Scottish Energy Centre
Institute for Sustainable Construction

CIC Start Online – Academic Feasibility Study

Scottish Energy Centre (HEI)

&

Re-Tek (UK), Ltd (SME)

ASSESSMENT ON THE CHOICE OF A RENEWABLE ENERGY SOURCE FOR RE-TEK'S OFFICE AND WAREHOUSE FACILITY IN EAST KILBRIDE

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PARTNERS DETAILS

FUNDING BODY: **CIC START ONLINE -** European Regional Development Fund (Lowlands and Uplands Scotland 2007-2013 programme) and SEEKIT programme of Scottish Government

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1.0 EXECUTIVE SUMMARY

CIC Start Online funded by European Regional Development Fund and SEEKIT programme of Scottish Government has made it possible for this academic partnership between RE-TEK (UK) Ltd and the Scottish Energy Centre part of Edinburgh Napier University to suggest alternatives for the integration of micro-renewables in to the reduction of energy demand at the company's factory plant and offices located in East Kilbride, South Lanarkshire.

The project was initiated by a staff visit from Edinburgh Napier University to the company's factory and offices in October 2011 where a tour of the facilities was performed by Mr. Kevin Culligan in which the buildings operation and energy demand were explained together with the company's real desire to move into a low carbon commercial operation unit and enhance their already high sustainable credentials.

The outcomes of this feasibility study are to be utilised to create a projection towards the design and implementation of micro-renewable technology in the building. The results out of this study will portray the feasibility of the technology in terms of its sizing and operation and its potential pay back investment. The figures related to capital cost of each of the technologies have been taken as close to real market based prices in line with the buildings limitations. It is strongly recommended that the summary of results and suggestions out of this report are designed appropriately and consulted with MCS accredited installers particularly technology suppliers.

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2.0 INTRODUCTION – AIMS AND OBJECTIVES

Following the successful award of the funding provided by CIC Star Online, Re-Tek (UK) Ltd in collaboration with the Scottish Energy Centre (SEC) at Edinburgh Napier University have been creating different feasibility studies in relation to the best performing and cost effective way to lower carbon emissions and energy bills within the business operation.

The report sought to define the practicality of incorporating low carbon technologies and mitigation measures into the business in order to make the business more sustainable as well as to keep up the company's green credentials that are key to the progress and nature of the business.
The company focuses on the responsible recycling of electrical goods and appliances, particularly computers and screens previously belonging to businesses who have recently upgraded their machinery. This particular line of business contributes greatly to the management and re-use of components that previously were discarded into local landfills where toxic materials and elements were damaging the environment. Many of the electrical goods are either recycled or re-used in many forms.

The combined benefits of a sustainable business in its nature with the inclusion of micro-renewable low carbon technology, are the reduced life cycle cost of assets, reduced operating spending whilst delivering and contributing to the Governments carbon reduction targets and presenting or in this case enhancing a greener image for marketing the business.

The inclusion of these low carbon technologies will also contribute to lowering the buildings environmental footprint which will lead eventually to lowering the buildings Energy Performance and enhance its operational scores when issuing new Energy performance certificates for commercial, industrial and office buildings. This is something that will come into force in the near future, imposed by the Scottish Government and the Building Standards Division.

By installing and no longer depending fully on grid connected energy supply the business is positioned as a safer and individually operational company that will withstand future energy shortages but will ultimately be in a more stable financial form by the reduction of energy bills.

The objectives are:

- Conduct an evaluation of the buildings current energy use
- Evaluate in accordance with the site and building restrictions on the best renewable technology
- Indicate what the pay back periods will be for the investment of the technology
- Calculate the carbon savings around the investment and operation of the technology
- Tap into current and future funding mechanisms for the implementation of micro-generation technology
- Advise on the next steps for the adequate design and installation

2.1 BACKGROUND & OVERALL WORKSCOPE

The funding will be utilised to perform a report on the current energy consumption and potential energy needs around the operation of the building. It will also be for the assessment of the building and its location in line with climatic data of the region which will provide the tools to conduct sizing and location of technology around the site and building.

The warehouse and office includes over 1,900 m^2 and employs 18 full time staff. It is located in the town of East Kilbride in the Kelvin South Business Park.

The site entrance is through Hurlawcrook Road in which two warehouses are located. The first warehouse is independent to Re-Tek and is currently occupied by another company. The second warehouse separated by parking bays and a large lorry turning yard is located at the end of the site, this being the building belonging to Re Tek (UK) Ltd. Because of the nature of the business, the building utilises the large turning yard for the adequate parking and exit of lorry's. The main entrance to the warehouse is located to the northeast where a pedestrian footpath leads staff and visitors to the main offices and warehouse access. A service foot path separates the building to the boundary of the site. Other neighbourly sites surround the two warehouses; the only built up sites are the ones located to the southwest and northwest where other warehouses are built. The back sites are currently un-built.

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Site Location:

Fig. 01 – Identification of site boundaries

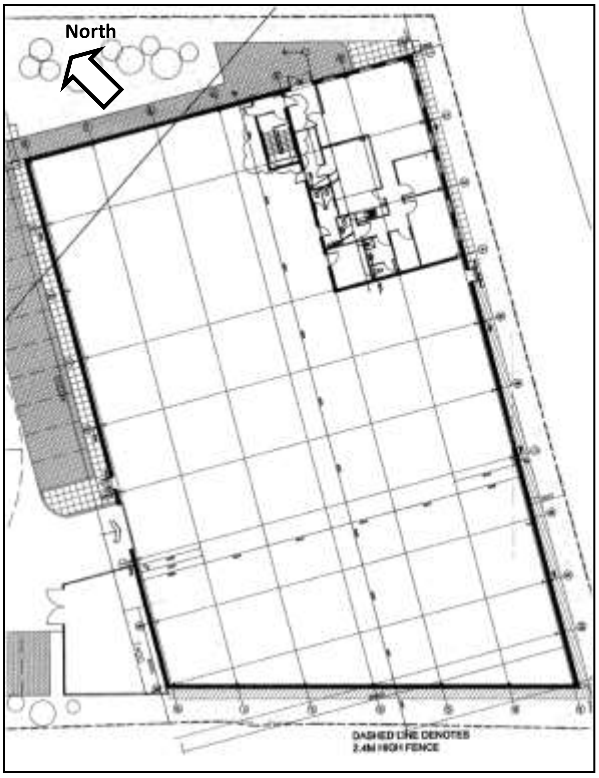

Fig. 02 – Building general arrangement

The two main areas of the building are the offices that account for approximately 400 m^2 of the building area and the storage with process areas that account for the remainder of the space (1,500m^2).

The offices have storage areas, staff workplaces and also both office staff toilets and warehouse staff toilets. There are two storeys of office area.

3.0 ENERGY AUDIT

The company uses the majority of its energy in the management and erasing of data from computing equipment that is recycled and re-used. One of the services that the company offers is the safe deleting of data from many computers therefore electricity is needed to power the devices and erasing equipment that is used to provide this service. Powerful computers conduct this task requiring ventilation and adequate electrical distribution. Electricity is also used to effectively operate the industrial warehouse doors that provide access to new equipment or to offer the departure of equipment for re-use and re-distribution. The warehouse is divided into three important sections.

1. The storage and segregation of different types of equipment
2. The dismantling area where the re-cycling of metals, components and pieces are separated and sold
3. The safe erasing and deleting of data in many of the computing equipment

The handling of much of this equipment is key to the company as it provides proper organisation and distribution of the products that are being processed. Much of these operations are conducted by forklifts that carry and distribute timber racks with equipment ready to be segregated, erased or re-cycled. The charging of these forklifts is performed on a daily basis and there are three charging points in the warehouse.

In general terms the use of electricity is mainly used to power:

1. Computing equipment that erases data
2. Ventilation for computing equipment
3. Forklift charge up

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4. Secondary machinery for separating elements from the equipment
5. Warehouse space heating
6. Office equipment and lighting

Space heating is provided in mixed forms. The office areas have a conventional gas boiler and radiators while the warehouse area with a larger volume to cover has four Combat Warm air heaters. These together with the electrical requirements of the business account to the majority of the electrical demand of the building.

Hot water is used in the toilets located in the office areas and in the warehouse and for space heating in radiators.

Fig. 03 Combat air heaters in the warehouse

Fig. 04 Conventional Gas boiler

Fig. 05 Main computer hub

Fig. 06 Warehouse electric door

Fig. 07 Forklift charge up station

3.1 CURRENT ENERGY DEMAND

From the energy demand provided a summary of the primary energy supply to the business is given in table 1 below:

Energy source	Annual cost (£)	Usage (kWh)	Unit Cost (p/kWh)	CO_2 (tonne)
Electricity	8,554	59,307	12.7	10.9
Gas	4,740	100,742	3.0	52.8
Total	**£13,294**	**160,049**	**-**	**63.7**

Table 01 Energy Demand in the warehouse per fuel – source: Re-Tek (UK) Ltd

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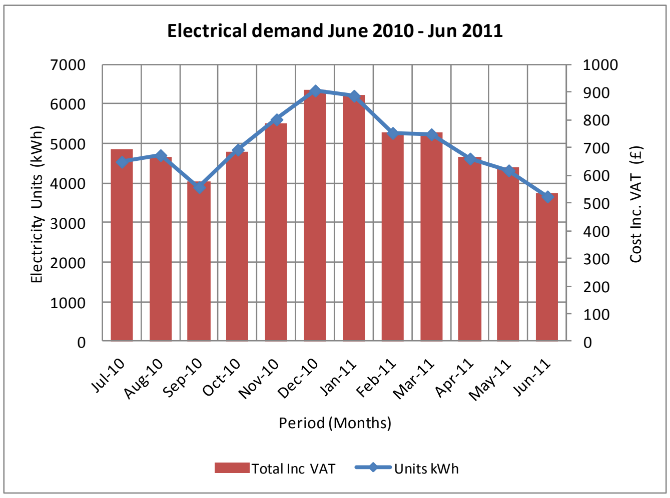
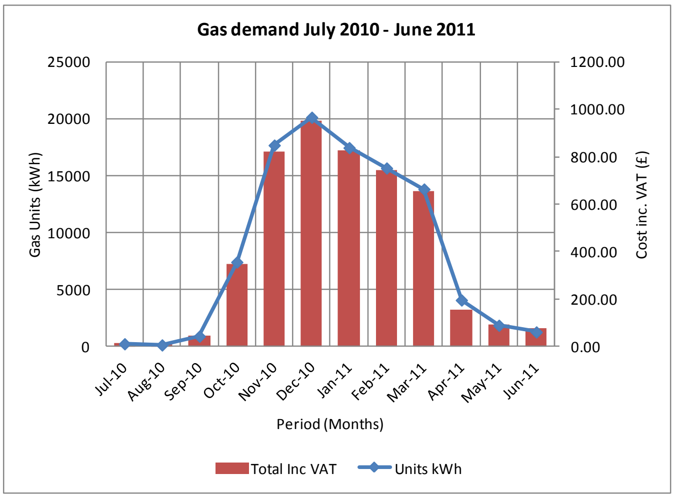


Graph 01 Electrical demand over the last year



Graph 02 Gas demand over the last year

By far the largest energy use can be attributed to the gas consumption that accumulates to an average of 15,400kWh during the heating season (October to March). In terms of cost, the average cost during the heating season was of £725.0 with a maximum gas bill of £950 in December. This was due to the use of boilers for space heating in the offices. The summer months experience low usage of gas when small amounts of heating are needed. Electricity is also consumed heavily throughout the year with an average consumption of 4,950kWh while the average bill payment was of £712.0.

It is clear that the use of low carbon technology could lower the dependence on grid connected energy. This can be achieved in various ways with a combination of technology integrated renewables as a means of support to the current electrical grid connected demand. This methodology will lower the energy consumption thus the energy bills.

Focus should be taken on producing energy that can fulfil the space heating demand in the winter months while also producing some electrical energy throughout the year to offset the high electrical usage.

4.0 ENERGY MANAGEMENT

This section of the report discusses the energy use and possible savings that could be achieved by applying energy management techniques in a number of areas of the business.

4.1.1 Energy Policy

Many organisations have produced a statement which sets out a policy towards saving energy. This statement can then act as a simple motivating document for members of staff. It should be simple, easy to read and cover all major potential initiatives to be taken by the organisation to improve energy efficiency. Once produced, it should be circulated to all staff and a copy posted on the main notice boards.
All staff could be brought together to discuss how the policy should be implemented. This could involve selecting an "Energy Champion" who would be responsible for planning and implementing a programme of measures and keeping all staff aware of activities.

4.1.2 Checking energy use

Throughout UK business there are significant errors introduced through faulty meter reading, unmonitored energy use and inaccurate billing. Businesses can save significant energy costs through carefully comparing meter readings with bills. Also by noting these readings against site usage it may be possible to identify anomalies in energy usage. The company maintains comprehensive utility accounts from which the annual energy usage figures presented in Table 1 were abstracted. Discussions with key staff identified that no specific energy consumption figures for the various elements of the business were recorded in conjunction with the utility figures; such as space heating in warehouse areas, electricity used for charging up forklifts, data abstraction and lighting. In the same way the use of gas where separated figures can be abstracted from space heating and water heating. By normalising such operation-specific energy consumption in this manner (e.g. kWh, units) this may indicate areas where improvements can be made and may also highlight inefficiencies.

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4.1.3 Staff awareness and good housekeeping

Very simple practices such as switching off unnecessary equipment and lighting, turning heating off instead of opening windows and general communication about the comfortable heating and lighting requirements can produce significant results.
It is recommended that a staff awareness scheme be introduced. It is typically estimated that up to 5% savings in energy use could be made through such measures, which is equivalent to a saving of over £5,450 per annum.
Some means of raising awareness are:

• Making staff aware of the cost of energy and potential savings.
• Raising energy use during staff meetings.
• The use of a suggestion box, and giving token awards for good ideas.
• Poster campaign to encourage good practice.
• Clear labelling of switches and controls.
• Giving feedback to staff to encourage further participation.
• Staff training courses.

It may be appropriate to appoint an "Energy Champion" to help monitor energy use and motivate others to save energy.
Staff should also be encouraged to undertake an equipment audit to include the power rating and estimated annual consumption of each major item of equipment. In this way it will become clear what items cost the most to run and which should be replaced when resources become available. For lighting note should be kept on the numbers of different types of lighting utilised.

4.1.4 Energy Purchasing

The fuel supply market has been opened up to full competition and the management should seek alternative quotations for supply of fuels to the business on a regular basis.

5.0 FEASIBILITY CALCULATIONS

The methodology behind the feasibility of the different low carbon technologies was done taking into consideration all the limitations around the performance of the technology and any constrains given the location, building type and building design.

Many renewable technologies can present themselves as very feasible in principle but at the same time dependant on the yearly maintenance regime and careful monitoring of output and efficiency. It is recommended that regardless of the technology, that an energy conscious person who has an understanding of the equipment both in its maintenance and operation can manage and keep track of the systems. It is also recommended, especially where industrial operations are present, to meter and zone different uses of energy in order to monitor more efficiently. A building management system (BMS) would be very beneficial as it can be programmed to tack all the technology and also give system efficiencies and faults when they occur which is important when maintenance and replacement of equipment should occur.

5.1 RENEWABLES NOT ANALYSED

For various reason some technologies were not part of this feasibility, mainly because they pose difficulties in their installation or their output and would not be worth the capital investment. That is the case of the following:

- **All Hydroelectric devices** – It is understood that there is no meaningful water stream near the site where a small hydro-electric device can produce electricity.
- **Ground source heat pump** – This device can be very effective but can bring some difficulties in its installation. For vertical installations the cost can be considerably high and only certain locations and soil types can benefit from it. The horizontal type requires considerable amounts of space and in order for it to be representative and worthwhile a big installation would have to be installed.
- **Air source heat pumps** – Can also be beneficial as an air handling unit with heating and ventilating through a heat exchanger. The system would have to overrun the current heating system in the warehouse and would require new ducting systems and space for distributing the air. This system would require an office fit out.

The technologies mentioned above were installations that were thought to be difficult to manage and install and would prove to be more costly with longer payback periods. This does not mean to say that the above technology is not suitable for industrial use, it simply points out that for this building and location it is not cost effective.

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5.2 RENEWABLES ANALYSED

The technologies that were analysed in detail include devices that are widely available and easily installed as a "retrofit" add on to the building or on site. Some are more costly than others and pose different constrains.

These were:

- Solar Photovoltaic panels
- Solar thermal
- Wind
- Biomass & Combined heat and Power (mini CHP) – District heating

In all of them, both a sizing and payback exercise was conducted. This report does not indicate a specific design but it points out the size of the devices, the number of components and the estimated cost and number of years for payback. The use of current governmental incentives was used, for example the Feed in Tariff (FIT) and the renewable heat incentive (RHI) due to be in place late 2012. The use of energy bill savings was also taken into account for the payback.

There are some expected financial aspects implemented into the calculations of payback. These are:

- Retail index price increase – applied to the FIT and RHI at 5.2% per year
- Estimated electricity rate increase by inflation – average of 7.3% per year
- Yearly degradation of equipment which decreases the efficiency – estimated at 0.5% per year

These are estimated figures that have been applied to the calculation of payback and which may differ as the years go by. It is important to have an expected pattern of degradation and index price increase in order to conduct realistic assumptions.
The estimated payback periods will be in line with the government assisted pay packages (FIT & RHI). Equipment is known to last longer with good maintenance and component replacement when needed.

5.3 ELECTRICAL DEMAND REDUCTION

5.3.1 Solar PV

Photovoltaic (PV) systems convert energy from the sun into electricity through semi conductor cells. PVs supply electricity to the buildings they are attached to or to any other load connected to the electricity grid. Electricity is usually fed back to the grid when the generated power exceeds the local need. More electricity is produced with more sunlight, but energy can still be produced in overcast or cloudy conditions, so PVs can be used successfully in all parts of the UK, including the Highlands of Scotland, where the average annual sum of global irradiation per square meter received on a horizontal plane is 2.3 kWh/m2. Photovoltaic panels can be fitted to existing buildings, designed into new buildings or attached to individual items such as street lights, parking meters or the sides of bridges.

In the northern hemisphere PVs should ideally face between south-east and south-west, at an azimuth (orientation) of about 30-40°. Most systems in Britain operate more efficient in these tilt angles and in Scotland the average efficient tilt is ± 2˚ of 30˚. Systems should be in locations that will be un-shaded at all times of day if possible. Gable roofs, chimneys, cables, TV aerials, trees and other buildings in the vicinity should be identified as potential. Trees or other parts of the building may cause the performance of the system to drop in the early morning or early afternoon.

The feasibility study presented economic and technical results that have been calculated and produced by using one of the leading design software tools on the market for European photovoltaic systems called PVSyst. It requires the following information to obtain accurate results:

- Tilt of pitched roof (if flat roof an ideal & optimum tilt can be suggested)
- Orientation of roof (southern orientations)
- The amount of power required, in order to size the system
- Type of modules specified – monocrystalline or polycrystalline

In order to conduct the report and to make sense of the results obtained by the software; it is essential to know the following:

- The initial demand of energy
- Cost of the panels and equipment

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- Funding mechanisms – government or other
- Cost of the price per kWh by the energy providers

The above provided the tools to conduct an economic feasibility framework which would determine whether the installation was feasible both technically and economically.

Band (kW)	Current generation tariff (p/kWh) Before April 2012	New generation tariff (p/kWh) After April 2012
≤4kW (new build)	37.8	21.0
≤4kW (retrofit)	43.3	21.0
>4-10kW	37.8	16.8
>10-50kW	32.9	15.2
>50-100kW	19	12.9
>100-150kW	19	12.9
>150-250kW	15	12.9

Table 02 Solar PV Feed in tariff rates source: DECC2012

In terms of funding from the government the feed in tariff is the best suited scheme, essentially it includes two tariffs:

- The generation tariff
- The export tariff

The solar PV generation tariff guarantees a fixed payment (usually paid quarterly) based on the size of solar PV system that is installed and the amount of power (measured in kWh) that the solar PV system is capable of generating. Payments are guaranteed for 25 years and payment rates are index linked to inflation (using the Retail Price Index). In the summer of 2011 OFGEM issued a review of higher rates payable for systems installed before the end of March 2012. Payment rates are fixed based on the installation date, systems installed before 31st March 2012 will be fixed at the highest rate for the full 25 years. The rates are outlined in table 02.
The solar PV export tariff applies to the proportion of clean energy that is exported (i.e. sold via the grid) and is set at 3.1pence per kWh.

There are other constrains that have to be analysed. And the MCS accredited installer should include them while designing and providing their services.

This feasibility study explored two sizes of installation. One that complies with the kW band between 4 and 10kW at a FIT rate of 16.8 p/kWh and the other is a bigger 45kW system taking up a larger amount of the roof space in order to generate more electricity and fulfil the buildings demand.

Analysis No. 1

The panels have been proposed to be located for a more efficient and worthwhile generation output facing southeast. The current warehouse roof tilt has been calculated at 6° and it is recommended that with the aid of mounting and racking equipment that a tilt of 20° is reached. Taking into consideration the location, its orientation and the average solar insolation of that location the following calculations were obtained. For more information see annexes 01 & 02.

Project - Building location	Roof usable area (m^2)	Roof - Tilt/azimuth	Option No.	Solar panel Technology	Phases	Number of modules	Power (Wp) per module	Total power (kW)	Number of inverters	Size	Strings	Produced Energy (kWh/y)	Specific Production (kWh/kWp/y)
Re-Tek (UK) Ltd Warehouse	*1,900*	20° & -60° southeast	**1**	*Polycrystalline*	Single	*51*	*190*	*9.7*	*1*	*8.0kW*	*3x17*	*6,944*	*717*

Table 03 Expected output from a <10kW system

It requires 51 modules of 190kW each, which will produce about 6,900kWh/year and take up 70.5 m^2 of the total roof space. The graphs below indicate the expected pay back periods and also the FIT accumulation taking into account the electricity bill savings.

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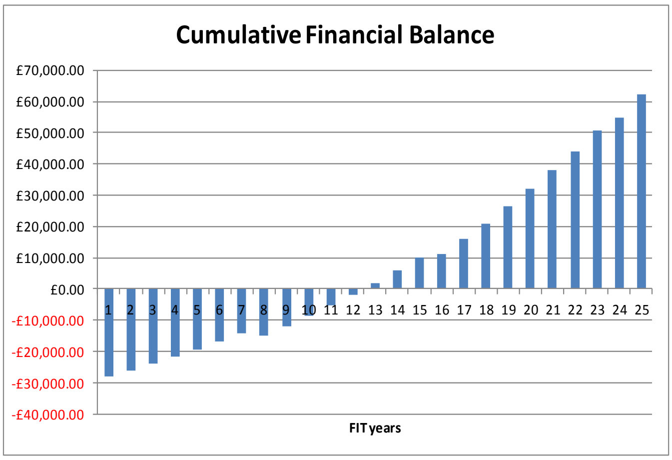
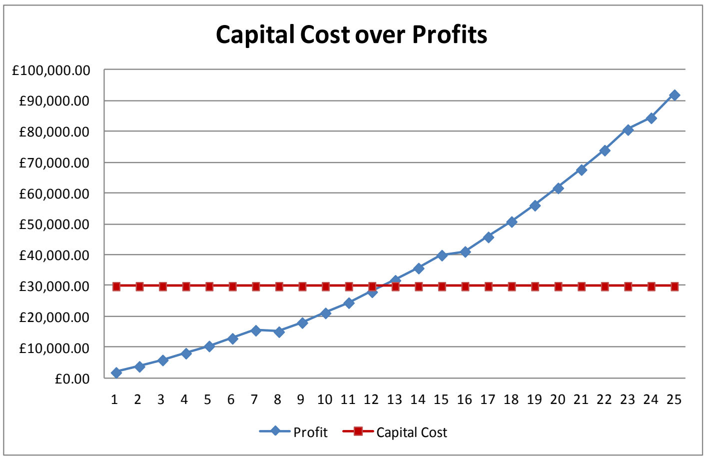




Graph 03 Indicating the cumulative pay back capital cost vs FIT gain

Graph 04 Capital cost is paid back when crossing the FIT accumulation

The above calculations take into consideration expected annual maintenance cost of £200 and an inverter upgrade or replacement every 8 years.

As can be appreciated, with an estimated capital cost of just under £30K, including module costs racking and mounting equipment and all the extra components, i.e. isolators and FIT meters, the expected payback will be approximately in year 13 of the FIT scheme. There is an expected £60K plus capital gain after the system has been paid back, this is obtained from FIT and electricity bill savings.

The annual 6,900kWh expected to be produced by this system will account to approximately 12% of the annual buildings electrical needs.

Analysis 02

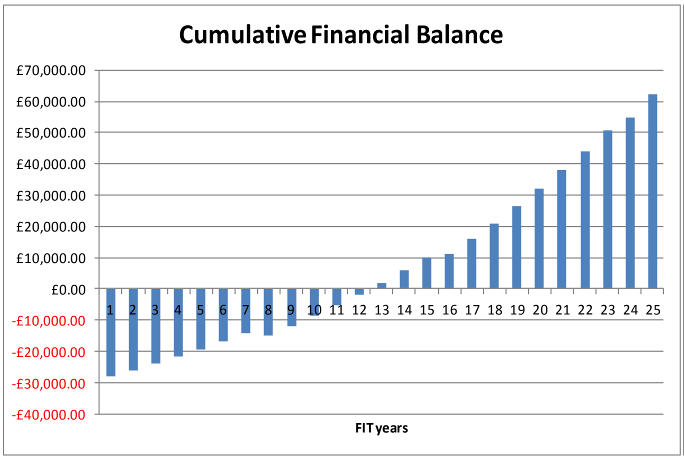
A more ambitious installation has been calculated with the same tilt needs and the same orientation requirements similar to analysis 01.

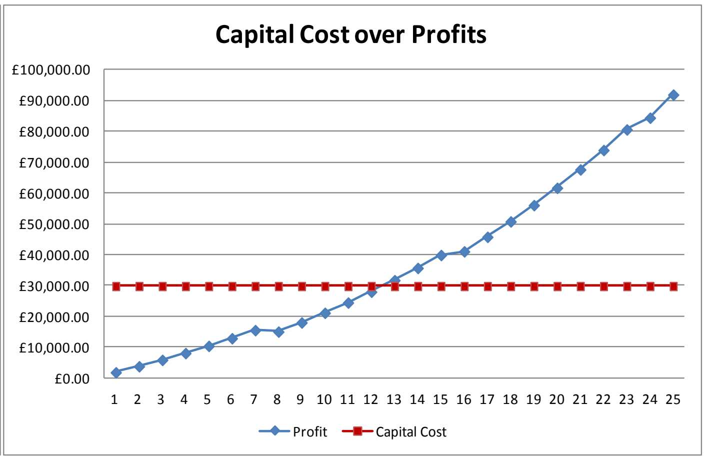
Project - Building location	Roof usable area (m^2)	Roof - Tilt/azimuth	Option No.	Solar panel Technology	Phases	Number of modules	Power (Wp) per module	Total power (kW)	Number of inverters	Size	Strings	Produced Energy (kWh/y)	Specific Production (kWh/kWp/y)
Re-Tek (UK) Ltd Warehouse	*1,900*	20° & -60° southeast	**2**	*Monocrystalline*	Single	*162*	*280*	*45.4*	*1*	*40.0kW*	*9x18*	*32,133*	*708*

Table 04 Expected output from a <50kW system

This system requires 162 modules of 280Wp per module giving a total power of 45.4Wp. By using an inverter of 40kW an annual output of over 32,000kWh would be produced.

The calculated approximate capital cost including panel cost, labour and tax account to around £75,000 with an expected pay back with the use of the lower FIT and the energy savings, of 13 years. See attachments 03 & 04 for more information on the solar PV sizing and outputs.





Graph 05 Indicating the cumulative pay back capital cost vs FIT gain

Graph 06 Capital cost is paid back when crossing the FIT

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5.3.2 WIND TURBINES

The government Department of Energy and Climate Change (DECC) NOABL database provides mean average wind speed data for a 1km square at this location of 6.1m/s at 10m above ground level (a.g.l.) and 6.9m/s at 25m a.g.l. It is estimated for instance that a 10kW turbine at a hub height of 12m could generate in the order of 34,500kWh. In order to calculate the total yearly income the following is calculated: 20% from exported electricity back to the grid, 80% applied as FIT income using the below data (table 05) and electricity savings, resulting in approximately £12,081 total income. Utilising a smaller turbine of 5kW rated capacity at a hub height of 9m could generate in the order of 15,300kWh. The total earnings from it are calculated in the same manner with £92 per annum in export (20%) with the additional FIT remainder (80%) £3,428 and the electricity savings at £1,837 a total yearly income of £5,357 could be obtained.

It is recommended that a comprehensive site survey be undertaken first by an approved installer to validate the available resource, location suitability, electrical supply/demand capacity and any planning issues. Advice should be sought from a Microgeneration Certification Scheme (MCS) approved installer http://www.microgenerationcertification.org/.

Energy Source	Scale	Tariff (p/kWh)	Duration (years)
Wind	≤1.5kW	35.8	20
Wind	>1.5 - 15kW	28.0	20
Wind	>15 - 100kW	25.4	20
Wind	>100 - 500kW	20.6	20
Wind	>500kW - 1.5MW	10.4	20
Wind	>1.5MW - 5MW	4.9	20

Table 05 FIT rates for wind generators Source: Energy saving Trust

Description	Height	Estimated Output (kWh/year)	Total Capital Investment (exc. VAT)	FIT	Income from FIT (year) - 80%	Export 20% - 3p/kWh	Electrcity bills saving (£) @12p/kWh	Total savings per year (£)	Tariff Duration	Payback (years)
Wind Turbine 5kW	9	15,305	22,500	£ 0.280	£3,428	£92	£1,837	£5,357	20	4
Wind Turbine 10kW	12	34,518	45,000	£ 0.280	£7,732	£207	£4,142	£12,081	20	4

Table 06 Summary table of feasibility results

There are many problems around the installation of wind on sites that are restricted as the one at Re-Tek in East Kilbride. It is important that the installation of these masts with wind generators require a perimeter clearance away from the building and any car parking areas. It is also important to say that many of the wind generator manufacturers over estimate their annual out puts of power and it is advisable to take precaution over the outputs stated by their technical specifications.
Please see annex 05 for product examples.

5.4 GAS DEMAND REDUCTION

5.4.1 SOLAR THERMAL

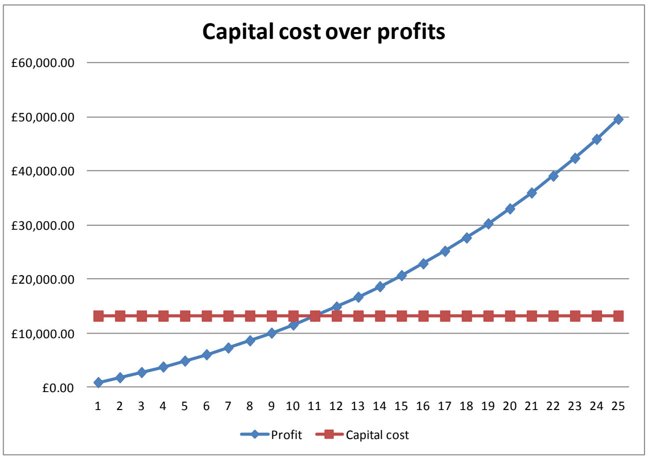
Based on similar solar insolation information data, solar thermal water heaters can be installed similarly to solar PV panels on the roof. Once again the recommended tilt for panels is 20° where extra racking will be needed. The selected technology was the evacuated tube system which uses 20 tubes per panel with an overall area of 2.49m^2. This system can receive at this given location a solar insulation of 2.79kWh/m^2/day. This would produce 3.49kWh/day, if we consider heat losses this figure is reduced to 2.62kWh/day. This provides an estimated annual energy output of 960kWh per panel system. The warehouse consumed over the last year just over 100,000kWh of gas. The total heated water that could be produced with 10 panels would be of just under 9,600kWh per year or close to 10% of the warehouses demand. It is clear that during the summer months this production of energy will be larger than the winter months. The figures below are estimated average figures throughout the year.

Technology	No. Panels	Output (kWh/year)	Capital Investment (exc. VAT)	RHI	Income from RHI (year)	Gas bill saving (£) 3p/kWh	Total savings per year (£)	Tariff Duration	Payback (years)
Solar Thermal	10	8,965	£ 10,944	£ 0.089	£ 798	£ 269	£ 1,067	20	13

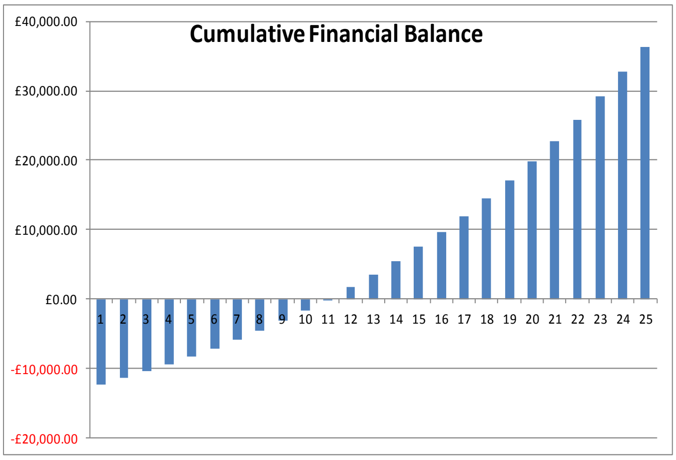
Table 07 Solar thermal expected output

Contact details: Julio Bros W - Scottish Energy Centre - email: j.bros-williamson@napier.ac.uk
John Currie - Scottish Energy Centre - email: j.currie@napier.ac.uk

Advice should be sought from a Microgeneration Certification Scheme (MCS) approved installer http://www.microgenerationcertification.org/.



Graph 07 Capital cost investment reaching a payback at 12 years



Graph 08 Cumulative figures

The estimated capital cost of the 10 panels with labour cost and tax is approximately £13,000. An estimated yearly maintenance cost is also taken into consideration, as well as the systems yearly decrease in efficiency and possible retail price index increase in the tariffs provided by the RHI.
The calculations show that the system is capable to be paid off in 10 years and with the RHI scheme an estimated income of close to £35K can be obtained (subject to the RHI and the gas bill savings).

5.4.2 BIOMASS BOILERS AND MICRO CHP

Biomass for burning as a fuel includes wood energy crops, agricultural crop residues, wood manufacturing by-products and farm animal litter. Although burning biomass releases carbon dioxide (CO_2) to the atmosphere, this is principally offset by the CO_2 absorbed in the original growth of the biomass, or captured in the growth of new biomass which replaces the materials used when it is sustainably sourced. Using biomass for heating therefore results in very low net 'lifecycle' carbon emissions relative to conventional sources of heating, such as gas, heating oil or electricity.
The selection of the fuel to be used can be complex as it depends on many factors. While cost is a key driver for fuel selection, the space available for fuel storage, access for fuel deliveries and the method of delivery are all key considerations.

Types

Pellet boilers and stoves

Pellet boilers and stoves range in size from a few kilowatts (kW), for houses or small commercial buildings, to megawatt (MW) size units for district heating systems. Pellet systems are generally the most responsive of the biomass boilers, have the simplest controls and are the closest to fossil fuelled boilers in terms of maintenance and operating intervention.

Log stoves

Traditional log stoves provide radiant heat to a room. They need to be manually fed with fuel as required to maintain the heat output, and achieve significantly higher efficiency (around 70%) than open fires. Some log stoves incorporate a boiler to provide hot water to heat radiators. Some may also incorporate a hob and/or oven for cooking. As mentioned, log stoves generate radiant heat into the room in which they stand and it is not possible to provide hot water without also heating the spaces.

Batch type log boilers

Log boilers also require wood to be manually loaded into the boiler, making them suitable for houses or small applications where labour is available. In contrast to a log stove, however, they are typically loaded just once or twice a day, and this batch of logs is then burned in one go, at high temperature and efficiency. This means that log boilers require a large water storage cylinder (a buffer tank, accumulator tank or thermal store) to capture the heat produced.

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Wood chip boilers

To date, wood chip boilers have dominated the commercial market in the UK. Fuelled by wood chips, these boilers can be configured to run on a wide range of different fuel specifications with moisture contents from 15% to 50%. Boiler sizes range from 40 kW to power station sized boilers of 100 MW and more. Boiler responsiveness is determined by the fuel moisture content that the boiler is designed to accept; in general the wetter the fuel, the less responsive and efficient the boiler.

The possibility of installing a micro Combined Heat and Power (CHP) unit near the building can be an alternative worth venturing into. Typically the installation of such technologies requires an energy centre from which a district heating pipe network is routed to service the building. Ideally such a space can be identified to install a centralised CHP plant; potentially utilising any of a number of low-carbon technologies including natural gas or biomass fuel.

The district heating network will generally be provided via special high thermal insulation pipe work (installed with monitoring capability for water ingress/leakage) usually installed below ground and servicing the office area. This can result in localised disruption during construction as a retrofit measure. A Hydraulic interface unit is installed, which look very similar to wall-hung boilers, and which incorporate heat exchangers to provide space heating and hot water requirements. Heat metering appliances measure the flow and return temperatures, together with mass flow rate, of hot water servicing.

The benefits of such an installation are economies of scale in primary fuel procurement and the reduction in the local maintenance associated with individual gas boilers. If low carbon technologies such as woody biomass heating can be incorporated into such a scheme then a very significant carbon reduction can be achieved. However, spatial constraints and local emissions regulations may preclude this in an urban environment.

A wood chip or pellet boiler could be considered as an alternative to installing a modern condensing gas boiler. Modern biomass boilers are available in a range of capacities with many optional functions depending on the site's requirements. Additionally, biomass heating systems have comparable operating efficiencies to traditional gas or oil fuelled boilers and due to the relatively low cost of biomass fuel can result in reduced running costs. As a carbon neutral fuel solution, wood fuel is exempt from the Climate Change Levy and biomass schemes can attract financial incentives that can be used to mitigate initial capital investments of equipment installation and ongoing running costs.

The following issues need to be considered when planning for the installation of a biomass boiler. An accredited installer will be able to provide more detailed advice.

- Boiler cost – biomass boilers are typically more expensive than fossil fuel equivalents due to the relative size of the boilers and mechanical fuel feeding mechanisms.
- Location - generally a biomass boiler will require a larger boiler room than traditional boilers due to the relative size of the boiler and additional space required for the fuel hopper and feed system.
- Fuel type – biomass boilers are designed for different fuel types depending on the application. Examples of these are logs, wood chip, pellets and briquettes.
- Feed system – an automatic system which will draw fuel from the fuel store is generally installed. Automatic systems tend to be expensive and require more space but reduce any labour input in terms of their operation.
- Storage - There must be sufficient storage space for excess biomass fuel and clear access to deliver this to the boiler.
- Flue: The vent material must be specifically designed for wood fuel appliances and there must be sufficient air movement for proper operation of the boiler. Chimneys can be fitted with a lined flue.
- Regulations - The installation must comply with all safety and building regulations.
- Planning - In Lanarkshire the council enforces air quality standards for combustion appliances in line with DEFRA designated smoke control areas, for which exempt appliances burning authorised fuels apply http://smokecontrol.defra.gov.uk/index.php.

It is estimated that installing a wood chip biomass boiler plant (120MWh heating demand, 1.9p/kWh) fitted with appropriate zone controls to complement the individual heating needs could save some £1,984 per annum on conventional gas heating costs (3.5p/kWh and £165 per dwelling) and £6,920 per annum on electric heating (8p/kWh and £575 per dwelling). Biomass fuelled heating will potentially be eligible for the Renewable Heat Incentive (RHI) when this is introduced in 2012.

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At the present time, indicative rates (RHI) for solid biomass fuelled heating are 7.6p/kWh (Tier 1) and 1.9p/kWh (Tier 2) for heating installations up to 200kW capacity, and could potentially generate an annual income of up to £9,000, depending on the boiler capacity installed. Advice should be sought from a Microgeneration Certification Scheme (MCS) approved installer for cost, installation, and planning http://www.microgenerationcertification.org/.

If a larger CHP is not the preferred option as explained above, the alternative is to install a micro CHP device of 2kW output. It would produce an estimated 5,000kWh per year at a total capital cost investment of £4,200. The estimated income from the FIT would be of £550 per year and the electricity savings would account to an additional £600 adding up to a total estimated annual income and savings of £1,150 which would give an estimate 4 years payback time.

Description	Height	Estimated Output (kWh/year)	Total Capital Investment (exc. VAT)	FIT	Income from FIT (year)	Electric bills saving (£) @ 12p/kWh	Total savings per year (£)	Tariff Duration	Payback (years)
Micro CHP (<2kW)	-	5000	£ 4,200.00	£ 0.11	£550.00	£600.00	£1,150.00	10	4

Table 08 Mico CHP outline and cost effectiveness

BIOMASS

A Carbon efficient biomass boiler of 30kW with an efficiency of 90% would run approximately 2400 hrs/ year under full load using wood pellet bio-fuel. 16.67 tonnes of wood pellets would be used a year costing approximately £175 per tonne which would have to be securely stored in a fire safe store. The annual estimated energy from this boiler would be 72,000kWh. With the RHI in place, it is estimated that the system would fall under Tier 1 at 7.9p/kWh for the first 1,314hrs (5.5 months) of operation; the remaining hours would be paid fat 2p/kWh. The total CO2 savings from a device like this one is approximately 1.7tonnes per year. The estimated annual RHI would be £3,766 while the estimated cost of wood pellets would be £2,888 per year. This leaves £878 and the gas bill savings to pay for the capital cost invested in the device.
The estimated capital cost for a device of 30kW is in the region of £24,000 which includes the device and the installation together with a flue and the commissioning.

Description	Height	Estimated Output (kWh/year)	Total Capital Investment (exc. VAT)	RHI	Income from RHI (year)	Gas bills saving (£) @ 3p/kWh	Cost of biomass per year (£)	Total savings per year (£)	Tariff Duration	Payback (years)
Small Biomass	-	72,000	£ 24,000.00	£ 0.05 average	£3,766.00	£2,160.00	£2,888.00	£3,038.00	20	8

Table 09 Estimated outputs from a biomass boiler

6.0 CONCLUSIONS

An initial energy audit identified that the business consumes over 160,000kWh of energy per annum at a cost of over £13,300, generating some 64 tonnes of CO_2; the energy being primarily used for space heating in offices and electricity for the operation of the business and heating the warehouse.

This study has shown that savings can be made in a number of areas, including basic energy management; particularly the recording and benchmarking of energy usage parameters which can be used to normalise the data and identify changes in operating efficiency for subsequent detailed analysis.

The various low carbon technologies suggested can all be implemented in a combined way in order to fulfil part of the annual energy needs. They can also be installed in stages where carbon reduction targets have been set meeting yearly reductions as part of a sustainability plan or energy efficiency strategy.

It is recommended that in all the suggestions and calculations that a MCS accredited installer re-calculates these with the specific design with all constrains and specific manufacturers specifications.

With added energy supply uncertainties and rising energy prices it is important to look at ways of adding a certain percentage of energy from renewable sources. This will not only add value to the property but will also boost the company's environmental credentials.

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Below is a summary table of the total outputs and savings that each technology can supply. It is recommended that an approach that suits the company's financial and environmental goals in projected years is chosen. A stepped approach may be the best way of achieving different company goals in the reduction of carbon. This will indicate a steady increase in energy saving in line with the company's growth and environmental programme.

Technology Type	Estimated output (kWh/year)	Payback period (years)	Energy savings – Gas (%)*	Energy savings – Electric (%)*	CO2 savings per year (tonnes)
Solar PV 10kW	7,000	13	-	12	3.7
Solar PV 45kW	32,000	13	-	54	16.8
Wind 5kW	15,000	4	-	25	8
Wind 10kW	35,500	4	-	60	18.6
Solar Thermal	9,000	13	9	-	1.7
Micro CHP	5,000	4	-	8	2.6
Biomass	72,000	8	70	-	1.7
Total	103,500	-	-	-	53.1

Table 10 Summary of total outputs per technology

The totals indicated in table 10 can be split into different combinations. There could be more conservative measures and approach that can implement the smaller investment routes, for example the smaller PV 10kW system in combination with the small 5kW wind turbine with the Micro CHP and the solar thermal panels. This combination would bring a total of energy savings to 36,000kWh saving per year.

The larger the capital cost investment, the larger the output and generation from all the devices. For example, if the Solar PV 45kW system and the biomass system were taken a large amount of the current energy demand would be met. 70% of the gas needs would be fulfilled, while 54% of electrical needs would be fulfilled.

7.0 SOURCES OF FUNDING

Listed below are a number of support schemes which can help realise the energy savings identified in the report.

- Energy Saving Scotland – small business loans provide interest free loans of between £1,000 and £100,000 to small to medium sized enterprises. The loans can fund the purchase and installation of energy efficiency and renewable measures. Contact: 0800 512 012 http://www.energysavingtrust.org.uk/scotland/Take-action/Businessfunding/

- Small-business-loans - Communities and Renewable Energy Scheme (CARES) is a Scottish Government programme for small-scale renewables, delivered by Community Energy Scotland. It offers advice and grants to community groups. This replaces the community stream of the Scottish Community and Householder Renewable Initiative (SCHRI). Contact: 01349 860120 http://www.communityenergyscotland.org.uk/

- Enhanced Capital Allowances provides businesses with 100% tax relief when they invest in qualifying energy efficient technologies. This can deliver a significant cash flow boost and shorten the payback period on the investment.

8.0 REFERENCES

- "Biomass heating – a guide to feasibility studies" – Forestry commission, biomass centre, DECC and REA.
- Energy saving trust web site – www.energysavingtrust.org.uk
- Department of Energy and Climate Change – www.decc.gov.uk
- OFGEM - Feed-in Tariff Scheme Comprehensive Review – http://www.ofgem.gov.uk/Sustainability/Environment/fits/Pages/fits.aspx
- RenewableUK - http://www.bwea.com/index.html

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Re-Tek - East Kilbride

INCOME GENERATION

Project: Re-Tek Feasibility Study

Case study: Re-tek

Solar Array Information :	Panel Ouput Size	PV Panel		Array Output (kWp)
	W	No.		
	190	51		9.69
Generation Information	**Array Size (kWp)**	**Yeild Factor**		**Total Generation (kWh)**
	9.69	717		163,660
Year 1 Electricity Generation	**kWh (Adjusted)**	**Cost per Unit**	**kWh/month**	
	6,948	£0.1260	578.9775	**Yearly Degradation of Panels Efficincy (%)**
Initial Feed-in-Tarrif Rate (£)	£0.17	Installation after 03/2012		
Export Tarrif (£)	£0.031			0.50%
Assumed Electricity Exported to Grid (%)	0.00%			
				CO_2 Saved Per Unit of Electricity Generated (Tonnes)
Retail Price Index (RPI)	5.20%			
Electricity Price Inflation (%)	7.30%			0.00052114
				Source: DEFRA 2010

Year on Year Table

	Yearly Generation kWh	FiT Rate £	Yearly FiT Income £	Electricity Cost per Unit £	Saving on Electricity Bills £	Export Rate £	Export Electricity £	Total Income £
Year 1	6947.73	0.168	£1,167.22	0.126	£875.41	0.03100	£0.00	£2,042.63
Year 2	6912.99	0.177	£1,221.77	0.135	£934.62	0.03261	£0.00	£2,156.40
Year 3	6878.43	0.186	£1,278.88	0.145	£997.84	0.03431	£0.00	£2,276.72
Year 4	6844.03	0.196	£1,338.66	0.156	£1,065.32	0.03609	£0.00	£2,403.98
Year 5	6809.81	0.206	£1,401.22	0.167	£1,137.38	0.03797	£0.00	£2,538.60
Year 6	6775.77	0.216	£1,466.72	0.179	£1,214.30	0.03994	£0.00	£2,681.02
Year 7	6741.89	0.228	£1,535.27	0.192	£1,296.43	0.04202	£0.00	£2,831.70
Year 8	6708.18	0.240	£1,607.03	0.206	£1,384.12	0.04421	£0.00	£2,991.15
Year 9	6674.64	0.252	£1,682.14	0.221	£1,477.73	0.04650	£0.00	£3,159.88
Year 10	6641.26	0.265	£1,760.77	0.238	£1,577.68	0.04892	£0.00	£3,338.45
Year 11	6608.06	0.279	£1,843.06	0.255	£1,684.39	0.05147	£0.00	£3,527.45
Year 12	6575.02	0.293	£1,929.21	0.274	£1,798.31	0.05414	£0.00	£3,727.52
Year 13	6542.14	0.309	£2,019.38	0.293	£1,919.94	0.05696	£0.00	£3,939.32
Year 14	6509.43	0.325	£2,113.77	0.315	£2,049.79	0.05992	£0.00	£4,163.56
Year 15	6476.88	0.342	£2,212.56	0.338	£2,188.43	0.06304	£0.00	£4,400.99
Year 16	6444.50	0.359	£2,315.98	0.363	£2,336.44	0.06631	£0.00	£4,652.42
Year 17	6412.28	0.378	£2,424.23	0.389	£2,494.47	0.06976	£0.00	£4,918.70
Year 18	6380.21	0.398	£2,537.54	0.417	£2,663.18	0.07339	£0.00	£5,200.72
Year 19	6348.31	0.418	£2,656.14	0.448	£2,843.31	0.07720	£0.00	£5,499.45
Year 20	6316.57	0.440	£2,780.29	0.481	£3,035.62	0.08122	£0.00	£5,815.90
Year 21	6284.99	0.463	£2,910.24	0.516	£3,240.93	0.08544	£0.00	£6,151.17
Year 22	6253.56	0.487	£3,046.26	0.553	£3,460.13	0.08989	£0.00	£6,506.39
Year 23	6222.30	0.512	£3,188.65	0.594	£3,694.16	0.09456	£0.00	£6,882.80
Year 24	6191.19	0.539	£3,337.68	0.637	£3,944.01	0.09948	£0.00	£7,281.69
Year 25	6160.23	0.567	£3,493.69	0.684	£4,210.76	0.10465	£0.00	£7,704.45
Year 26		0.597	£0.00	0.733	£0.00	0.11009	£0.00	£0.00
Total	163660.39		£53,268.35		£53,524.70		£0.00	£106,793.05

Grid-Connected System: Simulation parameters

Project : **Re-Tek project**

Geographical Site	**Glasgow**		**Country**	**United Kingdom**
Situation	Latitude	55.4°N	Longitude	4.3°W
Time defined as	Legal Time	Time zone UT+0	Altitude	10 m
	Albedo	0.20		

Meteo data : Glasgow, Synthetic Hourly data

Simulation variant : **Si-poly 190kW 8.0kW 9.7kW**

Simulation date 09/03/12 10h08

Simulation parameters

Collector Plane Orientation	Tilt	20°	Azimuth	-60°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module Si-poly	Model	**PV-TD190 MF5**		
	Manufacturer	Mitsubishi		
Number of PV modules	In series	17 modules	In parallel	3 strings
Total number of PV modules	Nb. modules	51	Unit Nom. Power	190 Wp
Array global power	Nominal (STC)	**9.69 kWp**	At operating cond.	8.73 kWp (50°C)
Array operating characteristics (50°C)	U mpp	383 V	I mpp	23 A
Total area	Module area	**70.5 m²**		

Inverter	Model	**IG Plus 100-2**		
	Manufacturer	Fronius		
Characteristics	Operating Voltage	230-500 V	Unit Nom. Power	8.00 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind=1 m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	281 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

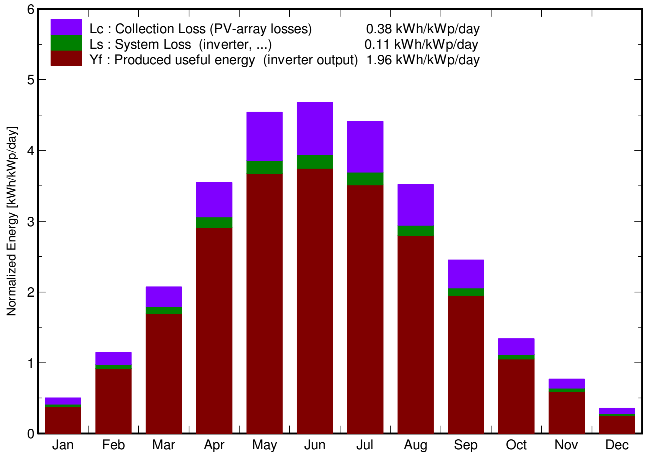
Project : **Re-Tek project**

Simulation variant : **Si-poly 190kW 8.0kW 9.7kW**

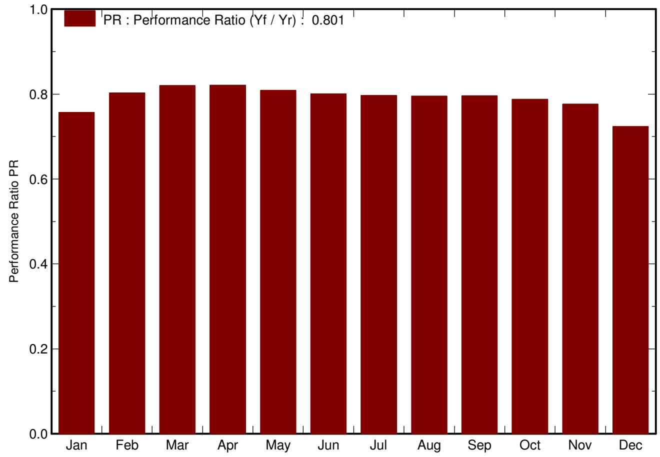
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	20°	azimuth	-60°
PV modules	Model	PV-TD190 MF5	Pnom	190 Wp
PV Array	Nb. of modules	51	Pnom total	**9.69 kWp**
Inverter	Model	IG Plus 100-2	Pnom	8.00 kW ac
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**6944 kWh/year**	Specific prod.	717 kWh/kWp/year
	Performance Ratio PR	80.1 %		

Normalized productions (per installed kWp): Nominal power 9.69 kWp



Performance Ratio PR



Si-poly 190kW 8.0kW 9.7kW

Balances and main results

	GlobHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	EffArrR	EffSysR
	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	%	%
January	14.0	3.50	15.6	14.7	124	114	11.32	10.40
February	29.0	3.70	32.1	30.5	265	250	11.73	11.03
March	61.0	5.30	64.2	61.4	538	510	11.89	11.27
April	103.0	7.10	106.4	102.4	890	846	11.86	11.28
May	140.0	10.10	140.7	135.5	1159	1103	11.68	11.11
June	141.0	13.10	140.5	135.4	1146	1090	11.56	11.00
July	136.0	14.10	136.7	131.6	1110	1056	11.51	10.95
August	108.0	14.00	109.1	104.8	884	840	11.50	10.92
September	71.0	12.20	73.6	70.4	598	567	11.53	10.93
October	39.0	9.60	41.5	39.5	336	316	11.49	10.82
November	19.0	6.10	23.1	21.9	186	174	11.44	10.66
December	10.0	4.40	11.0	10.4	86	77	11.01	9.95
Year	871.1	8.63	894.3	858.4	7322	6944	11.61	11.01

Legends:				
	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

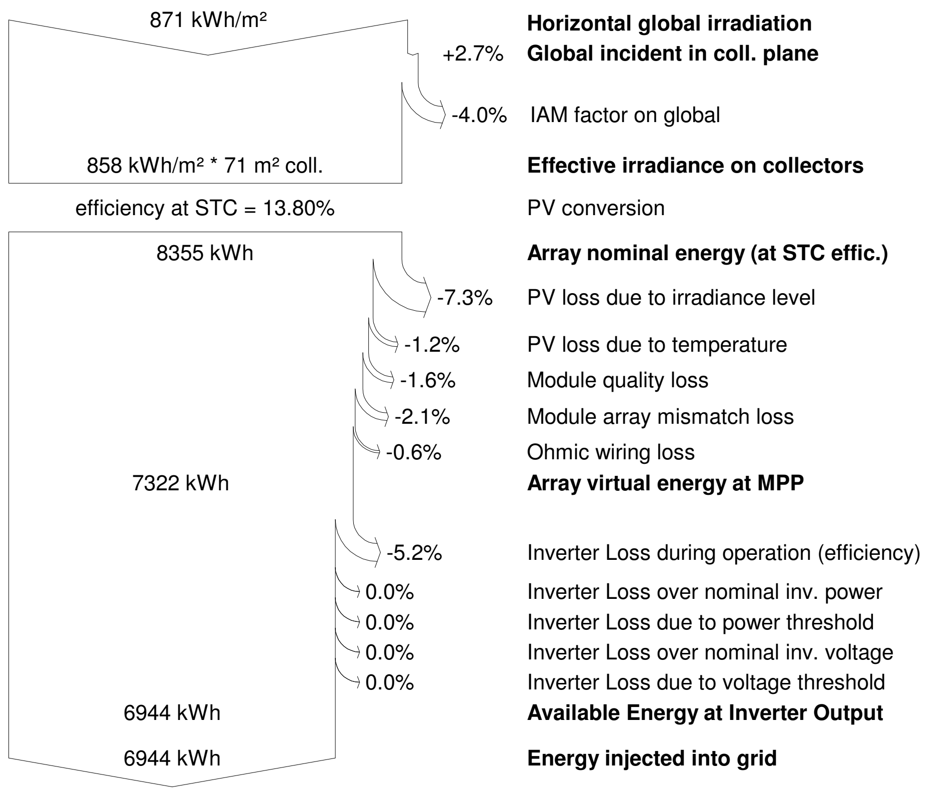
Grid-Connected System: Loss diagram

Project : **Re-Tek project**

Simulation variant : **Si-poly 190kW 8.0kW 9.7kW**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	20°	azimuth	-60°
PV modules	Model	PV-TD190 MF5	Pnom	190 Wp
PV Array	Nb. of modules	51	Pnom total	**9.69 kWp**
Inverter	Model	IG Plus 100-2	Pnom	8.00 kW ac
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Re-tek East Kilbride

INCOME GENERATION

Project: Re-tek Feasibility Study

Case study: Re-tek

Solar Array Information :	Panel Ouput Size	PV Panel		Array Output (kWp)
	W	No.		
	280	162		45.36

Generation Information	Array Size (kWp)	Yeild Factor		Total Generation (kWh)
	45.36	717		766,113
Year 1 Electricity Generation	kWh (Adjusted)	Cost per Unit	kWh/month	
	32,523	£0.1260	2710.26	

Initial Feed-in-Tarrif Rate (£)	£0.152	Installation after 03/2012	Yearly Degradation of Panels Efficincy (%)
Export Tarrif (£)	£0.031		0.50%

Assumed Electricity Exported to Grid (%)	0.00%

Retail Price Index (RPI)	5.20%	CO$_2$ Saved Per Unit of Electricity Generated (Tonnes)
Electricity Price Inflation (%)	7.30%	0.00052114

Source: DEFRA 2010

Year on Year Table

	Yearly Generation kWh	FiT Rate £	Yearly FiT Income £	Electricity Cost per Unit £	Saving on Electricity Bills £	Export Rate £	Income from Export Electricity	Total Income £	CO$_2$ Saving Tonnes
Year 1	32523.12	0.152	£4,943.51	0.126	£4,097.91	0.03100	£0.00	£9,041.43	16.95
Year 2	32360.50	0.160	£5,174.57	0.135	£4,375.08	0.03261	£0.00	£9,549.65	16.86
Year 3	32198.70	0.168	£5,416.43	0.145	£4,670.98	0.03431	£0.00	£10,087.42	16.78
Year 4	32037.71	0.177	£5,669.60	0.156	£4,986.91	0.03609	£0.00	£10,656.50	16.70
Year 5	31877.52	0.186	£5,934.59	0.167	£5,324.20	0.03797	£0.00	£11,258.79	16.61
Year 6	31718.13	0.196	£6,211.98	0.179	£5,684.30	0.03994	£0.00	£11,896.27	16.53
Year 7	31559.54	0.206	£6,502.33	0.192	£6,068.75	0.04202	£0.00	£12,571.08	16.45
Year 8	31401.74	0.217	£6,806.24	0.206	£6,479.21	0.04421	£0.00	£13,285.46	16.36
Year 9	31244.74	0.228	£7,124.37	0.221	£6,917.44	0.04650	£0.00	£14,041.80	16.28
Year 10	31088.51	0.240	£7,457.36	0.238	£7,385.30	0.04892	£0.00	£14,842.66	16.20
Year 11	30933.07	0.252	£7,805.92	0.255	£7,884.80	0.05147	£0.00	£15,690.72	16.12
Year 12	30778.40	0.265	£8,170.77	0.274	£8,418.09	0.05414	£0.00	£16,588.86	16.04
Year 13	30624.51	0.279	£8,552.67	0.293	£8,987.45	0.05696	£0.00	£17,540.12	15.96
Year 14	30471.39	0.294	£8,952.42	0.315	£9,595.31	0.05992	£0.00	£18,547.73	15.88
Year 15	30319.03	0.309	£9,370.86	0.338	£10,244.29	0.06304	£0.00	£19,615.15	15.80
Year 16	30167.44	0.325	£9,808.85	0.363	£10,937.17	0.06631	£0.00	£20,746.02	15.72
Year 17	30016.60	0.342	£10,267.32	0.389	£11,676.90	0.06976	£0.00	£21,944.22	15.64
Year 18	29866.52	0.360	£10,747.21	0.417	£12,466.67	0.07339	£0.00	£23,213.88	15.56
Year 19	29717.18	0.379	£11,249.53	0.448	£13,309.85	0.07720	£0.00	£24,559.39	15.49
Year 20	29568.60	0.398	£11,775.34	0.481	£14,210.06	0.08122	£0.00	£25,985.40	15.41
Year 21	29420.76	0.419	£12,325.72	0.516	£15,171.16	0.08544	£0.00	£27,496.88	15.33
Year 22	29273.65	0.441	£12,901.82	0.553	£16,197.26	0.08989	£0.00	£29,099.08	15.26
Year 23	29127.28	0.464	£13,504.85	0.594	£17,292.76	0.09456	£0.00	£30,797.62	15.18
Year 24	28981.65	0.488	£14,136.07	0.637	£18,462.36	0.09948	£0.00	£32,598.43	15.10
Year 25	28836.74	0.513	£14,796.79	0.684	£19,711.06	0.10465	£0.00	£34,507.85	15.03
Year 26		0.540	£0.00	0.733	£0.00	0.11009	£0.00	£0.00	0.00
Total	766113.03		£225,607.12		£250,555.27		£0.00	£476,162.39	399.25

Grid-Connected System: Simulation parameters

Project : **Re-Tek project**

Geographical Site	**Glasgow**		**Country**	**United Kingdom**
Situation	Latitude	55.4°N	Longitude	4.3°W
Time defined as	Legal Time	Time zone UT+0	Altitude	10 m
	Albedo	0.20		

Meteo data : Glasgow, Synthetic Hourly data

Simulation variant : **Retek 40kW System -1- Si-mono 280Wp 40kW 45.4kWp**

Simulation date 09/03/12 16h21

Simulation parameters

Collector Plane Orientation	Tilt	20°	Azimuth	-60°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module Si-mono	Model	**STP 280S-24/Vb**		
	Manufacturer	Suntech		
Number of PV modules	In series	9 modules	In parallel	18 strings
Total number of PV modules	Nb. modules	162	Unit Nom. Power	280 Wp
Array global power	Nominal (STC)	**45.4 kWp**	At operating cond.	41.2 kWp (50°C)
Array operating characteristics (50°C)	U mpp	296 V	I mpp	139 A
Total area	Module area	**314 m²**		

Inverter	Model	**IG 500**		
	Manufacturer	Fronius		
Characteristics	Operating Voltage	210-420 V	Unit Nom. Power	40.0 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind=1 m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	36 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

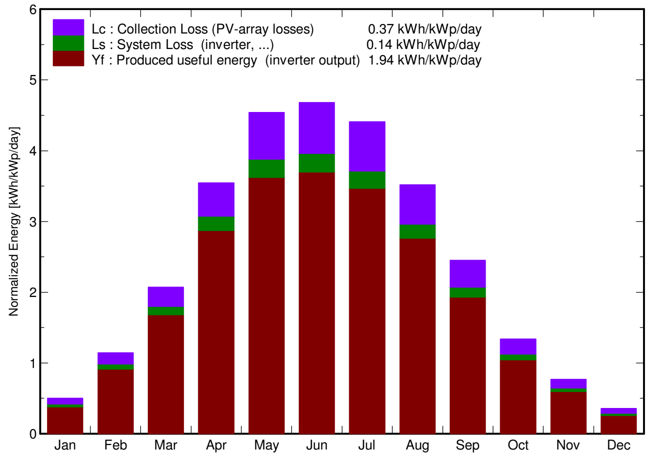
Project : **Re-Tek project**

Simulation variant : **Retek 40kW System -1- Si-mono 280Wp 40kW 45.4kWp**

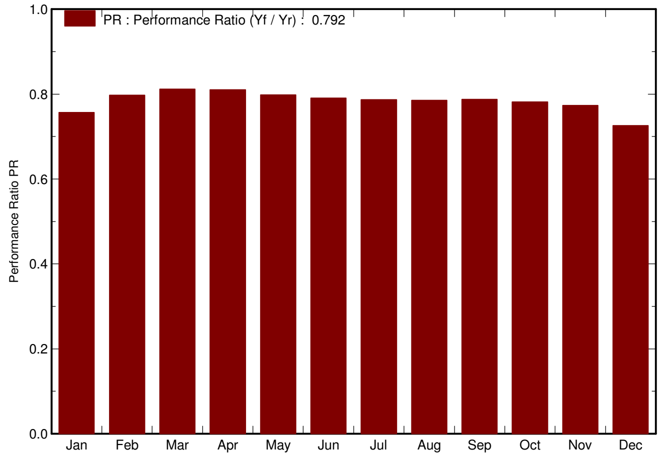
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	20°	azimuth	-60°
PV modules	Model	STP 280S-24/Vb	Pnom	280 Wp
PV Array	Nb. of modules	162	Pnom total	**45.4 kWp**
Inverter	Model	IG 500	Pnom	40.0 kW ac
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**32133 kWh/year**	Specific prod.	708 kWh/kWp/year
	Performance Ratio PR	79.2 %		

Normalized productions (per installed kWp): Nominal power 45.4 kWp



Performance Ratio PR



Retek 40kW System -1- Si-mono 280Wp 40kW 45.4kWp

Balances and main results

	GlobHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	EffArrR	EffSysR
	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	%	%
January	14.0	3.50	15.6	14.7	589	535	12.04	10.92
February	29.0	3.70	32.1	30.5	1251	1161	12.41	11.51
March	61.0	5.30	64.2	61.4	2532	2363	12.55	11.72
April	103.0	7.10	106.4	102.4	4187	3910	12.52	11.69
May	140.0	10.10	140.7	135.5	5457	5094	12.34	11.52
June	141.0	13.10	140.5	135.4	5393	5037	12.21	11.41
July	136.0	14.10	136.7	131.6	5224	4877	12.16	11.35
August	108.0	14.00	109.1	104.8	4163	3886	12.14	11.33
September	71.0	12.20	73.6	70.4	2816	2628	12.18	11.36
October	39.0	9.60	41.5	39.5	1584	1470	12.15	11.28
November	19.0	6.10	23.1	21.9	880	810	12.12	11.16
December	10.0	4.40	11.0	10.4	407	363	11.74	10.48
Year	871.1	8.63	894.3	858.4	34484	32133	12.27	11.43

Legends:	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

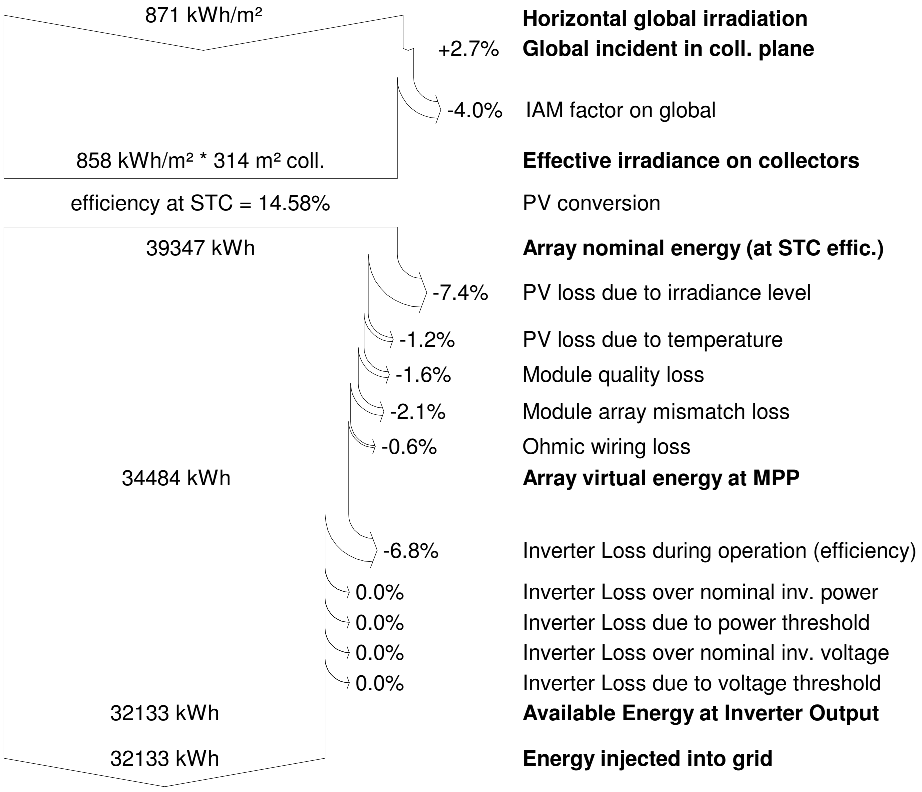
Grid-Connected System: Loss diagram

Project : **Re-Tek project**

Simulation variant : **Retek 40kW System -1- Si-mono 280Wp 40kW 45.4kWp**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	20°	azimuth	-60°
PV modules	Model	STP 280S-24/Vb	Pnom	280 Wp
PV Array	Nb. of modules	162	Pnom total	**45.4 kWp**
Inverter	Model	IG 500	Pnom	40.0 kW ac
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



INCOME GENERATION

Solar Thermal

Project: Re-Tek (UK) Ltd

Area (m2)		No Panels	Total Area
1 Panel Size	2.49	10	24.9
1 Panel Aperture Area	1.25		12.5

Installation Year Deficiency (%)
0.5%

Total Generation (kWh		/ Day)	/ Month)	/ Year)
Insulation	2.62	32.75	996.15	11,953.75

Renewable Heat Incentive	Tariff Duration (years)
£0.089	20

(Eligible sizes : < 200 kWth)

Estimated Global Heat Loss	%
	25%

Capital Investment	Price/kit	TOTAL
(excl. VAT)	£ 781.74	£ 7,817.40
(incl. VAT)	£ 938.09	£ 9,380.90

Corrected Total Generation (kWh	/ Day)	/ Month)	/ Year)
	24.56	747.11	8965.31

No. Year	Generation (kWh)	No. Year	Generation (kWh)
1	8,965.31	11	8,527.00
2	8,920.49	12	8,484.36
3	8,875.88	13	8,441.94
4	8,831.50	14	8,399.73
5	8,787.35	15	8,357.73
6	8,743.41	16	8,315.95
7	8,699.69	17	8,274.37
8	8,656.19	18	8,232.99
9	8,612.91	19	8,191.83
10	8,569.85	20	8,150.87