



Customer-Led Network
Revolution

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Enhanced Automatic Voltage control Cost Analysis

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Document Purpose

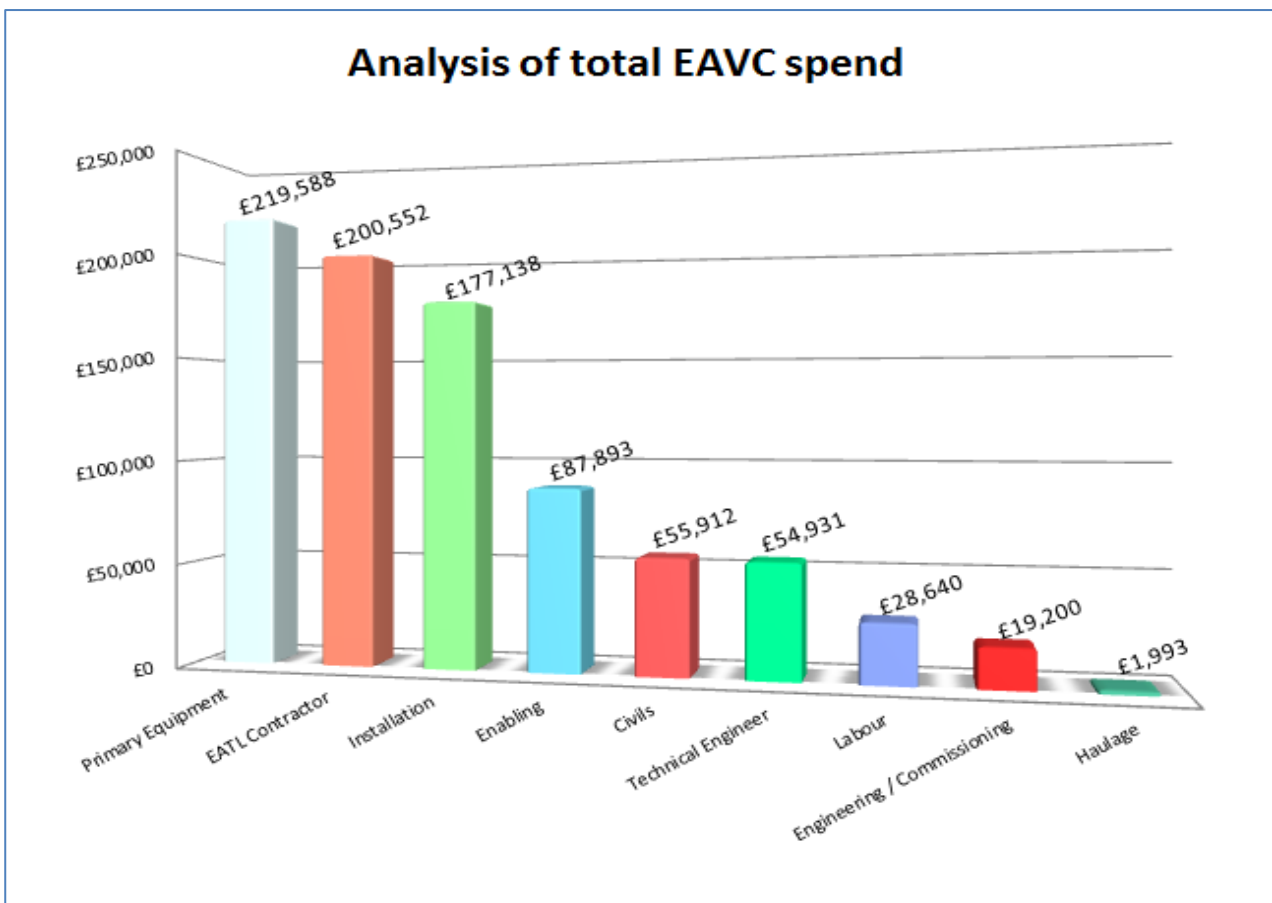
Enhanced Automatic Voltage Control (EAVC)

The following report is a detailed breakdown of costs attributed to the design, modification and installation of the voltage control systems applied across our network components including;

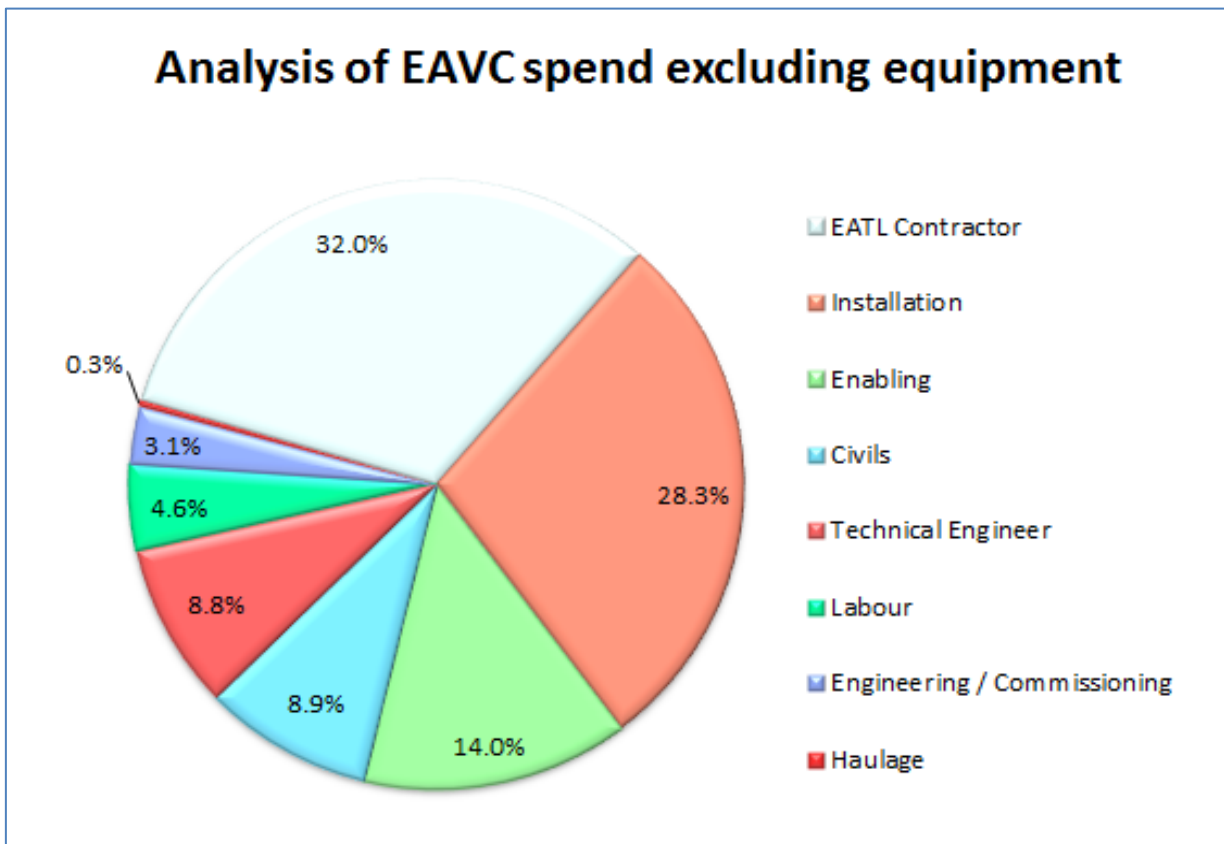
- Primary Transformers
- Secondary transformers
- High voltage in line regulators
- High voltage switched capacitors
- Low voltage regulators
- Integration of all systems into the control scheme

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 or conducting asset.

The total Northern Powergrid project costs for EAVC was just under £846k. A breakdown of the costs is presented in the charts below.



Cost Categories	Original Budget	Total spend to date	Budget v Spend Variance %
Primary Equipment		219,588	
Installation		177,138	
Enabling		87,893	
Civils		55,912	
Labour		28,640	
Engineering / Commissioning		19,200	
Haulage		1,993	
Total Enhanced Voltage Control	614,000	590,363	-4%
EATL contractor	228,000	200,552	-12%
Technical Engineer	114,000	54,931	-52%
Contingency Capex	45,000	-	-100%
Total	1,001,000	845,846	-15%



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.

The equipment contract comprises of the system design, installation and commissioning, warranty, logistics, delivery duty and project management.

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

EATL Contractor

The EATL contractor costs relate solely to fees incurred during the preparation for procurement, contract drafting and execution and configuring the test cells (for example defining the system specification, defining location and quantity of monitors and clarifying technical uncertainty), for each network trial with the integrated control system.

Installation

Installation costs are a combination of activities associated with the physical installation of the equipment at the substation not covered by the equipment supplier contract and not performed by Northern Powergrid. This work forms part of integration between the new control system, the voltage control device and the existing infrastructure at each site. Typical examples would be configuring the server head end, routing cables between equipment transducers and controllers, and the configuration of auxiliary supplies.

Enabling works

The prime enabling activities that were carried out on the sites and the network technology consist of site surveys, interaction with specialist engineers to develop design and protection schemes, work with mobile generation companies, and interaction with local communities and local authorities.

Key examples were: the use of mobile generation to secure supplies during the installation of the secondary transformer with on load tap changers; the subsequent reinforcement of auxiliary transformers and associated wiring to cater for the added burden of electrical components on each site.

Civil works

The civil works relating to the installation and configuration of the thermal rating equipment has been consolidated within the civil costs of the monitoring and enhance voltage control aspects of the CLNR project.

Technical Engineer

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

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 the 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.

Engineering and Commissioning

This category includes the 3rd party engineering effort and project management of the voltage control systems installation. This work includes the detailed design to supplement existing site designs and controls to fail safe and integrate unproven wide area control systems.

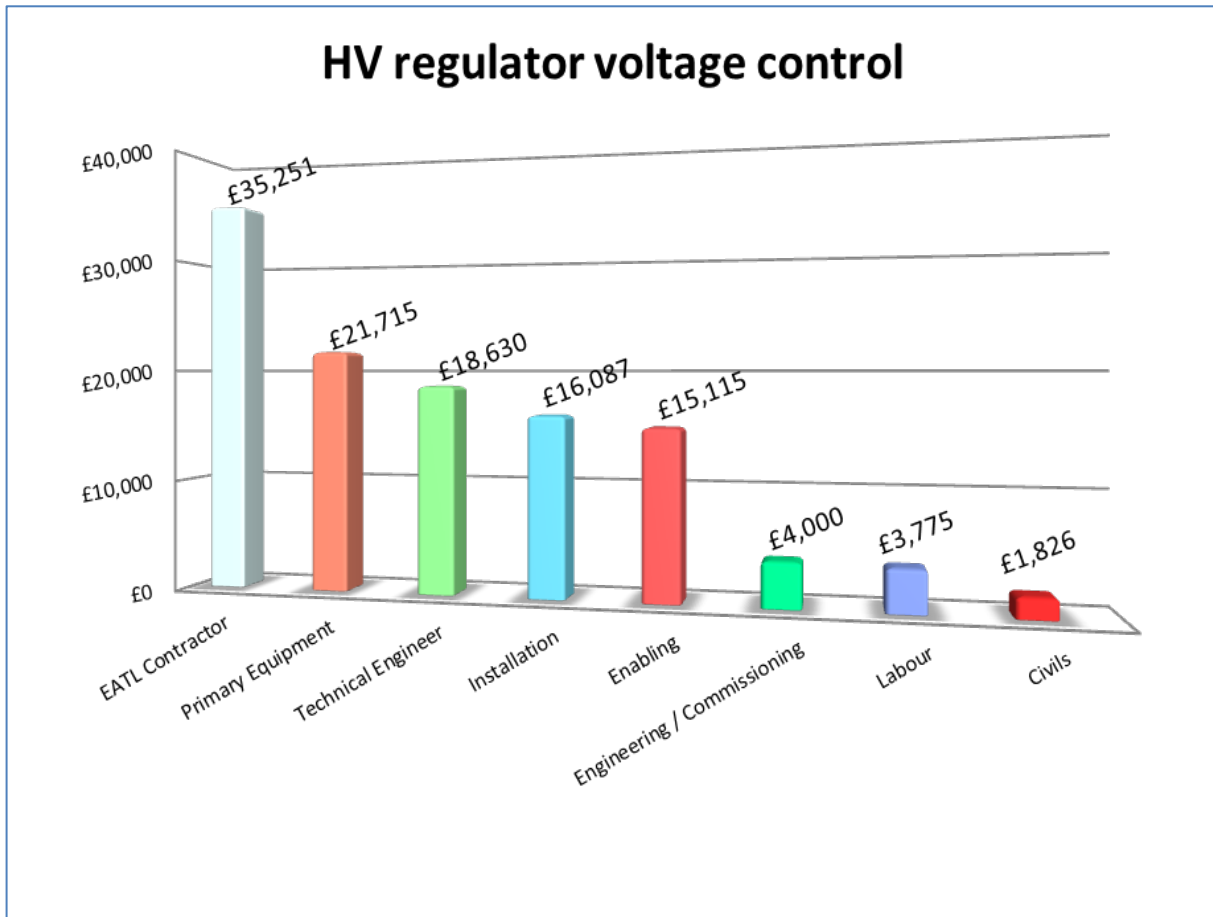
Operational Expenditure (OPEX)

No specifically identifiable operational expenditure has been incurred. However in the future there would be costs relating to ongoing interaction of the assets and the associated labour costs for Northern Powergrid to support the maintenance and inspection program that is in place.

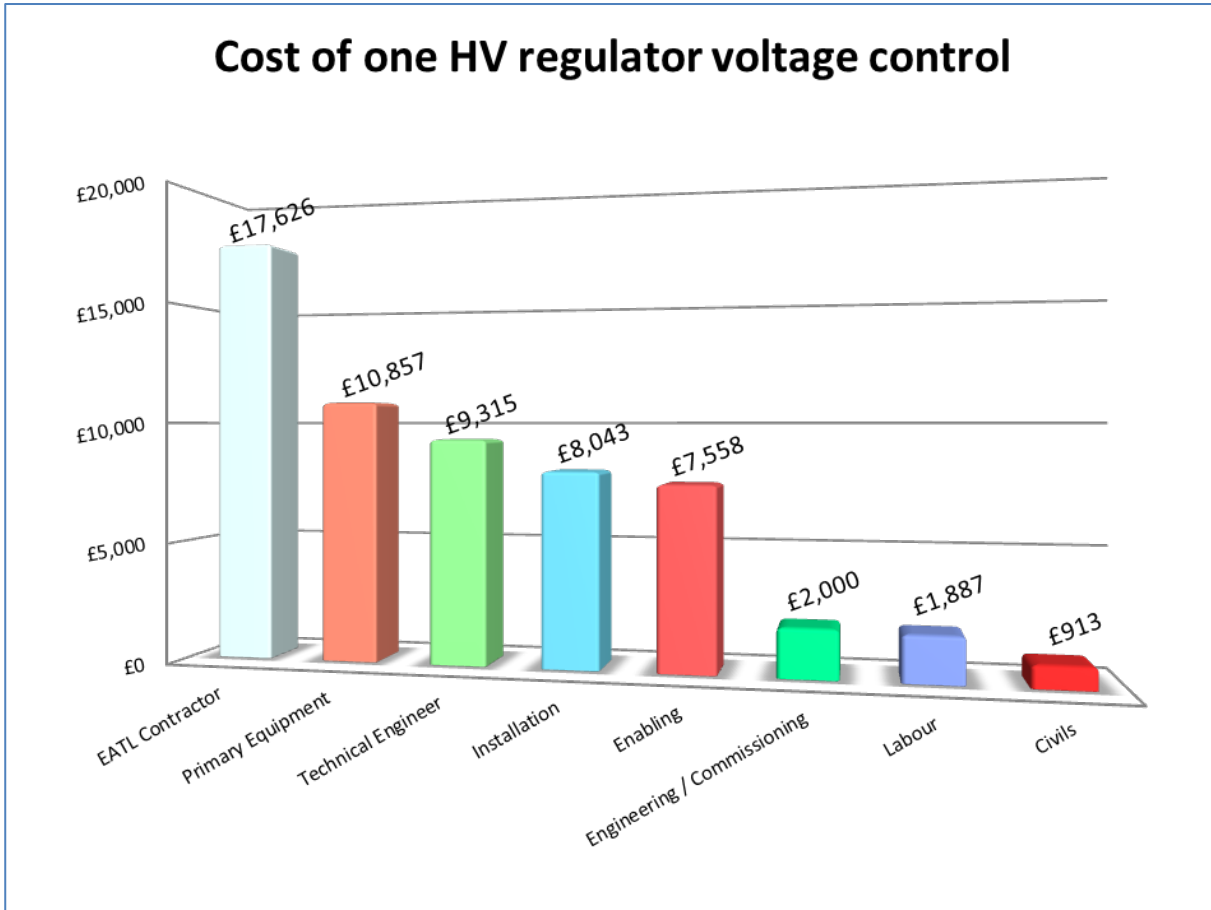
We estimate that small costs are likely for the ongoing maintenance of the control relays and upkeep of their software and firmware over an extended period. Such changes from our experience are negligible as opposed to the overall cost of the capital scheme.

HV regulator enhanced automatic voltage control

The total Northern Powergrid project cost for the HV regulator voltage control was just over £116k. A breakdown of the costs is presented in the graph below for the two regulators trialled.



The average cost for one regulator is just over £58k. A breakdown of the costs is represented in the graph below.

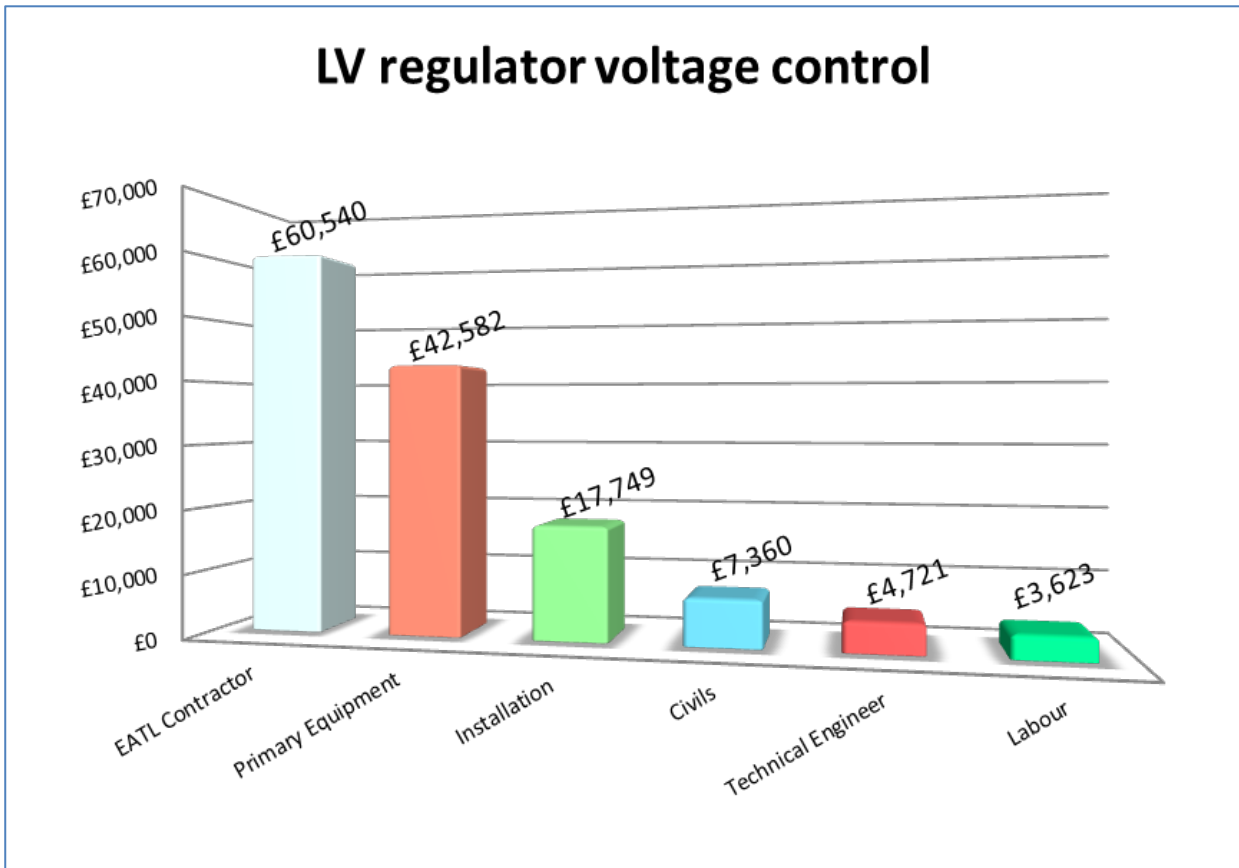


If this activity were to be completed again then the reduction in time, effort and rework due to lessons learned would reduce the applied cost. In our estimate the technical engineer would only spend half their time on another similar scheme, and where the inputs of EATL as a consulting engineer would not be required at all. Further reductions due to lessons learned make further savings on the installation of the system and we estimate that 90% of the actual as installed cost would apply.

The HV regulator solution does not include the cost of the regulator itself, merely the exchange and configuration of the enhanced relay solution and associated communications and monitoring.

LV regulator enhanced automatic voltage control

The total Northern Powergrid project cost for the LV regulator voltage control was just over £103k. A breakdown of the costs is presented in the graph below for the one regulator trialled.

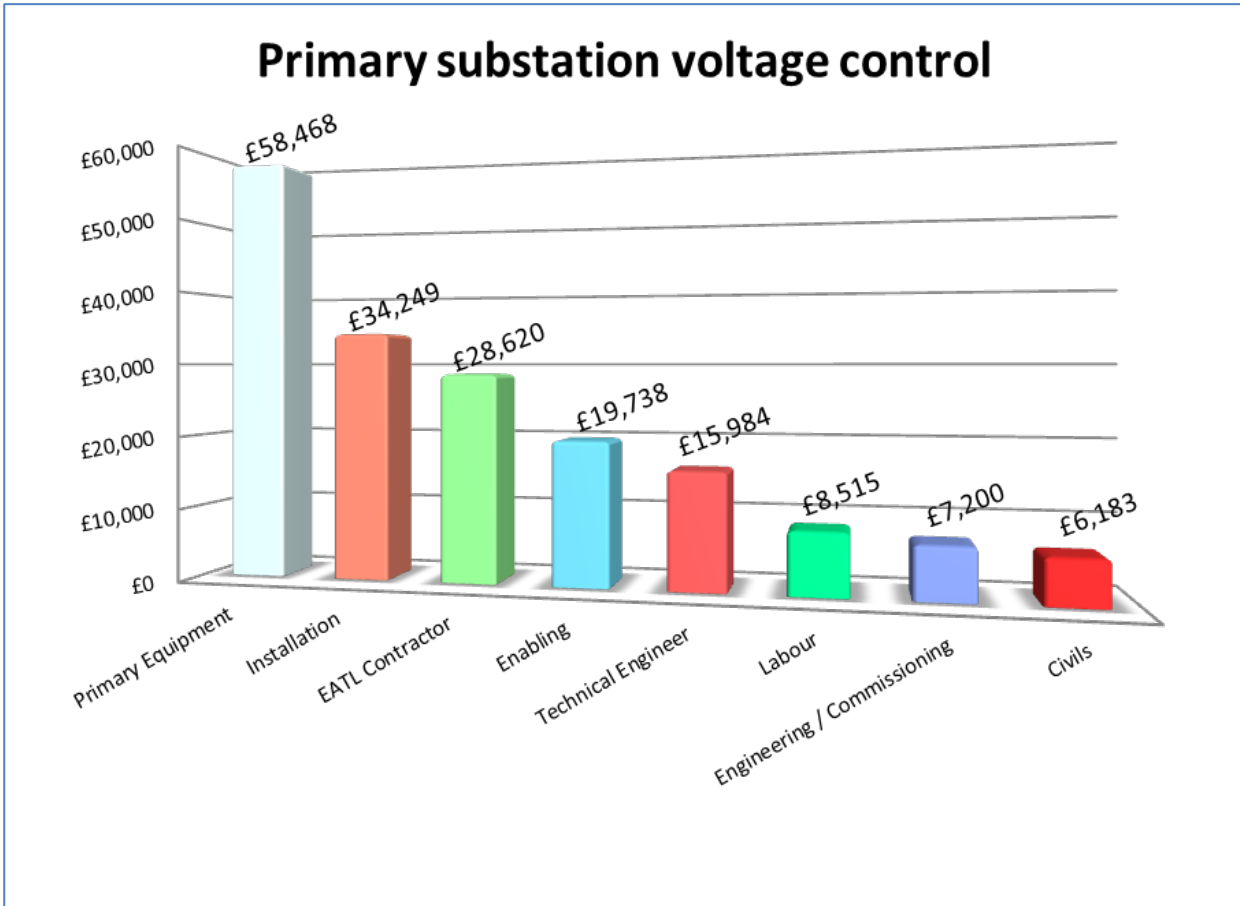


If this activity were to be completed again then the reduction in time, effort and rework due to lessons learned would reduce the applied cost. In our estimate the technical engineer would only spend half their time on another similar scheme, and where the inputs of EATL as a consulting engineer would not be required at all. Further reductions due to lessons learned make further savings on the installation of the system and we estimate that 90% of the actual as installed cost would apply.

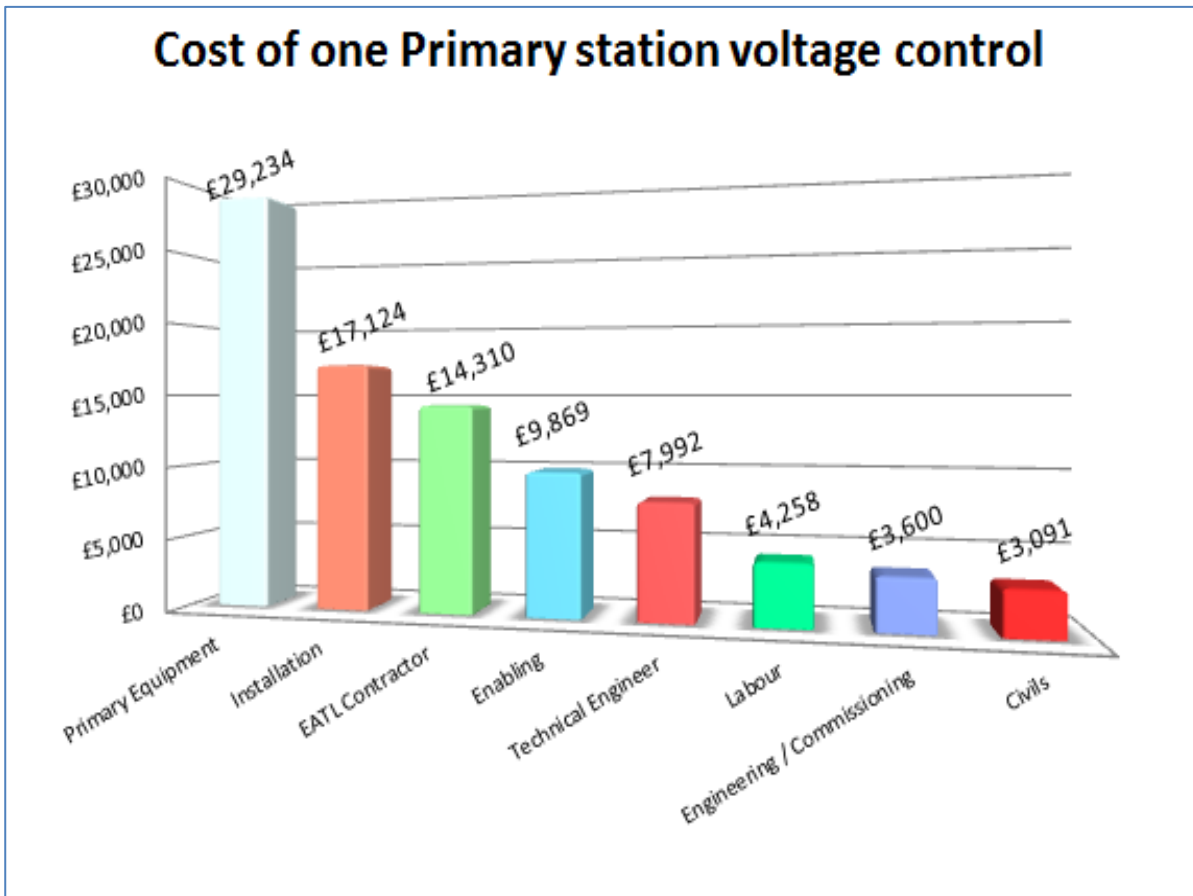
The LV mains regulator solution does include the cost of the regulator and controller, and configuration of the enhanced solution and associated communications and monitoring.

Primary substation enhanced automatic voltage control

The total Northern Powergrid project cost for the Primary substation voltage control was just under £179k. A breakdown of the costs is presented in the graph below for the two primary systems trialled.



The average cost for one primary system is just over £89k. A breakdown of the costs is presented in the graph below.

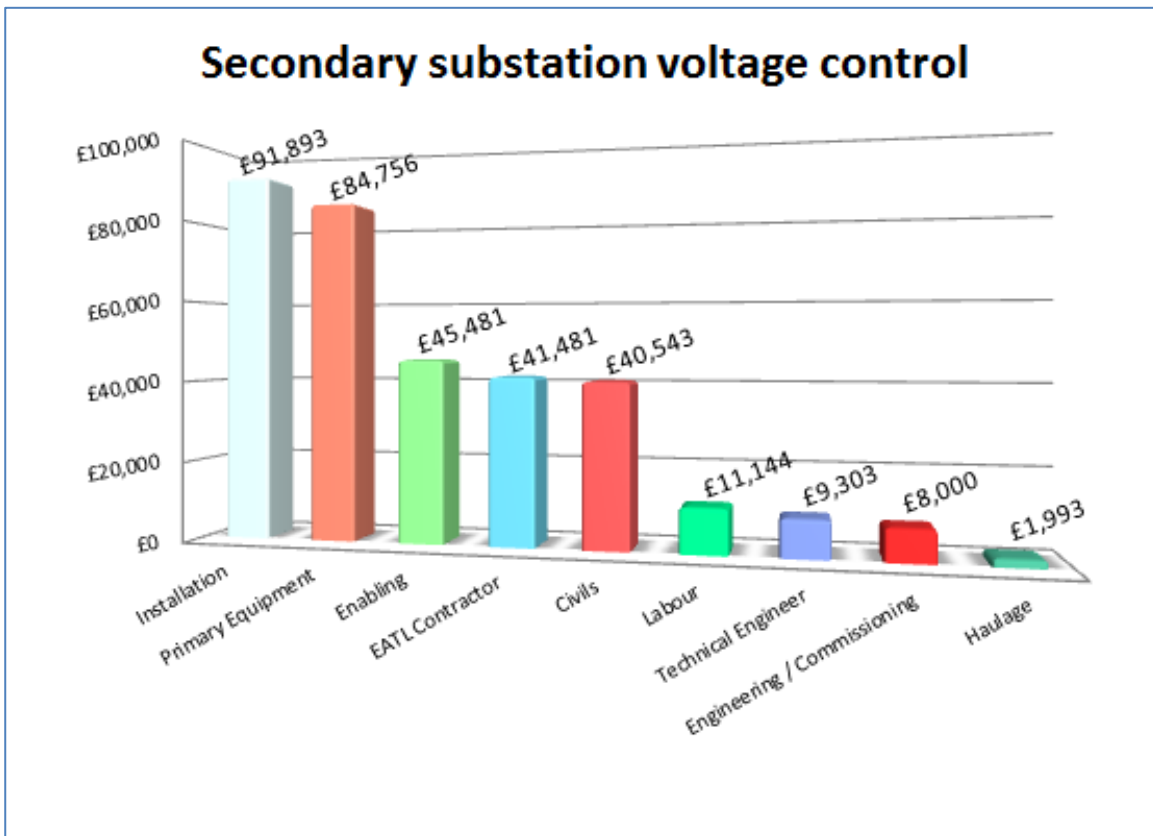


If this activity were to be completed again then the reduction in time, effort and rework due to lessons learned would reduce the applied cost. In our estimate the technical engineer would only spend half their time on another similar scheme, and where the inputs of EATL as a consulting engineer would not be required at all. Further reductions due to lessons learned make further savings on the installation of the system and we estimate that 50% of the actual as installed cost would apply, primarily due to the avoidance of the secondary automatic voltage relay that was deployed for backup protection would not be required.

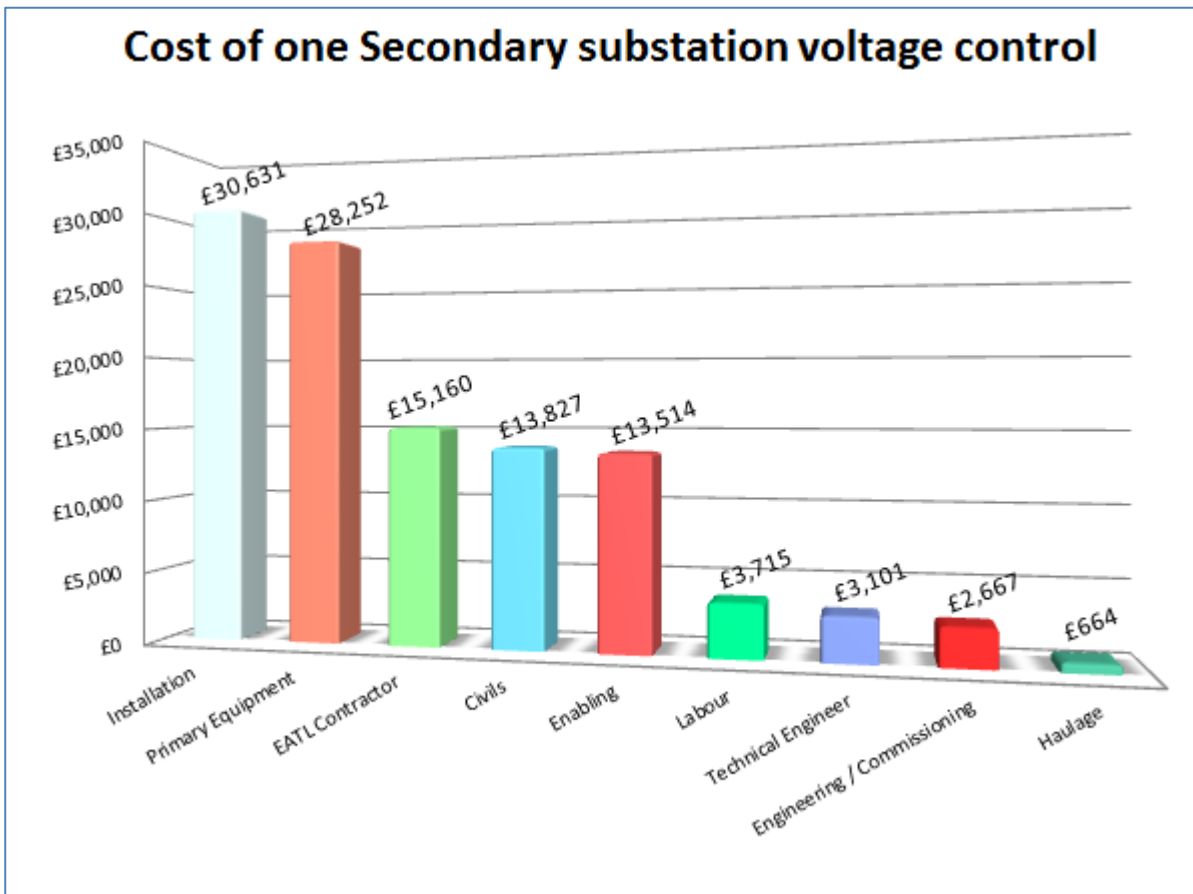
The Primary substation solution does not include the cost of the site, the transformer itself nor a modification to its tap changer mechanism, merely the exchange and configuration of the enhanced relay solution and associated communications and monitoring.

Secondary substation enhanced automatic voltage control

The total Northern Powergrid project cost for the Secondary substation voltage control was just over £334k. A breakdown of the costs is presented in the graph below for the 3 transformers trialled.



The average cost for one transformer is just over £111k. A breakdown of the costs is presented in the graph below.

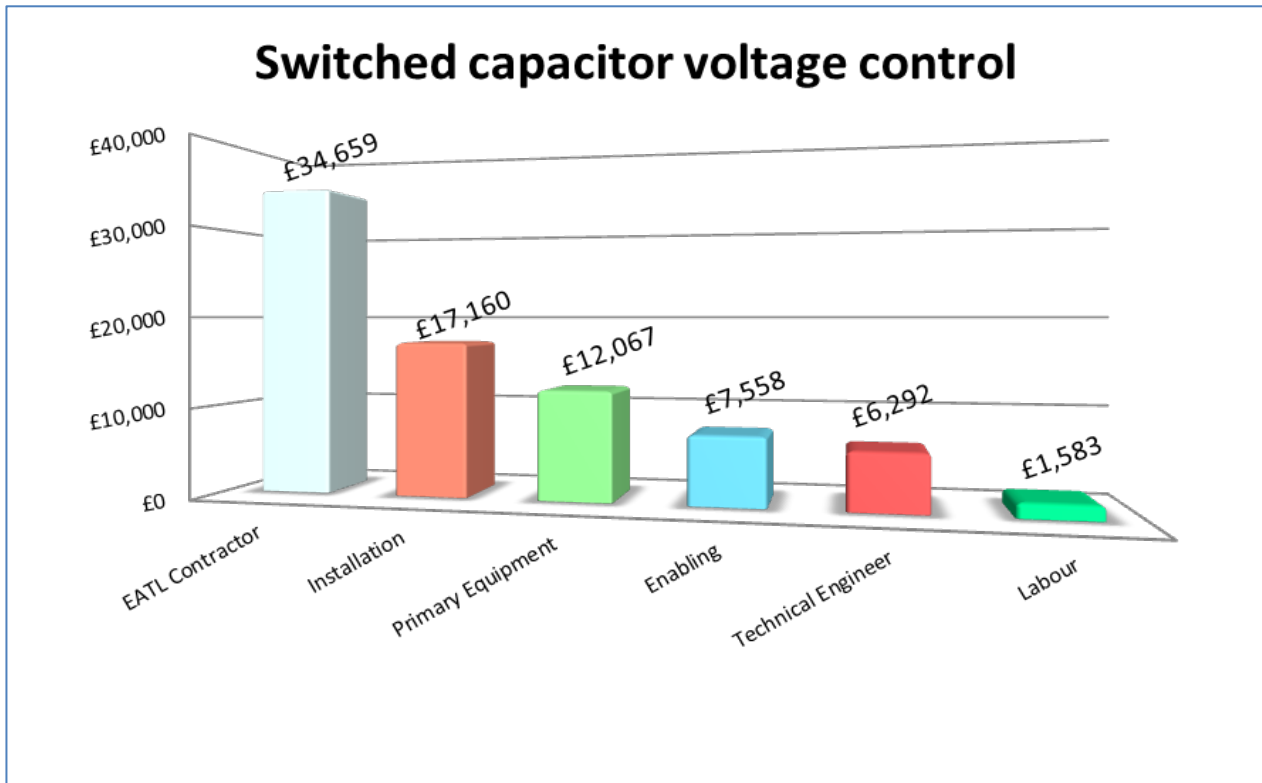


If this activity were to be completed again then the reduction in time, effort and rework due to lessons learned would reduce the applied cost. In our estimate the technical engineer would only spend half their time on another similar scheme, and where the inputs of EATL as a consulting engineer would not be required at all. Further reductions due to lessons learned make further savings on the installation of the system and we estimate that 90% of the actual as installed cost would apply.

The HV/LV on load tap changing transformer solution does include the cost of the transformer and controller, and configuration of the enhanced solution and associated communications and monitoring.

Switched capacitor enhanced automatic voltage control

The total Northern Powergrid project cost for the Switched capacitor voltage control was just over £79k. A breakdown of the costs is presented in the graph below for the one unit trialled.



It is unlikely that we would consider this application again as there is an open issue on this site. However, if this activity were to be completed then the effort and rework due to lessons learned are likely to increase the applied cost. In our estimate the technical engineer would still only spend half their time on another similar scheme, and the inputs of EATL as a consulting engineer would not be required at all.

The increase in costs due to lessons learned are likely due to additional work being required to resolve the issues at the switched capacitor site and we estimate that 130% of the actual as installed cost would apply along with 150% of the primary equipment costs.

The HV switched capacitor solution does not include the cost of the capacitor switch station itself nor associated switchgear, merely the exchange and configuration of the enhanced relay solution and associated communications and monitoring.

The Estimated cost of a capacitor station if re-engineered today of a similar scale incorporating this enhanced technology from the outset would be £2M (£1.9M without the enhanced functions)



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