BRITA in Pubs
Final Report-revision A
Submission date – May 2008

1. City College Plymouth – previously Plymouth College of Further Education
Author – Gilbert Snook, Head of Estates

1.1.1 General information

Year of construction	1972
Year of renovation –	see paragraph 1.14
Number of storeys	8
Heated volume	17352m^2
Total volume	18183 m^3
Gross internal floor area	6061m^2
Useable floor space	5784m^2

1.1.2 Site – Urban

Latitude	50:22:26^{o}N
Longitude	4:10:03^{o}W
Altitude	19.9m above sea level
Mean annual temp	10.6^{o}C
Mean winter temp	6.3^{o}C
Climate description	temperate

1.1.3 Building Type – Education and Research

1.1.4 Project Reduction

The demonstration project was taken to the end of detailed design when the refurbishment of the Tower Block was cancelled in February 2006. This was at the instigation of the British Government's Education Sector funding body called the Learning and Skills Council. The financial position of the college had deteriorated and the agreed recovery plan required the college to prepare a new property strategy.

At the point of cancelling the Tower Block refurbishment, it was agreed with the BRITA-in-PuBs Steering Group and the EU that the college should remain a demonstration partner and provide the following:-

Full design report.
BRITA Information Tool base on the completed Tower Block design and full information for the Wind Turbines which were installed.
General contribution into other Work Packages .
Significant input into Work package 9.
Final Report on the Wind Turbines.

1.1.5 Design Report

The complete design report can be found elsewhere. Reference should be made to www.brita-in-pubs.eu to see the BRITA Information Tool.

1.1.6 Wind Turbines

The rest of this final report presents the outcome of the installation of the wind turbines, the only element of this demonstration project taken through to completion.

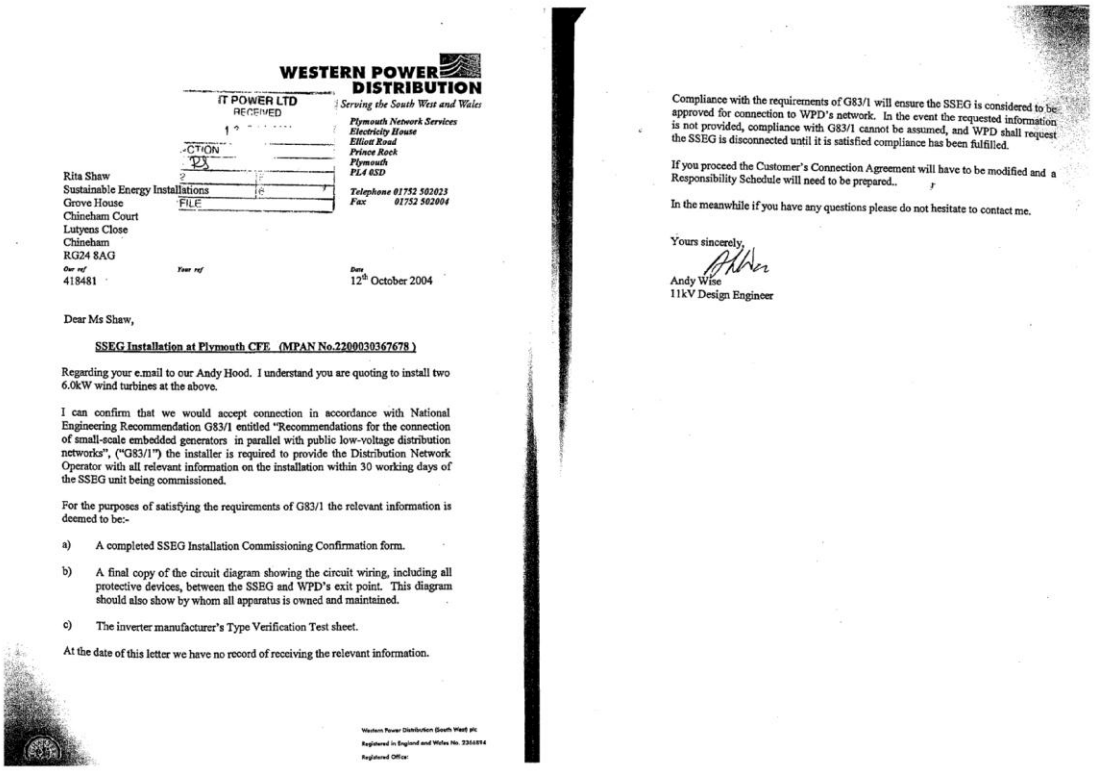
1.2 Before Retrofit

The wind turbines were planned to be installed on a modern extension to the main Tower Block called the Innovation Centre.

1.2.1 During the construction of the Innovation Centre some preliminary works took place. The original structural engineer verified the steel frame structure would be suitable to receive the wind turbines. This included the installation of stub support columns.

1.2.2 Existing Electrical System

The Innovation Centre has a standard electrical system. Consent from Western Power Distribution was obtained for the turbines output to be directly connected via inverters to the existing supply.



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ACTION
FILE

Rita Shaw
Sustainable Energy Installations
Grove House
Chineham Court
Lutyens Close
Chineham
RG24 8AG

Our ref 418481 Your ref Date 12th October 2004

Dear Ms Shaw,

SSEG Installation at Plymouth CFE (MPAN No.2200030367678)

Regarding your e.mail to our Andy Hood. I understand you are quoting to install two 6.0kW wind turbines at the above.

I can confirm that we would accept connection in accordance with National Engineering Recommendation G83/1 entitled "Recommendations for the connection of small-scale embedded generators in parallel with public low-voltage distribution networks", ("G83/1") the installer is required to provide the Distribution Network Operator with all relevant information on the installation within 30 working days of the SSEG unit being commissioned.

For the purposes of satisfying the requirements of G83/1 the relevant information is deemed to be:-

a) A completed SSEG Installation Commissioning Confirmation form.

b) A final copy of the circuit diagram showing the circuit wiring, including all protective devices, between the SSEG and WPD's exit point. This diagram should also show by whom all apparatus is owned and maintained.

c) The inverter manufacturer's Type Verification Test sheet.

At the date of this letter we have no record of receiving the relevant information.

Western Power Distribution (South West) plc
Registered in England and Wales No. 2366894
Registered Office:

Compliance with the requirements of G83/1 will ensure the SSEG is considered to be approved for connection to WPD's network. In the event the requested information is not provided, compliance with G83/1 cannot be assumed, and WPD shall request the SSEG is disconnected until it is satisfied compliance has been fulfilled.

If you proceed the Customer's Connection Agreement will have to be modified and a Responsibility Schedule will need to be prepared..

In the meanwhile if you have any questions please do not hesitate to contact me.

Yours sincerely,

Andy Wise
11kV Design Engineer

1.2.3 Energy Use

To put the turbine output into context, the electrical consumption per annum, for the whole Kings Road campus is about 2,000,000 kWh/a. The annual electrical consumption for the Tower Block is 650,000 kWh/a.

1.3 Energy saving concept

The following is an extract from the Operations and Maintenance Manual prepared by Sustainable Energy Installations

Overview/Description of the system.

The overall system consists of two kW roof-mounted wind turbines, and associated electrical equipment (namely controllers/rectifiers, inverters and switches), ensuring safety and power quality for the mains connection. Table 1 below gives details of the system installed.

Summary of system data

Wind turbines	Manufacturer	Proven Engineering
	Model	WT 6000

	Power rating	6kW
	Number installed	2
	Cut-in wind speed	2.5 m/s (5.6mph)
	Rated wind speed	12 m/s (25mph)
	Cut-out wind speed	none
	Mast	Self supporting, tilt down, height 9m
	Rotor	5.6m diameter, 3 blades
	Generator	Brushless, direct drive, permanent magnet, Nominal 300V
Inverters	Nominal AC power	2,750 W
	Maximum AC power	3,000 W
	Manufacturer	SMA
	Model	Windy Boy WB (SB) 3000
	Number installed	4 (two per wind turbines)
Mains connection	Protection	Integrated in inverter (over/under voltage, over/under frequency and islanding protection)
		Over voltage 264V
		Under voltage 209V
		Over frequency 50.5 Hz
		Under frequency 47Hz
	Engineering Recommendation	G83/1 – see note [1] below

SYSTEM DESIGN

Physical layout

The two wind turbines are mounted on the roof of the Innovations Centre building, as shown in Figure 1.

Figure 1 Wind Turbines on the Roof

Three-phase AC cables are routed from each wind turbine to the controllers (see Figure 2) and inverters (Figure 3), which are located in the plant room on

[1] The system installed falls just outside the scope of Engineering Recommendation G83/1. However, Western Power Distribution (the DNO) agreed to apply G83/1 to the installation.

the second floor (water storage tanks). AC isolators are also installed near the inverters (see Figure 4).

Figure 2 Wind Turbine Controller

Figure 3 Inverter

Figure 4 AC Isolators

AC cables are routed from the plant room on the second floor (water storage tanks) to the distribution board in the plant room on the ground floor, where the main incomer is situated. Dedicated MCBs for the wind turbines, a lockable three-phase AC isolator as well as a kWh meter are located adjacent to the distribution board, as shown in Figure 5 and Figure 6.

Figure 5 MCBs

Figure 6 Lockable Isolator and kWh Meter

Mechanical Design

The wind turbines are mounted on a 9 m self-supporting tilt down tower. The tower is mounted on an X-shaped girder base frame, which rests on stub columns which were provided during the construction of the Innovations Centre building. The base frame was designed by Proven, with input from structural engineers Structures One. The structural engineers' calculations can be found in their report *Structural Final Calculations*, dated 17 June 2005. A winch anchor point had to be provided for each turbine, for lowering and raising of the turbine.

Electrical design

The electrical installation conforms to BS7671 (IEE Wiring Regulations).

The wind turbines and base frames are earthed via the building's lightning protection system. The inverters are connected to the DNO earth.
The wind turbine generators generate three-phase AC power of nominal 300V. It should however be noted that the generator output voltage can be twice the nominal voltage under no-load conditions. The output from the generators is connected to a controller, which converts the three-phase AC to DC, and also contains an isolator. The conversion to DC is necessary because the generator output is not synchronised with the electricity grid.
The DC output from each controller is connected to two inverters. The inverters are sophisticated devices which convert DC power to AC power at high efficiency, and deliver AC power which is synchronised with the mains supply. They operate at up to 95% efficiency.

The inverters also contain important protection functions. They automatically cease generation in the event of a fault with the mains supply e.g. loss of supply, exceeding over or under voltage or frequency limits. The inverter automatically restarts 3 minutes after the grid supply is restored, or the grid frequency or voltage return to acceptable values. The inverters have been type approved in accordance with Engineering Recommendation G83/1 (the current recommendation for the connection of small generators to the electricity grid). AC cable then runs from the second floor plant room to the plant room on the ground floor, where it is connected to the building's electrical system via a kWh meter, a lockable isolator and MCBs protecting the AC wiring. This isolator is the main point of isolation for the wind turbine system.
Dual supply labelling and hazard warning labelling is provided throughout the installation

1.3.1 Predicted energy generation/payback

Calculation source	Installation cost €	Wind speed	Annual output	Payback period (years)
BRITA proposal	75000	-	30000 kWh	25
Clear Skies grant application	82000	5.2 to 6 m/s	33800 kWh	24
Private recalculation	82000	5.2 m/s	13000 to 22000 kWh	63 to 37

Payback based on the 2004 assumption of electricity at €0.1/kWh.

1.4 Life Cycle Assessment

The following assessment was produced by Dipartimento di RicercheEnergetiche ed Ambientali (DREAM) Università degli Studi di Palermo

The assessment was based on a notional real output of 11500 kWh/year. Average weather conditions and fault free operation of the turbines should see output approach this target.

Demo Partner: Plymouth College of Further Education
Building/Location: Plymouth College, Plymouth (England)

Brief Description of the retrofit action:

The retrofit was done at Plymouth college with installation of two wind turbines on the roof of the building. Each turbine has a power of about 6 kW, at about 21m above ground level. It is important to note that the measured electricity output of the turbines was much lower than predicted values due to local disruption of air currents

Measured/estimated yearly Energy Saving		
Wind turbines (Electricity)	11.500	[kWh/year]

Primary energy saving and emissions		
Primary energy save (E_{year})	604.798	[kWh]
Global Emission saving (EM_{S-i})	117,314	[$ton_{CO2\ eq.}$]

Summary of materials employed and main components		
Component	Unit	
Galvanised steel	4,1	[ton]
Cables	25	[m]

Demo Partner: Plymouth College of Further Education
Building/Location: Plymouth College, Plymouth (England)

Energy and Environmental Indexes:		
Global Energy Requirements (GER)	26.653	[kWh]
Global Warming Potential (GWP)	6,9	[ton $CO_{2\text{-Eq.}}$]
Nutrification Potential (NP)	2,4	[kg PO_4]
Acidification Potential (AP)	32,2	[kg SO_2]
Ozone Depletion Potential (ODP)	0,1	[g CFC_{11}]
Photochemical Ozone Creation Potential (POCP)	3,5	[kg C_2H_4]

Contributors to data survey: Dr. Gilbert Snook

Life Cycle Analyst: Fulvio Ardente

1.5 Construction Phase Description

The turbines were installed by the contractor, also responsible for the Clear Skies Grant and the design. The contractor's name is Sustainable Energy Installations.

The construction period was as follows:

- Winch anchor points week beginning 3 October 2005
- Electrical equipment week beginning 17 October 2005
- Transport of turbines from manufacture 24 October 2005
- Installation of turbines 25th and 26th October 2005