7.7 ENERGY CENTRE

7.7 ENERGY CENTRE

OVERVIEW

Net Zero Carbon Aspirations
The project gives a platform to create a 'wow' factor by incorporating new & innovative technologies and systems, to provide a net zero carbon, electricity, heating, and cooling solution to serve the load demands of the development. Additionally, there is scope for a solution which aligns with Aberdeen City Council's hydrogen strategy, to generate demand and interest in hydrogen as a power source in order to achieve their climate goals and to capitalise on the unique skills-base of the region.

Future-proofing
The energy centre solution will need to meet the requirements of Aberdeen City Council Climate Change Plan 2021-25: Towards a Net Zero and Climate Resilient Council. The Plan sets out the approach, pathway, and actions towards net zero and climate resilient Council assets and operations, by 2045. As such, energy-efficient designs will be incorporated alongside renewable and low carbon energy sources, with consideration provided on how further de-carbonisation could be achieved in the future.

Resilience
Given the scale and importance of the facilities planned within the development, the energy demands will be significant and critical to function. Consideration should therefore be given to added robustness and security of energy supplies so the energy centre solution should incorporate a degree of redundancy and back-up. This integrates smoothly with renewables-powered electrolysis or CHP (Combined Heat and Power) units adapted to support hydrogen, either partially or as the sole fuel source.

SUSTAINABLE DESIGN

Overview
The development must be sustainable, and consideration will be given to this in all aspects of the design. With regards to the Energy Centre solution, the starting point is to minimise the amount of energy required to power the development.

Energy Hierarchy
The Energy Hierarchy divides the developments energy strategy at its initial stages, into three criteria; Lean, Clean and Green, each with individual energy targets as is displayed in figure 1. The method in which these targets are to be met is as follows.

- Be Lean: Optimisation of Building Fabric performance in conjunction with low Air Permeability to illustrate passive design measures.
- Be Clean: Investigating the usage of Green Hydrogen as a sole fuel source or in conjunction with a Gas/Green Hydrogen CHP mixture, as this will demonstrate how energy is to be supplied efficiently.
- Be Green: The investigation into the feasibility of implementing the Renewable Energy options.

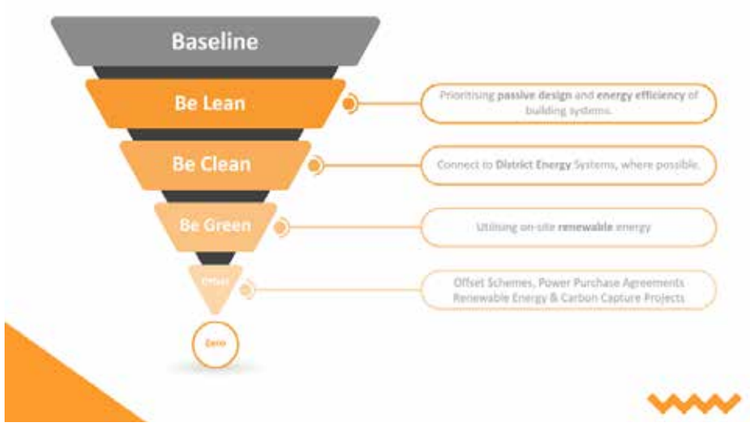


Figure 1: Energy Hierarchy

Reducing Operational Energy use
Various strategies can be employed to reduce the operational energy use for this development. This is to be achieved through the implementation of the Energy Hierarchy initially by means of Passive Design, through effective insulation and optimisation of the Building Envelope. Targeted shading can be implemented alongside technological solutions, such as occupancy-based lighting approaches and highly efficient HVAC systems. The performance of these HVAC systems can be improved further in conjunction with an integrated intelligent Building Management System (BMS). There is also a possibility for more innovative solutions: as the ice rink demands cold air and produces waste hot air, this could be integrated with the leisure centre, which demands hot air and produces waste cold air. Finally, another method that would be employed to reduce operational energy usage, would be to visualise and educate building energy managers, building users and visitors to drive energy consumption down.

Smart Buildings
The main driver of the Smart Building concept is to integrate people and systems for the development in a dynamic and functional way, along with providing an environment that is flexible, effective, comfortable and secure through the use of integrated technical building systems communications and control. This would be achieved by creating the IOT (Internet of Things) enabled environment. This concept is when sensors, software and online connectivity are used with in the development to create and record data. The purpose of this data generation is to allow insight into the usage patterns and trends of the development, which can be optimised using an integrated intelligent BMS.

Health & Wellbeing
The WELL Building Standard is a non-compulsory building certification scheme that is regarded as the leading framework for building health and wellbeing, which looks to apply, verify, and measure features that support and improve human health and wellness.

This standard was developed by integrating scientific, medical research and literature on environmental health, behavioural factors, health outcomes and demographic risk factors that affect health, with leading practices in building design, construction, and management.

WELL v2 consists of ten concepts these being: Air, Water, Nourishment, Light, Movement, Thermal Comfort, Sound, Materials, Mind and Community.

Each concept is comprised of features with distinct health intents. Features are classified as either preconditions or optimizations.

Preconditions define the fundamental components of a WELL space and serve as the foundation of a healthy building. WELL v2 offers a universal set of preconditions for all projects.

All preconditions are mandatory for WELL v2 certification. All parts in preconditions are mandatory.

Optimizations are optional pathways for projects to demonstrate achievement in WELL v2. Project teams are allowed the flexibility to pick the optimizations they want to pursue.

WELL v2 certification would set a precedent of high Health and Wellbeing standards throughout the development's lifespan.

Circular Economy
The Circular Economy concept is based on the premise that everything is engineered to be constantly reused or recycled, along with keeping resources in use for as long as possible, in conjunction with the extraction of its maximum value. With regards to this project the Circular Economy concept would be put into action by firstly considering the proposed development's whole life costs and benefits.

This will include operational costs as well as any environmental and social impacts in the project's lifespan. Secondly promoting the developments adaptability in terms of Climate Change adaption, functional adaptability, and any possible wider resilience issues.

These two factors would be the main points in following the Circular Economy guidelines.

Climate Resilience
Aberdeen city council is committed to achieving net zero by 2045, and to achieve a 75% reduction in carbon emissions by 2030 (compared to 2015/26).

The expansion and pioneering of hydrogen as a viable energy source would be a significant step towards this goal and would provide encouragement for non-council organisations to explore and adopt hydrogen as a power solution, further de-carbonising the region.

Social Value
Aberdeen City Region Hydrogen Strategy & Action Plan outlines the ambition for Aberdeen to become an international hub for the development and promotion of hydrogen energy, therefore this development is a significant opportunity to deliver the world's first hydrogen-powered sports stadium, generating a large amount of interest and focus on the region, in conjunction with the developing of key skills which can be used to assist in future projects in the region.

This would represent a significant opportunity for the city of Aberdeen to develop a significant and world-leading hydrogen industry and assist the city on its path towards net zero carbon emissions.

EXISTING INFRASTRUCTURE & ASSETS

Existing District Heating Network
Aberdeen Heat & Power is an independent not-for-profit company established by Aberdeen City Council and they operate a district heating network which serves various properties and housing within Aberdeen City Centre.

This network includes a connection into the existing Ice Rink building at the beach which feeds the Ice Rink, Beach Ballroom & Leisure Centre. The network is also linked into the nearby Seaton CHP Energy Centre and into the NESCOL College Building at the Gallowgate.

In addition to this there is a 4-year-old 1MW rated natural gas fired CHP engine within the Ice Rink which provides all heating and electricity for the existing buildings, and it can also export both heat and electricity if demand permits.

This current CHP unit's configuration is illustrated below in figure 2 which provides the schematic layout for the CHP system.

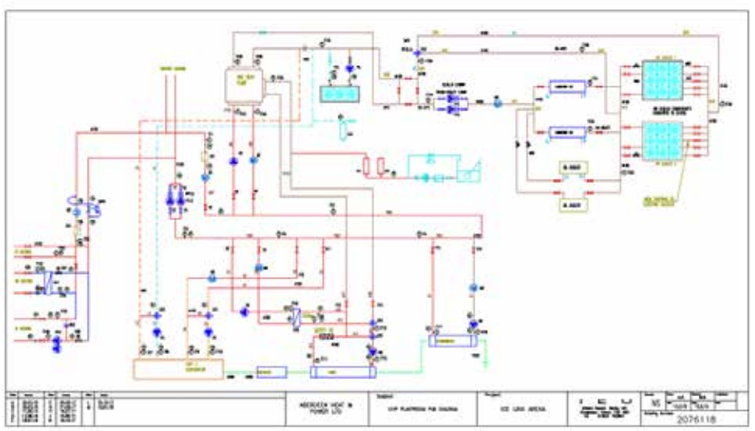


Figure 2: Current CHP Unit Schematic

LOAD PROFILE

The load profile of the proposed new development will required to be developed in more detail as the design progresses, however initial observations are as follows:

- The three existing buildings are currently served by a 1MW CHP so with the proposed new Ice Rink & Leisure facilities of around the same scale this load will change;
- The cooling demand for the Ice Rink will be counterbalanced by the heating demand for the swimming pools;
- The stadium will have some significant peak loads including circa 0.5MW for floodlighting, and circa 1.5MW for undersoil heating alone;
- The grow light rigs for pitch maintenance are also sizeable loads, but would not be in operation during events so are not considered to affect the peak load;
- An EV charging strategy will need to be developed as this could be a significant load on its own.

Taking all of the above into account it will be essential to have a modular approach to the energy centre design to ensure flexibility and resilience with regard to the load profile. The development is likely to have a stable demand during summer which will increase in winter and peak to a much higher demand during an event.

ENERGY CENTRE OPTIONS

CHP Overview
CHP technology works by using a fuel source, typically natural gas, to generate electricity which can be either utilised via a private wire, exported to the grid, or a combination of the two. The CHP engine harnesses the heat generated from this process to create hot water which is distributed through insulated district heating pipework to provide heating and hot water for the Beach Ballroom, Leisure Centre, Ice Arena & Stadium buildings, after which it returns to the energy centre to be reheated by the CHP.

By generating the electricity and heat through one fuel simultaneously, it is much more efficient than traditional power generation as there is less wasted energy, providing a solution that could improve energy efficiency by 40-45% subject to good utilisation of heat.

Green Hydrogen CHP
Aberdeen City Council is currently in the process of appointing a joint venture partner to help it build a "first of its kind" green hydrogen production hub to serve the city. This appointment is expected to be made during October 2021.

Depending on the development timescales and the availability and affordability of green hydrogen. It would be desirable to consider a green hydrogen powered CHP energy centre solution to provide all heating, cooling and electricity required for this development.

With this option the existing Aberdeen Heat & Power natural gas CHP heat network connections could also potentially be retained for increased resilience and to assist with peak loads as well as the import and export of heat.
As part of this solution, and in order to realise the value of the existing CHP asset, it would be a viable option to relocate the existing 1MW natural gas CHP engine to the either the nearby Seaton or NESCOL Energy Centre's as we understand from Aberdeen Heat & Power there is space provided for future expansion in both of these locations.

The big advantage of this option is that green hydrogen is mainly produced by water electrolysis using renewable electricity and as such will help deliver a carbon neutral development.

Investigations would have to be conducted into the current available scale of hydrogen-powered CHP units, and significant electrolysis facilities may be required to provide such a device with sufficient fuel. Both points may represent capital and space constraints on the project.

Natural Gas CHP future proofed to use Green Hydrogen
Depending on the development timescales and the availability and affordability of green hydrogen, a future proofed natural gas energy solution could be considered given there is an existing natural gas supply available on the site, albeit capacity would require to be reviewed.

As part of this solution, and in order to realise the value of the existing CHP asset, it would be a viable option to relocate the existing 1MW natural gas CHP engine to the either the nearby Seaton or NESCOL Energy Centre's as we understand from Aberdeen Heat & Power there is space provided for future expansion in both of these locations.

With this option, new natural gas engines would be utilised in a modular arrangement operating in parallel to ensure maximum efficiency regarding load demand.

All new natural gas CHP engines would be dual fuel future proofed. Therefore, be able to operate on Green Hydrogen or a blended mixture of Green Hydrogen and natural gas, later if the timescales for the availability of Green Hydrogen and a suitable distribution network are not compatible, with the timescale for this project.

The disadvantage of this option is that initially, the heat and power for the development would still be derived from a fossil fuel with the associated carbon emissions although these can be partly offset by the use of other technologies.

Energy from waste
An Energy from Waste Centre operates by firstly, waste being put into a combustion chamber. Air is then added to the combustion process, then several grates are used to push and turn the waste until ash is created. This ash is then taken away and used by the construction and other industries.

The facility then recovers energy from the waste in the combustion process, using a conventional boiler and economiser, to power a turbine that generates the required electricity or hot water.

The disadvantages of using this system is that an energy from waste centre requires a steady stream of waste to power it, and the spatial requirements are substantially

larger than other systems due to the waste storage required. Also, the amount of waste required to fuel an energy from waste centre is considerable and contracts with the local authority would be required to safeguard such a supply. Also due to there already being a proposed energy from waste facility in the local area, this being in the Tullos Industrial Estate in Aberdeen. It is unlikely to be a feasible solution by the Local Authority due to the proximity of these two sites. This is also in conjunction with the delivery of waste, having to be continuous, this would lead onto increasing the amount of traffic on site.

Another factor is that energy from waste developments are regarded as being a fairly new technology within the UK, with several energy from waste projects being documented as failing to achieve their targeted outputs, or creating more pollution than expected due to incorrect operation. Therefore, if allowed to proceed with this technology by the Local Authority, a large risk would be associated with this system. Furthermore, once the waste stream has been identified, reliably sourced and processed into ash, the plant will require full-time maintenance to keep it operational, as an energy from waste scheme requires specialist expertise for day to day running.

Biomass
Biomass can be used as a low carbon, low cost fuel source to power a CHP or a Turbine Unit. Biomass is defined as plant or animal material that is burned like ordinary fuels, but can be considered as having net-zero carbon emissions, as all the carbon emitted was absorbed by the ordinary growing of the plant or animal matter in the first instance. However, this would require a dedicated Central Plant (CP) unit, which wouldn't be compatible with Hydrogen, or indeed other fuel sources. Additionally, these units require regular maintenance because of the impurities and varying quality inherent with a fuel source of this nature.

Green Electricity
The UK's electricity system is on track to be powered free of fossil fuels and at 100% zero carbon in just four years' time according to a new National Grid Electricity System Operator (ESO) report. This is a key enabler for a zero-carbon electricity system by 2035.

Green Hydrogen is Hydrogen produced by water electrolysis using renewable electricity and us such will help deliver a carbon neutral development. It can be an effective way to store energy produced during times when peak electricity supply occurs, which may occur many hours away from times of peak demand.

Phasing & Enabling Considerations
Consideration will be required to be given to phasing and enabling works associated with the proposed development. Due to the existing heat network and existing utility services traversing the proposed development site.

It is anticipated an enabling works contract will be required to alter and divert the existing services without any disruption to the heat network that links to and serves the existing energy centres at both Seaton & NESCOL.

ENERGY CENTRE LOCATION

Consideration will be required to be given to the optimum location for the proposed Energy Centre, to serve the development along with the size, scale, and servicing requirements associated with it.

The final location will be subject to further design development, but a space allocation has meantime been included within the stadium building footprint.

The physical size and shape of the space required will be determined by a load modelling study once the preferred development option and Energy Centre option is confirmed.

There will be sizeable external louvre requirements for supply and discharge ventilation for the CHP engines and flue arrangements will require to be considered about visual impact.

There are two obvious options available in this regard namely:
- Integrated space internal to the Stadium & Leisure facilities buildings
- Standalone building

OTHER LZC TECHNOLOGIES

The proposed development presents a good opportunity to incorporate various forms of Low and Zero Carbon renewable energy sources and technologies, consideration will therefore be given to the inclusion of the under-noted options

Wind Turbines
Wind turbines are one of the lowest cost means of producing electricity. A wind turbine on the Beachfront would serve not only as a striking visual reminder of both the green credentials of the project and the ongoing realignment to renewable energy in the region, but would also form a cost-efficient means of energy production throughout the year. However, it should be noted that wind studies would have to be conducted to determine the suitability of this site for a wind turbine, and there would be noise and space constraints regarding its installation.

Wave and Tidal Turbines
Wave and Tidal Turbines are two distinct means of generating power from the regular motions of the sea. Both are highly dependent on the local marine conditions and not all sites are suitable. However, they offer some advantages over other forms of renewable power generation, in that they generate a highly predictable quantity of energy.

These forms of energy production are in their relative infancy, although Tidal Stream Turbines are becoming increasingly established. It is feasible that over the course of the construction of this project, wave and tidal energy production develops sufficiently to allow the installation of such units at the site, providing a dependable form of baseload energy production.

Tidal Barrages or Tidal Lagoons are alternative methods of extracting energy from the sea, which powers turbines as water moves from high tide to low tide. These would be unlikely to be suitable for this project, as they require a large footprint and capital investment.

PV
Photo-voltaic panels are a low cost, discrete means of energy generation which can generate appreciable amounts of power throughout the year. While they are unlikely to play a key role in the energy strategy of this development – as we expect higher baseload energy demand during winter, when PV panels are at their least effective – they can offer a simple and effective means of offsetting energy demand, especially during the summer months.

Fuel Cells
Fuel cells are a method of generating electricity from natural gas with significantly reduced emissions. By reforming natural gas into Hydrogen and combusting the Hydrogen, around 25% of the CO2 emissions of burning natural gas are avoided. These cells produce both useful heat, electricity, and potentially cooling.
They are, however, not effective at responding to rapid changes in demand which could pose an issue around large events such as at the stadium. This in conjunction with the large capital cost. Illustrates that they are unlikely to be a viable option, when compared to adapting the current CHP system to be compatible with Hydrogen.

Energy Storage
Due to the stochastic nature of renewable energy production, it is rare for times of peak production to occur at the same time when peak energy requirements are needed. As such, a means of energy storage would allow the renewable power sources to be utilised more efficiently. One option to consider, is onsite hydrogen electrolysis, which could produce green hydrogen for use either within or out with this development. A sufficiently large provision of onsite hydrogen electrolysis could allow for hydrogen fuel pumps to be provided to the public at this site, which would integrate with Aberdeen City Council's strategy to reduce barriers to hydrogen access as a fuel source.

Alternative means of energy storage are available. Battery-based storage can help moderate peaks and troughs in power requirements, but their efficiency can be limited. Water-based energy storage can achieve higher levels of efficiency but would involve a significant amount of built infrastructure and therefore capital cost at the development.

ASHP
Air source heat pumps regulate indoor temperatures by transferring heat between external air and the building. They can be highly efficient, producing up to 4kW of heat for every 1kW of electricity by extracting that heat from the external air. However, this efficiency is reliant on mild temperatures, and on days with extreme temperatures – where demand is at its highest – their efficiency is at its lowest. The cold winters experienced in Aberdeen would likely put high strains on the system, and other supplementary systems would likely need to be introduced to provide sufficient heating for the development.

Solar Thermal Panels
An alternate application of solar panels is to directly use the heat energy generated by solar radiation to supplement a boiler or other hot water system within a building. This can be applicable to reduce demand on a boiler, but as we expect peak heating loads to occur during winter, when solar energy is at its lowest, this is unlikely to be a cost-effective approach.

Ground Source Heating
Below-ground temperatures are very stable throughout the year, typically sitting around 10-14oC. This creates the opportunity for the approach of air source heat pumps to be adapted for underground applications, with significant efficiencies available due to the mild and steady temperature. However, as these can be expensive to install, extensive ground studies would be required to ensure viability, and could be limited by the site's proximity to the sea. Due to these factors this is unlikely to be a viable solution.

CARBON OFFSETTING

Depending on the final combined Energy Centre & LZC strategy it may be necessary to introduce an element of carbon offsetting to achieve a net zero carbon status facility. Examples of how this could be achieved include:

- Forestry and Conservation
- Renewable energy. Solar Wind or Hydro
- Community projects
- Waste to energy.

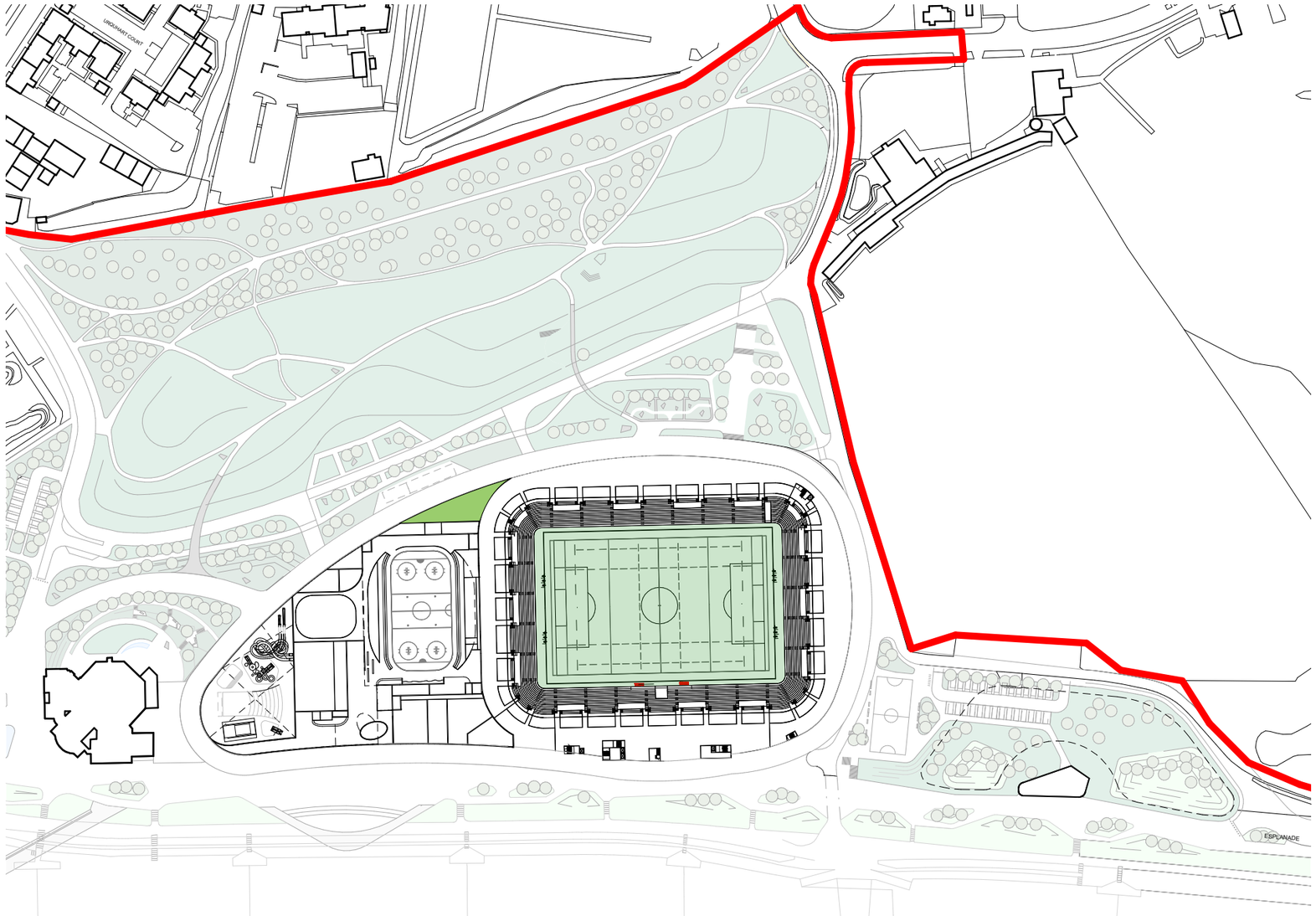
RECOMMENDATIONS

At this early stage in the design development of the project we would recommend that a full options appraisal is carried out to determine the best Energy Strategy for the proposed development.

During this appraisal we would expect that collaboration will be possible with the Councils chosen Green Hydrogen Joint Venture partner to fully explore and understand the feasibility of this option.

We would also anticipate consulting with other 3rd Party CHP specialists.

This appraisal would include all load profiling, sizing, location considerations, technical specifications, capital costs and running costs considerations.



POTENTIAL ENERGY CENTRE LOCATION AT LEVEL 01
OF STADIUM / LEISURE COMPLEX (TBC)

AFL architects

TECA CASE STUDY

The Design Team have exemplar experience in sustainable design, in particular the recent successful delivery of the Energy Centre at the Events Complex, Aberdeen (TECA).

The facility is a one of a kind sustainable development in Scotland, promoting Aberdeen as a 'World Energy City' and 'Energy Capital of Europe'.

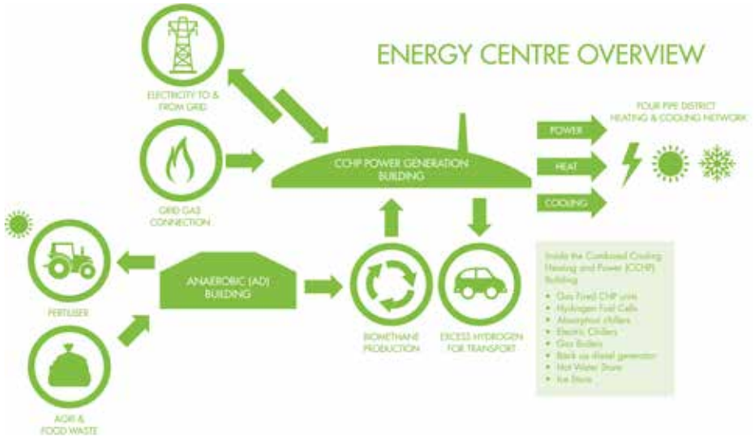
Rated BREEAM Excellent, TECA is the most sustainable venue of its kind in the UK, and reflects Aberdeen's economic strategy to showcase renewable technologies.

The key elements of the sustainable design strategy for the facility are the on-site Energy Centre (CCHP) and Anaerobic Digestion Plant.

The Energy Centre consists of a modular combined cooling/heating/power plant (CCHP). It has the largest installation of hydrogen fuel cells in the UK and operates on a modular basis, addressing seasonal variations in demand and providing flexibility for future expansion. The Energy Centre building envelope is constructed using reclaimed granite from the demolition of existing buildings and it has a green/sedum roof.

The AD Plant uses local crops, farm and food waste to create renewable Bio Fuel and fertiliser. Gas produced from this organic waste is fed into the CCHP plant. The plant provides resource efficient energy for the TECA facility, adjacent hotels and, potentially, all future development within the wider Masterplan area and neighbouring communities.

The centre is also home to a hydrogen fuel cells programme that fuels the buses serving TECA as part of an ambitious integrated hydrogen transport project.



TECA Energy Centre Strategy

TECA Energy Centre formed using Reclaimed Granite

Interior Installation of TECA Energy Centre

Hydrogen Transport Project