

**Commercial-in-Confidence**  
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## **GLOUCESTER ENERGY FROM WASTE**

### **CONNECTION FEASIBILITY STUDY**

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# GLOUCESTER ENERGY FROM WASTE

## CONNECTION FEASIBILITY STUDY

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## 1. INTRODUCTION

Gifford LLP has been commissioned by Balfour Beatty Construction Northern Limited to conduct a grid connection feasibility study in support of its bid to Gloucestershire County Council for the construction of a 15MW energy from waste plant at Javelin Park.

Gifford has made no direct contact with Central Networks West (Eon UK) in respect of this study which does not constitute any formal process towards a connection offer from Central Networks West.

## 2. LOCATION OF THE PROPOSED GENERAL DEVELOPMENT

The location of the proposed energy from waste facility is at Javelin Park (SO801104), Haresfield, on the south-western edge of Gloucester. The site was formerly RAF Moreton Valence. The airfield has been redeveloped as agricultural land, the M5 motorway and a substantial garden centre adjacent to Javelin Park. Access to the site is by the B4008 at junction 12 of the M5. Immediately to the north of the motorway lie the former RAF Quedgeley and RAF Hardwicke depots which are being redeveloped for substantial residential, distribution and light commercial use including Waterwells Business Park and the Kingsmead residential area. Some of the commercial land under development is currently owned by the property developer St Modwens. Indeed, whilst lying within Stroud District, this area represents one of two growth nodes for the city of Gloucester, the other being another former airfield site at Brockworth (at junction 11a of the M5).

## 3. LOCAL NETWORK CONTEXT

Electricity supply to the city of Gloucester and its surrounding towns of Cheltenham, Tewkesbury and Stroud are fed primarily from the national transmission system via the grid supply point at Walham on the northern section of the Gloucester ring road and the nearby bulk supply point at Port Ham. This links to two major 132kV substations at Castlemeads (serving the city) and Ryeford (serving the Stroud area) to the south. The southern section of the city is supplied from a 33/11kV substation in the Tuffley district.

Central Networks West is the licensed distribution network operator for the area and owns the entire local electricity distribution infrastructure. Central Networks West is part of E.ON UK, itself a subsidiary of E.ON GmbH.

There are relatively few small generators connected in the Gloucester area, totalling 12.14MW. Of these, only two are relevant to this study: the 1.4MW generator at the Frampton landfill connected at the Netherhills substation and the 0.83MW Netheridge sewage gas plant connected at the Tuffley substation. However, both are connected at 11kV so do not need to be considered in depth.

Gifford is not aware of any significant planned generation projects in the immediate locality which could have an impact on the Javelin Park plant.

## 4. CONNECTION VOLTAGE

It is assumed for this study that the proposed Javelin Park plant will have an output capacity of 15MW and annual planned operating hours around 7500 (86%). A typical 11kV circuit would not

normally be capable of accommodating full load output at all times from such a plant. It should be noted that the level of network security at 11kV is generally substantially lower than is offered at 33kV. Whilst specific situations (e.g. at a substation busbar where a full reverse transformer capability exists) may permit a lower voltage (and therefore cheaper) connection, in order to avoid constraints on the operation of the plant, it is recommended that connection at 33kV is sought.

## 5. CONNECTION OPTIONS

Being on the south-western edge of Gloucester the Javelin Park site is remote from the main electrical infrastructure which serves the city from the northwest. It is similarly remote from the infrastructure serving the Stroud area to the south.

The nearest 33/11kV substations are at Tuffley, Netherhills and Ryeford. These options have been summarised in Table 1. Connection at the busbar on the higher voltage side at the substation would allow energy to be used to meet demand on the 11kV circuit and/or to be distributed on the 33kV circuits. Therefore, whilst more expensive than connecting to circuits, connection at substations offers a more secure outlet for energy generated.

Substation	OS Grid	Approximate Distance	Transformer Capacity to 11kV	Minimum (Summer) Export	Reverse Capability
Tuffley	SO817153	5km	2@ 15MVA+ 2@ 23MVA	2@ 31.7MVA	Full
Netherhills	SO765071	5km	2@ 5MVA	20.8MVA	Partial
Ryeford	SO813045	6km	2@ 23MVA + 1@ 24MVA	43MVA or 71MVA	Partial Full
Brockworth	SO866163	10km	3@ 15MVA	2@ 31MVA	Full

**Table 1: Substation Options**

Brockworth is included because of the proximity of both Javelin Park and this substation to the M5 which may provide a relatively simple access route. Other substations exist in the locality, but are not considered due to their additional remoteness and difficult geography to access.





**Figure 1: Javelin Park and Substations to the South**

Figure 1 shows the position of the generation site at Javelin Park to the potential connection points at substations to the south. In this view, the town of Stroud is located at the bottom left corner. It may also be possible to connect to the 33kV circuit that joins Netherhills and Ryeford which takes almost a straight line route between the two.

Figure 2 shows the position of the generation site at Javelin Park to the potential connection points at substations to the north. The southern districts of Gloucester occupy the top centre of this view.



**Figure 2: Javelin Park and Substations to the North**

In addition, there are three possible circuit connections which are summarised in Table 2.



Circuit	Circuit Type	Approximate Distance	Direction	OS Grid Ref of Connection
Ryeford-Camp	33kV single	6km	Southeast	n/a
Ryeford-Netherhills	33kV double	6km	South	SO7706 or SO7904
Castlemeads-Berkeley	132kV double	2.5km	Northwest	n/a

**Table 2: Circuit Options**

The Ryeford-Camp circuit is not attractive for a tee connection due to the difficult and scenic terrain as well as a summer rating below 15MVA. Connection to the Castlemeads-Berkeley circuit at 132kV is excessive for a 15MW generator and likely to require a very high cost substation.

For each case, the current fault capability has been assessed on a prima-facie basis and is included to show where costs might arise. In general at 33kV, the fault in-feed on current is significantly less than the equipment rating; therefore no upgrading of existing circuit breakers is likely to be required. However, on the 11kV networks feeding from the 33/11kV substations examined in this section, current fault levels are close to equipment rating such that the connection of the generator might lead to some equipment requiring replacement and incurring potentially significant cost. Full fault analysis and the accurate identification of cost can only be carried out by, or in co-operation with, the network operator.

The possible connection routes for each option have been identified for minimising wayleave and planning risk. Therefore, paths along existing transportation or utilities infrastructure axes have been chosen in preference to 'as the crow flies' minimum distances. Whilst this might result in 'worst case scenarios' in construction cost terms, they should provide lower risk in terms of timescale and legal expense. These routes and costings are intended as a guide to inform high level decision making and would require further investigation to prove deliverability.

## 5.1 Tuffley Substation



**Figure 3: Tuffley 33/11kV Substation**



The 33/11kV substation at Tuffley is located alongside the A38 Cole Avenue. The substation represents the nearest point of the 33kV network to the north of the Javelin Park site. It contains four transformers each rated at 15MVA. The substation is on a stub connected by a double underground cabled circuit from Castlemeads which is located on the northwest of the city. The peak recorded demand (at 11kV) supplied through this substation is 27.7MW.

Far Substation	Near Substation Node ID	Circuit Length (km)	Summer Max Rating (MVA)	Winter Max Rating (MVA)
Castlemeads	TUFF331A	4.812	31.7	35.7
Castlemeads	TUFF332A	4.854	31.7	35.7

**Table 3: Tuffley Substation 33kV Circuits**

The peak demand at this substation is relatively high and in combination with the double circuit to Castlemeads this makes it a very secure connection point for a 15MW generator.

The fault parameters of the substation are summarised in Table 4.

Parameter	Values of 33kV side	Values on 11kV side
Equipment fault rating 3ph	not published	make 32.8kA break 13.1kA
Short circuit fault current 3ph	make 19.8kA break 8.1kA	make 13.7kA break 4.9kA

**Table 4: Fault Parameters for Tuffley**

Figure 3 shows there should be adequate space within the compound for the additional equipment that would be required for connection. This additional equipment is unlikely to be significant given the margin on existing fault protection facilities.

The probable route to the substation is through largely residential area so it is likely that underground cabling will be required for almost the entire distance. The route follows the B4008 in a northerly direction, using the bridge at junction 12 to cross the M5, to its junction with the A38. It can then follow the A38 to its junction with the A430, before turning east for the remaining 500m along the A38 Cole Avenue. Distance approximately 5.8km.

## 5.2 Netherhills Substation



**Figure 4: Netherhills 33/11kV Substation**

The 33/11kV substation at Netherhills is located at Fromebridge near the A38/B4071 junction. Its main purpose is to serve the relatively small demand (peak 5.5MW) from a rural area including Frampton on Severn and other villages along the banks of the Severn. The substation represents the nearest point of the 33kV network to the south of the Javelin Park site. It is situated on a double 33kV circuit between Lydney and Ryeford which also has a double tee connection to Elton (in the Forest of Dean) and a single tee to Coaley (south of Ryeford). It contains two transformers each rated at 15MVA.

Far Substation	Near Substation Node Id	Circuit Length (km)	Summer Max Rating (MVA)	Winter Max Rating (MVA)
Ryeford	NETH33 1	5.740	20.8	25.9
Lydney	NETH33 1	17.5	20.8	25.9
Elton (via tee)	NETH33 2	16.000	20.8	25.9
Coaley (via tee)	NETH33 2	6.479	20.8	25.9

**Table 5: Netherhills Substation 33kV Circuits**

The very low demand served by this substation means that connection here will be reliant on the performance of the circuits to which it is attached. However, these circuits do offer sufficient outlet for busbar connection to be a secure option. The fault parameters at the substation, which are summarised in Table 6, indicate that this facility has a capability well beyond its current 11kV service requirement.

Parameter	Values of 33kV side	Values on 11kV side
Equipment fault rating 3ph	make 32.8kA break 13.1kA	make 50.0kA break 20.0kA
Short circuit fault current 3ph	make 15.5kA break 6.7kA	make 7.0kA break 2.6kA

**Table 6: Netherhills Fault Parameters**



There are two possible routes to the substation:

- i. The route heads due west from Javelin Park to then follow the M5 south to about 1km south of junction 12 (A419) where the Ryeford-Netherhills 33kV line crosses the motorway. The route can follow the existing poled circuit to the substation. This route is approximately 6.5km and would require wayleaves on private land for most of the distance.
- ii. The route heads due west from Javelin Park to cross the M5. It then follows an unclassified lane to its junction with the A38. It can then follow the A38 south to near its junction with the B4071 where it can follow the existing poled circuit to the substation. Distance approximately 6km.

### 5.3 Ryeford Substation



Figure 5: Ryeford 132/33/11kV Substation

This 132/33/11kV substation is located alongside the A419 Stonehouse/Ebley bypass. Its main purpose is as a bulk supply point to the Stroud district, including the villages of the Severn valley and the industrial area at Stonehouse. Being a bulk supply point, it occupies a strategic position on the distribution network serving a peak load of 126.8MW at 33kV and 23.1MW from its 11kV network. Although slightly further away from the Javelin Park site than Netherhills, the Ryeford substation offers an extremely robust connection point. It contains three transformers, two rated at 23MVA (node A) and one rated at 24MVA (node B).

Far Substation	Near Substation Node Id	Circuit Length (km)	Summer Max Rating (MVA)	Winter Max Rating (MVA)
Netherhills	RYEF33 B	5.740	20.8	25.9
Dursley	RYEF33 B	7.568	41.3	51.4
Dudbridge	RYEF33 A	2.886	36.2	51.4
Cherrington	RYEF33 A	15.533	10.1	12.6



Far Substation	Near Substation Node Id	Circuit Length (km)	Summer Max Rating (MVA)	Winter Max Rating (MVA)
Coaley	RYEF33 A	7.304	41.3	51.4
Camp	RYEF33 A	12.542	10.1	12.6

**Table 7: Ryeford Substation 33kV Circuits**

The fault parameters at the substation, which are summarised in Table 8, show that there is substantial capacity in the fault protection facility, at least at the 33kV level.

Parameter	Values of 33kV side	Values on 11kV side
Equipment fault rating 3ph	make 43.7kA break 17.5kA	make 32.8kA break 13.1kA
Short circuit fault current 3ph	make 27.9kA break 10.1kA	make 25.1kA break 8.7kA*

**Table 8: Ryeford Fault Parameters**

There are three possible routes to the substation:

- i. The route follows the path of the B4008 south through Little Haresfield and Standish to its bridge over the Bristol-Gloucester railway line. From here it could follow the railway south to where the A419 crosses then follow the A419 east to the substation. Most of this route could be pole mounted. Distance approximately 7.5km.
- ii. The route follows the path of the B4008 south through Little Haresfield and Standish to the northern edge of Stonehouse from where it would need to be cabled to the junction of the B4008 and the A419 then on to the substation. Distance approximately 6.9km.
- iii. The route heads due west from Javelin Park to then follow the M5 south to about 1km south of junction 12 (A419) where the Ryeford-Netherhills 33kV line crosses the motorway. The route can then follow the existing poled circuit to the substation. Distance approximately 9.8km.

#### **5.4 Brockworth Substation**

The 33/11kV substation at Brockworth is located behind the Invista Textiles UK factory on the Brockworth Business Park on the east side of Gloucester near junction 11A of the M5. Its main purpose was to serve the Invista factory, but now includes the distribution and commercial and office tenants of the business park as well as the residential development known as Coopers Edge. The local demand served by this substation will rise beyond the reported maximum of 9MW. The substation is served from Castlemeads by a double 33kV circuit and is also connected to the Rotol substation located at Staverton to the north. It contains three transformers each rated at 15MVA. A direct 33kV feeder supplies the Invista factory which suggests a very high electrical load at that site.



Figure 6: Brockworth 33/11kV Substation

Far Substation	Near Substation Node Id	Circuit Length (km)	Summer Max Rating (MVA)	Winter Max Rating (MVA)
Castlemeads	BROC33 1	8.265	31.0	35.0
Castlemeads	BROC33 2	8.123	31.0	35.0
Rotol	BROC33 3	6.911	24.7	30.8

Table 9: Brockworth Substation 33kV Circuits

The fault parameters at the substation are summarised in Table 10 below.

Parameter	Values of 33kV side	Values on 11kV side
Equipment fault rating 3ph	make 43.8kA break 17.5kA	make 32.8kA break 13.1kA
Short circuit fault current 3ph	make 30.8kA break 13.5kA	make 26.8kA break 9.9kA*

Table 10: Brockworth Fault Parameters

The probable route to the substation heads due west from Javelin Park to then follows the M5 north to the Lobleys Drive bridge, from where it would cross Brockworth Business Park to the substation. Distance approximately 11.5km requiring wayleaves over private land for most of the route.

#### 5.5 Circuit Tee Ryeford-Netherhills

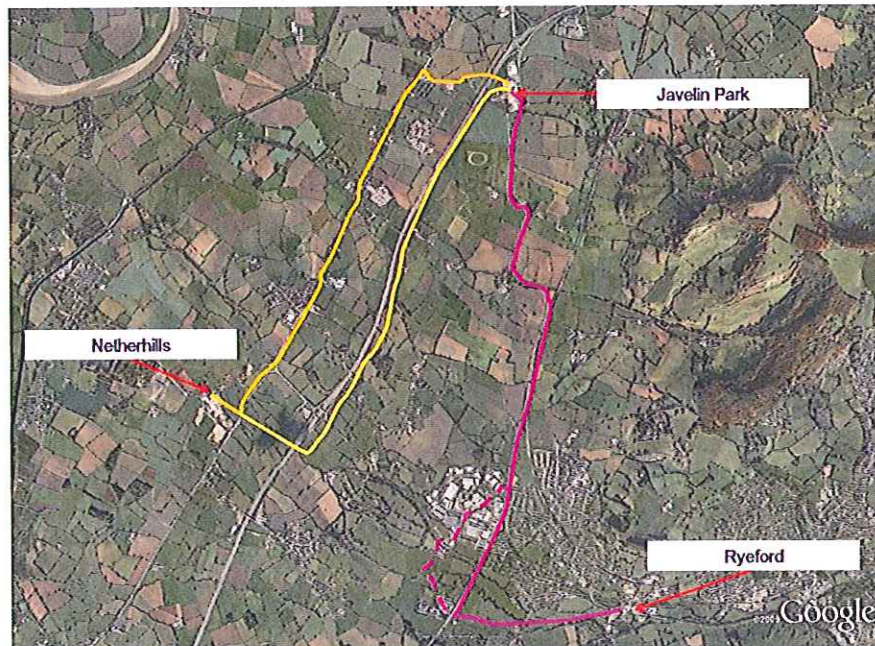
The 33kV double circuit between Ryeford and Netherhills substations runs approximately east-west about 6km south of Javelin Park. A circuit tee connection is usually cheaper than a busbar connection at a substation, but is less secure as it is dependent on that circuit being able to take the generation output at all times.

There are two possible routes to the Ryeford-Netherhills circuit:



- i. The route follows the path of the B4008 south through Little Haresfield and Standish to its bridge over the Bristol-Gloucester railway line. Part of this section already has roadside poling (probably telephone). From here it could follow the railway south to the sewage treatment works where it connects to the existing circuit. Distance approximately 6.6km.
- ii. The route follows the path of the B4008 south through Little Haresfield and Standish to its bridge over the Bristol-Gloucester railway line. Part of this section already has roadside poling (probably telephone). From here it could follow the railway south to the level crossing at Oldends Lane, Stonehouse. Following Oldends Lane to its junction with the A419 then south to a pole-mounted connection on the existing circuit. Distance approximately 6.8km.

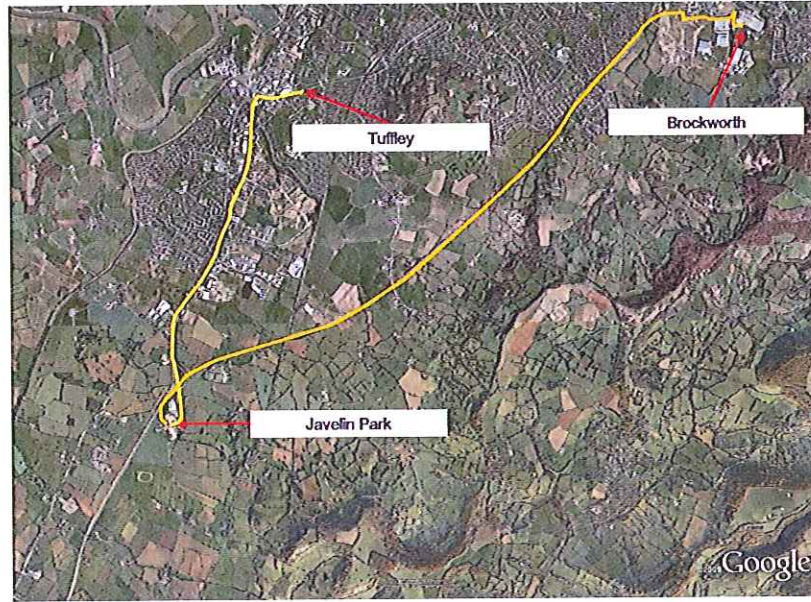
Figure 7 shows some of the possible routes south from Javelin Park. The yellow route is described in Section 5.2i, whilst the orange route is described in Section **Error! Reference source not found.**ii. The solid purple route is described in Section 5.3i, with the variant ii shown by the dotted line. Variant iii of the route to Ryeford follows the yellow route to the point where it turns to cross the motorway. Instead the route turns southeast to link with the purple routes. The circuit tee connections follow the purple routes to the points where they turn east.



**Figure 7: Southern Routes**

Figure 8 shows the probable routes for connecting to Tuffley or Brockworth substations. Both routes follow major roads, although the route following the M5 would be crossing private land for most of the distance due to restrictions on access to motorway verges





**Figure 8: Northern Routes**

**6. CONNECTION COSTS**

This section is for information only to assist in the evaluation of the connection options. Budgetary values are given to show the relative costs of each option. Balfour Beatty can contract directly for these elements if they can be delivered more economically than by the network operator. Work within a substation compound or involving the direct connection to distribution network equipment is restricted and must be carried out by Central Networks West or its approved contractor. No provision has been made for these costs in this assessment. Actual costs for non-contestable work will be identified in the formal connection offer from Central Networks.

For all options, one or more on-site control buildings will be required to house and meter the Point of Supply and also house the customer switchgear and the transformer such that energy is exported at 33kV. As these are common to all the connection options, the cost of this equipment has not been included in this analysis. Cost in relation to wayleaves has also been excluded.

Beyond the Point of Supply, line costs to the Point of Common Coupling to the distribution network circuit breaker are based on the following:

Item	Indicative Cost
33kV 240mm <sup>2</sup> aluminium triplex cable direct buried in the public highway	
33kV 240mm <sup>2</sup> aluminium triplex cable direct buried in the soft verge	
33kV 240mm <sup>2</sup> aluminium triplex overhead mounted on poles	
Directional drilling under obstacles (e.g. railway line)	

**Table 11: Indicative Line Costs**

Cable or overhead line costs would be lower for 11kV, but would be in similar relative proportion.

Circuit breakers suitable for the loads under consideration should be budgeted at £25,000 each. Our preliminary investigations show that pole mounted utilities may already exist for part of some of the routes identified. It may be possible to share a modified facility or indeed to modify the route in order to do so. However, have made no allowance for any cost saving which might arise from using any existing facility.

### 6.1 Tuffley Substation

Using the indicative costs from Table 11 and the possible routes identified in Section 5.1 the comparative cabling costs for the Tuffley substation option are summarised in below.

Route	Soft Verge	Highway	Overhead	Directional	Total Cabling Cost
1	5.48km	0km	0km	190m	

### 6.2 Netherhills Substation

Using the indicative costs from Table 11 and the possible routes identified in Section 5.2 the comparative cabling costs for the Netherhills substation option are summarised in below.

Route	Soft Verge	Highway	Overhead	Directional	Total Cabling Cost
1	0km	0km	6.5km	0m	
2	1.15km	0km	4.86km	20m	

### 6.3 Ryeford Substation

Using the indicative costs from Table 11 and the possible routes identified in Section 5.3 the comparative cabling costs for the Ryeford substation option are summarised in below.

Route	Soft Verge	Highway	Overhead	Directional	Total Cabling Cost
1	1.65km	0km	5.8km	46m	
2	1.0km	1.5km	4.8km	40m	
3	0km	0km	9.78km	0m	

### 6.4 Brockworth Substation

Using the indicative costs from Table 11 and the possible routes identified in Section 5.4 the comparative cabling costs for the Brockworth substation option are summarised in below.

Route	Soft Verge	Highway	Overhead	Directional	Total Cabling Cost
1	1.4km	0km	10.0km	45m	



## 6.5 Circuit Tee Ryeford-Netherhills

Using the indicative costs from Table 11 and the possible routes identified in Section 5.5 the comparative cabling costs for the Brockworth substation option are summarised in below.

Route	Soft Verge	Highway	Overhead	Directional	Total Cabling Cost
1	0km	0km	6.65km	0m	
2	0.96km	0km	5.8km	55m	

## 7. INFRASTRUCTURE CHANGES

A potentially significant inclusion in the 2008 version of the Central Networks West Long Term Development Statement was consideration in 2012 of a network reinforcement at Quedgeley, to serve the increasing demand in the south-western area of Gloucester. This demand growth is centred on the redevelopment of the former RAF depots to the north of the Javelin Park site as identified in Section 2. Although its precise location is not stated, this new substation is likely to be located around 2km from Javelin Park and would be a 132/11kV substation on the Castlemeads-Berkeley circuit.

However, this project has been dropped from the list of planned work in the latest (2009) published edition. The omission is probably because the capital works programme is a major issue with respect to allowable revenues under the distribution price control review which has only been concluded by the energy regulator, Ofgem, since publication. This does not mean that the work will not happen unless its omission is due to reduced funds available and reduced need both resulting from the recession. It does highlight a potential longer term adequacy issue for the distribution network operator.

This situation has implications for a generator at Javelin Park. Central Networks West is likely to be very interested in connecting at the Tuffley substation (at the generator's cost) in order to avoid (its own) investment in the new substation.

## 8. ENERGY SALE OPPORTUNITIES

The profitability of a generation project can be enhanced using energy sales methods other than simply to a licensed utility supplier. These range from on-site sales, where the consumer is co-located with the generator, to simple contractual instruments through a supply agreement. Such commercially driven arrangements can substantially change the most economically advantageous connection from that which is technically simplest or least cost. They should therefore be considered at the strategic business level rather than simply as electrical engineering facilitation.

### 8.1 Contractual Electricity Sales to Gloucestershire County Council

In its information provision to bidders, Gloucestershire County Council has indicated that it would consider being a purchaser of energy from the Javelin Park generator. The Council has a long history of purchasing its energy from local waste sources dating back to the mid-1990s. Unfortunately, there is no single Council-owned consumption point of any size in close proximity to Javelin Park to make a direct connection viable. However, it is possible to contract through a



licensed supplier (or indeed for the generator operator to become a licensed supplier) in order to do this.

## 8.2 Private Network Supply

Despite being located close to a commercial development area, the business parks to the north of Javelin Park are primarily office and light industrial/commercial units which are not currently used by significant energy consumers. However, potentially suitable manufacturing/process engineering consumers exist at the Stroudwater Business Park on the western edge of Stonehouse. The substation connection at Ryeford (see Section 5.3) or the circuit connection (see Section 5.5) could involve a route to the Point of Common Coupling through this business park.

Businesses located at the Stroudwater Business Park include:

- Dairycrest Severnside, the UK's largest dairy.
- Schlumberger Technology Centre, manufactures pumps and tools for the oil and gas industry.
- SKF Aeroengine UK, manufactures bearings and other engine components for Rolls Royce.

Direct connection to one or more consumers (i.e. before the Point of Common Coupling) would establish the consumers as electrically 'on-site' to the generator. This means that whilst they can still be supported by the network, their primary supply source will be the Javelin Park generator. This in turn means that much of the delivery cost related to their electricity consumption (up 5% of the value) could be avoided. It would also mean that generator revenue would be closer to retail electricity prices than the default wholesale price. Such an arrangement could be beneficial to both generator and consumer.

A similar arrangement could be made at Brockworth with the Invista factory, which would involve connecting to its transformer adjacent to the Brockworth substation. The additional cost of reaching Brockworth from Javelin Park appears to make this option less attractive, but it should not be discounted as over 10 years the additional capital cost could be recovered at less than 1% increment on the sales price.

A full investigation of the commercial opportunities for electricity sales should be conducted prior to any commitment undertaken in relation to a specific network connection for the generator. This is especially true in the case of Javelin Park where connection to the network could be made in a number of geographically dispersed locations. Alongside this, careful consideration of the exact metering and transformer arrangements in relation to the generator side of the Point of Common Coupling should be made in order to realise the value of direct connection and private wire connections.