ORKNEY HIGHLAND PARK ENERGY SYSTEM

RENEWABLES HEAT WHISKY

Photo: Søren Solkær

Glossary

A glossary of all terms and abbreviations used in the report.

Active Network Management (ANM) – a system deployed by SSEN (see below) to allow additional generators onto their Orkney network, by curtailed their output such that conductors do not become overloaded.

BURGAR3A. A 4-way network interconnection point at the base of Hammar's Hill.

Constraint Managed Zone (CMZ): A geographic region served by an existing network where network requirements related to network security of supply are met using flexible services, such as Demand Side Response, Energy Storage and stand-by generation.

Green House Gas (GHG) – gasses which cause global warming.

Hammar's Hill – A hill on the North West Orkney Mainland with 5 turbines on it. At the base of the hill is a point on the network where there is a 4-way interconnection called BURGAR3A.

ISLAND NAMES: Eday, Westray, Sanday, Shapinsay, Stromsay, Flotta, Lyness, Hoy, South Ronadlsay, Burray and Rousay are some of the grid connected islands that make up Orkney. Scorradale is the connection point from Orkney to the Scottish mainland.

KIRKWA3B: A 3-way network interconnection point south of Kirkwall (the main town on Orkney) and close to the distillery.

Last-in First-Out (LIFO): One of the commercial terms associated with the Orkney ANM. The last generator to get a connection agreement is the first generator to be curtailed. The ANM system operates 6 of these lists depending which network component is overloaded. Generators can be on more than one list.

Long Term Development Statement (LTDS): A series of documents from network operators such as SSEN which describe the electrical networks including schematic and geographical diagrams as well as basic information on loads, generators and information on components such as transformer and circuit ratings.

Scottish & Southern Electrical Networks (SSEN): The owner and operator of the electrical distribution networks on Orkney and Northern Scotland.

Contents

Executive Summary

A partnership including Highland Park Distillery, SSE Enterprise, Lumenion GmbH, Protium Energy Ltd & Adrian Wilson (Consultant) was formed to assess the feasibility of replacing kerosene currently burnt at the Orkney-based distillery with a heat store to raise steam for the distillation process.

Orkney is uniquely blessed in the UK with 120% of current electrical demand met by renewable energy sources. However, it also has electrical grid constraints, requiring significant levels of generation curtailment. This project is in part to see how much of that constrained electricity can be released by the addition of a high temperature heat store at the distillery.

The technology the consortium has reviewed for this task is a high temperature heat store from Lumenion. This takes electricity, stores it as heat & then produces steam which can be fed straight into the distillery to drive the mashing & distillation processes. The heat store allows the distillery to capture low-cost curtailed electricity when available to offset the higher Greenhouse Gas (GHG) emissions when compared to kerosene.

A model was produced, representing the Orkney network, the active network management rules, the island's generators & the islands load's to estimate the amount of curtailed electricity. It is clear from the results that most of the curtailment was caused by conductors connecting the majority of Mainland to the north western edge of Mainland & the islands off that north western edge.

The model was then modified to include the heat store & the Highland Park load connected to the local grid; this relieves only a small amount of curtailment. The model then looked at connection to the grid at the north western edge of Mainland, which relieves a significant amount of energy - 6,511MWh pa which is enough to supply 45.3% of Highland Park's load.

As part of the project, we reviewed the contractual arrangements necessary for SSE Enterprise to own & operate the heat store and provide Highland Park with steam on a contract basis. A draft Heads of Terms document has been produced by Highland Distillers and SSE Enterprise.

The contracting for the constrained electricity has proven more difficult. The Active Network Management system on Orkney operates on a Last-In First-Out basis. This means that the ability to trade with selected generators is not yet possible as there is no way to stop the system allowing the next generator on the list to generate more against any load that the heat store provides. A work-around plan has been developed but its acceptability & efficacy has yet to be tested.

The heat store design, the electrical design, & the design for integration into the distillery have all progressed to a working concept stage from where the detailed designs can commence. However, the commercial model requires more development to enable an investment decision.

The technology has potential to support net zero by 2050 in several market sectors.

Overview of the Project

The aim is to replace this CO_2-emmitting process with a direct and highly efficient transformation of constrained renewable energy into high temperature CO_2–free process heat. The study will investigate the viability of a high temperature heat store which takes electricity (when available) and stores it as heat, and then converts that heat to high temperature fluids (in this case steam) on demand.

Orkney is uniquely blessed in the UK with 120% of current electrical demand met by renewable energy sources. However, it also has electrical grid constraints, requiring significant levels of generation curtailment. The islands have an Active Network Management system, which is trying to get more renewable generation connected by introducing controlled loads such as EVs. It is highly likely that the addition of a multi-megawatt dispatchable load would enhance the system and facilitate even more renewable energy on the archipelago, while tapping into low priced but otherwise curtailed electricity production.

Key objectives to investigate include:

- Availability of low-cost zero-Greenhouse Gas (GHG) electricity on Orkney to fill the store.
- Requirements for heat output (Steam, potentially high temperature fluids) and energy demands; both peak and profiles.
- Opportunities for additional heat loads (other distilleries, hospital, local hotel, new business park around the distillery).
- Business case and model for ownership and heat supply (Distillery, Network Operator, Energy Management company, etc).
- Wider market for releasing constrained renewables and providing high temperature fluids.

Key benefits of the project are:

- Removal of kerosene (and GHG emissions) from this distillery thus paving a path for other off grid sites.
- Additional zero GHG emitting generation potential realised from curtailed or new generation on the islands.
- UK manufacturing and local value added.

Prior to submission, the partnership had already considered electrifying the load with an electric boiler, a heat pump, using hydrogen, and using a battery as detailed in section 3b of the funding submission. The partnership concluded that large amounts of energy may be wasted by the conversion process for constrained renewable electricity whereas the heat store can use the constrained electricity directly and more efficiently. No further work has been done on this subject as part of this project.

Experimental/modelling Results and Conclusions

System Model

To assess the likely availability of constrained generation, a model of the Orkney network, the Orkney Active Network Management system, Orkney generators, and Orkney loads was built. In order to determine how much of that constrained energy can be captured, the model was expanded to include the Highland Park load and the heat store, then the forecast of energy released was calculated. The details of this modelling and some analysis compared to actual data is included in an Appendix.

In summary, the electrical network was modelled (the majority of the 33kV conductors), and at each connection point generators and loads were added. The generators were generally wind with the model for the turbine taken from https://www.thewindpower.net On Orkney the load factor of 10 of the turbines was known so these were used to develop wind profiles which in conjunction with the generator model gave the load factor. For other turbines, which were close to a known turbine, the same wind profile was used. Finally, for other turbines a load factor estimate was made using a website with relative outputs. Other models were deployed for wave, tidal and oil based generators.

The generation and load profiles gave unconstrained generation profiles, which were then constrained using the Active Network Management rules

Constrained Energy on Orkney

The model runs for 24 hours / 365 days so 8760 sets of calculations are made looking initially at the loads and unconstrained generation, to determine which of the conductors are exceeding their seasonal ratings. The generators are then constrained in order of their commissioning date (a proxy for the commercially sensitive connection agreement date) such that the last on the list is first to be curtailed (LIFO). Lists are deployed for each overloaded conductor and generators can be on more than one list.

The output is as follows:

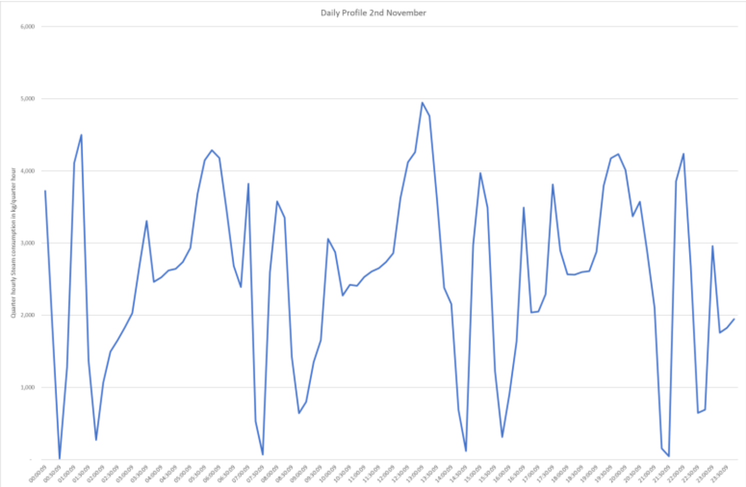
	Constrained energy by control point (MWh pa)					
Generator	[1] & [2]	[3]	[4]	[5]	[6]	[7]
Totals	367	9,491	36	1,021	0	0

What is certain, from modelling and talking to the Orcadians, is that Conductor [3] constrains the majority of the energy on Orkney.

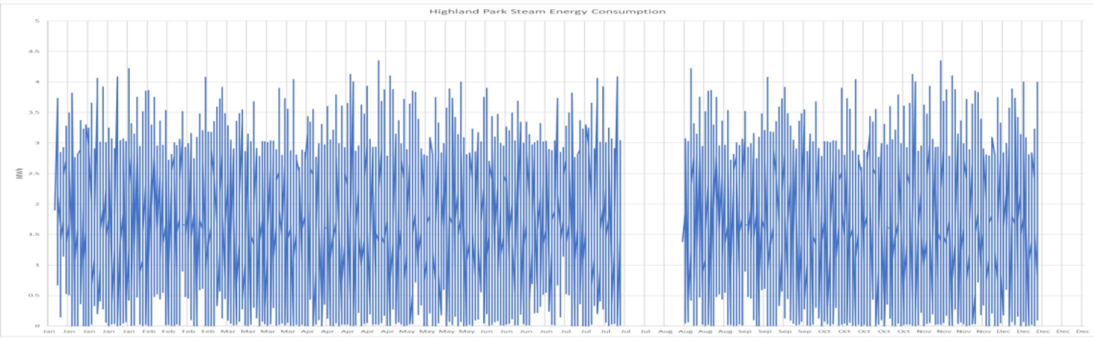
Highland Park Load

Highland Park distillery on Orkney has a steam demand which is currently met by burning Kerosene to raise steam. This feasibility study is examining if the distillery can be decarbonised using constrained renewable generation by providing additional load on Orkney at their distillery.

A typical daily profile of the steam demand is shown below. The profile shows dramatic changes in the demand.



Synthesising two months of data into an annual profile, now in thermal MWh, shows the maximum demand is 4.4MW and average is 1.67MW when operating. There is a summer and Christmas shutdown period. This demand totals 12,982MWh pa.



Lumenion Heat Store Model

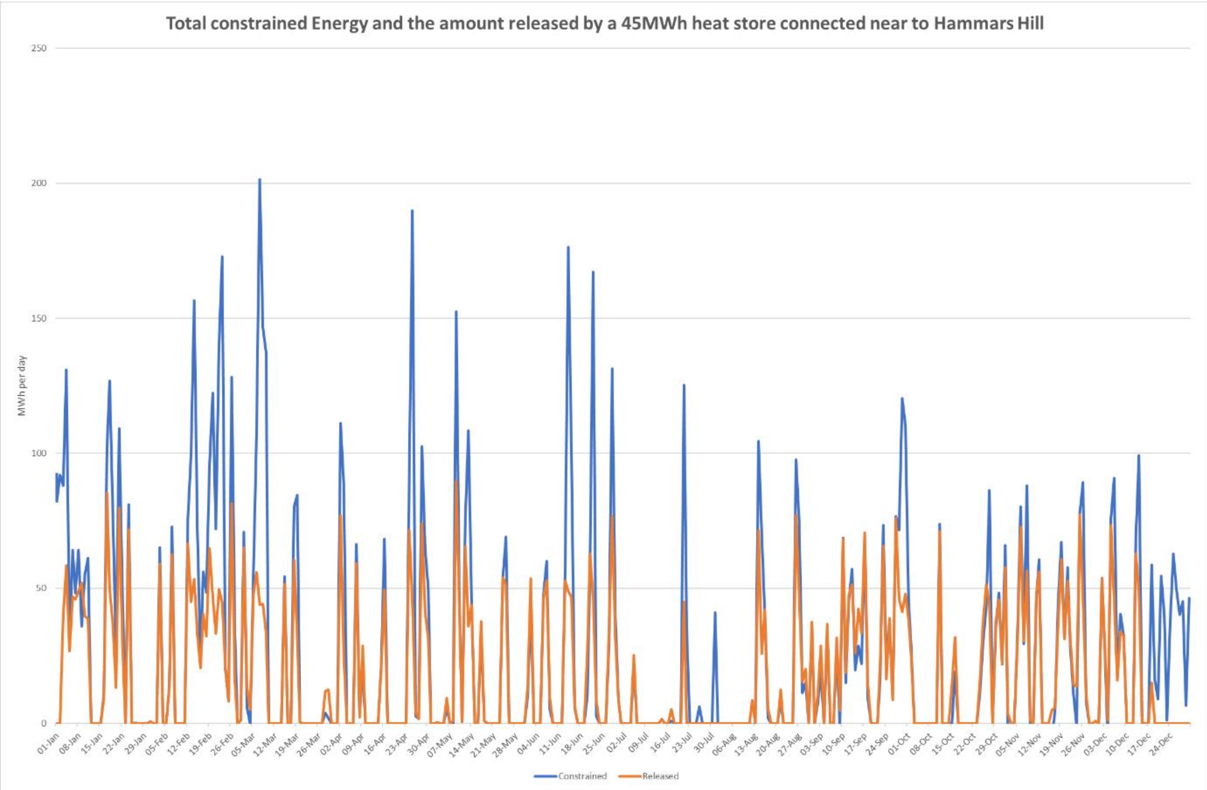
The Lumenion heat store takes electricity and stores it as heat. A water/steam circuit is used to extract the heat for the distillery process.

The key model parameters are

1. Energy stored,
2. Electricity input,
3. steam output
4. overall efficiency.

They are linked by thermodynamics such that 10 units of heat stored enables 1 unit of steam output and 3 units of electricity input. So, a 4.5MW thermal output as needed for the full Highland Park load would require a 45MWh thermal store and the input would be 13.5MW. The round-trip efficiency for a 45MWh store is 95%.

Model Results



6,511MWh of energy released will feed through to 5,878MWh of steam, some 45.3% of the distillery heat load. All of the model results assume that the network is intact, so it is conservative. If a network connector were to be unavailable due to maintenance or a fault outage, the amount of constrained energy would be much higher.

In the last week of the project, some data on an actual wind turbine was obtained. Comparative analysis is provided in an appendix.

Model Conclusions:

The model output shows that if the heat store is connected electrically at a point where constraint [3] can be relieved, then around 50% of the distillery's heat load can be met from constrained renewable electricity which, without the store being available, would be curtailed.

Description of the Demonstration Project

It is the corporate strategy of Highland Distillers to become net zero by 2030. Demonstrating that the heat store technology works, and that constrained energy can be captured is the aim of this project. As shown in the modelling section, around half of the distillery's heat can be sourced from constrained renewable electricity if a connection is made to a point on the electrical network 22km away from the distillery. It is likely that this connection will take 1 year to be approved (Planning & Section 37), and another 1-2 years to obtain easements and then built. This is too long to be considered under the Green Distilleries fund.

As a step towards full distillery integration, a smaller heat store is proposed which will capture constrained energy from the local grid and prove that the technology integrates well into the distillery operations. When the local grid is constrained (by a feeder outage) then the heat store can capture some of the distillery's demand and prove the trading operations. The distillery can also prove that the store's input, storage capability and output meet the design criteria by using constrained grid electricity, and additionally, that the integration works. Analysis of the heat store's usefulness, when connected locally, levelled out after 15MWh so this size was selected for the demonstration phase of this project Once proven, a second heat store will be added with commissioning to coincide with when the 22km connection is established.

The demonstration will therefore comprise the following items:

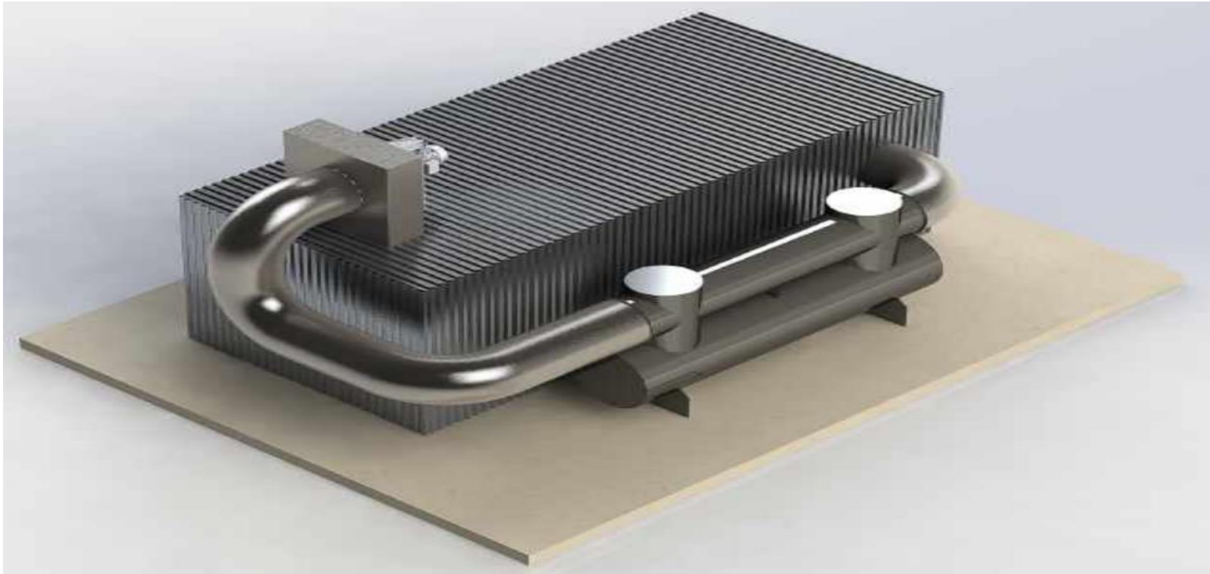
- The heat store, 15MWh capacity, with output of 1.5MW (steam, 165°C 6.8 Bar) and input 4.5MW electricity. [A second heat store 30MWh/3.0MW/9MW will follow as a second project.]
- A connection to the local grid, rated at 14MW so the option to feed both heat stores from a local supply exists, thereby future proofing the design. [A second 14MW connection, 22km away will form part of a second project.]
- Foundations for the heat store, pipework connections to the boiler house (~125m) and break-ins to the existing steam and return condensate lines during suitable shutdown periods.
- Cladding of the heat store in suitable materials.
- Development of a trading scheme for the curtailed electricity. Integration of the same into the heat store control system. [There are some significant risks in this work package, detailed in the risk section of this document.]
- Demonstration of the operation of the heat store including the trading of curtailed electricity.

Design of Demonstration

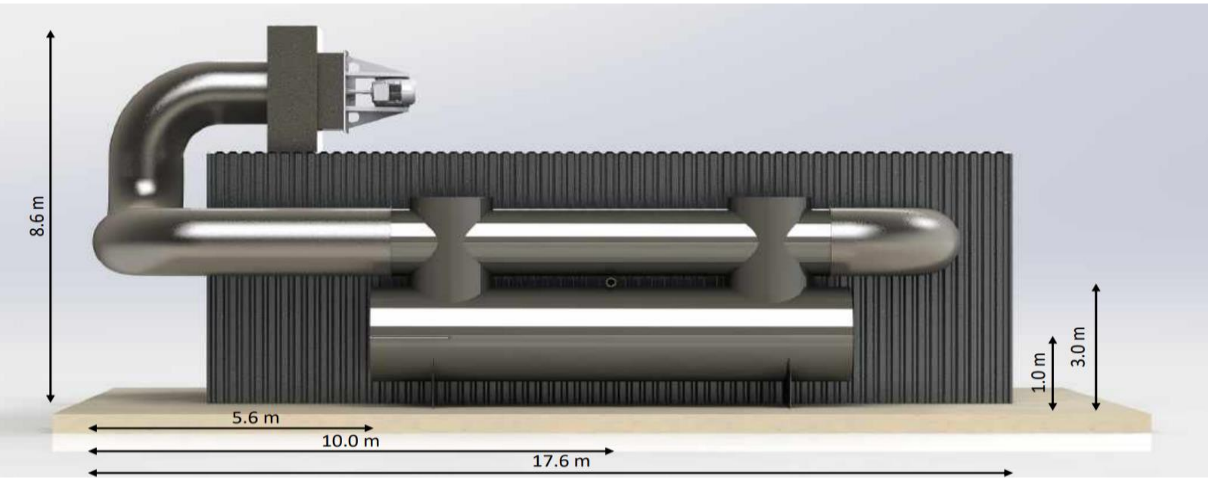
An outline design for implementation of the pilot scale demonstration. Where possible include diagrams and plot plans, please ensure the images are clear.

Heat Store Design

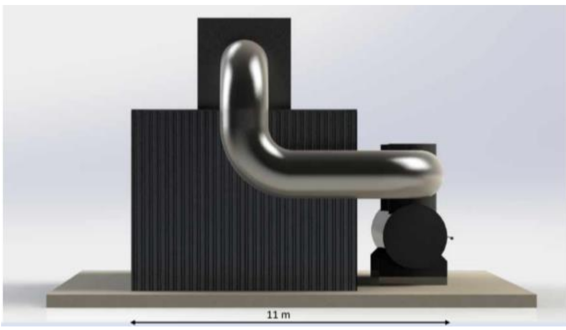
The 15MWh heat store has been concept designed by Lumenion and the details of the outline design are being discussed with two Scottish engineering & manufacturing companies. Items such as the manufacturability of the heat store to suit the weight of the workshop cranes, and the transport methods for example have been through several iterations of design. The design has progressed to the budget price stage. Images from the 3D CAD package showing the outline design is shown below:



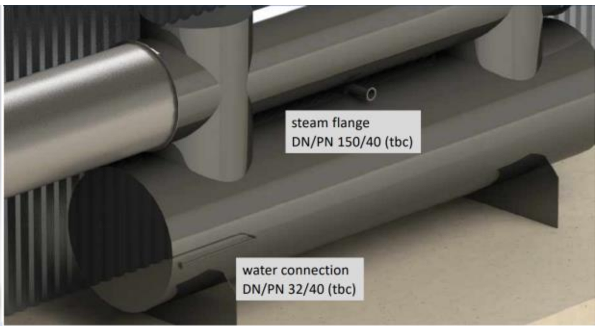
Isometric View showing the fan, heat exchanger and outer cladding of the heat store



View from the distillery looking South



View looking west



Details of the steam and condensate connections

Benefits and Barriers

BENEFITS

There are significant benefits of adopting the heat store technology on Orkney. When it is windy, Orkney has more generation than the conductors can handle, so generators are curtailed, particularly on the outlying islands. If alternative loads can switch on, on-demand, and take the electricity, the generators benefit, otherwise the opportunity to generate will be lost.

The dispatchable loads ought to be able to bid for the constrained electricity and obtain it for attractive prices. This however is not supported by the SSEN ANM system. Furthermore, there are regulatory barriers preventing SSEN supporting the energy trading process. Consequently, SSEN are not in a position to change the trading conditions of the ANM system, which is operated in a last-in first-out basis.

This project has considered how to work with these limitations and has a plan to proceed which requires *all ANM* generators to agree to trade their constrained electricity. While the commercial case needs further scrutiny and is not assured, the system could work as follows:

- All generators agree to automatically trade if they are constrained, through the same system (TraDER or some other aggregator system) in strict LIFO order.
- A minimum price is set for all generators and load providers such that the marginal operating costs of the wind turbine are covered.
- Loads bid for 10-minute packages of energy a few seconds/minutes ahead of time and their bids confirmed or otherwise. The 10 minutes is assumed to be short enough that generators won't lose out significantly if network conditions change and matches the TraDER system.
- The load comes onto the network and the generators are less constrained.
- The aggregator system deals with the payments.

BARRIERS

There is a significant risk that either the generators will not agree to this system or that a suitable aggregator cannot be found.

A second significant risk is that the network constraints change significantly due to a new connection to the mainland. A 220MW connection running to the Orkney mainland from the Scottish mainland has been approved by Ofgem subject to 135MW of generation connections being contracted prior to the end of 2021. This will not release the constraints to the outer islands. However if additional connections are needed, it is possible that the constrained energy will no longer exist. On the other hand, it is also possible that the new generators will increase the amount of curtailed generation. When the ANM system was commissioned in 2009, it took 3 years until the entire capacity had been mopped up by the additional generators, such is the abundance of renewable energy that can be harnessed around Orkney.

A third risk is that the other providers of dispatchable loads outbid the distillery for the energy. The likely candidates are Hydrogen Production on Eday, Ammonia production at

Hammar's Hill in the planning process, and the ReFLEX project aggregating EV, Battery and Storage Heater loads across the islands, but most likely mainly on the Orkney mainland.

MITIGATION

Hydrogen and Ammonia production should be very price sensitive as the processes are inefficient. However, the products may well receive some subsidy. The Ammonia plant is adding 8.4MW of wind to Hammar's Hill, which ironically may increase the amount of constrained energy if the maximum site load is less than this. There is a good chance that we can outbid these electricity users.

The ReFLEX group of aggregated EV, storage heater and battery load however only need to beat the next best tariff, e.g. overnight economy 7 or similar. It is therefore likely that they can out-bid us for the energy. However, they are unlikely to have significant loads on the outlying islands so the impact should be minimal.

The 45MWh heat store – the ultimate aim – will have an output that matches the peak load for Highland Park. This means the entire Highland Park steam load can be converted to renewable electricity rather than kerosene, half of which is purchased at prices lower than kerosene.

In 2019 Highland Park Distillery emitted 4,932 Tonnes CO_2e from on-site combustion, 87.5% of which was from kerosene used for raising steam. The Lumenion heat store could provide the site with 100% of its steam energy demand removing 4,315 Tonnes CO_2e per year given adequate constrained energy locally.

2019		
Kerosene	1,698,599	litres
Kerosene Emissions Factor (EF)	2.54039	kg CO_2e/litres
CO_2e	4,315.1	tonnes
Coke	179	tonnes
Coke EF	3,222.04	kg CO_2e/tonne
CO_2e	576.7	tonnes
Peat	112	tonnes
Peat EF	361.86	kg CO_2e/tonne
CO_2e	40.5	tonnes
Total	**4,932.38**	**tonnes CO_2e**

Emission factors for Kerosene and Coke from DUKES 2020: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020
Emission factor for peat from the SWA.

Two store sizes were contemplated; a 15MWh unit connected to the local Kirkwall Gird, or a 45MWh unit connected to a more constrained part of the network near Hammar's Hill. The aim is to run the distillery on constrained electricity, which should provide lower fuel costs.

Heat Store size	Electricity source	Electricity In	Proportion of steam supplied	CO_2e Savings
15MWh	Constrained @ Kirkwall	325 MWh pa	2.3%	99 tonnes
45MWh	Constrained @ Hammar's Hill	6,681 MWh pa	45.3%	1,954 tonnes
45MWh	Constrained @ Hammar's Hill & green energy contract	13,665 MWh pa	100.0%	4,315 tonnes

Further value from the heat store:

On the days when there is no constrained electricity, if it is assumed that the heat store will act as a boiler and generate heat on an as needed basis from electricity contracted in a more conventional way. In doing this, the heat store can be used to shift load away from peak distribution periods, by charging up when the distribution charges are lower and, in particular, avoiding the few peak hours (16:00-19:00 Monday-Friday) and thereby saving in the example below 2.17p/kWh in distribution charges. Some intelligence may be needed in the charging algorithm, if electricity is expected to be constrained. In that way, if the differential rate is more than 2.17p/kWh, releasing the constraint is given priority.

Tariff	Red unit Charge	Amber Unit Charge	Green Unit Charge
HV Site Specific No 4	2.620p/kWh	0.455p/kWh	0.176p/kWh

With the correct commercial agreements in place with for example, an aggregator, the heat store can provide balancing load to the grid. Electricity priced at £20/MWh is available around 20% of the time from the balancing & settlement market. DNO charges and the aggregator fees need to be added to this price, however this could also provide a good supply of low-cost energy.

Costed Development Plan

Project Management

The project will be managed by Protium Energy

Project Management	£105,200

Lumenion Heat Store

Description of work with local engineering & manufacturing companies.

Both companies have shown their capabilities to provide either groups of parts of the Lumenion solution or serve as a total systems provider. Non-binding indicative quotes are in preparation.

UK Content

Based on exchange with above suppliers so far, UK value added of over 70% of CAPEX seems to be achievable

Lumenion:	Total		UK Content	
Design	£	60,000	£	15,000
Heat store Hardware	£	2,165,000	£	1,680,000
3 x HV Transformers	£	130,000	£	55,000
Installation	£	150,000	£	75,000
Commissioning	£	80,000	£	24,000
Sub total		**£2,585,000**	**(72%)**	**£1,849,000**
SSE Due Diligence	£	13,608	£	12,096
Highland Park Interfacing	£	11,520	£	11,520
UK interfacing & CDM	£	18,900	£	18,900

Electrical Connection

A firm connection price would ideally be obtained; however, these can take 65 working days and are therefore out of the timescale for this project. Budget prices have been requested from SSEN and even this is due on the regulatory deadline of the 29th of March (originally promised for the 1st March).

Until then, the working assumption for a connection at KIRKWA3B is £160,000 plus 19 days interfacing and supervision.

Connection: SSEN (Estimate)	£160,000
Management	£14,963

Integration into Highland Park

Early deliverables from the Lumenion design package have identified the size and specification of the foundations, the overall footprint and the connection points and sizes for the steam and return condensate connections. The price includes a building to house the heat store.

Heat store building	£940,000
Pipework etc	£203,000

Commercial Agreements

HEAT PURCHASE AGREEMENT

SSE Enterprise and Highland Distillers have progressed well with outlining the Heads of Terms for a Heat Purchase Agreement. A full draft of these has been circulated and legal teams from both sides have assessed and agreed the commercial and legal points that would need to be incorporated in order to successfully supply steam to the distillery from the heat store. An advanced draft of these terms is available, and the contracting parties are happy to share and discuss this with BEIS however it cannot be final until signed.

ELECTRICITY SUPPLY/PROCUREMENT

The challenges around how to procure the curtailed renewable electricity at the right price and in the right profile have been well outlined above in this report. Significant developments have been made during the feasibility study to better understand the current limitations of the Orkney Active Network Management system and the commercial arrangements in place with the existing generators. The data and information gathered to date have shown us that more work is required to fully assess the options available to harness the curtailed renewable electricity on Orkney. These challenges are the biggest barriers to reaching an investment decision for the project and so need further work in order to establish the viability of the project.

To date we have spoken to the ReFLEX project, the TraDER project, three parts of the SSEN organisation (Active Network Management, Trader Project Engineer and a Network Design engineer) and the Orkney Renewable Energy Forum to try to find a way through the trading issue.

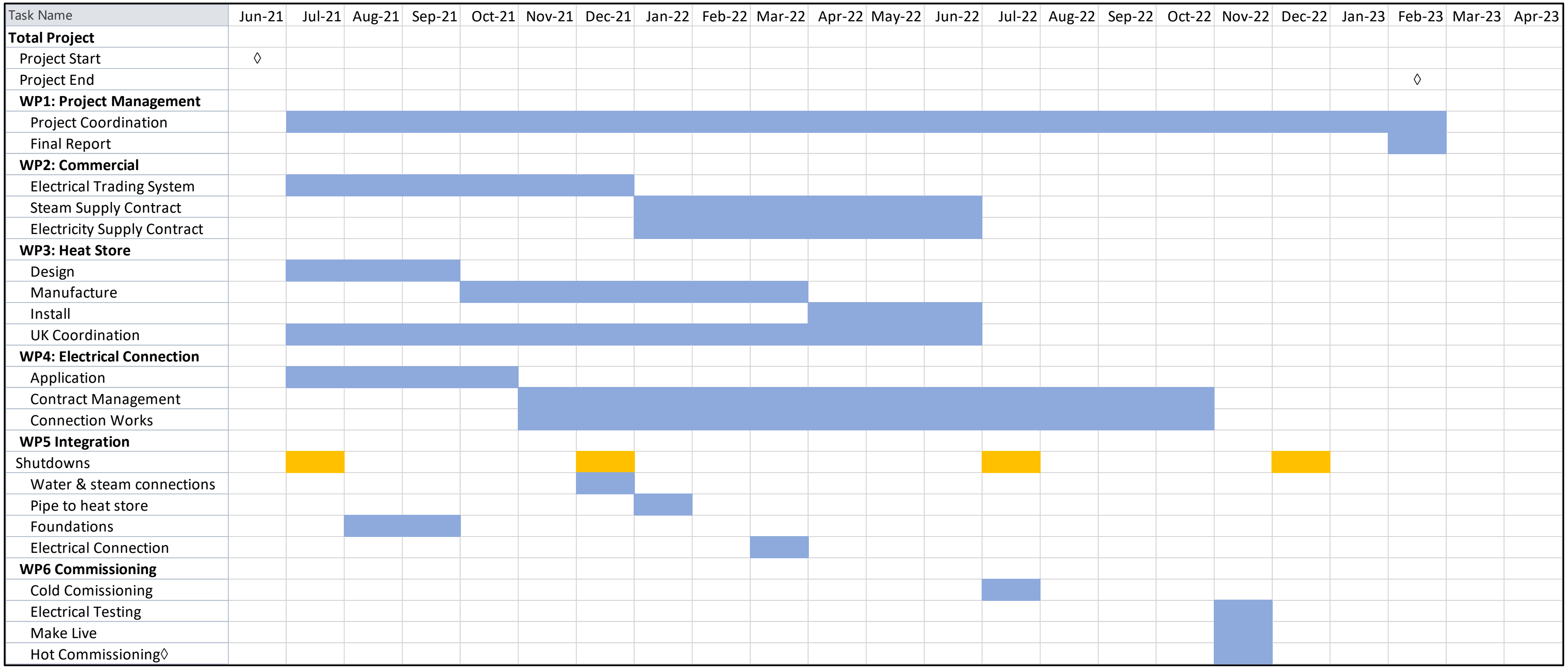
For the next stage of the project, we will develop the trading of dispatchable load matched to curtailed generation. Time has been allowed to bring all generators on board and use the existing TraDER infrastructure while keeping within the SSEN LIFO rules. There will be significant legal development work associated with this and the SSE Enterprise / Highland Park steam contract. Subsequent to this, trading rules can be developed and fed into a trading model.

Legal and commercial	£118,949

	Project Total	UK Content
Project Management	£105,200	£105,200
Heat Store	£2,629,028	£1,891,516
Electrical Connections	£174,963	£174,963
Integration into Highland Park	£1,1030,000	£1,103,000
Legal and commercial	£118,949	£118,949
Total	**£4,171,139**	**(83%) £3,446,627**

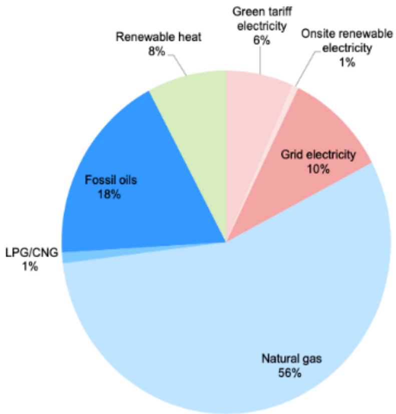
Project Programme

(Indicative until the SSEN network quote is received)

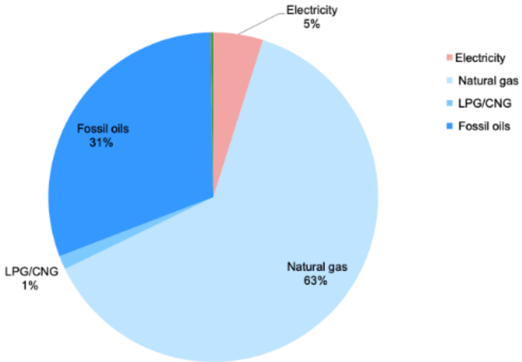


Rollout Potential

The production of whisky is around seven times more energy intensive than that of gin and directly produced around 530,000 tonnes of CO_2 equivalent in 2018. The majority of these emissions come from the generation of heat for the distillation process, which accounts for approximately 83% of the distillation industry's fuel consumption. 56% of the fuel used is natural gas. However, due to the remote location of some of the distilleries, the industry still uses a range of fossil oils such as kerosene, which emit an even greater amount of CO_2 than natural gas or grid electricity.



Distilleries UK fuel mix 2018



Distilleries UK greenhouse gas emissions mix 2018

This clearly suggests that there is significant room for making a positive contribution by utilisation of renewable energy sources, especially replacing direct fossil fuels

For example: In the distilling context, island distilleries such as on Islay and Jura where they have a significant production capacity of 25,000,000 litres of pure alcohol per year (ten times that of Highland Park) as well as abundant wind and tidal generation potential. Assuming the low carbon marketing drivers for Highland Park are applicable to these owners, then assuming an emissions intensity of 1.8kg CO_2e per Litre of pure alcohol produced this would equate to 45,000 Tonnes CO_2e emissions annually when at full production. The Islay electrical network is already subject to a Constraint Management Zone so the addition of more renewable generation will almost certainly lead to an ANM Zone. The 127 Scottish distilleries are distributed around the country, although there is a significant cluster in Speyside. We have details available for all 127 distilleries and at the appropriate time will make contact with them to discuss their heat needs and our technology.

Area	No.	Likely fuel
Islands & Campbeltown	24	Largely Kerosene or Fuel Oils
Highlands	36	Mixed
Lowlands	16	Largely gas
Speyside	51	Largely gas
Total	127	

Route to Market Assessment

The take up of the heat store requires 3 driving factors:

- Altruistic, marketing, financial (e.g., significant carbon tax) or legal impetus for change
- Heat loads (>300kW average) in the temperature range 100°C – 550°C
- Access to variable quantities of, or variably priced electricity.

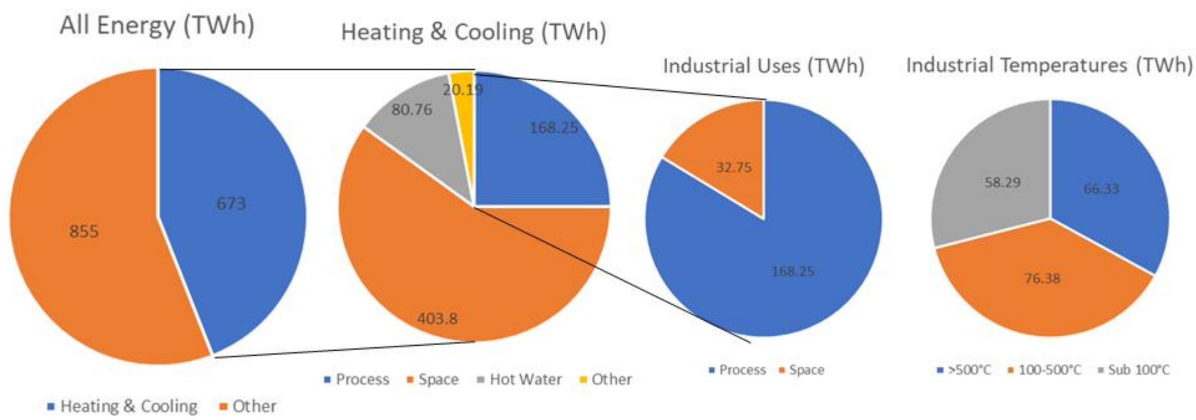
The first factor above (Impetus for change) is driven by company owners / boards and the government.

The second factor (high temperature heat loads) is found in many industries:

- Food and beverage (Distilling, brewing, baking, dairy, vegetable preparation, etc)
- Rubber & Plastic industries
- Paper & printing
- High temperature manufacturing – e.g., machine construction, vehicle production, etc
- Metal processing
- Chemical and pharmaceutical industry
- Thermal power stations

The final factor (access to variable quantities/ price of electricity) can be found in a number of ways

- Networks which are actively managed, such as on Orkney, but also widespread in the Scottish Borders, Norfolk, and Cambridgeshire, with smaller areas across the entire UK from Cornwall to Shetland.
- Renewable generators on permanently constrained network connections.
- Renewable generators specifically installed to feed the heat store.
- Traded electricity – balancing market or other low-priced electricity.



UK annual energy demand of 1528TWh includes 673TWh for heating and cooling. Of this demand, 201TWh is used by industry and of that, 76 TWh of demand is in the 100-500°C range and addressable by the heat store technology. Highland Park's 13GWh pa demand represents 0.017% of the addressable market.

Barriers to heat store adoption across the UK

The main barriers to the widespread adoption of heat stores to make thermal energy GHG free, is if one of the three factors mentioned above is missing. They all contribute to the financial analysis of any potential project, so if the heat load is too small, the heat store would be relatively expensive, if variable access to low-cost electricity is not possible then storing it makes no sense, and if there is no benefit to the organisation then there is no impetus to change. For those customers who have no marketing or altruistic driver, the investment decision will be put off until there is a legal requirement or financial driver that forces change. This latter point is clearly in the hands of government.

Other than this generic barrier, the heat store technology is new, and so demonstration of the product and its integration into the distilling market is hugely advantageous, especially with a world-renowned brand such as Highland Park. The scale up from the more modest installations in Berlin will prove this is possible. The technology is based on well-known engineering components so the risk here is limited.

The main risk to the technology is that adoption is too slow for the company owners to support and they cut their losses, or that the technology adoption is too fast and working capital limits demand.

Benefits flowing from heat stores, other than lowering the cost of electrification of heat loads and the saving of GHG emissions, include improved opportunities for constrained network generators and providing an additional balancing load to network system operators.

Dissemination

In the process of understanding the situation on Orkney the team have spoken to the following groups:

- The ReFLEX group to discuss dispatchable loads. It is likely we are competitors.
- The ANM group within SSEN to discuss the ANM rules and how flexible loads can engage with their systems.
- The TraDER Project – SSEN and mainly Elexon engineers to discuss trading and how the AMN system impacts on the trading possibilities. If the TraDER system is further deployed to other network areas, this could prove significant.
- The Orkney Renewable Energy Forum members (exclusively made up of Community Energy Scotland members in the meeting) to discuss the curtailments, likelihood of the acceptance of more overhead lines, and the issues with LIFO ANM rules. They thought that Scapa Whisky and the Kirkwall Hospital could be further locations to explore with the heat store technology.

Paving the way for further dissemination we have engaged with:

- The Orkney Renewable Energy Forum members to discuss the Orkney Energy Strategy.
- The Renewable Energy Association agreed that this initiative and follow up initiatives with other industries get full access to the various communication platforms provided by the REA
- Cabinet Secretary for Rural Economy and Tourism, Fergus Ewing MSP, who has asked for an update on the outcomes of the project.
- Manufacturing Partners: The two engineering & manufacturing companies have each delivered energy related plant into industries that Lumenion is targeting

In the course of the project the project partners have gathered data, narrative and marketing materials to support high quality presentations, brochures and discussions such as in social media.

The marketing messages shall cover following areas:

- Description of the storage system, the electrical network, and the distillery
- Integrating the storage system into a distillery
- Integrating the storage system into a constrained electrical network
- GHG savings, both present day and future, as the grid goes green
- Business case – both present day and future, as prices become more volatile.

Key partners in the dissemination activities will be Highland Park and its owners, Lumenion, SSE Enterprise, manufacturing partners, the Scotch Whisky Association, the Malt Distillers Association of Scotland, and the Energy Network Association. We would also target publications in Utility Week, IET magazine, etc. Edrington could produce an article for the Brewer and Distiller International magazine, the trade publication of the Institute of Brewing and Distilling.

Conclusions

The heat store concept design has confirmed that the steam requirements for the Highland Park Distillery can be met, both in terms of pressure and temperature and in terms of quantity/maximum demand. Plans for the integration of the heat store into the distillery have progressed to the budget pricing stage and the project is in a good position to move to detailed design.

The model and conversations with Orcadians have shown that the majority of the constrained energy on the island cannot be harvested locally at the Distillery, but at a point 22km away. Connecting the heat store to here electrically would allow 45.3% of the Distillery heat demand to be met by constrained electricity.

SSE Enterprise, who would ultimately intend to own and operate the heat store, and Highland Distillers, the Distillery owners, have produced an initial draft Heads of Terms for the provision of steam, demonstrating the ability to progress with the decarbonisation of the Distillery.

Trading to allow the curtailed generation to be matched with dispatchable load proved difficult, with this project. ReFLEX and TraDER both found the same issues relating to the ANM system rules, preventing the bilateral trades between generators. A potential solution has been identified involving an automated system of trades with all generators following the ANM's LIFO rules. This is the largest risk facing the consortium and until it is solved, there is no investible case. Further work is required here either through the green distilleries fund or via alternative schemes.

A second risk revolves around the other providers of dispatchable loads who would also trade for the constrained energy. Market forces may drive up the price for the constrained energy to uneconomical levels.

A third major risk is the impact that a potential new 220MW connection will have on the Orkney Network. The connection itself will not de-constrain the network but works to allow the new generators may achieve this. Alternatively, the new generators may actually cause more constraint issues and improve the availability of low-cost energy for Highland Park.

Overall, the technology has the ability to decarbonise the 100°C to 500°C heat market, support congested electrical networks and constrained generators by providing a dispatchable load. The establishment of UK manufacturing represents an inward investment opportunity with good replication opportunities since the Highland Park project represents 1/5000th of the potential UK market.