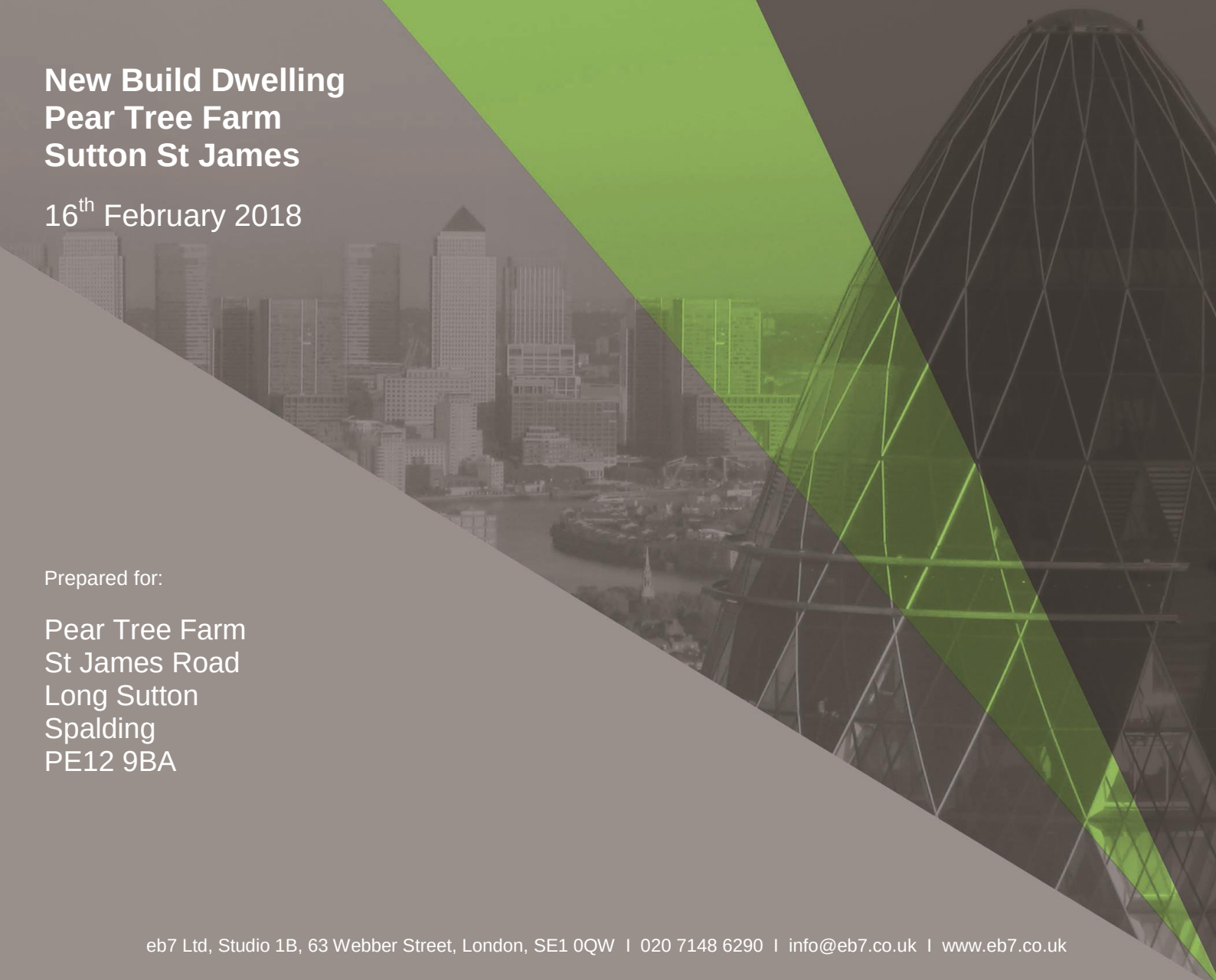
Energy Strategy & Sustainability Statement

New Build Dwelling
Pear Tree Farm
Sutton St James

16th February 2018



Prepared for:

Pear Tree Farm
St James Road
Long Sutton
Spalding
PE12 9BA

eb7 Ltd, Studio 1B, 63 Webber Street, London, SE1 0QW I 020 7148 6290 I info@eb7.co.uk I www.eb7.co.uk

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1.0 Introduction

The proposed development at Pear Tree Farm has been designed to achieve the highest of environmental performance standards following the principles of Paragraph 55 of the National Planning Policy Framework (NPPF).

eb7 Sustainability Ltd has been appointed to develop a strategy and to report upon just how the proposed development of the Long Sutton site will comply with these requirements.

The energy efficiency and energy hierarchy requirements have been applied in order to deliver a zero-carbon dwelling; equivalent to former Code for Sustainable Homes CODE 5 standard. This has been achieved through innovative passive design, the adoption of high standards of insulation, innovative HVAC design providing renewable heating via a ground source heat pump and electricity generation via roof mounted photovoltaic (PV) panels.

2.0 The Site & Proposal

The proposed site is located to the north-east of Sutton St James, located on the St James Road. The land is currently occupied by a collection of farm outbuilding and a large area of concrete hardstanding.

The proposal seeks to re-develop the site with a newly constructed dwelling of a very high quality design, arranged over 2 stories; ground floor accommodation includes living areas, a home office, games room and car and boat storage, with 5 bedrooms and a games room at first floor.

To the north-west is a swimming pool and gym complex thermally separated from the main dwelling.

.2.1 Planning Policy Context

The project sits within the borough boundaries of South Holland District Council and is therefore required to comply with the South Holland District Council Local Plan (2006).

It is considered that the most relevant panning policies to the Project at Pear Tree Farm are those implied via the National Planning Policy Framework

2.2 Energy Efficiency

In considering the impact of National Planning Policy Framework (NPPF), Paragraph 55 of the NPPF indicates that:

Any design justified under this policy must:

- be truly outstanding or innovative, helping to raise standards of design more generally in rural areas;
- reflect the highest standards in architecture;
- significantly enhance its immediate setting; and
- be sensitive to the defining characteristics of the local area.

The applicant wishes to meet the above criteria by adopting a highly sustainable approach to the development and deliver a zero-carbon dwelling, utilising innovative design potential, in addition to modern techniques and technologies.

The proposals included in this report are initial conceptual ideas, however as the detailed design develops/is costed, other alternative solutions may arise and offer the same delivery of a highly sustainable and energy efficient dwelling.

3.0 Baseline energy results

3.1 The Energy Hierarchy

This report will consider the scheme against the above noted criteria by implementing the methodology as set out in the Energy Hierarchy.

Application of the Energy Hierarchy sets out how any development proposals should make the fullest contribution to minimising carbon dioxide emissions in accordance with the following 3 stage analysis:

1 - Be lean: use less energy

2 - Be clean: supply energy efficiently (off-site measures)

3 - Be green: use renewable energy (on-site measures)

The new dwelling at Long Sutton will be designed to limit the emissions of carbon dioxide to the atmosphere from the operation of the building services as per the 'Energy Hierarchy'; the first step in which, as set out above requests that buildings be designed to use improved energy efficiency measures – Be Lean. This will reduce demand for heating, cooling, and lighting, and therefore reduce operational costs while also minimizing associated carbon dioxide emissions.

Thereafter, this report will consider the opportunities to introduce renewable and energy generating technologies to further reduce and off-set carbon emissions.

In order to do this, the "Baseline" energy demand must be established, this is the energy consumption and associated emissions from the development meeting only the minimum standards required under the Building Regulations (Approved Document Part L).

3.2 New Build Housing

The baseline emission levels – the Target Emission Rate (TER) as required for Building regulations compliance - is obtained by applying the design to a reference 'notional' building the characteristics of which are set by regulations – SAP2012; The new Part L Building Regulations 2013 came into force on April 2014 and introduced a completely new notional dwelling as detailed below:-

Table 4 Summary of concurrent notional dwelling specification

Element or System	Values
Opening areas (windows and doors)	Same as actual dwelling up to a maximum proportion of 25% of total floor area [1]
External Walls (including opaque elements of curtain walls) [6]	0.18 W/m²K
Party Walls	0.0 W/m²K
Floor	0.13 W/m²K
Roof	0.13 W/m²K
Windows, roof windows, glazed rooflights and glazed doors	1.4 W/m²K [2] (Whole window U-value) g-value = 0.63 [3]
Opaque doors	1.0 W/m²K
Semi glazed doors	1.2 W/m²K
Air tightness	5.0 m³/hr/m²
Linear thermal transmittance	Standardised psi values – See SAP Appendix R, except use of y=0.05 W/m²K if the default value of y=0.15 W/m²K is used in the actual dwelling
Ventilation type	Natural (with extract fans) [4]
Air conditioning	None

Element or System	Values
Heating System	Mains gas If combi boiler in actual dwelling, combi boiler; otherwise regular boiler Radiators Room sealed Fan flue SEDBUK 2009 89.5% efficient
Controls	Time and temperature zone control [5] Weather compensation Modulating boiler with interlock
Hot water storage system	Heated by boiler (regular or combi as above) If cylinder specified in actual dwelling, volume of cylinder in actual dwelling. If combi boiler, no cylinder. Otherwise 150 litres. Located in heated space. Thermostat controlled Separate time control for space and water heating
Primary Pipework	Fully Insulated
Hot water cylinder loss factor (if specified)	Declared loss factor equal or better than 0.85 x (0.2 + 0.051 V2/3) kWh/day
Secondary Space Heating	None
Low Energy Lighting	100% Low Energy Lighting
Thermal Mass Parameter	Medium (TMP=250)

SAP first creates the notional reference building, based upon the same shape and form as the proposed dwelling and applies the above the characteristics as defined in SAP2012.

Once all of the baseline emission rates have been calculated in line with the above Government approved methodologies, they are considered as stage 'zero' of the energy hierarchy as described earlier and Target Emission Rate sets the benchmark for the worst performing, but legally permissible, development.

Table 1 below, details the baseline regulated emission rates (as calculated above) for the new dwelling and the total baseline emission rates before then applying the energy hierarchy.

Table 1 – Baseline energy consumption and CO2 emissions

Unit	Baseline (Target) Emission Rate (regulated energy use) Kg/sqm	Total baseline emissions Kg
Pear Tree Farm	14.11	12,074

The baseline SAP TER outputs as generated by the appropriate approved software are attached at **Appendix A** for reference, confirming the above tabulated figures.

4.0 Design for Energy Efficiency

Good practice guidance for energy efficient design is offered as follows:-

- orientating windows of habitable rooms within 30 degrees of south and utilising southern slopes
- locating windows at heights that allow lower sun angles in the winter and installing shading mechanisms to prevent overheating during summer months
- using soft landscaping, including deciduous tree planting, to allow natural sunlight to pass through during the winter months whilst providing shade in the summer
- integrating passive ventilation, for example wind-catchers installed on roofs
- planting green roofs to moderate the temperature of the building to avoid the need for mechanical heating and/or cooling systems
- where appropriate, use water recycling measures for energy efficiency and conservation of resources.

Long term development sustainability is delivered via the fabric first approach. The fabric energy efficiency of a home is determined by the annual space heating and cooling demand in KWh per m^2, assessed using SAP.

This section sets out the measures included within the design of the dwelling, to reduce the demand for energy, both heating fuel and electricity (not including energy from renewable sources). The table at the end of this section details the amount of energy used and CO_2 produced by the proposed dwelling after the energy efficiency measures have been included.

To achieve reductions in energy demand the following measures have been included within the design and specification of the dwelling:

4.1 Orientation & Passive Design

To consider the issues of orientation and passive design for the proposed development, the design team have followed the methodology of the Cooling Hierarchy:-

- **minimise internal heat generation through energy efficient design**

The project will be designed to best practice thermal insulation levels as noted, full details of which are noted under 4.3 below.

Not only does good insulation assist in reducing heat losses in the winter, it has a significant impact on preventing heat travelling through the build fabric during the summer.

- **reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls**

The dwelling has been specifically orientated to the south, with principle living areas able to harvest significant solar gain throughout the year, while the first floor overhang to the south elevation protects these areas from overheating during the peak summer periods.

All glazing will be specified with a g-value of 0.45 or better in order to further ensure there is no overheating risk during the peak summer months.

The swimming pool also has a significant glazed façade to a south westerly orientation, this also enables this complex to act as a heat sink and deliver recovered heat into the main dwelling area and domestic hot water system.

The 1st floor bedroom areas and north & east facing elements have much reduced glazed areas – reducing the potential for heat loss through these elements.

As noted above, the dwelling will be highly insulated to enable retention of heat during the heating season, while protecting the internal environment from external heat during the summer months.

A large green and biodiverse roof will be installed to the swimming pool/gym and boat store to aid local evaporative cooling.

- **manage the heat within the building through exposed internal thermal mass and high ceilings**

An exposed dense concrete ground floor slab will allow the low temperature hot water (LTHW) system to work at its optimum levels, thus maximising the efficiency of the system. Floor insulation will be located below the concrete slab to maximise the thermal mass enabling the slab to be heated to a low level by the heating systems during winter periods, enabling a low flow temperature (35°C) and thereafter regulate the heat via the absorption of excess heat during the summer months, that can then be vented from the building during cooler periods.

The dwelling been designed with floor to ceiling heights at a minimum of 2.8m, with the use of vaulted roofs and double height spaces to aid thermal stratification and stack effect ventilation (see below).

- **passive ventilation**

All glazing is designed to have large opening areas to introduce high levels of natural ventilation to further assist in the reduction of overheating risks.

The dwelling is specifically designed to enable cross ventilation

Further passive ventilation controls are afforded via a stack ventilation system, the stair core is central to the ground floor accommodation and is designed to be vaulted up to roof level, in this way, natural ventilation is introduced into the building via low level trickle ventilation and/or open windows (when purge venting during summer) and ventilated at high level.

The swimming pool/gym complex will be mechanically ventilated, but the high potential for heat recovery in these areas will enable further energy efficiencies (see 6.6 below).

With the above strategy in place, there is no expectation of the need, nor the design intention, to introduce mechanical ventilation or mechanical cooling within the main accommodation block, while heat loads will be reduced though the passive design measures.

4.2 Heating system

For the "energy efficient notional model", the primary heating system for the dwellings is assumed to be a high efficiency condensing gas boiler – noting that there is no mains gas on site - providing hot water via a design that will incorporate a highly insulated unvented DHW cylinder on a heating circuit to provide domestic hot water.

A typical installation would be:-

- Vaillant EcoTec boiler – (89.3% SEDBUK efficiency)

To increase the efficiency in the use of the heating system, the following controls will be used in a 'boiler interlock' system to eliminate needless firing of the boiler.

- Time and temperature zone control
- Boiler fitted with a delayed start thermostat, designed specifically to work with the high thermal mass under floor heating.

4.3 Fabric heat loss

Fabric

Ground Floor construction of the dwelling will be load-bearing Lincolnshire Clipsham Stone external skin, Insulation and blockwork. Most internal finishes will be plasterboard but there will be some internal stonework to the First Wall over the double height space on the South and alongside the stair in the Entrance Hall going full height. The superstructure will be Glulam. Steel will be used only for cross-bracing.

First Floor and pool area construction will be Clipsham stone slips, insulation and a cross laminated timber (CLT) structure. The floor will be CLT with insulation above and a carpeted finish. Wall finishes will be a mixture of plasterboard and visual grade CLT. The roof will be a CLT structure supported with Glulam beams. The roof finish internally will be a mixture of plasterboard and visual grade CLT.

The embodied carbon of timber products is relatively low when compared to many other construction materials. Carbon is stored during tree growth and continues to be stored through its use as a building structure. Eventually, at the end of its long life-cycle carbon is then either released through natural decomposition, returning other nutrients to the soil, or through the generation of heat via combustion.

Insulation measures will be utilised to ensure the calculated u values exceed the Building Regulations minima, with specific guidance taken from the design team: -

New wall constructions are yet to be specified, but the design team is targeting achieving a u-value of 0.15 via the highly-insulated CLT construction

The roof structures will meet a u-value of 0.10.

The roof cladding on the main dwelling is to be of natural slate, while an extensive green roof is proposed for the swimming Pool/gym and boat store.

Ground floor will target a u value at 0.10 or better, with a minimum of 150mm of insulation in the floor structure located below the main concrete slab.

Glazing

New glazing for windows will be triple glazed with the glazing units achieving an area weighted average u-value of 0.58w/m^2 K or better.

Air Tightness

The project will be tested for air tightness with a target value of 4.5m^3/hr/m^2 for the new build dwelling in line with best practice for a naturally ventilated dwelling.

The pool/gym complex will be tested separately – seeking a target <2.5m^3/hr/m^2 to optimise the mechanical ventilation system.

Construction Details

Heat loss via non-repeating thermal bridging will be minimised by the use of Accredited Construction Details throughout the structure to ensure compliance with the minimum standards for dwelling fabric energy efficiency under SAP2012.

4.4 Ventilation

Main Accommodation

The main dwelling will have a low energy natural ventilation strategy in line with System 1, AD Part F - utilising opening windows for purge ventilation and free cooling.

As noted above, the main stairwell will be utilised as a stack ventilator, enables low level ventilation at ground and first floors to draw in fresh air, which as it is heated within the dwelling. The inherent natural buoyancy of the warm air enables it to be drawn into the ventilated roof void and exhausted via automated openings.

Specific cross ventilation grills will be installed at high level in the living, kitchen and dining areas to optimise the operation of the stack system.

This central stack, combined with the wind driven cross ventilation throughout the development will enable, in conjunction with the other above noted passive control measures, naturally cooled and ventilated environment.

Swimming Pool/Gym

Clearly, a swimming pool requires an element of heat input to maintain temperature, while the surface of the pool is in a state of constant heat exchange/evaporation with the adjacent air.

The intentions of the proposed design is to harness and recover that heat to:

- A - Recover the heat into the pool room and gym environment
- B – Deliver any residual heat into the main heating systems providing heat and hot water to the dwelling

To achieve this, a heat pump dehumidifier will be specified – this draws moist air over a cold surface with a fan. The cold evaporator coil of the refrigeration device cools the air and condensation is formed on the surface, which is removed thus dehumidifying the air, and then a condenser coil reheats the air. The now dehumidified warm air is released into the room.

The fresh air is introduced via a heat recuperator, this recovers the heat in the outgoing exhaust air via a passive heat exchanger; where there is no energy input to the unit. It absorbs the heat in the exhaust air stream and transfers this into the fresh air stream over a series of aluminium plates. Typical efficiencies for these exchangers are 60% - 90%.

Any excess heat from the heat pump dehumidification process above and beyond that required in the main pool hall will be ducted to the gym and/or main dwelling.

4.5 Lighting

A 100% of internal light fittings throughout the development will be dedicated low-energy/compact fluorescent fittings, with extensive use of LED lighting.

Any store areas will have PIR controls, and external lighting will be on dawn-disk controls to ensure any such lighting is not operating unnecessarily.

To further reduce energy consumption, the developers will adopt Code for Sustainable Homes principles; providing A+ rated white goods, ensuring all external lighting systems are fitted with high efficacy luminaries with appropriate daylight controls and providing smart metering to the dwelling to enable occupants to accurately measure and manage their energy consumption.

4.6 Energy Efficiency Results

The following table shows a comparison between the baseline scheme assessed under the SAP methodology Part L1A minima and the scheme following the introduction of energy efficiency measures:-

Table 2 – Energy consumption and CO2 reductions

Unit	Building Emission Rate (regulated energy use) Kg/sqm	Total emissions Kg
Pear Tree Farm	11.21	9,592

The results show that, for the new development with the energy efficiency measures, the reduction in CO_2 emissions is **20.56%.**

The proposed development therefore, goes beyond the requirements of the now stringent 2013 Building Regulations AD Part L1A using passive energy efficiency measures.

The SAP Building Emission Rates outputs are attached at **Appendix B.**

5.0 Sourcing Clean Energy Sources

The second stage of the energy hierarchy requires the sustainable energy strategy should clearly demonstrate how major development will meet national standards. Density and the number of residential units within a development scheme are important considerations in determining the practicality and viability of meeting carbon reduction targets, particularly for delivering district energy and heating.

Clearly, as a development of a single dwelling in a relatively remote location, there will be no access to any form of district heating or energy sources, nor would there be any viability in developing such a network in this rural location.

Accordingly, this report goes on to consider the use of on site renewable opportunities.

6.0 Renewable and Energy Generating Technologies

Renewable energy can be defined as energy taken from naturally occurring or renewable sources, such as sunlight, wind, waves/tides, geothermal etc. Harnessing these energy sources can involve a direct use of natural energy, such as solar water heating panels, or it can be a more indirect process, such as the use of Biofuels produced from plants, which have harnessed and embodied the suns energy through photosynthesis.

The Fabric Energy Efficiency measures outlined under 4 above have the most significant impact on the heating and hot water energy requirements for the dwelling, and the associated reduction in gas consumption.

It should be noted that each Kwh of gas energy saved reduces emissions by 0.216kgCO_2/kwh, whereas, grid based electrical energy has a emissions factor of 0.519kgCO_2/kwh and accordingly, emphasis will be placed upon "off-setting" grid based electricity in order to achieve the optimum use of renewable technologies.

This becomes a more significant approach given that there is no mains gas available on site.

This section then sets out the feasibility of implementing different energy technologies in consideration of: -

- Potential for Carbon savings
- Capital costs
- Running costs
- Payback period as a result of energy saved/Government incentives
- Maturity/availability of technology
- Reliability of the technology and need for back up or alternative systems.

6.1 Government incentives

6.1.1 Feed in Tariff

Feed in Tariffs (FiTs) replaced ROCs for renewable energy generators rated at less than 5MW in April 2010. FiTs are payments made for every kilowatt-hour kWh of renewable electricity generated and the level of the payment is laid down by the government, and varies for different renewable energy sources and at different scales. Unlike the flat rates paid for ROCs, FiTs are designed to compensate for less efficient/more expensive sources of renewable energy – and for the first time – make the investment in low and zero carbon technologies viable for both domestic generators and larger companies alike.

Recent reviews of Feed in Tariff rates will lead to lower returns on such technologies in 2016 and beyond, but the expectation is that system capital costs and enhanced efficiencies will compensate for this over the medium term.

6.1.2 Renewable Heat Incentive

The Renewable Heat Incentive (RHI) was formally launched by the UK Government on 10th March 2011. The RHI will pay a tariff payment to renewable technologies that provide heat energy from a renewable source such as biomass boilers, air source heat pumps, with the payment relating to the KWh of heat energy provided e.g. if a property has a heat load of 20,000 KWh per annum, and it is 100% provided from a renewable source, then the tariff is paid against the 20,000KWh.

The Government decided on a two stage delivery - the first stage being for non-domestic schemes, which commenced in July 2011, with domestic scheme having come on stream in April 2014.

6.2 Wind turbines

Wind turbines come in two main types'- horizontal axis and vertical axis. The more traditional horizontally axis systems rotate around the central pivot to face into the wind, whilst vertical axis systems work with wind from all directions.

The potential application of wind energy technologies at a particular site is dependent upon a variety of factors. But mainly these are: -

- Wind speed
- Wind turbulence
- Visual impact
- Noise impact
- Impact upon ecology

The availability and consistency of wind in urban environments is largely dependent upon the proximity, scale and orientation of surrounding obstructions.

The site has a relatively open aspect, when potentially the required exposure to the appropriate level of consistent and adequate wind flows to justify a wind turbine installation.

That said, the design and installation of wind turbines is highly specialised and involves many considerations – often external/remote from the main application area; environmental impact, local fauna, noise impact etc.

This may be an opportunity that the applicant may wish to pursue, but this report would recommend that the applicant does so as a separate excise out with the confines of this application.

6.3 Solar Energy

6.3.1 Solar water heating

Solar water heating panels come in two main types; flat plate collectors and evacuated tubes. Flat plate collectors feed water, or other types of fluid used specifically to carry heat, through a roof mounted collector and into a hot water storage tank. Evacuated tube collectors are slightly more advanced as they employ sealed vacuum tubes, which capture and harness the heat more effectively.

The proposed new dwelling has access to areas of roof space appropriate for the installation of solar panels.

Indeed the main draw-back of solar water heating is that it requires a level of management to ensure that there is an end use for any generated hot water as and when it is generated. In the normal domestic scenario, this results in the solar thermal systems producing hot water during the summer days when properties are not occupied and when there is no heating load.

The presence of a swimming pool immediately reverses this situation – the pool providing a ready heat sink for the heat generated via the appropriate heat exchange equipment.

Thereafter, as noted above, heat losses from the pool are then recovered and re-used via the heat pump dehumidifier/recuperator system as noted above (4.4 Ventilation).

As the energy consumption for a swimming pool is not accounted for in the SAP calculations, therefore, the proposed solar thermal heating system will be omitted form the SAP.

6.3.2 Photovoltaics (PV)

Solar panel electricity systems, also known as solar photovoltaics (PV), capture the sun's energy using photovoltaic cells. These cells will be accumulated on a PV panel, usually about 2.0m x 1.0m. These panels are then wall, roof or floor mounted and are connected directly to the electricity grid via the host properties meter. In this way, the electrical generation can be fully exported and is not related to the consumption of the dwelling and offer a low-management renewable option, although the host property does get the benefit from generation, when generation and domestic consumption coincide.

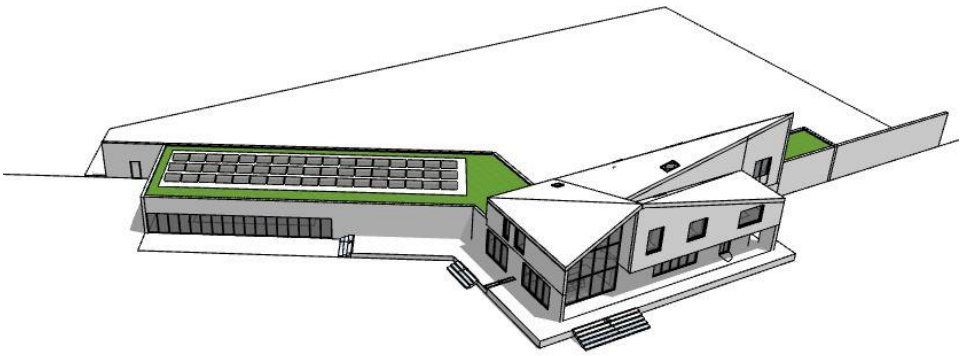
PV panels also offer a much more attractive return from the Feed in Tariff often achieving 7-8% returns or better.

As noted above, the roof space would be appropriate for solar PV panels.

The proposed design is to make use of the large roof area of the pool room, which allows for us to take advantage of the south-west orientation, maximising the potential generation for this property, whilst maintaining the aesthetics of the development.

This report has assumed the installation of fifty, 330 watt PV panels, amassing a total array of 16.50Kwp – ensuring that electricity is being generated throughout the entire span of sun-lit hours

Proposed PV Layout – initial sketch design



It has been confirmed that 3 phase electricity is available on site makes the relatively large scale PV installation viable subject to a G83 application to the distribution network operator (DNO).

6.4 Biomass heating

Biomass is a term given to fuel derived directly from biological sources for example rapeseed oil, wood chip/pellets or gas from anaerobic digestion. It can only be considered as a renewable energy source if the carbon dioxide emitted from burning the fuel is later recaptured in reproducing the fuel source (i.e. trees that are grown to become wood fuel, capture carbon as they grow).

Biomass heating systems require space to site a boiler and fuel hopper along with a supply of fuel. There also needs to be a local source of biomass fuel that can be delivered on a regular basis.

A boiler of this type would replace the need for a conventional gas boiler and therefore offset all the gas energy typically used for space and water heating, however, biomass releases high levels of NO_x emissions and would therefore have to be considered carefully against the high standard of air quality requirements appropriate for a sustainable construction.

Given the practical limitations as outlined above, the use of biomass fuel for the development is not considered appropriate.

6.5 Ground source heat pump (GSHP)

Ground source heating or cooling requires a source of consistent ground temperature, which could be a vertical borehole or a spread of pipework loops and a 'heat pump'. The system uses a loop of fluid to collect the more constant temperature in the ground and transport it to a heat pump.

The heat pump then generates increased temperatures by 'condensing' the heat taken from the ground through the refrigeration expansion-compression cycle, producing hot water temperatures in the region of 45°C. This water can then be used as pre-heated water for a conventional boiler or to provide space heating with a low grade heat under floor heating system.

The use of a ground source heating/cooling system will therefore require:

- Vertical borehole or ground loop
- Use of under floor heating
- Space for heat pump unit

As a rule of thumb, the collector loop area for a GSHP equates to 2.5 x the internal floor area of the host dwelling. Due to the large available area of open space on the site, we have a rare opportunity to exploit the environmental benefits of a GSHP.

With this in mind it, this report has included a GSHP as the source of heating for the central heating and domestic hot water via a low heat-loss cylinder and under floor heating under the dense concrete ground slab in order to maximise the impact of high thermal mass and LTHW.

Additionally, the GSHP will be the core supplier of heat to the swimming pool – offering an all year load for the heat pump, enabling seasonal efficiencies for the GSHP to be maximised via the increased summer time heat load.

6.6 Air source heat pump (ASHP)

Air source heating or cooling also employs the principle of a heat pump. This time either, upgrading the ambient external air temperature to provide higher temperatures for water and space heating, or taking warmth from within the building and dissipating it to the outdoor air.

It must be remembered that heat pumps utilise grid based electricity and the associated emissions, so that actual the reduction in emissions can be limited. Assuming a seasonal system efficiency of 320% (Coefficient of Performance of 3.2) and that the air source heat pump will replace 100% of the space heating/hot water demand, then the system would reduce the overall CO_2 emissions by approximately 17%. Table 3, below demonstrates, on the assumption of a demand of 1000Kwh/year for heating and hot water.

Table 3 – Air Source Heat Pumps – emission calculations

Type of Array	Energy Consumption (Kwh/yr.)	Emission factor ($kgCO_2$/Kwh)	Total CO_2 emissions (kg/annum)
90% efficient gas boiler	11111	0.216	2400
320% efficient ASHP	2813	0.519	1460
100% efficient immersion (back-up)	1000	0.519	519

A theoretical carbon saving of 17.5%

With the above data in mind, clearly an ASHP could be an option, however, it must be born in mind that air source heat pumps can often require immersion back up for peak load times (very cold weather) and for hot water production – this can often affect overall efficiently quite dramatically.

The heat pump would also require external installation – which would in turn create a visual impact as well as a potential noise nuisance to neighbours in the location.

Given such impacts, it is considered that air source heat pumps would not be appropriate at this location, and those alternative technologies, as identified above – in particular, the use of a ground source heat pump - would be more appropriate.

6.7 Final Emissions Calculation

The results of the assessment of suitable technologies relative to the nature, locations and type of development suggest that the only potential solution would be the installation of the afore mentioned Photovoltaic (PV) array to generate and offset electricity, as well as a GSHP to provide a renewable source of heating.

Solar thermal panels would be used for the sole purpose of providing heat to the swimming pool.

Potentially, the PV array would equate to a total of 15.84Kwp, which would generate some 113,042Kwh per annum off-setting approximately almost 6.8 tonnes of carbon per annum.

Accordingly, the GSHP and PV array has been incorporated into the design and the final SAP DER outputs are attached at **Appendix C**:-

Table 4 – Final energy consumption and CO2 reductions

Unit	Building Emission Rate (regulated energy use) Kg/sqm	Total emissions Kg
Pear Tree Farm	0.00	00.00

The data at Table 4 confirms that overall emissions have been reduced by over **100%** over and above the baseline model and a **79.44%** reduction in emissions has been achieved directly from the use of energy generating and renewable technologies, i.e. over and above the energy efficient model.

7.0 Sustainable Design & Construction

The Code for Sustainable Homes (the Code)

The Code was the national standard for the sustainable design and construction of new homes.

This has now been formally withdrawn by DCLG, and planning authorities are no longer able to require developments to meet the technical guidance within the Code for Sustainable Homes.

However, the applicants do acknowledge intentions of the methodology - to deliver a sustainable development and will therefore pro-actively deliver the following:-

Materials

- Construction techniques will be considered against the BRE Green Guide to ensure that, where practical, the most environmentally friendly construction techniques are deployed. In addition, construction materials will be sourced from suppliers capable of demonstrating a culture of responsible sourcing via environmental management certification.
- In particular, the dwelling shall incorporate a highly sustainable cross-laminated, timber frame design (CLT). Provided the timber is sustainably sourced there are significant environmental advantages in the use of CLT. The embodied carbon of timber products is relatively low when compared to many other construction materials. Carbon is stored during tree growth and continues to be stored through its use as a building structure.
- The principle contractor with be required to produce a site waste management plan and sustainable procure plan, in line with BREEAM requirements – the procurement plan will follow the waste hierarchy Reduce; Reuse & Recycle.
- The Site Waste Management Plan (SWMP) will be developed prior to commencement of development stage to inform the adoption of good practice waste minimisation in design. This will set targets to minimise the generation of non-hazardous construction waste using the sustainable procurement plan to avoid over-ordering and to use just-in-time delivery policies.
- The developer will also maximise the use of recycled and secondary aggregates.
- Waste and recycling – appropriate internal and external storage space will be provided to ensure that residents can sort, store and dispose of waste and recyclable materials.

Pollution

- The contractor will also monitor the use of energy and water use during the construction phase and incorporate best site practices to reduce the potential for air (dust) and ground water pollution.

- The main contractor will be required to register the site with the Considerate Constructors Scheme and achieve a score of 25 or more.

Energy

- The new dwelling will incorporate renewables technologies as noted in the main report above.
- The dwelling will also be supplied with a Home User Guide offering practical advice on how to use the home economically and efficiently.
- This will be further enhanced by the installation of smart energy metering, enabling the occupants to accurately assess their energy usage and thereby, manage it.

Water

- The development will minimise water use as far as practicable by incorporating appropriate water efficiency and water recycling measures. The new dwelling will target an internal water use at 105litres/person/day.
- The dwelling will have rainwater harvesting – water butts connected to rainwater pipes to enable the recycling of rainwater for the upkeep the garden.
- SuDs – a flood risk assessment has been produced to consider and ensure that the proposed development is resilient to risk of flooding from ALL sources, and to ensure that surface water run-off is no greater than was associated with the site pre-development - using SuDs techniques; permeable surfaces, infiltration and attenuation as appropriate.

9.0 Summary & Conclusions

This report has detailed the baseline energy requirements for the proposed residential development, the reduction in energy demand as a result of energy efficiency measures and the potential to achieve further CO_2 reductions using renewable energy technologies.

The baseline results have shown that if the dwelling was built to a standard to meet only the minimum requirements of current building regulations, the total amount of CO_2 emissions for the property would be **12,074Kg/year**.

Following the introduction of the fabric energy efficiency measures into the development, as detailed in section 4, the total amount of CO_2 emissions for the property would be reduced to **9,592Kg/year**, a reduction of **20.56%.**

There is also a requirement to reduce CO_2 emissions across the development using onsite renewable technologies, where practical and feasible. Therefore, the report has considered the feasibility of the following technologies:

- Wind turbines
- Solar hot water
- Photovoltaic (PV) systems
- Biomass heating
- CHP (Combined heat and power)
- Ground & Air source heating

The results of the assessment of suitable technologies relative to the nature, locations and type of development suggest that the preferred solution to be the installation of a GSHP to provide renewable LTHW heating; and a 16.5Kwp panel Photovoltaic (PV) array - producing some **13,585Kwh/annum.**

Additionally, solar thermal panels will be specified to provide heating for the swimming pool.

The SAP models (reproduced at **Appendix C**) for the development which have also been detailed above in Table 4, show a final gross emission level for the development of **0.00Kg/year** representing a total of **100.0%** reduction in emissions over the baseline model.

Overall, regulated emissions controlled via Part L of the Building Regulations for the proposed dwelling achieve over 100% reduction in DER/TER.

Appendix A

Baseline Energy Use:-

SAP 2012 – Dwelling TER outputs

TER WorkSheet: New dwelling design stage

User Details:

Assessor Name:	George Farr	**Stroma Number:**	STRO028460
Software Name:	Stroma FSAP 2012	**Software Version:**	Version: 1.0.4.10

Property Address: Feb 18 - V2 Base & Lean

Address :

1. Overall dwelling dimensions:

	Area(m²)		Av. Height(m)		Volume(m³)	
Ground floor	557.24 (1a)	x	2.98 (2a)	=	1660.58	(3a)
First floor	298.44 (1b)	x	3.78 (2b)	=	1128.1	(3b)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	855.68	(4)				
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) =		2788.68	(5)

2. Ventilation rate:

	main heating		secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							4	x 10 =	40	(7a)
Number of passive vents							0	x 10 =	0	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

			Air changes per hour	
Infiltration due to chimneys, flues and fans =	(6a)+(6b)+(7a)+(7b)+(7c) =	40	÷ (5) =	0.01 (8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Number of storeys in the dwelling (ns)			0 (9)
Additional infiltration		[(9)-1]x0.1 =	0 (10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction			0 (11)
if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35			
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0			0 (12)
If no draught lobby, enter 0.05, else enter 0			0 (13)
Percentage of windows and doors draught stripped			0 (14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =		0 (15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =		0 (16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area			5 (17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)		0.26 (18)

Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used

Number of sides sheltered			0 (19)
Shelter factor	(20) = 1 - [0.075 x (19)] =		1 (20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =		0.26 (21)

Infiltration rate modified for monthly wind speed

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Monthly average wind speed from Table 7

(22)m=	5.1	5	4.9	4.4	4.3	3.8	3.8	3.7	4	4.3	4.5	4.7

TER WorkSheet: New dwelling design stage

Wind Factor (22a)m = (22)m ÷ 4

(22a)m=	1.27	1.25	1.23	1.1	1.08	0.95	0.95	0.92	1	1.08	1.12	1.18

Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m

0.34	0.33	0.32	0.29	0.28	0.25	0.25	0.24	0.26	0.28	0.3	0.31

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 0 (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100]

(24a)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24b)

c) If whole house extract ventilation or positive input ventilation from outside
if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24c)

d) If natural ventilation or whole house positive input ventilation from loft
if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0.56	0.55	0.55	0.54	0.54	0.53	0.53	0.53	0.53	0.54	0.54	0.55	(24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25)m=	0.56	0.55	0.55	0.54	0.54	0.53	0.53	0.53	0.53	0.54	0.54	0.55	(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Doors			1.87	x	1	=	1.87			(26)
Windows Type 1			80.62	x1/[1/(1.4)+ 0.04]		=	106.88			(27)
Windows Type 2			23.83	x1/[1/(1.4)+ 0.04]		=	31.59			(27)
Windows Type 3			18.32	x1/[1/(1.4)+ 0.04]		=	24.29			(27)
Windows Type 4			16.4	x1/[1/(1.4)+ 0.04]		=	21.74			(27)
Windows Type 5			32.7	x1/[1/(1.4)+ 0.04]		=	43.35			(27)
Windows Type 6			34.73	x1/[1/(1.4)+ 0.04]		=	46.04			(27)
Rooflights Type 1			2.737197	x1/[1/(1.7) + 0.04]		=	4.653236			(27b)
Rooflights Type 2			1.402692	x1/[1/(1.7) + 0.04]		=	2.384576			(27b)
Rooflights Type 3			1.315024	x1/[1/(1.7) + 0.04]		=	2.23554			(27b)
Floor Type 1			557.24	x	0.13	=	72.44119			(28)
Floor Type 2			106.2	x	0.13	=	13.806			(28)
Walls Type1	709.78	208.47	501.31	x	0.18	=	90.24			(29)
Walls Type2	31.47	0	31.47	x	0.18	=	5.66			(29)
Walls Type3	2.89	0	2.89	x	0.18	=	0.52			(29)
Roof Type1	328.53	5.45	323.08	x	0.13	=	42			(30)
Roof Type2	365	0	365	x	0.13	=	47.45			(30)

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Total area of elements, m²	2101.11			(31)
Internal wall **	1078.32			(32c)
Internal wall **	155.28			(32c)
Internal floor	192.24			(32d)
Internal ceiling	192.24			(32e)

** for windows and roof windows, use effective window U-value calculated using formula 1/[(1/U-value)+0.04] as given in paragraph 3.2*
*** include the areas on both sides of internal walls and partitions*

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 556.57 (33)

Heat capacity Cm = S(A x k) ((28)…(30) + (32) + (32a)…(32e) = 134135.64 (34)

Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K Indicative Value: Medium 250 (35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation.

Thermal bridges : S (L x Y) calculated using Appendix K 65.33 (36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss (33) + (36) = 621.9 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 × (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	512.4	510.37	508.38	499.04	497.29	489.15	489.15	487.64	492.28	497.29	500.83	504.52	(38)

Heat transfer coefficient, W/K (39)m = (37) + (38)m

(39)m=	1134.3	1132.27	1130.28	1120.94	1119.19	1111.05	1111.05	1109.55	1114.19	1119.19	1122.73	1126.43	

Average = Sum(39)$_{1...12}$ /12= 1120.93 (39)

Heat loss parameter (HLP), W/m²K (40)m = (39)m ÷ (4)

(40)m=	1.33	1.32	1.32	1.31	1.31	1.3	1.3	1.3	1.3	1.31	1.31	1.32	

Average = Sum(40)$_{1...12}$ /12= 1.31 (40)

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41)m=	31	28	31	30	31	30	31	31	30	31	30	31	(41)

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N 3.85 (42)
if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)
if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 125.74 (43)
Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)													
(44)m=	138.31	133.28	128.25	123.23	118.2	113.17	113.17	118.2	123.23	128.25	133.28	138.31	

Total = Sum(44)$_{1...12}$ = 1508.88 (44)

Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)

(45)m=	205.12	179.4	185.12	161.39	154.86	133.63	123.83	142.1	143.79	167.58	182.92	198.64	

Total = Sum(45)$_{1...12}$ = 1978.38 (45)

If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)

(46)m=	30.77	26.91	27.77	24.21	23.23	20.04	18.57	21.31	21.57	25.14	27.44	29.8	(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel 150 (47)

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If community heating and no tank in dwelling, enter 110 litres in (47)
Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in (47)
Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day):		2.11	(48)
Temperature factor from Table 2b		0.54	(49)
Energy lost from water storage, kWh/year	(48) x (49) =	1.14	(50)
b) If manufacturer's declared cylinder loss factor is not known:			
Hot water storage loss factor from Table 2 (kWh/litre/day)		0	(51)
If community heating see section 4.3			
Volume factor from Table 2a		0	(52)
Temperature factor from Table 2b		0	(53)
Energy lost from water storage, kWh/year	(47) x (51) x (52) x (53) =	0	(54)
Enter (50) or (54) in (55)		1.14	(55)

Water storage loss calculated for each month ((56)m = (55) × (41)m

(56)m=	35.37	31.94	35.37	34.23	35.37	34.23	35.37	35.37	34.23	35.37	34.23	35.37	(56)

If cylinder contains dedicated solar storage, (57)m = (56)m x [(50) – (H11)] ÷ (50), else (57)m = (56)m where (H11) is from Appendix H

(57)m=	35.37	31.94	35.37	34.23	35.37	34.23	35.37	35.37	34.23	35.37	34.23	35.37	(57)

Primary circuit loss (annual) from Table 3: 0 (58)

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m
(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59)m=	23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss calculated for each month (61)m = (60) ÷ 365 × (41)m

(61)m=	0	0	0	0	0	0	0	0	0	0	0	0	(61)

Total heat required for water heating calculated for each month (62)m = 0.85 × (45)m + (46)m + (57)m + (59)m + (61)m

(62)m=	263.74	232.35	243.75	218.13	213.49	190.37	182.46	200.73	200.53	226.21	239.66	257.27	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)
(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

Output from water heater

(64)m=	263.74	232.35	243.75	218.13	213.49	190.37	182.46	200.73	200.53	226.21	239.66	257.27	

Output from water heater (annual)$_{1...12}$: 2668.69 (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	115.1	102.01	108.46	99.05	98.39	89.82	88.08	94.15	93.2	102.62	106.21	112.95	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	(66)

Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5

(67)m=	73.84	65.59	53.34	40.38	30.18	25.48	27.54	35.79	48.04	61	71.19	75.89	(67)

Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5

(68)m=	828.29	836.89	815.23	769.12	710.91	656.21	619.66	611.06	632.72	678.83	737.04	791.74	(68)

Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5

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(69)m=	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	(69)

Pumps and fans gains (Table 5a)

(70)m=	3	3	3	3	3	3	3	3	3	3	3	3	(70)

Losses e.g. evaporation (negative values) (Table 5)

(71)m=	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	(71)

Water heating gains (Table 5)

(72)m=	154.71	151.81	145.77	137.57	132.25	124.75	118.38	126.55	129.45	137.93	147.52	151.82	(72)

Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m

(73)m=	1140.66	1138.09	1098.15	1030.88	957.16	890.26	849.39	857.22	894.02	961.58	1039.56	1103.27	(73)

6. Solar gains:

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation.

Orientation:	Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
North	0.9x 0.77	x	32.7	x	10.63	x	0.63	x	0.7	=	106.27	(74)
North	0.9x 0.77	x	32.7	x	20.32	x	0.63	x	0.7	=	203.08	(74)
North	0.9x 0.77	x	32.7	x	34.53	x	0.63	x	0.7	=	345.08	(74)
North	0.9x 0.77	x	32.7	x	55.46	x	0.63	x	0.7	=	554.29	(74)
North	0.9x 0.77	x	32.7	x	74.72	x	0.63	x	0.7	=	746.67	(74)
North	0.9x 0.77	x	32.7	x	79.99	x	0.63	x	0.7	=	799.34	(74)
North	0.9x 0.77	x	32.7	x	74.68	x	0.63	x	0.7	=	746.28	(74)
North	0.9x 0.77	x	32.7	x	59.25	x	0.63	x	0.7	=	592.08	(74)
North	0.9x 0.77	x	32.7	x	41.52	x	0.63	x	0.7	=	414.9	(74)
North	0.9x 0.77	x	32.7	x	24.19	x	0.63	x	0.7	=	241.74	(74)
North	0.9x 0.77	x	32.7	x	13.12	x	0.63	x	0.7	=	131.09	(74)
North	0.9x 0.77	x	32.7	x	8.86	x	0.63	x	0.7	=	88.59	(74)
Northeast	0.9x 0.77	x	16.4	x	11.28	x	0.63	x	0.7	=	56.55	(75)
Northeast	0.9x 0.77	x	16.4	x	22.97	x	0.63	x	0.7	=	115.11	(75)
Northeast	0.9x 0.77	x	16.4	x	41.38	x	0.63	x	0.7	=	207.39	(75)
Northeast	0.9x 0.77	x	16.4	x	67.96	x	0.63	x	0.7	=	340.6	(75)
Northeast	0.9x 0.77	x	16.4	x	91.35	x	0.63	x	0.7	=	457.83	(75)
Northeast	0.9x 0.77	x	16.4	x	97.38	x	0.63	x	0.7	=	488.1	(75)
Northeast	0.9x 0.77	x	16.4	x	91.1	x	0.63	x	0.7	=	456.6	(75)
Northeast	0.9x 0.77	x	16.4	x	72.63	x	0.63	x	0.7	=	364.01	(75)
Northeast	0.9x 0.77	x	16.4	x	50.42	x	0.63	x	0.7	=	252.71	(75)
Northeast	0.9x 0.77	x	16.4	x	28.07	x	0.63	x	0.7	=	140.67	(75)
Northeast	0.9x 0.77	x	16.4	x	14.2	x	0.63	x	0.7	=	71.16	(75)
Northeast	0.9x 0.77	x	16.4	x	9.21	x	0.63	x	0.7	=	46.18	(75)
East	0.9x 1	x	18.32	x	19.64	x	0.63	x	0.7	=	109.96	(76)
East	0.9x 1	x	18.32	x	38.42	x	0.63	x	0.7	=	215.11	(76)
East	0.9x 1	x	18.32	x	63.27	x	0.63	x	0.7	=	354.26	(76)
East	0.9x 1	x	18.32	x	92.28	x	0.63	x	0.7	=	516.66	(76)

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East	0.9x	1	x	18.32	x	113.09	x	0.63	x	0.7	=	633.19	(76)
East	0.9x	1	x	18.32	x	115.77	x	0.63	x	0.7	=	648.18	(76)
East	0.9x	1	x	18.32	x	110.22	x	0.63	x	0.7	=	617.09	(76)
East	0.9x	1	x	18.32	x	94.68	x	0.63	x	0.7	=	530.07	(76)
East	0.9x	1	x	18.32	x	73.59	x	0.63	x	0.7	=	412.01	(76)
East	0.9x	1	x	18.32	x	45.59	x	0.63	x	0.7	=	255.25	(76)
East	0.9x	1	x	18.32	x	24.49	x	0.63	x	0.7	=	137.11	(76)
East	0.9x	1	x	18.32	x	16.15	x	0.63	x	0.7	=	90.43	(76)
South	0.9x	0.77	x	80.62	x	46.75	x	0.63	x	0.7	=	1151.9	(78)
South	0.9x	0.77	x	80.62	x	76.57	x	0.63	x	0.7	=	1886.52	(78)
South	0.9x	0.77	x	80.62	x	97.53	x	0.63	x	0.7	=	2403.09	(78)
South	0.9x	0.77	x	80.62	x	110.23	x	0.63	x	0.7	=	2716.01	(78)
South	0.9x	0.77	x	80.62	x	114.87	x	0.63	x	0.7	=	2830.25	(78)
South	0.9x	0.77	x	80.62	x	110.55	x	0.63	x	0.7	=	2723.73	(78)
South	0.9x	0.77	x	80.62	x	108.01	x	0.63	x	0.7	=	2661.25	(78)
South	0.9x	0.77	x	80.62	x	104.89	x	0.63	x	0.7	=	2584.45	(78)
South	0.9x	0.77	x	80.62	x	101.89	x	0.63	x	0.7	=	2510.31	(78)
South	0.9x	0.77	x	80.62	x	82.59	x	0.63	x	0.7	=	2034.79	(78)
South	0.9x	0.77	x	80.62	x	55.42	x	0.63	x	0.7	=	1365.4	(78)
South	0.9x	0.77	x	80.62	x	40.4	x	0.63	x	0.7	=	995.35	(78)
Southwest	0.9x	0.77	x	34.73	x	36.79		0.63	x	0.7	=	390.53	(79)
Southwest	0.9x	0.77	x	34.73	x	62.67		0.63	x	0.7	=	665.21	(79)
Southwest	0.9x	0.77	x	34.73	x	85.75		0.63	x	0.7	=	910.17	(79)
Southwest	0.9x	0.77	x	34.73	x	106.25		0.63	x	0.7	=	1127.75	(79)
Southwest	0.9x	0.77	x	34.73	x	119.01		0.63	x	0.7	=	1263.17	(79)
Southwest	0.9x	0.77	x	34.73	x	118.15		0.63	x	0.7	=	1254.04	(79)
Southwest	0.9x	0.77	x	34.73	x	113.91		0.63	x	0.7	=	1209.03	(79)
Southwest	0.9x	0.77	x	34.73	x	104.39		0.63	x	0.7	=	1107.99	(79)
Southwest	0.9x	0.77	x	34.73	x	92.85		0.63	x	0.7	=	985.52	(79)
Southwest	0.9x	0.77	x	34.73	x	69.27		0.63	x	0.7	=	735.2	(79)
Southwest	0.9x	0.77	x	34.73	x	44.07		0.63	x	0.7	=	467.76	(79)
Southwest	0.9x	0.77	x	34.73	x	31.49		0.63	x	0.7	=	334.21	(79)
West	0.9x	0.77	x	23.83	x	19.64	x	0.63	x	0.7	=	143.04	(80)
West	0.9x	0.77	x	23.83	x	38.42	x	0.63	x	0.7	=	279.81	(80)
West	0.9x	0.77	x	23.83	x	63.27	x	0.63	x	0.7	=	460.8	(80)
West	0.9x	0.77	x	23.83	x	92.28	x	0.63	x	0.7	=	672.05	(80)
West	0.9x	0.77	x	23.83	x	113.09	x	0.63	x	0.7	=	823.63	(80)
West	0.9x	0.77	x	23.83	x	115.77	x	0.63	x	0.7	=	843.13	(80)
West	0.9x	0.77	x	23.83	x	110.22	x	0.63	x	0.7	=	802.69	(80)
West	0.9x	0.77	x	23.83	x	94.68	x	0.63	x	0.7	=	689.5	(80)
West	0.9x	0.77	x	23.83	x	73.59	x	0.63	x	0.7	=	535.93	(80)

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West	0.9x	0.77	x	23.83	x	45.59	x	0.63	x	0.7	=	332.02	(80)
West	0.9x	0.77	x	23.83	x	24.49	x	0.63	x	0.7	=	178.35	(80)
West	0.9x	0.77	x	23.83	x	16.15	x	0.63	x	0.7	=	117.63	(80)
Rooflights	0.9x	1	x	2.74	x	26.61	x	0.63	x	0.7	=	28.91	(82)
Rooflights	0.9x	1	x	1.4	x	26.61	x	0.63	x	0.7	=	14.81	(82)
Rooflights	0.9x	1	x	1.32	x	16.8	x	0.63	x	0.7	=	8.77	(82)
Rooflights	0.9x	1	x	2.74	x	53.79	x	0.63	x	0.7	=	58.44	(82)
Rooflights	0.9x	1	x	1.4	x	53.79	x	0.63	x	0.7	=	29.95	(82)
Rooflights	0.9x	1	x	1.32	x	32.18	x	0.63	x	0.7	=	16.8	(82)
Rooflights	0.9x	1	x	2.74	x	92.95	x	0.63	x	0.7	=	100.98	(82)
Rooflights	0.9x	1	x	1.4	x	92.95	x	0.63	x	0.7	=	51.75	(82)
Rooflights	0.9x	1	x	1.32	x	59.16	x	0.63	x	0.7	=	30.88	(82)
Rooflights	0.9x	1	x	2.74	x	142.44	x	0.63	x	0.7	=	154.75	(82)
Rooflights	0.9x	1	x	1.4	x	142.44	x	0.63	x	0.7	=	79.3	(82)
Rooflights	0.9x	1	x	1.32	x	107.87	x	0.63	x	0.7	=	56.3	(82)
Rooflights	0.9x	1	x	2.74	x	180.71	x	0.63	x	0.7	=	196.33	(82)
Rooflights	0.9x	1	x	1.4	x	180.71	x	0.63	x	0.7	=	100.61	(82)
Rooflights	0.9x	1	x	1.32	x	159.03	x	0.63	x	0.7	=	83.01	(82)
Rooflights	0.9x	1	x	2.74	x	187.72	x	0.63	x	0.7	=	203.94	(82)
Rooflights	0.9x	1	x	1.4	x	187.72	x	0.63	x	0.7	=	104.51	(82)
Rooflights	0.9x	1	x	1.32	x	176.47	x	0.63	x	0.7	=	92.11	(82)
Rooflights	0.9x	1	x	2.74	x	177.6	x	0.63	x	0.7	=	192.94	(82)
Rooflights	0.9x	1	x	1.4	x	177.6	x	0.63	x	0.7	=	98.87	(82)
Rooflights	0.9x	1	x	1.32	x	162.27	x	0.63	x	0.7	=	84.7	(82)
Rooflights	0.9x	1	x	2.74	x	148.43	x	0.63	x	0.7	=	161.25	(82)
Rooflights	0.9x	1	x	1.4	x	148.43	x	0.63	x	0.7	=	82.64	(82)
Rooflights	0.9x	1	x	1.32	x	120.08	x	0.63	x	0.7	=	62.67	(82)
Rooflights	0.9x	1	x	2.74	x	110.34	x	0.63	x	0.7	=	119.87	(82)
Rooflights	0.9x	1	x	1.4	x	110.34	x	0.63	x	0.7	=	61.43	(82)
Rooflights	0.9x	1	x	1.32	x	74.77	x	0.63	x	0.7	=	39.03	(82)
Rooflights	0.9x	1	x	2.74	x	64.97	x	0.63	x	0.7	=	70.59	(82)
Rooflights	0.9x	1	x	1.4	x	64.97	x	0.63	x	0.7	=	36.17	(82)
Rooflights	0.9x	1	x	1.32	x	39.1	x	0.63	x	0.7	=	20.41	(82)
Rooflights	0.9x	1	x	2.74	x	33.49	x	0.63	x	0.7	=	36.38	(82)
Rooflights	0.9x	1	x	1.4	x	33.49	x	0.63	x	0.7	=	18.64	(82)
Rooflights	0.9x	1	x	1.32	x	20.63	x	0.63	x	0.7	=	10.77	(82)
Rooflights	0.9x	1	x	2.74	x	21.68	x	0.63	x	0.7	=	23.55	(82)
Rooflights	0.9x	1	x	1.4	x	21.68	x	0.63	x	0.7	=	12.07	(82)
Rooflights	0.9x	1	x	1.32	x	14.12	x	0.63	x	0.7	=	7.37	(82)

Solar gains in watts, calculated for each month (83)m = Sum(74)m …(82)m

(83)m=	2010.73	3470.02	4864.39	6217.71	7134.69	7157.07	6869.46	6174.67	5331.71	3866.83	2416.66	1715.38

(83)

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Total gains – internal and solar (84)m = (73)m + (83)m , watts

(84)m=	3151.39	4608.11	5962.55	7248.59	8091.85	8047.33	7718.85	7031.89	6225.74	4828.41	3456.22	2818.65

(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (°C) 21 (85)

Utilisation factor for gains for living area, h1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(86)m=	1	1	0.99	0.97	0.91	0.77	0.6	0.67	0.89	0.99	1	1

(86)

Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c)

(87)m=	19.32	19.55	19.89	20.3	20.67	20.9	20.97	20.96	20.77	20.27	19.7	19.28

(87)

Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C)

(88)m=	19.82	19.82	19.82	19.83	19.83	19.84	19.84	19.84	19.84	19.83	19.83	19.83

(88)

Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a)

(89)m=	1	1	0.99	0.96	0.86	0.67	0.46	0.53	0.83	0.98	1	1

(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m=	17.57	17.91	18.4	19.01	19.5	19.77	19.83	19.83	19.65	18.96	18.14	17.52

(90)

fLA = Living area ÷ (4) = 0.15 (91)

Mean internal temperature (for the whole dwelling) = fLA × T1 + (1 – fLA) × T2

(92)m=	17.84	18.16	18.62	19.2	19.68	19.94	20.01	20	19.82	19.16	18.38	17.79

(92)

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m=	17.84	18.16	18.62	19.2	19.68	19.94	20.01	20	19.82	19.16	18.38	17.79

(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that Ti,m=(76)m and re-calculate the utilisation factor for gains using Table 9a

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Utilisation factor for gains, hm:

(94)m=	1	1	0.99	0.95	0.86	0.68	0.48	0.55	0.83	0.98	1	1

(94)

Useful gains, hmGm , W = (94)m x (84)m

(95)m=	3149.35	4592.35	5882.41	6895.21	6939.05	5461.74	3708.75	3856.94	5163.71	4719.19	3449.19	2817.54

(95)

Monthly average external temperature from Table 8

(96)m=	4.3	4.9	6.5	8.9	11.7	14.6	16.6	16.4	14.1	10.6	7.1	4.2

(96)

Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]

(97)m=	15353.62	15009.86	13703.57	11549.58	8933.73	5938	3784.7	3992.6	6372.44	9580.39	12660.84	15307.53

(97)

Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m

(98)m=	9079.98	7000.57	5818.94	3351.15	1484.04	0	0	0	0	3616.73	6632.39	9292.55

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 46276.35 (98)

Space heating requirement in kWh/m²/year 54.08 (99)

9a. Energy requirements – Individual heating systems including micro-CHP)

Space heating:

Fraction of space heat from secondary/supplementary system 0 (201)

Fraction of space heat from main system(s) (202) = 1 – (201) = 1 (202)

Fraction of total heating from main system 1 (204) = (202) × [1 – (203)] = 1 (204)

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Efficiency of main space heating system 1 | 93.5 | (206)

Efficiency of secondary/supplementary heating system, % | 0 | (208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year
Space heating requirement (calculated above)	9079.98	7000.57	5818.94	3351.15	1484.04	0	0	0	0	3616.73	6632.39	9292.55	
(211)m = {[(98)m x (204)] } x 100 ÷ (206)	9711.2	7487.24	6223.46	3584.12	1587.21	0	0	0	0	3868.16	7093.46	9938.55	(211)

Total (kWh/year) =Sum(211)$_{1...5,10...12}$= | 49493.42 | (211)

Space heating fuel (secondary), kWh/month

= {[(98)m x (201)] } x 100 ÷ (208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(215)m=	0	0	0	0	0	0	0	0	0	0	0	0

Total (kWh/year) =Sum(215)$_{1...5,10...12}$= | 0 | (215)

Water heating

Output from water heater (calculated above)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	263.74	232.35	243.75	218.13	213.49	190.37	182.46	200.73	200.53	226.21	239.66	257.27

Efficiency of water heater | 79.8 | (216)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(217)m=	90.16	90.11	90.01	89.76	89	79.8	79.8	79.8	79.8	89.79	90.08	90.17

(217)

Fuel for water heating, kWh/month

(219)m = (64)m x 100 ÷ (217)m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(219)m=	292.53	257.85	270.79	243	239.88	238.56	228.64	251.54	251.29	251.92	266.06	285.31

Total = Sum(219a)$_{1...12}$ = | 3077.37 | (219)

Annual totals	**kWh/year**	**kWh/year**
Space heating fuel used, main system 1		49493.42
Water heating fuel used		3077.37
Electricity for pumps, fans and electric keep-hot		
central heating pump:	30	(230c)
boiler with a fan-assisted flue	45	(230e)
Total electricity for the above, kWh/year sum of (230a)…(230g) =		75 (231)
Electricity for lighting		1304.08 (232)

12a. CO2 emissions – Individual heating systems including micro-CHP

	Energy kWh/year		**Emission factor** kg CO2/kWh		**Emissions** kg CO2/year	
Space heating (main system 1)	(211) x		0.216	=	10690.58	(261)
Space heating (secondary)	(215) x		0.519	=	0	(263)
Water heating	(219) x		0.216	=	664.71	(264)
Space and water heating	(261) + (262) + (263) + (264) =				11355.29	(265)
Electricity for pumps, fans and electric keep-hot	(231) x		0.519	=	38.93	(267)
Electricity for lighting	(232) x		0.519	=	676.82	(268)
Total CO2, kg/year	sum of (265)…(271) =				12071.03	(272)

TER WorkSheet: New dwelling design stage

TER = 14.11 (273)

Appendix B

SAP 2012 Dwelling Emission Rate Outputs

"Design for Energy Efficiency"

DER WorkSheet: New dwelling design stage

User Details:

Assessor Name:	George Farr	**Stroma Number:**	STRO028460
Software Name:	Stroma FSAP 2012	**Software Version:**	Version: 1.0.4.10

Property Address: Feb 18 - V2 Base & Lean

Address :

1. Overall dwelling dimensions:

	Area(m²)		Av. Height(m)		Volume(m³)	
Ground floor	557.24 (1a)	x	2.98 (2a)	=	1660.58	(3a)
First floor	298.44 (1b)	x	3.78 (2b)	=	1128.1	(3b)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	855.68	(4)				
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n)	=	2788.68	(5)

2. Ventilation rate:

	main heating		secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							9	x 10 =	90	(7a)
Number of passive vents							0	x 10 =	0	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

			Air changes per hour	
Infiltration due to chimneys, flues and fans =	(6a)+(6b)+(7a)+(7b)+(7c) =	90	÷ (5) =	0.03 (8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Number of storeys in the dwelling (ns)			0 (9)
Additional infiltration		[(9)-1]x0.1 =	0 (10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction			0 (11)
if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35			
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0			0 (12)
If no draught lobby, enter 0.05, else enter 0			0 (13)
Percentage of windows and doors draught stripped			0 (14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =		0 (15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =		0 (16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area			4.5 (17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)		0.26 (18)
Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used			
Number of sides sheltered			0 (19)
Shelter factor	(20) = 1 - [0.075 x (19)] =		1 (20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =		0.26 (21)

Infiltration rate modified for monthly wind speed

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Monthly average wind speed from Table 7

(22)m=	5.1	5	4.9	4.4	4.3	3.8	3.8	3.7	4	4.3	4.5	4.7

DER WorkSheet: New dwelling design stage

Wind Factor (22a)m = (22)m ÷ 4

(22a)m=	1.27	1.25	1.23	1.1	1.08	0.95	0.95	0.92	1	1.08	1.12	1.18

Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m

0.33	0.32	0.32	0.28	0.28	0.24	0.24	0.24	0.26	0.28	0.29	0.3

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 0 (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100]

(24a)m=	0	0	0	0	0	0	0	0	0	0	0	0

(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0

(24b)

c) If whole house extract ventilation or positive input ventilation from outside
if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0	0	0	0	0	0	0	0	0	0	0	0

(24c)

d) If natural ventilation or whole house positive input ventilation from loft
if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0.55	0.55	0.55	0.54	0.54	0.53	0.53	0.53	0.53	0.54	0.54	0.55

(24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25)m=	0.55	0.55	0.55	0.54	0.54	0.53	0.53	0.53	0.53	0.54	0.54	0.55

(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Doors			1.87	x	1.2	=	2.244			(26)
Windows Type 1			82.76	x	1/[1/(0.58)+ 0.04]	=	46.91			(27)
Windows Type 2			24.46	x	1/[1/(0.58)+ 0.04]	=	13.87			(27)
Windows Type 3			18.81	x	1/[1/(0.58)+ 0.04]	=	10.66			(27)
Windows Type 4			16.84	x	1/[1/(0.58)+ 0.04]	=	9.55			(27)
Windows Type 5			33.57	x	1/[1/(0.58)+ 0.04]	=	19.03			(27)
Windows Type 6			35.65	x	1/[1/(0.58)+ 0.04]	=	20.21			(27)
Rooflights Type 1			2.81	x	1/[1/(0.58) + 0.04]	=	1.6298			(27b)
Rooflights Type 2			1.44	x	1/[1/(0.58) + 0.04]	=	0.8352			(27b)
Rooflights Type 3			1.35	x	1/[1/(0.58) + 0.04]	=	0.783			(27b)
Floor Type 1			557.24	x	0.1	=	55.724	110	61296.4	(28)
Floor Type 2			106.2	x	0.12	=	12.744	75	7965	(28)
Walls Type1	709.78	213.96	495.82	x	0.15	=	74.37	60	29749.2	(29)
Walls Type2	31.47	0	31.47	x	0.14	=	4.5	60	1888.2	(29)
Walls Type3	2.89	0	2.89	x	0.15	=	0.43	60	173.4	(29)
Roof Type1	328.53	5.6	322.93	x	0.1	=	32.29	9	2906.37	(30)
Roof Type2	365	0	365	x	0.1	=	36.5	9	3285	(30)

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Total area of elements, m²	2101.11			(31)
Internal wall **	1078.32	9	9704.88	(32c)
Internal wall **	155.28	75	11646	(32c)
Internal floor	192.24	18	3460.32	(32d)
Internal ceiling	192.24	9	1730.16	(32e)

** for windows and roof windows, use effective window U-value calculated using formula 1/[(1/U-value)+0.04] as given in paragraph 3.2*
*** include the areas on both sides of internal walls and partitions*

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 342.21 (33)

Heat capacity Cm = S(A x k) ((28)…(30) + (32) + (32a)…(32e) = 133804.93 (34)

Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K = (34) ÷ (4) = 156.37 (35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation.

Thermal bridges : S (L x Y) calculated using Appendix K 85 (36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss (33) + (36) = 427.21 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 × (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	509.64	507.72	505.83	496.98	495.33	487.62	487.62	486.19	490.59	495.33	498.68	502.18	(38)

Heat transfer coefficient, W/K (39)m = (37) + (38)m

(39)m=	936.85	934.93	933.04	924.19	922.53	914.83	914.83	913.4	917.79	922.53	925.88	929.39	

Average = Sum(39)$_{1...12}$ /12= 924.18 (39)

Heat loss parameter (HLP), W/m²K (40)m = (39)m ÷ (4)

(40)m=	1.09	1.09	1.09	1.08	1.08	1.07	1.07	1.07	1.07	1.08	1.08	1.09	

Average = Sum(40)$_{1...12}$ /12= 1.08 (40)

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41)m=	31	28	31	30	31	30	31	31	30	31	30	31	(41)

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N 3.85 (42)
if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)
if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 125.74 (43)
Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)													
(44)m=	138.31	133.28	128.25	123.23	118.2	113.17	113.17	118.2	123.23	128.25	133.28	138.31	

Total = Sum(44)$_{1...12}$ = 1508.88 (44)

Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)

(45)m=	205.12	179.4	185.12	161.39	154.86	133.63	123.83	142.1	143.79	167.58	182.92	198.64	

Total = Sum(45)$_{1...12}$ = 1978.38 (45)

If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)

(46)m=	30.77	26.91	27.77	24.21	23.23	20.04	18.57	21.31	21.57	25.14	27.44	29.8	(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel 300 (47)

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If community heating and no tank in dwelling, enter 110 litres in (47)
Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in (47)
Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day):		1.89	(48)
Temperature factor from Table 2b		0.54	(49)
Energy lost from water storage, kWh/year	(48) x (49) =	1.02	(50)
b) If manufacturer's declared cylinder loss factor is not known:			
Hot water storage loss factor from Table 2 (kWh/litre/day)		0	(51)
If community heating see section 4.3			
Volume factor from Table 2a		0	(52)
Temperature factor from Table 2b		0	(53)
Energy lost from water storage, kWh/year	(47) x (51) x (52) x (53) =	0	(54)
Enter (50) or (54) in (55)		1.02	(55)

Water storage loss calculated for each month ((56)m = (55) × (41)m

(56)m=	31.64	28.58	31.64	30.62	31.64	30.62	31.64	31.64	30.62	31.64	30.62	31.64	(56)

If cylinder contains dedicated solar storage, (57)m = (56)m x [(50) – (H11)] ÷ (50), else (57)m = (56)m where (H11) is from Appendix H

(57)m=	31.64	28.58	31.64	30.62	31.64	30.62	31.64	31.64	30.62	31.64	30.62	31.64	(57)

Primary circuit loss (annual) from Table 3: 0 (58)

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m
(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59)m=	23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss calculated for each month (61)m = (60) ÷ 365 × (41)m

(61)m=	0	0	0	0	0	0	0	0	0	0	0	0	(61)

Total heat required for water heating calculated for each month (62)m = 0.85 × (45)m + (46)m + (57)m + (59)m + (61)m

(62)m=	260.02	228.98	240.02	214.52	209.76	186.76	178.73	197	196.92	222.48	236.05	253.54	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)
(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

Output from water heater

(64)m=	260.02	228.98	240.02	214.52	209.76	186.76	178.73	197	196.92	222.48	236.05	253.54	

Output from water heater (annual)$_{1...12}$ 2624.79 (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	112.12	99.32	105.47	96.17	95.41	86.94	85.09	91.17	90.32	99.64	103.33	109.97	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	(66)

Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5

(67)m=	73.84	65.59	53.34	40.38	30.18	25.48	27.54	35.79	48.04	61	71.19	75.89	(67)

Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5

(68)m=	828.29	836.89	815.23	769.12	710.91	656.21	619.66	611.06	632.72	678.83	737.04	791.74	(68)

Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5

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(69)m=	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	(69)

Pumps and fans gains (Table 5a)

(70)m=	3	3	3	3	3	3	3	3	3	3	3	3	(70)

Losses e.g. evaporation (negative values) (Table 5)

(71)m=	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	(71)

Water heating gains (Table 5)

(72)m=	150.7	147.8	141.77	133.57	128.24	120.75	114.37	122.54	125.44	133.93	143.51	147.81	(72)

Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m

(73)m=	1136.65	1134.08	1094.14	1026.88	953.15	886.25	845.38	853.21	890.02	957.57	1035.56	1099.26	(73)

6. Solar gains:

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation.

Orientation:	Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
North	0.9x 0.77	x	33.57	x	10.63	x	0.57	x	0.8	=	112.8	(74)
North	0.9x 0.77	x	33.57	x	20.32	x	0.57	x	0.8	=	215.57	(74)
North	0.9x 0.77	x	33.57	x	34.53	x	0.57	x	0.8	=	366.31	(74)
North	0.9x 0.77	x	33.57	x	55.46	x	0.57	x	0.8	=	588.39	(74)
North	0.9x 0.77	x	33.57	x	74.72	x	0.57	x	0.8	=	792.61	(74)
North	0.9x 0.77	x	33.57	x	79.99	x	0.57	x	0.8	=	848.52	(74)
North	0.9x 0.77	x	33.57	x	74.68	x	0.57	x	0.8	=	792.2	(74)
North	0.9x 0.77	x	33.57	x	59.25	x	0.57	x	0.8	=	628.51	(74)
North	0.9x 0.77	x	33.57	x	41.52	x	0.57	x	0.8	=	440.42	(74)
North	0.9x 0.77	x	33.57	x	24.19	x	0.57	x	0.8	=	256.61	(74)
North	0.9x 0.77	x	33.57	x	13.12	x	0.57	x	0.8	=	139.16	(74)
North	0.9x 0.77	x	33.57	x	8.86	x	0.57	x	0.8	=	94.04	(74)
Northeast	0.9x 0.77	x	16.84	x	11.28	x	0.57	x	0.8	=	60.04	(75)
Northeast	0.9x 0.77	x	16.84	x	22.97	x	0.57	x	0.8	=	122.22	(75)
Northeast	0.9x 0.77	x	16.84	x	41.38	x	0.57	x	0.8	=	220.2	(75)
Northeast	0.9x 0.77	x	16.84	x	67.96	x	0.57	x	0.8	=	361.63	(75)
Northeast	0.9x 0.77	x	16.84	x	91.35	x	0.57	x	0.8	=	486.1	(75)
Northeast	0.9x 0.77	x	16.84	x	97.38	x	0.57	x	0.8	=	518.24	(75)
Northeast	0.9x 0.77	x	16.84	x	91.1	x	0.57	x	0.8	=	484.8	(75)
Northeast	0.9x 0.77	x	16.84	x	72.63	x	0.57	x	0.8	=	386.49	(75)
Northeast	0.9x 0.77	x	16.84	x	50.42	x	0.57	x	0.8	=	268.32	(75)
Northeast	0.9x 0.77	x	16.84	x	28.07	x	0.57	x	0.8	=	149.36	(75)
Northeast	0.9x 0.77	x	16.84	x	14.2	x	0.57	x	0.8	=	75.55	(75)
Northeast	0.9x 0.77	x	16.84	x	9.21	x	0.57	x	0.8	=	49.03	(75)
East	0.9x 1	x	18.81	x	19.64	x	0.57	x	0.8	=	116.74	(76)
East	0.9x 1	x	18.81	x	38.42	x	0.57	x	0.8	=	228.38	(76)
East	0.9x 1	x	18.81	x	63.27	x	0.57	x	0.8	=	376.1	(76)
East	0.9x 1	x	18.81	x	92.28	x	0.57	x	0.8	=	548.52	(76)

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East	0.9x	1	x	18.81	x	113.09	x	0.57	x	0.8	=	672.24	(76)
East	0.9x	1	x	18.81	x	115.77	x	0.57	x	0.8	=	688.15	(76)
East	0.9x	1	x	18.81	x	110.22	x	0.57	x	0.8	=	655.15	(76)
East	0.9x	1	x	18.81	x	94.68	x	0.57	x	0.8	=	562.76	(76)
East	0.9x	1	x	18.81	x	73.59	x	0.57	x	0.8	=	437.42	(76)
East	0.9x	1	x	18.81	x	45.59	x	0.57	x	0.8	=	270.99	(76)
East	0.9x	1	x	18.81	x	24.49	x	0.57	x	0.8	=	145.57	(76)
East	0.9x	1	x	18.81	x	16.15	x	0.57	x	0.8	=	96	(76)
South	0.9x	0.77	x	82.76	x	46.75	x	0.57	x	0.8	=	1222.7	(78)
South	0.9x	0.77	x	82.76	x	76.57	x	0.57	x	0.8	=	2002.47	(78)
South	0.9x	0.77	x	82.76	x	97.53	x	0.57	x	0.8	=	2550.79	(78)
South	0.9x	0.77	x	82.76	x	110.23	x	0.57	x	0.8	=	2882.94	(78)
South	0.9x	0.77	x	82.76	x	114.87	x	0.57	x	0.8	=	3004.2	(78)
South	0.9x	0.77	x	82.76	x	110.55	x	0.57	x	0.8	=	2891.14	(78)
South	0.9x	0.77	x	82.76	x	108.01	x	0.57	x	0.8	=	2824.82	(78)
South	0.9x	0.77	x	82.76	x	104.89	x	0.57	x	0.8	=	2743.29	(78)
South	0.9x	0.77	x	82.76	x	101.89	x	0.57	x	0.8	=	2664.6	(78)
South	0.9x	0.77	x	82.76	x	82.59	x	0.57	x	0.8	=	2159.85	(78)
South	0.9x	0.77	x	82.76	x	55.42	x	0.57	x	0.8	=	1449.31	(78)
South	0.9x	0.77	x	82.76	x	40.4	x	0.57	x	0.8	=	1056.52	(78)
Southwest	0.9x	0.77	x	35.65	x	36.79		0.57	x	0.8	=	414.51	(79)
Southwest	0.9x	0.77	x	35.65	x	62.67		0.57	x	0.8	=	706.06	(79)
Southwest	0.9x	0.77	x	35.65	x	85.75		0.57	x	0.8	=	966.06	(79)
Southwest	0.9x	0.77	x	35.65	x	106.25		0.57	x	0.8	=	1197	(79)
Southwest	0.9x	0.77	x	35.65	x	119.01		0.57	x	0.8	=	1340.74	(79)
Southwest	0.9x	0.77	x	35.65	x	118.15		0.57	x	0.8	=	1331.04	(79)
Southwest	0.9x	0.77	x	35.65	x	113.91		0.57	x	0.8	=	1283.27	(79)
Southwest	0.9x	0.77	x	35.65	x	104.39		0.57	x	0.8	=	1176.03	(79)
Southwest	0.9x	0.77	x	35.65	x	92.85		0.57	x	0.8	=	1046.04	(79)
Southwest	0.9x	0.77	x	35.65	x	69.27		0.57	x	0.8	=	780.35	(79)
Southwest	0.9x	0.77	x	35.65	x	44.07		0.57	x	0.8	=	496.48	(79)
Southwest	0.9x	0.77	x	35.65	x	31.49		0.57	x	0.8	=	354.73	(79)
West	0.9x	0.77	x	24.46	x	19.64	x	0.57	x	0.8	=	151.81	(80)
West	0.9x	0.77	x	24.46	x	38.42	x	0.57	x	0.8	=	296.97	(80)
West	0.9x	0.77	x	24.46	x	63.27	x	0.57	x	0.8	=	489.07	(80)
West	0.9x	0.77	x	24.46	x	92.28	x	0.57	x	0.8	=	713.28	(80)
West	0.9x	0.77	x	24.46	x	113.09	x	0.57	x	0.8	=	874.16	(80)
West	0.9x	0.77	x	24.46	x	115.77	x	0.57	x	0.8	=	894.85	(80)
West	0.9x	0.77	x	24.46	x	110.22	x	0.57	x	0.8	=	851.94	(80)
West	0.9x	0.77	x	24.46	x	94.68	x	0.57	x	0.8	=	731.8	(80)
West	0.9x	0.77	x	24.46	x	73.59	x	0.57	x	0.8	=	568.81	(80)

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West	0.9x	0.77	x	24.46	x	45.59	x	0.57	x	0.8	=	352.38	(80)
West	0.9x	0.77	x	24.46	x	24.49	x	0.57	x	0.8	=	189.29	(80)
West	0.9x	0.77	x	24.46	x	16.15	x	0.57	x	0.8	=	124.84	(80)
Rooflights	0.9x	1	x	2.81	x	26.61	x	0.57	x	0.8	=	30.68	(82)
Rooflights	0.9x	1	x	1.44	x	26.61	x	0.57	x	0.8	=	15.72	(82)
Rooflights	0.9x	1	x	1.35	x	16.8	x	0.57	x	0.8	=	9.31	(82)
Rooflights	0.9x	1	x	2.81	x	53.79	x	0.57	x	0.8	=	62.03	(82)
Rooflights	0.9x	1	x	1.44	x	53.79	x	0.57	x	0.8	=	31.79	(82)
Rooflights	0.9x	1	x	1.35	x	32.18	x	0.57	x	0.8	=	17.83	(82)
Rooflights	0.9x	1	x	2.81	x	92.95	x	0.57	x	0.8	=	107.19	(82)
Rooflights	0.9x	1	x	1.44	x	92.95	x	0.57	x	0.8	=	54.93	(82)
Rooflights	0.9x	1	x	1.35	x	59.16	x	0.57	x	0.8	=	32.78	(82)
Rooflights	0.9x	1	x	2.81	x	142.44	x	0.57	x	0.8	=	164.27	(82)
Rooflights	0.9x	1	x	1.44	x	142.44	x	0.57	x	0.8	=	84.18	(82)
Rooflights	0.9x	1	x	1.35	x	107.87	x	0.57	x	0.8	=	59.76	(82)
Rooflights	0.9x	1	x	2.81	x	180.71	x	0.57	x	0.8	=	208.4	(82)
Rooflights	0.9x	1	x	1.44	x	180.71	x	0.57	x	0.8	=	106.8	(82)
Rooflights	0.9x	1	x	1.35	x	159.03	x	0.57	x	0.8	=	88.11	(82)
Rooflights	0.9x	1	x	2.81	x	187.72	x	0.57	x	0.8	=	216.49	(82)
Rooflights	0.9x	1	x	1.44	x	187.72	x	0.57	x	0.8	=	110.94	(82)
Rooflights	0.9x	1	x	1.35	x	176.47	x	0.57	x	0.8	=	97.77	(82)
Rooflights	0.9x	1	x	2.81	x	177.6	x	0.57	x	0.8	=	204.81	(82)
Rooflights	0.9x	1	x	1.44	x	177.6	x	0.57	x	0.8	=	104.96	(82)
Rooflights	0.9x	1	x	1.35	x	162.27	x	0.57	x	0.8	=	89.91	(82)
Rooflights	0.9x	1	x	2.81	x	148.43	x	0.57	x	0.8	=	171.17	(82)
Rooflights	0.9x	1	x	1.44	x	148.43	x	0.57	x	0.8	=	87.72	(82)
Rooflights	0.9x	1	x	1.35	x	120.08	x	0.57	x	0.8	=	66.53	(82)
Rooflights	0.9x	1	x	2.81	x	110.34	x	0.57	x	0.8	=	127.24	(82)
Rooflights	0.9x	1	x	1.44	x	110.34	x	0.57	x	0.8	=	65.21	(82)
Rooflights	0.9x	1	x	1.35	x	74.77	x	0.57	x	0.8	=	41.43	(82)
Rooflights	0.9x	1	x	2.81	x	64.97	x	0.57	x	0.8	=	74.93	(82)
Rooflights	0.9x	1	x	1.44	x	64.97	x	0.57	x	0.8	=	38.4	(82)
Rooflights	0.9x	1	x	1.35	x	39.1	x	0.57	x	0.8	=	21.66	(82)
Rooflights	0.9x	1	x	2.81	x	33.49	x	0.57	x	0.8	=	38.62	(82)
Rooflights	0.9x	1	x	1.44	x	33.49	x	0.57	x	0.8	=	19.79	(82)
Rooflights	0.9x	1	x	1.35	x	20.63	x	0.57	x	0.8	=	11.43	(82)
Rooflights	0.9x	1	x	2.81	x	21.68	x	0.57	x	0.8	=	25	(82)
Rooflights	0.9x	1	x	1.44	x	21.68	x	0.57	x	0.8	=	12.81	(82)
Rooflights	0.9x	1	x	1.35	x	14.12	x	0.57	x	0.8	=	7.82	(82)

Solar gains in watts, calculated for each month (83)m = Sum(74)m …(82)m

(83)m=	2134.32	3683.32	5163.43	6599.97	7573.36	7597.14	7291.84	6554.3	5659.49	4104.53	2565.2	1820.81

(83)

DER WorkSheet: New dwelling design stage

Total gains – internal and solar (84)m = (73)m + (83)m , watts

(84)m=	3270.97	4817.4	6257.57	7626.85	8526.51	8483.39	8137.22	7407.51	6549.5	5062.1	3600.76	2920.07

(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (°C) 21 (85)

Utilisation factor for gains for living area, h1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(86)m=	1	0.99	0.97	0.91	0.79	0.62	0.48	0.54	0.77	0.95	0.99	1

(86)

Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c)

(87)m=	19.46	19.71	20.04	20.42	20.71	20.86	20.91	20.9	20.78	20.36	19.82	19.42

(87)

Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C)

(88)m=	20.01	20.01	20.01	20.02	20.02	20.03	20.03	20.03	20.02	20.02	20.02	20.01

(88)

Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a)

(89)m=	1	0.99	0.96	0.89	0.74	0.55	0.38	0.43	0.71	0.94	0.99	1

(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m=	17.91	18.27	18.75	19.3	19.68	19.87	19.91	19.9	19.78	19.22	18.45	17.85

(90)

fLA = Living area ÷ (4) = 0.15 (91)

Mean internal temperature (for the whole dwelling) = fLA × T1 + (1 – fLA) × T2

(92)m=	18.14	18.49	18.95	19.47	19.83	20.02	20.06	20.06	19.93	19.4	18.65	18.09

(92)

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m=	17.99	18.34	18.8	19.32	19.68	19.87	19.91	19.91	19.78	19.25	18.5	17.94

(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that Ti,m=(76)m and re-calculate the utilisation factor for gains using Table 9a

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Utilisation factor for gains, hm:

(94)m=	0.99	0.98	0.95	0.87	0.73	0.54	0.37	0.42	0.69	0.92	0.99	1

(94)

Useful gains, hmGm , W = (94)m x (84)m

(95)m=	3254.2	4726.58	5927.93	6614.06	6187.81	4543.95	2980.35	3119.8	4517.77	4669.42	3555.01	2909.99

(95)

Monthly average external temperature from Table 8

(96)m=	4.3	4.9	6.5	8.9	11.7	14.6	16.6	16.4	14.1	10.6	7.1	4.2

(96)

Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]

(97)m=	12827.84	12563.63	11474.61	9626.91	7366.17	4818.6	3029.55	3202.16	5212.52	7976.63	10559.54	12770.26

(97)

Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m

(98)m=	7122.79	5266.5	4126.73	2169.25	876.7	0	0	0	0	2460.57	5043.26	7336.04

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 34401.85 (98)

Space heating requirement in kWh/m²/year 40.2 (99)

9a. Energy requirements – Individual heating systems including micro-CHP)

Space heating:

Fraction of space heat from secondary/supplementary system 0 (201)

Fraction of space heat from main system(s) (202) = 1 – (201) = 1 (202)

Fraction of total heating from main system 1 (204) = (202) × [1 – (203)] = 1 (204)

DER WorkSheet: New dwelling design stage

Efficiency of main space heating system 1 — 90.4 (206)

Efficiency of secondary/supplementary heating system, % — 0 (208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year
Space heating requirement (calculated above)	7122.79	5266.5	4126.73	2169.25	876.7	0	0	0	0	2460.57	5043.26	7336.04	
(211)m = {[(98)m x (204)] } x 100 ÷ (206)	7879.19	5825.77	4564.97	2399.62	969.81	0	0	0	0	2721.87	5578.83	8115.09	(211)

Total (kWh/year) =Sum(211)$_{1...5,10...12}$= 38055.14 (211)

Space heating fuel (secondary), kWh/month

= {[(98)m x (201)] } x 100 ÷ (208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(215)m=	0	0	0	0	0	0	0	0	0	0	0	0

Total (kWh/year) =Sum(215)$_{1...5,10...12}$= 0 (215)

Water heating

Output from water heater (calculated above)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	260.02	228.98	240.02	214.52	209.76	186.76	178.73	197	196.92	222.48	236.05	253.54

Efficiency of water heater — 79.7 (216)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(217)m=	89.97	89.9	89.74	89.32	88.12	79.7	79.7	79.7	79.7	89.4	89.86	90	(217)

Fuel for water heating, kWh/month

(219)m = (64)m x 100 ÷ (217)m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(219)m=	288.99	254.72	267.47	240.17	238.05	234.33	224.25	247.17	247.08	248.84	262.69	281.73

Total = Sum(219a)$_{1...12}$ = 3035.5 (219)

Annual totals	**kWh/year**	**kWh/year**
Space heating fuel used, main system 1		38055.14
Water heating fuel used		3035.5
Electricity for pumps, fans and electric keep-hot		
central heating pump:	30	(230c)
boiler with a fan-assisted flue	45	(230e)
Total electricity for the above, kWh/year — sum of (230a)…(230g) =		75 (231)
Electricity for lighting		1304.08 (232)

12a. CO2 emissions – Individual heating systems including micro-CHP

	Energy kWh/year		**Emission factor** kg CO2/kWh		**Emissions** kg CO2/year	
Space heating (main system 1)	(211) x		0.216	=	8219.91	(261)
Space heating (secondary)	(215) x		0.519	=	0	(263)
Water heating	(219) x		0.216	=	655.67	(264)
Space and water heating	(261) + (262) + (263) + (264) =				8875.58	(265)
Electricity for pumps, fans and electric keep-hot	(231) x		0.519	=	38.93	(267)
Electricity for lighting	(232) x		0.519	=	676.82	(268)
Total CO2, kg/year		sum of (265)…(271) =			9591.32	(272)
Dwelling CO2 Emission Rate		(272) ÷ (4) =			11.21	(273)

DER WorkSheet: New dwelling design stage

EI rating (section 14)	86	(274)

Appendix C

SAP 2012 Dwelling Emission Rate Outputs

"On Site Renewable and Energy Generating Technologies"

DER WorkSheet: New dwelling design stage

User Details:

Assessor Name:	George Farr	**Stroma Number:**	STRO028460
Software Name:	Stroma FSAP 2012	**Software Version:**	Version: 1.0.4.10

Property Address: Feb 18 - V2

Address :

1. Overall dwelling dimensions:

	Area(m²)		Av. Height(m)		Volume(m³)	
Ground floor	557.24 (1a)	x	2.98 (2a)	=	1660.58	(3a)
First floor	298.44 (1b)	x	3.78 (2b)	=	1128.1	(3b)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	855.68	(4)				
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n)	=	2788.68	(5)

2. Ventilation rate:

	main heating		secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							9	x 10 =	90	(7a)
Number of passive vents							0	x 10 =	0	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

			Air changes per hour	
Infiltration due to chimneys, flues and fans =	(6a)+(6b)+(7a)+(7b)+(7c) =	90	÷ (5) =	0.03 (8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Number of storeys in the dwelling (ns)			0 (9)
Additional infiltration		[(9)-1]x0.1 =	0 (10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction			0 (11)
if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35			
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0			0 (12)
If no draught lobby, enter 0.05, else enter 0			0 (13)
Percentage of windows and doors draught stripped			0 (14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =		0 (15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =		0 (16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area			4.5 (17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)		0.26 (18)
Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used			
Number of sides sheltered			0 (19)
Shelter factor	(20) = 1 - [0.075 x (19)] =		1 (20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =		0.26 (21)

Infiltration rate modified for monthly wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly average wind speed from Table 7												
(22)m=	5.1	5	4.9	4.4	4.3	3.8	3.8	3.7	4	4.3	4.5	4.7

DER WorkSheet: New dwelling design stage

Wind Factor (22a)m = (22)m ÷ 4

(22a)m=	1.27	1.25	1.23	1.1	1.08	0.95	0.95	0.92	1	1.08	1.12	1.18

Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m

0.33	0.32	0.32	0.28	0.28	0.24	0.24	0.24	0.26	0.28	0.29	0.3

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 0 (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100]

(24a)m=	0	0	0	0	0	0	0	0	0	0	0	0

(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0

(24b)

c) If whole house extract ventilation or positive input ventilation from outside
if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0	0	0	0	0	0	0	0	0	0	0	0

(24c)

d) If natural ventilation or whole house positive input ventilation from loft
if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0.55	0.55	0.55	0.54	0.54	0.53	0.53	0.53	0.53	0.54	0.54	0.55

(24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25)m=	0.55	0.55	0.55	0.54	0.54	0.53	0.53	0.53	0.53	0.54	0.54	0.55

(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Doors			1.87	x	1.2	=	2.244			(26)
Windows Type 1			82.76	x	1/[1/(0.58)+ 0.04]	=	46.91			(27)
Windows Type 2			24.46	x	1/[1/(0.58)+ 0.04]	=	13.87			(27)
Windows Type 3			18.81	x	1/[1/(0.58)+ 0.04]	=	10.66			(27)
Windows Type 4			16.84	x	1/[1/(0.58)+ 0.04]	=	9.55			(27)
Windows Type 5			33.57	x	1/[1/(0.58)+ 0.04]	=	19.03			(27)
Windows Type 6			35.65	x	1/[1/(0.58)+ 0.04]	=	20.21			(27)
Rooflights Type 1			2.81	x	1/[1/(0.58) + 0.04]	=	1.6298			(27b)
Rooflights Type 2			1.44	x	1/[1/(0.58) + 0.04]	=	0.8352			(27b)
Rooflights Type 3			1.35	x	1/[1/(0.58) + 0.04]	=	0.783			(27b)
Floor Type 1			557.24	x	0.1	=	55.724	110	61296.4	(28)
Floor Type 2			106.2	x	0.12	=	12.744	75	7965	(28)
Walls Type1	709.78	213.96	495.82	x	0.15	=	74.37	60	29749.2	(29)
Walls Type2	31.47	0	31.47	x	0.14	=	4.5	60	1888.2	(29)
Walls Type3	2.89	0	2.89	x	0.15	=	0.43	60	173.4	(29)
Roof Type1	328.53	5.6	322.93	x	0.1	=	32.29	9	2906.37	(30)
Roof Type2	365	0	365	x	0.1	=	36.5	9	3285	(30)

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Total area of elements, m²	2101.11			(31)
Internal wall **	1078.32	9	9704.88	(32c)
Internal wall **	155.28	75	11646	(32c)
Internal floor	192.24	18	3460.32	(32d)
Internal ceiling	192.24	9	1730.16	(32e)

** for windows and roof windows, use effective window U-value calculated using formula 1/[(1/U-value)+0.04] as given in paragraph 3.2*
*** include the areas on both sides of internal walls and partitions*

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 342.21 (33)

Heat capacity Cm = S(A x k) ((28)…(30) + (32) + (32a)…(32e) = 133804.93 (34)

Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K = (34) ÷ (4) = 156.37 (35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation.

Thermal bridges : S (L x Y) calculated using Appendix K 85 (36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss (33) + (36) = 427.21 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 × (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	509.64	507.72	505.83	496.98	495.33	487.62	487.62	486.19	490.59	495.33	498.68	502.18	(38)

Heat transfer coefficient, W/K (39)m = (37) + (38)m

(39)m=	936.85	934.93	933.04	924.19	922.53	914.83	914.83	913.4	917.79	922.53	925.88	929.39	

Average = Sum(39)$_{1...12}$ /12= 924.18 (39)

Heat loss parameter (HLP), W/m²K (40)m = (39)m ÷ (4)

(40)m=	1.09	1.09	1.09	1.08	1.08	1.07	1.07	1.07	1.07	1.08	1.08	1.09	

Average = Sum(40)$_{1...12}$ /12= 1.08 (40)

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41)m=	31	28	31	30	31	30	31	31	30	31	30	31	(41)

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N 3.85 (42)
if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)
if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 125.74 (43)
Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)													
(44)m=	138.31	133.28	128.25	123.23	118.2	113.17	113.17	118.2	123.23	128.25	133.28	138.31	

Total = Sum(44)$_{1...12}$ = 1508.88 (44)

Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)

(45)m=	205.12	179.4	185.12	161.39	154.86	133.63	123.83	142.1	143.79	167.58	182.92	198.64	

Total = Sum(45)$_{1...12}$ = 1978.38 (45)

If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)

(46)m=	30.77	26.91	27.77	24.21	23.23	20.04	18.57	21.31	21.57	25.14	27.44	29.8	(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel 300 (47)

DER WorkSheet: New dwelling design stage

If community heating and no tank in dwelling, enter 110 litres in (47)
Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in (47)
Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day):		1.89	(48)
Temperature factor from Table 2b		0.54	(49)
Energy lost from water storage, kWh/year	(48) x (49) =	1.02	(50)
b) If manufacturer's declared cylinder loss factor is not known:			
Hot water storage loss factor from Table 2 (kWh/litre/day)		0	(51)
If community heating see section 4.3			
Volume factor from Table 2a		0	(52)
Temperature factor from Table 2b		0	(53)
Energy lost from water storage, kWh/year	(47) x (51) x (52) x (53) =	0	(54)
Enter (50) or (54) in (55)		1.02	(55)

Water storage loss calculated for each month ((56)m = (55) × (41)m

(56)m=	31.64	28.58	31.64	30.62	31.64	30.62	31.64	31.64	30.62	31.64	30.62	31.64	(56)

If cylinder contains dedicated solar storage, (57)m = (56)m x [(50) – (H11)] ÷ (50), else (57)m = (56)m where (H11) is from Appendix H

(57)m=	31.64	28.58	31.64	30.62	31.64	30.62	31.64	31.64	30.62	31.64	30.62	31.64	(57)

Primary circuit loss (annual) from Table 3: 0 (58)

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m
(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59)m=	23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss calculated for each month (61)m = (60) ÷ 365 × (41)m

(61)m=	0	0	0	0	0	0	0	0	0	0	0	0	(61)

Total heat required for water heating calculated for each month (62)m = 0.85 × (45)m + (46)m + (57)m + (59)m + (61)m

(62)m=	260.02	228.98	240.02	214.52	209.76	186.76	178.73	197	196.92	222.48	236.05	253.54	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)
(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

Output from water heater

(64)m=	260.02	228.98	240.02	214.52	209.76	186.76	178.73	197	196.92	222.48	236.05	253.54	

Output from water heater (annual)$_{1...12}$ 2624.79 (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	112.12	99.32	105.47	96.17	95.41	86.94	85.09	91.17	90.32	99.64	103.33	109.97	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	192.72	(66)

Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5

(67)m=	73.84	65.59	53.34	40.38	30.18	25.48	27.54	35.79	48.04	61	71.19	75.89	(67)

Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5

(68)m=	828.29	836.89	815.23	769.12	710.91	656.21	619.66	611.06	632.72	678.83	737.04	791.74	(68)

Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5

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(69)m=	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	42.27	(69)

Pumps and fans gains (Table 5a)

(70)m=	3	3	3	3	3	3	3	3	3	3	3	3	(70)

Losses e.g. evaporation (negative values) (Table 5)

(71)m=	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	-154.17	(71)

Water heating gains (Table 5)

(72)m=	150.7	147.8	141.77	133.57	128.24	120.75	114.37	122.54	125.44	133.93	143.51	147.81	(72)

Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m

(73)m=	1136.65	1134.08	1094.14	1026.88	953.15	886.25	845.38	853.21	890.02	957.57	1035.56	1099.26	(73)

6. Solar gains:

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation.

Orientation:	Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
North	0.9x 0.77	x	33.57	x	10.63	x	0.57	x	0.8	=	112.8	(74)
North	0.9x 0.77	x	33.57	x	20.32	x	0.57	x	0.8	=	215.57	(74)
North	0.9x 0.77	x	33.57	x	34.53	x	0.57	x	0.8	=	366.31	(74)
North	0.9x 0.77	x	33.57	x	55.46	x	0.57	x	0.8	=	588.39	(74)
North	0.9x 0.77	x	33.57	x	74.72	x	0.57	x	0.8	=	792.61	(74)
North	0.9x 0.77	x	33.57	x	79.99	x	0.57	x	0.8	=	848.52	(74)
North	0.9x 0.77	x	33.57	x	74.68	x	0.57	x	0.8	=	792.2	(74)
North	0.9x 0.77	x	33.57	x	59.25	x	0.57	x	0.8	=	628.51	(74)
North	0.9x 0.77	x	33.57	x	41.52	x	0.57	x	0.8	=	440.42	(74)
North	0.9x 0.77	x	33.57	x	24.19	x	0.57	x	0.8	=	256.61	(74)
North	0.9x 0.77	x	33.57	x	13.12	x	0.57	x	0.8	=	139.16	(74)
North	0.9x 0.77	x	33.57	x	8.86	x	0.57	x	0.8	=	94.04	(74)
Northeast	0.9x 0.77	x	16.84	x	11.28	x	0.57	x	0.8	=	60.04	(75)
Northeast	0.9x 0.77	x	16.84	x	22.97	x	0.57	x	0.8	=	122.22	(75)
Northeast	0.9x 0.77	x	16.84	x	41.38	x	0.57	x	0.8	=	220.2	(75)
Northeast	0.9x 0.77	x	16.84	x	67.96	x	0.57	x	0.8	=	361.63	(75)
Northeast	0.9x 0.77	x	16.84	x	91.35	x	0.57	x	0.8	=	486.1	(75)
Northeast	0.9x 0.77	x	16.84	x	97.38	x	0.57	x	0.8	=	518.24	(75)
Northeast	0.9x 0.77	x	16.84	x	91.1	x	0.57	x	0.8	=	484.8	(75)
Northeast	0.9x 0.77	x	16.84	x	72.63	x	0.57	x	0.8	=	386.49	(75)
Northeast	0.9x 0.77	x	16.84	x	50.42	x	0.57	x	0.8	=	268.32	(75)
Northeast	0.9x 0.77	x	16.84	x	28.07	x	0.57	x	0.8	=	149.36	(75)
Northeast	0.9x 0.77	x	16.84	x	14.2	x	0.57	x	0.8	=	75.55	(75)
Northeast	0.9x 0.77	x	16.84	x	9.21	x	0.57	x	0.8	=	49.03	(75)
East	0.9x 1	x	18.81	x	19.64	x	0.57	x	0.8	=	116.74	(76)
East	0.9x 1	x	18.81	x	38.42	x	0.57	x	0.8	=	228.38	(76)
East	0.9x 1	x	18.81	x	63.27	x	0.57	x	0.8	=	376.1	(76)
East	0.9x 1	x	18.81	x	92.28	x	0.57	x	0.8	=	548.52	(76)

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East	0.9x	1	x	18.81	x	113.09	x	0.57	x	0.8	=	672.24	(76)
East	0.9x	1	x	18.81	x	115.77	x	0.57	x	0.8	=	688.15	(76)
East	0.9x	1	x	18.81	x	110.22	x	0.57	x	0.8	=	655.15	(76)
East	0.9x	1	x	18.81	x	94.68	x	0.57	x	0.8	=	562.76	(76)
East	0.9x	1	x	18.81	x	73.59	x	0.57	x	0.8	=	437.42	(76)
East	0.9x	1	x	18.81	x	45.59	x	0.57	x	0.8	=	270.99	(76)
East	0.9x	1	x	18.81	x	24.49	x	0.57	x	0.8	=	145.57	(76)
East	0.9x	1	x	18.81	x	16.15	x	0.57	x	0.8	=	96	(76)
South	0.9x	0.77	x	82.76	x	46.75	x	0.57	x	0.8	=	1222.7	(78)
South	0.9x	0.77	x	82.76	x	76.57	x	0.57	x	0.8	=	2002.47	(78)
South	0.9x	0.77	x	82.76	x	97.53	x	0.57	x	0.8	=	2550.79	(78)
South	0.9x	0.77	x	82.76	x	110.23	x	0.57	x	0.8	=	2882.94	(78)
South	0.9x	0.77	x	82.76	x	114.87	x	0.57	x	0.8	=	3004.2	(78)
South	0.9x	0.77	x	82.76	x	110.55	x	0.57	x	0.8	=	2891.14	(78)
South	0.9x	0.77	x	82.76	x	108.01	x	0.57	x	0.8	=	2824.82	(78)
South	0.9x	0.77	x	82.76	x	104.89	x	0.57	x	0.8	=	2743.29	(78)
South	0.9x	0.77	x	82.76	x	101.89	x	0.57	x	0.8	=	2664.6	(78)
South	0.9x	0.77	x	82.76	x	82.59	x	0.57	x	0.8	=	2159.85	(78)
South	0.9x	0.77	x	82.76	x	55.42	x	0.57	x	0.8	=	1449.31	(78)
South	0.9x	0.77	x	82.76	x	40.4	x	0.57	x	0.8	=	1056.52	(78)
Southwest	0.9x	0.77	x	35.65	x	36.79		0.57	x	0.8	=	414.51	(79)
Southwest	0.9x	0.77	x	35.65	x	62.67		0.57	x	0.8	=	706.06	(79)
Southwest	0.9x	0.77	x	35.65	x	85.75		0.57	x	0.8	=	966.06	(79)
Southwest	0.9x	0.77	x	35.65	x	106.25		0.57	x	0.8	=	1197	(79)
Southwest	0.9x	0.77	x	35.65	x	119.01		0.57	x	0.8	=	1340.74	(79)
Southwest	0.9x	0.77	x	35.65	x	118.15		0.57	x	0.8	=	1331.04	(79)
Southwest	0.9x	0.77	x	35.65	x	113.91		0.57	x	0.8	=	1283.27	(79)
Southwest	0.9x	0.77	x	35.65	x	104.39		0.57	x	0.8	=	1176.03	(79)
Southwest	0.9x	0.77	x	35.65	x	92.85		0.57	x	0.8	=	1046.04	(79)
Southwest	0.9x	0.77	x	35.65	x	69.27		0.57	x	0.8	=	780.35	(79)
Southwest	0.9x	0.77	x	35.65	x	44.07		0.57	x	0.8	=	496.48	(79)
Southwest	0.9x	0.77	x	35.65	x	31.49		0.57	x	0.8	=	354.73	(79)
West	0.9x	0.77	x	24.46	x	19.64	x	0.57	x	0.8	=	151.81	(80)
West	0.9x	0.77	x	24.46	x	38.42	x	0.57	x	0.8	=	296.97	(80)
West	0.9x	0.77	x	24.46	x	63.27	x	0.57	x	0.8	=	489.07	(80)
West	0.9x	0.77	x	24.46	x	92.28	x	0.57	x	0.8	=	713.28	(80)
West	0.9x	0.77	x	24.46	x	113.09	x	0.57	x	0.8	=	874.16	(80)
West	0.9x	0.77	x	24.46	x	115.77	x	0.57	x	0.8	=	894.85	(80)
West	0.9x	0.77	x	24.46	x	110.22	x	0.57	x	0.8	=	851.94	(80)
West	0.9x	0.77	x	24.46	x	94.68	x	0.57	x	0.8	=	731.8	(80)
West	0.9x	0.77	x	24.46	x	73.59	x	0.57	x	0.8	=	568.81	(80)

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West	0.9x	0.77	x	24.46	x	45.59	x	0.57	x	0.8	=	352.38	(80)
West	0.9x	0.77	x	24.46	x	24.49	x	0.57	x	0.8	=	189.29	(80)
West	0.9x	0.77	x	24.46	x	16.15	x	0.57	x	0.8	=	124.84	(80)
Rooflights	0.9x	1	x	2.81	x	26.61	x	0.57	x	0.8	=	30.68	(82)
Rooflights	0.9x	1	x	1.44	x	26.61	x	0.57	x	0.8	=	15.72	(82)
Rooflights	0.9x	1	x	1.35	x	16.8	x	0.57	x	0.8	=	9.31	(82)
Rooflights	0.9x	1	x	2.81	x	53.79	x	0.57	x	0.8	=	62.03	(82)
Rooflights	0.9x	1	x	1.44	x	53.79	x	0.57	x	0.8	=	31.79	(82)
Rooflights	0.9x	1	x	1.35	x	32.18	x	0.57	x	0.8	=	17.83	(82)
Rooflights	0.9x	1	x	2.81	x	92.95	x	0.57	x	0.8	=	107.19	(82)
Rooflights	0.9x	1	x	1.44	x	92.95	x	0.57	x	0.8	=	54.93	(82)
Rooflights	0.9x	1	x	1.35	x	59.16	x	0.57	x	0.8	=	32.78	(82)
Rooflights	0.9x	1	x	2.81	x	142.44	x	0.57	x	0.8	=	164.27	(82)
Rooflights	0.9x	1	x	1.44	x	142.44	x	0.57	x	0.8	=	84.18	(82)
Rooflights	0.9x	1	x	1.35	x	107.87	x	0.57	x	0.8	=	59.76	(82)
Rooflights	0.9x	1	x	2.81	x	180.71	x	0.57	x	0.8	=	208.4	(82)
Rooflights	0.9x	1	x	1.44	x	180.71	x	0.57	x	0.8	=	106.8	(82)
Rooflights	0.9x	1	x	1.35	x	159.03	x	0.57	x	0.8	=	88.11	(82)
Rooflights	0.9x	1	x	2.81	x	187.72	x	0.57	x	0.8	=	216.49	(82)
Rooflights	0.9x	1	x	1.44	x	187.72	x	0.57	x	0.8	=	110.94	(82)
Rooflights	0.9x	1	x	1.35	x	176.47	x	0.57	x	0.8	=	97.77	(82)
Rooflights	0.9x	1	x	2.81	x	177.6	x	0.57	x	0.8	=	204.81	(82)
Rooflights	0.9x	1	x	1.44	x	177.6	x	0.57	x	0.8	=	104.96	(82)
Rooflights	0.9x	1	x	1.35	x	162.27	x	0.57	x	0.8	=	89.91	(82)
Rooflights	0.9x	1	x	2.81	x	148.43	x	0.57	x	0.8	=	171.17	(82)
Rooflights	0.9x	1	x	1.44	x	148.43	x	0.57	x	0.8	=	87.72	(82)
Rooflights	0.9x	1	x	1.35	x	120.08	x	0.57	x	0.8	=	66.53	(82)
Rooflights	0.9x	1	x	2.81	x	110.34	x	0.57	x	0.8	=	127.24	(82)
Rooflights	0.9x	1	x	1.44	x	110.34	x	0.57	x	0.8	=	65.21	(82)
Rooflights	0.9x	1	x	1.35	x	74.77	x	0.57	x	0.8	=	41.43	(82)
Rooflights	0.9x	1	x	2.81	x	64.97	x	0.57	x	0.8	=	74.93	(82)
Rooflights	0.9x	1	x	1.44	x	64.97	x	0.57	x	0.8	=	38.4	(82)
Rooflights	0.9x	1	x	1.35	x	39.1	x	0.57	x	0.8	=	21.66	(82)
Rooflights	0.9x	1	x	2.81	x	33.49	x	0.57	x	0.8	=	38.62	(82)
Rooflights	0.9x	1	x	1.44	x	33.49	x	0.57	x	0.8	=	19.79	(82)
Rooflights	0.9x	1	x	1.35	x	20.63	x	0.57	x	0.8	=	11.43	(82)
Rooflights	0.9x	1	x	2.81	x	21.68	x	0.57	x	0.8	=	25	(82)
Rooflights	0.9x	1	x	1.44	x	21.68	x	0.57	x	0.8	=	12.81	(82)
Rooflights	0.9x	1	x	1.35	x	14.12	x	0.57	x	0.8	=	7.82	(82)

Solar gains in watts, calculated for each month (83)m = Sum(74)m …(82)m

(83)m=	2134.32	3683.32	5163.43	6599.97	7573.36	7597.14	7291.84	6554.3	5659.49	4104.53	2565.2	1820.81

(83)

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Total gains – internal and solar (84)m = (73)m + (83)m , watts

(84)m=	3270.97	4817.4	6257.57	7626.85	8526.51	8483.39	8137.22	7407.51	6549.5	5062.1	3600.76	2920.07

(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (°C) 21 (85)

Utilisation factor for gains for living area, h1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(86)m=	1	0.99	0.97	0.91	0.79	0.62	0.48	0.54	0.77	0.95	0.99	1

(86)

Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c)

(87)m=	19.46	19.71	20.04	20.42	20.71	20.86	20.91	20.9	20.78	20.36	19.82	19.42

(87)

Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C)

(88)m=	20.01	20.01	20.01	20.02	20.02	20.03	20.03	20.03	20.02	20.02	20.02	20.01

(88)

Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a)

(89)m=	1	0.99	0.96	0.89	0.74	0.55	0.38	0.43	0.71	0.94	0.99	1

(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m=	17.91	18.27	18.75	19.3	19.68	19.87	19.91	19.9	19.78	19.22	18.45	17.85

(90)

fLA = Living area ÷ (4) = 0.15 (91)

Mean internal temperature (for the whole dwelling) = fLA × T1 + (1 – fLA) × T2

(92)m=	18.14	18.49	18.95	19.47	19.83	20.02	20.06	20.06	19.93	19.4	18.65	18.09

(92)

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m=	18.14	18.49	18.95	19.47	19.83	20.02	20.06	20.06	19.93	19.4	18.65	18.09

(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that Ti,m=(76)m and re-calculate the utilisation factor for gains using Table 9a

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Utilisation factor for gains, hm:

(94)m=	1	0.98	0.95	0.87	0.73	0.55	0.38	0.44	0.7	0.93	0.99	1

(94)

Useful gains, hmGm , W = (94)m x (84)m

(95)m=	3254.8	4729.64	5938.77	6646.12	6256.65	4650.85	3107.66	3241.69	4594.57	4686.54	3556.88	2910.35

(95)

Monthly average external temperature from Table 8

(96)m=	4.3	4.9	6.5	8.9	11.7	14.6	16.6	16.4	14.1	10.6	7.1	4.2

(96)

Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]

(97)m=	12968.37	12703.86	11614.57	9765.54	7504.55	4955.82	3166.77	3339.16	5350.19	8115.01	10698.42	12909.67

(97)

Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m

(98)m=	7226.9	5358.68	4222.79	2245.98	928.44	0	0	0	0	2550.79	5141.91	7439.49

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 35114.98 (98)

Space heating requirement in kWh/m²/year 41.04 (99)

9a. Energy requirements – Individual heating systems including micro-CHP)

Space heating:

Fraction of space heat from secondary/supplementary system 0 (201)

Fraction of space heat from main system(s) (202) = 1 – (201) = 1 (202)

Fraction of total heating from main system 1 (204) = (202) × [1 – (203)] = 1 (204)

DER WorkSheet: New dwelling design stage

Efficiency of main space heating system 1 — 319.7 (206)

Efficiency of secondary/supplementary heating system, % — 0 (208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year
Space heating requirement (calculated above)	7226.9	5358.68	4222.79	2245.98	928.44	0	0	0	0	2550.79	5141.91	7439.49	
(211)m = {[(98)m x (204)] } x 100 ÷ (206)	2260.52	1676.16	1320.86	702.53	290.41	0	0	0	0	797.87	1608.35	2327.02	(211)

Total (kWh/year) =Sum(211)$_{1...5,10...12}$= 10983.73 (211)

Space heating fuel (secondary), kWh/month

= {[(98)m x (201)] } x 100 ÷ (208)

(215)m=	0	0	0	0	0	0	0	0	0	0	0	0	

Total (kWh/year) =Sum(215)$_{1...5,10...12}$= 0 (215)

Water heating

Output from water heater (calculated above)

	260.02	228.98	240.02	214.52	209.76	186.76	178.73	197	196.92	222.48	236.05	253.54	

Efficiency of water heater — 224.4 (216)

(217)m=	224.4	224.4	224.4	224.4	224.4	224.4	224.4	224.4	224.4	224.4	224.4	224.4	(217)

Fuel for water heating, kWh/month

(219)m = (64)m x 100 ÷ (217)m

(219)m=	115.87	102.04	106.96	95.6	93.48	83.23	79.65	87.79	87.76	99.14	105.19	112.99	

Total = Sum(219a)$_{1...12}$ = 1169.69 (219)

Annual totals	**kWh/year**	**kWh/year**
Space heating fuel used, main system 1		10983.73
Water heating fuel used		1169.69
Electricity for pumps, fans and electric keep-hot		
central heating pump:	30	(230c)
Total electricity for the above, kWh/year — sum of (230a)…(230g) =		30 (231)
Electricity for lighting		1304.08 (232)
Electricity generated by PVs		-13585.26 (233)

12a. CO2 emissions – Individual heating systems including micro-CHP

	Energy kWh/year		**Emission factor** kg CO2/kWh		**Emissions** kg CO2/year	
Space heating (main system 1)	(211) x		0.519	=	5700.55	(261)
Space heating (secondary)	(215) x		0.519	=	0	(263)
Water heating	(219) x		0.519	=	607.07	(264)
Space and water heating	(261) + (262) + (263) + (264) =				6307.63	(265)
Electricity for pumps, fans and electric keep-hot	(231) x		0.519	=	15.57	(267)
Electricity for lighting	(232) x		0.519	=	676.82	(268)
Energy saving/generation technologies Item 1			0.519	=	-7050.75	(269)

DER WorkSheet: New dwelling design stage

Total CO2, kg/year	sum of (265)…(271) =	-50.74	(272)
Dwelling CO2 Emission Rate	(272) ÷ (4) =	-0.06	(273)
EI rating (section 14)		100	(274)