Tyseley Environmental Energy District (TEED) WP4: Development of Designs - Option 3

Strategic Innovation Fund (SIF)
Ofgem Round 2: Discovery – Accelerating decarbonisation of major energy demands

21/06/2023

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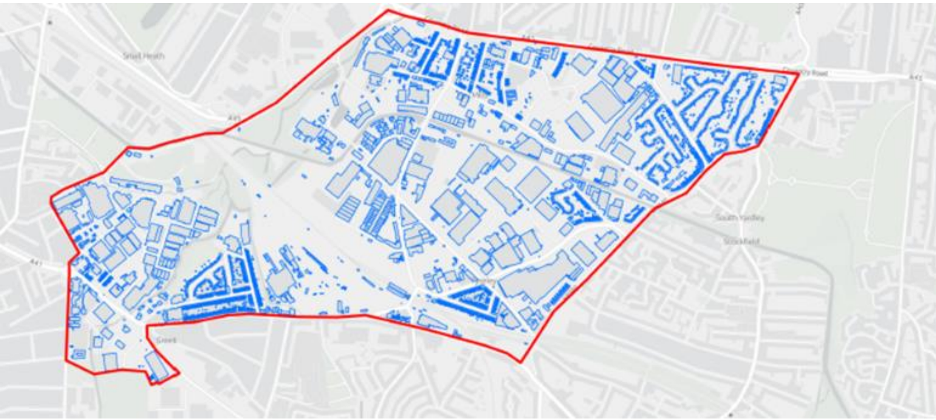
EXECUTIVE SUMMARY

Background

The Tyseley Environmental Enterprise District has been shortlisted by Ofgem for round 2 of the Discovery Phase of the Strategic Innovation Fund (SIF).



The Tyseley Area

The Discovery Phase, the current phase of the project, focuses on high level project concept and feasibility. This will be followed by the Alpha Phase which focuses on project development, and the Beta Phase which explores deployment and demonstration.

The Discovery Phase for the Tyseley Environmental Enterprise District (TEED) is being delivered by a consortium led by National Grid comprising of EQUANS, Pinnacle Power and SSE working in collaboration with the University of Birmingham and National Grid ESO. National Grid and the consortium are supported by Smart Grid consultancy who are acting as programme managers.

To enable different options and solutions to be analysed, three different options were identified and assigned to each member of the consortium:

1. *Heat Network*, developed by Pinnacle Power*;*
2. *Heat Network and microgrids*, developed by SSE and;
3. *Heat Network, microgrids and mobility* lead by EQUANS

This report outlines the outcome of the work carried out by EQUANS during the Discovery phase of the Tyseley Environmental Enterprise District Strategic Innovation Fund project ("The Project").

Objectives

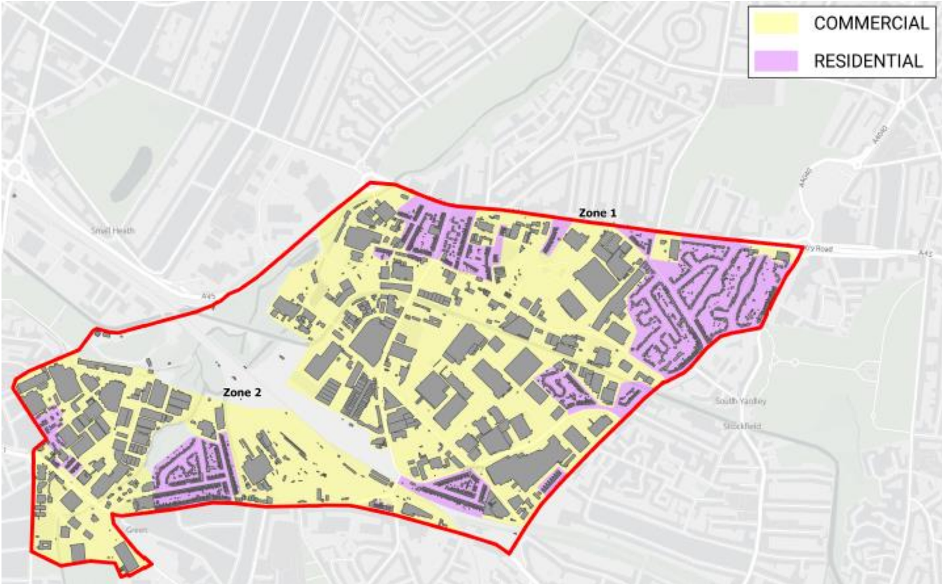
The objective of the Project is "accelerating decarbonisation of major energy demands", with TEED as the focus area, but with potential for replicability across the wider West Midlands area and beyond, exemplifying how decarbonisation of industry can drive local decarbonisation.

To align with the objectives, EQUANS identified a cost-effective technical solution, which would make the Tyseley area net zero by either 2035 or

2042, in line with the UK carbon budgets and would minimise/negate requirements to reinforce the electrical grid.

EQUANS Methodology

The Tyseley area was divided into two zones, and each zone split in to a Domestic and non-domestic area (Residential & Commercial respectively)



Domestic and Non-Domestic areas within the Two TEED Zones

It was assumed that each zone is currently served by the nearest of the two primary high voltage substations (132kV/11kV).

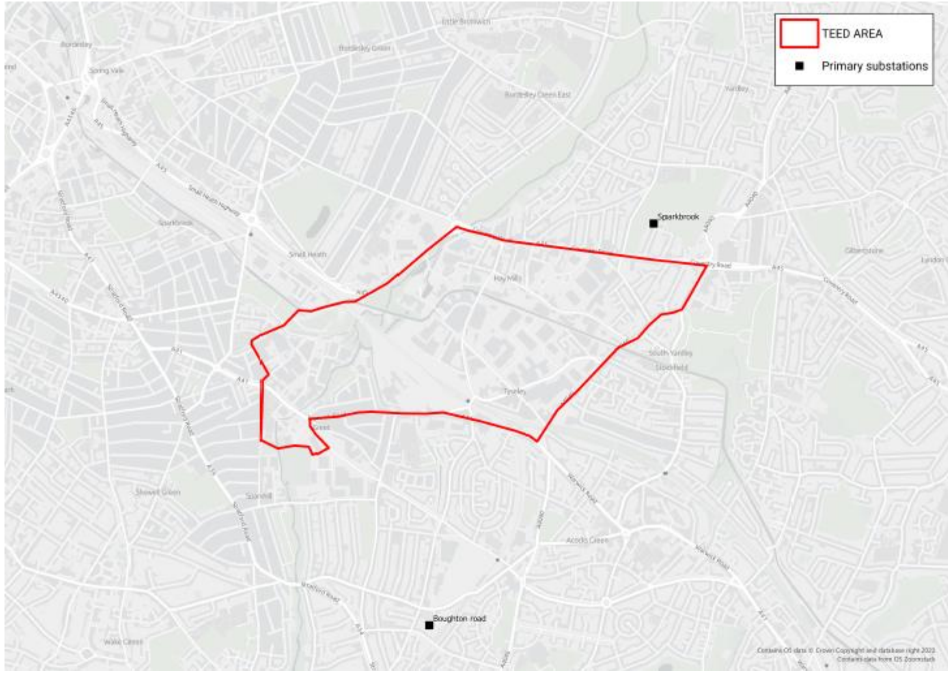
The heat, power and transport demand for the TEED areas were estimated, applying publicly available benchmarks. These were applied to building floor areas according to the building use type and road length.

Energy Demand Assessment

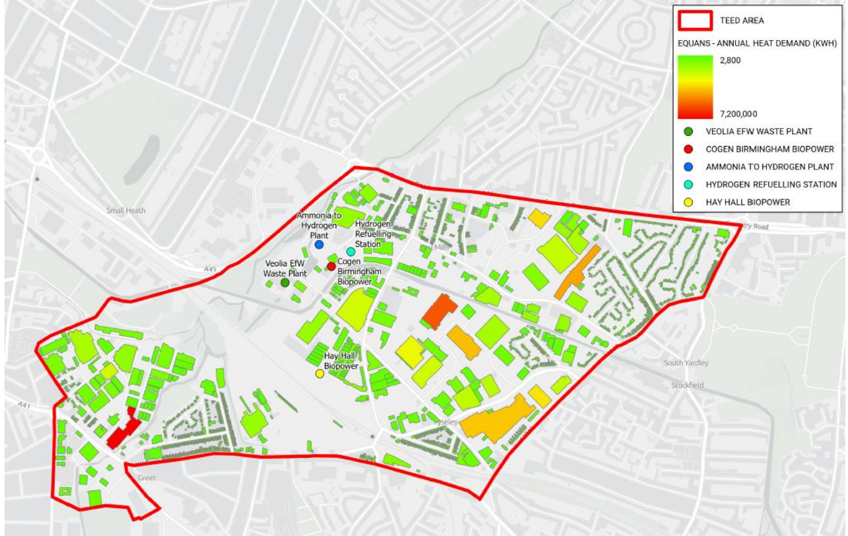
From the gathered data, a baseline demand was estimated for the area.

The overall annual thermal demand for the TEED area was estimated in the order of 133GWh.

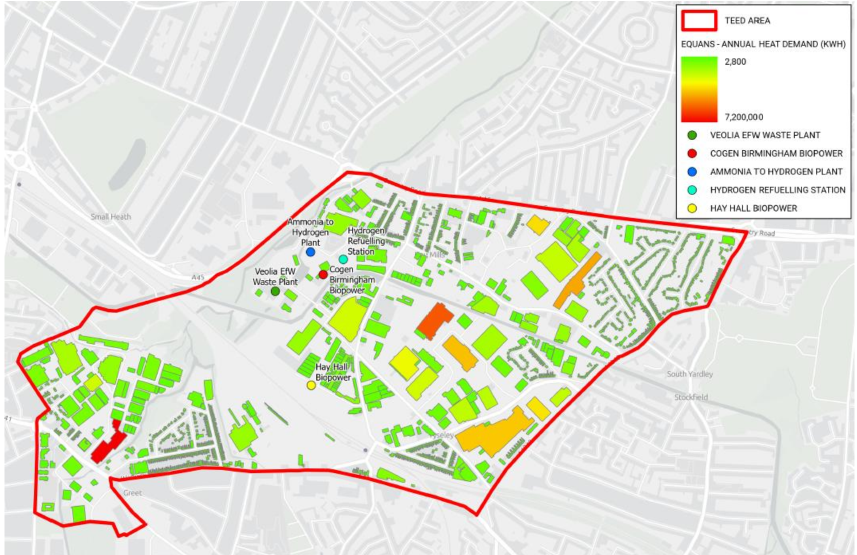
The overall annual power demand for the TEED area was estimated in the order of 79GWh.



Locations of the Primary Electrical Substations



TEED Heat Map



TEED Power Demand Map

Existing and Planned Energy Generation Plants

Existing and planned energy generating plants were identified in the area. These include:

a. An Energy from Waste Plant operated by Veolia
b. A biomass gasification plant operated by Cogen
c. A planned municipal waste gasification power plant, Hay Hall Biopower
d. An ammonia cracker, currently under construction, for the production of hydrogen
e. A 3MW electrolyser and hydrogen refuelling station.

In addition, the following facilities were identified within the TEED area:

f. A motive Fuels' hydrogen refuelling station
g. A datacentre, potentially capable of providing low-grade heat from cooling processes.
h. A microgrid that feeds the Tyseley Energy Park (TEP) demand

Potential Investments

Potential investments in technologies were considered such as:

- Heat network infrastructure
- Electric network infrastructure
- Thermal Storage
- Building Fabrics Retrofit

- Heat Pumps
- Green Mobility Solutions
- Further capacity for electrolysis
- Further capacity for municipal waste
- Solar PVs and batteries within buildings

It should be noted that outside the Tyseley Energy Park (TEP) microgrids were discounted as private wires create counter-productive redundancies within the energy system. Instead, energy efficiency and distributed energy resources were observed in the same way as microgrids, to reduce the dependence on the centralised energy system.

Proposed Solution

Modelling

A model was developed in Decisio™, a decision-enabling multi-vectors platform, which makes use of AI to establish the optimal combination of technologies to meet the following objectives:

- Minimising whole-life cost;
- Minimise grid reinforcement requirements and;
- Accelerate decarbonisation within the Tyseley area.

Outcome

The optimal solution was identified as a combination of centralised and decentralised energy solutions, depending on the area, as follows:

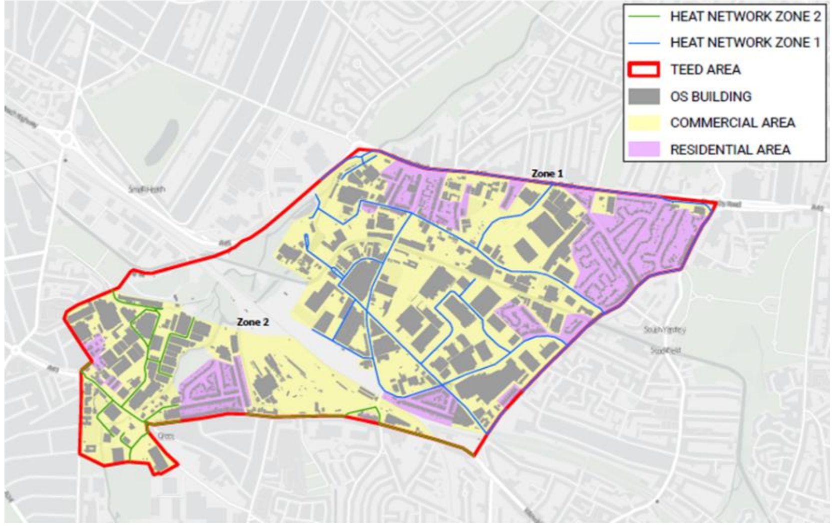
I. Within the non-domestic areas of Zone 1, the optimal solution was identified as a heat network fed by low-grade heat available from the Veolia EfW and/or the Birmingham Biopower plants.

II. Within the non-domestic areas for Zone 2, a heat network fed by waste heat from cooling processes from the SCC data centre was identified as the optimal solution.

III. Within residential areas, heat pumps would be installed along with hot water tanks. The case for solar photovoltaic on residential roofs, along with batteries would require further investigation during the next phase of the Project.

IV. The option to export high-grade heat from existing and future power plants to Birmingham city centre to facilitate decarbonisation of existing building stocks, should be looked at in greater detail during the next phase of the Project.

V. Electrification of transport has been fully taken on board. The case for hydrogen for heavy transport and the speed of integration of EVs would require further investigation during the next phase of the Project.



As the heat networks would distribute local heat at low temperature, heat pumps would be required within buildings.

The case for interconnecting the two heat networks was not investigated during this study.

Conclusions & Next Steps

This study investigated options to deploy heat networks, energy efficiency, distributed energy resources and mobility within the TEED area, and it is part of the Discovery Phase of the strategic innovation fund, which provides major investments in innovative projects.

During this phase EQUANS:

I. Developed an understanding of the TEED area;

II. Carried out a high-level estimate of the energy and transport demands;

III. Identified existing and planned energy generation facilities in the areas, including sources of waste heat;

IV. Considered a number of investment opportunities to accelerate the path towards decarbonisation, exploiting synergy across energy systems;

V. Built a modular whole system energy model capable of modelling a combination of possible solutions using the Decisio™ software, powered by AI;

VI. Assessed that there could be a case for a district heating within high heat density areas within TEED, which could be complemented by heat pumps installed within buildings in areas with low heat density;

VII. Established that the case for decentralised energy systems, such as heat networks, would benefit from investment in the development of low-carbon low-cost heat and power generations, such as energy from waste facilities, in the medium term. This solution minimised impacts on local electricity generation and provided a more efficient form of Heat Pump heat to connected buildings using less primary energy and electricity supply needs with low kWh of electricity needed per kWh thermal produced.

VIII. Assessed potential demand reduction through domestic retrofit to enable lower demand as these are not connected to the heat network. In addition to a reduced heating demand impacting the

To identify

electrically driven heat pumps, solar PV and batteries were also observed.

IX. Identified electric vehicles as a potential pathway to decarbonise transportation in the area; The heat solution helps unlock electricity supply locally and grid capacity for transport electrification and

X. Evaluated that the proposed solution would minimise the risk for further grid reinforcement in the area.

Whilst EQUANS identified an optimal solution, it is recognised that:

a. Whole systems modelling is complicated and a system boundary had to be drawn that was proportionate to this stage of the project. For this reason certain elements were excluded from the modelling (e.g. process heat demand, detailed mobility decarbonisation pathways, hydrogen infrastructure, carbon capture and storage, detailed building fabric retrofit, impact of free or reduced cost pooled SolarPV and battery). These elements would be included in the next phase and the existing analysis would require further refinement, meaning some variations to the proposed solutions are likely.

b. There are significant risks that are to be addressed, including technical, commercial and legal, ranging from data quality to stakeholder engagement and from lack of certainty of future plans for the area (e.g. the planned Hay Hall municipal waste gasification plant) to lack of local plan and national policy that would for instance require buildings to connect to a heat network or identify other synergies within the locality.

c. Our analysis around requirement for grid reinforcement would need refinement and an hourly model would need to be developed during the next stage.

d. The case to export high-grade heat from existing and future energy from waste plants to Birmingham city centre has not been evaluated economically or environmentally, though it is believed that this option could provide further benefits (e.g. decarbonisation of existing buildings stock in Birmingham) and should be explored further during the next stage of the project.

EQUANS will work with the consortium during the next stage to refine the optimal solution and de-risk the project and develop the design.

INTRODUCTION

1.1 Background

The Tyseley Environmental Enterprise District has been shortlisted by Ofgem for round 2 of the Discovery Phase of the Strategic Innovation Fund (SIF).

The SIF consists of a multi-phase approach for shortlisted projects to mitigate the risk associated with innovations. The Discovery Phase, the current phase of the project, focuses on feasibility. This will be followed by the Alpha Phase on experimental development, and the Beta Phase on deployment and demonstration.

The Discovery Phase for the Tyseley Environmental Enterprise District (TEED) is being delivered by a consortium, comprising Tyseley Energy Park (TEP), National Grid ESO, University of Birmingham (UoB), Equans, Pinnacle Power and SSE led by National Grid Electricity Distribution

To enable different options and solutions to be analysed, three different options were identified and assigned to each member of the consortium:

1. *Heat Network*, developed by Pinnacle Power*;*
2. *Heat Network and microgrids*, developed by SSE and;
3. *Heat Network, microgrids and mobility* lead by EQUANS

It was intended that such approach would drive innovation by gathering different views with resulting different approaches. This would lead to an optimal solution where a range of views would overlap.

This report outlines the outcome of the work carried out by Equans during the Discovery phase of the Tyseley Environmental Enterprise District Direction ("The Project").

1.2 Project Objectives

The objective of the Project is "accelerating decarbonisation of major energy demands", with TEED as the focus area, but with potential for replicability across the wider West Midlands area, exemplifying how decarbonisation of industry can drive local decarbonisation.

This study intends to cover:

- Demand for heat, electricity and hydrogen in the TEED area over the next two decades
- Electricity grid and its constraints and most effective upgrades
- Heat grids across the TEED, with a link to the BDEC scheme
- Potential for short- and medium-term energy storage for demand management and grid balancing
- Impact of the City waste and transport strategy on energy requirements
- Potential for a low-temperature network recovering heat from bio and/or hydrogen electrolyser and integration of large-scale thermal storage
- Potential for a high-temperature heat network with heat from EfW

- Scope for technology integration alongside EV charging to manage demand side and integration of micro-mobility
- Hydrogen-grid for industrial and rail decarbonisation
- An understanding of regulatory, planning and system constraints

The objective of this study is to identify a cost-effective technical solution which would make the Tyseley area net zero by either 2035 or 2042, and which would minimise/negate requirements to reinforce the electrical grid.

Given the time and data constraints of the project, industrial process heat was excluded from the analysis. It is recommended that this demand is included in subsequent Alpha phase analysis.

1.3 The Tyseley Area

Tyseley lies in East Birmingham and has historically suffered from high level of fuel poverty. Within Tyseley lies the Tyseley Environmental Enterprise District (TEED) which is composed of 250 businesses mixed in with ~8,000 residents.

The TEED area is centred around the Tyseley Energy Park (TEP) and the Veolia Energy from Waste plant. Additional assets are currently generating energy within the area namely the Gravis Birmingham Biopower gasification plant and a hydrogen electrolyser.

The TEED area, which this study is focused on is shown in Figure 1.

Based on the information available, it is believed that the TEED area is served by two primary high voltage substations (132kV/11kV), the locations of which is shown Figure 2: Sparkbrook (north) and Boughton Road (south), where the total installed capacity for the area is 106MVA and 89MVA respectively.

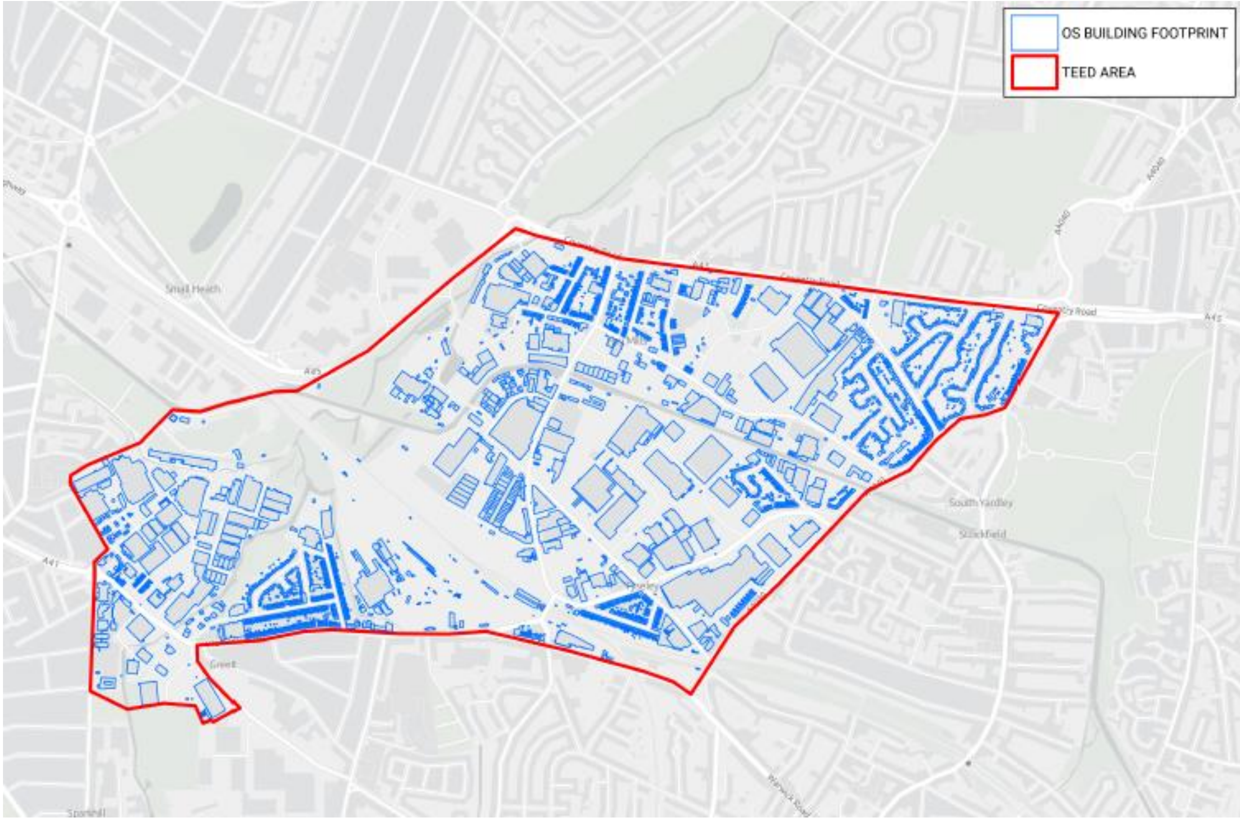


Figure 1: The TEED Area

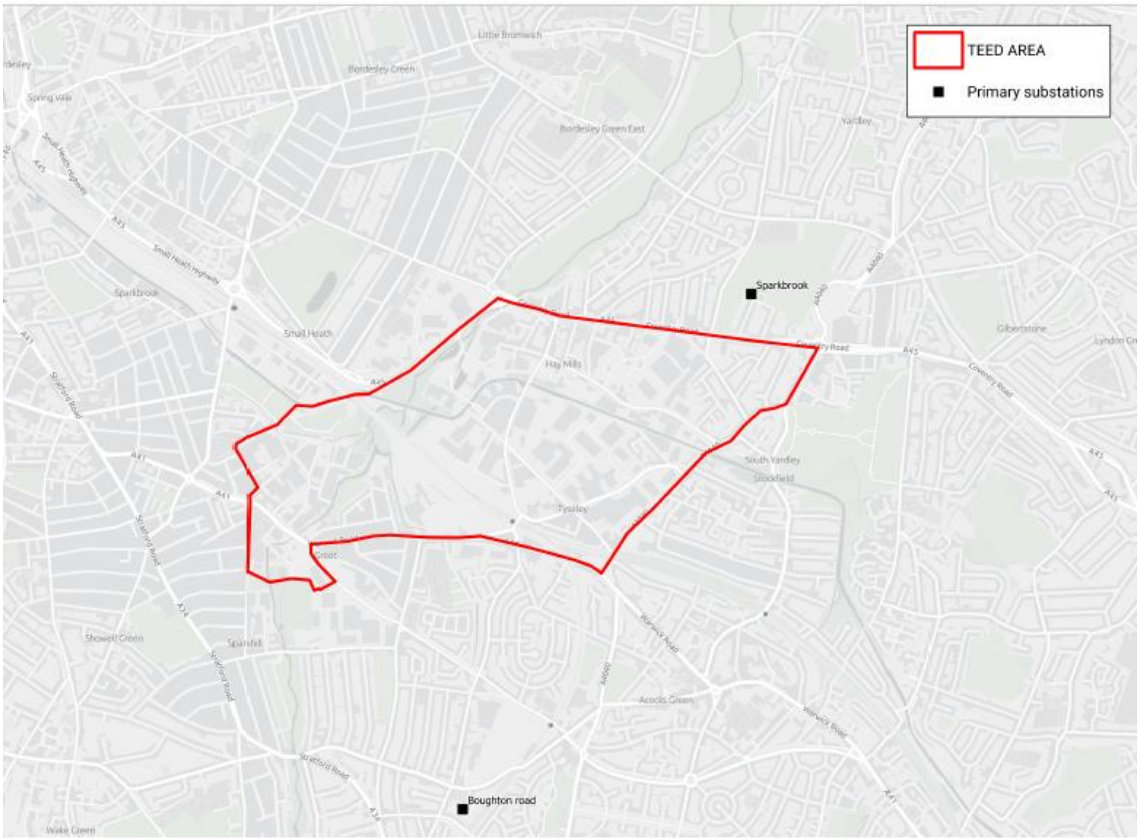


Figure 2: Location of Primary Electrical Substations

1.4 Report Structure

The report outlines the methodology used to establish demand, generation and associated carbon and costs for the area as well as the outcomes of high-level modelling. The report contains three sections:

- **Methodology**, outlining our approach to achieve the objectives of this study;
- **Recommended Solution**, outlining the concept of EQUANS proposed solution and;
- **Conclusions,** in which recommendations are discussed.

Assumptions have been appended at the end of this report.

METHODOLOGY

2.1 General approach

It is widely accepted that a 'whole systems approach' is required to enable effective decarbonisation. This allows the implication of decarbonisation decisions on wider infrastructure to be assessed and for the most cost-effective overall combination of technologies to be identified. This would allow a holistic net zero solution to be developed within the confines of infrastructure practicalities, such as electricity grid capacity and reinforcement. To demonstrate the feasibility of the whole systems analysis, a model has been developed using BMA's Decisio platform.

Decisio enables the modelling of different energy vectors and informs investment decisions on the basis of user-defined objectives. Details of the analysis performed on Decisio are outlined in section **Error! Reference source not found.**.

In order to develop a model in Decisio, EQUANS first established:

1. Existing demands (the baseline) in the Tyseley area, including thermal, power, transport, which are outlined in section 2.3
2. Existing and planned energy generators and sources of waste heat in the Tyseley area, which are outlined in section 2.4;
3. The range of solutions, or investment decisions, that would be investigated and compared, to generate an optimal solution against the objectives, which are described in section 2.5

The underlying assumptions are outlined in the next section.

2.2 Underlying Assumptions

For the purpose of the modelling, existing demands were aggregated spatially and temporally to provide a desired level of granularity.

This section outlines key assumptions around temporal and spatial granularity that underly the modelling carried out in Decisio.

2.2.1 Spatial Granularity

It was decided to subdivide the TEED area into two zones separated by the railway as shown in Figure 3. It was assumed that each zone would be served by the nearest primary substations (Figure 2).

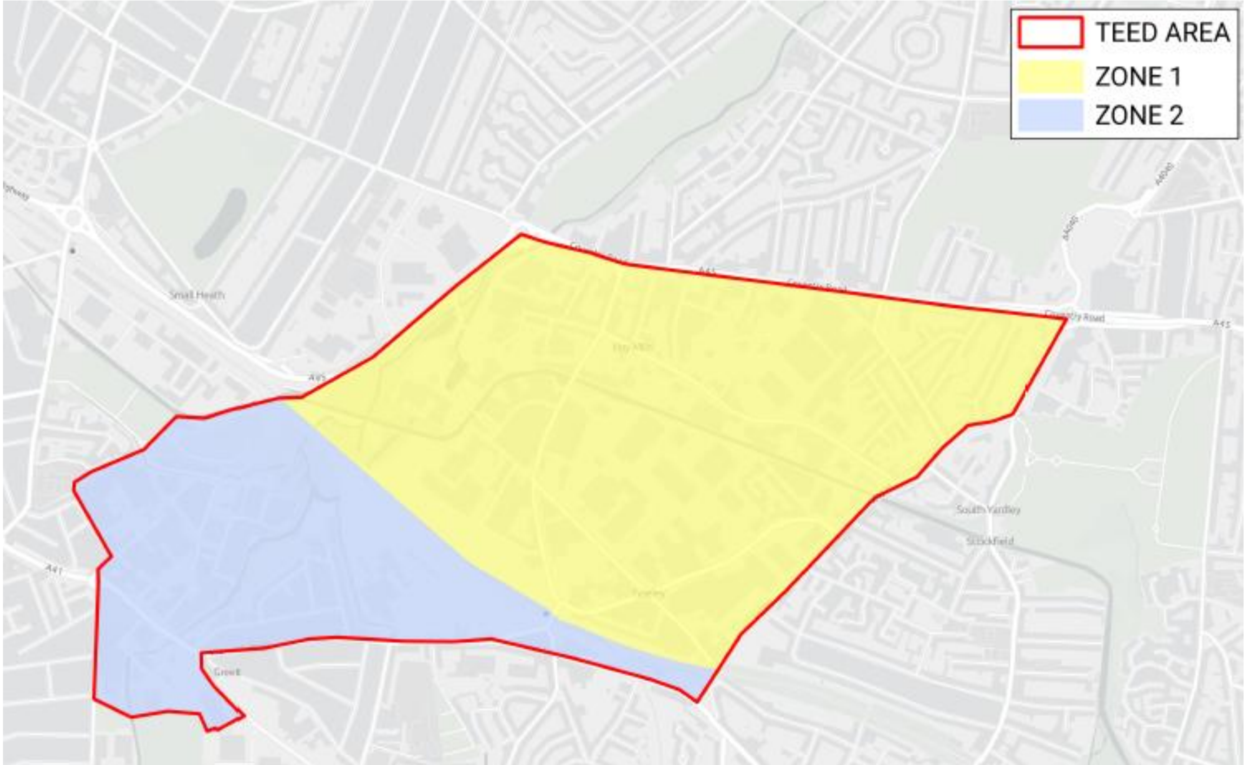


Figure 3: Location of Primary Electrical Substations

Each of the two zones were sub-divided into non-domestic and domestic consumers, as shown in Figure 4.

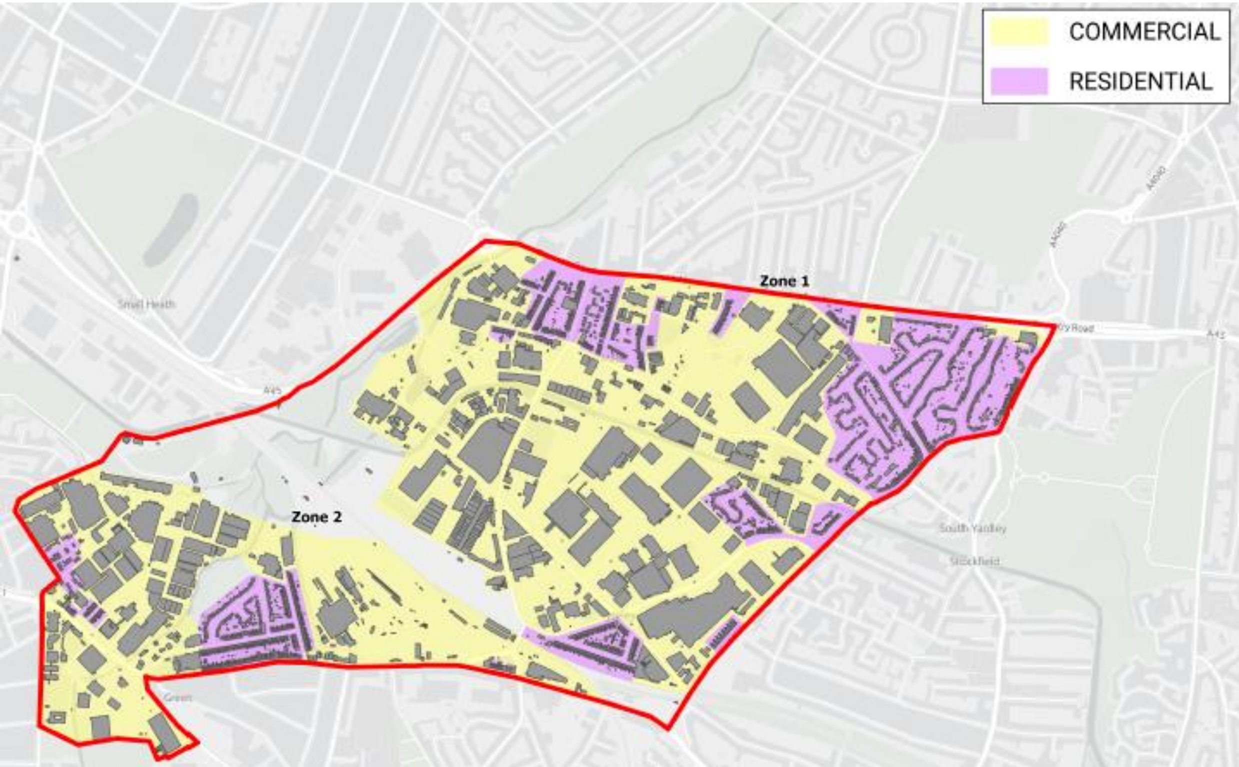


Figure 4: Location of Primary Electrical Substations

This approach is intended to restrict the potential development of heat network infrastructure solely within non-domestic areas, for which a higher heat density is expected to facilitate the economic case for a decentralised energy solution as opposed to embedded generation within individual properties. The railway would also form a natural barrier for development and given different heat sources are available in each zone, would increase the accuracy of the analysis.

The option for installing a heat network within residential area or for a site-wide heat network should be explored during the next phase of the Project.

2.2.2 Temporal granularity

As agreed with the consortium, the time horizon for this study would cover the carbon budget periods from 2023 to 2042, with a focus on the following years:

- 2028,
- 2035 and
- 2042

In addition to the above, EQUANS decided to subdivide each year in two periods, to account for the seasonality of thermal demand and some power generating assets (e.g. solar photovoltaics): winter and summer.

For these two periods, demand and energy generations were modelled during:

- **A winter average day,** defined as the average daily demand between the 1st of November and the 30th of April;
- **A winter peak-day**, defined as the daily demand during the day of the year where energy consumption is highest;
- **A summer average day**, defined as the average daily demand between the 1st of May and the 30th of September;
- **A summer peak day**, assumed to be equal to the summer average day and
- **An hourly peak**, defined as the highest instantaneous demand.

2.3 Baseline Demand

A Sankey diagram of our estimated baseline demand is shown in Figure 5, whilst the methodology to assess the demand is outlined in following sub-sections.

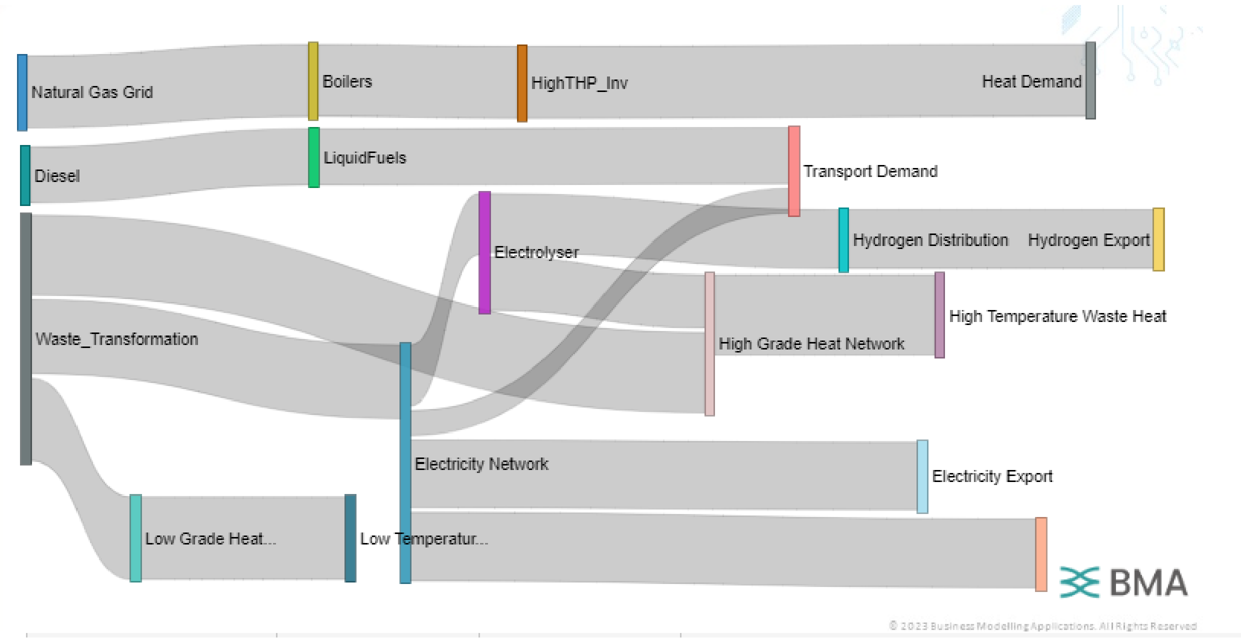


Figure 5: Baseline Energy Flows

2.3.1 Thermal Demand

2.3.1.1 Annual Demand

Buildings' annual and peak heat demands were calculated using publicly available benchmarks, i.e. *BSRIA's Rule-of-thumb Categories*[1] and *CIBSE's Energy Benchmarks* [2] , as well as benchmark figures agreed by the consortium and outlined in more detail in Annexes A and B. Demands were calculated by applying the relevant benchmark to each building's respective floor area.

The 'TEED Polygons with Hnz Data' spreadsheet provided buildings' surface area and number of floors. This spreadsheet also provided buildings' use class in the majority of cases (2,067 out of 3,288 buildings).

Where a building's use class was not provided, this was determined using the assumptions listed in Table 1, which were agreed with the consortium.

Building surface (m²)	Building type
0-30	N/A – Discounted
31-250	Dwelling
251-2,000	Office
2,001 and above	Warehouse/storage facility

Table 1: Use Class Categorisation According to Floor Area

[1] Hawkins, Glenn/BSRIA (2011) *BG 9/2011 Rules of Thumb*, 5th edition
[2] The Chartered Institution of Building Services Engineers (2008) *TM46 Energy Benchmarks*

A number of buildings were excluded from the heat demand calculations:

- Any building with a surface of inferior or equal to 30m^2;
- Any domestic building located in commercial zone 1 and commercial zone 2

2.3.1.2 Demand Profiling

The heat demand for the two zones, and for the areas (non-domestic or domestic), have been defined using hourly profiles for either domestic or non-domestic customers derived from EQUANS experience.

The duration curves derived from this exercise and for the four sub-areas are shown in Figure 6. These express the number of hours a given load would be exceeded in a year.

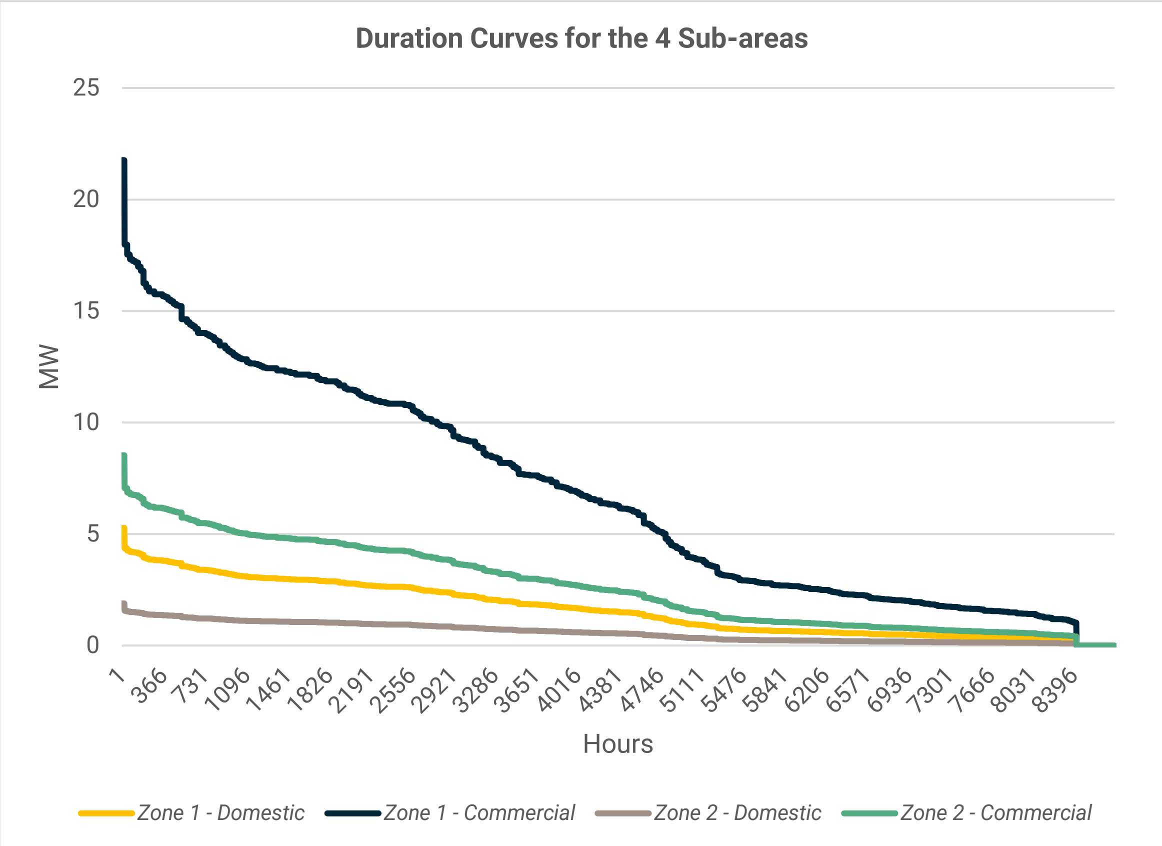


Figure 6: Baseline Energy Flows

2.3.1.3 Periodic Demands

The overall annual thermal demand for the TEED area was estimated in the order of 133GWh.

The annual thermal demand associated with non-domestic areas within both Zone 1 and 2 was estimated in the order of 113GWh.

The annual thermal demand for domestic areas, within zone 1 and 2, was estimated in the order of 19.5GWh.

The estimated thermal demands for all the periods being analysed (winter and summer) and for all sub-areas is shown in Table 2.

Time Period	Node Name	Period Demand (MWh)	Average Day Demand (MWh)	Peak Day Demand (MWh)	Hourly Peak (MW)
Winter	Non-Domestic Zone 1	80,234	371	543	29.0
	Non-Domestic Zone 2	31,461	146	213	11.4
	Domestic Zone 1	12,141	56	127	5.3
	Domestic Zone 2	4,356	20	45	1.9
Summer	Non-Domestic Zone 1	1,390	9	9	0.4
	Non-Domestic Zone 2	545	4	4	0.1
	Domestic Zone 1	2,256	15	15	0.6
	Domestic Zone 2	809	5	5	0.2

Table 2: Periodic Thermal Demands for all Zones

2.3.1.4 Heat Demand Map

A heat map for the area is show in Figure 7.

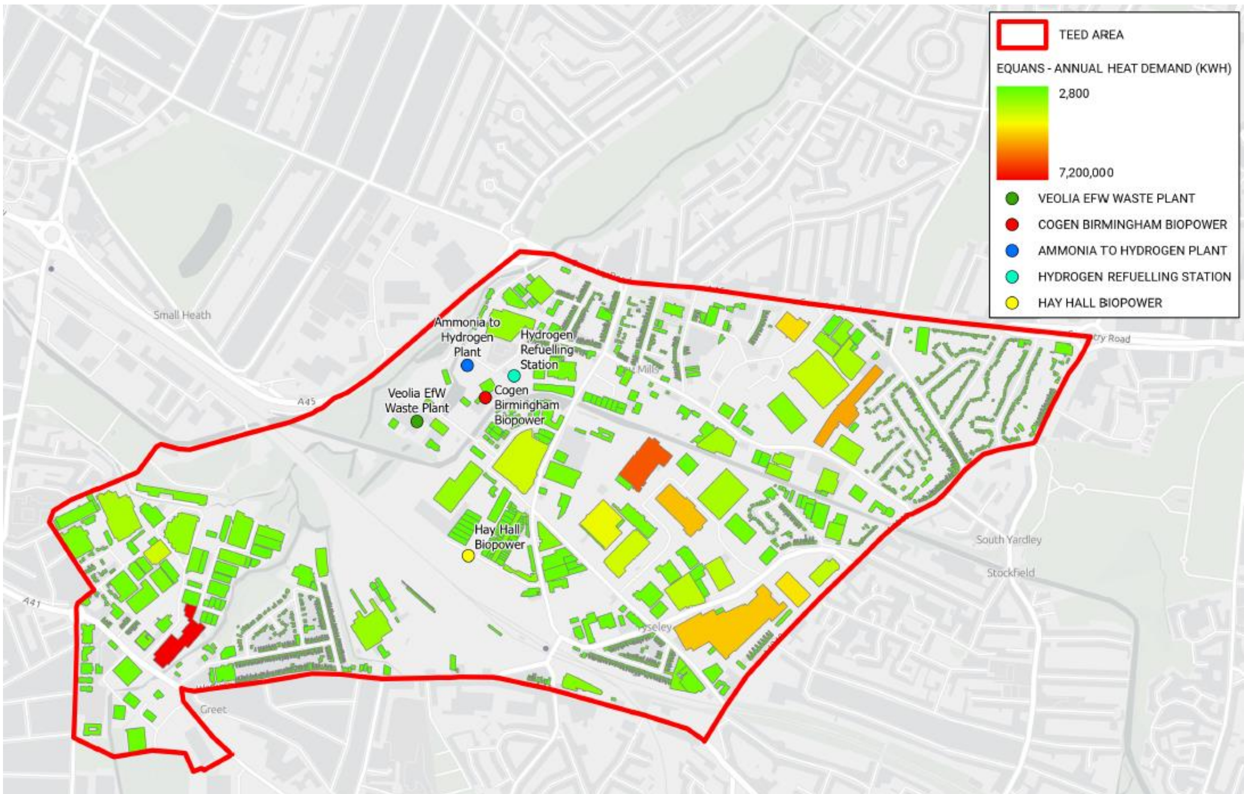


Figure 7: TEED Heat Demand Map

2.3.2 Power Demand

2.3.2.1 Annual Demand

Buildings' annual and peak electricity demands were calculated using publicly available benchmarks, i.e. *BSRIA's Rule-of-thumb Categories*[3] and *CIBSE's Energy Benchmarks* [4] , as well as benchmark figures agreed by the consortium and outlined in more detail in Annexes C and D. Demands were calculated by applying the relevant benchmark to each building's respective floor area.

Dwelling's peak electricity demand were calculated differently, by assuming 5.5kW per dwelling, as indicated by BRIA's Rule-of-thumb Categories.

The 'TEED Polygons with Hnz Data' spreadsheet provided buildings' surface area and number of floors. This spreadsheet also provided buildings' use class in the majority of cases (2,067 out of 3,288 buildings).

Where a building's use class was not provided, this was determined using the assumptions listed in Table 1, which were agreed with the consortium.

A number of buildings were excluded from the electricity demand calculations:

- Any building with a surface of inferior or equal to $30m^2$;
- Any domestic building located in commercial zone 1 and commercial zone 2

2.3.2.2 Profiling

The power demand for the two zones, and for the areas (non-domestic or domestic) have been defined using hourly profiles for either domestic or non-domestic customers derived from EQUANS experience. Seasonality of the power load has been disregarded for the purpose of this exercise, as it is not considered significant.

The assumed daily power profiles for domestic and non-domestic zones are shown in Figure 8.

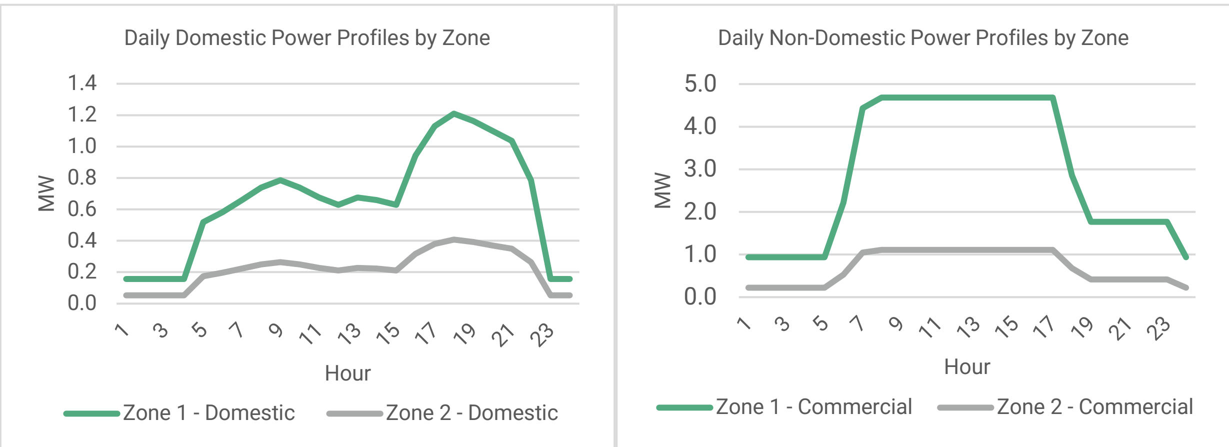


Figure 8: Daily Electricity Profile for Domestic (on the left) and non-Domestic (on the right) Zones

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[3] Hawkins, Glenn/BSRIA (2011) *BG 9/2011 Rules of Thumb*, 5th edition
[4] The Chartered Institution of Building Services Engineers (2008) *TM46 Energy Benchmarks*

2.3.2.3 Periodic Demands

The overall annual power demand for the TEED area was estimated in the order of 79GWh.

The annual power demand associated with non-domestic areas, within both Zone 1 and 2, was estimated in the order of 64GWh.

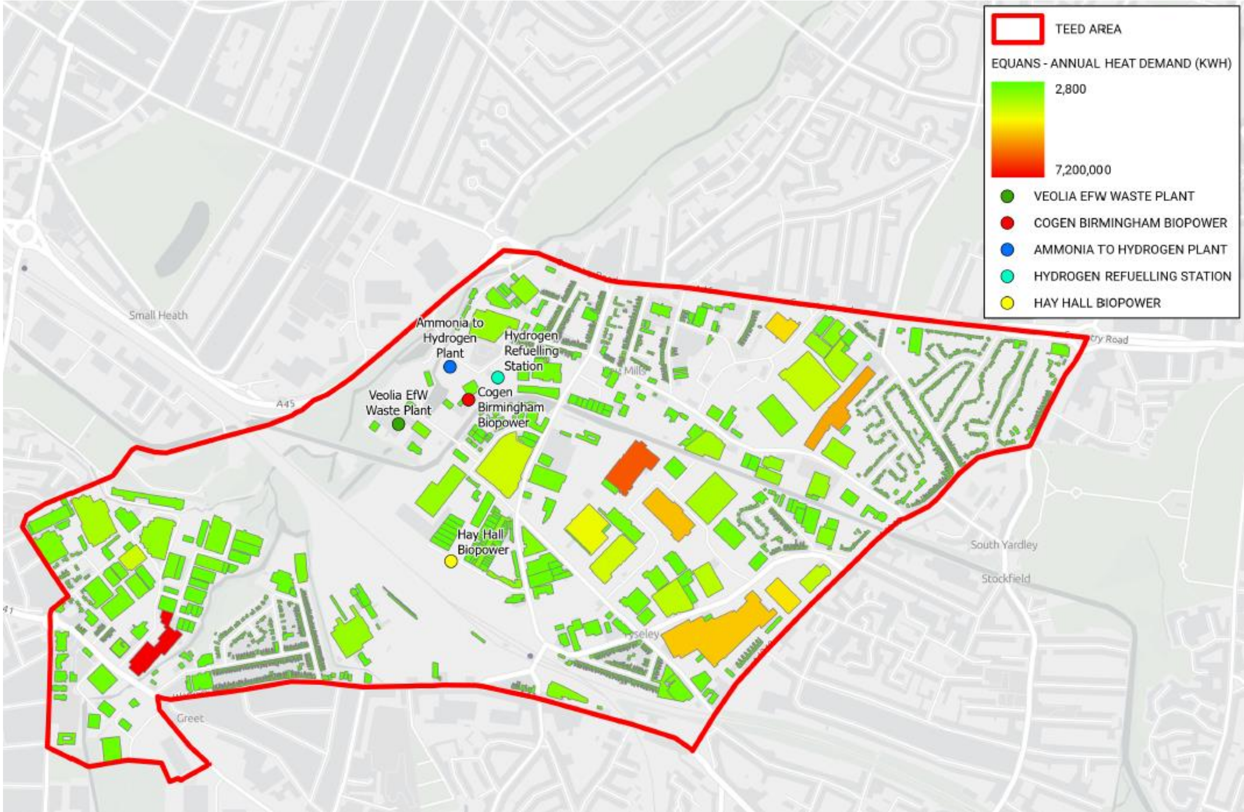
The annual heat demand for domestic areas, within zone 1 and 2, was estimated in the order of 15GWh.

The estimated thermal demands for all the periods being analysed (winter and summer), and for all sub-areas is shown in Table 2.

Time Period	Node Name	Period Demand (MWh)	Average Day Demand (MWh)	Peak Day Demand (MWh)	Hourly Peak (MW)
Winter	Non-Domestic Zone 1	25,848	71	71	4.68
	Non-Domestic Zone 2	6,124	17	17	1.11
	Domestic Zone 1	5,694	16	16	1.2
	Domestic Zone 2	1,920	5	5	0.4
Summer	Non-Domestic Zone 1	25,848	71	71	4.7
	Non-Domestic Zone 2	6,124	17	17	1.1
	Domestic Zone 1	5,694	16	16	1.2
	Domestic Zone 2	1,920	5	5	0.4

Table 3: Periodic Power Demands for all Zones

2.3.2.4 Power Demand Map



A power demand map for the area is provided in Figure 9.

Figure 9: TEED Power Demand Map

2.3.3 Transport Demand

Demand for transport miles have been modelled independently in Zone 1 and 2 and grouped by vehicle type; car (domestic), Non-domestic (Light Goods Vehicles) and Heavy Duty Miles (Heavy Goods Vehicles). To determine transport demand in each zone, the Department for Transport daily traffic count data for each vehicle type has been multiplied by road length (within the TEED area) to characterise mileage demand in each zone for a defined primary road. Kings Road in Zone 1 and Warwick Road in Zone 2. This provides a forecast for transport miles for each of these vehicle types.

For the purpose of modelling, we have assumed demand to be non-seasonal and split equally between summer and winter. Based on the type of charging behaviour amongst non-domestic (predominantly off-peak demand) and domestic vehicles (predominantly peak demand) we have assumed no peak demand over a 24-hour period.

Time Period	Node Name	Period Demand (Miles)	Average Day Demand (Miles)
Winter/Summer	Car Miles Zone 1	826,404	4,528
	Car Miles Zone 2	4,402,196	24,122

	Non-domestic Miles Zone 1	180,306	988
	Non-domestic Miles Zone 2	660,329	3,618
	Heavy Duty Miles Zone 1	30,051	165
	Heavy Duty Miles Zone 2	110,055	603

Table 4: Periodic Transport Demands for all Zones

2.4 Existing and Planned Energy Generation Plants and Waste Heat Sources

This section outlines the existing energy generations plants in the Tyseley area, including generation of waste heat from cooling processes.

The location of each energy source is shown in Figure 10, and a short description of each is provided within the following sub-sections.

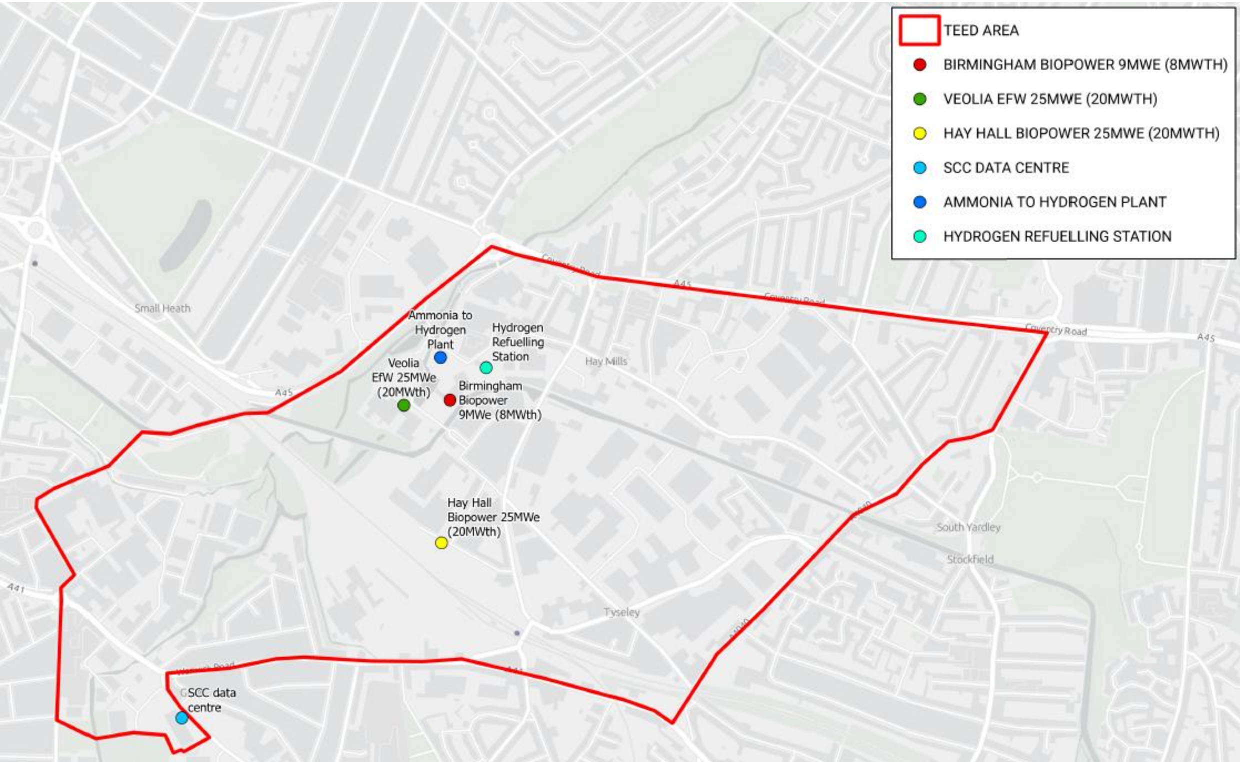


Figure 10: Locations of Existing and Planned Energy Generation Plants and Waste-Heat Sources

2.4.1 Veolia EfW

The existing Veolia's EfW power plant process approximately 350,000 tonnes of waste per year. The power plant has a power capacity of $25MW_e$ and operates with an availability of c. 80%, with a major shutdown each spring. Currently no heat is being extracted from the EfW.

Based on our understanding of the Tyseley EfW plant, we believe that there are low impact/cost options for extracting heat from Tyseley to feed a heat network including:

- Extract from a bleed on the high-pressure steam header, which could potentially enable the extraction of about 50MWth of heat though it would reduce the power generated by about 1MW for each 3.5MW of heat extracted;

- Recover low grade heat from the steam turbine condenser, which is likely to have a temperature between 35°C and 40°C.

It has been assumed that the plant will be decommissioned in 2030.

2.4.2 Gravis Birmingham Biopower

The existing Cogen 10MW$_e$ waste wood biomass gasification plant processes 72,000 of waste wood. The power lead plant enables 1 MWe private wire connections to the Horsfall and Webster industrial plant and other local industry. Currently no heat is being extracted from the EfW.

We understand that theoretically heat could be extracted:

- From "breaking" into existing turbine extraction ports or exhaust, though this option will likely lead to expensive heat, low capacity, and significant challenges to understand impact on process/turbine operation and warranties;

- From low grade heat recovery from air cooled condenser, which is understood to have a temperature in the order of 40°C.

It is understood that the availability of the plant is in the order of 80%, and that the economics of the plant rely on the ROC contract which expires in Jan 2036, which could potentially lead to the plant ceasing operation at this point.

2.4.3 Hay Hall Cogen Biopower

The planned Hay Hall waste-gasification plant is understood to be capable of processing 277,000 tonnes per year with a capacity of 25MW$_e$.

It is assumed that the power plant will be designed to be CHP ready, being capable of providing a thermal capacity of 8MWth if power capacity is reduced to 21MW$_e$.

In addition, it is expected that a large volume of low-grade heat would be available from the steam turbine condenser.

Whilst timescale for the development of this plant is not clear, we have assumed that the plant would be in operation by 2035.

2.4.4 SCC Cole Valley Data Centre

Based in Birmingham, SCC-owned Cole Valley DC1 offers over 2,400 m² of Data Centre white space over five Data Halls.

Cooling within the Data Halls is delivered via hot/ cold-aisles arrangement or through cold-aisle contained pods. Data hall cooling units are provided at varying levels of redundancy (N+1, N+2) based on customer demand.

A chilled water service is deployed throughout the Data Halls with multiple chiller units presented in a N+1 redundant configuration. The total site cooling capacity is understood to be 3.4MW at N+1.

Theoretically low-grade heat would be available from cooling processes and SCC expressed interested in being involved in the Project.

2.4.5 Motive fuels – Electrolysis and hydrogen refuelling station

Tyseley Energy Park is home to Motive Fuels' largest hydrogen refuelling facility and is capable of producing 800kg/day of hydrogen for mobility applications. The facility has on-site electrolytic hydrogen production, compression and storage, as well as a hydrogen refuelling station.

Hydrogen is produced on site using a 3MW Motive Power Proton Exchange Membrane (PEM) electrolyser, which splits water into hydrogen and oxygen. The hydrogen is dispensed at 700bar and 350bar allowing it to cater for different mobility and off-grid hydrogen applications.

The facility was opened in 2021 and is currently used to refuel Birmingham's buses as well as other private vehicles.

2.4.6 Ammonia Cracker

The Ammogen project is an innovation project located at the Tyseley Energy Park which is currently under construction. The project is being developed by a consortium consisting of Germsev, Tyseley Energy Park, University of Birmingham, H2SITE, Yara and EQUANS and is supported by the Department of Energy Security and Net Zero.

The project will demonstrate how Ammonia (NH_3) can be cracked into Nitrogen (N_2) and Hydrogen (H_2). The nitrogen will be safely vented to the atmosphere and the hydrogen will be used for local mobility applications.

This innovation project will demonstrate how hydrogen can be stored and transported in the form of Ammonia before being reformed back to hydrogen at the point of use. Ammonia has a higher volumetric energy density than hydrogen and is a leading option for transporting hydrogen over long distances.

The project is expected to be commissioned in December 2023 and will produce up to 200kg/day of fuel cell grade hydrogen making it the world's largest and most efficient ammonia to hydrogen conversion unit of it its kind.

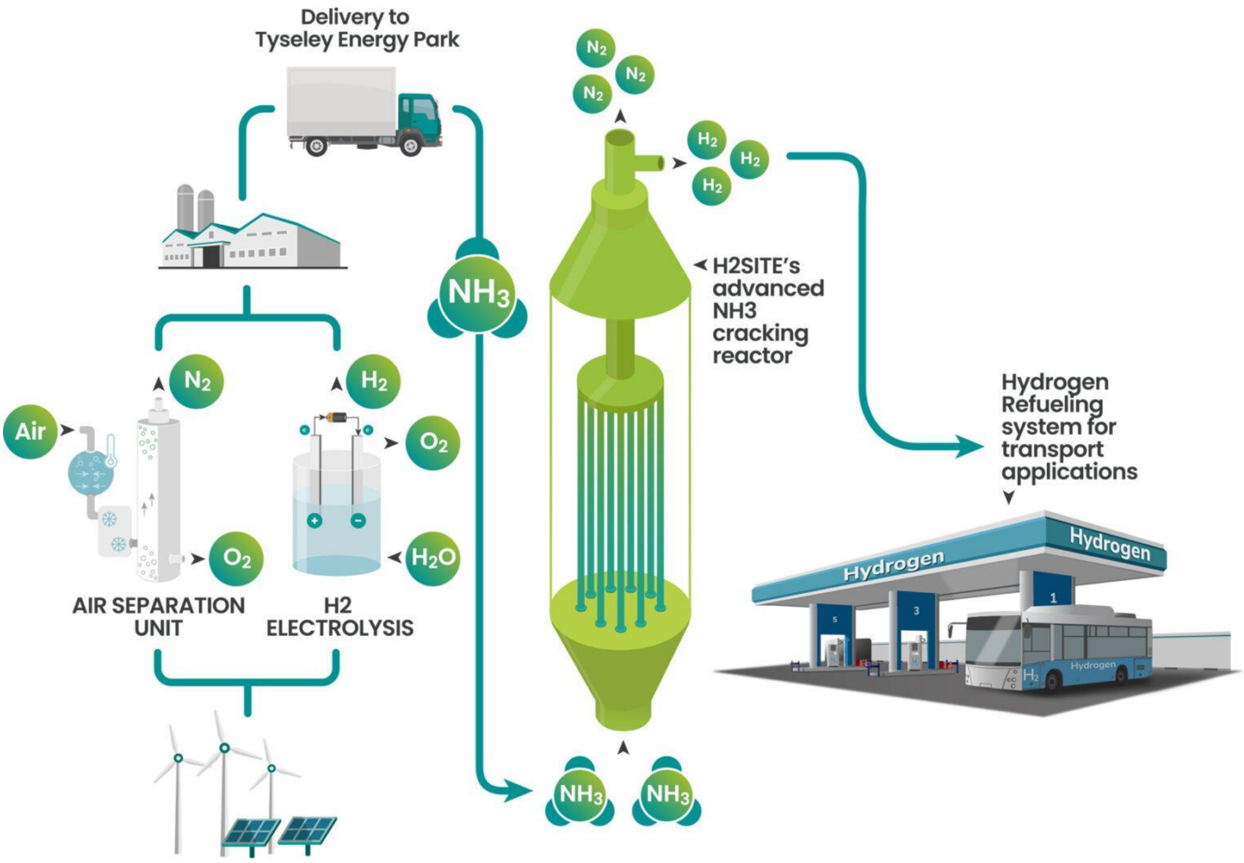


Figure 11: A representation of the Ammogen Project

2.4.7 Grid generation

As described in section 1.3, the two zones within the TEED area are currently connected to two primary substations (132kV/11kV) Sparkbrook and Boughton Road where the total installed capacity for the area is 106.88MVA and 89.23MVA respectively.

The majority of the generation is provided by Sparkbrook with an installed capacity estimated at 81MVA while Boughton Road provides approximatively 12MVA to the area.

Based on the "WPD Best View" Distribution Energy Future Scenarios (DEFS) and the current planning tools used by National Grid Energy Distribution (NGED), the area has a robust network with 17.22MVA and 5.7MVA spare capacity available for the TEED area from the Sparebrook and Boughton Road Primary respectively. The substations will only require reinforcement in 2028 and 2033. Therefore, the consortium assumed that no costs would be incurred for line reinforcement regardless of whether works would be required at the primary substation level (controls and transformer).

To establish the spare capacity, the build capacity of each distribution substation in the area was added together and divided by the total build capacity of each substation downwards of the respective primary substations. This enabled to establish a percentage of the total installed capacity at the primary substation level and subsequent spare capacity. This approximation does not account for diversity of loads across the network.

2.4.8 Other

Many of the current waste heat sources, including the Veolia and Birmingham Bio plants, have a likely life length shorter than needed to support the economics of the infrastructure to capture and use their waste heat (a heat network). TEED area has valuable land close to the city and energy demands. There could be significant value for the local area and city in designating the land currently used for waste processing for future plants that provide a continued supply of low/net zero heat to the surrounding built environment. This could result in co-location of generating plant such as EfW treatment, data centers and potentially industrial uses to keep as much of the energy generated in the system. Industrial uses could also benefit from the local production of hydrogen through electrolysis which could in turn support the heat energy system through the supply of additional waste heat.

This type of approach would be a move into the direction of a circular economy and closed energy system. From a Net Zero carbon perspective the residual carbon form EfW and biomass energy generation would need to be considered. As technologies develop, solutions that would minimise the carbon emitted could be installed such as EfW gasification and/or carbon capture. Innovation in Carbon Capture, Utilisation and Storage for EfW plants is a key focus of the industry and the technology is being developed. There is the potential for small scale capture technologies linked to the aggregates sector with the carbon being utilized in aggregate recycling to be implemented at TEED. This type of solution would provide additional circular economy benefits.

The approach of developing a heat network with low grade waste heat will enable flexibility in future heat sources. In addition to the sources already identified, heat recovery from water sources, such as the canal, and from smaller industrial sources such as the local concrete production on Tyseley could be considered.

To give greater certainty that the heat network could be developed for continued life beyond the end of the current EfW contract, TEED and Birmingham City Council should look to allocate land and develop strategies to support this, to prover business case certainty to any infrastructure investment.

2.5 Potential Investments in Additional Technologies

This section outlines the potential solutions that have been investigated using the Decisio software.

2.5.1 Heat Networks

The development of heat networks has been considered as a potential solution to decarbonise the Tyseley area.

This option could enable the decarbonisation of the area, whilst limiting the investment requirement to reinforce the electrical grid, due to the large presence of waste heat or low-cost low-carbon heat from existing and planned power plants in the area.

Decentralised solutions are generally most cost effective in areas with high heat density and, for this reason, this option has only been explored within the two non-domestic areas east and west of the railway and only as two separate heat networks. This is due to the high capital costs expected to cross natural (e.g. canals) and infrastructural (e.g. the railway) barriers that are between the two areas, however further investigation would be required to establish the case for a single heat network serving the non-domestic areas in Zone 1 and 2.

Indicative routes for the heat networks serving the two areas are shown in Figure 12.

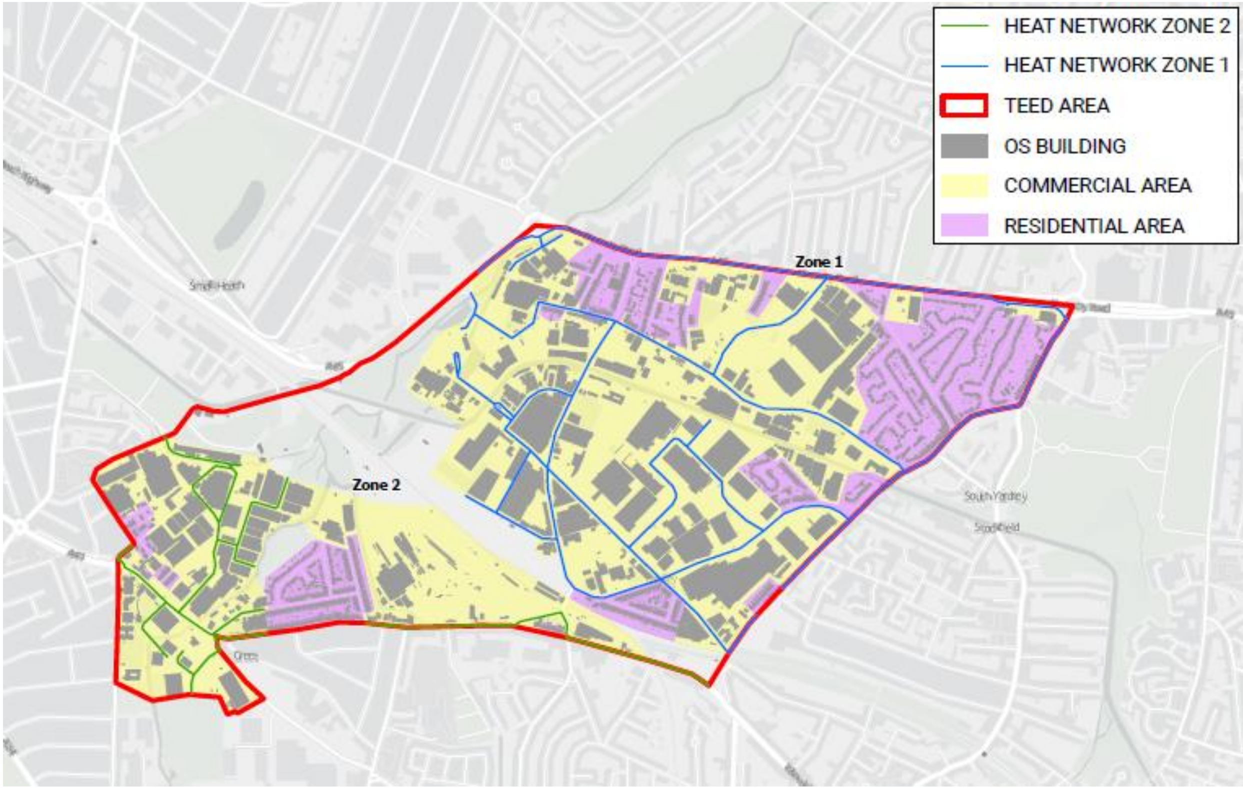


Figure 12: Indicative Heat Network infrastructure within the commercial areas in Zone 1 and 2

As outlined in section 2.4, there are a number of opportunities to access either:

a. waste heat (low-grade heat at approximately 40˚C) or

b. to extract heat by sacrificing power generation (high-grade heat) from power plants.

Depending on the nature of the heat (low-grade or high-grade), three technical solutions could be implemented, which are described below and have all been considered for the purpose of this study.

A thermal store has been considered for the three options to facilitate peak-shaving and reducing the requirement for reinforcement of the electrical grid.

2.5.1.1 Option 1 - Low-Grade Heat Distributed at High Temperature

This option, illustrated in Figure 13, would recover low-grade heat from existing and planned sources, which would then be transmitted to a local energy centre developed in proximity to the heat source. The energy centre would then boost heat to a temperature suitable to supply buildings in the Tyseley area without the need to retrofit heating systems withing the end-consumer premises.

High-grade heat, where available, could be exported to Birmingham city centre to facilitate its decarbonisation without the need to retrofit heating systems within the town centre buildings.

Low-grade heat could be recovered by the existing data centre within zone 2, whilst there are a few existing and planned low-grade and high-grade heat sources within zone 1.

Under this option an energy centre of approximately 22MW$_{th}$ and 9MW$_{th}$ would be required to serve the non-domestic areas within zone 1 and zone 2 respectively.

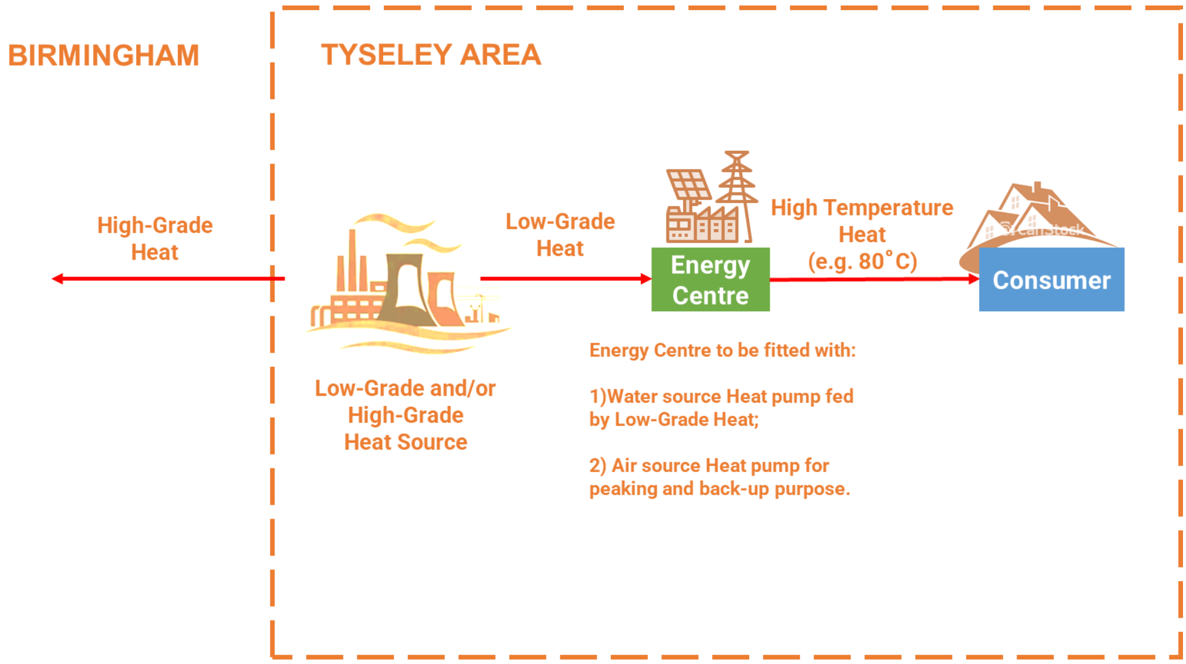


Figure 13: Heat Network Option 1 Illustration

2.5.1.2 Option 2 - Low Grade Heat Distributed at Low Temperature

This option, illustrated in Figure 14, would recover low-grade heat from existing and planned sources and distributed locally. Consumers would be fitted with water-source heat pumps to boost the temperature to suit the operating temperature of individual building heating systems.

A local energy centre of smaller scale than option 1 may also be developed for peaking and back-up purposes. A detailed energy model would be required to establish the need for, and the size of the energy centre, though for the purpose of this study it was assumed that this would be sized to the average annual load of the area it serves. Therefore, the energy centre capacity required was assumed to be approximately 9MW$_{th}$ for zone 1 and 4MW$_{th}$ for zone 2.

As per option 1 high-grade heat, where available, could be exported to Birmingham city centre to facilitate its decarbonisation without the need to retrofit heating systems within the town centre buildings.

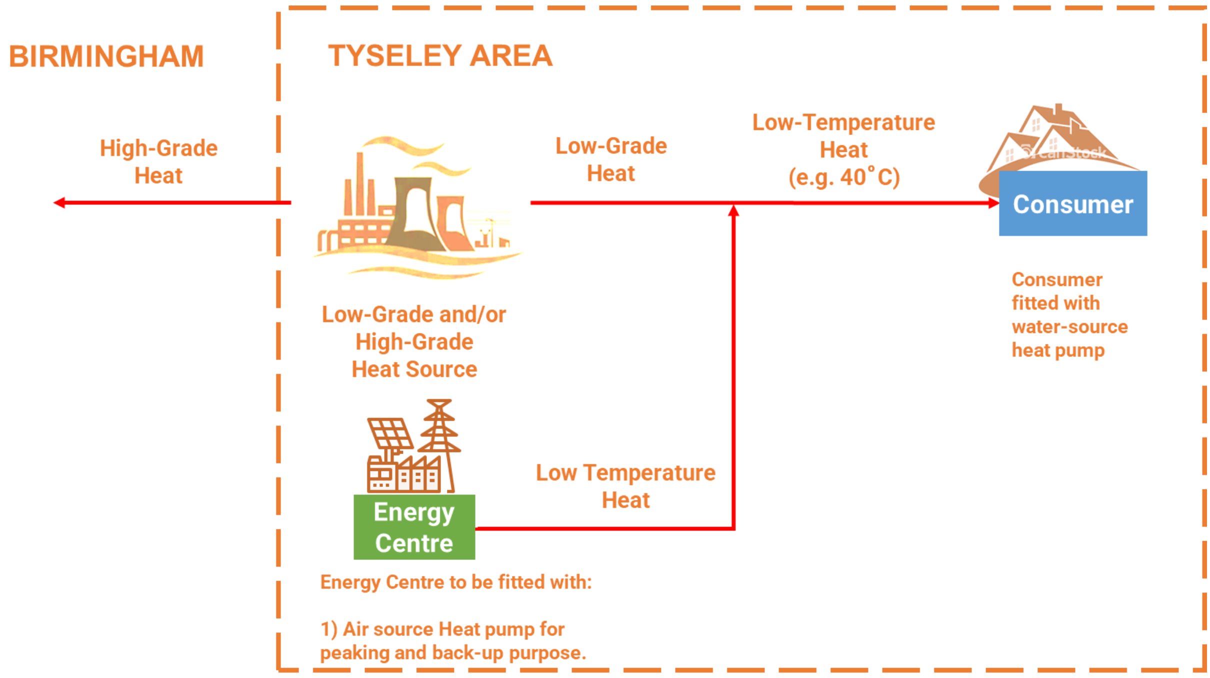


Figure 14: Heat Network Option 2 Illustration

2.5.1.3 Option 3 - High Grade Heat distributed at High Temperature

This option, illustrated in Figure 15, would recover high-grade heat from existing and planned sources and distributed locally at a temperature suitable to serve the existing building heating systems.

A local energy centre may also be developed for peaking and back-up purposes. A detailed energy model would be required to establish the need for, and the size of the energy centre, though for the purpose of this study it was assumed that this would be sized to the average annual load of the area it serves. Therefore, the energy centre capacity required was assumed to be approximately $9MW_{th}$ for zone 1 and $4MW_{th}$ for zone 2.

As per option 1 and 2 high-grade heat where available, and in excess of the Tyseley demand, could be exported to Birmingham city centre to facilitate its decarbonisation without the need to retrofit heating systems within the town centre buildings.

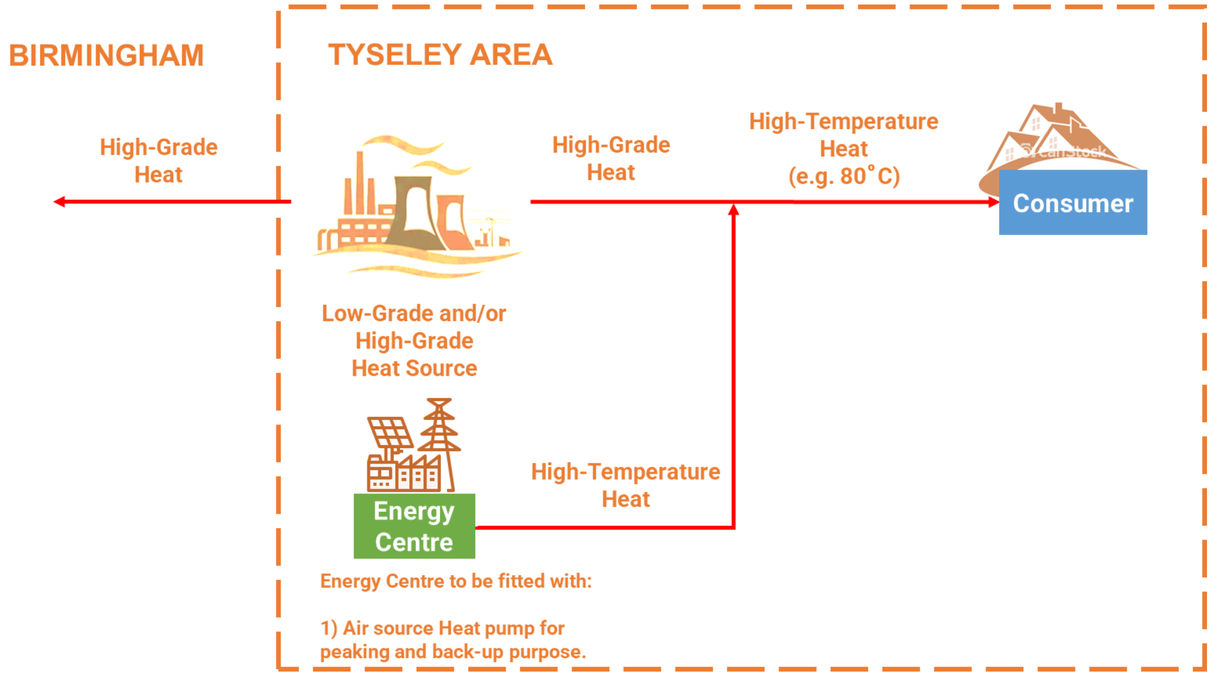


Figure 15: Heat Network Option 3 Illustration

2.5.2 Individual Heat Pumps

The thermal demand within each zone could also be decarbonised by installing air source heat pumps in individual buildings, as opposed to a decentralised solution (i.e. heat networks). This solution is coupled with retrofit of building to ensure the bills of households are protected against the increased cost of electrified heat.

These could potentially be coupled with solar photovoltaic panels installed on building roofs (see section 2.5.5) and batteries to limit the need to reinforce the electrical grid as a result of heat being electrified.

Within the Decisio model, this option has been compared to other solutions in both domestic and non-domestic areas within zone 1 and 2.

2.5.3 Electrolysis

Electrolysis is the process of converting water (H2O) to hydrogen (H2) and oxygen (O2) using a technology called an electrolyser. When the electrolyser is powered by renewable electricity, then the resulting hydrogen is deemed to be zero carbon.

Hydrogen is poised to play a central role in the UK's zero carbon transition and DESNZ estimates that it will account for 20 – 35% of final energy demand by 2050. Primary use cases are expected to be within industry and heavy transport, alongside potential uses for space heat and power generation/flexibility. However, the prevalence of hydrogen will vary significantly across the country with more use expected around the coastal industrial clusters.

Given TEED's location, it is unlikely that hydrogen will be directly supplied to homes, therefore this use case was excluded from the analysis. Industrial process heat was also excluded from the analysis and long duration hydrogen storage / flexibility services was also excluded due to the lack of existing or planned renewable generation within the area.

For these reasons, the only modelled offtake for hydrogen was in transport applications. Should there be any demand for hydrogen in transport, the waste heat from electrolysis (roughly 80°C) could potentially be scavenged for district heating applications.

2.5.4 Waste Gasification

An emerging solution for the treatment of municipal solid waste (MSW) is waste gasification. Waste gasification involves the gasification of waste into syngas which can be further treated to produce hydrogen. Increasingly, this is being regarded as a 'higher value' and more sustainable use of MSW than Energy from Waste. That said, it is still a nascent technology with technological risk and an unclear path to commercialisation (waste gasification is not currently eligible for hydrogen production support through DESNZ hydrogen business models process). In our analysis, the model was allowed to decide between keeping the EfW or developing a waste gasification solution on the site.

2.5.5 Solar PV and Batteries

To provide additional generation across the area, Solar PV and battery has been assumed to be an option both for household and industrial buildings. This would reduce the overall import need of the area in turn reducing reinforcement costs, reducing costs of household bills and providing real zero carbon electricity. It was assumed that about 40% of all roofs would be able to support PV on their roof accounting for only 3 out of 4 directions being suitable and only 50% of all roofs being able to support the structure specifically for warehouse type buildings.

Within our model, this option has been compared to grid import.

2.5.6 Building Fabrics Retrofit

The overall heat demand of the area as well as the household bills can be significantly reduced by improving the fabric of the domestic houses. Retrofitting the fabric of the house include measures like window and door replacement, loft insulation and external wall insulation. Installing heat pumps, solar PV and batteries in parallel provides the biggest impact in terms of carbon and bill reduction for the inhabitant.

The average heat demand of a building is currently estimated at 145kWh/m^2/year in the UK reducing this down to 90kWh/m^2/year approximatively equivalent to EPC C or 50 kWh/m^2/year approximately equivalent to EPC A could reduce the heat demand by 25% and 43%. This has the potential to reducing carbon and bills assuming 2/3 of energy consumption is linked to heating.

2.5.7 Green Mobility Solutions

Considering the types of EV demand across each zone, both non-domestic (LGV/HGVs) and domestic vehicles, there is an opportunity to reduce grid reliance using a smart load balancing system based on variable charging times and speeds across zone areas. Lower power charging solutions may be suitable to meet demand for commercial EV fleets during off peak hours when wider reliance on the grid is less intensive. During peak hours, peak demand via public charging could be offset via a smart load balancing system by integration with lower power fleet charging networks.

2.6 Carbon Emissions

The analysis done by University of Birmingham provided a Baseline Sankey Diagram that outline MWh and CO2-emissions per sector. This provided the baseline CO2-emissions for gas at 0.18kgCO2e/kWh and for electricity at 0.16kgCO2e/kWh. This was extrapolated using the efficiencies of the different technologies.

For the energy from waste wood the emissions were estimated at 0.233 kgCO2e/kWh[5] while emissions from Municipal wastes were assumed at 0.110kgCO2e/kWh[6].

The project assumed that the EfW emissions could not be compensated and could not be reduced beyond the minimum for the operation of the EfWs. As can be seen in Figure 16 emissions can therefore not be reduced beyond the emission of the EfW online at any one point. For electricity the emissions were assumed to reduce to net zero by 2035 linearly from 2021 onwards.

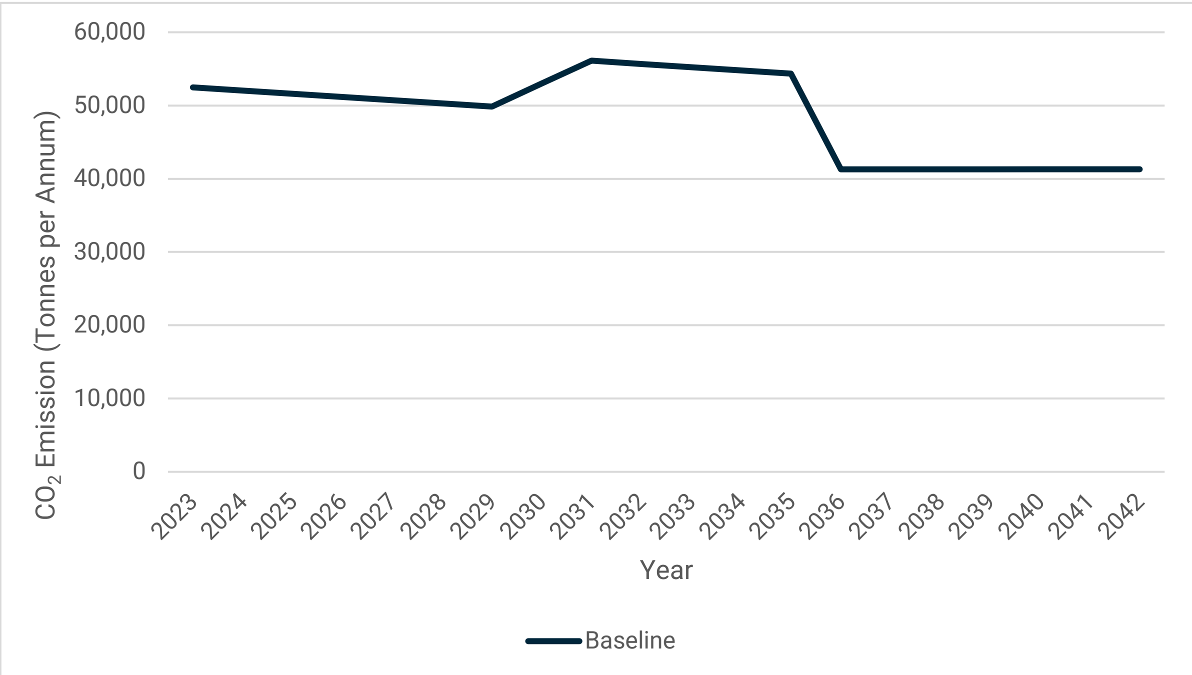


Figure 16: Baseline Carbon emission

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[5]https://impactful.ninja/the-carbon-footprint-of-biomass-energy/#:~:text=Biomass%20energy%20has%20the%20fourth,on%20a%20life%2Dcycle%20basis, June 2023

[6] https://eprints.kingston.ac.uk/id/eprint/35228/#:~:text=The%20greenhouse%20gas%20emissions%20from,the%20partial%20co%2Dmingled%20model. June 2023

RECOMMEDED SOLUTION

3.1 Modelling

A model was carried out to identify the optimal energy solution for the TEED area using BMA's Decisio^{TM}, a Decision Intelligence Platform that specialises in helping navigate a profitable transition to resilient, low-carbon business models with proven AI-assisted decision-making. Decisio^{TM} is a robust platform that is already used by many utility companies across water, energy and materials value chains to optimise their own end-to-end systems and is unique in its ability to support data-driven whole systems modelling and mass scenario analysis in a user-friendly and collaborative environment. Specifically with regards to this study, Decisio^{TM} enabled:

- The optimisation of the whole Tyseley energy system, simultaneously for heat, power and transport energy demand, so as to identify the lowest whole-life cost Net Zero pathway and minimise grid reinforcement.

- A top-down / bottom-up optimisation of the energy systems, for which demand was modelled at a granular local level, and reconciled with whole system (e.g. national) supply and transmission capabilities. For the Tyseley area, it enabled the simultaneous modelling of Zone 1 and 2, which had variable connectivity across the energy vectors.

- A multi energy vector modelling, where demand for energy is vector independent. For example, transport energy demand could be met by multiple energy vectors from oil, electricity, or hydrogen subject to supply availability and the necessary infrastructure investment. This removed the need for the user to arbitrarily decide on the blend of energy vectors to meet demand, for example ratio of BEV to ICE domestic vehicles, and allowed Decisio^{TM} to identify the true optimal.

- The agility to update the analysis as new data become available, providing a platforms that could be issued during the alpha phase of the project, when the study will be refined further.

To do this Decisio™ encapsulates a range of technologies, analytics, methodologies and decision science principles into a single 'processor' that is controlled from a single user interface and that has the security and governance built-in to support the smooth adoption of AI. The model developed during this discovery phase project should be regarded as the first iteration of a whole system model for the TEED area. The model was built in a modular way, allowing the analysis to be refined in subsequent stages of the project as more data becomes available. Furthermore, in future stages, wider engineering, financial and operational aspects of value chain can be incorporated into the model, increasing the technical and commercial robustness of the modelling.

5.1.1. Value Chain Diagram

The baseline demand (outlined in section 2.3), the existing energy generation plants (section 2.4) and the proposed solutions (section **Error! Reference source not found.**) were translated into the D ecisio™ model.

The resulting value chain diagram is shown in Figure 1.

Tyseley Energy Park Value Chain

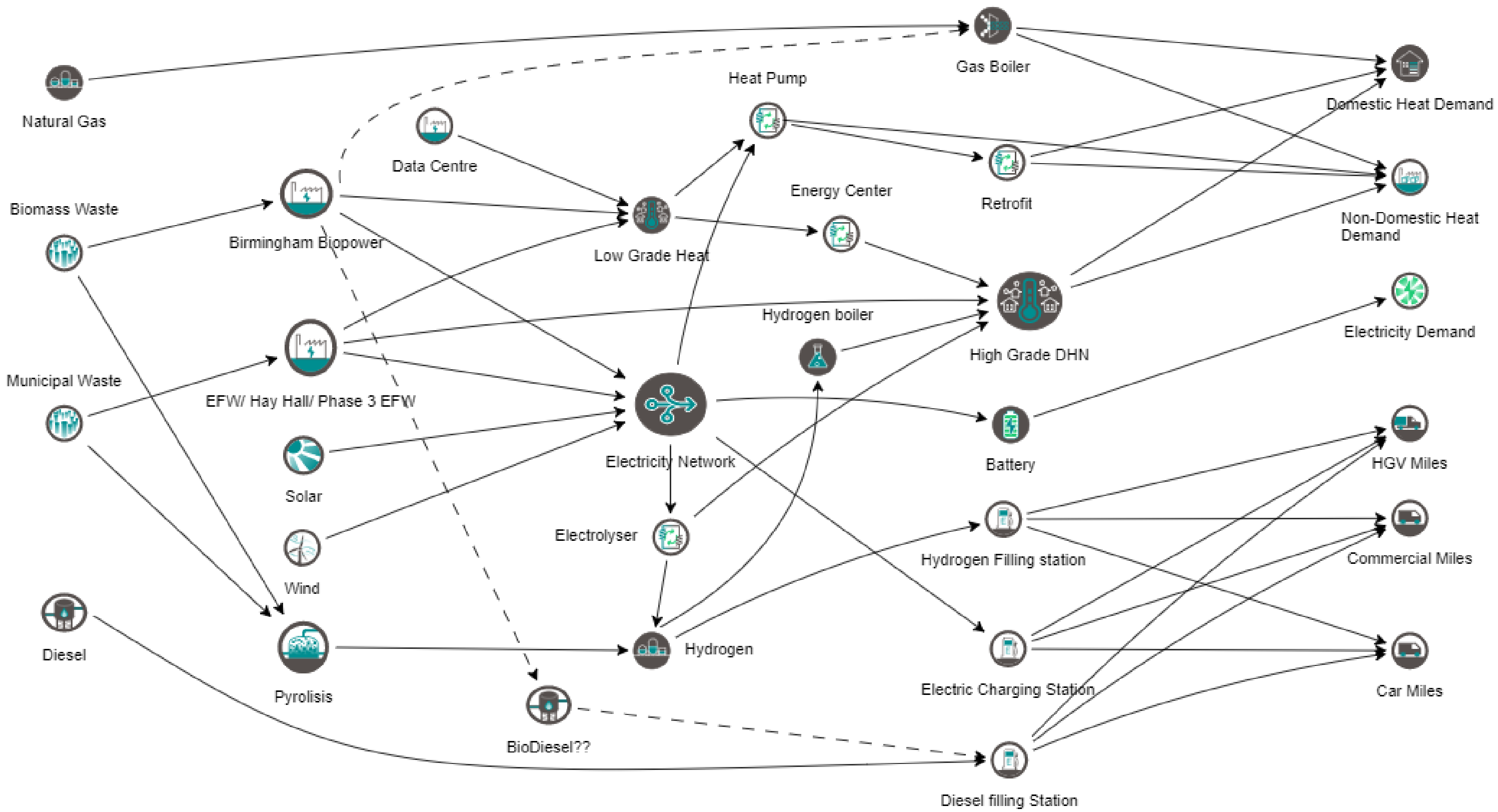

Figure 17: TEED Value Chain

5.1.2. Modelling Key Assumptions

The modelling was carried out so to identify the combination of energy solutions that would minimise:

- Whole-life cost;
- Grid reinforcement requirement and;
- Accelerate decarbonisation within the Tyseley area.

In addition, all energy solutions were modelled in isolation to identify individual KPIs.

With regards to phasing the following assumptions were made:

- The Veolia EfW to be decommissioned in 2030
- The Gravis Birmingham Biopower plant to be decommissioned in 2036
- The Hay Hall EfW to be developed by 2030
- Heat pumps uptake at 5% per year for the first 4 years and then 10% per year thereafter
- 100% electrification of transport [7]

Investment timeline in all other assets were left unconstrained, letting Decisio™ to establish the timeline for investments.

The outcome of the modelling and the optimised solution is outlined in the following section.

3.2 Optimal Solution

Decisio™ was configured to model numerous decarbonisation scenarios, some of which considered vectors in isolation and some of which could be considered a whole systems solution. The model was also configured to consider different scenarios where waste treatment continued at current and forecast rates, and an alternative scenario where waste treatment within the TEED area could be retired. The CO2 emission trajectory for each of these scenarios is shown in Figure 18.

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[7] It is recommended that the potential for hydrogen to decarbonise heavy mobility is analysed in more detail during the alpha stage. No assumption have been made with regard to EV uptake for passenger vehicles

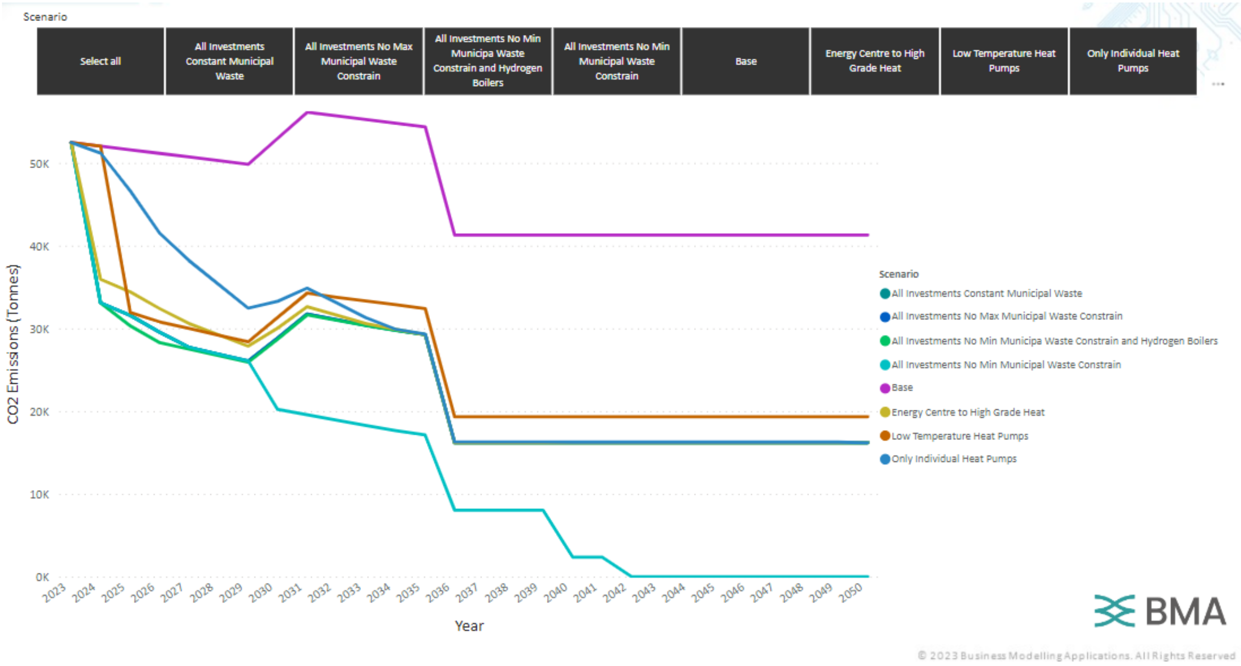

Figure 18 CO2 emissions for modelled decarbonisation scenarios

As can be seen in Figure 18 decarbonisation initiatives that consider one vector (i.e. heating) are able to demonstrate a reduction in overall emissions, however, cannot be considered a net zero scenario as they are discounting emissions in other sectors.

For this reason, an optional overall solution was selected that could be considered a whole systems solution that was able to consider the measures that needed to be implemented to decarbonise multiple different sectors.

The optimal solution was identified as a combination of centralised and decentralised energy solutions, depending on the area, as follows:

I. Within the non-domestic areas of Zone 1, the optimal solution was identified as a heat network fed by low-grade heat available from the Veolia EfW and/or the Birmingham Biopower plants.[8]

II. Within the non-domestic areas for Zone 2, a heat network fed by waste heat from cooling processes from the SCC data centre was identified as the optimal solution. [8]

III. Within residential areas, heat pumps would be installed along with hot water storage tanks. The case for solar photovoltaic on residential roofs, along with batteries would require further investigation during the next phase of the Project.

IV. The option to export high-grade heat from existing and future power plants to Birmingham city centre to facilitate decarbonisation of existing building stocks, should be looked at in greater detail during the next phase of the Project.

[8] A back up plant would be required for maintenance times and down times.

The optimal solution, is described in the following sub-sections, whilst a summary of the energy flows and KPIs for the optimal solution is provided in

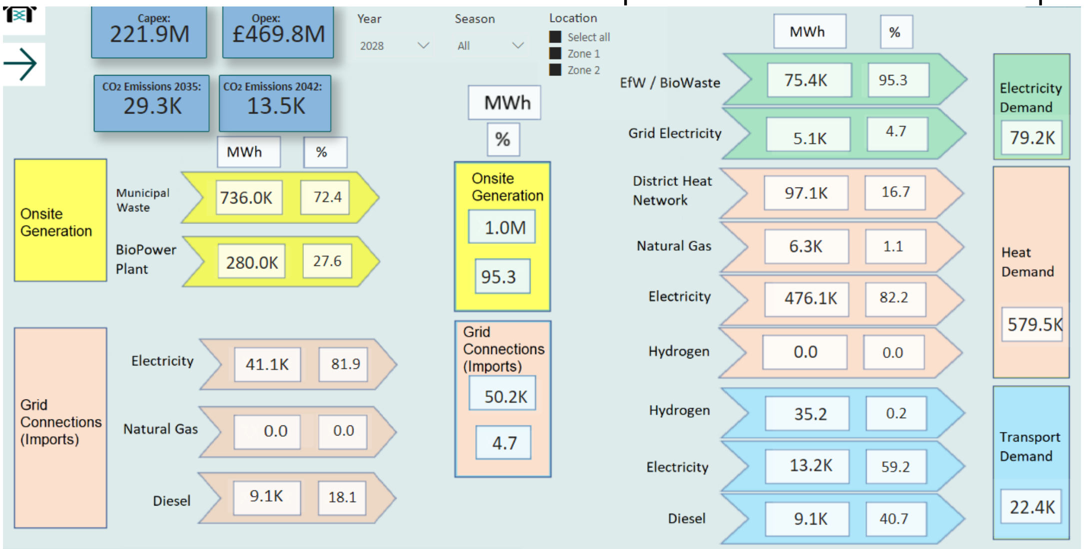

Figure 19,

*Figure 20*Figure 21

Figure 20 for 2028, 2035 and 2042 respectively

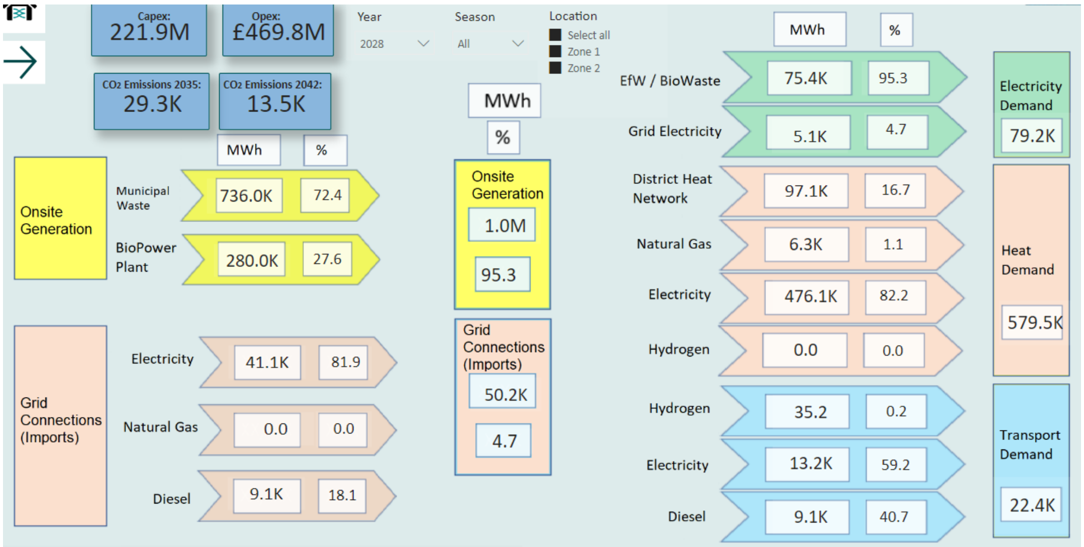

Figure 19: energy flows and KPIs for Optimal Solution (2028)

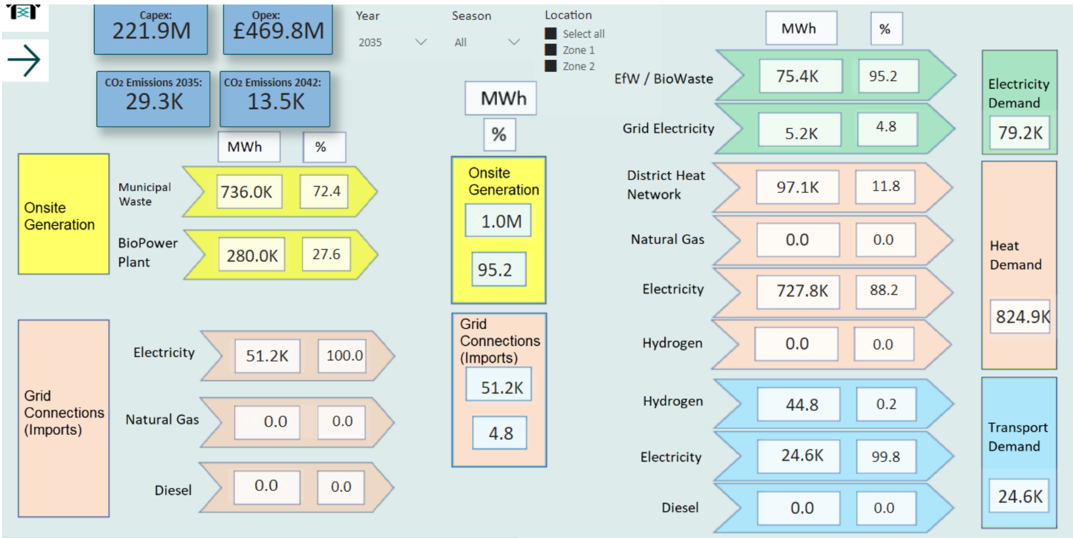

Figure 20: energy flows and KPIs for Optimal Solution (2035)

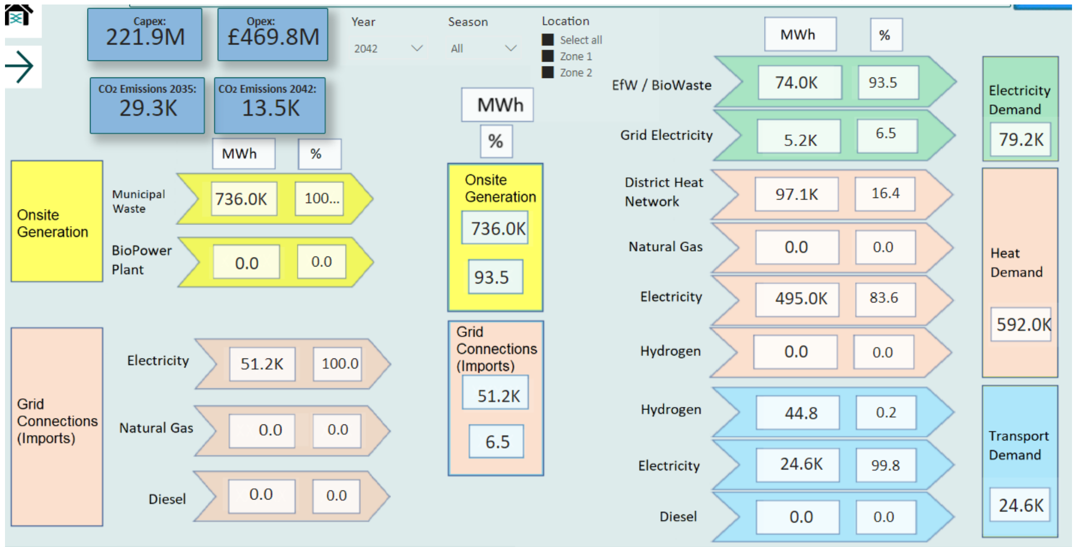

Figure 21: energy flows and KPIs for Optimal Solution (2042)

3.2.1 Heat

With regards to thermal energy, the optimal solution was identified as a combination of air source heat pumps fitted within domestic properties, along with building fabric retrofit, and a heat network within the non-domestic areas.

Among the heat network options described in section 2.5.1, option 2 (low grade heat distributed a low temperature) was identified as the most viable.

In zone 1, low-grade heat would be recovered from the Veolia EfW and or the Birmingham Biopower plants in the short/medium term, or an additional EfW plant, such as the planned Hay Hall Cogen Biopower, in the medium/long term.

In zone 2, low-grade heat would be recovered from the existing SCC Data centre.

In addition, building fabrics of non-domestic buildings would be retrofitted and heat pumps installed within would boost the low-grade heat temperature to suit building heating system requirements.

An energy centre fitted with heat pumps for peaking and back-up purposes along with thermal storage will be developed in both zones.

The thermal store will enable smoothing the thermal peak loads at the energy centres and therefore the electrical load on the grid, preventing/reducing the requirement for grid reinforcement.

Thermal storage would also be installed within domestic properties to smooth the thermal load within the domestic areas.

Finally, high-grade heat from zone 1 would also be exported towards Birmingham city centre to support the council's decarbonisation aspirations, though the carbon and economic performance associated with this have not been included in the analysis.

3.2.2 Power

In relation to power consumption and generation, the existing and planned power plants on site are capable of supplying approximately 95% of the Tyseley demand.

For the purpose of this study, it was assumed that on-site power generation would be used within the Tyseley area. Further, refinement of the modelling would be required to better assess the specific role with regards to household bills and CO_2 for solar PV installed on building roofs and for batteries within buildings.

For the optimal solution, our modelling established that no reinforcement of electrical grid would be required, although further refinement would be required during the next stage of this study. In particularly a half-hourly or hourly modelling resolution would be required to refine this assessment as well as pricing adjustment for solar generation.

3.2.3 Transport

In this stage of the project, it was assumed that transport would be completely electrified to explore if this solution was compatible with the local electricity network. As explained above, no electricity network reinforcement was required, suggesting that full electrification could be technically possible in Tyseley.

However, in reality, there may be some applications in heavy / long distance transport where electrification isn't practical and hydrogen presents the best decarbonisation option. Some bus operators are also exploring hydrogen in more detail based on fuel cycle analysis and experience operation BEVs in extreme weather conditions.

It is therefore expected that some hydrogen refurling will be required in the TEED area, to provide the infrastructure capable of servicing these requirements. It is recommended that potential for hydrogen mobility across the TEED area is explored in greater detail during the alpha phase project where more granular modelling will be possible.

3.2.4 Hydrogen

Despite there being existing hydrogen production and consumption within the TEED area, hydrogen was not selected as a long-term decarbonisation solution. There were several reasons for this:

- Industrial process heat was excluded from the scope of the analysis. This should be examined in subsequent Alpha phase modelling and, if there is significant industrial process heat requirements, this could justify the investment in hydrogen infrastructure to service this demand and that of other sectors.
- A simplistic view was taken on the decarbonisation of transport and fuel duty / specific technical constraints were not modelled. The pathway for transport decarbonisation was purely based on cost optimisation, with some practical considerations excluded. For example, there are certain HGV applications and bus routes that are more likely to decarbonise using hydrogen. However, analysis to this granularity was not possible during a discovery phase project and would be explored further at Alpha.

TEEDs location does mean it is less likely to have large hydrogen deployment that other areas of the UK, however there is likely to be some deployment for transport and potentially industrial applications. This is an area that would be explored in more detail in a subsequent Alpha phase project.

3.2.5 Energy Flows

The Sankey diagrams, illustrating the energy flows for the optimal solution in 2042 is shown in

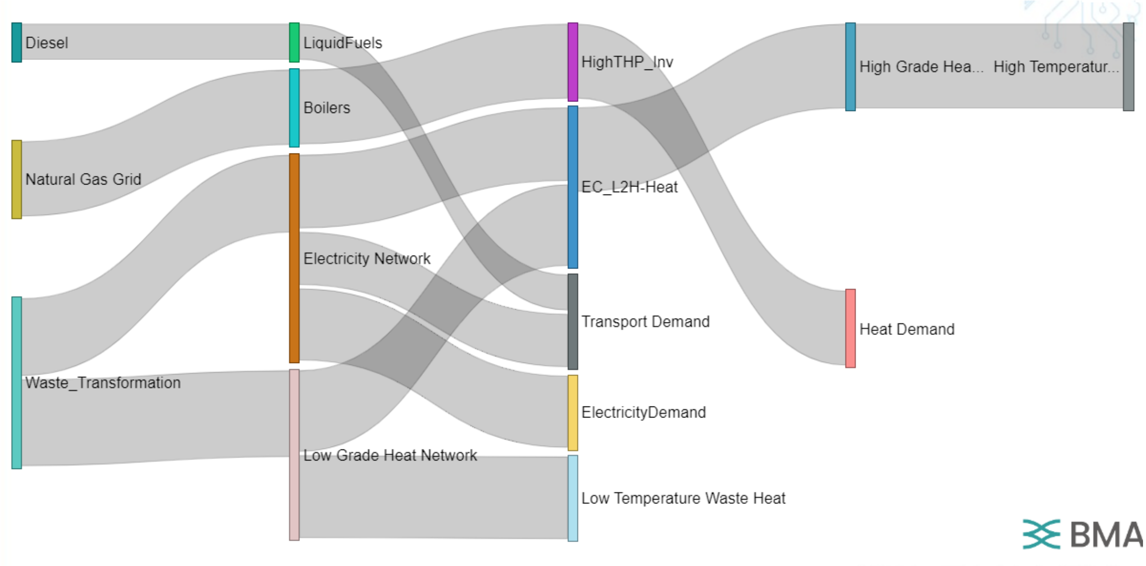

Figure 22.

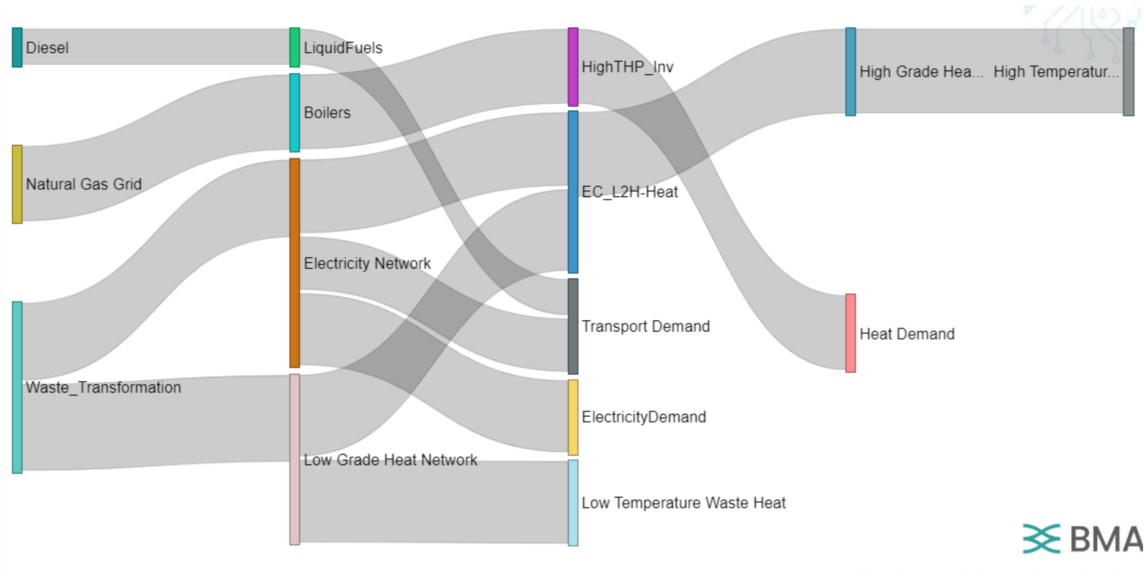

Figure 22: Sankey Diagram for Optimal Solution (2042)

3.2.6 CAPEX

The total CAPEX for the optimal solution was estimated in the order of £229M and includes:

- Development of heat networks, including heat substations and energy centre fitted with heat pumps and thermal storage
- Deployment of heat pumps, including a degree of solar PV and batteries instalation
- Electrification of transport

The CAPEX associated with the Hay Hall EfW has been excluded, on the basis this is already a planned investment.

The CAPEX assessment at this stage is high level and based on costs benchmarks, and further refinement would be needed during the next phase of the project.

3.2.7 Carbon emission

The carbon emissions of the TEED area over the project timeline are shown in Figure 23.

A continuous reduction in CO2 emissions is expected between 2023 and 2030 due to the electrical grid decarbonising and the deployment of heat networks within non-domestic areas, heat pumps within domestic areas, and building fabric retrofit in domestic and non-domestic areas.

An expected increase in carbon emissions in 2030 would be the result of the planned Hay Hall power plant, which was assumed to increase municipal waste processing in the TEED area. It is noted that further refinement is required during the next stage to ensure municipal waste processing capacity in the area is aligned with Birmingham City Council targets and aspirations.

A further reduction in carbon emissions is expected in 2036 when it was assumed that the Birmingham Biopower Plant would be decommissioned.

Whilst the Tyseley area would not become net-zero during this period under the proposed solution as the emissions from the waste facilities will continue regardless how demand is met. It should be noted that:

I. The analysis did not account for any carbon benefit associated with the excess power generation or any high grade heat that would be exported out of the TEED area;
II. Potential for Carbon Capture and Storage (CCS) in the area has not been considered, which could potentially drive further innovation in the area.

It should also be noted that developing a local heat network and a high-grade heat transmission line to Birmingham City Centre would create a technology-agnostic infrastructure which would facilitate the decarbonisation of the TEED area and Birmingham City centre. This is because thermal generation on the site could be easily swapped from energy from waste to zero-carbon technologies in the future.

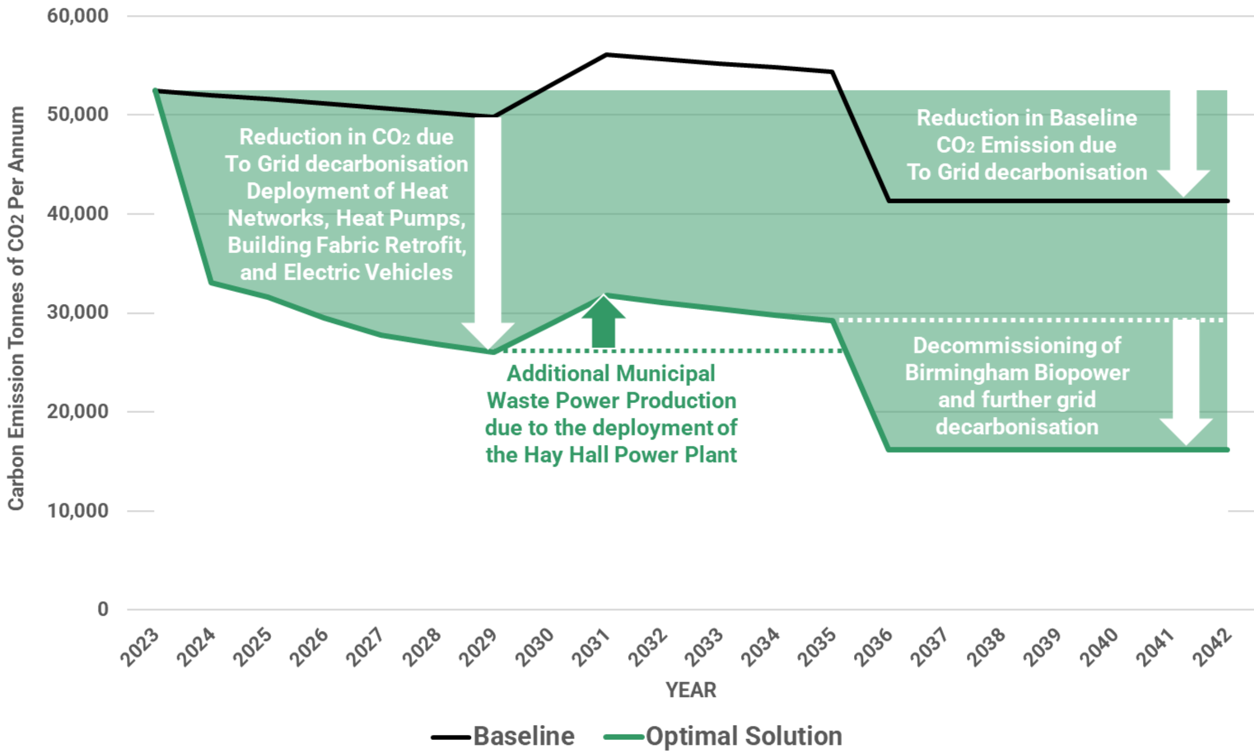

Figure 23: Baseline and Optimal Solution Carbon Emission of the TEED area over the project timeline

3.3 Risk Assessment

It should be noted that the Project is currently at the discovery phase and that there are significant risks that need to be addressed. A better understanding of the risk and further refinement of assumptions and data during the alpha phase of the Project will certainly lead to variations in the optimal solution.

However, the efforts carried out, and the understanding of the TEED area developed during this stage certainly create a basis to build on during the next stage. In addition, the model developed during this stage could easily be refined to accommodate new information and increase resolution.

The key risk currently identified are outlined in the following sub-sections, although this is not a comprehensive list and we expect to refine it during the alpha phase of the project.

3.3.1 Technical Risks

Energy demands were estimated using publicly available benchmarks, and in some cases, buildings use class were identified using assumptions agreed with the consortium and/or following a desktop investigation. In addition, many non-domestic buildings appear to be storage facilities, with potentially low or very low energy consumption. It is crucial that a better understanding of the energy demand in the area is developed during the next phase.

There are significant uncertainties related to energy generation on site, in particular around the magnitude of low-grade heat available in the area. These include not only the Birmingham Biopower and the Veolia Energy from Waste facilities, but also the SCC data centre and the planned Hay Hall facility. Stakeholder engagement would be required to understand local energy generation (electricity, high-grade and low-grade heat) as well as appetite to supply heat to a heat network.

The design of the proposed solution has not been developed sufficiently at this stage. There are a number of risks associated with this, including availability of space for energy centres and thermal storage, planning risks, uncertainty related to CAPEX and OPEX among others.

It is recognised that an hourly model would be most adequate for the purpose of this study, which will be carried out during the next phase of the Project.

3.3.2 Commercial and Legal Risks

Given the existing presence of low-grade heat in both zones, heat networks could be implemented theoretically from inception, although, unless certainty is given around continuity of supply from other sources (such as the Hay Hall Cogen Biopower) it is unlikely that these would attract any investment from the private sector.

In addition, no policy requirements currently exist in the area to remove the risk of buildings not connecting to heat networks (though buildings with high heat demand in the area are expected to be mandated to connect to a network once the UK government heat network zoning policy would come into effect).

CONCLUSIONS & NEXT STEPS

This study investigated options to deploy heat networks, microgrids and mobility within the TEED area, and it is part of the Discovery Phase of the strategic innovation fund, which provides major investments in innovative projects.

During this phase EQUANS:

I. Developed an understanding of the TEED area

II. Carried out a high-level estimate of the energy and transport demands;

III. Identified existing and planned energy generations facilities in the areas, including sources of waste heat;

IV. Consider a number of investment opportunities to accelerate the path towards decarbonisation exploiting synergy across energy systems;

V. Built a modular whole system energy model capable of modelling a combination of possible solutions using the Decisio™ software, powered by AI Assessed that there could be a case for a district heating within high heat density areas within TEED, which could be complemented by heat pumps installed within buildings in areas with low heat density;

VI. Established that the case for decentralised energy systems, such as heat networks, would benefit from investment in the development of low-carbon low-cost heat and power generations, such as energy from waste facilities, in the medium term;

VII. Assessed potential demand reduction through domestic retrofit to enable lower demand as these are not connected to the heat network. In addition to a reduced heating demand impacting the electrically driven heat pumps, Solar PV and batteries were also observed.

VIII. Identified electric vehicles as a potential pathway to decarbonise transports in the area; and;

IX. Evaluated that the proposed solution would minimise the risk for further grid reinforcement in the area.

An optimal solution was identified (points VI To VIII above), although it is recognised that:

a. Whole systems modelling is complicated and a system boundary had to be drawn that was proportionate to this stage of the project. For this reason certain elements were excluded from the modelling (e.g. process heat demand, detailed mobility decarbonisation pathways, hydrogen infrastructure, carbon capture and storage, detailed building fabric retrofit, impact of free or reduced cost pooled SolarPV and battery). These elements would be included in the next phase and the existing analysis would require further refinement, meaning some variations to the proposed solutions are likely.

b. There are significant risks that are to be addressed, including technical, commercial and legal, ranging from data quality to stakeholder engagement and from lack of certainty of future plans for the area (e.g. the planned Hay Hall municipal waste gasification plant) to lack of local and national policy that would require buildings to connect to a heat network.

c. Our analysis around requirement for grid reinforcement would need refinement and a hourly model would need to be developed during the next stage.

d. The case to export high-grade heat from existing and future energy from waste plants to Birmingham city centre has not been evaluated economically or environmentally, though it is believed that this option could provide further benefits and should be explored further during the next stage of the project.

EQUANS will work with the consortium during the next stage to refine the optimal solution and to de-risk the project and develop the design.

ANNEX A — HEAT DEMAND ASSUMPTIONS

Category	Unit	Metric	Source
Bars, pubs or clubs	350 *	kWh/m2/year	Table 1 TM 46 Energy Benchmarks
Houses	88.8	kWh/m2/year	As agreed with the Consortium
Dry sports and leisure facilities	330 *	kWh/m2/year	Table 1 TM 46 Energy Benchmarks
General offices	94	kWh/m2/year	As agreed with the Consortium
General retail	130.6	kWh/m2/year	As agreed with the Consortium
Hospitals: clinical and research	420 *	kWh/m2/year	Table 1 TM 46 Energy Benchmarks
Public buildings with light usage	105 *	kWh/m2/year	Table 1 TM 46 Energy Benchmarks
Restaurants	370 *	kWh/m2/year	Table 1 TM 46 Energy Benchmarks
Schools and seasonal public buildings	122.8	kWh/m2/year	As agreed with the Consortium
Storage facilities	160 *	kWh/m2/year	Table 1 TM 46 Energy Benchmarks

* These benchmarks show gas consumption for the different building use types. These benchmarks were converted to heat demands using a boiler efficiency of 80%.

Category	Unit	Metric	Source
Domestic Retrofit Heat Demand Reduction	145	kWh/m^2/year	R. Mitchell, S. Natarajan, 2020, UK Passivhaus and the energy performance gap available at: https://www.passivhaustrust.org.uk/UserFiles/File/Technical%20Papers/2020%2006_Passivhaus%20and%20the%20Performance%20Gap_University%20of%20Bath_Rachel%20Mitchell%20and%20Sukumar%20Natarajan.pdf

ANNEX B — PEAK HEAT DEMAND ASSUMPTIONS

Building Type	Unit	Metric	Source
Bars, pubs or clubs	100	W/m²	Table 18, BSRIA (no equivalent, assumed similar usage as 'Retail buildings')
Houses	60	W/m²	Table 18, BSRIA ('Domestic buildings')
Dry sports and leisure facilities	100	W/m²	Table 18, BSRIA (no equivalent, assumed similar usage as 'Retail buildings')
General offices	70	W/m²	Table 18, BSRIA ('Offices')
General retail	100	W/m²	Table 18, BSRIA ('Retail buildings')
Hospitals: clinical and research	100	W/m²	Table 18, BSRIA (no equivalent, assumed similar usage as 'Retail buildings')
Public buildings with light usage	87	W/m²	Table 18, BSRIA (no equivalent, assumed similar usage as 'Educational buildings')
Restaurants	100	W/m²	Table 18, BSRIA (no equivalent, assumed similar usage as 'Retail buildings')
Schools and seasonal public buildings	87	W/m²	Table 18, BSRIA ('Educational buildings)
Storage facilities	80	W/m²	Table 18, BSRIA ('Industrial buildings')

ANNEX C — POWER DEMAND ASSUMPTIONS

Building Type	Unit	Metric	Source
Bars, pubs or clubs	130	kWh/m2/year	Table 28, BSRIA
Houses	65	kWh/m2/year	Table 1 TM 46 Energy Benchmarks ('Long term accommodation' category, which includes domestic homes)
Dry sports and leisure facilities	95	kWh/m2/year	Table 28, BSRIA
General offices	95	kWh/m2/year	Table 28, BSRIA
General retail	165	kWh/m2/year	Table 28, BSRIA
Hospitals: clinical and research	90	kWh/m2/year	Table 28, BSRIA
Public buildings with light usage	20	kWh/m2/year	Table 28, BSRIA
Restaurants	90	kWh/m2/year	Table 28, BSRIA
Schools and seasonal public buildings	40	kWh/m2/year	Table 28, BSRIA
Storage facilities	35	kWh/m2/year	Table 28, BSRIA

ANNEX D — PEAK POWER DEMAND ASSUMPTIONS

Building Type	Unit	Metric	Source
Bars, pubs or clubs	W/m^2	225	Table 19, BSRIA (No equivalent, assumed similar usage as 'Restaurants')
Houses	W/m^2 per dwelling	5.5	Table 19, BSRIA
Dry sports and leisure facilities	W/m^2	50	Table 19 BSRIA ('Sports centres with swimming pool')
General offices	W/m^2	62	Table 19, BSRIA ('Offices – non air conditioned)
General retail	W/m^2	160	Table 19, BSRIA ('Shops')
Hospitals: clinical and research	W/m^2	65	Table 19, BSRIA ('Hospitals')
Public buildings with light usage	W/m^2	35	Table 19, BSRIA (No equivalent, assumed similar usage as 'Schools – naturally ventilated')
Restaurants	W/m^2	225	Table 19, BSRIA
Schools and seasonal public buildings	W/m^2	35	Table 19, BSRIA ('Schools – naturally ventilated')
Storage facilities	W/m^2	17	Table 19, BSRIA ('Warehouses/stores')

ANNEX E – TRANSPORT DEMAND ASSUMPTIONS

- Transport distance forecasting generated using DFT road traffic statistics benchmarks/estimates. Manual count points defined using:

Kings Road: HTTPS://ROADTRAFFIC.DFT.GOV.UK/MANUALCOUNTPOINTS/947756

Warwick Road: HTTPS://ROADTRAFFIC.DFT.GOV.UK/MANUALCOUNTPOINTS/28476

- 2023 penetration rates for domestic and commercial vehicles generated using SMMT and ZapMap data:

https://www.zap-map.com/ev-stats/ev-market/#:~:text=As%20of%20the%20end%20of%20May%202023%2C%20there%20are%20over,growth%20of%2040%25%20on%202021

https://www.racfoundation.org/motoring-faqs/mobility#:~:text=A1)%20At%20the%20end%20of,the%20end%20of%20September%202020

BEV Cars: 780,000/33,200,000 = 2.35%

BEV Commercial: 40,756/4,630,000 (LGVs) = 0.88%

ANNEX F – CARBON EMISSION ASSUMPTIONS

CATEGORY	Name	Description	Unit	Metric	Source
Electricity	Grid Electricity		0.16	KgCO_2/kWh	Consortium
Gas Network	Grid Gas		0.18	KgCO_2/kWh	Consortium
Road transport	Average road emissions		0.27	KgCO_2/kWh	Consortium
Energy from Waste	Low Grade Heat		0.0000	KgCO_2/kWh	Assumed
	High Grade Heat		0.0275	KgCO_2/kWh	Assumed
	Electricity		0.1100	KgCO_2/kWh	Assumed
Birmingham Bio Power	Low Grade Heat		0.0000	KgCO_2/kWh	Assumed
	High Grade Heat		0.0583	KgCO_2/kWh	Assumed
	Electricity		0.2330	KgCO_2/kWh	Assumed
Hay Hall Biopower	Low Grade Heat		0.0275	KgCO_2/kWh	Assumed
	High Grade Heat		0.0000	KgCO_2/kWh	Assumed
	Electricity		0.1100	KgCO_2/kWh	Assumed

ANNEX G — CAPEX ASSUMPTIONS

Building Type	Unit	Metric	Source
Heat Network	1627.0	£/m	Assessment of the Costs, Performance, and Characteristics of UK Heat Networks, UK Department of Energy and Climate change, 2015, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/424254/heat_networks.pdf *Costs have ben inflated to 2023 costs using the Bank of England inflation calculator
Customer Heat Substations	30.7	£/MWh	
Ancillary Plants	89.1	£/MWh	
Thermal Store	1638.3	£/m3	
Energy Centre Building	2	£M Cost per Energy Centre Building	Allowance
Heat Pumps - Commercial and Large Scale	127	£/MWh	Based on £1M per MW incuding installation commissioning and contingency
Heat Pumps - Residential	1,850	£/MWh	Unit Cost, additional measure and installation, Assumed average size at 8kWh, https://es.catapult.org.uk/report/electrification-of-heat-home-surveys-and-install-report/
Solar PV	1,900	£/kW	https://www.greenmatch.co.uk/blog/2018/07/solar-battery-storage-system-cost
Battery	850	£/kWh	https://www.greenmatch.co.uk/blog/2018/07/solar-battery-storage-system-cost
Retrofit	£45,000	£/kWh/m2	Your Home Better Manchester average cost between £50k and £45k
Electrolyser (2020)	£1700	£/kW	Inc. BoP DESNZ H2 Production Costs
Electrolyser (2030)	£900	£/kW	Inc. BoP DESNZ H2 Production Costs
EVCP and infrastructure	£340	£/kW	https://chargingshop.eu/product/efacec-qc45-fast-charging-station/