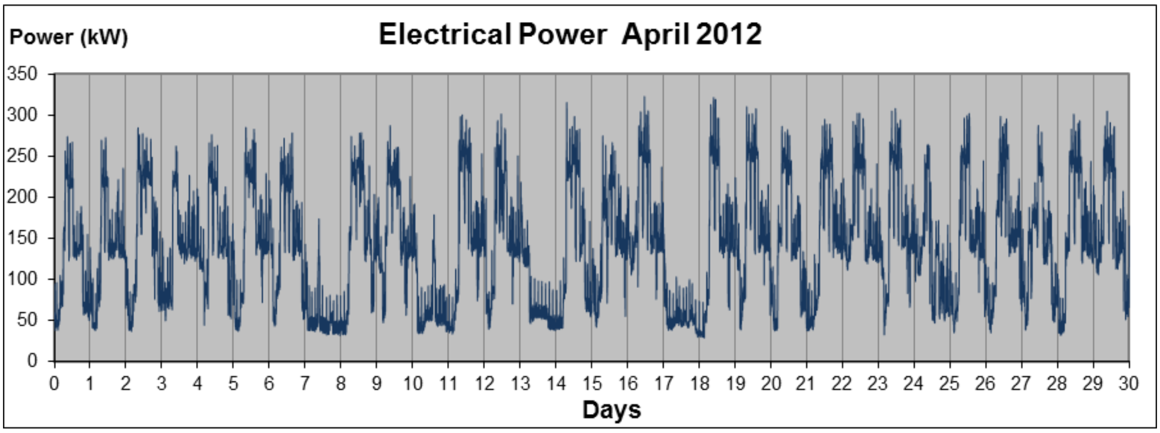

Figure 5. Cyclical electrical power consumption for April 2012.

By monitoring the full year electrical consumption and by assessing SB operation, it has been possible to identify the following activities during a typical working day.

Time/hours	Process
0:00 to 1:30	Cleaning
1:30 to 5:00	Standby
5:00 to 7:00	Warming up
7:00 to 10:00	Working
10:00 to 10:30	Break
10:30 to 13:00	Working
13:00 to 13:30	Lunch break
13:30 to 15:30	Working
15:30 to 18:00	Waiting for Cleaning
18:00 to 19:30	Cleaning
18:45 to 19:30	break
19:30 to 0:00	Cleaning

Table 2. SB plant activities for one day of operation.

Using table 2 and the data logged power consumption, it has been possible to categorise and associate each SB working activity with an electrical consumption footprint. Thus the SB average power consumption during a 24 hour period is shown in figure 6. It illustrates the different periods of low and high energy consumptions throughout the day.

Figure 6 helps in the visual understanding of what is the standard working day behaviour. It also supports the identification of where to focus the efforts in trying to reduce the energy consumption.

Of importance, there are two points that should be investigated from the below diagram (figure 6). These are the 'warm up' and 'maintenance' periods. The question is 'can these two periods be shorter' or cancelled'. If they are shorter or completely cancelled, energy consumption will automatically reduce. These two periods are further discussed in the Energy Savings Assessment section.

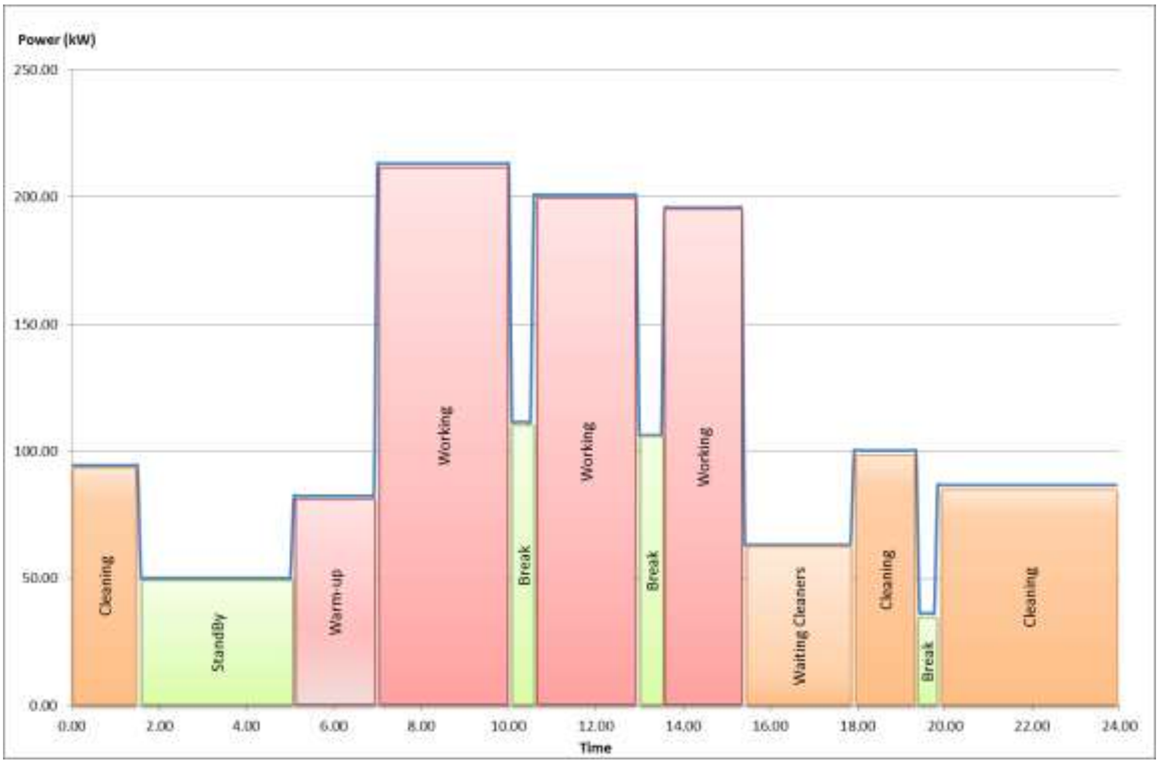

Figure 6. Average Electrical power consumption of the SB Plant.

Electricity can potentially be generated locally by a Renewable Energy System (RES). Such a system could reduce the amount of energy imported from the grid, reduce the cost of electricity consumed and therefore reduce CO2 emissions associated with the SB plant.

The Renewable Energy systems that potentially can be considered for Shetland Business have been initially shortlisted as:

- Wind Turbine
- Solar Photovoltaic

Even if The Shetland Islands have one of the best wind resource in UK and Europe, a Wind Energy System is not recommended because of the following site reasons:

Scalloway harbour has a small footprint with very congested activities and several organisations operating within the same area. Therefore there is a very little space available for installing a Wind Turbine.

The presence of wind turbulence also means that the area is not fully suitable for Wind Energy. In fact the prevailing Wind Direction in Scalloway Harbour is South West. This direction is obstructed by surrounding hills that will affect badly the performance of the Turbine for most of the Year.

Though there are substantial wind turbulences, and the area is surrounded by hills, wind could still be investigated using the weather data downloaded throughout 2012. Note that this wind investigation was not performed due to the above reasons, but can be a viable option if SB is looking to reduce its emission footprint.

Wind Energy is not suitable for Scalloway Harbour due the limited surface area available and for the high presence of wind turbulence

On the other hand Shetland Business has an extended footprint available on the rooftop that can potentially be used for installing a Solar Photovoltaic system.

The total roof surface area for SB is about 2,960 m^2. However, not all of this surface can be used for installing photovoltaics. The roof with orientation towards South, West and East can be used for photovoltaics, while the ones facing north are discarded because considered not productive.

Among the total SB roof area, it is possible to identify three (03) areas that are suitable for photovoltaics:

- **Zone A** with orientation West and surface 1,030 m^2
- **Area B** with orientation East and surface 470 m^2
- **Area C** with orientation South and surface 450 m2.

By installing the full space area available on the roof of SB, **it is possible to achieve a maximum Solar Photovoltaic System installation of 289kW.** This can be divided as follow:

- Zone A - 153 kW
- Zone B - 69 kW
- Zone C - 67 kW

The Estimation of Energy Production and the economic benefits of the Solar Photovoltaic are presented for each zone, as the solar PV will perform differently in accordance to the location and orientation.

Table 3 presents an estimate of the Energy production for the Solar Photovoltaic for the full year. The total Energy that could be generated by the solar photovoltaic is about 192.7MWh. This represents about the 17.5% of the total energy used by SB during a full year.

Solar Energy can cover about 17.5% of the total energy consumed by Shetland Business

Month	Zone A	Zone B	Zone C
January	862	351	866
February	2770	1200	2140
March	7020	3100	4300
April	12100	5390	6370
May	16200	7270	7790
June	16800	7540	7720
July	15500	6950	7250
August	12600	5650	6320
September	8190	3690	4790
October	3850	1700	2720
November	1190	511	1080
December	463	175	494
Total	97400	43500	51800

Table 3. Estimation of energy generated by the solar Photovoltaic (in kWh)

The economic and environmental benefits of a solar photovoltaic as installed at SB are as follows:

- Production of Green electricity at no cost (apart from the initial capital investment) locally with zero CO2 emission.
- Energy savings from not using imported electricity.
- Revenue income through the Feed In Tariff (FIT) Government scheme that rewards the energy generated by renewable sources.
- Selling surplus green energy exported into the grid.

Assuming 80% of the Energy generated by the photovoltaic system is used directly by SB and 20% is exported into the Grid and an electricity cost of 8.8 p£ per KWh. It is possible to summarise the economic benefits of a solar photovoltaic in table 4.

SOLAR BENEFITS	
Savings from not importing electricity	£ 13,581
FIT (Government Scheme)	£ 12,539
Sale of Exported electricity	£ 1,736
TOTAL BENEFITS (Yearly)	**£ 27,856**

Table 4. Potential yearly economic benefit of a solar photovoltaic for SB

The potential economic contribution of a solar photovoltaic for SB is estimated at about £27,000 per year

The solar photovoltaic system has an expected lifetime of 25 years with 10 year on production guaranteed of up 90% of efficiency. The average cost for a 289kW Solar Photovoltaic system that could be installed at SB is in the range of £320,000. Therefore the Solar system investment has a payback time period of about 11 years (if most of the power is used by SB).

Currently the Shetland Islands have a network grid that is restricted and with limited capacity to absorb intermittent renewable energy into the network. The ability to connect a solar system into the network requires permission and approval of the local DNO.

The current plan for developing a large Energy storage system in Shetland would facilitate the connection of Renewables into the Grid. However there is no guarantee that this option will receive granting from the grid operator.

By analysing the Average electrical power consumption of a typical working day at SB it is possible to identify the following recommendations:

Reduction of Standby power

At night periods, when there is no business activity and the cleaning process has terminated, there is still substantial energy consumption due to the Standby energy consumption of the plant. During the period between 1.30am and 5.00 am the average power consumption is about 50kW.

It is therefore recommended to reduce the night energy standby consumption by isolating standby equipment from the mains.

It is recommended to reduce the energy consumed in the Standby period by isolating from the power supply any appliances that is not operating

Reduction of Warm-up period

During early mornings and before the operation of the plant at full power, there is a warming-up period were the machines are turned from the standby status into ready to operate mode. During the period between 5.00am and 7.00 am the average power consumption is about 82kW. It is therefore recommended to reduce the warming up duration to the absolutely shortest period of time.

It is recommended to reduce the warming up period by retarding the starting of the machines till it is strictly necessary

Put in place shut-down procedures for the breaks

During working activity periods, there are usually two breaks of about 30 minutes each. During these breaks, the business activity is stopped. The first break is about at 10.00am and the second one at 13.30. By putting in place a shut-down procedure during the break periods, it is possible to save energy and therefore reduce the electricity consumption, thereby reducing electrical bills. The computed savings could be up to a maximum of £2,500, without including inflation factors.

If the shut-down procedure is guaranteed for each break, the estimated energy savings per year is about 28MWh, with a cost saving associated of £2,500 per year

Reduction of Reactive Power

Due to the nature of the electrical appliances within the SB plant, there is a large presence of inductive load that create a large reactive power being used for operating the business. The total reactive energy used during the year 2012 is about 590MVarh.

Shetland Business consumed 590MVarh of reactive energy in the 2012.

Figure 7 shows the monthly Reactive Energy consumption for Shetland Business. The use of large reactive energy causes sanctions from the Grid Supplier and leads to extra electricity costs. The incurred cost for the consumption of Reactive Energy in 2012 was £2,183. By installing a power factor corrector for plant, it will be possible to reduce the amount of reactive power used and reduce the cost of electricity bills.

The installation of a Power Factor Corrector unit can reduce the cost of electricity bills and bring savings of about £2,100 per year.

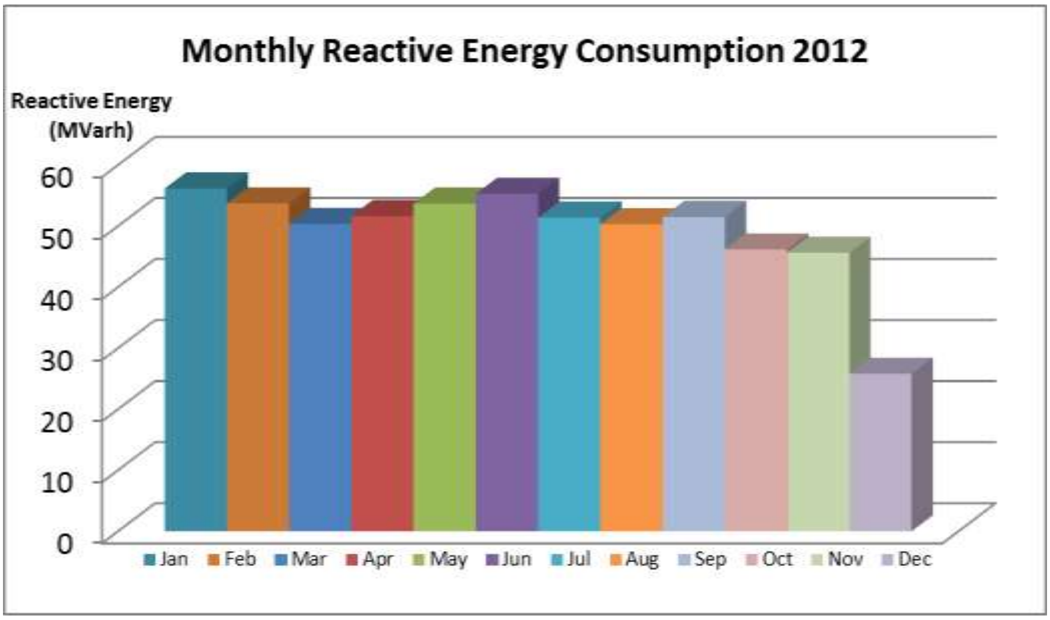

Figure 7. Monthly Reactive Energy for the plant

The average cost for a 370kVA Power factor corrector suitable for Shetland Business is about £4,000. Therefore the investment of purchasing a Power Factor Corrector has a payback time period of about 1 and half year to 2 years.

Shifting the cleaning process

Usually the SB working activities are terminated in the afternoon between 3.30 pm and 4.30 pm. After this period the plant is still in its operational mode (standby). It is therefore waiting for the Cleaning activity that usually starts at 6.00pm.

In this period, machines are still operating in order to facilitate the cleaning process. The average electricity consumption in this period is about 63kW.

By shifting the cleaning process as soon as the working activity is finished, it is possible to complete the cleaning process earlier in the night and reduce the energy consumed during the Waiting period.

Assuming the Cleaning process is started as soon as the working activity is completed, it is possible to estimate a saving of energy per year of about 8.5MWh, with associated cost of £750 per year.

SUMMARY OF THE FINDINGS

In summary it is recommended to introduce the following actions:

- **Install a Solar Photovoltaic (if grid connection is granted)**
- **Introduce Energy Saving measures, such as:**
  - **Reduction of Stand-by power periods**
  - **Reduction of Warm-up periods**
  - **Put in place a shut-down procedure for the Breaks**
  - **Installing a Power Factor Corrector for reducing reactive power**
- **Introduce energy shifting measures.**

Figure 8 shows the monthly savings that is possible to achieve by putting in place the Energy savings recommendation.

Putting in place the Energy Savings and Green Energy Generation recommendations, it is estimated the total saving per year is about £33,000

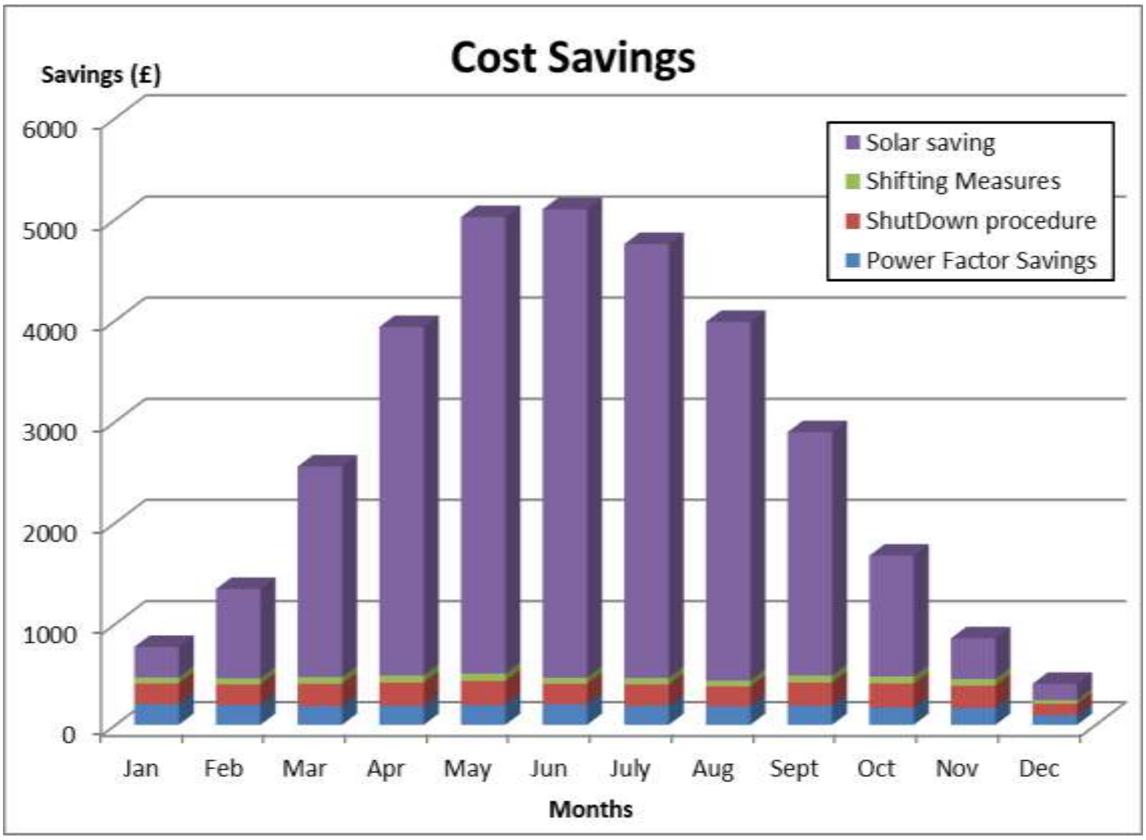

Figure 8. Estimation of Cost saving per year

APPENDIX A – EXAMPLE OF CSV FILE EXPORTED BY DATALOGGERS

The Datalogger used for monitoring Scalloway Harbour are able to export a CSV file every 24 hours containing the logged data.

Data structure in the CSV file is as follows:

Title:

Name (Name datalogger) + parameter 1 (cod) + parameter 2 (cod) ....+ parameter 20 (cod).

Data:

Time Stamp (700717_073046) + parameter 1 value(2) + parameter 2 value(919) ...+ parameter 20 value(5).

Example:

Name Datalogger, 7688,7689,7690,7691,7692,7693,7697,7698,7699,7700,7702,7703,….,7712

700717_073046,2,919,81,2449,944,187,81,2452,100,3226,49,77,22,162,499,2,2,2,4,5

700717_073546,2,923,81,2447,944,188,80,2445,100,3226,49,77,21,146,499,2,2,2,4,5

The first row of data identifies the name of the datalogger and the parameters recorded. The successive rows are the recorded data, where time stamp 700717_073046 is broken down left to right as follows:

70 = year 1970,

07 = month July,

17 = day 17th,

07 = hour,

30 = minutes,

46 = seconds

Datalogger Data recorded from Shetland Business

SB Energy Datalogger,7688,7689,7690,7691,7692,7693,7697,7698,7699,7700,7702,7703,7704,7705,7706,7707,7708,7710,7711,7712

120319_084002,2533,3113,2973,2332,2378,2350,500,865,881,832,523,665,593,1781,604,738,693,298,355,391,2980,0

120319_084502,2160,2896,2701,2342,2388,2359,500,827,862,800,421,600,514,1535,509,696,642,286,351,386,2981,1

120319_085002,2702,3315,3102,2330,2376,2345,500,895,903,872,558,705,629,1892,622,779,721,274,331,352,2982,2

120319_085502,4109,4936,4516,2315,2351,2335,500,879,890,854,836,1041,908,2791,956,1167,1061,452,527,548,2983,3

120319_090002,3984,4645,4386,2318,2356,2333,500,847,846,814,785,929,835,2553,931,1102,1030,498,589,601,2984,4

120319_090502,3484,4115,3860,2322,2363,2335,500,847,843,804,690,827,730,2247,796,970,895,431,527,535,2985,5

120319_091002,3569,4236,4035,2333,2374,2351,500,846,855,820,707,863,780,2350,835,1009,960,447,525,546,2986,6

120319_091502,3424,4199,3881,2325,2365,2338,500,853,864,825,682,864,750,2296,798,999,908,413,502,510,2987,7

120319_092002,3847,4552,4317,2311,2346,2326,500,849,857,826,763,923,837,2523,897,1076,1013,471,553,570,2988,8

120319_092502,3890,4638,4408,2305,2343,2322,500,843,854,816,742,912,823,2477,882,1070,1010,476,559,585,2989,9

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