Belfast

Queen’s Island Decarbonisation Plan

Context

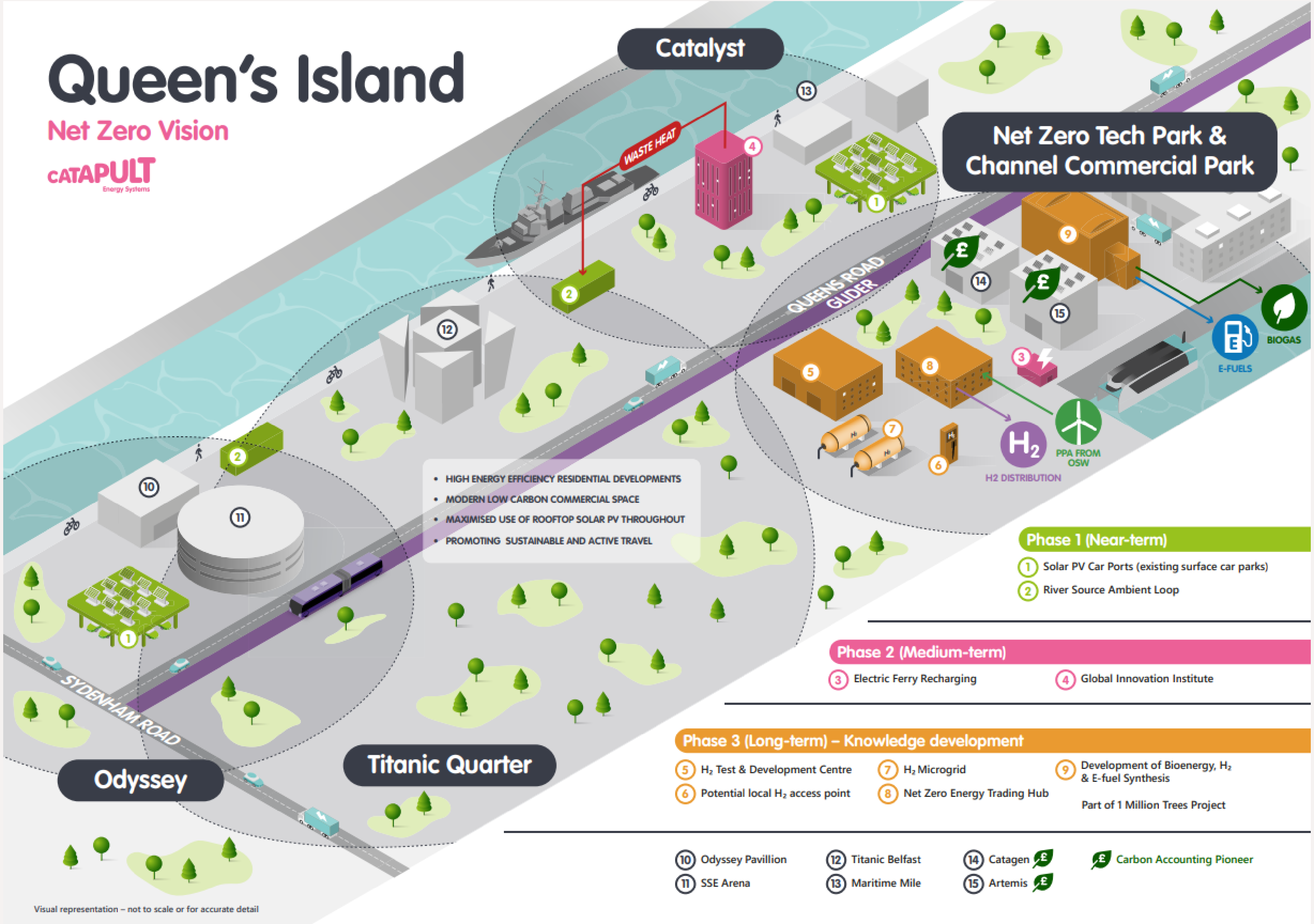
This document provides the output from the Queen's Island decarbonisation plan activity. This has been the product of a desk-based survey of the existing buildings and energy use within the area. It is intended to provide a high-level carbon reduction pathway and view of the site's decarbonisation potential for both electricity and heat over time, broken down into a series of phased activities. The plan also proposes the key components for future decarbonisation and Net Zero developments on Queen’s Island. The emergence of a Net Zero Technology Park is a key enabler for innovation in this area and this will help drive decarbonisation at scale for Queen's Island, Belfast, Northern Ireland and beyond.

Based on the scope of works agreed, two initiatives have been chosen which have been modelled to provide an initial assessment as to size, scale, cost and techno-economic decarbonisation impacts to site. The heating activity is centered around an ambient loop network, which is where ambient temperature water is delivered around a building, or group of buildings, to deliver heating and cooling via decentralised heat pumps. We have provided a solution which could supply heat to a number of existing buildings centered around the Belfast Metropolitan College. This solution is designed to be scalable, although in this first stage it has been suggested that it can connect over time to the Citi building, PRONI, Titanic Belfast and Titanic Hotel (designated as southern cluster). Alongside this development, there is an assessment on the potential for additional renewable electricity generation in the area. This study suggests two solar carports: one at Odyssey and another at Catalyst. This would help support the transition to electrification of the area.

The pack is enhanced with key metrics, data and modelling outputs to enable future discussions and feasibility studies. The projects include a first staging for an ambient loop network and two potential solar carport developments.

Note that this work has been done in parallel with a Local Area Energy Plan (LAEP) for Belfast. There are a number of key differences between the two programmes which may lead to some differences in outcomes. The first is the scale and granularity of the scope, where the LAEP considers the whole of the Belfast area and the decarbonisation plan focusses in on Queen’s Island. This in itself highlights differences in suitable solutions due to the granularity of data available for use at the focused level. Additionally, while the LAEP considers the baseline or current view of the energy demands, the decarbonisation plan includes a view on the future potential through specific developments which can lead to different recommendations.

Net Zero Vision



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Executive Summary

Summary

A pathway has been outlined to support the decarbonisation aims of Queen's Island. This consists of an ambient loop network supplying zero-carbon heating and hot water to a cluster of buildings surrounding the Belfast Met, supported by renewable generation from solar carports. This pathway would require capital investment of:

£15 million
Total net CapEx

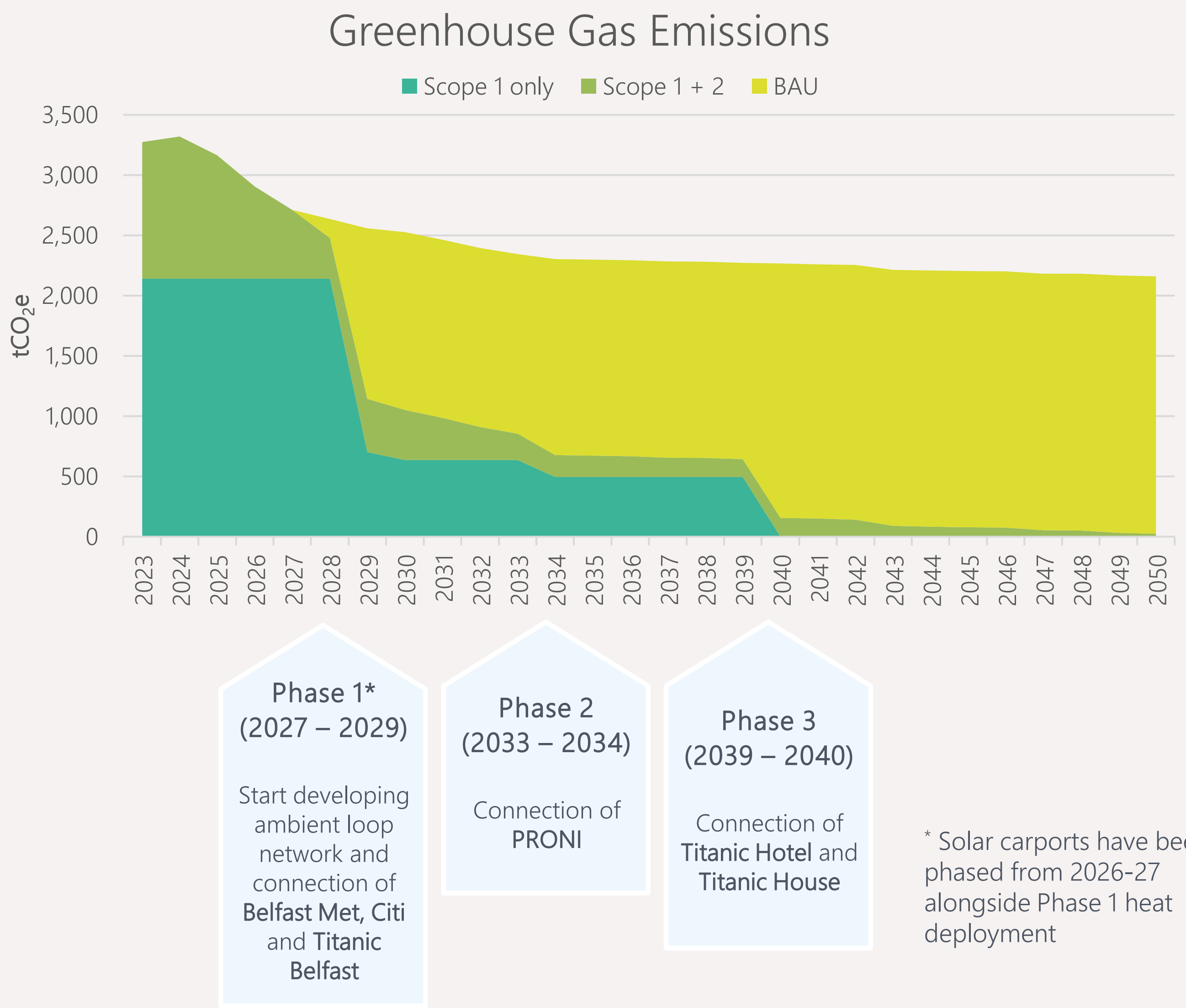
Providing:

£2.5 million
Cumulative cost savings to 2050

Saving:

2,136 tCO_2e
in 2050 against a business-as-usual pathway

7.3 GWh
energy in 2050 against a business-as-usual pathway



* Solar carports have been phased from 2026-27 alongside Phase 1 heat deployment

Decarbonisation Pathway

Focus on modelled solution:

The focus has been only on a part of the site, selected as it contains existing buildings that need to be decarbonised; relatively high emissions (lots of natural gas consumption); engaged stakeholders; plant reaching end-of-life expected over next 5-10 years; reasonably high density; and with waterfront access (for seawater source heat pump).

Also, could work well as an initial cluster from which to expand to both new and existing development, with the opportunity to recover waste heat from industrial processes/data centre.

Ambient Loop network connecting existing buildings, supplied by seawater source heat pump (SSHP)– install phased over time

- Belfast Met
- Citi Gateway
- Titanic Belfast
- PRONI
- Titanic House / Hotel

Solar carport A – Odyssey (2.2 MW_p)

Solar carport B – Catalyst (0.7 MW_p)

Decarbonisation Pathway

Growing the potential / future expansion:

Additional benefits:
- Unlock potential for waste heat to be used on existing network
- Connect up the whole area to benefit from future changes (tie-in with Vision):
    - Possibility for micro-grid / energy as service for area
    - Increased flexibility / resilience

Additional benefits (cont.):
- Fixed price energy costs
- Innovation led
- Plug-and-play / cost effective heat supply
- Future-proof area
- Free up roof real estate

Option to extend network to future potential waste heat source (Global Innovation Institute)

Option to extend/replicate ambient loop for existing Catalyst buildings

Option to supply domestic hot water, heating or cooling to future site developments

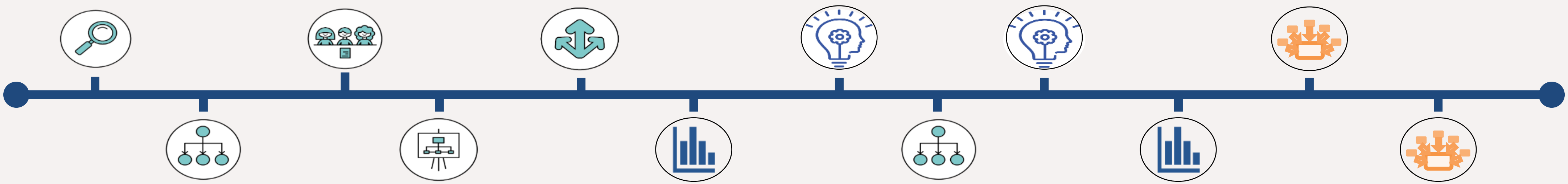
Support development of Net Zero Technology Park

Introduction

What is a Decarbonisation Plan?

"A decarbonisation plan is a **whole energy system** approach to considering how a site can achieve Net Zero over time. The key objective is to eliminate the use of fossil fuels on site and replace with a decarbonised alternative, while also considering the knock-on impacts on the other systems in place.

An effective plan **identifies a cost-effective pathway** for the site, considering a timeline for carrying out a set number of interventions in order to achieve the Net Zero goals."



Step 1
Sites identified and confirmed. Establish site ability to participate, agree list of staff who will be involved.

Step 2
Provide briefing to sites and outline requirements

Step 3
Site kick-off meeting. Stakeholders engaged at site and departmental level

Step 4
Project initiation form completed, information gathered, site overview (virtual) and visit scheduled

Step 5
Site progresses onto Information Gathering stage of process

Step 6
Model site energy use and future site plans

Step 7
Develop decarbonisation Concept Design for site

Step 8 Checkpoint
Present initial decarbonisation Concept Design options. Agree options for modelling

Step 9
Complete engineering assessment for agreed options

Step 10
Build techno-economic model to provide supporting metrics

Step 11
Document decarbonisation Concept Design proposal

Step 12 Checkpoint
Present finalised decarbonisation pathway

Approach

Utilising a consistent whole site energy system approach that considers aspects such as:

- Existing site buildings and uses, where necessary accounting for potential changes e.g., building demolition / repurposing
- A joined-up approach considering the influence of heat decarbonisation on building fabric and site power strategies alongside the changes needed to energy systems and infrastructure
- Achieving a cost-effective transition, evaluated using the Green Book methodology and forward carbon emission projections alongside techno-economic appraisals to assess opportunity costs
- Stakeholder engagement approach
- Asset replacement over time
- Wider energy system integration and constraints

The decarbonisation plan has been based on the production of both forward projected business-as-usual (BAU) and post intervention carbon emissions (tCO_2e) based on the proposed decarbonisation pathway, utilising a consistent methodology. This provides a projection of emissions reduction from implementing the pathway (and the options considered); considering total emission reduction and non-traded or direct emissions.

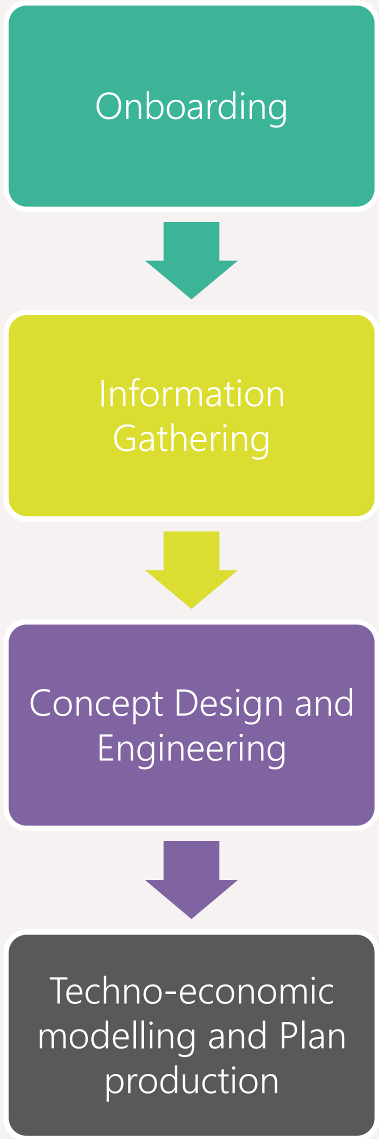
Process

- Site/stakeholder relationships
- Current situation, forward plans and baseline

- Understand site constraints, energy use, systems, buildings, transport, interactions and other key metrics
- Options identification

- Produce BAU forward projection
- Multi-disciplinary approach using heat, building services and power specialists to develop integrated initial site concept/pathway
- Engineering analysis tests and develops options, providing CAPEX, forward OPEX and energy/carbon impact

- Economic modelling of pathway and preferred options
- Refinement, stakeholder engagement and site develop Concept Design



Project Scope

The geographic scope of this project is the Queen's Island area of the Belfast docks. Specifically, the task is to consider two decarbonisation solutions for the area.

01 Citi Gateway Offices
05 Public Record Office of Northern Ireland
06 Belfast Metropolitan College
08 Titanic Belfast
15 Titanic Hotel Belfast

Data was gathered as far as possible from all buildings with the Queen's Island area (included in Appendix). However, our design solution was narrowed down to several key buildings.

This project is a high-level feasibility study and any outputs are indicative only. There are a few assumptions and restrictions as a result:

- Annual or monthly energy consumption data
- Energy benchmarks used where not available
- Baseline year used was 2022 (which had a high number of public holidays)
- Space heating demand profiled according to heating degree days
- Costs are indicative only (based on benchmark costs and do not include allowances for building alterations, ground contamination issues, local variance, etc.)
- Electrical grid upgrade haven't been included at this stage, though initial investigation suggests that impact is reduced

Setting the Scene: Queen's Island

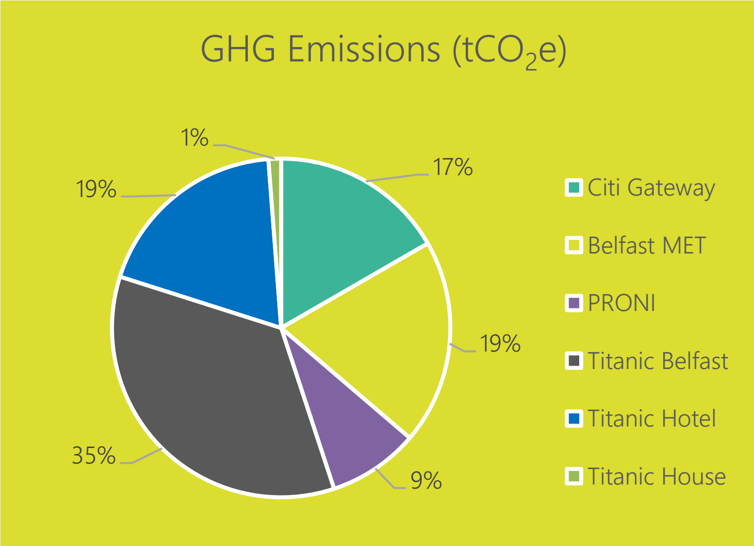
Current Emissions

Metered Energy Consumption and Emissions

Energy consumption data was collected for the financial year 2022/23 for the majority of the buildings in scope, with the exception of Titanic Hotel*. This is summarised in the table below.

Carbon emissions associated with this consumption has been calculated using DESNZ Commercial/Public Sector carbon emission factors for 2023.

Building	GIA (m^2)	Electricity (kWh)	Natural Gas (kWh)	GHG Emissions (tCO_2e)
Citi Gateway	12,375	3,136,582	363,171	515
Belfast Met*	22,000	1,800,000	1,900,000	604
PRONI	9,825	895,586	767,079	268
Titanic Belfast	11,000	1,212,203	4,964,838	1,080
Titanic Hotel**	8,624	776,160	2,587,200	583
Titanic House	1,112	99,142	126,181	37
	64,936	**7,919,673**	**10,708,469**	**3,088**



* Average consumption assumed
** Consumption estimated using CIBSE Type 1 (Good Practice) benchmark

Emissions and Net Zero Targets

" The Climate Change Act 2022 targets are a reduction of greenhouse gas emissions [reduction in scope one and two CO_2 emissions compared to 1990 levels] of:

- *48% by 2030.*
- *100% by 2050. "*

" Belfast Met has committed to reducing by 2030:

- *50% carbon emissions.*
- *30% energy consumption.*

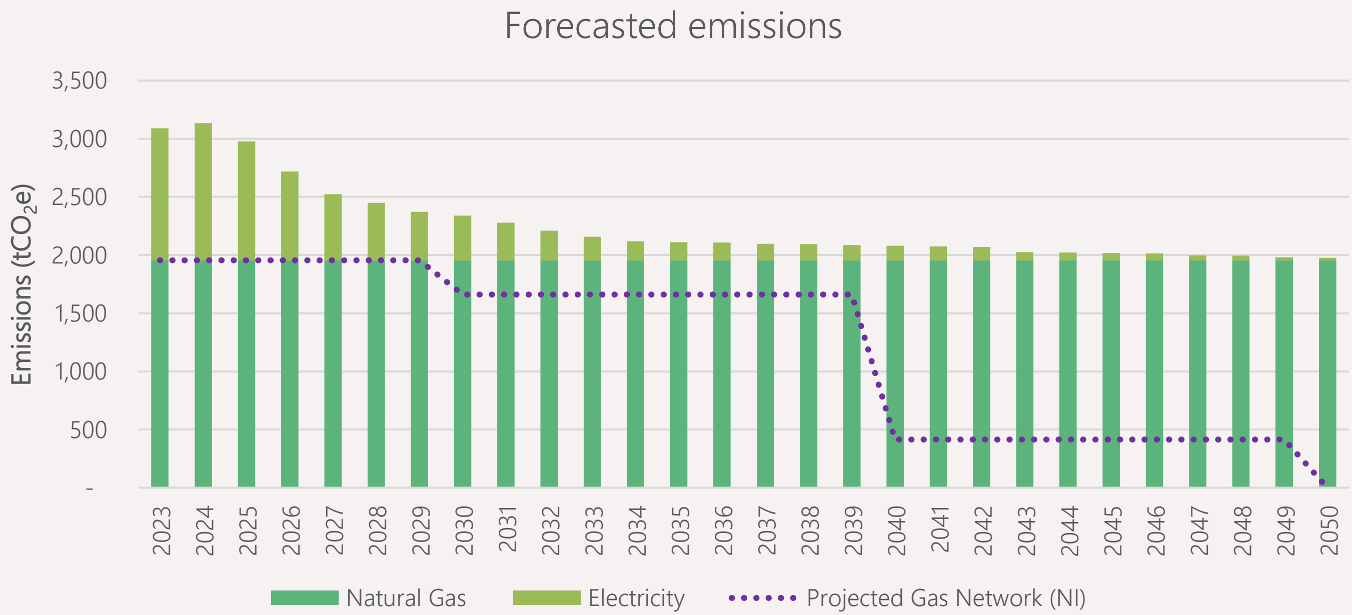
[against a 2016-17 baseline] "

To help form a decarbonisation pathway for Queen's Island we have forecasted the emissions of the current building stock within scope (energy consumption) to 2050 to understand the business-as-usual (BAU) situation. This uses UK Government Green Book projections for emission factors, which indicate that the electricity consumed is on a Net Zero trajectory whereas the natural gas emissions will remain unchanged over time.

Baseline emissions for the selected buildings are 3,088 tCO_2e and, on current trajectory, emissions for the buildings in scope in 2050 would be 1,975 tCO_2e (a 36% reduction). This is based on no decarbonisation of the natural gas grid.

It is noted that there are projections for the Northern Ireland gas network to undergo decarbonisation over this timeline due to the increase in biomethane injection. Projections suggest that emissions could reduce by 15% in 2030, 75% in 2040 and 100% by 2050*.

While this could substantially change the outlook, it is suggested that this pathway would require a reduction in gas consumption meaning that electrification of heat is still a key target.



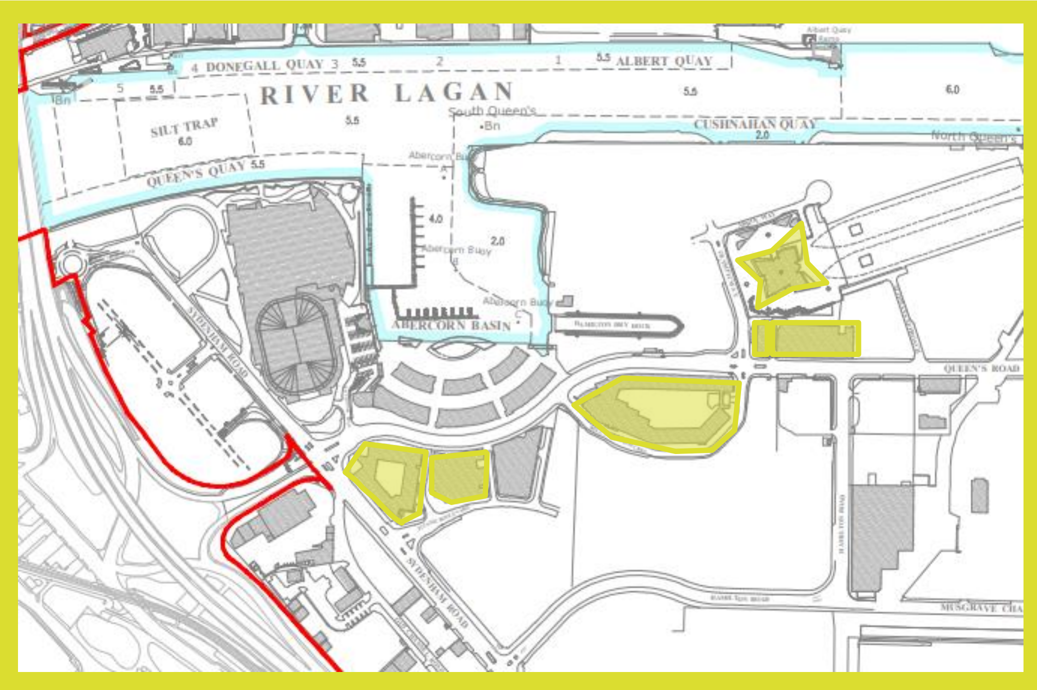
* NI Gas Network Pathway to Net Zero report

Heating

Existing Heating and Hot Water

A survey was conducted of the buildings within scope to find out type and age of existing heating provision. This found a mix of natural gas use for both heating and hot water provision as well as instances of electric provision.

An element of complexity was found in the case of the Titanic Belfast building as this is supplied via a gas-fired CHP installation. This has been accommodated within the modelling as there are additional impacts from the electricity generated. It is also understood that cooling is provided from this system.



Building	Heating provision	Hot water provision	Year of installation
Citi Gateway	Electric	Gas	2012
Belfast Met	Gas	Gas	2011
PRONI	Gas	Gas	2011
Titanic Belfast	Gas (CHP + boiler)	Gas (CHP + boiler)	2011
Titanic Hotel	Gas	Gas	2017
Titanic House	Gas	Electric	2017

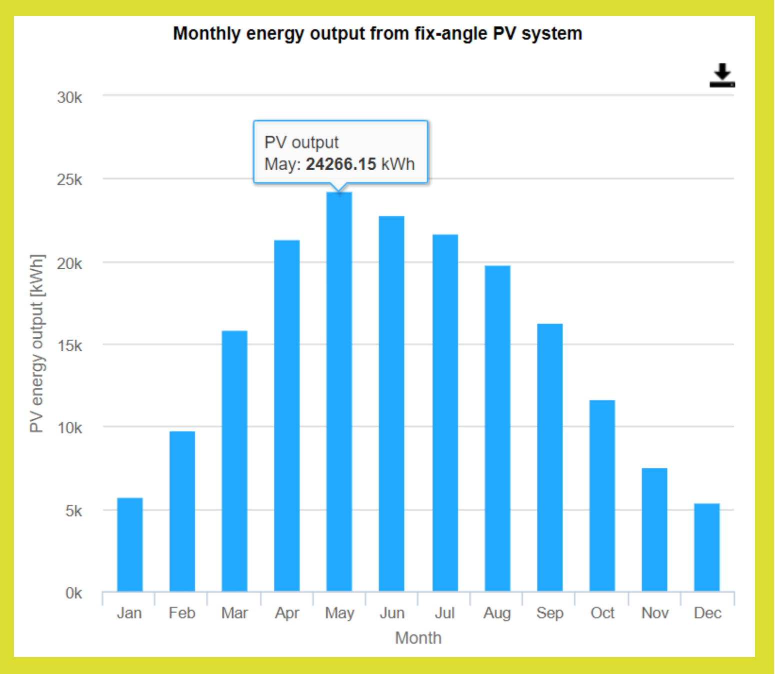
Local Generation

Existing Generation

From data made available and desktop research it is understood that the only generation on site is the existing CHP installation at Titanic Belfast. It is noted that there is a substantial rooftop PV installation at the Odyssey, however this has been excluded from the baseline analysis.

There is also a planned rooftop PV installation for the Belfast Met, which we have estimated an annual generation output from.

Building	Generation type	Assumed annual generation (kWh)	Year of installation
Belfast Met	Solar PV	161,411	TBC
Titanic Belfast	CHP	1,022,130	2011



Beyond this, it is understood that the future development of the site will aim to achieve self-sufficiency and therefore is likely to include additional installation of rooftop solar PV. This has been excluded on the basis that it will have a positive impact on the site electricity demand.

An initial assessment was made as to the existing roof space and suitability for further deployment of rooftop PV. However, it was found that there would be substantial challenges with the available space to warrant further investigation. Additionally, initial screening has been conducted on the viability of wind generation within the boundary of Queen's Island. Whilst the resource would be suitable, the significant constraints on the location mean that this has also been excluded from further consideration.

Source: PVGIS

Assessing Options for the Future

Long List Options

Outcome of Concept Design

Intervention type	Long-list option	Include / exclude	Rationale
Heating	Ambient loop system with seawater source heat pump (SSHP)	Modelled	Ambient Loop (Shared-loop) heat networks consist of a communal distribution system moving low-grade heat between the source and the individual heat pumps contained within each property. This differs from the traditional centralised heat network (HN), as each property is fitted with its own heat pump unit, rather than relying solely on centralised energy centre. Shared-loop networks can offer reduced capital expenditure for infrastructure by utilising plastic pipes with minimal thermal insulation. However, overall capital cost including the building-level heat pumps can be higher than for conventional heat networks and, in this case, the seawater heat exchanger introduces some complexity, for example with respect to corrosion and licensing.
Renewable Generation	Ground-mounted / Solar Car Park Canopy PV	Modelled	There are parking spaces on the areas that are suitable for solar PV carports installations. This solution can work to offset the running cost of the proposed heat networks and provide some form of resilience in the local electrical network.
Heating	*Conventional low temperature hot water (LTHW) heat network with seawater source heat pump (SSHP)*	*Not modelled*	*A conventional heat network operating at up to 70°C flow and 40°C return, with a seawater-source heat pump as the primary heat generator. Technical, environmental and economic performance can be optimised with thermal storage and secondary heat generators for 'peak lopping'*
Heating	*Localised low-temperature hot water (LTHW) air source heat pump (ASHP)*	*Not modelled*	*ASHP can readily be used to replace existing wet heating systems on site and considered for areas that are heated by direct gas systems. System type (HT or LT) would vary depending on upgrades of the LTHW systems feeding radiators and AHU's such as in the Met to be practical examples. Other consideration would be heat recovery and combining heat pumps and Chillers, or any buildings with UF heating would form higher priorities as will buildings where boilers are approaching end of life.*
Heating	*Localised domestic hot water (DHW) high-temperature ASHP*	*Not modelled*	*DHW demands could be provided by an independent DHW high-temperature ASHP that can more efficiently supply the demand. A modular system would be best suited where demand varies considerably, e.g. in the SSE arena*
Heating	*Ground source heat pump (GSHP)*	*Not modelled*	*There are several variants of GSHP systems. In Belfast, the most promising option is the use of groundwater abstraction/reinjection with ambient loop heat networks, which is the subject of ongoing research. While this type of solution may in due course prove to be the best option, there are significant risks/uncertainties at this stage, e.g. source temperature, historic ground contamination from industry.*
Heating	*Localised bivalent systems*	*Not modelled*	*This solution has been excluded because, while it offers short-term flexibility in meeting heat demand, it could require significant on-site infrastructure for either storing or generating hydrogen/biogas for decarbonisation. Alternatives have been explored to investigate potential for off-site generation of biogas (biomethane) which could be transported to site via existing infrastructure. However, it was deemed that this type of fuel is more likely to be used in higher value systems.*
Energy Storage	*Battery Storage*	*Not modelled*	*On a high-level assessment approach, it is deemed a battery storage solution for individual buildings or network to be excluded due to low ratio of solar PV potential when compared to the current energy consumption and increased electricity demand if any sort of heat pump solutions are installed. However, PV system design should consider future retrofitting of Battery Storage as should any potential larger scale renewable energy generation schemes.*

Pros and Cons for Long List

Long-list option	Pros	Cons
Ambient loop system	• Shared ambient-loop networks can result in lower infrastructure costs compared to high-temperature HN systems, as they can often use cost-effective plastic pipes • Provides capability for both heating and cooling in buildings • The shared components for an ambient loop system are significantly less complex and less capital intensive than a high temperature network where a high-capacity central heat pump would be required • The small temperature gradient between the network and ambient conditions leads to minimal system losses • Each property/building is equipped with its own heat pump unit, offering residents individual control and responsibility for their heating needs, similar to having individual boilers • Integration of multiple buildings on different flow/return temperatures can be more easily managed to obtain optimum system efficiency • System flexibility is high, as new additions to the network can be relatively easily connected in phases • Local water source heat pumps connected to an ambient loop are likely to be less capital intensive and require smaller installation space when compared with local air source heat pumps • Renewable Energy Sources: Shared ambient-loop systems can utilize various renewable energy sources, such as ground heat, surface water, or sewage treatment, promoting sustainable and green energy practices. Seawater is available as an abundant heat source for the development in question • Seawater temperature likely to result in higher heat pump performance than air source heat pumps during the coldest periods with less effect on heat pump capacity than local air source heat pumps • Flexibility to accommodate any future waste heat for use in buildings, particularly given the potential temperature available	• The overall capital cost, including building-level plant and equipment, is likely to be higher than for a conventional heat network, though this depends on network length and how any cooling demand is met • The lower temperature difference across the ambient loop typically results in larger pipe diameters than for modern, conventional networks, though this is mitigated by the fact that less heat is distributed across the network. Furthermore, once the minimal thermal insulation requirements are considered, the capital cost of distribution pipework is likely to be lower than for conventional networks • Every building installed on the ambient loop network would require its own heat pump. This is more capital intensive at the point of connection than a conventional high temperature heat network with traditional heat interface units • High temperature backup heat sources may still be required at a local level (e.g. gas boiler or redundant air source heat pumps), for buildings requiring very high levels of resilience • Building-level thermal storage may be required for customers requiring additional resilience and/or intending to benefit from time-of-use electricity tariffs • Planning consent is likely to be required for installation of any shared loop system and a noise test is likely to be required and potential planning conditions. Planning approval including inlet and outlet discharge consent and DNO requirements also need to be considered • Local building controls will likely require replacement or modification to integrate with a new heat source • Low Return On Investment and potential short term utility cost increase • Central high temperature heat buffering is not possible, resulting in a need for an overall higher heat pump capacity than traditional high temperature shared heat loops • Electrical reinforcements may be required to multiple buildings on the ambient loop in order to support local heat pumps. This is likely to be more complex than a traditional centralised system where reinforcements may only be required to a single energy centre • Maintenance cost associated with sea water filtration systems

Pros and Cons for Long List

Long-list option	Pros	Cons
Ground Mounted PV (Solar Carport)	• Available carparks that could be used to install solar carports. • The solar carport will provide protection from the elements to the cars and people using the spaces • It also allows for integrations such as EV charging station being directly power by the PV system (not modelled in scenario) • Offsetting increased running cost of any heat electrification to be implemented • Good visual impact on the site as it will show the green goals being implemented on the site • Good payback periods	• The sizing of the system depends directly on the layout of the car parks. It may require a redesign to maximize the usage of space and electricity generation • DNO consent will be required via submission of a G99 application • Significant capital cost of electrical infrastructure, including connection to distribution network due to private wire underground runs and carport civil works • Planning consent is required
WSHP Heat Network	• *Substantial carbon savings would be achieved by switching from fossil-fuelled boilers (in most cases) to heat pumps* • *Potential to upgrade/replacement of air handling units (AHU) as part of project* • *Combine with improved Chiller efficiency (reuse of heat)* • *Opportunity to increase control efficiencies* • *Design to reduce system size by retaining existing gas boiler capacity and large buffer (thermal store) capacities*	• *Approval issues from with privately owned buildings and stake holders.* • *High investment Capex for the heat pumps, pipe work network and distribution* • *Additional work to upgrade heating distribution system (Radiators, AHU, and others) if building not capable of operating at lower temperatures (e.g. 60^{o}C)* • *Maintenance cost associated with Sea water filtration systems* • *Larger area required to be used for an energy centre than for comparable ambient loop system (high civil costs)* • *Sizing and location of the buffer vessel to reduce maximum capacity of the heat pump capacity* • *Expected low Return On Investment and potential short term utility cost increase* • *Electrical connection capacity available to be confirmed* • *Planning approval and DNO requirements* • *Disruption to buildings during retrofits*
Localised ASHP for independent buildings	• *Substantial carbon savings would be achieved by switching from fossil-fuelled boilers (in most cases) to heat pumps* • *Potential to upgrade/replace AHU (optimisation) as part of installation* • *Flexibility of integration with the current system* • *Opportunity to increase control efficiencies*	• *Available roof space may be required close to the plant rooms for installation of heat pumps. This could prove challenging with other building services required* • *Planning consent may be required for the installation of the ASHP units, and a noise test is likely to be required and potential planning conditions* • *It is normal for heat pump-based systems to provide lower-level heat almost continually during the heating season which keeps the internal temperature more constant and therefore avoids periods when higher peak demands are required.* • *The BMS will need to be optimised for the system running regime (which could lead to improved overall SCOP efficiencies), however this comes at an additional cost* • *Expected low Return On Investment and potential short term utility cost increase.* • *Requires an investigate to ensure that there is sufficient electrical connection capacity available.* • *Planning approval and DNO requirements.* • *Disruption to buildings during retrofits*

Scenarios

Modelled Scenarios for Queen's Island

Ambient Loop

Ambient Loop aims to provide a decarbonisation pathway for the heating of the existing buildings within the site, this being the major target for meeting the areas Net Zero ambitions. This solution has been put forward on the basis of some key buildings, however it is of note that this is a flexible solution that could accommodate further buildings or areas in future if found to be feasible.

Solar Carports

Solar Carports aims to quantify the potential for additional onsite renewable generation. In this instance, it was found the there is limited potential for additional roof-mounted PV and therefore an assessment is carried out for installation of solar carports on the large car parks on site.

Ambient Loop Heating

In its simplest form an ambient temperature heat network moves water around a building, or group of buildings, to deliver heating and cooling via decentralised heat pumps. The ambient loop acts as the water source/sink for water source heat pumps that can provide both heating and cooling. As heat pumps can efficiently deliver both heating and cooling at source/sink water temperatures close to ambient, the insulation requirements for such networks can be eliminated, or at least significantly reduced compared with their higher temperature equivalents. A deficit or excess of heat in the network is most commonly addressed by introducing an element of ground source to the ambient loop. This can be via closed loops of pipe buried or drilled into the ground, or via open loop systems.

In this instance, the source of heat proposed is seawater from Belfast Lough, but the principle remains the same. At this stage, it is assumed centralised heat pump(s) in a dedicated energy centre will be required to upgrade heat from seawater (at 7-15^{0}C) to optimum ambient loop temperatures (15-25^{0}C). Each individual building would then have their own heat pump to raise it to the desired operational temperature.

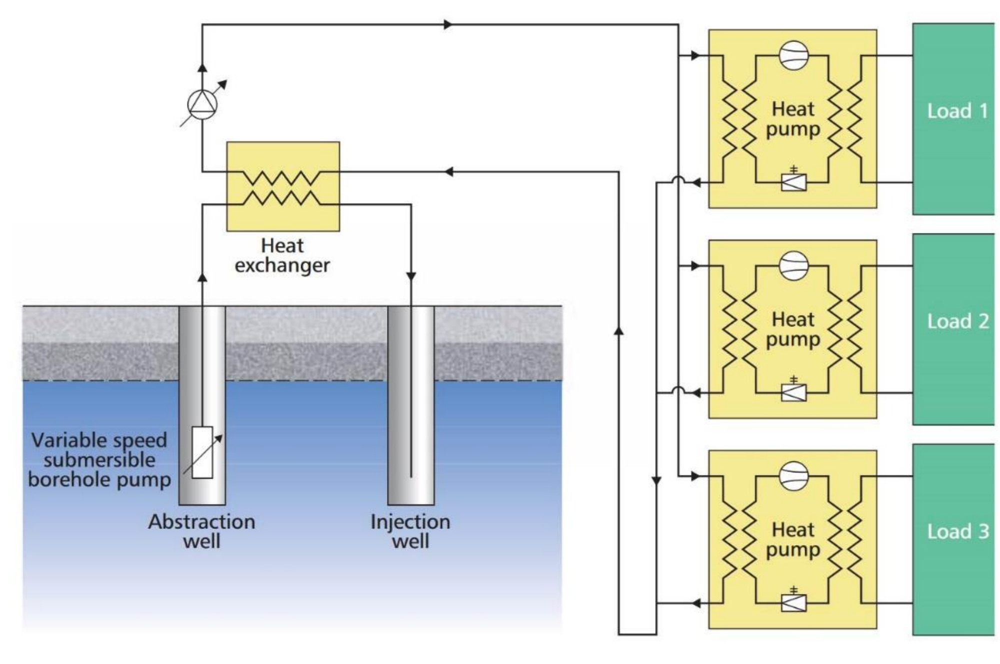
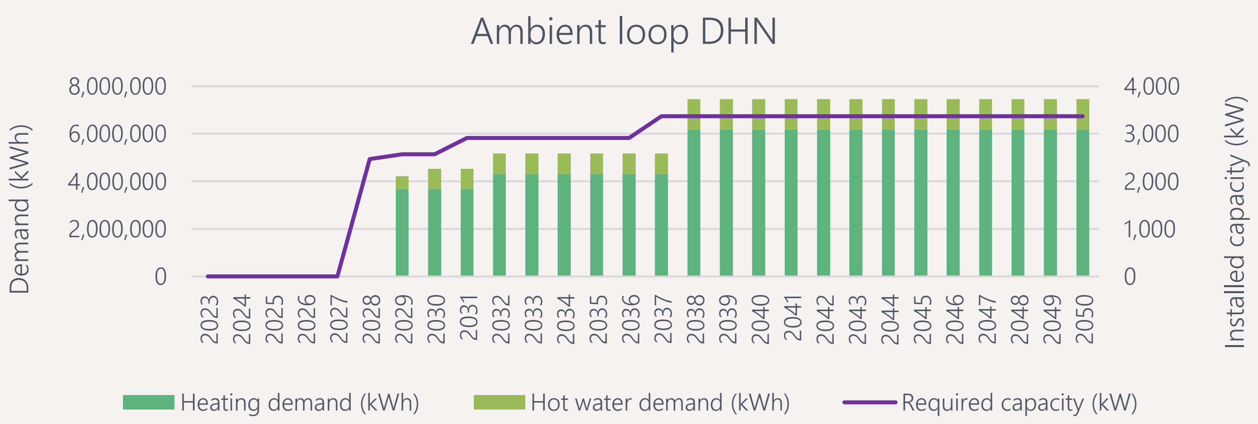


Figure 55 Example of an open-loop ambient temperature network (from CIBSE/GSHPA CP3: CIBSE, 2019a)

Using the dataset provided we have outlined a design encompassing the buildings identified in scope. The design is shown to be led by heating (though it is noted that this will be seasonal in nature).

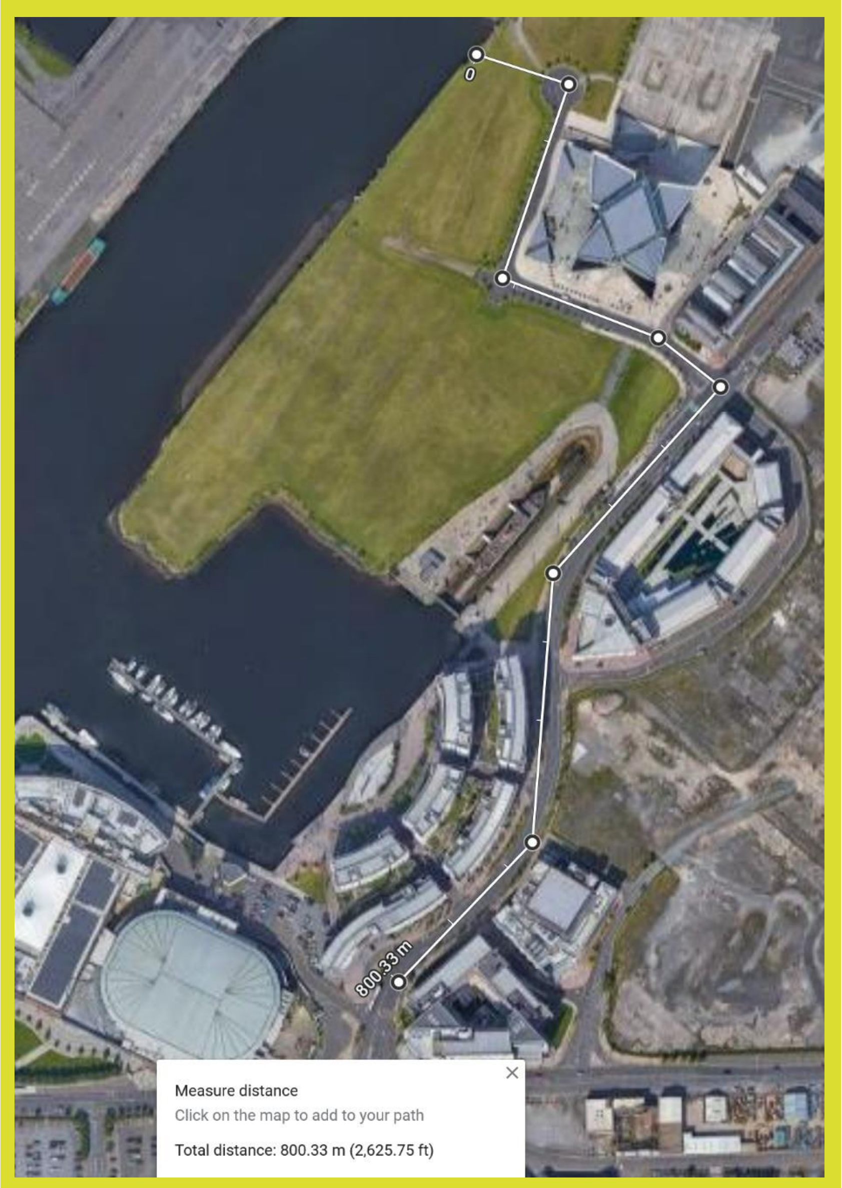
Over time, it is expected that circa 3.5MW$_{th}$ capacity will be required to serve the demands.



Ambient Loop Heating

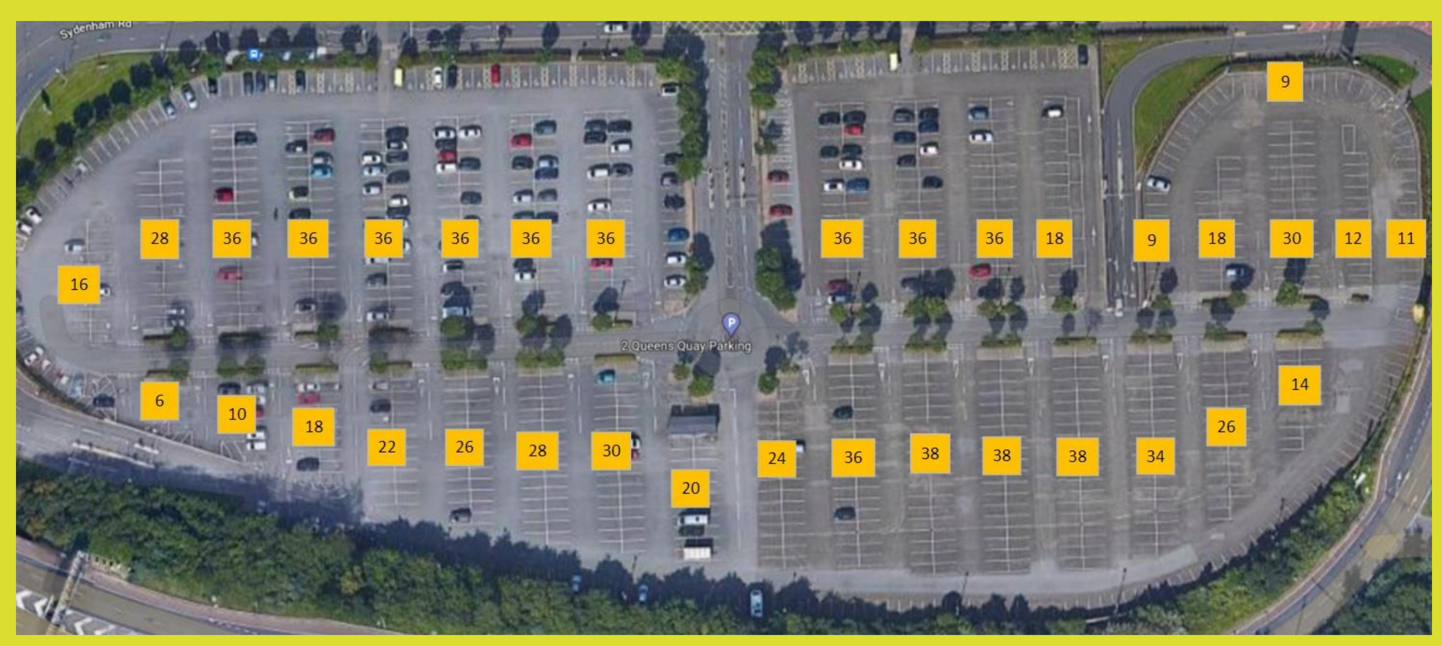
Key characteristics/metrics of proposed network:

Spine	
Length (m)	800
CAPEX rate (£/m)	1,500
CAPEX (£)	1,200,000
Estimated pipe size (mm DN)	200
Flow temperature (°C)	25
Return temperature (°C)	15
Temperature difference (K)	10
Branch (typical)	
Length (m)	25
CAPEX rate (£/m)	1,500
CAPEX (£)	37,500
Energy centre	
Gross internal floor area (m²)	250
CAPEX rate (£/m²)	2,650
CAPEX (£)	662,500
Heat generators (energy centre)	
WSHP capacity (kW)	3,436
SCOP	6.85
CAPEX rate (£/kW)	1,350
OPEX to CAPEX ratio	3.0%
Heat generators (buildings)	
WSHP capacity (kW)	varies
SCOP (heating)	3.15*
SCOP (hot water)	3.15*
CAPEX rate (£/m²)	450
OPEX to CAPEX ratio	3.0%



* These are conservative values being based on high temperature demand. These could increase to 4-8 for modern, energy-efficient buildings

Solar Photovoltaic



Solar Carport A

The study considered the potential to instal solar carports encompassing the car park at Odyssey.

Allowances have been made for accessibility and overshadowing potential. Also included is additional electrical infrastructure to be able to connect this installation to the local network.

In total, it was assessed that there are 883 spaces available for solar carport within the area identified.

Carport A	Metrics
Installation capacity	2,238 kW_p
Annual electricity generation	1,863 MWh
Solar carport cost	£3,003k
Additional electrical infrastructure cost	£305k
Total install cost	£2,767k
Annual operation cost	£49k per year
Simple payback	11 years
Cost per car parking space	£3,401 per space

Assumptions

- Proposed installation over 2026/27
- Full operation/generation not achieved until 2028
- Benefits assessed up to 2050, using Green Book methodology and forecast electricity prices
  - Electricity rate of 69p/kWh in 2023 dropping to 14p/kWh in 2034 until 2050
- Degradation factor (reduction in generation) of 0.5% per year included in modelling
- No export revenue modelled

Solar Photovoltaic

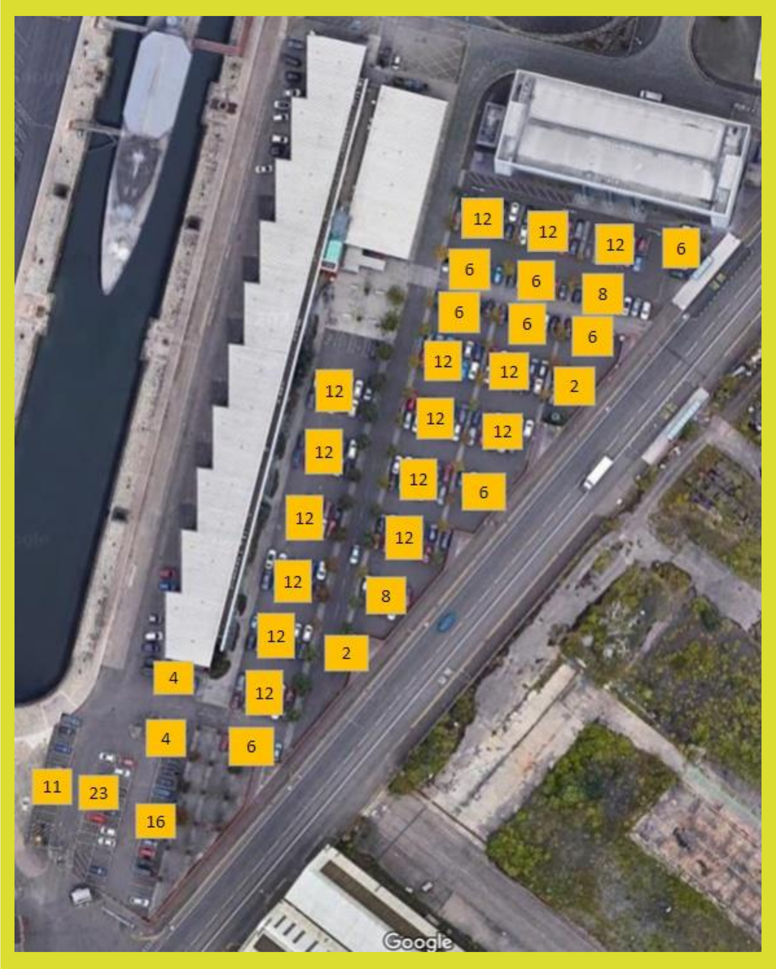
Solar Carport B

The study also considered the potential to instal solar carports encompassing a car park at Catalyst.

Allowances have been made for accessibility and overshadowing potential. Also included is additional electrical infrastructure to be able to connect this installation to the local network.

In total, it was assessed that there are 306 spaces available for solar carport within the area identified.

Same assumptions applied as for option A.



Carport B	Metrics
Installation capacity	776 kW_p
Annual electricity generation	646 MWh
Solar carport cost	£1,036k
Additional electrical infrastructure cost	£102k
Total install cost	£955k
Annual operation cost	£17k per year
Simple payback	11 years
Cost per car parking space	£3,386 per space

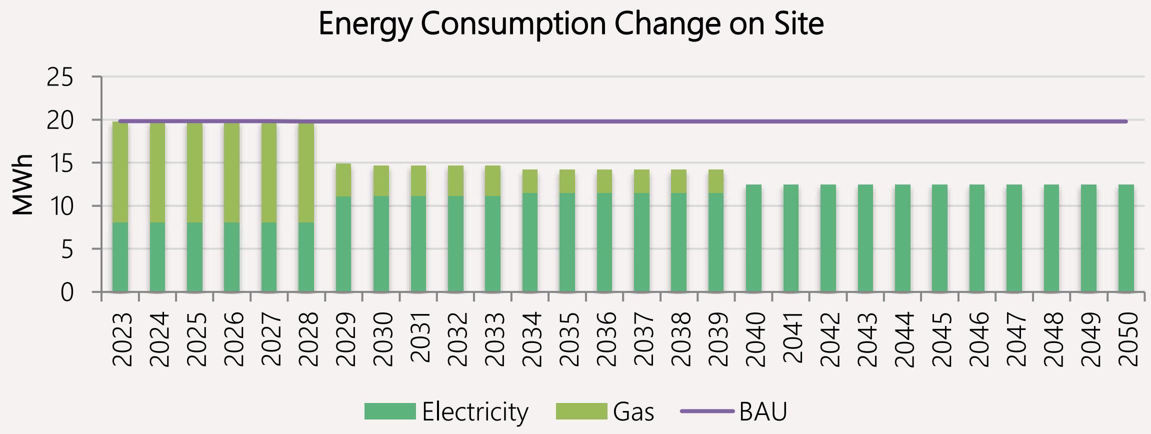
Scenario Summary

- As discussed, the ambient loop heat network has a high upfront cost. However, it is effective at removing the carbon from fossil fuel use in the existing buildings. This results in a good abatement cost, the cost it would take to remove carbon that would otherwise be emitted.
    - There are also additional benefits that have not been modelled such as additional flexibility, integration of waste heat and provision of cooling during the summer

- The purpose of combining onsite electricity generation with the ambient loop heat network is to help offset some of the running costs for heating. It also provides additional resilience to the local network as well as, in the short term, helping to reduce carbon.

- Overall, the plan would help reduce carbon emissions and along with it reduce the total energy consumed (through efficiency gains).

Intervention	Capital expenditure (£k)	Average carbon reduction per annum (tCO_2e)	Internal Rate of Return	Abatement Cost (£/tCO_2e)	Payback
Ambient Loop	9,810	1,795	None	230	None
Solar Carport A	3,003	37	2%	688	11
Solar Carport B	1,036	13	2%	678	11
Feasibility studies*	1,349	-	-	-	-



* 10% allowance for heat and renewable feasibility studies

Evaluation of Wider Benefits

Growing Future Benefits of Ambient Loop (not modelled)

- Connect remaining buildings in cluster
- Waste heat from Global Innovation Institute
- Extend network to Catalyst cluster
- Design consideration for future site development

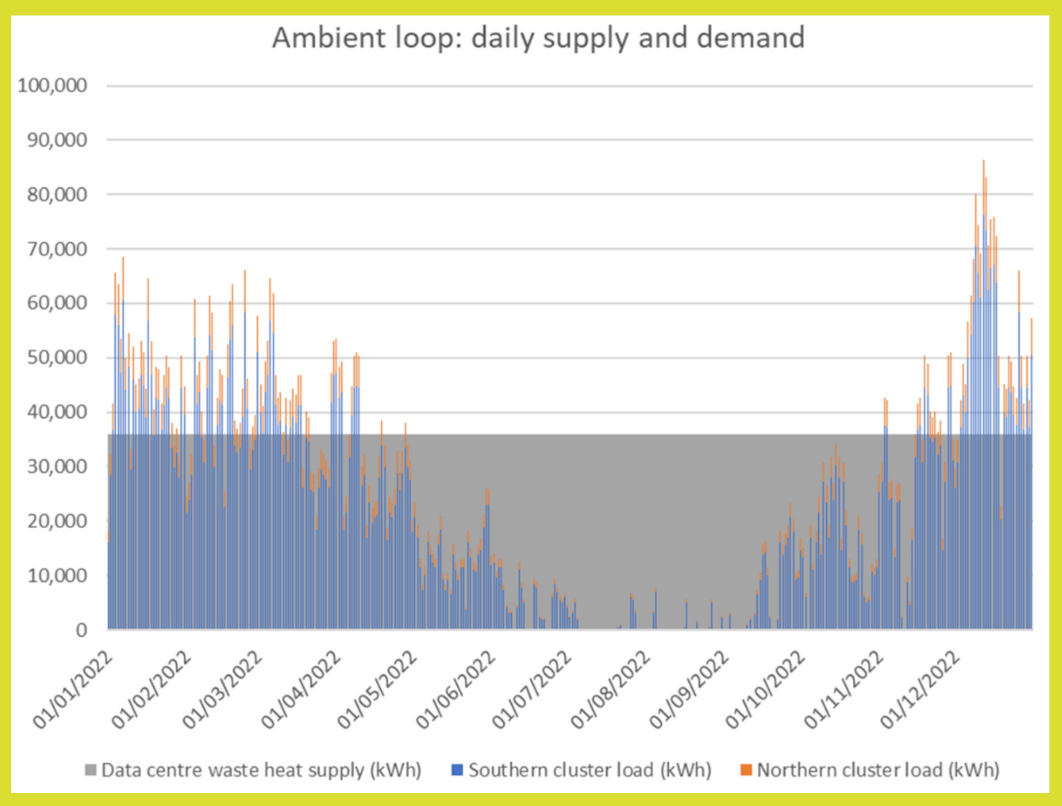
Connect buildings on existing network (potential for Olympic House at end of life, and Thomas Andrews House). This would further benefit the decarbonisation pathway for the whole area.

Connecting to the **Global Innovation Institute** will enable potential waste heat to be utilised within the ambient loop network. Based on the expected waste heat potential, this could be a substantial benefit in terms of operating efficiency and justify the additional capex for the infrastructure.

Extend to Catalyst and therefore maximising the benefit to the wider Queen’s Island area. Based on preliminary information the demand would be suitable for an ambient loop solution, which coupled with waste heat from the Global Innovation Institute, would further futureproof the site.

To be assessed as a **design consideration** for any future site development, particularly given the potential from the waste heat, to be included on the network for provision of hot water. Having an existing ambient loop network is also likely to positively impact on the development of the proposed Net Zero Technology Park.

Initial Analysis on Waste Heat



- Preliminary analysis of the heat demands (including Catalyst buildings) suggests that the southern cluster (centred around the Belfast Met) is circa 8 times higher than the northern cluster (Catalyst).
- Possibility to provide a substantial proportion of the heat demand of the whole Queen's Island. This is on the assumption that the Global Innovation Institute would be rejecting around 1.5 MW_{th} of heat between 35-45^{0}C.
- This will substantially increase the efficiency of any heat pumps on the network.
- To further benefit this option, it would be beneficial to consider an aquifer thermal energy storage (ATES) solution. This can be used to store the excess waste heat generated during the summer months where heat is not as high a demand and utilise it better during the colder months (on the basis that hot water demand will be lower than heating demand)
- This approach would also benefit from any additional sources of waste heat from buildings on the site (site cooling plant, etc.)

Conclusions and Recommendations

Conclusions

Emissions Reduction

- This plan has effectively shown a practical approach to achieving Net Zero for the target buildings.
- The timeline to delivering these is challenging but highlights the need to act to achieve targets.

Local Generation

- While there is limited scope for renewable generation on existing buildings, the study provides options for solar carports providing a substantial generation capacity for the area.
- There is also expected to be further rooftop PV capacity installed as part of future development on site.

Costs

- The projected costs and benefits are high, as expected. However, the positives of a good abatement cost (which could help leverage funding) and future stability in annual heating costs for the businesses in the area will undoubtedly further support future development.

Growing Benefits

- The plan highlights some of the potential benefits when incorporating future energy users and waste heat into the network.
- This approach also provides additional flexibility and resilience in the area which will attract future growth.

**Conclusions enable recommended actions and projects in Belfast's Net Zero Pathways*

Appendix

Summary of Queen's Island baseline assessment

Building or plot	Annual fossil fuel import - baseline (kWh)	Annual electricity import - baseline (kWh)	Annual total fuel import - baseline (kWh)	Proportion of total	Heat system capacity - recorded (kW)*	Fossil fuel baseline source	Electricity baseline source	Suitability for heat network connection
Titanic Belfast	4,964,838	1,212,203	6,177,041	15%	1,320	Recorded	Recorded	High
Titanic Hotel	3,451,000	1,518,440	4,969,440	12%	150	Recorded	Recorded	High
SSE Arena	1,132,725	3,651,685	4,784,410	11%	5,100	Recorded	Recorded	High
MET (Belfast Metropolitan College)	1,900,000	1,800,000	3,700,000	9%	1,860	Recorded	Recorded	High
Citi Gateway	363,171	3,136,582	3,499,753	8%	-	Recorded	Recorded	High
Premier Inn	2,018,400	765,600	2,784,000	7%	-	Benchmark	Benchmark	High
W5	419,561	1,352,584	1,772,146	4%	2,500	Recorded	Recorded	High
Olympic House	0	1,745,024	1,745,024	4%	-	Benchmark	Benchmark	High
PRONI	767,079	895,586	1,662,665	4%	500	Recorded	Recorded	High
ARC 2 Bed Apartments	658,224	952,896	1,611,120	4%	-	Benchmark	Benchmark	Medium
Painthall, Media Campus	29,851	834,923	864,774	2%	-	Recorded	Recorded	Low
Oakbank CCP Units	289,907	330,697	620,604	1%	-	Recorded	Recorded	Medium
Concourse 1	263,533	344,246	607,779	1%	585	Recorded	Recorded	High
Concourse 2	263,533	344,246	607,779	1%	600	Recorded	Recorded	High
Concourse 3	263,533	344,246	607,779	1%	600	Recorded	Recorded	High
Pinebank CCP Units	249,858	285,013	534,871	1%	-	Recorded	Recorded	Medium
White Star House	210,826	275,397	486,223	1%	500	Recorded	Recorded	High
ARC 1 Bed Apartments	191,982	277,928	469,910	1%	-	Benchmark	Benchmark	Medium
Innovation Centre	184,473	240,973	425,446	1%	924	Recorded	Recorded	High
CSIT/ECIT Building	184,473	240,973	425,446	1%	400	Recorded	Recorded	High
ARC 3 Bed Apartments	202,000	194,880	396,880	1%	-	Benchmark	Benchmark	Medium
Amazon Warehouse	0	394,320	394,320	1%	-	Benchmark	Benchmark	Medium
Legacy Building	131,766	172,123	303,890	1%	140	Recorded	Recorded	High
Ashbank CCP Units	134,493	153,416	287,909	1%	-	Recorded	Recorded	Medium
Thomas Andrews House	104,954	163,500	268,454	1%	40	Benchmark	Recorded	High
Life @W5	60,714	195,730	256,444	1%	400	Recorded	Recorded	High
ARC Apartments Block A&B	0	252,133	252,133	1%	-	Benchmark	Recorded	Not applicable
Elmbank CCP Units	113,572	129,551	243,123	1%	-	Recorded	Recorded	Medium
Titanic House	126,181	99,142	225,323	1%	-	Recorded	Recorded	High
ARC Apartments Block E&F	0	174,424	174,424	0%	-	Benchmark	Recorded	Not applicable
ARC Apartments Block C&D	0	163,096	163,096	0%	-	Benchmark	Recorded	Not applicable
Titanics Dock & Pumphouse	52,707	68,849	121,556	0%	50	Recorded	Recorded	High
Dock Café	0	37,000	37,000	0%	-	Benchmark	Recorded	High
Total	**18,733,355**	**23,141,728**	**41,875,083**	**100%**	**15,669**			

* Not all data was available for existing capacity

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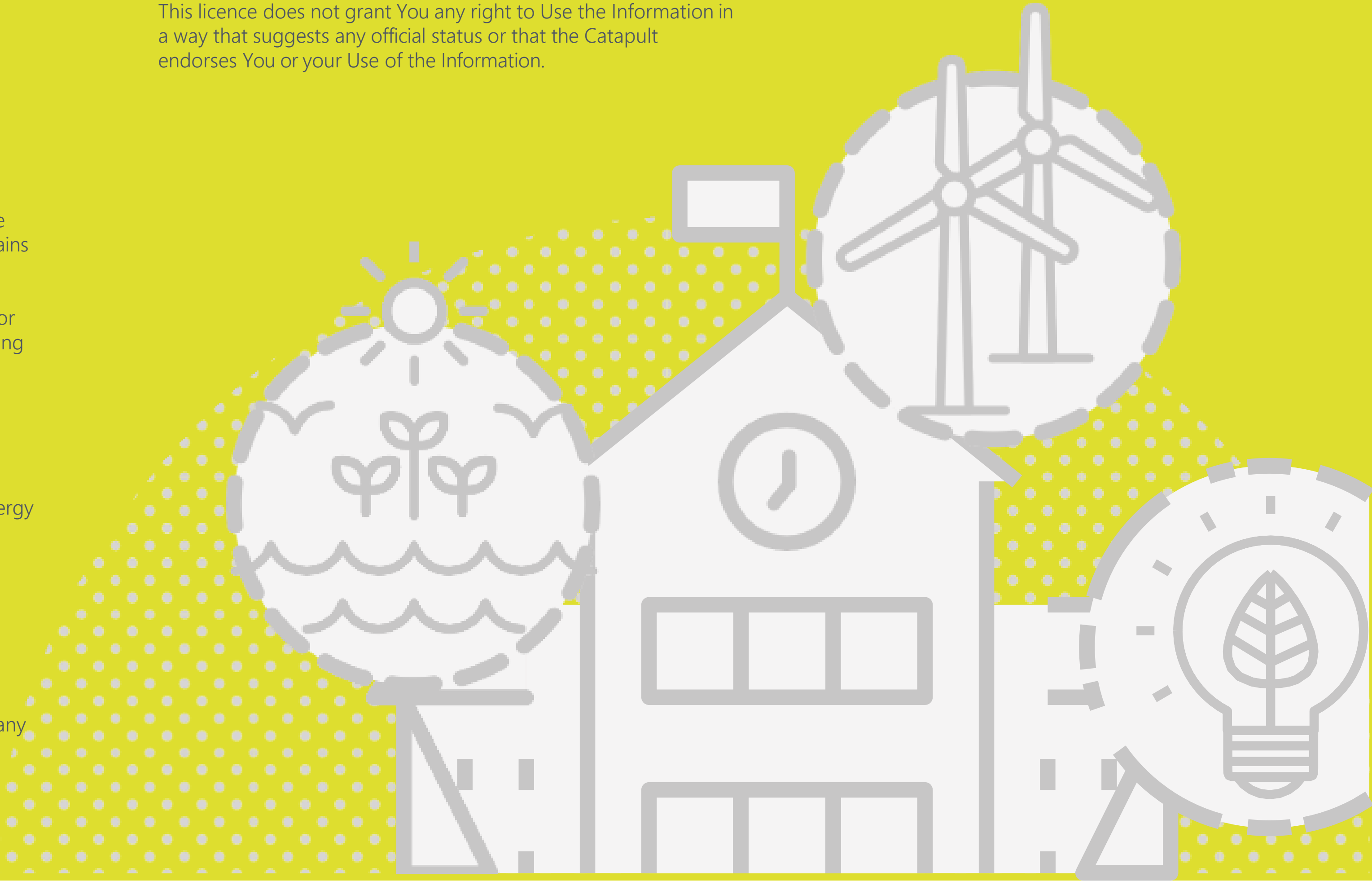

If there are any questions about the method or outputs in this Decarbonisation Plan, then please feel free to contact the Energy Systems Catapult team on:

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