Customer-Led Network Revolution

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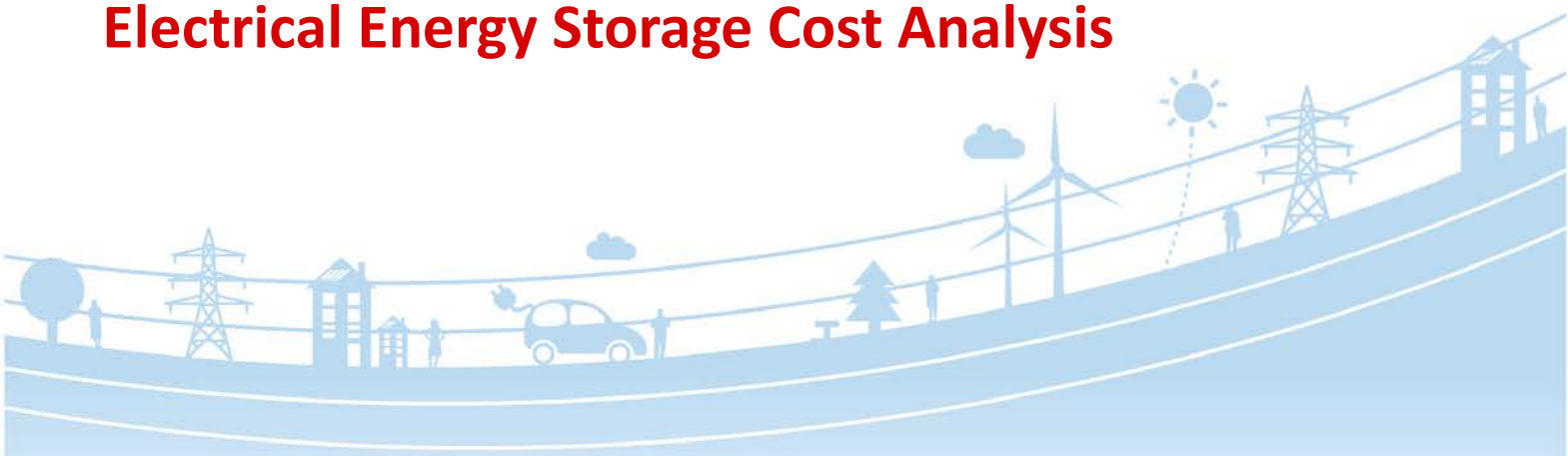
Electrical Energy Storage Cost Analysis



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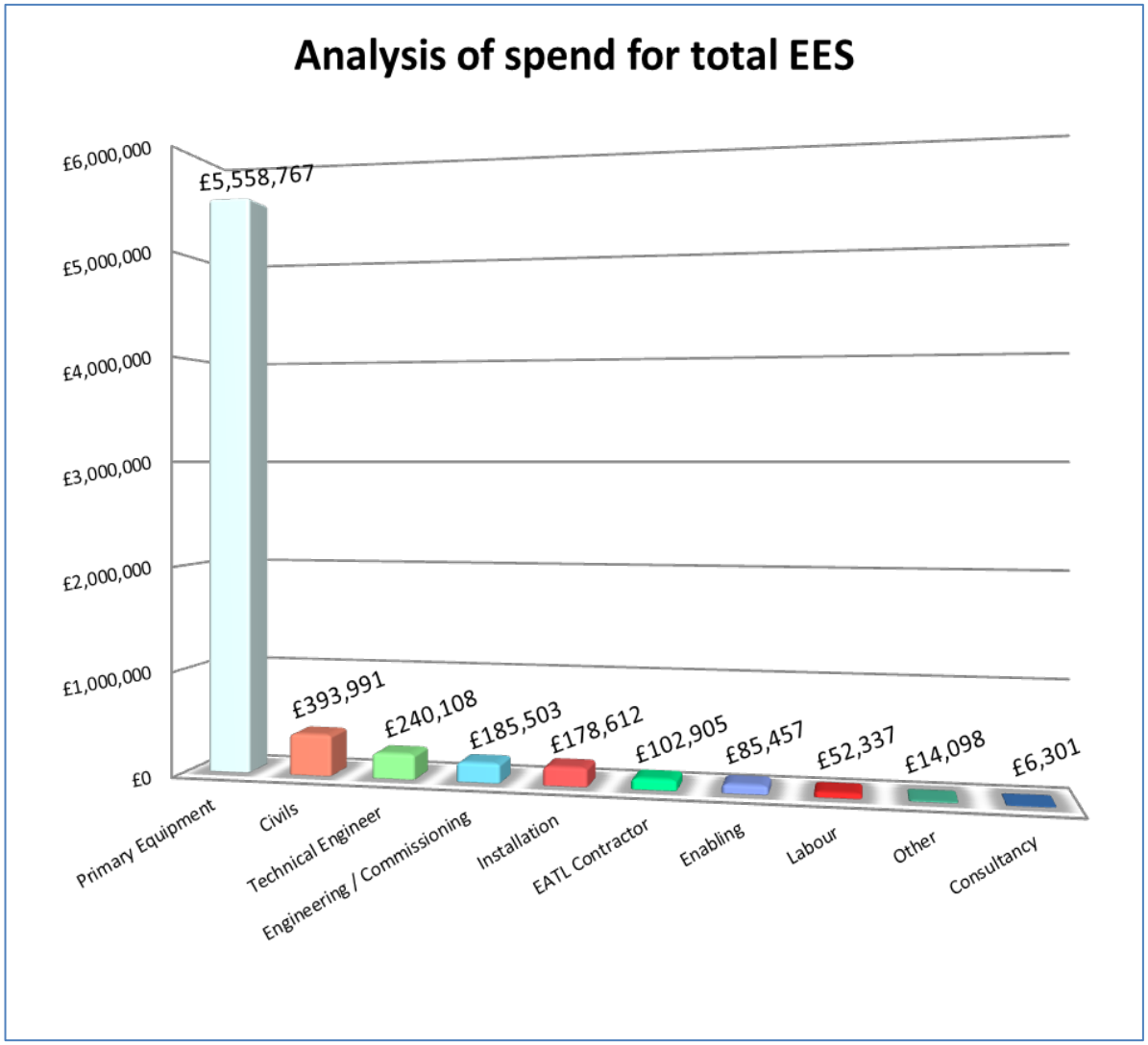
Document Purpose

The following report shows a breakdown of the costs attributed to the fleet of battery systems as deployed at six of Northern Powergrid's substations on the CLNR project. The costs consist of the combination of equipment and resources deployed on the Rise Carr 2.5MVA/5MWh battery, the two 100kVA/200kWh systems at High Northgate and Wooler Ramsey, and the three 50kVA/100kWh systems at Harrowgate Hill, Wooler St Mary and Elgar Drive.

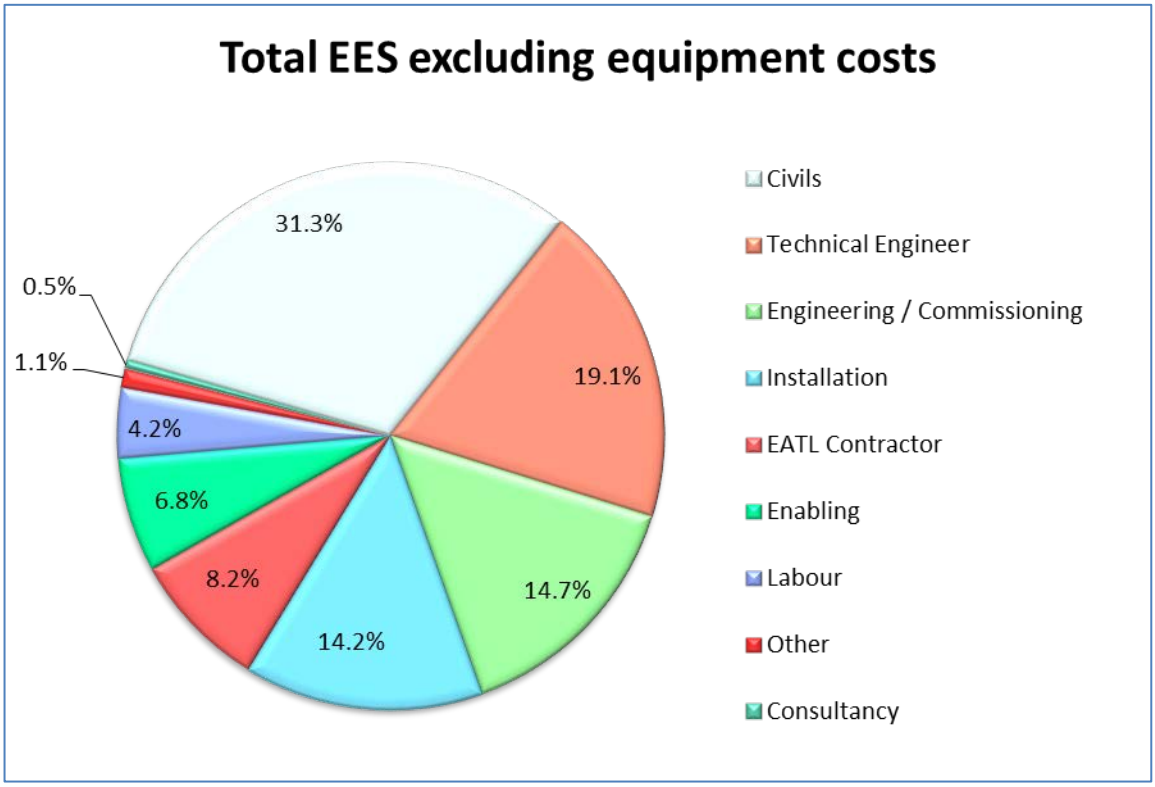
The cost categories have been chosen to best illustrate the areas of work undertaken to safely install and commission the equipment on a UK DNO owned substation.

The total Northern Powergrid project cost for EES was just over £6,818k. A breakdown of the costs is presented in the charts below.



The table below shows the total costs for all six Electrical Energy Storage units as per the category headings for the project.

Cost Categories	Original Budget	Total Spend to Date	Budget v Spend Variance %
Primary Equipment		5,558,767	
Civils		393,991	
Engineering / Commissioning		185,503	
Installation		178,612	
Enabling		85,457	
Labour		52,337	
Other		14,098	
Consultancy		6,301	
Total Storage Unit Costs	**5,566,000**	**6,475,067**	**16%**
EATL contractor	146,000	102,905	-30%
Technical Engineer	114,000	240,108	111%
Contingency Capex	1,002,000	-	-100%
Total	**6,828,000**	**6,818,080**	**0%**



Primary Equipment

The primary equipment category captures the actual costs associated with the contract tendered to achieve the installation, delivery and deployment of the specified network technology by NEC Energy Solutions (NECES, formally known as A123 Systems Inc.)

The equipment contract comprises of the battery systems' engineering design and chemistry (consisting of lithium ion, iron, nano-phosphate), its control systems, the ABB and Dynapower power conversion systems, containment security, fire protection and suppression systems, internal and interconnection wiring, the heating and ventilation systems, installation and commissioning, warranty, three year limited parts and labour service contract, logistics, crane usage, delivery duty and project management.

There were variations to the original order to either modify the battery unit to comply with Northern Powergrid policies on both safety and protection, or to facilitate its integration with the remote control platform.

The total cost of the variations across the battery fleet was £150k 3% of the total primary equipment costs.

Civils

The civil works aspect is heavily affected by the site at which the system is deployed. Post site assessment surveys and base prices were achieved which are indicative of what the actual costs would be to redeploy similar systems elsewhere. These costs consist of ground works, drainage capacity increase and diversion, access route extension and strengthening, cable trenching, foundation casting, plinth erection, cable raceway and ducting manufacture, gantry design, fabrication and installation, existing building modifications and fire prevention measures.

The fabrication of gantries was required so the site complied with Northern Powergrid's flood prevention scheme.

Of the total £394k spent on civils, £337k related solely to the Rise Carr site.

Variations to the original contract for the Rise Carr site were caused by load bearing improvements and the removal of contaminated waste (including asbestos) costing the project just over £304k.

Below is a table of costs for the Rise Carr site

Rise Carr Civils	What	Comment	Next Time
24,000	Electrical and civil design drawings	Would be cheaper next time due to the avoidance of rework and lessons learnt	12,000
130,000	Initial civil works at Rise Carr substation	Survey works and desktop feasibility study would stay the same	130,000
120,000	Contract variations for unusual site specific issues	These should be expected - e.g. foundations, accessibility	120,000
50,000	Contract variations for unusual site specific issues	Soil contamination and waste management (incl. asbestos)	-
13,000	Small costs incurred for CLNR trial purposes	Would not be required as part of BaU	-
337,000			**262,000**

Based on the table above the civils costs would decrease to £262k from £337k – a reduction of 22%. This would not apply to the smaller batteries where the costs were quite small and the sites would generally require a small amount of modification. Thus the cost of EES 1 would fall by £65k next time

Engineering and Commissioning

This category includes the 3rd party engineering effort and project management of the battery systems installation. This work includes the detailed hazard identification and operability study (HAZID and HAZOP) process that was deployed to consider what role technology specific aspects played in our site risk assessments across the entire battery fleet.

The engineering and commissioning cost were £185k for the project, we estimate that these costs were increased by the delays encountered on the project and that these costs would be reduced by around 30% to £130k.

Installation

Installation costs are those combined activities associated with the physical installation of the equipment at the substation that were not covered by the primary equipment contract and not performed by Northern Powergrid. This work forms part of integration between the new control system, the battery system and the existing infrastructure at each site. Typical examples would be the routing of the alarm system outputs from the battery system to our Scada remote terminal unit and associated scheme design, wiring and installation labour from 3rd party suppliers.

The installation costs of £179k included both protection and control equipment that would be required again, following the CLNR learning these system costs would be cheaper next time – we expect we would not need the NVD therefore this would reduce the costs by 20% to £143k.

Enabling

The prime enabling activities that were carried out on the sites and the network technology consist of site surveys work with mobile generation companies, leasing fees, solicitors' fees, and interaction with security companies, local authorities, the local community and the emergency services.

Key examples were: the diversion of the 33kv feeder which passed beneath the intended battery system footprint at Rise Carr costing the project around £58k; and the upgrade to the existing primary substation auxiliary transformer for the added burden of the battery systems auxiliary supplies. Security improvements at higher risk substations allowed the development of temporary wayleave agreements and improvements to perimeter protection. Noise surveys and improvements were required at the smaller rural sites and these were conducted by a 3rd party attenuation expert at a cost of just under £20k.

Due to the enabling costs relating to the diversion of a 33kV cable, we expect none of this work would be required again. Rise Carr's specific site layout caused this rerouting, and it would be highly unlikely that this work would need to take place elsewhere.

Technical Engineer

These costs were for the engineering works associated with the systems design, redesign and debugging of the first of a kind product or technology. Costs were heavily affected by multiple visits to each deployed site and would reduce considerably for subsequent sites.

Of the £240k technical engineer costs, we estimate a large proportion of these are first in class costs plus any extra time spent on the project caused by delays and over scoping, we would estimate that these costs would be reduced by 60% to £96k.

EATL Contractor

The EATL contractor costs relate solely to fees incurred during the preparation for procurement, contract drafting and execution.

The £103k EATL contractor costs were incurred as this was a trial and would not be required for BaU, therefore these costs would not be incurred in future.

Labour

This is the measure of the amount of activity performed by Northern Powergrid employees that covers the activities of Northern Powergrid's program delivery department; it is inclusive of work done by field engineers, fitters, jointers, linesmen, craft attendants, safety auditors, supervisors and quality inspectors. Importantly it is not inclusive of the engineering works associated with the systems design, redesign and debugging of the first of a kind product or technology that are included in the Technical Engineer category.

The labour costs of £52k were inflated due to the project delays and also the nature of the work being first in class. We would estimate a very small reduction in costs (10%) as the actual time lost was not great.

Consultancy

These are charges that have been incurred overcoming the financial crisis of chapter 11 bankruptcy experienced by A123 systems Inc., the primary equipment contractor. We estimate that there would be a small amount of legal consultancy costs that would be incurred as part of BaU (£2k).

Other

The other category is the consolidation of much smaller costs incurred on the project that relate to haulage, and safety.

Operational Expenditure (OPEX)

No specifically identifiable operational expenditure has been incurred. This work is currently carried out under the original tendered contract with NECES. However in the future there would be costs relating to the ongoing maintenance of the asset and the associated labour costs to support the full maintenance program in place with NECES. Any losses incurred due to parasitic loss of both round trip efficiency and auxiliary supplies supplying HVAC and system operational power.

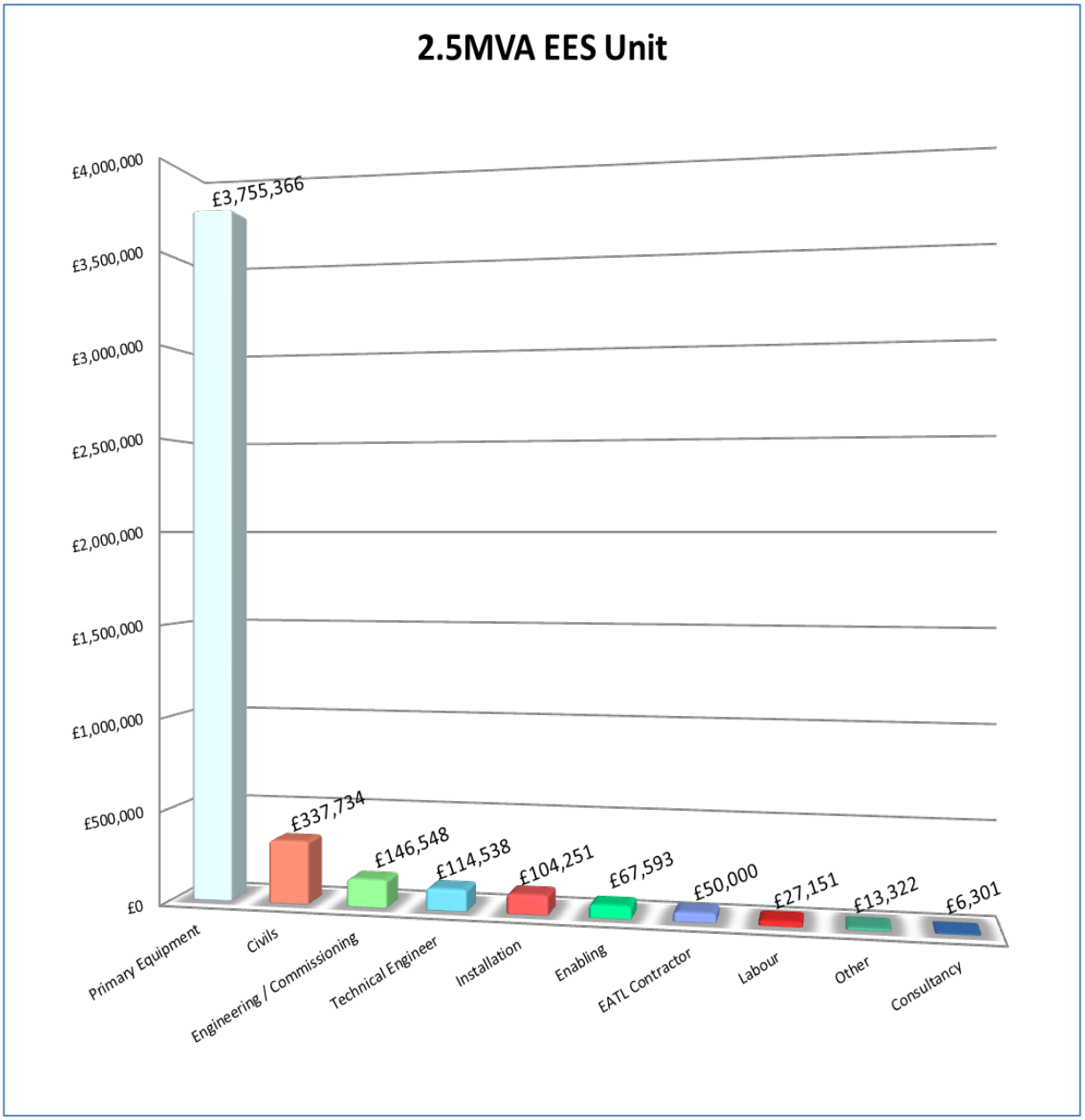
CLNR has not run long enough to comment on battery lifetime. The manufacturers estimate for the battery system lifetime is 18-20 years. We would assume one full battery change after 10 years – i.e. our current estimate of about £1.2 M over a 20 year period plus £50k for remote support, general maintenance and site visits over the same 20 year period. The coordination of the system with a remote controller reduces the need for routine site attendance that assists the maintenance burden.

Battery round trip efficiency of energy imported vs energy exported less the loads required to maintain the battery and the site in its ready state are important to factor into the systems ongoing operational costs. The loads required to maintain the site are primarily parasitic, with consumption of power used to maintain the site integrity and security, but more so to operate and control the environment systems (air conditioning etc.) in which the battery and inverter unit sit.

System Parameter	EES 1 (Rise Carr)	EES 2 (High Northgate)	EES 3 (Harrowgate Hill)
Capacity of energy storage system	5000 kWh (nominal)	200.3 kWh (measured)	105.9 kWh (measured)
Round Trip Efficiency (excluding parasitic losses)	83.2%	86.4 %	83.6 %
Average Parasitic Load (losses of the system auxiliaries)	29.5 kW	2.50 kW	1.77 kW
Round Trip Efficiency including parasitic losses, assuming one charge/discharge cycle per day	69.0%	56.3%	41.2%

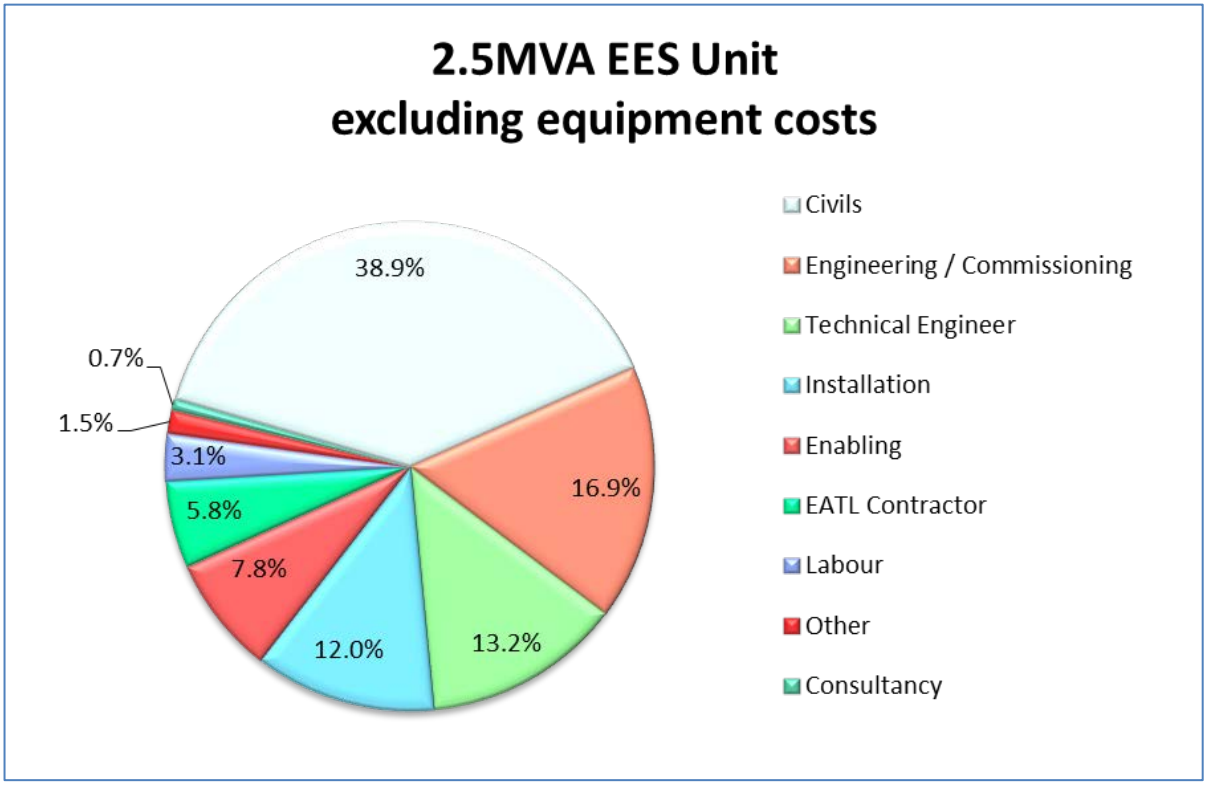
2.5MVA 5MWh Electrical Energy Storage Unit

The total Northern Powergrid project cost for EES 2.5MVA was just under £4,623k. A breakdown of the costs is presented in the charts below.



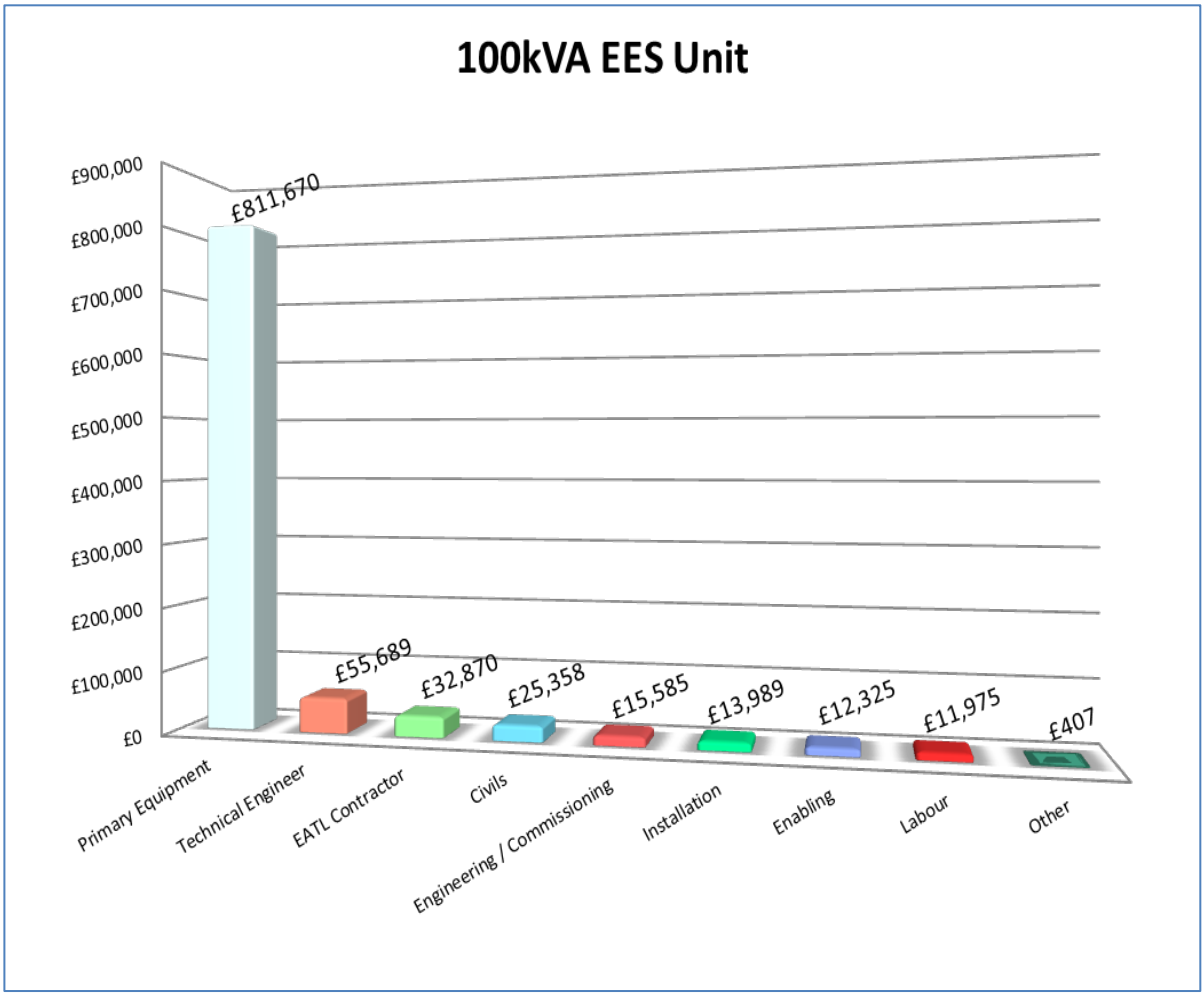
The table below shows the cost of a 2.5MVA 5MWh Electrical Energy Storage Unit.

Cost Categories	Original Budget	Total spend to date	Budget v Spend Variance %
Primary Equipment		3,755,366	
Civils		337,734	
Engineering / Commissioning		146,548	
Installation		104,251	
Enabling		67,593	
Labour		27,151	
Other		13,322	
Consultancy		6,301	
Total Storage Unit Costs	**4,646,000**	**4,458,266**	**-4%**
EATL contractor	60,000	50,000	-17%
Technical Engineer	44,350	114,538	158%
Contingency Capex	919,200	-	-100%
Total	**5,669,550**	**4,622,804**	**-18%**



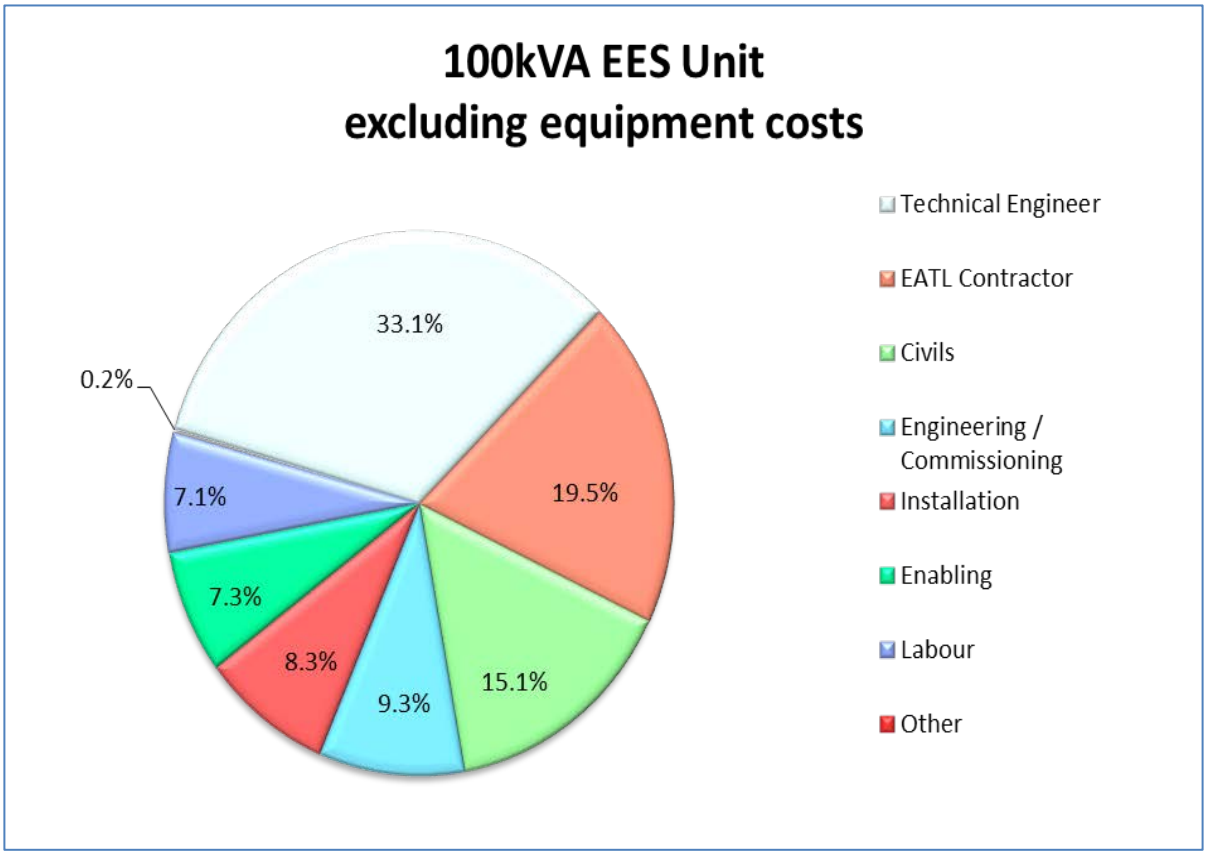
100kVA 200kWh Electrical Energy Storage Units

The total Northern Powergrid project cost for EES 100kVA battery was just under £980k for two. A breakdown of the costs is presented in the charts below.



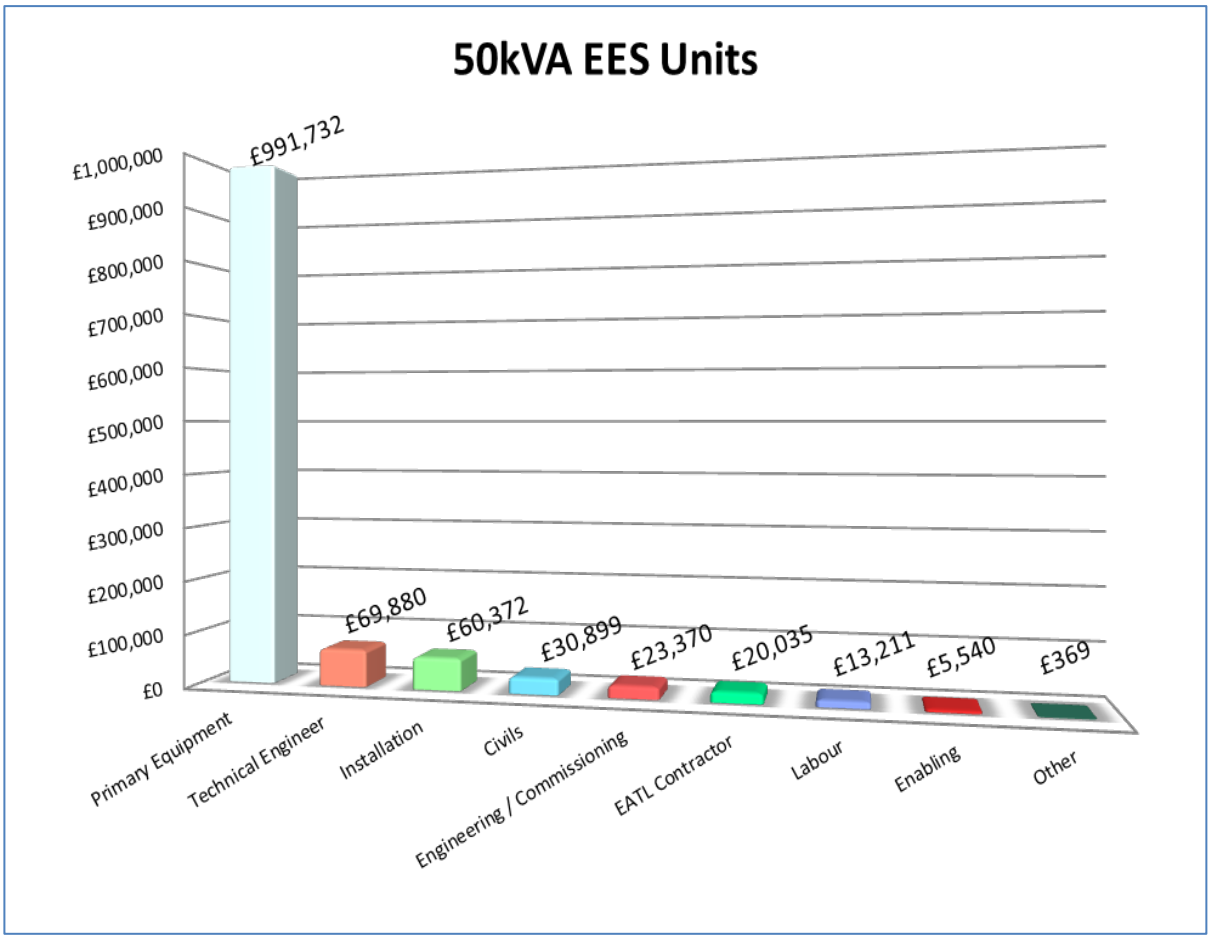
The table below show the average cost for one 100kVA Electrical Energy Storage unit.

Cost Categories	Original Budget	Total Spend to Date	Budget v Spend Variance %
Primary Equipment		405,835	
Civils		12,679	
Engineering / Commissioning		7,792	
Installation		6,995	
Enabling		6,162	
Labour		5,987	
Other		204	
Total Storage Unit Costs	**268,010**	**445,654**	**66%**
EATL contractor	27,000	16,435	-39%
Technical Engineer	22,110	27,845	26%
Contingency Capex	23,800	-	-100%
Total	**340,920**	**489,934**	**35%**



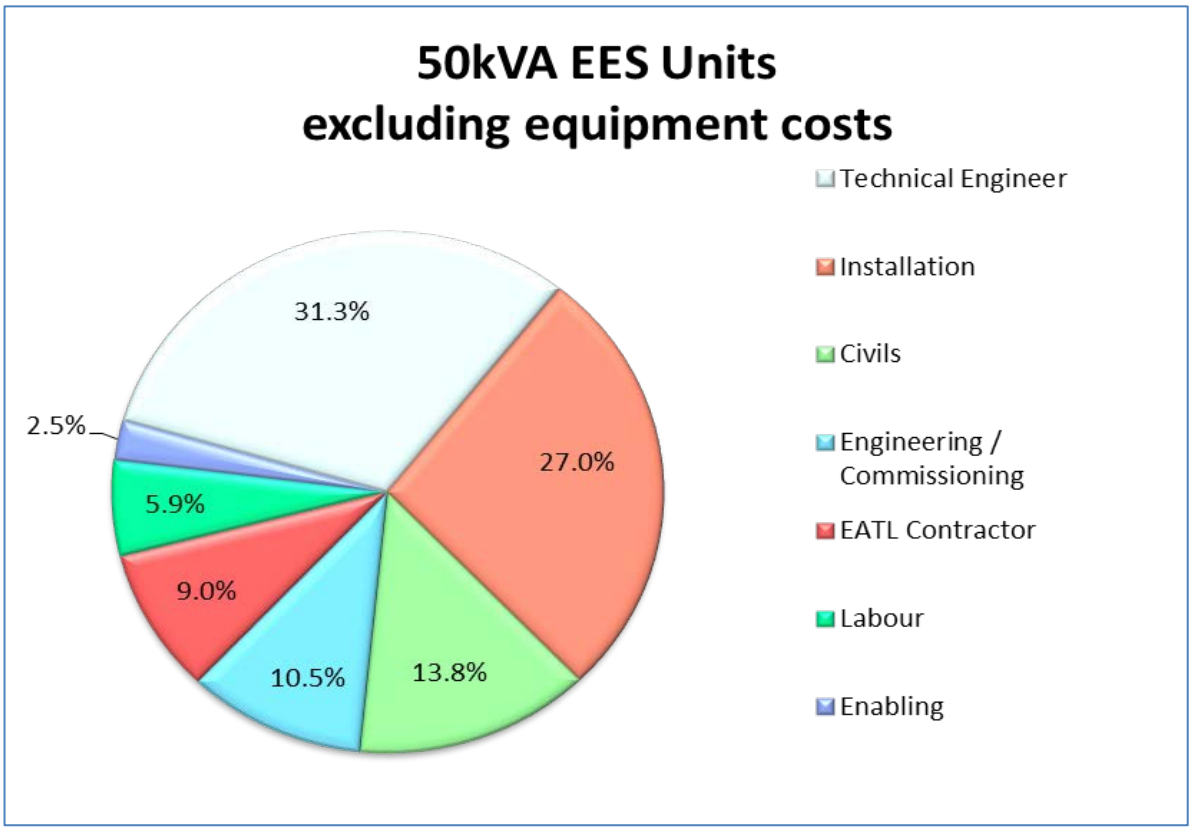
50kVA 100kWh Electrical Energy Storage Units

The total Northern Powergrid project cost for EES 50kVA was just under £1,232k for three. A breakdown of the costs is presented in the charts below.



The table below show the average cost for one 50kVA Electrical Energy Storage unit.

Cost Categories	Original Budget	Total Spend to Date	Budget v Spend Variance %
Primary Equipment		330,577	
Installation		20,124	
Civils		10,300	
Engineering / Commissioning		7,790	
Labour		4,404	
Enabling		5,540	
Other		1,847	
Total Storage Unit Costs	**384,046**	**380,581**	**-1%**
EATL contractor	32,000	6,678	-79%
Technical Engineer	25,099	23,293	-7%
Contingency Capex	35,405	-	-100%
Total	**476,549**	**410,553**	**-14%**



For enquires about the project contact
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