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BUILDING SERVICES CONSULTING ENGINEERS
ENVIRONMENTAL | DYNAMIC MODELLING | SUSTAINABLE DESIGN

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Project: YSGOL Y GARNEDD

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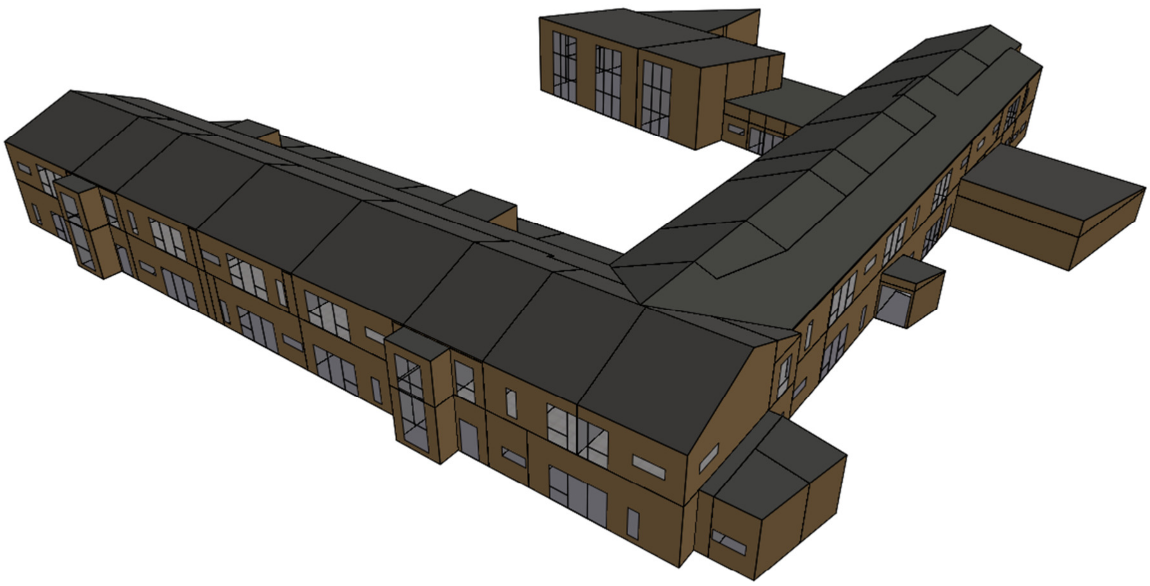

ENVIRONMENTAL SERVICES - REGULATION 25A 'ALTERNATIVE SYSTEMS' REVIEW v1.02

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1. INTRODUCTION

The following review was prepared by a CIBSE accredited low carbon consultant in design and simulation and aims to demonstrate that the proposed new build school has considered alternative technologies and ideologies in line with Regulation 25A to assist in reducing the buildings potential energy and carbon emissions emitted in operation.

PROJECT DETAILS	
Project Name:	Ysgol Y Garnedd
Building Address:	Ysgol Y Garnedd Ffordd Penfhos Bangor, Gwynedd
Country:	Wales
Postcode:	LL57 2LX

CERTIFIER DETAILS	
Company:	Davies M&E Partnership Ltd
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Regulation 25A:

Regulation 25A, the consideration of high-efficiency alternative systems for new buildings, is a European Energy Performance of Buildings Directive (Directive 2010/31/EU) and was introduced on the 9th January 2013 for public authorities and for all other buildings on the 9th July 2013 and is written as:

1. *Before construction of a new building starts, the person who is to carry out the work must analyse and take into account the technical, environmental and economic feasibility of using high efficiency alternative systems (such as the following systems) in construction, if available:-*
   a) *Decentralized energy supply based systems based on energy from renewable sources;*
   b) *Cogeneration*
   c) *District or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources; and*
   d) *Heat pumps*

The person carrying out the work must:-

a) *Not later than the beginning of the day before the day on which work starts, give the local authority a notice which states that the analysis referred to in paragraph 1 (above)*
   1) Has been undertaken
   2) Is documented, and
   3) The documentation is available to the authority for verification purposes, and
b) *Ensure that a copy of the analysis is available for inspection at all reasonable times upon request by an officer of the local authority"*

2. BUILDING DESIGN

There are three ways of improving a buildings energy performance, passive, active and renewable:

Passive:

Passive design refers to a design approach that uses the buildings orientation, construction and design to minimise the amount of energy required to condition its internal environment by maximising the effects of natural elements, such as the sun and wind. Good passive design should require very little maintenance and reduce a building's energy consumption by minimising or eliminating the mechanical systems used to regulate indoor temperature and ventilation as well as lighting.

Passive design takes advantage of the sun's limitless energy by maximising the solar heat gain and natural day light entering a building, through optimal glazing orientation and location. While good levels of insulation assist in minimising heat losses, and the use of appropriately sized and positioned operable windows can provide natural ventilation.

Active:

Active design refers to a design approach that maximizes the efficiencies of both the fixed mechanical and electrical building services, such as boilers, chillers, air conditioners and light fittings, as well as the efficiencies of the "loose" equipment installed for the buildings operation, such as fridges, freezers, IT equipment. Good active design incorporates optimally scheduled and coordinated preventative maintenance to ensure that the equipment operates at its optimal efficiency all of the time.

Active design takes advantage of the increasing system efficiencies commercially available for mechanical and electrical services and systems. This along with good design practices of optimally sizing and selecting equipment means energy usage will be reduced.

Renewable:

Renewable integration is a way of designing and operating a building and its services to efficiently utilize environmentally friendly, naturally occurring inexhaustible energy acquired locally. Renewable technologies using appropriate equipment can harvest energy from the sun, the wind, flowing water or from biofuels.

To encourage energy independence and reduce strain on the already stretched and ageing national energy infrastructure, while lowering the countries carbon emissions in-line with European guidelines, incentive schemes to assist in recovering the higher capital costs of the technology have been set up such as:

Feed In Tariffs (FIT's) – This is a government approved, energy provider backed payment scheme, in which electricity generated and used within a building in kWh is subsidised and any excess electricity generated can be sold back to the national grid.

Renewable Heat Incentives (RHI's) – This is a government approved quarterly payment scheme based upon the metered thermal energy generated in kWh from renewable technologies.

3. HIGH EFFICIENCY ALTERNATIVE TECHNOLOGIES

To reduce the buildings energy consumption, operating costs and CO_2 emissions a renewable technology could be installed, with the following technologies officially recognized by the BRE as renewable and low carbon technologies:

Solar Hot Water

Solar water heating systems use the energy from the sun to heat water, most commonly for domestic hot water purposes. The system uses a heat collector, generally mounted on the roof to capture the suns solar rays to heat a fluid which is then used to heat up water stored in either a separate hot water cylinder or in a twin coil hot water cylinder inside the building. The systems work very successfully in all parts of the UK, as they can work in diffuse light conditions.

The collectors should ideally be mounted on a south-facing roof, although southeast/ southwest will also function successfully, at an elevation of between 10 and 60°. The panels can be bolted onto the roof or integrated into the roof with lead flashings. Solar water heating systems are suitable for any building type that has sufficient year round hot water needs (ideally during the day) and a suitable south-facing roof of sufficient size.

Photovoltaic Panels

Photovoltaic systems convert energy from the sun into electricity through semi-conductor cells. These semi-conductor cells are connected together and mounted into modules. These modules are then connected to an inverter to turn their direct current (DC) output into an alternating current (AC) for use. PV systems require only daylight, not sunlight to generate electricity (although more electricity is produced with more sunlight), so energy can still be produced in overcast or cloudy conditions. Photovoltaic systems can be used successfully in all parts of the UK.

Photovoltaics come in modular panels which can be fitted on to roofs (similar to a roof light) or in slates or shingles which can be an integral part of the roof covering (looking similar to normal roof tiles). Photovoltaic cells can be incorporated into glass or cladding systems for easier building integration. Photovoltaic systems can therefore be discreet 'made invisible' by being designed as an integral part of the buildings surfaces. Photovoltaic panels should ideally face between south-east and south-west, at an elevation of about 30-40°. However, in the UK even flat roofs receive 90% of the energy of an optimum system. Photovoltaic systems are suitable for all buildings that have day time electricity usage.

Wind Turbines

Wind turbines convert the power of wind into electricity by utilizing blades which are free to rotate into the wind. The blades then drive a generator either directly or via a gearbox (generally for larger machines) to produce electricity. An inverter is required to convert the electricity generated from a direct current (DC) to an alternating current (AC) and can then either be linked to the grid or used to charge batteries.

Modern wind turbines can be quiet, with simple maintenance requirements, but they can be large and can make a significant impact upon the local landscape. They also require reasonable and consistent wind speeds to operate effectively.

Small Scale Hydro Power

Small scale Hydro Power is the utilisation of a local, free flowing water way such as a steam or river to generate electricity. Small or "micro" hydroelectricity systems generate electricity by using the energy of the moving water to turn a small turbine. The greater the flow and volume of water, the more electricity, that can be generated. Hydro Power systems are very site specific however and require direct access to running water and planning permission to build on/divert water flow for optimal efficiency.

Tidal Power

A tidal power system utilizes the oceans movement to produce electricity. This can be done by building dams similar to conventional hydroelectric power plants so that when the tide comes into the shore; it can be trapped in reservoirs and then, when the tide drops, be controllably released to generate electricity just like a regular hydroelectric power plant. Alternatively a tidal reef or tidal stream generator could be used which is essentially an underwater wind turbine which rotates based upon the constant movement of the tide in order to generate electricity.

Wave Power

Wave Power originates from the influx of energy into the oceans and seas via solar gains and wind. The energy contained within waves around the world is huge, but accessing it is very difficult with many factors affecting its deployment a reality.
Waves are not consistent therefore there is a definite problem with matching supply and demand. While identifying suitable areas with adequate wave heights is difficult with the highest concentration of wind power found in the windiest areas, which are mainly between latitudes 40 and 60 in both northern and southern hemispheres. The technology must be able to withstand the freak wave heights that can be experienced, in rough and remote locations where access can be difficult.
There are three main categories that wave power can be split into; these are Near Shore, On Shore and Off Shore. There are obvious environmental and social considerations to go with these locations.

Near Shore installations are typically within 12 miles of the shore and have an aesthetic influence on typically picturesque areas, they also have a definite effect on shipping and marine life.
Off Shore installations are typically at a sea depth greater than 50m, they have less aesthetic affect upon an area, but can affect shipping and marine life.
On Shore wave installations have the greatest affect upon an area as they need to be integrated within the environment, methods of minimising this effect are to incorporate the technology into harbor walls.

Biofuel Boilers

Biofuel heating systems use energy from biological matter such as wood chips, logs and pellets produced from managed forests, urban tree pruning, farmed coppices or farm and factory waste or they can use energy from biogas generated from a mixture of gases produced by the breakdown of organic matter in the absence of oxygen (anaerobic digestion). Biogas can be produced from regionally available raw materials such as recycled waste such as manure, sewage, municipal waste, green waste, plant material, and crops.

Biofuel boilers do require fuel storage facilities and regular de-ashing and maintenance, due to the varying quality of fuel used in the combustion process, to ensure optimal operation.

Combined Heating & Power systems 'Bio-fuelled or Natural gas fired'

Combined Heating and Power systems utilise the bi product of producing energy as a form of heating. When electricity is generated in central power stations around 65% of the primary energy is rejected as waste heat into the atmosphere. Combined heat and power units generate electricity locally so that the waste heat can be used for beneficial purposes for general heating or hot water purposes. Where all of the waste heat generated can be used, CHP units can have overall efficiencies of up to 85% compared to 40% for conventional power stations.

CHP systems have the advantage of being used with 'private wire' systems in certain circumstances and so are able to supply power even in the event of failure of the grid supply.

Community 'District' Heating & Cooling

A Community 'District' Heating & Cooling scheme is designed to provide either/or heating and cooling from a central source to more than one building or dwelling within an areas via a pipe network. The premise being that central plant efficiencies can be maximized and that varying renewable technologies can be more readily incorporated, allowing for a more responsive, energy efficient and cost effective solution. However these schemes are difficult to retro fit to existing complexes due to the infrastructure required for distribution pipework and the need for a purpose built central plant building to house the equipment.

Heat Pumps

Heat Pumps harvest the ambient heat from their natural surroundings for heating purposes. This is done by utilising an electrically driven vapour compression or absorption cycle to optimize the low grade heat collected, to a usable heating level, which can then be used in conjunction with either under floor heating circuits, over-sized radiators or to multi split air conditioning systems to provide heating/cooling as required. Heat pumps have some impact on the environment as they need electricity to run, but the heat they extract from the ground, air, or water is constantly being renewed naturally, and the efficiencies achievable are very high compared to typical combustion alternatives.

- Water Source Heat Pumps absorb energy from either open or closed loop pipes laid in local water sources, rivers, or lakes.
- Geothermal (Ground) Source Heat Pumps absorb energy from loop pipes buried in the ground either horizontally or vertically:
  - Horizontal
    – Slinkies or trenches 1 – 3m deep, which rely on large areas of land absorbing solar gains to replenish ground temperatures.
  - Vertical
    – Boreholes drilled deep into the earth 60m+, which relies on the fairly consistent year round, static ground temperature.
- Air Source Heat Pumps absorb energy from the surrounding air.

Gas Absorption Heat Pumps

Gas absorption heat pumps work along the same principles as air source heat pumps but utilise a high efficiency gas condensing burner, this gives a lower but more consistent year round efficiency.

Gas absorption heat pumps are just as easy to integrate into a heating system as a condensing boiler, with the additional benefits of higher carbon savings, lower environmental impact (low NOx emissions) and reduced running costs (utilising cheaper gas instead of electricity). The units are designed for external installation so there is a requirement for an external compound but no requirement for extra internal plant room space.

4. ALTERNATIVE TECHNOLOGY APPRAISAL

Alternative technology analysis based upon potential benefits, ease of technical integration, budget constraints and environmental impact.

Technology	**Sub Group**	**Preliminary Appraisal**		**Feasible**
		Requirements & Benefits	Limitations & Issues	
Solar Thermal Array	Roof / Wall Mounted	Modest and consistent domestic hot water required Orientation & Inclination of roof. Low maintenance / costs. Able to claim Renewable Heat Incentives. Can be installed individually or in conjunction with central plant.	Effect on buildings visual appearance. Reasonable domestic hot water requirements, lowers during summer months when most hot water could be generated. Physical weight upon structure. Piping and distribution. Metering & Maintenance.	**NO** ***Low carbon saving potential, peak functionality outside of building operation.***
Photovoltaic Array	Ground Mounted Roof Mounted Building Integrated	Modest electricity demand required. Low maintenance / costs Able to claim Feed In Tariffs Significant carbon savings possible with reduced dependency on fossil fuels.	Capital Cost Access requirements Overshadowing can affect panel efficiency Effect on buildings visual appearance. Weight upon structure	**YES** ***High carbon saving potential, electricity used all year, potential to export.***
Wind Turbine	Vertical Axis Horizontal Axis	Modest electricity demand required. Low maintenance / costs. Stand alone, Column mountable. Roof mountable. Able to claim Feed In Tariffs.	Capital Cost. Low average wind speed expected on site. Potential to create low frequency noises. Aesthetic impact on surroundings. Roof mounted structural / vibration impact. Turbulence. Planning Permission.	**NO** ***Unsuitable location.***

Technology	Sub Group	Preliminary Appraisal		Feasible
		Requirements & Benefits	Limitations & Issues	
Hydro	Small Scale Tidal Power Wave Power	Modest electricity demand required. Reasonable maintenance requirements / costs. Able to claim Feed In Tariffs.	Capital Cost. Aesthetic impact on surroundings. No suitable local water sources, rivers, streams, coast line. Effect on local marine life / water tables. Planning Permission.	**NO** ***Unsuitable location.***
Biofuel Boiler	Wood / pellets Rape Seed Oil Biogas	Modest & consistent heating & hot water demand required. Good CO_2 savings. Able to claim Renewable Heat Incentives. (under review)	Planning Permission. Significant plant space and area needed for fuel deliveries & storage. Reliable local fuel supply chain required. Regular maintenance required; de-ashing etc. Requires a back-up system.	**NO** ***Spatial requirements, for equipment, storage, deliveries and maintenance. (National Biomass fuel Supply shortage / RHI under review due to high uptake)***
Combined Heat & Power (CHP)	Gas CHP Biomass/fuel CHP MiniCHP MicroCHP	Modest & consistent heating & hot water demand required. Reasonable & consistent electricity load required. Efficient use of fuel. High CO_2 savings.	Capital cost. Maintenance Intensive. Significant plantroom space & storage area for fuel deliveries required. Potential noise intrusion Detailed Base loads required for optimal sizing. Reliable fuel supply chain required (Biofuel)	**NO** ***Capital cost, seasonal demand variation, no appropriate equipment available.***
Community 'district' Heating & Cooling	CHP Systems Biofuel Boilers Heat pump Stations	Modest & consistent heating & hot water demand required. Central maintenance requirement. High CO_2 savings possible.	Capital cost. Detailed Base loads required for optimal sizing. Positioning of central plant, storage facilities & distribution network. Maintenance scheduling	**NO** ***Insufficient demand & lack of local Facilities/requirement.***

Technology	Sub Group	Preliminary Appraisal		Feasible
		Requirements & Benefits	Limitations & Issues	
Heat Pumps	Air (ASHP) Ground (GSHP) Water (WSHP)	Modest heating & hot water demand required. High COP's / Efficient use of fuel. Minimal maintenance. Flexible Installation. CO_2 savings possible. Some are able to claim Renewable Heat Incentives (water, heating circuits only). (under review)	Capital cost. Specialist maintenance required. Local water source required for water sourced heat pumps i.e. rivers, streams etc. Full ground survey required to determine geology for ground source heat pumps. Area of land required. Air source heat pumps not quite as efficient & require a defrost cycle in extreme conditions.	**POTENTIAL Requires further review for capital *cost, operating flexibility, as well as noise and visual effect on site.***
Gas Heat Pump	(GaHP)	Modest heating & hot water demand required. Good consistent COP's / Efficient use of fuel. Minimal maintenance. Flexible Installation. CO_2 savings possible.	Annual (GAS) maintenance required. Requires external space. Minimal noise intrusion. GaHP systems are in their infancy in the UK, early stages of commercialisation giving a reasonable technical risk.	**POTENTIAL Requires further review for capital *cost, operating flexibility, as well as noise and visual effect on site, external siting required.***

5. CONCLUSION

The building is being designed to follow good design practices, utilizing passive design ideologies to first minimise the energy required to condition and inhabit the internal environment, and then by maximising the system efficiencies of all new plant equipment.

A good quality of workmanship is expected with high quality, low U-value constructions and robust building techniques specified, to minimise air leakage rates and heat losses. While the size, position and operability of the glazing has been considered to provide beneficial solar gains, natural ventilation and day light penetration into the building, which will greatly assist in reducing heating, ventilation and artificial lighting requirements.

Following these passive measures, energy efficient active measures have been undertaken with appropriate and optimally sized heating systems and 'LED' low wattage lighting specified where possible. The controls for which have been selected based upon their suitability and responsiveness to operate only as and when required. Where natural ventilation may be insufficient, energy efficient mechanical ventilation has been specified to ensure energy efficient operation in maintaining optimal internal conditions.

Ideally all heating, cooling and lighting equipment should be selected from the latest Enhanced Capital Allowance (ECA) lists, thus ensuring that they perform at suitably high efficiencies and produce the lowest carbon emissions and operating costs possible.

In order to improve the buildings efficiency and to assist with Part L compliance, both a heat pump arrangement and a photovoltaic array will be considered further to supplement the buildings heating and electricity requirements. As the technologies are scalable and may be appropriate both technically and functionally, offering low maintenance, high cost effectiveness and efficient operation.

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