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Sustainability Review

of

New Depot, Langley Park Farm West

for

Maidstone Borough Council

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1 Introduction

Tuckers Consultancy Ltd have been commissioned by Maidstone Borough Council to review the Sustainability Options and Costings report produced by TPS Carillion who are acting as Employers Agent and providing professional services on the New Depot, Langley Park Farm West project.

The aim of the report is to interrogate the costs and assumptions made in capital cost and life cycle calculations.

2 Conclusions

1. The capital, maintenance and energy cost estimates in both the TPS and this report, used to calculate life cycle costs are very preliminary calculations and do not meet the quality standards set out in the Building Regulations and The Energy Performance of Buildings Regulations.

2. The conclusions presented below are highly simplified preliminary estimates which consider simple bolt on solutions, other more complex scenarios could be envisaged particularly for heatpumps and CHP. The key stages of the development should be identified and further design and performance reviews must be planned and carried out using industry standard techniques by the design and build team to ensure the sustainability targets are met.

3. Wind turbines could significantly reduce the carbon emission of this project but we have identified significant planning issues which will be difficult to over come. On balance, the time and cost which will probably be incurred in mitigating the planning issues without guarantee of success, wind turbines should not be considered further.

4. Solar PV can significantly reduce the carbon emission of this project and should be incorporated in the scheme to meet the Part L2A building regulations Target Emission Rate requirement. Solar Photo Voltaic is also eligible for a DTi Low Carbon Buildings Project phase 2 grant and can easily meet the benchmark £/tonne CO2 criterion.

5. Solar hot water can significantly reduce the carbon emission of this project and should be incorporated in the scheme to meet the Part L2A building regulations Target Emission Rate requirement. Solar hot water is also eligible for a DTi Low Carbon Buildings Project phase 2 grant, the proposed installation must be optimised to meet the benchmark £/tonne CO2 criterion.

6. Free Cooling and Energy Saving Controls will significantly reduce energy consumption and should be incorporated in the scheme to meet the Part L2A building regulations Target Emission Rate requirement.

7. A condensing boiler is highly recommended and probably essential to meeting the Part L2A Target Emission Rate.

8. We do not consider Heatpumps, Combined Heat & Power or Bio Mass boilers to be suited to this project due to the characteristics of the building and its intended use.

9. TPS have not made a case for increased thermal insulation and we also consider it to be a very poor use of capital, which might be spent in improving other more dominant heat losses, such as infiltration or external doors.

10. Rain water harvesting and Sedum roofs are sustainability measures which address issues other than carbon emission such as water resources, habitat and waste. From an energy consumption point of view the payback will be very long and the ecological and habitat benefits would have to be compelling to justify its cost.

3 Recommendations

1. Set an EPC asset rating target. Band A is a very low carbon emission building. The minimum target for this building will be top of band B as a lower band B rating will probably encounter problems with compliance on Target Emission Rate. A Band A rating will require a significant proportion of the energy demand to be met by renewables. (See appendices for brief description of TER and EPC asset rating.)

2. The design and build contractor, Gallagher, should demonstrate what Part L2A trade offs enhancements and/or renewables have been included to attain a Part L2A compliance. e.g. Wind turbines, Solar PV, Solar hot water, automatic PIR lighting control, room temperature and time controls, automatic energy monitoring and targeting, heat recovery on ventilation, fan power, air leakage testing etc.

3. Knowing the predicted energy consumption with some rational degree of accuracy is crucially important to the carbon emission and economics calculations. In our opinion there is sufficient available design information available in the design brief, proposal drawing and outline specification documents to create a useful thermal model and trial the sustainability options.

4. Some renewable and low carbon technologies are eligible for the DTi's Low Carbon Buildings Programme Phase 2 funding, which is available to support renewable and low carbon technologies for charitable bodies and public sector organisations, including local authorities, providing certain efficiency benchmarks and eligibility criteria are met. Efficient utilisation of grant aid is essential for the economic application of sustainable technology at the present time and should be considered.

4 Design Brief and Sustainability Criteria

Inspection of the drawings and Gallagher proposal documents show a fairly typical steel framed light weight commercial, light industrial, building. The design has been arrived at from an aspirational goal for a BREEAM "Excellent" building, with a minimum target of "Very Good". BREEAM takes into account a range of environmental features, such as transport and refuse disposal and as such may not be the best tool to evaluate the building physics, energy performance and carbon emissions, which must be the primary focus for a sustainable building.

The TPS report states that their report "is heavily limited by the lack of design data currently available specific to the proposed depot".

In our opinion there is sufficient available design information available in the design brief, proposal drawing and outline specification documents used in the preparation of this report to create a useful thermal model and trial the sustainability options. Knowing the predicted energy consumption with some rational degree of accuracy is crucially important to the carbon emission and economics calculations.

TPS report does not include a Part L2A Target Emission Rate, a target EPC asset rating nor any energy consumption or carbon emission design criteria.

TPS report attempts to evaluate building physics, energy performance and economics without any realistic building model to optimise energy consumption or carbon emission.

There is industry common misconception that buildings can still be designed and then the energy consumption and carbon emissions calculated. Part L2A and the EPBR now force the designer to consider the TER at the very outset. Failure to do so will result in a poorly optimised building and systems, which will result in increased costs and delays in trying to achieve compliance during construction and may have long term consequences for the asset rating.

5 The Sustainability Options

We have examined the TPS report entitled Sustainability Options & Costings, MSWord file Sustainability Report DRAFT V5 30-05-08.doc.

1) The report is a list of renewable and low carbon systems and equipment with no supporting guidance on how they were to be applied separately or in combination to provide an optimised solution, be it low capital cost, renewable energy, or high efficiency low carbon selection criteria.

2) The capital costs, whilst it is understood are of a budgetary nature, are in our opinion 30% higher than our recent experience suggests.

3) The improved insulation option is not discussed in similar detail to the other options.

The list of options is reasonably comprehensive and can be split into 3 categories:

5.1 Renewables:

1) Wind turbine electricity

2) Photovoltaic electricity

3) Solar hot water

4) Bio mass boiler

Renewables are characterised by having a zero carbon contribution during operation, they have a varying carbon debt resulting from embodied energy during manufacture and construction and decommissioning, which has a pay back period. Embodied energy calculations are debated widely, as they are subject to assumption and generalisation and can vary enormously.

5.2 Low Carbon:

1) Air source heat pump

2) Ground source heat pump

3) Condensing boiler

4) CHP

5) Thermal elements (insulation and other fabric measures)

6) Free cooling

Low carbon technologies are characterised by utilising traditional hydrocarbon energy sources including grid supplied electricity, in ways which maximise efficiency.

5.3 Environmental:

1) Rain water harvesting
2) Sedum roof

Environmental measures address issues other than carbon emission such as water resources, habitat and waste.

6 Life Cycle Costs

6.1 Nett Present Value

The TPS report attempts to rate the various sustainability options in terms of their lifecycle cost using the net present value with a 3.5% discount rate. We make no comment on the discount rate used but it is obviously subject to the normal caveats about financial projections

The TPS life cycles costs seem to have been calculated over a 15 year term for mechanical and electrical systems. Product life cycles, particularly for electronic components are getting shorter and we have found obsolescence and spares availability can be a real problem after 15 years or so.

It should be noted that the DTi LCBP phase 2 bench marks use 25 years payback for PV and 20 years for other technologies.

This report presents the TPS NPV values as originally presented and TCL NPV values calculated to the DTi's Low Carbon Buildings Programme Phase 2 time scales.

It should be noted that NPV is the net present value of the investment and ideally should be greater than the capital investment. Few low and zero carbon technologies actually achieve this and some like heat pumps and CHP can never provide any return on investment.

6.2 Fuel Costs

The life cycle costing assumes fixed fuel costs, which seem very optimistic given recent head lines. Long term interest rates, inflation and fuel costs are not easily predictable and the head line consumer rates are always much higher than tendered long term contracts which is council policy.

The TPS estimate of annual gas heating energy consumption seems high. For the primary boiler plant they have used 120GJ per annum. A recent project of 538m² of similar construction with high efficiency lighting and high efficiency gas fired LPHW radiator heating has a projected annual heating energy consumption of 43.79GJ and a lighting energy consumption of 41.93GJ. At today's prices the projected annual energy bill will be around £2,137. This installation will just achieve the TER and will be asset rated band B on the construction EPC.

The recalculated lifecycle costs have been based on annual energy yields priced at an average day and night time rate of £0.1/unit. In effect we have assumed energy costs about 20% higher than today's rates.

Using this as pro rata guide for a Depot total floor area of 1098m² the projected energy consumption for gas fired LPHW radiator heating system would be 89.37GJ and a lighting energy consumption of 85.57GJ. At today's prices the projected annual energy bill will be around £4,500. It should be noted that the depot would have a larger volume to surface area ratio and thus less heat loss but that the work shop is likely to be less energy efficient; on balance the annual gas heating energy consumption should be 25% lower than the TPS calculation.

With respect to wind turbines and solar PV, TPS have used 5 day per week building occupancy to calculate energy yields with utilisation factors to account for all forms of variability. These forms of renewable energy, which displace grid electricity, should be calculated on annual energy yield based annual hourly wind and sunshine statistical data.

6.3 Grid Connection

To maximise the energy yield of Solar PV and wind turbines, they should be grid connected in order that surplus energy for instance, outside normal occupancy times, can be sold back to the grid. TPS have not considered the desirability for grid connection and a tariff with a favourable buy back kWh rate. If MBC are to realise their carbon neutral ambition it is highly likely they will have to commit to small scale renewables with grid connections in order that they can sell surplus energy back to the grid, therefore the maximising the return on investment. A key component of such a policy will be an electricity supply deal which both minimises energy cost and allows selling back to the grid at an economic return.

6.4 Capital Cost

TPS's capital costs are very broad budgetary figures and in respect of wind turbines, PV and solar hot water we have been able to provide a little more refinement based on current projects which has reduced capital cost.

It should be noted that the council as a non profit organisation can apply for up to 50% of the cost of installing approved microgeneration technologies, supplied and installed by Framework Suppliers, via the DTi's Low Carbon Buildings Programme Phase 2 funding scheme operated by BRE.

7 Sustainability Options

7.1 Wind Turbine

Wind Turbines are generally a simple bolt on solution to the existing electrical power system.

Wind speed varies with time. The Annual Mean Wind Speed for a given locality is an indication of how much wind energy is available. The useful energy available in the wind is a function of the cube of the wind speed, there is very little energy available to be harvested at wind speeds less than 4 m/s. In general, small wind turbines have a cut in wind speed of 3m/s, AMWS for the Maidstone area is 4.5 m/s, which means that a wind turbine project is from the outset only marginally viable and more detailed wind speed surveys or expert assessment of the actual site will be required.

TPS have selected a single 25kW mast mounted conventional windmill. In our opinion this is rather large for the site and will give rise to problems with both site layout and local planning guide lines. Given the time available for this report we have selected two 5kWp readily available turbines which could be located at each end of the site on the commercial light industrial boundary furthest away from the residential boundary.

7.1.1 Capital Cost

TPS estimate supplying and installing a single 25kW mast mounted conventional windmill, and interfacing with the incoming supply as a capital cost of £100,000.

We estimate supplying and installing two 5kWp mast mounted conventional windmills and interfacing with the incoming supply as a capital cost of £50,000. It should be noted that the council as a non profit organisation and using a grid connected and grant approved manufactures product is eligible for up to 50% grant for the supply and installation cost.

7.1.2 Annual grid supplied electricity saving

TPS estimate the annual output of a single 25kWp wind turbine with an annual 3120 annual hours utilisation and a 40% utilisation factor yields an annual grid supplied electricity saving of £3,120.

We estimate the annual output of a grid connected 2 X 5kWp wind turbine with a local annual mean wind speed of 4.5 m/s for the Maidstone area over 8760hours with a utilisation factor of 23% will yield an annual grid supplied electricity saving of £2,015.

7.1.3 Life Cycle Cost

TPS estimate for a capital cost of £100,000, annual maintenance of £500, end of life disposal cost of £4000 and annual grid supplied electricity saving of £3,120, all at a discount factor of 3.5% gives an NPV £72,212.

We estimate for; a capital cost of £50,000, annual maintenance of £1000 and an end of life disposal cost of £2000 and annual grid supplied electricity saving of £2015, all at a discount factor of 3.5% gives an NPV of £35,574.

Wind Turbines are eligible for a DTi Low Carbon Buildings Programme Phase 2 funding provided a certain level of efficiency can be shown in terms of £/Tonne CO_2 saved. For 5kWp turbines the criteria is £531/tonne CO_2. The proposed 5kWp turbines efficiency is £289/tonne CO_2, which is below the bench mark and therefore will be eligible for funding.

7.1.4 Environmental Impact

Two 5kWe turbines could save 11.5 Tonnes of CO_2 annually. Overall the building is estimated to emit 15 tonnes CO2 annually and wind turbines could reduce or offset (selling back to grid) this significantly.

Their manufacture involves the extensive use of steel, copper and plastics which have potential value for end of life recycling. The wind turbines themselves might be made from recycled materials?

Planning and environmental noise will be significant hurdles to cross in the development of a wind turbine solution. We have learned that even a 5kWp wind turbine will have to be sited at least 100m from a sensitive i.e. residential property.

7.1.5 Conclusion

Proximity to residential areas make planning issues with visual amenity and environmental noise the over riding issue. The possible locations for the wind turbines are very limited and an environmental noise solution is unlikely to be possible at least 100m from housing on this site. The low Annual Mean Wind Speed of the site would tend to require a tall mast to access clear air above the local buildings this will be at odds with the design requirements planning. Wind turbines could significantly reduce the carbon emission of this project but we have identified significant planning issues which will be difficult to over come. On balance, the time and cost which will probably be incurred in mitigating the planning issues without guarantee of success, wind turbines should not be considered further.

7.2 Photo Voltaic Solar Cells

Like Wind Turbines PV is generally a simple bolt on solution to the existing electrical power system.

PV generally has a very high capital cost and there is controversy as to the embodied energy in manufacture and the environmental impact of the toxic chemicals used in manufacture.

7.2.1 Capital Cost

For a 10kWp installation TPS use a capital cost of £40,000. Our recent experience suggests a more reasonable budget figure would be £60,000.

7.2.2 Annual grid supplied electricity saving

TPS estimate 10kW, 2600hr/yr with a 46% utilisation factor, an annual grid supplied electricity saving of £1,040.

We estimate the annual output of a grid connected 8760hr/yr with a utilization factor of 21%, an annual grid supplied electricity saving of £1,840.

7.2.3 Life Cycle Cost

TPS estimate, for a capital cost of £40,000, annual maintenance of £400, end of life disposal cost of £5,000 and annual grid supplied electricity saving of £1040, all at a discount factor of 3.5% TPS gives an NPV £35,613.

We estimate, for a capital cost of £60,000, annual maintenance of £400, end of life disposal cost of £2,500 and annual grid supplied electricity saving of £1840, all at a discount factor of 3.5%, gives an NPV of £43,917.

Solar PV is eligible for a DTi Low Carbon Buildings Programme Phase 2 funding provided a certain level of efficiency can be shown in terms of £/Tonne CO2 saved. For 10kWp solar PV the criterion is £990/tonne CO2. The proposed 10kWp solar PV is £277/tonne CO2, which is below the bench mark and therefore will be eligible for funding.

7.2.4 Environmental Impact

Solar PV could save 10 tonnes of CO_2 annually. Overall the building is estimated to emit 15 tonnes CO2 annually and Solar PV could contribute or offset this significantly.

The manufacture of PV involves high energy input and the use of highly toxic chemicals. Recent studies have challenged these issues suggesting that embodied energy is paid back in around 2.5 years and that the environmental impact at extraction and manufacture whilst an issue is managed and sustainable.

Modern PV has a self cleaning coating and maintenance is largely electrical testing. End of life disposal is not likely to be a significant problem, the manufacture has a duty to recycle the products under the WEEE regulations and there may even be a second-hand market.

Installation planning and environmental issues are much less of an issue when compared to wind turbines and acceptance is anticipated with out significant cost or delay.

7.2.5 Conclusion

Solar PV should be actively considered for incorporation in the building to meet the 10% renewables option detailed in the Part L2A building regulations. It is clear that a DTi LCBP phase 2 up to 50% grant could be obtained which makes PV an economic proposition.

7.3 Solar Hot Water Panels

Solar Hot water panels are generally a fairly simple bolt on to a conventional gas or electric HWS water hating system. Additional costs would be incurred if the base line HWS were point of use electric water heaters

7.3.1 Capital Costs

TPS estimate supplying and installing a 25kW Hot water Solar panels, and interfacing with the presumably gas fired HWS system to have a capital cost of £20,000.

We estimate a Hot water Solar panels installation capable of supplying 1500lt per day using evacuated glass tube solar collectors to require the supply and installation of 10 panels to have a capital cost of £39,000

7.3.2 Natural Gas Energy Saving

TPS estimate the gas saving as 25kW for 2600hr/yr with a utilization factor of 55%, an annual grid supplied natural gas fuel cost saving of £2,860.

Tuckers estimate a hot water demand of 390,000l/yr with a heat generator efficiency of 70% and a utilization factor of 55%, an annual grid supplied natural gas fuel cost saving of £1,144.

7.3.3 Life Cycle Cost

TPS estimates, for a capital cost of £20,000, annual maintenance of £400, end of life disposal cost of £1,000 and an annual grid supplied natural gas fuel cost saving of £2,860, all at a discount factor of 3.5% TPS gives an NPV of £27,736.

We estimate for a capital cost of £39,000, annual maintenance of £400, end of life disposal cost of £1,000 and an annual grid supplied natural gas fuel cost saving of £1,144, all at a discount factor of 3.5%, gives an NPV of £28,953.

Solar hot water is eligible for a DTi Low Carbon Buildings Programme Phase 2 funding provided a certain level of efficiency can be shown in terms of £/Tonne CO2 saved. For Solar Hot Water the criterion is £563/tonne CO2. The proposed Solar Hot Water is £63/tonne CO2, which is below the bench mark and therefore will be eligible for funding.

7.3.4 Environmental impact

Solar Hot Water could save 6 Tonnes of CO_2 annually. Overall the building is estimated to emit 15 tonnes CO2 annually and Solar Hot Water could reduce this significantly.

Solar hot water panels are a simple technology which given the potential daytime hot water load of the site may be quite effective. They have little embodied energy to payback, they can just as well be made from recycled materials, and have a low maintenance requirement. The reduction in carbon emission is generally considered worthwhile even if the payback is extended.

7.3.5 Conclusion

Solar hot water should be actively considered for incorporation in the building to meet the 10% renewables option detailed in the Part L2A building regulations. The system should be optimised to be below the grant funding benchmark.

7.4 Heat Pumps

Heat pumps can not be seen as a bolt on solution. Heat pump installations must be carefully optimised and avoid competition from other low and zero carbon heating solutions if the economics are to be succesfull.

The TPS report concentrates on conventional Air source to water heat pumps using grid supplied electricity. These have the advantage of being readily available from traditional comfort cooling manufactures and suppliers and use very conventional comfort cooling refrigeration vapour compression cycle technology. As such they will be subject to the F gas regulations and the regular inspection costs this entails. Air source heatpumps have a lower CoP than ground source heat pumps and in consequence they are not eligible for DTi LCBP phase 2 funding. However this need not preclude their selection as they are relatively cheap to buy and install.

Ground source heatpumps generally have a higher CoP than air source heat pumps and are eligible for DTi LCBP phase 2 funding. Ground source heat pumps have inherently high installation costs unless extensive pilling is a feature of the building structural design. Using the car park and hard standing as solar collector is particularly attractive from a seasonal co-efficient of performance point of view but in this country has been largely dismissed due to the perceived problems with settlement and damage to the relatively shallow depth pipes. TPS and our selves are forced to dismiss ground source for these reasons.

The optimum size of the air source heat pump is not clear. For a projected office heating load of around 70kW the 15kW heat pump chosen by TPS is probably too small.

7.4.1 Capital Cost

TPS estimate the cost of supplying and installing a single 15kW air source heatpump and interfacing with a presumably LPHW radiator heating system to have a capital cost of £20,000.

Tuckers estimate the cost of supplying and installing a single 15kW air source heatpump and interfacing with a presumably LPHW radiator heating system to have a capital cost of £12,000.

7.4.2 Energy Cost Saving

TPS estimate and energy saving of £1,487

The manufactures give typical installed energy savings as £185 for displaced gas heating and a CO2 saving of 830kg.

7.4.3 Life Cycle Cost

TPS estimate, for a capital cost of £20,000, annual maintenance of £500, an annual Energy saving of £1,487 and an end of life disposal cost of £1,500 all at a discount factor of 3.5% gives an NPV of £9,525.

We estimate, for a capital cost of £12,000, annual maintenance of £500 and an end of life disposal cost of £1500, an annual energy saving £185, all at a discount factor of 3.5%, gives an NPV of -£1,806. The energy savings are less than the maintenance costs so the capital is never repaid.

7.4.4 Environmental Impact

An air Source Heatpump would only save 1 tonne of CO_2 annually. Overall the building is estimated to emit 15 tonnes CO2 annually, an air Source Heatpump would not reduce this significantly.

If mains gas is not available then air source heatpumps are a viable heating technology for reduction of grid electricity running cost and carbon emissions. When mains gas is available the running cost and carbon emission reduction is less clear cut and relies on the grid supplied electricity carbon factor and the in practice achieved CoP, if both are worse than expected then carbon emission may actually increase.

7.4.5 Conclusion

As the site has mains gas available and the low NPV and extended payback, we do not recommend that heatpumps should be considered for this project.

7.5 Combined Heat and Power

CHP schemes can not be seen as a bolt on solution. CHP schemes must be carefully optimised and avoid competition from other low and zero carbon heating solutions if the economics are to be successful.

CHP schemes are usually sized to meet the 24/7 base electrical load to be economic. We estimate the max demand power to be around $25kW_e$ with a base load of less than $1kW_e$ and a peak HWS heat load of around $25kW_h$.

In our opinion only the smallest gas engine (derived from a car engine) would be suitable. An alternative might be micro CHP sized to serve the hot water heating load. To keep the CHP within the micro range and ensure 24 hour operation hot water service thermal store would be required.

A CHP scheme would only save 1 tonne of CO_2 annually. Overall the building is estimated to emit 15 tonnes CO2 annually, A CHP scheme would not reduce this significantly.

7.5.1 Conclusion

We concur with the TPS conclusion that a conventional automotive gas engine CHP is not suitable. The 24/7 base electrical load is not large enough to optimise a CHP installation.

7.6 Thermal Storage Hot Water Buffer Tank

Thermal storage might be used in conjunction with several of the technologies discussed in this report.

a) As a thermal store to buffer a solar hot water heat source over night.

b) A hot water buffer vessel is almost a prerequisite for a bio mass boiler to match the slow thermal response typical of bio mass boilers with variation in demand.

c) As a thermal buffer to facilitate constant load running with a CHP heat source.

d) As a thermal buffer to facilitate constant load running with a heatpump heat source.

7.6.1 Environmental impact

Thermal storage is essentially a passive enabler for various renewable and low carbon technologies. In its simplest forms the embodied energy is modest and the materials are recyclable.

7.6.2 Conclusion

Increased hot water storage is essential for a solar hot water system.

7.7 Free Cooling

An alternative form of thermal storage is within the thermal mass of the building fabric i.e. the walls floors and ceiling materials. The building structure as proposed is a light weight dry lined construction which has very little thermal mass. This has the effect of making the occupied space temperatures swing wildly from cold in the early morning to sufficiently hot in the afternoon to make the occupant demand comfort cooling.

This is alluded to in TPSs statement "During the summer months it is likely that the building would heat up during the day, and the use of stand alone air conditioning units may be contemplated by the users. This is a factor that cannot be controlled at the design stage."

TPS are correct in saying that the building may be subject to overheating but they are wrong in suggesting that this can not be controlled at the design stage. By selecting materials and finishes the thermal mass present in the occupied spaces can be usefully increased, reducing the swing in temperature and obviating the need for cooling. The advantageous use of fabric thermal storage can also be enhanced by using night purge ventilation.

Night purge ventilation works in conjunction with fabric thermal mass to cool the building at night to both reduce and time shift the peak summertime temperature in the afternoon.

7.7.1 Environmental impact

Night purge ventilation can use the existing ventilation system with a few enhancements. Therefore it's the additional materials and the attendant embodied energy is modest and the materials are generally recyclable.

The avoidance of comfort cooling is of the highest priority for a low carbon building.

7.7.2 Conclusion

Avoidance of comfort cooling must be a top priority and fabric thermal storage in conjunction with night purge ventilation offers a low carbon solution. A building dynamic thermal simulation software model is required to investigate this solution. This should not be seen as an optional exercise as the same software input, the time consuming bit, is required to generate Part L2A compliance reports and an EPC which is a requirement under the legislation.

7.8 Biomass boiler

In our experience this type of boiler is very unreliable. This is due to the natural variation of the fuel and the difficulties which arise with handling and combustion mainly due to huge variations in moisture content. Burning an unprocessed source of fuel such as grass, hedge and tree clippings is out of the question. For this type of plant to operate at a reasonable efficiency and deliver a reliable regulated heat source, the fuel it burns needs to have a regular calorific value and moisture content. This is achieve by collecting and processing green waste with saw mill and cultivated bio mass into fuel pellets but the cost, financial and carbon, has to include additional infrastructure and transport for; collection and storage, transport to and from processing, storage at point of use, storage and disposal of ash.

The automatic transfer from the fuel store to the furnace is much less reliable than oil or gas and requires daily attendance. The fuel store is a fire hazard (I have never seen a coal or oil store fire but I have seen the same bio mass fuel store burn down twice!). Chimney emissions are much higher than gas or oil.

In our opinion bio mass fuel is best suited to much larger boiler plant where its disadvantages become much less dominant in the running costs such as burning bio mass with coal in power stations or very large community heating projects. For a small heating boiler the effort is probably not worth the cost.

7.9 Condensing gas boiler

The building heating load will be relatively modest due to the effects of the building regulations with respect to U values air leakage etc. Furthermore the guidance on non domestic heating cooling and ventilation requires boilers to be at least 80% efficient. In order to achieve the Part L2A Target Emission Rate and gain an exemplary EPC band rating the boilers will almost certainly have to be 90% efficient or higher which puts them in the condensing range. To realise a fully condensing boiler efficiency the system return temperature must be designed to the manufactures' requirement for fully condensing operation typically 60 -65°C. For a given heat output larger radiator emitters will be required.

7.9.1 Capital Costs

The capital costs are probably marginally higher compared to a conventional 81-72°C LPHW system. Furthermore expenditure will probably be demanded in order to comply with the regulations.

7.9.2 Grid supplied Natural Gas annual cost

TPS estimate an annual energy consumption of 120GJ at a cost of £2663

We estimate an annual energy consumption of 89.4GJ at a cost of £1986

Life Cycle Cost

A condensing boiler is highly recommended and probably essential to meeting the Part L2A TER.

7.9.3 Environmental impact

Reduces the use of Natural gas fossil fuel

7.9.4 Conclusion

A condensing boiler is highly recommended and probably essential to meeting the Part L2A Target Emission Rate. Incorporation of other technologies discussed in this paper may affect the sizing of the boiler plant but fully condensing natural gas fired boilers are expected to provide the winter heating base load and hot water service.

7.10 Energy Saving Equipment

TPS suggest a list of energy saving equipment:

7.10.1 "Local extract fans to be fitted with heat recovery units to preheat any make up air"

Part L2A Target Emission Rate and the EPC asset rating give bonus allowance for heat recovery although Part L2A does allow a trade off between fan power and heat recovery. In order to achieve the Part L2A Target Emission Rate heat recovery may have to be incorporated in the final design. To gain an exemplary Part L2A Target Emission Rate and EPC band rating heat recovery is an obvious option.

7.10.2 The garage air compressor could be used to supply free heating to that area.

We are not aware of any proven methods to do this. The equipment manufacture may be able to offer advice. As the air compressor is not considered to be part of the building under Part L2A, capital spent in this area would not be directly reflected in the Part L2A Target Emission Rate and the EPC asset rating.

7.10.3 "Cold water booster sets could be incorporated to reduce / remove the need for potable water storage and thus reducing maintenance costs for water treatment"

Not sure what TPS are trying to say here. Unless the mains pressure is low the essentially low rise development could perfectly well operate on mains pressure without cold water storage. The addition of a cold water storage tank would not significantly affect the water hygiene costs.

7.10.4 "The use of PIR controlled or low flow showers, taps and toilets should be included as a matter of course"

All sanitation fittings should be selected and installed to ensure minimum water consumption. In our experience PIR urinals are effective. PIR Taps and showers have proven to be very unpopular with users. A much better approach is effective flow rate control using proprietary restrictors. In particular the hot water system should be designed to minimise cold dead legs and at the same time minimise circulating and standing losses. In this building it means locating the HWS system centrally in the toilet changing area and fitting thermostatic blending controls to the hot water.

7.10.5 "Zoned PIR controlled lighting using energy efficient fittings again should be included as a matter of course"

Lighting design will have to be designed to the highest efficiency standards Part L2A TER and the EPC asset rating give bonus allowance for automatic programmed controls with PIR over ride.

7.10.6 "Pulse Metering on the supplies should be included to enable monitoring of energy demand and Leak detection devises should be fitted to minimise loss"

Part L2A demands that the building should have a metering strategy such that at least 90% of the total energy consumption can be accounted for. In particular this means that lighting which is a controlled service under Part L2A has to be separately metered from small power which is not. Part L2A Target Emission Rate and the EPC asset rating give bonus allowance for approved Automatic Monitoring and Targeting which TPS may be referring to as pulse metering. Such a system would include water and gas meters (fitted with pulse heads) and thus cover leak detection. As a public authority building the Council will be obliged to display a Display Energy Certificate, which is recalculated annually based on energy bills. An approved Automatic Monitoring and Targeting system would produce this information semi automatically, the DEC will still have to be signed off by a Qualified Energy Assessor but the saving in Energy assessor survey time could well have a short payback.

7.10.7 Controls

TPS have not included controls. Part L2A Target Emission Rate and EPC asset rating calculations give bonus allowance for automatic temperature controls, which reduce energy consumption and thus carbon emission. In particular an allowance is made for individual room temperature controls and individual room time controls. As the building contains several distinct occupation patterns it would be highly recommended that individual time and temperature controls are fitted and would contribute to an exemplary Part L2A Target Emission Rate and EPC band rating.

7.11 Thermal Insulation

TPS have included in their summary sheet increased thermal insulation by increasing the building cladding thickness. The capital cost which is presumably reasonably accurate, as it is a price obtained via Gallagher from their cladding supplier, has a very long simple payback. This is to be expected as the U value of opaque fabric is now so low that windows and infiltration dominate the steady state heat loss and this points us to where the money is most effectively spent. Demonstrating the effect of increased insulation thickness versus improved air leakage and improved external doors can be done with a thermal model. These results can then be used to calculate payback

We agree with the TPS report the in that payback on thicker insulation will be very long.

We would go further and suggest the capital would be better spent on reducing air leakage and improving heat loss through external doors.

7.11.1 Air Leakage Testing.

Air leakage testing of the building fabric is demanded by Part L2A and reflected in the EPC asset rating. Air leakage testing has been introduced to improve the quality of building construction around window and door frames junctions at walls, eaves and ridges. Please do not assume that this issue relates to personnel and vehicles moving through external doors. Infiltration for external doors is calculated separately. The specified maximum air leakage rate is $10m^3/hr/m^2$ @ 50Pa. Reducing this to 5 $m^3/hr/m^2$ @ 50Pa has a dramatic effect on the infiltration heat loss and is directly reflected in a significant improvement of the Part L2A TER and EPC band rating.

7.11.2 External Doors

External doors for personnel and vehicles have a dramatic effect on heat loss. Fitting vestibules and automatic doors for personnel and rapid open closing automatic doors for vehicles will reduce energy consumption.

7.12 Rain water harvesting

Whilst conservation of water resources is a sustainability issue, this report is only addresses the energy and carbon emissions issues. TPS have not made a case for rainwater harvesting in their report although we understand it will be incorporated in the vehicle wash down facility.

Rain water harvesting may actually increase Carbon emissions due to pumping and filtration or UV sterilisation and unless renewables are used to off set this, carbon emission will increase.

We recommend that water consumption controls should have priority over rain water harvesting as they reduce the demand on water resources and save on hot water heating as well focus

7.13 Sedum roof

The ecological and habitat benefits of sedum roofs are not within the scope of this report.

TPS state in their report "It is extremely difficult to demonstrate any heat / energy saving benefits". Sedum roofs can be seen as expensive insulation, the argument is the same as for increased thermal insulation thickness, the payback will be very long and the ecological and habitat benefits of a sedum roof would have to be compelling to justify its cost.

8 Appendices

8.1 Target Emission Rate, Asset Rating

The target emission rate is set by comparing the building geometry under 2000 building regulations to the same building geometry under 2006 building regulations which have a 20% lower carbon emission rate. The 20% lower carbon emission is to be achieved largely through the air leakage reduction, improved windows and doors and specified boiler and chiller efficiencies, the U Values specified for opaque fabric remain essentially unchanged. A further 10% reduction is required if at least 10% of the building energy demand is not met by renewables. Therefore the target emission rate will be 20% lower for a new building with 10% renewables and 30% lower with out renewables.

In our opinion, an informed choice between sustainability options to be incorporated in a new building can not be made with out setting a Part L2A Target Emission Rate and a target EPC asset rating. Sustainability options would then be trialled in the various building physics thermal design software packages on the market and the resulting performance given an asset rating using a package specific SBEM module. In our opinion there is sufficient information in the plan and elevation drawings to input a quick and dirty model for trial purposes which would then be refined and ultimately produce the Part L2A TER compliance document and the EPC asset rating.

There are no obvious low energy/renewable features incorporated into the building architectural features, other than compliance with building regulations Part L2A thermal elements i.e. “U” values, window areas. The controlled services i.e. heating cooling ventilation and lighting will also have to comply with Part L2A and in particular the Non Domestic Heating Cooling and Ventilation guide, which effectively specifies minimum efficiencies for conventional energy consuming services. Overall the building will have to comply with the requirements of the building regulations on; air leakage, target emissions rate, energy metering, automatic lighting and HVAC controls which are carbon emissions driven and designed to encourage incorporation of at least 10% renewables in new buildings, although it has proved possible to meet TERs without renewables.

The EPC asset rating is calculated separately using the same building geometry with a bench marked adjustment for the buildings use, using the national calculation method SBEM. The building, as currently conceived will only achieve a low B rating, when a sustainable EPC banding would be an A or A+.

Design software tools are widely available to rapidly and cost effectively assess sustainable solutions in respect of their carbon emissions and asset ratings it is surprising that they have not been applied.

8.2 F Gases

"F gases" are a family of chemicals that contain fluorine and commonly used as refrigerant gases in air conditioning. Most "F gases" are very powerful greenhouse gases which contribute to global warming if emitted to the atmosphere.

Many commercial, industrial and public sector organisations have obligations under the EC Regulation on certain fluorinated greenhouse gases. In particular, if you use, maintain or install refrigeration and/or air-conditioning equipment you are likely to be affected. Refrigeration and air-conditioning users may also be affected by the EC Ozone Regulation which is phasing out certain ozone depleting substances (ODS).

8.3 Capital, Energy, NPV compared

Ref.	Description	Capital Cost	Annual Maintenance	Disposal	Energy Saving	Life	NPV	Tonne CO2 Saved	£ / Tonne CO2	Benchmark £ / Tonne CO2
1a	TPS Wind Turbine	£100,000	£500	£4,000	£3,120	15	£72,212	17.722	373	294
1b	TCL Wind Turbine	£50,000	£1,000	£2,000	£2,015	20	£35,574	11.445	289	531
2a	TPS Solar PV	£40,000	£400	£5,000	£1,040	15	£35,613	5.907	318	990
2b	TCL Solar PV	£60,000	£800	£2,500	£1,840	25	£43,917	10.451	277	990
3a	TPS Solar HWS	£20,000	£400	£1,000	£2,860	15	£27,736	16.245	200	388
3b	TCL Solar HWS	£39,000	£400	£1,000	£1,144	20	£28,953	6.498	123	388
4a	TPS Air Source Heat Pump	£20,000	£500	£1,500	£1,487	15	£9,525	8.446	N/A	N/A
4b	TCL Air Source Heat Pump	£12,000	£500	£1,000	£185	20	-£1,806	1.051	N/A	N/A
									N/A	
5a	TPS CHP	£40,000	£500	£1,500	£411	15	£-1,853	1.767	N/A	N/A
5b	TCL CHP	£40,000	£1,094	£1,500	£411	20	£-9,195	0.797	N/A	N/A

8.4 Energy and Carbon Emission Estimates

Maidstone Depot	TPS Gas Heating	TCL Gas Heating	TCL Lighting	Total
Net Offices Area (m²)		730		
Work Shop Area (m²)		368		
Total area (m²)		1098		
Annual Energy Consumption (GJ)	119.81	89.37	85.57	174.95
Energy Cost (£/kWh)	0.08	0.08	0.1	
Annual Energy Cost (£)	£2,662	£1,986	£2,377	£4,363
Carbon Factor (kgCo2/kWH)	0.194	0.194	0.422	
CO2 emissions (kg)	6,456	4,816	10,031	14,847