B Braun Medical, Project Hermes

Low or Zero Carbon Technology Report

August 2015

B Braun Medical

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Sheffield
S35 2PW
United Kingdom
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Executive Summary

This report is intended to provide a comparison of Low and Zero Carbon Technologies that may be suitable for use in the new B Braun Medical office building in Sheffield. Initially the technologies have been assessed against site suitability and the impacts associated with installation. The detailed assessment compared the selected technologies against carbon saving and financial paybacks including government incentives to obtain the most suitable solution for the project.

The following technologies were excluded due to site limitations or other factors:

- Solar Water Heating
- Biomass
- Combined Heat and Power (CHP)
- Ground source heat pump (GSHP)
- District Heating
- Small scale hydro, tidal power, wave power

It was found that each of the following LZC technologies could allow for a sufficient reduction in carbon emissions to comply with Part L Building Regulations and provide the required 10% of energy demand to meet Sheffield’s planning requirements.

The recommended technologies are:

- Photovoltaics (PV)
- Small power wind turbines
- Air source heat pump (ASHP)

We recommend that a combination of photovoltaic panels and air source heat pumps (ASHP) would be the most effective for the site in terms of carbon reductions and efficient energy provision.
1 Introduction

This report has been prepared by Mott MacDonald for B Braun Medical. The purpose of this report is to review the feasibility of low or zero carbon technologies in relation to the development and to establish the most appropriate options for the new B Braun office in Sheffield. The suitability of multiple LZC technologies will be assessed on the scope of energy production and resultant decrease in CO₂ emissions, site suitability and viable costs for the client.

Figure 1.1: B Braun Medical building

Source: DLA Architecture

The B Braun Medical building has an approximate floor area of 1800m² and includes an auditorium, multiple offices, demonstration suites, a cafe space, and a large open entrance and forum area.
2 Environmental Drivers

For this development there are a number of environmental drivers. Part L 2013 is a legal requirement as part of the UK Building Regulations.

The site is located in the Sheffield City boundary and as a result there are planning requirements to meet for the project.

The client, B Braun Medical has opted to push for an ‘Excellent’ BREEAM rating so there are criteria to be met to achieve the target.

2.1 Part L 2013

Part L 2013 of the Building Regulations sets the legal requirements for the energy efficiency and carbon emissions for the construction of new buildings and to certain works on existing buildings. Levels are set for the required rather than which materials and schemes should be used.

The carbon emissions of the completed building (Building Emission Rate – BER) must be below a calculated target value (Target Emission Rate – TER). The B Braun building has a Target Emission Rating (TER) of 19.5 kg CO₂/m².

2.2 Sheffield City Council

Sheffield City Council’s CS65 policy sets out the approach to planning for low carbon and renewable energy, and carbon reduction.

Figure 2.1: Sheffield City Council policy CS65

Policy CS65

Renewable energy capacity in the city will exceed 12MW by 2010 and 80MW by 2021. The Smyleywood and Helesly Wood areas are potential locations for large-scale wind generation though not to the exclusion of other sustainable locations. Where appropriate, developments will be encouraged to connect to the City Centre District Heating Scheme. Shared energy schemes within large developments or between neighbouring developments, new or existing, will also be encouraged. All significant developments will be required, unless this can be shown not to be feasible and viable, to:

a. provide a minimum of 10% of their predicted energy needs from decentralised and renewable or low carbon energy, and
b. generate further renewable or low carbon energy or incorporate design measures sufficient to reduce the development’s overall predicted carbon emissions by 20%.

This would include the decentralised and renewable or low carbon energy required to satisfy (a).

The renewable or low carbon energy technologies must be operational before any new or converted buildings are occupied. If it can be demonstrated that the required reduction in carbon emissions cannot be met through decentralised renewable or low carbon energy and/or design and specification measures, a contribution towards an off-site carbon reduction scheme may be acceptable.

Source: Climate Change and Design
To comply with CS65 (a) 10% of the building’s predicted energy demand needs to be provided by decentralised low carbon or renewable energy.

Policy CS65 part (b) is not being implemented at present. Current Building Regulations requirements for carbon reduction have resulted in a further 20% reduction in emissions being unviable for most schemes. The most recent draft of the supplementary planning document (SPD) for Community Infrastructure Levy (CIL) and Planning Obligations contains the following clause highlighting the non-implementation of CS65 part (b) at present.

Figure 2.2: Extract from Draft CIL and Planning Obligations SPD

8. Renewable Energy and Carbon Reduction

5.47 Core Strategy Policy CS65 (b) requires significant developments to generate renewable or low carbon energy or incorporate design measures sufficient to reduce the development’s overall predicted carbon dioxide emissions by 20% (including any energy already generated to meet part (a) of the policy). The policy also sets out that if it is not possible to achieve this requirement, a contribution to an off-site carbon reduction scheme may be acceptable instead. However, part (b) of the policy is not currently being implemented because, since adoption of the Core Strategy, Building Regulations requirements for carbon reduction have increased to such a point that achieving a further 20% reduction would render most schemes unviable. Therefore the part of the policy referring to a contribution to an off-site scheme in lieu of achieving this requirement is not currently relevant. Should this approach change in the future, this SPD will be updated to reflect the mechanism for taking a contribution to an off-site carbon reduction scheme.

Source: Sheffield City Council. Draft SPD for consultation 6/7-3/8/15

2.3 BREEAM

The main client requirement for the B Braun Medical project is that it achieves an ‘Excellent’ BREEAM rating. The minimum standards for each BREEAM rating are shown in table 2.1.
Table 2.21: Minimum BREEAM standards

<table>
<thead>
<tr>
<th>BREEAM issue</th>
<th>Pass</th>
<th>Good</th>
<th>Very Good</th>
<th>Excellent</th>
<th>Outstanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ene 1 – Reduction of CO₂ emissions</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Ene 2 – Sub-metering of substantial energy uses</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Ene 5 – Low or zero carbon technologies</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: BREEAM Offices 2008

The ‘Excellent’ rating requires a minimum of six credits for Energy Credit ENE 1 – Reduction of CO₂ emissions. To achieve this requirement the building must obtain a CO₂ index (EPC Rating) of 40.

Table 2.3: ENE 1 - CO₂ index benchmarks and BREEAM credits

<table>
<thead>
<tr>
<th>BREEAM Credits</th>
<th>CO₂ Index (EPC Rating)</th>
</tr>
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<tr>
<td></td>
<td>New Build</td>
</tr>
<tr>
<td>1</td>
<td>63</td>
</tr>
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<td>2</td>
<td>53</td>
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<td>3</td>
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<td>4</td>
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<td>5</td>
<td>43</td>
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<tr>
<td>6</td>
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<td>7</td>
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<tr>
<td>8</td>
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</tr>
<tr>
<td>9</td>
<td>28</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: BREEAM Offices 2008

In addition a minimum of one credit must be achieved for Energy Credit ENE 5 – Low or zero carbon technologies. To achieve this requirement this feasibility study has to be undertaken to establish the most appropriate LZC technology for the development.
2.4 Air Quality

Although the air quality is not a particular requirement for this scheme however it may need to be considered for biomass technology due to the burning of fuels and the impact that this may have.

Figure 2.4: Sheffield City Council CS66

Policy CS66

Action to protect air quality will be taken in all areas of the city. Further action to improve air quality will be taken across the built up area, and particularly where residents in road corridors with high levels of traffic are exposed to levels of pollution about national targets.

Source: Climate Change and Design

Sheffield’s City Council policy CS66 supports the air quality management initiatives currently running in the city. These initiatives are based on a developed Air Quality Management Area (AQMA) covering the city. Figure 2.3 shows the AQMA in blue and the site is located close to the north-east city boundary.

Figure 2.5: Sheffield Air Quality Management Area

Source: DEFRA
2.5 Summary

The building must achieve a BER of below the target value of 19.5 to comply with Part L 2013 building regulations.

Sheffield City Council’s CS65 policy requires 10% of the building’s predicted energy demand to be provided by low carbon or renewable energy.

To achieve the BREEAM ‘Excellent’ Rating the building must obtain a CO₂ index (EPC rating) of 40 or below.

In the next section we have assessed the different renewable or low carbon technologies that could contribute in meeting these targets.
3 LZC Technologies – Initial Assessment

This section is an initial assessment of different Low or Zero Carbon technologies.

The assessment considers the requirements of each system, the suitability of the site and building proposal and energy demands.

3.1 Photovoltaics (PV)

Photovoltaic panels generate electricity using light energy from the sun. PV systems can be integrated into the structure of a building or installed on an existing roof or façade.

To ensure the maximum efficiency the panels need to be situated between south east and west, and remain predominantly unshaded throughout hours of operation. The panels also need to be placed at an ideal angle of 30-40° to be most effective.

Photovoltaic cells are most efficient when the sun is shining although they do still work in overcast weather.

PV panels operate silently however the visual impact of the system should be considered. The panels can be considered unsightly and can also cause reflections and glare within the surrounding area.

For B Braun the existing warehouse roof is oriented to the south with no shading. There are already PV panels fitted to this roof, and we suggest that further PV panels that could be installed here to serve the proposed building.

Figure 3.2: Sun path over site, 21/6 at 12:00pm

Source: IES VE
As an office building there will be constant yearly demand for electricity resulting in photovoltaics being a viable option for energy production for the scheme.

**Electric Car Chargers**

As part of the scheme there will also be the construction of an additional car park deck which would provide an alternative location for the PV panels.

This will also provide an opportunity to provide electric charging points for cars that is served from a renewable source.

**Photovoltaics will be considered for the strategy.**

### 3.2 Solar water heating

Solar thermal panels use energy from the sun to generate hot water. There are two types of panels that are commonly used: evacuated tube collectors and flat plate collectors.

Evacuated tube collectors are the more efficient system, requiring less roof space, however are more expensive and fragile. To ensure maximum efficiency the system should be situated on south facing roofs, or within 30° of south, and should remain unshaded throughout hours of operation.

As explained in above the site has roof space in the correct position and orientation to maximise the efficiency of this scheme.

Solar water heating systems are suited to buildings requiring a large quantity of hot water. Within the proposed building there are several washrooms, shower rooms, clinic areas and a kitchen/canteen area which will require hot water throughout operation hours. Whilst the peak demand for hot water is significant, the base hot water use will only serve the limited staff numbers at second floor area.

Space heating is not a suitable provision of a solar water heating system as a substantial collector area would be required in addition to a very large thermal store which would be capable of storing heat energy for winter months.
The visual impact of the system should be considered alongside the space required internally for a hot water storage cylinder.

Solar water heating will not be considered for the strategy because of fluctuating hot water demand.

3.3 Wind power

Wind power can be used to generate electricity through the use of turbines. The can be used in parallel to a mains supply or with a battery back-up system. Turbines can either be building mounted or free standing depending on development requirements and site conditions. The two basic kinds of wind turbines are horizontal axis and vertical axis, with horizontal axis being the more efficient in most applications. Horizontal axis turbines have a central hub with evenly spaced blades that rotate at an almost constant rate regardless of wind speed. Vertical axis turbines can be installed without a tower, making them easier to integrate with the building's structure.

Minimum wind speeds of 3.5-5m/s are required for most turbines to produce electricity and regulators are included that operate when the wind speed exceeds the safe limit.

Table 3.3: Average wind speeds on site

<table>
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<tr>
<th>Height above ground level (m)</th>
<th>Average wind speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>4.7</td>
</tr>
<tr>
<td>25</td>
<td>5.4</td>
</tr>
<tr>
<td>40</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Source: NOABL Wind Map, BERR database

Large and medium turbines are unsuitable for this scheme due to the space required for such equipment, however small turbines could be considered. On site there is unobstructed space that can be used for a wind turbine installation, either building mounted or free standing.

For building mounted turbines vibration and noise issues need to be considered. Shadow flicker is also an issue with turbines and should be investigated. The visual impact normally associated with wind turbines might not be as problematic on site because of the location on an industrial estate and the aesthetics of a turbine may interact favourably with that of the new building.

Small wind power turbines will be considered for the strategy.
3.4 **Biomass**

Biomass boilers burn fuels such as virgin wood and energy crops in the form of chips or pellets to generate heat. Although carbon is released during fuel combustion it is equivalent to the about absorbed during growth of the fuel so the technology is carbon-neutral, disregarding any treatment and transport required.

The scheme is best suited to constructions with a fairly constant heat load, making it suitable for buildings with constant demand such as hospitals, so possibly not feasible for the B Braun Medical office.

Sheffield’s City Council policy CS66 supports air quality in the city through the application of an Air Quality Management Area (AQMA). Policy CS66 restricts fuels that can be burnt so as not to impact adversely on air quality. The city is also a Smoke Control Area meaning any biomass equipment would need to be approved for exemption. A further drawback of using a biomass boiler is the storage facilities required for fuel on site.

At present closest manufacturer of wood pellets is in Derbyshire, adding to carbon emissions associated with transport of the fuel. Within the area wood chips are a viable fuel source due to the amount of wood available from woodland thinning.

**Biomass will not be considered for the strategy due to the lack of a significant base heat demand, delivery and storage of the fuel, and the AQMA in the city.**

3.5 **Combined Heat and Power (CHP)**

Combined heat and power systems generate electricity and heat simultaneously. Heat is recovered from the exhaust gases from the engine or turbine electricity generation. CHP systems are best suited to applications with year round demand for heating, hot water and electricity such as offices and are around 80% efficient.

The only possible visual impact from a CHP scheme would be the flue. Noise and vibration disturbances could be more problematic however these can be overcome using acoustic enclosures and anti-vibration mountings.
CHP can often work alongside other LZC technologies but can sometimes reduce the viability of other scheme installations that provide heating energy such as biomass boilers and solar water heating. To overcome this possible problem biomass could be used instead of gas as a fuel for the CHP system.

**CHP will not be considered for the strategy due to the lack of constant heat demand.**

### 3.6 Heat Pumps

#### 3.6.1 Ground source heat pump (GSHP)

GSHPs work by extracting heat from the ground for space heating and hot water.

A water and anti-freeze mixture is circulated through loops of pipe laid in the ground and heat is absorbed by the liquid. This is then passed through a heat exchanger and the low temperature heat is concentrated to a higher usable temperature and pumped into the building. The temperature extracted by the pump remains consistent when the pipework for the system is installed deep enough to avoid seasonal fluctuations.

GSHPs are particularly suitable for low temperature heating systems in larger buildings with good levels of thermal insulation, and can also be used to provide cooling in warm months.

To make the system viable there needs to be sufficient ground for the pipework installation and the ground conditions should also be considered. The system can be regarded as disruptive whilst being constructed due to the area of work however once installed there is no lasting visual or noise impact.

However the ground conditions and the limited space around the proposed building prohibit the use of the ground as a thermal store/reservoir.

**GSHP will not be considered for the strategy due to the large area of ground required to place the pipework.**
### 3.6.2 Air source heat pump (ASHP)

ASHPs work by extracting heat from the air for space heating and hot water, and can also be used to provide cooling.

The systems are easier and cheaper to install than their ground source counterparts, however can be slightly less efficient.

An ASHP requires a collector external to the building, much like an air handling unit (AHU). The technology can be operational down to temperatures of -15°C, which will be suitable for site.

During winter the ASHP may need to be left on continuously due to the lower temperatures delivered by the system, to obtain sufficient heat.

There are two main types of ASHP: air-to-water and air-to-air. Air-to-water systems are used with a wet central heating system and can provide hot water. The delivery temperature is lower than traditionally used making it particularly suitable to underfloor heating, although radiators can also be run off the system. The system may require a storage tank for the hot water produced.

If temperatures are particularly low a backup system may be required, however with regards to the B Braun Medical building it will be well insulated so the ASHP is likely to be sufficient.

Air-to-air systems produce warm air that is circulated through the building by fans and can therefore be used to directly heat or cool the building depending on requirement.

Please note that this system does not provide hot water.

Noise is the main factor to be considered with installation because of the fans incorporated in the units, although this can be mitigated by placing within a plant compound.

**Air source heat pumps will be considered for the strategy.**

### 3.7 District Heating

Sheffield's City Centre District Heat System (DHS) is a network of over 44km of piping supplying heat to over 140 buildings. The system...
provides this in the form of hot water produced by energy recovery from waste incineration.

Gas and oil fired boilers are used as backups for the network and three of these can be seen in figure 3.7 as the light blue circles.

Figure 3.7: Sheffield District Heat System

The energy recovery facility (ERF, shown as the dark blue square) operates on the same principles as CHP. The electricity produced powers the ERF and other site buildings with the majority being sold to the National Grid.
As shown in figure 3.8 the site is not located within a reasonable distance of the existing DHS and is therefore not a viable option.

District heating will not be considered for the strategy due the distance between the system and site.

3.8 Other energy resources

Small scale hydro power, tidal and wave power have not been considered as the resources are unavailable on site.

3.9 Further analysis

The technologies that are to considered further are:
- Photovoltaics (PV)
- Small power wind turbines
- Air source heat pump (ASHP)

On the B Braun site there are photovoltaic panels installed on the roof of one of the existing warehouses so provides a suitable precedent. The technology is well suited to the requirements of the proposed building and can be sized to provide 10% of the predicted energy demand, complying with Sheffield’s CS65 policy.
Small power wind turbines would be a viable option for the site given documented wind speed data, however a detailed survey would need to be carried out to confirm sufficient speeds. The survey would investigate any possible interruptions to air flow from surrounding building and identify any issues that could prevent a wind scheme from being efficient.

Air source heat pumps are a feasible option for the site for providing both heating and cooling. The plant can be located within a compound, mitigating any visual and noise impact. An air-to-water pump system would be, attached to a wet central heating system and could also be used to provide hot water for the site.

These technologies have been analysed for their compliance to both the building regulations and Sheffield City Council’s 10% renewable energy requirement.

IES Virtual Environment software was used to carry out an analysis for the simplified building energy model (SBEM). The analysis provides a building emission rate (BER) and target emission rate (TER) for the building for the different LZC technologies considered. To comply with Part L of the Building Regulations the BER must be less than the TER.

<table>
<thead>
<tr>
<th>LZC Technology</th>
<th>BER</th>
<th>TER</th>
<th>Part L Compliant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building with no renewables</td>
<td>22.8</td>
<td>19.5</td>
<td>No</td>
</tr>
<tr>
<td>Photovoltaics (106m²)</td>
<td>18.4</td>
<td>19.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Small Power Wind Turbine (3 x 5kW VAWT)</td>
<td>21.1</td>
<td>19.5</td>
<td>No</td>
</tr>
<tr>
<td>Air Source Heat Pump (ASHP)</td>
<td>20.0</td>
<td>17.9</td>
<td>No</td>
</tr>
</tbody>
</table>

Source: IES VE

The photovoltaic panels and the small power wind turbines have been sized to provide 10% of the energy demand of the building, complying with policy CS65. This allows the systems to be compared with a fixed parameter to provide a fair comparison.

For this analysis the air source heat pump was included in place of a natural gas boiler for a LTHW system. The difference between the BER and TER for the building without renewables and with the ASHP option demonstrates that the pump does reduce the carbon emissions for the
building however does not satisfy the building regulations as a stand-alone option since it is a Low rather than a Zero carbon alternative.

Table 3.9 shows that the only technology to comply with both Part L 2013 and CS65 on its own is photovoltaics.

For wind turbines to meet the both requirements, would require 7 small roof mounted units which will cost around 30-50% more than the PV panels required.

### 3.10 Recommendation

The Low or Zero Carbon recommendation for the proposed building on the B Braun site is to use Photovoltaic panels. These panels could be installed alongside existing panels already mounted on the roof of the existing warehouse. The technology is well suited to the requirements of the proposed building, meets the requirement of the Building Regulations and will provide 10% of the predicted energy demand, complying with Sheffield’s CS65 policy.

Air source heat pumps remain a feasible option for the site for providing both heating and cooling. The plant can be located within a compound, mitigating any visual and noise impact. An air-to-water pump system would provide the cooling and supplement the heating system for the proposed building.

A combination of photovoltaics and air source heat pump (ASHP) is recommended as the most effective for the site in terms of carbon reductions and efficient energy provision.