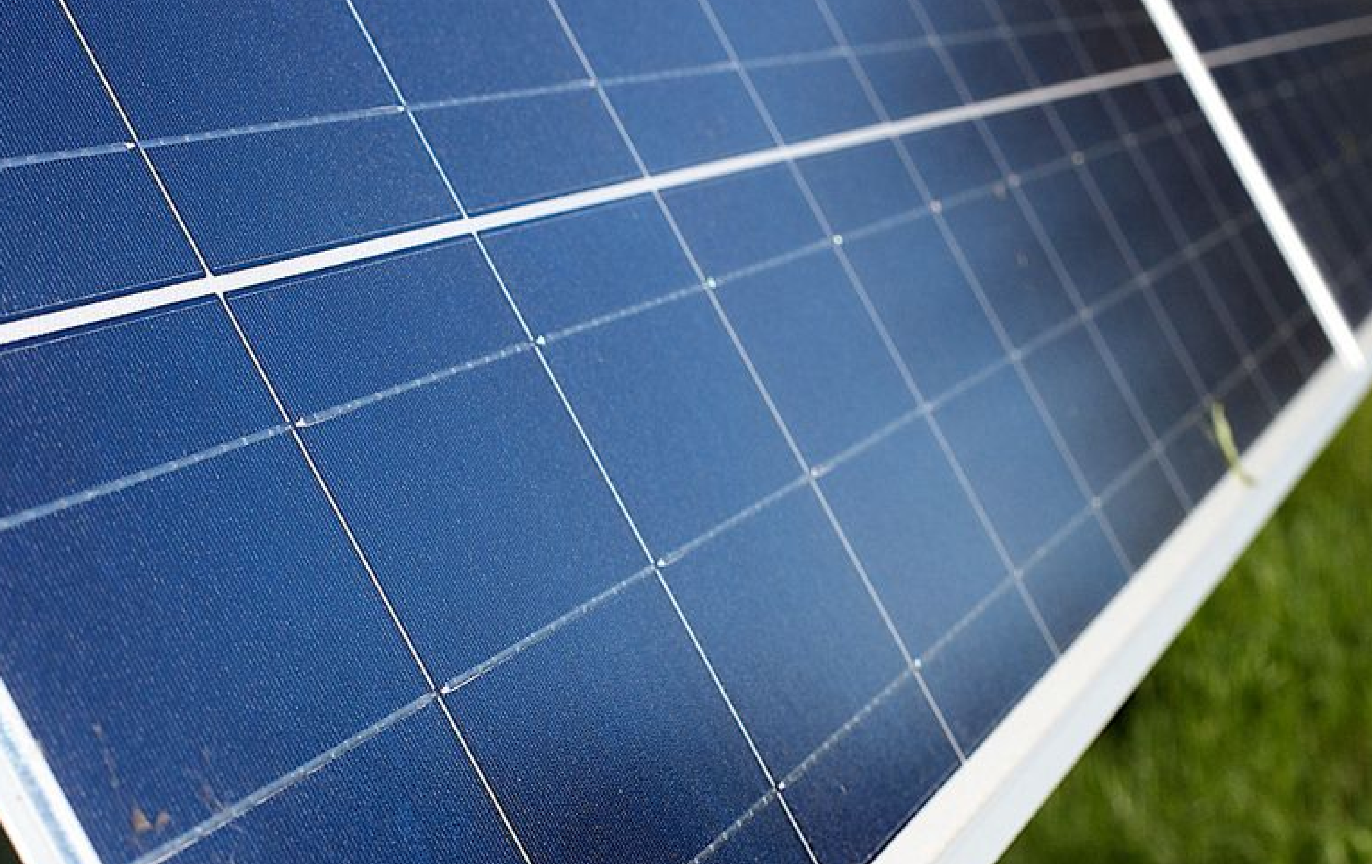

Greater Norwich Energy Infrastructure Study

Report Description

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Contents

1. Executive summary

Greater Norwich Development Partnership is responsible for all development across the areas belonging to the councils of Norwich, Broadland and South Norfolk and have ambitious growth plans for 42,900 homes and around 45,000 jobs to be delivered between 2015 and 2036. One critical aspect to the success of their plans is adequate energy supplies and they commissioned Egnida to review the current infrastructure and to identify areas where there may be constraints with energy supplies now and in the future. Further ways to work around these constraints and mitigate their impact, whether alternative approaches to energy supplies or planning policy, have been explored. This study is intended to provide evidence in order for the emerging GN Local Plan to support development and the spatial distribution of growth.

By reviewing existing energy demand for electricity, gas and heat we created and mapped a baseline across the region, identifying areas of the highest demand. Plans for development, both commercial and domestic, were also reviewed and the likely additional peak power demand was forecast, based on benchmarks and coming changes to government policy. The final important element is the capacity at each electricity substation across the region. These are the crucial parts of the infrastructure, which can dictate if development is possible or not. The peak capacity available has been assessed and then each substation has been categorised according to the available capacity at peak times.

The results of the analysis are illustrated in Figure 1. The areas of planned development are shown, colour-coded in blue according to the peak load of each site. Also shown are local 33/11kV substations, represented by dots colour-coded according to the available capacity. This shows the current load on these substations and does not account for 'reserved' capacity where part of the available headroom on the substation has already been committed to a future customer. The substations in green have no capacity issues, however there is only one on the map. **Those in dark orange and red already have little spare capacity and will struggle to serve any additional development without any mitigation measures**.

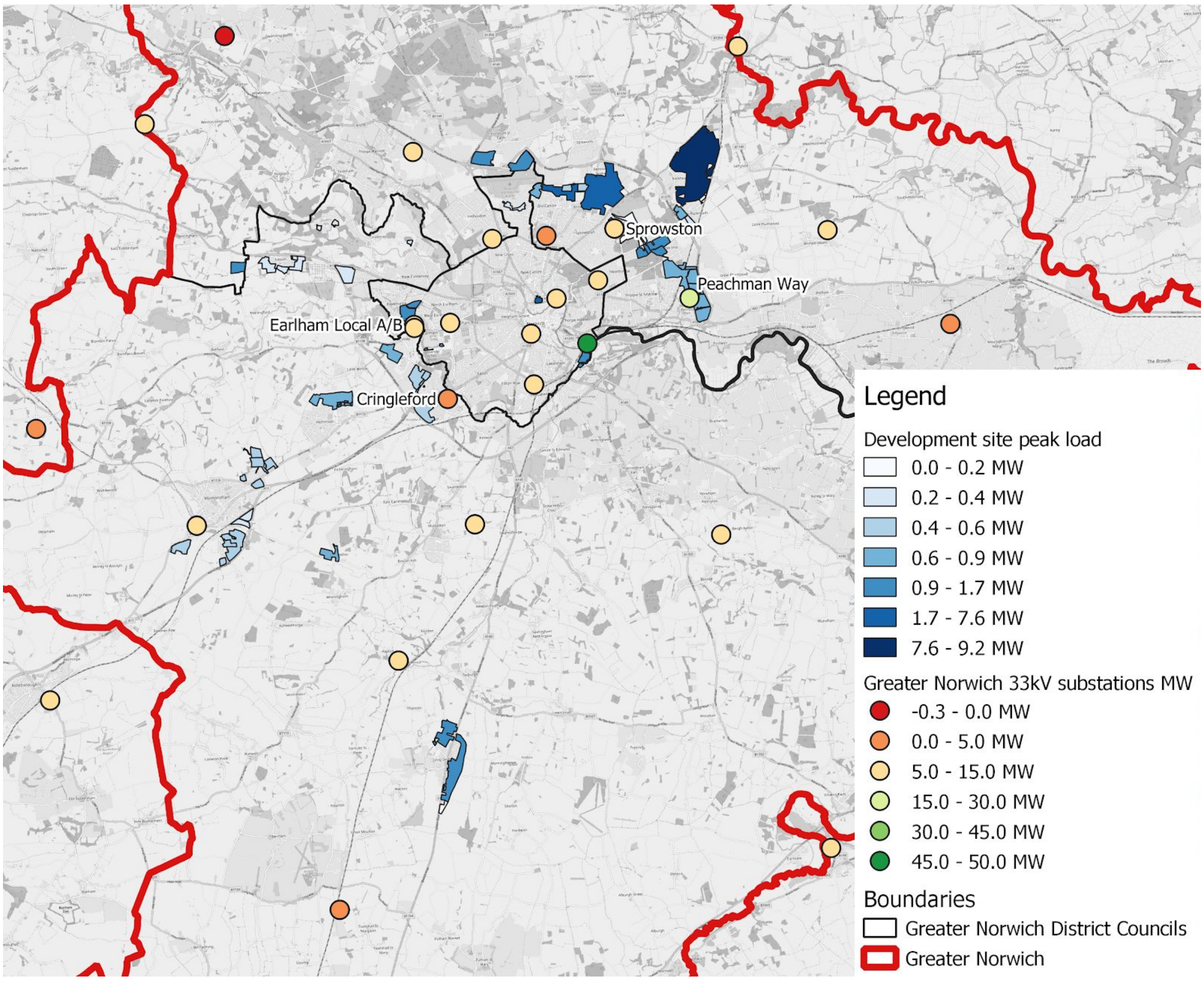


Figure 1: Planned development sites and existing substation spare capacity within Greater Norwich

Where cumulative required capacity from new development sites exceeds existing available capacity then not all of the planned development will be able to proceed without potentially costly and time-consuming reinforcement works.

Primary substations (33/11kV) where forecast demand from planned development exceeds locally available capacity: **Sprowston, Peachman Way, Earlham Grid Local, and Cringleford.**

Table 1 shows each of the substations where forecast demand exceeds capacity including reserved capacity, and the development sites affected. This table accounts for reserved capacity, which adds an additional barrier to new development where some of the available headroom is already committed. Beyond these, potential additional sites to be delivered as part of the new local plan that are provisionally located at Sprowston (Sprowston Primary) and Costessey (Earlham Grid Local) will also be particularly affected by these constraints, as they are located in already constrained areas.

Table 1: Development sites associated with each constrained substation

Substation (132/33kV)	Affected development sites	Current substation rating	Rating including reserved capacity	Rating after planned development
Sprowston Primary	Beeston Park Home Farm Sprowston Land off Salhouse Road Land south of Green Lane East Land south of Green Lane West Land south of Salhouse Road Rackheath White House Farm	Light Amber 5-15 MW	Dark Amber 0-5 MW	Red < 0 MW
Peachman Way Primary	Broadland Gate Brook Farm Land east of Broadland Business Park Land north of Broadland Business Park	Pale Green 15-30 MW	Dark Amber 0-5 MW	Red < 0 MW
Earlham Grid Local A/B	Costessey GN Food enterprise zone Longwater / Easton Norwich Research Park Three Score	Light Amber 5-15 MW	Light Amber 5-15 MW	Red < 0 MW
Cringleford Primary	Cringleford Hethersett	Amber 0-5 MW	Red < 0 MW	Red < 0 MW

There will be a shortfall in electricity supply for the developments shown in Table 1 unless remedial action is taken. **This would prevent some of these sites from being developed within planned timescales and would incur additional cost.**

Locations which are currently more suitable for additional development with greater levels of available capacity are:

- Southeast and Southern Norwich City - particularly where load has been freed up by reductions in industrial usage.
- Areas to the east of South Norfolk district, supplied by Ilketshall Grid

While there may be electricity capacity in these identified locations, this will not be the sole determinant of where growth goes, so where development is delivered in other areas a plan needs to be in place to overcome constraints.

Network constraints are clearly going to present a major barrier to delivering all of the planned growth in the local plan, and are already having an impact on development, with capacity issues in areas such as the Norwich Research Park and the Broadland Growth Triangle. Traditional reinforcement is both a lengthy and costly process, and so innovative solutions are required in order to facilitate growth within Greater Norwich.

Recommended approaches for grid constraints

The traditional solution to grid constraints is to upgrade the local network connection at the substation and in the local infrastructure. However, **the capital costs to do this would be between £2.5 million and £10 million**, depending on the scale of the development. It is also likely to take several years before the work can be undertaken. There are ways to avoid or reduce the costs of improved network connection. Each site will be different, dependent on what activity will be undertaken on the site and the local vicinity. However, the following list of alternative approaches should be considered for all sites affected by grid constraints:

- Semi-islanded approaches utilising on-site generation and smart energy management solutions can enable development in constrained areas. Semi-islanded development sites including high levels of on-site, renewable or low carbon generation and batteries can be designed such that local benefits can be maximised while also having a positive effect on local electricity networks.
- Work with the DNO to offer demand side response services, where on-site generation could be turned up or load reduced in response to network signals, can help balance supply and demand more locally and assist system operators to deal with local constraint issues, so at times of network stress.
- Investment in infrastructure on these sites should be delivered through an Energy Services Company model, which can then provide a steady revenue stream for those involved.

On a modelled constrained site including on-site CHP and solar generation, with private wire electricity sale and heat supply through a heat network **an investment of £3.7m in capital expenditure would result in a rate of return of 8% over 25 years** through selling generated electricity to customers on site, while capping peak loads on the local network negating the need for traditional reinforcement.

It is recommended that the pilot sites are developed in such a way so that appropriate solutions can be identified and tested for how they could be delivered technically and economically. These solutions can then be applied to other sites with similar issues, and should be assessed with a view to understanding the potential for replication of each technical solution.

Public sector organisations are best placed to unlock the barriers to development that a grid constraint network present as they are motivated to encourage development in their areas, have a long term investment view, a low risk profile allowing a lower cost of capital for investments and can play a vital facilitation role between the key parties. In order for the public sector to facilitate infrastructure improvements or innovative approaches to power delivery it is likely to require the establishment of an Energy Services Company to facilitate local authority involvement in this and manage investment and risk.

Planning policy

In addition to the commercial facilitation role that the Councils can play, consideration of how **local planning policy could help facilitate development** will be beneficial to optimise the schemes coming forward. The details of the policy would have to be developed by each local authority, however the following areas are recommended focus areas in order to shape developments and ensure grid constraints are not a barrier:

- Minimising energy demand from new development – by exceeding Part L Building Regulations requirements.
- Ensuring energy is used efficiently – look at balancing the demands across as site by identifying complementary tenancies and activities.
- Managing peaks of electrical demand in new developments - use on-site ESCOs to balance supply and demand through the use of renewable energy and batteries.
- Reducing carbon intensity of energy supplies through increasing renewable generation locally and requiring greater carbon reduction from developers

Next steps

Further actions to progress this study are:

- Incorporate planning policy recommendations into **Greater Norwich Local Plan**
- Undertake **more detailed feasibility studies** considering identified pilot sites in order to model potential semi-islanded approach in greater detail
- Get buy-in from local authority senior leadership for development of an **Energy Services Company** to deliver local infrastructure investment
- For sites in areas that are particularly constrained ensure **alternative approaches to energy infrastructure** are considered

2. Introduction

Broadland, Norwich and South Norfolk councils, the Greater Norwich (GN) authorities, have an existing Joint Core Strategy (JCS), and supporting Local Plans, covering the period to 2026.

Working with Norfolk County Council and the Broads Authority through the Greater Norwich Development Partnership (GNDP), GN authorities are reviewing and rolling forward the joint Greater Norwich Local Plan (GNLP) to 2036, covering both strategic policies and the allocation of housing, commercial and other sites. Estimated growth requirements out to 2036 have been produced by the GNDP; the evidence suggests a target of 42,900 houses and around 45,000 jobs 2015-2036.

To support the delivery of their planned growth, the GN authorities require a strategic approach to identifying any areas of constraint, securing the anticipated power requirements and putting in place mechanisms and policies to address these constraints. This study will support both the planning and delivery of growth. It will provide evidence in order for the emerging GN Local Plan to support development and the spatial distribution of growth. It will also identify electricity grid constraints and opportunities at key committed sites and advise on suitable energy policies.

This study will provide a robust evidence base for the GNLP, support the drafting of effective energy policies, the development of the growth strategy and help ensure delivery of committed sites.

3. Existing energy demand

In order to understand the area's energy infrastructure, local energy demands have been analysed and considered in context with the electricity network constraints

3.1. Existing energy demands for electricity and heat

Electricity consumption has been mapped by Middle Super Output Area (MSOA), a geographic unit by which the Department for Business, Energy and Industrial Strategy (BEIS) publishes this data, this is shown in Figure 2 below. From this we can see that the most concentrated electricity demand is seen in central Norwich. These figures are an aggregation of both domestic and industrial demand in the area. Electricity demand has also been considered in the context of peak power demand through analysis of UK Power Networks (UKPN) load data. This is presented further into the report.

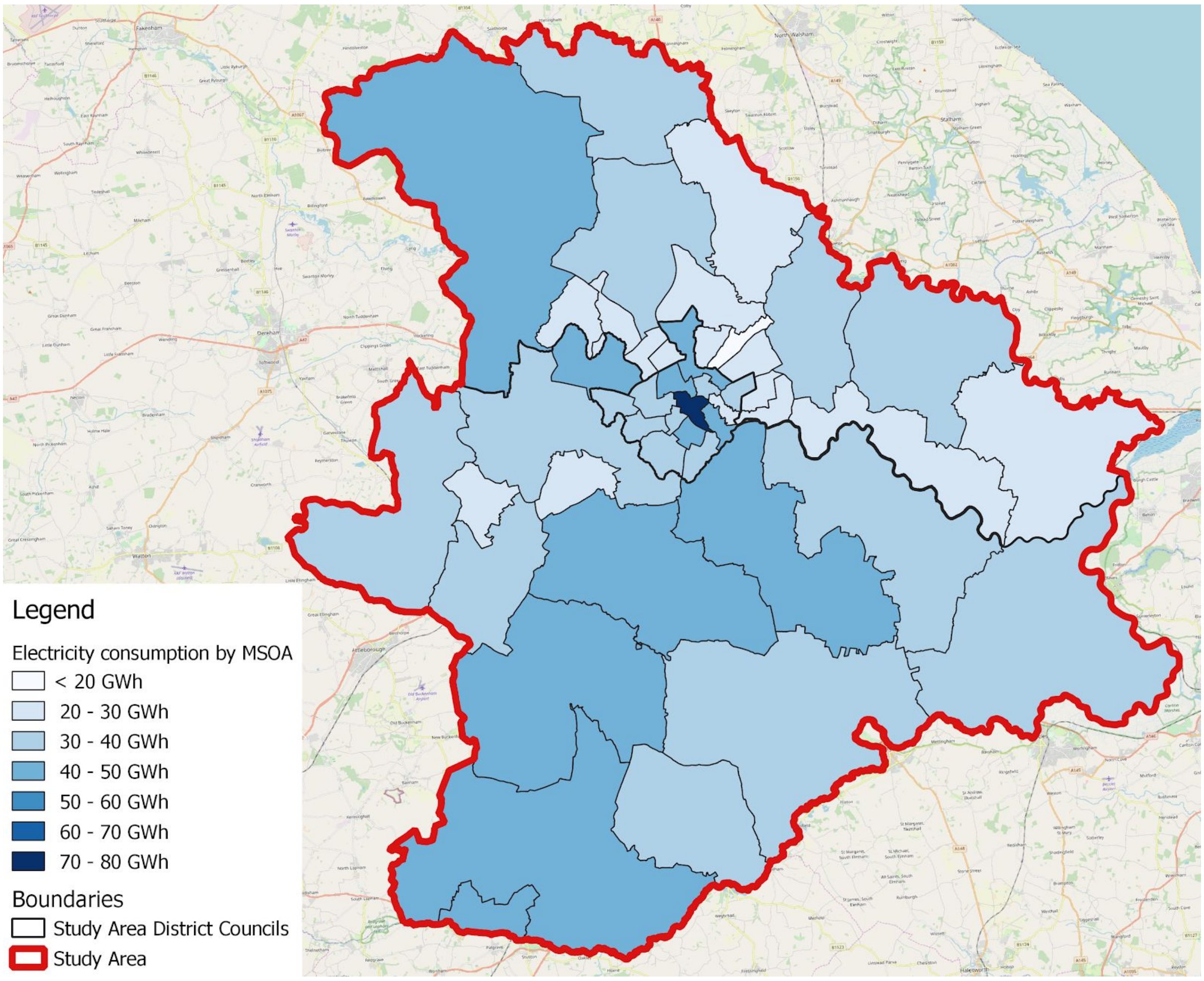


Figure 2: Electricity demand by Middle Super Output Area in Greater Norwich, 2017

One avenue that needs to be considered is opportunities to supply energy through heat networks. This is important as it is potentially an alternative means of supplying heat to homes without utilising in-home gas boilers or electric heating/heat pumps which can impose additional demands on the grid at peak times. To aid in this we have mapped existing heat networks within Norfolk to better understand what the potential for connections to existing networks may be. These are shown in Figure 3 below.

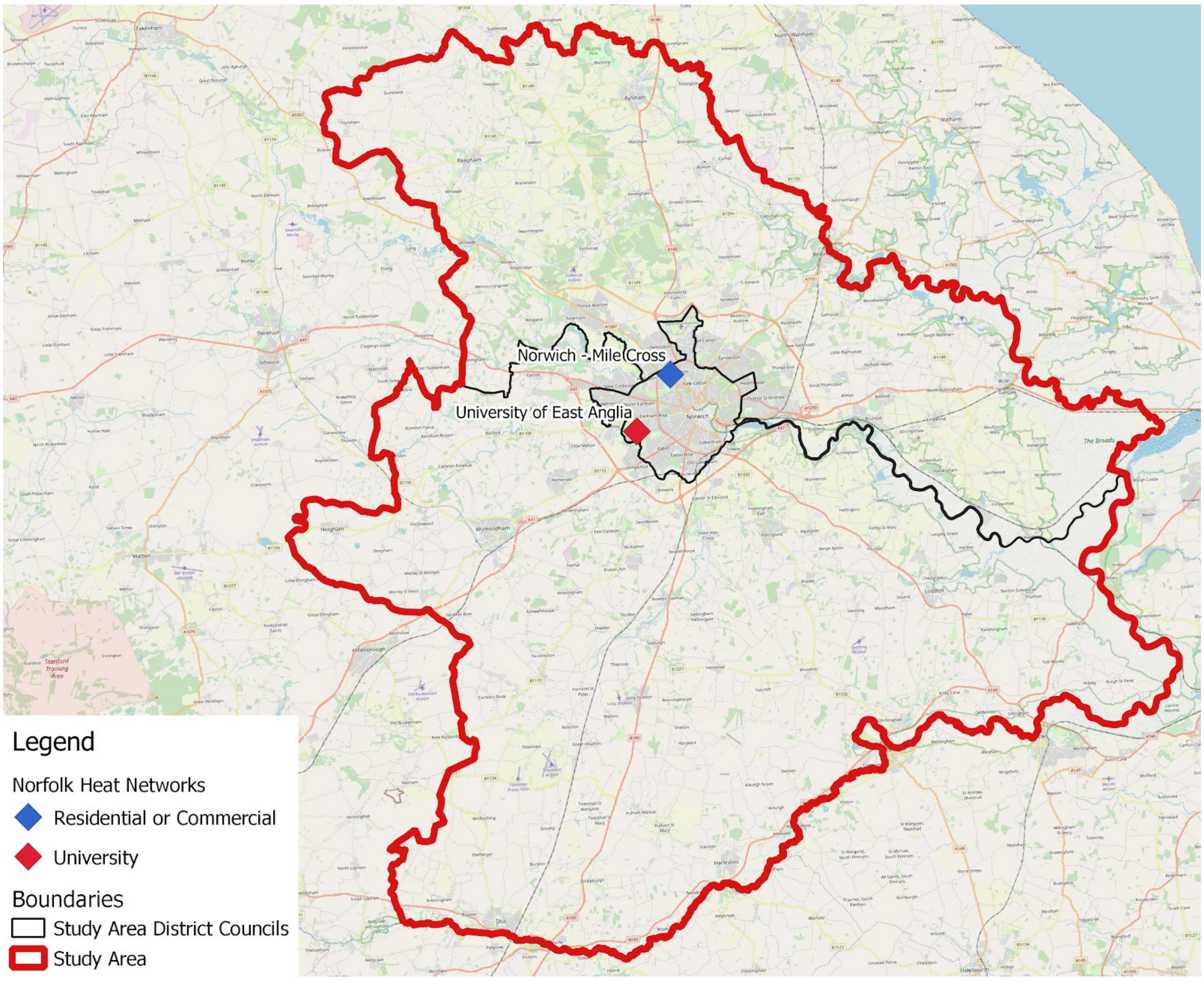


Figure 3: Existing heat networks within Greater Norwich, 2019 (ADE)

The University of East Anglia (UEA) has a heat network supplying heat to buildings on its campus. This is fed by gas-powered Combined Heat and Power units generating heat and electricity, with top-up provided by gas boilers. Generated electricity is also used on site to offset demand. The Mile Cross heat network is a residential network supplying heat only in the northwest of the city. No planned heat networks of significant scale were identified within the study area.

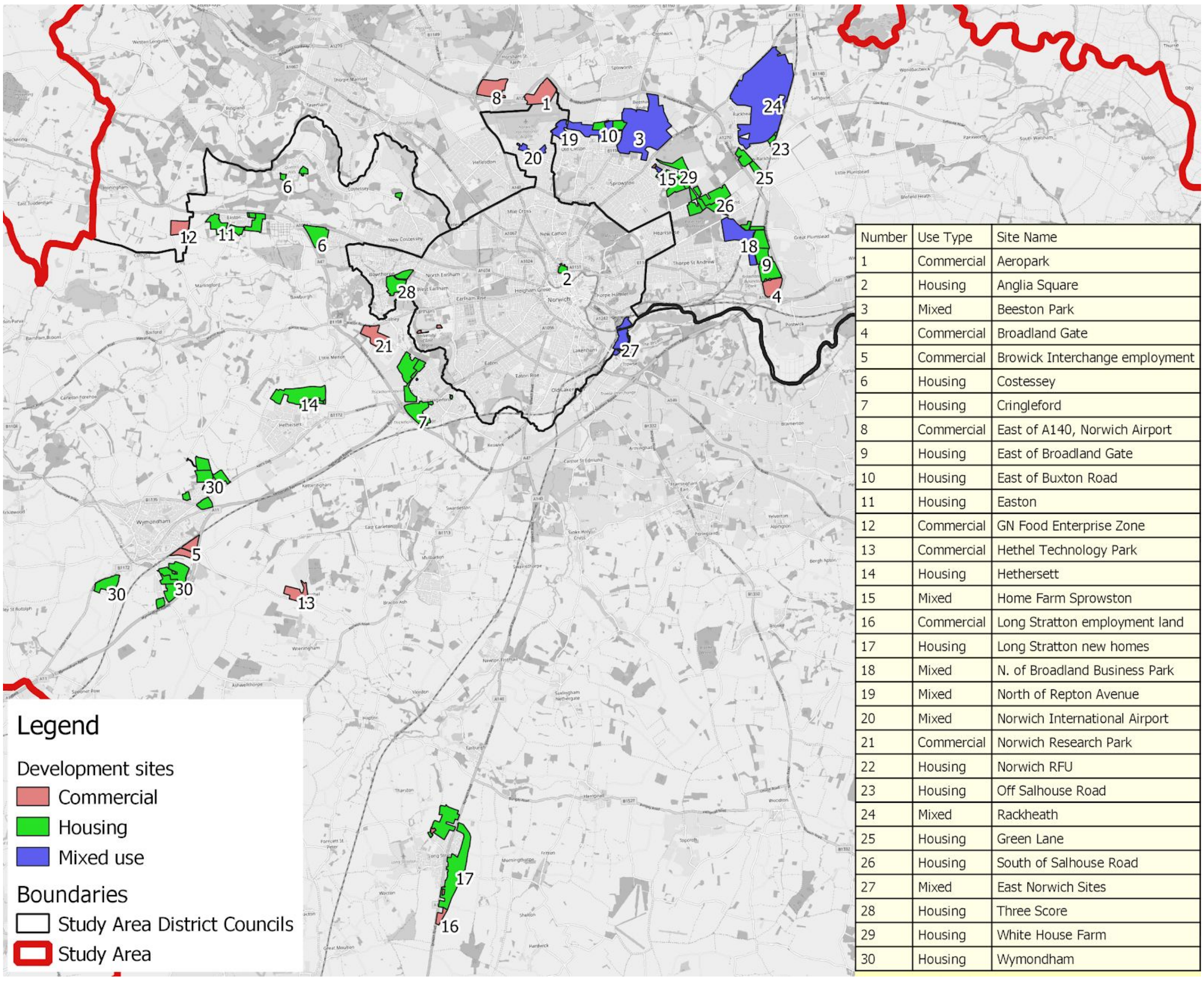
3.2. Projected future demands for electricity, heat and power

Modelling has been undertaken to understand the likely impact of local growth on energy and power demands in order to consider how this might be able to be delivered locally.

3.2.1. Review of energy demand for committed sites

Energy modelling has been undertaken to consider how energy and power demands for new sites are likely to vary. The 2014 Joint Core Strategy (JCS) for Broadland, Norwich and South Norfolk identified sites for new development out to 2026; the new Greater Norwich Local Plan (GNLP) will run to 2036 and identify further sites. Figure 4 sets out the locations of the large-scale development sites identified in the JCS and other Local Plan documents. These include housing sites of 90 homes and above and commercial sites of around 1 hectare and above.

Broad locations for the additional growth to 2036 to be brought forward through the GNLP have been provisionally identified for plan making purposes. These locations are referenced in section 3.2.3, however, specific sites for this additional growth have not yet been identified.



Number	Use Type	Site Name
1	Commercial	Aeropark
2	Housing	Anglia Square
3	Mixed	Beeston Park
4	Commercial	Broadland Gate
5	Commercial	Browick Interchange employment
6	Housing	Costessey
7	Housing	Cringleford
8	Commercial	East of A140, Norwich Airport
9	Housing	East of Broadland Gate
10	Housing	East of Buxton Road
11	Housing	Easton
12	Commercial	GN Food Enterprise Zone
13	Commercial	Hethel Technology Park
14	Housing	Hethersett
15	Mixed	Home Farm Sprowston
16	Commercial	Long Stratton employment land
17	Housing	Long Stratton new homes
18	Mixed	N. of Broadland Business Park
19	Mixed	North of Repton Avenue
20	Mixed	Norwich International Airport
21	Commercial	Norwich Research Park
22	Housing	Norwich RFU
23	Housing	Off Salhouse Road
24	Mixed	Rackheath
25	Housing	Green Lane
26	Housing	South of Salhouse Road
27	Mixed	East Norwich Sites
28	Housing	Three Score
29	Housing	White House Farm
30	Housing	Wymondham

Figure 4: Committed major development sites in the Greater Norwich area

For each commercial site, energy benchmarks for likely site occupancy based on planning use classifications have been used to model total energy demands on the site. These have been combined with load profiles for the different types of commercial demand in order to understand peak power demands. For some sites floor areas are known, while for others only the total hectares of the site are known, for sites without floor areas, reasonable assumptions have been made on expected likely floor area based on the size of the site. Figures with asterisks alongside them show assumed figures. Table 2 shows the data inputs for each site.

Table 2: Commercial site data and assumptions

Site	Site area (Hectares)	Floor area (m^2)	Commercial use types
Aeropark	37	95,035	B1b, B1c, B2, B8, D1
Norwich Research Park	40	99,000	B1b
Browick Interchange employment site, Wymondham	15	46,500*	B1 ,B2, B8
Hethel Technology Park	15	46,500*	Advanced engineering & Technology
Long Stratton employment land	9.5	29450*	B1,B2, B8
Norwich International Airport		30,000	Commercial and Industrial
Land east of A140, Norwich Airport	35	108,500*	B1 ,B2, B8
Land north of Broadland Business Park (Laurel Farm)	15	57,481	B1 ,B2, B8
Broadland Gate	21.5	42,000	B1, B8, A1-A4, C2, D1, D2
Rackheath	25	77,500*	B1 ,B2, B8
Beeston Park		25,600	B1, A1-5, C1, D1, & D2
Home Farm Sprowston	0.8	2,400	A1
Land north of Repton Avenue		5,600	B2
GN Food Enterprise Park	19	50,000	B2, B8

These development sites are at an early stage, so it is not possible to precisely model future energy demands. These figures should be viewed as an estimate based on reasonable assumptions and the best available data. The modelling outputs for commercial sites for a typical February day are shown in Figure 5.

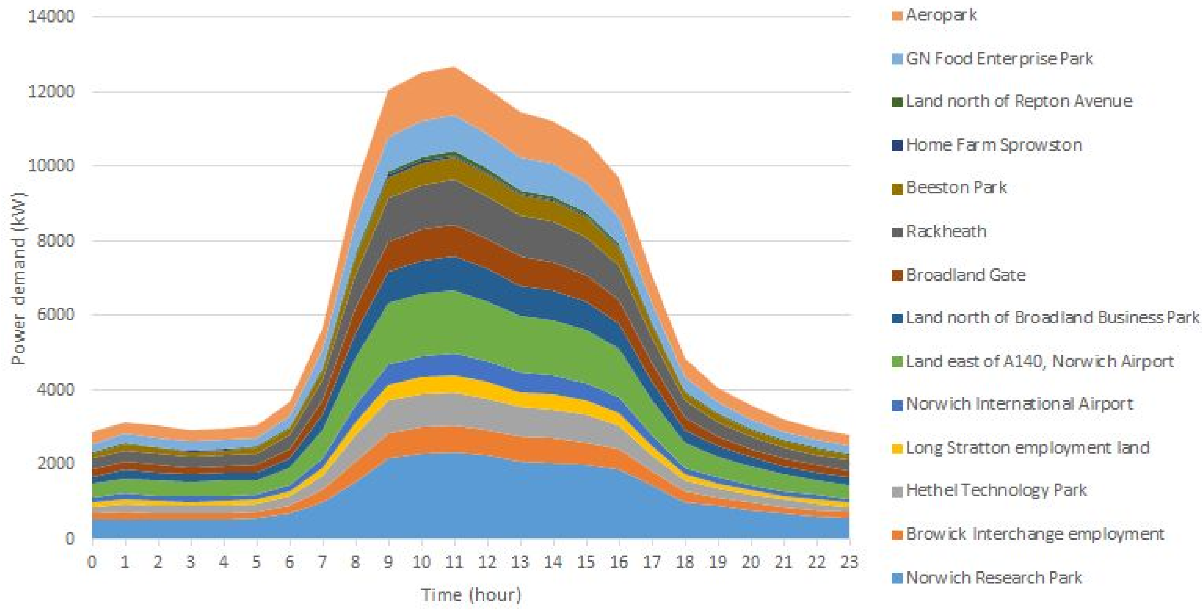


Figure 5: Commercial demand modelling for typical February day

Electricity demand from housing depends on a number of factors. Within this modelling exercise we have utilised After Diversity Maximum Demand (ADMD) figures for peak domestic power. ADMD is used in the design of electricity distribution networks where demand is aggregated over a large number of customers. Network peak demand, considering diversity between customers is time coincident where within each household there are times, mainly the 4-8 pm period, in which electricity is used simultaneously, for example when many appliances are used at the same time. Within an individual property demand can vary substantially, but as larger numbers of properties are considered the variance between instantaneous load in each property reduces overall peak loadings for a given area.

Modelled demand for each large committed development site is given in Table 3 below. Peak power demand shown is based on an ADMD of 2kW per house. The impact of this on a per substation basis is shown in Table 4 in section 4.

Table 3: Development sites, energy and power demands

Development sites	Commercial floor area (m^2)	Dwellings to be built	Modelled total electricity demand (MWh)	Peak power demand (kW)
Aeropark	95,035		4,788	1,304
Anglia Square		1,209	3,875	2,418
Beeston Park	25,600	3,520	13,083	7,640
Broadland Gate	42,000		3,119	856
Brook Farm		600	1,860	1,200
Browick Interchange	46,500		2,620	724

Costessey		432	1,339	864
Cringleford		1,421	4,405	2,842
East Norwich Sites		1,200	3,720	2,400
GN Food Enterprise Park	50,000			459
Hethel Technology Park	46,500		3,023	895
Hethersett		1,067	3,308	2,134
Home Farm Sprowston	2,400	91	493	235
Land east of A140	108,500		6,112	1,690
Land east of Broadland Business Park		1,333	4,132	2,666
Land east of Buxton Road		225	698	450
Land north of Broadland Business Park	57,481		3,238	895
Land north of Repton Avenue		340	1,418	788
Land off Salhouse Road		95	295	190
Land south of Green Lane East		153	474	306
Land south of Green Lane West		322	998	644
Land south of Salhouse Road		1,183	3,667	2,366
Long Stratton employment land		1,836	4,405	459
Long Stratton	29,450		1,659	3,672
Longwater / Easton		901	2,793	1,802
Norwich International Airport		40	1,950	577
Norwich Research Park	99,000		8,692	2,338
Norwich RFU		250	775	500
Rackheath	77,500	4,000	13,666	9,207
Three Score		828	2,567	1,656
White House Farm		160	3,652	320
Wymondham		2,270	7,037	4,540

These demands have been mapped and are shown in Figure 6 below. These then need to be considered within the context of the spare capacity at each substation.

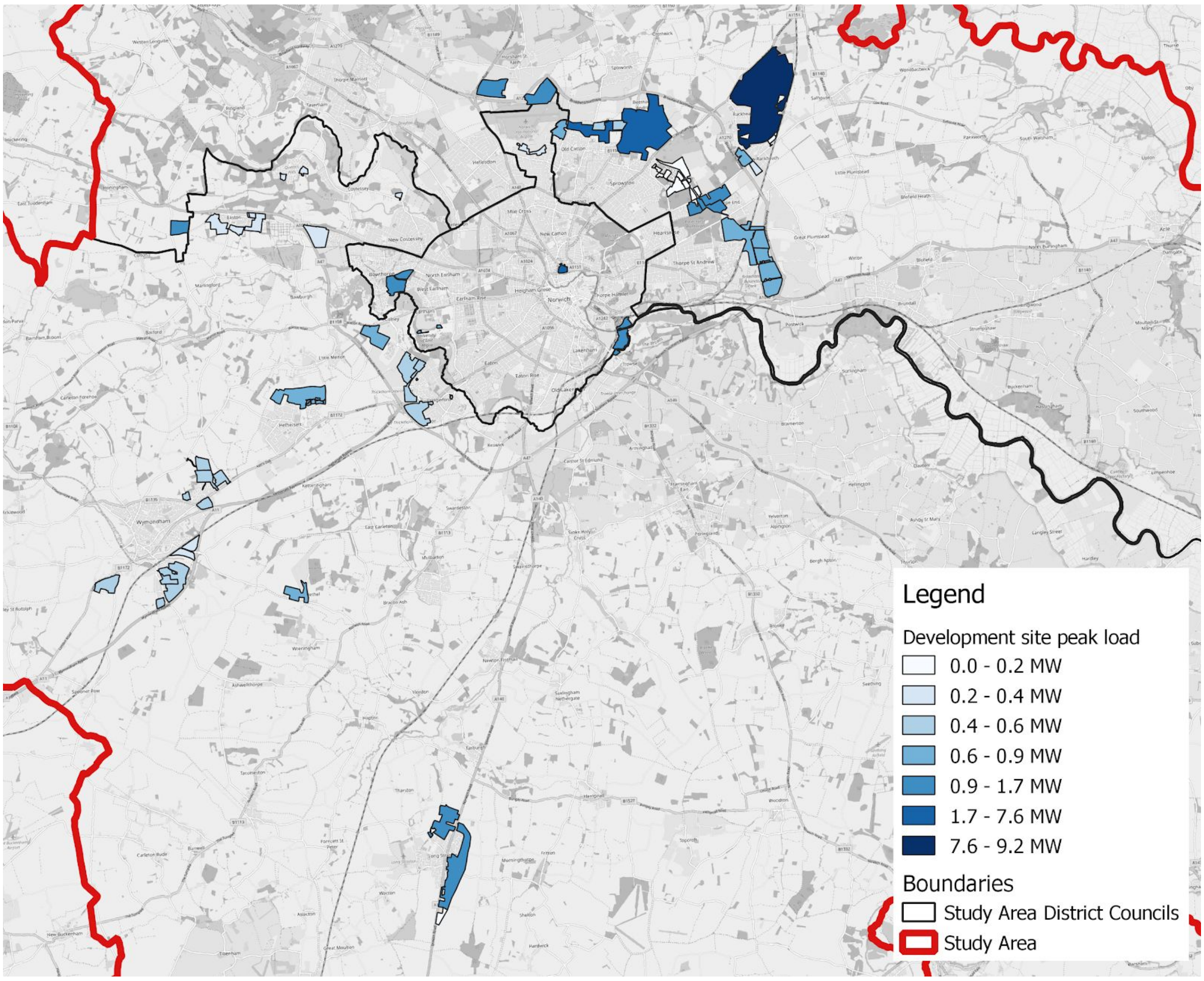


Figure 6: Peak demand mapping of Greater Norwich development sites

The figures presented within this mapping represent standard typical assumptions for domestic demand of 2 kW per house ADMD. The following section explores scenarios in which this assumption may need to be altered, in particular in relation to increased use of low-carbon technologies.

3.2.2. After Diversity Maximum Demand variations

ADMD for a standard property connected to the gas network is assumed at a typical 2 kW per household, however this can vary, for some types of household occupancy this may be lower, and may be substantially higher for households with additional technologies included, such as electric heating, heat pumps or electric vehicle charging. Figure 7 shows how the after diversity maximum demand per household for standard properties changes with an increased number of households included within the group.

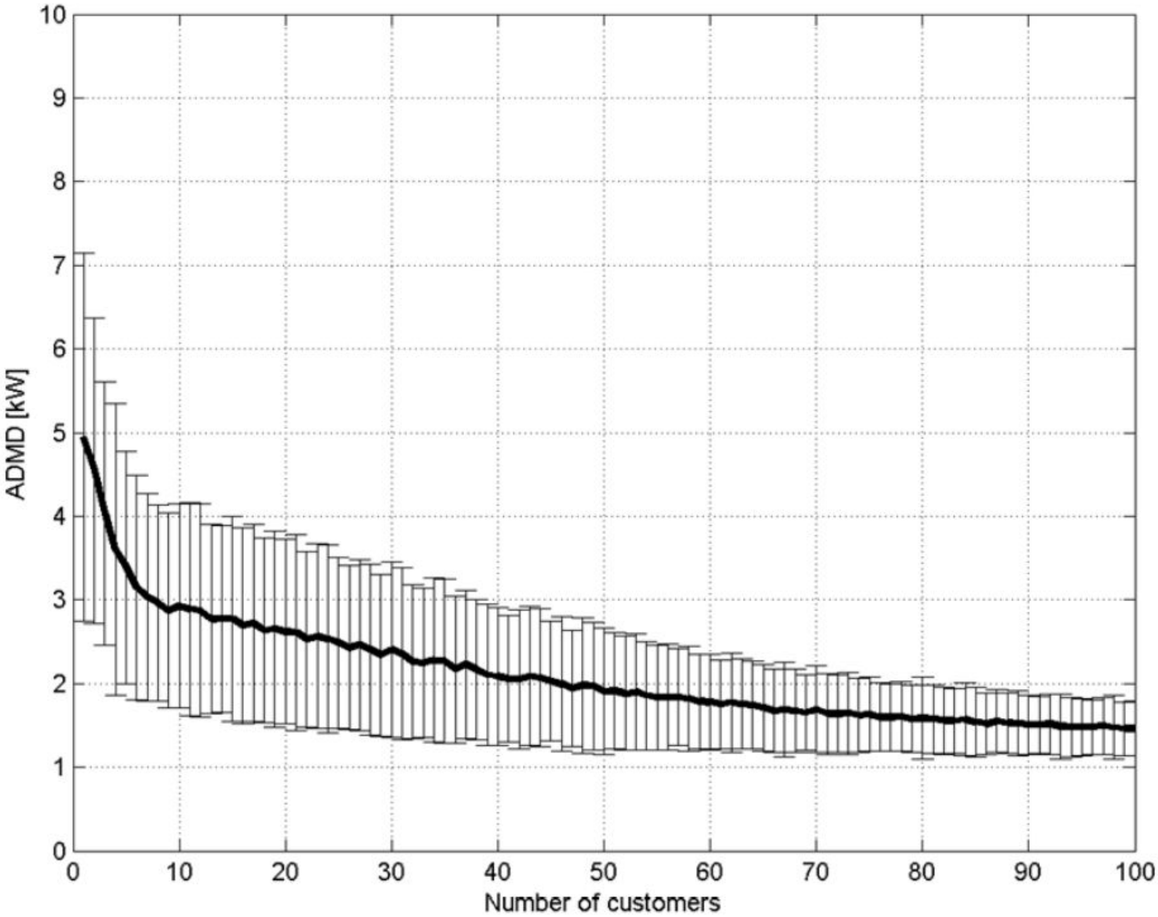


Figure 7: After diversity maximum demand (ADMD) curve for medium income households, Network Revolution 2015[1]

Peak domestic demand typically occurs between and 4 and 8pm on a weekday, with contributions from lighting, cooking and appliances. Additional contributions for heating or electric vehicle charging can make a major difference to the peak demands per property, however. There are lower levels of diversity when considering heating loads supplied by electricity, as all houses within a local area are likely to experience similar temperatures, requiring heating input at the same time.

This depends heavily on the type of heating systems involved and the energy efficiency of properties. Direct electric heating imposes significant demands on the grid compared to a technology such as heat pumps, which utilise electricity to extract heat from the ground or the air, and are two to four times as efficient. Even when heat pumps are utilised, the time coincident nature of heating demand overlaps substantially with existing winter evening peaks for electricity, which can impose additional burdens on local networks.

There is greater opportunity for load shifting of heating demand in properties with greater energy efficiency. In a well-insulated property, heat will be lost to the outside more slowly, so a property heated to the desired temperature before the peak 4-8pm period would retain more

[1] http://www.networkrevolution.co.uk/project-library/diversity-maximum-demand-admd-report/

of its heat and require less input in topup. This is seen most obviously in ultra-low energy property designs emphasising a fabric-first approach such as homes designed according to the German Passivhaus standard which has strict requirements on the maximum space heating load allowed per property as part of the design.

National carbon reduction targets will require substantial cuts in emissions from the built environment, including homes, and the Government have provided support through the Renewable Heat Incentive[2] (RHI) to encourage the take-up of renewable forms of heating, including heat pumps. Utilising electricity to supply heat reduces associated carbon emissions further still as the carbon emissions factor for electricity falls with greater penetration of renewable and low-carbon generation technologies into the national generation mix.

Scenario	Description	ADMD Per Home (kW) Diversified	ADMD Per Home (kW)
0	Gas Fired Heating With A Conventional House	0.75	2.0
1a	30% Deployment Of HP	0.80	2.0
1b	60% Deployment Of HP	1	2.5
1c	Full Deployment Of HP	1	2.5
2a	30% Deployment Of Total Electrification In Smart Grid Scenario	1	2.5
2b	60% Deployment Of Total Electrification In Smart Grid Scenario	1.5	3.0
2c	Full Deployment Of Total Electrification In Smart Grid Scenario	2	5.0
3a + 2c	Full Deployment Of Total Electrification In Smart Grid Scenario + 30% Deployment Of EV's At On Peak Fast Charge	3	7.0
3b + 2c	Full Deployment Of Total Electrification In Smart Grid Scenario + 60% Deployment Of EV's At On Peak Fast Charge	3.5	9.0
3c + 2c	Full Deployment Of Total Electrification In Smart Grid Scenario + Full Deployment Of EV's At On Peak Fast Charge	4.5	11.5

Figure 8: Modelled ADMD figures under different scenarios from Strathclyde University's Wire Resilience Impact Scenario Calculator (WRISC)[3]

Figure 8 shows the difference in modelled ADMD under different uptake scenarios of low carbon technologies, including heat pumps and electric vehicles. This shows the substantial additional demands that can be imposed by high penetration of low carbon technologies and the need to incorporate an appropriate plan for some of these issues when considering new developments.

While developments built today are unlikely to include an electric vehicle charging within every household, the market share of electric vehicles is increasing rapidly. Alongside the government commitment for no new petrol- or diesel-only vehicles to be sold post-2040 it is

[2] https://www.ofgem.gov.uk/environmental-programmes/non-domestic-rhi/about-non-domestic-rhi
[3] http://www.esru.strath.ac.uk/EandE/Web_sites/13-14/WRISC/index.html

clear that the demand from electric vehicles is likely to keep increasing. Infrastructure put in place in new developments between now and 2036 will need to be future-proofed to cope with likely changes in habits. The major differences in peak demand per household when including significant proportions of on-peak electric vehicle fast charging (7kW) demonstrate the importance of smart charging and incentivising households to charge at off peak times.

Government has already taken steps to address this through the passage of the Automated and Electric Vehicles Act 2018. This legislation aims to ensure all charge points sold or installed are 'smart', meaning they can receive, process and react to information or signals, such as by adjusting the rate of charge or discharge; transmit, monitor and record information such as energy consumption data; comply with requirements around security; and be accessed remotely. This will enable smarter domestic electric vehicle charging to become the norm, reducing the owner involvement required to adjust charging cycles to respond to incentives.

The Government's 2018 'Road to Zero' strategy sets out ambitions and policies for the decarbonisation of road transport. One such commitment is related to ensuring the houses built in the coming years are electric vehicle ready, stating "*it is our intention that all new homes, where appropriate, should have a chargepoint available*". Within high density developments in Greater Norwich it is unlikely to be appropriate for all new homes to have their own charging points, however communal parking areas should offer shared charging points. The need for chargers needs to be considered alongside other factors such as availability of local public transport. Where charging points are not provided new homes should be made 'EV ready' with pre-wiring put in place so that putting in a home charging point is straightforward in future.

3.2.3. Review of demand from additional development

Within large sites considered as part of this demand analysis there are 22,836 homes planned to be built on these. The GNLP identifies a forecast of 41,300 homes to be delivered from 2018 to 2036. 34100 of these are on committed sites, with a further 7,200 to be delivered as new allocations, including a buffer to ensure delivery.

New housing delivered on small sites of 25 homes or less may not have a major immediate local impact due to their small scale, however cumulatively demand for these houses contribute significantly to total additional peak electrical demand across Greater Norwich.

Based on standard ADMD figures, the additional 20,029 homes to be delivered would have a cumulative peak demand of over 40 MW. As many of these would be delivered on smaller, possibly rural, sites without access to gas the electrical demand for these may be higher still. These small sites are unlikely to be suitable for a heat network, so the most likely technology solution would be an oil boiler, biomass boiler or a heat pump. Future changes to the carbon factors utilised in the Standard Assessment Procedure will make oil a less likely solution into the future, indicating heat pumps are a more likely solution. Further to this, in the 2019 Spring Statement the Chancellor also announced that there will be no fossil fuel heating systems in new homes built after 2025. This will have a major impact, likely leading to greater uptake of heat pumps even in areas close to the gas network.

The potential 40 MW of additional demand would represent a significant additional aggregate load even at the higher voltage level. While the distribution is likely to be dispersed enough that no significant local ‘hotspots’ of additional demand are created, this additional load also needs to be considered and the upstream impacts of this on UKPN’s higher voltage network and the trans. This is explored further in section 4.1.1.

Of the 7,200 additional homes, locations for these have not been fully identified as yet, but some potential sites for large scale housing development greater than 1,000 homes are shown in Figure 9 below. From this it can be seen that these sites are in similarly constrained area to existing development sites, and while there is some spare capacity available, this is likely to be utilised by already planned sites.

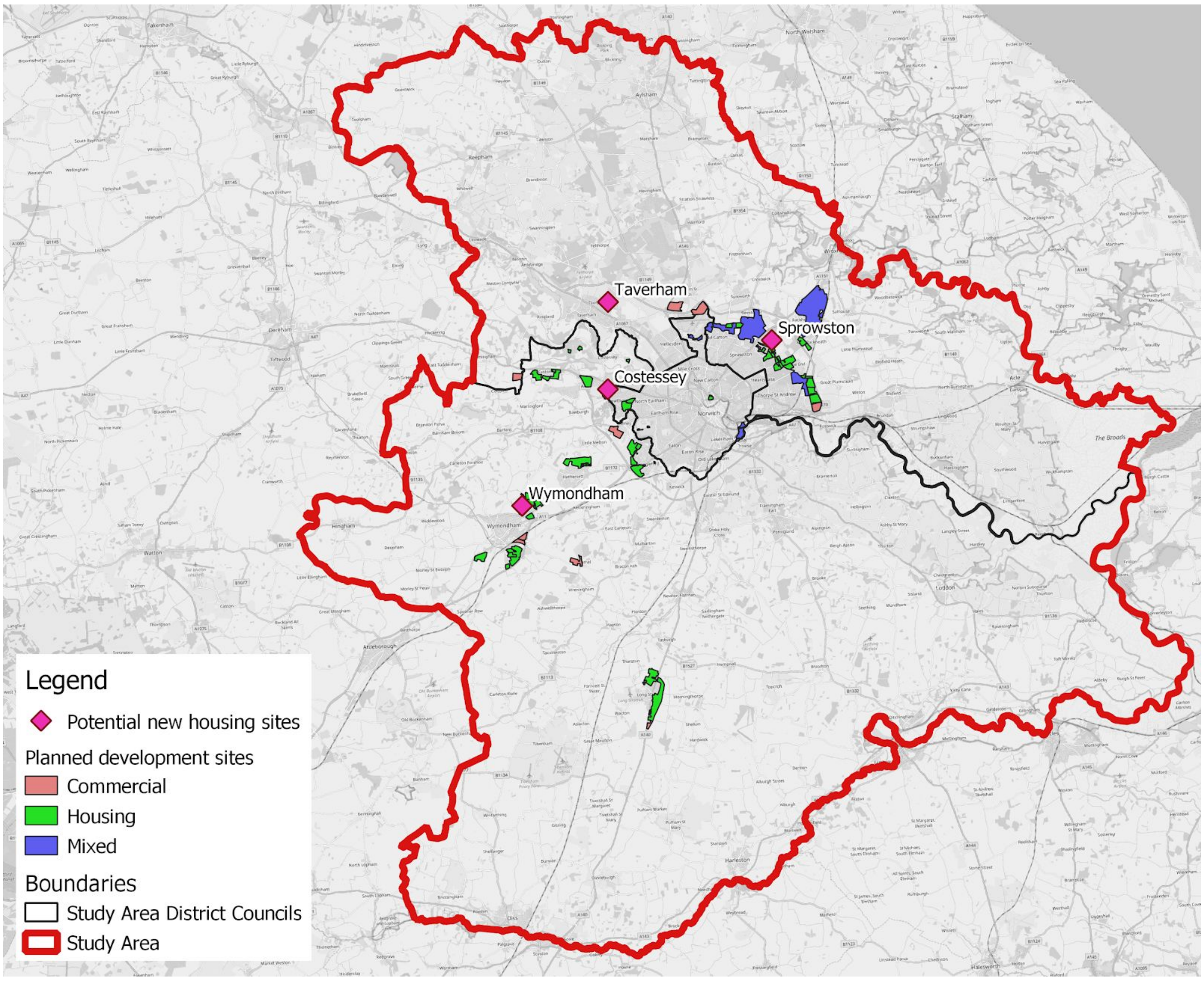


Figure 9: Potential additional sites for new housing development (>1000 homes)

4. Electricity network constraints analysis

The electricity network within Greater Norwich is shown in Figure 10 below. Electricity is primarily supplied to the area from the Grid Supply Point (GSP) at Norwich Main, where there is an incoming feed at 400kV from the National Grid. At voltages below this, the electricity network is operated by the Distribution Network Operator (DNO), UK Power Networks (UKPN).

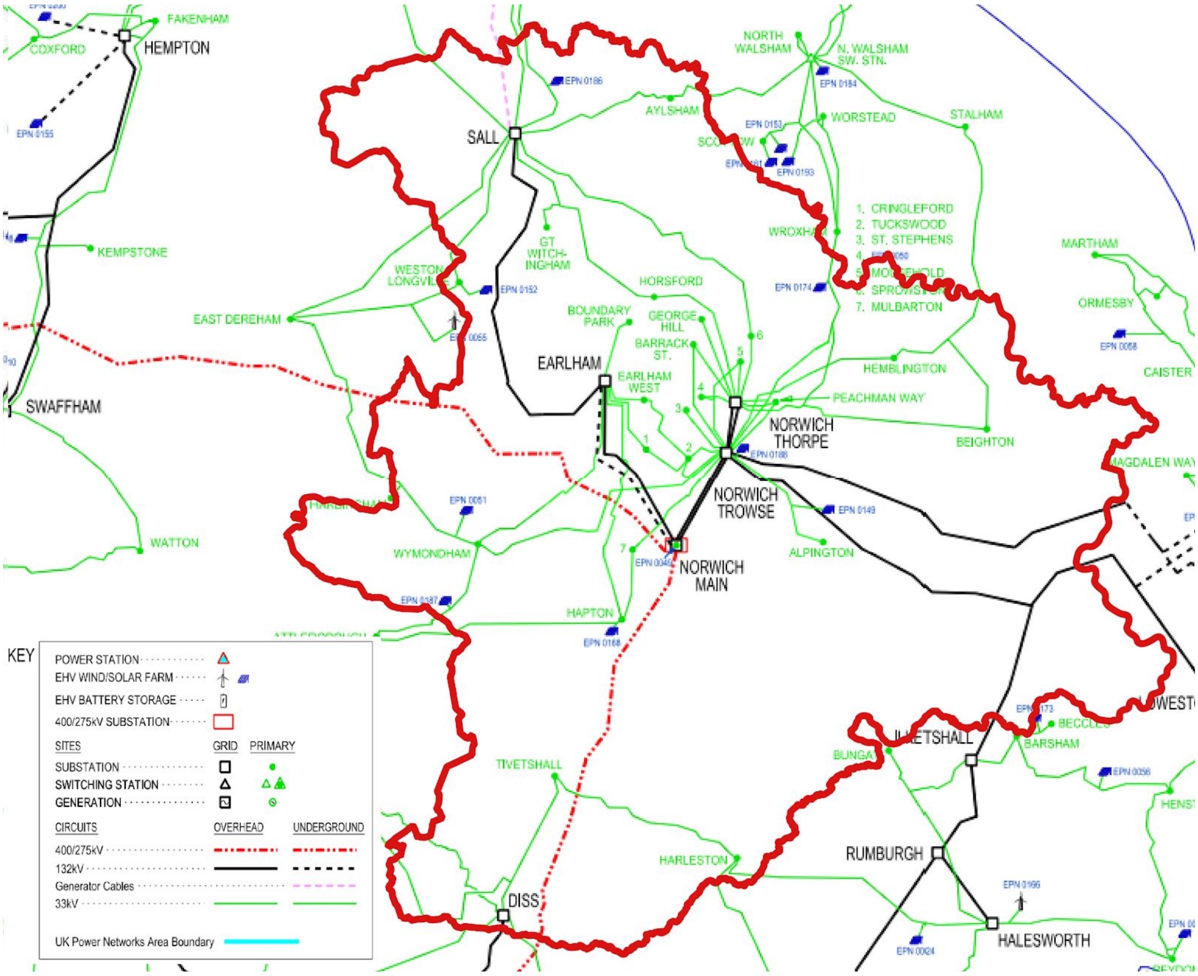


Figure 10: Electricity network in Greater Norwich at 400kV, 132kV and 33kV (UKPN 2018)

From the incoming feed at Norwich Main, the 132kV network shown in black runs to Bulk Supply Points (BSPs) at Sall, near the village of Salle, Earlham on the west edge of Norwich, and Thorpe and Trowse, southeast of Norwich. At these substations the electricity voltage is stepped down from 132kV to 33kV. Some of South Norfolk is supplied from the BSP at Diss, which is supplied from a GSP further south at Bramford. Each of the BSPs supplies a number of further Primary substations, connected by the 33kV network shown in green, where electricity is stepped down again from 33kV to 11kV. Some large industrial sites will be connected at 11kV, but the majority of loads, commercial and domestic are connected at 415V or 230V. The network below 33kV is not shown on this map.

4.1. Existing electricity network constraints

As part of this brief loading on the electricity network has been investigated. This has been undertaken in discussion with UK Power Networks the Distribution Network Operator (DNO) responsible for East Anglia, London and the South East. Reported figures from the biannually updated Long Term Development Statement have been reviewed, mapped and analysed in order to better understand the status of the local network.

Figure 11 shows primary substations supplying Greater Norwich mapped and colour coded using a traffic light system according to percentage loading on each of these. This considers peak power winter demand for the area connected to the substations against the maximum rated capacity of the transformers within the substation. From this it can be seen that the majority of substations in the Greater Norwich area are over 60% loaded, indicating high levels of capacity usage locally, however there are some exceptions.

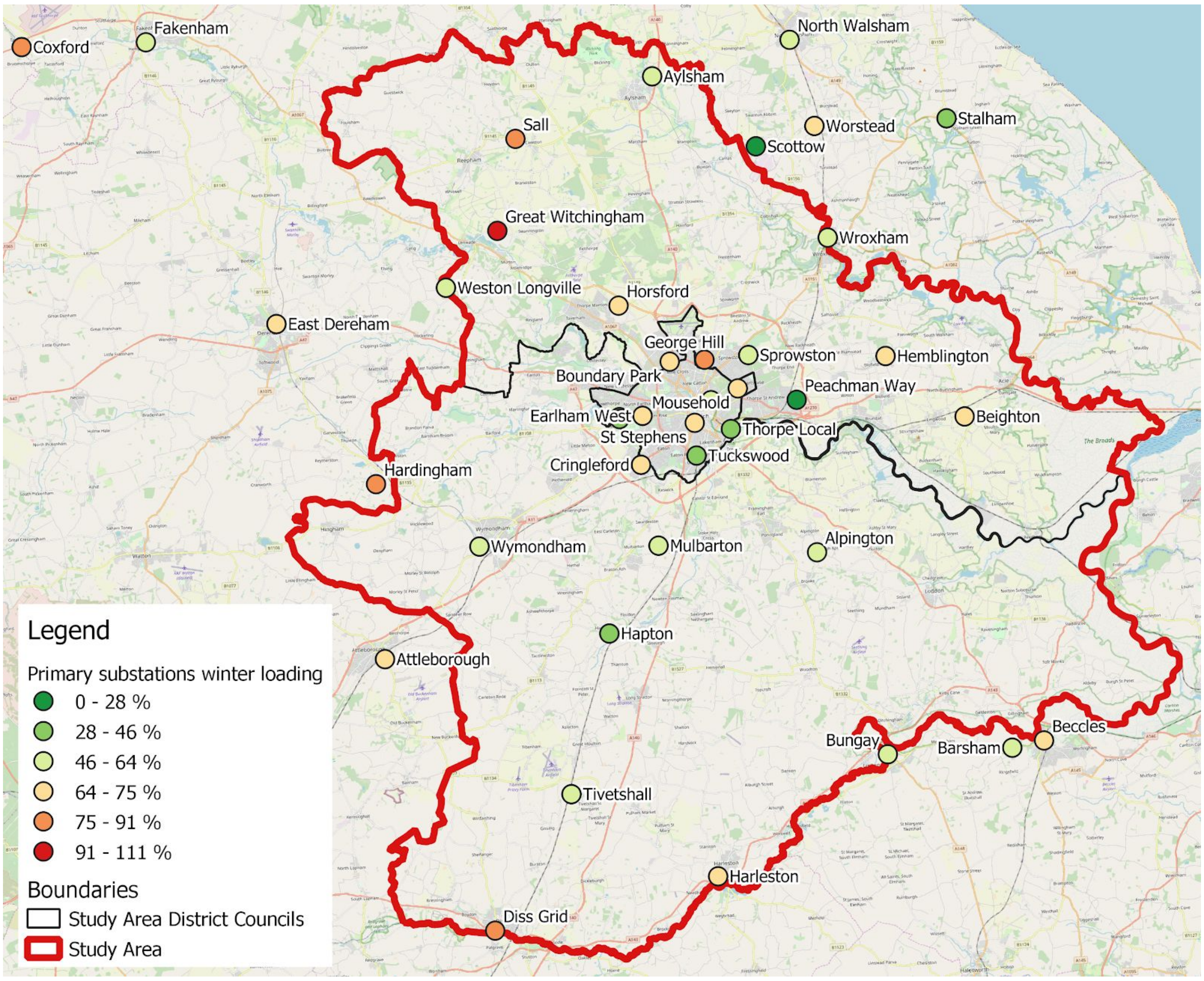


Figure 11: Winter loading % on Primary (33/11kV) substations within the Greater Norwich area

However, more important is how much physical capacity is available at each site at times of peak demand. Figure 12 shows fewer substations as green or yellow and more in dark orange or red compared to Figure 11. This indicates that even for those substations that had a reasonable proportion of spare capacity compared to their maximum capacity, many of these still have less than 10 MW available peak capacity. The only site now shown in green is Thorpe Local, a site within Norwich City centre that has significant levels of spare capacity and is connected directly to the 132kV network.

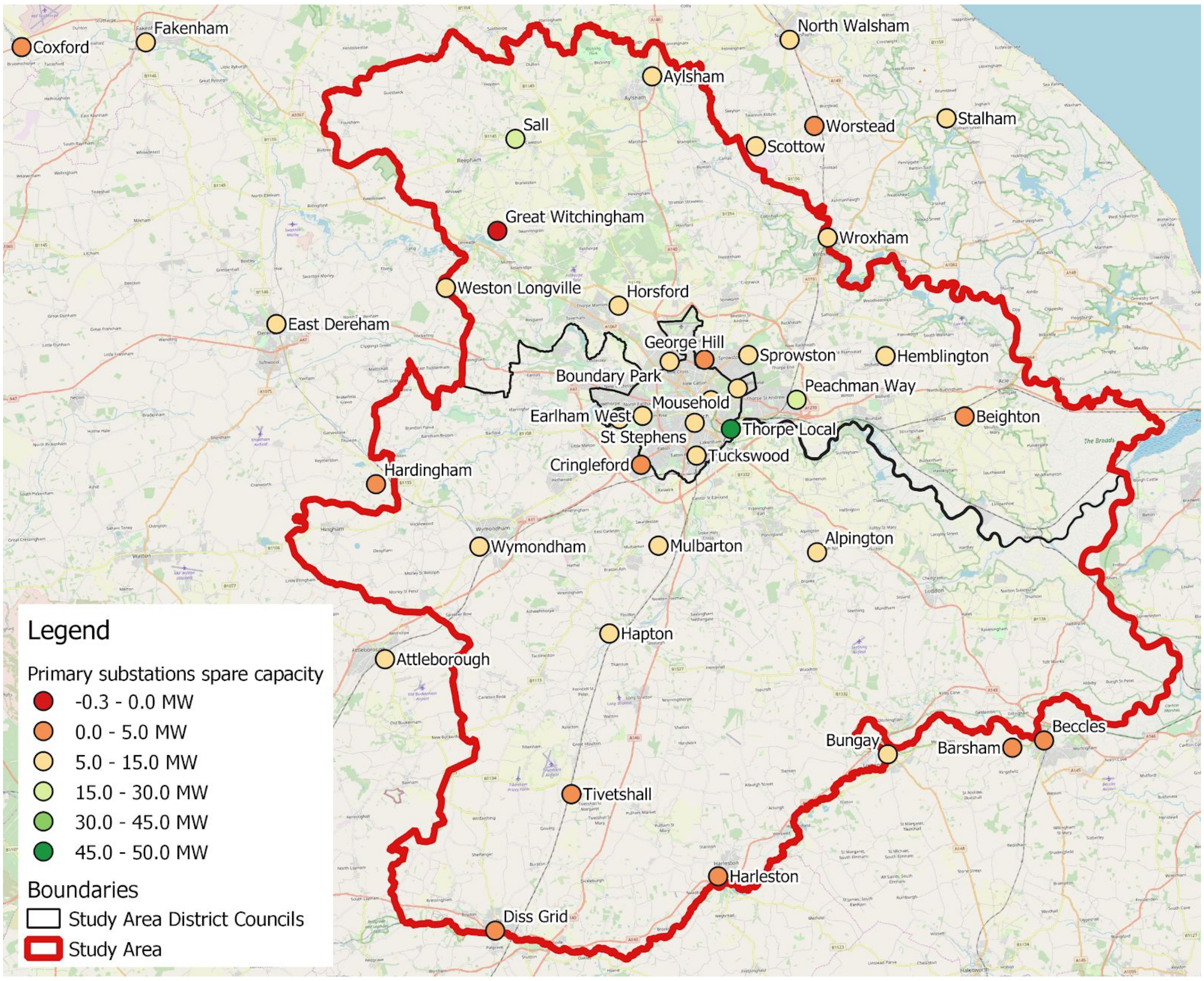


Figure 12: Available winter peak capacity on Primary (33kV/11kV) substations within Greater Norwich

One constrained development site in South Norfolk - Hethel Technology Park - has been unable to secure a connection to the local network as the 33kV network supplying the nearest primary substation at Hapton Primary is at maximum capacity. To provide additional capacity at Hapton it would be necessary to install a new 132/33kV substation at the Norwich Main site. This can take a substantial amount of time, around 5 years, and is also subject to agreeing a lease for the land required.

These figures show only connected capacity, however alongside this the DNO has also made connection offers to customers that have not yet connected to the network. Any party can request and accept a quotation for a particular site which will reserve capacity for a finite period. Beyond this it is possible to enter into a 'Reservation of Capacity' agreement, although this will incur ongoing charges.

This means that even in areas where there appears to be some spare capacity new development may not be able to proceed. In those development sites that are more advanced towards implementation developers involved in these sites may have partially secured some of this capacity for delivery of these sites, so consideration of reserved capacity as 'utilised' and unavailable for development can be misleading, but it provides guidance as to where the areas of most constraint are. Table 4 shows each development site against its closest Primary substation, and cumulative additional power demand for each, as well as the 132kV substation it is fed from.

Table 4: Peak demands per site against each substation

<table>
<tr><th rowspan="2">Grid substation</th><th rowspan="2">Primary Substation</th><th rowspan="2">Development site</th><th colspan="2">Modelled additional peak power demand (kW)</th></tr>
<tr><th>Per site</th><th>Per substation</th></tr>
<tr><td>132kV direct</td><td>Thorpe Local</td><td>East Norwich sites</td><td>1,200</td><td>1,200</td></tr>
<tr><td rowspan="6">Earlham</td><td>Boundary Park Primary</td><td>Norwich International Airport</td><td>577</td><td>577</td></tr>
<tr><td rowspan="5">Earlham Grid Local A/B</td><td>Costessey</td><td>864</td><td rowspan="5">7,634</td></tr>
<tr><td>GN Food enterprise zone</td><td>974</td></tr>
<tr><td>Longwater / Easton</td><td>1,802</td></tr>
<tr><td>Norwich Research Park</td><td>2,338</td></tr>
<tr><td>Three Score</td><td>1,656</td></tr>
<tr><td rowspan="7">Earlham/ Trowse</td><td rowspan="2">Cringleford Primary</td><td>Cringleford</td><td>2,842</td><td rowspan="2">4,976</td></tr>
<tr><td>Hethersett</td><td>2,134</td></tr>
<tr><td rowspan="3">Hapton Primary</td><td>Hethel Technology Park</td><td>895</td><td rowspan="3">5,025</td></tr>
<tr><td>Long Stratton</td><td>459</td></tr>
<tr><td>Long Stratton employment land</td><td>3,672</td></tr>
<tr><td rowspan="2">Wymondham Primary</td><td>Browick Interchange</td><td>724</td><td rowspan="2">5,264</td></tr>
<tr><td>Wymondham</td><td>4,540</td></tr>
<tr><td>Thorpe/ Trowse</td><td>Barrack St Primary</td><td>Anglia Square</td><td>2,418</td><td>2,418</td></tr>
</table>

	George Hill Primary	Land east of Buxton Road	450	1,738
		Land north of Repton Avenue	788	
		Norwich RFU	500	
	Horsford Primary	Land east of A140	1,690	2,994
		Aeropark	1,304	
	Peachman Way Primary	Broadland Gate	856	5,617
		Brook Farm	1,200	
		Land east of Broadland Business Park	2,666	
		Land north of Broadland Business Park	895	
	Sprowston Primary	Beeston Park	7,640	20,908
		Home Farm Sprowston	235	
		Land off Salhouse Road	190	
		Land south of Green Lane East	306	
		Land south of Green Lane West	644	
		Land south of Salhouse Road	2,366	
		Rackheath	9,207	
		White House Farm	320	

Reserved capacity is not accounted for within these graphics, and is not published by the DNO, as it can change rapidly as new budget estimates and quotes are requested and existing offers are accepted or rejected if an offer holder decides not to proceed.
Discussions with UKPN have flagged up areas in which reserved capacity would present an additional problem. This information is not able to be published, however sites where forecast load exceeds local capacity are:

- Area around Earlham and the Norwich Research Park
    - Significant amounts of spare capacity has already been reserved by users within the Research Park, this has been offset when considering additional modelled load for the site itself

- The Broadland Growth Triangle including Rackheath and Beeston Park and other areas supplied by Peachman Way Primary and Sprowston Primary
- Cringleford - new housing close to Cringleford Primary, spare capacity utilised as backup for the hospital

Table 5 shows the spare capacity at each substation alongside the forecast load on each substation and whether it is the forecast load alone or that combined with reserved capacity that is the major cause of constraint.

Where cumulative required capacity from new development sites exceeds existing available capacity then not all of the planned development will be able to proceed without potentially costly and time-consuming reinforcement works. There will be a shortfall in electricity supply for the developments shown in Table 5 unless remedial action is taken. This would prevent some of these sites from being developed within planned timescales and would incur additional cost.

Table 5: Constrained substations and development sites

Substation (33/11kV)	Affected development sites	Spare capacity (MW)	Development site load (MW)	Issue caused by
Sprowston Primary	Beeston Park Home Farm Sprowston Land off Salhouse Road Land south of Green Lane East Land south of Green Lane West Land south of Salhouse Road Rackheath White House Farm	5.1	20.9	Forecast demand
Peachman Way Primary	Broadland Gate Brook Farm Land east of Broadland Business Park Land north of Broadland Business Park	11	5.6	Reserved capacity
Earlham Grid Local A/B	Costessey GN Food enterprise zone Longwater / Easton Norwich Research Park Three Score	14.3	7.6	Reserved capacity
Cringleford Primary	Cringleford Hethersett	5.6	5.0	Reserved capacity

4.1.1. EHV network constraints

Issues upstream from the substations mapped in Figure 11 and Figure 12 can impose an additional constraint on development. These upstream 132/33kV substations are mapped in Figure 13 below.

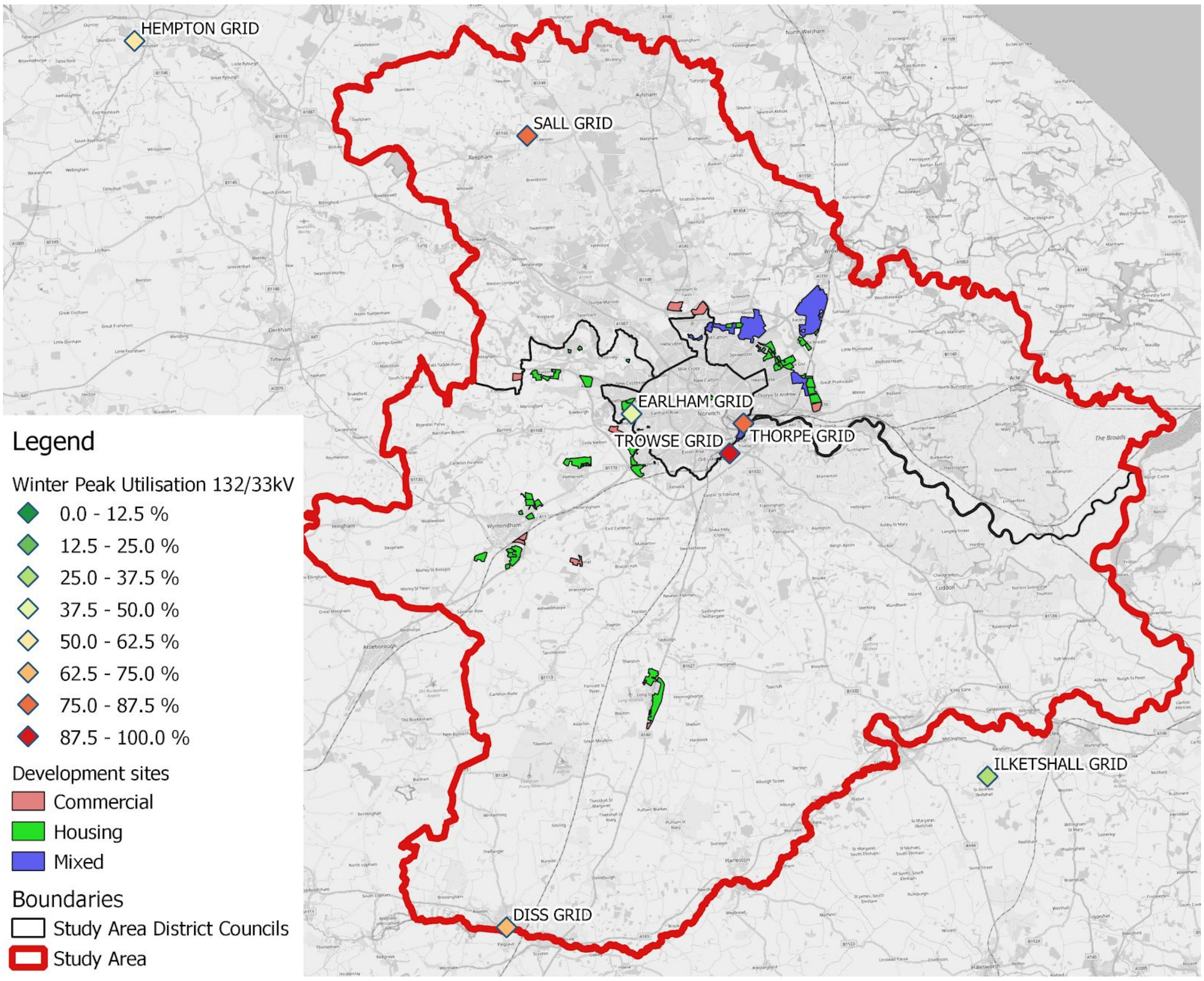


Figure 13: Development site locations as Figure 4 and winter loading of 132/33kV substations

It can be seen from Figure 13 above that there is only limited capacity available at several of the major substations supplying the Greater Norwich area. Table 6 below shows the data in more detail. From this it can be seen that those close to capacity include Thorpe and Trowse in and close to Norwich itself and Sall Grid near Cawston in the northwest of Broadland district. These substations all have a winter peak loading of over 80%. Trowse in particular is very close to capacity, over 96% loaded with only 4 MW of spare capacity.

Table 6: Network loading for Greater Norwich 132/33kV substations

Substation (132/33kV)	Peak winter load (MW)	Firm capacity (MW)	Winter peak loading
Earlham Grid	53.6	109.7	49%
Sall Grid	90.5	109.7	82%
Thorpe Grid	88.8	109.7	81%
Trowse Grid	105.3	109.7	96%
Ilketshall Grid	22.6	72.9	31%
Diss Grid	45.4	65.8	69%

These 132kV substations also supply some areas outside of Greater Norwich, meaning that load growth from new development outside Greater Norwich will also have an impact on spare capacity at this level. In particular, Thorpe and Trowse Grid supply parts of North Norfolk, Sall Grid supplies parts of North Norfolk and Breckland, Ilketshall Grid primarily supplies Waveney and Diss Grid also supplies parts of Mid-Suffolk, St. Edmundsbury and Breckland districts. The areas supplied by these substations can be seen most clearly from Figure 10.

Potential future growth and associated grid constraints within North Norfolk have been assessed in a separate report. Total additional loading on Sall, Thorpe and Trowse from planned growth within North Norfolk to 2036 is likely to be upwards of 14 MW. This likely future load growth adds additional pressure to the constrained 132kV substations supplying much of Greater Norwich.

4.2. Planned network reinforcement

The following section sets out UKPN's approach to dealing with network reinforcement both through traditional measures and through procurement of flexibility.

4.2.1. Conventional reinforcement

UKPN business-as-usual reinforcement

As highlighted above, one major potential barrier to new development is available capacity at 132kV, in particular Thorpe and Trowse. These two substations run interconnected at 33kV, with any additional demand on the 33kV network divided between the two. The levels of new demand committed is higher than available capacity on these substations, however the timescales for the development of some of this demand is uncertain.

Reinforcement work at this voltage level is included within the DNO's business plan submission to OfGEM for forthcoming regulatory periods when their assessment is that the load is likely to 'naturally' grow to an extent to require the works within that period. However, the work will only be undertaken once the load has materialised, as OfGEM does not encourage DNO's to invest 'ahead of need' as they see that as not utilising the funds received from the customers in the most efficient manner.

Future reinforcement at Thorpe / Trowse was included within UKPN's 'RIIO-ED1' business plan (Apr 2015 – Mar 2023) submission to OfGEM, however the load has grown more slowly than anticipated so UKPN may not undertake the works within that period. However, even where reinforcement is included within the strategic plan, if UKPN receive an application that 'triggers' the work before it has been fully authorised, then the applicant is still likely to have to pay at least a proportion of the costs in line with their Common Connection Charging Methodology Statement. This means that despite reinforcement being planned by UKPN, constraints at 132kV level can still present a barrier to new development.

Local network projects
There are a number of other projects underway that will provide reinforcement of the UKPN network. Within the Greater Norwich area there are two such schemes being delivered in 2018/19 in the area of interest. These are:

> **33kV cable from Boundary Park Primary to Earlham Grid 33kV reinforcement**
> This scheme involves reinforcing the 33kV connection running from Earlham Grid 132/33kV substation to Boundary Park Primary 33/11kV in Hellesdon, replacing old cable that has become fault-prone. It does not provide any additional capacity at this time, as that is limited by the transformers and switchgear at Boundary Park.
>
> **Bramford-Norwich - 132kV reconfiguration**
> Bramford and Norwich are both Grid Supply Points which deliver power to parts of Greater Norwich. This reconfiguration of the connection between them adjusts supply such that a section of network around the Beccles / Barsham area that is currently supplied from Norwich, will in future be supplied from Bramford (near Ipswich). It will only affect loads supplied by the 132kV Ilketshall Grid substation on the southeastern side of South Norfolk district.

4.2.2. Alternatives to conventional reinforcement

UKPN standard reinforcement proposals are based on the use of conventional network assets such as transformers, overhead lines and underground cables. UK Power Networks is incorporating flexibility services that achieve net load reduction as an alternative to network reinforcement. Flexibility is the ability to change generation and demand in order to support UKPN in its role of developing and operating the distribution network.

Flexibility services are provided by any technology or process that can reduce or shift peak demand - importing less or exporting more power to the distribution network as an additional amount relative to its baseline operations – to support UK Power Networks in its role in operating the distribution network. These services can be procured by network operators by offering generators or loads financial incentives to respond to signals to turn load or generation up or down if requested.

UKPN has proposed in its Flexibility Roadmap of 2018 to adopt a 'flexibility first' approach to delivering additional network capacity, in order to drive lower costs and increased renewable energy on the network through more competition. Flexibility services may provide a lower cost route to increasing renewable generation capacity on the network than traditional reinforcement. The core applications for flexibility on the distribution network as described in the roadmap are:

- deferral of network reinforcement
- managing planned maintenance,
- and managing unplanned interruptions.

UKPN has consulted with industry on the design of its' flexibility programme, and has published 28 network locations where flexibility could be used across their three licence areas. A competitive tender process has been undertaken for services to be delivered in the winters of 2017/18 and 2018/19, which has awarded contracts at two network locations. Further areas where flexibility is needed have been identified and will be procured by a tender to be held by March 2019 designed to meet flexibility needs from 2019/20 and 2020/21. These have been procured through the Piclo Flex platform[4].

None of the sites considered to date have been within the Greater Norwich area, however this may change as UKPN identifies further opportunities to procure flexibility services. Greater Norwich local authorities should engage with UKPN in order to highlight the potential opportunities for rollout of flexibility services in the area. The high level of local distributed generation and industrial loads makes the area well placed to provide flexibility services.

4.3. Delivery of development sites in constrained areas

Delivery of development sites within areas with substantial constraints can prove challenging, as where predicted loads exceed available capacity the additional cost of reinforcing the network can prove prohibitive for development. Reinforcements or upgrades to the electricity network are required when demand exceeds capacity. If development sites cannot proceed due to insufficient capacity, alternative measures must be considered in order to deliver these. Figure 14 shows the development sites and peak loads alongside the spare capacity on each Primary substation.

[4] https://support.picloflex.com/article/24-uk-power-networks

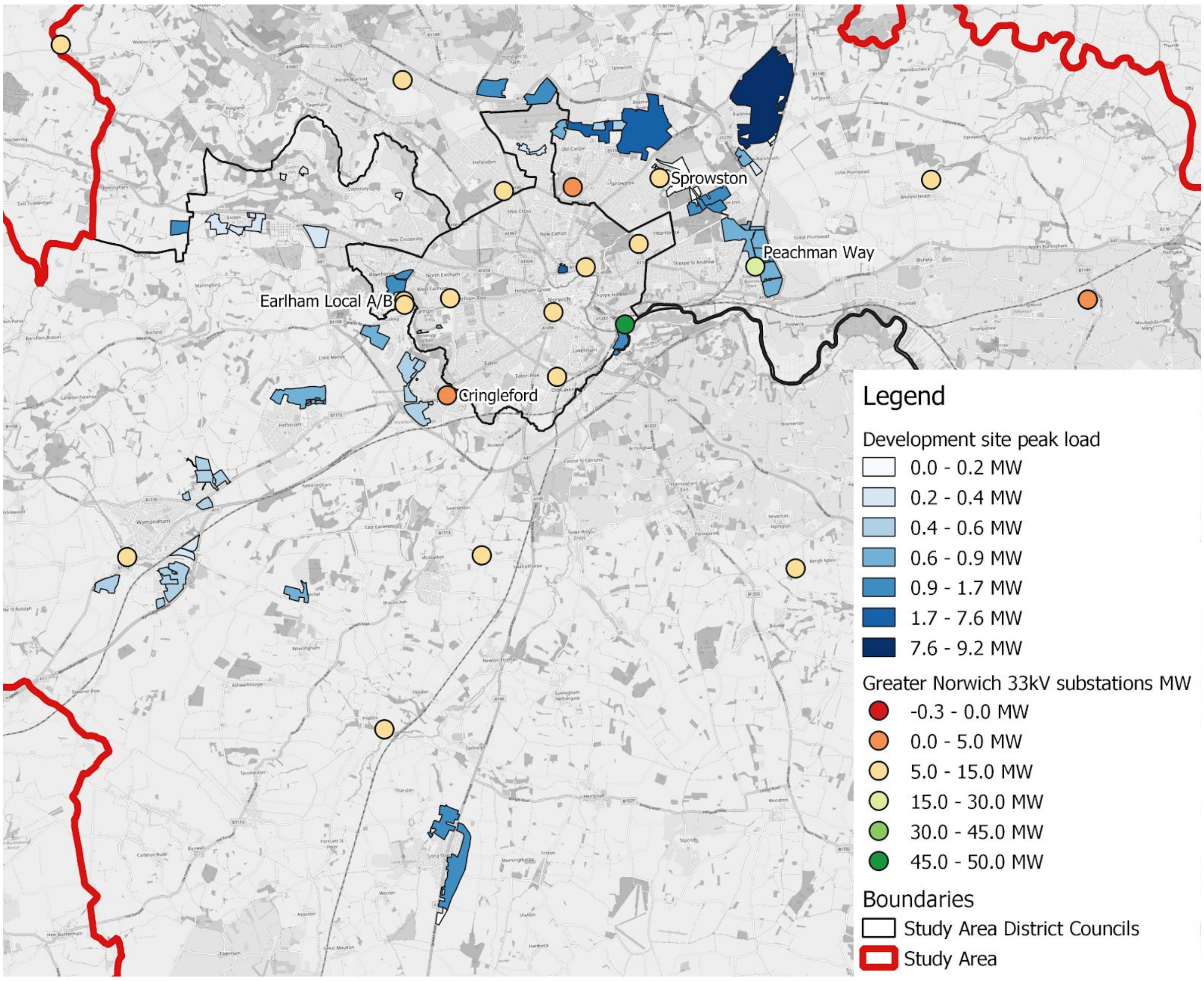


Figure 14: Greater Norwich development site peak loads alongside primary substations

4.3.1. Identified pilot sites

At an initial stage of this study we identified three potential pilot sites through analysis of constraint data, and review of other information about each site. One site for each of the three council areas was identified as suitable for further investigation. Further feasibility studies are being taken forward to explore issues on each of these sites and model appropriate options for these in greater detail. The identified sites are not the only constrained sites or the only areas that could benefit from innovative energy approaches, however they were deemed most relevant at the initial stage, considering network constraints, existing knowledge of the site and potential for undertaking an innovative approach to energy on the site.

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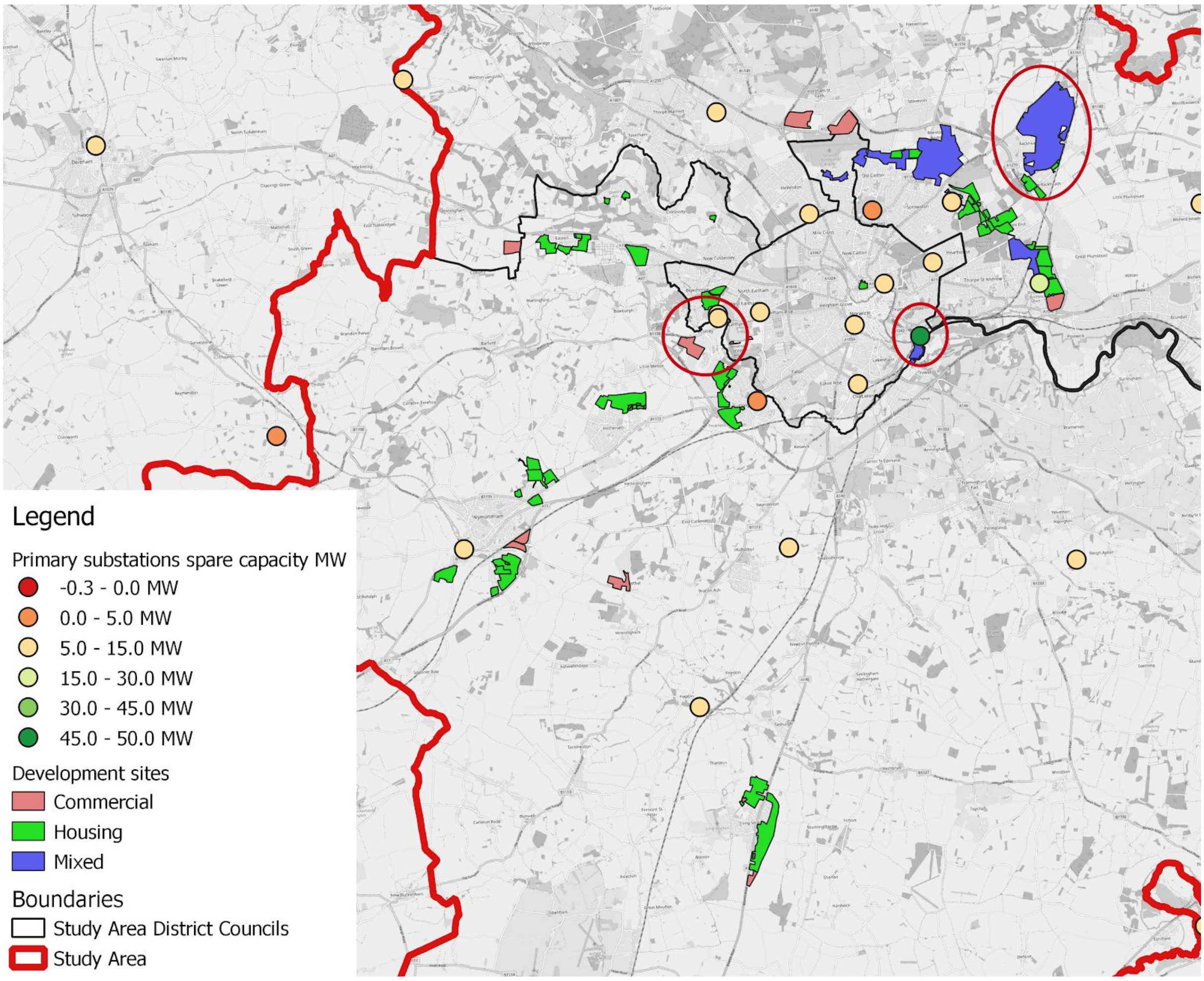

Figure 15: Greater Norwich development sites, identified pilot sites circled in red

Norwich Research Park - South Norfolk

The Norwich Research Park (NRP) is to the west of Norwich, in South Norfolk. The area includes:

- The commercial and research properties within the research park;
- The University of East Anglia (in Norwich);
- Norfolk and Norwich University Hospital;
- Neighbouring future development sites related to the Research Park

This site was selected due to the significant new development proposals on the site, known constraints to securing new grid connections, and an appetite for and expertise in innovation within a number of parties involved on the site, particularly the University.

The additional load comes from 40 hectares of new commercial development, however the site is highly constrained. The University of East Anglia adjacent to the site has on-site generation and well considered and long-term plans to manage their electricity and gas demand, to decarbonise and maximise their use of on-site electricity generation. There are a number of stakeholders interested in development in this area, and a range of proposed solutions involving smart energy management. The hospital site has been the site for a feasibility study conducted by the Energy Systems Catapult considering potential integrated energy solutions for the site. The hospital also reserves significant amounts of local capacity from the local Cringleford substation as backup to its supply.

Rackheath - Broadland
Rackheath is a new development site of 293 hectares total that is part of the Broadland Growth Triangle to the northeast of Norwich. The endorsed masterplan for the sites incorporates 4,000 new homes and 25 hectares of employment land which will be delivered in a series of phases. The wider Growth Triangle is understood by Broadland District Council to be the largest urban extension in England, with capacity for more than 13,500 homes.

The site was selected due to the scale of the development, with Rackheath the largest single site within the development, the significant local constraints and the fact it is an entirely new development rather than an expansion of an existing site presents greater opportunity to put in innovative approaches to new infrastructure provision.

The local 33kV/11kV electricity substations are significantly loaded, with additional unused capacity reserved, and under 0.5 MW available for new demand connections. This indicates it will be particularly challenging to deliver the desired levels of growth within the currently available capacity. Other utilities investigations undertaken for the Rackheath development indicate that available capacity may be even more constrained that suggested by this assessment and thus the challenge of delivery even greater. Peak electrical demand for the Rackheath site is estimated at 9.2 MW, while the wider Growth Triangle which would also be connected in similar locations is estimated at 17.3 MW.

East Norwich - Norwich
These sites are close to the city centre. This site was selected partly due to the planning allocation for on site generation and the opportunities for multiple local generation technologies to support local energy provision, but also due to the significant available local network capacity that could allow a demonstrator project to operate in ideal conditions. The area is relatively unconstrained as a legacy of previous industrial loads and is close to major UKPN infrastructure, supplied directly from the 132kV network. A smart energy solution would be able to operate within theoretical import caps to demonstrate the potential impact of smart control and demand management on peak load.

The area includes three component sites:

- Utilities site – 6.9 ha site allocated for mixed use development to include housing, employment and renewable power generation
- Deal Ground – 8.1 ha site allocated for residential-led mixed use development
- Carrow Works – a large adjoining site on which industrial activity is to cease. The expectation is that the site will be redeveloped for residential-led mixed use, though the principle of redevelopment of the site has not been established.

There is the potential for inclusion of a heat network including supply from Surface Water Source Heat Pump (SWSHP) heat supply from the River Wensum and from on-site energy generation. There has been previous work carried out supported by the BEIS Heat Networks Development Unit (HNDU) to assess the potential for water source heat pump use on the

River Wensum. The sites have the potential to be developed as an exemplar development with opportunities to model the impact of the design of buildings and infrastructure on site that include a local heat network and electrified transport.

4.4. Areas suitable for further development without reinforcement

With the significant additions in load from new development sites, constrained areas will prove more difficult to locate new homes or commercial sites in. Additional sites would ideally be delivered in those areas that are less constrained. Due to the constraints on the higher voltage distribution network at 132kV all sites will experience some form of constraint. As discussed in section 4.2.1 reinforcing these upstream assets is included as part of UKPN's business plan, however due to the timescales involved and their requirement to see clear need for new capacity before investing in the network, the timescales may not align with those preferred by the council or developers. Longer term additions in development to 2036 will face different issues to those experienced today, as technological change and reinforcement undertaken until that point alleviate or change the locations of today's constraints.

Locations which might be most suitable for additional development on this basis include:

- Southeast and Southern Norwich - particularly where load has been freed up by reductions in industrial usage. There is, however, a need to be aware of the constraints upstream at Norwich Trowse 132/33kV
- Areas to the east of South Norfolk district, supplied by Ilketshall Grid shown in Figure 13

While there may be electricity capacity in the locations identified, this will not be the sole determinant of where growth goes, so where development is delivered in other areas a plan needs to be in place to overcome constraints.

In many other parts of the study area, including much of the major northeast-southwest Greater Norwich development corridor, forecast additional demand is likely to bring assets close to and exceeding capacity necessitating future reinforcement.

5. Strategic options review

This section outlines some innovative proposals to deliver required heat and power for grid constrained sites. This involves analysis and costing of potential solutions for the identified problem areas. Modelling has been undertaken to understand how local generation, storage and automation options could impact the viability of identified development sites. Additionally, these options are compared to the necessary grid upgrade fees, using indicative costs. This is to enable an assessment of the options on a financial basis.

5.1. Alternative proposals to deliver required heat and power

New development sites unable to secure network capacity for all of their forecast needs may need to look to alternative means of securing energy supply for their operations. The addition of differing forms of on-site generation, storage or other technologies may be able to facilitate an alternative approach. For example a mixed use development site such as Rackheath may be suitable for on-site energy generation and infrastructure to be installed in order to reduce the peak loading on the network. The existing site of the Norwich Research Park would be more complicated to carry out this approach on due to existing infrastructure already being in place, but there could be benefits from incorporating smart controls, generation and capacity swapping.

5.1.1. Smart control and demand side management

There are a number of different measures that fall under the category of demand side management:

- Smart meters and smart grids – which means:
    - Monitor and control systems.
    - Constraint management tools to monitors and controls loads across the grid. For example, power aggregators who can help system operators to reduce electricity consumption at peak times across industrial and commercial clients.
    - Helping utilities avoid the cost of distribution network reinforcement.
- Capacity swapping – facilitating the swapping of excess capacity at certain times of year between large energy users to negate the need for grid expansion.
- Time of Use Tariffs: Time of Use tariffs are designed to incentivise customers (domestic and commercial) to use more energy at off-peak times, in order to balance demand. The benefits are twofold: demand is managed and customers can lower their bills.
- Complementary tenancies – balancing predicted heat and electricity demand of businesses/organisations
- Large-scale on-site generation to reduce import requirements

Semi-islanded development

An islanded site is one that is not connected to the electricity network, and is entirely self-sufficient for energy. A semi-islanded development site is one which maintains a connection to the wider electricity network, but utilises on-site generation or storage to reduce the site's reliance on imported electricity and reduce peak demands.

Under normal operating conditions 'behind the meter' embedded generation and storage reduces the power drawn from the distribution network. This can be made up of technologies such as:

- on-site solar PV,
- heat pumps,
- combined heat and power systems,
- diesel generators or;
- battery storage.

It is important to account for non-standard operating conditions, where due to maintenance, economics, or weather conditions; the site can resume taking some, or all of its power, from its grid connection. The unpredictable nature of this phenomenon would not reduce the peak system requirements needed to be supplied by the network, unless a level of guarantee around the maximum peak demands to site were maintained with sufficient on-site reliability to meet the required proportion of demand.

The development of a semi-islanded site including high levels of generation does not have to be an additional burden on the local distribution network, however. Systems can be designed such that local benefits can be maximised while also having a positive effect on local networks. For example, through engagement with the DNO to offer demand side response services, where on-site generation could be turned up or load reduced in response to network signals. This can help balance supply and demand more locally to minimise required input from higher level networks. These services can also be procured to assist system operators when dealing with local constraint issues, so at times of network stress, on-site generation could be increased.

For example, if operating a Combined Heat and Power plant on site, electricity production could be maximised during peak times to reduce network stress, while additional associated heat produced is stored in a thermal store and used to supply local heat demands at a later time. Battery storage could also assist with this, storing electricity to be used at peak times.

Regulatory considerations

The sale of electricity typically requires an electricity supply licence which can be costly and difficult to obtain. The regulatory costs incurred from complying with the industry codes and securing a supply licence are not scalable and often require significant up-front investment and ongoing resourcing which, for small entrants, adds major overheads. However, for small-scale generation schemes, there is an exemption which allows for the supply of up to 5MW of self-generated electricity to local consumers, of which no more than 2.5MW may be to domestic premises. The scale of any scheme developed including on-site generation would need to be within these limits. Behind the meter generation and storage do not have to comply with these limits, however would only be able to supply a single business with a single meter point.

There are no requirements to hold a licence for the supply of heat, however, operators must comply with the Heat Network (Metering and Billing) Regulations 2014, amended 2015, which place obligations on heat suppliers to fit heat meters and ensure billing is fair, transparent and based on actual consumption. Suppliers selling heat to the domestic or micro-business market are also encouraged to sign up with the Heat Trust[5] which provides an independent ombudsman service to customers and operators of district heat networks.

Impact on network charging
Where a fully-dimensioned grid connection is maintained by a site that utilises on-site generation with consumption behind the meter, the site avoids contributing to many of the funding mechanisms on which upkeep of the electricity network depends. Many of these costs are charged on a per kWh basis, so reducing energy import through on-site generation reduces network costs payable, despite retaining the ability to impose similar peak demands on the network to other customers through their grid connection. This is an area Ofgem are concerned about as if more engaged consumers are able to avoid paying network costs, a greater proportion of costs will fall on vulnerable consumers less able to shift their consumption or self-generate. Network charging is under review with alternative proposals being put forward as part of Ofgem's Targeted Charging Review.

5.1.2. Innovative approaches to infrastructure investment

The significant costs associated with network upgrades, when quoted to individual developers, can prove prohibitive. This is particularly the case where a development site is owned by multiple land-owners and is being developed piecemeal by a number of smaller developers. When a DNO provides a quote for reinforcement to a developer this will include a large amount of the fixed cost of replacing or reinforcing an asset, even where not all of that reinforced capacity will be used by the individual developer. This means that to each of a number of small developers the development cost appears prohibitive even if it would be possible to offset the cost of this infrastructure against the full development site. Individual developers will also often reserve as much available local capacity as possible, potentially more than they need, leading to local substations appearing to be more constrained than they are in reality from the network's perspective.

One way of mitigating this approach is through a single developer investing in the site as a whole and putting in infrastructure, before selling off smaller fully serviced parcels of land to other developers to build on. This is an approach already often undertaken by large developers with respect to roads and amenities, and could be expanded to cover upgrades in electricity infrastructure where appropriate.

- Radiostation Rugby, a 6,000 home mixed use development site near Rugby, Warwickshire, has been developed by Urban and Civic in partnership with Aviva Investors , with site infrastructure put in place including roads, schools, GP surgeries and green space.[6]
- The Hamptons, Peterborough, a large urban expansion to the south of Peterborough where the overall site has been developed by O&H Properties[7] who have taken this approach, working with UKPN in order to put in electricity infrastructure, and sold off smaller plots to be built on by housebuilders. The developers committed to upgrading

[5] http://www.heattrust.org/
[6] https://www.urbanandcivic.com/projects/strategic-sites/radiostation-rugby/site-details/
[7] http://www.ohhampton.co.uk/news/archive/the-hamptons-an-exemplar-for-future-growth/

the nearest electricity substation early on, and this work was completed in 2010. Nine years on the site is still expanding, with the power requirements being supplied by the upgraded substation.

- Snetterton Business Park, Cambridge Norwich Tech Corridor[8]. Breckland council secured £2.65m of Capital Growth Programme funding from New Anglia LEP to commit to the construction of a new 33/11kV substation. This investment will provide an additional 6 MVA of capacity on top of the site's existing 3 MVA that is fully utilised. It is hoped that securing the power supply to the site will create 1,700 new jobs and safeguard 1,450 more.

This approach typically requires a single private developer investing in a new development site as a whole as a long term investment, but is more challenging to deliver in areas where land ownership is more fragmented. In these situations there may be a role for the local authority to be involved as the infrastructure investor, liaising with multiple landowners to deliver investment on the site. For this approach to work, it is likely to be necessary for one or more Greater Norwich authorities to establish an Energy Services Company (ESCo) as a Special Purpose Vehicle (SPV) to deliver investment. The ESCo could then pay UKPN to undertake the necessary work while charging individual developers their share of the costs. Liaison with landowners and developers from an early stage is important to ensure that this approach would be viable, as commitment from all stakeholders would be required to ensure that this approach was workable. Delivering energy investment with an ESCo is explored in more detail in Appendix I.

Cambridgeshire: Mobilising Local Energy Investment
Cambridgeshire County Council (CCC) is a front-runner in energy, leading the way in local authority energy investment with an award-winning programme with more than £20m in energy generation and energy efficiency projects. Having successfully delivered projects with 40 schools, seven corporate buildings and having developed their 12MW solar farm, the County Council is proving to be a leader in bringing renewables into the mainstream as a reliable source of energy. As well as having completed multiple large and smaller scale projects, CCC's work is on-going in the development of their project pipeline, with the establishment of their Smart Energy Grid and newer projects such as the community heat scheme. More detail can be found in Appendix II.

5.2. Modelling and cost comparison of interventions

5.2.1. Costing of reinforcement options

New connections to the network are charged for the assets they require that are fully utilised by them, such as a new substation on the site of a new development. Developers must also pay for upstream reinforcement if their connection requires it. As outlined in Table 7 below, these costs can be very high. For this reason, it is worth assessing options to see if these charges can be reduced or negated to any extent, in order to avoid developments being stalled or cancelled.

[8] https://newanglia.co.uk/investment-snetterton/

UKPN's charges and the rules that are followed when determining costs are set out in their Common Connection Charging Methodology Statement (CCCMS). Additional reinforcement upstream in the network is typically charged using a Cost Apportionment Factor (CAF) where the new asset owner pays for the percentage of the network reinforcement that they will be utilising.

The Electricity (Connection Charges) Regulations 2002 prescribe the circumstances in which, when a Customer has paid in full for Distribution System assets, they are entitled to a future rebate of charges should another customer connect to those assets. Customers who connect to those assets within the following 5 years pay a connection charge in line with the proportion of the connection they are using which is paid as a rebate to the customer who invested in those assets. For Distribution System assets where the customer has paid in proportion to their required capacity, then they are not entitled to a future rebate of charges should another customer connect to those assets.

Costs borne by DNOs are ultimately paid for by the consumer through their electricity bills, so DNOs have a responsibility to get value for money for their investments. This restricts their ability to invest in assets ahead of need due to the risk of forecast usage being incorrect and the asset becoming 'stranded'.

Specific prices for individual sites can only be provided through requesting a budget estimate for connection cost from UKPN, however guidelines for different levels of reinforcement can be understood through reference to the CCCMS.

Table 7: New substation/transformer costs, UKPN Connections Charging Statement 2018

Area	Item	Min	Max	Average
EHV/HV Primary substation	New indoor single transformer substation	£2.5m	£5m	£3.75m
	New indoor double transformer substation	£3.5m	£6.5m	£5m
	New outdoor single transformer substation	£3.5m	£6m	£4.75m
	New outdoor double transformer substation	£4m	£6m	£5m
	Add an additional transformer at existing indoor substation	£1.5m	£2.5m	£2m
	Add an additional transformer at existing outdoor substation	£1m	£3m	£2m
132kV/EHV substation	New indoor single transformer substation	£4.5m	£7.5m	£6m
	New indoor double transformer substation	£6m	£10m	£8m
	New outdoor single transformer substation	£6m	£9.5m	£7.75m
	New outdoor double transformer substation	£8m	£13m	£10.5m

	Add an additional transformer at existing indoor substation	£4m	£6m	£5m
	Add an additional transformer at existing outdoor substation	£3m	£6m	£4.5m

The costs for upgrades to the network become progressively higher at higher voltages, running into the millions of pounds for major upgrades. A new substation at 33/11kV costs between £2.5 and £6m, while a new substation at 132/33kV costs between £4.5m to £10m depending on scale.

As identified within Section 4 there are a number of areas in which constraints are close to being reached or are likely to be reached as new development sites are brought forward over the period of the Greater Norwich Local Plan. These sites fall into four categories:

- Case 1: No reinforcement required
- Case 2: Reinforcement required to cables at 11kV or 11kV/LV substations
- Case 3: Reinforcement required to cables at 33kV or 33kV/11kV substations
- Case 4: Reinforcement required to cables at 132kV or 132kV/33kV substations

Those sites within Case 1 no further consideration has been made. For sites within Case 2, costs are likely to be able to be delivered as part of business as usual for major development sites, where 11kV connection upgrades will often be required.
Cases 3 and 4 are more likely to present a barrier to development moving forward due to the significant costs involved with reinforcement at these levels.

5.2.2. Cost of an exemplar constraints mitigation scheme

In order to operate a scheme within constraint limits, investment can be made in local generation and distribution technology. This modelled opportunity considers an initial phase of development on the Rackheath site, including a mix of commercial and domestic development. This utilises combined heat and power, solar PV and gas boilers to generate heat and electricity on site and operate a local heat and private wire network. The results suggest that alternative approaches to traditional reinforcement may be viable, and should be explored in greater detail on pilot sites. Peak demand can be halved using this approach, keeping peak demands for this modelled initial phase below 1.6 MW, from a previous peak demand of 3 MW. Table 8 shows the up-front capital investment necessary for this scheme

Table 8: Capital costs for investment in local generation to manage on-site peak demands

Item	Cost per unit	Capex
1.2 MWe CHP	£900 / kWe	£1,080,000
500kW Solar PV array	£1,000 / kW	£500,000
Heat network pipework	£700 / m	£700,000

Gas boilers	£70 / kWth	£168,000
Private wire connection	£100/m	£100,000
Energy centre	£1000 / m2	£30,000
Thermal Store	£1000 / m3	£116,256
Building connections and metering	£30,000 per connection	£360,000
Commissioning, design, project management and contingency	22% of capital cost	£667,536
Total		**£3,701,792**

Table 9: Modelled scheme annual cashflow

	Tariff	Energy	Cost
Electricity sales	11 p/kWh	6,670 MWh	£ 733,792
Heat sales	3 p/kWh	8,304 MWh	£ 249,120
Gas fuel costs	2.03 p/kWh	20,342 MWh	(£ 412,955)
Combined other operational costs	-	-	(£ 213,486)
Annual cashflow			**£ 356,472**

A 25 year cashflow model was used in order to produce internal rates of return and net present value for the modelled scheme, using a discount rate of 3.5% from HM Government's Green Book.

Net present value	£2.01m
Internal Rate of Return	8.3%

These figures suggest an investment in energy infrastructure on this site to generate and sell power locally could be an attractive long-term financial investment and a solution to alleviating grid constraints to enable local development to go ahead. More detailed modelling would be needed to be undertaken to confirm these results. This would also need commitments from major occupiers of the site to take heat and power.

5.3. Case Studies

Appendix II details four case studies of innovative approaches to energy provision taken elsewhere. Graylingwell Park and Gateshead District Energy are examples of ESCos being used to supply heat and power to development sites, with differing roles for the local authority. These may be suitable approaches to consider for Rackheath in particular for delivery of heat and power.

Graylingwell Park

Graylingwell Park is a former Victorian hospital situated in 85 acres of wooded parkland. The site sits within Chichester's urban area and adjoins other land, previously owned by the health authority which is now the NHS Trust and a former barracks, and part of the University of Chichester. A heat network was developed to heat the site, valued at £7.2m with over 12km of buried mains and 780 interface units. The energy centre and network development programme has a phased approach with a final completion date of 2019.

In order to bring this forward an ESCo - Graylingwell Energy Services Ltd - was established, specialising in the generation and distribution of environmentally-sound, affordable heating and hot water in Graylingwell Park. This ESCo operated as a vehicle for investment delivered on a private sector basis. Appendix II has further detail on this development.

Gateshead District Energy

The scheme originated in 2010, stemming from the Council's ambition to reduce energy costs and carbon emissions in Gateshead Town Centre. The scheme connects a 7km network of pipes from the South Bank of the Tyne into central Gateshead servicing public buildings, businesses and social housing tower blocks. The overall project represents a £14m energy scheme. In order to create a more resilient energy scheme, the Gateshead Energy Centre has a full set of back up facilities. When customers do not need heat, or when the CHP engines are being serviced, heat is provided from conventional gas boilers, which operate as a back-up. When the CHP units are not running or the demand for electricity is higher than capacity, 100% renewable energy is sourced from Gateshead Council's own grid connection, using an energy tariff in order to do so. An ESCo was developed to manage the investment and operation of the scheme.

Cambridgeshire: Mobilising Local Energy Investment (MLEI)

Cambridgeshire County Council (CCC) is a front-runner in energy, leading the way in local authority energy investment with an award-winning programme with more than £20m in energy generation and energy efficiency projects. This case study demonstrates a local model for delivery of energy investment by a local authority that has been successfully used to meet local goals and generate revenue. The MLEI model could be considered by Greater Norwich as an example of best practice local authority energy investment.

West Midlands Energy Innovation Zones: Tyseley Energy Park

Tyseley Energy Park is an example of an Energy Innovation Zone (EIZ) being developed by the West Midlands Combined Authority to integrate low-carbon technologies across energy systems, develop business models and market arrangements which are needed to support new approaches to clean energy, and to overcome the regulatory and other barriers necessary for them to flourish. The EIZ model is one that may be appropriate for Greater Norwich to consider in areas where regulatory barriers, such as timescales and trigger points involved in DNO investment in electricity network reinforcement.

5.4. Energy policy proposals

The aim of the following planning policy proposals is to provide a framework to promote a sustainable approach to energy supply, demand and management in new developments within the Greater Norwich area. There are also wider recommendations, which would be beneficial to this aim but which lie outside pure energy/carbon policy or the authorities' remit. The policy proposals have been aligned to an energy hierarchy approach, which requires ensuring energy demand is minimised before attempting to do anything with regards to its demand profile or carbon content. These recommendations should be considered within the context of the wider planning and energy policy landscape, which is explored in greater detail in the Local Energy East Strategy[9] and the UK Green Building Council Policy Playbook[10].

5.4.1. Planning policy

In order to facilitate energy efficient development a range of potential planning policy measures are set out below against a series of aims, in particular:

- Minimising energy demand from new development
- Ensuring energy is used efficiently
- Managing peaks of electrical demand in new developments
- Reducing carbon intensity of energy supplies

These aims follow from the information presented earlier in the report and from the wider energy context of the energy trilemma; the need for energy to be reliable, affordable and sustainable. To bring forward development in areas of electricity constraints like those highlighted earlier in this report, it is important to minimise peak power demands where possible. Tied in with this is the need to reduce overall energy demand from new development, which will also help reduce peak electricity demand, particularly where heating is supplied by electricity. These should be assessed by planning officers for suitability for inclusion as part of the Greater Norwich Local Plan.

Aim	Potential planning policy measures
Minimise energy demand of the new development	New residential and commercial developments need to meet Part L building regulations relevant at the time of construction and include at least two of the following: brise soleil, shutters on S/W facing facades, thermal mass, careful orientation, windows able to provide natural ventilation, green roof

[9] http://cambridgeshirepeterborough-ca.gov.uk/assets/Uploads/Local-Energy-East-LEE-Strategy.pdf
[10] https://www.ukgbc.org/wp-content/uploads/2018/07/Driving-sustainability-in-new-homes-UKGBC-resource-July-2018-v4.pdf

	Require developers to demonstrate they have taken steps to close the performance gap between designed building energy standards and real world performance. This could be done through reference to a third party standard such as BSRIA soft landings[11] or the National Energy Foundation Assured Performance Process[12].
Ensure energy is used efficiently	For new commercial developments, require that a mix of energy uses is on each site, so as to create complementary tenancies and maximise the efficiency of any CHP plant.
Manage peaks of electrical demand in new developments	Residential developments over 50 homes and all commercial developments need to consider how an Energy Services Company (ESCo) could serve their site. The ESCo would include in its remit the management of load profiles (to reduce the impact on the grid) and energy storage.
	Each new housing and commercial development to provide EV charging points. For homes, there must be the ability for houses to connect an EV, with pre-wiring for charging points put in place where charging points are not installed. For flats or high density housing at least 20% of parking spaces should be EV spaces.
	Ensure the houses built in the coming years are electric vehicle ready, in line with the Government's Road to Zero strategy so that all new homes, where appropriate depending on local transport provision and housing density, should have a chargepoint available, and this should be smart charge enabled.
	Require developers involved on Greater Norwich development sites to engage with the local authority on energy provision where requested.
Reduce carbon intensity of energy supplies	Each development has to reduce carbon emissions by 20% above Part L minimum.
	If the 20% carbon reduction is proven to be technically impossible, the remaining carbon reduction can be bought out (at a price/tCO2) and this goes into a carbon offset fund for the local authority to spend on carbon reduction activities (tree planting/large scale renewable installations).

[11] https://www.bsria.co.uk/services/design/soft-landings/
[12] http://www.nef.org.uk/service/search/result/assured-performance-process

5.4.2. Other areas of energy policy

There are measures which may not be directly related to planning policy, but where other policy could be put in place or options explored by the local authorities in order to manage energy demand locally or deliver other positive energy outcomes.

Aim	Wider proposals
Minimise energy demand of the new development	Review cost of Passivhaus and comparable fabric first approach developments from recent exemplar developments within Greater Norwich and elsewhere in the region to understand exactly what the cost uplift of constructing to low energy standards is over traditional building methods. Developments at Ditchingham, Hellesdon, Goldsmith Street and Three Score could be referenced as best practice. While Passivhaus or similar ultra-low energy development cannot be required through planning policy, the local authorities should continue to fund or promote low energy demand development which takes a 'fabric first' approach.
Ensure energy is used efficiently	Identify areas where district heat networks are already in operation or will be soon and then widen the zone, so that any new development within that area must connect to the heat network.
Manage peaks of electrical demand in new developments	Each new development needs to provide travel plans in order to make sure that sustainable travel is made an easy option for new residents/tenants
	Engagement between local authorities and developers interested in constrained sites over energy provision on those sites. including local ESCO to deliver non-standard approaches to energy supply of constrained sites
Reduce carbon intensity of energy supplies	Create planning innovation zones for commercial areas, where the installation of small scale renewable energy installations (e.g. under 50kW) does not require planning permission through the use of a Local Development Order

Higher levels of ambition

These policies represent a medium level of ambition within the context of the existing constraints and wider national policy goals. Commitments to reduce energy use and lower carbon emissions are important, but may not go far enough

In October 2018 the Intergovernmental Panel on Climate Change (IPCC) released a special report on the impacts of global warming of 1.5 °C above pre-industrial era levels in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. It highlighted the urgency of taking action on climate change, setting out that the world has just 12 years to make massive and unprecedented changes to global energy infrastructure to limit global warming to moderate levels.

An overarching outcome around zero net carbon is being adopted internationally and nationally by some councils with commitments made by local authorities as part of the UK100 group[13] to devise plans to achieve 100% clean energy at city/local level by 2050 that are ambitious, cost effective and take the public and business with them.
Many councils have also recently adopted climate emergency positions[14]. Norwich City are among those to have declared a climate emergency and are a member of the UK100. Other local authorities in the area to have declared a climate emergency include Suffolk County Council and Cambridge City Council.

A longer term goal of new developments becoming zero-net carbon should be considered within this context as an option for reducing carbon emissions in the long term. In May 2019 the Committee on Climate Change will publish new advice to the UK government on the UK's long-term climate change targets having considered the scale and feasibility of getting to net-zero carbon emissions, this advice should be considered by the Greater Norwich Development Partnership and where appropriate acted upon.

[13] https://www.uk100.org/
[14] https://climateemergency.uk/

6. Conclusions and recommendations

6.1. Energy infrastructure and demand management recommendations

It is clear that the increase in energy demand from projected housing and commercial growth across Greater Norwich imposes a significant challenge to some of the existing energy infrastructure, without major upgrades to existing infrastructure at significant cost the planned levels of development will not be possible in some areas. New development sites in constrained areas have been highlighted as particularly challenging to bring forwards; this can negatively impact local growth. Table 10 shows each of the substations where forecast demand exceeds capacity including reserved capacity, and the development sites affected. The development sites associated with these substations are likely to experience constraints at some point and are the areas most suitable for innovative constraint mitigation measures.

Table 10: Development sites associated with each constrained substation

Substation (132/33kV)	Affected development sites	Current substation rating	Rating including reserved capacity	Rating after planned development
Sprowston Primary	Beeston Park Home Farm Sprowston Land off Salhouse Road Land south of Green Lane East Land south of Green Lane West Land south of Salhouse Road Rackheath White House Farm	Light Amber 5-15 MW	Dark Amber 0-5 MW	Red < 0 MW
Peachman Way Primary	Broadland Gate Brook Farm Land east of Broadland Business Park Land north of Broadland Business Park	Pale Green 15-30 MW	Dark Amber 0-5 MW	Red < 0 MW
Earlham Grid Local A/B	Costessey GN Food enterprise zone Longwater / Easton Norwich Research Park Three Score	Light Amber 5-15 MW	Light Amber 5-15 MW	Red < 0 MW
Cringleford Primary	Cringleford Hethersett	Amber 0-5 MW	Red < 0 MW	Red < 0 MW

Where cumulative required capacity from new development sites exceeds existing available capacity then not all of the planned development will be able to proceed without potentially costly and time-consuming reinforcement works. There will be a shortfall in electricity supply for the developments shown in Table 10 unless remedial action is taken. This would prevent some of these sites from being developed within planned timescales and would incur additional cost.

Regulatory barriers to the DNO delivering investment in energy infrastructure through traditional means can lead to significant reinforcement costs payable before a development can move forward. Costs borne by DNOs are ultimately paid for by the consumer through their electricity bills, so DNOs have a responsibility to get value for money for their investments. This restricts their ability to invest in assets ahead of need due to the risk of forecast usage being incorrect and the asset becoming ‘stranded’. This can lead to local growth being curtailed. Alternative approaches may be necessary to enable planned development sites within the Greater Norwich Local Plan to move forward without having to pay significant sums of money and wait for the DNO to undertake reinforcement. This should be facilitated by policy requiring developers to engage with the local authority on energy, as set out in section 5.4.

Greater Norwich local authorities should engage with UKPN in order to highlight the potential opportunities for rollout of flexibility services in the area. The high level of local distributed generation and industrial loads makes the area well placed to provide flexibility services.

Alternative approaches to be explored:

- Potential semi-islanded approaches utilising on-site generation and smart energy management solutions may be appropriate to enable development to proceed in constrained areas. Semi-islanded development sites including high levels of on-site, renewable or low carbon generation can be designed such that local benefits can be maximised while also having a positive effect on local electricity networks.
- Engagement with the DNO to offer demand side response services, where on-site generation could be turned up or load reduced in response to network signals, can help balance supply and demand more locally and assist system operators to deal with local constraint issues, so at times of network stress. UKPN has proposed in its Flexibility Roadmap of 2018 to adopt a ‘flexibility first’ approach to delivering additional network capacity, in order to drive lower costs and increased renewable energy on the network through more competition.
- Identified pilot sites should be explored in further detail, with feasibility studies conducted to consider appropriate solutions and how they could be delivered technically and economically. These solutions could potentially be applied to other sites with similar issues, and should be reviewed in order to understand the potential for replication of the technical solution.
- Investment in infrastructure on these sites could be delivered through an Energy Services Company model as set out in Appendix I. The potential for local authorities to be involved within this type of approach is being explored further in an additional study

investigating appetite for local investment and suitability of public, private or hybrid investment model approaches.

6.2. Planning policy recommendations

Appropriate planning policy can be used to facilitate development on constrained sites, through incentivising mitigation measures and cross-site collaboration. Engagement between local authorities and developers interested in constrained sites over energy provision is important to facilitate development. Requiring developers to coordinate with a local ESCo on the site, if one exists, to deliver non-standard approaches to energy supply would potentially unblock sites where risk-averse developers are unable to bring a site forward within the context of existing constraints.

Change in the energy sector has been particularly rapid over the last ten years. The Greater Norwich Local Plan needs to take account of these changes and how energy use is likely to change in future. In particular it is important to consider measures in relation to the future take-up of electric vehicles and changes to building regulations including the use of SAP 10 assessment software alongside other challenges such as the energy trilemma of reliability, affordability and sustainability.

The Government's 2018 'Road to Zero' strategy commits to ensuring the houses built in the coming years are electric vehicle ready, stating "*it is our intention that all new homes, where appropriate, should have a chargepoint available*". GNLP planning policy should reflect this.

A range of planning policy recommendations and associated energy policy recommendations for the GNLP are set out in section 5, in order to facilitate energy efficient development. These are set out against some key aims, in particular:

- Minimising energy demand from new development
- Ensuring energy is used efficiently
- Managing peaks of electrical demand in new developments
- Reducing carbon intensity of energy supplies

6.3. Next steps

Based on these recommendations a list of next steps has been produced.

- Incorporate planning policy recommendations into Greater Norwich Local Plan
- Undertake more detailed feasibility studies considering identified pilot sites in order to model potential semi-islanded approach in greater detail
- Get buy-in from local authority senior leadership for development of an Energy Services Company to deliver local infrastructure investment
- For sites in areas that are particularly constrained ensure alternative approaches to energy infrastructure are considered

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7. Appendix I: Delivering energy investment through an ESCo

In order to deliver energy investment there are a number of approaches that can be taken. This section summarises some of the common governance themes in energy projects which can be employed in order to successfully develop a scheme. These tend to be complex enterprises with multiple stakeholders; different models will suit different project requirements and funding streams. Bringing forward a complex related scheme will often require establishing an Energy Services Company (ESCo) or a Multi Utility Services Company (MUSCo) to access a full range of funds, undertake projects across multiple local authority areas, satisfy state aid rules for public investment and to protect the local authority investment. For sites where an innovative approach to energy delivery is being considered, an ESCo is likely to be the best vehicle to enable this.

This section discusses a high-level overview of delivering energy investment through an ESCo. A further study exploring local priorities in more detail and the best way of delivering these is being taken forward alongside this.

What is an Energy Services Company?

An Energy Service Company (ESCo) is a legally incorporated and defined special purpose vehicle with limited liabilities designed to promote energy-related activities, typically alongside a local authority.

Activities related to Greater Norwich might include:

- Secure funds, design, deliver and operate energy infrastructure or services :
- Procure, design, fund, build and deliver individual technical solutions;
- Provide the long-term legal structure to source funds and own assets;
- Manage the ongoing operations and network expansion over time;
- Mitigate risk to the investors, public and local authorities
- Manage public capital investment;
- Distribute the benefits; and
- Provide a managed exit strategy for investors at the right time.

An ESCo can be set up in a number of different ways, either as a private entity or as a joint-venture with local authorities and would take responsibility for managing energy supply and demand within a given area. In some models the ESCo can change characteristics over time as the roll out of the services progresses.

Discussions undertaken to date have highlighted a number of key considerations that will influence the ultimate design of a governance model and include:

- Project leadership and sponsorship;
- Delivering the local authority wider policy outcomes, including facilitating growth;
- Managing financial and political risk to the Council;
- Managing the risk to other investors;
- Procurement of the energy network and ownership of assets;
- Creating and delivering the commercial benefits;
- Sharing the benefits; and
- Future-proofing the energy network over time

The area served could be a relatively small and confined location, for example a business park, or it could be across several larger developments, not necessarily physically connected. The exact remit of the ESCo will vary dependent on the site and local requirements, but can include any of:

- Electricity, gas and heat supplies;
- Energy efficiency measures;
- Management of energy equipment and facilities, including battery storage if appropriate;
- Installation of suitable renewable energy technologies;
- Management of demand profile (electricity and heat) to minimise costs (e.g. through aggregation services).

The ESCo is a vehicle to hold and manage the design, network delivery, operating, regulatory and financial risk in providing the defined energy services. Additionally, ESCos can sometimes be expanded to be a 'MUSCo' (Multi-utility service company), to include services such as water, broadband or waste.

The ESCo is paid by customers for the services it delivers, based (either wholly or in part) on the connection of energy services, the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria. To attract the required level of investment there will need to be a contractual mechanism in place to demonstrate a secure revenue stream over time.

Multi-level ESCos

The ESCo is a commercial vehicle with commercial and social objectives – (e.g.such as managing air quality associated with generation) and as such can operate across a number of projects. There are multiple models that can be reviewed against the core objectives e.g. the primary ESCo creates a subsidiary ESCo per project and seeks funds for the associated project.

The further study considering ESCos delivered alongside this work will take account of the views of the objectives of the local authorities and third party stakeholders (e.g. developers); third party investors, state aid compliance and government incentives, the management of risk for all parties; and performance of the services alongside tax implications and final technical, legal and management solutions.

Capital investment

Energy projects are long term investments and are capital intensive and thus subject to the stringent project modelling and evaluation to ensure that the business and financial cases are commercially and socially secure. Energy assets typically have a long life cycle and will require maintenance and potentially refinancing over time.

The attractiveness of the ESCo project to the public and commercial lenders will depend on the level of risk and type of finance being sought alongside the levels of government support and incentives. A properly designed ESCo has the flexibility to manage the risk profile of each aspect of the project to appeal to certain types of investors and thus manage the overall cost of capital (interest rates).

Where heat networks are involved, pipework can cost in excess of £1,000 per metre; costs can quickly build to multi-million-pound projects. However, once installed returns should be reliably recovered for the project duration. It is typical for projects to be financed over 25-40-year terms, with rates of return calculated over these periods as long term investments.

It is likely that a project will be constructed in a number of phases, thus requiring multiple funding rounds. Projecting these phases allowing for known risks around bringing on certain developments will be key to ensuring the business model is robust.

Initial capital can be obtained from a combination of sources including third party investment capital, non-recourse project finance, government incentives and grants, local Council budgets; equity investment and loans from either public or private sector. Capital may be raised from issuing of shares, which is often the case with community owned schemes. In each case the rewards required will depend on the level of risk.

Types of operating model

There are multiple configurations of operating which can be employed depending on the attitudes of the key stakeholders around risk and control. Each piece of an operating heat or private wire network can be owned and operated by different parties, although the more actors within the system the riskier a project can become.

These broadly fall into the following categories;

- Public – a municipal approach or community owned company;

- Hybrid - usually a public/private joint venture or special purpose vehicle;
- Private – wholly owned and operated within the private sector. This can include community owned companies.

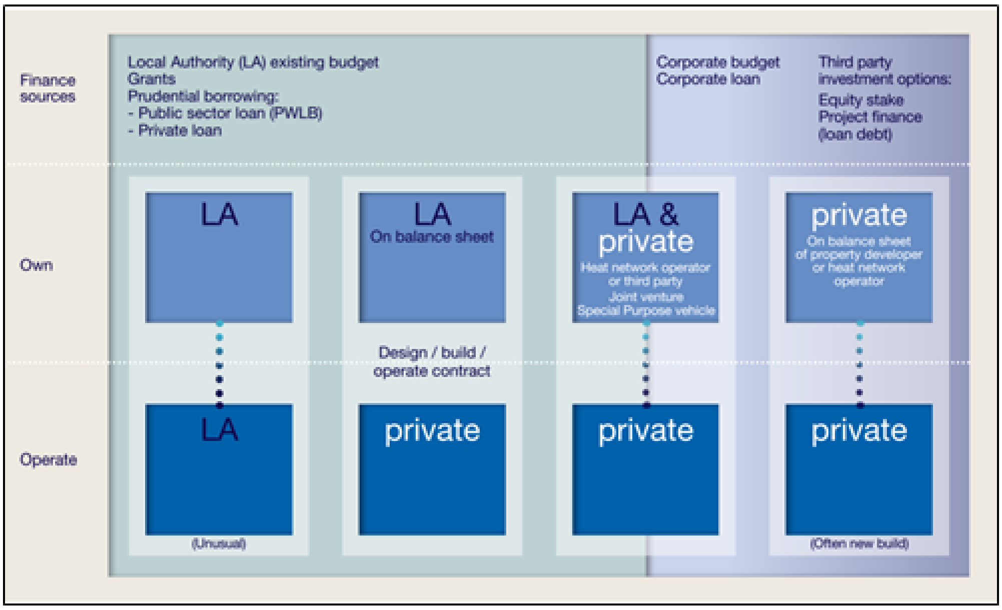

Figure 16: Investment models (image courtesy of BEIS HNDU)

Figure 16 shows these different models and the potential sources of funding appropriate for different approaches.

8. Appendix II Good practice case study review

Best practice in heat and power solutions driving economic growth

Author: Sustainability West Midlands
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Report information

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Disclaimer: This report represents the independent advice commissioned by Sustainability West Midlands, and not necessarily that of the funders.

About Sustainability West Midlands

We are the sustainability adviser for the leaders of the West Midlands. We are also the regional sustainability champion body for the West Midlands, designated by government. We are a not-for-profit company that works with our members in the business, public and voluntary sectors. Our Board is private sector led and has cross-sector representation; they are supported by our team of staff and associates.

Our vision is that by 2020 businesses and communities are thriving in a West Midlands that is environmentally sustainable and socially just.

Our role is to act as a catalyst for change through our advice to leaders, to develop practical solutions with our members and share success through our communications.

www.sustainabilitywestmidlands.org.uk
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1 Introduction

Sustainability West Midlands (SWM) have been commissioned to work in partnership with Egnida to provide a Local Energy Infrastructure Study for Greater Norwich, including Key Housing and Commercial Sites.

This report highlights examples of projects delivered by Local Enterprise Partnerships (LEPs) and local authorities to secure heat and power solutions to underpin their growth plans drawing out best practice and lessons learnt, with particular focus on:

- Local generation and controls
- Commercial and/or housing sites in areas with constrained electricity networks
- Urban and rural examples
- Smart networks
- Heat networks

Each case study highlights the specific issues addressed, the challenges associated with project delivery and the solutions implemented. All of the case studies, whilst at differing stages in their development, demonstrate excellent examples of local energy infrastructure that has worked to lower their carbon emissions, increase the stability of the energy supply and have prepared the area for the future of energy demand.

2 Best practice case studies

2.1 West Midlands Energy Innovation Zones: Tyseley Energy Park

2.1.1 Background

The Energy Innovation Zones (EIZs) have been designed to stimulate clean energy innovation to drive productivity, exports and growth. They work not only to demonstrate new technologies, but to turn them into fully commercial propositions.

The main focus of the EIZs is to integrate low-carbon technologies across energy systems, develop business models and market arrangements which are needed to support new approaches to clean energy, and to overcome the regulatory and other barriers necessary for them to flourish. Mayor of the West Midlands, Andy Street, echoed this in saying the EIZs will reduce emissions and lower energy bills, meanwhile developing local supply chains, creating jobs, skills and markets. Most recent estimates support the notion that clean tech products and services will be a huge financial success, suggesting a market worth well over $3trn a year, which local businesses and communities will be able to tap into and benefit from, with the development of the EIZs and the continued work taking place on their sites.

These zones could be set up anywhere across the UK, but the West Midlands, the birth place of the idea, has a unique combination of factors that have facilitated development. The region faces some acute energy, business and social challenges. The West Midlands has some of the worst instances of fuel poverty in the UK, coupled with a high concentration of energy-intensive manufacturing. It is also an area of grid constraint, struggling to connect all residents to stable sources of energy, and has considerable challenges relating to poor air quality. The West Midlands very much needs the Energy Innovation Zones to deliver clean, green energy to fuel the economy for generations to come. The EIZ's reduced emissions and lower energy bills will benefit both domestically and commercially, tackling fuel poverty and giving companies the energy needed to maximise their productivity, without contributing further to the problem of air quality.

The aim is to deliver multiple EIZs across the West Midlands, specifically in the Black County, Coventry and Warwickshire, Tyseley and Birmingham as well as the UK Central Hub in Solihull.

2.1.2 Tyseley Energy Park (TEP)

Tyseley Energy Park is one of the sites within the larger Tyseley Environmental Enterprise District, which was established in 1720, by Webster and Horsfall Limited (WHHL), one of Birmingham's oldest manufacturing companies. TEP is an integrated, distributed energy facility that has emerged and continues to grow on the industrial site that is Tyseley Environmental Enterprise District.

Inputs
- £47 million in Phase One
- £3.89 million in Phase Two
- £2.5 million in Phase Four

The strategic decision was made by the site owners to focus their manufacturing for specialist applications, meaning they required less space for operations. This led to the decision to develop the now additional 10-acre spot into TEP, providing employment and economic security to the people of the area, as well as enhancing natural and social capital. The management of TEP makes room for innovation that works to benefit the local economy and community. The local management of energy infrastructure planning and investment helps to meet local needs. It creates publicly-managed contexts in which industrial partners and private investors can develop and deploy new technologies at a sufficient scale to give them a platform to develop a position in the global market, in turn, creating new markets.

Challenges
- Fuel poverty
- Grid constraint
- Poor air quality

Results
- 10 MWe Biomass power station
- Construction of 'Green-Fuel' refuelling station

The EIZs are designed to encourage commercial-scale deployment of systematic innovation, this is already being realised, one example being the UK's first silent revolution wind turbines, which will be used as power generation for TEP. The company behind them will also expand these noiseless turbines onto the street, with the potential to replace lamp posts, generating power and lighting the street simultaneously.

Next Steps
- District heating system development
- Development of the 'Innovation Hub'

The development of the park has been split into four phases; phase one has already been completed and phase two is in development.

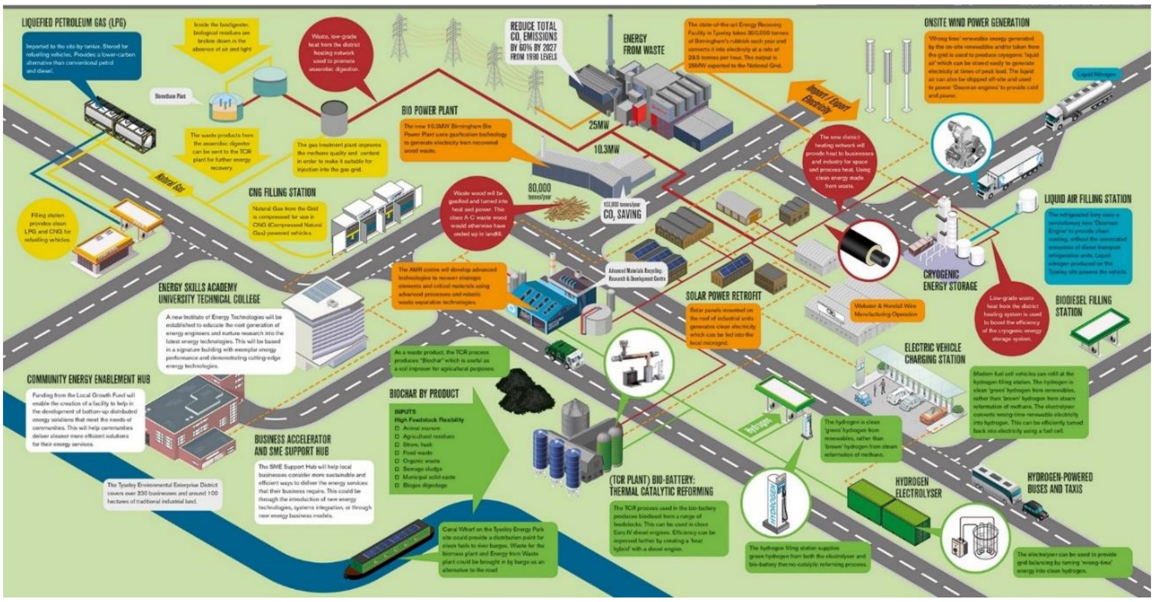
Phase One
Phase one of the development of TEP has seen a £47 million investment for the development of a 10 MWe biomass power station, which burns 80,000 tonnes of wood waste per annum, diverting it from landfill. This is being used to supply the National Grid, but also to meet the energy needs of the industrial site, namely the operational energy use of WHHL as well as Rent-E, a company which rents electric taxis to Uber drivers.

Phase Two
Construction is currently being carried out for the development of 'Green-Fuel' vehicle refuelling facilities, funded by £3.89m from Greater Birmingham & Solihull LEP and a private investor. The facilities included are; a 3 MW Proton Exchange Membrane (PEM) electrolyser, for the production of Hydrogen, a Compressed Natural Gas 'CNG' refuelling station, CNG being an alternative to diesel for HGVs, seeing a 90% reduction in emissions compared to a diesel truck. There is also a biodiesel refuelling facility, providing biodiesel and related products. The site will be capable of refuelling up to 500 vehicles a day with these low-emission alternatives, with further capacity also coming from a range of 150kW electric vehicle rapid chargers. The range of available fuels support Birmingham's move towards cleaner air with the forthcoming Clean Air Zone (CAZ) giving local businesses and communities to the capability to upgrade to a low-emission vehicle and fleet, also attracting new business and stimulate regeneration in the area. The construction of the facility and access road has already created more than 135 jobs as well as apprenticeships for the younger generation.

Phase Three
The location of TEP has made it optimal to become the energy-waste nexus for the City of Birmingham. Next to the park is an energy-from-waste plant, which has long been a feature of the Tyseley skyline. The plant converts 350,000 tonnes of municipal waste into electricity, exporting 25 MWh (after plant needs) to the national grid, with the ash by-product being used in road building. There is significant potential to connect businesses across the city to the waste heat from the Energy from Waste plant, using a district heating network, the development of which is phase three of development.

Phase Four
The University of Birmingham have invested £2.5 million into the site for the development of phase four, an 'Innovation Hub'. This is intended to develop skills and training with TEP, together with collaborative research and development of manufacturing, helping companies successfully engage with the transport, energy and circular economy revolution.

The image below shows the ‘vision’ of what Tyseley Energy Park will look like when it is complete, including some of the smaller developments such as the UK’s first ‘silent’ turbines and the retrofitting of industrial units which will feed into the local microgrid.



Key Contacts
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2.2 Gateshead District Energy Centre

2.2.1 Background

This award-winning district heating scheme was established in 2017 in Gateshead. It is the first of its kind and scale in the North East, working to generate low-carbon, low cost energy for 350 homes and businesses in the area. The centre uses two 2MWe gas-powered combined heat and power (CHP) plants to generate enough electricity to power 5,000 homes. The waste heat from the engines is recovered and is used to provide hot water for heating.

The scheme originated in 2010, stemming from the Council’s ambition to reduce energy costs and carbon emissions in Gateshead Town Centre. The scheme evolved into a major infrastructure project that sought to underpin the future redevelopment of the Town

Centre, with the hope that it will stimulate inward investment and job creation as well as becoming a valuable asset to the Council.

The scheme connects a 7km network of pipes from the South Bank of the Tyne into central Gateshead servicing public buildings, businesses and social housing tower blocks. The overall project represents a £14m energy scheme.

The Council's aims for the district energy scheme are:

- To provide low cost heat and power to existing homes, organisations and businesses in the urban core of Gateshead, reducing their running costs and improving their competitiveness.
- To create new business growth in Gateshead, by offering low cost, low carbon heat and power to new commercial development.
- To reduce Gateshead's carbon footprint, by providing heat and power with half the carbon emissions of grid energy supplies.
- To help households suffering with fuel poverty reduce the cost of heating their homes.

2.2.2 Approach

The development of the project was carried out by Edina who were awarded the contract by the council, with support from WSP PB Ltd, to install and maintain the 4MW gas CHP plant. The scheme has been and will continue to be fully funded, with support from European Regional Development Fund, and owned by Gateshead Council, operated through the Gateshead Energy Services Company, also owned by the Council.

It was very important throughout all stages of development that the community were onboard and supportive of this project and therefore making the benefits to the community known, was essential. An example of how this was achieved was the main contractors hosting site visits for Gateshead college (a recipient of heat from the scheme). This involved giving presentations and careers advice to the students. As well as this, students of the college produced artwork for the site which were displayed and recognised on the Energy Centre open day.

The scheme is 'heat-led' meaning that the Energy Centre first and foremost works to provide customers with their heat requirements, with the electricity being generated as a result of the CHP engines running. The electricity is not being exported to the national grid. Instead, Gateshead Council have made the decision to supply customers directly through a network of private wire agreements. The argued benefit being this allows for lower customer costs as well as reducing the costs and losses of exporting to the grid.

In order to create a more resilient energy scheme, the Gateshead Energy Centre has a full set of back up facilities. When customers do not need heat, or when CHP engines are being serviced, heat is provided from conventional gas boilers, which operate as a back-up. When the CHP units are not running or the demand for electricity is higher than capacity, 100%

renewable energy is sourced from Gateshead Council's own grid connection, using an energy tariff in order to do so.

An important aspect of the development of the Energy Centre was that it would be able to meet future demand as well as current demand. The scheme is and will continue to play a significant role in the redevelopment of the Town Centre, as such the energy infrastructure has been designed and developed to give a major commercial advantage to the Baltic Business Quarter as well as the wider Gateshead Quays. Developers and businesses working in this area are able to take advantage of the low-cost energy supplier, strategically situated for their benefit.

As well as this, the Energy Centre has been designed to connect to new residential developments, such as the redevelopment of the Freightliner site and the new Exemplar Neighbourhood, for which planning is underway. These new neighbourhoods will include up to 1,000 new homes which are all planned to be supplied by the Energy Centre. As a part of the ongoing expansion of the energy scheme, a 3MW battery storage system was completed in 2017 with the capacity to meet energy needs for 3,000 homes.

2.2.3 Results

Due to the recent completion of this scheme, it is more difficult to identity the exact results of the scheme, as they are still revealing themselves as monitoring and assessment takes place. However, the scheme has been successful in cutting carbon emissions, achieving a reduction of 2,900 tCO_2 per annum after the initial development, which increased to 5,300 tCO_2 per annum after expansion. It is calculated that this figure will increase again, to 6,100 tCO_2 after phase three of development has been completed. This includes installing 250m^3 of thermal energy storage that would allow 95% of the 10MWh heat demand to be supplied solely from the CHP engines.

Financial successes can be recognised also. Looking at the investment in the scheme, the Council projects an 8% return over 40 years. This investment and the establishment of the scheme has resulted in lower costs for energy and heat for customers in the area. Due to the lower cost, the Council has been able to guarantee customers discounts starting from 10% on heat costs and 5% on power, leading to even lower costs and attracting commercial and residential interest.

Due to the successes of the scheme, it was recognised and accredited with an international award from the Association of Decentralised Energy. It was recognised for its for its innovation, social impact, and the difference it has made to the sector. Key elements recognised were the application of the private wire, breaking new ground, bringing into question the effectiveness of current licencing and legislations around electricity distribution and supply. Also, the fact that it has been able to integrate all elements of energy, proving that energy can be decentralised and remain commercially viable, whilst still being fully integrated with national networks.

2.2.4 Next Steps

- Continued maintenance and support from Edina
- Connection to Regent Court, comprising of 160 homes
- 1km extension of both heat and private wire network, trialling new plastic district heating pipe technology, to the Gateshead Leisure Centre area. This technology would seek to replicate steel pipes using plastic, further lowering costs of future developments and creating an opportunity to develop the local supply chain to the project.
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2.3 Cambridgeshire: Mobilising Local Energy Investment

2.3.1 Background

Cambridgeshire County Council (CCC) is a front-runner, leading the way in local authority energy investment with an award-winning programme with more than £20m in energy generation and energy efficiency projects. Having successfully delivered projects with 40 schools, seven corporate buildings and having developed their 12MW solar farm, the County Council is proving to be a leader in bringing renewables into the mainstream as a reliable source of energy. As well as having completed multiple large and smaller scale projects, CCC's work is on-going in the development of their project pipeline, with the establishment of their Smart Energy Grid and newer projects such as the community heat scheme.

2.3.2 Projects

Cambridgeshire County Council has used the National Re:fit Programme to make guaranteed energy-efficiency savings and improve the condition of its schools and corporate buildings across the county. The Council secured £20m of investment for energy-saving retrofits and renewable energy to schools, council land and buildings. A mini-competition was run and Bouygues were appointed as the main contractors in early August 2014.

<u>Challenges</u>

Cambridgeshire faces a number of challenges that means it has had to develop new forms of energy generation. The combination of grid constraints, reducing finance incentives, load balancing, technological interactions and the emergence of electric vehicles has meant that new business models are required. The projects being developed by CCC aim to meet these challenges with innovative solutions.

One of the major challenges Cambridgeshire faces is being off gas grid. Being unable to easily connect to the grid has meant that many areas have been left to rely on oil as their primary source of energy. The use of oil as an energy source is something that locals want to remedy. Oil is a very unsustainable energy source due to the required drilling and burning. It is also difficult to budget for as prices are in constant fluctuation. The use of oil can deter new residents from moving into the area due to its 'dirty' image and unsightly tanks. Furthermore, grid constraint has meant that planning for new developments has been restricted due to the lower capacity electricity network available.

Load balancing also remains a key challenge that needs to be addressed. Load balancing refers to the use of techniques by power stations to store electrical power during low demand periods for release at peak times. Addressing this would give Cambridgeshire greater capacity to develop future projects with improved stability.

The below examples provide clear evidence of how Cambridgeshire has addressed these challenges, making them more resilient and more prepared for the energy demand of the future.

<u>Soham Solar Farm</u>

Included in the project's scope was the delivery of a 12 MW large-scale solar park in Soham. The project is supported by the Council's successful bid to the then Department of Energy and Climate Change's Contracts for Difference (CfD) renewable auction, which has pre-set financial terms for the energy generated. The use of Re:fit meant that the project had guaranteed performance levels while still being comfortably under market rates for large-scale solar parks, where no such guarantee is provided. Coupling this with guaranteed price for energy generated and the capped installation and maintenance service charge, means that the Council have a guaranteed revenue income of around £1m each year, topped up by further boosts from extra energy output.

At A Glance

- £1m annual gross benefit
- 135,170 tonnes of CO2e saved over 25 years
- 11,000MWh generated per annum
- Supplies over 3,000 homes
- Took 16 weeks to build
- More than 45,000 panels

The solar farm has become an extremely valuable asset due to the secure income stream and guaranteed positive business case that will enable a total net return of more than £10m.

Smart Energy Grid

> At A Glance
>
> - £24m over life span
> - Avoids 12,000 tonnes of CO2e over its life
> - 43,000MWh generated over 25 years
> - Overcomes local energy grid constraints
> - Supports local businesses and develops local supply chains
> - Integration of energy and transport solutions

The Smart Energy Grid (SEG) project plans to provide just less than 1MW capacity of renewable electricity. This electricity will be exported directly to local businesses through a private wire purchase agreement, while battery storage is being used to enable the park and ride site to provide energy for LED lighting and for electric vehicle charging.
The project is looking to overcome significant market failure and innovate through bringing a number of products together to work in a system. The project is needed for a variety of reasons, one being Cambridgeshire's local distribution is at capacity in many places. Adding this source to the network not only solves this issue, but it contributes to reducing carbon emissions and meeting associated targets. As well as this, the project works alongside the Government's Clean Air Plan, in helping to reduce pollution but increasing the viability of using electric vehicles in the area. This has proved to work as electric vehicle registrations increased by over 40% in 2018 compared to 2017. This can be compared to the still impressive, 26% increase in the UK as a whole, showing Cambridgeshire's above average uptake in EVs.

Swaffam Prior Community Heat Scheme

This project is still in the early stages of development. In efforts to attract new residents and to improve the sustainability of the area, residents and CCC have been developing a scheme to replace the use of oil for heat and hot water in Swaffam Prior, which 70% of the buildings in the community rely on. The aim is to replace this with a ground source district heating scheme. There are just over 280 houses that could join the scheme, as well as the primary school, swimming pool, two churches, a pub, former youth club and village hall.
£20,000 was invested to see if the project could be developed and a further £40,000 Government grant was awarded via the Heat Network Delivery Unit (HNDU) scheme to carry out the next step of development, a Technical Economic Feasibility Study (TEFS). A further £20,000 was awarded by the Combined Authority for the development of this project following a successful presentation with Mayor James Palmer. Work on the project will be determined based on the success or failure of the TEFS.

Solar-plus-storage parks
The newest project announced from CCC's renewables projects pipeline is the development of two landmark solar-plus-storage projects. These will be developed on decommissioned landfill sites, which will be the first of their kind in the UK.

Plans were announced for energy projects on landfill sites in Woodston and Stanground. The Stanground site is proposed to be the largest, combining a 2.25MW solar array with a 10MW battery storage system. While the Woodston project will use a 3MW battery. Both sites are to be used for demand-side response services and to offer load balancing to the national grid.

The revenue generated from the services will be used to help fund the county council's frontline services. An estimated revenue is £46m over 25 years.

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2.4 Graylingwell Park

2.4.1 Background

Graylingwell Park is a former Victorian hospital situated in 85 acres of wooded parkland. The site sits within Chichester's urban area and adjoins other land, previously owned by the health authority which is now the NHS Trust and a former barracks, and part of the University of Chichester.

The site was taken over by the Homes and Communities Agency (HCA) as one of 96 sites from the NHS and was marketed as a mixed-use development opportunity. At the time (2011), the project created the UK's largest net zero carbon development with 780 new and refurbished dwellings, 40% of which were affordable housing, and 11,000 square metres of non-housing.

A heat network was developed to heat the site, valued at £7.2m with over 12km of buried mains and 780 interface units. The energy centre and network development programme has a phased approach with a final completion date of 2019.

2.4.2 Challenges

- Planning capacity; the scale of this development was unprecedented at the time for a local authority such as Chichester, with the previous largest scheme having been 180 homes. Having the public sector on side as a partner helped with speeding the process along.
- Private finance; during the development, the financial situation was changing. The planning process and development of Graylingwell Park began in 2005/06 and has continued since,

meaning it experienced the turmoil of the 2008 financial crash. This left the developers with uncertainty as to whether houses would be sold due to difficulty raising mortgages. This had an impact on the speed of development.

2.4.3 Approach

Due to the 'first-of-its-kind' nature and the scale of this project, it was important to ensure the proper services would be available to maximise the efficiency and the benefits of the development. In order to do this Graylingwell Energy Services Ltd was established, specialising in the generation and distribution of environmentally-sound, affordable heating and hot water in Graylingwell Park. The company operates solely for those within Graylingwell, meaning their focus lies wholly with the betterment of the development. The Chichester Design Protocol played a key role in the planning of Graylingwell.

Planning

As the development of this site was so large, it was important to get community support for the project and ensure that issues were heard and addressed. To do this, consultation was made a priority from the beginning of the project, giving locals an opportunity to be heard early on in the preparation of the Supplementary Planning Document, all through the process to workshops and feedback sessions for the early master plan and upon submission of the planning application. Main concerns regarding the site development were;

- Traffic generation
- Car parking
- Environmental impact
- Community facilities
- Sustainability
- Employment

One of the more innovative approaches to encouraging community engagement happened in the form of a weekend planning workshop was set up for the design element of the project. This opened the existing forum up to many more people and led to a number of people acting as 'community champions'. This meant that when the scheme reached the Planning Committee, four people spoke up in support, including the chair of the 'local residents' association. This left locals feeling their voices were being heard and they had a genuine impact on the development of the project, this was a big help in securing planning permission.

A Community Development Trust (CCDT) was set up and was endowed with assets including the conversion of a listed chapel, a new community hall, an artist studio workshop (converted from former farm-buildings) and a small community office converted from a water tower. These community facilities generate a rental income that is used by the CCDT to sustain the viability of the building fabrics. The CCDT also works to ensure residents from both the new development and surrounding neighbourhoods are able to mix at a variety of functions promoting activities for all ages.

A bus service has been provided from the beginning of residential use and the residents have been given passes, with the aim to encourage them to use their cars less frequently. This has helped in reducing traffic generation and keeping carbon emissions lower. As well as this, residents were encouraged to preserve the 'green' environment by making use of the cycle routes and car clubs that have been set up. These initiatives were introduced through the delivery of a 'Green Travel Plan'.

Installations

The development has been built to level 6 of the Code for Sustainable Homes in terms of energy and level 4 overall for the other aspects of the code. This has been achieved through the variety of renewables systems and low emissions systems set up, as well as the orientation and building materials used. To manage the Park's energy, Graylingwell Energy constructed a centrally-managed energy centre. To meet these standards, homes were fitted with a select series of efficient utilities. This meant the installation of:

- High levels of insulation and high-performance glazing.
- Water efficient equipment. Showers and baths with a maximum flow rate of less than 8 litres per minute and taps with that of 2.5 litres per minute.
- A+ rated appliances. For those who chose to purchase furnished homes, they were supplied with A+ rated equipment. Those to the contrary were given information on the most efficient equipment to buy.
- Rainwater collection and storage. Rainwater is collected and stored for irrigation of the land. Feasibility studies will be carried out to understand whether this could be used for a grey water scheme. This is where water, outside of the traditional sewage system, is captured or reused in place of day to day water. While not fit for human consumption, this water is ideal for irrigation of land.
- Maximising space. More than 50% of roof area is used for rainwater harvesting or green roofs.

All the homes built have been done so using timber-frame fabric design and high levels of insultation to ensure heat loss is minimised and energy efficiency is at a maximum. As well as this, all the south facing homes have been equipped with solar PV panels on their roofs, generating electricity for the homes with the surplus being sold to the national grid, and each dwelling being provided with manuals to understand the energy efficiency features and instructions for best use of the PV system. In order to minimise the external pollution and environmental damage resulting from the construction, key building materials met A+ ratings under the BRE's Green Guide to Specification. Furthermore, operational waste going to landfill was reduced by providing a storage space for sorting recyclables. Smart Meters have been installed in all dwellings, allowing residents to accurately interpret their energy bills.

To further reduce the impact of the development, materials used were locally sourced within 35 – 50 miles of the site, as well as those found on site. Moreover, existing buildings, structures and their components were re-used as much as possible. At conception it was intended that 30% of building materials were reclaimed or recycled materials, this was done alongside the initiative to reduce materials from non-renewable sources to a minimum. As well as this, the site has benefitted from the installation of a Combined Heat and Power (CHP) system, which is managed by the energy centre. The CHP system services all 780 dwellings, providing them with heat through insulated pipes meaning the homes do not require gas heating. The energy generated from the PV panels offsets the carbon emissions from the gas used in the CHP system.

As part of the clause for development, once 400 properties had been built, the ESCO, the company running the Energy Centre, installed two new biomass boilers to help reduce the carbon emissions for all properties on Graylingwell Park. As a result, the site has two 349 kW biomass boilers with the capacity to supply the whole development. There are two 10 tonne fuel stores where the wood pellets are stored, providing fuel for approximately two weeks. To further mitigate any environmental impact from the development of the site, the operating company appointed an ecologist that worked to understand the long-term impact on biodiversity and enhance the ecological value of the development. As a result, some 622 mature trees were retained and an additional 1,428 trees, including fruit trees, have been and are being planted.

Results

The development was awarded a series of commendations including:

- Sustainable Larger Social Housing Project of the Year, 2010 Sustainable Housing Awards
- Best Low or Zero Carbon Initiative, 2010 Housebuilder Awards
- Gold for 'Best Sustainable Development' and Silver for 'Best Brownfield Development, at What House? Awards 2011

Next Steps

- Ongoing maintenance of the site
- Feasibility studies for a grey water system using rainwater
- Continued support to increase and improve biodiversity of the area

General sustainability achievements:

- An exceptional exemplar for energy-provision in a 21st century community. Designed and built with low impact materials and fitted with energy efficient equipment and appliances, powered by the PV panels mounted on the roof which power homes and supply the grid, but also offset CO_2 emissions from the CHP plant.
- Buildings use locally sourced material and minimise energy use, water and waste during demolition, construction, operation and management.
- Engagement with the local community throughout the design and development process. Ensuring local stakeholders were heard and their concerns met, particularly on sustainability.
- 40% of the residential properties in Graylingwell are 'affordable homes.'

Key Contacts
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3 Common Themes and Recommendations

Throughout these examples of best practice there are key areas which can be highlighted as common aspects that have played a role in their success.

3.1 Community engagement

Engaging well with the local community, including both residents and also other businesses, is proven to be one of the best ways to get support for the project and feedback on what they think will be important elements of the project. This is evident throughout all of the case studies and particularly notable in the Graylingwell Park example. Not only did this project seek input via consultation, they also hosted regular workshops to actively engage with the community. This resonated so well with those in the area that many volunteered to be ‘community champions’ and spoke on behalf of the project to the Planning Committee, playing a huge role in securing the go-ahead for a project of this size.

3.2 Local relevance

A second common theme evident in these case studies is the importance of making the project locally relevant. Most of these projects, while they may have contracted an external organisation for development, are owned by their respective local authorities. The development of a council owned energy organisation such as Graylingwell Energy Services Ltd allows control and further development to remain in the hands of the stakeholders, the people living and working in the area.

3.3 Future planning

A final recommendation is to design for expansion. In all of these projects, while at differing stages of completion, they have implemented in their planning and design a desire to either expand their network/project or have ongoing support and maintenance after completion. The best examples include Gateshead and Cambridge. The Gateshead example shows clear use of innovation. After the initial installation of their Energy Centre with the necessary infrastructure, they have further installed battery storage which has expanded their capacity for a larger network. Furthermore, in Cambridge they have analysed the entire area to identify locations for new projects and continue to prepare them for development. These developments as well as those made in the other projects enable future planned developments to connect into these existing networks, future proofing heat and power usage in their respective areas.

4 Appendix 1: Sources of Information

West Midlands EIZs
https://i2.wp.com/www.energycapital.org.uk/wp-content/uploads/2018/03/tysley-eiz.jpg?ssl=1
https://www.energycapital.org.uk/energy-innovation-zones-background/
https://www.energycapital.org.uk/eizs-across-the-west-midlands/
https://www.energycapital.org.uk/tyseley-energy-park/
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https://www.energycapital.org.uk/eizs-across-the-west-midlands/uk-central-hub-eiz/
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Gateshead
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https://www.theplanner.co.uk/news/battery-storage-scheme-completed-in-gateshead
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