Capacity to Customers
Customer Survey
Proactive Power Quality Monitoring Report

27 March 2015

VERSION HISTORY

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Final Draft	27th March	Kate Quigley	Final Draft	
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GLOSSARY OF TERMS

Abbreviation	Term
CATI	Computer Aided Telephone Interviews
C_2C	Capacity to Customers
CEP	Customer Engagement Plan
DNO	Distribution Network Operator
ECP	Engaged Customer Panel
EHV	Extra High Voltage
ENW	Electricity North West
HV	High Voltage
I&C	Industrial & Commercial
LCNF	Low Carbon Network Fund
MPAN	Meter Point Administration Number
NOP	Normally Open Point
OSIS	Operator Service Information Service
PSR	Priority Services Register
SDI	Short Duration Interruption
SDRC	Successful Delivery Requirement Criteria
SFIC	Supply Fault Incident Centre

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1. FOREWORD

This proactive power quality monitoring report marks the culmination of an 18-month customer engagement exercise that has involved approximately 660 (mostly domestic) customers throughout the Electricity North West region.

The customer survey from which this report is derived was jointly designed by Electricity North West and its market research provider, Impact Research. The research methodology and sampling approach was piloted and externally validated by an independent peer reviewer, Professor Ken Willis of Newcastle University.

Impact Research then conducted the customer surveys and summarised their findings in this proactive power quality monitoring report.

Electricity North West welcomes the report and recommends it to all Low Carbon Networks Fund (LCN Fund) stakeholders. The report findings will be incorporated into the closedown report for the Capacity to Customers (C_2C) Project.

Throughout the Trial, Electricity North West and Impact Research have continued to engage with customers in order to continuously refine understanding of the market for demand response contracts. Each time findings were documented and incorporated into learning and dissemination material such as future documents or industry knowledge dissemination presentations. This report and any related learning material has been published on the Project website.

2. EXECUTIVE SUMMARY

This report is submitted as part of the Electricity North West Capacity to Customers (C_2C) second tier LCN Fund Project.

C_2C seeks to test if new and/or existing customers are willing to adopt new forms of commercial arrangements which allow the network operator to place short duration restrictions on their demand and/or generation as necessary, in response to infrequent fault outage events.

This document and the analysis therein forms part of the Project dissemination and specifically details the learning from a strategic piece of customer engagement undertaken by Impact Research, an independent market research company. The purpose of the engagement was to help understand any relative shift in the overall customer experience due to the changes in operating arrangements brought about by the C_2C Method, through measuring its impact, if any, on the perceived reliability of customers' power quality, interruption frequency and duration.

The customer engagement undertaken was proactive in that it surveyed customers regardless of whether or not they had noticed any adverse power quality effects or had any reason to contact Electricity North West. The customer engagement was conducted at three separate intervals during the Trial phase of the Project.

The C_2C Method ie the reconfiguration of HV circuits into HV closed rings may result in an increase in short duration interruptions (SDIs). C_2C seeks to test if an increase in SDIs is acceptable to domestic customers. In terms of research limitations, it should be noted that while the research outlined in this report successfully establishes perceptions of power quality, it provides only a limited understanding of the acceptability of the SDIs. To explore this further, a reactive, event-based piece of customer engagement has been conducted to specifically address this requirement, the key findings of which can be found on the C_2C website.

The research approach referenced within this document was submitted as part of the customer engagement plan (CEP) approved by Ofgem on 28 June 2012.

2.1. Research hypothesis

The C_2C Project was designed to specifically answer seven key hypotheses:

- The C_2C Method will release significant capacity to customers (in the range of 75% to 100% of available capacity/circuit rating) from existing infrastructure
- The C_2C Method will enable improved utilisation of network assets through greater diversity of customers on the network ring
- The C_2C Method will reduce like-for-like power losses initially but this benefit will gradually erode as newly released capacity is utilised
- The C_2C Method will improve power quality resulting from stronger electrical networks
- The C_2C Method will facilitate lower reinforcement costs for customers for the connection of new loads and generation
- The C_2C Method will effectively engage customers in a new form of demand and/or generation side response thereby stimulating the market and promoting the future use of commercial solutions to address the Problem
- The C_2C Method will facilitate a reduction in the carbon costs of network reinforcement.

A suite of customer engagement studies were undertaken to address the key customer related component: hypothesis six, which sought to engage customers in a new form of demand and/or generation side response. The key learnings from this aspect of customer engagement have been disseminated and are accessible through the C_2C website and in video content.

The proactive power quality monitoring project is primarily concerned with enhancing the learning which supports hypothesis four, primarily a technical-based assertion that the C_2C Method will improve power quality:

The C_2C Method will improve power quality resulting from stronger electrical networks.

This hypothesis can be supported through customer engagement if it can be demonstrated that Electricity North West's customer base of domestic and industrial and commercial (I&C) customers have noticed a discernible improvement in their power quality since the C_2C Trial began.

The C_2C Trial was conducted on 13% of the whole Electricity North West distribution network. The initial screening process identified circuits that had the greatest recent connection activity or supplied future development areas in the region and were highly loaded to increase the likelihood of attracting C_2C connections during the Trial period. The Trial area included 360 circuits which were operated as closed rings. Circuits with an above average fault history were discounted from the ring selection to prevent an increase in customer fault disturbance. In order to gain an understanding of these circuits in relation to C_2C, 20 circuits with higher than average fault rates were selected to run as radial feeders.

In addition the circuits were classified to check that the selection was representative of the whole of the network and other distribution networks. In the interest of representativeness the sites selected as part of the C_2C Trial were geographically spread across the entire North West region, as depicted in Chart 1.1.a. Customer engagement was therefore carried out with customers across the broad C_2C Trial area, with analysis aggregated to Cumbria, Lancashire and Greater Manchester sub regions. A more detailed report on the site selection method is available on the C_2C website.

Chart 1.1a: The C_2C Trial circuits (highlighted in yellow)

The research was designed to measure customers' perceptions of their power quality and reliability, measured in terms of fault frequency, fault duration and observations of dips and spikes during the Trial period. The instrument used to measure customers' perceptions was a quantitative customer survey. The research methodology included the use of a test group of domestic customers on each of the C_2C Trial circuits and a control group of domestic

customers who live at a property outside of the C_2C Trial area. This control provided a frame of reference for measuring the relative change in perception amongst customers on each of the C_2C Trial circuits.

I&C customers were also incorporated into the research design which enabled Electricity North West to understand the impact of the C_2C Method on domestic customers' power quality perception and that of existing I&C customers. These I&C customers were all located on C_2C Trial circuits and comprised two groups: those who did, or did not sign a C_2C managed connection agreement/managed supply construction and installation agreement.

The analysis included within this document examines three key questions:

- Where the C_2C Method is deployed and involves meshing the HV network, do customers report any perceived differences in their power quality or supply reliability?
- If any effects are noticed by customers, do they present a barrier to the rollout of the C_2C Method?
- Where detected by customers, do SDIs enhance perception of power quality or supply reliability?

2.2. The research approach

The research approach referenced in this document was submitted as part of Electricity North West's C_2C CEP.

In the CEP Electricity North West committed to carry out detailed research with domestic and I&C customers in the Trial area and a reference population not in the Trial area to assist in understanding any relative shift in the overall customer experience and include such aspects as power quality, interruption frequency and duration and to re-survey customers at appropriate points during the Trial.

300 domestic customers who live on selected C_2C circuits were recruited to take part in the customer engagement, a statistically robust sample size. A series of classification questions were used to ensure that the customers recruited to take part in the customer engagement were demographically representative of Electricity North West's customer base. The same process was used to recruit domestic customers who live on control circuits so that direct comparisons could be made between the two groups.

The research methodology and sampling approach was piloted and externally critiqued by an independent peer reviewer, Professor Ken Willis.

In total, 661 quantitative computer aided telephone interviews (CATI) were completed with domestic and I&C customers on C_2C Trial circuits (350) and domestic customers on control groups (311) across three separate phases of research: August 2013, February and August 2014. A sample size of 661 is statistically robust at an aggregated level and all analysis contained in this report has been significance tested at the 95% confidence level which is a market research industry standard.

The proportion of customers surveyed in each of the three aggregated regions within the North West, across the three phases of research, broadly represented the population density on each of the C_2C Trial and control circuits. However, the demographic and socio-economic profile of customers surveyed in each of the three regions was also weighted to further mitigate against any risk of differences in power supply quality perception being driven by sampling bias as opposed to genuine variations in customer perception.

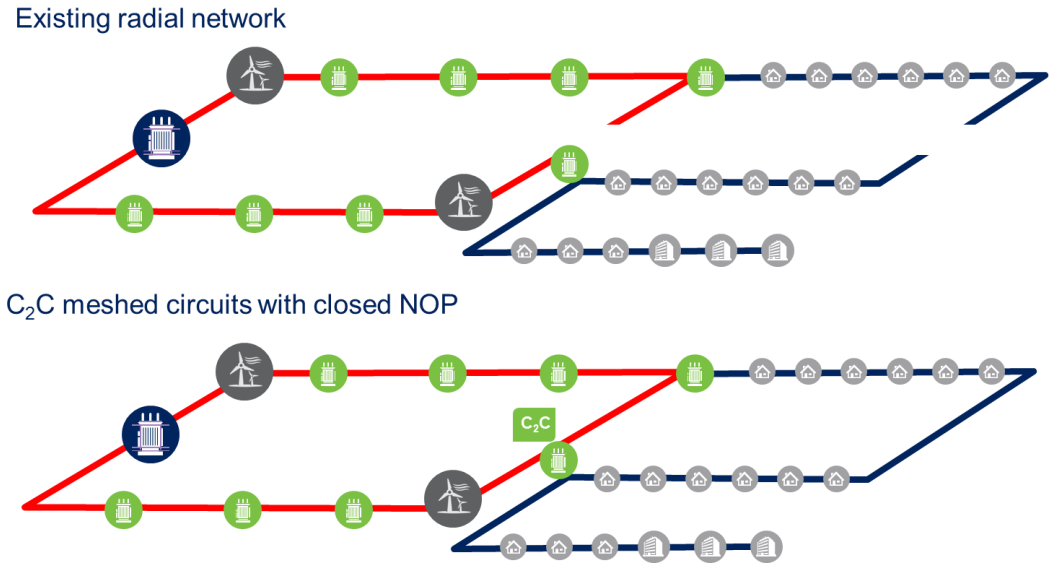
With the exception of I&C customers who had signed a C_2C commercial agreement, the survey population was a different selection of customers in each phase of customer engagement. The survey itself lasted approximately 15 minutes.

2.3. The C_2C technology

To ensure that the C_2C Project delivers results and learning that is transferable to all GB distribution network operators (DNOs), the C_2C Method has been tested on 180 high voltage (HV) closed rings, from the low to medium fault rate circuits and 20 HV circuits and a smaller number of extra high voltage (EHV) circuits across the network. The target networks supply electricity to about 317,000 customers, close to 13% of Electricity North West's overall customer base.

The C_2C Method involves changing existing radial electricity circuits to a meshed formation which facilitates interconnection and adaptive automation. In this formation the normally opening point (NOP) on the C_2C Trial circuits is changed. High voltage (HV) networks are generally interconnected by an NOP which is only used in the event of a network fault/outage. Closing the NOP allows all customers affected by a fault, to be re-supplied by an alternative circuit. This represents a change in operating arrangements and has the potential to significantly increase the number of customers who are affected by a fault. However, it is anticipated that the faults experienced are likely to be of shorter duration.

Chart 1.3: Illustration of a C_2C meshed Trial circuit



The analysis contained in this report and its appendices explores the relationship between the change in operating arrangements facilitated by the C_2C Method on each of the C_2C Trial circuits and customers' perception of power quality.

Measurement of power quality can take many forms. The volume of customers affected by a fault (ie a power cut), the frequency of faults occurring and the duration of faults are all key regulatory measurements. In addition to these regulatory measures, customers may observe dips and spikes in voltage that manifest themselves in discernible effects to their appliances and therefore influence their perception of power quality.

The application of the C_2C Method could significantly decrease the average duration of faults experienced by customers, given that in many cases Electricity North West will not need to dispatch an engineer to fix a fault. This is because the automation enabled will restore supply to the majority of customers in a matter of minutes. This type of fault is called an SDI and previous qualitative customer engagement has indicated that customers perceive this change in operating conditions as relatively good news.

This report, in conjunction with more detailed reactive post-fault customer engagement seeks to verify the assertion from previous research that the change in operating conditions is perceived as beneficial for customers by virtue of an improved perception of power supply quality.

2.4. Summary of the key findings

2.4.1. Where the C_2C Method is deployed and involves meshing the HV network, do customers report any perceived differences in their power quality or supply reliability?

The change in operating conditions on C_2C Trial circuits has not adversely affected customer perception. Indeed, the net change in perception amongst customers on C_2C Trial circuits either achieves parity with the status quo or a more favourable position for all three key power quality measures: frequency, duration and dips and spikes.

This perception is also echoed amongst customers who are either already registered on the priority services register (PSR) or are eligible for inclusion. The implication of this is that perception of power quality is not adversely affected, even amongst vulnerable customers who could be interpreted as being more sensitive to changes in power supply quality due to an elevated dependency on their electricity supply.

2.4.2. If any effects are noticed by customers, do they present a barrier to the rollout of the C_2C Method?

The analysis suggests that the most discernible aspect of power quality supply for all survey participants is the frequency of faults, with customers in all groups more likely to notice a change in the number of faults experienced than any other power quality metric.

The most significant learning, albeit still at a relatively small level, is the enhanced service with regards to the frequency of faults, particularly amongst those on C_2C Trial circuits. The results suggest that the introduction of the C_2C Method improves perceptions of the occurrence of faults when compared with the preceding year(s).This complements evidence specifically supporting the notion that the detection of faults since the C_2C Trial began is significantly lower amongst those on C_2C Trial circuits compared to control circuits. This finding suggests that power quality is more favourable using the C_2C Method compared to business as usual operating conditions and as such the effects noticed do not present a barrier to the rollout of the C_2C Method.

2.4.3. Where detected by customers, do SDIs enhance perception of power quality or supply reliability?

It was within the remit of the proactive monitoring customer engagement to explore the impact that the detection of an SDI can have on the acceptability of a power cut duration.

Lasting under three minutes, the SDI duration is by far the most acceptable to customers, significantly more so than durations of up to 60 minutes. Electricity North West's business as usual fault management procedures mean that in the event of a fault, approximately 90% of customers' power supplies are restored in one to three hours. The analysis undertaken in this study has indicated that customers' expectations of a good standard of service are that power should be restored in a much shorter time period than current service levels. The implication of this is that any change in operating conditions that serves to increase the proportion of faults that are SDIs, is likely to enhance power quality perception. But, by how much can power quality perceptions be enhanced as a result?

A relatively small number of customers across the three phases of research claimed to have experienced an SDI. However, amongst those that did, the acceptability of the fault duration (asked on a one to ten rating scale) was 27% higher (ratings of 8-10 combined) than all other fault durations aggregated together. This is similar to the 24% uplift observed in separate reactive post-fault customer engagement. The reactive post-fault study consisted of a much larger, statistically robust sample and was conducted in parallel with the proactive monitoring. The reactive post-fault survey engaged with customers in the days immediately after a C_2C fault, be that an SDI or a longer duration fault.

3. KEY FINDINGS

3.1. Introduction

This section of the report summarises the key findings of the customer survey analysis which addresses three key questions, as stipulated in the executive summary.

3.2. Where the C_2C Method is deployed and involves meshing the HV network, do customers report any perceived differences in their power quality or supply reliability?

3.2.1. Overall summary

The change in operating conditions on C_2C Trial circuits has not adversely affected customer perception. Table 2.2.1a below indicates that the net change in perception amongst customers on C_2C Trial circuits across the three combined phases of research is one of either achieving parity with the status quo or a more favourable position, particularly for the key power quality measures: frequency, duration and dips and spikes.

Table 2.2.1a: Power supply quality, key measures

Since the beginning of April 2013, do you feel that the frequency of power cuts, duration (length) of power cut, number of dips and spikes at the property has increased, stayed the same or decreased?			
		C_2C circuit*	Control circuit
		n=323	n=285
A) Frequency	Increased	3%	6%
	Stayed the same	89%	87%
	Decreased	8%	7%
	Net % change**	4%	0%
B) Duration	Increased	2%	2%
	Stayed the same	93%	89%
	Decreased	5%	9%
	Net % change **	3%	7%
C) Dips and spikes	Increased	3%	7%
	Stayed the same	94%	88%
	Decreased	3%	5%
	Net % change **	0%	-2%

* C_2C Trial circuits include domestic and I&C customers
** Note that the net % change = (% decreased - % increased). % has been rounded.

The analysis also shows that the most discernible aspect of power quality supply for all survey participants is the frequency of faults, with customers in all groups (C_2C Trial and control circuits) noticing changes in this metric more so than any other across the three phases of customer engagement. This is inherent in the frequency of faults having the lowest proportion of customers saying that there had been no change in the metric since the beginning of April 2013 compared to duration and dips and spikes.

3.2.2. Frequency of faults

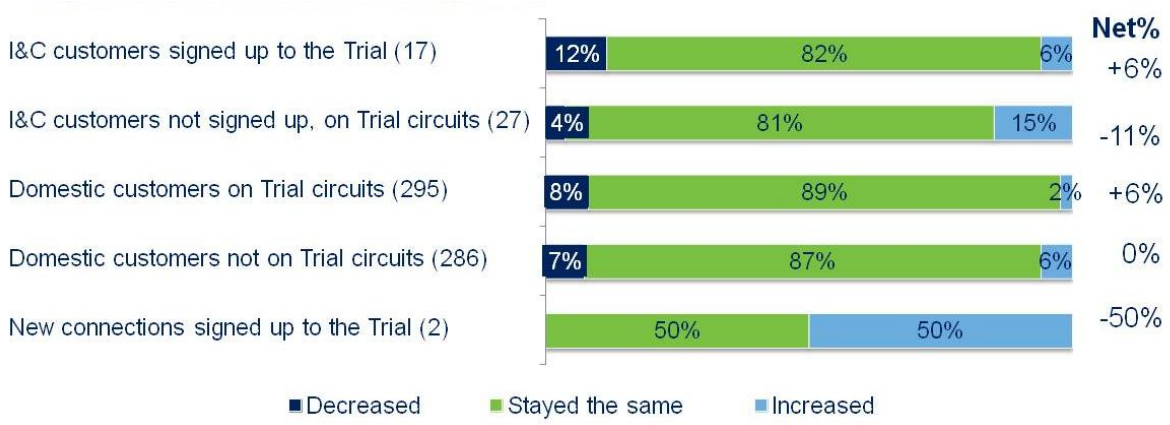
The most significant learning is the enhanced service with regards to the frequency of faults, by virtue of there being fewer noticeable faults occurring under the C_2C Method on Trial circuits. This is particularly evident amongst I&C participants who signed up to the C_2C Trial and domestic customers living on Trial circuits. The results suggest that the introduction of the C_2C Method improves perceptions of the occurrence of faults when compared with power supply quality in the preceding year(s).

The analysis presented in chart 2.2.2a indicates that the net change in perception of the frequency of faults since the start of the C_2C Trial improved amongst I&C customers who signed up to the Trial and conversely deteriorated amongst those who did not. In reality I&C customers represent approximately 8% of Meter Point Administration Numbers (MPANs) across Electricity North West's network and consequently form a relatively small proportion of the survey sample. Although the frequency of faults deteriorating by 11% for I&C customers who had not signed up is notable, there was no control group of I&C customers on non-C_2C Trial circuits with which to compare this observation. The inclusion of a control group of I&C customers was outside of the scope of this research but should be considered for future innovation projects.

On balance, customers who were surveyed as part of the C_2C Trial circuits groups were in agreement that their perception of the frequency of faults had improved over and above that of group four, domestic customers who were not on Trial circuits.

Chart 2.2.2a: Perception of the frequency of faults, by customer type

Do you feel the frequency of power cuts has increased, decreased or stayed the same since April/start of C_2C?



The positive change in perception was also echoed amongst customers who were either already registered on the priority services register (PSR) or eligible for inclusion.

Eligibility for the PSR is based on one or more of the following: being 65+ years old; having a member of the household that has a disability; is seriously ill; has mobility problems, visual or hearing impairment and/or medical equipment.

Analysis has indicated that perception of power quality under C_2C conditions was not adversely affected amongst vulnerable customers, where greater sensitivity to changes in power supply quality could have been observed through greater dependence on their supply. In fact, little sensitivity to changes in operating conditions was detected amongst PSR eligible customers. This is shown by the proportion of customers not noticing a change in the frequency of faults in Table 2.2.2b being significantly higher than that of non-PSR eligible participants.

The implication of this is that there is no evidence to detract from rolling the C_2C Method out as business as usual or any need to be unduly sensitive to the needs of vulnerable customers over and above the level that which current service levels dictate.

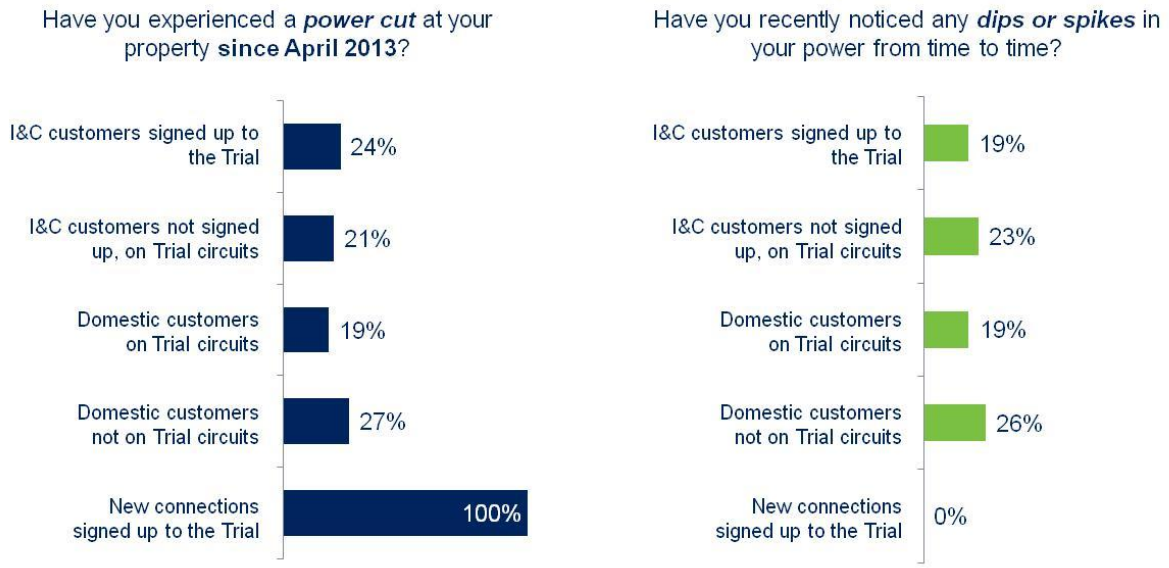
Table 2.2.2b: Power supply quality, key measures, C_2C circuits, PSR status

Since the beginning of April 2013, do you feel that the <Frequency of power cuts, Duration (length) of power cut, Number of dips and spikes at the property has increased, stayed the same or decreased?				
		C_2C circuit*	C_2C circuit & PSR eligible	C_2C circuit & non-PSR
		n=323	n=192	N=104
A) Frequency	Increased	3%	3%	2%
	Stayed the same	89%	92%	84%
	Decreased	8%	5%	14%
	Net % change**	**4%**	**3%**	**11%**
B) Duration	Increased	2%	2%	0%
	Stayed the same	93%	95%	94%
	Decreased	5%	3%	6%
	Net % change **	**3%**	**1%**	**6%**
C) Dips & spikes	Increased	3%	1%	4%
	Stayed the same	94%	96%	93%
	Decreased	3%	3%	3%
	Net % change **	**0%**	**2%**	**-1%**

* C_2C Trial circuits include both domestic and I&C customers
** Note that the net % change = (% decreased - % increased). % has been rounded.

The analysis in Chart 2.2.2c also confirms the perceived improvement in power quality by highlighting that fewer households on the C_2C Trial circuits claimed to have experienced a fault compared to control circuits. The same can be said for exposure to dips and spikes in customers' power supply. These findings support evidence suggesting that power quality is more favourable using the C_2C Method when compared directly to business as usual operating conditions.

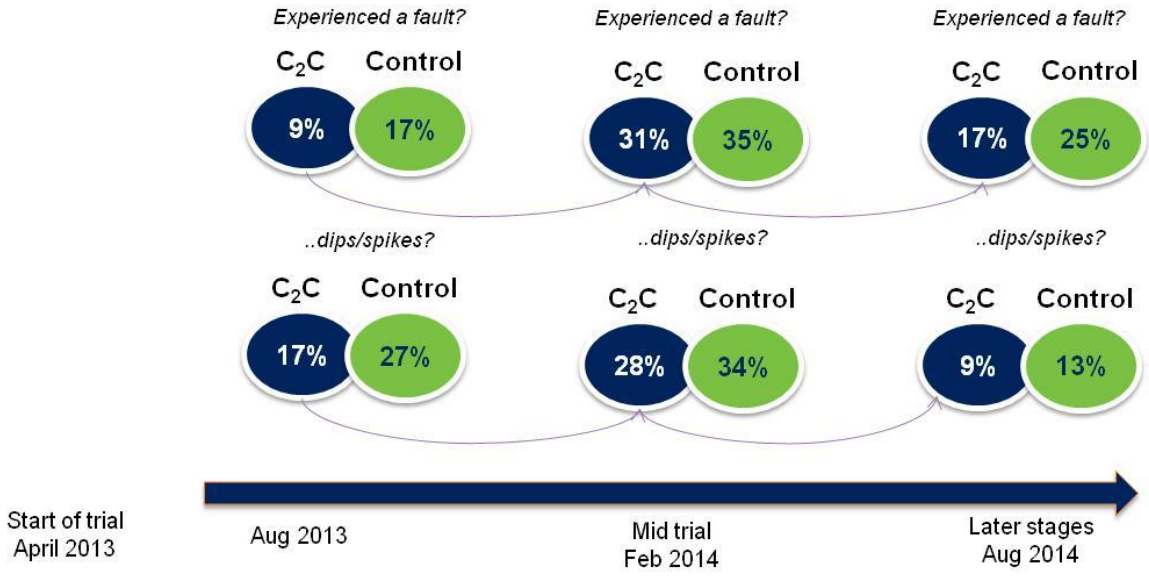
Chart 2.2.2c: Proportion of customers claiming to have experienced a fault and/or dips and spikes in their power supply since the start of the C_2C Trial



It is also interesting to note that a seasonal variation in the results was detected, with a peak in the number of customers detecting a fault and/or dips in spikes (since the start of the C_2C Trial) in the February 2014 (winter) phase of the customer engagement. Chart 2.2.2d illustrates the significant increase in detection of faults occurring for both C_2C Trial and control circuits during this particular phase. Movement in the level of fault detection and observations of dips and spikes follows the same pattern for C_2C and control circuits over the course of the C_2C Trial. The magnitude of the increase in detection of faults between the August 2013 and February 2014 phase was significant for both C_2C and control circuits, however, higher for C_2C circuits.

Chart 2.2.2d: Proportion of customers claiming to have experienced a fault and/or dips and spikes in their power supply in each phase of the research

Have you experienced a power cut at your property since April 2013?
Have you recently noticed any dips or spikes in your power from time to time?



This finding points to a seasonal influence in sensitivity towards power quality, which is likely to be linked to increased usage of everyday electrical appliances during the winter period such as lighting and heating. Increased usage of appliances is likely to increase the opportunity for customers to notice an adverse effect, should one occur.

Table 2.2.2e suggests some indicative differences (although not statistically significant) in the perception of the frequency of faults on C_2C Trial circuits by region, with the greatest improvement in perception linked to the aggregated Cumbria region. This region is mostly rural terrain with a greater concentration of overhead power lines and a relatively higher fault rate compared to Greater Manchester. It is apparent that customers in this region are relatively sensitive to changes in power quality and are more likely to find the C_2C Method discernible and a significant improvement compared to the status quo.

Table 2.2.2e: Power supply quality, frequency of faults by region

Since the beginning of April 2013, do you feel that the frequency of power cuts at the property has increased, stayed the same or decreased?							
		N/S Cumbria C_2C Trial circuits	N/S Cumbria control circuits	N/S Lancs C_2C Trial circuits	N/S Lancs control circuits	Manc/ Peak C_2C Trial circuits	Manc/ Peak control circuits
		n=33	n=54	n=186	n=53	n=102	n=178
A) Frequency	Net % change	10%	4%	5%	10%	1%	-4%

3.2.3. Duration of faults

As Table 2.2.1a referenced in a previous section, fewer customers noticed a change in the duration of faults than observed a change in the frequency of faults. This is naturally a reflection of relatively few customers experiencing a fault within the C_2C Trial period. However, where a difference had been felt, the net change in perception was positive for those on each of the C_2C Trial and control circuits (As supported by Table 2.2.3a). Essentially this means that a greater proportion of customers felt that the duration of faults experienced had decreased than increased compared to previous fault occasion(s).

Table 2.2.3a: Power supply quality, duration

Since the beginning of April 2013, do you feel that the duration (length) of power cut, has increased, stayed the same or decreased?			
		C_2C Circuit*	Control circuit
		n=323	n=285
B) Duration	Increased	2%	2%
	Stayed the same	93%	89%
	Decreased	5%	9%
	Net % change **	3%	7%

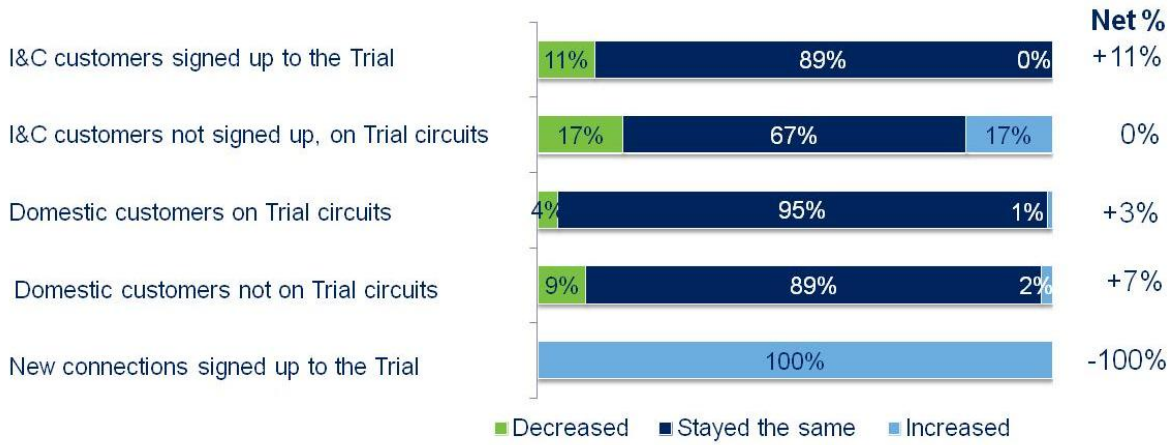
* C_2C Trial circuits include both domestic and I&C customers
** Note that the Net % change = (% decreased - % increased). % have been rounded

Analysis amongst the five customer groups (shown in Chart 2.2.3b) indicates that the net movement in perceived fault duration is either neutral or positive for all customer groups, except group five where one new managed connection customer felt that the duration of faults had increased during the C_2C Trial period. This is conceivable given the nature of the C_2C managed connection agreement meaning that in the event of a relevant power cut, supply could be reinstated up to eight hours after other customers had their power restored**.** It should also be noted that by virtue of being a new connection customer, there would be no

benchmark available for faults experienced at the site of the new connection prior to C_2C, only experiences related to other sites.

Illustration 2.2.3b: Perception of the duration of faults, by customer type

Do you feel the duration of power cuts has increased, decreased or stayed the same since April/start of C_2C?



The statistics in Table 2.2.3a suggest that customers on control circuits were more likely to have perceived a decrease in the fault durations experienced since the start of the C_2C Trial. Table 2.2.3c further analyses fault duration split by the three aggregated regions and reveals that this improvement in perception amongst control circuits was driven particularly by significantly higher ratings in the Lancashire region.

Table 2.2.3c: Power supply quality, duration of faults by region

Since the beginning of April 2013, do you feel that the level of dips and spikes in your supply, has increased, stayed the same or decreased?							
		N/S Cumbria C_2C Trial circuits	N/S Cumbria Control circuits	N/S Lancs C_2C Trial circuits	N/S Lancs control circuits	Manc/ Peak C_2C Trial circuits	Mancr/ Peak control circuits
		n=33	n=54	n=186	n=53	n=102	n=178
B) Duration	Net % change*	0%	+6%	+4%	+20%	-2%	+1%

*Note that the Net % change = (% decreased - % increased). % have been rounded

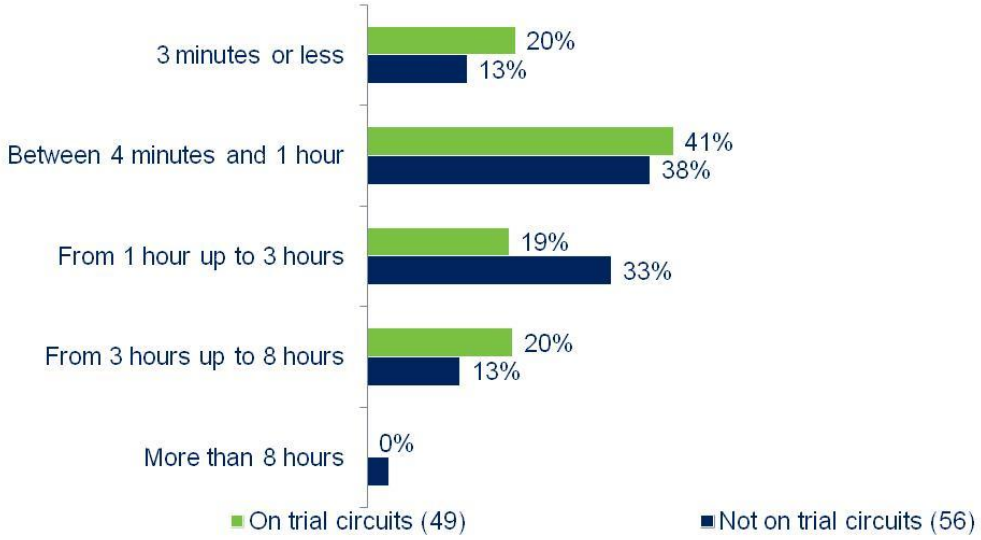
A holistic examination of changes in customer perception and the extent to which they are influenced by fault duration is achieved by exploring the actual fault duration, as recorded by network monitoring technology. This additional data is reported in section 2.6. However, at this stage of the analysis the primary concern is with customer recall of the duration of the last fault experienced, if at all.

The sample size of customers experiencing a fault during the C_2C Trial period was relatively small; hence the differences in the fault durations reported in Chart 2.2.3d are indicative of a trend of shorter fault durations on C_2C Trial circuits, albeit, not statistically significant. The trend is supported by a higher recall of SDI faults amongst customers on each of the C_2C Trial circuits and a higher concentration of faults lasting one to three hours (business as usual conditions) on control circuits. This outcome is in line with expectations of the C_2C Method as defined in section 1.3.

It is also important to recognise that in the context of power quality, dependant on the location of the faults on C_2C Trial circuits, not all customers experience an SDI as opposed to a longer interruption ie some customers still see longer interruptions if they are in the faulted area of the circuit. This goes some way to explain the polarised experience of one in five customers noticing a C_2C activated SDI and an equal proportion observing a fault lasting between three and eight hours.

Chart 2.2.3d: Duration of the last fault experienced, by customer type (aggregated)

Thinking about the most recent power cut/interruption you experienced, how long did it last?



3.2.4. Dips and spikes

Although the inclusion of dips and spikes as a measure of customers' perception of power quality is valid, it is typically a more challenging adverse effect for customers to quantify. The terminology dips and spikes was explained in the customer survey with a supplementary definition: *"By dips and spikes we mean lights flickering or dimming of lights, wavy lines on computer screen and equipment such as household appliances that trip out and possibly need resetting".* This definition made it apparent that the effect of dips and spikes may manifest themselves in the inefficiency or malfunction of common electrical appliances. An exploratory analysis of verbatim collected from customers who claimed to have noticed a dip or spike in their power supply confirmed this interpretation, such as:

"I have noticed during evenings that my lights flicker constantly. It is affecting my life a lot more and I have not had any information about why this is happening and if it is Electricity North West related or weather related."
Female, 45-54, North Lancashire, domestic C_2C Trial circuits

And also:

"I have noticed it takes longer to boil my kettle in the morning"
Male, 45-54, Manchester, domestic C_2C Trial circuits

Evidence presented earlier in Chart 2.2.2c suggests that when asked directly, customers on control circuits were significantly more likely to say that they had recently experienced dips or spikes in their power supply (26%) relative to those on each of the C_2C Trial circuits (19%).

In Electricity North West's other second tier LCN Fund Project, CLASS, a key learning from the baseline customer survey was that in the main, the biggest adverse effect experienced by customers, in business as usual circumstances, was their lighting appliances flickering,

dimming and/or brightening. This adverse effect was reported by approximately one in five customers; hence the absolute level of dips and spikes reported by customers surveyed in the proactive monitoring research is comparable.

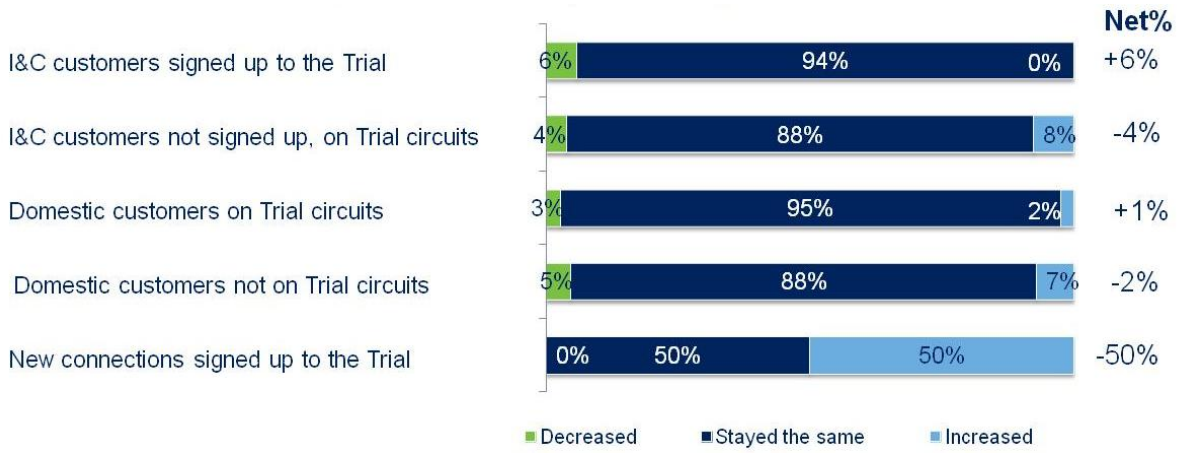
Interestingly, customers on each of the C_2C Trial circuits were as likely to feel changes in the volume of dips and spikes were as indiscernible as changes in the duration of faults, with an equal proportion claiming nothing had changed since the C_2C Trial began. Chart 2.2.4a supports this notion with significantly fewer customers in group three (domestic customers, C_2C Trial circuits) noticing a change in the levels of dips and spikes than customers in group four (domestic customers, control circuits).

The largest shift in perception, although not statistically significant, was amongst group one, where there was a 6% net improvement in power quality perception amongst I&C customers who had signed up to the C_2C Trial. This is another positive endorsement amongst I&C customers who had signed up to the Trial and were therefore typically more engaged in the C_2C Method and its benefits.

Similar to other power quality measures, ratings amongst I&C customers who had not signed up were less positive and indicative of the extra effort potentially required to engage more widely with these customers about power quality. That said, the effort applied to this activity should be counterbalanced by the limited volume of I&C customers that notice a discernible difference in their supply and are consequently satisfied with the service received. Future research could seek to explore I&C customers' power quality perceptions segmented by type of industry to establish more specifically where sensitivity exists to variances in power quality.

Chart 2.2.4a: Perception of the occurrence of dips and spikes, by customer type

Do you feel the number of dips and spikes has increased, decreased or stayed the same since April/start of C_2C?



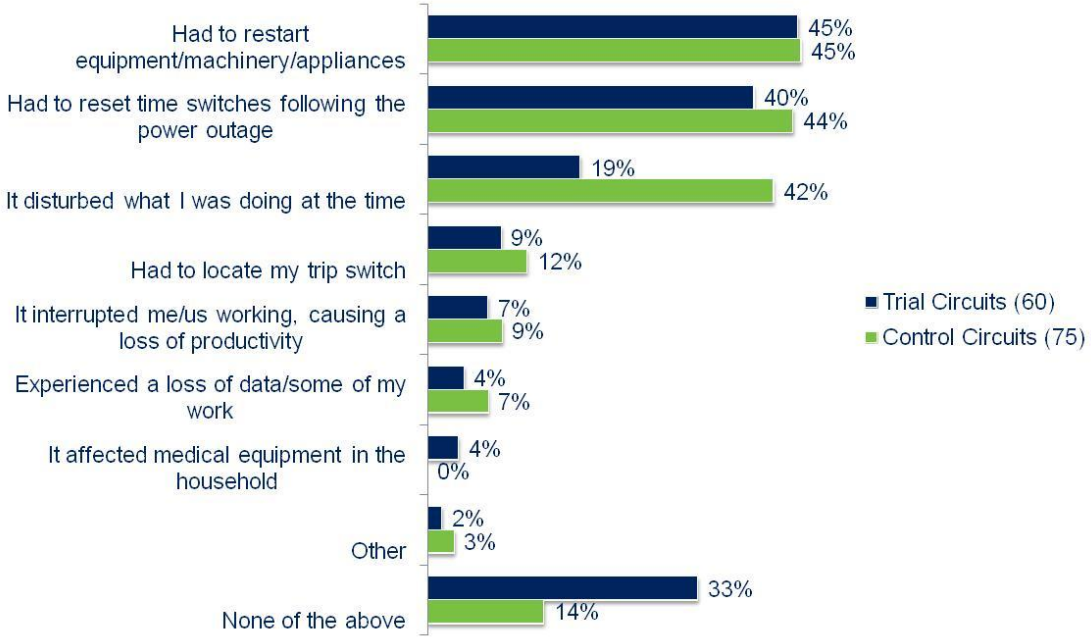
3.3. If any effects are noticed by customers, do they present a barrier to the rollout of the C_2C Method?

3.3.1. Potential barriers

Chart 2.3.1a indicates the type of effects that may be noticed by customers as the result of a fault occurring. As these effects represent problems for customers, they have the potential to be barriers to acceptance of the C_2C Method. Restarting equipment and resetting switches are top of the list of behaviour reported by customers. This is followed by simply being disturbed at what they were doing at the time, though this is notably higher on control circuits than on C_2C Trial circuits and reflects the higher proportion of SDIs among faults on C_2C Trial circuits (see section 2.6 for more discussion of actual SDI occurrence).

Chart 2.3.1.a: Acceptability of the last fault duration, proactive monitoring research

During the last power cut did you do any of the following?



Among those customers stating that they experienced some inconvenience, Table 2.3.1b indicates that there is a lower acceptance of faults.

Table 2.3.1b: Acceptability of power cut by effect of the power cut

	Acceptability of power cut (Ratings of 8, 9 and 10%)	Experienced on C_2C Trial circuits
None	41%	33%
Had to restart equipment/machinery/appliances	38%	45%
Had to reset time switches following the power outage	37%	40%
Had to locate my trip switch	32%	9%
It interrupted me/us working, causing a loss of productivity	29%	7%
It disturbed what I was doing at the time	21%	19%
Experienced a loss of data/some of my work	0%	4%

The baseline acceptance of faults was 41% (ratings of 8-10 on a 1-10 rating scale) where none of the effects listed in Table 2.3.1a had been experienced. The relative drop in acceptance for the two main effects experienced was very small. Significant drops in acceptability are only seen for the much fewer cases of major intrusion (loss of productivity, disturbed time and loss of data/work). Also, as indicated earlier in Chart 2.2.2c, fewer customers on C_2C Trial circuits recall experiencing a fault, and those that do recall a fault report negative effects slightly less than on control circuits. From this it may be concluded that negative experiences with the potential to act as barriers to acceptance of the C_2C Method are unlikely to have much impact in reality.

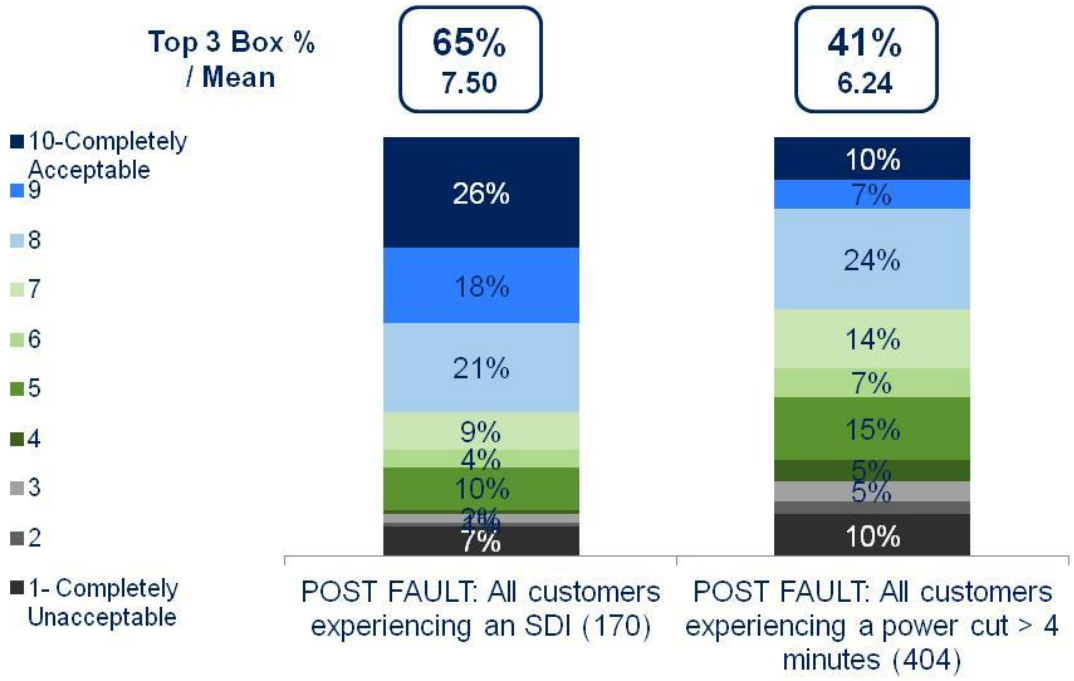
3.4. Where detected by customers, do SDIs enhance perception of power quality and supply reliability?

A separate reactive post-fault piece of research was conducted in parallel with the proactive monitoring research which surveyed customers in the days immediately after a C_2C fault had been experienced on C_2C Trial circuits. The key findings in this section are summarised from a standalone detailed report, the reactive post fault study and are valuable given the shared focus of both studies into the perception of power quality. The key difference between the two studies was the proactive nature of the monitoring research and its broad survey sample compared with the reactive, event-based and targeted sample of the post fault survey. The reactive post fault study consisted of a much larger, statistically robust sample of SDI and non-SDI fault durations.

Chart 2.4a has been extracted from the reactive post-fault key findings and is helpful in demonstrating that a fault lasting four or more minutes achieves an acceptability rating of 41% and an SDI achieves an uplift on this of 24% (65%), a statistically significant improvement with sufficient responses to ensure that the finding is credible. It is also encouraging to see that at the upper echelons of the rating scale, a quarter of customers said that an SDI was a 'completely acceptable' fault duration, significantly more than observed for longer fault durations.

Chart 2.4a: Acceptability of the last fault duration, reactive post-fault survey

To what extent did you find the length of this power cut/interruption acceptable?

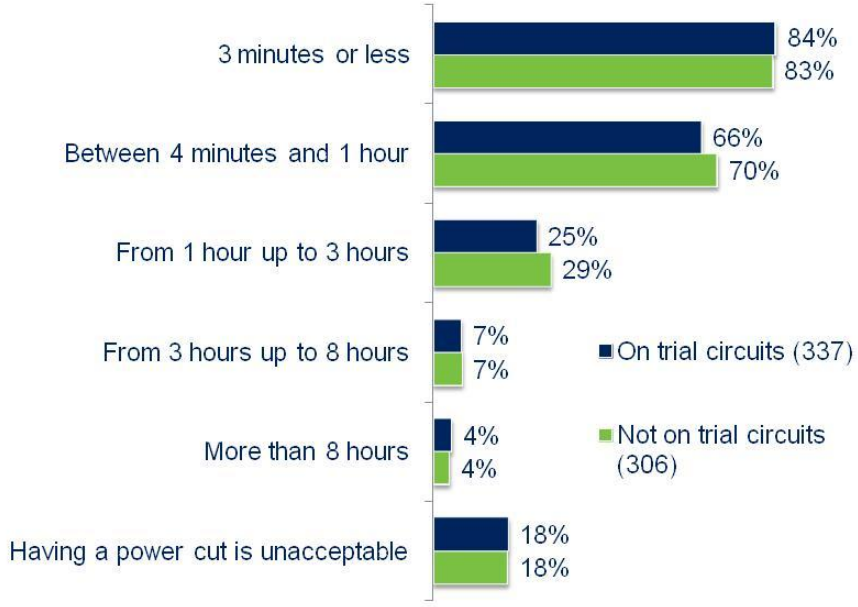


The proactive monitoring and reactive post-fault surveys differentiated between the influence of the last fault occasion on power quality perception and what would be an acceptable fault duration should another fault occur in the future. Analysis of this additional forward thinking question avoided making the assumption that previous customer acceptance was likely to extend to future faults. This was particularly relevant given that the frequency of faults is an important driver of power quality perception.

Chart 2.4b incorporates a complimentary, yet noteworthy finding from the proactive monitoring study and signposts that there is a significant fall in the acceptability of faults beyond SDI levels and also that acceptability falls to a very low level beyond a duration of one hour. Furthermore, approximately one in five customers feel that experiencing an additional fault in the future would be unacceptable.

Chart 2.4b: Acceptability of future fault durations

Assuming you experience another unplanned power cut in the future what would be an acceptable power cut duration?



Whilst there is evidence to support the hypothesis that SDI faults significantly increase the acceptability of the fault duration, the limited number of SDI faults that affected customers in the proactive monitoring customer survey population prevented this from significantly enhancing power quality perception amongst the general population at large.

The implication of this analysis is that the C_2C Method beholds an important benefit in improving or at least defending fault acceptability ratings through reduced fault durations. However, repeat faults are an acute risk to overall power quality perception now and in the future.

3.5. Priority services register (PSR)

Customer acceptance of smart grid technologies is a prerequisite to the C_2C Method being transitioned to business as usual operating conditions. This is not least why active customer participation was an integral part of the C_2C Project and will form an important part of the learning and development for future low carbon programmes.

Key learnings from LCN Fund C_2C Project: Engaged Customer Panel, highlighted the desire amongst customers to know about changes to their electricity supply (particularly if the message is positive), understand more about their DNO and what to do in the event of a power cut.

In the C_2C customer engagement plan (CEP) approved by Ofgem on 28 June 2012, Electricity North West committed to communicating with customers from the outset and providing a basic understanding of the Project objectives and the importance of the low carbon agenda. This was achieved through the publication of a customer leaflet, distributed to all customers on each of the C_2C Trial circuits. The leaflet made reference to the PSR, the extra support and services available to vulnerable customers and hints and tips for all customers on what to do in the event of a power cut.

The proactive monitoring survey included a question to establish if customers recalled receiving the C_2C leaflet through the post. 13% of all customers recalled receiving it; however, it is likely that in the later stages of research the ability of customers to accurately recall receipt declined significantly. Given the significant investment in developing, publishing and delivering the C_2C customer leaflet it would be prudent in future innovation projects to

administer a customer survey shortly after they have been delivered. The survey would assist in understanding if the communication strategy had been effective in influencing awareness of Electricity North West and the innovation project in question and also if it has any bearing on the perception of power supply quality.

The proactive monitoring survey also included a series of questions regarding the PSR. 5% of customers surveyed claimed that they were already registered on the PSR, a further 6% were eligible and aware that they could sign up to it if desired and 37% of eligible customers wanted to know more about how they could sign up to the PSR. These customers were contacted after the survey had been completed and told how they could sign up, an additional positive outcome of the research.

The key findings from the proactive monitoring customer survey suggest that vulnerable customers such as those eligible for the PSR are generally insensitive to the C_2C Method due to any effects of it on power supply quality being indiscernible. Despite this, it is still imperative for Electricity North West and other DNOs to invest more resources in raising awareness of the PSR in order to provide enhanced support and services to vulnerable customers, which is perceived as a positive form of customer engagement.

3.6. The use of network data for the C_2C Trial period to test reality vs customer perception

3.6.1. Introduction to the data

Electricity North West supplied network information in the form of a detailed fault history for the majority of customers that took part in each phase of the customer survey. This information could only be supplied where customers had given their prior explicit permission for Impact Research to share MPAN and unique identification data for this purpose.

Impact Research conducted analysis of faults that occurred between the C_2C Trial beginning (April 2013) and the month in which they took part in the customer survey. Re-interruptions, where an interruption happened very quickly after the first fault occurred, were not classed as an isolated fault for the purposes of this analysis. Where re-interruptions had occurred, the duration of the subsequent faults was added to the original fault duration to give a total duration for the fault.

The primary objective of this analysis was to establish if there was a correlation between customer perception of power quality events and reality.

The use of network data has the benefit of grounding the research in the reality of what is recognised to be true of the electricity circuits in question, although it should be seen as an enhancement to the data, rather than any form of detraction, given that the perception of customers is a valuable insight regardless of its absolute foundation in truth.

In addition to the data weighting methodology clarified in section 4.7, a further weighting was applied to the technical network data that reflected the incidence of the electricity feeders serving the customers who were part of the survey population. The proportion of interviews conducted amongst customers on each of the feeders and the volume of customers fed by each feeder in reality, as a proportion of the total population of all the feeders represented in the survey, were important in constructing the additional weighting. By looking at the data in this way, Impact Research was able to give customers who are served by an electricity feeder covering a wider customer base, a higher level of influence than those who are served by feeders covering a much smaller area. The results produced from this weighting technique were very similar to the original demographic and socio-economic weighting method, giving the results further credibility. This means that confidence can be upheld in any differences in customer perception between those on C_2C and control circuits being genuine, as opposed to results being skewed by any sort of methodological process.

Whilst the analysis of network data that follows in section 2.6.2 supports the hypothesis "*The C_2C Method will improve power quality resulting from stronger electrical networks*" it is

important to place this into the context of the likely impact on the general population of customers served by the electricity circuits in question. The proactive monitoring report and analysis therein has been borne out of a representative survey of the general population, a relatively small proportion of which had experienced an issue with the constancy of their electricity supply within the C_2C Trial period. Given the generally stable nature of customers' electricity supplies, it is unsurprising that the vast majority find changes to power quality indiscernible. This neutrality is positive in the sense that customers do not perceive any adverse effect to an already high level of constancy of supply.

3.6.2. Fault detection

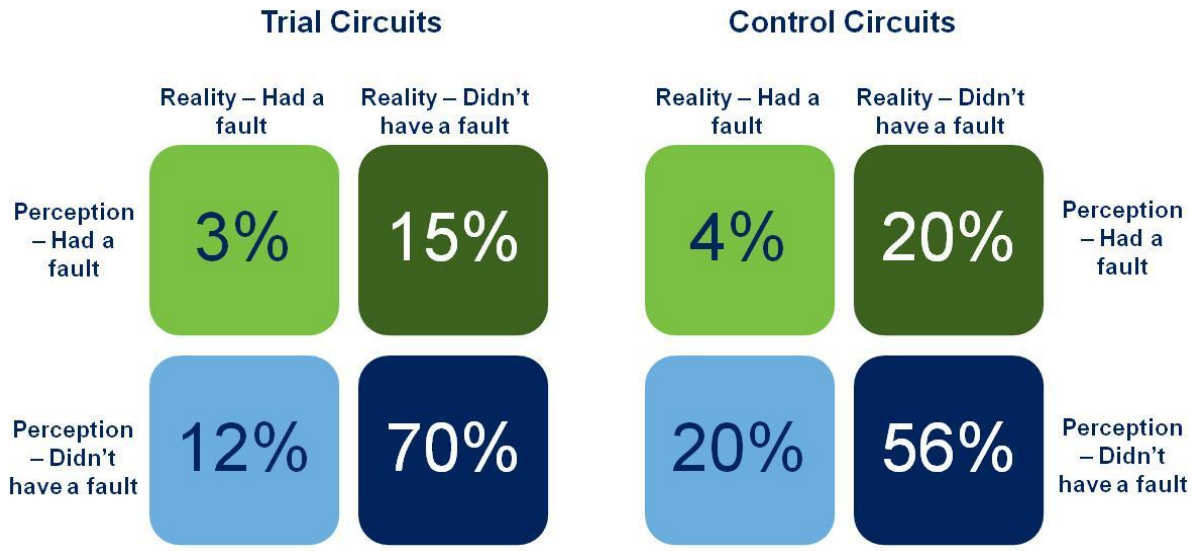
Technical data presented in Table 2.6.2a supports the notion that fewer domestic customers on C_2C Trial circuits experienced a fault (14%) when compared to domestic customers on control circuits (24%) since the C_2C Trial commenced. From this information it can be concluded that the absolute level of fault detection amongst customers is broadly in line with the reality. However, what this does not reveal is whether customers detecting faults did so accurately, or if there is a degree of misattribution occurring.

Table 2.6.2a: Perception of fault occurrence vs reality

	Perception % customers affected by one or more fault	Reality % customers affected by one or more fault
1. I&C customers who have signed up to the Trial (n=17)	24%	6%
2. I&C customers who have not signed up to the Trial but are on Trial circuits (n=29)	21%	17%
3. Domestic customers who are on Trial circuits (n=289)	17%	14%
4. Domestic customers who are on control circuits (n=295)	24%	24%
5. New connections who have signed up to the Trial (n=2)	100%	0%

Analysis presented in Chart 2.6.2b indicates that the majority of customers, be it those on C_2C Trial circuits or control circuits, correctly recalled that they had not experienced a fault since the C_2C Trial commenced. Accurate recall of confirmed faults was similar for customers on C_2C Trial circuits (3%) and control circuits (4%). However, there were significantly more customers on control circuits misattributing observations of faults (40%) compared to those on C_2C Trial circuits (27%). That is, there was a relatively high number of participants recalling a fault when there was not one and vice versa. This higher level of misattribution amongst the control group may be linked to a significantly higher claimed incidence of dips and spikes, with the potential for some confusion as to whether these incidents were indeed a fault or not.

Chart 2.6.2b: Perception of fault occurrence vs reality



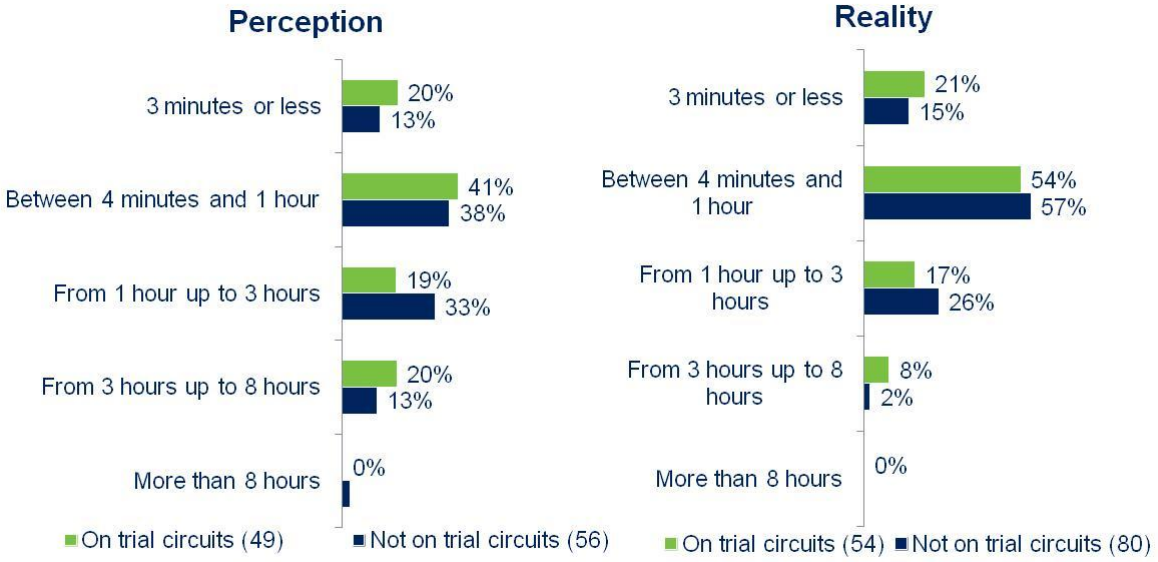
Notwithstanding the level of fault misattribution, another analysis route taken was to understand whether there was a correlation between customers who were recognised to have had the opportunity to detect a real fault and their power quality perception.

3.6.3. Fault duration detection

At the outset of the Project it was anticipated that faults under C_2C conditions would be generally shorter in duration than on control circuits. The reality, as demonstrated in Chart 2.6.3a, is that there was a greater incidence of SDI faults on C_2C Trial circuits compared to control circuits, validating the assertion that fault durations could decrease for some customers. In reality the differences between fault durations for customers on C_2C Trial and control circuits may not be statistically significant; however, they do provide an indication of a positive trend emerging.

The analysis in Chart 2.6.3a also supports the current Electricity North West standard of restoring approximately 90% of faults in one to three hours and demonstrates that this would not be threatened by the implementation of the C_2C Method.

Chart 2.6.3a: Perception of fault duration vs reality



However, despite the reality of there being a greater concentration of SDI faults on each of the C_2C Trial circuits, there were also a higher proportion of customers suffering prolonged interruptions to their supply, with 8% experiencing a fault lasting from three to eight hours (vs 2% on control circuits). This serves to polarise the experience of some customers on each of the C_2C Trial circuits and detract from the improved service other customers have experienced from being exposed to an SDI. It also goes someway in explaining why the average duration of faults on C_2C Trial circuits was 45 minutes and 43 minutes on control circuits.

It is also notable that customers' perception of fault duration is generally longer than the reality; for instance there are significantly more customers claiming they experienced a power cut lasting three to eight hours than is actually the case. This could be a function of the proactive monitoring survey being conducted too long after the event for perception to always be accurate and indeed some customers over-estimating the duration of the fault.

An important development in the integration of technical network data was the ability to discriminate between faults that had occurred on each of the C_2C Trial circuits that were specifically activated under C_2C conditions and those that were not. C_2C is only activated on faults that cause the circuit breaker at the primary to trip which may include transformer faults.

Across the three phases of research, 52% of faults that the survey population on C_2C Trial circuits were exposed to were C_2C activated faults. By looking at the C_2C activated faults in isolation, it was established that the average fault duration of C_2C activated faults on Trial circuits was 33 minutes compared to 53 minutes for non- C_2C activated faults. This supplementary information is further credible evidence that faults that are activated by C_2C conditions are genuinely shorter in duration than those on control circuits.

Faults are currently one of the main drivers for a customer to engage with a DNO like Electricity North West and their fault experience is therefore a key determinant of their overall satisfaction with their electricity supply. The implication of this is that any attempt to improve the experience of customers experiencing a fault by reducing the fault duration is likely to have a significant impact on the acceptability of the fault occurring for those customers. This in turn could have a broader benefit for DNOs; for instance a higher proliferation of SDI faults may prevent customers contacting Electricity North West when incidents occur and relieve the pressure placed on the contact centre. An improved perception of fault management also has the potential to reflect itself in Electricity North West's standing in the Interruption Incentive Scheme (IIS) introduced by Ofgem.

In summary, although there is only likely to be a relatively small proportion of the general population served by C_2C circuits being exposed to a fault; and fewer still experiencing a C_2C activated fault, there is sufficient evidence to suggest that C_2C conditions do improve power quality for those directly exposed to C_2C conditions, paving the way for C_2C to be rolled out as business as usual.

4. LESSONS LEARNED FOR FUTURE INNOVATION PROJECTS

This section of the report seeks to disseminate the lessons learned from conducting the proactive monitoring research. The lessons learned are specifically focused on describing how Electricity North West and other stakeholders can utilise the learning from any challenges encountered in carrying out the customer engagement or indeed the implications of the key findings for future work in the area of power supply quality. The lessons are as follows:

The frequency of faults is the most discernible power quality metric to customers

Customers are more likely to find changes in the frequency of faults easier to detect and quantify, which intrinsically means that the metric has a higher weighting on perception of power quality.

The perception of an improved service is likely to be exacerbated in rural regions such as Cumbria where there is typically a higher fault rate and variation in the levels of tolerance and/or expectations that are attached to fault experiences.

The importance of this metric also increases in the event of a customer experiencing a fault, whereby the acceptability of subsequent fault duration is influenced by the number of previous faults detected. This serves to highlight the importance of DNOs being sensitive to the fault rate of circuits and any change in operating conditions that would deem it more likely customers are affected by faults that are discernible to them.

Extracting, matching and overlaying fault data onto customer perception information provides considerable insight into the drivers of power supply quality

Depending on the software used to hold customer data and the capability and resources available for data manipulation, considerable effort may be required to match any survey participants and their feedback to technical (network) data. This exercise involves carefully cross-examining what, if anything, the customer has detected against actual faults that have occurred on the electricity feeder they are served by and the duration of those fault(s) should they fall within the time period of interest.

Substantial learning has been gained from completing this exercise such as: the ability to validate the hypothesis that the C_2C Method decreases the average fault duration and improves power quality for those directly exposed to C_2C conditions. Without differentiating between C_2C activated faults and other faults on C_2C Trial circuits, it would not have been possible to support the hypothesis with such confidence.

Nor would it have been possible to understand the extent to which customers actually find fault occasions discernible. Significantly more customers on control circuits failed to correctly identify the existence (or not) of a fault during the C_2C Trial period. There may be some correlation here with the significantly higher (perceived) observation of dips and spikes on control circuits, with the possibility that some customers confuse dips and spikes as being supply interruptions.

It is important to survey a robust sample of I&C customers segmented by industry

The proactive monitoring survey methodology was predominantly focused on achieving a robust and representative sample of domestic customers on C_2C Trial circuits and control circuits. To supplement this, the views of a relatively small number of I&C customers were captured, mainly as a means of having a point of comparison for the ten I&C customers who had signed up to the C_2C Trial.

While the sampling frame was in proportion to the actual customer profile of the Electricity North West network, it did not enable statistically robust results to be drawn from the I&C customer surveys (*particularly non trialists*). In the case of I&C C_2C trialists, the data collected represented a large proportion of a small universe, meaning the results were representative, despite being drawn from a relative small sample. However, the benchmark created of ten surveys in each phase of the research amongst I&C non-C_2C trialists represented a small population of a larger universe and constrained the analysis that could be undertaken.

A sample of approximately 50 I&C customers surveyed in each phase of the research would have provided greater opportunity for statistical analysis; for instance, the ability to understand sensitivity to changes in power quality by I&C industry sectors, such as manufacturing.

It is also worth noting that the addition of an I&C benchmark of customers on control circuits would have enhanced the significance of the findings that can be drawn from changes in power quality perception on C_2C Trial circuits amongst I&C customers.

It would be a worthwhile exercise to use customer engagement as a means of evaluating the effectiveness of future innovation project awareness campaigns

The proactive monitoring survey helped to identify a significant number of customers (approximately two fifths) that are eligible for the PSR and wish to know more about how they can sign up to the PSR. In light of the significant investment required in developing, publishing and delivering the C_2C customer leaflet before the Trial began, which included information about the PSR, it would be prudent in future innovation projects to administer a customer survey shortly after delivery of the customer leaflet.

The customer survey would seek to enhance understanding of whether the communication strategy employed has been effective in influencing awareness of the DNO, PSR and innovation project in question, and also if it has had any positive bearing on perception of power supply quality. The implication of this would be the ability to use customer feedback to refine future customer communication strategies and increase the return on investment made by DNOs.

5. RESEARCH METHODOLOGY

5.1. Introduction

This section of the report provides supplementary information on the customer engagement methodology used to test the hypothesis:

"The C_2C Method will improve power quality resulting from stronger electrical networks."

A quantitative research method was used to evaluate the hypothesis.

5.2. Quantitative research

In order to demonstrate the viability of scaling up the C_2C Method for use across Great Britain, a quantitative research approach was proposed in order to prove the concept. Customer engagement has provided sufficient evidence, within an accepted statistical margin of error, that the C_2C Method will have no adverse effect on customers' perceptions of power quality, and in fact serve to improve perception.

Sufficient evidence has been provided through a large and statistically robust sample of research participants who took part in customer surveys over the course of the C_2C Trial. The survey collected information regarding observations survey participants had made, if any, regarding changes in the quality of their power supply since the Trial began.

Computer aided telephone interviews (CATI) offered a good compromise between value for money, being able to reach a representative survey sample and relatively high rates of participation. CATI was therefore the methodology used for the proactive monitoring surveys.

5.3. Defining customer impact

It was envisaged from the outset of the Project that there would be no discernible impact on the reliability of customers' electricity supply as a result of the C_2C Method.

For the purposes of this study, customer impact was defined as, but not limited to, the following three key measures:

- Frequency of faults occurring over the 12 month period prior to being surveyed and more specifically since the C_2C Trial began
- The total duration of any faults that had been experienced
- Any observation of dips and spikes, including lights flickering or dimming, wavy lines on computer screen and equipment such as household appliances that trip out and possibly need resetting.

The first two measures are traditionally used by DNOs to measure the reliability and security of customers' electricity supply. The third measure was also considered to be important given that it acknowledges that perceptions of power quality could go beyond customers experiencing a fault and includes observations linked to the efficiency of everyday appliances such as lighting.

The survey also included a series of questions that measured the extent to which customers' perceptions of power quality were influenced by observations they had made before the C_2C Trial began. When surveyed, participants compared their current experience of the service provided by Electricity North West with that of the pre-Trial time period in order to establish any changes in service. Provision was also made for participants to not answer (skip) specific questions that required them to have a frame of reference; particularly if they had not been residing or working in their property for more than 12 months.

Customer perception of power quality was also cross-referenced with actual fault data to understand if there was a correlation between the two data sources. Overlaying technical information onto customer perception data was supported in the peer review conducted by Ken Willis:

"It is useful to compared actual 'revealed' events with 'stated perceptions' of events. The two often differ, as various studies have shown (see for example Slovic et al, 1980)."

In the analysis stage if customers claimed to have noticed a change in the quality of their electricity supply relative to the status quo (the 12 month period prior to the C_2C Trial), the impact was defined as either an improvement (decrease) in the incidence of adverse effects (faults, fault duration and/or dips and spikes) or deterioration (increase in incidence). Survey participants were then given the opportunity to elaborate as to why they felt they had noticed a change in power quality and to indicate the extent to which this had personally affected their household or business, if at all.

5.4. Customer sample frame

5.4.1. Customer type

In order to understand if customers' perceptions of power quality had changed as a result of the C_2C Method, Impact Research engaged with a group of customers who were on C_2C Trial circuits (test) and a group that were not on Trial circuits (control). There were five groups of customers that were of particular interest:

- Existing I&C customers who *had* signed a C_2C commercial agreement
- Existing I&C customers who had not signed a C_2C commercial agreement but whose premises were on a C_2C Trial circuit
- Domestic customers who were residing at a property on a C_2C Trial circuit
- Domestic customers who were not residing at a property on a C_2C Trial circuit
- New I&C customers who had signed a C_2C commercial agreement.

Existing customers were defined as households or businesses with an existing connection to the electricity network ie they had a MPAN.

New I&C customers were defined as businesses that originally did not have an MPAN for their commercial premises and accepted a C_2C quotation for a new connection to the electricity network, specifically on a C_2C Trial circuit. Customers were able to accept a C_2C quotation for a new connection at any stage during the Trial, with many doing so in reality during the later stages of the Trial. It was important to incorporate these customers into the customer engagement to test how discernible changes in power quality were after the C_2C commercial agreement had been signed and how acceptable these changes, if any, were in light of that agreement.

Groups two, three and four included a unique sample of survey participants in each phase of the research. All of the customers in groups two and three would have at least had the opportunity to become aware of C_2C through the customer leaflet delivered to all premises on each of the C_2C Trial circuits before the Trial began. Conversely groups one and five consisted of predominantly the same survey participants each time given that there was a finite population of customers that had signed a C_2C commercial agreement from which surveys can be administered. As additional customers signed a C_2C commercial agreement they were added to the list of customers to contact in the next phase of the customer engagement.

5.4.2. Survey targets

Based on their experience of conducting similar pieces of customer engagement, Impact Research established a target for the number of customer surveys to be completed in each of the groups and phases of customer engagement. The target for groups one and five (I&C customers signing a C_2C agreement) were dependent upon Electricity North West achieving their target of signing up ten existing and ten new connections customers to the C_2C Trial. The contact details for these customers were provided to Impact Research as and when the agreements had been signed. A nominal target of ten surveys per phase was also set for group two to provide a benchmark with which to compare the results from group one.

The target set on the number of customer surveys to be completed in groups three and four (domestic customers) was 200 in total in each phase of the research, split equally amongst the two groups. In order to set an appropriate target Impact Research considered the composition of Electricity North West's customer base. Table 4.3a represents the volume of domestic and I&C MPANs across the entire Electricity North West operating region. Profile 01 and 02 are domestic customers and the remaining profiles are I&C. This information source suggests that 92% of Electricity North West's customer base comprises domestic customers. It was therefore appropriate for the majority of surveys in the proactive monitoring research to be amongst domestic customers and for one of the key comparisons to be between groups three and four.

Table 4.3a: Electricity North West MPAN count by profile class

Latest Total MPAN Count			
	Profile	**MPAN Count**	**Total**
All Suppliers	Profile 01 Dom UR	1,981,187	
	Profile 02 Dom Two Rate	199,193	
	Profile 03 Non Dom UR	121,314	
	Profile 04 Non Dom Two Rate	35,957	
	Profile 05 LF 0-20	3,120	
	Profile 06 LF 20-30	3,716	
	Profile 07 LF 30-40	2,027	
	Profile 08 LF 40+	3,190	
	Profile 00 HH	9,245	
	TOTAL		**2,358,949**

5.4.3. Sampling methodology

In order to construct a sampling frame for groups two to four, Impact Research used a tried and tested sampling technique called probability sampling. Probability sampling is a technique wherein the samples are gathered in a process that gives all the individuals in the target population equal chances of being selected. Randomization was applied to the samples to ensure that there was no systematic order bias as to who was contacted and in

what order. Through applying probability sampling, random selection and contacting customers across a range of daytime and evening shifts the survey sample was more likely to be representative of the general population.

Survey participants in groups two and three were randomly selected from a C_2C Trial circuit master database, while group four was randomly selected using the same technique from a control circuit database supplied by Electricity North West. The approach taken to selecting customers to take part in the survey ensured that there was no bias towards customers that had ever contacted Electricity North West in the past.

Care was also taken to ensure that the survey results from group four, the control group of domestic customers not on C_2C Trial circuits, could be directly compared to those in group three, the test group of domestic customers on C_2C Trial circuits. To facilitate a fair comparison between the groups the following attributes were taken into account when selecting the non-Trial circuits to ensure the groups were as homogeneous as possible:

- Fault history of the circuits
- Proportion of domestic vs commercial customers
- Planned minor or major maintenance on selected circuits
- Location eg urban, suburban, rural.

5.5. Screening criteria

The primary objective of the survey methodology developed by Impact Research and peer reviewed by Ken Willis was to elicit customers' perceptions of their power quality. Therefore, in the case of domestic customers it was not necessary to survey the electricity bill payer of the household. This approach runs contrary to common practice in market research studies which generally aim to sample customers with decision-making responsibility. The screening criteria used to recruit participants to take part in the domestic customer survey ensured that respondents were at least a permanent member of their household.

The same screening approach was used to recruit I&C customers to take part in the customer engagement. Many of these I&C customers were small to medium-sized businesses, where in fact the person most likely to be affected by changes in power quality was also the individual paying the electricity bill. However, for larger I&C establishments employing greater numbers of workers, it was more important to survey the most appropriate person affected by electricity supply considerations. Previous learnings from the C_2C programme of customer engagement had demonstrated that the likely job titles of customers within the target sample frame would be:

- Facilities manager
- Production (operations) manager
- Property manager
- Managing director/CEO
- Office manager or administrator.

This screening approach has since been used successfully in Electricity North West's other second tier LCN Fund Project, Customer Load Active System Services (CLASS) whereby 200 I&C customers were recruited to take part in a series of customer surveys.

5.6. Customer survey

The final version of the customer survey used for all of the analysis groups referenced in this report can be found in Appendix A. It should also be noted that a peer review was conducted of the customer survey methodology itself which made references to the questionnaire and this review can also be found in Appendix B.

In practise the customer survey was completed, on average, in approximately 15 minutes. This was a sufficient duration in which key power quality metrics could be explored, while

also mitigating the risk of a decrease in response rates due to excessive questionnaire length. To support the research hypothesis, the most important power quality metrics included in the survey were as follows:

- The number of faults experienced in the 12 months prior to taking part in the survey and since the C_2C Trial began
- The duration of the most recent fault, if the customer had experienced one in the 12 months prior to taking part in the survey and/or since the C_2C Trial began
- Observations of any dips and spikes in the customer's power supply in the 12 months prior to taking part in the survey and/or since the C_2C Trial began.

A series of classification questions were also asked in the survey as a means of ensuring a statistically robust and representative sample had been achieved by virtue of surveying a broad demographic of customers, atypical of the general customer base. These classification questions included, but were not limited to, gender, age and household composition.

5.7. Survey completion

Impact Research contacted customers across all the sample groups on three separate occasions, strategically timed to be at set intervals throughout the original 18 month C_2C Trial period (Phase one, August 2013, Phase two, February 2014 and Phase three, August 2014). This phased approach enabled the power quality results to be monitored from one season to the next, the benefit of which was the understanding of whether perception of power quality changed as the C_2C Trial period elapsed.

Table 4.7a indicates the target volume of survey responses and how many surveys were actually completed in each phase of the research:

Table 4.7a: Volume of surveys completed vs. targets set

	Phase 1 target	Phase 1 achieved	Phase 2 target	Phase 2 achieved	Phase 3 target	Phase 3 achieved	Total achieved
Group 1	10	2	10	6	10	8	16
Group 2	10	10	10	10	10	10	30
Group 3	100	100	100	100	100	111	311
Group 4	100	100	100	100	100	102	302
Group 5	10	0	10	1	10	1	2
Total	230	212	230	217	230	232	661

The total volume of surveys completed amongst group one mean that the results contained within this report are a fair representation of the ten customers that signed a C_2C commercial agreement. The survey completion targets for groups two to four were achieved, ensuring a robust survey population. However, the quantity of surveys Impact Research was able to complete with group five was constrained to the one and only new I&C customer who had signed a C_2C commercial agreement within the time period that the three phases of customer engagement were carried out. The implication of this is that there are limited key learnings specifically related to group five.

To minimise any risk of difference in customer perception of power quality being linked to variations in the profile of customers surveyed, the survey data was weighted. A weight is a value assigned to each customer interviewed, which indicates how much each customer will count in a statistical procedure eg if a customer has a weight of two, then their answers have twice the influence in the dataset. This enables the statistics calculated to be more

representative of a population or in this instance enables the data in the two groups to be directly comparable.

The weights applied to the customer survey data ensure the profiles of domestic customer groups three and four are similar based on:

- Gender
- Age
- Social grade (based on occupation and job role)
- Household size.

An acceptable range of variation between two samples in which they can still be considered to be similar is approximately five percent. Table 4.7b below indicates that the weighted profile of customers in groups three and four conforms to this standard in all cases.

Table 4.7b: the weighted survey profile of customers on C_2C Trial circuits compared to customers not on C_2C Trial circuits

	Trial circuits *(337)*		Control circuits *(306)*	
	Unweighted	Weighted	Unweighted	Weighted
Male	42%	40%	41%	38%
Female	58%	60%	59%	62%
18-34	5%	4%	5%	3%
35-54	20%	23%	23%	24%
55+	75%	73%	72%	73%
AB	5%	6%	12%	11%
C1C2	24%	28%	26%	30%
DE	71%	65%	61%	59%
Just me in HH	35%	37%	36%	38%
2 people in HH	43%	42%	44%	44%
3+ people in HH	21%	21%	19%	18%
PSR Household	65%	65%	54%	53%

5.8. Use of technical network data

Following the completion of each phase of the customer surveys and where prior consent had been explicitly given, Impact Research shared the details of customers who had taken part in the proactive monitoring survey with Electricity North West. This included the customers MPAN, a unique identifier.

Electricity North West subsequently appended real fault data to the customer survey perception data collected at an individual customer level. Impact Research was then able to compare the technical fault data with customers' perceptions of their power supply quality and explore the correlation, if any, between the two.

Prior to embarking on this analysis Impact Research had supposed that if there were inconsistencies between perceptions and reality, it would be of equal interest to a scenario where there is a strong correlation between perception and reality. For example, if a customer claimed to have not experienced any faults, but technical data shows that they had experienced a fault; it could indicate that faults of a certain duration (that occur at a certain time of day) are more likely to be indiscernible to customers. This was an important consideration given the expected increase in SDIs on C_2C Trial circuits.

5.9. Peer review

5.9.1. The objective of the peer review

A peer review was carried to consider the suitability of the proactive monitoring research methodology proposed by Impact Research and its ability to provide robust quantitative research that would assist in answering the C_2C hypothesis. The peer review was also intended to maintain standards of quality, improve performance and provide enhanced credibility.

The peer review was undertaken by Professor Ken Willis. Ken Willis is Emeritus Professor of Environmental Economics at Newcastle University. His research concentrates on environmental valuation (using stated preference, and revealed preference travel-cost and hedonic price models) and cost-benefit analysis; covering biodiversity, cultural heritage, energy, forests, landscape, quarries, recreation, transport, waste disposal and water quality and supply.

5.9.2. Executive summary of the peer review

The narrative within this section is an executive summary of the peer review submitted by Professor Ken Willis. The full report, which includes the executive summary contained therein, is included in Appendix B.

The proactive monitoring research methodology summarises the measurement of customers' perceptions of power quality/reliability (fault frequency, duration, dips and spikes) for those customers on each of the C_2C Trial circuits, compared to the perceptions of those domestic customers who are not on C_2C Trial circuits.

The research methodology outlined by Impact Research is an admirable and precise examination of the effect of C_2C on customer perceptions.

The sample size in the I&C groups are small, and may limit any segmentation of data in the analysis. The sample size for domestic customers allows for a more representative sample of customers.

The proposed analysis of the data is realistic. Accurate, reliable and robust estimates of domestic customers' perceptions of their power quality/reliability (fault frequency, duration, dips and spikes) throughout the C_2C Trial period, compared to perceptions of domestic customers not on C_2C Trial circuits, should be achieved.

Any regional and vulnerability analysis needs to standardise for the socio-economic composition of domestic customers across regions and between vulnerable and non-vulnerable customers. Otherwise regional variation and vulnerability may be confounded by other variables.

6. CONCLUSION

The proactive monitoring survey provided an essential forum to gain constructive and independent feedback from customers on the perception of their power supply quality during the C_2C Trial.

The use of technical network data to illustrate the fault history of C_2C Trial and control circuits was an invaluable insight into genuine changes in power quality, the extent to which these changes manifested themselves in customers' perception and as a means of validating the hypothesis that, "*The C_2C Method will improve power quality resulting from stronger electrical networks.*"

This report summarises the key findings of the proactive customer engagement carried out with a representative sample of customers across three phases of quantitative research.

7. NEXT STEPS

There will be ongoing learning and dissemination as the C_2C Project is closed down and the key learnings will be reviewed to reflect customer feedback across the various customer engagement activities, of which the proactive monitoring research is just one.

In line with the vision of the LCN Fund, all outputs and learning gained from customer engagement activities will be made available to other DNOs. Specifically, all communication materials, research materials and key findings developed in the Project are publicised on the C_2C website. All relevant learning will be shared at C_2C learning events, through trade magazines and in other appropriate forums.

8. APPENDICES

8.1. Appendix A: Survey instrument

Monitoring Questionnaire

11th June

Capacity to Customers

Introduction (Phone Interview)

Type of customer fieldwork in August 2013, February 2014 and August 2014	
• I&C customers who have signed up to the Trial	3 dips x 10 customers
• I&C customers who have not signed up to the Trial but are on Trial circuits	3 dips x 10 customers
• Domestic customers who are on Trial circuits • Domestic customers who are not on Trial circuits • New connections who have signed up to the Trial	3 dips x 100 customers 3 dips x 100 customers 3 dips x 10 customers

INTERVIEWER TO CODE THE FOLLOWING DETAILS FROM THE SAMPLE PROVIDED:

- WAVE NUMBER 1 (AUGUST 2013), 2 (FEBRUARY 2014) or 3 (AUGUST 2014)
- CUSTOMER NUMBER: SEE TABLE ABOVE
- CUSTOMER TYPE: DOMESTIC OR COMMERCIAL
- CONNECTION TYPE: EXISTING (CUSTOMER TYPE 1-4) OR NEW (CUSTOMER TYPE 5)
- CUSTOMER NAME
- CUSTOMER ADDRESS
- CUSTOMER TELEPHONE NUMBER

INTERVIEWER PROMPT FOR DOMESTIC CUSTOMERS:

Good morning/afternoon/evening. My name is ..... from Feedback Research

INTERVIEWER PROMPT FOR COMMERCIAL CUSTOMERS:

Please can I speak to “whoever is responsible for matters relating to your electricity supply”?

INTERVIEWER INFORMATION: Note that the job titles and/or responsibilities of our commercial customers could cover, but not be limited to the following: Electricity Management, Operations/Maintenance/Site Manager, Facilities Manager, and Procurement.

INTERVIEWER READ OUT TO ALL CUSTOMERS:

We are carrying out a market research study on behalf of Electricity North West, your regional electricity distributor.

Your feedback is really important to us. This survey should take approximately **5-10 minutes** to complete.

INTERVIEWER READ OUT TO COMMERCIAL CUSTOMERS (CUSTOMER TYPE 1, 2 AND 5)

As a thank you for your participation you will have the choice of a £20 e-giftcard or a £20 charity donation.

Unprompted Awareness

INTERVIEWER READ OUT:

It's Electricity North West's job to deliver a safe, reliable supply of electricity from the national grid to your property through their network of overhead lines, underground cables and substations. Most of the time they provide you with a continuous and reliable electricity supply. But occasionally an unforeseen fault might cause a power cut to your home or business.

ASK CUSTOMER TYPE 1-4
SINGLE CODE

Q1: In the last **year**, **how many** power cuts have you experienced at your property?
Note; by this we mean how many **unplanned** power cuts have been experienced at the property in total in the last 12 calendar months. (These power cuts are not planned, I.e. customers are not notified in advance)

One	1
Two	2
Three	3
Four	4
Five or more	5
Don't know	6
None	7 GO TO Q5

ASK IF CUSTOMER TYPE 1-4 AND Q1 ≠ CODE 6
SINGLE CODE

Q3: How does the total number of power cuts you have experienced in the last year compare to **previous years**?

Note; by this we mean **unplanned** power cuts

More than in previous years	1
Similar to previous years	2
Less than in previous years	3
I don't know	4
I haven't been at this current address for more than a year	5

ASK CUSTOMER TYPE 1-4 AND Q1 ≠ CODE 6
SINGLE CODE

Q4: How does the number of power cut(s) you have experienced at your property in the last year compare to your expectations?
Note: by this we mean **unplanned** power cuts

Much higher than expected	1
Slightly higher than expected	2
As expected	3
Slightly less than expected	4
Much less than expected	5

ASK ALL
SINGLE CODE

Q5: And have you experienced a power cut at your property **since April 2013**?

Interviewer: April 2013 was when C_2C went live If the customer has experienced one or more power cuts then please code 'yes'.

Yes	1
No	2
Don't know	3

ASK ALL WHO HAVE EXPERIENCED A POWER CUT Q5=1
MULTI CODE
NOTE THAT THIS QUESTION LIST NEEDS UPDATING BEFORE EACH WAVE. THE AUGUST 2013 WAVE WILL
CURRENTLY SHOW CODES 1-5 AND 17

Q6: Do you recall the month(s) in which you recently experienced a power cut at your property?

Month	Code
April 2013	1
May	2
June	3
July	4
August	5
September	6
October	7
November	8
December	9
January 2014	10
February	11
March	12
April	13
May	14
June	15
July	16
Don't know	17

ASK ALL WHO HAVE EXPERIENCED A POWER CUT Q5=1
SINGLE CODE

Q7: Were you in the property *at all* during the time of the most recent power cut?

Yes	1
No	2
I can't remember	3

ASK IF Q5 = CODE 1
SINGLE CODE

Q8: Thinking about **the most recent** power cut/interruption you experienced, how long did it last?

Interviewer: Where customer is vague, please try and prompt an answer eg if customer says "a couple of minutes", please ask "would you say 3 minutes or less?"

UNPROMPTED, CODE INTO THE FOLLOWING LIST:

3 minutes or less	1
Between 4 minutes and 1 hour	2
From 1 hour up to 3 hours	3
From 3 hours up to 8 hours	4
More than 8 hours	5
Don't know	6

ASK IF CUSTOMER TYPE 1-4 AND Q5 = CODE 1 AND Q8 ≠ CODE 6
SINGLE CODE
Q9: How does the length of this recent power cut compare to your previous experiences of power cuts **at this property**?

I haven't experienced a power cut at this property before	1
Shorter duration compared to previous experiences	2
Similar to previous experiences	3
Longer duration compared to previous experiences	4
Don't know	5

ASK ALL WHO HAVE EXPERIENCED A POWER CUT Q5=1 AND Q8 ≠ CODE 6
SINGLE CODE

Q10: Most of the time Electricity North West provides you with a continuous and reliable electricity supply. But occasionally, an unforeseen fault might cause a power cut to your home/property. On average customers experience a power cut once in every three years.

[INTERVIEWER, PLEASE FOCUS THE CUSTOMERS ATTENTION NOT ON THE FACT THE POWER CUT HAPPENED, BUT ON THE LENGTH OF TIME IT LASTED]

Despite having this recent power cut, did you find the **length of this power cut**/interruption acceptable?

Yes	1
No	2

ASK ALL WHO HAVE EXPERIENCED A POWER CUT Q5=1 AND Q8 ≠ CODE 6
SINGLE CODE

Q11: On a scale of 1-10 where 1 is completely unacceptable and 10 is equal to completely acceptable to what extent did you find **the length** of this power cut/interruption acceptable?

INTERVIEWER: PLEASE EMPHASISE THAT THIS QUESTION IS TALKING ABOUT THE POWER CUT DURATION (I.E. THEIR ANSWER AT Q5) NOT THE FACT THAT THE POWER CUT OCCURED

Completely Unacceptable									Completely Acceptable	NA
1	2	3	4	5	6	7	8	9	10	11

ASK ALL WHO DID NOT FIND THE DURATION ACCEPTABLE Q10=2
MULTI CODE

Q12a: Why do you find the length of this recent power cut/interruption ***not*** acceptable?

UNPROMPTED LIST, CODE INTO FOLLOWING CATEGORIES

I had to restart equipment/machinery/appliances 1
It affected medical equipment in the household eg dialysis machine 2
I had to reset time switches following the power outage 3
(eg Economy 7 or off peak metering, water heating timer, electric clocks, video recorders)
I experienced a loss of data/some of my work 4
I have experienced too many power cuts at this address so a power cut of any duration is not acceptable to me 5
I had to locate my trip switch 6
It disturbed what I was doing at the time 7
It caused a loss of productivity (*if work from home/commercial customer*) 8
I/someone in my household is vulnerable/ill/registered disabled 9
Other [PLEASE SPECIFY] 10

Customer prompted comments box:

Interviewer- use this box to note down any comments the customer makes as they answer this question, it is really important we understand all of the reasons the customer considers the duration of the power cut to be unacceptable

ASK ALL WHO HAVE EXPERIENCED A POWER CUT Q5=1
SINGLE CODE, PROMPTED LIST

Q12b: In the recent power cut/interruption did you or anyone else in your property experience any of the following things as a result of the power cut?

Select all that apply.

Had to restart equipment/machinery/appliances 1
It affected medical equipment in the household eg dialysis machine 2
(customers may have had to operate medical equipment using battery power or interrupt their treatment)
Had to reset time switches following the power outage 3
(eg Economy 7 or off peak metering, water heating timer, electric clocks, video recorders)
Experienced a loss of data/some of my work 4
Had ~~had~~ to locate my trip switch 5
It disturbed what I was doing at the time 6
It interrupted me/us working, causing a loss of productivity 7
Other [PLEASE SPECIFY] 8
None of the above 9

Customer prompted comments box:

Interviewer- use this box to note down any comments the customer makes as they answer this question, it is really important we understand all of the reasons the customer considers the duration of the power cut to be unacceptable

ASK ALL
SINGLE CODE

Q13: Assuming you experience another unplanned power cut in the future…

IF DOMESTIC CUSTOMER: what **would** be an acceptable power cut duration for you?
IF COMMERCIAL CUSTOMER: what **would** be an acceptable power cut duration for your organisation?

Interviewer: Read through codes 1-5 and at the point the customer says no, code the remaining power cut durations automatically as no.

3 minutes or less	1 YES/NO
Between 4 minutes and 1 hour	2 YES/NO
From 1 hour up to 3 hours	3 YES/NO
From 3 hours up to 8 hours	4 YES/NO
More than 8 hours	5 YES/NO

Interviewer: If customer feels power cuts are unacceptable, select code 6 and select 'no' for codes 1-5

Having a power cut is just ***not*** acceptable	6

ASK IF GROUP 1 OR 5 AND Q13 = CODE 6
OPEN ENDED

Q13B: Why do you say that?

Customer prompted comments box: Interviewer- use this box to note down any comments the customer makes as they answer this question, it is really important we understand all of the reasons the customer feels a power cut is unacceptable even though they've signed up to C2C.

ASK ALL
SINGLE CODE

Q14: Thinking about the electricity supply to your property, have you **recently** noticed any dips or spikes in your power from time to time?

READ OUT: By dips and spikes we mean lights flickering or dimming of lights, wavy lines on computer screen and equipment such as household appliances that trip out and possibly need resetting.

Yes	1
No	2
Don't know	3

ASK IF CUSTOMER TYPE 1-4 AND Q14 = CODE 1
SINGLE CODE

Q15: How does the frequency of dips and/or spikes you have experienced at your property recently compare to your expectations?

Much higher than expected	1
Slightly higher than expected	2
As expected	3
Slightly less than expected	4
Much less than expected	5

ASK IF CUSTOMER TYPE 1-4 AND Q14 = CODE 1
SINGLE CODE

Q16: How does the frequency of dips and/or spikes you have experienced recently compare to **previous years**?

More than in previous years	1
Similar to previous years	2

Less than in previous years 3

ASK IF Q14 = CODE 1
SINGLE CODE

Q17: And have these dips and/or spikes affected your daily routine?

Yes 1
No 2
Don't know 3

Customer prompted comments box:

Interviewer- use this box to note down any comments the customer makes as they answer this question, it is really important we understand all of the reasons the customer gives for their routine being affected.

ASK IF CUSTOMER TYPE 1-4 AND Q14 = CODE 1
SINGLE CODE

Q18: Comparing dips and/or spikes you have experienced **recently** to those in **previous years**, would you say…..?

INTERVIEWER BRIEFING NOTE: THIS QUESTION IS ABOUT THE CUSTOMERS RECENT EXPERIENCE VS. PREVIOUS YEARS. FOR INSTANCE A CUSTOMER MAY NOT FEEL THAT THE DIPS/SPIKES HAVE HAD MUCH OF AN EFFECT ON THEIR DAILY ROUTINE AT THE MOMENT BUT THE IMPORTANT THING IS HOW THIS COMPARES TO PREVIOUS YEARS. IF THEY FEEL THERE HAS BEEN NO CHANGE AND THE DIPS/SPIKES HAVENT HAD MUCH OF AN IMPACT IN THE PAST OR PRESENT - USE CODE 2.

PLEASE READ OUT THE FOLLOWING OPTIONS:

These dips/spikes have had **less** of an effect on my daily routine 1
These dips/spikes have just **as much** of an effect on my daily routine 2
These dips/spikes are now having **more** of an effect on my daily routine 3
I never used to experience dips/spikes in my power so I cannot compare 4
Don't know 5

ASK CUSTOMER TYPE 1, 2, 3 AND 5
SINGLECODE
IMPACT TO PROVIDE INTERVIEWERS WITH A COPY OF THE CARD IN A BRIEFING PACK

Q19: Do you recall receiving a leaflet through your letterbox from Electricity North West at any stage, explaining that they had made some improvements to the electricity circuit your property is located on?

Interviewer: please explain what the leaflet looks like in order to help customers answer this question.

Yes 1
No 2

ASK CUSTOMER TYPE 1 AND 5
SINGLECODE

Q20A: Since signing up to the C_2C Trial, do you feel that the <INSERT STATEMENTS A,B and C> on-site has increased, stayed the same or decreased?

	A	B	C
	Frequency of power cuts	Duration (length) of power cuts	Number of dips and spikes
Increased	1	1	1
Stayed the same level	2	2	2
Decreased	3	3	3
Don't know (DON'T READ OUT)	4	4	4
N/A	-	5	-

ASK CUSTOMER TYPE 2, 3 AND 4
SINGLECODE

Q20b: Since the beginning of April 2013, do you feel that the <INSERT STATEMENTS A,B and C> at the property has increased, stayed the same or decreased?

PLEASE FOCUS THE CUSTOMER'S ATTENTION ON THEIR OWN PROPERTY AND NOT THAT OF THEIR FRIENDS, FAMILY, AND NEIGHBOUR/NEIGHBOURING BUSINESSES ETC.

	A	B	C
	Frequency of power cuts	Duration (length) of power cuts	Number of dips and spikes
Increased	1	1	1
Stayed the same level	2	2	2
Decreased	3	3	3
Don't know (DON'T READ OUT)	4	4	4
N/A	-	5	-

AFTER STATEMENT A, B AND C AT Q20a AND Q20b, IF CODE 1 OR 3 ASK
OPEN ENDED

Q21: How did you notice that?

Customer prompted comments box: Interviewer- use this box to note down any comments the customer makes as they answer this question, it is really important we understand everything that the customer has noticed for them to feel their power quality has changed?

QD1: Code respondent gender [**DO NOT ASK-INTERVIEWER TO CODE**]

Male 1
Female 2

ASK ALL
SINGLECODE

QD2: For classification purposes, can you tell me which of the following age bands do you fit into?

18-24 1
25-34 2
35-44 3
45-54 4
55-64 5
65+ 6

ASK ALL DOMESTIC CUSTOMERS
SINGLECODE

QD3: Which one of the following categories best describes the employment status of the **Chief Income Earner** (CIE) in your household?

1. Semi or unskilled manual worker (eg caretaker, parkkeeper, non-HGV driver, shop assistant etc.) D
2. Skilled manual worker (eg Bricklayer, Carpenter, Plumber, Painter, Bus/Ambulance Driver, HGV driver, pub/bar worker etc.) C2
3. Supervisory or clerical/junior managerial/professional/administrative (eg Office worker, Student Doctor, Foreman with 25+ employees, salesperson, etc.) C1
4. Intermediate managerial/professional/administrative (eg Newly qualified (under 3 years) doctor, Solicitor, Board director of small organisation, middle manager in large organisation, principle officer in civil service/local government etc.) B
5. Higher managerial/professional/administrative (eg Doctor, Solicitor, Board Director in a large organisation 200+ employees, top level civil servant/public service employee etc.)A
6. Student C1
7. Casual worker – not in permanent employment E
8. Housewife/Homemaker E
9. Retired and living on state pension E
10. Retired and not living on state pension **ASK QD4**
11. Unemployed or not working due to long-term sickness E
12. Full-time carer of other household member E

SINGLECODE
ASK IF 10 AT D3 SELECTED
SHOW THE SAME LIST AS D3 EXCLUDING CODE 9&10

QD4: Which **ONE** of the following categories best describes the employment status of the Chief Income Earner before they retired?

RECODE D3 & D4 INTO:

1. A
2. B
3. C1
4. C2
5. D
6. E

ASK ALL COMMERCIAL CUSTOMERS
SINGLECODE

QD20: What is the main activity of your organisation?
Please select one option from the list below.

A		Agriculture, forestry and fishing	1
B		Mining and quarrying	2
C		Manufacturing and Processing	3

D		Utilities (operational sites)	4
E		Wholesale and retail trade	5
F		Accommodation and food services	6
G		Transportation	7
H		Information & communication including data centres	8
I		Storage/Warehouse	9
J		Distribution Generators	10
K		Commercial & office premises	11
L		Education	12
M		Human health and social work activities	13
N		Arts, entertainment and recreation	14
O		Other [SPECIFY]	15

SINGLE CODE
ASK ALL DOMESTIC CUTSOMERS

QD5: Which of the following best describes your marital status?

Single - living at home with parents	1
Single - living alone/house sharing	2
Married/Cohabiting	3
Separated/widowed/divorced	4
Prefer not on say	5

SINGLE CODE
ASK ALL DOMESTIC CUSTOMERS

QD6:How many members/people (including children) are there in your household altogether (that is currently living at home with you)?

Just me	1
2	2
3	3
4	4
5	5
6 or more	6

SINGLE CODE
VALIDATION= MUST BE LESS THAN TOTAL AT D6
ASK IF DOMESTIC CUSTOMER AND QD6 = CODES 2-6

QD7: How many children under 18 are there in your household altogether (*that is currently living at home with you)?*

0	1
1	2
2	3
3	4
4	5
5	6
6 or more	7

ASK ALL DOMESTIC CUSTOMERS
MULTICODE

QD8: Which of the following electrical items do you have in/at your household?

Electric Shower	1
Electric Storage Heaters	2

Boiler/Water heater	3
Immersion heater	4
Fan heater/cooler/de-humidifier	5
Dishwasher	6
Tumble drier	7
Microwave	8
Electric oven	9
Desktop PC/monitor/laptop	10
Games console(s)	11
Electric kettle	12
Electric car	13

ASK ALL COMMERICAL CUSTOMERS
MULTICODE

QD9: Which of the following electrical items do you have in/at your organisation's site?

Air conditioning	1
Tills	2
Computers, laptops, monitors and/or PC projectors	3
Printing machines/photocopiers	4
Refrigerators/Freezers	5
Coffee machine(s) or vending machines	6
Water chillers	7
Electric heaters	8
Electric hand driers	9
Building alarms	10
Manufacturing/industrial machinery	11
Electric car charging points	12

ASK ALL DOMESTIC CUSTOMERS
MULTICODE

Some groups of people have more dependency or need for electricity at all times than others.

QD10: Which, if any, of the following applies to you or your household?

Select all that apply

	A – I (the customer being spoken to)	B – Someone else in my household
Spend a lot of the day at home	1	1
Spend a lot of the evening at home	2	2
Have a disability	3	3
Have medical equipment (eg dialysis)	4	4
Are seriously ill	5	5
Have mobility problems	6	6
Have visual or hearing impairment	7	7
None of the above	8	8

ASK IF QD10A=4 OR QD10B=4
SINGLE CODE

QD11: You mentioned that you have medical equipment in your household. Has a power cut *ever* affected your medical equipment?

Interviewer- by this we mean has a power cut interrupted the operation of medical equipment, by having to stop treatment, re-set equipment, visit hospital etc.

Yes	1
No	2

ASK IF QD11=1
SINGLE CODE

QD11B: And has a power cut affected your medical equipment **since April 2013**?

Interviewer- by this we mean has a power cut interrupted the operation of medical equipment, by having to stop treatment, re-set equipment etc.

Yes	1
No	2

ASK IF QD11B=1
OPEN ENDED

QD11C: Thinking about the time(s) **since April 2013** when the medical equipment was affected, please describe what happened.

INTERVIEWER – PLEASE PROBE FOR AS MUCH INFORMATION AS POSSIBLE: WHAT HAPPENED? HOW DID THE CUSTOMER FEEL WHEN IT HAPPENED? WHAT DID THE CUSTOMER DO?

ASK IF QD2=6 OR QD10A/QD10B=3 OR 4 OR 5 OR 6 OR 7
SINGLE CODE

QD12: Electricity North West offer a priority service for their more vulnerable customers, who may need additional specialised help from them during a power cut. As part of its priority service Electricity North West works with the British Red Cross who can help you with practical necessities when things go wrong.

According to the answers you have given in the previous questions, you/your household are eligible to sign up to Electricity North West's priority service register. Are you already on this register?

Yes	1
No	2

ASK IF QD12=2
SINGLE CODE

QD13 Were you aware that **<u>you</u>** could sign up to this register?

Yes	1
No	2

ASK IF QD12=2
SINGLE CODE

QD14 Would you like to know now how to register for the Priority Service Register?

Yes	1

No 2

IF YES: INTERVIEWER READ OUT: To Register customers can call Electricity North West on 0800 195 4141 or complete the form on the website www.enwl.co.uk

ASK IF QD14=1
SINGLE CODE

QD14B: To register you can call Electricity North West on 0800 195 4141 or complete the form on the website www.enwl.co.uk. If you would like to receive more information about the Priority Service Register, Electricity North West can send you a leaflet about it.

Would you be happy to have your details, including address, passed on to Electricity North West so they can send you this leaflet?

Yes 1
No 2

ASK IF QD14B=1
SINGLE CODE

QD14C:Please can you confirm your address, so Electricity North West can send you this leaflet?

Address	

ASK ALL
SINGLECODE

QD15. Do you (*IF CUSTOMER TYPE 1 OR 2: does your organisation*) have access to a portable generator for use in the event of a loss of power supply?

Yes 1
No 2
Don't know 3

ASK ALL
SINGLECODE

QD16:Do you have a photo voltaic generating system (solar panels) <IF DOMESTIC: at your property; IF COMMERCIAL: on-site>?

Yes 1
No 2
Don't know 3

Thank you for your help in this research. Please be assured that the answers that you have given will not be attributed to you personally, but will be presented in grouped form only for analysis purposes, **unless you give your express permission for us to attribute your responses to you...**

ASK ALL
SINGLECODE

QD17:Would you be happy to have the feedback you have given to us today attributed to you so that Electricity North West are aware that you have taken part in this market research?

Yes	1
No	2

ASK ALL
SINGLECODE

QD18:Would you be happy for us to get in touch with you again in the future to discuss the service you receive from Electricity North West for market research purposes?

Yes	1
No	2

QD19: Would you be happy for your data to be passed to Electricity North West, or one of its 3rd party partners in order that they can discuss with you any aspect of your electricity supply in the future?

Yes	1
No	2

8.2. Appendix B: Peer review

Executive summary

The proactive monitoring research methodology outlines the measurement of customers' perceptions of power quality/reliability (fault frequency, duration, dips and spikes) for those customers on each of the C_2C Trial circuits, compared to the perceptions of those domestic customers who are not on C_2C Trial circuits.

The research methodology outlined by Impact Research is an admirable and precise examination of the effect of C_2C on customer perceptions.

The sample size in the I&C groups are small, and may limit any segmentation of data in the analysis. The sample size for domestic customers allows for a more representative sample of customers.

The proposed analysis of the data is realistic. Accurate, reliable, and robust estimates of domestic customers' perceptions of their power quality/reliability (fault frequency, duration, dips and spikes) throughout the C_2C Trial period, compared to perceptions of domestic customers not on C_2C Trial circuits, should be achieved.

Any regional and vulnerability analysis needs to standardise for the socio-economic composition of domestic customers across regions and between vulnerable and non-vulnerable customers. Otherwise regional variation and vulnerability may be confounded by other variables.

The objective of this peer review

This peer review considers the suitability of the proactive monitoring research methodology proposed by Impact Research to provide robust quantitative research that will assist in answering the C_2C hypotheses. The peer review is also intended to maintain standards of quality, improve performance and provide credibility.

This review has been undertaken by Professor Ken Willis. Ken Willis is Emeritus Professor of Environmental Economics at Newcastle University. His research concentrates on environmental valuation (using stated preference, and revealed preference travel-cost and hedonic price models) and cost-benefit analysis; covering biodiversity, cultural heritage, energy, forests, landscape, quarries, recreation, transport, waste disposal and water quality and supply.

He is currently the editor of the Journal of Environmental Economics & Policy. He has undertaken research projects on renewable energy and its impact on rural development and sustainability in the UK, for the Department of Trade and Industry; on the growth potential for micro-generation in England, Wales and Scotland, for the Department of Business, Enterprise & Regulatory Reform; a cost-benefit analysis of sustainable public procurement, for the Department for Environment, Food & Rural Affairs; and consumer values and uptake rates for photovoltaic systems by households in Cyprus.

Ken also has a wealth of experience in evaluating the suitability of market research methodologies and the application of advanced statistical analysis techniques onto market research data. Given his expertise within the energy sector he is well placed to provide a peer review of the C_2C proactive monitoring research methodology.

The rest of this report focuses on an assessment of the proactive monitoring research methodology prepared by Impact Research for Electricity North West and is based entirely on the informed opinion of Ken Willis.

Proactive monitoring

The proactive monitoring report, by Impact Research for Electricity North West, sets out the aim of the research, which is to measure customers' perceptions of their power quality/reliability (fault frequency, duration, dips and spikes) throughout the C_2C Trial period and to compare the perceptions of those customers who are not on each of the C_2C circuits (control) vs those that are (test).

Research and survey methodology

The research methodology outlined by Impact Research is an admirable and rigorous examination of the effect of C_2C on customer perceptions. The research will assess whether C_2C affects customers' perceptions of power quality, compared to a situation without C_2C. This will be achieved by comparing I&C customers who have signed a C_2C agreement with I&C customers who have not signed a C_2C agreement but whose premises are on a C_2C Trial circuit; and comparing domestic customers who are on a C_2C Trial circuit with domestic customers who are not on a C_2C Trial circuit.

The computer aided telephone interview (CATI) survey proposed by Impact Research is appropriate: it is more cost-effective then a computer aided personal interview (CAPI) survey, while minimising self-selection bias compared to an online survey.

The sample sizes in the I&C groups are small, and may limit any segmentation of data in the analysis. The sample size for domestic customers allows for a more representative sample of customers.

Impact Research aims to account for fault history; proportion of domestic vs commercial; planned minor or major maintenance on selected circuits; and location (urban, suburban, rural) in selecting non-Trial circuits, with these 'control' circuits being as homogeneous and as similar as possible to the C_2C circuits. This is appropriate and desirable.

Fieldwork

The interviewing approach proposed is excellent. The questionnaire topics are comprehensive, covering the number of faults in the last year; length of most recent fault; observations on any dips and spikes in power supply; attitudes to all these events; power supply changes since C_2C; and demographic information including use and dependency on electrical equipment.

The questionnaire should note the postcode of the customer. This will allow some analysis on whether there is a spatial variation in discernible effects by customers of variations in power quality.

Analysis

The proposed analysis of the data is realistic. The sample size for domestic customers should permit accurate, reliable, and robust estimates of customers' perceptions of their power quality/reliability (fault frequency, duration, dips and spikes) throughout the C_2C Trial period compared to perceptions of domestic customers not on C_2C circuits. For I&C customers the small sample size will make the results less robust, but nevertheless the I&C results will provide a qualitative indication of tendencies.

The analysis proposes investigating regional differences, and differences between vulnerable and non-vulnerable customers. Regional variations and differences between vulnerable and non-vulnerable domestic customer perceptions may arise because of differences in the socio-economic composition of customers. Any regional and vulnerability analysis needs to standardize for the socio-economic composition of domestic customers across regions and between vulnerable and non-vulnerable customers. Otherwise regional variation and vulnerability may be confounded by other variables. A logit model of individual customer responses could be undertaken to assess which variables, including instrumental variables

for ‘region’, and for ‘vulnerability’, account for a noticed discernable effect on power quality. This would indicate whether customers in each region, and by vulnerability, had statistically significant different perceptions of their power quality/reliability.

Results can be weighted, as Impact Research suggest, to take account of any difference in the sample profile (eg in terms of age, social grade, etc.) compared to the population of customers. However, weighting is not a good substitute for a representative sample. Where sample sizes are small weighting should be used with caution. Assigning a customer a weight of 2, so that their answers would have twice the influence on the results, may simply give greater weight to some aberrant response uncharacteristic of that population sub-group.

Impact Research propose concentrating on net changes in the perception of power quality over time, ie the proportion of customers who perceive a decrease in adverse power quality minus the proportion of customers who perceive an increase in adverse power quality. This has justification.

After completing the surveys, Impact Research and Electricity North West propose comparing actual fault data (collected by Electricity North West) with customers’ perceptions as revealed by the surveys. It is useful to compared actual ‘revealed’ events with ‘stated perceptions’ of events. The two often differ, as various studies have shown (see for example Slovic et al, 1980). Cognitive psychology suggests reasons for discrepancy between actual and perceived risks arising from issues of representativeness, availability, and anchoring (see Tversky and Kahnemann, 1974) as well as other attitudes towards the risk such as dread, magnitude, etc. (see Slovic et al, 1980). Thus actual events and perceived events might differ because faults occurring at a specific time of day are more discernable to customers (availability bias). Perceived risk is important since it drives C_2C acceptability and customer contract reservation price. However, overall customer utility is maximized if expected utility is applied based on actual or actuarial risk. A comparison of actual with perceived risk will provide some indication of allocative and resource inefficiency in the C_2C market.

Conclusion

The proactive monitoring research methodology proposed by Impact Research is admirable. The research methodology will provide accurate and reliable measurements of customers' perceptions of power quality/reliability (fault frequency, duration, dips and spikes) throughout the C_2C Trial period, compared to the perceptions of those domestic customers who are not on C_2C circuits.

References

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