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## NIA Project Annual Progress Report Document

### Date of Submission

Jul 2022

### Project Reference Number

NIA2\_NGESO006

## Project Progress

### Project Title

Resilient Electric Vehicle Charging: "REV"

### Project Reference Number

NIA2\_NGESO006

### Funding Licensee(s)

NG ESO - National Grid ESO

### Project Start Date

July 2021

### Project Duration

1 year and 6 months

### Nominated Project Contact(s)

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## Scope

- The project will analyse the impact of EV charging on grid short term frequency and voltage stability, and cascade fault prevention and recovery.
- An individual charger has a small impact on the grid. So, the analysis will therefore focus on categories of failures which could cause a correlated change by multiple chargers at the same time and/or local area.
- Brainstorming sessions with multiple stakeholders will be employed to identify the widest possible range of risks.
- EV charger response to power and control communication faults will be investigated by desk-based research and sample measurement.
- Identified risks will be analysed via desk research. From this a prioritised list of risks, in the form of an FMEA (Failure Mode Effect Analysis), will be produced for further investigation.
- Small scale grid simulation studies will be used to address uncertainties in the desk-based analysis.

## Objectives

The final outputs will be:

- A research report on potential causes of instability
- A research report on the effects of instability (NIA Project Completion Report)

## Success Criteria

The following will be considered when assessing whether the project is successful:

- Identification of one or more “black swan” risks
- Impact on ESO risk management processes related to EV and DSR
- Contribution to behind the meter DSR regulation processes
- The estimate potential financial benefit of EV DSR by 2030

## Performance Compared to the Original Project Aims, Objectives and Success Criteria

### Project Overview

Decarbonization of the economy will drive a transformation of the GB power system beyond that already caused by the growth in renewable energy.

By around 2040:

- peak demand is forecast to increase by 50% in all Future Energy Scenarios.
- demand for energy will at least double over the same time period in three out of four scenarios.

Much of this new demand will come from “smart” loads, controlled by software systems, whose behaviour will be very different to traditional system demand. Just as inverter-connected generation has brought new challenges for grid operation, the presence of these new types of smart load will introduce system risks that have not been seen before.

Project REV is investigating what these risks might be for one rapidly growing group of technologies, Electric Vehicle Charging (EVC) and Vehicle-to-Grid generation (V2G).

### Project Plan

The project consisted of two work packages:

Work Package 1 (WP1) – Cause (How could EV charging make the grid less stable?). Identify the mechanisms which may impact short term grid stability and recovery from incidents.

Work Package 2 (WP2) - Effect (How big could the impact be on the grid as EV adoption increases?). Model the impact on UK wide grid stability.

### Project Activities

#### WP1: Cause (How could EV charging make the grid less stable?)

The initial phase of WP1 consisted of a series of brainstorming sessions with industry experts with the objective of identifying as many ways as possible that EV charging could make the grid less stable. These sessions took the format of a technical introduction to the specific subject being discussed, follow by a structured brainstorm. Topics covered included:

- Power quality supplied to the charger
- Impact of power quality on the EV charger power converter, control, and protection systems
- Impact of the EV charger population on grid stability and operability
- Communication and control system inputs to the charger including market signals and aggregation
- Impact of the external control system, time, and cyber threats within the charger and on the grid

Each topic was explored from a wide range of stakeholder perspectives including Consumer, Distribution Network Operator, System Operator, Energy Supplier, ChargePoint Operator, Aggregator, Hacker, OEM, Communication Systems Operator.

Over 100 issues were identified in the brainstorming sessions. These were initially loosely grouped for analysis. The team then confirmed each issue was technically plausible and large enough to have a significant impact on grid stability. Tasks included:

- Confirming the technical viability of the mechanism;
- Identifying if similar issues had been encountered before with other technologies or in different regions around the world;
- Assessing appropriate impact thresholds which apply to the GB grid and estimating the number of EVs required to have a significant impact on the grid;

- Testing the fault ride-through performance of a sample EV smart charger to confirm hypothesised performance, including degradation of both power supply and communication links.

Our analysis then focused on issues which, if they were to remain unmitigated, could lead to power outages. This resulted in the grouping under topic headings in the WP1 report: “Six ways in which Electric Vehicle chargers present a risk to grid security” (available on the [Smarter Networks Portal](#)) The report dissemination was supported by a webinar with Q&A.

## WP2: Effect (How big could the impact be on the grid as EV adoption increases?)

WP2 is currently ongoing. It is analysing the six ways in which Electric Vehicle chargers present a risk to grid security identified within WP1.

Small scale grid simulation studies are being used to expand on the analysis from WP1. These studies are using the NGENSO full system model, known as the Off-Line Transmission Analysis (OLTA) model. This modelling allows consideration of wide area effects such as Voltage Stability, Transient Stability and Oscillatory stability.

We are also analysing measurement data from the grid during normal and anomalous operation. This includes:

- The impact of power steps related to time-of-use tariffs on grid frequency and the related balancing actions required to maintain operation within regulatory limits.
- Typical voltages in the LV network seen by EV chargers and the impact on fault ride-through

Our analysis is highlighting the limitations of current load modelling within grid analysis tools. Load response is becoming more complex as we move from directly connected loads to far greater use of power converters and software control systems.

We are also expanding on the WP1 analysis of the impact of mass EV and V2G adoption on OC6 demand control and the restoration process.

During WP2 we are estimating the potential financial benefit that EV DSR could provide by 2030, highlighting that smart charging, as opposed to unmanaged charging, has the potential to reduce costs for consumers. Project REV has highlighted a wide range of potential issues that could arise from mass adoption of smart EV charging and V2G. The aim of the project is to help address these issues before they have a detrimental impact within the GB grid and ensure that the benefits of smart charging can be realised, without major downsides.

Alongside the core WP2 activities the project REV team have also been sharing knowledge gained within the project in discussions with a range of teams within NGENSO, several DNOs and the ENA.

## **Required Modifications to the Planned Approach During the Course of the Project**

The project has proceeded in line with the general concept of the original plan. However, the breadth of the issues identified in WP1 and the complex nature of some, exceeded initial expectations.

Involving a wide range of experts in WP1 brainstorming was very helpful, however most tended to have expertise in their specific domain and none had prior familiarity with all topics discussed. To support wide-ranging analysis of the issues, a significant proportion of each brainstorming sessions had to be given over to training, to ensure a shared understanding of the topics under discussion, allowing wide-ranging informed debate. This was reflected through to the WP1 report, which also aims to provide relatively simple explanations of topics for those outside the specific domains.

The complete EV DSR system architecture is both complex and rapidly evolving, from products and services to market structures and other regulations. As a result, the initial concept of undertaking a detailed Failure Modes & Effects Analysis within WP1 was dropped in favor of a simple, accessible presentation of a scale of Red, Amber or Green (RAG) risks which was more appropriate to the fluid evolving market.

The wide number of issues identified in WP1 resulted in the need to prioritise activities in WP2. Emphasis was placed on topics where there was the greatest level of uncertainty and where simulation studies were viable within the scope of available modeling capabilities and the project timeline.

## **Lessons Learnt for Future Projects**

Project REV has been a first of its kind analysis of the potential impact of EVs on GB grid stability. It has identified a very wide range of issues and highlighted both the speed and the scale of the change which will occur over the next few years.

The challenge for future related projects is to address these issues, while learning from lessons identified within Project REV.

- Smart charging is a complex, rapidly evolving system of systems; knowledge sharing across technology domains is important to aid development of solutions enhancing resilience. A wide range of expertise was brought together, including transmission and distribution systems, communications, home energy systems and vehicle electronics design; this experience was then supplemented with contributions from a wide range of invited experts. This breadth of knowledge was essential to identify risks in this emerging and complex environment.
- There are a wide range of stakeholders, whose objectives are not naturally well aligned.
- Short term fixes can have unintended longer-term consequences, for example the German 50.2Hz problem mentioned in the WP1 report.
- Retrospective changes can be very slow and expensive to implement, for example the Accelerated Loss of Mains Change Program mentioned in the WP1 report.
- Setting up the capability to carry out simulation studies using OLTA was anticipated to be challenging. Even though a generous allowance was made for this in the project timeline, the capability still came on line later than planned.
- OLTA study processes are highly customized to NGENSO business practices and the GB network, and Project REV benefitted greatly from access to an experienced OLTA user.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

## The Outcomes of the Project

The project is still ongoing but is already making good progress toward achieving the defined success criteria.

### Identification of one or more “black swan” risks

The WP1 brainstorming activity identified a number of risks which were not well known or understood within the industry. These have been documented in the WP1 report and described in a webinar which was used to further raise awareness.

### Contribution to behind the meter DSR regulation processes

The Project REV WP1 report is already proving influential. In the recent BEIS consultation “Delivering a smart and secure electricity system: the interoperability and cyber security of energy smart appliances and remote load control”, Question 9 on Grid Stability quotes and draws heavily on the findings of WP1.

[Delivering a smart and secure electricity system: the interoperability and cyber security of energy smart appliances and remote load control - GOV.UK \(www.gov.uk\)](https://www.gov.uk/government/consultations/delivering-a-smart-and-secure-electricity-system-the-interoperability-and-cyber-security-of-energy-smart-appliances-and-remote-load-control)

Project REV is thus contributing to behind the meter DSR regulation processes and its influence will go beyond EVs to include other DSR appliances such as heat pumps.

### Impact on ESO risk management processes related to EV and DSR

Project REV is also having a direct impact on the Grid Code working groups used by the industry to address emerging risks. Knowledge generated in the project has contributed to the following groups:

- GC0151 & GC0155 Fault Ride-Through
- GC0154 Interconnector Ramping
- GC0156 Restoration

Project REV findings are also being shared with the Energy Networks Association to assist in future development of Engineering Recommendation G99 (“Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019”).

More broadly, the Project REV WP1 report has been shared and received with interest by international organisations including:

- Global Power Systems Transformation Consortia
- Electric Power Research Institute
- National Electric Reliability Corporation

Learning from the project has also been shared cross-sector, for example via the Safety Critical Systems Club, which is the UK’s professional network for sharing knowledge about system safety.

### The estimated potential financial benefit of EV DSR by 2030

This topic will be addressed in the WP2 report alongside analysis of the potential impacts of the issues identified in WP1.

## **Data Access**

Details on how network or consumption data arising in the course of a NIC or NIA funded project can be requested by interested parties, and the terms on which such data will be made available by National Grid can be found in our publicly available “Data sharing policy related to NIC/NIA projects” and [www.nationalgrideso.com/innovation](http://www.nationalgrideso.com/innovation).

National Grid Electricity System Operator already publishes much of the data arising from our NIC/NIA projects at [www.smarternetworks.org](http://www.smarternetworks.org). You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.

## **Foreground IPR**

The reports produced in the course of the project, including the WP1 Report, will be made available on the [Smarter Networks Portal](#) as they are released.