How we delivered the 98MW/196MWh Pillswood BESS Project

Case Study | Alex Thornton, operations director at Harmony Energy, gives us a deep dive into the biggest battery storage project in Europe, including the bold decision to be an early-mover into 2-hour lithium-ion BESS, in a market of much shorter duration assets.

Credit: Harmony Energy.

FACT SHEET:

Project name: Pillswood BESS
Location: Hull, UK
Capacity: 98MW (196MWh Lithium-ion)
Energisation date: November 2022
Developer/asset owner: Harmony Energy, **Harmony Energy Income Trust (HEIT)**
Battery technology providers: Tesla
Distribution network operator: Northern Powergrid

TIMELINE:

- **2016:** Planning and preparation begins
  - a) Technical analysis of the distribution network
  - b) Negotiations with landowners
  - c) Design phase
- **2017:** First planning application submitted
- **December 2020:** Planning rights secured
- **April 2021:** Contract with Tesla signed
- **November 2021:** HEIT lists on the London Stock Exchange
- **November 2021:** Construction begins
- **November 2022:** System is energised
- **January 2023:** Phase 2 fully operational
- **March 2023:** Official launch and site opening

PROJECT OVERVIEW:

The Pillswood Battery Energy Storage System (BESS) near Hull in northern England was officially opened by Harmony Energy and its investment company, Harmony Energy Income Trust, in March 2023.

This 98MW/196 MWh scheme is Europe's largest by capacity, using a Tesla 2-hour Megapack technology system.

The site is located next to National Grid's Creyke Beck electricity substation. The world's largest offshore wind farm, Dogger Bank, also feeds into the same substation, planned to be the connection point for the first two phases of Dogger Bank.

Investigating the potential for energy storage in the UK

The project was conceived in early 2016, when Harmony Energy made a leap of faith into the energy storage sector. As a company, we had a strong belief that the energy storage market in the UK was fundamental to the country's ambitions to decarbonise. The UK's target at the time was a commitment to an 80% reduction of greenhouse gas emissions by 2050.

European and UK government policies were driving a reduction in emissions and, in the UK, we were also seeing a reduction in the reliance on centralised coal-fired power stations. With the resulting movement towards wind and solar, we firmly believed that BESS had an increasing role to play in the energy supply of the future.

In 2016, we had already started conversations with Tesla about the potential for 2-hour lithium-ion batteries. Where other UK developers were only speaking about 30 minute or 1-hour duration batteries, we identified that the UK energy system would need longer duration storage as we continued to decarbonise and decentralise generation.

Harmony's mission statement was clear: develop, build, own and operate energy storage projects at utility-scale with lithium-ion batteries being the product of choice.

The Pillswood project is born

Following the review of the Electricity Distribution Network data, we identified Creyke Beck substation, at Cottingham near Hull, as a potential viable grid connection point for a large-scale BESS. This initial technical analysis including a desktop appraisal of the site, led us to confirm that there was sufficient capacity at this substation to connect a project of this size.

Local Distribution Network Operator (DNO) Northern Powergrid confirmed that there was sufficient capacity and reinforcement on the network for batteries with a combined grid connection of 98MW. The concept of Pillswood was born.

The next stage involved pre-planning consultations with the local planning authority. During this stage, we identified key risks to the project. The main risk being the site's status as a flood sacrifice zone, used as a floodplain to prevent people's houses flooding in the event of an extreme weather event. This would necessitate an elevation of the batteries and formed a founding principle of the layout of the project.

Securing property rights

Harmony Energy then entered into negotiations with landowners and adjacent landowners with a view to obtaining a long-term lease for the project build.

Initially, it was planned for the site access to utilise existing level crossings. Although we received initial consent for this, following further discussions with Network Rail, it became clear that this would be too complicated due to local site constraints. Further solutions were put into consideration, including the option of building a new bridge across the railway. However, this option proved challenging technically and financially so was deemed unsuitable.

The remaining option was to build a new access road from the west, and we subsequently began discussing terms for that option. Negotiations began in pursuit of extremely complex agreements with three separate landowners who could grant alternative access across their land.

During the four-year development period of this project, we encountered fundamental challenges which led to us changing our plans multiple times and the access track is just one example of this.

Securing the land rights with four different landowners was one of the largest pieces of work during the entire project, with in-house staff and lawyers from all stakeholders involved in negotiating, drafting and executing the land agreements.

Entering the design phase

Once the grid connection was confirmed at 98MW, Harmony Energy could begin the design phase within the space available. The design had two elements to it: the new DNO 132/33kV substation; and our battery system. There were around four or five different iterations over the process. We worked in close partnership and collaboration with Tesla in order to adapt the design to make sure we were creating the best solution whilst trying to value engineer within the specific site constraints.

Due to the designation of the site, we were faced with the task of designing the first ever project of this scale to be elevated on a steel platform. As the site is located in a flood sacrifice zone, our design needed to incorporate the elevation of equipment which would raise the batteries from the ground without impacting on the volume of water that the site could accommodate in a flood event. This brought many challenges as the design needed to

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solve three singular needs: to guarantee that the platform was structurally sound on engineering terms; to ensure that the project could operate safely even in a once-in-a-century-flood event (combined with the added likelihood of the access being inaccessible during such a flood); and to maintain the cost-effectiveness of the solution.

This made the design totally unique, with all the electrical equipment designed to sit approximately 1.8 metres above ground level. The height calculations were made in consultation with the environment agency and local planning authority according to both detailed engineering design data and thorough risk assessments which took historical data, flood modelling and additional safety factors into account.

In light of these discoveries, we consulted a structural engineering company to carry out some preliminary structural design work to determine the feasibility of this elevated platform even before negotiations with Tesla on contracts had taken place.

The final proposed design incorporated the construction of four large steel platforms. This had the added advantage of the fact that all electrical cables were run above ground, reducing the amount of cable trenching and civil works on site.

The final site design incorporated:

- 78 individual mega pack battery units, manufactured in the United States
- 40 MV/LV transformers, manufactured locally by Wilson Power Solutions in Leeds
- Two 33kV customer switch rooms supplied by CRT in Italy
- One 1.4km access track
- Over 20,000 m2 site – the size of three football pitches side by side
- A new 132/33kV substation constructed by Northern Powergrid

Getting the project shovel-ready

During the development phases, Harmony Energy submitted numerous planning applications, all taking into account the latest developments in lithium battery technology. After 17 revisions, we submitted our final 98MW grid connection planning application to the local planning authority.

Due to the sustainable credentials of the batteries which do not produce emissions, the council took the view that the construction of the battery energy storage site would be a necessary development. Our plan also proposed landscaping to create biodiversity gains, including trees and over 1km of hedge planting on the site and along the 1.4km access track. All of this results in a minimal impact on the landscape.

By the end of 2020, we had secured grid capacity, planning and land rights which meant we were ready to move on to the next stage.

HEIT acquires and funds the project

In November 2021, Harmony Energy successfully floated its investment arm, Harmony Energy Income Trust Plc (HEIT), on the London Stock Exchange, raising £210 million. HEIT has preferential rights to acquire and build out the next 1GW of Harmony Energy's development pipeline into the future which provides investors with an opportunity to participate in the construction and growth of the battery energy storage and renewable energy market in the UK.

HEIT acquired and funded the project for Pillswood at the construction-ready stage – once planning, grid connection, construction and battery supply contracts and the lease option over the land had been secured. As a result, investors were protected against the usual development risks inherent in a project like this, while benefitting from value uplift as the project went from construction to operation.

One of the most remarkable aspects of battery energy storage schemes like Pillswood is that they are constructed without depending on government subsidy which is a significant benefit to taxpayers and consumers in the UK. Historically, new renewable energy infrastructure has always required subsidy to make them financially viable.

Forging ahead with construction despite supply chain challenges

Work began in autumn 2021 with the construction of a 1.4km access track, complete with two bridges and two culverts. The track runs across agricultural fields so in order to prepare the ground for the build, the topsoil needed to be stripped, the soil stabilised through the injection of lime to form a hard formation, and then compacted stone was added on top.

In January 2022, we began to prepare the battery site itself, which involved the installation of 478 individual piles, each to a depth of around 15m. These were installed to support the steel frame elevating all of the electrical equipment approximately 1.8m off the ground. Ground beams were inserted to connect the piles, before our specialist construction team began building up the legs of the platforms on which the batteries would sit.

Constructing the scheme to a tight timescale in a challenging geopolitical and global supply chain environment was no mean feat. International shipping issues were affecting lead times, particularly on the electrical equipment which we were reliant on. To reduce the risk of delays on components, we spoke directly with

manufacturers and suppliers, often spending days negotiating a multitude of assets, from steel beams to cranes, trucks and staff. The global supply chain was experiencing significant strain as we came out of Covid-19 lockdowns but through effective communication we were able to maintain and develop strong relationships with the supply chain, allowing us to mitigate much of the impact.

During the access track construction, we also encountered a number of underground utilities. Safe working practices and bespoke construction strategies were deployed to protect and mitigate any immediate or future impact on the in-situ utilities.

Rapid construction of the new substation

Simultaneously to this, Northern Powergrid was working hard on the construction of the new distribution substation adjacent to our site. Northern Powergrid had a large scope of work to complete to connect our project which included refurbishment of a 132kV circuit breaker, installation of 132kV cable and building a new 132/33kV substation with 33kV switchboard. Again, due to the nature of the site, Northern Powergrid's new assets were built on a raised platform so that the equipment could be lifted out of the flood zone. Due to the scale, complexity and timescales of the project, Northern Powergrid worked at an incredible speed, safely delivering the build of their works in record time.

During this phase, the Harmony Energy team coordinated the three parties: Northern Powergrid, the distribution network operator providing grid connection; Tesla, providing the Megapack batteries; and G2, the subcontractor responsible for plant construction including civil work, the access track, and facilitating connections between transformers and megapacks.

Successful energisation of the project

As the construction phase begins to finish, thoughts turn to energisation. Before we could energise the site, all parties have to ensure that the new system is safe and ready to be switched on. We engaged with the control centre for Northern Powergrid to run through a sequence of safety checks and tests in order to make sure that the site would not impact the network. Numerous cold commissioning checks were done on all the equipment including cable pressure, sheath tests, communications tests and emergency stop buttons.

The moment then came for Northern Powergrid to close their 132kV circuit breaker and energise the transformer. There were no loud noises, lights or surprises which was exactly what everyone was hoping for. Despite knowing that the works were completed by professionals, there was a sense of relief from the Harmony team as we left site at 11pm on a Friday night knowing that the Northern Powergrid transformer was energised.

Following the first stage of energisation, Northern Powergrid was able to energise their 33kV switchboard. Shortly after that, the project was energised as Northern Powergrid closed the metering circuit breakers. Once again, the teams and Senior Authorised Persons (SAP) from Northern Powergrid, Tesla and G2 worked as a single unit to ensure that the system was energised in a safe and controlled manner. With the energisation documentation issued, Northern Powergrid left the project team to conclude the on-site activities.

Rigorous testing before the project officially goes live

Each 33kV circuit was energised under a controlled routine and the MV/LV transformers were energised and left to 'soak' overnight. Further safety checks followed, along with control procedures, and breaker tests. Tesla then conducted their own tests where they moved energy around within the batteries.

Finally, we moved into the live commissioning tests where all of our previous hard work is put under scrutiny. Firstly, commissioning tests are carried out at 20% as part of the G99 procedures. Once passed, these restrictions are lifted to enable the system to be tested at 100% power. Alongside these G99 commissioning tests the project team also conducted performance tests, to make sure that the batteries were performing as they should do.

After an intensive period of testing and control procedures, the Pillswood scheme was fully energised a month ahead of schedule and in time to support National Grid in providing stable, secure power to the network over the challenging winter period.

The project will continue to be operated through Autobidder, Tesla's algorithmic trading platform. Autobidder has demonstrated a strong track record over the past two years in managing both the Holes Bay and Contego BESS projects. These are two existing battery storage projects also developed by Harmony Energy Limited in conjunction with FRV.

An exciting future ahead for BESS projects

Looking to the future, the whole globe needs to come together collectively to support developments like these if we want to enable clean energy generation and to protect the future of our planet. The Pillswood BESS project is the first of eight similar battery energy storage schemes scheduled for delivery by HEIT in the coming year. Harmony also has plans to replicate its UK success in continental Europe to address the urgent need to deploy significant volumes of BESS to support the deployment of intermittent renewable energy generation.

In the medium to long-term, we see the technology moving towards longer duration batteries. With the growth of solar and wind, battery energy storage sites will be even more important for a sustainable future. ■

Author

Alex Thornton has over 15 years' experience building and managing fast-growing businesses in the renewables energy sector. As operations director at Harmony Energy, a developer, owner and operator of utility-scale battery storage projects, Thornton manages and supports its project development, delivery and asset management teams. He also oversees the build-out of Harmony's battery energy storage systems. He works closely with Tesla, Balance of Plant contractors, DNOs and local stakeholders at all stages of project delivery. Harmony Energy is currently focused on developing projects in the UK, France and New Zealand.