Customer-Led Network Revolution

Customer-Led Network Revolution

Cost Benefit Analysis

DOCUMENT NUMBER
CLNR-L144

AUTHORS
Duncan Yellen, Laurence Elner, EA Technology Limited

ISSUE DATE
27 March 2015

Customer-Led Network Revolution

Contents

Reviewed by	Dave Miller and Michael Walbank, Northern Powergrid
Approved by	Mark Nicholson, Northern Powergrid

Date	**Issue**	**Status**
23/01/15	1.0	Published
27/03/15	1.1	Minor revisions following consultation period

Executive Summary

The Customer Led-Network Revolution (CLNR) project has successfully purchased, commissioned and tested a wide range of smart solutions for distribution networks. In many cases, this was the first deployment of these technologies seen in the UK or globally. For all of these technologies, the costs and benefits have been carefully monitored and assessed and the cost benefits based on the actual installed costs and monitored performance of the smart solutions have been calculated for each ED period and from 2020 to 2050 using the Transform Model. The technologies and learning assessed were:

- Enhanced Automatic Voltage Control (EAVC)
- Real Time Thermal Rating (RTTR) of transformers, underground cables and overhead lines
- Demand Side Response (DSR)
- Electrical Energy Storage (EES)
- New Low Carbon Technologies (LCT) load profiles

The calculations and our learning from installing these technologies show that CLNR has been a major success in identifying potential improvements to current "business as usual" practices. The major findings are as follows:

1. For the time period from 2020 - 2050, the full suite of CLNR smart technologies is predicted to reduce distribution reinforcement costs by between £3.25bn and £17.7bn dependent on the uptake rate of LCTs[1].

2. A possible further reduction of at least £500m has been identified for the period from 2020 to 2050 based on better load profile data for LCTs. The extra diversity in electricity use observed in the project needs to be compared with others' work and stress tested to consider how it could be affected by more severe winter periods. For example, the Low Carbon London project reported the potential for a significant increase in peak heat pump consumption associated with the coldest weather periods; mainly due to a loss of diversity. This learning is to be considered by DNOs through the Transform Model governance process and due to its uncertain nature is excluded from the benefits quantified above.

3. The major smart grid technologies which appear most likely to succeed include:
    a. EAVC HV Regulator
    b. EAVC Distribution OLTC
    c. DSR for I&C customers
    d. RTTR for primary and secondary Transformers
    e. RTTR for EHV and HV Overhead Lines

[1] The benefits shown here should not be added to those benefits from alternative innovative solutions demonstrated in other trials or projects since they are likely to be addressing the same reinforcement costs (albeit with different solutions).

4. Energy storage remains an expensive technology for DNOs but could become competitive for an Energy Services Company in a few years' time and CLNR has helped to move the understanding of this technology forward.

5. There is further scope for substantial savings from the learning of this project in some areas, this will require further work. These areas include:
    a. A review of Engineering Recommendation P27 where we are recommending new rating values for OHLs on redundant circuits.
    b. Time of Use Tariffs for DSR for domestic customers, this will require further research, development and regulatory review.

6. In addition to the benefits quantified above, the CLNR project has helped keep the UK in the vanguard of smart technology development and this will undoubtedly lead to opportunities for job creation and carbon reduction.

Glossary

ADSL	Asymmetric Digital Subscriber Line
ANM	Active Network Management
AVC	Automatic Voltage Control
BaU	Business as Usual
BT	British Telecom
CDM	Construction (Design and Management) Regulations
CLNR	Customer-Led Network Revolution
DNO	Distribution Network Operator
DNP	Distributor Network Protocol
DSR	Demand Side Response
DSSE	Distribution System State Estimator
EAVC	Enhanced Automatic Voltage Control
EES	Electrical Energy Storage
ESQCR	Electricity Safety, Quality and Continuity Regulations
FAT	Factory Acceptance Testing
FDWH	Flexible Data Warehouse
GPRS	General Packet Radio Services
GUS	Grand Unified Scheme (Control Infrastructure)
HV	High Voltage
I&C	Industrial and Commercial
I/O	Input/Output
ITT	Invitation To Tender
LV	Low Voltage
LCNF	Low Carbon Network Fund
LDC	Line Drop Compensation
NMS	Network Management System
NPg	Northern Powergrid
NPS	Network Product Specifications
OLTC	On-Load Tap Changer
PV	Photovoltaic
RDC	Remote Distribution Controller
RTTR	Real-Time Thermal Ratings
RTU	Remote Terminal Unit
SAT	Site Acceptance Testing
VPN	Virtual Private Network
VCC	Voltage Var Control

1 Introduction

The aim of this report is to estimate the overall cost benefit to the UK economy achieved through implementation of the CLNR programme through the period 2015 - 2050. The initial project business case gave benefits from 2020 -2050 so as well as calculating the benefits through ED1 to ED4 the benefits gained in 2020 – 2050 are also calculated. To achieve this aim we will look at the economic cost benefit of each individual smart technology installed in the CLNR trial and also calculate the overall impact of the programme, when all the technologies are implemented simultaneously.

Whilst summary details of the performance of the technologies are given here, this report is not intended to be a detailed discussion of the benefits of the smart technologies tested. For in depth discussion of the performance of these technologies reference should be made to the report Optimal Solutions for Smarter Distribution Systems and the VEEEG reports [2]produced by Newcastle University.

The original GB-wide Cost-Benefit Analysis (CBA) for CLNR was calculated using a spreadsheet methodology. Since submission of the original bid, this spreadsheet methodology has evolved and has been developed into a computer model for assessing the network cost benefit of Smart Grid technologies. This model is now in use by all the GB DNOs to calculate projected smart grid costs and network benefits versus "Business As Usual" (BAU). The benefits are assessed assuming future scenarios for electricity use as laid down by DECC to satisfy the 4th Carbon Budget.

1.1 The Transform Model™

The Transform Model was developed by EA Technology with inputs from a number of project partners and with the full engagement of all British DNOs. It is now licensed to the DNOs, Ofgem, DECC and National Grid and is being used as part of all DNOs' business plans for the next regulatory period (RIIO-ED1). The model uses DECCs fourth Carbon Budget scenarios to look at the potential costs associated with the proliferation of new Low Carbon Technologies such as EVs, PV and Heat Pumps.

The Transform Model was originally produced for the GB Smart Grid Forum. It considers the entire GB network at 33kV and below. It does this by using a number of representative network elements that can be replicated in the appropriate proportions to give an overall network that is a reasonable approximation to the GB distribution network.

The model considers the impact of Low Carbon Technologies (LCTs) on the representative networks. Technology uptake forecasts which are aligned to Government (DECC) scenarios are modelled for Heat Pumps (residential, business and public); Electric Vehicles; Photovoltaics; and Distributed Generation (taken from National Grid scenarios). Conventional load growth is also taken into account within the model alongside load growth attributed to the uptake of low carbon technologies

[2] CLNR-L248: Optimal Solutions for Smarter Distribution Systems and CLNR Trial Analysis documents are available on the CLNR website project library: http://www.networkrevolution.co.uk\resources\project%20library

The model determines the "headroom" in terms of capacity of each representative network element. It then models the change in headroom with the uptake of Low Carbon Technologies, including distributed generation, and load growth. The model identifies the point at which headroom is consumed and investment is required. It considers many solutions (both conventional and "smart") that could be applied to produce the additional headroom required. A "merit order stack" of solutions is defined in the model. This represents the relative merits of each solution in terms of its cost, the headroom it releases and any second order benefits or costs. All solutions are dynamically ranked for all network types annually to 2050.

For our work to calculate the cost benefit we have developed new solution templates based on the work of the Transform Model but populated using real data from the CLNR trials. The CLNR Solution Templates cover RTTR, EAVC and EES. Subsequently the solutions have been configured into the Transform Model in order to analyse the impacts of the acquired knowledge and lessons learnt from the CLNR outputs. These solutions describe the benefit in terms of the increased headroom or legroom available within statutory limits that the solutions can provide.

1.2 Methodology and assumptions

To calculate the CBA of the CLNR programme it is necessary to produce detailed forecasts of current and likely future costs of the technologies investigated and also a detailed understanding of the technical benefits released. The same costs and benefits are used in both the Transform Model CBA and the carbon benefits calculations.

Over the course of the CLNR programme, all expenditure on the smart grid technologies investigated have been carefully recorded[3] and cover:

- Electrical Energy Storage Cost Analysis
- Enhanced Automatic Voltage Control Cost Analysis
- Grand Unified Scheme Costs Analysis
- Real Time Thermal Rating Costs Analysis

The costs identified for each technology have then been revisited with the following methodology:

1. Estimate how much the technology cost and how this might change next time
2. How much of the installation cost was incurred as first in class or for experimental reasons and would not need to be spent again
3. How much was spent on site specific issues (i.e. asbestos removal), which would not form part of the generic unit cost for modelling purposes.

Following this analysis a final estimate for how much each technology would cost to be installed (and to be operated) next year has been made.

[3] CLNR Cost Analysis for individual smart grid technologies will be published on the CLNR website project library http://www.networkrevolution.co.uk\resources\project%20library

1.3 DECC LCT Growth Projections

The Transform Model uses DECC's fourth carbon budget scenarios to project out to 2050, the amount of reinforcement required to the UK distribution network to accommodate the growth of Low Carbon electrical technologies such as heat pumps, PV and electric vehicles. The UK Government has implemented a carbon budget which places a restriction on the total amount of greenhouse gases the UK can emit over a 5-year period. Under a system of carbon budgets, every tonne of greenhouse gases emitted between now and 2050 will count. The Government has set the first 4 carbon budgets in law, covering the period from 2008 to 2027 and have committed to halving UK emissions relative to 1990 during the fourth carbon budget period (2023 to 2027). In order to meet the 4th Carbon Budget the Government has laid out four possible scenarios:

1. High Abatement in Heat (i.e. significant uptake of Heat Pumps)
2. High Abatement in Transport (i.e. significant uptake of electric cars)
3. High Abatement in Heat and Transport
4. Carbon Credit Purchase.

These four scenarios of electricity growth have been used in the following analysis to predict the requirement for smart technologies to accommodate LCT driven load growth to 2050.

The scenario that the DNOs are predicting for ED1 based on their consultations of stakeholders is now known to be closest to scenario 4. It is however different to scenario 4 in that higher levels of PV uptake are predicted. Therefore expenditure will be likely to be higher than scenario 4 but closer to scenario 4 than any of the other scenarios. Thus when presenting the estimated benefits of a technology we consider this to be closest to the actual savings for ED1 although we should not expect a precise match. Beyond ED1 and out to 2050 it is equally likely that any of the four scenarios given by DECC could be followed, so for our savings estimates out to 2050 we provide a range estimate based on all four scenarios.

2 Benefit by Technology

In this section we look at the cost benefits based on actual installed costs and performance of each of the individual smart technologies and learning found in CLNR:

- Enhanced Automatic Voltage Control (EAVC)
- Real Time Thermal Rating (RTTR) of transformers, underground cables and overhead lines
- Demand Side Response (DSR)
- Electrical Energy Storage (EES)
- New Low Carbon Technologies (LCT) load profiles

The benefits identified in this section are modelled against Business As Usual for the four DECC scenarios for both ED1 and out to 2050. It should be noted that the benefits are not cumulative as each smart solution is being modelled in isolation from the other CLNR solutions to give an initial view as to its individual cost effectiveness[4]. To look at the total combined impact of the CLNR smart solutions, all the solutions are combined with the Active Network Management (ANM) system (GUS) in the next section to provide an overall benefit estimate for CLNR based on the interaction of all these solutions. The savings for ED1 are versus BAU and since the DNOs have been using the Transform Model to estimate ED1 savings, these savings are already captured in DNOs' current business plans for ED1. All the benefits estimated using the Transform Model are estimated looking only at LCT driven load growth and are presented as a range of potential benefits for the four DECC LCT growth scenarios. As noted earlier, the DNOs are in reality tracking most closely to scenario 4 in ED1, so for ED1 only we take this scenario as the basis for benefits.

2.1 Enhanced Automatic Voltage Control (EAVC)

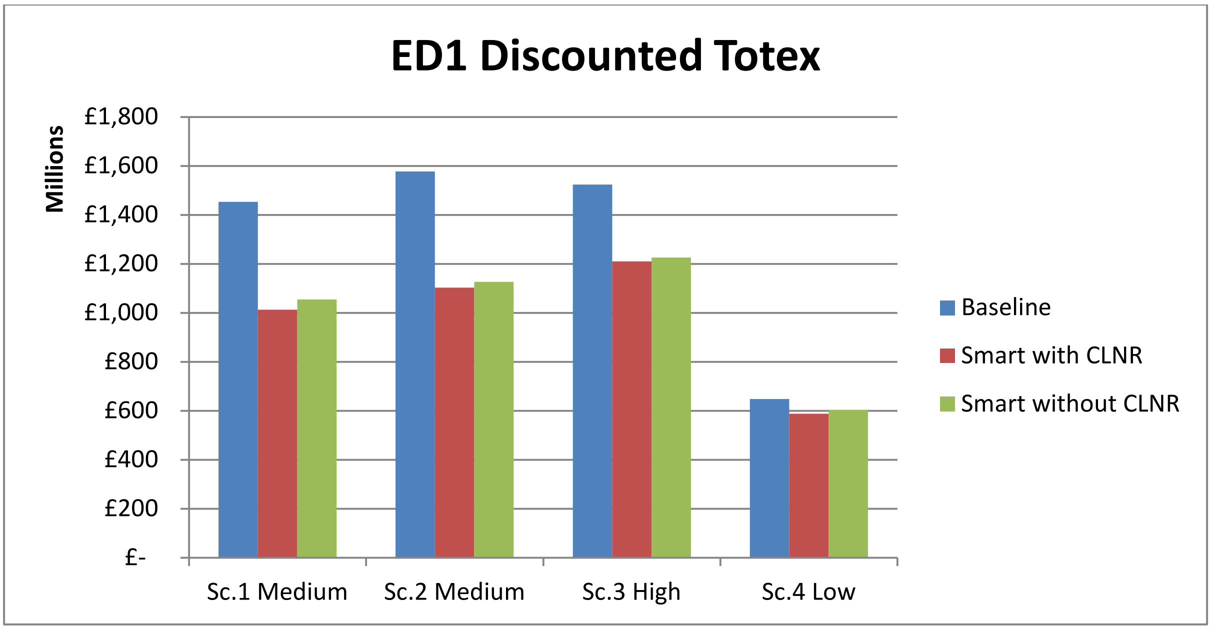
Several design options were considered for EAVC solutions within the CLNR project. The detailed assessment of the costs spent in the trial for EAVC is documented in the EAVC Cost Analysis report. The definitive solutions trialled as part of this project, their costs, benefits and their estimated costs next time were as follows:

EAVC Solution	Cost in Trial	Cost next time	Benefit	Comment
HV Regulator	£58k	£52k	10% Legroom	
LV Regulator	£103k	£93k	1.25% head and legroom	Increased tap range proposed
Primary Substation[5]	£89k	£45k	No benefit found	Therefore not modelled
Distribution	£111k	£100k	8.7%/7.4% head and	

[4] This is why the individual benefits identified in each section of this report do not sum to the total benefit identified
[5] Note AVC at a primary substation is regarded as BAU – in this case there is no additional benefit from EAVC

OLTC			legroom	
HV Switched Capacitors	£2m	£2m	12% Legroom	Includes cost of Capacitors
LV Regulator – new approach	£103k	£93k	5% head and legroom	Increased tap range proposed
Distribution OLTC with GUS	£107k	£96k	16% head and legroom	Additional benefit with GUS

The solution templates for all of these technologies have been documented in the CLNR Solution Templates. Applying all of these technologies in the Transform Model, except for the distribution OLTC with GUS solution (last row in table above), gives the following results for the GB network during ED1.



This shows that the CLNR EAVC solutions in ED1 are giving a cost saving versus business as usual of between £50m - £450m dependent on the LCT scenario. For scenario 4 this equates to savings in ED1 of £50m and the CLNR EAVC solutions offer £22m of further savings against other available smart solutions. Looking at when these solutions are deployed we see:

Solution	ED1	ED2	ED3	ED4
HV Regulator	0-137	381-809	457-780	402-890
Distribution OLTC	0-36	0	0	0

It can be seen that EAVC Distribution OLTC is only cost effective during ED1. This is probably attributable to the fact that constraints due to PV dominate in the DECC scenarios in ED1 whilst after ED1 the constraints are due to proliferation of heat pumps and EVs. The selection of the EAVC HV regulator is consistent through to 2050 with up to 6 or 7 new deployments per year per DNO licence area.

Looking over the entire period to 2050 the total benefit provided by EAVC solutions is estimated by Transform to be between £1,400m to £10,000m dependent on LCT growth scenario.

The precise split of solutions employed will depend heavily on the growth of LCTs and the impact of clustering and these values should be seen as indicative only.

2.2 Real Time Thermal Rating (RTTR)

Several design options were considered for RTTR solutions within the CLNR project. The detailed assessment of the costs spent in the trial on RTTR is documented in the RTTR Cost Analysis report. The definitive solutions trialled as part of this project, their costs and their estimated benefits are shown in the table below (note no reductions in costs for the next generation of installations was identified):

CLNR identifies three different categories of benefits from RTTR compared to current Engineering Recommendations P15 Transformers, P17 Underground Cables and P27 Overhead Lines:

1. Possible uplift to generic network ratings (i.e. available uplift vs P27)
    a. P15 no additional benefit identified.
    b. P17 no additional benefit identified, case exists for de-rating cables requiring further study.
    c. P27 no additional benefit identified for non-redundant circuits, rising to a maximum of 25% (EHV) and 34% (HV) for redundant circuits.
2. Use of a thermal rating assessment tool and local measurement data to calculate additional available uplift for specific assets
    a. P15 additional benefit range of 15% to 30% for HV/LV transformers 7% to 22% for EHV/HV transformers.
    b. P17 no benefit for EHV/HV, up to 10% benefit for LV (5% assumed).
    c. P27 additional benefit range of 25-32% (EHV) and 14 - 59% (HV).
3. Use of RTTR equipment combined with controls to provide additional benefits such as enhancing DSR, EES etc. (by reducing calls)
    a. P15 additional benefit range of up to 73% when combined with storage.
    b. P17 no additional benefit beyond that identified above.
    c. P27 additional benefit of 18% for HV when combined with DSM.

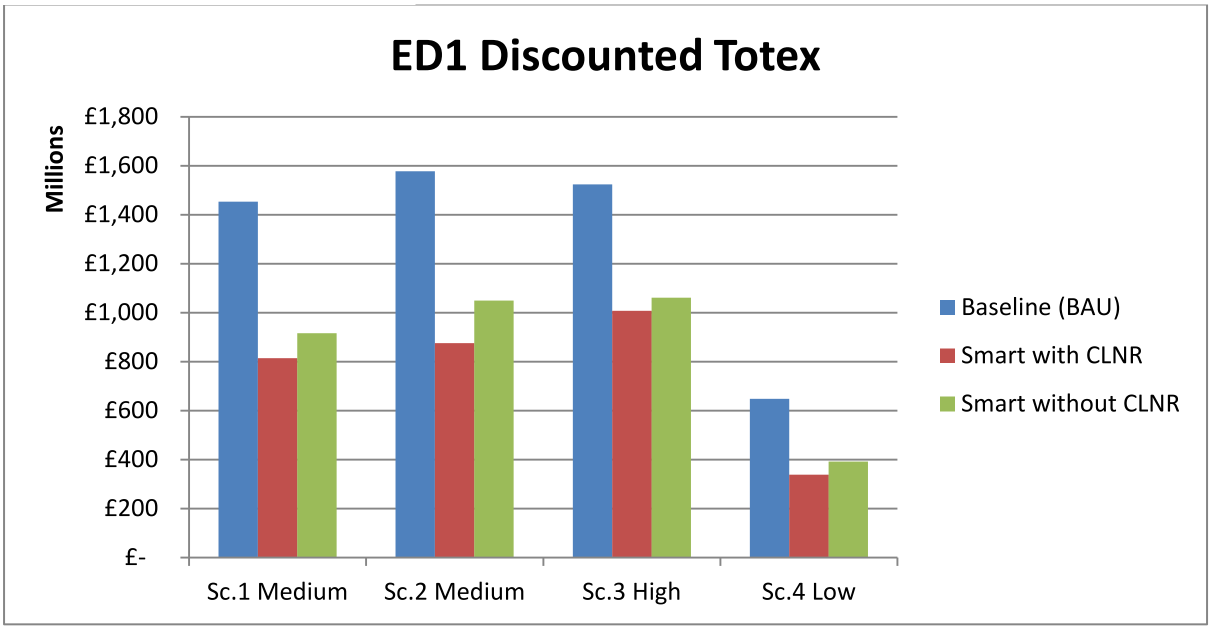
For the case of possible uplift of generic network ratings we have demonstrated that there is significant scope for improvement in OHL ratings. This is discussed further in our review of Engineering Recommendations P15, P17 and P27. These benefits will need to be accepted by the industry in a revision of P27 and the financial benefit is not calculated here.

In use cases 2 and 3 the most conservative benefit has been used for modelling economic returns and these are shown below.

RTTR Solution	Cost in Trial	Benefit (2) Bespoke thermal ratings	Benefit (3) RTTR combined with controls	Comment
Primary Transformer	£20k	7% Thermal Headroom	Not Assessed	The solution requires redesign and testing before this can be deployed.
Secondary Transformer	£15.5k	15% Thermal Headroom	73% in combination with small EES	Includes cost to connect to calculation engine.
UGC HV/EHV	£55k	0	Not available	Based on CLNR learning we would not use this solution.
UGC LV	£26k	5% Thermal Headroom	Not available	
OHL EHV	£16.6k	25% Thermal Headroom	Not Assessed	
OHL HV	£12.3k	14% Thermal Headroom	18% combined with DSM	Benefit 3 only available linked with DSM and requiring GUS.

It should be noted that the headroom available for RTTR OHL is site specific and the benefits noted are indicative only, in reality a range of benefits are available and we have modelled the most conservative value. Any implementation of RTTR OHL will require a full site, line and environment survey to identify the potential benefits and risks associated.

Based on the above solutions, the Transform Model identifies the following potential benefits in ED1.



We can see that RTTR looks to be a very promising option. Smart solutions including RTTR offer savings versus BAU of around £300m in ED1 in scenario 4 and the CLNR RTTR solutions offer additional savings of £53m when competing with all other smart solutions. Looking at the individual technologies we see the following estimated number of deployments by technology:

Technology	ED1	ED2	ED3	ED4
Primary Tx	184	500-1200	900-1400	100-1000
Secondary Tx	0	16-700	30-1200	200-2,700
EHV OHL	0	1-35	50-100	50-100
HV OHL	0	50-600	0-400	100-600

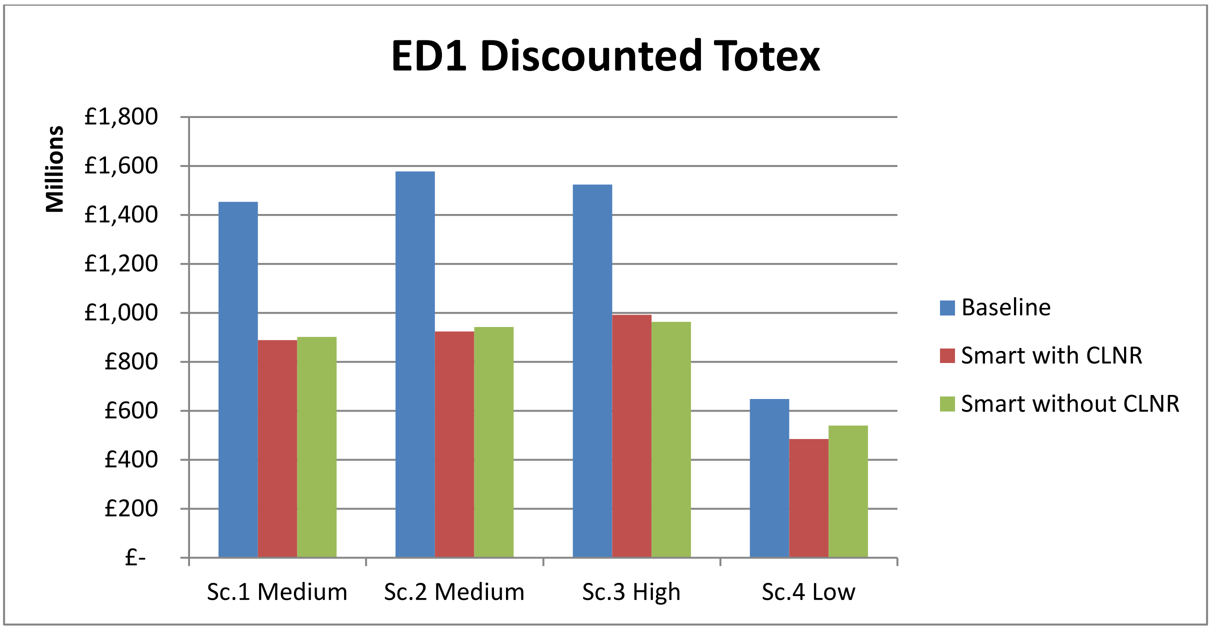
Looking over the entire period to 2050 the total benefit provided by RTTR solutions, when compared against other smart solutions is estimated by the Transform Model to be between £300m to £2,200m dependent on LCT growth scenario.

2.3 Demand Side Response (DSR)

The learning for DSR within CLNR has come from the use of DSR contracts for Industrial and Commercial (I&C) customers and the use of Time of Use Tariffs for domestic customers. Whilst the learning from the domestic studies is promising, regulatory constraints currently make developing DNO based time of use tariffs difficult and so we have focussed our effort on modelling the benefit of I&C DSR. The detailed assessment of the costs spent in the trial on DSR is documented in the DSR Cost Analysis report.

Our learning suggests that I&C DSR will be available from the marketplace at a cost of up to £2,190/MWh. Our proposed policy for use of DSR is that the market should be tested whenever a network constraint falls below this price point. This means the price paid for DSR will vary up to this price. We have therefore used the Transform Model to identify the number of times DSR would be offered to the market, rather than the number of times it would be implemented. A price of at least £1,000/MWh has been used as the threshold price.

At this cost, the Transform Model suggests DSR would be offered to the market 1763 times in ED1. At present there is insufficient learning to identify the probability of success of the market offering. At 100 % take up by the market this would imply that DSR can offer savings of around £160 m in ED1 against business as usual in scenario 4 and around £55m against other smart solutions, as illustrated below:



Clearly more learning is required to determine how often DSR will be applied. The figures for DSR should therefore be regarded as a range estimate at this stage. Looking out to 2050 the number of times contracts are offered to the market place are modelled to be as follows:

	ED1	ED2	ED3	ED4
DSR Offered	1,763	4,000- 125,000	15,000-200,000	55,000-300,000

Out to 2050, dependent on scenario we see a total benefit versus BAU of between up to £60m and up to £700m dependent on LCT uptake scenario assuming 100% uptake of DSR contracts offered.

2.4 Electrical Energy Storage (EES)

Three sizes of EES systems have been installed in CLNR. The detailed assessment of the costs spent in the trial on EES is documented in the EES Cost Analysis report. The definitive solutions trialled as part of this project, their costs, operating expenditure and their monitored benefits were as follows:

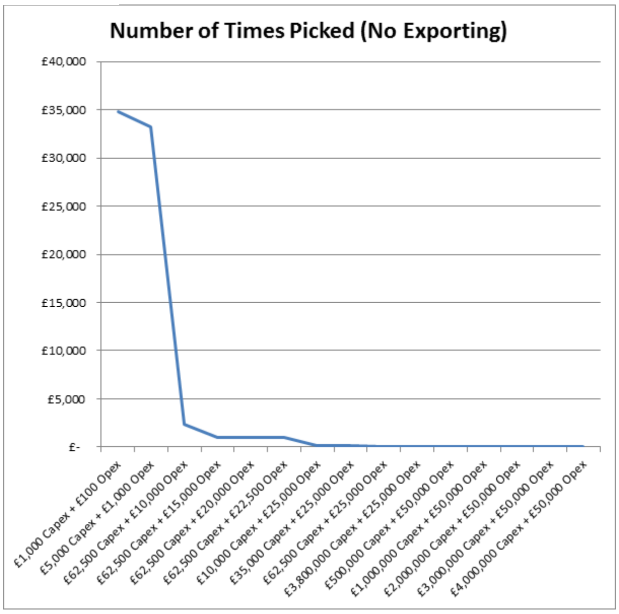
Storage Solution	Cost in Trial	Cost next time	Opex p.a	Actual full Discharge
EES 1 - 2.5 MVA	£4,623	£4,150k	£75k	5,292 kWh
EES2 – 100 kVA	£490k	£490k	£10k	200.3 kWh
EES3 – 50 kVA	£410k	£410k	£10k	105.9 kWh

The operating costs of the unit are extremely low, however, the expected lifetime of the unit (20 years) suggests that it is likely that a full battery replacement could be required during the operational lifetime which would increase annualised operating costs over the 20 years. There would also be some costs relating to the ongoing maintenance of the asset and the associated labour costs to support the full maintenance program in place. This does also give an option point for the asset when the batteries need replacing to assess whether refurbishment would be cost effective.

Assuming one full battery change after 10 years (at our current estimate cost of £1.2m) plus costs for remote support, general maintenance and site visits we estimate the annualised opex costs including one full battery replacement would be around £75k p.a. for EES1 and around £10k for EES2 and EES3.

In the case of benefits calculations, the benefits of storage are calculated in the Transform Model ™ based on the rated output of the unit and as the trials showed that the storage system achieved these ratings have been used. Losses incurred due to parasitic loss of both round trip efficiency and auxiliary supplies for heating, ventilation and air conditioning and system operational power are considered within the operation performance of the units.

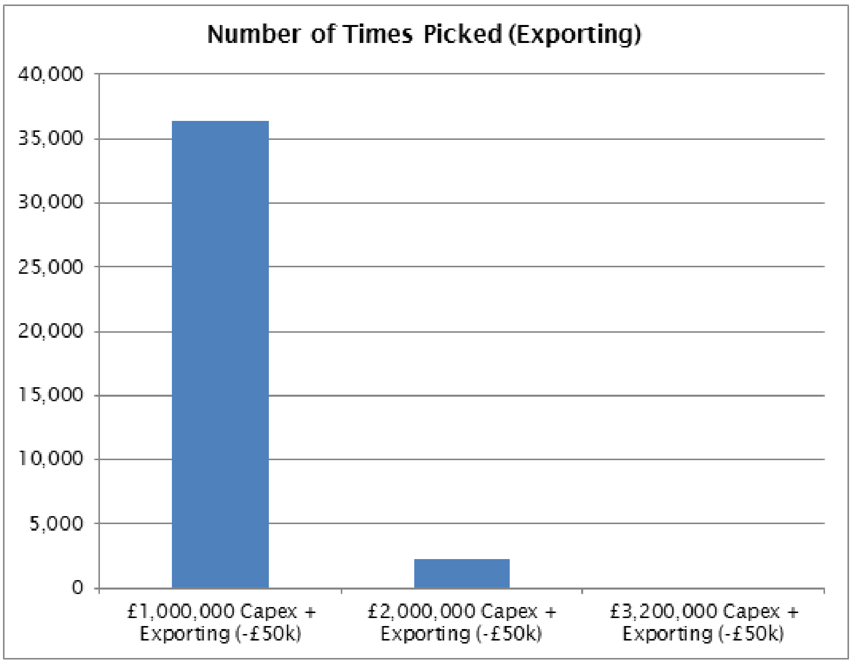
The chart below shows the number of times EES1 is an economic solution for a DNO from now to 2050, based on the current projected cost of £4m reducing as per cost curve 3 in the Transform Model. It can be seen that with operating costs and without energy trading income, the cost of the large battery would have to come down from £4m to just £62k to be competitive. This is perhaps unsurprising as for most of the year the battery will not be called into service.



However the economics become much more viable if we assume that a third party owns the unit and they are interested in maximising income from trading energy or providing other services such as frequency response.

Calculating the possible income available from frequency response will obviously benefit from real trial data which can be achieved next year. We estimate the gross income achievable to be £125k, assuming it is entirely dedicated to Fast Frequency Response (FFR) outside of winter peak hours and the FFR tenders are successful at the 2013 average price published by National Grid. This figure needs to be netted down to remove operating costs, administration and any third party fees so at this stage we propose a relatively conservative net annual income of £50k.

The chart below shows the number of times EES1 is an economic solution for a DNO from now to 2050, with £50k of income achieved after covering all operating costs. If this level is achievable then EES becomes a viable solution for a DNO at a capex of around £2m. Discussions with the battery manufacturers suggest that the battery costs might reduce by 40% in the next order and this would reduce installed costs to £3.2m which begins to make this look a viable solution. This cost will need to fall further to around £2m before the technology becomes competitive, but given the rate of improvement this seems possible in a few years' time.

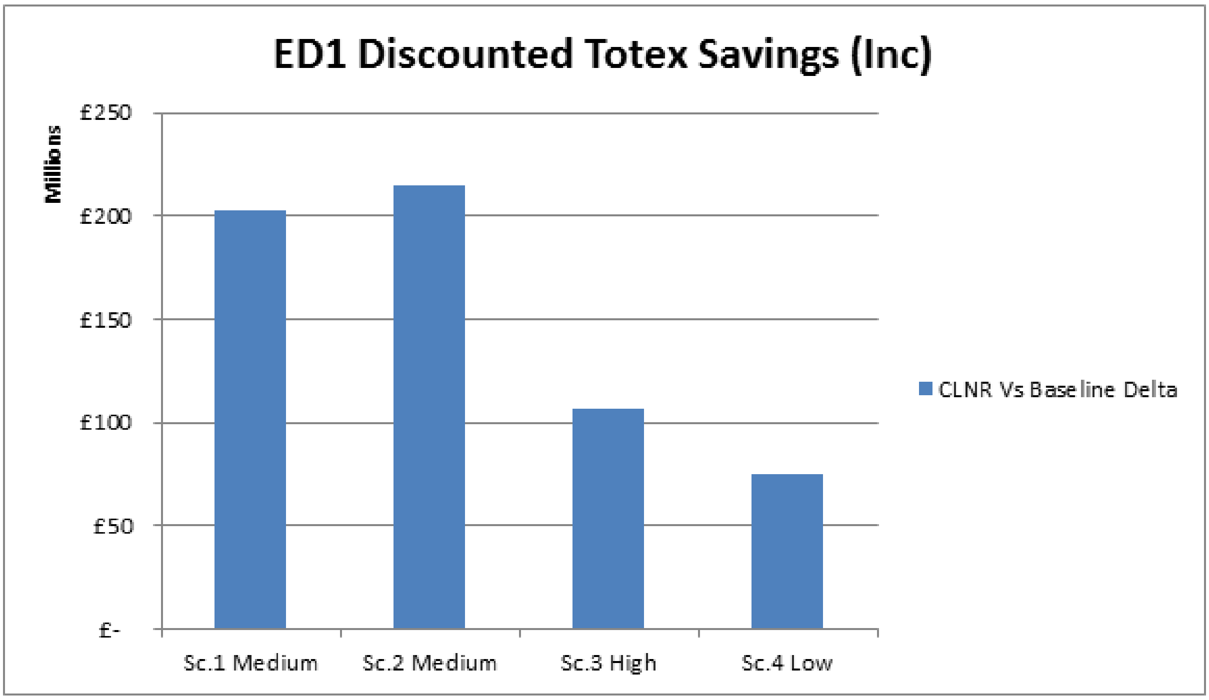


We therefore believe that there is good evidence to support the view that energy storage could become a viable alternative in the longer term. This seems unlikely to happen within ED1 and is probably more likely to be operated by a third party interested in developing energy storage services as a distinct business. We therefore include projections for energy storage as a possible solution out to 2050.

As the projected benefits of storage are not yet proven we do not calculate any benefits as yet for storage but propose that further work is conducted to demonstrate both the potential income stream and the potential for further cost reduction.

2.5 Low Carbon Technologies (LCT) Load Profiles

One of the outputs of CLNR has been to provide a much better understanding of the load profiles exhibited by each of the LCTs trialled in the programme. These profiles are shown in detail in our associated paper on ACE 49. By gaining better data on Heat Pump, PV and EV profiles, better estimates of the future impact of LCT growth can be made. By comparing current profiles in the Transform Model to the CLNR data we find that predicted spend could potentially fall by around £75m in ED1 as shown in the chart below and by between £500m and £3 billion out to 2050.



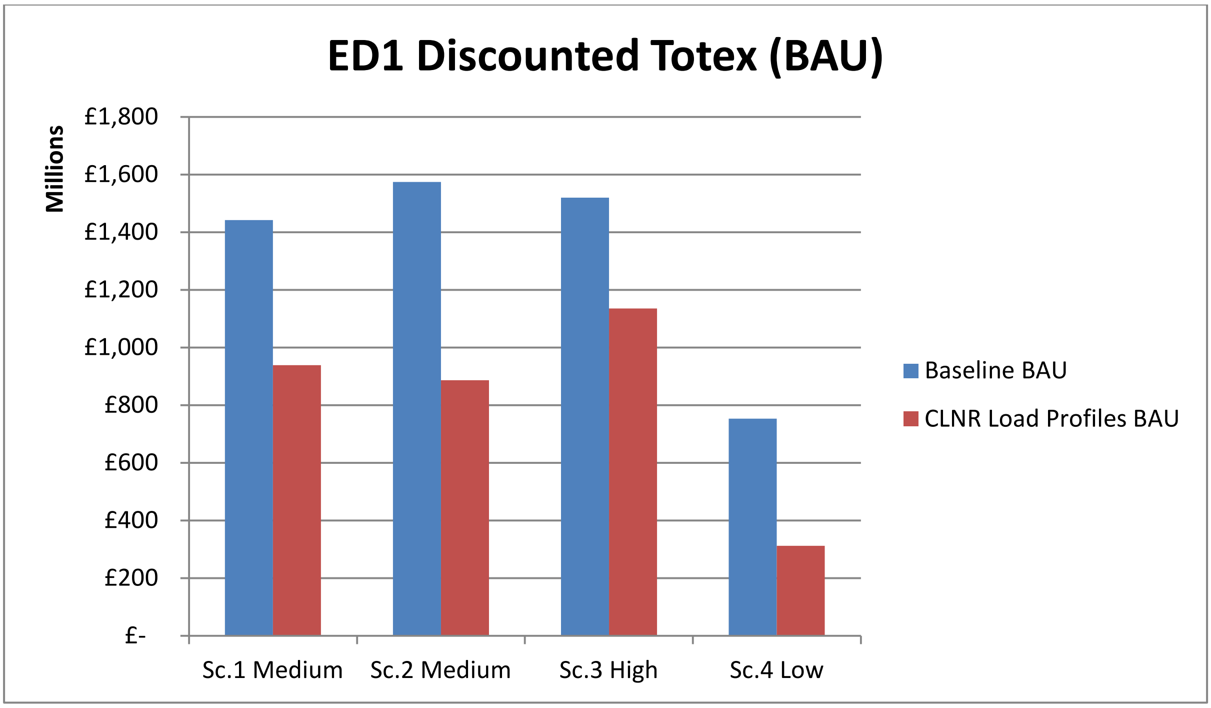
If these load profiles are agreed by the DNOs in their peer review process and accepted through Governance into the Transform Model there would therefore be a reduction in predicted spend. These values will therefore be passed through to Transform Governance for further review.

3 Cost Benefit of CLNR

Having looked at the cost benefit of each of the technologies individually we now look at the total benefit achieved through operating all of the technologies together with the GUS activated. To do this we also need to add in the costs and the additional benefits gained from using GUS. The total cost for installing the GUS on four test networks was £4,800k and the operating costs are about £20k p.a. These costs and the extra solutions which GUS can help with as noted below are all added into the Transform Model to provide a final project cost benefit calculation. The cost of scaling the GUS up to the entire network is handled within Transform, additional smart solutions and enablers are purchased as required but the initial cost of the central control system is taken as a one off strategic investment of £4.8m.

The GUS is installed once and provides enabling benefits to allow enhanced EAVC Distribution OLTC, which gives increased head and legroom and the GUS also enables the RTTR solutions to combine with DSR and EES solutions for Transformers and overhead lines. For the Transform model we have extended this cost to the entire Northern Powergrid network with investment as required by solutions.

Looking first at ED1, the Transform Model gives the following benefits.



For Scenario 4 this shows that without smart solutions, reinforcement costs during ED1 would have been £753m and with all CLNR benefits (including updated load profiles) the costs could be as low as £311m (£385m if the load profile reduction is excluded). This suggests a costs saving in ED1 in the range of around £350m - £400m. As noted earlier, this saving is already recognised in the DNOs' ED1 business plans. The actual expenditure of DNOs in ED1 for LCT reinforcement is forecast to be around £500m. This is larger than the £385m figure from the Transform Model as it is known that the DNOs have used a higher proliferation rate for PV than in scenario 4. Unfortunately exact DNO scenario data is not available but the comparison looks sensible.

Looking further ahead, the savings predicted versus BAU are as follows:

DECC Scenario	ED1	ED2	ED3	ED4[6]	2020-2050
Scenario 1	£503m	£5,476m	£3,539m	£5,012m	£15,600m
Scenario 2	£687m	£2,601m	£4,042m	£4,995m	£14,700m
Scenario 3	£384m	£5,528m	£4,268m	£4,976m	£17,700m
Scenario 4	£441m	£349m	£850m	£664m	£3,250m

Table of Discounted Totex Savings by Scenario

The total benefit in discounted total expenditure predicted by the Transform Model lies in the range £3.25bn to £17.7bn over the period 2020 – 2050.

[6] Note ED1 to ED4 runs 2015 to 2046 so these values do not sum

4 Conclusions

Estimating the future impact of the learning of CLNR out to 2050 is, by necessity, imprecise. In an unprecedented era for the UK, where electricity use is currently falling year on year, current levels of spend on distribution network reinforcement are low. Yet if the Government wishes to meet its long term carbon reduction targets it seems likely that electricity will be the fuel of choice for an increasing proportion of the country's needs for both transportation and heat. The Government has produced scenarios for the future showing a range of options of how this might be achieved and these have been used to model the potential savings which CLNR has delivered.

Our calculations show, using these projections for future electricity demand growth, that the learning from CLNR may provide eventual benefit from 2020 to 2050 of between £3.25bn and £17.7bn of discounted total expenditure. The realisation of these benefits is dependent on the rate of proliferation of Low Carbon Technologies. Equally important is that the development and implementation of projects like CLNR under the LCNF banner not only produce tangible cost benefits for the DNOs but also that they keep the UK at the forefront of the development of smart technologies which delivers not only these direct cost savings but also economic development opportunities for the UK and the delivery of opportunities for carbon emission reduction. These benefits are difficult to quantify but are undoubtedly substantial.

In addition to the economic and environmental benefits not quantified, the main quantified benefits of the project can be summarised as follows:

1. From 2020 - 2050, the full suite of CLNR smart technologies is predicted to reduce distribution reinforcement costs by between £3.25bn and £17.7bn dependent on the uptake rate of LCTs.
2. A possible further reduction of at least £500m has been identified for the period from 2020 to 2050 based on better load profile data for LCTs. The extra diversity in electricity use observed in the project needs to be compared with others' work and stress tested to consider how it could be affected by more severe winter periods. For example, the Low Carbon London project reported the potential for a significant increase in peak heat pump consumption associated with the coldest weather periods, mainly due to loss of diversity. This learning is to be considered by DNOs through the Transform Model governance process and due to its uncertain nature is excluded from the benefits quantified above.
3. The major smart grid technologies which appear most likely to succeed include:
    a. EAVC HV Regulator
    b. EAVC Distribution OLTC
    c. DSR for I&C customers
    d. RTTR for primary and secondary Transformers
    e. RTTR for EHV and HV Overhead Lines
4. Energy storage remains an expensive technology for DNOs but could become competitive for an Energy Service Company in a few years' time and CLNR has helped to move the understanding of this technology forward.

5. There is further scope for substantial savings from the learning of this project in some areas, this will require further work. These areas include:
    a. A review of Engineering Recommendation P27 where we are recommending new rating values for OHLs on redundant circuits.
    b. Time of Use Tariffs for DSR for domestic customers, this will require further research, development and regulatory review.
6. In addition to the benefits quantified above, the CLNR project has helped keep the UK in the vanguard of smart technology development and this will undoubtedly lead to opportunities for job creation and carbon reduction.

Customer-Led Network Revolution

Contact info@networkrevolution.co.uk

www.networkrevolution.co.uk