NW Bicester Outline Application

Energy Statement Addendum

Application 1: Land to the North of the Railway Line and A4095 Lords Lane and West of B4100 Banbury Road, surrounding Lords Farm and Hawkwell Farm, Bicester, Oxfordshire

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Energy Statement - Addendum

Application 1: Land to the North of the Railway Line and A4095 Lords Lane and West of B4100 Banbury Road, surrounding Lords Farm and Hawkwell Farm, Bicester, Oxfordshire.

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NW Bicester

Energy Statement – Addendum

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Report No 5027-UA005241-UE21R-01

Date December 2014

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Appendices

1 Introduction

This report represents an update to the Energy Statement for Application 1 (report ref: 5023-UA005241-UE21R-01) of the NW Bicester development. The report proposes a revised technological solution to meeting the energy demands of the development following the 'Be Lean' measures and therefore supersedes the original statement.

1.1 Energy Demand

The baseline energy demand following the 'Be Lean' enhanced fabric energy efficiency (FEE) measures are as follows:

Table 2.1 Be Lean – Energy Baseline following Enhanced FEE

All Buildings	Enhanced FEE Demand	Enhanced FEE Emissions
Total Regulated Electricity	1,960,497 kWh	1,017,498 kgCO2
Total Regulated Gas	14,203,671 kWh	3,067,993 kgCO2
Sub Total Regulated	**16,164,167 kWh**	**4,085,491 kgCO2**
B'Regs 2013 Baseline	**17,754,632 kWh**	**4,396,947 kgCO2**
Total Un-regulated Electricity	8,946,005 kWh	4,642,977 kgCO2
Total Un-regulated Gas	937,125 kWh	202,419 kgCO2
Sub Total Un-regulated	**9,883,130 kWh**	**4,845,396 kgCO2**
TOTAL	**26,047,297 kWh**	**8,930,886 kgCO2**
B'Regs 2013 Baseline	**27,637,762 kWh**	**9,273,591 kgCO2**
B'Regs 2010 (+6%)		**9,865,522 kgCO2**
B'Regs 2006 (+25%)		**13,154,029 kgCO2**

To achieve the True Zero Carbon Target the revised strategy outlined below therefore needs to reduce the carbon emissions by a minimum of 8,930,886 kgCO2.

2 Low and Zero Carbon Technology (Be Clean and Be Green)

After the initial savings through energy efficiency measures, the next step in a sustainable energy strategy is the consideration of ‘onsite’ low carbon (be clean) and renewable energy (be green); referred to as low and zero carbon (LZC) technology.

Utilising energy generated locally (onsite) reduces energy lost through transmission and distribution, and can often take advantage of more advanced generating technologies that combine to provide energy more efficiently. Local generation, or decentralised generation, is produced on a smaller scale nearer to the point of consumption and can offer a number of benefits, including:

- Using generated energy more efficiently by reducing distribution losses
- Contributing to security of energy supply by increasing local energy production
- Increasing reliability of supply providing the opportunity to operate ‘on or off grid’
- Reducing carbon emissions through more efficient use of fossil fuels and greater use of locally generated renewable energy
- Provides the opportunity to create stronger links between energy production and consumption.
- Can be linked to fund complementary programmes of work, such as retrofitting microgeneration equipment in existing housing stock.
- Provides a visible message of commitment to sustainable energy

Zero carbon or renewable energy comes from harnessing natural energy flows from the sun, wind, or rain. Many such as solar, wind and hydro, directly produce energy and do no emit any carbon dioxide in the process. Others such as biomass, use solar energy to grow renewable plant material that can subsequently be used for energy. Examples here are wood, straw, etc. However, biomass use still generates carbon dioxide when it is burnt. The difference being that this carbon is only that taken from the atmosphere when the plant grew. This is unlike carbon emissions from fossil fuels that are essentially new to the atmosphere, causing increases in atmospheric carbon dioxide levels and climate change. Therefore, when used to replace fossil fuels, biomass leads to a net reduction in carbon emissions; particularly where local supply chains can provide a sustainable supply of biomass.

Of the available renewable energy technologies, some are ‘intermittent’ in nature, such as solar and wind. Others such as biomass, ground source heat pumps and anaerobic digestion can service baseload duties.

The table below identifies the energy generation technologies and approaches considered.

Table 2.1 LZC Technologies

Macro Solutions (typically district scale or larger)	**Micro Solutions** (typically building related)
Anaerobic Digestion CHP	Air source heat pumps
Biomass heat, biomass power (CHP)	Ground source heat pumps
Energy from Waste CHP	Solar Thermal (building mounted)
Gas CHP	Solar Photovoltaic (building mounted)
Large scale PV array	Wind energy (building mounted)
Large scale wind energy	

2.1 Preferred Approach

The preferred approach to delivering the energy and carbon reduction consists of the following:

- Enhanced fabric energy efficiency
- Site wide District Heat Network – providing all thermal demand across the site
- LZC technology sited within an Energy Centre providing hot water to the DHN and power
- Thermal demand regulated by inclusion of thermal stores
- Residential and non-residential roof space to be used for Solar PV (orientated in southerly direction)

2.1.1 District Heat Network and Thermal Stores

A District Heat Network (DHN) is a network of insulated pipes used to deliver heat, in the form of hot water or steam, from the point of generation to the end user. They provide the means to transport heat efficiently provided distances do not become too far. A DHN enables heat to be delivered to point of use from a centralised location.

Inclusion of a thermal store(s) is proposed for Application 1 to regulate the heat demand. This will enable the hot water generated at the Energy Centre to be buffered, stored and released into the distribution network as needed.

2.1.2 LZC Technology: Gas CHP and Biomass CHP

It is proposed to utilise Combined Heat and Power (CHP) as the primary engine(s) within the Energy Centre; as this integrates the production of usable heat and power (electricity), in one single, highly efficient process. It is proposed to utilise both gas-fired reciprocating CHP engines and biomass gasification CHP engine.

Gas-fired reciprocating engines have intake, compression, power, and exhaust cycles. In the intake phase, as the piston moves down in its cylinder, the intake valve opens, and the upper portion of the cylinder fills with fuel and air. When the piston returns upward in the compression cycle, the spark plug emits a spark to ignite the fuel-air mixture. This controlled reaction, or "burn," forces the piston down, thereby turning the crank shaft and producing power. Reciprocating engines can be used in a variety of applications because of their small size, low unit cost, and useful thermal output. They offer low capital cost, easy start-up, proven reliability, good load-following characteristics, and heat recovery potential.

Biomass gasification CHP options offer significant carbon savings due to the low carbon content of the fuel but have a higher capital cost (comparative to Gas CHP alternatives) and require biomass fuel delivery and storage.

For the reasons outlined above, Gas CHP is proposed to meet the majority of the thermal demands (~58%). A smaller proportion (~32%) will be met through Biomass CHP, however, due to the significant carbon reductions that this technology provides it will help to ensure the development is able to meet the True Zero Carbon target.

The proposed CHP technologies for Application 1 have been sized to meet 90% of the thermal demand, allowing for maintenance and downtime and to avoid significant heat dumping. The split between Gas CHP and Biomass CHP, as indicated above, will be further refined and finalised following more detailed analysis at the reserved matters stage. The remaining thermal demands (10%) will be met by highly efficient conventional gas boilers.

The use of CHP technology also contributes to meeting the electrical needs of the development at the same time, however, it is recognised that further LZC technology will be required to meet the True Zero Carbon target as described below.

2.1.3 Solar PV

It is proposed that the remaining carbon reductions required to achieve the True Zero Carbon Target will be achieved through the provision of roof mounted Solar PV.

Solar Photovoltaic (PV) systems convert energy from the photons within sunlight into electricity through the aid of photocells; made of semi-conductor material, usually Germanium or Silicon. PV systems are suitable for any type of building but they require significant unshaded south facing space.

The maximum total annual solar radiation is usually at an orientation due south and at a tilt from the horizontal equal to the latitude of the site minus approximately 20 degrees. The latitude of Bicester is 51.9 degrees. Therefore 32 degrees is the optimal tilt in Bicester, south facing. However, efficiencies of up to 95% can be achieved within an orientation arc from south-west to south-east facing roofs and inclination from 20 to 50 degrees; which provides some flexibility in layout and design.

2.2 Reduced Energy Demand and Carbon Emissions

Following the FEES enhancements the remaining carbon reductions required for Application 1 are 8,930,886 kgCO_2.

2.2.1 CHP Technology

To estimate the carbon emissions reductions secured by a CHP driven DHN the following assumptions have been made:

Thermal demands:

- Gas CHP 58%
- Biomass Gasification CHP 32%
- Conventional high efficiency gas boiler 10%

Gas CHP (Data sheets provided in Appendix A):

- Power to heat ratio: 1.09:1
- Carbon content of fuel: 0.216 kgCO$_2$/kWh

Biomass Gasification CHP (Data sheets provided in Appendix A):

- Power to heat ratio: 1.08:1
- Carbon content of fuel: 0.016 kgCO$_2$/kWh

Based on these assumptions and the CIBSE CHP calculation method a GAS CHP and Biomass CHP driven DHN to meet 90% of the thermal demands will reduce the carbon emissions as follows:

Table 2.2 CIBSE Method Calculations

Electricity Demand (P)	10,906,502	*kWh*
Thermal Demand (H) (including losses)	17,572,464	*kWh*
Heat Generation from Biomass CHP (H_{CHP})	5,623,188	*kWh*
Heat Generation from Gas CHP (H_{CHP})	10,192,029	*kWh*
($H-H_{CHP}$) Heat (Demand - Generation)	1,757,246	*kWh*
[($H-H_{CHP}$)/$\eta_b$boiler X $E_{f,boiler}$]	414,825	*kgCO2*
Biomass		
F_{CHP} - Biomass Fuel to run CHP	15,805,719	*kWh*
(F_{CHP} X $E_{f,CHP}$) - Biomass fuel X fuel factor	252,891.50	*kgCO2*
Electricity Generated from CHP (P_{CHP})	6,073,044	*kWh*
Gas		
F_{CHP} - Gas Fuel to run CHP	26,918,064	*kWh*
(F_{CHP} X $E_{f,CHP}$) - Gas fuel X fuel factor	5,814,302	*kgCO2*
Electricity Generated from CHP (P_{CHP})	9,350,485	*kWh*
($P-P_{CHP}$) Elect. (Demand - Generation)	- 4,517,027	*kWh*
($P-P_{CHP}$)X electricity fuel factor	- 2,344,337.08	***kgCO2***
Total Emissions with CHP	**4,137,682**	**kgCO2**
	4,138	**tonnes**

The CHP will therefore reduce the carbon emissions by approximately **4,793,205 kgCO$_2$**. This leaves a further reduction 4,137,682 kgCO$_2$ to be achieved through the provision of roof mounted solar PV.

2.2.2 Solar PV technology

To calculate the Solar PV requirements the following general assumptions have been made:

- Annual PV output per kWp: 850.00 kWh/year
- PV peak output: 1.41 kWp at 850 kWh
- Typical PV Area per kWp: 10.00 m^2

The following assumptions have been made for the residential aspect:

- PV installed on 85% of south facing roof area: 60,376 m^2

The following assumptions have been made for the commercial aspect:

- Total Available Roof Area: 11,132 m^2
- % Roof with PV installed: 60%
- Total PV area: 6,679 m^2

Based on these assumptions the following calculations can be made:

Table 2.3: Building Mounted Solar PV

All Buildings	Enhanced FEE Emissions
Remaining carbon emissions	4,137,682 kgCO2
Solar PV generation	- 4,170,998 kgCO2
Sub Total	**- 33,317 kgCO2**

The above table demonstrates that the provision of solar PV to 85% of the available south facing residential roof space and 60% of the non-residential roof space would achieve an approximate reduction of 4,170,998 kgCO_2. This exceeds the reduction required to achieve True Zero Carbon target.

3 Phasing of CHP

There are a number of parameters which need to be considered in order to agree upon a proposed phasing strategy for the implementation of the site wide requirement to achieve True Zero Carbon. Parameters to consider include (but not limited to) the following:

- CHP engine(s)
  - Sizing
  - Efficiency
  - Capital Cost
- Build out rate
- Spatial Distribution

3.1 CHP

The energy centre for Application 1 will comprise (worst case scenario):

- To serve circa up to 2600 homes plus non-domestic
- Flue height – circa 18m (estimation based on previous modelling AQA)
- Indicative Gas CHP Engines sizes - Either:
  - 2 x E850 engines;
    - Electrical Output: 853 kW
    - Electrical Efficiency: 42.8%
    - Heat Output: 891 kW
    - Thermal Efficiency: 44.7%
    - Overall gross efficiency (LHV): 78.30%

or

  - 4 x E425 engines
    - Electrical Output: 430 kW
    - Electrical Efficiency: 38.5
    - Heat Output: 468 kW
    - Thermal Efficiency: 41.8
    - Overall gross efficiency (LHV): 72.6%

- Indicative Biomass Gasification CHP:
    - 2 x 400kWe Engine
        - Electrical Output: 400 kWe
        - Electrical Efficiency: 39%
        - Heat Output: 370 kW
        - Thermal Efficiency: 36%
        - Overall gross efficiency (LHV): 74%
- Plus supporting gas boilers

3.2 Build Out Rate

The DHN will be installed as the new road network is constructed, which will facilitate connection. The Energy Centre will be one of the first infrastructure elements to be constructed; however, temporary portable gas boiler units may be utilised to enable building to receive heat/hot water in the short term.

As identified above the smaller CHP engines are slightly less efficient than the larger engines but represent a lower capital cost. This would therefore enable the CHP engines to be installed more readily as the development progresses and achieve True Zero Carbon on a 'per 500 homes' basis. The larger engines would increase this to every 1000 homes. The Biomass CHP would also need to be installed before the True Zero Carbon target is met. This could be installed according to the agreed rate above.

At a construction rate of circa 250 homes a year the site would therefore be achieving the True Zero Carbon target every 2 years respectively. However, further optimisation may improve this ratio.

3.3 Spatial Distribution

The DHN within Application 1 will inevitably be constructed in conjunction with the strategic road network. This will therefore influence both the spatial distribution and build out rates of the respective residential and non-residential aspects. This in turn will influence the ability of the properties to connect to the proposed energy centre for Application 1 and achieve the True Zero Carbon target.

4 Summary

Following the FEES enhancements the remaining carbon reductions required for Application 1 are 8,930,886 $kgCO_2$.

The proposed CHP DHN would reduce the carbon emissions by approximately **4,793,205 $kgCO_2$**. This leaves a further reduction 4,137,682 $kgCO_2$ to be achieved through the provision of roof mounted solar PV.

The provision of solar PV to 85% of the available south facing residential roof space and 60% of the available commercial roof space would achieve an approximate reduction of 4,170,998 $kgCO_2$. This exceeds the reduction required to achieve True Zero Carbon.

4.1 Summary of requirements

The strategy outlined within this statement achieves the True Zero Carbon target through predominantly on-site technology rather than any significant reliance on off-site/off-set allowable solutions. However, whilst a preferred approach is identified it is recognised that further optimisation of the available technical solutions will continue as detailed design progresses; such as refinement of available roof area for PV, selection and sizing of CHP engines and associated thermal store to optimise delivery of the thermal demand carbon emission reductions.

The table below provides a summary of the development requirements and the current proposals to address them.

Policy	Requirement	Application 1 Proposals
Policy Bicester 1 – NW Bicester Eco-Town	True Zero Carbon CSH Level 5 BREEAM Excellent	True Zero Carbon CSH Level 5 BREEAM Excellent
CSH Level 5 – Ene 1 Dwelling Emission Rate	100% improvement on 2010 Building Regulations	100% improvement on 2010 Building Regulations
BREEAM Excellent	Energy Performance Ratio (EPR_{NC}) of 0.375 (6 credits) or higher.	Energy Performance Ratio (EPR_{NC}) of 0.375 (6 credits) or higher.
Building Regulations	Zero Carbon from regulated energy	Zero Carbon from regulated energy

Appendix A: CHP Datasheets

Technical Datasheet

E850 250NOx L33 Natural Gas CHP Unit

Energy Balance and Part Load Data @ 0.95PF		**Units**	**100%**	**75%**	**50%**
Electrical Output	(+/-3%)	kW	853	640	426
Electrical Efficiency (Net)	(+/-5%)	%	41.5%	40.3%	38.2%
Heat Output	(+/-10%)	kW	931	733	530
Thermal Efficiency (Net)	(+/-8%)	%	45.3%	46.2%	47.5%
Fuel Input (Net)	(+/-5%)	kW	2053	1588	1116
Total Efficiency (Net)	(+/-8%)	%	86.9%	86.4%	85.7%
Heat Output from Jacket Water	(+/-8%)	kW	462	341	236
Heat Output from Exhaust Gas @ Outlet Temp.	(+/-8%)	kW	469	392	294
Aftercooler Heat Output	(+/-8%)	kW	51	41	30
Radiated Heat Output	(+/-8%)	kW	37	28	20
Combustion Air Flow (30 C, 100 kPa, 30% RH)	(+/-5%)	m^3/h	3937	2968	2032
Fuel Mass Flow (ρ = 0.75kg/Nm^3)	(+/-5%)	kg/h	154.0	119.1	83.7
Fuel Volume Flow (LHV = 10kWh/Nm^3)	(+/-5%)	Nm3/h	205.3	158.8	111.6
Exhaust Mass Flow (Wet)	(+/-5%)	kg/h	4737	3574	2449
Exhaust Volume Flow @ Outlet Temp.	(+/-5%)	m^3/h	5276	3981	2728

Engine Details

Manufacturer		MTU
Model		AoE 8V4000L33
Fuel Type		Natural Gas
Min. Methane Number		80
Cylinders		8
Aspiration		Turbocharged
Speed	rpm	1500
Aftercooler		Yes

Hot Water Details

Max. Water In/Out Temp.	°C	78/89°C
Max. Water Flow Rate*	l/s	20.77
Max. Glycol Content	%	30
Connection Size	mm	100
Flange Type		PN16
Pressure Loss**	kPa	TBC
Max. Test Pressure	Bar	9.75

* Assuming Cp = 4.21 kJ/kg·K and ρ = 968.55 kg/m^3

** Pressure loss figures stated are at max. water flow rate. Internal unit only.

Exhaust Details

Connection Size	mm	450
Flange Type		PN10
Outlet Temp.	°C	120
Max. Allowable Backpressure	Pa	TBC

Ventilation Details

Ventilation Rate***	m^3/s	5.37
Max. Air Inlet Temp.	°C	35
Max. Air Outlet Temp.	°C	50
Enclosure Pressure Drop	Pa	TBC

*** Vent rate is stated at max. air outlet temp, 100kPa

Aftercooler Details

Max. Water Inlet Temp.	°C	40
Water Flow Rate	l/s	6.11
Connection Size	mm	65
Flange Type		PN16
Pressure Loss	kPa	70
Max. Test Pressure	Bar	6
Ethylene Glycol Content	%	40

Generator Details

Manufacturer		Stamford
Model		PE734C-312
Type		Synchronous
Rating	kVA	1445
Voltage	V	400
Phase	Ph	3
Frequency	Hz	50
Protection Class		IP23
Rated Power Factor	PF	0.8
Xd Dir. Axis Synchronous		2.76
X'd Dir. Axis Transient		0.17
X"d Dir. Axis Sub-Transient		0.12
T" Sub-Transient Time Const.		0.01
T'do O.C Field Time Const.		2.23
CHP Protection Device	A/Ph	TBC
Indicative Client Protection Device	A/Ph	TBC
Current Per Phase @ 0.8PF	A	1528
Current Per Phase @ 0.95PF	A	1296
Efficiency @ 0.8PF	%	96.2%
Efficiency @ 0.95PF	%	96.9%
Indicative Main Cable Size [a] †	mm^2	TBC
Indicative Earth Cable Size [b] †	mm^2	TBC

[a] 4-Core XLPE/SWA/PVC to BS5467, Max 50 meters.

[b] 1-Core 6491B to BS7211, Max 50 meters.

† Sizes and lengths based on IET 17TH Edition BS7671, Installation method 31.

Fuel Details

Connection Size	mm	80
Flange Type		PN16
Min/Max. Supply Pressure	mbar	120/300

Emissions @ 5% O2

NOx	mg/Nm^3	250
CO	mg/Nm^3	1000
NOx (With Catalyst)	mg/Nm^3	N/A
CO (With Catalyst)	mg/Nm^3	TBC

Weight Details

Enclosure (Dry)	STD/PREM.	kg	TBC/TBC
Container (Dry)	STD/PREM.	kg	TBC/TBC

Noise Data

Enclosure SPL @ 1m	SN/LN	dB(A)	70/65
Container SPL @ 1m	SN/LN	dB(A)	75/65

NB: Output figures are based on operation at ISO 3046 conditions with the exception of exhaust output, which is quoted to 120°C, figures are stated from manufacturer's declared performance figures subject to the manufacturer's tolerances and subject to change without notice. Values for de-rated units are estimates only. Energy balance data assumes perfect combustion. All information detailed is for guidance only and is subject to change without notice due to our commitment to continuous improvement - all values should be confirmed with ENER-G Combined Power Ltd on a project specific basis.

Datasheet Issue Date	03/04/2014	T: +44 161 745 7450	ENER-G House
Database Revision	4.1.3	F: +44 161 745 7457	Daniel Adamson Road, Salford
Sheet	1 of 1	www.energ.co.uk	Manchester, M50 1DT, UK

Technical Datasheet

E425 Natural Gas CHP Unit

Energy Balance and Part Load Data @ 0.95PF		Units	100%	75%	50%
Electrical Output	(+/-3%)	kW	430	323	215
Electrical Efficiency (Net)	(+/-5%)	%	38.5%	37.4%	34.1%
Heat Output	(+/-10%)	kW	468	394	320
Thermal Efficiency (Net)	(+/-8%)	%	41.8%	45.7%	50.7%
Fuel Input (Net)	(+/-5%)	kW	1119	862	630
Total Efficiency (Net)	(+/-8%)	%	80.3%	83.1%	84.9%
Heat Output from Jacket Water	(+/-8%)	kW	189	161	136
Heat Output from Exhaust Gas @ Outlet Temp.	(+/-8%)	kW	279	233	184
Aftercooler Heat Output	(+/-8%)	kW	67	35	14
Radiated Heat Output	(+/-8%)	kW	66	43	33
Combustion Air Flow (30 C, 100 kPa, 30% RH)	(+/-5%)	m^3/h	2048	1578	1154
Fuel Mass Flow (ρ = 0.75kg/Nm^3)	(+/-5%)	kg/h	83.9	64.6	47.3
Fuel Volume Flow (LHV = 10kWh/Nm^3)	(+/-5%)	Nm3/h	111.9	86.2	63.0
Exhaust Mass Flow (Wet)	(+/-5%)	kg/h	2473	1905	1393
Exhaust Volume Flow @ Outlet Temp.	(+/-5%)	m^3/h	2754	2122	1552

Engine Details

Manufacturer		Perkins
Model		4008-30 TRS1
Fuel Type		Natural Gas
Min. Methane Number		75
Cylinders		8
Aspiration		Turbocharged
Speed	rpm	1500
Aftercooler		Yes

Hot Water Details

Max. Water In/Out Temp.	°C	80/90°C
Max. Water Flow Rate*	l/s	11.48
Max. Glycol Content	%	30
Connection Size	mm	80
Flange Type		PN16
Pressure Loss**	kPa	33.7
Max. Test Pressure	Bar	9.75

* Assuming Cp = 4.21 kJ/kg·K and ρ = 968.55 kg/m^3

** Pressure loss figures stated are at max. water flow rate. Internal unit only.

Exhaust Details

Connection Size	mm	250
Flange Type		PN10
Outlet Temp.	°C	120
Max. Allowable Backpressure	Pa	4250

Ventilation Details

Connection Size	mm	900
Ventilation Rate***	m^3/s	5.48
Max. Air Inlet Temp.	°C	30
Max. Air Outlet Temp.	°C	45
Enclosure Pressure Drop	Pa	240

*** Vent rate is stated at max. air outlet temp, 100kPa

Aftercooler Details

Max. Water Inlet Temp.	°C	45
Water Flow Rate	l/s	8.30
Connection Size	mm	65
Flange Type		PN16
Pressure Loss	kPa	75
Max. Test Pressure	Bar	3.5
Ethylene Glycol Content	%	50

Generator Details

Manufacturer		Stamford
Model		HCI544E-311
Type		Synchronous
Rating	kVA	610
Voltage	V	400
Phase	Ph	3
Frequency	Hz	50
Protection Class		IP23
Rated Power Factor	PF	0.8
Xd Dir. Axis Synchronous		2.88
X'd Dir. Axis Transient		0.15
X"d Dir. Axis Sub-Transient		0.11
T" Sub-Transient Time Const.		0.012
T'do O.C Field Time Const.		2.5
CHP Protection Device	A/Ph	800
Indicative Client Protection Device	A/Ph	800 (Adjustable)
Current Per Phase @ 0.8PF	A	768
Current Per Phase @ 0.95PF	A	654
Efficiency @ 0.8PF	%	95.3%
Efficiency @ 0.95PF	%	96.3%
Indicative Main Cable Size [a] †	mm^2	TBC
Indicative Earth Cable Size [b] †	mm^2	TBC

[a] 4-Core XLPE/SWA/PVC to BS5467, Max 50 meters.

[b] 1-Core 6491B to BS7211, Max 50 meters.

† Sizes and lengths based on IET 17TH Edition BS7671, Installation method 31.

Fuel Details

Connection Size	mm	65
Flange Type		PN16
Min/Max. Supply Pressure	mbar	20/50

Emissions @ 5% O2

NOx	mg/Nm^3	480
CO	mg/Nm^3	791
NOx (With Catalyst)	mg/Nm^3	N/A
CO (With Catalyst)	mg/Nm^3	N/A

Weight Details

Enclosure (Dry)	STD/PREM.	kg	10500/12500
Container (Dry)	STD/PREM.	kg	TBC/TBC

Noise Data

Enclosure SPL @ 1m	SN/LN	dB(A)	70/65
Container SPL @ 1m	SN/LN	dB(A)	75/65

NB: Output figures are based on operation at ISO 3046 conditions with the exception of exhaust output, which is quoted to 120°C, figures are stated from manufacturer's declared performance figures subject to the manufacturer's tolerances and subject to change without notice. Values for de-rated units are estimates only. Energy balance data assumes perfect combustion. All information detailed is for guidance only and is subject to change without notice due to our commitment to continuous improvement - all values should be confirmed with ENER-G Combined Power Ltd on a project specific basis.

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Sheet	1 of 1	www.energ.co.uk	Manchester, M50 1DT, UK

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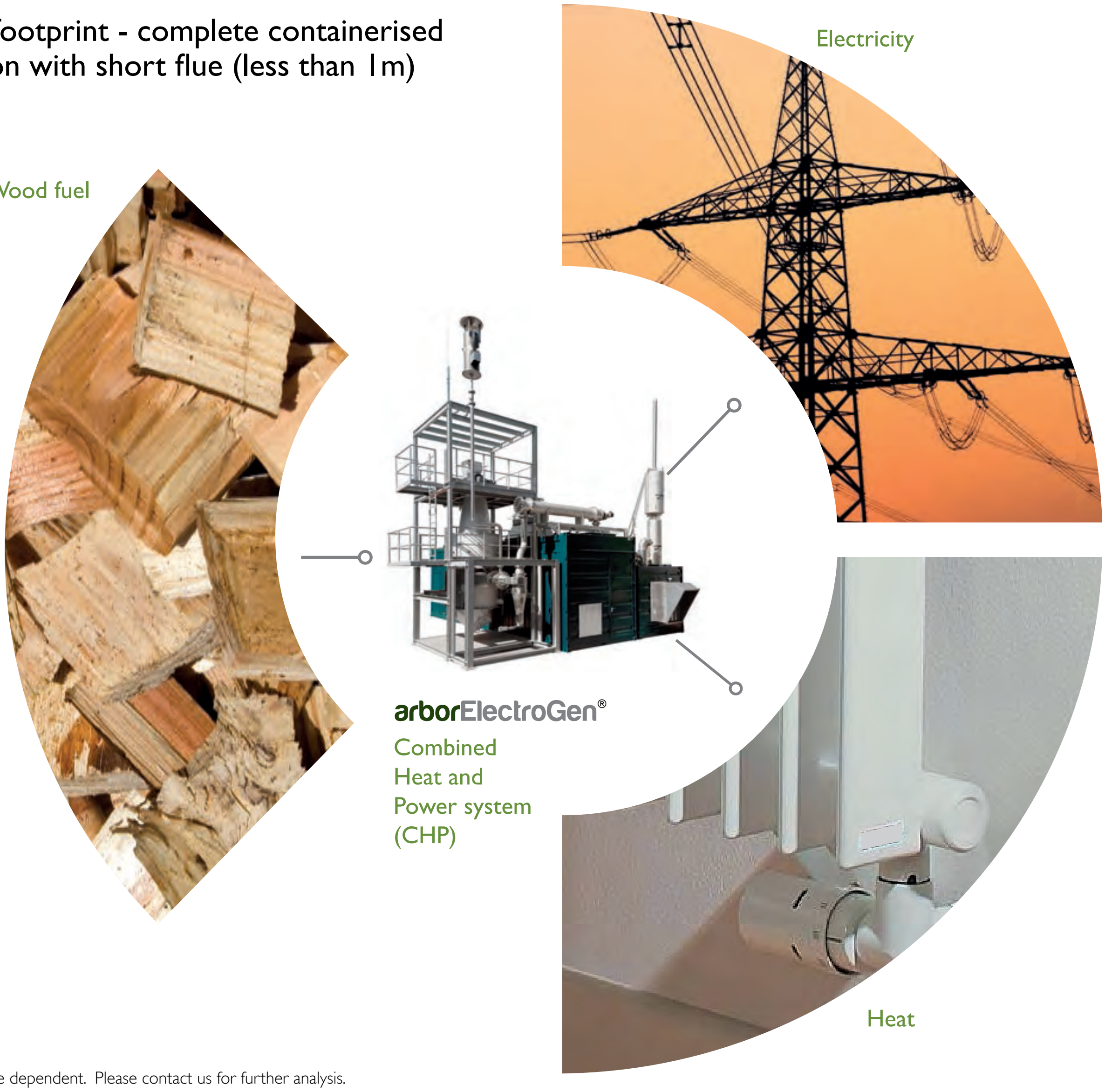
200 400 800

ArborElectroGen® is a range of proven, biomass-fuelled combined heat and power systems (CHP) that deliver cost effective, low-carbon heat and power for a variety of applications.

- Generate heat and electricity from woody biomass and energy crops
- Low carbon, renewable energy, and other biomass fuels that are even cheaper than the grid
- Better returns than heat-only biomass technologies
- Easy integration into existing heating systems
- Small footprint - complete containerised solution with short flue (less than 1m)

PROJECTED PAYBACK < 5 YEARS*

CARBON OFFSET >1,000 TONNES



*Payback is site dependent. Please contact us for further analysis.

delivering revenue from renewables

Arbor Heat and Power
The Oak Barn, Lodge Farm, Aunby,
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arbor
heat and power

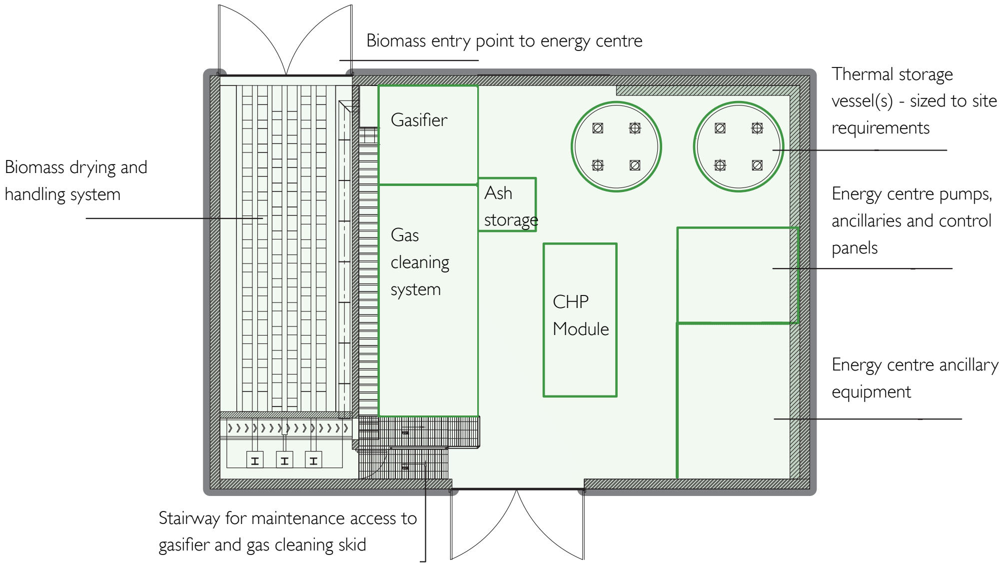
200 400 800

arborElectroGen®

CHP	200	400	800
Fuel	Woodchip / Granular Waste Material / Digestate from BioGas plants / Compressed Feedstock / Waste Wood		
Electrical Capacity[1]	200 kWe	400 kWe	800 kWe
Electrical Efficiency[1]	39 %	39 %	41 %
Thermal Capacity	185 kW	370 kW	702 kW
Thermal Efficiency	36 %	36 %	36 %
Rated Thermal Input	513 kW	1026 kW	1950 kW
Pilot Fuel Consumption[2]	2.5 kg/h	2.5 kg/h	4.0 kg/h
Pilot Fuel Percentage[3]	5 %	5 %	2.20 %
Fuel			
Woodchip Consumption	170 kg/h	340 kg/h	645 kg/h
Gas Output	370 Nm^3/h	740 Nm^3/h	1500 Nm^3/h
Overall System Dimensions (without fuel storage)			
Height (without flue)	9m (8m)	11m (10m)	11m (10m)
Length	12m	12m	12m
Width	10m	10m	12m
System			
Electrical Efficiency[4] η el	29 %	29 %	31 %
Thermal Efficiency[5] η th	58 %	58 %	58 %
Total System Efficiency η (el + th)	87 %	87 %	89 %

All specifications in accordance with the exhaust gas emission values required in Germany. **1** Electrical power/efficiency based on the ISO standard rating at the ambient reference conditions from ISO 3046-1 with the applicable tolerance. **2** In continuous operation at full load. **3** % of rated thermal input. **4+5** Efficiency depends on the composition and consistency of the biomass. Biomass is a natural material and can exhibit considerable variability. All subject to manufacturers modifications.

Typical layout plan for energy centre



Features

- Flue height less than 1m and emissions less than natural gas
- Compatible with Arbor Heat and Power approved 100% renewable fuels eligible for draw down of Renewable Obligation Certicates (ROCs) and Renewable Heat Incentive (RHI).
- Remote Monitoring and Control Capability, Energy Metering & Data Logging.
- Automatic Grid Synchronisation.
- Fully Compliant with G59/2 & UK wiring regulations.
- Provision of long term maintenance and fuel supply contracts by Arbor Heat and Power. Details available on request.

Notes

All data and characteristics to be verified on a per-project basis.

Volter (UK) Ltd (trading as Arbor Heat and Power) and its suppliers reserve the right to amend the technical specification without notice. E&OE.

The rated outputs and the specific fuel consumption assume an air temperature of 273 k and an air pressure of 1,013 mbar.

Fuel Consumption, Thermal and power outputs based on use of Arbor Heat and Power specified fuels. Use of other fuels may affect system performance and elligiblity for draw down of Renewable Obligation Certificates (ROCs) and other financial incentives.

delivering revenue from renewables

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arborElectroGen®

How it works

Simple Concept

The ArborElectroGen® system converts woody biomass into a gas that fuels a Combined Heat and Power system (CHP). Producing almost equal amounts of heat and electricity, the system offers one of, if not, the most cost-effective ways to meet the ever more stringent carbon reduction demands of schemes like the Code for Sustainable Homes and BREEAM. The desirable heat to power ratio makes the technology far better suited to the matching of power and thermal demands of a building, facility or community network without dumping valuable heat. Whilst the bulk of the delivery of the UK's built environment continues to focus on producing renewable heat to meet the demands of planning requirements, Arbor Heat and Power's ArborElectroGen® system targets renewable electricity – a commodity that, if supplied from the National Grid, emits around three times more carbon than the natural gas required to produce it. The heat generated by the ArborElectroGen® would be used to provide on-site space heating and hot water, offsetting the need for traditional fossil fuel sources (e.g. natural gas, oil, LPG). Similarly, the generated electricity would be used to offset the need to import grid electricity - and at times when the electricity is not required it would be fed back into the grid with a resulting revenue stream.

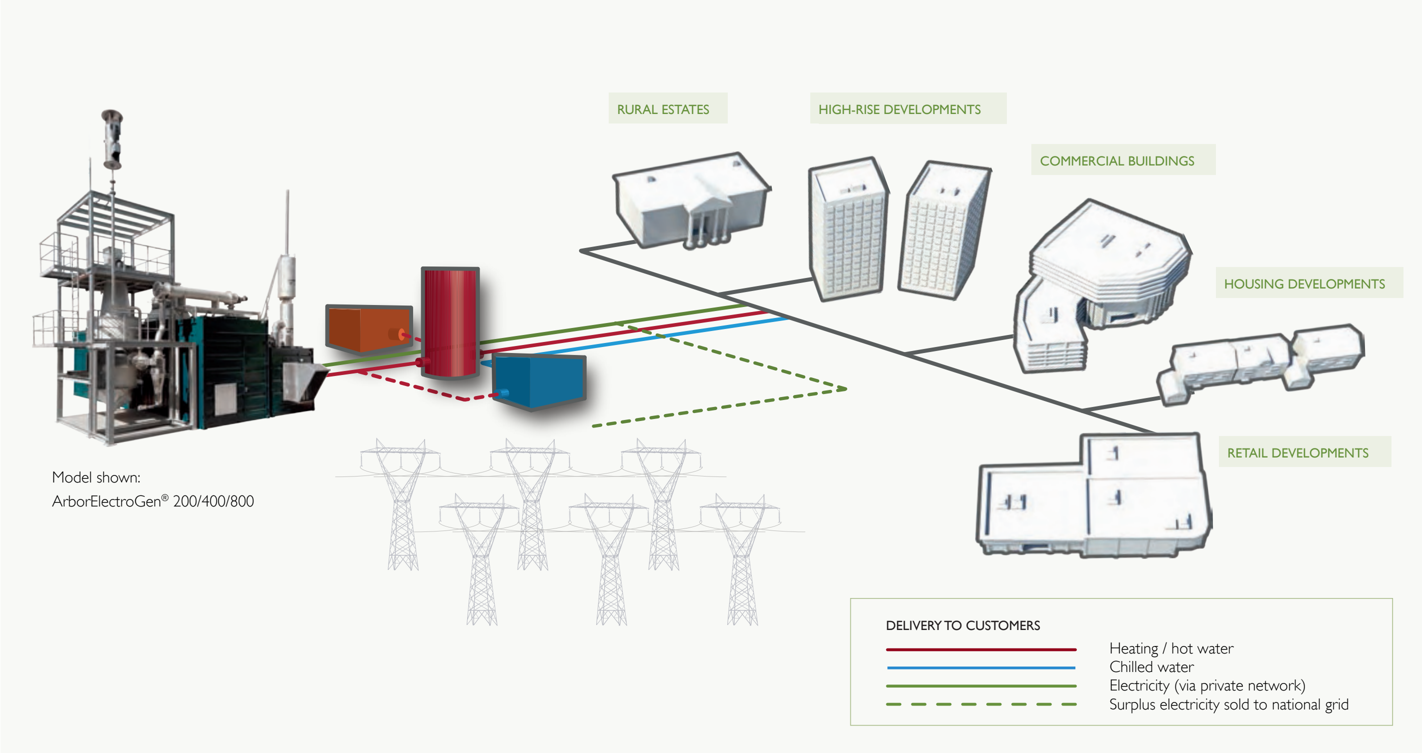
GASIFIER AND COOLING SYSTEM PRODUCES CLEAN COMBUSTIBLE GAS (SYNGAS)

SYNGAS USED TO PRODUCE HEAT AND POWER IN CHP SYSTEM

OPTIONAL TOP-UP BOILER FOR PEAK DEMAND

THERMAL STORAGE BUFFER TANK TO OPTIMISE EFFICIENCY

OPTIONAL CHILLED WATER PRODUCTION



Model shown:
ArborElectroGen® 200/400/800

Feedstock

Gas can be generated from a wide range of coarse biomass materials:

- Coarse wood chips
- Granular waste materials such as legume husks
- Compacted, treated wastes such as digestate from biogas plants
- Fine feedstock compressed into briquettes/maxipellets

Consistent feedstock is essential for keeping the biomass power plant highly available and efficient.

- Grain size: 40-100 mm + 20 mm thickness
- Low fines fraction + Humidity: 15 - 25 %

Gas generation

The unit's core component is a double-fire gas generator. It is specifically designed to generate a clean syngas by combining updraft and downdraft airflow principles. As a result, many undesired tars and other pollutants are cracked and largely broken down in a high-temperature zone.

Gas cleaning

The gas is then thoroughly cleaned in a water filter, which strips out dust particulates as well as other pollutants. Downstream, a specially developed wet electrostatic precipitator removes the remaining unwanted aerosols.

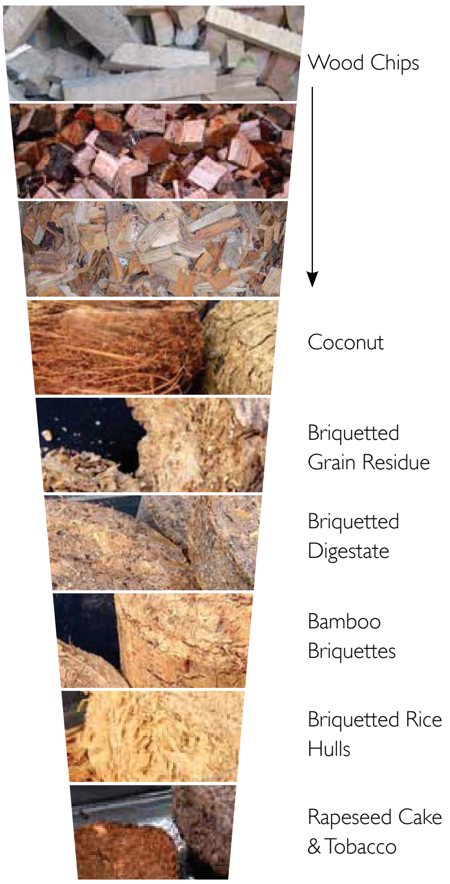
Benefits of high gas purity:

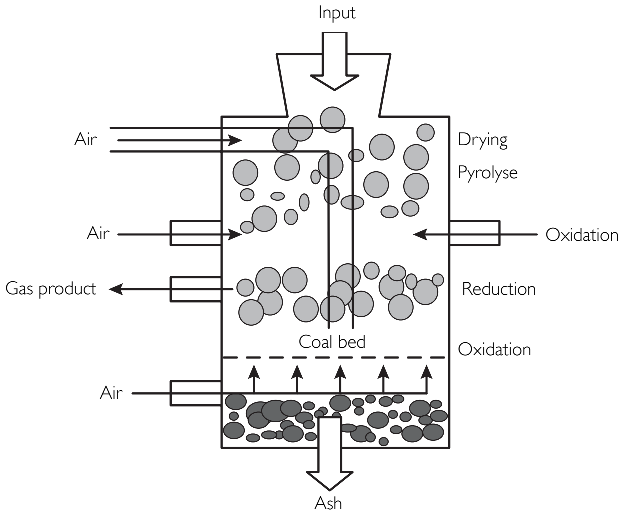
- Reliable transportation of gas over extended distances
- Highly efficient utilization in the CHP unit
- Exceptional efficiency

Combined heat and power unit (CHP)

The cleaned gas is piped to the packaged CHP unit, where it is used to generate heat and power. Over 3,000 CHP units have been successfully deployed in various lean gas applications around the world. The innovative technology also enhances efficiency. Depending on the application, the CHP units can achieve electrical efficiencies in excess of 40 percent when powered by syngas from the biomass power plant.

Fuel Options





Double-fire process

The next steps…

For a free, no-obligation, initial assessment of how the ArborElectroGen® system could help meet your site's energy needs, please visit Arbor Heat and Power's website: www.arborhp.com or email: info@arborhp.com or telephone the Technical Sales team on T: 01778 590 074.