# Tyseley Environmental Enterprise District

## Stage 4 Options Development

sse
Energy Solutions

# Contents



## Figures

## Tables

# EXECUTIVE SUMMARY

## Introduction

Tyseley Environmental Enterprise District (TEED) is located 2.5km south-east of Birmingham City Centre, between the A45 Coventry Road and the A41 Warwick Road  it covers an area of over 100 Ha. The TEED Vision Report 2022 sets out the ambition to leverage the existing assets and initiatives within the area including green and blue infrastructure, established transport routes, 230 local businesses and the low and zero carbon businesses and energy systems within Tyseley Energy Park and connections with the University of Birmingham. This vision reflects Birmingham City Council's commitment to net zero carbon.

Tyseley Energy Park has various assets including:

- TEP 10MW Biomass Plant
- Tyseley 26MW Energy from Waste Plant (operated by Veolia)
- Low & Zero Carbon Refuelling Station – offering electric charging, hydrogen, Green D+ and gasoil

Further investment is planned in future including a potential replacement of the Veolia Tyseley Energy from Waste (EfW) plant, a 3.5MW electrolyser, a prospective new EfW or a pyrolysis plant and a further 25MW EfW at the Hay Hall site.

### Strategic Innovation Fund

A Strategic Innovation Fund (SIF) bid was led by NGED with a consortia comprising **Tyseley Energy Park**, **University of Birmingham** (whose Birmingham Energy Innovation Centre is located at the Tyseley Energy Park), **Birmingham City Council**, NGESO, Equans Pinnacle Power and SSE.

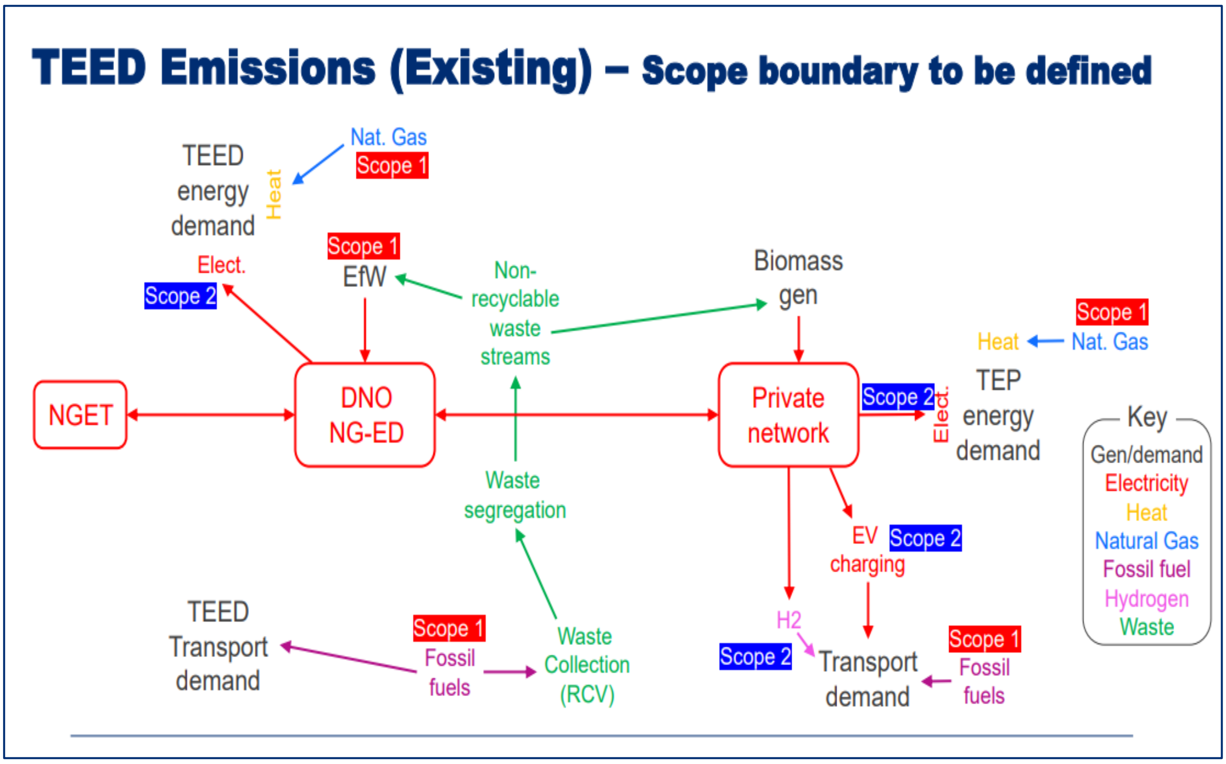
SSE ES was invited to join the consortium to develop high level design and optioneering for a mixed vector energy system (heat, power, hydrogen) with integrated energy storage across TEED.

The SSE project scope includes consideration of the opportunities around heat (district heating network) and microgrid incorporating private wire and EV charging opportunities.

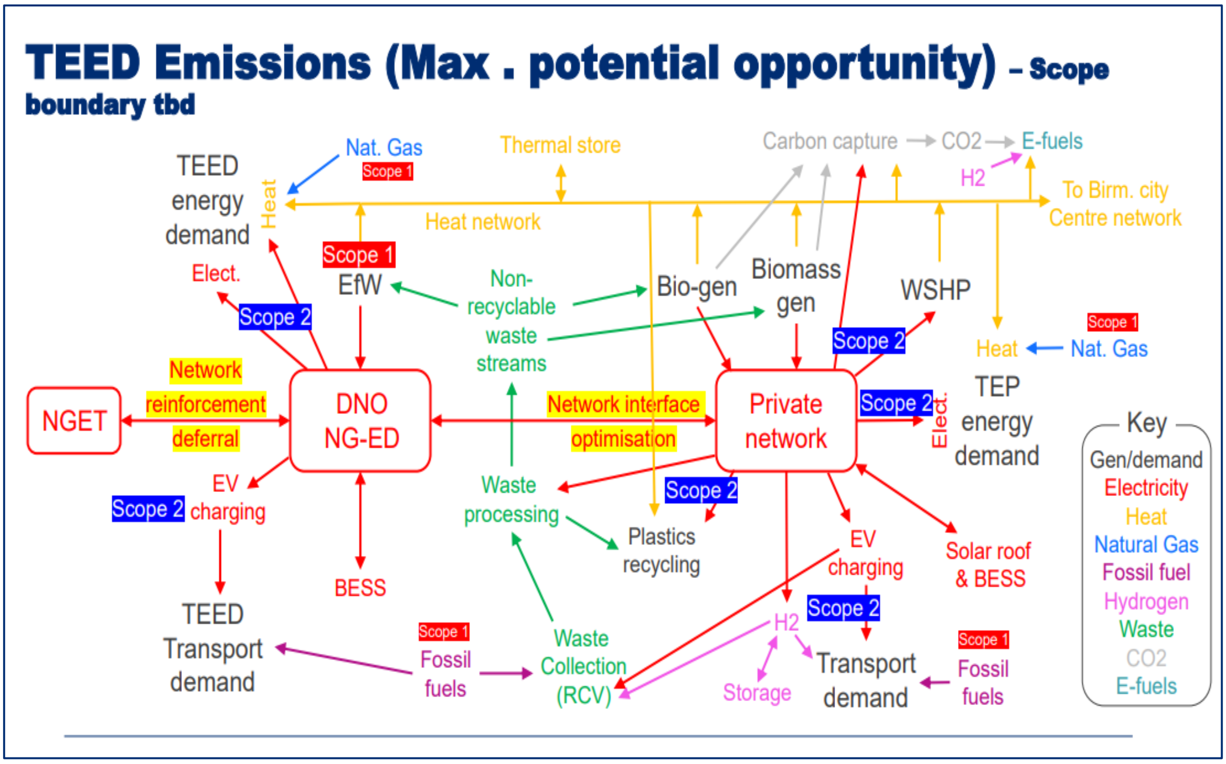
## Masterplan Development

### Baseline Position

The baseline position includes a number of existing energy systems and corresponding emissions scopes This includes electricity generation from the EfW and Biomass plants into the grid, the transfer and usage of waste streams to service these plants and the energy demand from both the TEED and TEP areas in terms of domestic and business energy usage. The biomass plant electricity serves a private network to feed the Webster & Horsfall manufacturing facility. Heat from the EfW and Biomass is currently not captured and hence this demand is met through natural gas with corresponding impact on scope 1 emissions.




## Opportunity Scoping

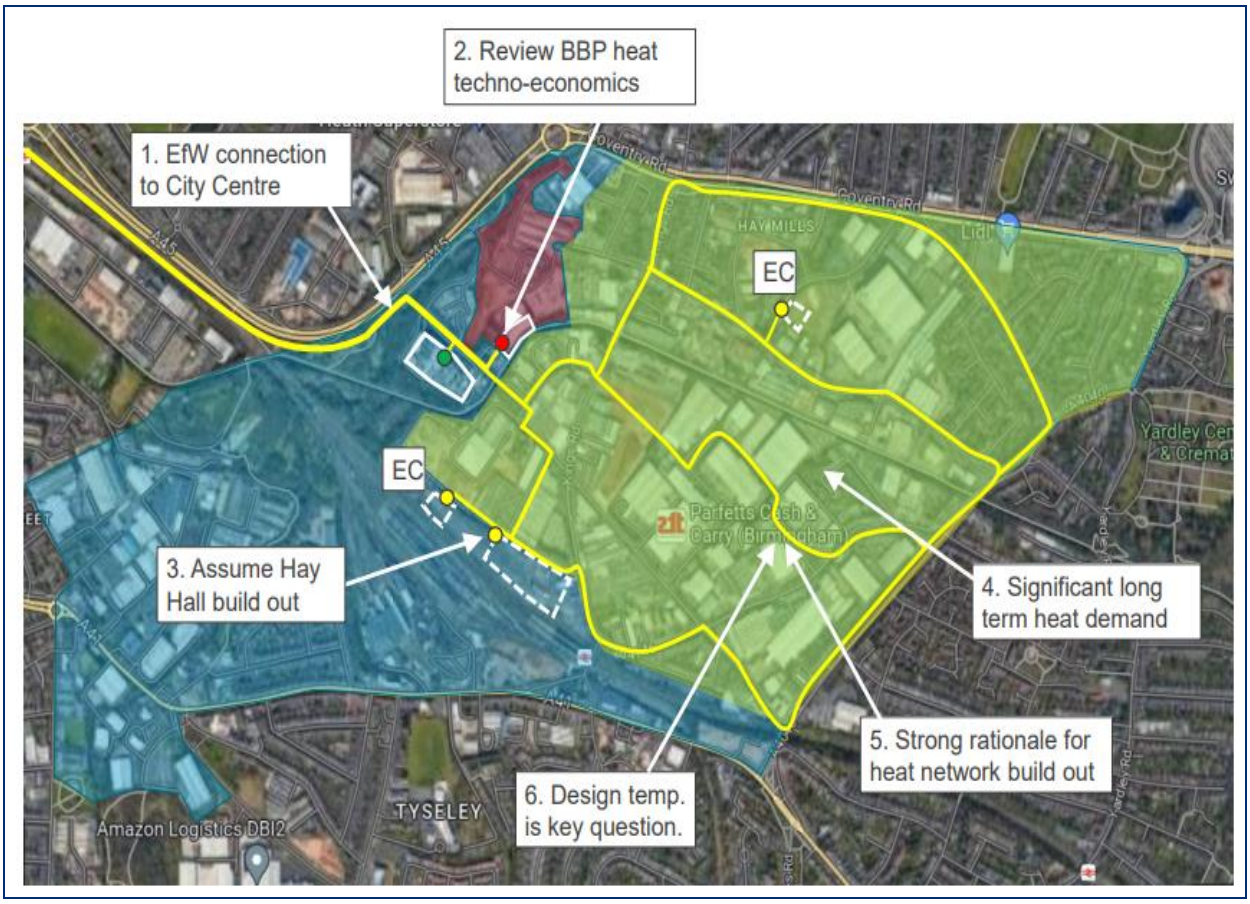



## Proposed Masterplan Framework

Review of the existing and proposed future infrastructure, potential vectors and customer base led to development of a masterplan framework including the following proposals and assumptions:

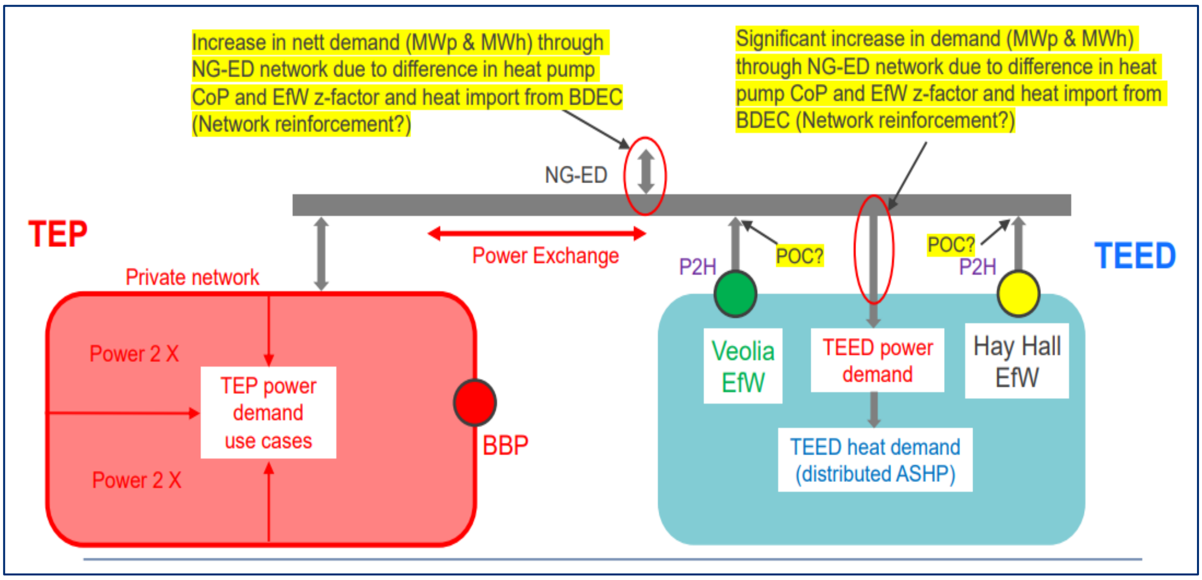
- Connect the Veolia EfW to City Centre Heat network to provide local anchor production with suitable back up, this would provide a suitable basis for the TEED heat network;

- Review of the techno-economics of the BBP plant as a source of resilient heat;
- Assume that Hay Hall EfW will replace / operate in parallel with the Veolia EfW plant providing consistent heat capacity over time;
- Assume proposed heat network confined to area north of rail-line (yellow area in figure 6 below), assumed technical difficulties and restrictive costs involved in crossing the rail-line;
- Assume significant heat demand across the TEED area for a 40-50 year period;
- Assume a design temperature for the proposed network flow ~100oC, return ~60oC




The base case characterises TEP as primarily an electrification zone based on the benefits of the existing private wire infrastructure, the NGED grid connection and the assumption that the Birmingham Bio-power facility will have poor heat techno-economics. The wider TEED area can be understood as a heat zone with the existing and proposed EfW plants (existing Veolia plant and proposed Hay Hall plant) and the resilience from connection with the City centre network providing the capacity and a good techno-economic case for heat.

The counterfactual position involves electrified heat utilising distributed Air Source Heat Pumps. In this scenario both TEP and TEED would be electrification zones based on the Biopower, private wire and the NGED. This would lead to an increase in net demand through the NGED network feeders due to the differentiation in the heat pumps Coefficient of Performance and the EfW z-factor and the heat import from BDEC. This could facilitate power to X conversion to carbon neutral fuels opportunities within TEP. The increase in electrical demand would also require investment in network reinforcement.




## Decarbonising Heat

As per the above framework assumptions, the focus on demand within the TEED core area is based on the following high level analysis.

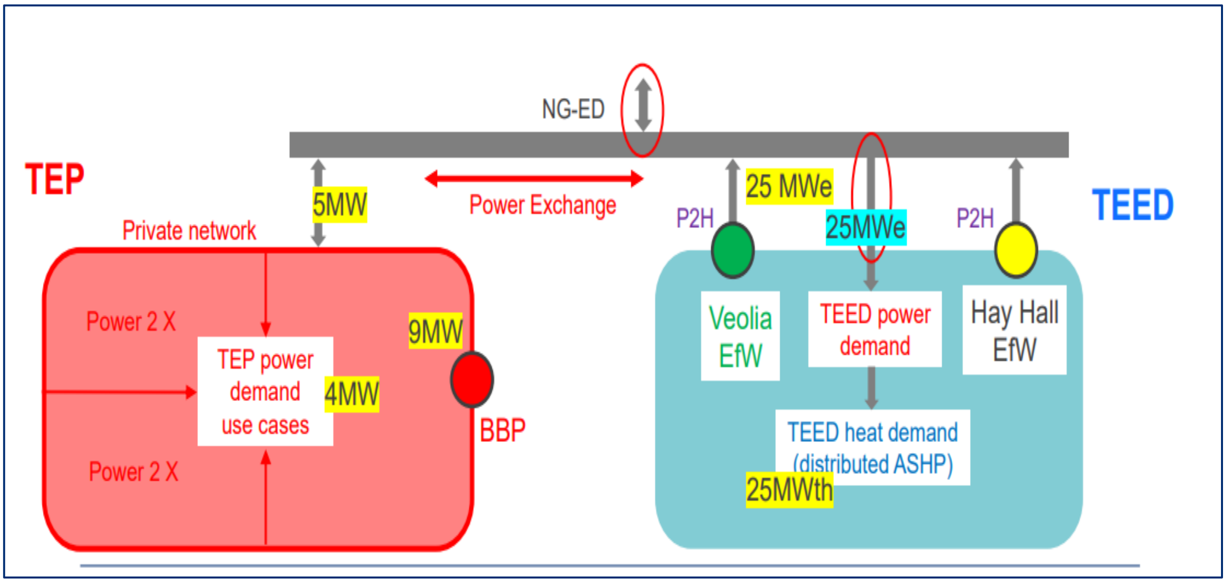
| Sector Total Estimates | Demand - Electrical p.a. | Demand – Heat p.a. |
|---|---|---|
| Residential | 3.5MW – 3.5GWh | 9.6MW – 14.3GWh |
| Non-Domestic | 6.8MW – 15GWh | 24.6MW – 31.3GWh |
| Total | 10.3MW – 18.5GWh | 34.2MW – 45.6GWh |
| Diversity Factor for heat peak @75% | - | 25.7MW |

The derived level of heat demand is therefore assessed as proportionate to the forecast 25MWth offtake.

### Heat Network Density

The network estimated length would be 11.6km within TEED with an additional route connection to the city centre scheme. On this basis a heat density of 2.2kWp/m would be required equating to 4MWh p.a./m.


Consideration of the requirements of the electrified distributed heat option against the base case position is illustrated below. A net increase of electricity from ~10MW to ~25MW is anticipated due to the additional peak capacity requirements of Air Source Heat Pumps (ASHP), assuming a CoP of 1.6.



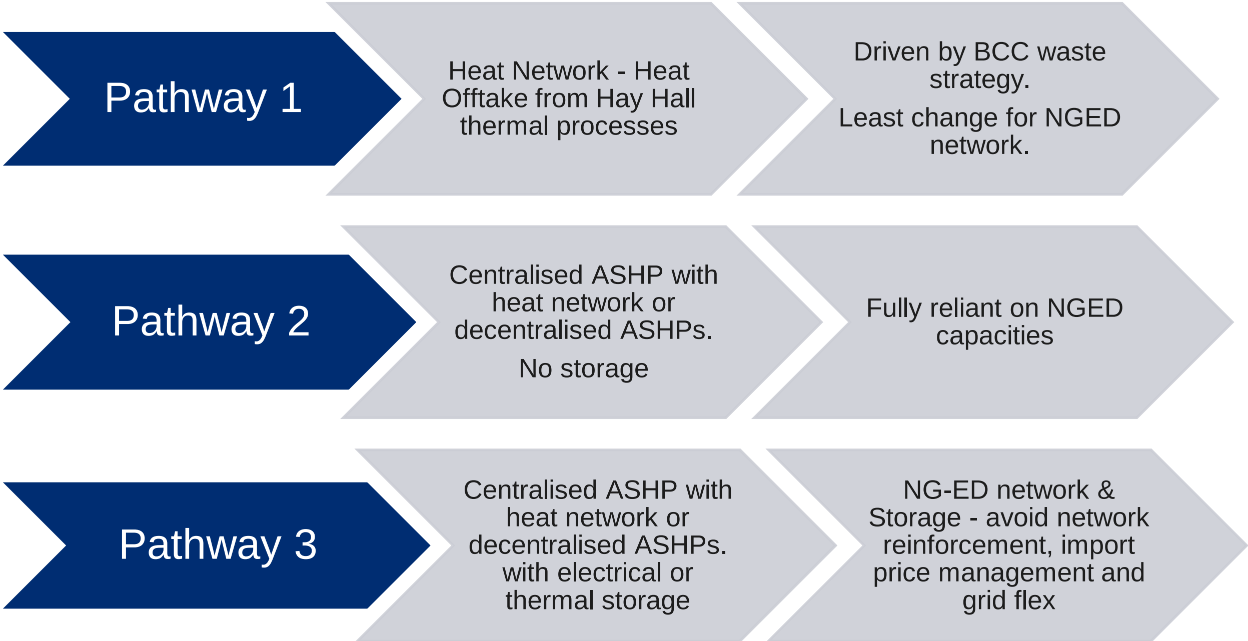

## Heat Network vs Distributed Electrified Heat (ASHP)

| Option | Capex Implication | Trade-off | Carbon Implication |
|---|---|---|---|
| 25MWth heat network (EfW heat offtake assume Z factor of 6) | High | Forego 4Mwe, create 25MWth (high utilisation) | Low carbon system – grid carbon intensity / 6 |
| Provide additional 15Mwe capacity (NGED network | Medium | Forego 12.5MWhe, create 25MWhth (low energy utilisation) | Medium carbon system – grid intensity / 2 |

| | | | |
|---|---|---|---|
| reinforcement), 25MWth at CoP 1.6 | | | |

## Delivery Pathways

The foregoing sets out the case for decarbonisation of heat within the local geography as the key opportunity. The decarbonisation of the EfW facilities or BBP presents significant challenges at the current time. To achieve the decarbonisation of heat there are 3 identified pathways:




A comparison of Pathways 2 and 3 and further analysis could identify the opportunity for embedded electrical and thermal storage to avoid network reinforcement thresholds. In order to assess the impact of reinforcement and therefore the value of utilising storage, it is proposed that a request is made to NGED for budget offers including contestable, non-contestable, network reinforcement and indicative timescales for both scenarios on the basis of:

- Non storage Energy Centres scenario:
    - Three 11kV points of connection for ASHP ECs for up to 7.5 MVA import each – but limited to 15 MVA total import across the 3 connections;
    - With electricity demand curves as per figure above

- Storage ECs scenario:
    - Three 11kV points of connection for ASHP ECs for up to 5.6 MVA import each – but limited to 11.2 MVA total import across the 3 connections;
    - With electricity demand curves as per figure above;
    - Battery electrical storage system = 3MWe / 6MWh per EC.

# Basis of Design Development

In progressing from the high level master-planning, demand analysis and pathway routes set out, a number of key assumptions were made to develop the design to a suitable level which could be assessed in an outline business case:

**Assumptions:**

- The project focus is on a low carbon heat network infrastructure;
- Due to the SSE assessment of the technical challenges associated with thermal extraction from the EfW facility the optimal technical solution would be an electrified air source heat pump solution which could be enduring or become a back up / top up if Hay Hall EfW is developed;
- The project only considers TEED area north of the railway (physical/stakeholder barrier) and assume that the southern area will be fed from another heat network;
- There is sufficient demand headroom at the Sparkbrook and Boughton Road 132/11kV subs for the electrified heat – however, we could assume some local 11kV upgrade works/costs;

## Updated Domestic Demand Assessment

The calculation of baseline year gas consumption was split into domestic and non-domestic sectors. The dataset was then cut to the TEED area by comparing the project boundary with postcode polygons (OS Code-Point with Polygons ) to obtain a list of postcodes within TEED.

There were found to be 127 postcodes in the TEED area, 78 of which appeared in the BEIS dataset. Across these 78 postcodes, the total number of domestic gas meters was calculated to be 1823 and these meters collectively consumed 25,208 MWh in 2021.

Applying this data to the SSE target core area to the north of the railway line below resulted in an estimate of 1,328 domestic property meters. The estimated breakdown of gas consumption and conversion to heat demand is summarised below.

| Domestic Meters Estimate | Demand – Gas p.a. | Demand – Heat p.a. | Demand Heat per meter p.a. |
|---|---|---|---|
| Residential Meters 1,328 | 18.36GWh gcv | 14.9GWh | 10.22MWh[1] |
| Total (excl. cooking gas) | - | 13.57GWh | - |

## Updated Non Domestic Demand Assessment

The lowest geography for which this information is available is at the MSOA (middle-layer super output area) level. There are two MSOAs which overlap with the TEED area, Birmingham 078 and Birmingham 140, which respectively in 2021 had 73 meters consuming 53,406 MWh and 84 meters consuming 29,191 MWh.

Following these steps, the ND gas consumption in the areas of overlap between TEED and Birmingham 078 and 140 respectively were estimated to be 48,393 MWh and 13,266 MWh. This leads to the total annual non-domestic gas consumption for the TEED area to be approximated at 61,659 MWh. Applying a

[1] 14,900/1328 = 11.22MWh p.a heat per meter less ~1MWh per meter for cooking = 10.22MWh heat p.a. per meter

2021 carbon intensity factor for natural gas of 0.18316 kg CO2e / kWh, means ND gas consumption was responsible for 11,293 tonnes of CO2e emissions in 2021.

Applying this data to the SSE target core area to the north of the railway line and applying a ratio of 95% of non-domestic meters falling within the MSOA 078 boundary resulted in an estimate of ~80 non-domestic property meters. The estimated breakdown of gas consumption and conversion to heat demand is summarised below.

**Table 1 Updated Non-Domestic Heat Demand SSE Target Core Area**

| Non-Domestic Meters Estimate | Demand – Gas p.a. | Demand – Heat p.a. |
|---|---|---|
| Meters ~80 | 45.97GWh gcv | 37.3GWh |

## Revised Heat Demand

Revised heat demand levels are provided below, based on analysis of updated data sources and refinement of assumptions. The revised total peak is 33MWth and total energy of 50.85GWhth.

| Sector / Property Type | GIFA / Meters | Demand – Heat kWthp / MWth p.a | Total Heat peak MWth | Total Energy GWhth |
|---|---|---|---|---|
| Domestic | ~1,328 units/meters | 8 / 10.22 | 10.6 | 13.57 |
| Non-Domestic | 233,500m2 (Each 1,000m2) | 100 / 153 | 21.5 | 35.69 |
| Industrial – 1 Factory | 3,500m2 | 244.2 | 0.5 | 0.85 |
| Retail - Supermarket x2 | 4,000m2 (each) | 130.6 | 0.3 | 0.52 |
| School | 1,800m2 | 122.8 | 0.13 | 0.22 |


## Demand Segmentation

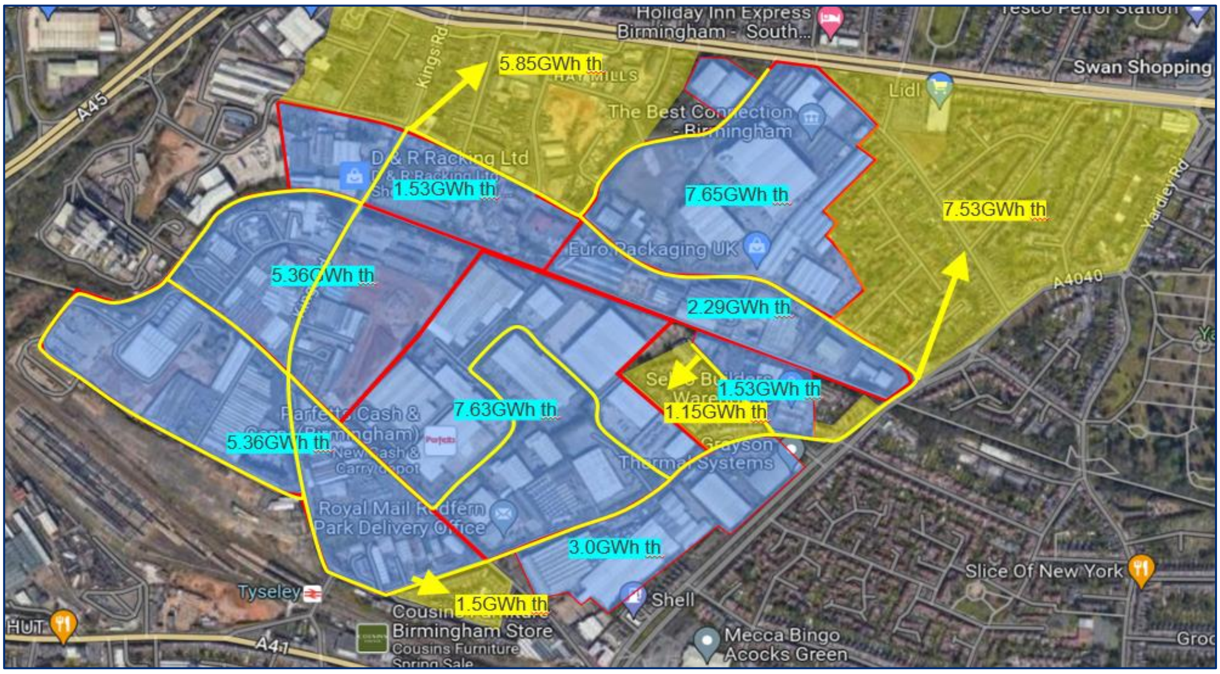
In further refining the project and developing its commercial feasibility based on the demand segments within the local geography there are a number of key anchor areas as set out below.


| Target Area Geography | Connections | Demand GWh | Connection Capacity MWh |
|---|---|---|---|
| Anchor Area | 85 | 28.3 | 333 |
| Non-Anchor Area | 1,368 | 22.55 | 16.5 |

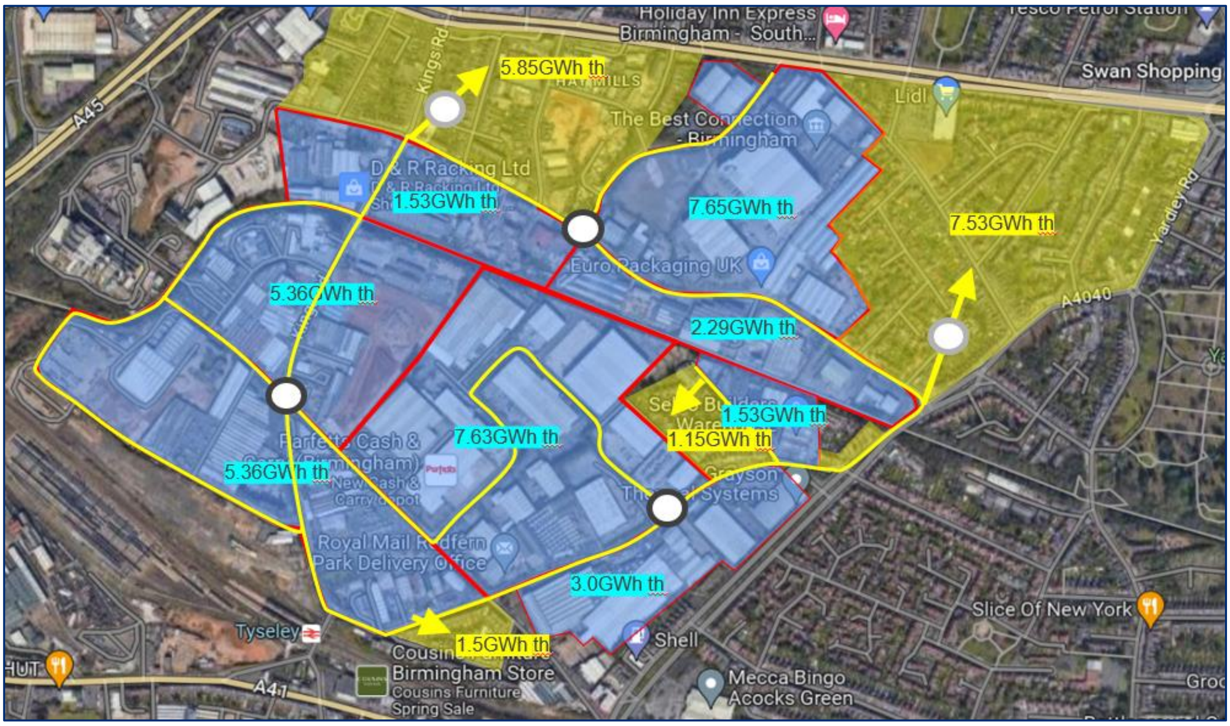
## Anchor Demand Area & Expansion Potential

There are a number of physical constraints within the anchor area, notably the issue of dealing with canal crossings. On the basis that these constraints can be mitigated, it is envisaged that the network can be expanded in phases utilising the canal crossings infrastructure, this is illustrated below.


The network could be expanded east and west to include non-anchor areas in an initial phase, increasing the number of connections to 125 and then north-west and north-east in further phases adding significant domestic connections (~1,310) as shown below, if economically viable.




In identifying the location of prospective energy centre infrastructure within the network, there are a number of potential sites where it is envisaged an initial number of centres could be deployed with additional centres added as part of the expansion phasing.



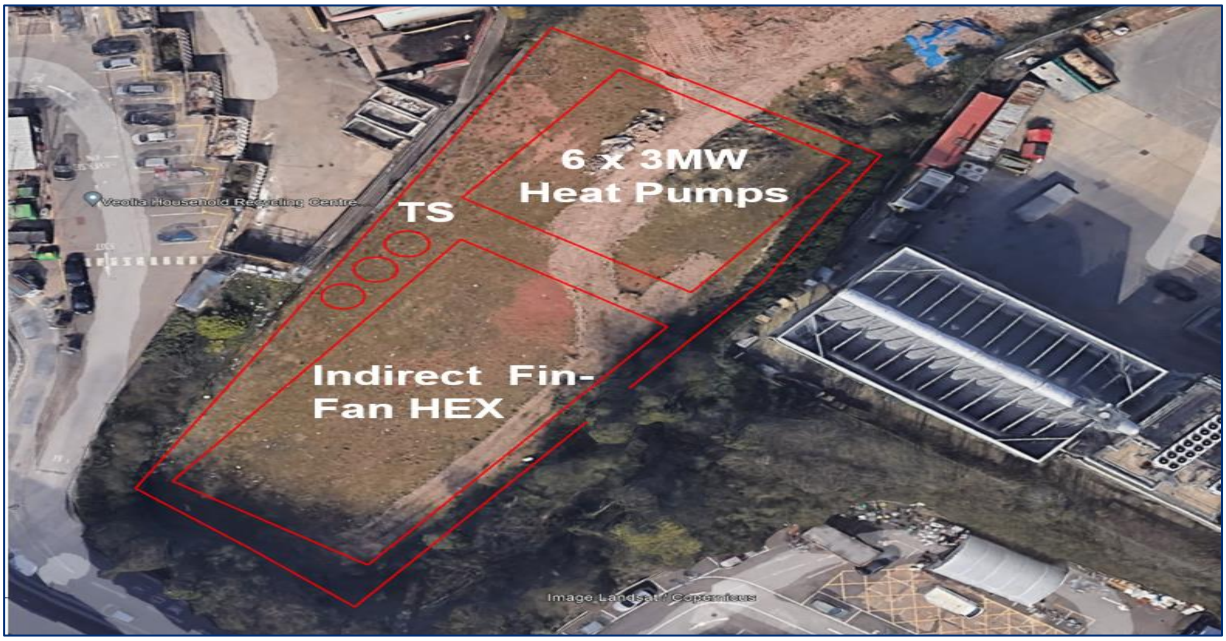

## Further Basis of Design Refinement

Additional detail was added to the basis of design to tailor it to the identified segments of demand within the target area with more alignment of the proposed network spines and main branches with the location of property and facilities. Further analysis of the Energy Centre location was guided by assumptions on availability of land, impact upon surrounding areas (especially due to cold plume nuisance from the ASHPs), access for O&M and levels of noise/disruption. Further analysis of the demand within the expanded anchor area led to refinement to an estimated 15MW peak.

The Energy Centre concept specification has been based upon the following parameters:

- 15MW Peak
- N + 1 redundancy
- 6 x 3MWth units
- 80°C/60°C flow and return temperatures
- Indirect ammonia air-source (with glycol intermediate loop, for improved safety)
- Seasonal Coefficient of Performance of 2.7 for the heat pump system
- 3 x 150m$^3$ thermal stores

An indicative oblique layout of major equipment is illustrated below at the preferred site location, noting that no confirmation of the availability of this land has been sought.




The refined scheme would be predicated upon around 125 connections with a combined annual demand of 34.5 GWh with the segmented peak demand profile as set out below.

## Outline Business Case

**Assumptions:**

- The project focus is on a low carbon heat network infrastructure;
- Due to the SSE assessment of the technical challenges associated with thermal extraction from the EfW facility the optimal technical solution would be an electrified air source heat pump solution which could be enduring or become a back-up / top up if Hay Hall EfW is developed;
- The project only considers hot water and space heating requirements in the TEED area;
- The project only considers TEED area north of the railway (physical/stakeholder barrier) and assume that the southern area will be fed from another heat network;
- There is sufficient demand headroom at the Sparkbrook and Boughton Road 132/11kV subs for the electrified heat – however, we could assume some local 11kV upgrade works/costs;
- Key decarbonisation years are 2021, 2028, 2040 and 2050;
- In progressing with electrified heat network infrastructure there are other decarbonisation options which will not be pursued within the discovery phase including:
    - Electricity through solar or wind;
    - Liquid fuels through EV charging or production of low carbon fuels.

| Component | Value |
|---|---|
| Infrastructure Costs | |
| Development phase devex £m | 4 |
| Devex grant £m | 1.6 |
| Heat network capex £m | 7.5 |
| Energy centre capex £m | 16 |
| Energy supply and demand | |
| Heat demand MWhth p.a | 34,500 |
| Energy costs | |
| Time weighted (real) electrical energy cost £/MWhe | 210 |
| Effective heat sale price £/MWhth (excluding connections charges) | 116 |
| Revenues | |
| Use of heat network charge £m p.a | 3.80 |
| Connection capex recovery £m/connection (125 connections) | 0.0315 |
| Heat supply £m p.a | 3.72 |
| NPV £m | 6.72 |
| IRR % | 9.00% |

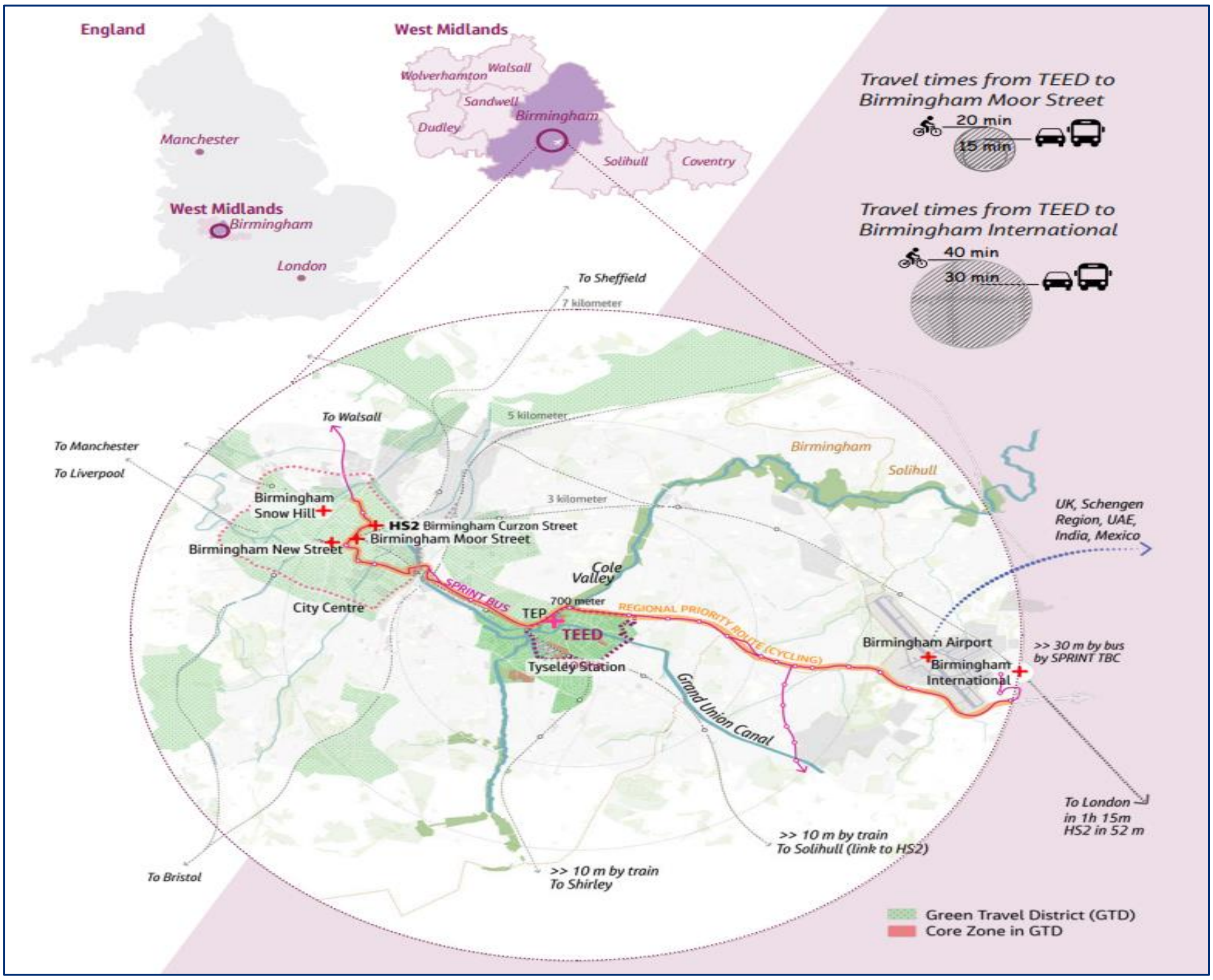
# 1. Introduction

## 1.1. PROJECT BACKGROUND

Tyseley Environmental Enterprise District (TEED) is located 2.5km south-east of Birmingham City Centre, between the A45 Coventry Road and the A41 Warwick Road  it covers an area of over 100 Ha. The area has been designated as the City's Environmental Enterprise District in the Birmingham Development Plan adopted in 2017 which defines the area as "*an economic zone for low carbon economy in Birmingham, encouraging recycling, energy production and renewables including manufacturing and supply chain development*". The TEED Vision Report 2022 sets out the ambition to leverage the existing assets and initiatives within the area including green and blue infrastructure, established transport routes, 230 local businesses and the low and zero carbon businesses and energy systems within Tyseley Energy Park and connections with the University of Birmingham. This vision reflects Birmingham City Council's commitment to net zero carbon.

A Local Development Order was adopted in 2017 in order to encourage development by reducing costs and providing certainty for developers and businesses through a simplified planning process. It is anticipated that the zone will ultimately provide over 100,000 square metres of new floorspace and over 1,500 jobs.

**Figure 1 TEED Geographical Context (Joint Vision for TEED, 2022)**

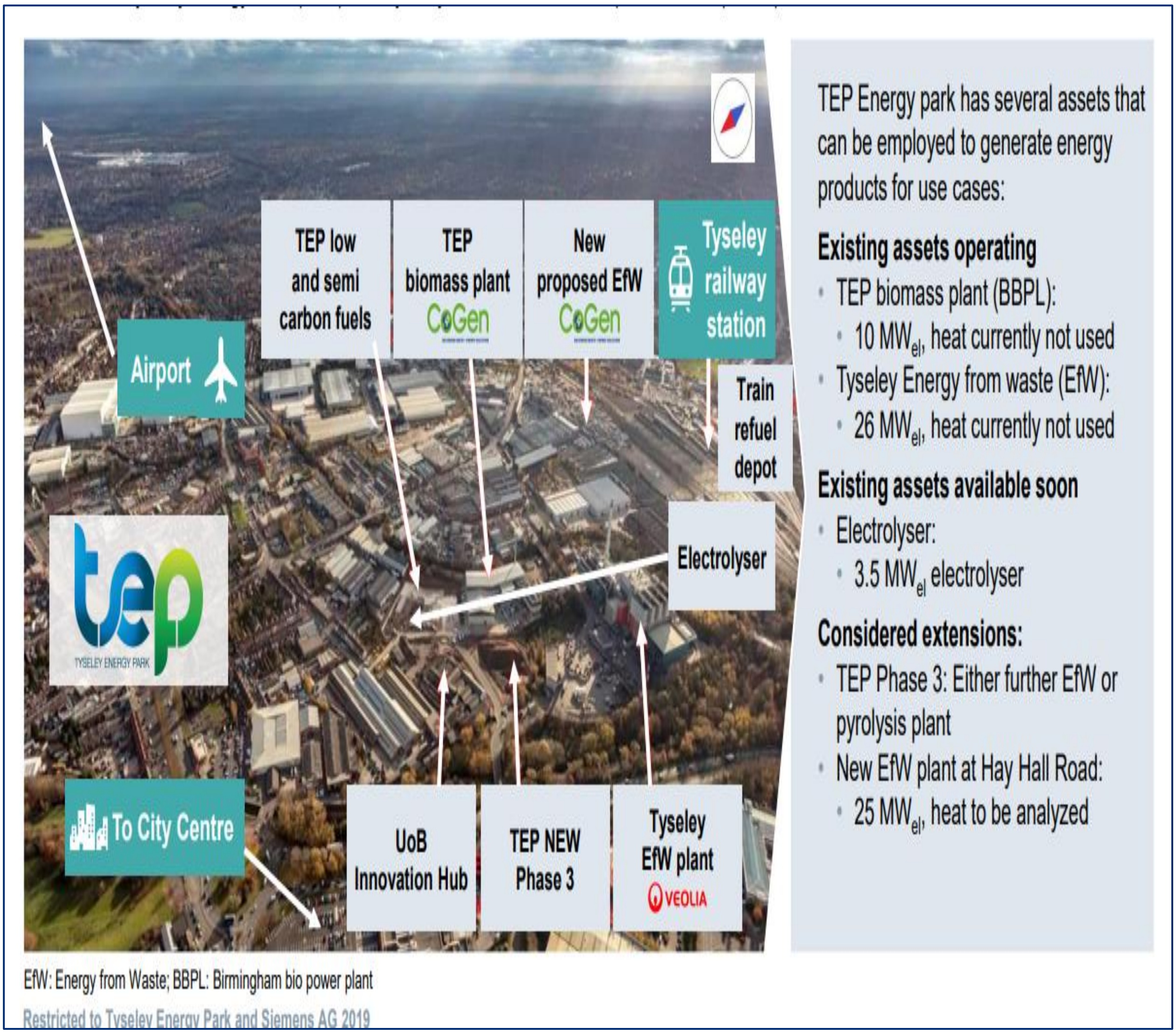


Tyseley Energy Park sits within the TEED area, it has various assets including:

- TEP 10MW Biomass Plant
- Tyseley 26MW Energy from Waste Plant (operated by Veolia)
- Low & Zero Carbon Refuelling Station – offering electric charging, hydrogen, Green D+ and gasoil

Further investment is planned in future including a potential replacement of the Veolia Tyseley Energy from Waste (EfW) plant, a 3.5MW electrolyser, a prospective new EfW or a pyrolysis plant and a further 25MW EfW at the Hay Hall site.

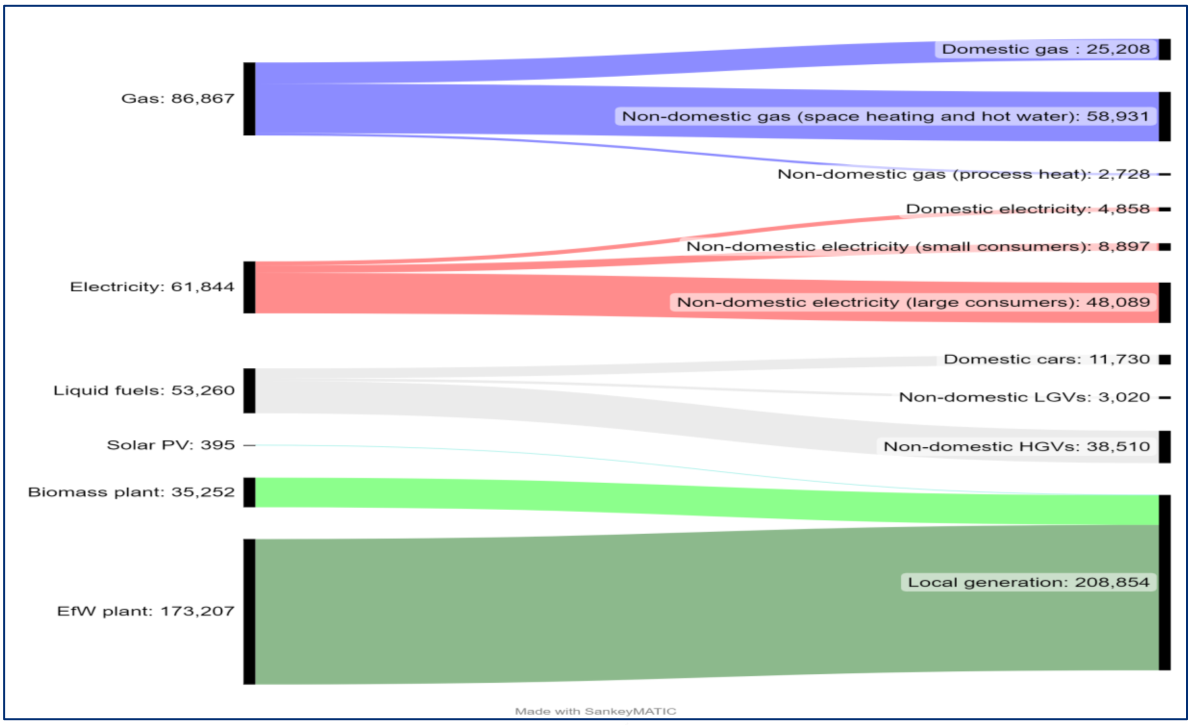
**Figure 2 Overview of Tyseley Energy Park**



## 1.2. CARBON BASECASE

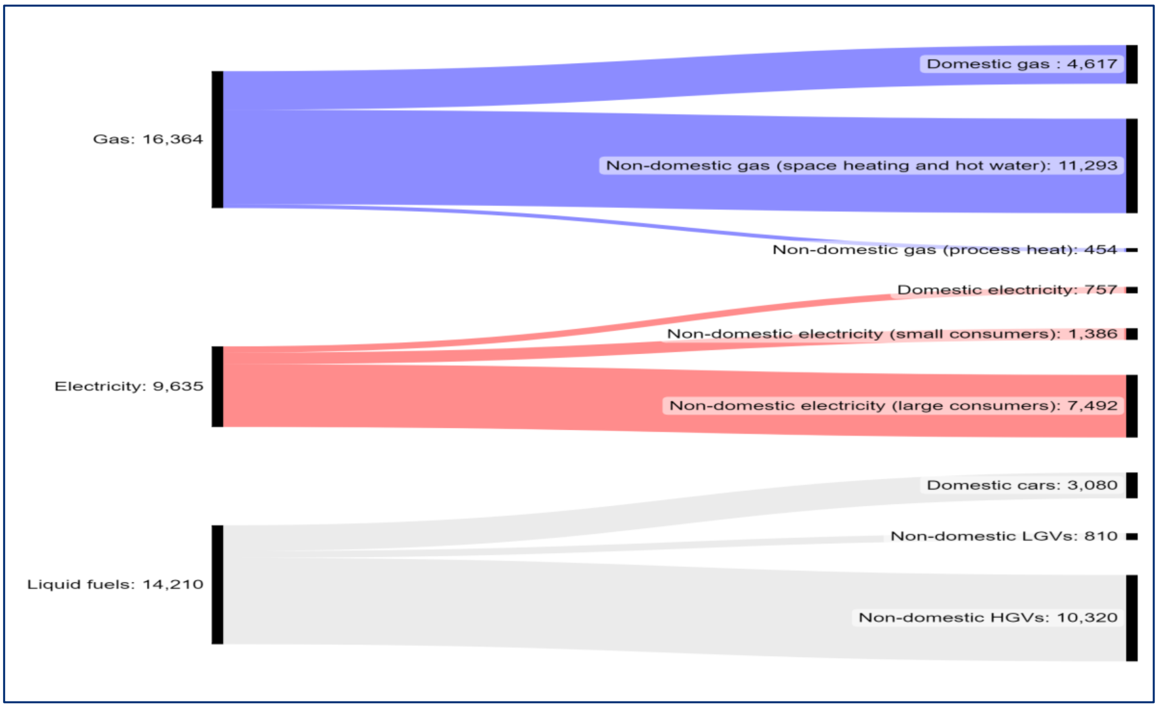
The following Sankey diagram has been created by University of Birmingham to baseline the energy production and consumption in MWh within the TEED area using 2021 data.

**Figure 3 TEED Energy Production & Consumption, University of Birmingham, 2021**




The corresponding carbon emissions associated with consumption of energy in the TEED area are shown in the Sankey diagram below in tCO2e and are derived from BEIS carbon intensity factors for the year 2021. The carbon emissions from the Veolia EfW are deemed to be out of scope of the project.

**Figure 4 TEED Carbon Emissions, BEIS 2021**



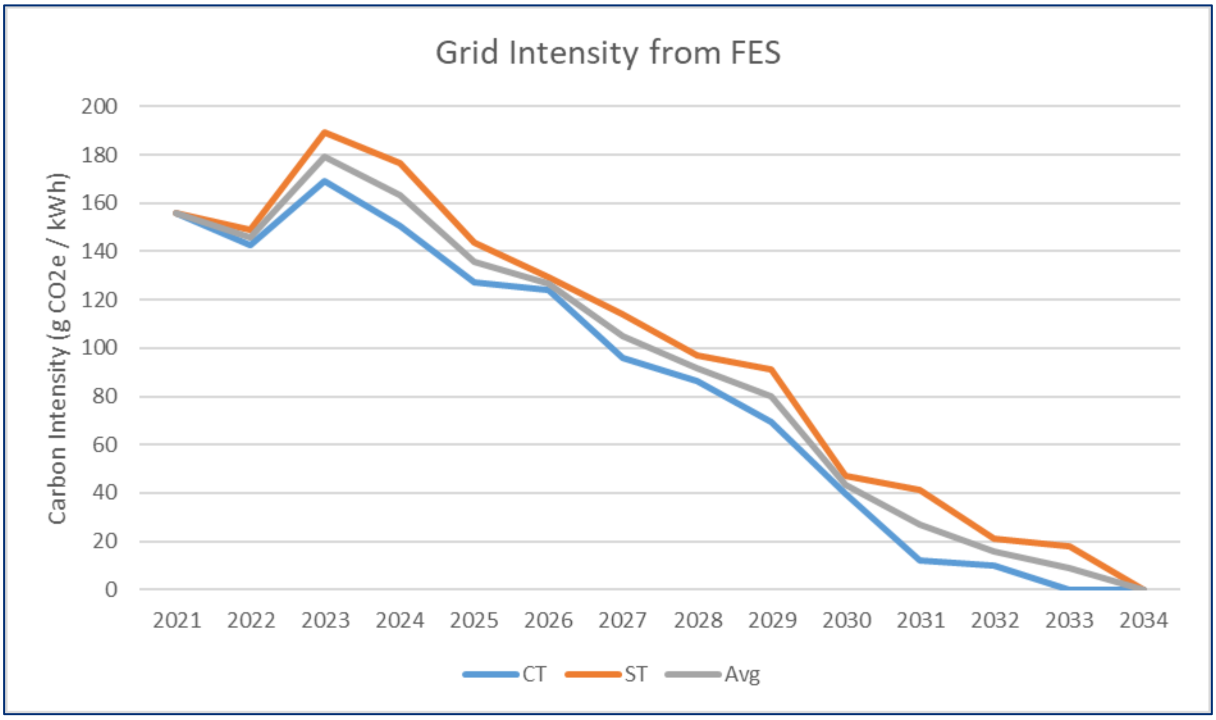
The possible decarbonisation pathways are focussed on natural gas, electricity and liquid fuels.

Natural Gas

SSE believes that the greatest decarbonisation opportunity is through a transition away from natural gas as a fuel for space heating and hot water in domestic and non-domestic buildings in the TEED area. SSE has applied techno-economic judgement in narrowing the focus of the decarbonisation to the non-domestic buildings north of the railway line using an electrified energy centre feeding a heat network. SSE's experience suggests that major rail lines represent a significant physical constraint to services crossings and in particular with respect to heat pipes. SSE further believes that the domestic heat decarbonisation can most effectively be achieved through the deployment of de-centralised heat pumps at each dwelling.

From the 16,364 tCO2e from natural gas in the Sankey diagram above, SSE is aiming to address 7,786 tCO2e (in 2021) associated with the non-domestic gas consumption (for space heat and hot water) north of the rail line. The basic premise for decarbonisation is the transition from gas to electricity as the primary fuel source in the knowledge that electricity is due to be fully decarbonised the 2024 in accordance with the graph below which has been assumed within the TEED project.

**Figure 5 Future Energy Scenarios, Grid Carbon Intensity**




SSE see that it may also be possible to accelerate the heat decarbonisation by connecting to the Biopower private network and consuming the majority of the electricity from the Biopower plant which is considered to have a carbon intensity close to zero. This electricity connection has been included as a variant and it may also have economic advantages based on lower electricity rates.

Electricity

SSE does not believe that there is a significant practical, techno-economic case for reducing the carbon emissions from the consumption of electricity within the TEED area.

The possible approaches could be to extend the existing private wire network into the wider TEED industrialised areas and take power directly from the Biopower plant. However, in SSE experience this electrical system reconfiguration comes with a multitude of infrastructure challenges / constraints and is very unlikely to be successful in a retrofit environment such as TEED. So SSE is recommending that the existing EfW and Biopower generation continues to be exported to the NG-ED system and then re-imported to consumers. This represents the most resilient and cost effective arrangement for consumers.

Another approach could be to connect solar or wind generation within the TEED area. However, this would be likely very small scale due to the existing use of land and there is already an excess of electricity generation on the site. So SSE believes that the decarbonisation of electricity consumption in the TEED area best comes from the reducing carbon intensity of the grid system and as indicated in the graph above.

Liquid fuels

This is the third energy vector associated with significant carbon emissions in the TEED area in 2021. SSE believes that this emissions category will reduce within the TEED area without any direct intervention due to the transition from fossil fuels to HVO, electricity and hydrogen which is already underway. If it is assumed that electricity and hydrogen dominate the transport sector in the coming years then the carbon emissions will in theory approach zero in 2035 – but subject of course to the volume of legacy fossil fuelled vehicle still being used.

There is an opportunity for the TEED area to support this transport fuel transition and decarbonisation through the deployment of further EV charging, hydrogen production or further decarbonised liquid fuel production on site. The existing private network in the TEP area is ideally positioned to facilitate this opportunity. SSE suggests that EV charging for HGVs may be the most promising pathway to pursue.

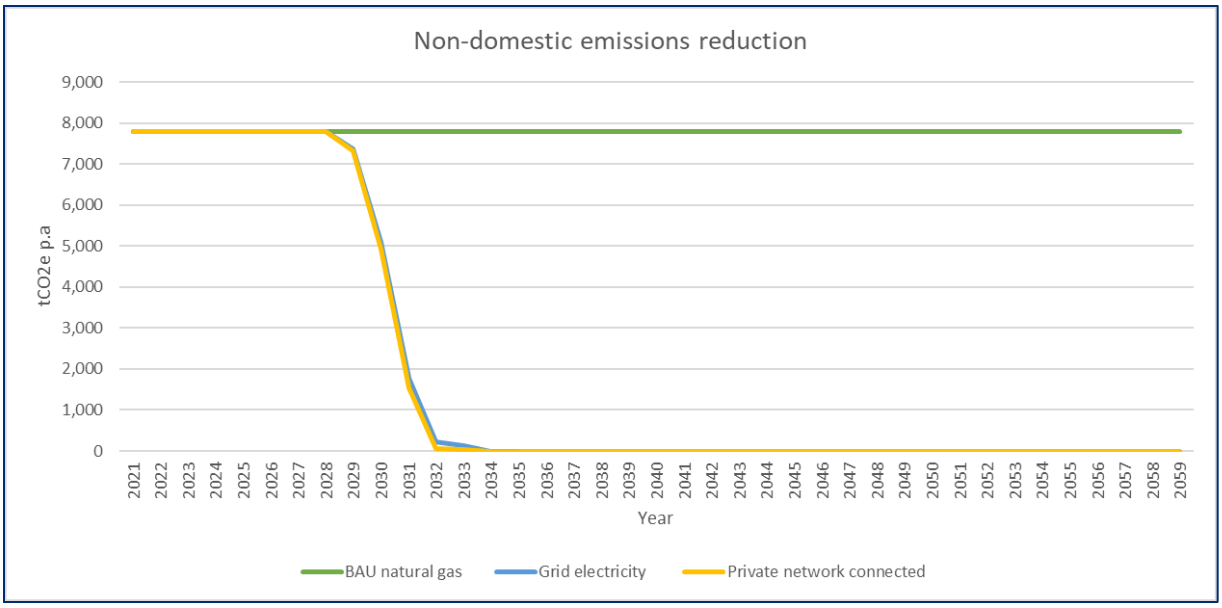
Summary

SSE believes that decarbonisation of TEED area consumption will happen through the electrification of the energy vectors.

The decarbonisation of heat can be achieved through the transition from natural gas to electricity as a fuel source. Domestic decarbonisation will likely be most effectively achieved through the deployment of de-centralised heat pumps at each dwelling. This report focuses on the development of an electrified heat network for non-domestic customers in the area.

The following graph forecasts the reduction in the carbon emissions associated with the non-domestic consumption from the 2021 baseline of 7,786 $tCO_2e$ p.a for both the grid electricity fuelled heat network scheme and the variant connected to the private network.

**Figure 6 TEED Non-domestic Emissions Reduction against 2021 Baseline**




## 1.3. OFGEM STRATEGIC INNOVATION FUND ROUND 2

A Strategic Innovation Fund (SIF) bid was led by NGED with a consortia comprising **Tyseley Energy Park**, **University of Birmingham** (whose Birmingham Energy Innovation Centre is located at the Tyseley Energy Park), **Birmingham City Council**, NGESO, Equans Pinnacle Power and SSE.

The proposed project involved use of the digital twin being developed by the University of Birmingham to understand how by creating a smart local energy system there could be efficiencies in DNO network design and carbon and social benefits for the local community.

SSE ES was invited to join the consortium to develop high level design and optioneering for a mixed vector energy system (heat, power, hydrogen) with integrated energy storage across TEED.

The SIF fund is awarded by Ofgem and administered by Innovate UK; there are 3 funding stages incorporated in the award.

- Discovery Phase (3 months duration), max award £150k
- Alpha Phase (6 months duration), max £500k
- Beta Phase (years), unlimited.

Successful applicants from the Discovery Phase will be invited to apply for the Alpha Phase.

### 1.3.1. SSE ES Scope

The SSE project scope includes consideration of the opportunities around heat (district heating network) and microgrid incorporating private wire and EV charging opportunities. The defined scope included a number of research questions which serve as a structure for devising the high-level masterplan response:

- How much capacity would there be for a heat network?
- How much would be microgrid with individual heat pumps?
- Availability of local power generation?
- Grid reinforcement saving?
- Scale of microgrid?
- Challenge of micro grid around connections and supply?

➢ Should add electrical storage and options around solar generation?

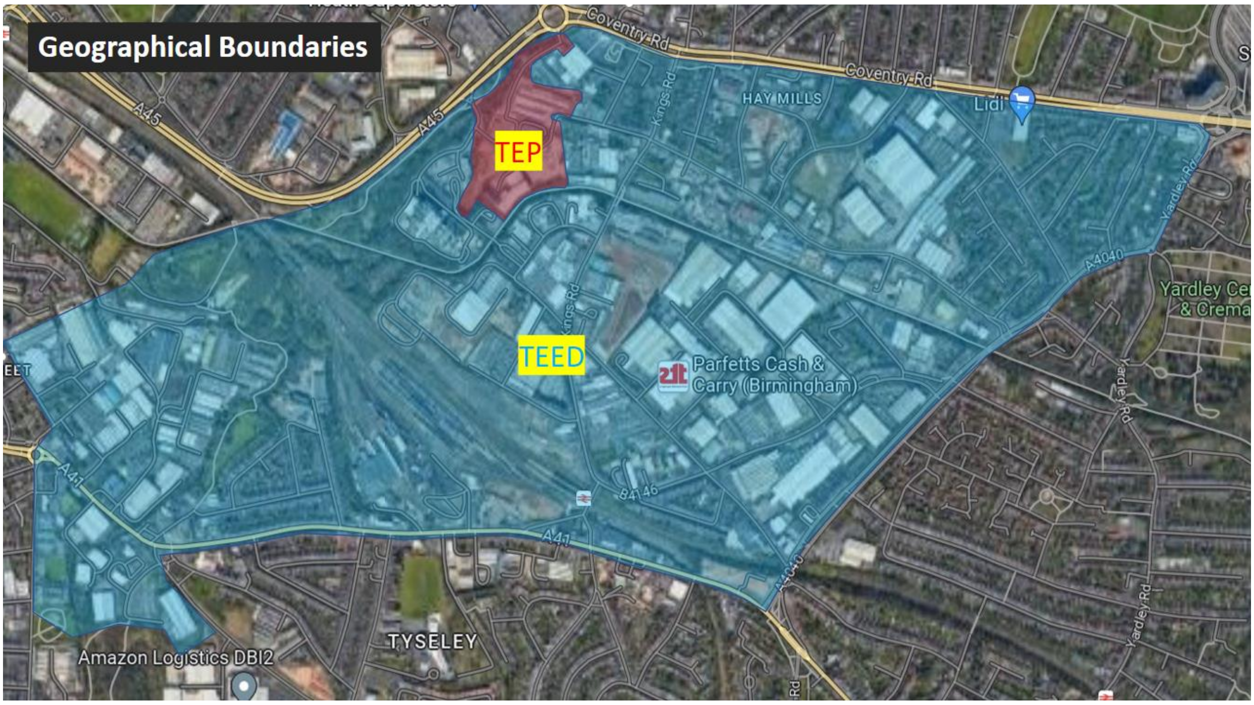
### 1.3.2. Data Availability

As the project has evolved there have been constraints around access to relevant data from WPs 1-3, SSE has undertaken a high level overview based on a number of assumptions in order to progress with high level master-plan analysis.

# 2. MASTERPLAN DEVELOPMENT

Following collaboration amongst the project team, it was agreed that the boundary for the TEED SIF project would be as outlined in figure 3 below in order to include potential additional nodes and customers for the energy vectors that were to be investigated.

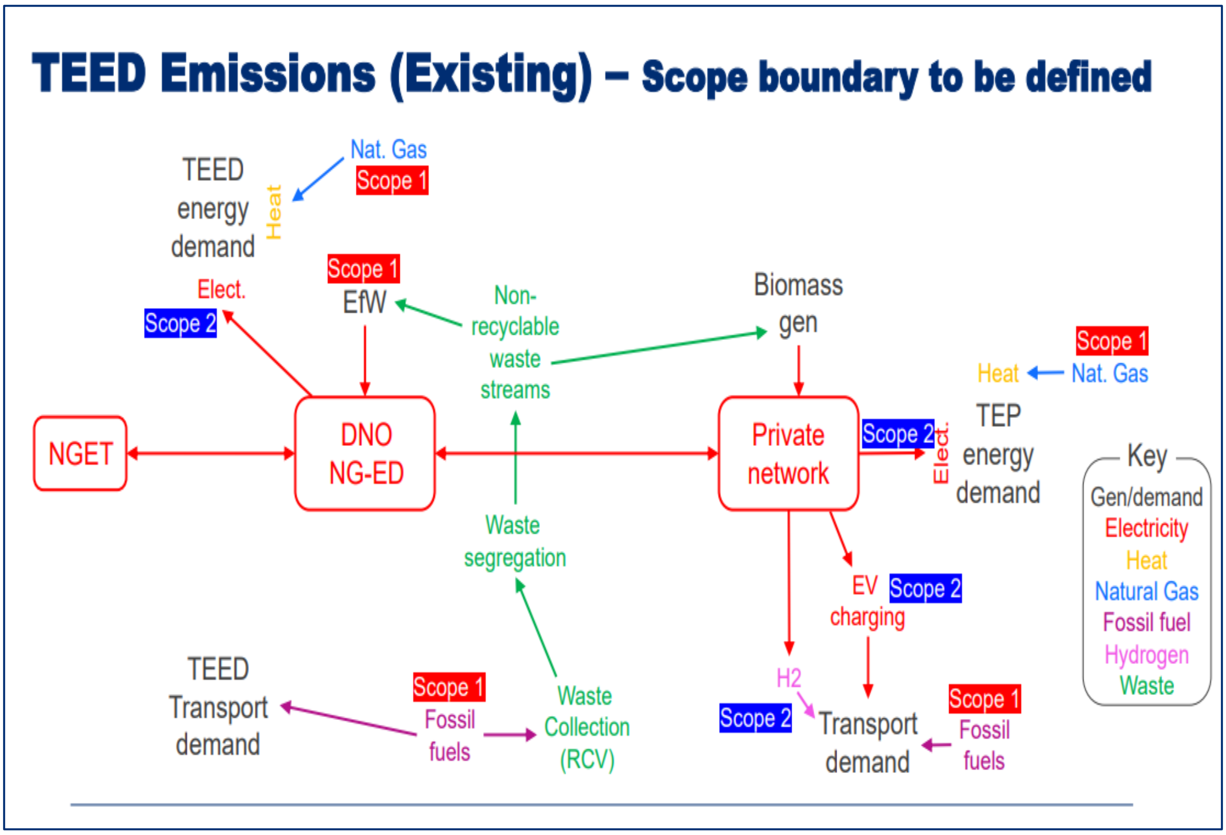
**Figure 7 TEED SIF Boundary**



## 2.1. Baseline Position

The baseline position includes a number of existing energy systems and corresponding emissions scopes as summarised in figure 4. This includes electricity generation from the EfW and Biomass plants into the grid, the transfer and usage of waste streams to service these plants and the energy demand from both the TEED and TEP areas in terms of domestic and business energy usage. The biomass plant electricity serves a private network to feed the Webster & Horsfall manufacturing facility. Heat from the EfW and Biomass is currently not captured and hence this demand is met through natural gas with corresponding impact on scope 1 emissions.

**Figure 8 TEED Energy Systems and Emissions Scopes**



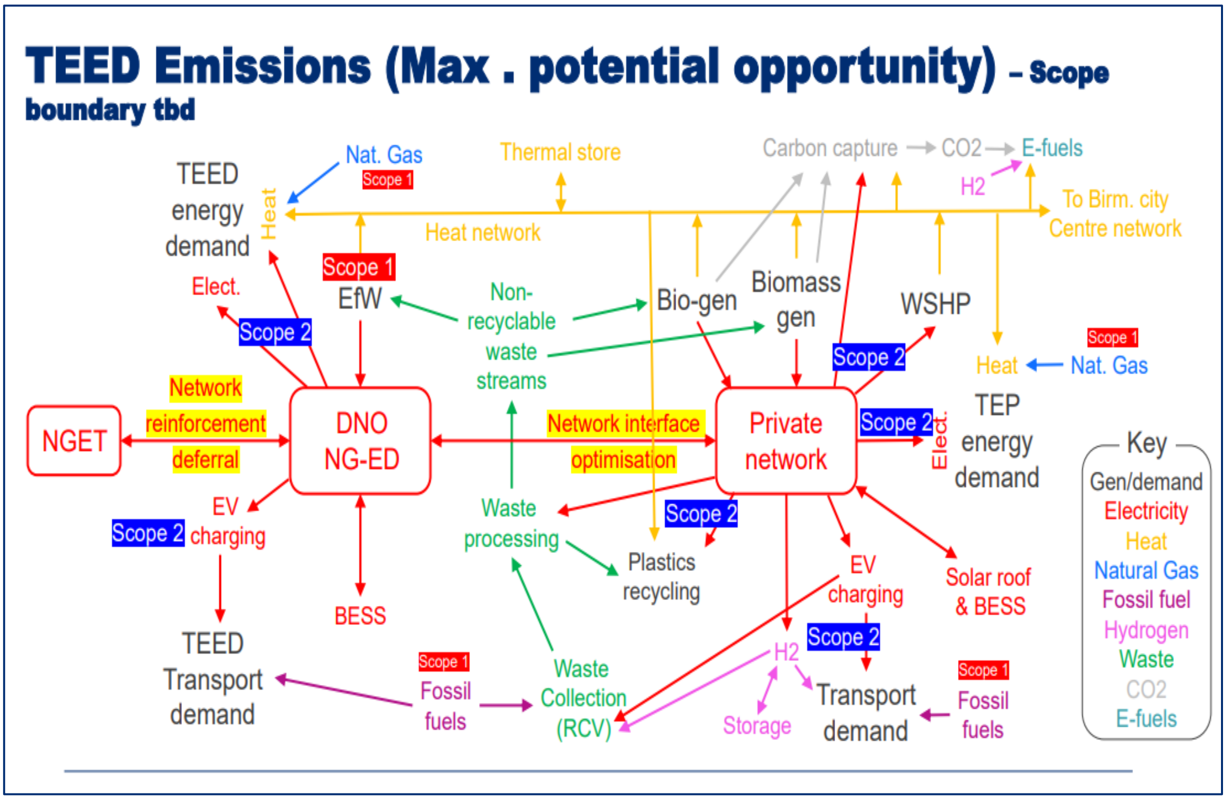

### 2.1.1. Opportunity Scoping

High level analysis of the potential opportunities around extant infrastructure and future infrastructure investment could include:

- Capturing the heat from existing and future assets;
- Creation of a heat network covering the TEED area, meeting thermal demand for domestic, business and industrial user groups;
- Linkage of the heat network with the existing Birmingham City centre network;
- Additional Bio generation plant utilising city waste streams generating additional electricity and heat;
- Potential for deployment of Water Source Heat Pumps utilising canal generating heat for the network;
- Potential for deployment of solar PV (roof and ground mounted subject to suitable sites);
- Potential for deployment of Battery Energy Storage Systems (in parallel with PV arrays, EfW & other generation;
- Potential for deployment of electrical vehicle charging hubs;

- Potential for deployment of carbon capture and E-fuels processing;
- Deferral of required network reinforcement
- Network Interface Optimisation

**Figure 9 TEED Opportunities & Emissions Scopes**

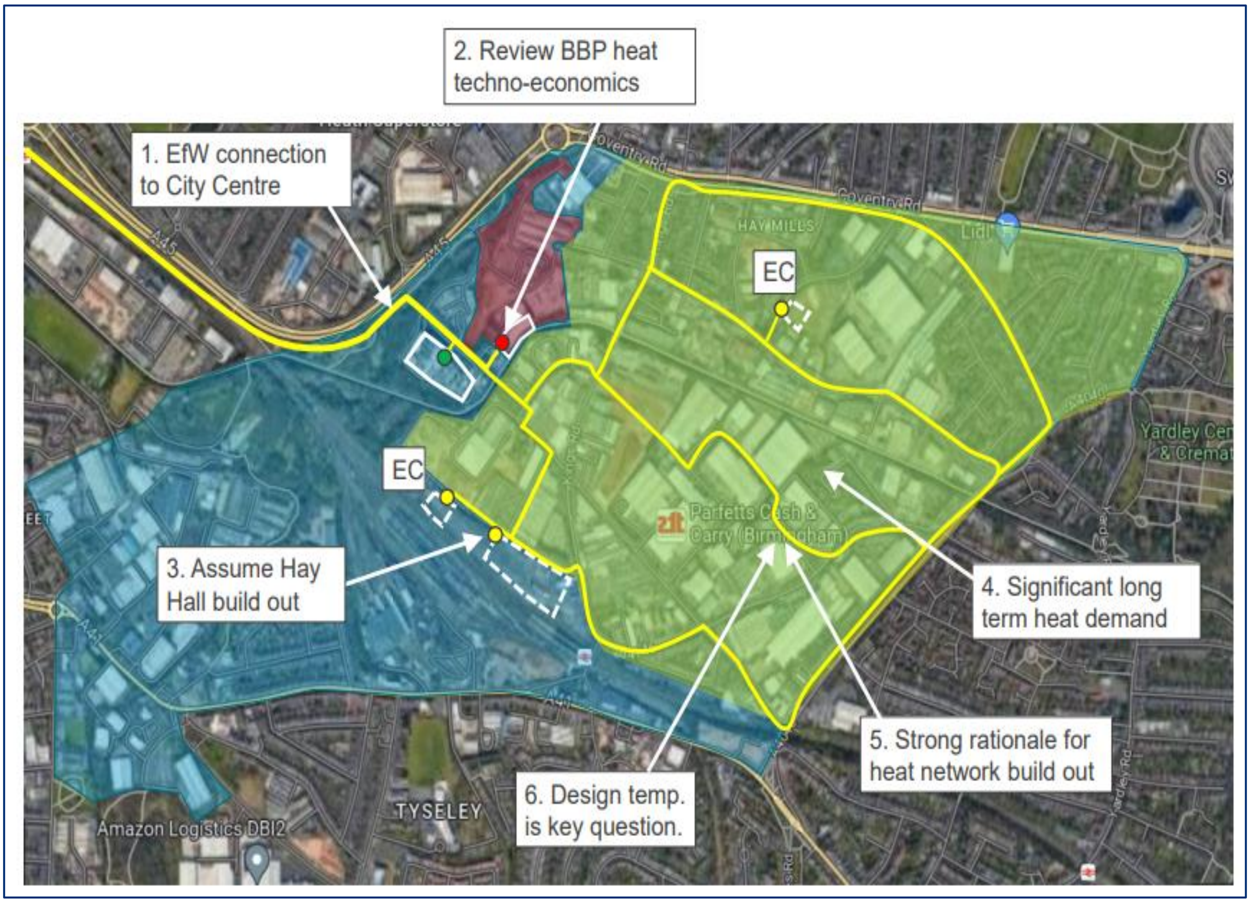



## 2.2. Proposed Masterplan Framework

Review of the existing and proposed future infrastructure, potential vectors and customer base led to development of a masterplan framework including the following proposals and assumptions:

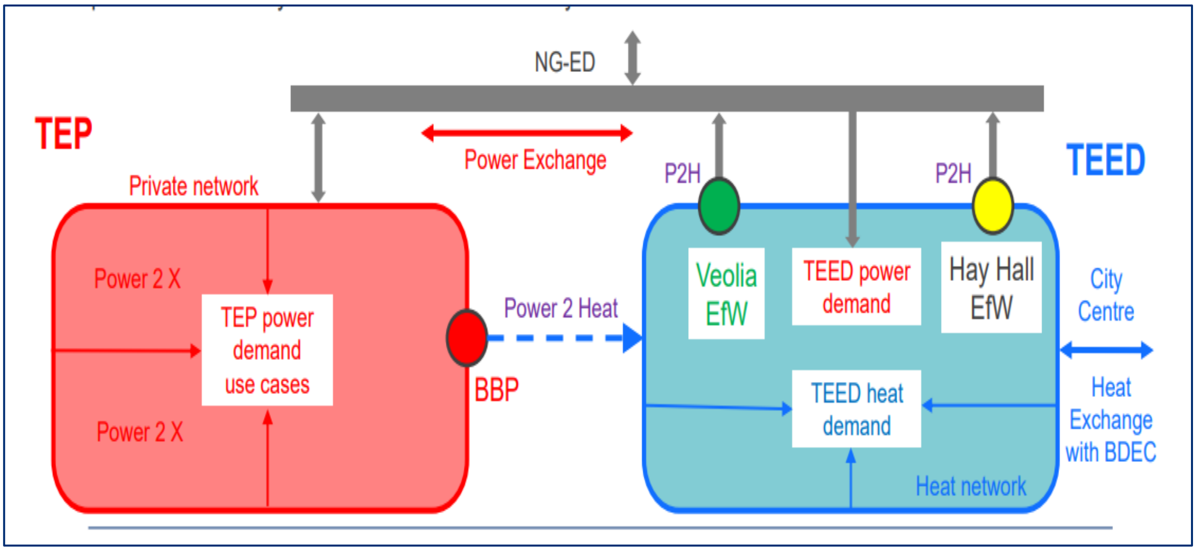
- Connect the Veolia EfW to City Centre Heat network to provide local anchor production with suitable back up, this would provide a suitable basis for the TEED heat network;
- Review of the techno-economics of the BBP plant as a source of resilient heat;
- Assume that Hay Hall EfW will replace / operate in parallel with the Veolia EfW plant providing consistent heat capacity over time;
- Assume proposed heat network confined to area north of rail-line (yellow area in figure 6 below), assumed technical difficulties and restrictive costs involved in crossing the rail-line;
- Assume significant heat demand across the TEED area for a 40-50 year period;
- Assume a design temperature for the proposed network flow ~100oC, return ~60oC

**Figure 10 Proposed Masterplan Framework**



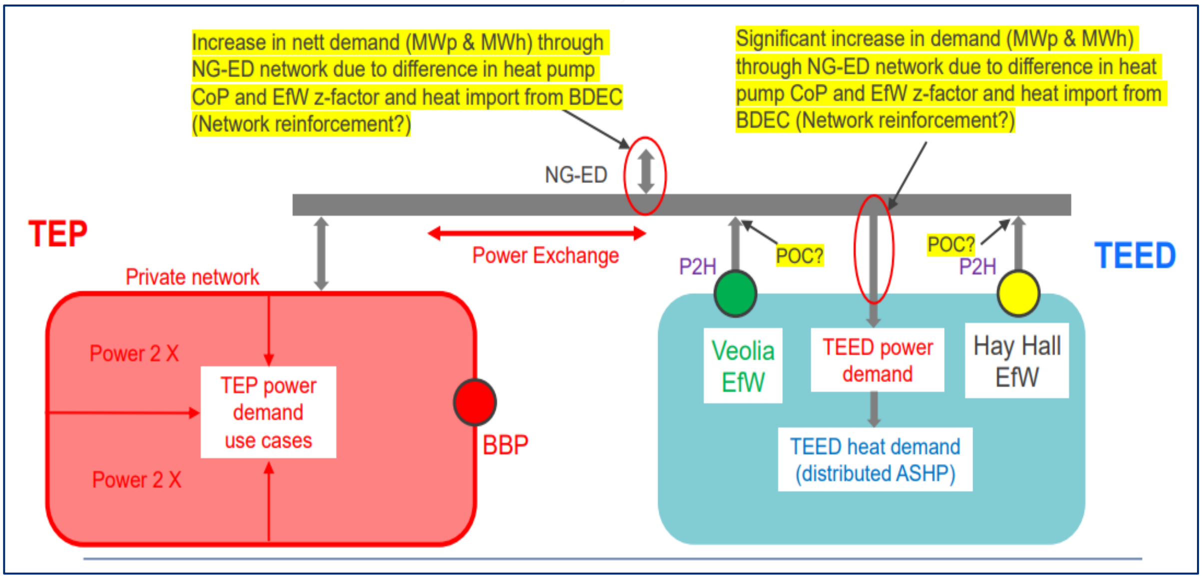

In terms of further characterising the geography in terms of its respective energy infrastructure assets and in answering the research questions focused on the capacity for a heat network and the potential for electrification / microgrid for heat pumps outlined above a view has been formed around the base case and the counterfactual electrification scenario. The base case characterises TEP as primarily an electrification zone based on the benefits of the existing private wire infrastructure, the NGED grid connection and the assumption that the Birmingham Bio-power facility will have poor heat techno-economics. The wider TEED area can be understood as a heat zone with the existing and proposed EfW plants (existing Veolia plant and proposed Hay Hall plant) and the resilience from connection with the City centre network providing the capacity and a good techno-economic case for heat.

**Figure 11 Base Case**




The counterfactual position involves electrified heat utilising distributed Air Source Heat Pumps. In this scenario both TEP and TEED would be electrification zones based on the Biopower, private wire and the NGED. This would lead to an increase in net demand through the NGED network feeders due to the differentiation in the heat pumps Coefficient of Performance and the EfW z-factor and the heat import from BDEC. This could facilitate power to X conversion to carbon neutral fuels opportunities within TEP. The increase in electrical demand would also require investment in network reinforcement.

**Figure 12 Counterfactual - Electrification of Heat - Decentralised Air Source Heat Pumps**



# 3. DECARBONISING HEAT

## 3.1. Power & Heat Demand in TEED 'core zone'

As per the above framework assumptions, the focus on demand within the TEED core area is based on the following high level analysis.

**Table 2 Estimated Demand Profile TEED Core Area**

| Sector / Property Type | Units / GIFA (estimate) | Demand - Electrical p.a. per unit | Demand - Heat p.a. per unit |
|---|---|---|---|
| Residential | ~1,180 units | 3kWp - 3MWh | 8kWthp – 12 MWh |
| Industrial - Warehousing | 215,000m2 | 25kWp – 50 MWh (per 1000m unit) | 100kWp – 125MW (per 1000m unit) |
| Industrial - Factory | - | Assume average | Assume average |
| Retail - Supermarket x2 | - | Assume average | Assume average |
| School | 1,500m2 | Assume average | Assume average |

**Table 3 Estimated Sector Demand Levels**

| Sector Total Estimates | Demand - Electrical p.a. | Demand – Heat p.a. |
|---|---|---|
| Residential | 3.5MW – 3.5GWh | 9.6MW – 14.3GWh |
| Non-Domestic | 6.8MW – 15GWh | 24.6MW – 31.3GWh |
| Total | 10.3MW – 18.5GWh | 34.2MW – 45.6GWh |
| Diversity Factor for heat peak @75% | - | 25.7MW |

The derived level of heat demand is therefore assessed as proportionate to the forecast 25MWth offtake.

Figure 13 Power & Heat Demand within TEED core zone

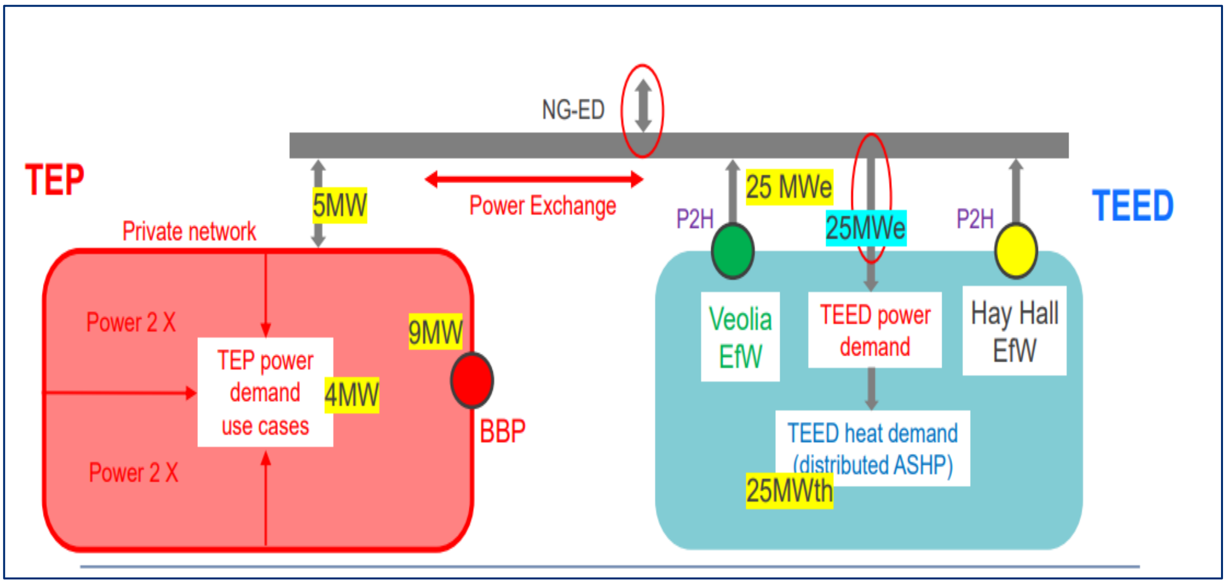

## 3.1.1. Heat Network Density

In the context of the aforementioned assumptions and derived demand a hypothetical district heating network configuration is outlined below. The network estimated length would be 11.6km within TEED with an additional route connection to the city centre scheme. On this basis a heat density of 2.2kWp/m would be required equating to 4MWh p.a./m.

**Figure 14 Heat Network Density**

Consideration of the requirements of the electrified distributed heat option against the base case position is illustrated below. A net increase of electricity from ~10MW to ~25MW is anticipated due to the additional peak capacity requirements of Air Source Heat Pumps (ASHP), assuming a CoP of 1.6. Under this scenario, within TEP there is no benefit in deployment of additional solar generation as this would not be economically justifiable unless there were additional private wire consumption.

**Figure 15 Electrified Heat Scenario**




## 3.2. Heat Network vs Distributed Electrified Heat (ASHP)

In the context of the high level analysis and assumptions outlined above, the heat network vs distributed electrification options can be summarised as below:

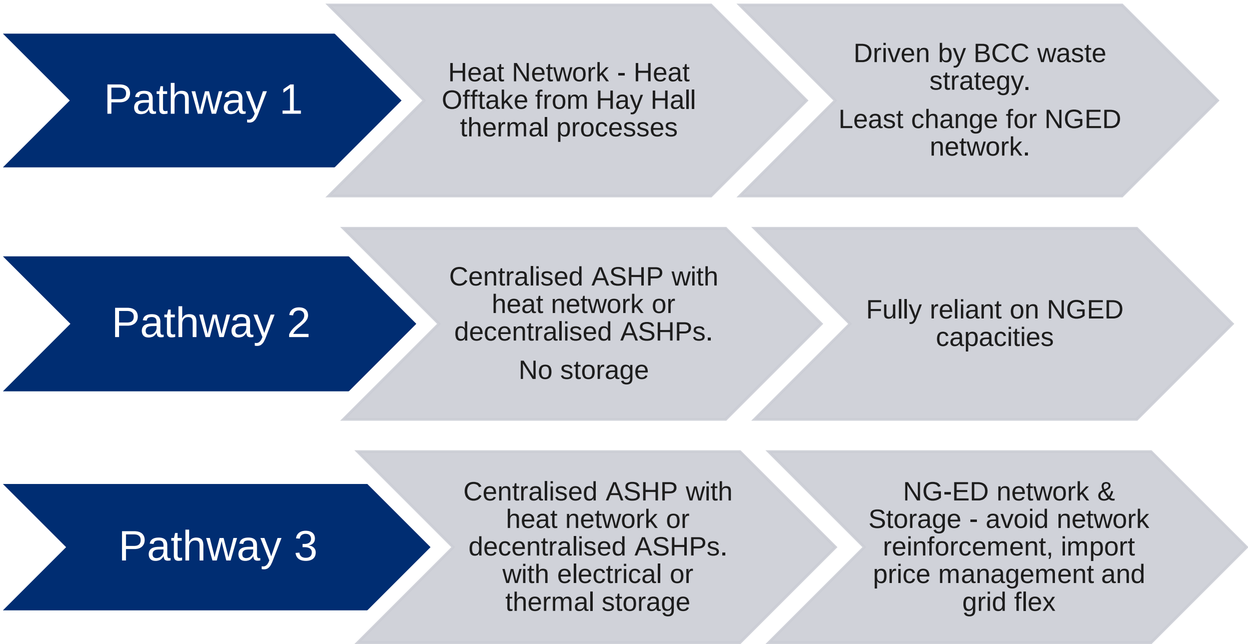
**Table 4 Heat Network vs Distributed Electrified Heat**

| Option | Capex Implication | Trade-off | Carbon Implication |
|---|---|---|---|
| 25MWth heat network (EfW heat offtake assume Z factor of 6) | High | Forego 4Mwe, create 25MWth (high utilisation) | Low carbon system – grid carbon intensity / 6 |
| Provide additional 15Mwe capacity (NGED network reinforcement), 25MWth at CoP 1.6 | Medium | Forego 12.5MWhe, create 25MWhth (low energy utilisation) | Medium carbon system – grid intensity / 2 |

Further detailed analysis of the financial, carbon and technical modelling is required to provide full comparison of the heat vs electrified heat options in terms of resilience, cost and carbon parallels.

## 3.3. Delivery Pathways

The foregoing sets out the case for decarbonisation of heat within the local geography as the key opportunity. The decarbonisation of the EfW facilities or BBP presents significant challenges at the current time. Decarbonisation of commuter traffic is viewed by Birmingham City Council as potentially detrimental to the existing Sprint bus service, however there is an opportunity around decarbonisation of other transport via the TEP private wire through power to X applications, e-fuels etc.
To achieve the decarbonisation of heat there are 3 identified pathways:




A comparison of Pathways 2 and 3 and further analysis could identify the opportunity for embedded electrical and thermal storage to avoid network reinforcement thresholds. This reinforcement may be at a NG-ED GSP entry point or lower in the HV/LV systems.

The existing NGED sub-stations in proximity to the TEED area are shown in the figure below.

**Figure 16 NGED Substations**


Hypothetical ASHP energy centres are illustrated in the following figure, it is envisaged that these would be ~12MWth 6MWe ASHP peak based on a CoP of 2.

**Figure 17 Proposed Heat Energy Centre Locations**


High level review of typical electrical demand patterns and duration curves for mixed heat demand fed via ASHP without storage and including storage is illustrated in the following figures for comparison.

Figure 18 Electrical demand and duration curve per energy centre (no storage)

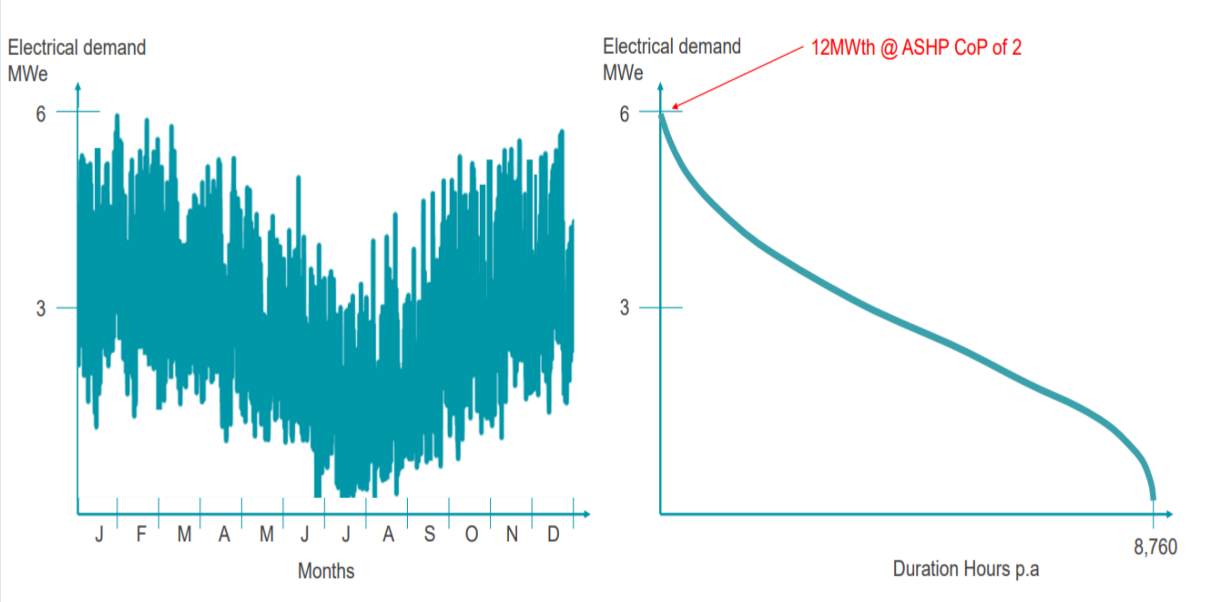
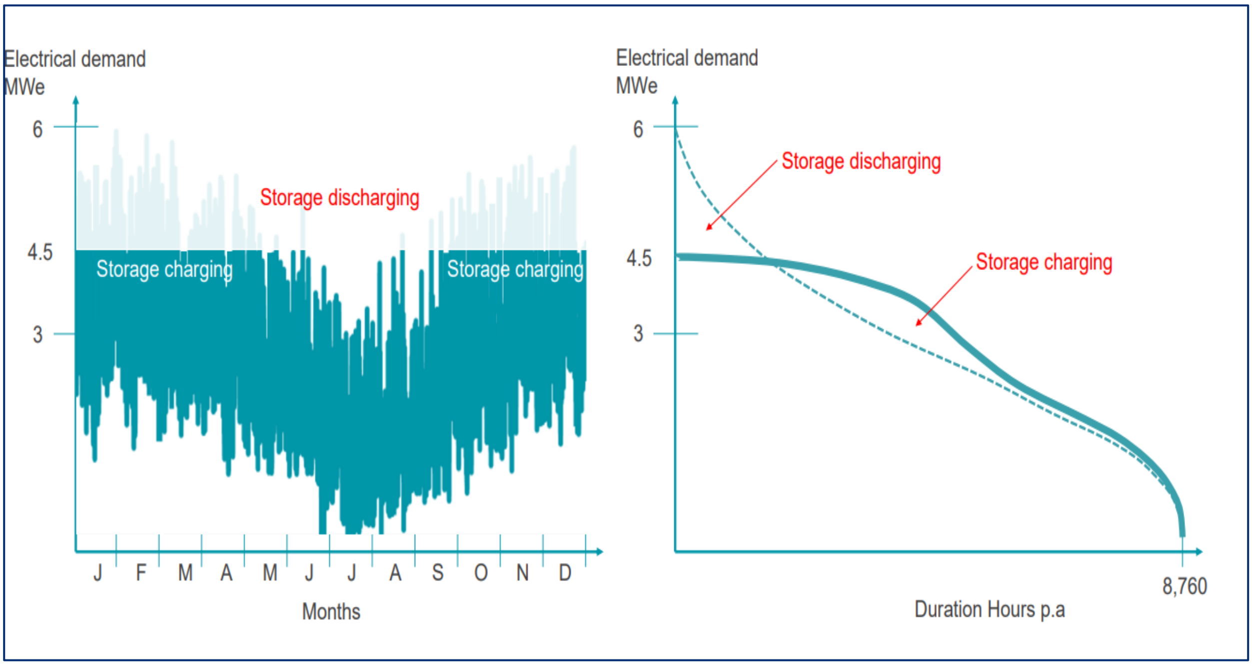



Figure 19 Electrical Demand and duration curve per energy centre with storage




This shows the impact of storage in terms of responsiveness to electrical shape shifting and flattening out the duration curve. This is based on an assumption of 3MWe (6MWth) storage capacity per energy centre.

In order to assess the impact of reinforcement and therefore the value of utilising storage, it is proposed that a request is made to NGED for budget offers including contestable, non-contestable, network reinforcement and indicative timescales for both scenarioson the basis of:

- Non storage Energy Centres scenario:
    - Three 11kV points of connection for ASHP ECs for up to 7.5 MVA import each – but limited to 15 MVA total import across the 3 connections;

- With electricity demand curves as per figure above

- Storage ECs scenario:
  - Three 11kV points of connection for ASHP ECs for up to 5.6 MVA import each – but limited to 11.2 MVA total import across the 3 connections;
  - With electricity demand curves as per figure above;
  - Battery electrical storage system = 3MWe / 6MWh per EC.

# 4. BASIS OF DESIGN DEVELOPMENT

## 4.1. Design Development

In progressing from the high level master-planning, demand analysis and pathway routes set out in section 3 a number of key assumptions were made in order to develop the design to a suitable level which could be assessed in an outline business case:

**Assumptions:**

- The project focus is on a low carbon heat network infrastructure;
- Due to the SSE assessment of the technical challenges associated with thermal extraction from the EfW facility the optimal technical solution would be an electrified air source heat pump solution which could be enduring or become a back up / top up if Hay Hall EfW is developed;
- The project only considers hot water and space heating requirements in the TEED area;
- The project only considers TEED area north of the railway (physical/stakeholder barrier) and assume that the southern area will be fed from another heat network;
- There is sufficient demand headroom at the Sparkbrook and Boughton Road 132/11kV subs for the electrified heat – however, we could assume some local 11kV upgrade works/costs;
- Key decarbonisation years are 2021, 2028, 2040 and 2050;
- In progressing with electrified heat network infrastructure there are other decarbonisation options which will not be pursued within the discovery phase including:
    - Electricity through solar or wind;
    - Liquid fuels through EV charging or production of low carbon fuels.

In devising and refining our basis of design response there were a number of key questions which shaped our approach:

- Is the demand in the north TEED area sufficiently dense for a full coverage network OR are there some physical constraints?
- Should we design the heat security of supply / asset redundancy for north TEED as an island or assume interconnection to other networks?
- Shall we assume that domestic and non-domestic demands are fed from the same network?
- Do we have the ability to map the heat demand based on the recent data assumptions made?
- Do we have the ability to create a heat network design?
- Do we have the ability to design the electrified heat production assets?
- Do we have the ability to create a carbo-techno-economic model?

## 4.2. Updated Demand Assessment

The basis of design was further refined through further analysis of additional demand level data and benchmarks.

### 4.2.1. Domestic Demand Assessment

The calculation of baseline year gas consumption was split into domestic and non-domestic sectors. For the domestic sector, annual postcode level gas consumption statistics for the year 2021 were sourced from BEIS.

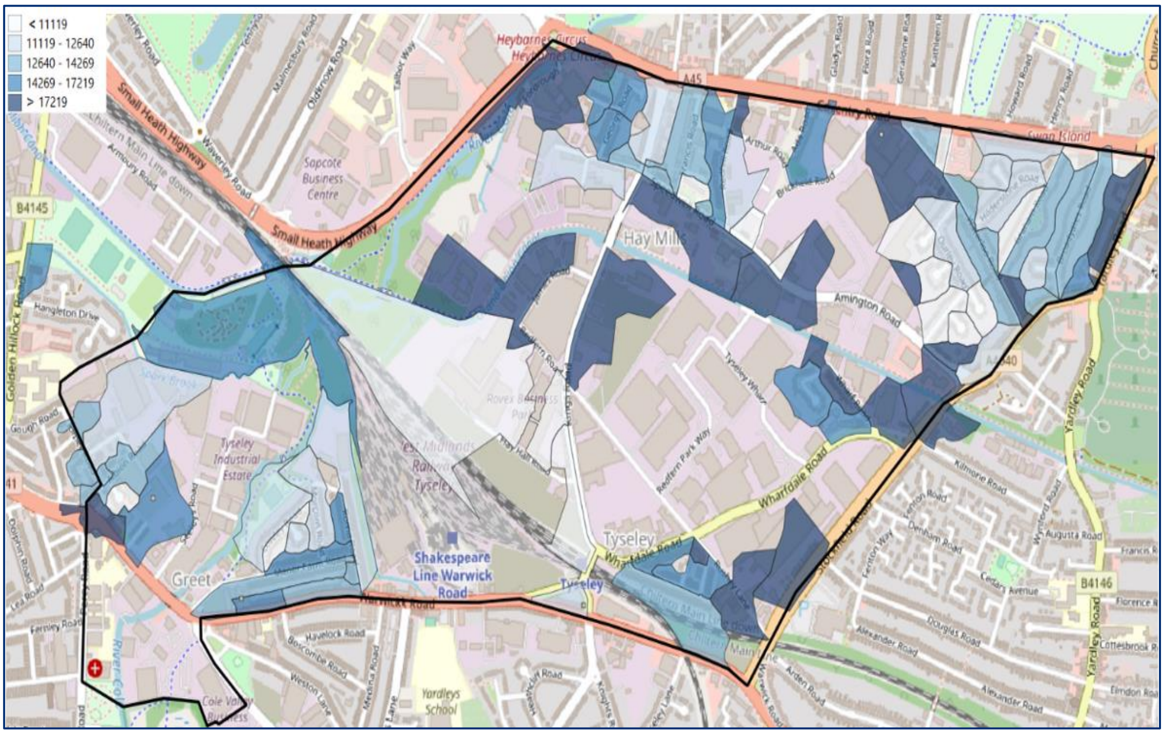
The dataset was then cut to the TEED area by comparing the project boundary with postcode polygons (OS Code-Point with Polygons ) to obtain a list of postcodes within TEED (a case-by-case judgement was made on whether to include postcodes which were partially inside or outside TEED, based on a visual inspection of where the majority of housing was in relation to the boundary).

There were found to be 127 postcodes in the TEED area, 78 of which appeared in the BEIS dataset. Across these 78 postcodes, the total number of domestic gas meters was calculated to be 1823 and these meters collectively consumed 25,208 MWh in 2021.

The average consumption per meter was 13,828 kWh which is slightly less than the average for Birmingham (14,464 kWh) but higher than that of England (12,979 kWh). A map of the mean consumption in kWh by postcode, broken into quintiles, is shown in figure 16.

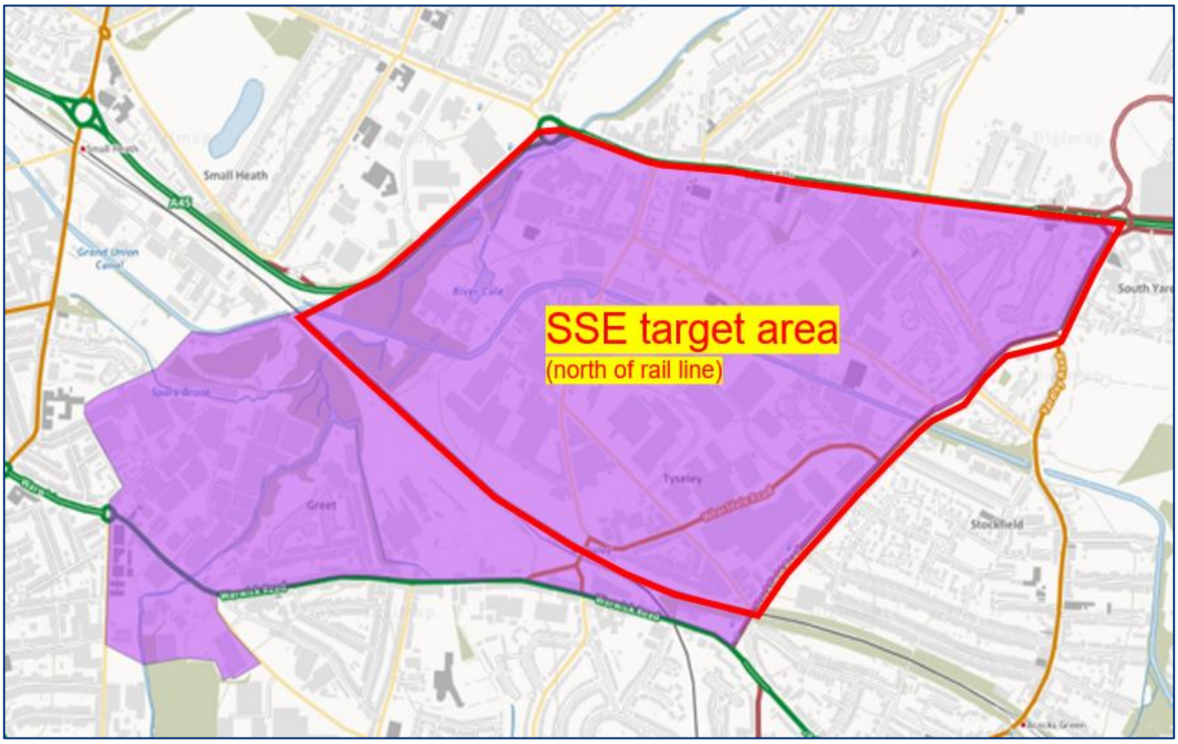
Applying a carbon intensity factor for natural gas of 0.18316 kg $CO_2e$ / kWh , means domestic gas consumption was responsible for 4,617 tonnes of $CO_2e$ emissions in 2021.

**Figure 20 Gas Mean Consumption by Postcode (kWh), BEIS, 2021**




Applying this data to the SSE target core area to the north of the railway line as outlined in figure 17 below resulted in an estimate of 1,328 domestic property meters.

Figure 21 SSE Project Target Core Area




The estimated breakdown of gas consumption and conversion to heat demand is summarised in table 4 below.

**Table 5 Updated Domestic Heat Demand SSE Target Core Area**

| Domestic Meters Estimate | Demand – Gas p.a. | Demand – Heat p.a. | Demand Heat per meter p.a. |
|---|---|---|---|
| Residential Meters 1,328 | 18.36GWh gcv | 14.9GWh | 10.22MWh[2] |
| Total (excl. cooking gas) | - | 13.57GWh | - |

## 4.2.2. Non Domestic Demand Assessment

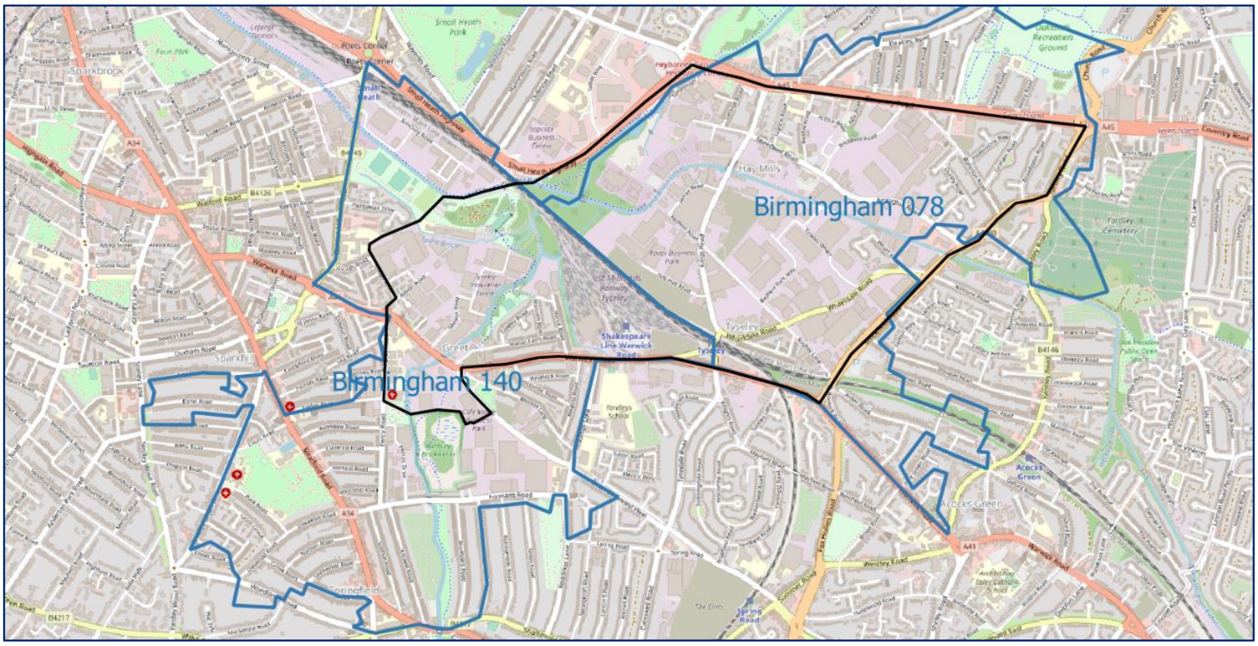
Due to there being less geographically granular data available from BEIS for non-domestic (ND) gas consumption, some approximations were derived. The lowest geography for which this information is available is at the MSOA (middle-layer super output area) level. There are two MSOAs which overlap with the TEED area, Birmingham 078 and Birmingham 140, which respectively in 2021 had 73 meters consuming 53,406 MWh and 84 meters consuming 29,191 MWh. The two MSOAs are shown against the TEED boundary in figure 18. To get a more nuanced estimate (rather than just adding the values for the two MSOAs together), using the WSP building footprint data, a building footprint area for non-domestic buildings was calculated for each MSOA and the intersection between each MSOA and TEED. The non-domestic gas consumption was then allocated to each intersecting area by the ratio of the footprint areas.

Following these steps, the ND gas consumption in the areas of overlap between TEED and Birmingham 078 and 140 respectively were estimated to be 48,393 MWh and 13,266 MWh. This leads to the total

[2] 14,900/1328 = 11.22MWh p.a heat per meter less ~1MWh per meter for cooking = 10.22MWh heat p.a. per meter

annual non-domestic gas consumption for the TEED area to be approximated at 61,659 MWh. Applying a 2021 carbon intensity factor for natural gas of 0.18316 kg CO2e / kWh, means ND gas consumption was responsible for 11,293 tonnes of CO2e emissions in 2021. Combining this with the derived value for the domestic sector results in total CO2e emissions for natural gas combustion within TEED being estimated at 15,910 tonnes.

**Figure 22 Non-domestic Meters - MSOAs, TEED Boundary**




Applying this data to the SSE target core area to the north of the railway line as outlined in figure 17 and applying a ratio of 95% of non-domestic meters falling within the MSOA 078 boundary resulted in an estimate of ~80 non-domestic property meters. The estimated breakdown of gas consumption and conversion to heat demand is summarised in table 4 below.

**Table 6 Updated Non-Domestic Heat Demand SSE Target Core Area**

| Non-Domestic Meters Estimate | Demand – Gas p.a. | Demand – Heat p.a. |
|---|---|---|
| Meters ~80 | 45.97GWh gcv | 37.3GWh |

### 4.2.3. Revised Heat Demand

Revised heat demand levels are provided in table 6 below, based on analysis of updated data sources and refinement of assumptions. The revised total peak is 33MWth and total energy of 50.85GWhth.

**Table 7 Revised Heat Demand / Distribution**

| Sector / Property Type | GIFA / Meters | Demand – Heat kWthp / MWth p.a | Total Heat peak MWth | Total Energy GWhth |
|---|---|---|---|---|
| Domestic | ~1,328 units/meters | 8 / 10.22 | 10.6 | 13.57 |
| Non-Domestic | 233,500m2 (Each 1,000m2) | 100 / 153 | 21.5 | 35.69 |
| Industrial – 1 Factory | 3,500m2 | 244.2 | 0.5 | 0.85 |
| Retail - Supermarket x2 | 4,000m2 (each) | 130.6 | 0.3 | 0.52 |
| School | 1,800m2 | 122.8 | 0.13 | 0.22 |

**Figure 23 Revised Heat Demand / Distribution**


## 4.2.4. Demand Segmentation

In further refining the project and developing its commercial feasibility based on the demand segments within the local geography there are a number of key anchor areas as set out in figure 20 below. Table 7 highlights the demand and connection requirements within the segmented target area geography.

**Figure 24 Demand Segmentation**


Table 8 Target Area - Demand Segmentation

| Target Area Geography | Connections | Demand GWh | Connection Capacity MWh |
|---|---|---|---|
| Anchor Area | 85 | 28.3 | 333 |
| Non-Anchor Area | 1,368 | 22.55 | 16.5 |

## 4.2.5. Anchor Demand Area & Expansion Potential

There are a number of physical constraints within the anchor area, notably the issue of dealing with canal crossings, identified in figure 21.

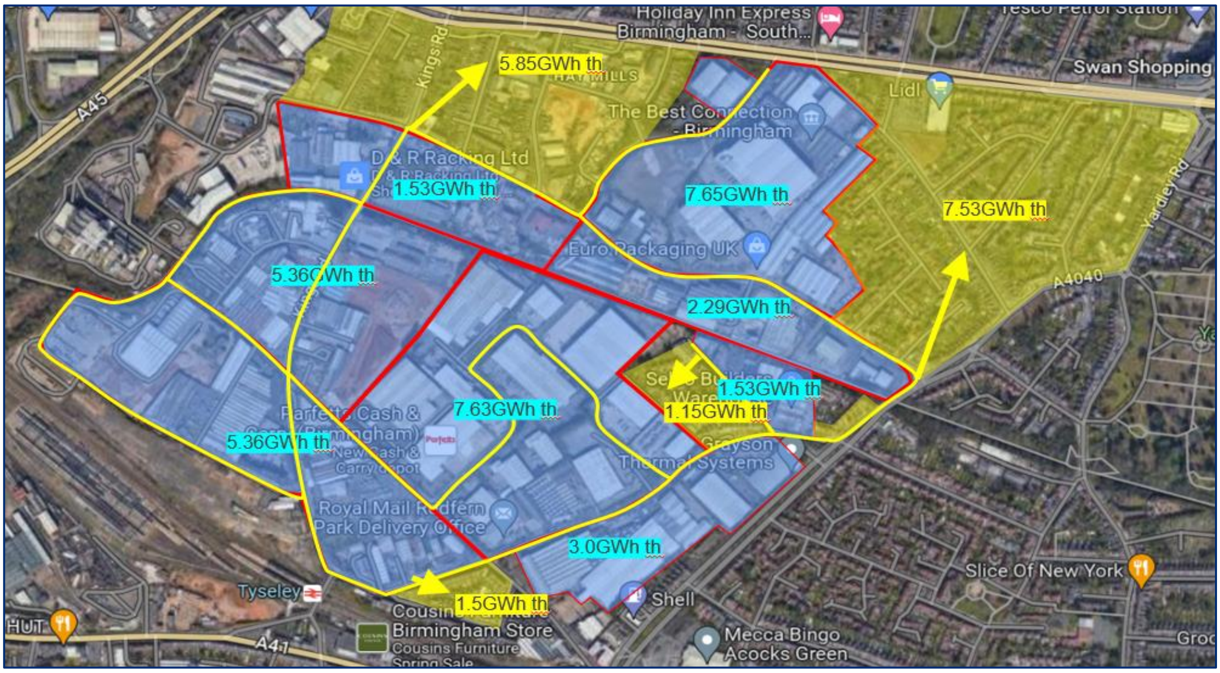
**Figure 25 Anchor Demand Areas - Constraints**


On the basis that these constraints can be mitigated, it is envisaged that the network can be expanded in phases utilising the canal crossings infrastructure, this is illustrated in figure 22.

**Figure 26 Potential Future Expansion Phase 1**

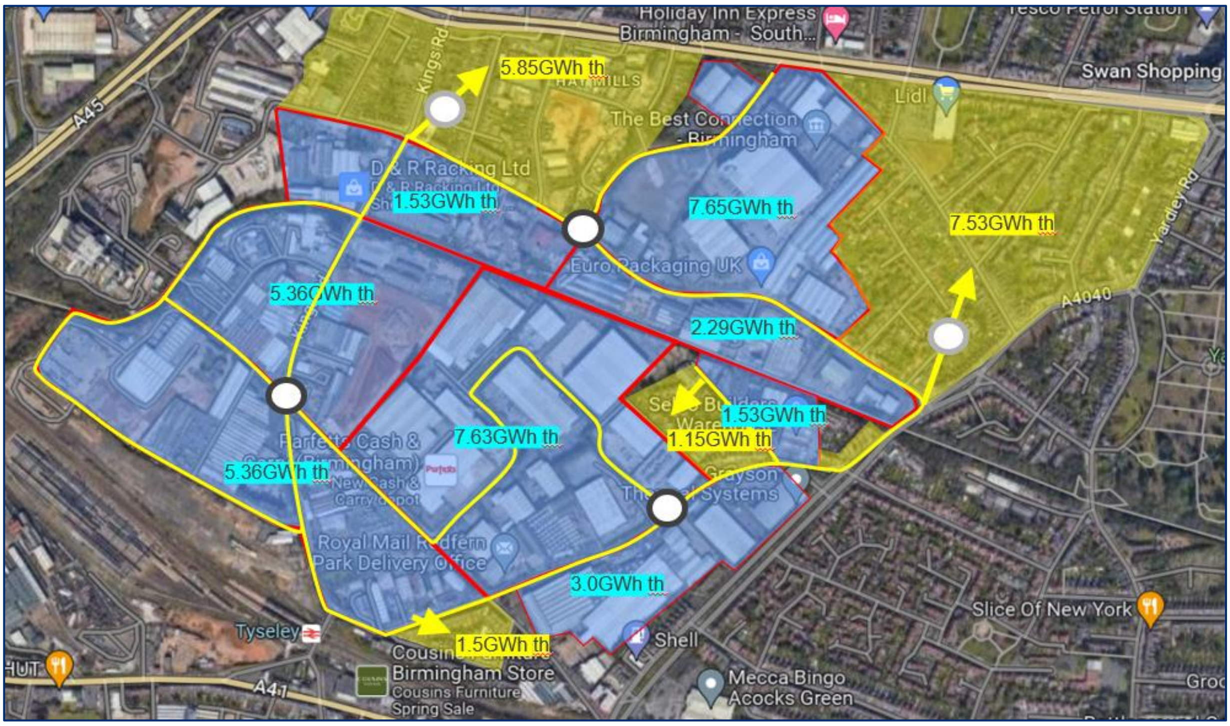

The network could be expanded east and west to include non-anchor areas in an initial phase, increasing the number of connections to 125 and then north-west and north-east in further phases adding significant domestic connections (~1,310) as shown in figure 23, if economically viable.

**Figure 27 Potential Future Expansion Phase 2**




In identifying the location of prospective energy centre infrastructure within the network, there are a number of potential sites where it is envisaged an initial number of centres could be deployed with additional centres added as part of the expansion phasing. This is shown in figure 24.

**Figure 28 Potential Location of Energy Centre Infrastructure (Phased)**



## 4.3. Further Basis of Design Refinement

### 4.3.1. Development of Heat Network Infrastructure

Additional detail was added to the basis of design to tailor it to the identified segments of demand within the target area with more alignment of the proposed network spines and main branches with the location of property and facilities. Further analysis of the Energy Centre location was guided by assumptions on availability of land, impact upon surrounding areas (especially due to cold plume nuisance from the ASHPs), access for O&M and levels of noise/disruption. The final proposed location was assessed as the optimal fit due to the lowest impact in the context of these parameters and mutual advantage with local Air Cooled Condensers of the existing power generation plants. The heat pump Energy Centre will produce a significant cold plume which will on occasion enhance the efficiency performance of the biopower and EfW plants.  And vice versa, by siting the EC close to the warm plumes from the biopower and EfW air cooled condensers, certain wind conditions will enhance the efficiency of the heat pumps. Within the Tysley Energy Park, this is shown in figure 25. Further analysis of the demand within the expanded anchor area led to refinement to an estimated 15MW peak.

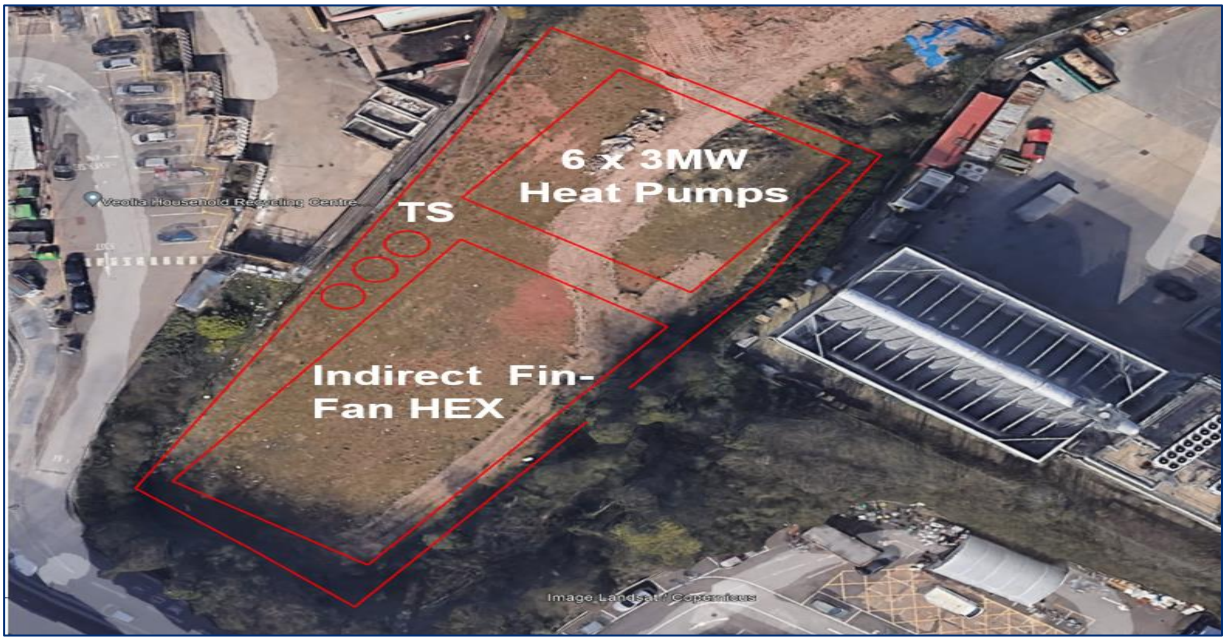
**Figure 29 Refinement of Expanded Network**


The Energy Centre concept specification has been based upon the following parameters:

- 15MW Peak
- N + 1 redundancy
- 6 x 3MWth units
- 80°C/60°C flow and return temperatures
- Indirect ammonia air-source (with glycol intermediate loop, for improved safety)
- Seasonal Coefficient of Performance of 2.7 for the heat pump system
- 3 x 150m$^3$ thermal stores

An indicative oblique layout of major equipment is illustrated in Figure 26 at the preferred site location, noting that no confirmation of the availability of this land has been sought.

**Figure 30 Proposed Energy Centre Site Configuration**




The refined scheme would be predicated upon around 125 connections with a combined annual demand of 34.5 GWh with the segmented peak demand profile as set out in Figure 27.

**Figure 31 Anchor Peak Heat Demand Refined**


Based on this network configuration and the parameters outlined above, indicative pipe sizing was estimated for the main spines and branches as set out in Figure 28.

**Figure 32 Indicative Network Pipe Sizing**


Without the certainty of which buildings would connect, the exact transitions in pipe dimensions are not given. Similarly, additional DN50 and smaller branches extending towards multiple building connections have not been shown but have been assumed as set out in table 9 below.

**Table 9 Network Connections**

| | | |
|---|---|---|
| DN250 | **300** | m trench length |
| **DN150** | 950 | m trench length |
| **DN100** | 700 | m trench length |
| **DN80** | 800 | m trench length |
| **DN65 and smaller** | 1000 | m trench length (excluding building connections/terminal runs) |
| **Total Route Length** | **3750** | **m** (without individual terminal runs to buildings) |

# 5. Outline Business Case Summary

In progressing from the high level master-planning, demand analysis and pathway routes set out above, a number of key assumptions were made in order to develop an outline business case:

**Assumptions:**

- The project focus is on a low carbon heat network infrastructure;
- Due to the SSE assessment of the technical challenges associated with thermal extraction from the EfW facility the optimal technical solution would be an electrified air source heat pump solution which could be enduring or become a back-up / top up if Hay Hall EfW is developed;
- The project only considers hot water and space heating requirements in the TEED area;
- The project only considers TEED area north of the railway (physical/stakeholder barrier) and assume that the southern area will be fed from another heat network;
- There is sufficient demand headroom at the Sparkbrook and Boughton Road 132/11kV subs for the electrified heat – however, we could assume some local 11kV upgrade works/costs;
- Key decarbonisation years are 2021, 2028, 2040 and 2050;
- In progressing with electrified heat network infrastructure there are other decarbonisation options which will not be pursued within the discovery phase including:
    - Electricity through solar or wind;
    - Liquid fuels through EV charging or production of low carbon fuels.

Below is a summary of the key components and high level quantification of costs and metrics that were used in preparation of a business case cashflow model.

| Component | Value | Comment |
|---|---|---|
| Infrastructure Costs | | |
| Development phase devex £m | 4 | Phased over 4 year project development period. |
| Devex grant £m | 1.6 | Estimated grant funding requirement. |
| Heat network capex £m | 7.5 | Phased over anticipated 3 year construction programme. |
| Energy centre capex £m | 16 | Phased over anticipated 3 year construction programme. |
| Ancillary / integration works capex £m | 1 | Phased over anticipated 3 year construction programme. |
| Customer connections | 125 | 125 connections based on Anchor Phase 1 Expansion (see above). |

| | | |
|---|---|---|
| Connection capex £m | 3.75 | Phased over 3 year period at end of construction period (£0.03m per connection). |
| Capex grant for main assets £m | 9.4 | Based on 40% of main capex assets. |
| Repex across all assets £m | 1.9 (assumed year 15) | Based on compressor replacement estimated at £250/kWth, hence capital outlay ~£1.9m in year 15. |
| Opex £m p.a | 0.176 | |
| EC and storage land rental £m p.a | 0.02 | High level estimate. |
| Heat network easement £m p.a | 0.05 | High level estimate. |
| Business rates for ECs & network £m | 0 | Assume rate relief. |
| NG-ED local upgrade & connection costs £m | 2 | High level estimate. |
| NG TNUoS and DUoS £m p.a | 0.32 | High level estimate. |
| Energy supply and demand | | |
| Heat demand MWhth p.a | 34,500 | |
| Heat production (to overcome losses) - factor | 110% | |
| sCOP and Electricity consumption | 2.7 | |
| Pumping and ancillary electricity consumption (above ASHP demand) | 20% | |
| Heat network utilisation % | 100 | By Y2032 |
| Energy costs | | |
| Time weighted (real) electrical energy cost £/MWhe | 210 | Based on estimated time weighting to heat production profile but taking 75% power from private wire (at £180/MWhe and 25% from grid (at £300/MWhe) |
| Effective heat sales price £/MWhth | 116 | Excluding customer heat network connection costs |
| Revenues | | |

| | | |
|---|---|---|
| Use of heat network charge £m p.a | 3.8 | |
| Connection capex recovery £m | 3.94 | £0.0315m per connection |
| Heat supply £m p.a | 3.72 | |
| NPV £m | 6.72 | |
| IRR % | 9.00% | |

### 5.1.1. Business Case Model Assumptions

The model has been derived based on the following assumptions:

- Key years for carbon emissions are 2021, 2028, 2040, 2050
- 30 year post tax real financial model for return on heat network. 6% discount rate which is typical of public funded schemes
- Construction phase for ECs, heat network and anchor demand connections is 3 years from Jan 2024
- Heat network construction starts Jan 2027
- Heat network commissioning Jun - Sept 2029
- First supplies of heat to anchor customers in Oct 2029
- Linear ramp up of customer demand from Oct 2029 to Oct 2031
- Devex and capex grant of 40% of core heat assets
- Anchor customers equates to 125 connections with an average of 276MWhth p.a. per connection - assume circa. £50k capex per connection
- Assume repex as function of replacing electrical compressors, £250/kWth
- Opex as £2/MWhth plus £100k p.a
- Assume some NG-ED local upgrade connection cost and TNUoS and DUoS charges
- 10% heat loss (of heat demand) on network
- sCOP of 2.7 for a typical annual heat profile
- 20% extra electricity for pumping, ancillaries, variable speed drives and fans
- Assume zero business rates
- £210/MWh (real) electricity cost - based on estimated time weighting to heat production profile but taking 75% power from private wire and 25% from grid
- Assume business model of: (a) connection capex is recovered at time of connection with a 5% margin; (b) heat price recovers non-connection capex and opex plus an 8% return; (c) energy costs are recovered through unit heat price with a margin of 5%
- Corporation tax at 25%

# 6. Electric Vehicle Hub Opportunities

SSE understands that there is 6-7MW of currently un-utilised capacity on the private electrical network. Some of this available capacity could be utilised by connection of EV charging facilities which may be better suited to HGV rather than light/commuter vehicles; given that Birmingham City Council may not wish to encourage commuter traffic at the expense of public transport and given that the vehicle access from the A45 may not be entirely suitable for large volumes of light vehicle access and egress.

There have been previous discussions between SSE and Webster & Horsfall which could form the basis for the development of HGV charging facilities on the site.

# Appendix

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