FuturoFirma
Sustainability Consulting

Interim Report

Life-Cycle Carbon Impact Assessment of the *Respond* project

Document History

Project name	Life-Cycle Carbon Impact Assessment of the *Respond* project
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Version	Issue Date	Status	Issuer	Comments
d0.1	20th March 2018	*Draft*	Herb Castillo	*1st Draft issued for review by ENW*
1.0	06th April 2018	*Final*	Herb Castillo	*Final version incorporating ENW's comments*

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1 Introduction and objectives

Since 2015, Electricity North West (ENW) has been undertaking the innovative Respond project, funded via Ofgem's Network Innovation Competition (NIC) mechanism.

FuturoFirma Sustainability Consulting have been commissioned by ENW to undertake an assessment of the Carbon impact of Respond *vis-à-vis* traditional approaches for managing fault levels on the HV and EHV Distribution network. *(In this context 'Carbon' is an umbrella term for the suite of gases that contribute to the greenhouse effect, and should be interpreted as such throughout this report.)*

A full report setting out the results of the carbon assessment will be published in June 2018.

In advance of that final report, this interim report provides a framework for carbon assessment in the context of Respond. Specifically, this report sets out:

- ✓ The goal and scope of the carbon impact assessment
- ✓ The methodology for calculating the carbon impacts
- ✓ The emission sources for traditional approaches and from Respond
- ✓ The data sources for undertaking the assessment
- ✓ The next steps for the assessment

2 The Respond Project

The increasing amounts of distributed generation and the corresponding increase in fault levels poses significant challenges to operation of the electricity distribution network.

To mitigate these risks, the Respond project is trialling a Fault Level Assessment Tool (FLAT) which calculates potential fault current in near real time and then utilises one of the three innovative techniques shown in Figure 1 below, to manage fault current safely.

Adaptive Protection	•Also known as sequential tripping, this technique involves changing the sequence of operation of protection and circuit breaker switching such that the potential fault current is managed
I_S-Limiter	• A technology used globally (but not currently in the UK) that can quickly detects rapid rise in current when a fault occurs and respond to break the current
Fault Current Limiting (FCL) Service	•Entering into commercial agreements with custopmers to operarate equipment so as to offer fault level management services to DNOs.

Figure 1: Summary of the Respond techniques

Adaptive Protection is being trialled at seven sites and I_S-Limiters are being trialled at two sites and at five sensing sites. It was envisaged that FCL would be trialled at two United Utilities sites and three other sites, but this is currently uncertain.

3 The potential for Respond to have Carbon impacts

One of the fundamental hypotheses underpinning the Respond approach is that implementation of the Respond techniques to manage fault levels using existing assets, can defer replacement of switchgear and cables (i.e., extend their useful life), and accelerate the uptake of low carbon demand and renewable generation.

In this regard, Respond presents potential for carbon savings relative to the traditional approaches for managing fault levels - which with increasing connection of distributed generation could lead to failure of network equipment if the fault current rises above the fault rating.

Specifically, the Respond techniques can realise carbon savings by extending the useful life of the assets (i.e., avoiding the need for disposal of assets and carbon-intensive works to install new assets), and by facilitating faster connection of Low Carbon Technologies.

However, Respond will also have some carbon impacts/penalties associated with the techniques. For example, there will be embodied carbon in the Respond equipment – particularly the I_S-Limiter, carbon emissions arising from the works to install the Respond equipment, and operational carbon impacts attributable to the Respond techniques.

The net carbon impact of Respond therefore, will require the subtraction of Respond's carbon penalties from the carbon savings, and then comparing to the carbon impacts of traditional approaches.

4 The Carbon Assessment methodology

A Life Cycle Assessment (LCA) approach – in accordance with ISO 14044, is being applied for undertaking the carbon assessment. In brief, LCA assesses carbon emissions throughout an asset life cycle, i.e., from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal.

ISO 14044 specifies requirements and provides guidelines for life cycle assessment (LCA) including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, relationship between the LCA phases, and conditions for use of value choices and optional elements.

4.1 Goal definition and scope

As already mentioned in previous sections, the goal of this assessment is to assess the carbon impact of Respond techniques relative to BAU approaches for managing fault levels in the Respond trial area.

The assessment covers the carbon impact at all stages of the life cycle of the assets and activities that are called upon to manage fault levels under both traditional and the Respond approach.

The assessment is limited to the Respond Trial area, which is comprised of a number of EHV and HV substations where Adaptive Protection and IS-Limiter are being trialled.

It should be noted however, that in order to show the potential carbon impacts of Respond at wider scale, extrapolation techniques will be used to provide an estimate of Respond carbon impacts at DNO or/and GB network levels.

4.2 Emissions in scope

To ensure that the life cycle carbon impacts are captured and that a robust comparative analysis of the carbon impacts of traditional and Respond approaches for managing fault levels is undertaken, the following emissions are being considered.

Embodied emissions

As a significant proportion of the carbon impacts from Traditional and Respond's approach to managing faults (positive and negative) will emanate from the network assets, the concept of 'embodied' emissions is highly relevant.

In simplest terms, Embodied emissions refer to the carbon emitted to extract, refine, process, transport and fabricate a material or product. For this assessment, a cradle to grave (end of life) view of embodied emissions is being taken, which include the emissions from disposal of the assets.

Direct (operational) emissions

There will be emissions arising during operation of the different approaches for managing fault levels on the network. The most likely source of these is potential leakage/discharge of the interrupting medium in switchgears, i.e., oil, SF6. There may also be directly related carbon savings or carbon emissions arising from the actions of customers participating in the FCL service, e.g., by them using or turning-off equipment at certain times.

Indirect Emissions

Indirect impacts are those outside of Respond's intentional activity, but which are indirectly attributable to it. It is envisaged for example, that Respond may accelerate the connection of Low Carbon Technologies (LCTs). This could represent a carbon saving, which are being considered in the assessment.

4.3 Emission Sources

Section 4.2 above sets out the general categories of emissions that are being considered in this assessment. This section builds on that by setting out – more specifically, some of the assets and activities that will either provide a carbon saving or a carbon penalty. These sources are summarised in Table 1 below.

Table 1: Sources of carbon savings and carbon penalties

Sources of carbon emissions or/and carbon savings	
Network Assets	
Switchgear	Respond has potential to extend the useful life of switchgear, thus (potentially) reducing its whole life impact by delaying disposal of the asset.
Cable	Replacement of switchgear would typically also necessitate the replacement of 1km of cable. Therefore, if Respond extends the life of switchgear, then the need to replace cable is also negated, which could provide a carbon saving.
Respond Equipment	
IS-Limiter	The IS-Limiter and its enclosure, will have embodied carbon, thus representing a carbon penalty for Respond.
Adaptive Protection	The relay used to enable Adaptive Protection will only have minimal carbon impact. For completeness however, it will need to be considered.
Enabling works	
Civil Works	By extending the useful life of existing assets, and thus negating the need for civil works that would have been required to install new assets, Respond will provide a carbon benefit. In the Trial, civil works were undertaken to install the Respond equipment, particularly the IS-Limiter and enclosure. In BAU however, there are plans to place the IS-Limiters on *modular process skids*, which would render them portable – thus negating the need for extensive civil works.
Operational	
Discharge of interrupting medium	If Respond causes any change (reduction or increase) in the amount of leakages from switchgear, then the carbon impact of this will need to be considered. The size of the impact will be impacted by the type of interrupting medium, e.g., SF6 would carry a higher penalty than oil.

4.4 Calculating the net carbon impact of Respond interventions

In simplest terms, the net carbon impact of Respond is the difference between the carbon impact of Traditional approach to managing fault levels on the network and the carbon impact of the Respond intervention.

This is summarised in the following equation:

$$CI = \sum_{y=0}^{n} TA_{CI} - R_{CI}$$

Where:

CI is the comparative carbon impact of applying the Respond interventions

$\boldsymbol{TA_{CI}}$ is the carbon emissions from Traditional approach to managing faults

$\boldsymbol{R_{CI}}$ is the carbon emissions managing faults using the Respond approaches

Carbon emissions from Traditional Approaches

In calculating the Carbon Emissions from Traditional approaches ($\boldsymbol{TA_{CI}}$), a number of carbon sources will be considered, including:

- Carbon emissions arising from the disposal of failed/decommissioned network assets
- An apportionment of the embodied Carbon Emissions in the replacement assets
- Carbon emissions arising from works to decommission/replace network assets
- Carbon emissions arising from operation of the assets, including leakage of the switchgear interrupting medium.

Carbon emissions/savings from Respond intervention

In calculating the gross Carbon Emissions arising from the Respond intervention ($\boldsymbol{R_{CI}}$) a number of carbon sources and savings will be considered, including:

- Carbon savings arising from extension of the useful life of the network assets, i.e., delayed disposal
- Embodied carbon emissions in the Respond equipment, enclosures, etc.
- Carbon emissions arising from the works to install the Respond equipment
- Carbon emissions arising from operation of the assets, including leakage of the switchgear interrupting medium.
- Carbon emissions from any changes in customer use of electricity (as part of FCL participation)
- Carbon savings arising from quicker connection of low carbon technologies to the network

4.5 Data Sources

Trial data to inform the analyses is being obtained from the Respond project. Data relating to the traditional approach for managing faults on the Distribution will be obtained through engagement with ENW stakeholders.

However, the challenge for LCA carbon analyses typically come back from the lack of data on embodied carbon or/and the carbon impact of assets and processes. To mitigate these challenges, this assessment is drawing on diverse sources of data and proxies, summarised in Table 2 below.

Carbon data required	Data Source
Embodied carbon in Network Assets, e.g., including Switchgear and Cables	• Environmental Product Declaration by Manufacturers • Previous ENW LCN and NIC projects • Peer reviewed Research publications
Embodied carbon in Respond Assets, e.g., the IS-Limiter	• Environmental Product Declaration by Manufacturer
Civil Works	• Previous ENW LCN and NIC projects
Operational impacts	• Greenhouse Gas Protocol (www.ghgprotocol.org) • UK emission conversion factors for greenhouse gas company reporting (BEIS)

5 Summary and Next Steps

This report has set out a carbon impact assessment framework for undertaking a comparative assessment of the carbon impact of Respond interventions relative to traditional approaches for managing fault levels. The framework articulates the goal, scope, data sources and methodology for undertaking the requisite analyses.

This framework will now be applied for undertaking a comparative life cycle carbon assessment of Respond, and a report will be published in June 2018 with the final results.