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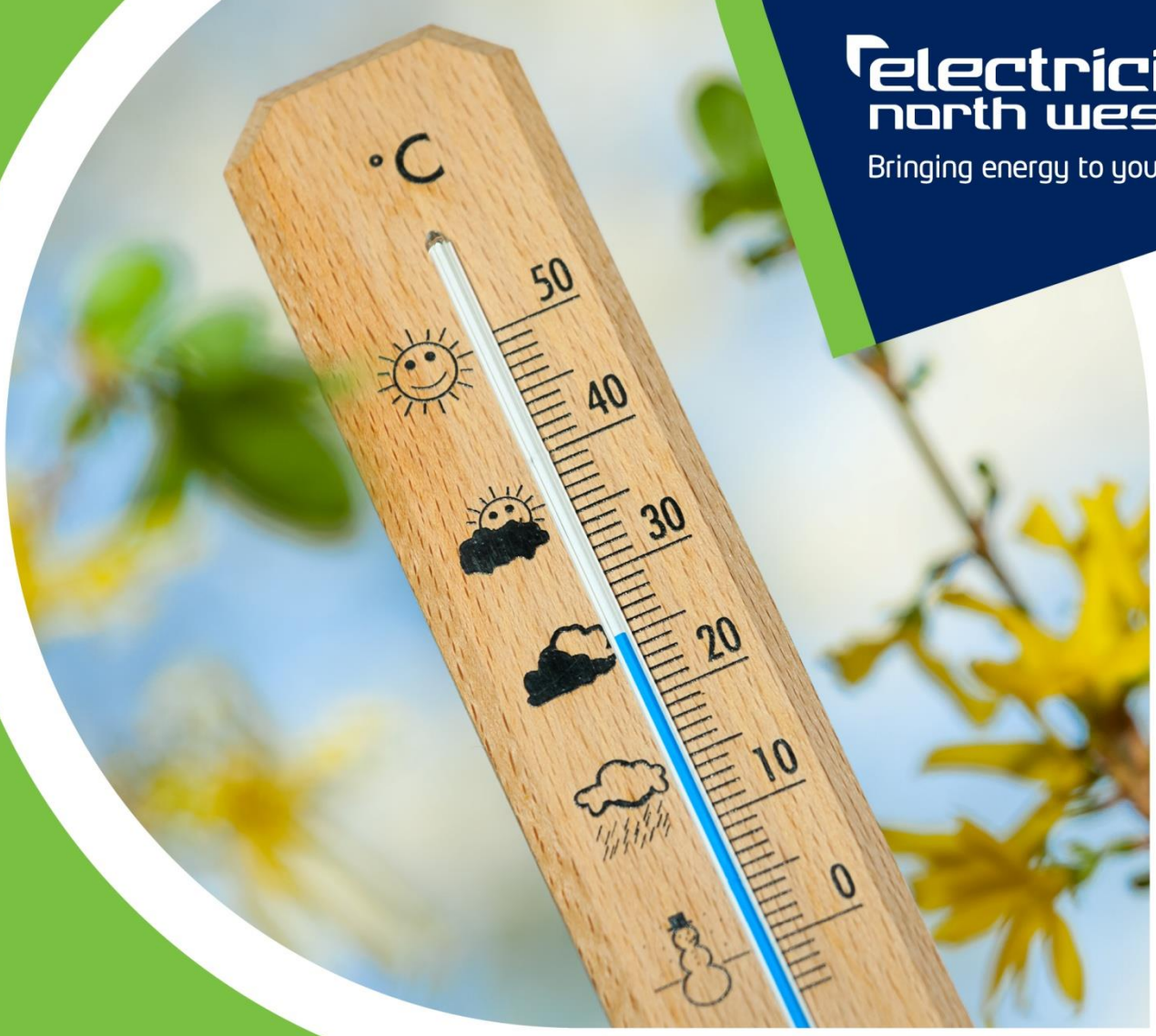



# Celsius

## Project Progress Report

9th December 2019

## VERSION HISTORY

| Version | Date | Author | Status | Comments |
|---|---|---|---|---|
| V0.1 | 11 Nov 2019 | Delroy Ainsworth | Draft | First draft |
| V0.2 | 26 Nov 2019 | Delroy Ainsworth | First Issue | For review |
| V0.3 | 28 Nov 2019 | Delroy Ainsworth | Second Issue | Final review |
| V1.0 | 04 Dec 2019 | Delroy Ainsworth | Final | |

## REVIEW

| Name | Role | Date |
|---|---|---|
| Dan Randles | Innovation Manager | 09 Dec 2019 |
| Jonathan Goodman | Finance Manager | 09 Dec 2019 |

## APPROVAL

| Name | Role | Date |
|---|---|---|
| Steve Cox | Engineering and Technical Director | 09 Dec 2019 |

# GLOSSARY OF TERMS

| Term | Description |
|---|---|
| Active cooling | Cooling provided by actively controlled means e.g. fans. |
| Ambient temperature | Temperature of the air surrounding a component |
| BAU | Business as Usual |
| Cable | An underground conductor used to distribute electrical power, installed directly in the ground or in ducts or troughs |
| Capacity | The amount of power that can be delivered by an asset |
| CBA | Cost Benefit Analysis |
| CCC | Electricity North West's Customer Contact Centre |
| CNAIM | Common Network Asset Indices Methodology |
| Current | The flow of electricity through a cable, measured in amperes |
| Demand | The amount of electrical energy that is being consumed at any given time |
| Distribution substation | A substation which usually contains high voltage (HV) switchgear, an HV/LV transformer, LV switchgear and short length of LV cable(s) and can be either pole- or ground-mounted |
| DNO | Distribution Network Operator |
| ENA | Energy Networks Association |
| GB | Great Britain |
| GRP | Glass Reinforced Plastic |
| High voltage (HV) | Voltages over 1kV |
| Hot spot temperature | The peak temperature reached at a position in a transformer winding which determines the maximum load the transformer can carry |
| LCN | Low Carbon Network |
| LCNI | Low Carbon Network Innovation |
| LCT | Low Carbon Technology |
| MDI | Maximum demand indicator |

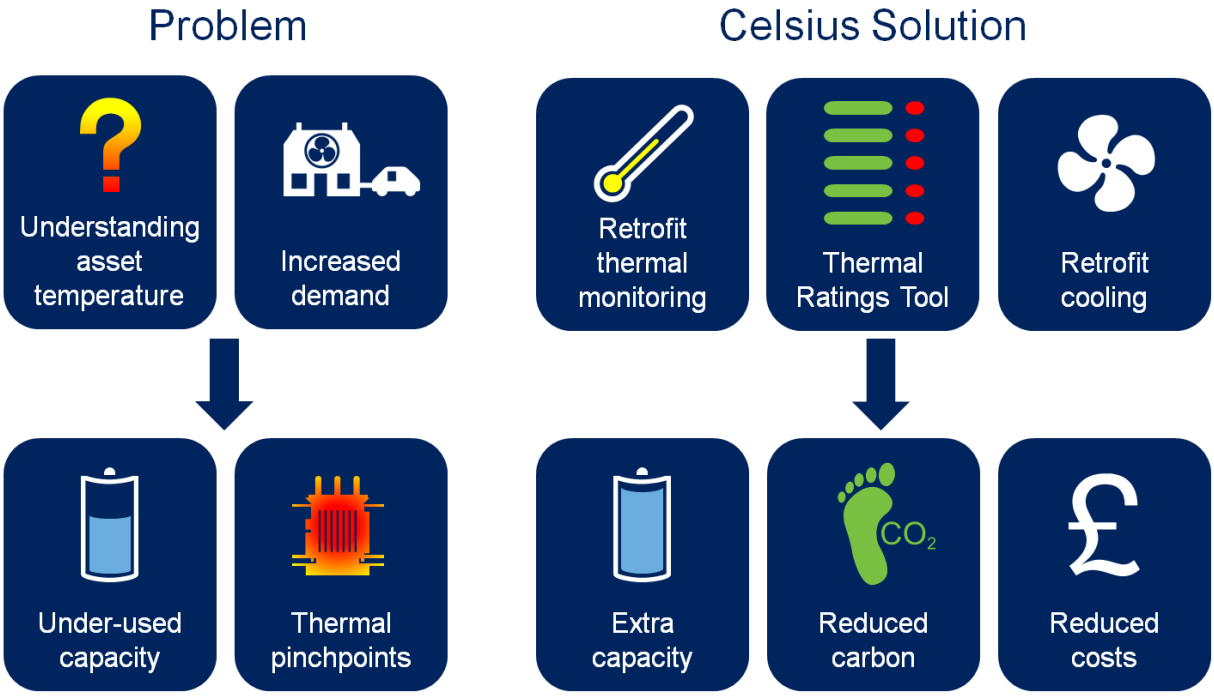
| | |
|---|---|
| NIC | Network Innovation Competition |
| Passive cooling | Cooling provided by non-controlled means e.g. reflective paint, shading from sunlight |
| PPR | Project Progress Report |
| SDRC | Successful delivery reward criteria |
| Thermal coefficient | The constant by which the external temperature needs to be multiplied to ascertain the hot spot temperature |
| Thermal constraint | The restriction of an electrical asset's capacity due to the operating temperature |
| Thermal headroom | The amount of capacity available for use |
| Thermal Ratings Tool | Software/Microsoft Excel-based solution to calculate the available capacity at a site, based on inputs of temperature, substation environment and asset type |

# 1 EXECUTIVE SUMMARY

## 1.1 The Celsius project

Celsius is funded via Ofgem's Network Innovation Competition (NIC) funding mechanism. The project was authorised to commence in December 2015 and is expected to be complete by March 2020.

Celsius explores innovative, cost-effective approaches to managing potentially excessive temperatures at distribution substations, which could otherwise constrain the connection of low carbon technologies (LCTs).




Celsius first seeks to identify potential thermal issues by establishing how different distribution substations in differing environments behave thermally under a variety of load and environmental conditions. Celsius will develop the following methodologies to better understand the real thermal ratings of distribution substation assets to unlock capacity:

- **Retrofit thermal monitoring**: By using improved technology to measure asset and ambient temperatures, and relating these to a range of environmental, load and seasonal factors, Celsius will enable understanding of real thermal ratings of assets, rather than the nominal ratings that are used today. This will allow improved understanding of the amount of latent capacity which could be accessed without further intervention.

- **Thermal Ratings Tool**: the learning from the retrofit thermal monitoring trials and analysis will be formalised and transferred into a simple tool that can be used by operations and planning employees at any network operator, to better understand the capacity of the existing or planned network.

Celsius will then identify, evaluate and demonstrate a range of retrofit cooling technologies that can be used to directly manage the temperature of assets. By managing temperature in this way, Celsius will deliver additional capacity release. Customer surveys will establish customer perception of retrofit cooling techniques and whether the application of these techniques is as acceptable to them as traditional reinforcement.

## 1.2 Project progress

This is the eighth six-monthly project progress report (PPR) for the Celsius project. This report covers the period from June 2019 to November 2019.

### Cooling technology installations

During the last reporting period we have continued to assess the following retrofit cooling techniques/technologies:

- Five outdoor transformers equipped with shades to prevent solar gain
- Ten outdoor transformers painted with anti-solar paint to prevent solar gain
- Twenty glass reinforced plastic (GRP) substations fitted with extra passive cooling vents, of which eleven also had roofs painted with anti-solar paint to prevent solar gain
- Nineteen brick-built substations fitted with extra passive cooling vents
- Two brick-built substations that form part of a larger building fitted with extra passive cooling vents
- Four substations where the LV underground cables excavated below the LV board and backfilled with a thermally improved backfill material
- Forty substations fitted with active cooling, twenty positive pressure systems and twenty negative pressure systems

The data obtained from these sites has been analysed in detail. All the various cooling technologies have had some effect on the thermal performance of the substation and will be explained in more detail later in the report. Due to the delay in installation, detailed in previous reports, the cable backfill sites are still being analysed.

### Monitoring equipment

As mentioned in the July 2019 PPR report, the data analysis carried out by Ricardo revealed a number of anomalies. These consisted of data gaps, data no longer being sent and obviously incorrect readings. E.g. 2000A reading on a 100kVA transformer. Some of these were easily attributed to faulty equipment that was swiftly replaced on site, but the causes of some issues proved more difficult to identify. The faulty equipment was sent back to ASH Wireless for them to investigate. The main issues identified were battery passivation, batteries reaching end of life, water ingress and failed Rogowski coils. This provided valuable learning when creating the specification for the business as usual (BAU) monitoring equipment.

### Thermal Ratings Tool

As per the last report further analysis of the calculations and data that feed into the Thermal Ratings Tool have been carried out by Ricardo, with assistance from the University of Southampton. This has produced some significant changes to the tool. This development and validation work is ongoing but it will result in a revision of the temperature behaviour report, which was published in August last year. The revised report will detail all the changes from the initial report. The Thermal ratings tool has been developed and validated using retrofit cooling trial data, and is now called the Enhanced Thermal Ratings Tool The tool will continue to be developed and the final version is planned to be published in January 2020.

### Business as usual

As mentioned in the previous PPR, consultation with the main business regarding implementation of Celsius techniques into BAU is progressing well and the once the Cost

Benefit Analysis (CBA) is complete (due December 2019) all the information needed will be available to allow for a proposal to integrate the techniques into BAU.

Transition to BAU would likely require changes to the Common Network Asset Indices Methodology (CNAIM), which is a common framework of definitions, principles and calculation methodologies, adopted across all GB Distribution Network Operators (DNO), for the assessment, forecasting and regulatory reporting of asset risk. UK Power Networks (a project partner) have been involved in the BAU discussions. This collaboration will ensure that any proposals would be acceptable to other DNOs and are transferable across GB networks.

In the last report, the possibility of obtaining remote Maximum Demand Indicator (MDI) readings from any site with Celsius monitoring equipment fitted was mentioned. Since then, there have been several data requests from design engineers who have visited substations with the intention of fitting data logging equipment only to find that the site has Celsius equipment fitted. The project provided them with far more data than they would have been able to get otherwise (the system provided the last 12 months of data, where normally they would only be able to get 2-3 weeks of data) and it meant they didn't have to return to site to remove their data loggers, and they also didn't need to wait weeks for the data. If Celsius sites were marked on company systems (which they would be if transitioned to BAU) then the design engineer wouldn't have had to visit site at all and could have obtained all the information they need without leaving the office.

### Passcomm

As mentioned in previous reports, Passcomm have developed a slimline version of their cooling unit. The slimline unit has been fitted to a "hot" substation on the network. This unit is lighter, smaller (and therefore much easier to install), and can be used in more situations with less of an impact on the substation and surrounding area. Initial analysis shows an instant drop in transformer temperature and this analysis will continue for the remainder of the project. The main purpose of this is to see if this slimline unit performs as well or better than the original unit. If it does, then it makes sense to consider this unit for BAU applications.

### Ricardo Energy and Environment

Ricardo Energy and Environment have been focusing efforts on data analysis of Celsius sites, validation and development of the thermal ratings tool, the CBA for the various Celsius solutions and continued involvement in the BAU consultation process. Ricardo also helped present the project at this year's LCNI conference in Glasgow.

### LCNI Conference

Celsius was presented at this year's LCNI conference in Glasgow. The presentation was a success and there was significant interest in the project on the Electricity North West stand. This was aided by having examples of the active cooling technology installations on display.

### Financial

The project actual cost-to-date is £4,387,000 and the estimated at-completion cost is £4,976,000 of a planned budget of £5,338,000 (including contingency).

The project is on track to meet its aims, objectives and all SDRC as per the project plan.

## 1.3 Risks

Project risks are monitored on a continuous basis, including the potential risks that were documented in the full submission. A review of risks is contained in Section 10 and the status of all risks is contained in Appendix A.

There have been several changes to the risk log since the last reporting period. No new risks have been identified but a number of risks have been closed. Full details can be found in Section 10 of this report.

### 1.4 Learning and dissemination

Details of all learning and dissemination activities conducted in this reporting period are summarised below and included in the communications register in Appendix F.

The Celsius Customer Survey report fulfils the following two 'customer workstream' Successful Delivery Reward Criteria (SDRC):

- Customer survey report quantifying the acceptability of innovative retrofit cooling techniques, September 2019
- Customer survey analysis evaluating the change, if any, in the acceptability of innovative retrofit cooling techniques by educating customers, September 2019

A Celsius Advertorial was published in the October edition of the IET magazine, October 2019

# 2 PROJECT MANAGER'S REPORT

### 2.1 Project background

Celsius will continue to develop an understanding of the operating temperatures of distribution substation assets, including transformers and cables, within a range of substation environments. The project will also deliver alternative, innovative ways to optimise thermal capacity, leading to faster, cheaper responses to the connection of LCTs.

### 2.2 General

This is the eighth reporting period, mainly focusing on data analysis, thermal ratings tool refinement, CBA, the carbon impact assessment and presenting/displaying at the LCNI conference. We have also been working closely with the main business to develop processes for transitioning Celsius into BAU, should it prove a success.

There were six SDRC deliverables in this reporting period which have been successfully completed, plus an additional 7$^{th}$ which has been delivered early:

- Publish customer survey report quantifying the acceptability of innovative retrofit cooling techniques, September 2019
- Publish customer survey analysis evaluating the change, if any, in the acceptability of innovative retrofit cooling techniques by education customers, September 2019
- Publish low cost monitoring solution specification, September 2019
- Publish Advertorials annually, October 2019
- Publish developed and validated Thermal Ratings tool using retrofit cooling trial data, November 2019.
- Issue project progress report in accordance with Ofgem's December production cycle, December 2019

- Hold annual knowledge sharing events. Provide one-to-one briefing sessions, December 2019

The key project management activities undertaken during the reporting period are summarised below:

- **Project monitoring and control:** The monitoring and control of the delivery of the Celsius project is ongoing.

- **Regular engagement with project partners:** The Celsius project team holds a weekly progress update meeting with the project partners to review project actions, risks and issues. Additionally, annual project steering groups are held with key stakeholders.

- **Cooling technology plan/installations:** The installation plan was fully implemented for the active and passive cooling technology contractors. All the cooling technologies have been installed and retrofit cooling data is being analysed.

### 2.3 Technology, trials and analysis workstreams

The key activities that were undertaken by the technology, trials and analysis workstream during the reporting period June to November 2019 are summarised below:

Creating the low cost monitoring solution specification for BAU transition. The purpose of this document is to describe the specification and requirements of a BAU monitoring solution, which will be deployed into substations and will allow more informed ratings to be estimated. This has been part of the general BAU discussions as to what equipment we need, and its ability to integrate with current company systems and policies.

The thermally improved cable backfill was successfully installed at four distribution substations. As explained in previous reports this was delayed due to data issues with the cable temperature measurements. These issues were rectified, but the installations were further delayed due to excavation contractor issues. This ultimately resulted in a different contractor being sourced at short notice.

The installations themselves were somewhat more involved than traditional backfill methods. The backfill consists of nine parts silica sand to one part bentonite granules. These had to be mixed together adding water until a concrete type consistency was achieved. This involved using a mixer and gallons of water which was very time consuming. It is estimated that this method took approximately 5 times longer than traditional backfill methods. This technique also requires a drying period, which means revisiting the site a few weeks after initial backfill (which must be left slightly below finished ground level) to apply a finishing layer. This is to allow the mixture to properly cure.

Installing thermal monitoring and applying a Celsius Rating increased the mean capacity rating by 30% across our trial sites, and it is predicted that the range of that increase for future sites would be between 10% and 50%, based on our findings throughout the project.

Additional capacity benefits can be obtained by retrofitting the following cooling technologies:

- Ten outdoor distribution transformers were painted with solar reflective paint. This should only be deployed where the transformer is exposed to direct solar radiation, and heating issues coincide with hours of sunlight. The capacity benefit achieved was between 0% and 15% higher than applying a Celsius Rating alone.

- Five outdoor distribution transformers had sun shades erected over them to reduce solar gain. There was no evidence of any additional capacity release from this type of

cooling. In fact, some of the trial sites actually showed a decrease in capacity. This is due to the shade reducing the natural air flow over the transformer.

- Nineteen brick-built substations had ventilation improved by the installation of additional vents. These displayed a wide variety of impacts on the rating, and the benefit depended on the configuration of the existing substation and the effectiveness of existing ventilation arrangements. The capacity benefit achieved was between 0% and 10% higher than applying a Celsius Rating alone.

- Twenty GRP constructed substations had additional vents installed. As with the stone/brick-built sites the benefit will depend on the configuration of the existing substation and the effectiveness of existing ventilation arrangements. The capacity benefit achieved was between 0% and 10% higher than applying a Celsius Rating alone.

- Eleven of these sites also had the roofs painted with solar reflective paint. There was no strong evidence to support an additional capacity release over the installation of vents alone. Theoretically it could improve the capacity but due to differences in substation layout and the limited number of sites, no additional capacity benefit was achieved.

- Two ‘unusual’ type substations had additional ventilation installed. These substations were part of larger buildings, which tend to have unusual layouts and shapes. No additional capacity was found at these sites. This is due to the limited number of data sites and the large variation in pre-existing ventilation arrangements.

- Four cable backfill sites have been backfilled with a thermally improved backfill. The analysis of this is ongoing due to the delays previously mentioned with data quality on contractor resources.

- Twenty Passcomm units were installed – active cooling positive pressure system. As with other technologies, the benefit depended on the configuration of the existing substation and the effectiveness of existing ventilation arrangements. These units were mainly installed in brick-built substations and the mean capacity release across those sites was 15% higher than applying a Celsius Rating alone. There was one unit installed in a GRP which yielded a 25% capacity release. The predicted capacity release range of this technology is between 10% and 50%.

- Twenty Ekkosense units were installed – active cooling negative pressure system. As with other technologies, the benefit depended on the configuration of the existing substation and the effectiveness of existing ventilation arrangements. There was a large variation in capacity released across our trial sites, meaning a mean capacity release of only a few percent. Based on the project findings, the predicted capacity release range would be between 0% and 34%.

It is worth noting that the additional capacity benefit varies significantly based on the existing conditions of the substation. For example; a heavily loaded, poorly ventilated substation would see a much greater benefit from retrofitting cooling technologies than a lightly loaded, well ventilated substation.

**Transition to business as usual**

Ongoing discussions with the main business regarding the transition of Celsius into BAU have included an evaluation of existing policies and processes, to establish where and how Celsius can be integrated. This exercise has provided very useful insight and learning, which is detailed in the learning outcomes section of this report.

## 2.4 Customer workstream

The key activities undertaken by the customer workstream, during the reporting period June to November 2019, are summarised below:

- Resolution of one further Celsius-related enquiry
- Final analysis of Celsius test survey and publication of Customer Survey Report quantifying the acceptability of Celsius cooling techniques, which also evaluates changes in acceptability associated with the education of customers

### Customer enquiry investigated and resolved

One further customer enquiry was received about a Celsius technique during this reporting period. This enquiry was raised by a member of the public who had observed an increase in the noise level from the substation and was concerned this might indicate a developing fault. A re-designed slimline Passcomm unit had recently been installed at this site. There have been no complaints of noise disturbance from customers residing in close proximity to the substation and Electricity North West investigations have revealed that whilst noise levels associated with the new slimline unit are slightly higher than anticipated, they are unlikely to cause disturbance to those living near to the substation. As such, it has not been considered necessary to adjust fan settings to reduce noise from the unit at this stage. However, this case remains under review and we will carry out any necessary adjustments, as a matter of urgency, should there be any report of noise disturbance.

### Final analysis and publication of Celsius Customer Survey Report

During this reporting period final analysis and reporting of Celsius test customer survey was completed. The ‘test’ customer survey was specifically designed to draw attention to the cooling technique deployed at the substation nearest to each respondent, to quantify the acceptability of the various retrofit cooling techniques. These results were assessed against the outputs of the baseline survey, which was undertaken before the installation of retrofit cooling techniques to provide a comparative measure.

The survey was designed to answer the following two hypotheses:

- Customers in the Celsius trial areas will find the implementation of innovative retrofit cooling techniques as acceptable as traditional reinforcement
- Customers who are educated as to the need for and benefits of Celsius are significantly more likely to find it acceptable

The key hypothesis was proven: in the trial survey, 89% of all respondents found the retrofit cooling technique installed at their nearest substation acceptable, but only 62% found traditional reinforcement acceptable, demonstrating that customers are significantly more accepting of Celsius retrofit cooling techniques than traditional reinforcement.

Only 15% of survey respondents noticed a change to a Celsius substation during the technical trials.

The analysis used a 1-10 point rating scale and the results report used ‘top 3 box’ percentages (T3B) i.e. score of 8, 9 or 10 out of 10. This follows standard reporting practises. Of the 15% of customers who noticed a change to a Celsius substation in the trial survey, 79% of this number gave a T3B score, indicating that they are accepting of the work that has been done. There were differences between customers living/working near active and passive substation sites: only 68% of customers near an active site gave a T3B score compared with 86% of customers near a passive site. Figure **Error! Reference source not**

**found.**.10 in the Celsius Customer Survey Report shows the T3B scores across the various intervention types.

The secondary hypothesis was disproven: the level of education given did not significantly impact acceptability of Celsius. The analysis revealed that 89% of 'educated' customers found Celsius acceptable compared with 90% of 'uneducated' customers. However, only 62% of uneducated respondents gave a score of 'completely acceptable' compared to 79% of educated respondents, indicating that the level of education did influence the strength of opinion.

This finding supports previous innovation research, which suggests that customers are generally more accepting and supportive of DNOs trialling new technologies or techniques that will ultimately benefit them (e.g. faster connection of LCTs with less disruption and lower costs), when the reasons are explained in sufficient detail.

### 2.5 Learning and dissemination workstream

The Celsius project team has participated in learning and dissemination events in this reporting period; the key events are:

- Publish advertorials annually, October 2019 – Celsius featured on a full page advertorial in the October IET Magazine.

- Participate in annual LCNI Conference, October 2019 – there was a Celsius presentation at this year's LCNI Conference at the Scottish Exhibition Centre in Glasgow. The active cooling technologies were also on display on the Electricity North West stand.

- Hold annual knowledge sharing events. Provide one-to-one briefing sessions, December 2019 – there was a Celsius presentation at the ENAs Electricity Innovation Forum in Glasgow.

- Issue project progress reports in accordance with Ofgem's June and December production cycle and publish on the Celsius website, December 2019.

Throughout each reporting period the project team engages with Electricity North West colleagues through various channels including newsletters, company intranet and site briefings.

Although this is the last six-monthly report there is still one learning and dissemination workstream activity to complete:

- Publicise Celsius within Electricity North West via the Volt intranet site, email bulletins and/or Newswire company magazine, March 2020

The Celsius communications register that details communications for the current reporting period is located in Appendix F.

# 3 BUSINESS CASE UPDATE

The project team is not aware of any developments that have taken place since the issue of the Celsius project direction that affects the business case for the project.

# 4 PROGRESS AGAINST PLAN

The project plan is monitored, reviewed and updated on a continuous basis. This process takes into consideration potential risks that were documented in the full submission and any change to these risks. The process also considers newly identified risks and issues that are highlighted during the project lifecycle.

# 5 PROGRESS AGAINST BUDGET

The project budget as defined in the project direction is shown in Appendix C.

Actual spend to date compared to project budget is summarised in Figure 5.1 below. The report includes expenditure up to and including 30 November 2019. It is noted that the project is currently performing favourably, relative to budget. Project expenditure as at the

end of November 2019 was £4,387,000 compared to a cost baseline of £4,976,000 including contingency.

In the previous reporting period the variance minus contingency was a £258,000 underspend. This is now a £90,000 overspend; this is for the most part due to the phased payments to project partners (contractors).

*Figure 5.1: Summary of project expenditure*

| Summary Ofgem Cost Category (excluding partner funding) | Spend to date (£'000s) | | | Total Project | | |
|---|---|---|---|---|---|---|
| | Actual | Budget | Variance | Forecast | Budget | Variance |
| Labour | 1,108 | 997 | (111) | 1,237 | 1,203 | (33) |
| Equipment | 1,325 | 1,333 | 8 | 1,335 | 1,333 | (2) |
| Contractors | 1,517 | 1,499 | (18) | 1,824 | 1,765 | (59) |
| IT | 191 | 203 | 12 | 209 | 209 | 0 |
| IPR costs | 0 | 0 | 0 | 0 | 0 | 0 |
| Travel & expenses | 0 | 0 | 0 | 0 | 0 | 0 |
| Payments to users | 31 | 31 | 0 | 31 | 31 | 0 |
| Contingency | 77 | 537 | 461 | 77 | 537 | 461 |
| Decommissioning | 0 | 0 | 0 | 29 | 29 | 0 |
| Other | 138 | 158 | 20 | 235 | 230 | (5) |
| **Total costs** | **4,387** | **4,759** | **371** | **4,976** | **5,338** | **361** |

Detailed expenditure is shown in Appendix D at project activity level.

# 6 BANK ACCOUNT

The Celsius project bank statement is shown in Appendix E. The statement contains all receipts and payments associated with the project up to the end of November 2019.

# 7 SUCCESSFUL DELIVERY REWARD CRITERIA (SDRC)

There were six SDRC due in this reporting period, all of which were delivered according to plan. There is also one additional SDRC that has been delivered ahead of schedule, these are shown in Figure 7.1 below.

*Figure 7.1: Celsius SDRC due in this reporting period*

| SDRC evidence | Planned date | Forecast date |
|---|---|---|
| CW.3.1 – Publish customer survey report quantifying the acceptability of innovative retrofit cooling techniques on the Celsius website by September 2019 | Sep-19 | Delivered |
| CW.3.2 – Publish additional customer survey analysis evaluating the change, if any, in the acceptability of innovative retrofit cooling techniques by educating customers, on the Celsius website by September 2019 | Sep-19 | Delivered |
| TAW.3 – Publish low cost monitoring solution specification on the Celsius website by September 2019 | Sep-19 | Delivered |
| LDW.3.4 – Publish advertorials annually by October 2016, October 2017, October 2018 and October 2019 | Oct-19 | Delivered |
| TAW.4.2 – Develop and validate Thermal Ratings Tool using retrofit cooling trial data, and publish on Celsius website by November 2019 | Nov-19 | Delivered |
| LDW.4.4 – Participate at four annual LCNI conferences from 2016 to 2019 | Nov-19 | Delivered |
| LDW.5.4 – Hold annual knowledge sharing events in September 2016, 2017, 2018 and December 2019. Provide one-to-one briefing sessions | Dec-19 | Delivered |

The status of the evidence for all Celsius SDRC is shown in Appendix B. Progress against the SDRC and the project plan will continue to be monitored.

# 8 LEARNING OUTCOMES

### Monitoring equipment

The monitoring equipment used in the trial was fit for purpose and provided a good level of data. As previously mentioned, there were some issues during the project with some of the equipment but the issues were all rectified, and any missing/incomplete data removed from the analysis. These issues did, however, provide some valuable insight into what the functional specification should be for a BAU monitoring solution. This is extremely important as the data needs to be reliable and consistent to allow a Celsius rating to be applied with confidence.

### Cable backfill sites

As previously mentioned, this was delayed due to data issues and exacerbated by excavation contractor issues. An alternative contractor was sourced to carry out the installations and all the sites were completed successfully. The cable backfill sites are currently being analysed.

The actual process itself was much more involved and time consuming than traditional cable backfilling techniques taking approximate 5 times longer to complete. This is due to the mixing process and the large amount of water required to get the mixture to the correct consistency. This method also requires an additional site visit to apply a finishing layer after a few weeks. Full details of the process can be found here: cable cooling systems.

## Noise

There has been one further report of noise from an active cooling site, specifically associated with the re-designed slimline Passcomm unit (positive pressure cooling fan system). This was reported by a passer-by who was aware of a fault at a nearby substation (unrelated to Celsius) and was concerned the noise indicated a potential developing fault. The passer by wasn't particularly disturbed by the noise, and no nearby residents have made any complaints. Subsequent Electricity North West investigations revealed that noise levels associated with the new slimline unit were slightly higher than anticipated, but were within acceptable limits and unlikely to cause disturbance to those living in close proximity to the substation. However, the new design was intended to deliver quieter operation and, as such, discussions concerning noise levels from the slimline unit are ongoing with the manufacturer. In light of the above, it is not proposed to reduce fan settings to lower noise because this is the only slimline unit installed on the network and it is therefore important that we obtain data that can be directly compared with the cooling efficiency of the original unit. However, this case remains under review and we will carry out any necessary adjustments to fan settings should there be a report of noise disturbance.

## Thermal Ratings Tool

As outlined in the previous report, the Thermal Ratings Tool was initially intended to be in three different formats. Two of these require information already available (the 'simplified Celsius rating' and the 'full Celsius rating') and one that requires measurement equipment to be fitted on site (the Celsius 'daily rating'). From the analysis conducted so far, we have concluded that the two non-measurement types yield too low a confidence level to be comfortably used. This is due to the on-site variables which cannot be accurately estimated.

The Thermal Ratings Tool has been continually worked on including development and validation using retrofit cooling trial data. The Thermal Ratings Tool is split into the following parts:

- Instructions – informs the user about the purpose and functionality of the tool.
- Celsius Intervention tool – this is where the user would input site information, and see the predicted capacity release based on the options chosen.
- Celsius Rating tool - this model calculates Celsius rating from user input data, including monitored data from site, and site information. This model only requires measured surface temperature, ambient temperature and load data as input variables. This then gives the user a Celsius Rating in kVA.
- Celsius Rating tool – weather - this model calculates Celsius rating from user input data, including monitored data from site, and site information. This model calculates a more informed Celsius rating by including weather data. This then gives the user a Celsius rating in kVA.

## Cooling performance

The initial evaluation of thermal data indicates that the majority of the cooling sites are showing a reduction in the temperature of the transformer, but with varying levels of success. Unsurprisingly the active cooling sites are showing the greatest reduction in temperature. The highest temperature reduction is at the substation where both a Passcomm unit and an Ekkosense unit are installed (Portland Grove), which proves the theory that they can work together effectively. The plan for this site is to switch each of the units for a period of time, so that the transformer is cooled solely by each of the two systems for a similar period. This exercise will provide a direct comparison in the same substation.

This positive, early finding suggests there may be benefit in deploying both systems in certain substations, to provide even greater capacity release. The scenarios where this would be beneficial from a financial perspective may be rare; however, some substations are situated in places that make the logistics of changing the transformer very difficult and expensive. In these circumstances, this approach could potentially be a better, more cost effective option.

Details of the performance of the individual technology types can be found in section 2.3 of this report.

### Active cooling installations

An additional cooling unit has been installed in this reporting period. This was the slimline Passcomm unit. The purpose of this is to see if it can be used instead of the original Passcomm unit whilst delivering the same cooling. The unit is smaller, lighter and has a lower level of air filtration. The expected benefits of this are:

- Easier installation
- Less impact on working substation space
- Quieter operation
- More efficient operation

### MDI Readings

Currently, when a substation is found to have high MDI readings, a data logger is installed on site to check the validity of the MDI reading, and then a decision is made based on that. This process involves going to site, setting up the data logger and leaving it to record information for 2-3 weeks. After this period the data logger will be collected from site and the information extracted on return to the office. In summary it requires 2 site visits and 2-3 weeks to obtain 2-3 weeks of data.

One of the benefits of having the Celsius monitoring equipment on site is that information about the state of the substation can be seen remotely. With this in mind, a number of Celsius sites were fitted with data loggers to see how the data compared with the Celsius data. The data aligned very well and gave us confidence that this could be used instead of traditional data loggers. Since this check, there have been several requests from design engineers for Celsius data. They were sent a years' worth of load data in a matter of minutes, to give a much more complete overview of the load profile of the transformer over the year.

### Celsius test survey

The results of the main Celsius 'trial' survey are fully reported in the Celsius Customer Survey Report**.** This document disseminates the key findings of the survey, as summarised in Section 2.4 of this report. Section 5 of the Customer Survey Report also documents the key learning outcomes from each phase of the customer research activity, focused on describing how DNOs and their stakeholders can capitalise on this process by identifying and responding to challenges that may arise in future customer engagement activities of a similar nature. The key lessons learned are:

- Re-engaging survey respondents can be challenging
- An imbalance in the number of active and passive sites led to fewer customer responses for active sites than planned
- Cash is the most popular, therefore the most appropriate form of incentive in recruiting customers into this form of research
- It is important but challenging to represent customers in close proximity to interventions

Initial evaluation of thermal data indicates that the majority of Celsius cooling sites are showing a reduction in transformer temperature with the active cooling sites showing the greatest reduction. However, noise complaints associated with active cooling, specifically units installed in close proximity to domestic properties, suggests that certain active techniques, particularly when set to deliver optimum cooling, may not always be appropriate for all substations in all residential areas. The customer survey also provides evidence that customers residing close to substations where active cooling techniques have been trialled are less accepting of these technologies than those near to passive sites and, unsurprisingly, those in closest proximity to the substations are most likely to be impacted. The key customer workstream learning outcome from this project is that customer sensitivity, particularly in relation to noise, should be a determining factor in the choice of a cooling technique in the transition to BAU.

# 9 INTELLECTUAL PROPERTY RIGHTS (IPR)

Electricity North West is following the default IPR arrangements. No IPR have been generated or registered during the reporting period. The IPR implications of forthcoming project deliverables are currently being considered and will be reported in the next project progress report.

# 10 RISK MANAGEMENT

Electricity North West employs recognised tested and audited risk management systems and processes as part of its day-to-day operations. Celsius benefits from this approach, which is further refined to fully accommodate the requirements of Celsius and to incorporate learning from previous experience in the delivery of LCN Fund and NIC projects. This approach considers risks and issues that are BAU and those specifically related to Celsius, all of which are documented in a common format.

The project risks identified in the Celsius bid document have been migrated into the Celsius delivery risk register and reviewed, and are still valid. Risks are monitored on a continuous basis, including the potential risks that were documented in the full submission. Project risks are described in detail in Appendix A.

Changes since the last reporting period:

**R004: Monitoring equipment reliability**

There is a risk of monitoring equipment failure leading to a requirement for additional resource to attend site to fix or replace.

**Update:** Some sites did require additional visits to rectify issues but sufficient data for the project has now been collected, therefore the risk is closed.

**R025: Potential data quality issues with monitoring data**

There is a risk that cooling data could be missing/inaccurate.

Analysis of cooling data has highlighted a few data issues which have required intervention/ site visits to rectify.

Ricardo now manually check the data monthly to ensure any further issues are identified and fixed in a timely manner.

ASH Wireless has been requested to visit some of the problem sites with Electricity North West to ensure there are no underlying issues going forward.

**Update:** Faulty equipment was sent to ASH Wireless for analysis, and problems with water ingress and batteries coming to end of life were identified. Only a small number of units were affected and the issues were rectified allowing sufficient data collection, so no further action is required. This should be a consideration when selecting equipment for BAU. Risk Closed

# 11 NEW RISKS IDENTIFIED CONSISTENCY WITH FULL SUBMISSION

At the end of this reporting period, it can be confirmed that the Celsius project is being undertaken in accordance with the full submission.

# 12 ACCURACY ASSURANCE STATEMENT

This document has been reviewed by a number of key business stakeholders. The project team and select members of the Celsius project steering group, including the lead member of the bid development team, have reviewed the report to ensure its accuracy. The narrative has also been peer-reviewed by the Electricity North West Engineering and Technical Director.

The financial information has been produced by the Celsius project manager and the project's finance representative, who reviewed all financial postings to the project each month to ensure postings are correctly allocated to the appropriate project activity. The financial information has also been peer-reviewed by the Electricity North West Finance Manager.

The Engineering and Technical Director has approved issue of this document.

# 13 APPENDICES

## Appendix A: Status of all risks

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| R001 | Project partner mobilisation | Mobilisation | There is a risk that the project partners are not able to mobilise their resources in time because of other commitments leading to a delay in achieving potential milestones, which could have a project reputation and financial repercussion. | 0 | 0 | Suitable partnership agreements that ensure collaborative working, value for customers' money and achievement of learning objectives in a timely manner have been identified for all partners.<br>A project initiation document will be issued to the project partners to ensure that all parties are ready.<br>Contingency: Electricity North West will seek new partners should existing partners fail to mobilise.<br>Risk closed December 2016 following successful mobilisation. | 0 | 0 | Closed |
| R002 | Thermal sensor lead time | Technology | There is a risk that the lead-time for delivery, installation and/or configuration of the thermal monitoring sensors may lead to a delayed start on the monitoring trial. | 0 | 0 | Project plan specifies that a purchase order will be raised to procure the sensors allowing the partner to begin manufacture.<br>Regular meetings/reports to track progress against plan.<br>Commitment to additional operational resource should any delays occur to the installation, testing and commissioning programme.<br>Contingency: Flexibility is built into the installation programme; phased installation plan starts in autumn 2016 to be completed by spring 2017. | 0 | 0 | Closed |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | A full year's data for comparison with the cooling trial could be gained by overlapping these tasks more than planned.<br><br>Risk closed October 2016 when installation commenced. | | | |
| R003 | Inadequate existing load monitoring | Technology | There is a risk that sites with existing load monitoring may not be suitable or the existing monitoring units may require a software/ hardware update for the sites to be included in the Celsius project. | 0 | 0 | Allowance in budget and plans to move some existing load monitors if necessary.<br><br>Communications with manufacturers of existing equipment to identify solutions early. Allowance in budget and plans to carry out updates.<br><br>Contingency: New power monitoring units, supplied by project partner Ash Wireless will be installed where this is deemed most cost-effective.<br><br>Risk closed December 2016 – existing load monitoring units were found to be unsuitable and planned contingency was initiated. | 0 | 0 | Closed |
| R004 | Monitoring equipment reliability | Technology | There is a risk of monitoring equipment failure leading to a requirement for additional resource to attend site to fix or replace. | 2 | 4 | Phased rollout of equipment to ensure systems are working properly before all sites are installed.<br><br>Some remote monitoring and diagnostics will be possible, for example of performance of the communications and through data validation.<br><br>Contingency: Budget for additional resource.<br><br>Update: Impact reduced to moderate due to large amount of trial data successfully gathered | 2 | 3 | Closed |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Update: Some sites did require additional visits to rectify issues but sufficient data for the project has now been collected, therefore the risk is closed. | | | |
| R005 | Project installation impact on BAU | Technology | There is a risk that internal transformer monitoring or retrofit cooling methods (and their installation) may have an impact on the network as a whole leading to disruption or outage. Probability is low (1) due to successful testing and rollout. | 1 | 5 | The technical and installation issues and requirements will be assessed before any installation is carried out, which should identify any risk at an early stage to allow this to be mitigated, or for the technology to be discounted from the trial.<br>Contingency: If any issues occur, then the technology will be removed and made good at the earliest signs. | 1 | 5 | Open |
| R006 | Poor communi-cations signal coverage | Technology | There is a risk that there is inadequate signal at sites and communication outages or battery life issues could prevent data being sent to data management system for the duration leading to gaps in data sets. | 2 | 2 | The data communications will use 'roaming' SIM cards, the signal will be checked prior to installation, if required an aerial will be installed. If inadequate signal the site will be excluded from the trial.<br>Data will be sent once a day, any failures to send data will be identified automatically and corrected.<br>Data being received will be continuously validated to identify missing or unrealistic data, so issues will be identified quickly.<br>Battery life requirements have been defined and agreed at an early stage.<br>Contingency: Select sites without signal issues. Where gaps in data | 2 | 2 | Open |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | occur, analysis can be carried out on the remaining data; where necessary, missing data will be simulated.<br><br>Sensors that are still required will be replaced. | | | |
| R007 | Availability of technology providers | Technology | There is a risk that a lack of suitable retrofit cooling technologies and vendors may result in a poor response to invitations to tenders, leading to reduced competitiveness of quotes and reduced value for money.<br><br>Impact set to moderate (3) due to good response from call for innovation**.** | 2 | 3 | A call for innovation in Celsius development showed that products are available from a number of vendors.<br><br>A thorough market search will identify as many options as possible.<br><br>Contingency: Early vendor engagement.<br><br>If there is significant difficulty in identifying enough suitable technology vendors, then the cooling trial can be implemented with fewer technology types.<br><br>Risk now closed – Invitations to tender led to sufficient providers being selected to install suitable cooling technologies. | 2 | 3 | Closed |
| R008 | Installation delay of cooling technologies | Technology | There is a risk that the lead-time for the retrofit cooling techniques may lead to a delay in the installation of this technology and delay the start of the monitoring trial. | 3 | 4 | During technology selection, each technology will be assessed based on a number of characteristics, including readiness and deployment issues. This will reveal early potential issues.<br><br>Contingency: Flexibility is built into the installation programme with a phased installation plan starting in winter 2018 to be completed by summer 2018.<br><br>If delays are unavoidable, then technology analysis could be carried | 3 | 4 | Closed |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | out using less than one year's data. The limitations to the assessment caused by this will be identified.<br><br>Retrofit cooling technology companies appointed and scheduled for installation to be complete to plan. | | | |
| R009 | Customer impact of retro fit technology | Customer | There is a risk that customers on trial networks might notice a visual or audible affect from a local retrofit intervention, or be inconvenienced during the installation of the technology.<br><br>This risk might result in a breakdown in customer relationship and reputation. | 3 | 4 | To ensure that there is no public or reputation damage to Electricity North West; Celsius will embed a process to quickly and appropriately manage any customer impacts.<br><br>Contingency: Customer impact will be carefully considered during site selection. This will mitigate against deploying specific interventions on certain networks where the risk of an adverse customer impact, specific to the customer/network/asset/ environment type, from a particular technique, is considered excessively high. | 3 | 4 | Open |
| R010 | Attendance at project events | Learning dissemination | There is a risk that attendance at events may be low due to the number of projects and knowledge dissemination events already taking place.<br><br>Learning may be inhibited due to stakeholders having different interests and learning styles | 2 | 3 | Electricity North West will try where possible to merge dissemination events and choose dissemination channels optimised to achieve maximum reach and coverage.<br><br>Dissemination will be carried out through multiple communication channels including 121 briefings<br><br>Contingency: Interested parties are able to contact the project team for any queries and request additional information. | 2 | 3 | Open |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| R011 | Governance changes | Closedown | There is a risk that new obligations and guidance will be released on key deliverables, such as the closedown report (e.g. the need to get it peer-reviewed) leading to a longer preparation and review period required. | 3 | 3 | Communication channels from Ofgem will be monitored and any updates to such requirements identified as early as possible.<br><br>Contingency: Additional time is allowed for closedown reporting and a DNO partner embedded in the project to provide ongoing review and challenge throughout project delivery. | 3 | 3 | Open |
| R012 | Project progress report | Project Management | There is a risk that the financial reporting contained in the six-monthly project progress report (PPR) may be inaccurate due to the requirement to submit the document on the 9th of each reporting month.<br><br>Electricity North West's finance system compiles project costs on the fifth working day of the subsequent month. This results in a small window for internal approval before release to Ofgem. | 3 | 4 | The risk has been highlighted to the Electricity North West finance team and the approval managers, and a delivery plan is agreed for each reporting period however there is still a risk that all finances are not up to date for the last month of the reporting period.<br><br>This has been brought to the attention of Ofgem.<br><br>Several reports have now been issued with the financial information up-to-date. | 3 | 4 | Open |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| R013 | Retrofit monitoring resource | Project Management | There is a risk that there is limited resource available to deliver the installation of retrofit monitoring. This may lead to a prolonged installation plan or to increased cost due to premium time working. | 4 | 4 | Two teams have been acquired for the installation period and we are seeking a third team. The installation plan is based upon two installation teams, working normal hours. If a third team is sourced this will reduce the likelihood of this risk. Also if there is any delay to the plan there is the option for premium time working to increase outputs and catch up with the plan.<br>Update: Closed due to completion of monitoring installation.<br>Risk closed. | 4 | 4 | Closed |
| R014 | Monitoring equipment firmware updates | Technology | There is a risk that the monitoring equipment software will need updating due to unforeseen bugs arising during the monitoring trial. | 3 | 4 | To reduce the impact of this risk, project partners ASH increased the functionality of the HUB monitoring device to allow for over the air (OTA) software upgrades. This has been tried and tested successfully. | 2 | 4 | Open |
| R015 | Cooling technology effectiveness | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that some of the cooling technologies deployed will have little impact, resulting in reduced learning. | 2 | 4 | Electricity North West is working with Ricardo to test a number of the cooling technologies in a lab environment prior to deploying onto the network.<br>Ricardo will produce a test report with recommendations for deployment.<br>A report documenting the findings and passive cooling technologies recommendations (dated 24 January 2018) is published on the Celsius website. | 2 | 4 | Open |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| R016 | Availability of operational resources. | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that operational resources may not be available to supervise the cooling installation contractors working in live substations. This would have the effect of delaying the retrofit active cooling work beyond the intended deadline of June 2018. | 2 | 4 | By negotiating a new contract with an outside agency and agreeing the programme of work this risk should be mitigated.<br>The contract has now been negotiated and operational resource is now available.<br>The risk remains open until the work is complete.<br>The work is now complete and risk has been mitigated.<br>Risk closed. | 1 | 4 | Closed |
| R017 | Completion of the thermal flow study by NPL | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that the National Physical Laboratory will not complete the thermal flow study step 2 ('Thermal Flow Modelling Work phase 2') by end-May 2018. This has the effect of potentially delaying the retrofit passive cooling work at 20 substations beyond the intended deadline of end of June 2018. | 4 | 2 | By issuing a section of the work earlier and by making use of additional resources to implement the passive cooling work this risk should be mitigated.<br>NPL has now issued the final report on the 31 May 2018.<br>Risk closed. | 4 | 2 | Closed |
| R018 | Temperature factors report data will not provide sufficient understanding | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that the Secondary Network Asset Temperature Factors Report will not provide a | 4 | 4 | This risk to the project is the subject of ongoing discussions between Electricity North West and Ricardo so that strategies may be developed to overcome this problem. | 4 | 4 | Closed |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| | of thermal behaviour. | | detailed understanding of the thermal behaviour of substation assets (in particular LV cables and transformers) under different asset environment conditions. | | | The Temperature Factors Report has been issued and reviewed. It meets with our requirements.<br><br>Risk closed. | | | |
| R019 | LV loading of cables and transformers will be delayed due to lack of operational resource | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that the LV loading of cables and transformers to improve data quality will be delayed due to lack of operational resource | 3 | 3 | The risk to the project will be mitigated by using Electricity North West operational teams whenever possible, to carry out the operational procedures necessary.<br><br>50% of the loadings were carried out during June and July to increase the loading of smart transformers in particular, to ensure that enough quality data was available to enable the hot spot temperature report to be published. Other loading is continuing.<br><br>Loading requirements completed by Electricity North West operational teams.<br><br>Risk closed. | 2 | 2 | Closed |
| R020 | Two UKPN sites delayed | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that the two UK Power Networks cooling sites will not be completed in time to be properly assessed. | 3 | 3 | Electricity North West solicitor to engage further with the UK Power Networks' solicitor to encourage a timely solution.<br><br>UK Power Networks has indicated that it cannot complete the legal requirements in a timely manner therefore the units have been installed in Electricity North West's region.<br><br>Risk closed. | 3 | 3 | Closed |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| R021 | Cooling fan failure | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that if the forced cooling fans fail, the substation temperatures may become excessive. This is further exacerbated by the fact that some existing passive vents need to be blocked off to allow optimal airflow for the active cooling unit. | 2 | 2 | Utilising the Electrotech NX12 RTU as a method of remotely sending a cooling fail alarm is being designed to mitigate the problem. | 2 | 2 | Open |
| R022 | Grid Key maps | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that there will be a delay in receiving load (amps) data because the iHost server located in Electricity North West's control centre is not configured to receive data from the cables in the substations. | 3 | 3 | All commissioning sheets of the Grid Key units have been resent to the appropriate IT engineers to ensure that reconfiguration can be carried out and site data also being validated.<br>Configuration completed successfully.<br>Risk closed. | 3 | 3 | Closed |
| R023 | Ekkosense control equipment instability | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that the retrofit cooling plan will be delayed since the Ekkosense control equipment will not perform to its specification. | 3 | 3 | Ekkosense is in consultation with the suppliers of the control units. Suspect induced voltages between the mains supply and control cables.<br>The Ekkosense units have however been set to 100% fan speed in the interim – which will provide good cooling data short term. | 2 | 2 | Closed |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Contingency: The sum of £69,300 has been withheld from Ekkosense until this matter is remedied<br><br>Temperature control units have been replaced at all sites with a different type of unit which is functioning correctly.<br><br>Risk closed. | | | |
| R024 | Installation of cooling equipment not effective | Technology / Trials & Analysis /Learning & Dissemination | There is a risk that the monitoring data will be inconsistent as some of the retrofit cooling equipment was not installed in the optimal position due to substation configuration restraints. | 3 | 3 | In some instances, the position of Passcomm units is being changed to more effectively cool the transformer.<br><br>In some instances, the Ekkosense venting hoses are being reinstalled to more effectively cool the transformer and in three instances sub-optimal Ekkosense installations are being modified.<br><br>The necessary adjustments have now been made to make the installations as effective as possible.<br><br>Risk closed. | 3 | 3 | Closed |
| R025 | Potential data quality issues with monitoring data | Technology | There is a risk that cooling data could be missing/ inaccurate.<br><br>Analysis of cooling data has highlighted a few data issues which have required intervention/site visits to rectify. | 2 | 3 | Ricardo will now manually check the data fortnightly to ensure any further issues are identified and fixed in a timely manner.<br><br>ASH Wireless has been requested to visit some of the problem sites with Electricity North West to ensure there are no underlying issues going forward.<br>Update: Faulty equipment was sent to ASH for analysis. Problems with water ingress and batteries coming to end of life identified. Only a small number of | 1 | 3 | Closed |

| Risk register ID | Risk title | Project phase/ workstream | Description | Probability score | Impact score | Mitigating action/contingency action | Revised probability score | Revised impact score | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | units affected which have been rectified and sufficient data collected so no further action is required. This should be a consideration when selecting equipment for BAU. Risk Closed | | | |

## Appendix B: Summary of project SDRC

| SDRC evidence | Planned date | Status |
|---|---|---|
| CW.1 – Send customer engagement plan and data privacy statement to Ofgem by June 2016 | Jun-16 | Delivered |
| LDW.2.1 – Publicise Celsius within Electricity North West via the Volt intranet site, email bulletins and/or Newswire company magazine by June 2016, March 2017, March 2018, March 2019 and March 2020 | Jun-16 | Delivered |
| LDW.6.1 – Issue project progress reports in accordance with Ofgem's June and December production cycle and publish on the Celsius website | Jun-16 | Delivered |
| LDW.1 – Launch Celsius project website by July 2016 | Jul-16 | Delivered |
| LDW.5.1 – Hold annual knowledge sharing events in September 2016, 2017, 2018 and December 2019. Provide one-to-one briefing sessions | Sep-16 | Delivered |
| LDW.3.1 – Publish advertorials annually by October 2016, October 2017, October 2018 and October 2019 | Oct-16 | Delivered |
| LDW.4.1 – Participate at four annual LCNI conferences from 2016 to 2019 | Nov-16 | Delivered |
| CI.3.1 – ENA workshop with DNOs held by November 2016 (to agree areas of changes to Engineering Recommendations P15 and P17) | Nov-16 | Delivered |
| LDW.6.2 – Issue project progress reports in accordance with Ofgem's June and December production cycle and publish on the Celsius website | Dec-16 | Delivered |
| CI.3.2 – Publish any areas for change identified at the ENA workshop and publish change proposal options to ER P15 and ENA ER P17 on Celsius website by February 2017 | Feb-17 | Delivered |
| LDW.2.2 – Publicise Celsius within Electricity North West via the Volt intranet site, email bulletins and/or Newswire company magazine by June 2016, March 2017, March 2018, March 2019 and March 2020 | Mar-17 | Delivered |
| TW.2.1 – Hold retrofit cooling workshop by May 2017 | May-17 | Delivered |
| LDW.6.3 – Issue project progress reports in accordance with Ofgem's June and December production cycle and publish on the Celsius website | Jun-17 | Delivered |
| TW.2.2 – Review of highest scoring technologies, circulate workshop outcomes to DNOs and publish on the Celsius website by July 2017 | Jul-17 | Delivered |
| CW.2.1 – Deliver customer focus group workshop by July 2017 | Jul-17 | Delivered |
| TW.1 – Publish equipment specifications and installation reports by September 2017 | Sep-17 | Delivered |
| LDW.5.2 – Hold annual knowledge sharing events in September 2016, 2017, 2018 and December 2019. Provide one-to-one briefing sessions | Sep-17 | Delivered |

| SDRC evidence | Planned date | Status |
|---|---|---|
| LDW.3.2 – Publish advertorials annually by October 2016, October 2017, October 2018 and October 2019 | Oct-17 | Delivered |
| TAW.2 – Publish thermal flow study report and initial recommendations for substation design on Celsius website by November 2017 | Nov-17 | Delivered |
| LDW.4.2 – Participate at four annual LCNI conferences from 2016 to 2019 | Nov-17 | Delivered |
| CW.2.2 – Publish lessons learned from testing customer communication materials on Celsius website by December 2017 | Dec-17 | Delivered |
| LDW.6.4 – Issue project progress reports in accordance with Ofgem's June and December production cycle and publish on the Celsius website | Dec-17 | Delivered |
| LDW.2.3 – Publicise Celsius within Electricity North West via the Volt intranet site, email bulletins and/or Newswire company magazine by June 2016, March 2017, March 2018, March 2019 and March 2020 | Mar-18 | Delivered |
| LDW.6.5 – Issue project progress reports in accordance with Ofgem's June and December production cycle and publish on the Celsius website | Jun-18 | Delivered |
| TAW.1.1 – Raw temperature monitoring data to be available from July 2017; and retrofit cooling monitoring data to be available from September 2018 | Sep-18 | Delivered |
| TAW.1.2 – Publish asset temperature behaviour analysis report on Celsius website by September 2018 | Sep-18 | Delivered |
| LDW.5.3 – Hold annual knowledge sharing events in September 2016, 2017, 2018 and December 2019. Provide one-to-one briefing sessions | Sep-18 | Delivered |
| TAW.4.1 – Develop Thermal Ratings Tool using monitoring data to evaluate site capacity on Celsius substations by October 2018 | Oct-18 | Delivered |
| TAW.6 – Publish asset health study report on Celsius website by October 2018 | Oct-18 | Delivered |
| LDW.3.3 – Publish advertorials annually by October 2016, October 2017, October 2018 and October 2019 | Oct-18 | Delivered |
| TW.3 – Publish cooling equipment specifications and installation reports by November 2018 | Nov-18 | Delivered |
| LDW.4.3 – Participate at four annual LCNI conferences from 2016 to 2019 | Nov-18 | Delivered |
| LDW.6.6 – Issue project progress reports in accordance with Ofgem's June and December production cycle and publish on the Celsius website | Dec-18 | Delivered |
| LDW.2.4 – Publicise Celsius within Electricity North West via the Volt intranet site, email bulletins and/or Newswire company magazine by June 2016, March 2017, March 2018, March 2019 and March 2020 | Mar-19 | Delivered |

| SDRC evidence | Planned date | Status |
|---|---|---|
| LDW.6.7 – Issue project progress reports in accordance with Ofgem's June and December production cycle and publish on the Celsius website | Jun-19 | Delivered |
| CW.3.1 – Publish customer survey report quantifying the acceptability of innovative retrofit cooling techniques on the Celsius website by September 2019 | Sep-19 | Delivered |
| CW.3.2 – Publish additional customer survey analysis evaluating the change, if any, in the acceptability of innovative retrofit cooling techniques by educating customers, on the Celsius website by September 2019 | Sep-19 | Delivered |
| TAW.3 – Publish low cost monitoring solution specification on the Celsius website by September 2019 | Sep-19 | Delivered |
| LDW.3.4 – Publish advertorials annually by October 2016, October 2017, October 2018 and October 2019 | Oct-19 | Delivered |
| TAW.4.2 – Develop and validate Thermal Ratings Tool using retrofit cooling trial data, and publish on Celsius website by November 2019 | Nov-19 | Delivered |
| LDW.4.4 – Participate at four annual LCNI conferences from 2016 to 2019 | Nov-19 | Delivered |
| TAW.5 – Publish the cost benefit analysis and carbon impact assessment reports, Celsius business case and buy order of retrofit cooling techniques on Celsius website by December 2019 | Dec-19 | On track |
| LDW.5.4 – Hold annual knowledge sharing events in September 2016, 2017, 2018 and December 2019. Provide one-to-one briefing sessions | Dec-19 | Delivered |
| TAW.4.3 – Develop and validate Thermal Ratings Tool, combining input data from the monitoring and cooling trials, and publish user guide on Celsius website by January 2020 | Jan-20 | On track |
| CI.1.1 – Produce Celsius closedown report by January 2020 | Jan-20 | On track |
| CI.3.3 – Incorporate relevant Celsius outputs into change proposal options for ER P15 and ER P17 and hold workshop with DNOs by January 2020 | Jan-20 | On track |
| LDW.2.5 – Publicise Celsius within Electricity North West via the Volt intranet site, email bulletins and/or Newswire company magazine by June 2016, March 2017, March 2018, March 2019 and March 2020 | Mar-20 | On track |
| CI.1.2 – Complete and publish peer review of Celsius closedown report by March 2020 | Mar-20 | On track |
| CI.2 – Publish Electricity North West's approach to managing thermal constraints at distribution substations on the Celsius website by March 2020 and train planners/operational engineers on new codes of practice | Mar-20 | On track |
| CI.3.4 – Submit proposals for changing ER P15 and ER P17 to ENFG by March 2020 | Mar-20 | On track |

## Appendix C: Project direction budget

Project direction ref: ENWL / Celsius / 9 December 2015, Annex 1: Project budget

| Cost Category | Cost (£) |
|---|---|
| **Labour** | 1,203,362.07 |
| | |
| **Equipment** | 1,333,237.01 |
| | |
| **Contractors** | 1,764,545.12 |
| | |
| **IT** | 209,136.13 |
| | |
| **IPR Costs** | 0 |
| | |
| **Travel & Expenses** | 0 |
| | |
| **Payments to users** | 30,815.94 |
| | |
| **Contingency** | 537,250.86 |
| | |
| **Decommissioning** | 29,357.76 |
| | |
| **Other** | 230,089.50 |
| | |
| **Total** | **5,337,794.39** |

| £000's<br>Excluding Partner Funding<br>Ofgem Cost Category | |
|---|---|
| **Labour** | **1,203** |
| Labour - project management | 469 |
| Labour - general | 288 |
| Labour - installation/commissioning | 446 |
| | |
| **Equipment** | **1,333** |
| Equipment - Materials | 349 |
| Equipment - General | - |
| Equipment - Monitoring Equipment | 984 |
| | |
| **Contractors** | **1,765** |
| Contractor - Project management | 74 |
| Contractor - Close Out | 25 |
| Contractor - Technology | 663 |
| Contractor - Trials & Analysis | 515 |
| Contractor - Thermal Flow Study | 97 |
| Contractor - BAU Process & Tool | 165 |
| Contractor - Customer Survey | 116 |
| Contractor - Customer Engagement Activities | 53 |
| Contractor - Cost Benefit Analysis | 32 |
| Contractor - Dissemination Activities | 24 |
| | |
| **IT** | **209** |
| IT - Hardware | - |
| IT - Software | 209 |
| | |
| **IPR costs** | **-** |
| IPR costs | - |
| | |
| **Travel & Expenses** | **-** |
| Travel & Expenses | - |
| | |
| **Payments to users** | **31** |
| Payments to users - Customer Survey | 31 |
| | |
| **Contingency** | **537** |
| Contingency | 537 |
| | |
| **Decommissioning** | **29** |
| Decommissioning | 29 |
| | |
| **Other** | **230** |
| Other - Rent | 57 |
| Other - Dissemination Activities | 149 |
| Other - Other | - |
| Other - DNO Workshop | 24 |
| | |
| **Total Project to date** | **5,338** |

## Appendix D: Detailed project expenditure

| £'000s<br>Excluding Partner Funding<br>Ofgem Cost Category | Spend to date | | | Total Project | | |
|---|---|---|---|---|---|---|
| | Actual | Plan | Variance | Forecast | Plan | Variance |
| **Labour** | **1,108** | **997** | **(111)** | **1,237** | **1,203** | **(33)** |
| Labour - project management | 423 | 368 | (55) | 476 | 469 | (7) |
| Labour - general | 221 | 198 | (22) | 297 | 288 | (8) |
| Labour - installation/commissioning | 464 | 431 | (34) | 464 | 446 | (18) |
| **Equipment** | **1,325** | **1,333** | **8** | **1,335** | **1,333** | **(2)** |
| Equipment - Materials | 340 | 349 | 9 | 350 | 349 | (1) |
| Equipment - General | 0 | 0 | 0 | 0 | 0 | 0 |
| Equipment - Monitoring Equipment | 986 | 984 | (1) | 986 | 984 | (1) |
| **Contractors** | **1,517** | **1,499** | **(18)** | **1,824** | **1,765** | **(59)** |
| Contractor - Project management | 42 | 53 | 12 | 77 | 74 | (3) |
| Contractor - Close Out | 0 | 2 | 2 | 25 | 25 | 0 |
| Contractor - Technology | 706 | 660 | (46) | 693 | 663 | (30) |
| Contractor - Trials & Analysis | 441 | 461 | 20 | 536 | 515 | (21) |
| Contractor - Thermal Flow Study | 91 | 97 | 6 | 91 | 97 | 6 |
| Contractor - BAU Process & Tool | 105 | 66 | (39) | 169 | 165 | (4) |
| Contractor - Customer Survey | 85 | 91 | 6 | 121 | 116 | (5) |
| Contractor - Customer Engagement Activities | 33 | 45 | 12 | 55 | 53 | (2) |
| Contractor - Cost Benefit Analysis | 0 | 3 | 3 | 32 | 32 | 0 |
| Contractor - Dissemination Activities | 14 | 20 | 6 | 24 | 24 | (0) |
| **IT** | **191** | **203** | **12** | **209** | **209** | **0** |
| IT - Hardware | 0 | 0 | 0 | 0 | 0 | 0 |
| IT - Software | 191 | 203 | 12 | 209 | 209 | 0 |
| **IPR costs** | **0** | **0** | **0** | **0** | **0** | **0** |
| IPR costs | 0 | 0 | 0 | 0 | 0 | 0 |
| **Travel & Expenses** | **0** | **0** | **0** | **0** | **0** | **0** |
| Travel & Expenses | 0 | 0 | 0 | 0 | 0 | 0 |
| **Payments to users** | **31** | **31** | **0** | **31** | **31** | **0** |
| Payments to users - Customer Survey | 31 | 31 | 0 | 31 | 31 | 0 |
| **Contingency** | **77** | **537** | **461** | **77** | **537** | **461** |
| Contingency | 77 | 537 | 461 | 77 | 537 | 461 |
| **Decommissioning** | **0** | **0** | **0** | **29** | **29** | **0** |
| Decommissioning | 0 | 0 | 0 | 29 | 29 | 0 |
| **Other** | **138** | **158** | **20** | **235** | **230** | **(5)** |
| Other - Rent | 34 | 23 | (11) | 57 | 57 | (0) |
| Other - Dissemination Activities | 96 | 119 | 23 | 154 | 149 | (5) |
| Other - Other | 0 | 0 | 0 | 0 | 0 | 0 |
| Other - DNO Workshop | 8 | 16 | 8 | 24 | 24 | 0 |
| **Total** | **4,387** | **4,759** | **371** | **4,976** | **5,338** | **361** |

| £'000s<br>Excluding Partner Funding<br>Ofgem Cost Category | Spend to date | | | Total Project | | |
|---|---|---|---|---|---|---|
| | Actual | Plan | Variance | Forecast | Plan | Variance |
| Labour | 1,108 | 997 | (111) | 1,237 | 1,203 | (33) |
| Equipment | 1,325 | 1,333 | 8 | 1,335 | 1,333 | (2) |
| Contractors | 1,517 | 1,499 | (18) | 1,824 | 1,765 | (59) |
| IT | 191 | 203 | 12 | 209 | 209 | 0 |
| IPR Costs | 0 | 0 | 0 | 0 | 0 | 0 |
| Travel & Expenses | 0 | 0 | 0 | 0 | 0 | 0 |
| Payments to Users | 31 | 31 | 0 | 31 | 31 | 0 |
| Contingency | 77 | 537 | 461 | 77 | 537 | 461 |
| Decommissioning | 0 | 0 | 0 | 29 | 29 | 0 |
| Other | 138 | 158 | 20 | 235 | 230 | (5) |
| **Total** | **4,387** | **4,759** | **371** | **4,976** | **5,338** | **361** |

## Appendix E: Project bank account

The bank statement below details all transactions relevant to the project in this reporting period. This includes all receipts and payments associated with the project effective up to the November 2019 month-end reporting period.

LLOYDS BANK

| As At: | | IUS / GBP<br>03-Jun-2019 | | Closing Ledger: | 1,432,354.49 |
|---|---|---|---|---|---|
| **Posting Date** | **Type** | **Details** | **Debits** | **Credits** | **Ledger Balance** |
| 04-Jun-2019 | Inter Account Transfer | TO A/C ,02749020 300002 | 65,540.67 | | 1,366,813.82 |
| 04-Jun-2019 | Inter Account Transfer | TO A/C ,02749020 300002 | 97,562.22 | | 1,269,251.60 |
| 10-Jun-2019 | Interest Payment | ITSTGOSS,ITST GOSS | | 888. 16 | 1 270, 139. 76 |
| 9-Ju-2019 | nterest ayme nt | TSTGOSS, ITST GOSS | | 706. 41 | 1 270, 846. 17 |
| 7-Ju-2019 | nter Account ransfer | CTAS,TO02749020 00002 | 42, 114. 38 | | 1 228, 731. 79 |
| 9-Au-2019 | nterest ayme nt | TSTGOSS, ITST GOSS | | 736. 16 | 1 229, 467. 95 |
| 9-Se-2019 | nterest ayme nt | TSTGOSS, ITST GOSS | | 730. 94 | 1 230, 198. 89 |
| 9-Oct-2019 | nterest ayme nt | TST(GROSS) , INTEREST (GROSS) | | 707.79 | 1,230,906.68 |
| 11-Nov-2019 | Interest Payment | INTEREST (GROSS) ,INTEREST (GROSS) | | 779.01 | 1,231,685.69 |
| 06-Dec-2019 | Inter Account Transfer | CELSIUS P4 ,TO 02749020 300002 | 72,069.79 | | 1,159,615.90 |
| 06-Dec-2019 | Inter Account Transfer | CELSIUS P5 ,TO02749020 00002 | 50, 759. 34 | | 1 108, 856. 56 |
| 6-Dec-2019 | nter Account ransfer | ELSI USP6, TO02749020 00002 | 40, 324. 18 | | 1 068, 532. 38 |
| 6-Dec-2019 | nter Account ransfer | ELSI USP7, TO02749020 00002 | 88, 900. 87 | | 979, 631. 51 |
| 6-Dec-2019 | nter Account ransfer | ELSI USP8, TO02749020 00002 | 53, 951. 63 | | 925, 679. 88 |
| | | **Totals** | 511, 223. 08 | 4 548. 47 | |
| | | **End of Report Ledger Balance** | | | 925, 679. 88 |

## Appendix F: Celsius communications register

The below updates have been added to the Celsius communications register for the reporting period up to November 2019.

| Date | Activity | Audience | Evidence |
|---|---|---|---|
| Oct 2019 | Advertorial | All stakeholders | Advertorial |
| Oct 2019 | Industry newsletter | All stakeholders | Newsletter page |
| Oct 2019 | LCNI conference | Industry stakeholders | Slide presentation |