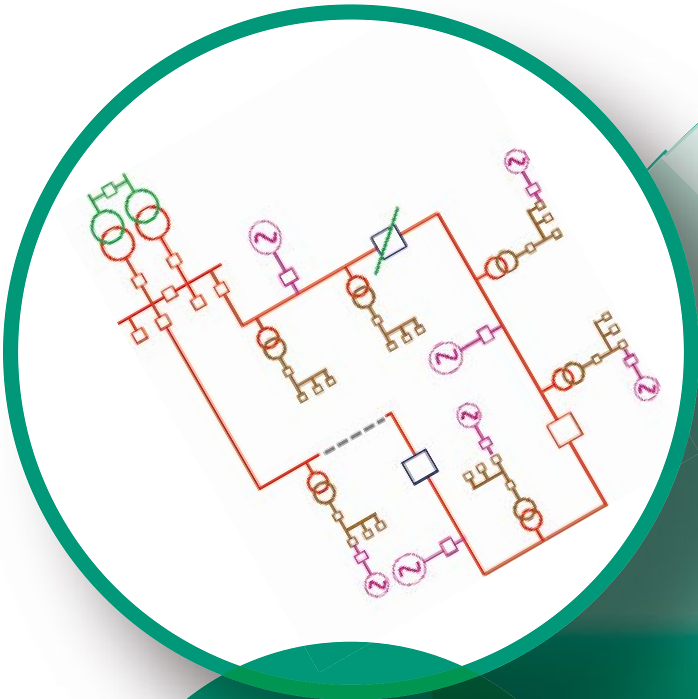
SP ENERGY NETWORKS

Flexible Networks for a Low Carbon Future



Methodology & Learning Report

Work package 2.2: Flexible Network Control

July 2015

Contents

1 Executive Summary

This methodology and learning report covers the work that has been undertaken under work package 2.2 on flexible network control within the project trial areas of St Andrews and Whitchurch. The objectives of the work package were to contribute to the increase in network headroom required within the trial areas, and to provide proof of concept and quantify the benefits and costs of using this type of network control.

The work undertaken was streamed along 2 complimentary paths: -

1 Developing the algorithms to release network capacity.

The networks were analysed by University of Strathclyde (UoS) and TNEI, making use of detailed network data collected under WP2.2 in order to develop the required switching algorithms. These were further validated using the prototype tool developed by UoS and SPEN to analyse how network reconfiguration should be done to reach a suitable compromise between losses and reliability. Ultimately the proposals were discussed with the wider business and other business considerations were taken into account in arriving at a final solution

2 Developing the next generation of telecontrol equipment

In order to achieve improved network performance for the benefit of customers and to implement flexible network control in business as usual there are requirements to both extend the installed base of network controllable points (NCP), and enhance their functionality. This report summarises the progress that has been made in developing the next generation of equipment in conjunction with Smart Grid Networks (SGN).The use of the logical sequence switching (LSS) package on our PowerOn Fusion SCADA system as a means of implementing the required control algorithms was also investigated.

The trial was successful in releasing network headroom at both the Whitchurch and St Andrews trial sites, contributing to the overall target of 20% increase in headroom.

Next generation telecontrol equipment has been developed and successfully deployed in the St Andrews area. A notable achievement has been the ability to retrieve analogue data from pole mounted and ground mounted switches – something that was not previously possible with the earlier generation of equipment.

2 Background

Incremental capacity can be created on the secondary (11kV) network by using flexible open points to link neighbouring groups with spare capacity or different demand profiles. This work package trialled flexible network control using automated 11kV switches on secondary networks in two of the trial sites to provide the capability to dynamically transfer load between primary substations.

We wanted to trial the technique in two trial areas with similar load issues but with different network topologies. St Andrews primary substation is a 2 transformer site and the associated network is designed to ensure that a single transformer can supply the total substation load in the event that the other transformer is off due to a fault or maintenance. Whitchurch primary substation is a single transformer site, part of a 3-substation group. The network is designed such that when one substation is off, the load can be supplied by the remaining substations in the group.

The real benefits of the developed methods have previously been difficult to quantify due to lack of real-world data. Work Package 1.2 was therefore a key input to this work-package as it provided such data through some additional higher resolution network data.

The Central Control Unit (CCU) is the Primary substation installed equipment, which marshals NCP's into the SCADA system. Although the installed generation of CCU is meeting immediate business requirements, as the business strives to improve network performance during the ED1 period including the implementation of flexible network control schemes there may be a need to extend the NCP base and enhance its functionality.

The advent of computers in telecontrol is relatively recent when compared to the expected life of electrical plant on the distribution network. To put this in context; within our business, computers have been used in telecontrol for 19 years whereas 41% of plant is over 20 years old and was not designed with modern telecontrol in mind. In developing telecontrol to its current state, much effort has gone into developing solutions that allow a basic level of control over legacy plant, and in implementing low bandwidth communications systems to facilitate that control.

Whilst significant progress has been made to date it has been recognised that in order to exploit the power of modern IT systems in managing the network it is also necessary to develop a new generation of telecontrol equipment (including communications) with the ability to recover time-synchronised, analogue data from the network. However it is also necessary to maintain backward compatibility with the current generation of telecontrol equipment.

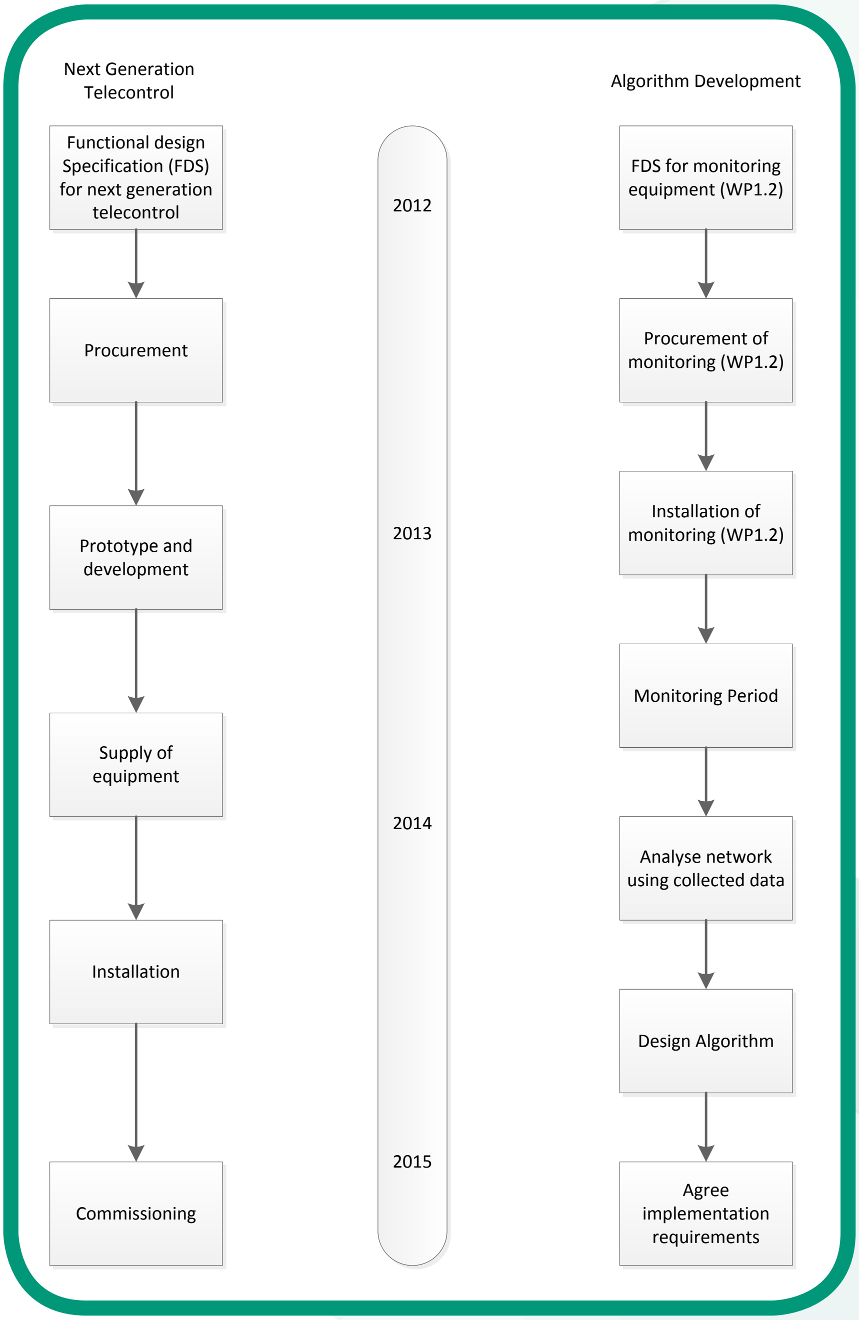
3 Details of the work carried out

3.1 Overall Approach

The work undertaken was streamed along 2 complimentary paths: -

1. Developing the algorithms to release network capacity
2. Developing the next generation of telecontrol equipment

This approach is illustrated in the block diagram below.



3.2 Next Generation Telecontrol

3.2.1 Functional Design Specification (FDS)

The current version of CCU can control 17 remote objects, or substations, each having 3 pairs of controls with 16 data points. (The number of controllable objects is limited by the legacy operating protocol of the host SCADA.) An NCP equipped primary installation comprises of a Master CCU with a Protocol Converter and Concentrator radio, to which Slave CCU's are daisy chained. Each CCU panel can accommodate a maximum of 7 objects. Therefore to control 17 NCP's, one Master with 7 bays and two Slaves with 7 and 3 bays each are needed.

If it becomes a requirement to control more than 17 substations from any one primary, another Master CCU (and Slaves) must be installed. This can have an impact upon the SCADA network scan rates and as it will have its own radio it can interfere with the existing installation, if there is insufficient physical separation of the antennae.

The specification for the next generation of equipment included the following requirements: -

Physical Size

This design is based on a microprocessor system utilising flat, touch screen, technology for the HMI. As this architecture allows the integration of the current CCU discrete components into a single platform, the enclosure becomes one half the size of a conventional CCU.

NCP Capacity

Although limited to controlling 17 remote objects, using protocol conversion into the current SCADA version, this can readily be extended to 70 objects when using modern protocols.

Protocol Conversion

Emulation of the DSP4 & Mk3 operating protocol of our legacy systems. In addition the new CCU can emulate all modern communication protocols enabling its compatibility with the SCADA upgrade.

Upgrade of radio system

The upgraded radio system will improve performance, reliability, and provide new features such as the ability to recover analogue data.

Logical Sequential Switching (LSS)

The new equipment shall facilitate the recovery of analogue data from network points and thus allow the mapping of HV secondary network load flow. This will allow the inclusion of real time data into LSS sequences, where network capacity may be a restriction to the introduction of automation.

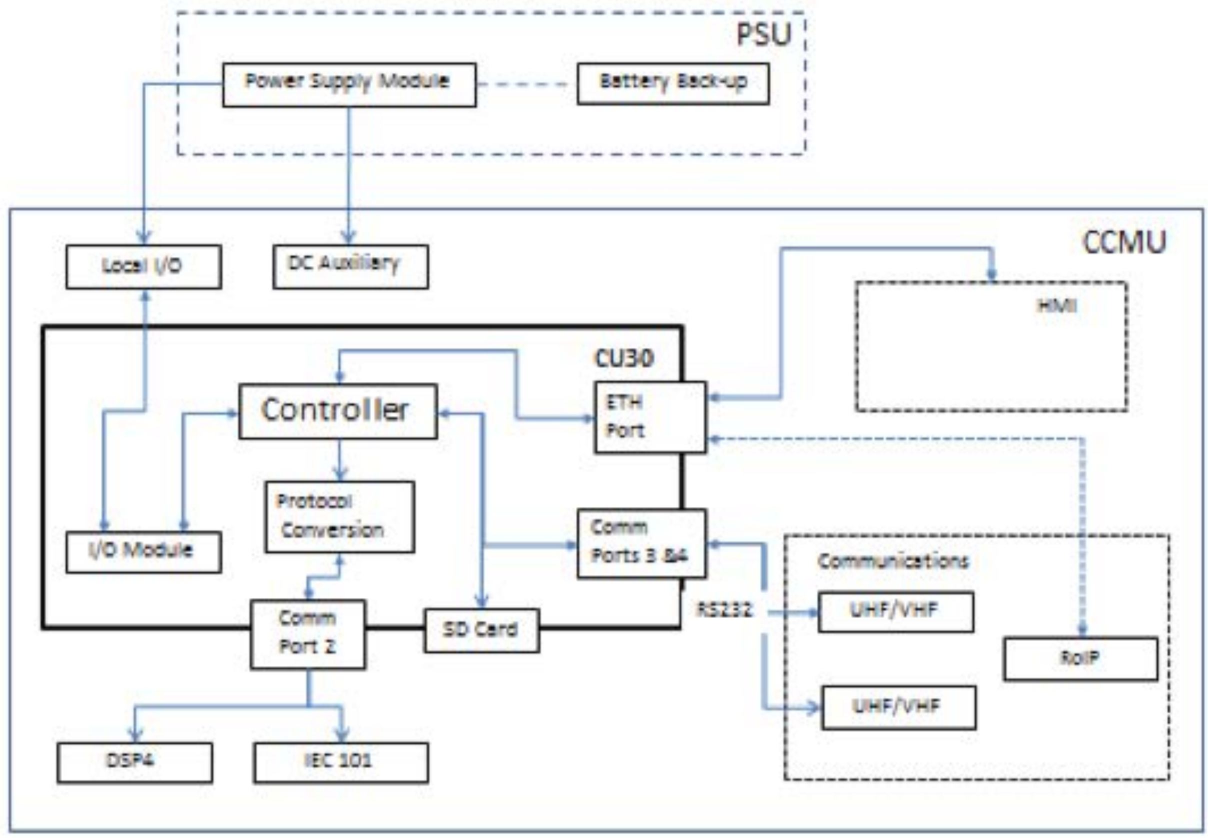
Financial Cost Benefit

The cost of a new style CCU is to be the same as a Master CCU. However as it will not require additional Slave CCU's, a typical primary installation enables a significant hardware saving.

3.2 Next Generation Telecontrol

3.2.1 Functional Design Specification (FDS) [continued]

Block Diagram of New CCMU

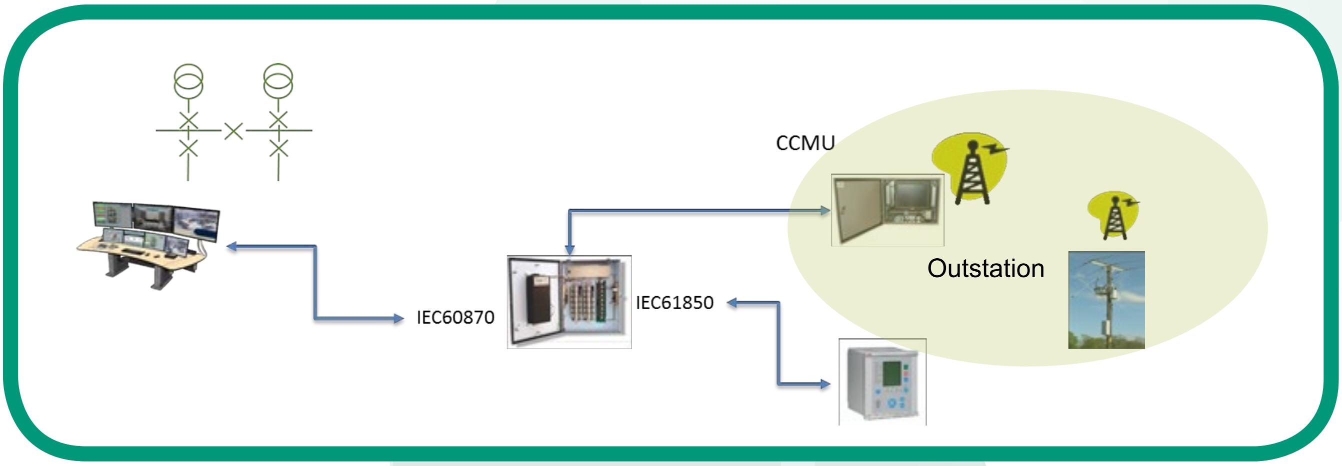


3.2.2 Prototyping and Development

Following a competitive tendering exercise, Smart Grid Networks (SGN) were selected to develop the next generation telecontrol equipment.

We found that an extended time was required to work through engineering issues and obtain equipment approvals. As an example of the type of issue that required to be addressed, we determined that the new generation network telecontrol equipment will operate over UHF radio channels in order to provide sufficient bandwidth to monitor analogue network data. However this equipment also needs to be compatible with legacy telecontrol equipment on the network and therefore a solution that also incorporates VHF radio communications had to be developed. This resulted in demanding engineering requirements, requiring additional time to resolve.

The next generation of equipment has been developed to use IEC61850 and IEC60870 protocols in order to allow integration with a future substation RTU being specified by SPEN which will act as a communications gateway to the SCADA system, both for the CCMU and other IEC61850 devices in the substation. The diagram below shows this arrangement and highlights the CCMU, outstation, and associated radio communications that we developed as part of the project.

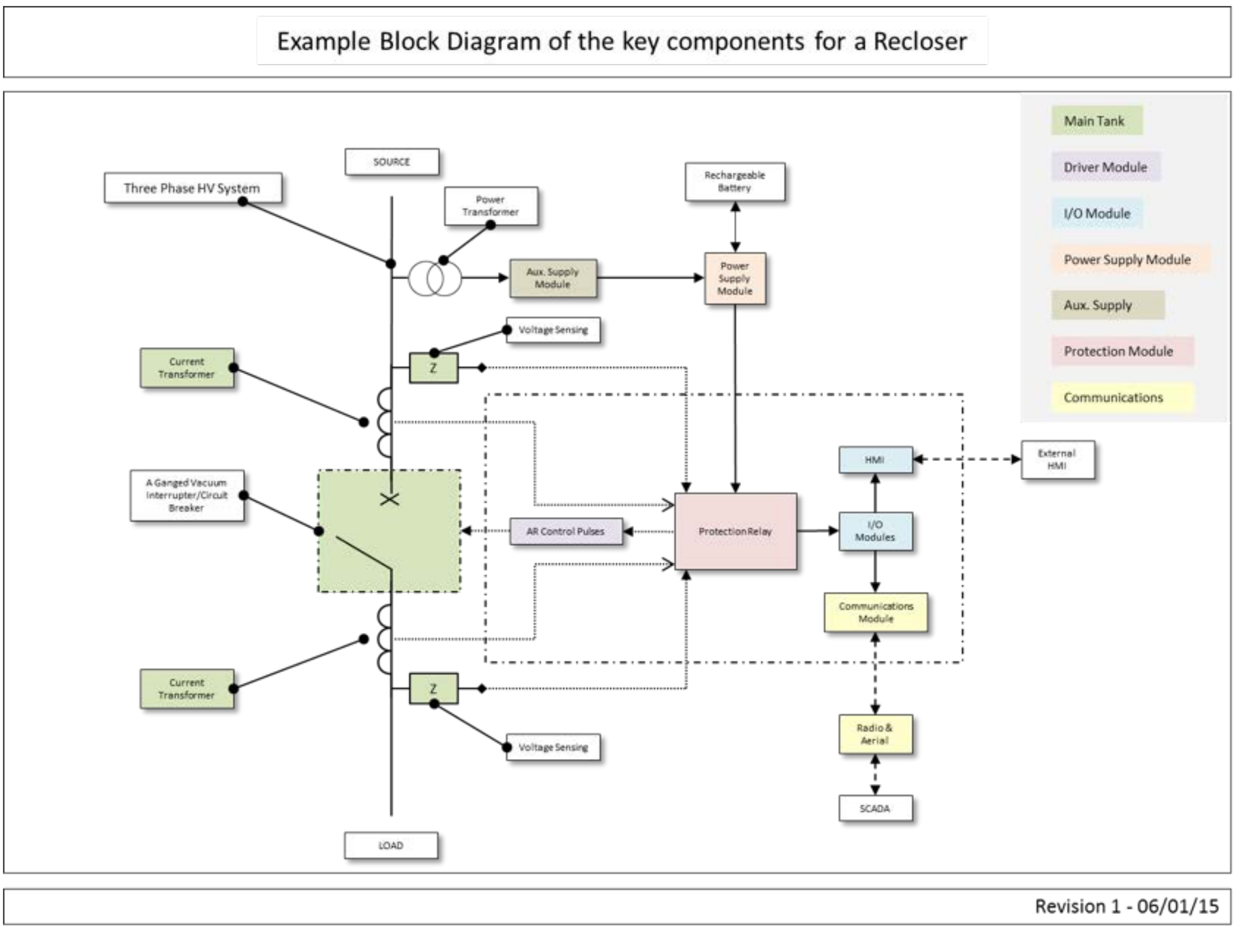


3.2.3 Installation and Commissioning

The new telecontrol equipment was installed in the trial areas of St Andrews and Whitchurch. Installation was undertaken by CG Automation under a SPEN framework contract. This company had been heavily involved in the rollout of the previous generation of equipment and it was found that the new equipment had similar installation requirements. There were however some significant differences: -

- Because the new equipment is required to monitor analogue values, it was necessary to monitor the 3-phase LV voltage at ground mounted secondary substations. This necessitated the design of a new cable assembly and fusing arrangement which is used in conjunction with specially adapted fuseholders in the LV cabinet to obtain the required signals.
- As the new generation equipment uses UHF radio communications instead of VHF, installation requirements for the radio antennas particularly at the primary substation sites was different. It was necessary to install the UHF antennas at a higher mounting height to ensure satisfactory coverage was obtained.

A typical block diagram for the derivation of smart data and close control of a PMAR is shown below.



3.2.3 Installation and Commissioning [continued]

Commissioning was carried out in a number of stages, some of which were able to run concurrently: -

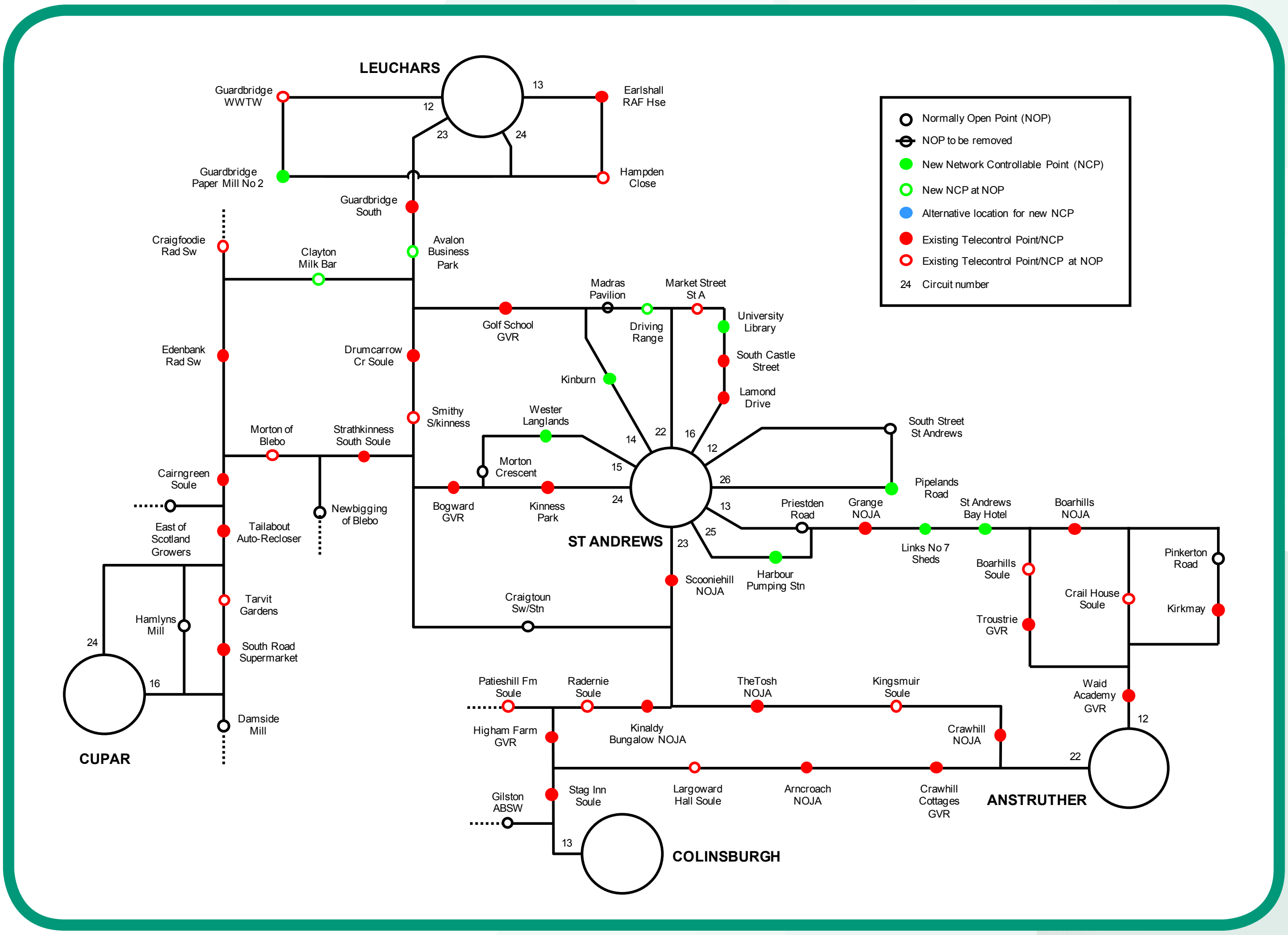
- Mapping of the outstation configurations to the new CCMU,s. This was a workshop based activity that was carried out concurrently with other site based commissioning works.
- Training by the manufacturer, SGN, for the SPEN automation technicians in the operation and commissioning of the new equipment.
- Initial powering-up and pre-commissioning checks of the outstations and CCMU's.
- Loading of the latest firmware versions to outstations, CCMU's and radios.
- Radio communications tests. These resulted in a requirement for repeaters to be installed for a small number of outstation sites.
- Loading of configuration files
- Setting of deadbands. The outstations report back analogue values when these move outwith preset deadbands. It is important that the deadbands are set such that the radio system is not swamped with data, and on the other hand important events are not missed. (as this is the development of a legacy system that is on a radio system that reports by exception, the radio traffic has to be minimised to mitigate any risk of blocking higher priority transmissions).

3.3 Algorithm Development – St Andrews

University of Strathclyde (UoS) assisted by TNEI have undertaken a modelling exercise to evaluate the available thermal headroom at St Andrews primary substation, and at adjacent primary substations. This work is detailed in Appendix 1 'Evaluation of Headroom and Load Transfer Opportunities at St Andrews Primary Substation'. Data from the secondary substation monitoring installed as part of the project was used in the modelling together with primary substation data from the existing PI historian, meter data for HV customers, and NOJA data from manual downloads. Opportunities to increase the headroom at St Andrews by permanent, seasonal or dynamic network reconfiguration to transfer load onto adjacent primary substations were identified and analysed.

The steps taken in developing the algorithm were as follows:

- Investigation of current capacity headroom
- Identification of transfer options
- Allocation of secondary load
- 2-stage analysis: whole winter then specific time
- Analysis results: capacity headroom increases from transfers



St Andrews area 11kV network

3.3 Algorithm Development – St Andrews [continued]

Two 33/11kV transformers are installed at each primary substation, as shown below

Table: Installed primary transformer capacity

Substation	Transformer rating	Firm capacity (MVA)
St Andrews	2 x 15/21MVA	21
Anstruther	1 x 10MVA + 1 x 12/24MVA	10
Cupar	2 x 15/21MVA	21
Leuchars	2 x 10MVA	10

3.3.1 Investigation of Current Capacity Headroom

Data for Winter 2013/2014 was obtained from Flexible Networks primary substation monitors at St Andrews, Anstruther, Cupar, and Leuchars primary substations for the period November 2013 – March 2014. From these, the date, time and magnitude of substation peaks were extracted.

In order to correct for the relatively mild winter of 2013/2014, St Andrews data was compared with PI records for 2002/03 – 2011/2012. A correction factor was determined and applied to the peaks from all substations.

Table: Available headroom at St Andrews area substations

Substation	2013/14 values		Scaled to average		Scaled to peak	
	Peak (MVA)	Headroom (%)	Peak (MVA)	Headroom (%)	Peak (MVA)	Headroom (%)
St Andrews	19.01	9.5	20.19	3.9	21.35	–1.7
Anstruther	6.99	30.6	7.42	25.8	9.59	4.1
Cupar	19.83	5.6	21.06	–0.3	22.27	–6.0
Leuchars	5.45	45.5	5.79	42.1	6.12	38.8

3.3.2 Identification of Load Transfer Options

Two forms of reconfiguration were considered:

1. Permanent or seasonal reconfiguration, whereby a normally open point is permanently moved or moved for winter and summer conditions.
2. Dynamic reconfiguration, whereby load is transferred between primaries within-day to take advantage of differences in timing of daily peak demand.

Analysis of the daily load patterns of the primary substations revealed that, whilst the substation loads have different daily profiles, the time of the daily peak loads tends to coincide. It was therefore concluded that dynamic reconfiguration would not be a suitable approach for St Andrews. This conclusion was supported by SPEN Network Control, as they considered that regular-within day switching could result in transient voltages on the network during the switching events that could be noticed by customers and are therefore undesirable. However there is available capacity on the transformers at Leuchars and Anstruther (but not Cupar) to accept load transfer on a permanent or seasonal basis.

From the St Andrews area 11kV network diagram above, it can be seen that the St Andrews peak load might be reduced by moving the following normally open points towards St Andrews:

Table: Principal reconfiguration opportunities

Normally Open Point	St Andrews Feeder	Remote Primary	Remote Feeder
Guardbridge South/Avalon Business Park	14	Leuchars	23/24
Clayton Milk Bar	14	Cupar	24
Morton of Blebo	24	Cupar	24
Kingsmuir Soule	23	Anstruther	22
Crail House Soule	25	Anstruther	12

The opportunities for load transfer using each of the circuits above were analysed in detail as described in the next section.

3.3.3 Analysis of Load Transfer Options

Transfer options were analysed using measured primary feeders loads and measured secondary substation load (not all secondary substations are monitored).

A two stage process was undertaken:

1. Whole winter analysis using simple algebraic calculation:
   - Considers all transfers up to whole feeder
   - Identifies dates and times of interest
   - Identifies cases likely to cause large circuit overloads
2. Loadflow analysis using TNEI network model
   - Calculation of headroom improvement
   - Identification of voltage & circuit capacity violations

As noted above, not all secondary substations have monitoring. For modelling purposes it was necessary to assign the unallocated load between unmonitored substations. This was done by assigning load in the ratio of the substation maximum capacities. The modelling was further refined by the inclusion of half-hourly metering data for large customers.

For each circuit, each potential reconfiguration option was modelled. An example of the results for St Andrews Circuit 23 is included in the table below. The option shaded grey in the table would result in a voltage violation.

Table: Headroom increase resulting from St Andrews feeder 23 transfer options

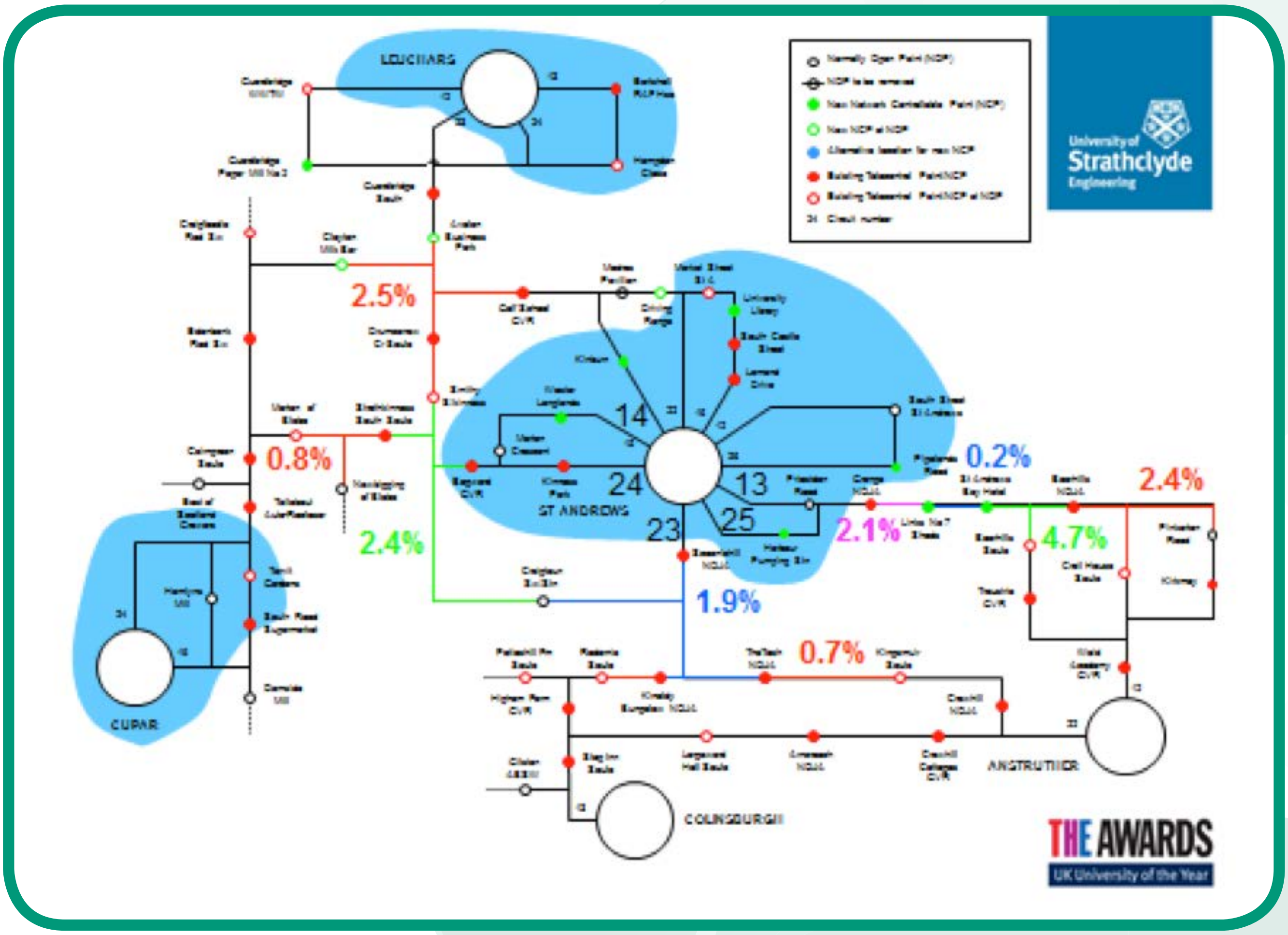
Reconfiguration option	St Andrews headroom increase at St Andrews peak (%)
The Tosh	0.7
Scooniehill	2.6
St Andrews 23	5.3

3.3.3 Analysis of Load Transfer Options [continued]

The analysis considered the effect of load transfer on the maximum demands at the adjacent primary substations to ensure that these would not be moved into LI 4 or LI 5 load index positions.

As part of 11kV reconfiguration, an automatic voltage regulator (AVR) is required to overcome an out of statutory voltage condition on St Andrews circuit 25 (13), under load transfer conditions from Anstruther circuit 12. The installation of the AVR is covered in detail in the Methodology and Learning Report for Work Package 2.4.

The initial report prepared by UoS identified a number of opportunities for progressively shifting load from St Andrews to adjacent primary substations by moving normally open points (NOP's) as illustrated below.



The following combination of opportunities were selected for consideration at a workshop involving representatives from Asset Strategy and Network Control: -

1) St Andrews Circuit 25 (Circuit 13) - Move NOP from Crail Soule to Grange NOJA 9.4% Headroom uplift
2) St Andrews Circuit 23 - Move NOP from Kingsmuir Soule to Scooniehill NOJA 2.6% Headroom uplift
3) St Andrews Circuit 24 - Move NOP from Morton of Blebo to Bogward GVR 2.4% Headroom uplift
4) St Andrews Circuit 14 - Move NOP from Avalon Bus. Park to Golf School GVR 2.5% Headroom uplift

3.3.3 Analysis of Load Transfer Options [continued]

An advantage of the solution was proposed is that it avoids moving any customers currently served from an underground circuit onto an overhead circuit. The potential resulting total headroom increase is 16.9%. These proposals were discussed at the workshop. The Control Room commented that it is undesirable to move NOP's from Soules to NOJA's or GVR's. It was requested that any opportunities to benefit from differing load profiles at adjacent primaries should be maximised. The issue of CI/CML implications was discussed and it was concluded that the movement of the NOP on a circuit is not a major consideration in comparison with other factors such as automation to provide restoration within 3 minutes.

Following the workshop the reconfiguration options were reviewed and further analysis undertaken by UoS.

The resulting proposals following review were as follows: -

1) St Andrews Circuit 25 - (Circuit 13) Move NOP from Crail Soule to Links No.7 Shed
   7.0% Headroom uplift

2) St Andrews Circuit 24 - Move NOP from Morton of Blebo to Bogward GVR and Strathkinness South Soule 2.4% Headroom uplift

3) St Andrews Circuit 14 - Move NOP from Avalon Bus. Park to Golf School GVR 2.3% Headroom uplift

These reconfigurations result in an overall headroom uplift at St Andrews primary of 11.7% without moving Anstruther primary into an LI 4 or LI 5 position.

However there is a preference to minimise load transfer onto Anstruther which is itself a heavily loaded primary. Therefore it is proposed to limit the extent of the transfer in 1) above to Boarhills NOJA giving a headroom uplift at St Andrews of approximately 2.5%. The overall resulting headroom increase at St Andrews is 7.2% and a further refinement to the open point for the Leuchars transfer results in an overall headroom increase at St Andrews of 6%.

Whilst this does increase the peak load on Anstruther by approximately 500kVA, analysis of the Anstruther transformer using the TNEI enhanced rating tool developed as part of the project confirms that the firm rating of this primary can be increased by 1MVA to 11MVA. Therefore the proposed load transfer does not cause any reduction in available capacity.

As part of the analysis, the effect of an N-2 event at St Andrews Primary has been considered. It has been concluded that P2/6 compliance can be achieved provided that the adjacent primary substations are intact.

The results of the analysis also determined that network reconfiguration at Guardbridge Switching Station is necessary to put the feeder towards Avalon Business Park onto Leuchars Feeder 23. The NOP is moved to Avalon Business Park.

Further improvements to the 11kV network were identified as follows: -

1) A new Soule switch adjacent to Clayton Milk Bar (as the Milk Bar switchgear can't be automated and replacement is uneconomic).

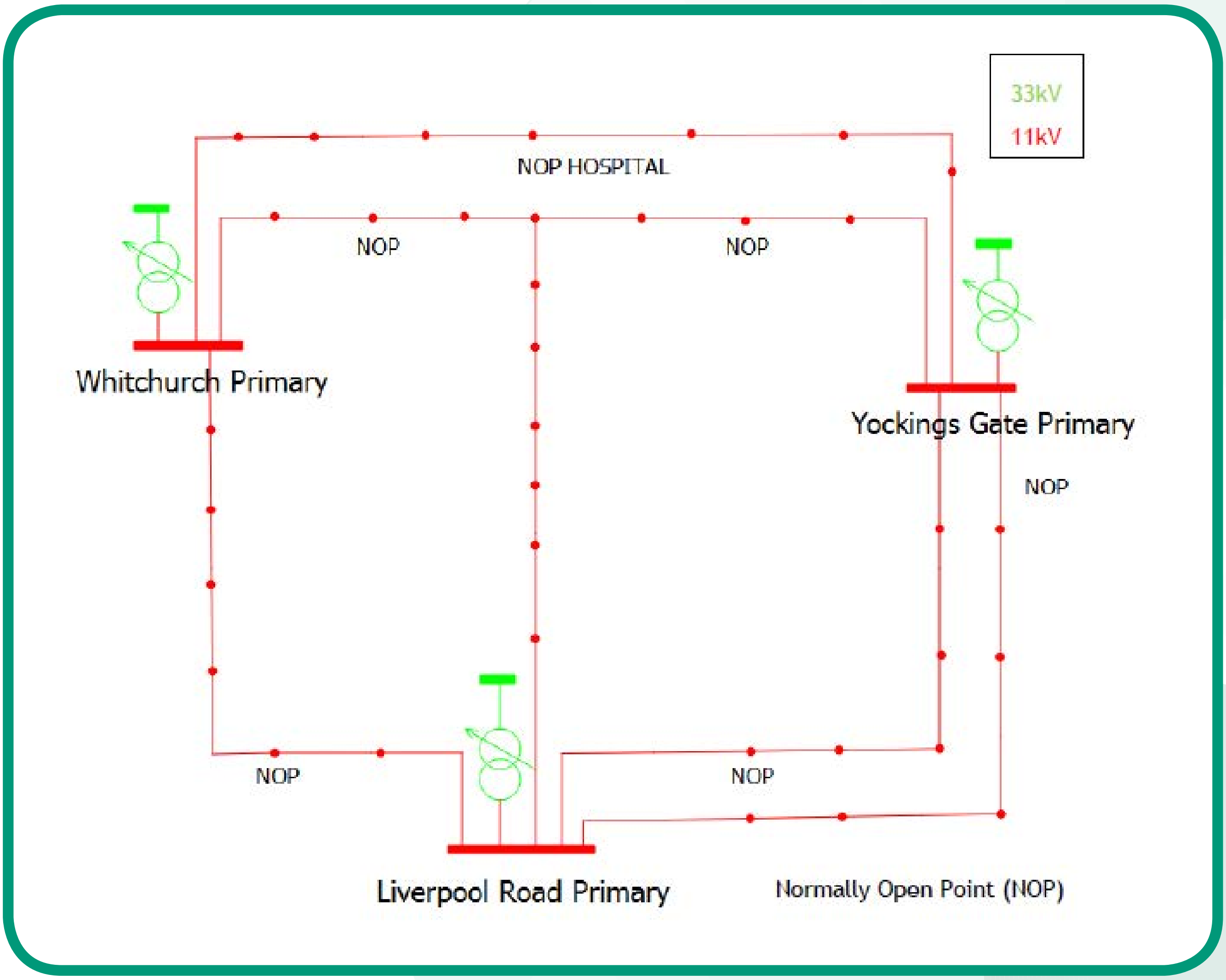
2) A new NOJA near to Avalon Business Park to protect the overhead lines under the revised feeding arrangement from Leuchars.

3) Replacement of the Crail House Soule with a NOJA.

3.4 Algorithm Development – Whitchurch

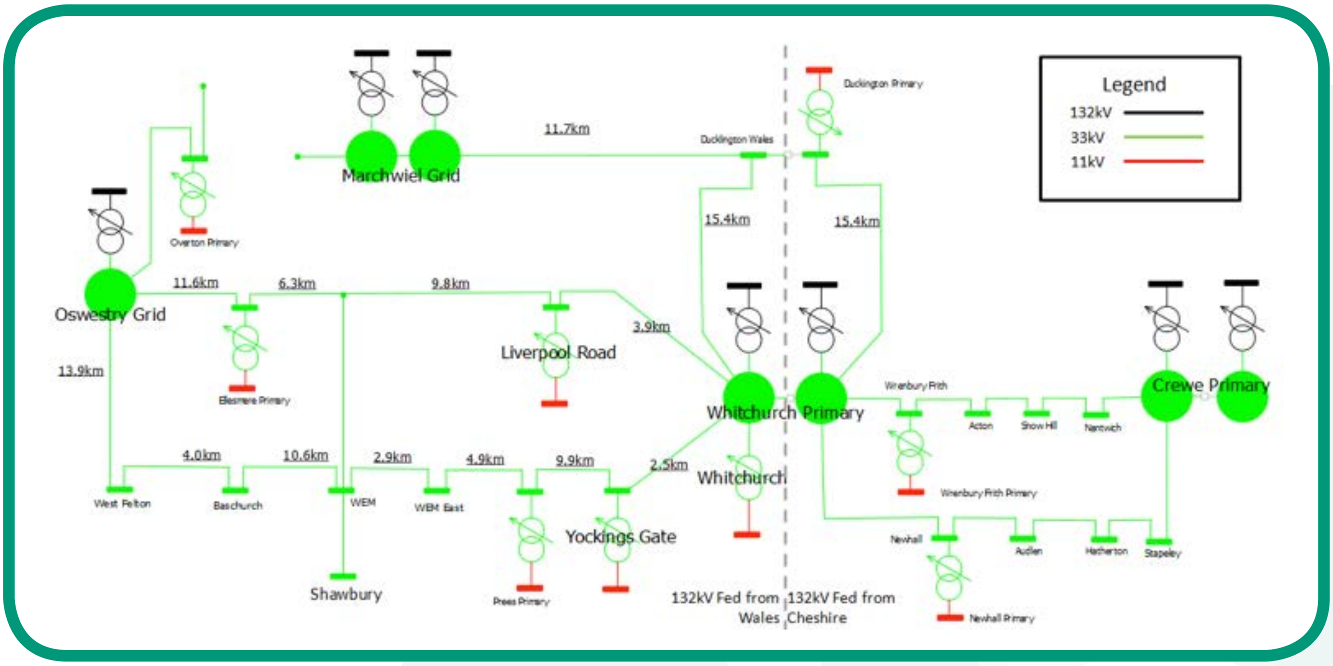
TNEI have undertaken a modelling exercise to evaluate the available thermal headroom at Whitchurch primary substation, and at adjacent primary substations. This work is detailed in **Appendix 2 Whitchurch Load Automation Feasibility Assessment**. Data from the secondary substation monitoring installed as part of the project was used in the modelling together with primary substation data from the existing PI historian, meter data for HV customers, and NOJA data from manual downloads. Opportunities to increase the headroom at Whitchurch by permanent, seasonal or dynamic network reconfiguration to transfer load onto adjacent primary substations were identified and analysed.

The Whitchurch group network is shown in the diagram below and it can be seen that the topology differs from St Andrews in that Whitchurch is a single transformer substation and is part of a group of 3 such substations. This gives rise to slightly different reconfiguration opportunities.



3.4 Algorithm Development – Whitchurch [continued]

The wider network including the neighbouring primary substation groups which are adjacent to the Whitchurch group are shown in the diagram below.



3.4.1 Investigation of Current Capacity Headroom

The theoretical group firm capacity for the Whitchurch group and adjacent 11kV groups is shown in the table below.

Table: Theoretical Group Firm Capacity

S/S Group	S/S Name	Voltage Level	Maximum Load of Previous Year (2012/2013)			Forecast Load Information					Group Firm Capacity	% Theoretical Network Headroom
						2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018		
		kV	MW	MVAr	MVA	MVA					MVA	
DUCKINGTON	Duckington	11	5.02	0.80	5.08	5.34	5.60	5.88	6.18	6.49	7.5	32%
NEWHALL	Newhall	11	2.14	1.03	4.26	4.47	4.69	4.93	5.17	5.43	5.2	18%
	Newhall		1.91	0.24								
WRENBURY FRITH	Wrenbury Frith	11	3.60	0.75	3.68	3.86	4.05	4.26	4.47	4.69	4	8%
ELLESMERE	Ellesmere	11	3.85	1.32	7.65	8.03	8.43	8.85	9.30	9.76	9	15%
MMB ELLESMERE	MMB Ellesmere		3.64	0.22								
LIVERPOOL RD	Liverpool Rd	11	4.28	0.56	16.58	17.40	18.27	19.19	20.15	21.15	20	17%
WHITCHURCH	Whitchurch		7.27	1.50								
YOCKINGS GATE	Yockings Gate		4.77	0.84								
OVERTON	Overton	11	3.76	0.69	3.82	4.01	4.21	4.42	4.64	4.88	7.5	49%
PREES	Prees	11	5.07	1.02	5.17	5.43	5.70	5.98	6.28	6.60	4	-29%

3.4.2 Identification of Load Transfer Options

Three forms of reconfiguration were considered:

1. Temporary or Permanent load transfer to interconnecting feeders within the Whitchurch group from high loaded feeders to low loaded feeders.
2. Permanent or seasonal reconfiguration, whereby load is permanently moved between network groups or moved for winter and summer conditions.
3. Dynamic reconfiguration, whereby load is transferred between network groups within-day to take advantage of differences in timing of daily peak demand.

Analysis of the daily load patterns of the primary substations revealed that, whilst the substation loads have different daily profiles, the time of the daily peak loads tends to coincide. It was therefore concluded that dynamic reconfiguration would not be a suitable approach for Whitchurch.

TNEI analysed feeder current data for the Whitchurch network group and 9 interconnecting feeders from 6 adjacent primary substations from 2010 to 2012. The analysis suggested that key opportunities for load transfer would be;

1. Whitchurch~ Bargates | Liverpool Road~Green End Arcade | Yockings Gate~Talbot St
2. Whitchurch~Hanmer to Ellesmere~Hanmer or Prees Tilstock
3. Whitchurch~Bradley Willey Moor to Wrenbury Frith~Willeymoor
4. Yockings Gate United Dairies to Liverpool Rd Care Home

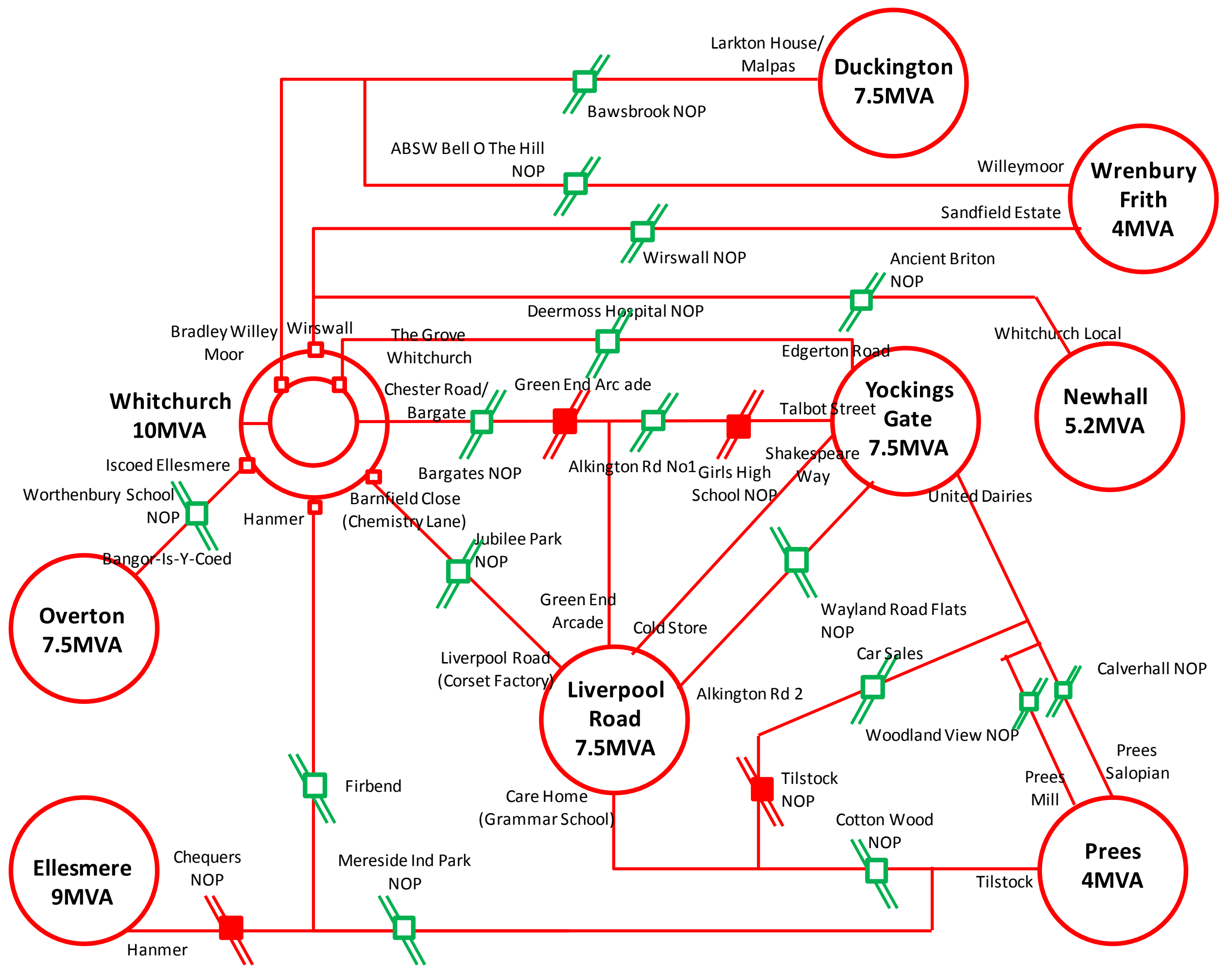
The fourth opportunity identified is primarily to improve CI and CML and was not considered further.

The analysis considered the effect of load transfer on the maximum demands at the adjacent primary substations to ensure that these would not be moved into LI 4 or LI 5 load index positions.

Initially it was anticipated that as part of 11kV reconfiguration, an automatic voltage regulator (AVR) would be required to overcome any out of statutory voltage condition on extended feeder(s) under load transfer conditions. Following the analysis work using the new monitoring data it was identified that the alternative network configurations did not create any requirement for voltage correction with a voltage regulator.

3.4.2 Identification of Load Transfer Options [continued]

The report prepared by TNEI identified a number of options for progressively shifting load from Whitchurch to adjacent primary substations by moving normally open points (NOP's) as illustrated in the diagram below.



3.4.2 Identification of Load Transfer Options [continued]

Table: Whitchurch network group headroom improvement

Loading condition	Yockings Gate	Liverpool Road	Whitchurch	Whitchurch Network Group
Current configuration (MVA)	6.06	7.64	8.03	14.44
Benchmark Headroom (%)	**19.2%**	**-1.9%**	**19.7%**	**27.8%**
Proposed new configuration (MVA)	5.75	6.4	6.41	12.81
New Headroom (%)	**23.2%**	**14.7%**	**35.9%**	**36.0%**
Improvement (MVA)	0.31	1.24	1.62	1.63
Improvement (%)	**4%**	**16%**	**20%**	**11%**

It was noted that while the circuit could be reconfigured for capacity gain in the Whitchurch sites, we had to be mindful of the customer numbers and feeder lengths that were being re-fed from alternative substations. This is due to the feeders have been optimised to minimise the numbers of customer Interruptions (CI's) and customer minutes lost (CML's) under circuit fault situations and of the effects moving the normal open points using the telecontrol scheme. The CI's & CML's were minimised as much as possible by the selection of the new open/tele-controllable points and recognition was made of the support that the extra tele-controllable switching point could make in fault outage restoration activities.

These reconfigurations result in an overall headroom uplift at Whitchurch primary of up to 11%. However until the additional capacity is actually required within the Whitchurch substation sites, some of the normal open points will remain configured for CI/CML optimised performance.

4 Business as Usual

In the ED1 period we will use flexible network control to defer conventional reinforcement where possible. We have already identified a small number of schemes which are suitable for the deployment of flexible network control, and are actively reviewing the remaining ED1 reinforcement schemes to identify further opportunities.

The development of the next generation of telecontrol equipment is an enabler to achieving a number of objectives in our ED1 business plan.

- Facilitate the connection and operation of generators of all sizes and technologies
- Allow the demand side to play a part in optimising the operation of the system
- Provide both Internal and External Customers with greater information with improved service
- Significantly reduce the environmental impact of the total electricity system
- Deliver required levels of reliability, flexibility, quality and security of supply

To facilitate the future distribution system operator (DSO) model we envisage that the network will be transitioned using a building block approach : -

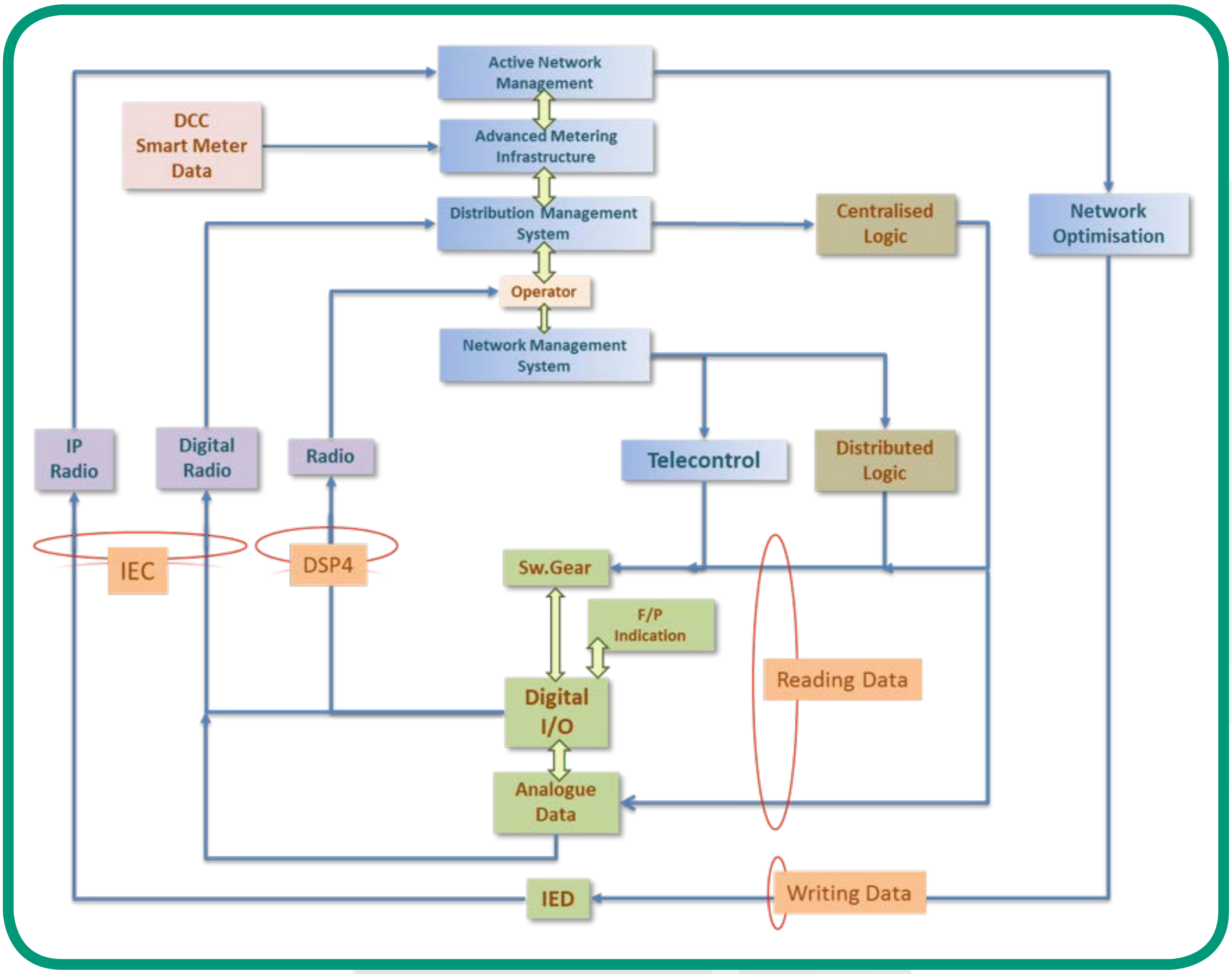
Building Block 1:	Visibility
Dynamic Network Monitoring	
Weather monitoring to enable dynamic rating	
Nursing ageing assets, extending life	

Building Block 2:	Controllability
Voltage Control with forward and reverse network flow	
Automation, to balance network loading	
Managing phase imbalance	

Building Block 3:	Intelligence
Active Network management	
Generation and Demand side Management	
Adaptive protection	

The next generation of telecontrol will be an essential requirement to implement Building Block 1, and Building Block 2 above.

Our vision of the network management system of the future is illustrated in the block diagram below.



5 Business Case

This project has implemented a number of techniques in combination to achieve the required increase in headroom within each trial area. The business case for the use of the techniques in combination is included in the Case Study report for each of the trial areas. This business case considers situations where flexible network control can be used on its own.

Flexible network control can facilitate the deferral of conventional reinforcement under different scenarios. Considering 2 typical applications: -

Deferral of 33kV Primary Substation Construction

In this scenario the existing primary substation is nearing capacity however there is capacity available on adjacent 11kV networks fed from alternative primary substations.

The lowest cost traditional method would be the provision of an additional primary substation including two new 33/11kV transformers, new 11kV switchgear, new 33 kV overhead line or underground cable, and extensive cable works to reconfigure the 11kV network. In our experience such projects take approximately 3 years to implement and the typical total cost is £6,200k.

In appropriate circumstances, flexible network control can defer the requirement for conventional reinforcement. The duration of the deferral period will be dependent on the rate of load growth which is itself dependant on a number of factors including the future uptake of low carbon technology. We consider the technique to be applicable where a deferral period of at least 8 years can reasonably be expected based on a range of load growth scenarios.

The cost of implementing flexible network control will vary depending on the extent of additional telecontrol and network switching points required. Referring to our Cost Benefit Analysis (Appendix 3) the approximate cost of implementing flexible network control based on our learning from the trial areas is estimated at £188k. We believe this is an appropriate cost to use when considering the implementation necessary to defer a primary substation.

Therefore under this scenario an expenditure of £6,200k is expected to be deferred for a minimum period of 8 years for an expenditure of £188k.

Deferral of 33kV Transformer Reinforcement

In these circumstances a primary substation is nearing capacity, however the existing transformer(s) have a significantly lower rating that the present standard maximum rating employed.

The lowest cost traditional method would be the replacement of the transformer(s) with new units having a higher rating, together with associated civil works and any upgrading of cables required. The budget costs for a typical project are £300k per transformer, a total of £600k for a 2 transformer primary substation.

In appropriate circumstances, flexible network control can defer the requirement for conventional reinforcement. Again, the duration of the deferral period will be dependent on the rate of load growth and we consider the technique to be applicable where a deferral period of at least 8 years can reasonably be expected based on a range of load growth scenarios.

As stated above, the cost of implementing flexible network control will vary depending on the extent of additional telecontrol and network switching points required. In this scenario, the costs from our Cost Benefit Analysis of £188k are again considered.

Therefore under this scenario an expenditure of £600k is expected to be deferred for a minimum period of 8 years for an expenditure of £188k. In our ED1 plan we have identified similar schemes where flexible network control can be implemented for approximately £95k, resulting in an increased financial benefit.

Under both of the above scenarios significant savings are achieved for our customers.

6 Conclusions

This work package has successfully facilitated the increase in available headroom of the primary substations in the trial areas of St Andrews and Whitchurch, thereby contributing to the success criteria for the project.

We have progressed the development of the next generation of secondary substation telecontrol equipment, installed the equipment in the St Andrews and Whitchurch trial areas and successfully commissioned to recover analogue data for the first time.

Benefits from this work package are: –

An enabler for the roll out of next generation telecontrol equipment which will benefit customers through reduced supply interruptions and reduced fault restoration times.

We have introduced the technique of Flexible Network Control into our business as usual processes, and that has enabled us to defer reinforcement projects at a number of locations resulting in savings for our customers.

We believe that this is a technique that is highly replicable in other DNO's.