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Prepared for:
Blacon Community Trust

Blacon Parade Energy Study

Authors: Mary Gillie, Robert Green, Linda Hull, Tony Knowles

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Blacon Parade Energy Study

Blacon Community Trust

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Blacon Parade Energy Study

by

Mary Gillie, Robert Green, Linda Hull, Tony Knowles

Summary

This report presents the results of an Energy Study undertaken to assess the opportunities presented by the redevelopment of the Blacon Parade area, to reduce energy use and CO_2 emissions through good building design and the installation of Low or Zero Carbon (LZC) Technologies. Based on theoretical building performance modelling of both existing and proposed buildings, a number of LZC technologies and combinations of technologies are assessed. Recommendations are made for further consideration of an integrated scheme based on a biomass boiler supplying the Blacon Parade buildings, plus heat pumps in the various dwellings and a large Photovoltaic array on the new Parade building.

Discussions are included on the commercial implications of adopting the LZC strategy, and the implications the strategy may have for the electricity distribution network and local enterprises.

Conclusions and recommendations for the next stage of work are provided.

Glossary

ac/h	Air changes per hour
BCT	Blacon Community Trust
BER	Building Emissions Ratio (see Section 2.4.2)
CDHT	Chester and District Housing Trust
CH	Central Heating
COP	Coefficient of Performance (of heat pumps)
DH	District heating scheme
DHW	Domestic Hot Water
EIR	Environmental Impact Rating (see Section 2.4.2)
EPS	Expanded Polystyrene
ISS	Inter-Seasonal (Energy) Storage
LZC	Low and Zero Carbon
MVHR	Mechanical Ventilation and Heat Recovery
ROC	Renewable Obligation Certificate (results in an incentive payment for renewable electricity generation)
SME	Small or Medium Enterprise
SPF	Seasonal Performance Factor
TFA	Total Floor Area
U	Heat transfer coefficient
kWh	Kilowatt hours
kWp	Nominal Peak PV output - kilowatts
kWh_e $kWh_{electrical}$	kWh of electricity
kWh_t $kWh_{thermal}$	kWh of heat

Contents

1 Introduction

This report presents the results of an Energy Study undertaken to assess the opportunities presented by the redevelopment of the Blacon Parade area to:

- Reduce energy use through good building design;
- Reduce CO_2 emissions through reduced energy consumption and through the installation of Low and Zero Carbon (LZC) Technologies;
- Create new economic and employment benefits, particularly to local SMEs.

The Energy Study is to be a key component in the 'Sustainable Blacon' initiative, which has four main aims:

1. Improving Blacon's natural environment
2. Making Blacon more energy efficient and installing low carbon and renewable energy technologies
3. Establishing new social enterprises for the Environmental Age.
4. Developing a model for other communities to follow, with practical and good practice responses to the challenges of Climate Change.

The Blacon Parade Redevelopment Area is shown Figure 1.1, with the various buildings and areas labelled. A major unknown at the time of writing is the exact form that the new Community Building will take. The expectation is that the whole Western Parade Block will be demolished and replaced with a new building that will include an enlarged convenience store, a health centre, and community areas (including space for accommodating small, local enterprises).

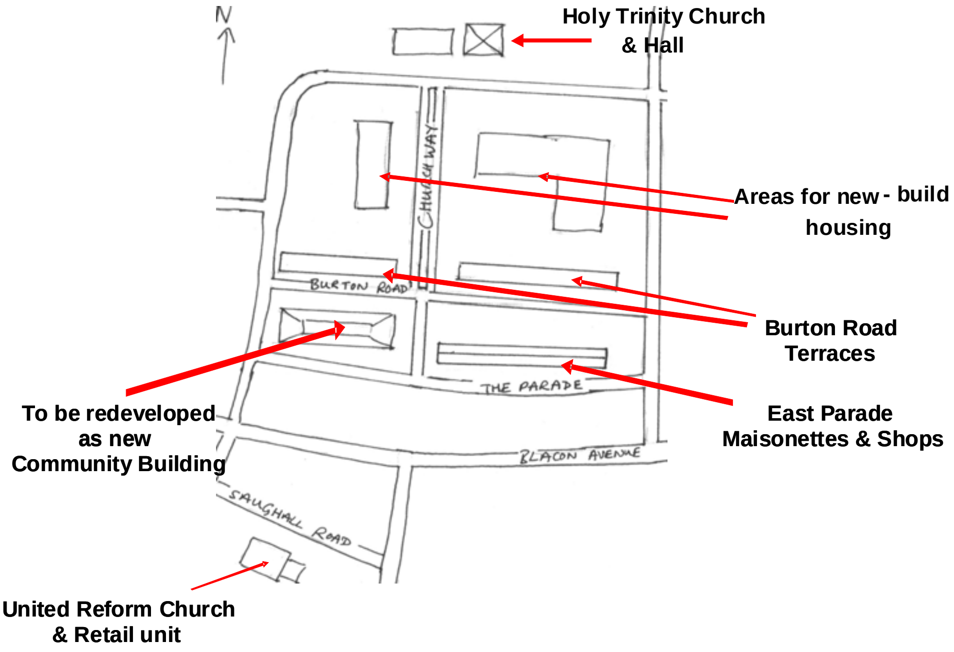

Figure 1.1: Overview of Blacon Parade Redevelopment Area

The starting point for this study has been to undertake an Energy Audit of the buildings on the Redevelopment Area. The findings from the audit are presented in Section 2, and encompass both an understanding of current use and predictions for future use, based on energy modelling.

The modelling produces energy demand profiles for both electricity and heat, and Section 3 presents a selection of these profiles to show how the energy use in different types of building vary with time of day.

Section 4 discusses a variety of energy systems – methods of supplying heat and / or electricity – and their costs and efficiencies, whilst Section 5 looks at both biomass and solar energy as potential resources for Blacon.

Section 6 then applies combinations of technologies to the Blacon Parade Redevelopment to assess the various options in terms of running costs and CO_2 emissions.

The Government imposed frameworks for encouraging the use of LZC technologies are currently under review, and scheduled to change within the next year. Section 7 discusses some of the implications of this changing landscape and the requirement or otherwise for an Energy Service Company (ESCo) type delivery mechanism for the Blacon Parade Redevelopment. Section 8 then considers the issues concerning connection of electricity generators to the local distribution network.

Section 9 discusses the implications of the Blacon Parade Redevelopment for local Small and Medium Enterprises (SMEs).

Finally, Section10 summarises the conclusions arising from this study and outlines the work that should be undertaken in the coming months.

This project comes at a time when there is increasing focus on the importance of energy efficiency and LZC energy technologies as a means to reducing the UK's emissions of CO_2 (and hence impact on Global Warming). The findings will be important both to the immediate project in Blacon and wider across the North West region and beyond.

2 Energy Audit

2.1 Audit Objectives

The key objectives of the audit are to:

- try to ascertain the current energy demand of the present buildings which will be included in the redevelopment scheme;
- suggest some fabric improvements to raise the efficiency of these buildings;
- predict the new, post improvement, energy performance of these existing buildings; and
- estimate the energy demand of the new buildings – the new residential houses and apartments, and the new Community Building.

The result of all these energy predictions provide an energy profile, which can then be matched to a low carbon energy generation solution.

2.2 Site Description

The Blacon Parade redevelopment project is in an urban area, north west of Chester. The proposed redevelopment concentrates on the central shopping and community facilities, including eight existing blocks of buildings.

East Parade Shops and Maisonettes

This building was built about 1954. The ground floor of the block contains eleven retail units with a range of businesses: bakers, grocer/butcher, grocer, chemist, charity shop, a post office covering two units, tanning salon, off licence, fish & chip shop.

The general layout of these units consists of a frontal shop area with an office/stock area behind. This latter area extends out to a single storey flat roofed extension to the rear of the building.

The maisonettes are built on the first and second floors above the retail units. There are nine three bedroomed terraced units in total. Located at either end of the maisonettes there is a two bedroomed flat on the first floor and a three bedroomed flat on the second floor.

West Parade Shops and Flats

This building stands directly in line with the east Parade. At present it accommodates four retail units and an office block on the ground floor, with thirty-two flats on the 1st and 2nd floors.

It has been proposed that this building is demolished, and replaced with a new Community Building that contains 3000m^2 of health centre and 950m^2 of community facilities. Only limited information about this new building was available at the time of this report.

Burton Road Terraces

Directly north of the parade and laid out into two blocks of terraced rows are the Burton Road terraces. Built between 1954 and 1960.

On each block there are six three bedroomed mid-terraced houses with two three bedroomed end-terraces at either end. Most are owned by the CDHT. Some have an ad hoc array of ground floor extensions to the south of the properties.

Holy Trinity Church

Positioned at the furthest northerly point of the redevelopment area stands the Holy Trinity church. Believed to have been built in the 1960's, this building consists of a large area for services with ancillary rooms housed in flat roofed extensions built around the main church area.

Holy Trinity Church Hall

Built at the same time as the church, the church hall is used for community functions. The building consists of a main hall area with stage, toilets, office, kitchen and store areas.

Community Buildings North of Burton Road

To the north of Burton Road lie two blocks of buildings, car parking areas and a certain amount of green area. In total this area comprises of about 7500m^2. It has been indicated that these buildings would be removed and replaced with new residential buildings. The proposed plan is for 32 apartments and 32 houses with a total combined floor area of about 4400m^2 to be built to code level five of the Code for Sustainable Homes (see Appendix B).

United Reform Church

The United Reform church was built in the 1960’s. The basic layout being a foyer leading into the service area which then leads onto meeting rooms toilets and kitchen area.

Small Retail Unit

Standing directly east of the United Reform church is a small retail unit, probably built in the 1990’s. The building comprises of two retail units: one is a bank, the other is a solicitors.

2.3 Audit Methodology

2.3.1 Data Capture

To enable the modelling of all the relevant buildings, sufficient data had to be collected about the buildings dimensions, construction, heating systems and usage.

Actual energy consumption from householder and business utility bills is particularly useful when modelling energy consumption, as it provides a benchmark against which the results of the modelling can be compared.

The method of data capture had four different approaches.

- A questionnaire was prepared and distributed to the owners of the retail units where possible.
- Direct contact with prominent individuals, e.g. church ministers, to gather information on relevant buildings.
- Liaison with Chester & District Housing Trust (CDHT) to gain access to some of the properties to conduct surveys and to examine utility bills.
- Liaison with the City Council Estates Department to try to obtain building plans.

2.3.2 Modelling

The modelling tool chosen for this project was a program called DesignBuilder, a state-of-the-art software tool. DesignBuilder provides an interface that allows a building design to be analysed through two different program modes:

- SBEM (Simplified Building Energy Model) mode, which adopts procedures from the national calculation method to give results in a SAP (Standard Assessment Procedure) format; and
- EnergyPlus mode, a dynamic thermal simulation engine.

Each building was built-up into a 3-D accurate model using the following information:

- Dimensional measurements.
- Constructional details.
- Heat system details.
- Orientation.
- Building usage.
- Occupancy patterns.
- Hourly weather data from Hawarden weather station.
- Domestic Hot Water (DHW) consumption – 49 litres/person/day.

Once this information had been added, a simulation of the buildings in their present formats could be undertaken and this could then be compared to data from other studies[1] or published benchmark figures[2].

A second analysis of the buildings was then run, setting the efficiencies of the heating systems to 100%, to model the heating loads.

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[1] Towards Low-Carbon Housing – Innovations Programme Feasibility Report - Centre for Sustainable Energy

[2] Energy Benchmarks TM46:2008 - CIBSE

Finally measures were adopted to increase the energy efficiency of the buildings. These measures included:

- Upgrading insulation where possible and introducing new insulation where practical;
- Reducing air infiltration rates;
- Upgrading glazing; and
- Adopting best practice lighting systems –using energy efficient lights, photoelectric controls, motion detectors etc.

Then, with the heating system efficiency again set to 100%, the simulation was run once more to understand what would be the new energy demand of these upgraded buildings

For modelling purposes, when a large building block contains many small identical units, only one representative example was modelled.

The tables in Appendix A contain the assumptions made for each of the models.

2.3.3 Modelling Issues

In the event, much real data was unavailable, and much of the modelling process proceeded based on guidelines and assumptions. Unfortunately more assumptions had to be made than were originally anticipated:

- No site or structural plans were made available that would have helped in the accuracy and speed of inputting the dimensions and structural elements into the modelling software. This operation had to be achieved by conducting site surveys, but, with limited access to properties and the structural survey being of an non-destructive nature, truly accurate figures were not obtainable.

- The poor response to the energy questionnaires has resulted in little idea of the actual energy consumption in the existing businesses.

- Limited access to householders to ascertain utility bills. This problem is exacerbated by the fact that many residents are on ‘pay-as-you-go’ cards, and therefore did not have heat and power bills.

- Very vague information on the sizing and design of the new buildings to be incorporated within the redevelopment scheme - this being due to the planning and design processes being at very early stages.

2.4 Audit Results

The Audit Results for each block of buildings is presented as a pair of before and after Tables. In each case Table 1 gives the current (as modelled) performance and includes a system efficiency for the heat supply system – a Seasonal Performance Factor (SPF - the ratio of energy delivered to energy supplied averaged over the year). Table 2 gives the performance after the proposed improvements have been made and with any heating system inefficiencies removed. All assumptions are detailed in Appendix A.

- The total floor area (TFA) represents the total area for each type of unit, and the total heat and electrical consumption figures are for this total area.
- The Building Emission Rate (BER) is derived from the SBEM calculations for each type of unit and the 2006 derivative indicates what the values would be if a similar building was built to Part-L2 2006 buildings regulations[*].
- The Environmental Impact Rating (EIR), part of the Energy Performance Certificate, provides a measure of a buildings impact on the environment in terms of carbon dioxide emissions. The higher the rating the less the impact on the environment.

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2.4.1 East Parade (Shops and Maisonettes)

Table 1.

Present Condition

Units	No	TFA m2	Total Heat kWh	Heat/m2 kWh	Total Electricity kWh	Elec/m2 kWh	BER Kg.CO2/m2/ annum	EIR	2006/BER Kg.CO2/m2/ annum	2006/EIR
Maisonettes	**9**	**718**	**97965**	**136**	**37044**	**52**	**23.9**	**C**	**14.6**	**B**
End Flats	**2**	**400**	**78970**	**197**	**18340**	**46**	**29.8**	**C**	**16**	**B**
End Shops	**2**	**275**	**32204**	**117**	**26374**	**96**	**238.8**	**F**	**63.5**	**B**
Middle Shops General Retail	**6**	**832**	**53412**	**64**	**51438**	**62**	**153.5**	**F**	**36.8**	**B**
Middle Shops Food Store	**6**	**554**	**35608**	**64**	**114680**	**207**	**153.5**	**F**	**36.8**	**B**

Table 2

Improved Fabric, Heating Systems Inefficiencies Removed, Best Practice Lighting Used.

Units	No	Total m2	Total Heat kWh	Heat/m2 kWh	Total Electricity kWh	Elec/m2 kWh	BER Kg.CO2/m2/ annum	EIR	2006/BER Kg.CO2/m2/ annum	2006/EIR
Maisonettes	**9**	**718**	**48645**	**68**	**27711**	**39**	**14**	**B**	**14.6**	**B**
End Flats	**2**	**400**	**42912**	**107**	**12356**	**31**	**29.8**	**C**	**16**	**B**
End Shops	**2**	**275**	**15744**	**57**	**12442**	**45**	**57.2**	**B**	**63.5**	**B**
Middle Shops General Retail	**6**	**832**	**35322**	**42**	**17814**	**21**	**44.8**	**B**	**36.8**	**B**
Middle Shops Food Store	**6**	**554**	**23548**	**42**	**92264**	**166**	**44.8**	**B**	**36.8**	**B**

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[*] Part L - Part of the building regulations is specifically concerned with the conservation of fuel and power, published 1st of April 2006.

Table 1 represents the results of modelling the various units that make up the East Parade as they are today. Note that, currently, the shop units derive their heat element from electrical consumption - this is additional to the total electricity figure quoted in Table 1, which relates only to the electricity consumed by lighting and appliances. Also, the differences in electrical usage between a general retail unit and a food store are due to the extra electrical equipment required for such businesses (e.g. chilled display cases).

Table 2 shows the results of building fabric improvement, the use of best practice lighting and the removal of any heating system inefficiencies. The levels of fabric improvement were instigated on a basis of what is realistically possible. The use of internal insulation, extra insulation in loft spaces, upgrading of fenestration to triple glazing, and improved floor insulation for the ground floor shops, have all been adopted.

The levels of air infiltration were also improved in the upgraded version of the model. In practice this could be achieved by better draft proofing, sealing of windows frames, sealing loft accesses etc.. The shop units were modelled on the assumption that they are particularly prone to higher levels of infiltration - a situation that could be remedied with draft lobbies on the entrances and more attention to detail to the doors and windows used at the rear of these units.

2.4.2 Burton Road Terraces

Table 1.

Present Condition

Units	No	TFA m2	Total Heat kWh	Heat/m2 kWh	Total Electricity kWh	Elec/m2 kWh	BER Kg.CO2/m2/ annum	EIR	2006/BER Kg.CO2/m2/ annum	2006/EIR
Mid Terrace	**12**	**814**	**161616**	**198**	**59700**	**73**	**39.6**	**D**	**17.2**	**B**
End Terrace	**4**	**251**	**61643**	**176**	**16616**	**66**	**40.3**	**D**	**18.2**	**B**

Table 2

Improved Fabric, Heating Systems Inefficiencies Removed, Best Practice Lighting Used.

Units	No	Total m2	Total Heat kWh	Heat/m2 kWh	Total Electricity kWh	Elec/m2 kWh	BER Kg.CO2/m2/ annum	EIR	2006/BER Kg.CO2/m2/ annum	2006/EIR
Mid Terrace	**12**	**814**	**116808**	**143**	**41124**	**50**	**14.8**	**B**	**15.1**	**B**
End Terrace	**4**	**251**	**40848**	**162**	**14248**	**56**	**24.8**	**B**	**18.2**	**B**

It was evident from the site survey that the wall cavities on these terrace houses had been filled, and so improvement to the U values[*] of the external walls can only be achieved with additional external or internal insulation. Additional loft insulation, additional internal wall insulation, upgrading to triple glazing, improved sealing of any openings and the use of best practice lighting, were all utilised in this model to bring the standard up to current building regulations.

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[*] U value is the heat transfer rate per unit area and per degree Celsius temperature difference, for any structural element

2.4.3 Churches, Church Hall and Retail Unit Next to Reform Church

Table 1.

Present Condition

Units	No	TFA m2	Total Heat kWh	Heat/m2 kWh	Total Electricity kWh	Elec/m2 kWh	BER Kg.CO2/m2/ annum	EIR	2006/BER Kg.CO2/m2/ annum	2006/EIR
Holy Trinity Church	**1**	**611**	**81653**	**133**	**4579**	**7**	**96.6**	**E**	**29.1**	**B**
United Reform Church	**1**	**367**	**40972**	**111**	**3495**	**9**	**65**	**D**	**28**	**B**
Holy Trinity Church Hall	**1**	**313**	**33604**	**107**	**8286**	**26**	**64.2**	**D**	**27.4**	**B**
United Reform Church Retail Unit	**1**	**224**	**16989**	**75**	**25944**	**115**	**245**	**F**	**108**	**C**

Table 2

Improved Fabric, Heating Systems Inefficiencies Removed, Best Practice Lighting Used.

Units	No	Total m2	Total Heat kWh	Heat/m2 kWh	Total Electricty kWh	Elec/m2 kWh	BER Kg.CO2/m2/ annum	EIR	2006/BER Kg.CO2/m2/ annum	2006/EIR
Holy Trinity Church	**1**	**814**	**47042**	**77**	**3372**	**5**	**40**	**B**	**29.1**	**B**
United Reform Church	**1**	**251**	**26377**	**72**	**2387**	**6**	**34.2**	**B**	**28**	**B**
Holy Trinity Church Hall	**1**	**313**	**20466**	**65**	**6820**	**22**	**47.3**	**C**	**27.4**	**B**
United Reform Church Retail Unit	**1**	**224**	**8678**	**39**	**17678**	**79**	**158**	**D**	**108**	**C**

Notable points to consider for the two churches are the specific usage patterns. For modelling purposes it was assumed that there are two periods of usage on Saturdays and Sundays and also mid-week, with no activity in the interim periods.

The church hall was modelled more on the lines of a day centre with full usage from nine to five during the week and closed at weekends.

Fabric upgrades to the Holy Trinity Church would be particularly challenging by the very nature of the building, but possibilities do exist for internal wall insulation and for insulating below the roof panels without impacting on the character of the building.

Upgrading the fabric of the Holy Trinity Church Hall, the United Reform Church and the retail unit could also be achieved with simple measures, but would probably fall short of Part-L2 2006 levels without more extreme levels of improvement.

2.4.4 New housing

Table 1.

Fabric to code level 5 (80% boiler SPF)

Units	No	TFA m2	Total Heat kWh	Heat/m2 kWh	Total Electricity kWh	Elec/m2 kWh	BER Kg.CO2/m2/ annum	EIR	2006/BER Kg.CO2/m2/ annum	2006/EIR
Apartments	32	2035	188672	92	112288	55	0	+A	22.5	B
Houses	32	2377	220414	92	131179	55	0	+A	22.5	B

Table 2

Fabric to code level 5 (100% boiler SPF)

Units	No	TFA m2	Total Heat kWh	Heat/m2 kWh	Total Electricity kWh	Elec/m2 kWh	BER Kg.CO2/m2/ annum	EIR	2006/BER Kg.CO2/m2/ annum	2006/EIR
Apartments	32	2035	150944	74	93952	46	0	+A	22.5	B
Houses	32	2377	176338	74	109758	46	0	+A	22.5	B

The new housing is to be built to code level five of the Code for Sustainable Homes. To achieve this level, the houses were modelled on existing houses built to this high standard[3]. The key design features to achieve this level are:

- U value of walls of 0.14 W/m2-K
- U value of roof of 0.1 W/m2-K
- Air leakage of 1m^3/m^2/hr

In order to achieve Code Level 5, a zero carbon heat source (e.g. Biomass boilers) and local electricity generation (e.g. Photovoltaic panels) will be needed, in addition to the high standard of build noted above.

2.4.5 New Community Building

At the time of modelling the community building, the overall design was suggested to be a single two storey building made up of approximately 3000m^2 of health centre and about 950m^2 of community facilities.

Of the 950m^2 of community facilities, 475m^2 is assumed to be a replacement convenience store on the ground floor. The other 475m^2 was designated to be office space either for Small and Medium Enterprises (SMEs) or as a replacement for the housing trust's offices which will be demolished to make way for the new building.

The following occupancy patterns were used in the model to reflect these activities.

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[3] Mid Street, Surrey
http://www.building.co.uk/Journals/Builder_Group/Building/27_June_2008/attachments/osbornecostcode.pdf

Table 1

	Health Centre	Offices	Convenience Store	Convenience Store
	% Occupancy	% Occupancy	% Occupancy	% Occupancy Saturday
Before 7	0	0	0	0
7 to 8	25	25	0	0
8 to 9	75	50	10	25
9 to 10	100	100	25	50
10 to 12	100	100	50	100
12 to 2	50	75	50	100
2 to 5	100	100	50	100
5 to 6	100	50	50	100
6 to 7	0	25	10	25
7 to Midnight	0	0	0	0
Saturdays	0	0		
Sundays	0	0	0	

Table 2 gives the results of the modelling using these assumptions.

Table 2.

No Heating Systems Inefficiencies Best Practise Fabric and Lighting.

Units	No	TFA m2	Total Heat kWh	Heat/m2 kWh	Total Electricity kWh	Elec/m2 kWh	BER Kg.CO2/m2/ annum	EIR	2006/BER Kg.CO2/m2/ annum	2006/EIR
Community Building	**1**	**3811**	**112,400**	**29**	**287579**	**75**	**61.9**	**C**	**35.3**	**B**

With a deep plan building such as this, the heat loss from the fabric is relatively low compared to the ventilation heat requirements. The following table illustrates the importance of controlled ventilation with heat recovery. Here, a break-down of the various energy uses is given. The ventilation assumes an air-change rate of 0.5 ac/h during the occupied periods. Heat recovery would be achieved with an MVHR system (Mechanical Ventilation with Heat Recovery), with the system supplying controlled amounts of fresh air and extracting similar amounts of room air.

Table 3: Break-down of energy use – kWh per year

Domestic Hot Water (DHW)	92,551
Electricity use (lighting and appliances)	287,579
Space heating - fabric only	9,002
Ventilation	54,216
Ventilation with 80% heat recovery	19,845

In a mixed use building, the best ventilation strategy (for minimising heat demand) is likely to be a zoned approach, with ventilation in each zone controlled on occupancy. Duct runs for each zone should be kept short to minimise the fan power input for the MVHR system(s).

The modelled electricity use represents a high proportion of the energy use. More information on actual end use is required to refine this figure. However, good use of daylight (e.g. light pipes providing lighting to the interior areas of the building) and careful selection of appliances (e.g. low energy computers), should be considered.

Similarly, the DHW load is significant, and again more information is required on the actual end use to refine this figure.

2.4.6 Target Efficiency Ratings for Refurbished Buildings

The ratings which would be expected from a refurbishment program are outlined below.

Baseline Energy Certification (As Built)	Building Regulations Enhancement (Anticipated)	NWDA required Enhancement (As Built)
A	A	A
B	A	A
C	B	A
D	C	B
E	D	C
F	E	D
G	F	E

The NWDA Sustainable Building Policy.

Most of the buildings modelled with the refurbishment improvements could achieve the required standard just with practical fabric improvements. Exceptions to this being the maisonettes, the end flats and Holy Trinity church hall. This could be due to either the original baseline energy certification being too high, or the level of improvement to the fabric being inadequate. In the later case, extra insulation could be added, although this may not be desirable from an aesthetic point of view.

The enhancement of ratings has looked at fabric improvement and upgrading of lighting systems in isolation, with the heating systems based on the original gas systems. However, if LZC technologies are now introduced to these properties, the required levels of enhancement will be achieved.

For example:-
Upgrading the fabric of the maisonettes, with the suggested improvements, would only achieve a ‘B’ rating, compared to the ‘A’ rating that is required. This higher rating could be achieved if the gas boiler was replaced with a biomass one.

2.4.7 Levels of Insulation

The levels of extra insulation added to the external walls tended to be in the order of about 50mm of expanded polystyrene (EPS). This amount would give significant improvement to the thermal efficiency of the walls without being too physically intrusive. For modelling purposes this additional layer was applied to the internal surface of the wall but equally it could have been applied to the external surface.

Other forms of insulation could have been chosen such as a multi foil product which potentially could reduce the thickness of insulation. Unfortunately some of the claims of high thermal resistivity have been questioned[4] and, therefore, to achieve required levels of insulation, a combination of products may need to be used. It was decided therefore not to consider these products in the modelling process.

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[4] The Thermal Performance of Multi-Foil Insulation, TI Ward & S M Doran, July 2005, BRE Scotland.

2.4.8 Summary of final energy demands

The following Table summarises the final energy demands as modelled. Buildings are grouped together in their natural groupings, with the final two columns showing totals for each type of building and each group.

Summary of modelled final annual energy consumption (kWh / year)

	Number	DHW	Electricity	CH	DHW+CH		all heat	all electric
Maisonettes	9	2,253	3,079	3,152	5,406		48,653	27,714
End Flats	2	6,898	6,178	14,558	21,457		42,913	12,356
General retail	6	258	2,969	5,631	5,889		35,331	17,816
End Shops	2	412	6,222	7,461	7,873		15,746	12,443
Food retail	4	258	23,066	5,631	5,889		23,554	92,265
							166,197	**162,595**
Terraced house	12	3,996	3,428	5,739	9,734		116,813	41,135
End Terraces	4	1,998	3,563	8,214	10,213		40,850	14,251
							157,663	**55,386**
New houses	32	2,801	3,431	2,710	5,511		176,345	109,784
New Apartments	32	2,398	2,937	2,319	4,717		150,950	93,975
							327,295	**203,759**
Church (HT)	1	0	3,373	47,043	47,043		47,043	3,373
Church hall (HT)	1	966	6,821	19,500	20,466		20,466	6,821
							67,509	**10,194**
Church (URC)	1	966	2,387	25,412	26,378		26,378	2,387
Church (retail)	1	1,912	17,678	6,767	8,679		8,679	17,678
							35,057	**20,065**
Health/Community	1	92,551	287,579	19,845	112,396		**112,396**	**287,579**

CH refers to Central Heating and DHW to Domestic Hot water production

To illustrate the savings that can be made through upgrading the fabric and improving the energy efficiency of lighting, the final Table in this section (see below) provides a summary of the “Present Condition” modelling results for the buildings that will remain. Included in this table are the percentage savings for the “Improved Fabric” results (as summarised above) compared to the “Present Condition”. In the case of heat, the “Improve Fabric” value has been modified by the use of a SPF for a good quality, modern gas boiler (0.9), with the exception of the retail / shops, where an SPF of 1 is used for both pre and post upgrade values.

Summary of savings through fabric upgrades

	Present Condition		Savings	
	all heat	all electric	Heat	electricity
Maisonette	97,965	37,044	45%	25%
End Flats	78,970	18,340	40%	33%
General retail	53,412	51,438	34%	65%
End Shops	32,204	26,374	51%	53%
Food retail	35,608	114,680	34%	20%
Terraced house	161,616	59,700	20%	31%
End Terraces	61,643	16,616	26%	14%
Church (HT)	81,653	4,579	36%	26%
Church hall (HT)	33,604	8,286	32%	18%
Church (URC)	40972	3495	28%	32%
Church (Retail)	16989	25944	43%	32%

3 Energy Use Profiles

In order to undertake a comprehensive analysis of the various Energy Systems, we need to take account of the way energy is used over each day. This is especially so for:

- technologies, such as Air Source Heat Pumps, where the performance is affected by the ambient temperature;
- technologies that are suited to use on a larger scale than that of an individual dwelling – e.g. large biomass boilers or Combined Heat and Power (CHP) – where District Heating becomes a possibility.

Where District Heating is used, the differing usage patterns from building to building can extend the operating hours of the boiler or CHP plant, making the system more cost effective than if it were applied to a single building.

With a CHP plant, the similarity of the heating pattern to that of the electricity demand is also important in terms of cost effectiveness. To date, the greatest value is obtained from the CHP plant if the electricity generated is consumed within a property served by, or associated with, the CHP plant. The conventional alternative is to sell any surplus electricity to an Energy Supply company who will pay a much lower rate per kWh than the rate the Supplier charges to supply electricity. However, it is possible that this situation will change with the introduction of Feed-In Tariffs – see Section 7.1 for a discussion of Feed-In tariffs.

Figure 3.1 to Figure 3.4 show the heating and electrical loads for a mid-week winter day where the ambient air temperature is 4.4^{o}C, i.e. a reasonably cold day. Figure 3.1 shows the combined heat load for all buildings within the various building categories, whilst Figure 3.2 shows the combined electrical load for these buildings. Figure 3.3 shows the total heat and electrical loads for a district heat scheme which supplies all of the buildings under consideration, whilst Figure 3.4 shows loads for a second district heating scheme just covering the new health centre / community building and Blacon Parade East (i.e. the retail and the maisonettes).

Hourly weather data from Hawarden weather station is again used (as in Section 2), and, although labelled as 2002, is a composite data set, giving typical annual values and seasonal variations.

Equivalent data is shown in Figure 3.5 to Figure 3.8 for a mild, spring, mid-week day.

Finally, Figure 3.9 to Figure 3.12 show the same set of results for a summer day.

Equivalent graphs for weekend days are included in Appendix G.

In the graph labels: “Retail” refers to the shops on Blacon Parade East, “Church(T)” refers to the Holy Trinity Church, “Church (R)” to the United Reform Church and “Health Centre / Community” refers to the new Community Building.

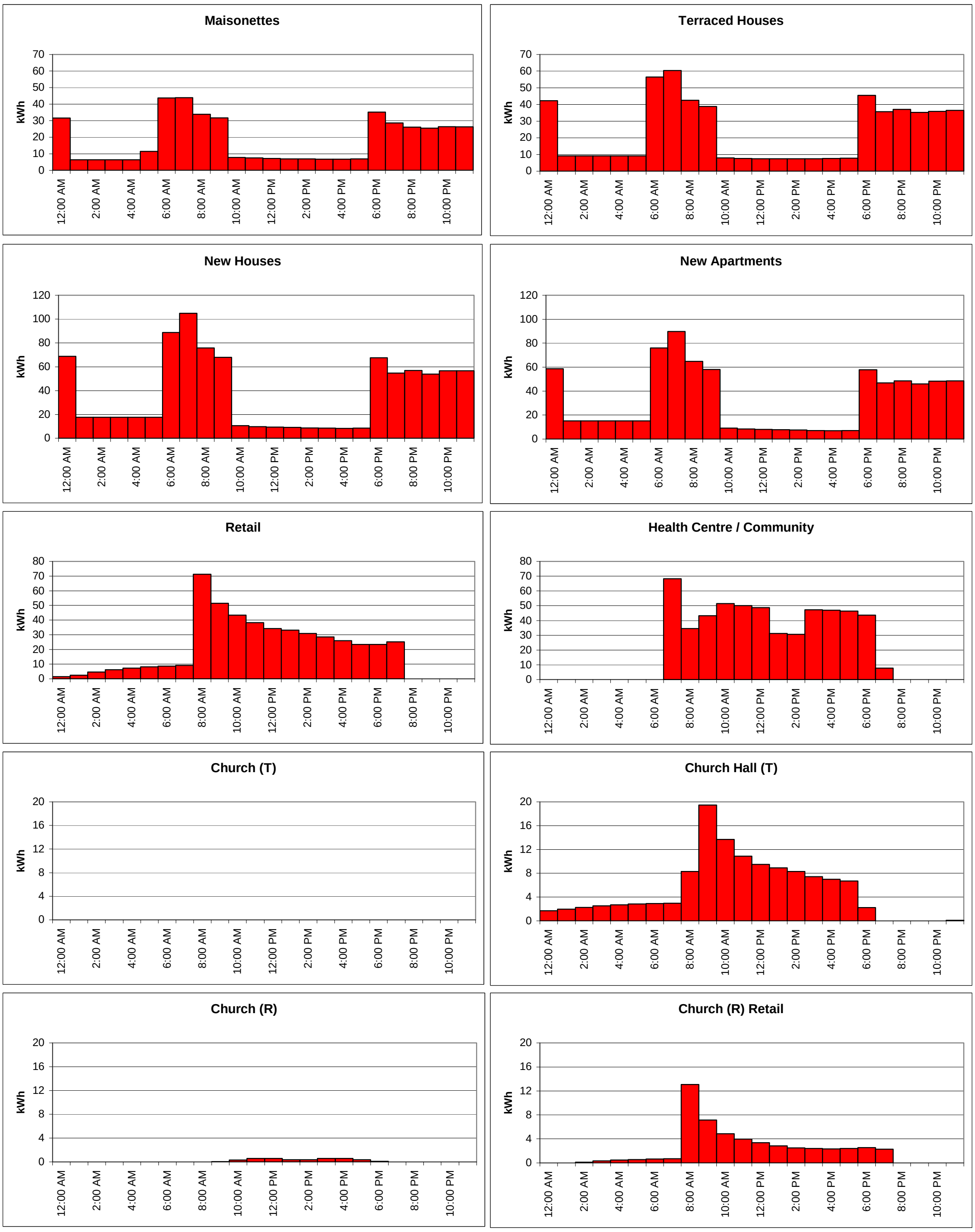


Figure 3.1 Heat profiles for a mid-week winter day (21 February 2002, Average Temperature 4.4^{o}C)

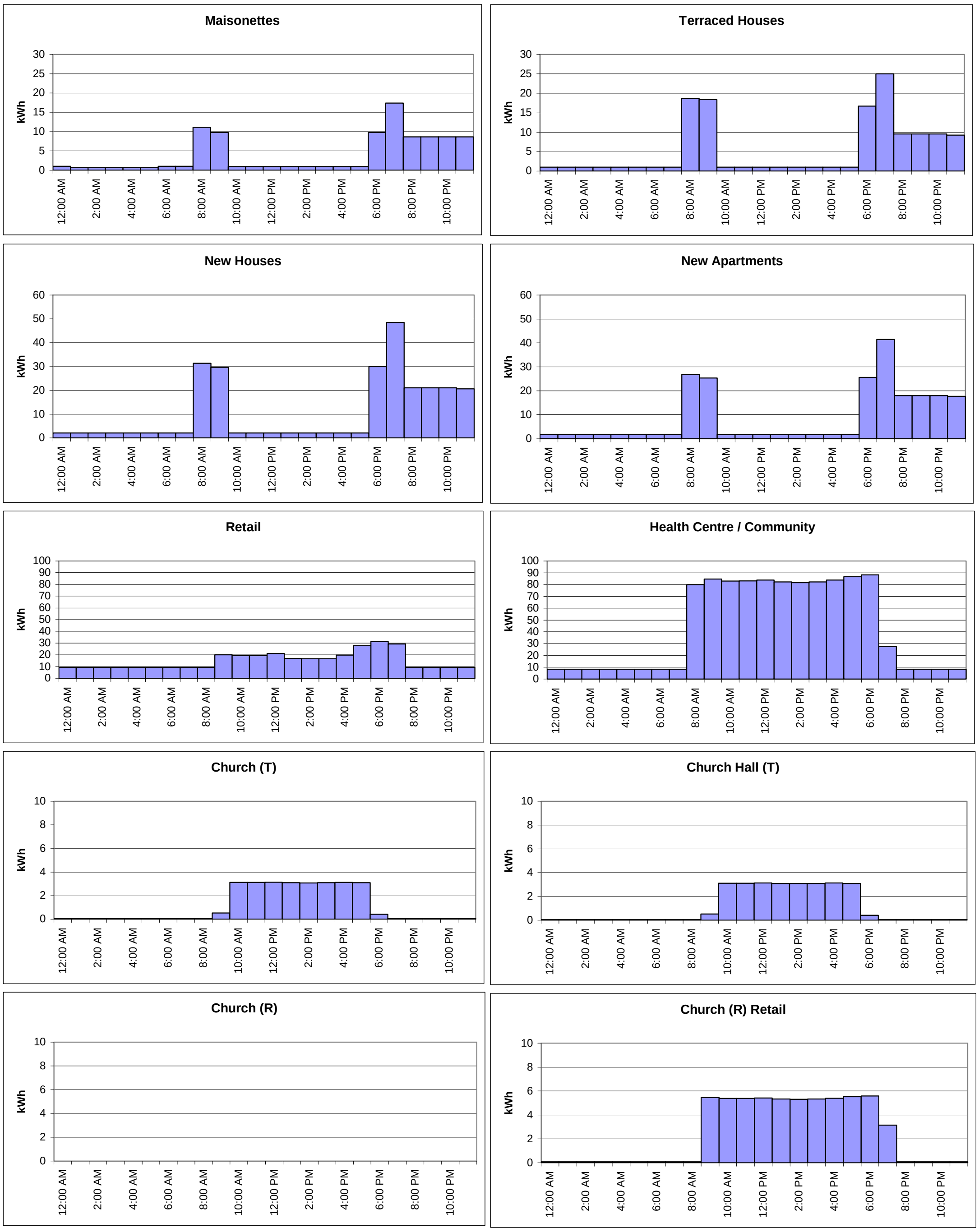
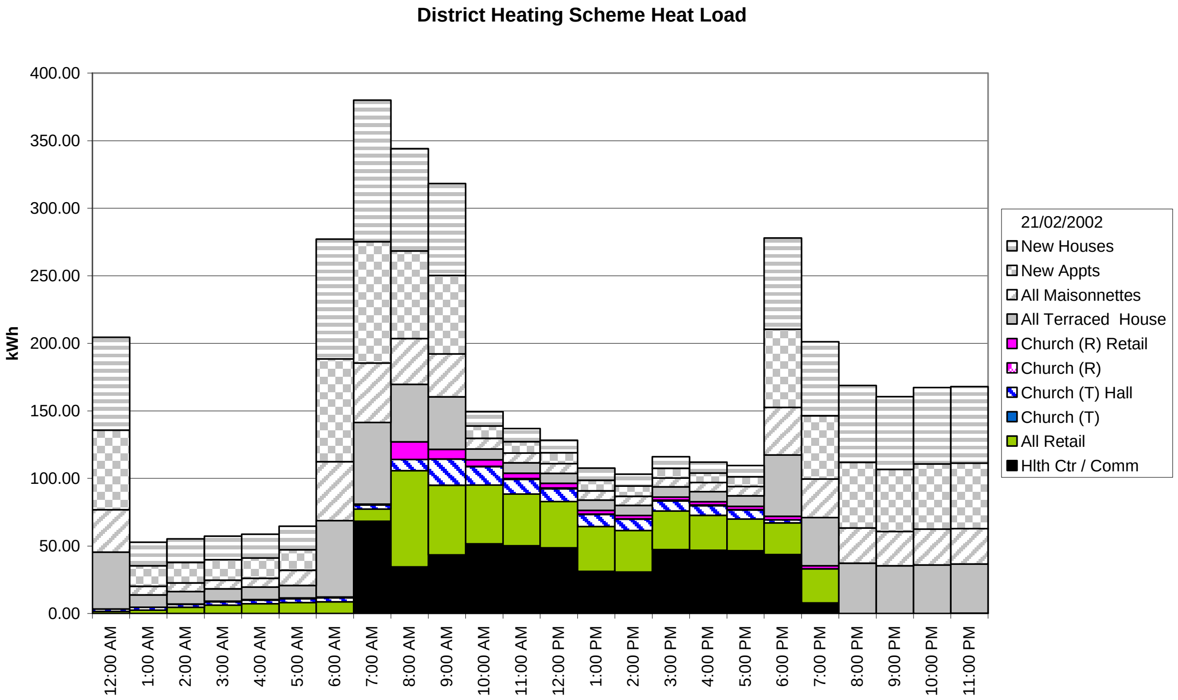


Figure 3.2 Electricity profiles for a mid-week winter day (21 February 2002, Average Temperature 4.4°C)



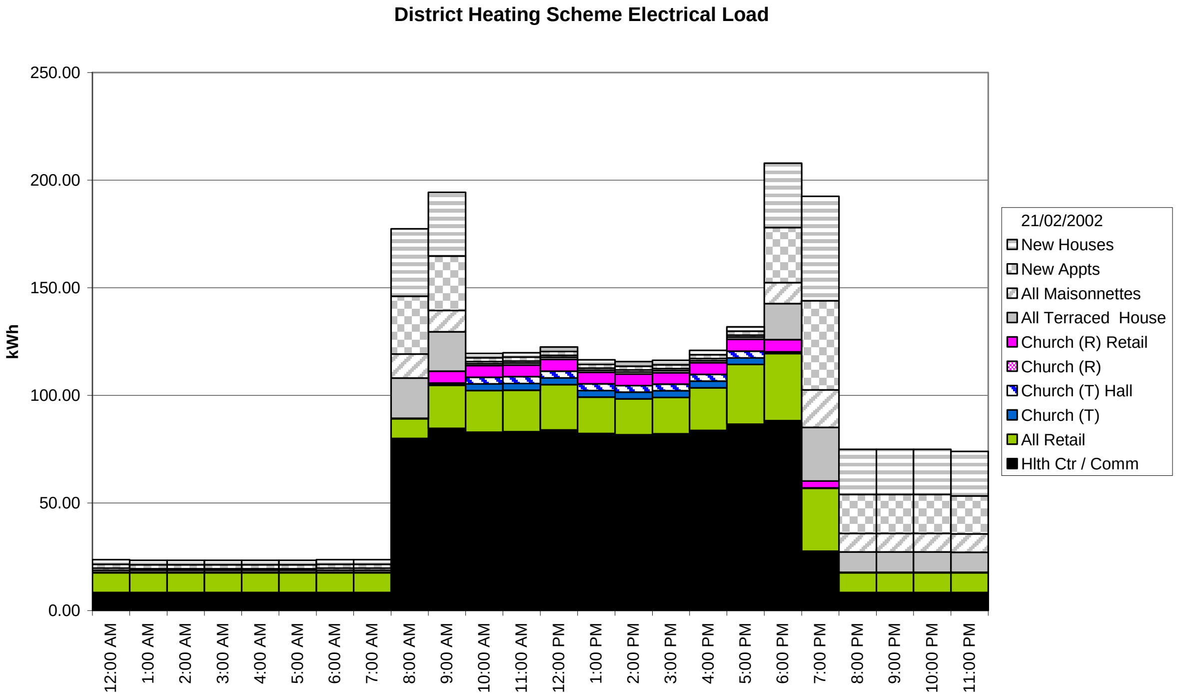


Figure 3.3 District Heating Scheme (1) - Heating and Electrical Loads (21 February 2002, Average Temperature 4.4^{o}C)

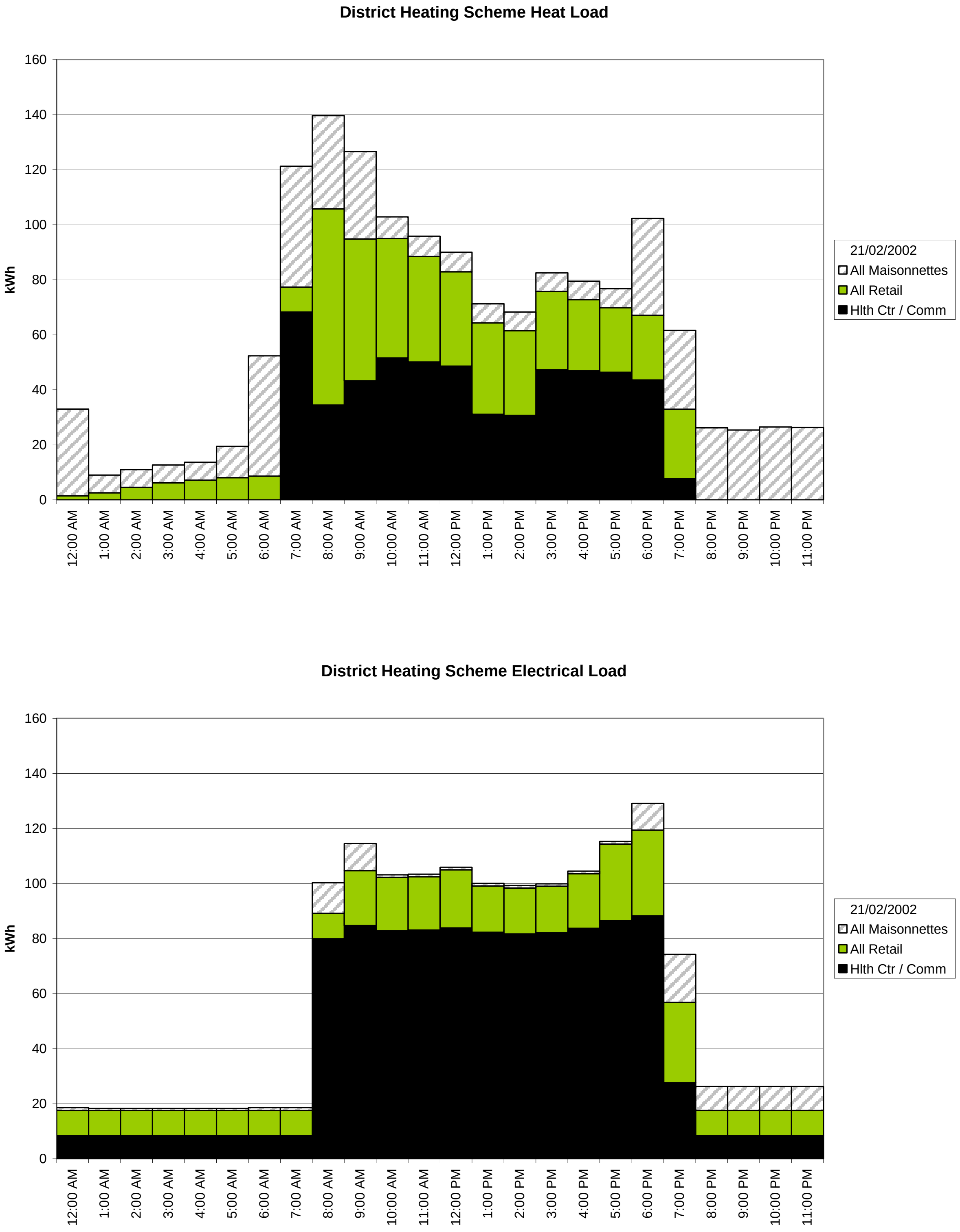


Figure 3.4 District Heating Scheme (2) - Heating and Electrical Loads (21 February 2002, Average Temperature 4.4°C)

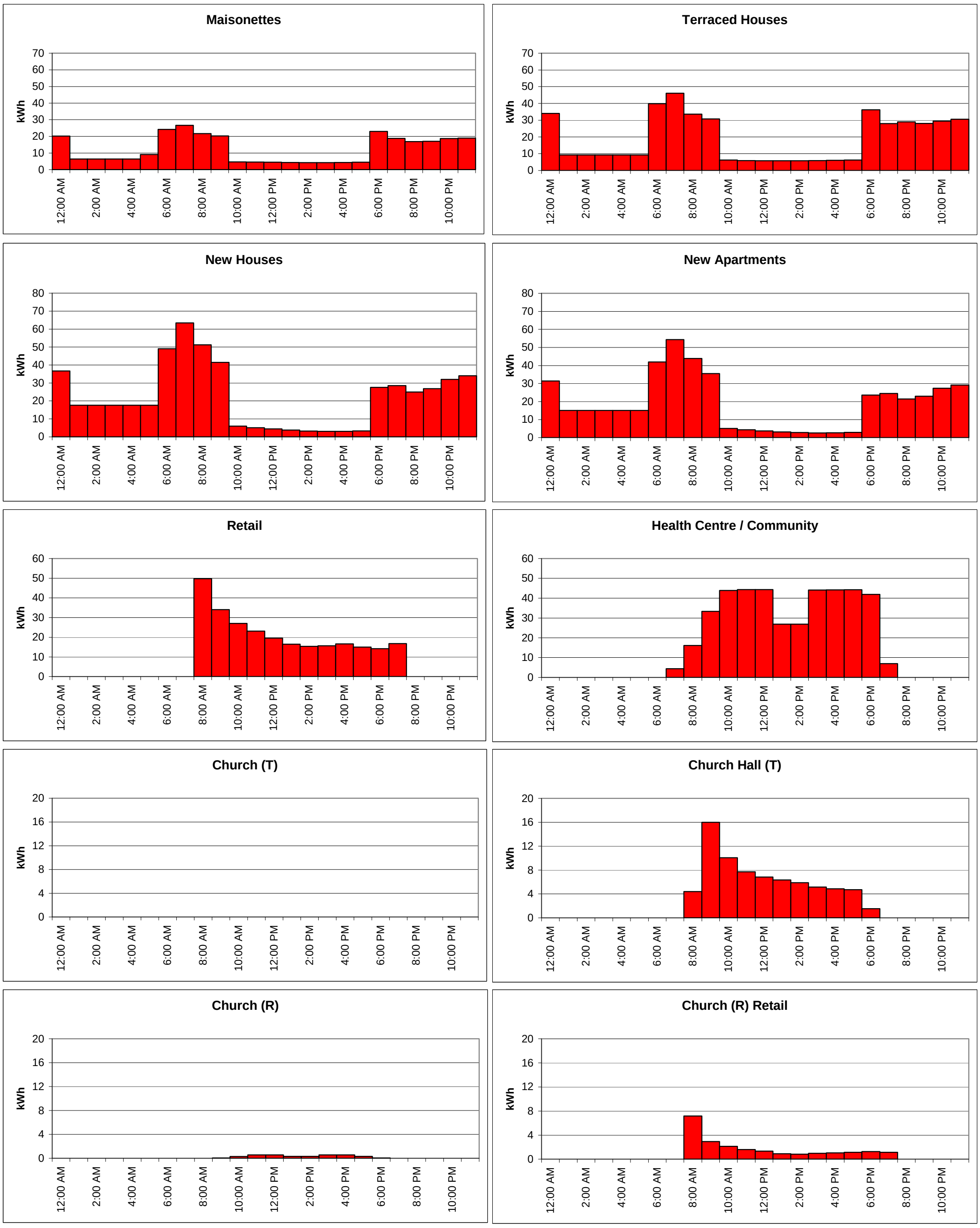


Figure 3.5 Heat profiles for a mid-week spring day (21st March 2002, Average Temperature 8.2°C)

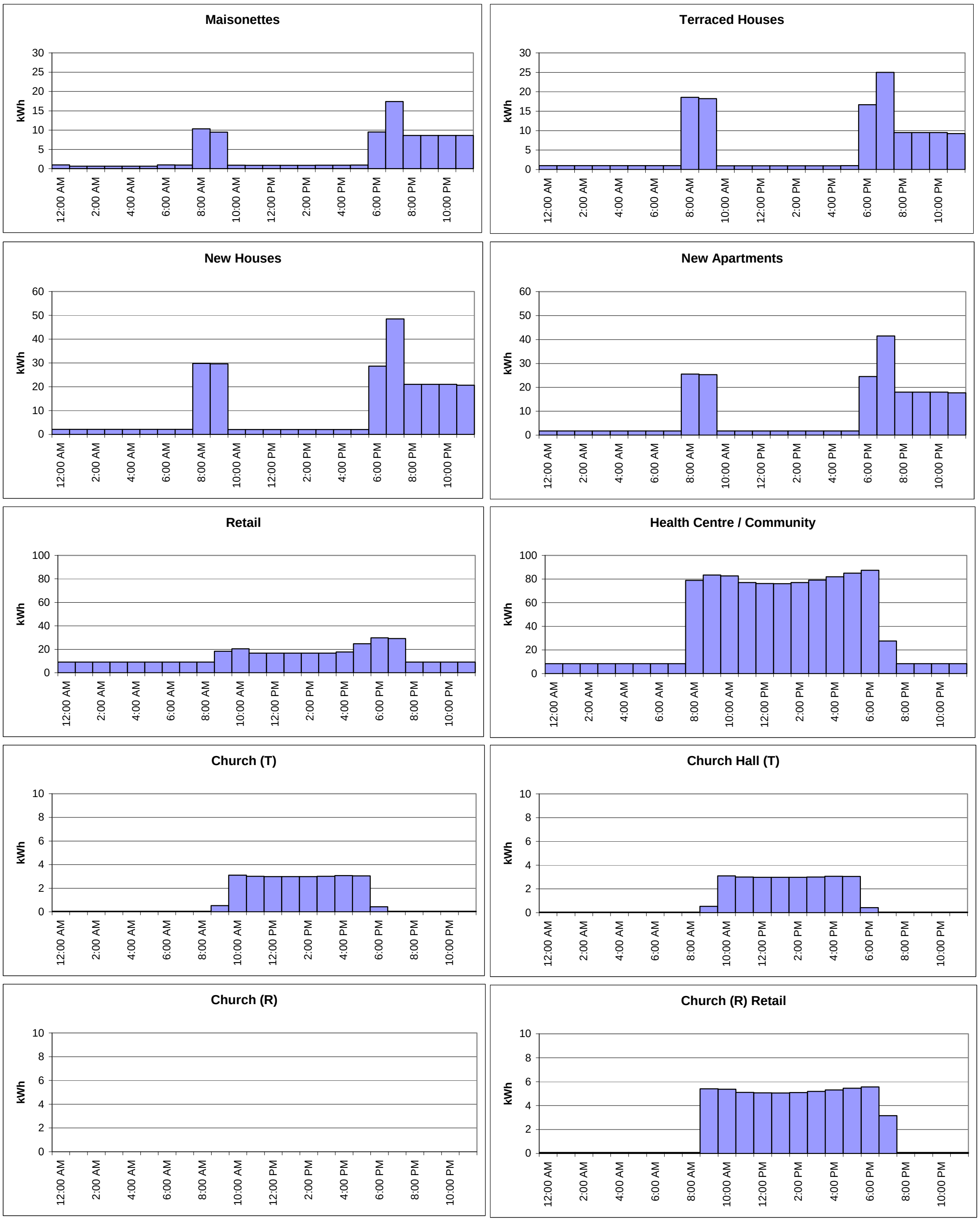


Figure 3.6 Eletricity profiles for a mid-week spring day (21st March 2002, Average Temperature 8.2°C)

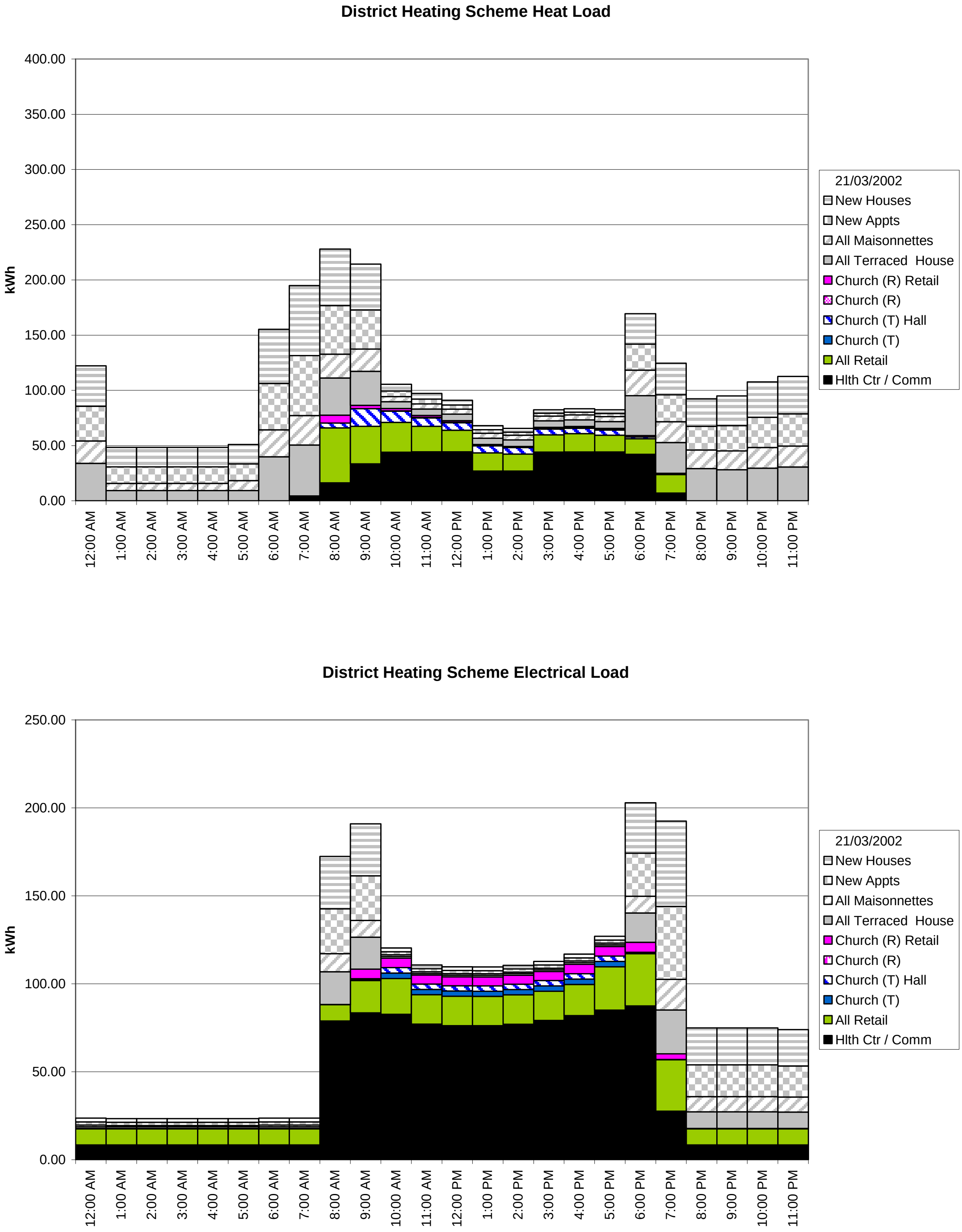


Figure 3.7 District Heating Scheme (1) – Heating and Electrical loads (21st March 2002, Average Temperature 8.2°C)

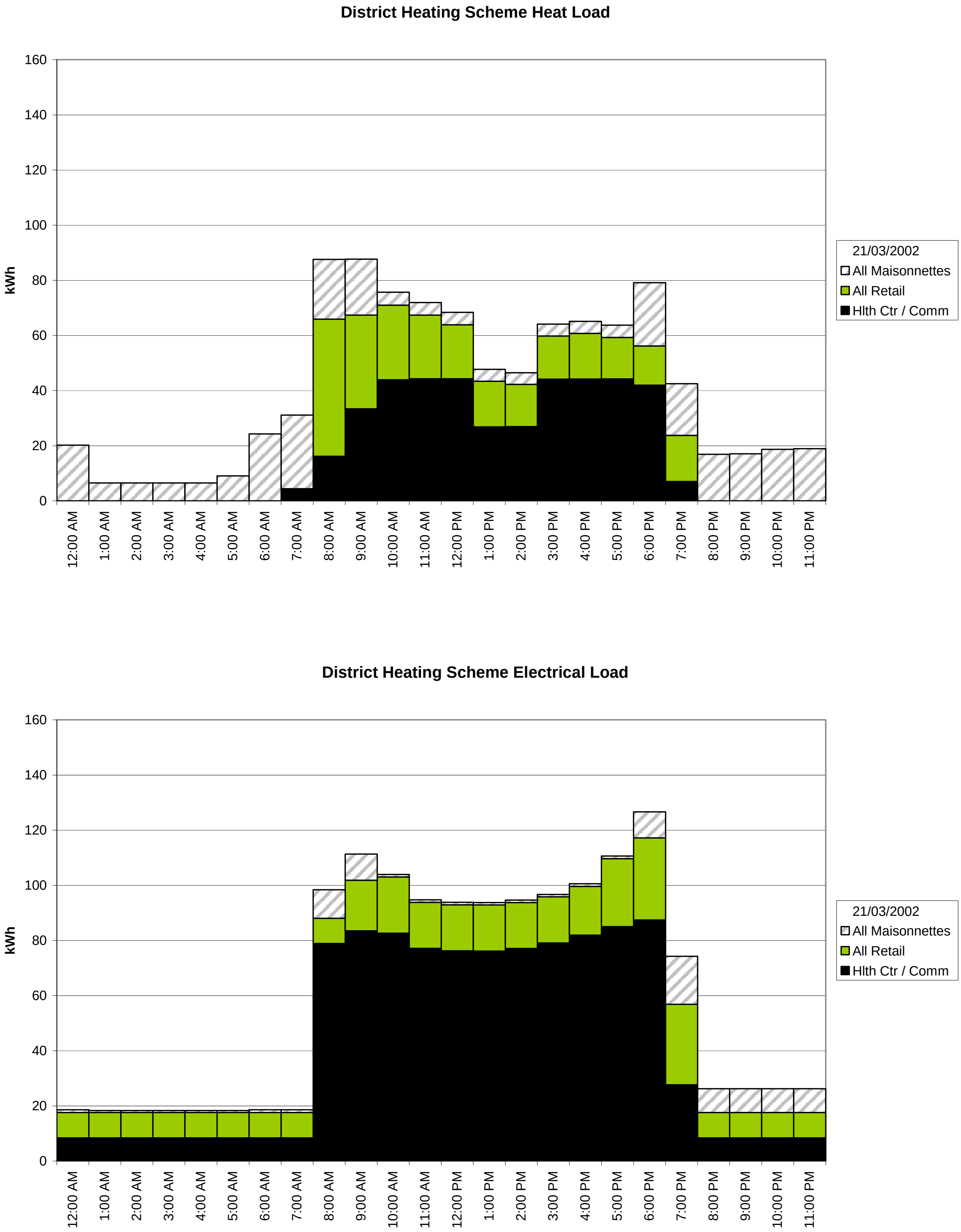


Figure 3.8 District Heating Scheme (2) – Heating and Electrical loads (21st March 2002, Average Temperature 8.2^{o}C)

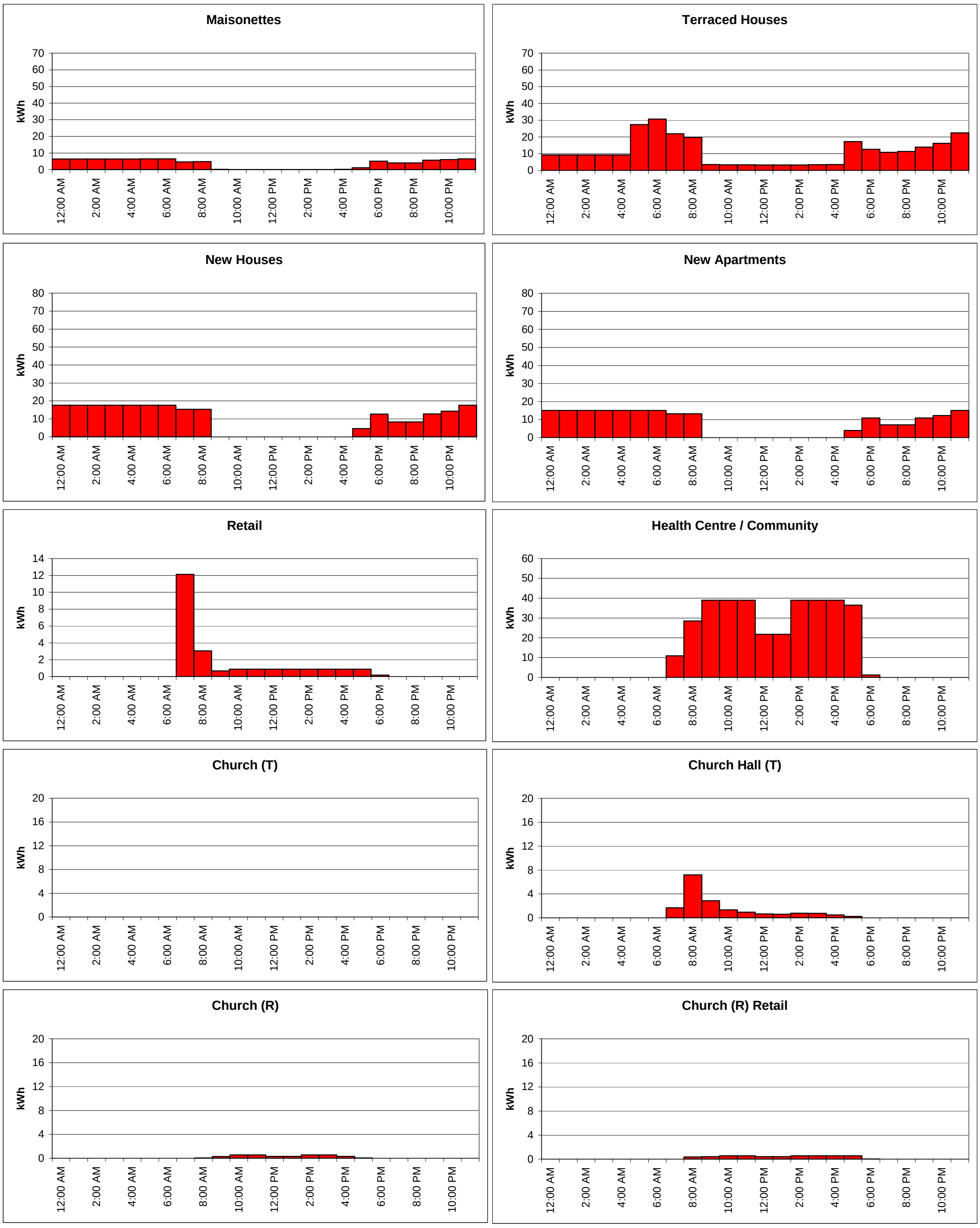


Figure 3.9 Heating profiles for a mid-week summer day (25 July 2002, Average Temperature 13.4°C)

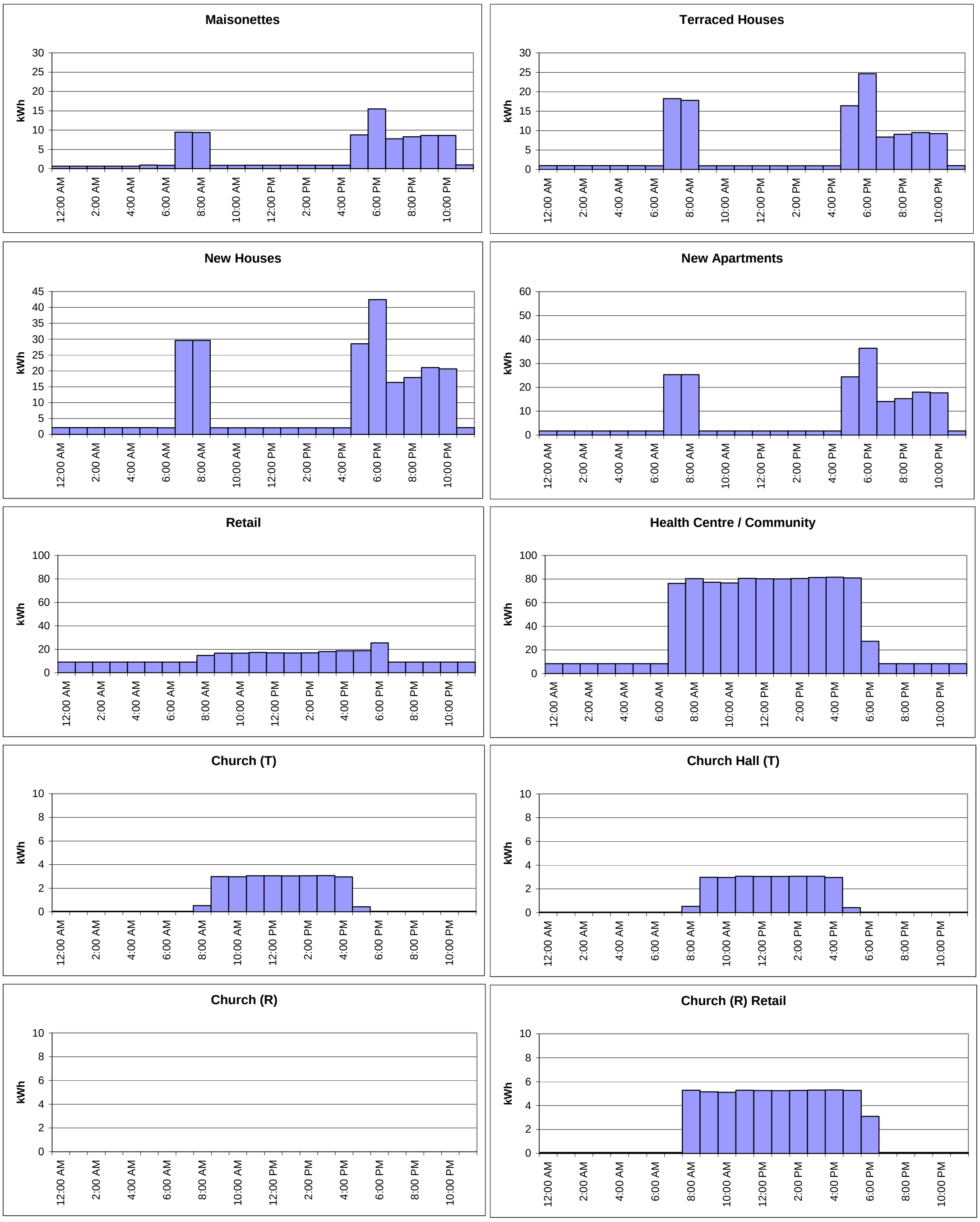
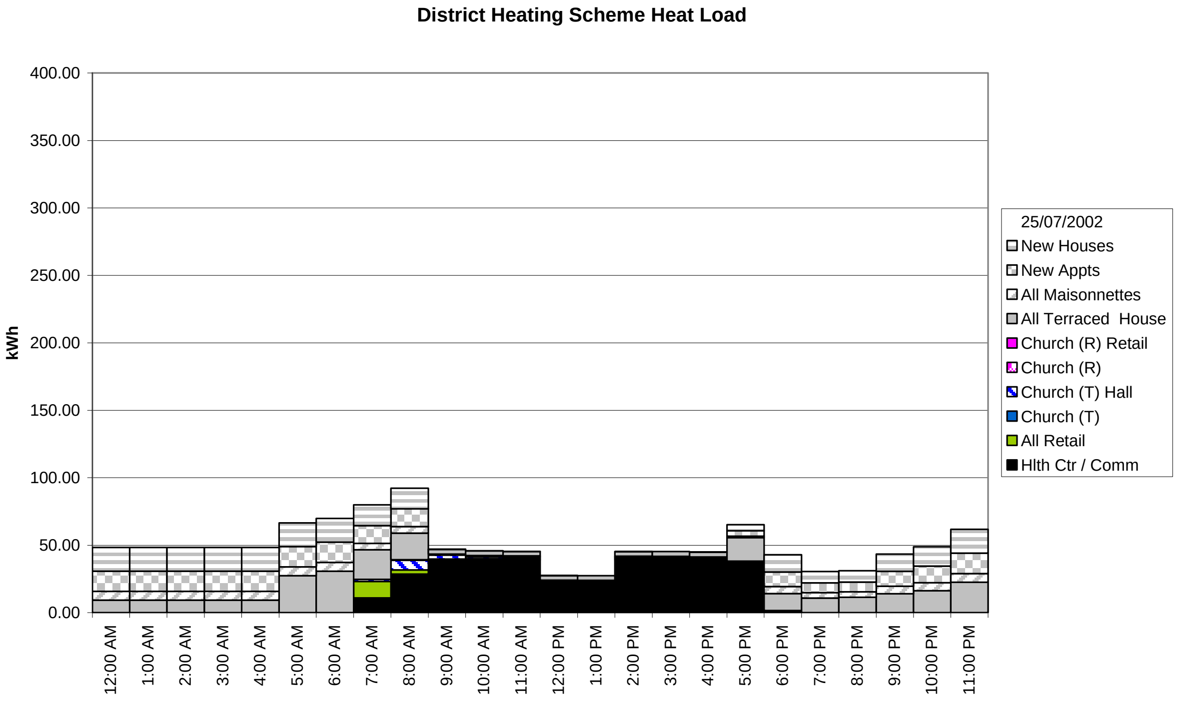


Figure 3.10 Electrical profiles for a mid-week summer day (25 July 2002, Average Temperature 13.4^{o}C)



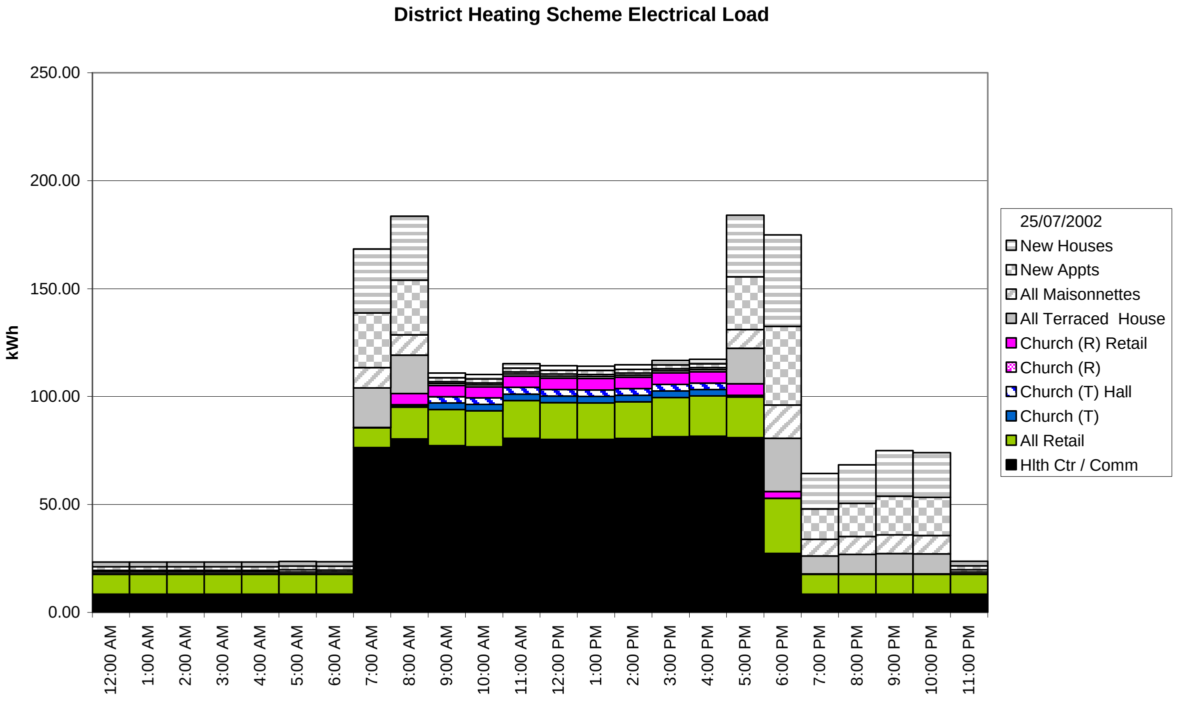


Figure 3.11 District Heating Scheme (1) – Heating and Electrical loads (25 July 2002, Average Temperature 13.4°C)

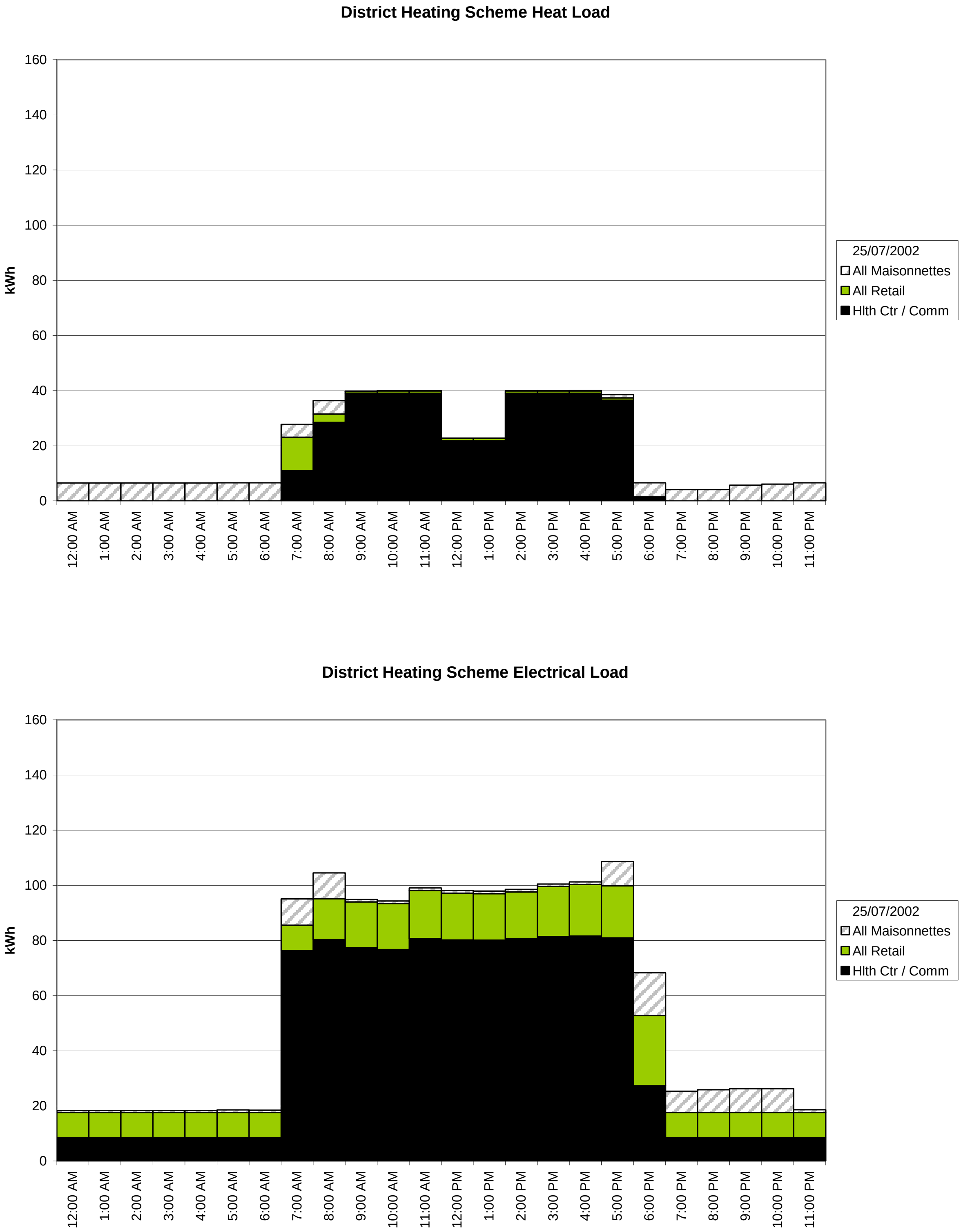


Figure 3.12 District Heating Scheme (2) – Heating and Electrical loads (25 July 2002, Average Temperature 13.4^{o}C)

4 Energy System Options and Costs

The energy consumption of the various building, and groups of buildings, will be analysed for a range of low or zero-carbon technologies, namely:

- Biomass boilers
- Combined Heat and Power (CHP) - both biomass fired and gas fired
- Heat pumps
- Solar thermal
- District Heating
- Photovoltaic electricity generation

In addition consideration is given to:

- Inter-seasonal energy storage
- Small-scale, building mounted, wind turbines

Examples of the use of each of these technologies were discussed in the previous EA Technology report undertaken for the BCT[5].

The discussion of Biomass, both for boilers and CHP plant, will be restricted here to the burning of wood pellets or wood chips. The wider aspects of Biomass, including a justification of the choice of pellets and chips as the most suitable biomass resource for an urban environment, are discussed further in Section 5.1.

Unless otherwise stated, all capital cost information presented here is taken from recent, openly published, sources[6,7].

4.1 Biomass boilers

Small biomass stoves suitable for use in individual dwellings, are readily available - many with back-boilers for the provision of DHW and Central Heating.

However, it is believed that larger-scale boilers, suitable for heating the new Community Building or feeding a District Heating scheme, will be of more relevance to the Blacon Parade redevelopment. Assumed parameters are:

Boiler size	100kW	200 kW	400kW
Capital cost	£700 / kW	£600 / kW	£500 / kW
Seasonal efficiency	85%		
Annual maintenance	2% of capital cost		
Fuel cost (wood pellets)	3.7p/kWh (£180 / tonne)		

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[5] Energy Efficiency and Renewable Energy Potential in Blacon, M Gillie, R Green and K Platt, EA Technology, Report Number. 6229, March 2008

[6] Power-In-Numbers, Energy Saving Trust, November 2008

[7] Feed-in Tariff for small-scale electricity generation – Technology cost document, report for DECC by Poyry and ElementEnergy, March 2009

Capital costs can vary quite widely with the individual circumstances. The values quoted here are taken from a recent Carbon Trust publication[8] and are the mid-price values for complete systems (i.e. boiler plus ancillaries, flue, design, installation etc.).

4.2 Combined Heat and Power

4.2.1 Biomass CHP

There are very few small-scale Biomass CHP systems on the market at present, and those that are, are newly developed. Thus costs are likely to be higher than in a mature market. The smallest UK manufactured unit identified is the Talbott's air cycle turbine.

Electrical output	100 $kW_{electrical}$
Thermal output	250 $kW_{thermal}$
Overall efficiency	82%
Capital cost	£470,000 [7]
Annual maintenance	4% of capital cost [7]
Fuel cost (wood pellets)	3.7p/kWh (£180 / tonne)

Stirling DK of Denmark[9], offer a $35kW_{electrical}$ Stirling cycle engine (plus multiples of this size), fuelled by gasified wood chips. This has a 4:1 heat to power ratio (i.e. 140 $kW_{thermal}$) and a claimed overall efficiency of 87%. Few systems have been installed and no example costs were available.

The performance of the new Community Building, plus District heating options centring on this building, is modelled using the Talbott's data as quoted above. Performance is analysed assuming a thermal store (water tank) is available that will store 1 hour's output from the CHP unit (250kWh) – thus enabling the CHP unit to run for a minimum of 1 hour at a time, and allowing it to achieve a heat output of greater than 250kW for short periods. A back-up boiler is called into play when the heating demand is greater than the combined thermal output of the CHP unit and any available capacity remaining in the thermal store. The store is replenished whenever the CHP unit is running and the heating loads are less than the thermal output of the CHP unit. The store is depleted whenever the heating loads are greater than the CHP thermal output, or whenever the heating loads are too low for the CHP unit to run.

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[8] Biomass heating – an introduction to potential users, Carbon Trust CTG016, February 2009
[9] www.stirling.dk

4.2.2 Gas-Fired Fuel Cell CHP

There are various types and sizes of gas-fired CHP units currently available, the most common being internal combustion engines which typically have heat to power ratios of around 2.5 : 1 – similar to the Talbott's biomass unit.

To explore the effect of a lower heat to power unit we need to look to fuel cells. Fuel cells generate electricity through the chemical reaction between hydrogen and oxygen (the reverse of electrolysis), with, in the context of CHP, hydrogen being produced from natural gas within the fuel cell enclosure. The following is based on the market leader fuel cell[10] - the PureCell200.

Electrical output	200 $kW_{electrical}$
Thermal output	250 $kW_{thermal}$
Overall efficiency	80% (assumed)
Capital cost	£360,000[11]
Annual maintenance	4% of capital cost
Fuel cost – natural gas	3.5p/kWh

The output of a Fuel Cell can be readily modulated down to levels well below the maximum, and hence the need is reduced for a thermal store to help match output to demand. However, for simplicity, and to compare the fuel-cell with the Talbott's Biomass CHP on a like-for-like basis, this refinement has not been modelled. Rather, to account for the non matching of heat demand to CHP output, the use of a 250 kWh thermal store is again assumed.

4.2.3 Gas-Fired Internal Combustion Engine

The above CHP units are likely to have too high a thermal output for the Blacon Parade development. As a comparison a third CHP unit is included, that of a relatively small internal combustion engine. Assumed parameters are:

Electrical output	20 $kW_{electrical}$
Thermal output	40 $kW_{thermal}$
Overall efficiency	85%
Capital cost	£1,500 / $kW_{electrical}$[7]
Annual maintenance	£100 / kW_e
Fuel cost – natural gas	3.5p/kWh

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[10] http://www.fuelcellmarkets.com/united_technologies_utc/products_and_services/l

[11] Based on known costs of $2500 / kWh for a unit of this scale

4.3 Heat Pumps

A Heat Pump takes in energy from a low temperature heat source (e.g. the outside air) and delivers this energy at a higher temperature where it can be used for Central Heating or DHW production. This transformation of low-temperature heat to higher-temperature heat requires the input of additional energy – usually in the form of electricity – with the greater the increase in temperature, the greater electricity input.

Two types of electrically driven heat pump are considered – air and water source heat pumps - both delivering heat to a conventional water based Central Heating system.

4.3.1 Air-Source Heat Pumps (ASHP)

Performance data is for a Calorex AW 4500 heat pump as set out below.

Outdoor Air temperature (^{o}C)	Water off temperature (^{o}C)	Heat Output (kW)	Electrical input (kW)	COP
0	55	2.97	1.54	1.93
0	35	3.39	1.11	3.05
7	35	4.4	1.18	3.73
20	55	6.1	1.78	3.43
20	35	6.3	1.37	4.60

"COP" is the Coefficient of Performance, and is the ratio of heat delivered to electricity consumed. For the purposes of modelling the energy performance of the buildings, the COP figures given above are extrapolated to other air and water temperatures. The "water off" temperature in the table above is the temperature of the water leaving the heat pump. In DHW mode a water off temperature of 65^{o}C is assumed (giving a COP at 0^{o}C air temperature of 1.9). In Central Heating mode, it is assumed that the water off temperature can be reduced as the heating load reduces, hence giving improvements to the COP.

Using standard radiators, water off temperatures are assumed to vary between 35 and 55^{o}C.

Capital costs are taken as (from[6]):

Cost = £4,000 + £282 / kW_t
where kW_t is the thermal output of the unit.

4.3.2 Ground Source Heat Pumps (GSHP)

Performance data is for a Calorex 3500 heat pump as set out below.

Source water on temperature (^oC)	Water off temperature (^oC)	Heat Output (kW)	Electrical input (kW)	COP
0	55	2.8	0.76	3.68
0	35	3.4	0.75	4.53
15	55	5	1.05	4.76
15	35	5.9	0.97	6.08

The COPs for GSHPs are considerably better than those for ASHPs at the same temperatures. This is due to the fan power (for the external heat exchanger) being included in the case of the ASHP, but no pump power (to circulate glycol through the ground loop) is included for the GSHP.

To account for this, an additional pump energy consumption is included in the analysis – assumed, in the case of a domestic heat pump to be 100W - whenever the unit is operating.

As with the ASHP, Central Heating water delivery temperatures are allowed to reduce when loads are low. GSHP are likely to be most suited to new-build, and new build will best be served by under-floor heating (to keep CH temperatures as low as possible). With under-floor heating, water supply temperatures are assumed to be variable between 30 and 40^{o}C.

Capital costs are taken as (from[6]):

$$\text{Cost} = £4{,}000 + £792 / kW_t$$

Heat extraction from the ground can either be via vertical bore holes (a plastic pipe – ground loop - inserted into a hole drilled 50 to 100m down into the earth) or by horizontal pipes laid ~ 2 metres below the surface. The high price / kW_t stated above accounts for the cost of bore holes (costs of ~ £30 per metre, with approximately 16m of bore hole required for each kW of heat extraction). Where space is available, lower costs are achievable using horizontal ground loops. However, in an urban environment, the bore hole option is likely to be preferable, and will also minimise any risk of damage to the ground loops during routine maintenance of the area.

4.4 Solar Thermal

Solar thermal heating systems use solar collectors, generally fitted to the roof of a building, to utilise heat from the sun to provide warm water. The water is stored in a hot water cylinder, where it is further heated by a boiler or immersion heater to the appropriate temperature (typically around 60^{o}C).

The typical annual performance of a solar thermal panel is 1,180kWh for a typical, single, 4m^2 panel (from[12]), when installed in a dwelling. This compares with calculated available thermal outputs from market leading products of 2,300 to 2,700 kWh / year[13] . The effectiveness of solar thermal panels is heavily dependant on the hot water usage pattern of the occupants – high users using more of the available energy than low users. The figures above imply that typically only ~ 50% of the maximum available energy from a solar panel is used in a domestic property, once usage patterns are allowed for.

4.5 District heating

The above technologies can all be applied to individual properties. However, unless the building is large and / or has a high heat demand, some technologies, particularly Biomass Boilers and CHP, are best incorporated into a District Heating scheme. The additional costs and performance implications of a District Heating network will now be discussed.

The heat loss from modern well insulated, District Heating pipe-work will be of the order of 10 to 15 W / m of pipe at typical District Heating temperatures[14]. Temperatures have to be maintained high at all times to allow the production of DHW at temperature in excess of 60^{o}C (to meet health and Safety requirements).

Costs are quoted as £5,300 per house[6] for a row of houses in a terraced street – of which £750 will be the cost of the heat exchanged between the District Heat pipe-work and the building.

4.6 Photovoltaic Electricity Generation

Typical costs for Photovoltaic (PV) panels are £4,000 / kWp[*] for new build rising to ~ £5,000 for retrofit to existing buildings[6]. There will be savings for larger single building installations and for mass installation in neighbouring properties. A discount of 5% for a 10kWp systems, rising to 20% for 1000kWp is assumed[6].

Annual performance will be approximately 900 kWh / kWp [13].

Efficiencies (defined as the output at a solar radiation of 1kW/m^2) vary with the type of solar cell – values between 8 and 15% are typical. A figure of 11% will be used here. This gives an annual production rate of 100kWh/m^2.

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[12] GIR 88, Solar hot water systems in new houses, Energy Saving Trust

[13] Calculated using RETScreen with weather data for Hawarden in North Wales

[14] Ecoflex Pipe Installation Technical Guide – see www.durotan.ltd.uk

[*] kWp is the nominal peak electrical output (i.e. the maximum output likely on a clear sunny day in the UK)

4.7 Inter-seasonal energy storage

Inter-seasonal storage refers to a system whereby heat energy is collected during one season and stored for use in another. For example, heat extracted from a building during the summer using air-conditioning equipment can be stored and used to heat the building during the winter. Alternatively, where buildings have little requirement for cooling during the summer, thermal energy from the sun can be collected during the summer and used to heat the building during the winter.

The heat energy is typically stored underground either in water stored in large aquifers or directly in the ground itself (for example using horizontal heat exchangers). The temperature at which the energy is stored is generally low (around 20 to 25^{o}C), therefore thermal energy stored in this way is generally not suitable for heating a building directly. As such, inter-seasonal storage systems would typically utilise a ground source heat pump to extract the heat from the store for use within the building.

A conventional ground source heat pump extracts heat directly from the ground which is typically at a temperature of around 10^{o}C. However, the use of inter-seasonal storage would raise the temperature of the ground to around 20 to 25^{o}C, which has a significant impact on the performance of the heat pump.

We have assumed that the need for air-conditioning during the summer will be designed-out from the new Communities Building. This implies that an inter-seasonal storage system would need to collect thermal energy from the sun during the summer, rather than rely on heat extracted from buildings.

One option for collecting the solar energy would be via the use of solar thermal panels commonly associated with the provision of solar hot water for domestic properties. Costs of individual panels are given in Section 4.4. For this application, the capital costs for the hot water cylinder would need to be excluded from the cost of the solar thermal installation, reducing the capital cost for new panels from the £3,700 for new build domestic installations to around £2,700 (based on a saving of £250 due the avoided cost of the hot water cylinder and a large scale installation discount of 20%). Annual thermal output will be close to the maximum available output, previously quoted, of 2,300 to 2,700 kWh / year, providing that the store is well matched to the size of the panels.

An alternative option would be to utilise a road surface as the solar collector. Such an approach, which is traded under the name Road Storage System®, has been developed by a company in the Netherlands. The system comprises an asphalt layer with a reinforced structure and a water-bearing medium. It is claimed that 10m x 40m of tarmac can generate 108MW of energy per annum[15]. The system was installed in the car park of IHS[16] in the Scottish Highlands in June 2006.

Possible arrangements for inter-seasonal heat storage, coupled to a Ground Source Heat Pump, are shown below.

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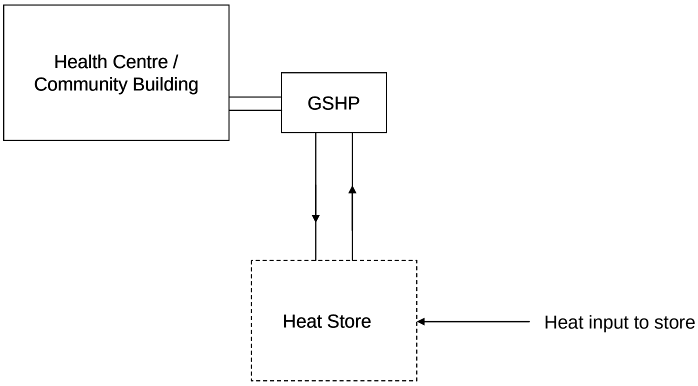
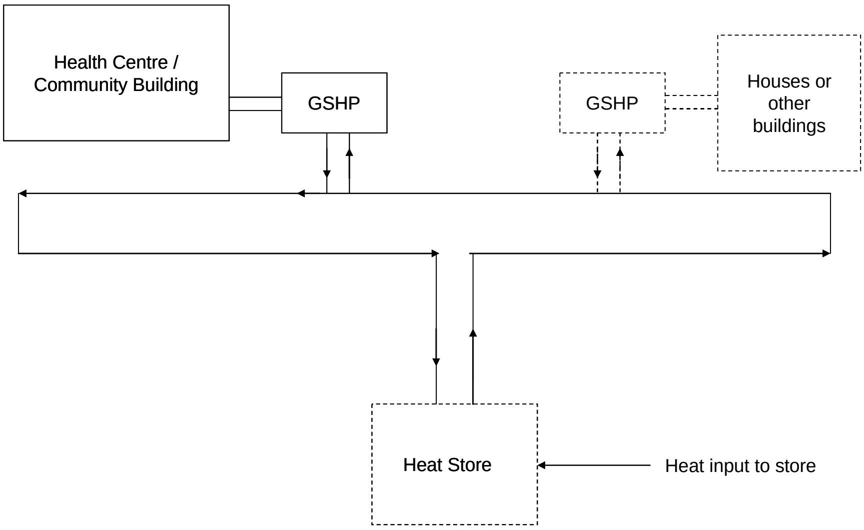
[15] www.invisibleheating.co.uk

[16] Invisible Heating Systems, the organisation who market Road Storage System® in the UK

Option 1: Dedicated inter-seasonal storage / GSHP system for health centre / community building



Option 2: Inter-seasonal storage system providing low temperature water loop for individual GSHPs



An interesting recent example of the use of inter-seasonal energy storage in a sustainable housing development is shown in Appendix C.

If air-conditioning is required in the new Community Building, or if the refrigeration loads in the convenience store are high, then cooling could be supplied at very low cost by incorporating a second thermal store, rather than just the single store shown here.

4.8 Small-scale, building mounted, wind turbines

The use of small-scale wind turbines in the urban environment has suffered some bad press over the last year or so, with reports of some installations failing to generate any electrical output.

The results of the Warwick Wind Trial into the performance of 26 small-scale (< 2 kW) , building mounted turbines were reported in January 2009[17]. The results were generally very disappointing, even with turbines mounted on the roofs of blocks of flats where wind speeds might be expected to be highest (in some cases the turbines actually used more electricity than they produced).

The Energy Saving Trust is currently conducting its own monitoring trial of small-scale wind turbines – due to report during 2009. It is recommended that small-scale wind turbines are not considered for the Blacon Parade Redevelopment, at least until after the results of the Energy Saving Trust trial are published.

4.9 Larger wind turbines

Although, as discussed above, the urban environment of Blacon is not regarded as suitable for small-scale wind turbines, it may be possible to install larger turbines to the west of Blacon. This was highlighted in the earlier report to the BCT by EA Technology[5].

An estimate of the wind resource available is included in Section 5.3. Capital costs (installed) are taken as[6]:

Wind turbine size	50 kW	100kW	1MW
Capital cost	£3,000/kW	£2,500/kW	£1,500/kW

with annual maintenance costs of 1% of capital.

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[17] Final report of the Warwick Wind trial available at www.warwickwindtrials.org.uk

5 Local Renewable Energy Resources

5.1 Biomass fuels

Biomass fuels cover all organic materials that can be used for the generation of energy. The generation can be via direct combustion, gasification or anaerobic digestion. Fuels include:

- Wood materials in the form of logs, chips or pellets
- Waste organic material (often turned into pellets)
- Energy crops
- Food, sewage or agricultural waste (often processed via anaerobic digestion)
- Biodiesel or bio-oil

5.1.1 Biodiesel

Biodiesel can be used for transport or used in small boilers or CHP units. It can be created from waste oils from the food industry. British and European standards regulate the quality and content depending on its use. Care must be taken however that its origin is from sustainable sources and not from crops that cause deforestation or worsen food shortages. There are a number of companies providing biodiesel in the UK. It is unlikely that biodiesel is the most appropriate fuel for Blacon as the boilers and CHP units are likely to be of a size appropriate for solid biomass which is generally cheaper. In the future it may be appropriate for use in other areas of Blacon or for transport. It should be noted that the road fuel tax can be reclaimed for biodiesel used for heating or electricity.

5.1.2 Food, Agricultural and Sewage Waste

With the growing pressure to reduce the bio-degradable element in landfill and new restrictions on the disposal of food waste, companies processing food are looking for new ways to dispose of the waste. One option is to use anaerobic digestion and use the methane produced in boilers or CHP units. There is however no supply chain yet developed in the UK. A similar process can be used for agricultural wastes such as slurries. Transporting and processing the waste and removing the bio-products to and from the centre of Blacon would be logistically difficult.

As part of the Parade is being redeveloped, it may be possible to process sewage waste via anaerobic digestion and use the methane in boilers or CHP. There may, however, be insufficient waste for this to be viable unless sewage from elsewhere in Blacon was included. United Utilities is pioneering work in this area. It would be necessary to work closely with United Utilities to ensure the process was to a high enough standard and there was a system to remove and dispose of all other bio-products.

5.1.3 Energy Crops

Purpose-grown energy crops such as elephant grass or miscanthus can provide a reliable source of fuel although there is generally a 2-3 year lead in time to the first harvest. The fuel can be burnt directly or used via gasification. The crops should be within a maximum of a 20 miles radius for the transportation of crops to be viable. There are no crops currently being grown this close to Blacon and therefore contracts would need to be negotiated with local farmers to start growing the crops.

5.1.4 Wood

By far the most developed biomass fuels in the UK are wood fuels. These come in the form of logs, wood chip or pellets. Logs are only suitable for small wood burners etc. unless processing is carried out on site which may be difficult in an urban environment such as Blacon. Wood chip is cheaper that pellets but pellets are a third the volume and easier to handle. Either form may be suitable for boilers or CHP.

There are a number of websites with contacts for woodchip and pellets suppliers. One example is:

http://www.therenewableenergycentre.co.uk/biomass-and-biofuel/woodchip-log-and-pellet-suppliers/

Two suppliers of pellets close to Blacon are:

http://www.liverpoolwoodpellets.co.uk/ourshop/
http://www.blazersfuels.co.uk/

With the large amount of forestry in Wales and the North West of England, finding a suppler for wood chips or pellets should not be a problem especially for large deliveries. Long-term contracts often offer a better price and provide stability and security of supply. Fewer larger deliveries are generally cheaper and reduce the flow of traffic into the Parade but require more storage space. It is important to ensure that strict standards are written into any contract. Although the transport carbon footprint may be greater, it is better to use fuel from further afield that is of a higher quality, than to use low grade fuel from a source that is closer to Blacon. Details of the minimum fuel standards required should be provided by the boiler manufacturer.

For wood chips, it is possible to stipulate a moisture content and energy value. It may be easier to pay for kWh produced as this incentivises the supplier to deliver dry fuel and reduces the storage volume required as well as providing a high quality fuel.

Pellets should adhere to strict standards on moisture content, energy value, size dust and ash produced. Samples should be sought before any contract is agreed and compensation paid if the quality of the fuel falls below minimum standards.

5.2 Solar

The areas for the various roofs as given below.

	Orientation	Area m2
Blacon Parade East	South	158
Burton Rd Terraces	South	346
Holy Trinity Church	South	135
Holy Trinity Church Hall	South	45
United Reform Church	SouthWest	25
United Reform Church	SouthEast	25
United Reform church retail	South	51
New Community Building	South	1068

plus the new build housing – which could, if desired, be orientated to face south.

There is sufficient roof space on all of the domestic properties to install a $4m^2$ solar thermal panel. This would typically save 50% of the DHW energy use.

In terms of PV, the new Community Building could represent a significant resource. Its $1000m^2$ roof could, depending on the choice of panels (or roof tiles) yield (at 100 kWh / m^2) 100,000kWh per year of electricity. This represents a 111kWp installation, costing approximately £355,000 (assuming a 20% discount for a large installation).

5.3 Wind

The wind resource around Blacon is not very great. Using the UK weathermap at http://www.berr.gov.uk/energy/sources/renewables/explained/wind/windspeed-database/page27326.html
the average wind speed at a height of 10 metres is between 4.7 and 5 m/s. Higher wind speeds are to the west and north of Blacon. At 25 metres, the average wind speeds are between 5 and 5.7m/s. At 45m, the average wind speed is around 6.1m/s.

Compared to the UK as a whole, these average wind speeds are not very high. It should be emphasised that this is an average over a one kilometre square and a well selected site within the area could have a higher wind speed.

Estimates based on weather data for Liverpool Airport suggest that a wind turbine with a nominal capacity of 150kW would generate approximately 243MWh/year[18] (average wind speed of 4.8m/s). The tower of this type of wind turbine is about 30 metres high with a rotor diameter of 27m.

As the wind resource is not that high, a turbine in the megawatt class would be more cost effective. This would also have a greater visual impact - which could be seen as either an advantage (a statement of energy awareness) or a disadvantage (obtrusive). Again using data for Liverpool Airport, a 1.5MW wind turbine would generate 3,205MWh/year (average wind speed of 6.4m/s at 65m). The tower of this type of wind turbine is about 65 metres high with a rotor diameter of 70m.

Without more detailed data on wind speed, or where the turbines could be sited, it is not possible to provide a more detailed analysis.

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[18] RETScreen wind turbine calculation

6 Energy System Analysis

In this section, the results are presented from the analysis of a range of possible low carbon, energy solutions for the Blacon Parade Redevelopment.

Fuel and electricity costs are taken as follows:

Gas	3.5 p/kWh
Electricity	12.5 p/kWh
Electricity exported	6.25p/kWh
Biomass	3.7 p/kWh

whilst CO_2 emission figures are assumed to be[19]:

Gas	0.185 kg CO_2/kWh
Electricity	0.537 kg CO_2/kWh

6.1 Base case

Table 6.1 gives the values for the base case – namely all buildings are supplied with grid electricity and have gas boilers to provide DHW and CH. The energy totals for DHW and CH are the heat requirements, whilst the costs and CO_2 emissions include a boiler seasonal efficiency of 88%.

Table 6.1: Base case costs and CO_2 emissions

	energy (kWh)				cost (£)			CO2 emissions (tonnes)	
	DHW	CH	Electric*		gas	electric		gas	electric
Blacon Parade - East	37,477	128,720	162,595		6,610	20,324		36.3	87.3
Burton Road Terraces	55,939	101,725	55,386		6,271	6,923		34.4	29.7
New houses & apartments	166,361	160,934	203,759		13,017	25,470		71.4	109.4
Trinity Church & hall	966	66,542	10,194		2,685	1,274		14.7	5.5
Reform Church & retail	2,878	32,179	20,065		1,394	2,508		7.6	10.8
New Health/Community	92,551	19,845	287,579		4,470	35,947		24.5	154.4
totals					**126,895**			**586.1**	

* ***Lighting and appliances***

6.2 Use of heat pumps in individual buildings

The analysis of heat pumps with the various buildings and heat sources, as discussed in Section 4.3, resulted in the performance values given in Table 6.2, where ASHP and GSHP refer to Air Source and Ground Source, and ISS to Inter-Seasonal Storage, as discussed in Section 4.7. With Inter Seasonal storage, a higher water source temperature of 22°C is assumed (compared to an assumed 8°C for a normal GSHP). “Underfloor” refers to the use of underfloor heating. In the case of the GSHPs additional pump power of 100W is assumed for the dwellings. This value is scaled up for the new Community Building, with an assumed doubling of the pump efficiency (small domestic pumps tend to be very inefficient), giving an assumed pump power of 1kW.

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[19] BNXS01: Carbon Dioxide Emission Factors or UK Energy Use, Market Transformation Programme, March 2009, www.mtprog.com

Table 6.2: Heat Pump Seasonal Coefficient of Performance (COP)

Houses	**CH**	**DHW**
ASHP + radiators	2.8	2.2
GSHP + radiators	3.3	2.7
GSHP + underfloor	4.5	2.7
GSHP(ISS) + radiators	4.8	3.5
GSHP(ISS) + underfloor	6	3.5
New Community Building		
GSHP + underfloor	5.2	2.8
GSHP(ISS) + underfloor	7.7	3.6

Applying these values to the loads in those buildings where heat pumps appear feasible, results in the values given in Table 6.3. ASHPs are selected for the Burton Road Terraces (limited ground space), whilst the more efficient GSHPs are used for the new buildings. The GSHPs use underfloor heating - a practical solution for new build (but not ISS – ISS is returned to later - see Section 6.7.2).

Table 6.3: Energy and CO_2 emissions with Heat Pumps used in the highlighted buildings (ASHP in Burton Road and GSHP in the new buildings).

	energy (kWh)				cost (£)			CO2 emissions (tonnes)	
	DHW	CH	Electric		gas	electric		gas	electric
Blacon Parade - East	37,477	128,720	162,595		6,610	20,324		36.3	87.3
Burton Road Terraces	25,427	36,330	55,386			14,643			62.9
New houses & apartments	61,615	35,763	203,759			37,642			161.7
Trinity Church & hall	966	66,542	10,194		2,685	1,274		14.7	5.5
Reform Church & retail	2,878	32,179	20,065		1,394	2,508		7.6	10.8
New Health/Community	33,054	3,816	287,579			40,556			174.2
totals					**127,637**			**561.0**	

A small overall reduction is seen in CO_2 emissions, although costs are little changed. The savings are shown in more detail in Table 6.4, in which just the heating costs and emissions are considered. At the assumed fuel prices, the ASHP is actually more expensive to run than the equivalent gas boiler, although both ASHP and GSHP show significant savings in annual CO_2 production (tonnes / year).

Table 6.4: Savings in heating costs and emissions through the use of Heat Pumps

	Base Case			HP Heating			Saving	
	£	CO2		£	CO2		£	CO2
Burton Road Terraces	6,271	34.4		7,720	33.2		-23.1%	3.6%
New houses & apartments	13,017	71.4		12,172	52.3		6.5%	26.8%
New Health/Community	4,470	24.5		4,609	19.8		-3.1%	19.3%

Maintenance costs for heat pumps should be minimal, whilst maintenance contracts for gas boilers tend to be around £100 per year. For the 16 Burton Road properties, this would save £1,600 per year and would be enough to overcome the apparent advantage for gas in running costs. For the 64 new houses and apartments, including the maintenance costs (£6,400 per year) in the annual gas costs, would mean that the GSHP would produce a 37% saving in heating running costs.

The energy performance modelling suggests that the Burton Road houses would require ASHPs with a nominal capacity of 4kW, and the new build dwellings, GSHPs of 3kW. Using the costs from Section 4.3, the individual capital costs are £5,100 and £6,400 respectively, whilst the equivalent cost for a gas boiler system will be around £2,000[6].

6.3 CHP Scenarios

A number of CHP scenarios were analysed, as summarised in Table 6.5.

Table 6.5: Summary of CHP scenarios

Scenario	Heat load	Electricity load	CHP Heat output	back-up heat	CHP electricity output	CHP Energy Input	Electricity Export	Electricity Import		run hours
Community Building - biomass 100 kWe / 250 kWt	112,396	287,579	112,250	0	44,900	191,646	10,950	253,629		449
Community Building - fuel cell 200kWe / 250 kWt	112,396	287,579	112,250	0	89,800	252,563	55,850	253,629		449
Community Building - gas engine 20 kWe / 40 kWt	112,396	287,579	108,520	3,853	54,260	191,506	962	234,282		2,713
Full District heating - biomass 100 kWe / 250 kWt	997,517	739,578	973,000	24,347	389,200	1,661,220	111,427	468,701		3,892
Full District Heating - fuel cell 200kWe / 250 kWt	997,517	739,578	973,000	24,347	778,400	2,189,250	409,904	377,977		3,892
Partial DH - gas engine 20 kWe / 40 kWt	298,303	450,174	220,000	78,287	110,000	388,235	1,779	341,953		5,500

From the very low run hours it is clear that the biomass CHP and fuel cell CHP (as defined in Section 4.2) will not be feasible when just considering the new Community Building. However, if used to feed a District Heating scheme, then run hours increase towards acceptable levels (normally at least 5000 per year is suggested as a target for CHP). The partial CHP scheme covers the new Community Building and the Blacon Parade East block of shops and flats.

6.4 Redevelopment-Wide CHP District Heating

In Table 6.6, the two Redevelopment-wide District Heating (DH) Schemes are compared to the base-case (gas boilers plus mains electricity).

Table 6.6: District Heating applied to the whole Redevelopment area

Scenario	Base Case	Biomass CHP	Fuel cell CHP
Load (kWh / year)			
Heat load	866,117	997,517	997,517
Electricity load	739,578	739,578	739,578
CHP Heat output		973,000	973,000
back-up heat		24,347	24,347
CHP electricity output		389,200	778,400
CHP Energy Input		1,661,220	2,189,250
Electricity Export		111,427	409,904
Electricity Import		468,701	377,977
Costs (£ / year)			
Electricity cost (import)	92,447	58,588	47,247
Electricity export value		-6,964	-25,619
Gas cost	34,448	968	77,592
Biomass cost		61,465	
Total fuel costs	**126,895**	**114,057**	**99,220**
CO2 Emissions (tonnes / year)			
Electricity CO2 (import)	397.2	251.7	203.0
Credit for export		-59.8	-220.1
Gas CO2	182.1	5.1	410.1
Total CO2 emissions	**579.2**	**197.0**	**393.0**

The first point to note is the significant increase in heat load for the DH schemes over the base-case (around 15%). This is the effect of the heat loss from the DH pipe-work (total length assumed as 1 km). The Fuel-Cell CHP unit gives a significant reduction in running costs, whilst the Biomass CHP unit gives, as would be expected, the lowest CO_2 emissions. However, the high heat loss – especially if compared to the heating loads of the new houses and apartments which will form the bulk of the DH network - raises a doubt about the effectiveness of resource use in this example (the heat loss from the DH network calculated here represents 40% of the combined DHW and CH loads of the new houses and apartments).

6.5 Partial District Heating – Gas-Fired CHP or Biomass Boiler

Table 6.7 shows results for a smaller DH network just supplying the new Community Building and Blacon Parade East (shops and flats). The CHP unit is the relatively small Gas-Fired Internal Combustion Engine (20 kW_e / 40 kW_t). Included in this comparison is the use of a Biomass Boiler. The running costs are lowest for the gas CHP engine, and there is a significant reduction in CO_2 emissions (~10%) compared to the base case. However, the biomass boiler gives twice the CO_2 savings.

Table 6.7: Small DH scheme (Parade only)

Scenario	**Base case**	**Gas Engine CHP**	**Biomass Boiler**
Loads (kWh / year)			
Heat load	278,593	298,303	298,303
Electricity load	450,174	450,174	450,174
CHP Heat output		220,000	
back-up heat		78,287	
CHP electricity output		110,000	
CHP Energy Input		388,235	
Electricity Export		1,779	
Electricity Import		341,953	
Costs (£ / year)			
Electricity cost (import)	56,272	42,744	56,272
Electricity export value		-111	
Gas cost	11,080	16,702	
Biomass cost			12,985
Total fuel costs	**67,352**	**59,335**	**69,257**
CO2 Emissions (tonnes / year)			
Electricity CO2 (import)	241.7	183.6	241.7
Credit for export		-1.0	
Gas CO2	58.6	88.3	
Total emissions	**300.3**	**271.0**	**241.7**

Table 6.8 just compares the costs and CO_2 emissions for heating. For the CHP system, the income from electricity generation (both in terms of reduced import and export) is credited against the gas cost. Similarly the saving in CO_2 emissions due to electricity generation is credited against the emissions from burning gas.

Table 6.8: Comparison of heating costs – small DH scheme

	Gas Heating			LZC Heating			Saving	
	£	CO2		£	CO2		£	CO2
Parade DH - Biomass boiler	11,080	60.8		12,985	0.0		-17.2%	100.0%
Parade DH - gas CHP	11,080	60.8		3,063	29.2		72.4%	51.9%

LZC = Low & Zero Carbon technology

The modelling suggests a biomass boiler capacity of around 150 kW is required for this scheme which gives a capital cost (from Section 4.1) of £97,500. Given this high capital cost, a more pragmatic solution would be to specify a slightly smaller biomass boiler and supplement this with gas boilers. For example a 100kW biomass would supply 97% of the annual heat demand, and cost approximately £70,000 (plus a cost of, say £4,000 for 2 relatively small back-up gas boilers).

Maintenance costs for the biomass boiler are estimated at 2% of the capital cost – i.e. £2,000 per year for the 150kW boiler and £1,400 per year for the 100kW boiler. This will more or less offset the cost of maintaining gas boilers in both new Community Building and the maisonettes in Blacon Parade East (12 maisonettes at £100 per year plus the Community Building gas boiler maintenance).

For the CHP unit, the costs (Section 4.2.3) are £30,000 plus a supplementary boiler (say £4,000 as above). Maintenance costs are estimated as £2,000 per year.

Thus the biomass boiler would cost some £40,000 more than the gas engine CHP unit, but would save an additional 30 tonnes per year in carbon. Unless a smaller biomass CHP unit can be found (at reasonable cost) then the biomass boiler offers the best option here, at least in terms of CO_2 reductions.

6.5.1 Biomass Boiler space requirements

Generally, each kilogram of wood pellets will provide 4.9kW/h of heating and a 1m³ of storage space will accommodate 600 to 650kg of wood pellets[20]. Therefore on this basis about 97m³ would be required for the full annual storage for the recommended scheme. Obviously deliveries would be on a more frequent basis than this. Assuming monthly deliveries (at least over the winter), a typical winter month would require about 12 m³.

An example of plant room[21] accommodating this size of storage, along with boiler and accumulator, would be about 6m long, by 2.4m wide by 2.6m high, giving a requirement of around 15m^2 of floor area.

Good vehicle access will be required for the pellet deliveries.

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[20] http://www.hoval.co.uk

[21] http://www.res-group.com/media/155491/carno.pdf

6.6 Recommended scheme: Parade DH (biomass boiler) with ASHPs in Burton Road and GSHPs in new build dwellings

Table 6.9 show results for combining the small DH scheme, i.e. the new Community Building and Blacon Parade East, with heat pumps for ASHPs for the Burton Road terrace and GSHPs for the new build dwellings (as discussed in Section 6.2).

Table 6.9 Parade DH with biomass boiler, plus heat pumps (ASHP in Burton Road and GSHP in the new housing)

	energy (kWh)				cost (£)			CO2 emissions (tonnes)	
	DHW	CH	Electric		fuel	electric		fuel	electric
Parade DH - biomass boiler	298,303		450,174		12,985	56,272			241.7
Burton Road Terraces	25,427	36,330	55,386			14,643			62.9
New houses & apartments	61,615	35,763	203,759			37,642			161.7
Trinity Church & hall	966	66,542	10,194		2,685	1,274		14.7	5.5
Reform Church & retail	2,878	32,179	20,065		1,394	2,508		7.6	10.8
totals					**129,403**			**505.0**	

For ease of comparison, Table 6.10 restates the base case (Section 6.1) with the individual values for the new Community Building and Blacon Parade East combined as single totals.

Table 6.10 Base case (Table 6.1) with New Community Building & Blacon Parade East as combined totals

	energy (kWh)				cost (£)			CO2 emissions (tonnes)	
	DHW	CH	Electric		gas	electric		gas	electric
Parade (East plus West)	278,593		450,174		11,080	56,272		60.8	241.7
Burton Road Terraces	55,939	101,725	55,386		6,271	6,923		34.4	29.7
New houses & apartments	166,361	160,934	203,759		13,017	25,470		71.4	109.4
Trinity Church & hall	966	66,542	10,194		2,685	1,274		14.7	5.5
Reform Church & retail	2,878	32,179	20,065		1,394	2,508		7.6	10.8
totals					**126,895**			**586.1**	

Overall, the running costs increase slightly – although as noted above, the heat pumps will give savings in terms of maintenance costs, whilst the maintenance costs for the Parade DH scheme will be little changed from those for the new Community Building and Blacon Parade East both heated by gas boilers. There are, however, substantial savings in CO_2 emissions for the proposed scheme compared to the base case (a 13.8% reduction).

The electricity consumption due to lights and appliances etc. is unchanged between the base case and the proposed scheme – the additional electricity consumption in the proposed scheme being solely due to the use of heat pumps. As can be seen in the summary in Table 6.11, lights and appliances account for over 70% of the total running costs and CO_2 emissions for the proposed scheme.

Table 6.11: Summary of electricity costs and emissions for lights and appliances as a percentage of the total running costs

	Lights & applicances			Totals			% of total	
	£	CO2		£	CO2		£	CO2
Proposed scheme	92,447	397.2		129,403	505.0		71.4%	78.6%
Base case	92,447	397.2		126,895	586.1		72.9%	67.8%

Removing these electricity costs shows that the proposed scheme saves over 40% of the CO_2 emissions due to heating the entire Redevelopment area.

Table 6.12: Percentage savings for heat loads alone

	Base case			Proposed scheme			Saving	
	£	CO2		£	CO2		£	CO2
Whole redevelopment area	34,448	189.0		36,956	107.8		-7.3%	42.9%

6.6.1 Capital cost summary

Table 6.13 summarises the capital costs presented previously for the small Parade DH scheme and the associated boilers, and the individual dwelling heat pumps. The estimated DH cost is based on 13 terraced dwellings (i.e. the maisonettes) together with the cost per dwelling from Section 4.5.

Table 6.13: Summary of capital costs for the proposed scheme

	Number	size kW	cost	total
			£	£
Parade DH - biomass boiler	1	100	70,000	70,000
- back-up boilers	2	30	2,000	4,000
- DH scheme	13	-	5,300	68,900
Burton Road Terraces	16	4	5,128	82,048
New houses & apartments	64	3	6,376	408,064
Avoided gas boiler costs (new build only)	64	-	2,000	-128,000
Total				**505,012**

This represents a capital cost of £6,235 per tonne of CO_2 saved.

6.7 Modifications to recommended scheme

We shall now consider a number of modifications to this recommended scheme.

6.7.1 Solar Thermal

As discussed in Section 5.2, solar thermal installations to the new housing (if orientated to face south), Blacon Parade East and the Burton Road Terraces, could reduce the DHW demand in these properties by around 50%.

Table 6.14: Proposed scheme with solar thermal DHW production

	energy (kWh)				cost (£)			CO2 emissions (tonnes)	
	DHW	CH	Electric		fuel	electric		fuel	electric
Parade DH - biomass boiler	279,565		450,174		12,169	56,272			241.7
Burton Road Terraces	12,713	36,330	55,386			13,054			56.1
New houses & apartments	30,808	35,763	203,759			33,791			145.2
Trinity Church & hall	966	66,542	10,194		2,685	1,274		14.7	5.5
Reform Church & retail	2,878	32,179	20,065		1,394	2,508		7.6	10.8
totals					**123,148**			**481.6**	

Applying the 50% reduction to the DHW totals, results in the values given in Table 6.14. Thus we see that CO_2 emissions are reduced from 505 tonnes per year to 481.6 tonnes per year – a reduction of 4.7%. Running costs reduce from £129,403 per year down to £123,143 (4.8%).

Solar thermal would be retrofitted to the 13 maisonettes / flats in Blacon Parade East and the 16 houses in Burton Road. Thus, using a capital cost of £4,500 per dwelling and applying a 20% discount for mass installations – the capital cost for the retrofits is £104,400. For the 64 new build properties, the total cost, at £3,700 per collector and again applying a 20% discount for mass installation), is £189,400.

Thus for a total cost of £293,800 the CO_2 emissions are reduced by 23.4 tonnes per year (Cost per tonne £12,500), with a reduction in running costs of £6,260.

6.7.2 Inter-Seasonal Energy Storage

The concept of Inter-seasonal Energy Storage (ISS) was introduced in Section 4.7. The benefit of this system is that it will enable a higher source temperature for the GSHPs and hence a higher COP – see Section 6.2, Table 6.2: Heat Pump Seasonal Coefficient of Performance (COP). Applying the enhanced COP values to the Proposed Scheme (Table 6.9) results in the following (Table 6.15):

Table 6.15: Parade DH with biomass boiler, plus heat pumps (ASHP in Burton Road and ISS-GSHP in the new housing)

	energy (kWh)				cost (£)			CO2 emissions (tonnes)	
	DHW	CH	Electric		fuel	electric		fuel	electric
Parade DH	298,303		450,174		12,985	56,272			241.7
Burton Road Terraces	25,427	36,330	55,386			14,643			62.9
New houses & apartments	47,532	26,822	203,759			34,764			149.3
Trinity Church & hall	966	66,542	10,194		2,685	1,274		14.7	5.5
Reform Church & retail	2,878	32,179	20,065		1,394	2,508		7.6	10.8
totals					**126,525**			**492.6**	

Running costs are reduced by £2,880, with CO_2 emissions down by 12.4 tonnes. Both reductions are small when looked at across the entire Redevelopment area, however it represents savings of 23% in the heating loads in the new houses.

An additional advantage of this type of scheme is that it could supply cooling, if required, at very low energy inputs (as can GSHPs). The only likely air-conditioning load is within the new Community Building – although there is a strong possibility that this could, with careful design, be avoided. However, the enlarged convenience store will have some refrigeration loads which could reject heat to the ISS.

Some form of solar collector is required to charge the ISS in the summer, for use during the winter. Information provided by ICAX[22] is that the use of an ICAX Asphalt Collector is much cheaper than a rooftop collector for the equivalent yield (i.e. using either the car parking area in front of the parade or the resurfaced roads around the new housing). Furthermore, ICAX claim that the total capital cost for the system (solar collector, ISS, controls and reduced capital costs for smaller heat pumps) could be less than that for an equivalent multiple installation of GSHP with bore holes.

The suggested scheme would also require distribution pipes around the new housing to feed the individual heat pumps. More work is required to determine the practicalities of the ISS scheme, and to decide whether it should focus on just the new build housing (as suggested here) or on the new Community Building or even the Redevelopment area as a whole.

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[22] http://www.icax.co.uk/ - suppliers of complete ISS systems

6.7.3 Photovoltaic Electricity Generation

As discussed in Section 5.2, the new Community Building could represent a significant resource for Photovoltaic (PV) Electricity Generation. The estimated yield of 100,000kWh per year (for a 111kWp installation, costing approximately £355,000) would reduce the CO_2 emissions by 53.7 tonnes per year and produce an income (assuming all is credited at 12.5p/kWh) of £12,500.

Currently renewable electricity generation attracts additional payments – know as ROCs or Renewable Obligation Certificates. Each ROC is currently worth approximately £50/MWh (5p/kWh), and PV attracts payments of 2 ROCs per MWh. Thus ROC payments would increasing the annual income to £22,500 (see Appendix E for more information on ROCs).

Hence a capital cost of £355,000 would save 53.7 tonnes per year of CO_2 (£6,600 per tonne) and produce an income of £22,500 per year.

6.7.4 Large wind turbine

Returning to the two examples of Section 5.3 and using the capital costs outlined in Section 4.9, the performance and costs for wind turbines installed on the western edge of Blacon will be approximately as set out in Table 6.16. Annual income assumes that the electricity is exported onto the network, achieving a value of 6.25p/kWh[*]. Annual income also includes a ROC payment of 1 ROC per MWh (i.e. an additional 5p/kWh).

Table 6.16: Wind turbine costs and performance

Nominal Size	Capital cost (£)	Generation (MWh/year)	CO2 saved (tonne/year)	Income (£/year)	Maintenance Cost (£/year)
150kW	375,000	243	130.5	27,338	3,750
1.5MW	2,250,000	3,205	1721.1	360,563	22,500

In terms of the capital cost per tonne of CO_2 saved, large scale wind is amongst the most cost effect of the LZC technologies. Even in Blacon, where the wind resource is not high, the costs per tonne are £2,900 and £1,300 for the 150kW and 1.5 MW machines respectively. However, these have to be balanced against the lifetime of the device – reference 6 suggest a lifetime of 10 years as against 40 years for PV.

If land could be found for a turbine of this size, careful community consultation would be needed to avoid hostility. Planning permission may be harder to obtain for a larger turbine and adverse reactions from local residents could further slow the planning process.

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[*] If it could be demonstrated that this electricity is used to offset electricity used in the Redevelopment area, then, theoretically, it could be valued at the standard electricity price, assumed here to be 12.5p/kWh. See later discussions on Feed-In Tariffs (Section 7.1) and Electricity Sale and Purchase (Section 7.2.2).

6.8 Summary of Energy System Analysis

The above analysis has resulted in a proposed scheme estimated to reduce CO_2 emissions for heating by 80 tonnes per year, approximately 40% of the emissions due to heating compared to the base case of gas heating. This scheme (Table 6.9) consists of:

- a biomass boiler serving a small District heating network comprising the new Community Building and the Blacon Parade East shops and maisonettes
- Air Source Heat Pumps for the Burton Road terraces
- Ground Source Heat Pumps for the new housing and apartments

It assumes that the existing buildings are refurbished to a high standard as set out in Section 2.4. The scheme would cost in the order of £505,000.

The economic case for the ASHP is not overwhelming, but is likely to improve with the introduction of a Renewable Heat Incentive as discussed in below in Section 7.1. The proximity of Burton Road to the new Community Building may mean that extending the proposed DH scheme to include Burton Road is also worth considering.

Of the modifications to this scheme considered in Section 6.7, both the Inter-Seasonal Energy Storage (ISS) and the use of PV look promising.

ISS appears to be capital cost neutral compared with the proposed scheme, although much design work will be required to confirm this. It will, however, give an improvement in running costs for the new build housing (and any other buildings that it might serve).

An array of PV panels on the roof of the new Community Building would offset 53 tonnes of Carbon per year and would provide an income of £22,000 per year for a capital cost of £355,000. In view of the relative cost effectiveness of this, it is worth considering expanding the PV area to include Blacon Parade East (and possibly, in time, other buildings).

Large-scale wind is also a possibility, although it would be remote from the immediate environs of the Blacon Parade Redevelopment.

The energy performance of the two Churches, and associated hall and retail property, can be significantly improved through fabric improvements (Section 2.4.3) but have not been included in any of the recommended LZC schemes. Both have good quality modern condensing boilers and these are felt to give a good solution for these properties. The Holy Trinity Church,, with its 135m^2 south facing roof, would be a good location for subsequent PV installations.

Depending on the outcome of further investigation into the practicalities of ISS, there is the possibility that one or both of the Churches and / or associated properties could be included in a ISS based DH scheme using GSHPs.

Currently the Blacon Parade East retail is not heated, except by ad-hoc use of electric heaters and the heat radiated from appliances. We believe that the best approach here is to upgrade to include Central Heating, and to use modern, accurate, controls to ensure that use is minimal when internal gains are high.

7 Commercial Implications

As illustrated above, there are many possible ways of introducing low and zero carbon energy technologies into the Blacon Parade Redevelopment. Some, such as solar thermal or Air Source Heat Pumps, are simple, dwelling-by-dwelling, building-by-building, initiatives. Others, such as the District Heating schemes, are more complex. Irrespective of the level of complexity, however, achieving the best outcome, in terms of capital costs and fuel bills, will require collective organisation and cooperation with both residents and businesses.

The setting up of an Energy Services Company (ESCo) is likely to be the most appropriate vehicle for achieving a sound, low-energy, low-carbon strategy, facilitating the introduction of renewable technologies across the development, and spreading the benefits to all involved.

The following sections explore the economic issues that will be important to the Blacon Redevelopment, the commercial arrangements that will be required and the possible ESCo organisational structure that could emerge. This is a very fluid area, as:

- the Government imposed frameworks for encouraging the use of low & zero carbon technologies are currently under review, and are scheduled to change within the next year;
- the choice of technologies, and the scale of application, will impact on the economics and, possibly, the most appropriate commercial arrangements;
- the regulatory position regarding ESCos is in the process of changing, and, although the present system does not allow many of the possible benefits to be realised, this could change in future[*].

7.1 Feed-In Tariffs and Renewable Heat Incentives

The Energy Act 2008 included enabling powers for the introduction of a new range of incentive payments for energy generated by decentralised, renewable, technologies. The payment will provide the owner of the energy generating device with an income for each kWh of energy generated. The new incentives will be:

- A feed-in tariff for small-scale electricity generation (up to 5MW)
- A renewable heat incentive
- An incentive for the feeding of bio-methane into the gas mains

A Government Consultation on the nature of these tariffs is to take place in the summer of 2009, with the feed-in tariff for electricity generation time-tabled for introduction in April 2010 and the renewable heat incentive in April 2011.

Some important points to note are:

- The introduction of both the feed-in tariff and the renewable heat incentive will have a major impact on the cost effectiveness of all renewable electricity and renewable heating measures, including biomass CHP and biomass District Heating.

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[*] Ongoing work in Ashton Hayes, near Chester, has dealt with the issues surrounding the development of community energy organisations in much greater detail. If the Blacon Parade is redeveloped, it may be possible to incorporate the redevelopment into this innovative work.

- The level (p/kWh) of the feed-in tariff and the renewable heat incentive are likely to be different for each of the technologies, and may have a large impact on the choice of technology for a particular circumstance.

- It is expected that the feed-in tariff will apply to both biomass driven and fossil fuel driven CHP, although at a higher level of payment for biomass. Biomass CHP will attract payments for both the electricity generated (feed-in tariff) and the heat generated (renewable heat incentive).

- Renewable heat incentives will apply to solar thermal and biomass heating. It will also apply to heat pumps, even though, arguably, heat pumps are not a renewable technology, since they are driven by electricity from the grid.

- Payments for single dwelling applications, particularly heat, may be "deemed" rather than measured (metered) – i.e. based on an assumed annual production rate.

The figure below illustrates how some see the tariffs being applied[23].

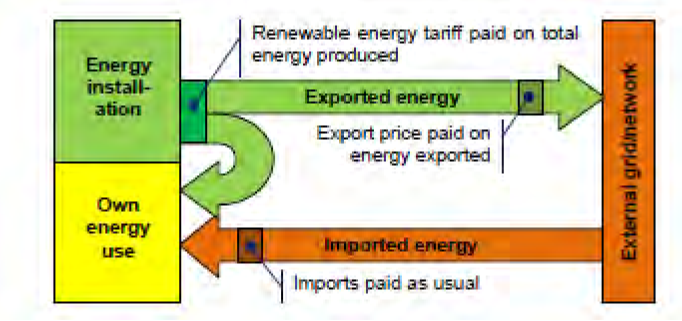

Figure 7.1: Feed-in tariff plus export payment

In this scenario, producers receive both the Renewable Energy Tariff and an export payment for any energy exported to the external network. They also use the generation to reduce the energy they import from the external network.

An alternative approach, as already in use in countries such as Germany, gives a payment for export. If the level of the tariff is set higher than the normal tariff for importing energy into the property (as it is with PV tariffs in Germany), then the following arrangement will be adopted.

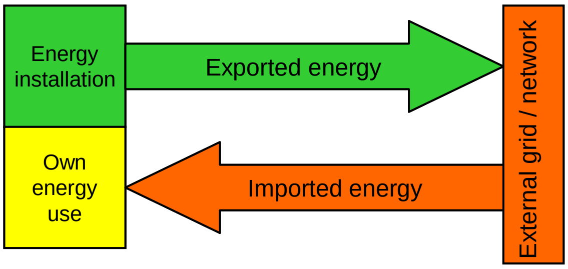

Figure 7.2: Feed-in tariff with no additional export payment

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[23] "Renewable Electricity and Heat Tariffs - Preliminary Blueprint, Renewable Energy Association and Stake Holder Working Groups, March 2009

In this case the householder or building operator would receive a bill (in the case of electricity) of:

[normal import electricity tariff x amount consumed] - [feed-in tariff x amount generated]

This is the approach advocated in the recent Conservative Party Policy Green Paper[24].

If the arrangement of Figure 7.1 is adopted, owners of the generation plant will be incentivised to use as much of the generation output as possible themselves[+]. In the second arrangement, Figure 7.2, the payments will be the same, regardless of whether or not the owner consumes the generated energy themselves.

Ownership models and arrangements for buying and selling energy locally may also be affected.

It is too early to state, at this stage, the exact impacts on the Blacon Parade Redevelopment, and a close eye should be kept on developments in this area.

For renewable electrical generation with a nominal output below 5 MW, the Feed-In Tariff is expected to replace the revenue stream currently available from Renewable Obligation Certificates (ROCs). ROCs will remain for larger generation, and possibly for community scale generation if the ROC payments exceed the Feed-In Tariff payments. For completeness, more details of the current ROC arrangements are provided in Appendix E.

7.1.1 Biomass to Gas conversion – Injection tariff

An interesting side note on the issues of renewable energy tariffs, is the proposal to provide a feed-in incentive for injecting bio-methane into the National Gas Grid. National Grid have estimated that up to 50% of domestic gas use could be met through bio-derived methane[25], greatly reducing the CO_2 emissions from mains gas. Depending upon the level of this incentive, this could increase the demand for the limited biomass resources that are available.

7.2 Energy Sales & Purchase

Despite the uncertainty surrounding Feed-In Tariffs and the Renewable Heat Incentive, it is expected that some form of local ESCo(s) will be required, that will coordinate the Sale and Purchase of energy for the whole, or a part of, the community. This is particularly apparent for schemes which involve the distribution of heat, either through a District heating scheme, or within a single multi-purpose, multi-occupancy, building, such as the proposed new Community Building.

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[24] "The low carbon economy, security, stability and green growth" Policy Green Paper No.8, The Conservative party, February 2009

[+] This would encourage the use of Demand Side Management (DSM). For completeness, some notes on DSM are included in Appendix D, along with a brief discussion of the related subject of metering.

[25] "The potential for renewable gas in the UK, NationalGrid, January 2009, available at: http://www.nationalgrid.com/uk/Media+Centre/Documents/biogas.htm

7.2.1 Heat

If one or more large boilers or CHP units were to be installed, the ESCo would sell the heat to each of the users. To discourage peaks in heating loads, the cost of heat at different times of day could be varied, with multi-register heat meters recording the use during each time / price period.

An interesting question is raised by the possibility of inter-seasonal storage and the use of a low temperature District Heating mains coupled to GSHPs. Here the ESCo will have incurred costs (both capital costs and the cost of running the central pumps). Two possibilities for recovering these costs from the end users are:

- sell heat to the properties (i.e. the ESCo owns and pays the running costs of the GSHPs and the heat output from the GSHPs is metered);
- the GSHP electricity consumption is metered separately from the rest of the consumption, and the end-users pay a different electricity tariff for the GSHP than for normal consumption.

In either approach, the ESCo can profit from the increased efficiency that the thermal storage provides, rather than the properties with GSHPs getting the benefit of the ISS for ‘free’.

7.2.2 Electricity

If Feed-In Tariffs take the form illustrated in Figure 7.2, then the ESCo would not become directly involved with the supply of electricity to the properties within the Redevelopment Area. The owner of each generator, would obtain the Feed-In payments. Where the ESCo itself is the owner, the ESCo would obtain the Feed-In payments and redistribute these to relevant parties within the community, or reinvest in more renewable technologies or energy efficiency measures, as appropriate. Each individual consumer would be billed against their consumption by whichever Electricity Supply Company (e.g. ScottishPower, nPower etc. etc.) they choose to be supplied by. The ESCo could, feasibly, negotiate a discounted Supply Tariff on behalf of interested consumers, from the Supply Company the ESCo itself deals with.

If Feed-In Tariffs take the form illustrated in Figure 7.1, then the maximum benefit from the generation would be obtained by minimising all Export. Conceptually, the simplest way of achieving this is through a Private Wire arrangement.

With a Private Wire arrangement, all electricity consumers within the Redevelopment Area would be connected to a local network, which, in turn, would be connected to the wider network owned by the Distribution Network Operator (DNO) – i.e. ScottishPower Energy Networks in the case of Blacon. As much of the locally produced generation as possible would be used within the Private Wire network, with any surplus, plus any shortfall that would need to be imported onto the Private Wire, being metered by a single Half-Hourly meter (registering both import and export) at the point of connection between the Private Wire network and the DNO owned network.

The ESCo would sell the surplus generation to, and buy the shortfall from, one of the large Licensed Electricity Suppliers. The ESCo would then bill the individual consumers for their consumption, and share out, or reinvest as appropriate, any profits arising from the Feed-In payments from the generation.

In order to minimise export from the Private Wire network, it maybe necessary to encourage changes in consumption patterns so that the electricity is used as and when it is generated.

This can be achieved through a combination of Demand Side Management and Smart Meters – see Appendix D.

Whilst the Private Wire arrangement would seem to be suitable for the Blacon Parade Redevelopment, recent judgements in the European courts on competition law have raised doubts over the arrangements for electricity supply that can be made on private networks. Ofgem (the Energy Industry Regulator) and the Government will be consulting in spring 09 with regard to arrangements for Private Wires networks. The situation will remain uncertain until this process is completed.

Even without a Private Wire arrangement, it is technically possible to use half-hourly metering to demonstrate that local generation is being used locally. However, work with the Ashton Hayes community has shown that this is unlikely to be workable, for the foreseeable future, within current electricity market arrangements. Current advice is, therefore, that the ESCo owned exported generation should be sold to one of the large Licensed Energy Supply companies. Individual consumers would buy their imported power from a Supplier of their choice – although the ESCo could, feasibly, negotiate a discounted rate on behalf of interested consumers from the Supply Company it deals with.

Thus, the picture for the Sale and Purchase of Electricity is currently unclear, and will remain so until the Government decides on the form that Feed-In tariffs will take, and, if they take the form of Figure 7.1. what, if any, restrictions will be applied to Private Wire arrangements.

7.3 Ongoing Expenditure

There is often a misconception that renewable energy is ‘free’. However, an ESCo will need to deal with the following types of expenditure and allow for these when setting its budgets and deciding on how to price the energy. The types of expenditure are:

- Capital costs including connection costs
- Possibly buying additional power from a supplier (depending on the model adopted).
- Cost of fuel (e.g. biomass)
- Maintenance costs
- Overheads for the ESCo

The first thing to consider is the capital costs associated with setting up the scheme. The costs of the generation equipment will obviously depend on the details of the scheme and the financing of the redevelopment as a whole. There may however be loans to repay, and the terms of such loans available may determine the viability of the scheme.

For the times when there is insufficient locally generated power, the ESCo could pay for power from a licensed supplier, negotiating on behalf of its members. This is likely to be offset against the value of the electricity sold to the licensed supplier, although the value of the import and the export may differ, depending on the terms of the agreement. There are a number of reasons for this differential, including the costs incurred in transporting the electricity to the end consumer, and the wholesale price which fluctuates significantly across a day

The ESCo must take into account the cost of fuel for biomass boilers or CHP units. Long term contracts generally provide the best deals and price stability. It is important that contracts have minimum standards for the quality of the biomass.

All technologies will incur maintenance costs. These may not be significant and, in the early years, many manufacturers will cover the costs as part of a warranty or equivalent. It is possible to agree maintenance contracts, with a flat fee, for boilers and CHP systems.

The ESCo must cover the day-to-day administrative costs of running a business, such as processing bills and payments, bills for professional advice (i.e. lawyers, accountants, etc) and dealing with any queries.

7.4 ESCo Organisational Structure

At present it is unclear what the commercial arrangements for the redevelopment of the Parade will be. It is expected that at least some of the heating and electrical generation will be owned and operated by an ESCo. This could be Sustainable Blacon Limited, or a subsidiary there of, or it could be a separate Community ESCo with its own ownership and voting structure.

Care must be taken to ensure that the residents and other stakeholders (such as local businesses, finance providers, local councils, etc) feel that they have input into the ESCo. This will cover both how equipment is managed and maintained, and how the energy and/or profit it produces is distributed.

If Sustainable Blacon Limited were to become the ESCo, the ESCo structure would have to be compatible with Sustainable Blacon's existing structure as a limited company. Control over the ESCo would be through some kind of share ownership or other voting rights. It is likely that the Constitution or Articles of Association adopted will define how the ESCo is accountable, but it is important to ensure that the community understands how this will work.

Should Sustainable Blacon decide to setup the ESCo as a distinct organisation from itself (either completely separately or as a subsidiary), it could be formed as a different type of organisation if this would be more appropriate to its purpose. There are a number of different legal formats that could be considered and these are outlined in Appendix F.

Whichever route is adopted to establish the ESCo, detailed legal advice will be needed.

7.5 Services Agency

Recent work with the community in Ashton Hayes has identified that one way of simplifying the organisation for community schemes is to set up a Services Agency. This organisation could organise billing and maintenance on behalf of a number of community ESCo schemes. It could also provide support in the form of setting up local organisations, finding funding, providing legal advice (e.g. ensuring any metering complied with relevant standards), and dealing with queries. By organising such services for a number of communities, not only would the process be simplified, but costs would be reduced through economies of scale.

8 Electricity Network Issues

8.1 Connections to the public electricity system

The UK has a reliable public electricity system and it is therefore unwise to attempt to operate as an islanded system independent of it, especially in an urban environment. The additional control and storage required to provide the equivalent level of quality of supply would far outweigh any benefits.

The local distribution network operator (DNO) owns and operates the public electricity distribution system. It is important to discuss plans for new generation with the local DNO at the earliest possible stage. This will help highlight any particular problems with connecting to the distribution system at the Blacon Parade which may allow mitigating measures to be built into the design.

The main problems that may occur when connecting generation to the network are:

- Voltage rise – normally voltage falls due to the load on the network. Generation can cause the voltage to rise above legal limits.
- Thermal limits – each circuit has a maximum current it can carry continuously under normal conditions.
- Fault level - the maximum current that the system can withstand if a fault occurs on the network.

As the Blacon Parade is in an urban environment with a robust cable network, it is unlikely that generation will cause issues with voltage rise or reach the thermal limits of the system (this usually only occurs on rural overhead systems). On urban networks, however, the maximum fault level could be reached if a large amount of generation is connected to the network. Increasingly, small-scale generation is now often connected through invertors. The use of an invertor reduces the current produced during a fault, possibly avoiding this issue.

In general however the following points should born in mind:

- Connection to the LV (Low Voltage - i.e. the 230V domestic supply) network is generally cheaper than at higher voltages e.g. 11kV.
- Accredited single generators under 16A per phase connected to the LV network (i.e. 3.7kW per phase) can be connected by approved fitters and then the DNO informed. These generators are approved under Engineering Recommendation G83/1. Permission must be sought for multiple installations of G83/1 approved generators in one area (for example in an existing street or new housing developments).
- It is likely that Blacon would want to connect larger generators, or a cluster of generators, for which the G83/1 standard does not apply. These must be designed to the G59 industry standard.
- It may be cheaper to connect a number of generators through one meter and one connection to the network. This requires just one design for the connection to the network and potentially cuts the cost of the equipment required.
- If there are plans for expansion of the generation in future, it may be cheaper to apply for connection for the maximum capacity expected in the future, rather initiate a second connection process at a later date.

Anyone wishing to connect to the distribution network must pay for the additional equipment that may be required to allow this to happen. If some equipment is shared between different generators connecting to the network, then these costs may be shared according to ‘cost apportionment rules’. However, it is unlikely that additional equipment will be required for connection to the LV network in an urban environment such as the Blacon Parade. This may also be the case for connections at 11kV. It is likely, given that there are already a number of shops in the Blacon Parade area, that the thermal limit is high, and there is a strong connection to the rest of the network. Any improvements to the network that are required should be made during the redevelopment, thus cutting costs.

Some connection design and installation work can be carried out by approved contractors rather than the DNO. Once the installation work is completed, the DNO will ‘adopt them’ and own and maintain them. All design work by third parties must be approved by a DNO. The DNO will make a connection offer detailing the terms and conditions of the connection with which the generator must comply. This offer is normally valid for 3 months.

EA Technology can provide further advice on connection design and appropriate metering requirements if the scheme proceeds.

8.2 Private Wires Network

The possibility of using a Private Wire arrangement was raised in Section 7.2.2. As it is planned to completely redevelop part of the Parade, this may offer quite a practicable solution and could result in running cost advantages - depending on the outcome of the Government’s deliberations over feed-in tariffs. In a Private Wires arrangement the DNO would not ‘adopt’ the network. This would result in the maintenance and safety responsibilities resting with whoever owned the wires (this could be the ESCo). However, these responsibilities could be subcontracted to a third party with the relevant expertise. The advantage of a private wires network is that more innovative metering arrangements could be carried out within the private wires network as discussed previously in Section 7.2.2.

9 Implications for SMEs

One of the many advantages to schemes such as the Blacon Redevelopment is that it could be used to encourage the start-up and growth of local Small and Medium Enterprises (SMEs). This section discusses possible areas for SME encouragement and the energy use implications on SME operations of accommodation within a modern, well designed, multifunctional building.

9.1 Local Suppliers

Several of the proposed LZC options will require involvement of (ideally, local) trades-people:

- Insulation / building upgrade contractors;
- Heat Pump installers;
- PV installers;
- Solar thermal installers – although not a strongly favoured option within this study, inclusion of some solar thermal may be a good way of show-casing the technology and encouraging others within the wider Blacon area to take-up the technology.

9.2 Energy Information Centre

Locating an Energy Information Centre within the new Community building is to be strongly recommended. This will help disseminate information about what the Redevelopment is hoping to achieve (has achieved) in terms of energy and Carbon emissions, and encourage others within the wider Blacon community to consider their own possible actions.

The Energy Information Centre would have live displays of energy use, generation (PV output) and carbon impact within the new Community Building and which will encourage occupants to be mindful of their own actions in reducing energy use and encourage progress towards Zero Carbon businesses.

The inclusion of a bio-mass boiler within the redevelopment will require a competent person to take responsibility for operation of the boiler and the logistics of accepting fuel deliveries. There would be some merit in including the energy information centre brief within this person’s remit.

9.3 SME Energy Use

If we assume 950m^2 of the new Community Building is to be for SME use, then this would create approximately:

- 700m^2 of useful office / work-space area which would be available (allowing 250m^2 for corridors, communal areas, facilities etc);
- 14 SME offices / work-spaces (at 50m^2 per work-space);
- 20 SME jobs (at an average of 1 – 2 people for work-space).

This represents a departure from the assumptions used in the modelling (where the need for both a convenience store and a health centre would reduce the space available for SMEs). However, to provide some rough figure it is felt to be a reasonable starting point at this stage, pending further information about this building.

Table 9.1 provides a comparison of the energy costs and emissions associated with an SME occupying the new Community Building and one occupying existing building stock (labelled “Current”). This assumes that the 14 SME work-spaces each contribute equally to the energy bills for the 950m^2 of the new Community Building and that the current SMEs occupy a similar area (including an allowance for facilities). The two electricity values are based on an assumption of good quality lighting (new building) and poor lighting (Current) using values from the DesignBuilder modelling tool (see Section 2.3.2). The Heat value for the current SME situation is taken as the average of the middle and end shops in Blacon Parade East (Section 2.4.1 Table 1). The output from the PV panel in the new Community Building is assumed to assigned to individual occupants on the basis of overall floor area.

Table 9.1: SME comparison of Energy use

	Area	Heat	Electric	PV - output
Community Building				
per m2	1	29	75	26
per SME	68	1,968	5,089	1,781
Current				
Standard / m2	1	90.5	110	-
per SME	68	6,141	7,464	-

Table 9.2 compares the energy costs and CO2 values assuming that the heating for the Current SMEs is by gas boilers with a SPF of 65% and the new Community Building is heated by a Biomass boiler (as in recommended in Section 6.6).

Table 9.2: SME comparison of Energy Costs and Emissions

	Heating		Electricity		Generation		Totals	
	£	CO2	£	CO2	£	CO2	£	CO2
SME - Community Building	86	0	636	2.7	-401	-1.0	321	1.8
SME - current	331	1.8	933	4.0	0	0	1,264	5.8

Both running costs and CO_2 emissions are reduced by over 70%.

9.4 Replication

The Blacon Parade arrangement of small shops and apartments is very typical of urban housing estates in the North West – in Chester alone there are at least 5 such groupings of buildings. Whilst the details will be location dependant, the basic philosophy of upgrades to sound existing buildings, adding new buildings where appropriate and including an Energy Centre to house (for example) a biomass boiler and be the focal point for PV installations, is sound and could be readily and widely spread-out across the North West to the benefit of local SMEs.

10 Conclusions & Future Work

The Blacon Parade Energy Study has investigated a wide range of options for reducing energy use and CO_2 emissions from the area.

- Improvements to the fabric and electricity use in those existing buildings that will remain after the Redevelopment is completed, have been modelled. These show significant improvements are both possible and practicable.
- The new build housing and Community Building have also been modelled to enable energy use profiles to be generated for the entire Redevelopment area.
- Based on these profiles, a number of Low and Zero Carbon (LZC) schemes have been investigated.

The scheme with the lowest CO_2 emissions will be a full, redevelopment-wide, District Heating (DH) network supplied by a biomass CHP unit. However, we do not recommend this scheme for the following reasons

- The redevelopment-wide DH network will introduce significant heat losses, increasing the energy use – especially when considered as a percentage of the heat loads of the new housing.
- Available biomass CHP units will be both expensive and not optimally sized for the redevelopment.

The scheme recommended here is a pragmatic approach based on:

- A small DH network encompassing the new Community Building and the existing, but refurbished, Blacon Parade east – this is to be supplied by a biomass boiler located at the new Community Building;
- Air Source Heat Pumps (ASHP) for the Burton Road terraces;
- Ground Source Heat Pumps (GSHP) for the new housing and apartments.

Such a scheme would reduce CO_2 emissions for heat provision by over 40% compared to the Base Case of utilising high efficiency gas boilers throughout. The scheme would cost in the order of £505,000.

The economic case for the ASHPs is poor, but is likely to improve with the introduction of a Renewable Heat Incentive. However, the proximity of Burton Road to the new Community Building may mean that extending the proposed DH scheme to include Burton Road is worthy of consideration as an alternative.

A further recommendation is to incorporate as much PV electricity generation into the new Community building (south facing roof areas) as possible – preferably through fabric integrated PV panels (assuming these prove to be the most cost effective).

A final recommendation is to investigate further the practicalities of Inter-Seasonal Energy Storage (ISS). Initial investigation suggest that this will be capital cost neutral compared to GSHPs, but will improve the performance.

There are currently a number of significant unknowns in the plans for the Redevelopment concerning the size, layout and use of the proposed new Community Building. Hence, calculations presented here should be treated with some caution, although as initial estimates they are believed to be sound, and can be scaled, to a reasonable approximation, if floor areas change.

As explained in Section 7, the economic case for LZC technologies is strongly affected by whatever incentive payments are available. These payments are likely to change within the next year. In particular, the Renewable Heat Incentive, when introduced, will improve the economic case for both biomass boilers and heat pumps. Existing ROC payments for electricity will be replaced by a new Feed-In tariff. These are expected to be as high, if not higher, than ROC payments and so are not expected to detract from the case made here for the inclusion of PV.

10.1 Actions required

10.1.1 New Community Building

The new Community Building has a fundamental impact on the recommendations for the whole redevelopment. Plans need to be advanced to confirm sizes, layouts and types of use. This study has highlighted a number of issues that should be included in the design process for this new building.

- Include Mechanical Ventilation and Heat Recovery – preferably on a local zone basis with control via occupancy sensors;
- Electricity use is likely to be significant and to dominate CO_2 emissions. Efforts should be made to incorporate natural light (light-pipes are recommended here).
- Incorporate high levels of PV;
- Investigate cooling loads for both space comfort and the refrigerated display cabinets in the convenience store. Both should be minimised through good design (e.g. doors on refrigerated cabinets). If cooling loads prove to be significant, then the lowest energy cost solution is likely to be the use of GSHPs (with or without ISS) – indeed the actual heat pump will not need to operate (just a pump to circulate the cold water from the ground loops).
- Include in the planning process both a space allowance and delivery access for a biomass heating system.

10.1.2 ESCo

The formation of an Energy Services Company is not strictly necessary at this stage. However, an ESCo is best placed to deal with two important issues associated with the recommended schemes:

- The supply of heat to both the multi-tenanted new Community Building and to Blacon Parade East;
- Issues surrounding the ownership of, and the share-out or reinvestment of income from, the PV installation.

10.1.3 Electricity Network Operator involvement

Early stage discussions should take place with Scottish Power Energy Network to inform them of the likely impacts of inclusion of PV within the Redevelopment.

10.1.4 Inter-Seasonal Storage

Initial investigations have suggested that this is a highly promising LZC technology. However, cost information is vague, in part because it will be dependant upon both ground conditions (the type of rock bed) and the availability of suitable un-shaded Asphalt surfaces to use as heat collectors. It is suggested that the new car parking area in front of the new Community Building maybe suitable for this.

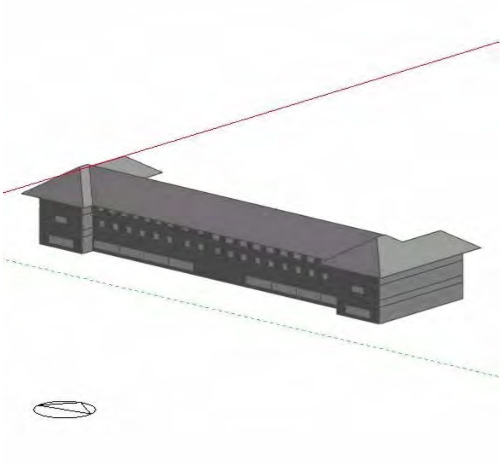
It is recommended that the design team undertake early stage discussions with the suppliers of ISS systems.

10.1.5 Monitoring

Thought should be given at an early stage to the monitoring that should be undertaken, both to provide feed-back to users and to demonstrate the effectiveness of the technologies employed.

Appendix A Modelling Details and Assumptions

East Parade Maisonettes



Number of units	**9**
Unit TFA	**79.7m2**
Usage	**Residential**
Occupancy	**0.03 people/m2**
Heating set point	**20 ºC**
DHW	**1.47 lites/m2/day**

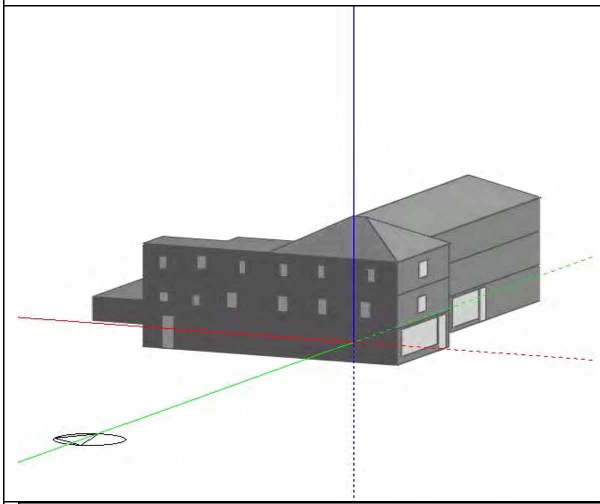
Present Modelling Elements

Element	Description	Value
Wall construction (1st floor)	Solid brick with 50mm internal insulation	0.571 W/m2-K
Wall construction (2nd floor)	Solid brick with 50mm internal insulation but with outer slate façade.	0.470 W/m2-K
Floor (above shops)	Concrete with timber flooring,	0.449 W/m2-K
Roof	Slate with roofing felt.	5.306 W/m2-K
Semi exposed ceiling	Plasterboard with 100mm glass wool.	0.373 W/m2-K
Openings	Double glazed	2.771 W/m2-K
Lighting	Reference setting with no lighting controls.	7 W/m2
Infiltration rate		1 ac/h
Heating System	Gas back boiler	0.65 SPF

Proposed Modelling Elements

Element	Description	Value
Wall construction (1st floor)	Solid brick with 100mm internal insulation	0.332 W/m2-K
Wall construction (2nd floor)	Solid brick with 100mm internal insulation but with outer slate façade.	0.306 W/m2-K
Floor (above shops)	Concrete with timber flooring,	0.449 W/m2-K
Roof	Slate with roofing felt.	5.306 W/m2-K
Semi exposed ceiling	Plasterboard with 275mm glass wool.	0.142 W/m2-K
Openings	Triple glazed	0.911 W/m2-K
Lighting	Best practice setting with lighting controls.	5 W/m2
Infiltration rate		0.75 ac/h
Heating System		1 SPF

East Parade End Flats



Number of units	**2**
Unit TFA	**200m2**
Usage	**Residential**
Occupancy	**0.02 people/m2**
Heating set point	**20 ºC**
DHW	**0.98 lites/m2/day**

Each unit comprises of - on the 1st floor a two bedroomed flat and on the 2nd floor a three bedroomed flat.

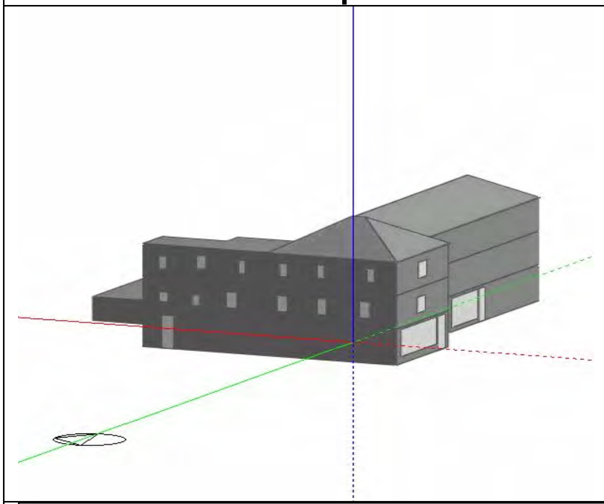
Present Modelling Elements

Element	Description	Value
Wall construction (1st floor)	Solid brick with 50mm internal insulation	0.571 W/m2-K
Wall construction (2nd floor)	Solid brick with 50mm internal insulation	0.571 W/m2-K
Floor (above shops)	Concrete with timber flooring,	0.449 W/m2-K
External floor	Uninsulated wooden floor with external rendering	2.244 W/m2-K
Roof	Slate with roofing felt.	5.306 W/m2-K
Flat roof	Bitumen/Ply 120mm EPS	0.307 W/m2-K
Semi exposed ceiling	Plasterboard with 100mm glass wool.	0.373 W/m2-K
Openings	Double glazed	2.322 W/m2-K
Lighting	Reference setting with no lighting controls.	6.6 W/m2
Infiltration rate		1 ac/h
Heating System	Gas back boiler	0.65 SPF

Proposed Modelling Elements

Element	Description	Value
Wall construction (1st floor)	Solid brick with 100mm EPS internal insulation	0.332 W/m2-K
Wall construction (2nd floor)	Solid brick with 100mm EPS internal insulation	0.332 W/m2-K
Floor (above shops)	Concrete with timber flooring,	0.449 W/m2-K
External floor	Uninsulated wooden floor with external rendering	2.244 W/m2-K
Roof	Slate with roofing felt.	5.306 W/m2-K
Flat roof	2006 Part L building regs flat roof	0.169 W/m2-K
Semi exposed ceiling	Plasterboard with 275mm glass wool.	0.142 W/m2-K
Openings	Triple glazed	0.786 W/m2-K
Lighting	Best practice setting with lighting controls.	5.5 W/m2
Infiltration rate		0.75 ac/h
Heating System		1 SPF

East Parade End Shops



Number of units	**2**
Unit TFA	**137m2**
Usage	**General retail**
Occupancy	**0.11 people/m2**
Heating set point shop	**20 ºC**
Heating set point shop store	**16 ºC**
DHW	**0.2 lites/m2/day**

Each unit comprises of a front shop with a rear store area which also contains a toilet and kitchen area.
Shop/store area ratio about 3.5:1
Assuming that three people work in the shop and require 10 litres/person/day of DHW.

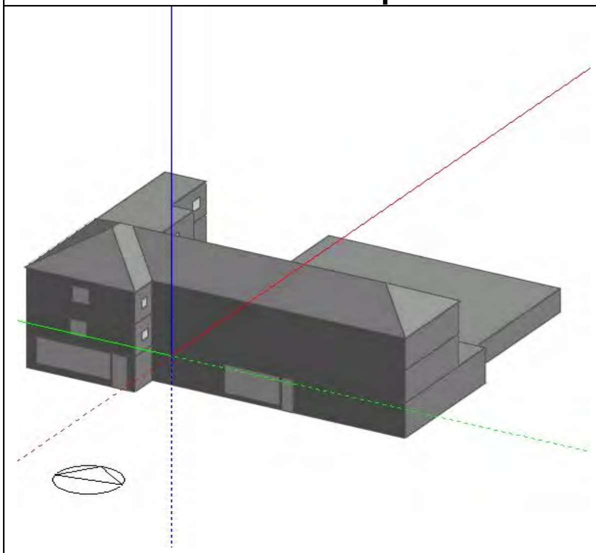
Present Modelling Elements

Element	Description	Value
Wall construction	Uninsulated heavyweight	1.498 W/m2-K
Ceiling	Concrete 300mm	2.823 W/m2-K
Ground floor	Uninsulated Heavyweight	1.463 W/m2-K
Internal partitions	Concrete wall 400mm	2.703 W/m2-K
Openings	Single glazed	6.148 W/m2-K
Lighting	Reference setting with no lighting controls.	19.5 W/m2
Infiltration rate		2 ac/h
Heating System	Electric heaters	1 SPF

Proposed Modelling Elements

Element	Description	Value
Wall construction	Heavyweight with 140mm EPS	0.242 W/m2-K
Ceiling	Concrete 300mm with 50mm EPS	0.306 W/m2-K
Ground floor	Heavyweight with 50mm EPS	0.552 W/m2-K
Internal partitions	Concrete wall 400mm	2.703 W/m2-K
Openings	Double glazed	1.951 W/m2-K
Lighting	Best practice setting with lighting controls.	15 W/m2
Infiltration rate		1.3 ac/h
Heating System		1 SPF

East Parade Middle Shops



Number of units	**10**
Unit TFA	**139m2**
Usage	**General retail/Food retail**
Occupancy	**0.11 people/m2**
Heating set point shop	**20 ºC**
Heating set point shop store	**16 ºC**
DHW	**0.2 lites/m2/day**

Each unit comprises of a front shop with a rear store area which also contains a toilet and kitchen area. The store area to the rear of the building is not the same for all units but has been averaged out.
Shop/store area ratio about 1:1.1
The electrical element for the food retail units was increased after the shops were modelled. The increased consumption was taken from benchmark figures[2] and then applied equally over the electrical profile. Assuming that three people work in the shop and require 10 litres/person/day of DHW.

Present Modelling Elements

Element	Description	Value
Wall construction	Uninsulated heavyweight	1.498 W/m2-K
Ceiling	Concrete 300mm	2.823 W/m2-K
Flat roof	Asphalt with 145mm glass wool insulation	0.25 W/m2-K
Ground floor	Uninsulated Heavyweight	1.463 W/m2-K
Internal partitions	Concrete wall 400mm	2.703 W/m2-K
Openings	Single glazed	6.148 W/m2-K
Lighting	Reference setting with no lighting controls.	13.8 W/m2
Infiltration rate		2 ac/h
Heating System	Electric heaters	1 SPF

Proposed Modelling Elements

Element	Description	Value
Wall construction	Heavyweight with 140mm EPS	0.242 W/m2-K
Ceiling	Concrete 300mm with 50mm EPS	0.306 W/m2-K
Flat roof	Asphalt with 270mm glass wool insulation	0.14 W/m2-K
Ground floor	Heavyweight with 50mm EPS	0.552 W/m2-K
Internal partitions	Concrete wall 400mm	2.703 W/m2-K
Openings	Double glazed	1.951 W/m2-K
Lighting	Best practice setting with lighting controls.	9.8 W/m2
Infiltration rate		1.3 ac/h
Heating System		1 SPF

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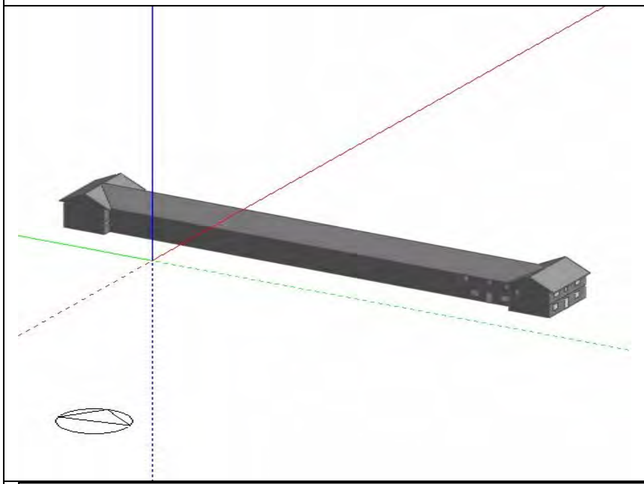
[2] Energy Benchmarks TM46:2008 - CIBSE.

Burton Road Middle and End Terraces



Number of mid terrace units	**12**
Number of end terrace units	**4**
Mid terrace TFA	**68 m2**
End terrace TFA	**63 m2**
Usage	**Residential**
Occupancy	**0.04 people/m2**
Heating set point	**20 ºC**
DHW	**1.8 lites/m2/day**

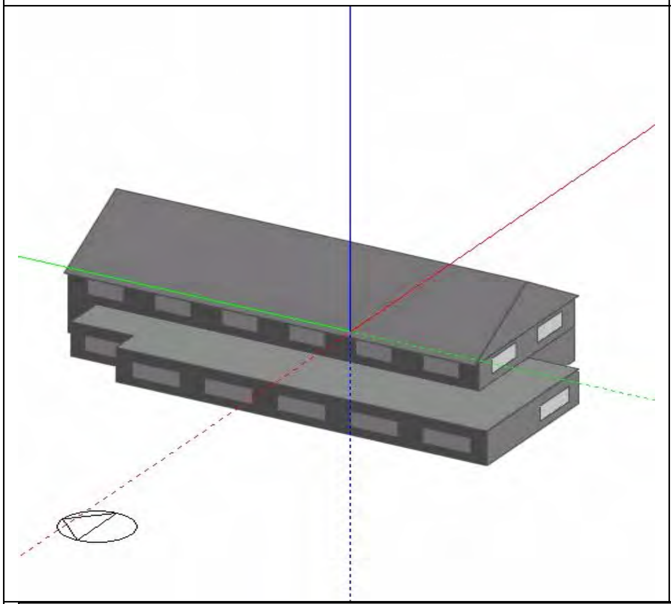
Present Modelling Elements

Element	Description	Value
Wall construction	Filled cavity	0.474 W/m2-K
Ground floor	Uninsulated slab	4.376 W/m2-K
Partition walls	Single brick plasterboard	1.993 W/m2-K
Semi exposed ceiling	Plasterboard with 200mm glass wool.	0.374 W/m2-K
Openings	Double glazed	2.78 W/m2-K
Lighting	Reference setting with no lighting controls.	8.1 W/m2 – End 7.4 W/m2 - Mid
Infiltration rate		1 ac/h
Heating System	Gas boiler	0.75 SPF

Proposed Modelling Elements

Element	Description	Value
Wall construction	Filled cavity with 50mm EPS	0.296 W/m2-K
Ground floor	Uninsulated slab	4.376 W/m2-K
Partition walls	Single brick plasterboard	1.993 W/m2-K
Semi exposed ceiling	Plasterboard with 275mm glass wool.	0.142 W/m2-K
Openings	Triple glazed	0.786 W/m2-K
Lighting	Best practice setting with lighting controls.	6.5 W/m2 – End 5 W/m2 - Mid
Infiltration rate		0.75 ac/h
Heating System		1 SPF

Holy Trinity Church



TFA **611 m2**
Usage **Day centre meeting room.**
Occupancy **0.2 people/m2**
Heating set point **20 ºC**

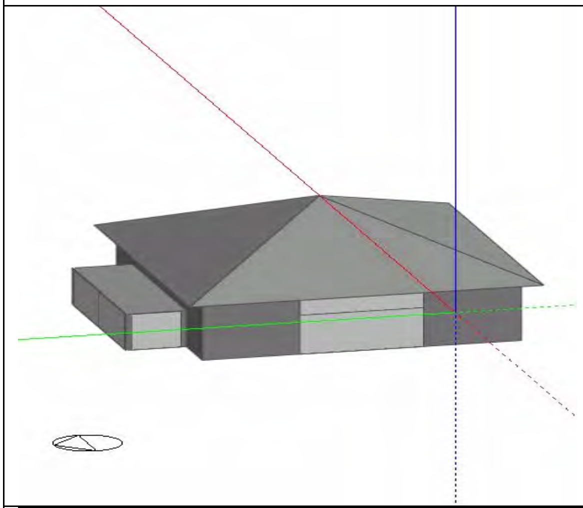
Present Modelling Elements

Element	**Description**	**Value**
Wall construction	Cavity wall	1.421 W/m2-K
Ground floor	Uninsulated medium weight	1.463 W/m2-K
Roof	Slate with cement panels.	2.643 W/m2-K
Flat roof	Uninsulated	1.54 W/m2-K
Openings	Single Glazing	6.144 W/m2-K
Lighting	Low standard with no lighting controls.	15 W/m2
Infiltration rate		2 ac/h
Heating System	Gas boiler	0.75 SPF

Proposed Modelling Elements

Element	**Description**	**Value**
Wall construction	Cavity wall with 50mm EPS	0.499 W/m2-K
Ground floor	Uninsulated medium weight	1.463 W/m2-K
Roof	Slate with cement panels with 50mm EPS	0.601 W/m2-K
Flat roof	Insulated with 200mm glass wool	0.169 W/m2-K
Openings	Single Glazing	6.144 W/m2-K
Lighting	Best practice with lighting controls.	9.9 W/m2
Infiltration rate		1.5 ac/h
Heating System		1 SPF

Holy Trinity Church Hall



TFA	**313 m2**
Usage	**Day centre meeting room**
Occupancy	**0.2 people/m2**
Heating set point	**20 ºC**
DHW	**0.4 litres/m2/day**

Assuming that the hall will require on average 120 litres of hot water per day.

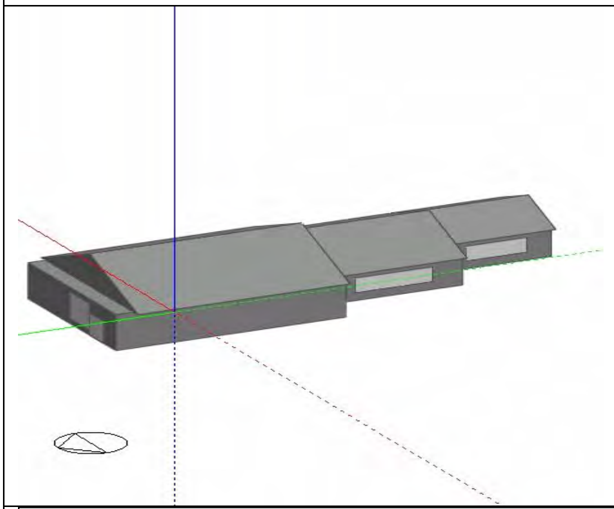
Present Modelling Elements

Element	Description	Value
Wall construction	Cavity wall uninsulated	1.834 W/m2-K
Ground floor	Uninsulated medium weight	1.463 W/m2-K
Semi exposed ceiling	Ceiling with 200mm glass wool.	0.193 W/m2-K
Flat roof	Insulated with 160mm EPS	0.235 W/m2-K
Openings	Glazing	1.978 W/m2-K
Lighting	Low standard with no lighting controls.	7 W/m2
Infiltration rate		1 ac/h
Heating System	Gas boiler	0.9 SPF

Proposed Modelling Elements

Element	Description	Value
Wall construction	Cavity wall uninsulated with 50mm EPS	0.541 W/m2-K
Ground floor	Uninsulated medium weight	1.463 W/m2-K
Semi exposed ceiling	Ceiling with 275mm glass wool.	0.142 W/m2-K
Flat roof	Insulated with 160mm EPS	0.235 W/m2-K
Openings	Triple Glazing	0.786 W/m2-K
Lighting	Best practice with lighting controls.	7 W/m2
Infiltration rate		0.75 ac/h
Heating System		1 SPF

United Reform Church



TFA	**367 m2**
Usage	**Day centre meeting room**
Occupancy	**0.2 people/m2**
Heating set point	**20 ºC**
DHW	**0.3litres/m2/day**

Assuming that the church will require on average 120 litres of hot water per day.

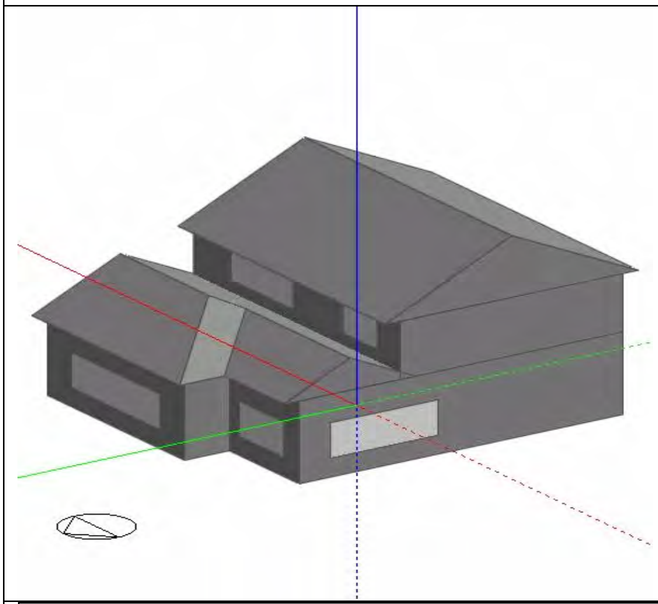
Present Modelling Elements

Element	Description	Value
Wall construction	Cavity wall uninsulated	1.834 W/m2-K
Ground floor	Insulated concrete floor	0.250 W/m2-K
Semi exposed ceiling	Ceiling with 132mm glass wool.	0.250 W/m2-K
Pitched roof	Unisulated	2.930 W/m2-K
Flat roof	Insulated with 145mm glass wool	0.250 W/m2-K
Openings	Double Glazing	2.708 W/m2-K
Lighting	Low standard with no lighting controls.	18.9 W/m2
Infiltration rate		2 ac/h
Heating System	Gas boiler	0.9 SPF

Proposed Modelling Elements

Element	Description	Value
Wall construction	Cavity wall uninsulated with 50mm EPS	0.541 W/m2-K
Ground floor	Uninsulated medium weight	1.463 W/m2-K
Semi exposed ceiling	Ceiling with 275mm glass wool.	0.132 W/m2-K
Pitched roof	Unisulated	2.930 W/m2-K
Flat roof	Insulated with 275mm glass wool	0.138 W/m2-K
Openings	Triple Glazing	0.786 W/m2-K
Lighting	Best practice with lighting controls.	8.4 W/m2
Infiltration rate		1.5 ac/h
Heating System		1 SPF

United Reform Church Retail Unit



TFA	**224 m2**
Usage	**Retail/Office**
Occupancy	**0.11 people/m2**
Heating set point	**20 ºC**
DHW	**0.4 litres/m2/day**

Assuming that ten people work in this unit and require 10 litres/person/day of DHW.

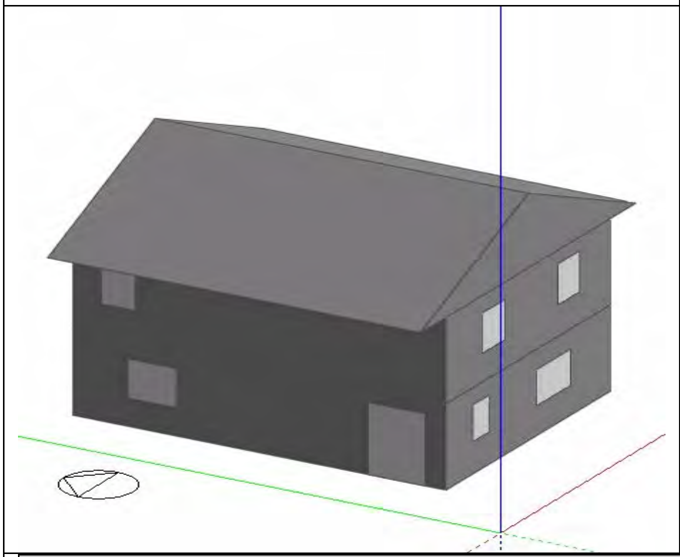
Present Modelling Elements

Element	Description	Value
Wall construction	Insulated cavity wall	0.350 W/m2-K
Ground floor	Insulated concrete floor	0.250 W/m2-K
Semi exposed ceiling	Ceiling with 132mm glass wool.	0.250 W/m2-K
Pitched roof	Unisulated	2.930 W/m2-K
Openings	Double Glazing	2.708 W/m2-K
Lighting	Low standard with no lighting controls.	25 W/m2
Infiltration rate		1ac/h
Heating System	Gas boiler	0.75SPF

Proposed Modelling Elements

Element	Description	Value
Wall construction	Cavity wall uninsulated with 50mm EPS	0.242 W/m2-K
Ground floor	Uninsulated medium weight	1.463 W/m2-K
Semi exposed ceiling	Ceiling with 275mm glass wool.	0.132 W/m2-K
Pitched roof	Unisulated	2.930 W/m2-K
Openings	Triple Glazing	0.786 W/m2-K
Lighting	Best practice with lighting controls.	18.9 W/m2
Infiltration rate		1.5 ac/h
Heating System		1 SPF

New Residential

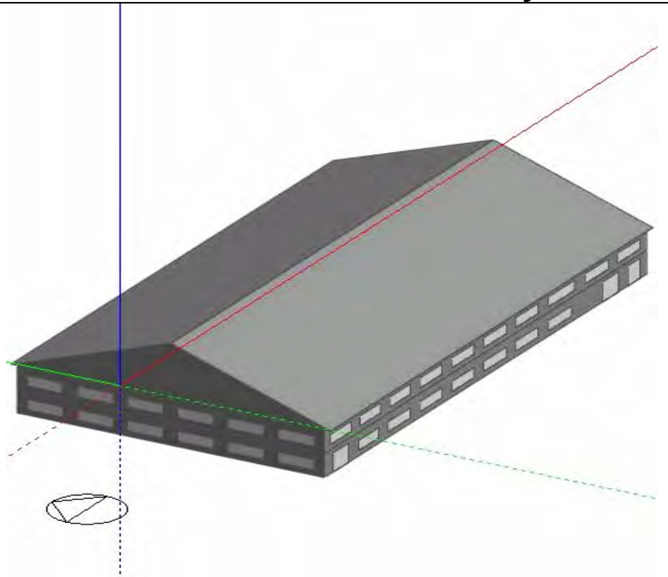


TFA	**63 m2**
Usage	**Residential**
Occupancy	**0.04 people/m2**
Heating set point	**20 ºC**
DHW	**1.96 lites/m2/day**

Modelling Elements

Element	Description	Value
Wall construction	Super Insulated cavity wall	0.14 W/m2-K
Ground floor	Insulated concrete floor	0.15 W/m2-K
Semi exposed ceiling	Ceiling with 132mm glass wool.	0.250 W/m2-K
Openings	Triple glazing Glazing	0.15 W/m2-K
Lighting	Best practice with lighting controls.	3.2 W/m2
Infiltration rate		0.3ac/h
Heating System		1 SPF

New Health Centre and Community Facilities



TFA	**3811 m2** **956m2 Com/fac** **2855m2 Health**
Usage	**Health Centre/Offices/Shop**
Occupancy	**0.11 people/m2 for all offices, shop and reception space.** **0.03 people/m2 rest.**
Heating set point	**20 ºC**
DHW	**1.3 lites/m2/day**

Best Practice Modelling Elements

Element	Description	Value
Wall construction	Best practice heavyweight	0.25 W/m2-K
Ground floor	Best practice heavyweight	0.15 W/m2-K
Semi exposed ceiling	Best practice	0.15 W/m2-K
Openings	Triple glazing Glazing	0.15 W/m2-K
Lighting	Best practice with lighting controls.	16.5 W/m2
Infiltration rate		0.3ac/h
Heating System		1 SPF

Appendix B

The Code for Sustainable Homes

The Code for Sustainable Homes is an environmental impact rating system for houses in England. Launched on December 13, 2006, as a successor to the Buildings Research Establishment's Ecohomes rating scheme.

The code measures the 'whole home' as a complete package, assessing its sustainability against nine categories

- Energy /CO2
- Water
- Materials
- Surface water run-off
- Waste
- Pollution
- Health and well-being.
- Management
- Ecology

The Code uses a 1 to 6 star rating system to show overall sustainability performance of a new home. It sets minimum standards for energy and water use at each level.

The levels of energy efficiency for the code (standard percentage better than Part L1A of the 2006 Building Regulations) are –

Code Level 1 10%
Code Level 2 18%
Code Level 3 25%
Code Level 4 44%
Code Level 5 100%*
Code Level 6 A zero carbon home.18%

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* Zero emissions in relation to Building regulations issues (i.e. zero emissions from heating, hot water, ventilation and lighting).

Appendix C

Example of a Thermal Storage System for Sustainable Housing

A social housing scheme in West London[26], comprising 128 new dwellings located in 5 buildings with an approximate total area of 8,500m², is claimed to be the UK's first example of an aquifer thermal storage system.

The technology works by extracting cold water (at approx 11.5°C) from a borehole in the summer months and using it to provide direct cooling. The energy cost is that of pumping only. In winter, the process is reversed. The heat generated by cooling the homes in summer months is discharged into a second borehole, creating a warm water field. When flow is reversed in the autumn/winter, this warmer water provides heating to the building, either directly or indirectly via heat pumps. The scheme utilises both a 'hot' and a 'cold' borehole to prevent any imbalance across the aquifer as there is no depletion of water over the year.

Two 600mm diameter boreholes were sunk to a depth of 80m at a distance of 50m apart, thereby eliminating cross contamination between the hot and cold fields. These two boreholes alone are claimed to satisfy the heating and cooling demands of all the apartments within the development.

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[26] http://www.fulcrumfirst.com/pages/News/westwaybeaconsresearchtoreality.htm

Appendix D

Demand Side Management

Depending on the outcome of the Government's decision on how Feed-In Tariffs are to be set, it may be beneficial for customers to be encouraged to vary their electricity loads throughout the day in-line with the available generation – the aim being to use as much of the generated electricity within the development (this specifically refers to the Feed-In Tariff arrangement shown in Figure 7.1 in Section 7.1). To achieve this it will be important to be able to move load to different times of the day. This type of load modification is known as Demand Side Management (DSM).

Residents may not be available, or necessarily aware, of when to switch load on or off and, therefore, manual switching will not be very effective. Thus, for demand side management to be practical, loads need to be switched automatically. If automatic DSM can be implemented, it may be of benefit to the poorest in society who can, via simple behavioural changes, cut the cost of electricity by using it at cheaper times of the day.

There are a number of ways to implement automatic demand side management. These can be divided into different categories. For possible applications in Blacon the following categories may be suitable:

- Time switches
- Devices to allow remote switching to turn off devices that are normally on.
- Devices to allow remote switching to turn on devices that are normally off. Generally there is a fixed period within which the load must be run but an optimum time(s) within the period can be selected.

Time switches are useful to run loads at a time when it is known that the average load will be low, for example during the night. If there is a large amount of photovoltaic generation, time switches could be used to ensure there is sufficient load during the day to match the generation. Likewise, if a CHP unit must be run at a particular time to provide heat, load can be switched on at these times. In general however, it is difficult to use time switches to match intermittent load and generation.

Devices that remotely switch loads off can be triggered if the load in an area is greater than the generation. If all the generation and load is on one feeder or fed from one transformer, measuring the power flow at the start of the feeder or through the transformer could detect when the load is greater than the generation. If there is significant power flow into feeder or transformer, the generation is less than the demand. This is the trigger to switch off loads. If the power flow reverses loads can be switched back on. There may be a time limit to the duration that a load can remain switched off. Preferably, load switching should be staggered to prevent sudden drops in power. To install such a system, the DNO would have to agree to allow the installation of a monitoring device on their feeder.

Devices that remotely switch on loads can be triggered if the load in an area is less than the generation. If all the generation and load is on one feeder or fed from one transformer, measuring the power flow at the start of the feeder or through the transformer could detect when the load is less than the generation. If there is significant power flow into feeder or transformer, the generation is greater than the demand. This is the trigger to switch on loads. The types of loads that could be switched on are dishwashers, washing machines, bread makers etc. Most of these types of load will need to run within a set time period – for example within 24 hours. To install such a system the DNO would have to agree to allow the installation of a monitoring device on their feeder.

There is no device specifically designed to turn loads off or on as described above however there are many systems that carry out similar tasks that could be adapted.

There are a number of systems to control loads on a site wide basis particularly for industrial sites that have highly developed energy management systems. Other manufacturers are focused more at the residential market. Although domestic systems concentrate on timers, motion sensors and security, some now also incorporate smart plugs that can be switched remotely. These would need to be triggered by a signal from a unit monitoring the power flow into or out of the feeder. Alternatively there are systems developed for utilities to manage their networks and monitor network conditions. In some cases these incorporate both control of loads and small-scale generation. The choice of system will be determined by price and the level of control, accuracy and reliability required. The more expensive systems will allow logic programming for example to ensure loads operate during a set period. Cheaper systems are likely to have less reliable communications.

To improve the energy efficiency of the retail and health centre buildings an energy management system may be appropriate and this could form the basis of an automatic DSM system.

Appendix E

Renewable Obligation Certificates

Renewable Obligation Certificates (ROC) scheme is a support mechanism for each MWh of renewable power generated. The large licensed energy suppliers are obliged to provide an increasing percentage of their power from sources that have these certificates or pay a “buy-out” or fine. The money from any fines is distributed to those who have certificates. Suppliers buy ROCs from renewable power generators and there is a market in the certificates. Suppliers who have more certificates than they need can sell to those who do not have enough. The minimum price for ROCs is the “buy-out” price set each year by Ofgem. The market price of the ROCs is higher as money from the “buy-out” is distributed to those with ROCs. ROCs are issued for all renewable electricity generation (not just that exported to the public network).

The number of ROCs received by different technologies varies.

Small wind (under 50kW)	2 ROC/MWh
Onshore wind (>50kW)	1 ROC/MWh
Photovoltaics	2 ROC/MWh
Hydro<50kW	2 ROC/MWh
Biomass CHP	2 ROC/MWh

If generation is connected through a single invertor to the public network, the different sources will probably need to be metered separately for ROC purposes.

OFGEM is responsible for issuing ROCs, as the administrator of the Renewables Obligation[27]. They can then be sold on, either as part of a contract with a licensed supplier or can be auctioned on-line[28]. There is an administrative cost for using the electronic auction facility. Note also that the price for ROCs on the auction may go up or down. Alternatively, an agent can be employed to aggregate ROCs from a number of small generators. This aggregation could also be performed by the Services Agency.

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[27] This document provides further information on ROCs (http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Documents1/publication%20draft%20microgeneration09.pdf) and is specifically targeted at smaller schemes (<50kW). The RO is updated on an annual basis and it is therefore important that communities check OFGEM’s website to ensure they have the most up-to-date information on the scheme.

[28] See http://www.nfpa.co.uk

Appendix F

Legal Formats for an ESCo

Limited Company

This is the most frequently adopted corporate structure. It can be limited by shares or guarantee and will look slightly different depending upon which approach is taken. It is a relatively flexible model that can be adapted to fit most circumstances.

Social Enterprise

Social Enterprises are businesses set up to tackle a specific social or environmental need, with profits made being reinvested back into the business. They can be private companies (as discussed above), cooperatives (see below) or Community Interest Companies (CICs).

Community Interest Company

CICs are a relatively new model for limited companies that wish to operate for the benefit of the community, rather than shareholders. There are a number of clauses that must be included in the organisation's constitution (or equivalent) and which are subject to stricter than normal rules on the treatment of assets. They are regulated by the CIC regulator to ensure that they do not deviate from this model and more information can be found on the regulator's website[29].

The legal model for a CIC has been specifically developed for social enterprises to provide a quick and easy model for setting up this type of organisation. Templates for the documents required to set up a CIC are available from the regulator's website to minimise the inconvenience. It also has the benefits of being based on the basic company model which is known and understood in the business world, whilst safeguarding the company's assets to ensure they are used for the community's benefit.

Co-operative

The International Co-operative Alliance defines a co-operative organisation as "*an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise*"[30].

There are seven key principles that an organisation must abide by to be considered a cooperative (Voluntary and Open Membership; Democratic Member Control; Member Economic Participation; Autonomy and Independence; Education, Training and Information; Co-operation among Co-operatives; and Concern for Community). Further information on co-operatives can be found on the Co-operatives UK website[31].

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[29] http://www.cicregulator.gov.uk/index.shtml

[30] http://www.cooperatives-uk.coop/Home/miniwebs/miniwebsA-z/whatIsACo-operative/co-operativeIdentity

[31] http://www.cooperatives-uk.coop

Development Trust

The Development Trust Association defines development trusts as "*organisations which are engaged in the economic, environmental and social regeneration of a defined geographical area*.[32]" Whilst they are referred to as Trusts, there is no standard legal form for the organization and they can use one of the other legal forms discussed above. Further information is available from the Development Trust Association[33].

Charitable Status

Setting up an ESCO so it is eligible to be registered as a charity is definitely not an 'easy' option. There is a specialised body of law that charities must comply with and, in some ways, the rules for charities regarding running, organisation and accounting are more stringent than for other organisations. There are however a number of benefits for which charities can be eligible which may be sufficiently beneficial to a scheme to outweigh the additional obligations.

Charities, for example, are eligible for tax relief on most income or gains, including profits from certain activities. Interest on bank/building society accounts, for example, should be paid 'gross' (i.e. without tax deducted) for charities. Similarly, donations made to a charity by taxpayers are eligible for 'Gift Aid' whereby the charity can claim back the basic rate tax paid by the donor for the money donated. Finally, the profits of charities that carry out trading activities as part of meeting their 'Primary Purpose' are generally exempt from tax. Further information is available from the Charity Commission.[34]

The Charities Act 2006 introduced a new form of organisation, the Charitable Incorporated Organisation (CIO), aimed at charities that wish to be set up with a corporate structure. A CIO would only need to be registered with the Charity Commission, making the reporting requirements a bit easier as the need to report separately to Companies House would be removed. The detail of the rules for such organisation is currently being consulted on by the Government but may be a workable alternative to some of the types of organisation discussed above.

Constitution

Whatever type of organisation is adopted, it is important to ensure that the 'rules' for the organisation incorporated in the Constitution or Articles of Association (or equivalent) are appropriate for the community's goals. These will cover things like who can be a member/shareholder of the organisation, who can be a director, how often elections for directors are held, how the organisation makes decisions, etc. Some of these decisions will be determined by the type of organisation.

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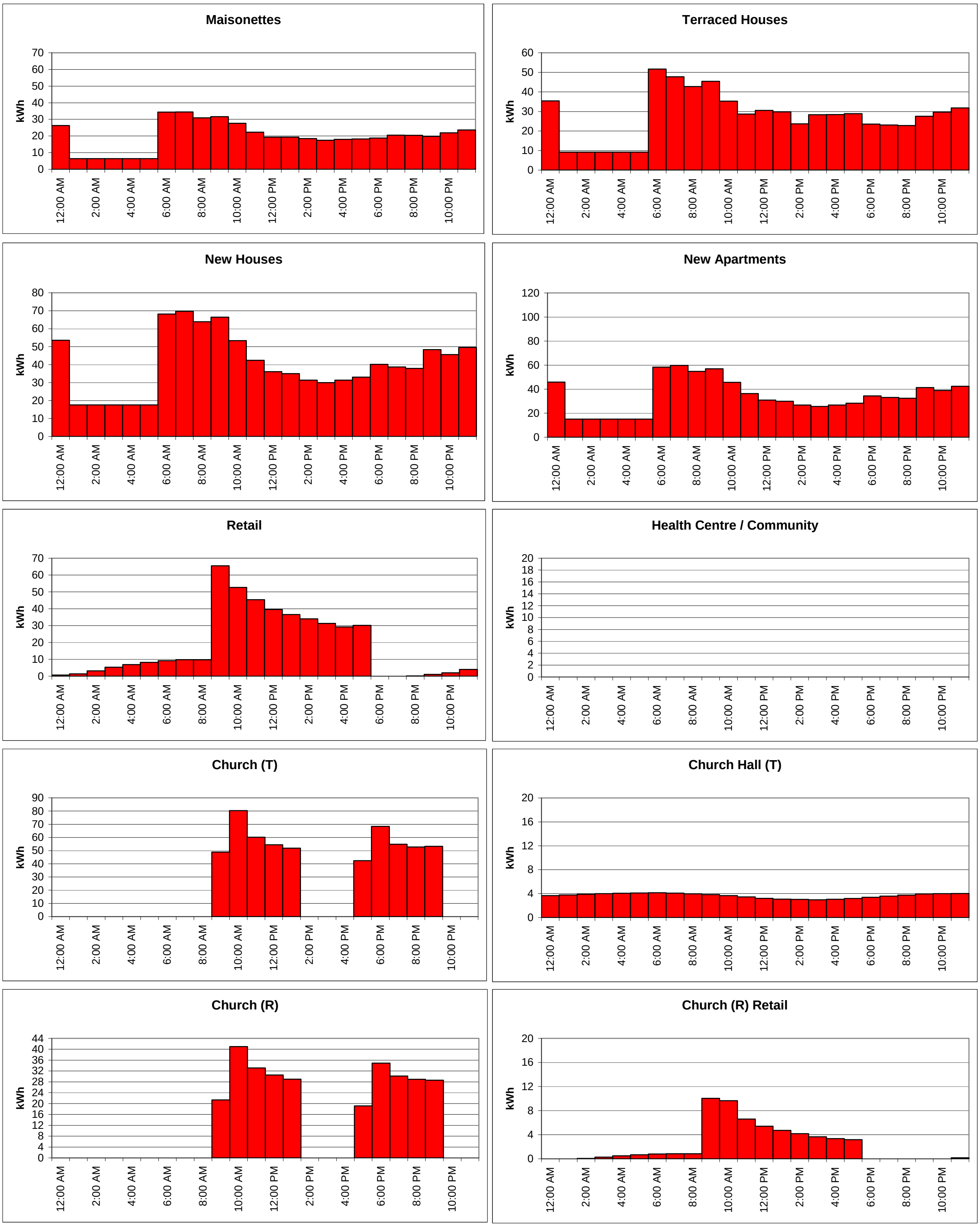
[32] http://www.dta.org.uk/aboutourmembers/whatisadevelopmenttrust.htm
[33] http://www.dta.org.uk/
[34] http://www.charitycommission.gov.uk

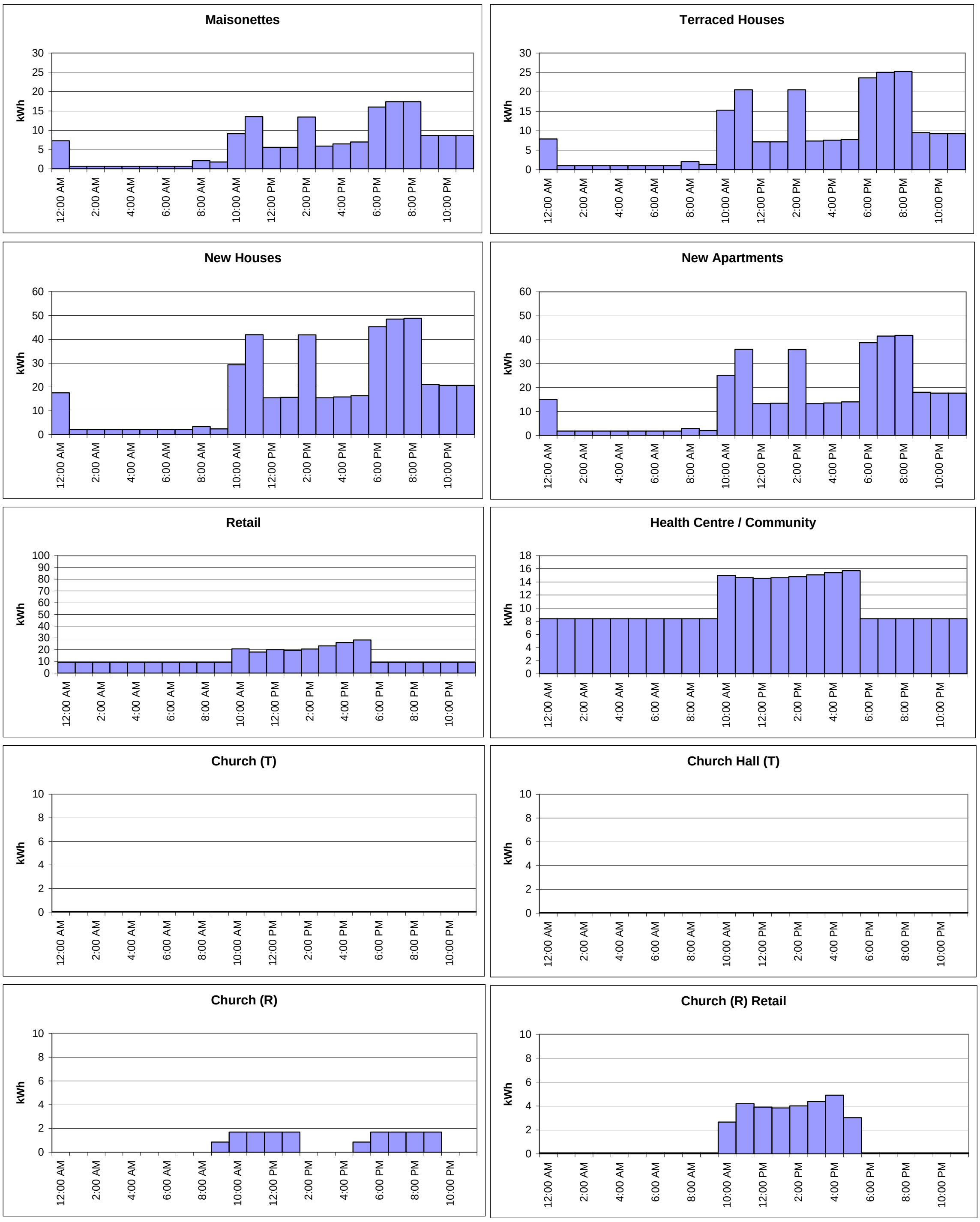
Appendix G

Additional Energy Profiles for weekends

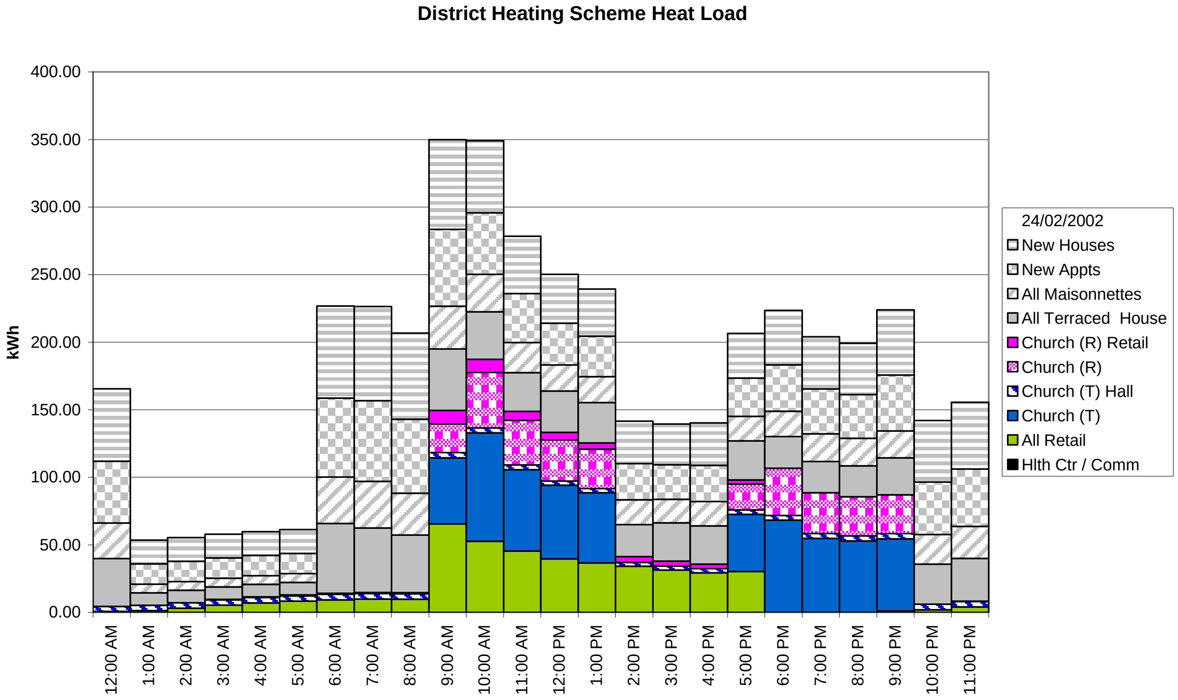
Winter

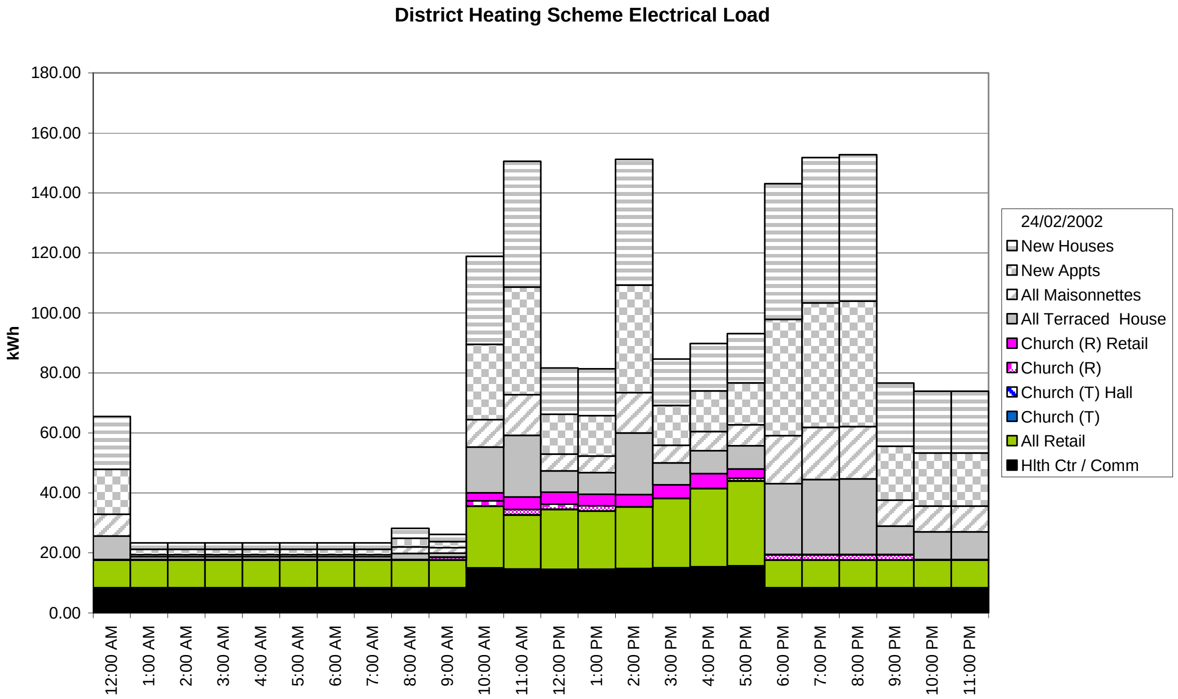


Heat profiles for a Sunday in winter
(24 February 2002, Average Temperature 3.1^{o}C)



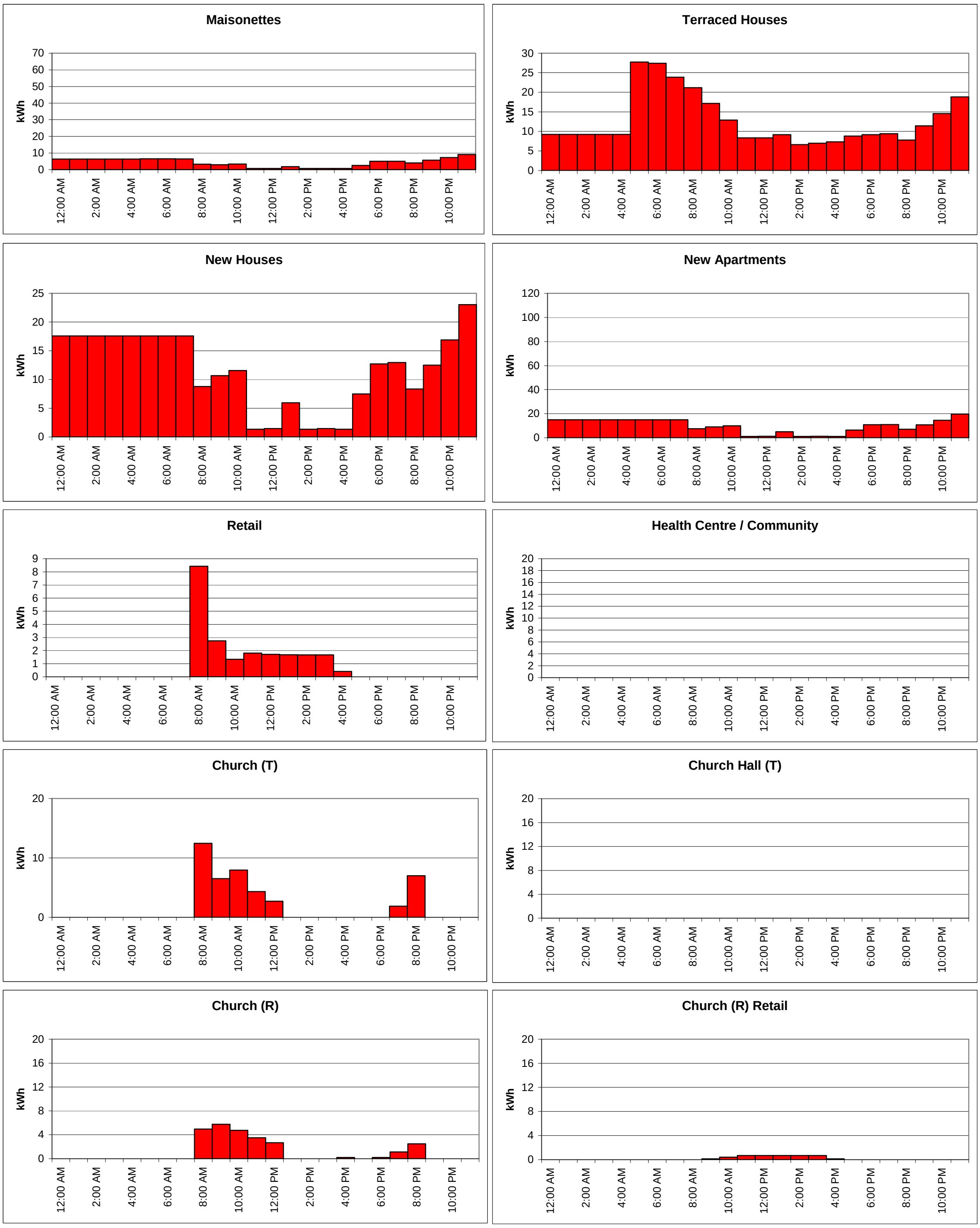
Electricity profiles for a Sunday in winter
(24 February 2002, Average Temperature 3.1^{o}C)



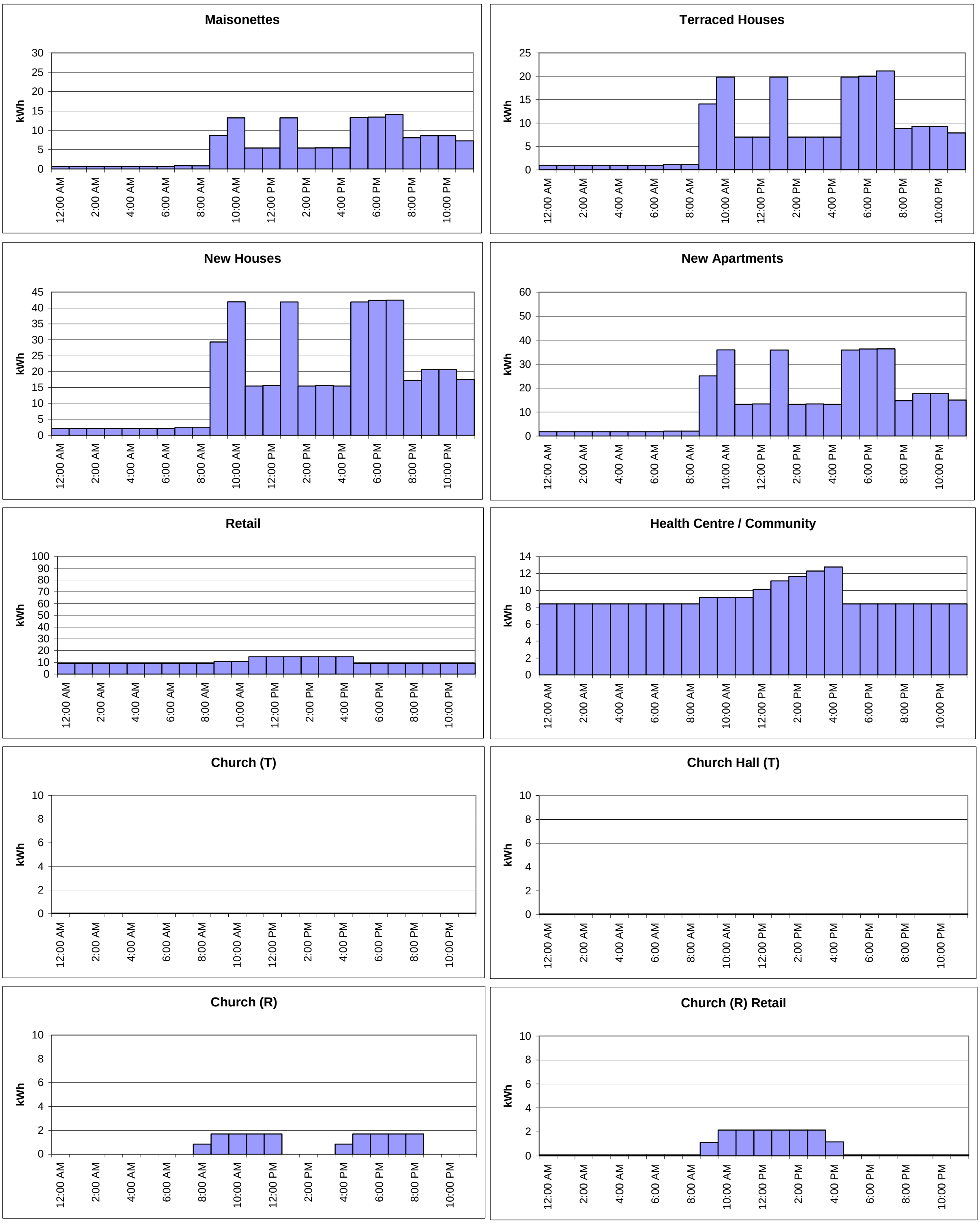


District Heating Scheme (1) - Heating and Electrical Loads (Sunday 24 February 2002, Average Temperature 3.1^{o}C)

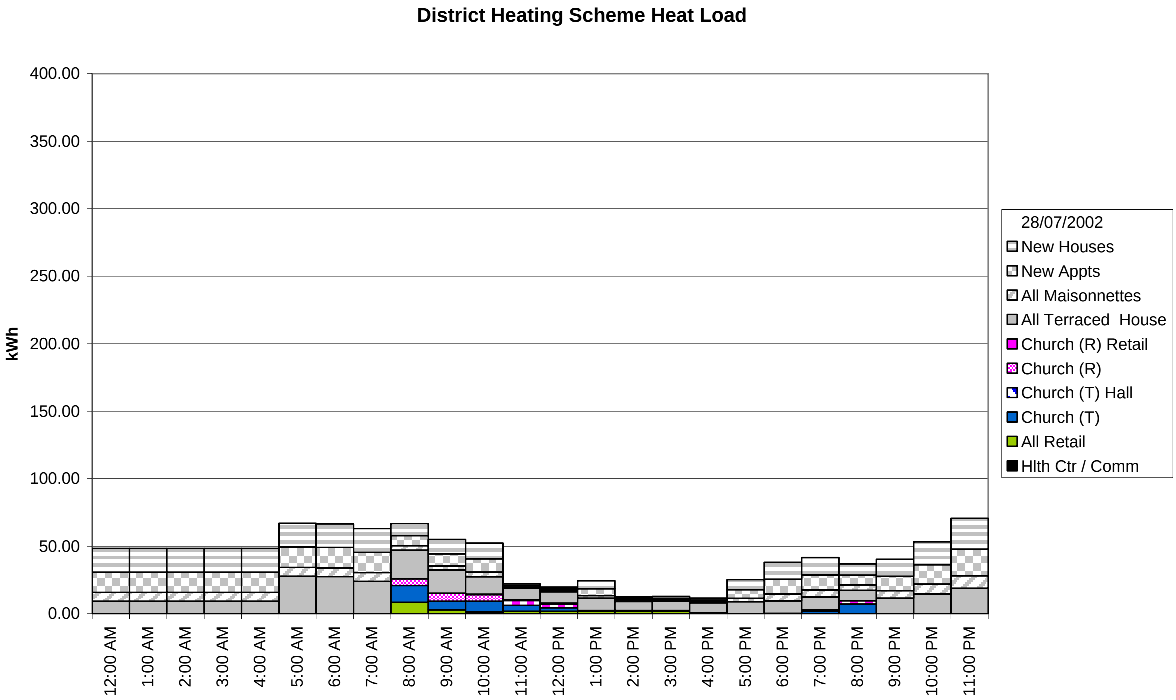
Summer

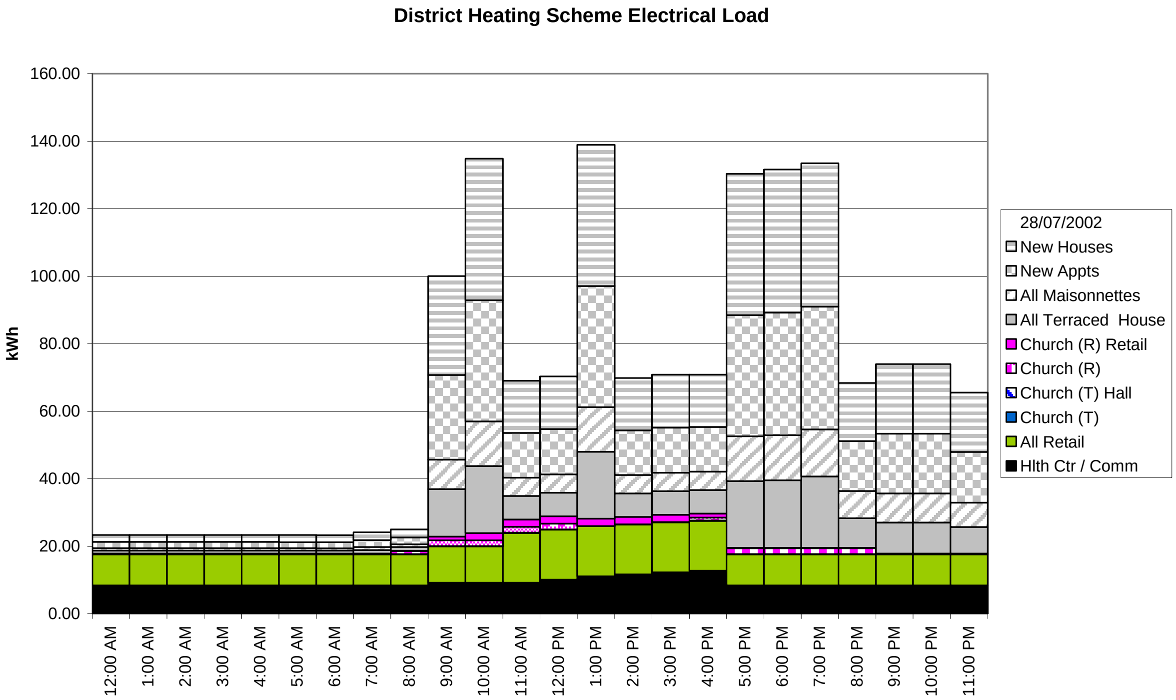


Heat profiles for a Sunday in summer
(28 July 2002, Average Temperature 14.6^{o}C)



Electricity profiles for a Sunday in summer
(28 July 2002, Average Temperature 14.6°C)





District Heating Scheme (1) - Heating and Electrical Loads
(Sunday 28 July 2002, Average Temperature 14.6^{o}C)