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Integration of Renewable Energy technologies into CIBSE-Buildings

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Abstract
This report represents possible solutions to cut Carbon Dioxide (CO2) emissions of the Chartered Institution of Building Services Engineers (CIBSE) though implementing renewable energy technologies. Two renewable energy technologies are purposed here to cut down the CO2 emissions as well as reducing the total usage of electricity and gas. With Photovoltaic PV system, electricity usage from main grid is reduced by 17.9%, subsequently reducing the annual CO2 emissions by 31390 kgCO2. Complete integration of Biomass boiler for space heating can substantially reduce the emissions, however there still some emissions need to be addressed due to the fuel transportation and production, hence total emissions due to thermal energy generation is reduced by 9.1%. Total capital cost of the both renewable energy technologies are relatively high with £75966.71, however with adequate annual cost saving, the payback period is approximated to be 9.7 years.

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Table below represents the Annual savings and budget capital cost of the renewable energy technologies.

	Estimated annual saving				Budget	
Renewable energy technologies	**Cost saving (£)**	**Energy saving (kWh)**		**CO_2 saving (kg CO_2)**	**Capital cost (£)**	**Payback period (years)**
Biomass boiler	£1,687.34	G	**33512.3**	**6495.7**	£4,502.00	2.7
PV system	£6,125.50	E	**36648**	**12800**	£71,464.71	11.7
Total	**£7,812.85**			**19295.7**	**£75,966.71**	**9.7**

I. Introduction

In UK, emissions from home, commercial and public buildings accounts for 17% of greenhouse gas (CO2) emissions. These are due to fossil fuel use in thermal energy generations in buildings, and in extension, two third of the emissions from power sectors are mainly due to the electricity consumption of the buildings.

The purpose of the report is to reduce the carbon dioxide (CO2) emissions of the Chartered institution of Building Service Engineers (CIBSE) headquarter building by 60%, through incorporating suitable renewable energy technologies with reasonable payback period to the building. Through incorporating simple measures, the CO2 emission was reduced by 33% in 2007, hence the challenge required to further reduce CO2 emission by 27% in order to meet the competition requirement of 60%. The geographical location of the CIBSE headquarter is situated in a densely populated region of London, which has great influence on evaluation of possible energy technologies.

II. Baseline of energy consumption

New baseline for the energy consumption is constructed through evaluating the Action Energy Saving Report in 2007, as shown in table 1. The climate change Levy is deducted from the actual unit cost of gas and electricity that considered for the baseline, and in extension VAT is reduced to 5%. Furthermore, the actual CO2 emission factors for electricity and gas are used to determine the annual CO2 emissions with regard to the new baseline of energy consumption.

	Electricity	Gas	Total
Annual energy use (kWh)	68700	128400	
Annual energy cost inc VAT (£)	8690.55	6464.94	15155.49
Unit cost (p/unit) [1]	12.65	5.035	
kWh/m2 floor area	57.25	107	
CO2 emission factor (kg/kWh) [2]	0.34885	0.18381	
Carbon dioxide emissions (kg CO2)	30943	23601.2	47567.2
Carbon dioxide per area (kg CO2/m2)	26.0	19.8	45.8

Table 1 – Annual energy use and costs, and related carbon dioxide emissions

Despite the reduction in CO2 emissions and annual energy usage, the annual cost of gas and electric are increased in comparison to the old baseline due to increase in unit cost. In terms of CO2 emissions due to electrical energy consumption, it has greater impact than gas, as the actual CO2 emission factor for electricity is higher in comparison to that of the emission factor of gas, hence reducing the electrical energy consumption from the main grid through utilising renewable energy source is in essence to reduce to reach the goal of 27% cut in overall CO2 emissions. On the other hand, thermal energy consumption is solely due to central heating of the building, where as the existing heating system is supported with gas boiler, hence the heating system can be completely reformed through utilising renewable heating system.

III. Consideration of Renewable energy technologies

Through assessing different renewable energy technologies, Photovoltaic (PV) system and Biomass heating technology are showing the best suitability to the CIBSE building in terms of renewable energy capacity, hence these two renewable energy technologies are addressed to meet the competition goal of 60% CO2 emission cut.

3.1 Photovoltaic system

Photovoltaic (PV) systems directly convert solar energy into electrical energy. PV energy systems are designed to generate some or all of the electrical energy demand of a building through installing the PV modules onto the roof top. The building still remains connected to the main power grid as any energy needed above the PV system can provide can still be taken from the main grid.

PV systems for buildings are classified into two types; the grid tied systems which have no battery backup capability and the stand-alone systems which are grid connected and backup batteries are included. Operation of grid tied (grid connected) system directly depends on the availability of utility. This type of PV systems is very reliable with high efficiency and easy to integrate into the building, and in extension, these are cost effective systems in comparison to stand-alone system.

To design quality PV system, one must consider the reduction in electricity cost, environmental impact, capital budget, and size and orientation of PV array for electrical power generation. In extension, electrical loss due to wiring fuses and inverter must be kept to minimum. For instillation PV array, it is important to ensure the roof capable of accommodating the designed system size and weight. Once a system design has been chosen, attention to installation detail is critical as installations problems have direct impact on the performance of the system.

3.2 Biomass heating system

Biomass fuels are considered to be carbon-neutral meaning the carbon dioxide that emit from biomass bounces back into atmosphere and get observed by trees, hence closing CO2 cycle. However, biomass heating system creates small net of CO2 emissions due to harvesting, transport and production of biomass fuel. Hence, Biomass boilers have the CO2 emission factor of 5.5g/kWh. Biomass boilers technologies are reliable, clean with operating efficiency at 92%, which is assume it exactly same efficiency with modern gas boilers.

Regarding to selection of biomass boiler for a building depends several different factors which are needing to be considered:

- Size of the property – Requirement of heating increase as the building gets larger, therefore a larger (Thermal energy) boiler is needed as heating demand increases. As larger boilers consume fuel at higher rate, a boiler with automatic feed mechanism requires much larger space.
- Space – Biomass boilers tend to be larger than conventional gas boilers and wood pellets need storage space, thus sufficient space is needed to accommodate the unit.
- Fuel supply – Having your own supply can be very convenient. If the space is not a concern, wood chip and log would be problem, however space is restricted pellets are to be preferred.
- Access – For large quantity fuel delivery, direct access to the fuel store is important. However, in urban areas fuel delivery need to consider carefully.

3.3 Wind turbine system

Implementation of wind turbine is not feasible for the building because looking at wind speed is not sufficient at the location of the building as there are too many obstacles in the vicinity. Also, you need to consider the average wind speed at the location, which need to be at least about 6m/s. Furthermore, wind turbines are way too expensive, hence payback period is much longer.

Besides, there are no place you could install the wind turbine as it massive and small turbines are not useful.

IV. Suitability of selected renewable solution and rated power capacity

4.1 Photovoltaic system

PV system ensures that some of electrical energy consumption of CIBSE headquarter contributed from renewable energy source, subsequently which will provide significant cut in CO2 emissions. Even though, there is significant constraint regarding to the sun peak hours and solar radiation (energy) in London, through optimising the tilt angle and orientation of PV models it is still possible to harvest sufficient solar energy, however size of the system must be enlarged for sufficient electrical energy production.

The proposed PV system consists of 134 + 21 with total 155 modules with module efficiency of 19.6% and each module has maximum rated power of 320W. 134 modules PV system can be roof-mounted onto the conference centre as it provides sufficient space with tilt angle of 35° also the orientation of roof-top ensures good peak sun hour as it faces south-south west and 21 modules PV system it faces south-south east.

Through evaluating the PV system with 155 modules, the results show that the system has annual energy capacity of 36648 kWh, as shown in Figure 1. Solar energy generation varies through about the year due to solar radiation depends on the sun altitude, hence highest energy is producing during summer.

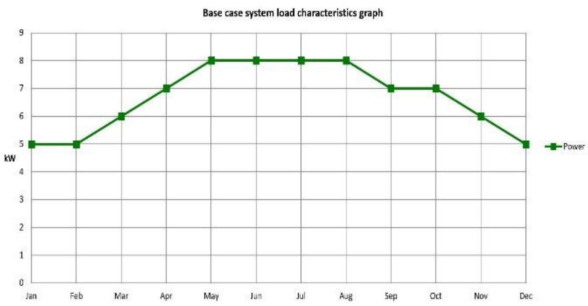

Figure1 – Renewable energy (PV system)

4.2 Biomass heating system

If a wood pellet biomass boiler to be added to the exciting gas boilers needed to reduce the Kwh for boilers. The boiler room has adequate space to accommodate a boiler and fuels storage, however accessibility still need to be considered properly. The boiler room is situated in basement of the delta house and has dimension of 3.6m*3.0m*2.7m, where fuel storage need to be constructed for pellets to be fed automatically to the boiler. Through evaluation, HDG R Series 12kW Biomass boiler has adequate capacity (30576kWh/yr) to produce the annual thermal energy consumption of the CIBSE headquarter of 33512.3kWh, and the boiler has physical dimension of 0.71m x 1.249m x 1.768m, which leave enough space for fuel storage after boiler installation. However, the annual fuel consumption is 7.75 tonnes (11.94 m^3), for which fuel supply need to be arranged 1-2 times a year.

Biomass Boiler Size (kW)	12
Required days for boiler to run per years	196
Required hours for boiler to run per years	2842
Annual thermal energy (kWh)	34104

Table 2 – HDG R series 12kW Biomass boiler capacity

V. Energy and emission saving and renewable energy cost and payback

Addition to simple straight forward measures that has been taken previously, renewable energy technologies are proposed to reduce the energy consumptions and the overall CO2 emissions. Through implementing renewable energy technologies, 41% of electrical and 15% of thermal energies are reduced in total. CO2 emission due to electrical consumption further reduced to 41.37% with implementation of PV system. On the other hand, CO2 emission from gas consumption reduced Kwh and reduced amount of CO2 emission hence the emissions can be said to be reduced by 57.92%. Therefore, the overall emissions are cut by 27%, hence meeting competition criteria of 60%.

	Electricity	Gas	Total
Annual energy saving (kWh)	36648	33512	70160.3
Annual energy saving (%)	41	15	
Reduction in CO2 emissions (kg CO2)	12800.0	23420	36220.0
Reduction in CO2 emissions (%)	41.37	57.92	61

Table 3 – Total Energy and Carbon dioxide saving

As stated previously, PV system has power generation capacity of 12800kWh/yr, which is 13% of electrical energy required, and the biomass boiler has a capacity to provide all required thermal energy with maximum annual capacity of 33512.3kWh.

Capital cost for PV system and Biomass boiler are £71,464.71 and £4,502, respectively. Payback period for PV system are relatively with 11.7 years in comparison to 2.7 years of payback period of biomass boiler, and in extension, the annual cost saving for PV system is greater than that of biomass boiler as states in table 4. However, combined payback period of both renewable energy systems are 12 years.

	Capital cost	**Cost saving**	Payback period (years)
PV system	71464.71	3970.84	11.7
Biomass boiler	4502	1687.34	2.7
Total	75966.71	5658.18	9.7

Table 4 – Capital Cost, cost saving and Payback period (PV system and Biomass boiler)

VI. Solutions and recommendations

Grid tied PV systems are designed to contribute to the electrical energy consumption of the building. Integration of PV system is simple, and the PV panels can be roof-mounted to the Conference centre134 modules PV system can be roof-mounted as it faces south-south west and 21 modules PV system it faces south-south east. The system requires low maintenance and the energies that been produced when utility is not available (mainly during weekend) can sold to the main grid. PV system has high life expectancy of 25 years or higher with payback period of 11.7 years. In terms of space heating, a single HDG R Series 12kW biomass boiler has reduce capacity to saving the thermal energy consumption of CIBSE, however scheduled fuel supply and maintenance are needed but it is very reliable with high efficiency, and has a moderate payback period of 2.7 years, which is very reasonable in comparison its high life expectancy of 40years.

Also, excludedwind turbinesystem because it is not feasible for the building and looking at wind speed is not sufficient at the location of the building as there are too many obstacles in the vicinity. Also, you need to consider the average wind speed at the location, which need to be at least about 6m/s. Furthermore, wind turbines are way too expensive, hence payback period is much longer.

Besides, there are no place you could install the wind turbine as it massive and small turbines are not useful.

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