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Power Outage Alert and Power Restoration Alert Technical & Enhancement Paper

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1 Document Control

1.1 Version History

Version	Revision Date	Amended by	Summary of Changes
1	07/08/2020		Issued to ENA/BEIS/DNOs
2	19/08/2020		Updates following DNO Feedback
3	17/11/2020		Added Appendix E – Telefónica Network Resilience Information Added Appendix F – Enhancement Costs
4	04/02/2021		Added Appendix G – Additional Telefonica Enhancement Options T5 CH reboot timing change. T6 Change to CH dither change and Arqiva change to CH timings. Added Appendix H – Additional outage scenario analysis requested by DNOs.
5	21/04/2021	Janine Hughes	- Added ‘amended by’ column to this table. - Added Appendix I – Revised costs for recommended Option 3a & 3b - Amended costs in body of document to reflect revised costs from SPs. (Commercial copy only)

1.2 Distribution list

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1.3 Assurance

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1.4 Reference

This document is associated with the following documents, and has been drafted on the basis of these versions:

Ref	Title and Originator's Reference	Source	Issue Date	Version
R1	PR1226	DCC	03/04/2020	1
R2	Power Alerts Project Briefing Paper	DCC	01/12/2016	1.9
R3	CSP DSP POA PRA Tech. Paper	DCC	12/05/2020	4
R4	DP096-DNO POAs Modification Report (including Annex A)	SECAS	19/02/2020	0.2

Table 1 Referenced Documents

2 Introduction

DCC has, under the Smart Energy Code, an obligation to provide the Energy Industry with all Power Outage Alerts (POAs) and Power Restorations Alerts (PRAs) within 60 seconds. DCC is not currently fully meeting the obligation. BEIS had given DCC a derogation against this obligation this expired in October 2018.

To enable DCC to understand the CSP and DSP capabilities to handle POA/PRAs, a study is required which produces the below outputs:

- DCC current performance in respect of POA/PRAs, from a volume, speed and quality perspective
- How the current systems operate and process POA/PRAs and constraints
- Options to improve POA/PRAs performance with rough order magnitude costs and delivery timescales

Even though the customers for these alerts is the Energy Industry the Distribution Network Operators are the most impacted and therefore DCC have been engaged with them to understand their detailed requirements. Each enhancement option has been evaluated against the DNO requirements[1].

Problem Statement

The fundamental problems that this study aims to address are:

- POAs not being delivered within 60 seconds.
- PRAs not being delivered within 60 seconds.
- POAs being lost.
- PRAs being sent when they shouldn't be sent.

SEC Obligation

The relevant obligation in the SEC is:

Section H3.14 of SEC defines the target response time for alerts in general (H3.14 (g), sending a User an Alert, within 60 seconds measured from the Alert being communicated to (Device Alerts) or generated by (Non-Device Alerts) the Communications Hub Function.

[1] The requirements are referenced from the "Power Outage and Power Restoration Alerts DNO Requirements" paper presented to the ENA Smart Metering Steering Group on the 7th October 2019. Please refer to the annex of reference document: **DP096-DNO POAs Modification Report [R4].**

Ref	Definition	Description
POA.1	POA for all outages > 3 minutes	Supply all AD1s with no message loss
POA.2	POAs delivered < 5 minutes	AD1s to be delivered within 5 minutes from the time outage occurred to when it is delivered to DNOs
POA.3	POAs must be reliable	There should be reliable delivery of AD1s
POA.4	POAs must be trustworthy	Messages should be accurate and not result in false positives (i.e. AD1 sent without an actual power outage) or false negatives (i.e. power outage without an AD1 sent)
POA.5	POAs must be consistent	AD1s should be consistent between meter types, CH types and CSP regions
PRA.1	All PRAs required	Supply all 8F35/8F36 messages with no message loss
PRA.2	PRAs delivered in < 1 min	8F35/8F36 messages to be delivered within 1 minute from the time it was generated by the ESME to when it is delivered to DNOs
PRA.3	PRAs must be consistent	8F35/8F36 messages should be consistent between meter types, CH types and CSP regions
PRA.4[2]	PRAs must be trustworthy	Messages should be accurate and not result in false positives (i.e. 8F35/8F36 sent without an actual power restore) or false negatives (i.e. power restore without a 8F35/8F36 sent)
GEN.1[3]	No loss of PRAs/POAs during planned outages	AD1s, 8F35, 8F36 messages retained for later processing when planned system outages occur under system maintenance windows
GEN.2[4]	No loss of PRAs/POAs during unplanned outages	AD1s, 8F35, 8F36 messages retained for later processing when unplanned system outages occur

Table 2 DNO Requirements

The scope of this document assesses current and enhanced system performance against the following set of scenarios provided by the DNOs[5]:

[2] This requirement was not in the paper provided by the ENA Smart Metering Steering Group on the 7th October 2019 but has been added by the service providers

[3] This requirement was not in the paper provided by the ENA Smart Metering Steering Group on the 7th October 2019 but has been added by the service providers. This requirement was considered at the request of DCC

[4] This requirement was not in the paper provided by the ENA Smart Metering Steering Group on the 7th October 2019 but has been added by the service providers. This requirement was considered at the request of DCC

[5] These scenarios are aligned to the list of questions provided by the DNOs as well as the initial version of the supporting documentation that was provided with the PR1226 request (**CSP DSP POA PRA Technical Paper Reqts**). The alternate reference is a new reference given to the same scenarios provided by DCC in a later version of the same reference document: **CSP DSP POA PRA Technical Paper Reqts [R3]**

Scenario	Alternate Reference	Description
A		Single 5000 property outage in the Telefónica region
B		Single 5000 property outage in the Arqiva region
C	1	Overhead power line comes down. 30 homes in a village are taken off supply as are 15-20 local supply points at neighbouring farms
D	2	Substation damaged - 5,000 lose power simultaneously
E	3	20,000 homes in a major city lose power within 30 seconds a smaller power event occurs meaning the loss of power occurs in a different part of the same SP region (e.g. 20,000 homes in London – 6 homes in Western Super Mare)
F	4	An event knocks down a high voltage cable in a major city (as per DNO discussions assumed to be scenario for outage of 30,000 properties)
G	5	Storm travelling West to East knocks out a total of 100,000 MPAN's over a 20-hour period on average 5,000 homes an hour with a mix of high volt and low voltage. Due to re-routing, alerts may be generated and restored within the 3 minutes
H	6	Storm travelling South to East from Bristol to Glasgow affecting 100,000 MPAN's over 7 hours to include 20,000 simultaneous supply points in Birmingham, 15,000 in Manchester and 65,000 being a mix of high voltage / low voltage in other cities, towns and villages
I		Transmission Line Failures - National Grid Transmission System failures which can impact 1 – 200,000 customers. These average at around 9 incidents per annum and includes incidents affecting small numbers of very large industrial/commercial customers

Table 3 DNO Power Outage Scenarios

Project A (PR1226) which has produced this paper forms part of the wider DNO Programme, which is also comprised of Project B (CR1349), Project C (PR1227) and Project D. It is expected that the outcomes of Project A, B and C once decided, will form the basis of the scope for Project D. Project D will then be the vehicle to introduce a power outage alerts (POAs) and Power Restorations Alerts (PRAs) solution or service changes that will lead to improved DNO operating efficiencies.

3 Executive Summary

- This paper provides an overview of the capability and behaviour of the Smart Metering service provider systems regarding how Power Outage Alerts (POAs) and Power Restore Alerts (PRAs) are processed from the CHs and ESMEs to the Industry and DNOs.

- Based on the gaps identified, the study explored a number of potential enhancements, see appendix F.

    - Telefónica identified four options ranging from £Xm to £Xm
    - Arqiva identified six options ranging from £Xk to £Xm
    - CGI identified nine options ranging from £Xk to £Xm

- These enhancements could be introduced to improve performance against the SEC obligation and DNO requirements. Table 4 summarises these findings, referenced against the DNO requirements and also indicates the current performance.

- The conclusion is that due to constraints neither the SEC obligation nor the DNO requirements can be fully met, however some of the DNO requirements can be met through enhancements identified.

- In summary for POAs, there are only 2 options which would introduce delivery of AD1 messages under 5 minutes, see below the Arqiva and Telefonica options (also shown in POA.2 in table 4).

    - Arqiva's option for increased alert channels
    - Telefónica's option to deploy the Network Evolution CH with super capacitor. However the existing 2G/3G hubs would require one of the alternate improvements to reduce the current AD1 message delivery times

- In summary for PRAs, the Solution Enhancements proposed by CGI and Arqiva would introduce the most benefit to delivery of all PRAs (PRA.1 in table 4) but not in all circumstances, as the sending of the PRA first requires the ESME to reboot and second requires the CH to still have power and be connected to the network, or in the event of a longer outage to reboot and re-attach to the network. Telefónica can improve this only via deployment of the Network Evolution CH with super capacitor, but ultimately the ESME must itself reboot and any CH must reboot and re-attach to the network before being able to send the PRA.

- Technical constraints to Arqiva's solution means that, even with a solution enhancement, Arqiva cannot meet this PRA.2 requirement. CGI has an option available for reducing spurious PRAs and two options or prioritising POAs/PRAs based on importance to the DNOs aimed at addressing the requirement of PRAs being trustworthy (PRA.4).

- Based on the Indicative Delivery Planning, the proposed timeline for PIT completion of the options spans from one month to over eighteen months which would shape whether any agreed enhancements could be subject to a launch within any of the planned November 2021, June 2022 or November 2022 major releases.

In Table 4 □ notes improvement is achieved.

Option (✓ denotes improvement is achieved)	POA.1 – POA for all outages >3 minutes (transactions per min)	POA.2 – POAs delivered <5 minutes (range in minutes for outages up to 30K)	POA.3 – POAs must be reliable (transactions per min)	POA.4 – POAs must be trustworthy	POA.5 – POAs must be consistent	PRA.1 – All PRAs required (transactions per min)	PRA.2 – PRAs delivered in <1 min (range in minutes)	PRA.3 – PRAs must be consistent	PRA.4 – PRAs must be trustworthy	GEN.1 – No loss of POAs/PRAs during planned outages	GEN.2 – No loss of PRAs/POAs during unplanned outages	Benefits	ROM Costs
TEF Current Performance	**5000**	**6-13**	**5000**			**200000**	**<1 – 3.5**			**Msg Loss**	**Msg Loss**		
TEF.1 – Existing IT System Enhancements	15000	5-12	15000	✓	✓	200000	<1 – 3.5	✓	✓	✓	✓	Higher throughput of POA messages and reduction in POA delivery times by 1 minute. This enhancement only benefits DNOs.	£Xm -£Xm (Setup) / £Xk - £Xk Per Annum (OPEX)
TEF.2 – Cloud based Micro Service	15000	5-8	15000	✓	✓	200000	<1 – 3.5	✓	✓	✓	✓	Higher throughput of POA messages and reduction in POA delivery times by 1-5 minutes, depending on outage volumes. Cloud based microservices for power alerts will be specific for DNOs but the microservices concept would be part of an overall move to a microservices based architecture. Elements of this can be re-used for other DCC changes including SECMOD7 which covers firmware updates for HAN devices.	£Xm -£Xm (Setup) / £Xk - £Xk Per Annum (OPEX)
TEF.3 – Network Evolution CH with super capacitor (values apply to new CH only)	30000	4	30000	✓	✓	200000	<1 – 3.5	✓	✓	✓	✓	Higher throughput of POA messages and reduction in POA delivery times which meet DNO requirements. Higher volumes of PRAs (8F35 messages) will be delivered in under 1 minute as CH will remain powered on longer. 4G CHs are part of the Network Evolution programme plans but the super capacitor is a requirement that is specific to addressing DNO requirements.	$X to $X per unit (USD)
TEF.4 – Firmware & Network Infrastructure Updates	5000	5-12	5000			200000	<1 – 2.5					1 minute reduction in POA/PRA delivery times. Note: this is not considered a viable option by Telefónica and therefore no cost / timelines have been provided. This enhancement only benefits DNOs.	N/A
ARQ Current Performance	**5000**	**3-12**	**5000**			**35000**	**3-45**			**Msg Loss**	**Msg Loss**		
ARQ.1 – Reinstate CH PRA	5000	3-12	5000			35000	3-12			Msg Loss	Msg Loss	Provides fast indication of power restoration. These CH restoration alerts are in addition to the current 8F35 and 8F36 alerts so no change in overall reliability or performance of meter PRAs. Benefit is particularly noticeable for larger outages where a significant proportion of the restoration alerts would arrive within 3-12 minutes of power being restored. This enhancement only benefits the DNOs.	£ X

Option (✓ denotes improvement is achieved)	POA.1 – POA for all outages >3 minutes (transactions per min)	POA.2 – POAs delivered <5 minutes (range in minutes for outages up to 30K)	POA.3 – POAs must be reliable (transactions per min)	POA.4 – POAs must be trustworthy	POA.5 – POAs must be consistent	PRA.1 – All PRAs required (transactions per min)	PRA.2 – PRAs delivered in <1 min (range in minutes)	PRA.3 – PRAs must be consistent	PRA.4 – PRAs must be trustworthy	GEN.1 – No loss of POAs/PRAs during planned outages	GEN.2 – No loss of PRAs/POAs during unplanned outages	Benefits	ROM Costs
ARQ.2a – Increased Alert Channels	5000	3-12 (50% alerts in 4 mins)	5000			35000	3-45			Msg Loss	Msg Loss	Greater throughput of AD1 alerts particularly during larger outages. Also Improves speed of delivery for the majority of alerts and reduces the number of alerts lost due to message collisions in large outages. This enhancement only benefits the DNOs.	£X - £X Million
ARQ.2b – Increased Bulk Traffic Channels	5000	3-12	5000			35000	3-37			Msg Loss	Msg Loss	Greater throughput of 8F35 and 8F36 power restoration messages. Improves speed of delivery. Benefits all DCC users.	£X - £X Million
ARQ.3 – Improved backhaul resilience	5000	3-12	5000			35000	3-45			Msg Loss	Msg Loss	Reduces the number of significantly delayed POA messages. Also reduces number of duplicate messages. Benefits all DCC users.	N/A (IA required to determine ROM)
ARQ.4 – Relaxed throttle between CSP and DSP	Up to 35000 (for outages >100K only)[6]	3-12	Up to 35000 (for outages >100K only)			35000	3-45			Msg Loss	Msg Loss	Reduces chance of alerts from one large outage event delaying the delivery of alerts from a second isolated small incident. Also improves throughput of alerts during very large outages. This enhancement only benefits the DNOs.	£ X
ARQ.5 – Buffering alerts at the CSP – DSP gateway	5000	3-12	5000			35000	3-45			✓	✓	Reduces messages lost during planned and unplanned outages of the DSP. Buffers alerts and resends them once the DSP service is restored. This benefits all DCC users.	£ X million
ARQ.6 – Deduplication at the CSP – DSP gateway	5000	3-12	5000		✓	35000	3-45			Msg Loss	Msg Loss	Reduces delayed duplicate messages. This benefits all DCC users.	N/A (IA required to determine ROM)
DSP Current Performance	**12000**	**0.0048**	**12000**			**96000**	**0.0004**			**Msg Loss**	**Msg Loss**		

[6] A rate of 35,000 messages per minute would only be reached in very large power outage scenarios involving over 100,000 premises. The message rate will be the same as current performance for power outages involving a lower number of premises.

Option (✓ denotes improvement is achieved)	POA.1 – POA for all outages >3 minutes (transactions per min)	POA.2 – POAs delivered <5 minutes (range in minutes for outages up to 30K)	POA.3 – POAs must be reliable (transactions per min)	POA.4 – POAs must be trustworthy	POA.5 – POAs must be consistent	PRA.1 – All PRAs required (transactions per min)	PRA.2 – PRAs delivered in <1 min (range in minutes)	PRA.3 – PRAs must be consistent	PRA.4 – PRAs must be trustworthy	GEN.1 – No loss of POAs/PRAs during planned outages	GEN.2 – No loss of PRAs/POAs during unplanned outages	Benefits	ROM Costs
DSP.1 – Provision of new shared Infrastructure	24000	0.0048	24000			192000	0.0004			Msg Loss	Msg Loss	Provides additional motorway capacity for processing all DCC traffic (i.e. Service Requests, Service Responses, DCC Alerts and Device Alerts) including POAs and PRAs. This enhancement benefits all DCC Users	£Xk - £Xk
DSP.2 – Prioritising POAs and PRAs over other northbound traffic	24000	0.0048	24000			192000	0.0004			Msg Loss	Msg Loss	Ensures POAs and PRAs are prioritised over all other northbound DCC traffic (i.e. Service Responses, DCC Alerts and Device Alerts). Prioritisation of POAs/PRAs over other northbound traffic will only benefit DNOs. However, this enhancement also includes rationalisation of POA production (e.g. only sending one POA per HAN rather than one per ESME) which would benefit Suppliers in addition to DNOs.	£Xk - £Xm
DSP.3 - New dedicated resources for POAs and PRAs	24000	0.0048	24000			192000	0.0004			Msg Loss	Msg Loss	Routes POAs and PRAs to new, dedicated motorway infrastructure reserved solely for the purpose of processing POAs/PRAs. This enhancement primarily benefits DNOs but also benefits other DCC Users in that processing of POAs/PRAs no longer performed in the main motorway which, therefore, frees up additional capacity for other traffic.	£Xk - £Xk
DSP.4 – Cloud-based Dedicated DNO POA/PRA resources	24000	0.0048	24000			192000	0.0004			Msg Loss	Msg Loss	As per option DSP.3.	N/A
DSP.5 – Prioritisation within POAs and PRAs by Postcode/ Time	24000	0.0048	24000	✓		192000	0.0004		✓	Msg Loss	Msg Loss	Prioritises POAs/PRAs from postcodes experiencing few POAs/PRAs over those from postcodes experiencing very high volumes of POAs/PRAs. In doing so, priority is given to smaller outages, of which the DNO may not be aware, over larger outages of which they are aware. This enhancement only benefits DNOs.	£Xk - £Xk
DSP.6 – Prioritisation within POAs and PRAs by Canary Indicators	24000	0.0048	24000	✓		192000	0.0004		✓	Msg Loss	Msg Loss	Prioritises POAs/PRAs from a DNO-defined set of ‘canary’ MPANs chosen by the DNO to provide essential information on the health of the DNO network (e.g. one canary MPAN per feeder). This enhancement only benefits DNOs.	£Xk - £Xk
DSP.7a – Reduce Spurious PRAs: Traffic management	12000	0.0048	12000			96000	0.0004		✓	Msg Loss	Msg Loss	Reduces PRA volumes received by DNOs by up to 20% by filtering hundreds of spurious 8F35s per day from defective ESMEs by removing 8F35s from the SECMP0062 Exemption List. This enhancement only benefits DNOs.	£Xk - £Xk

Option (✓ denotes improvement is achieved)	POA.1 – POA for all outages >3 minutes (transactions per min)	POA.2 – POAs delivered <5 minutes (range in minutes for outages up to 30K)	POA.3 – POAs must be reliable (transactions per min)	POA.4 – POAs must be trustworthy	POA.5 – POAs must be consistent	PRA.1 – All PRAs required (transactions per min)	PRA.2 – PRAs delivered in <1 min (range in minutes)	PRA.3 – PRAs must be consistent	PRA.4 – PRAs must be trustworthy	GEN.1 – No loss of POAs/PRAs during planned outages	GEN.2 – No loss of PRAs/POAs during unplanned outages	Benefits	ROM Costs
DSP.7b – Reduce Spurious PRAs: Block list	12000	0.0048	12000			96000	0.0004		✓	Msg Loss	Msg Loss	Reduces PRA volumes received by DNOs by up to 20% by filtering hundreds of spurious 8F35s per day from defective ESMEs by implementing a block list for known defective ESMEs. This enhancement only benefits DNOs.	£Xk - £Xk
DSP.8 - Buffering During DSP Planned Maintenance[7]	12000	0.0048	12000			96000	0.0004			✓	Msg Loss	Implements a buffer for all DCC traffic (i.e. Service Requests, Service Responses and Device Alerts) which can be activated during periods of planned and unplanned DSP outage. This enhancement benefits all DCC Users.	£Xk - £Xm

Table 4 Solution Options Summary

- There is no current measure available on reliability or trustworthiness of POAs/PRAs although some analysis is underway as covered in Appendix A – Power Alert Data Analysis to determine the root cause of any scenarios where alert messages are lost or being sent incorrectly which will have an impact on the reliability or trustworthiness of AD1 and 8F35/8F36 messages.

- An analysis was performed on POAs/PRAs received by the DSP over the 7-day period from 09 June to 15 June 2020 and of POAs received from Arqiva over the period 17 May to 18 June 2020. The findings from this analysis are included in Appendix A – Power Alert Data Analysis.

[7] CGI's buffering enhancement would buffer all Service Requests, Service Responses and Device Alerts (including POAs/PRAs) in the event of a controlled DSP outage. Since all messages will be buffered, the benefits of this enhancement extend to all DCC Users, not just the DNOs. The use of the word 'controlled' reflects the fact that the decision on whether or not to buffer messages will be taken by the CGI support team and enabled manually. In the case of a planned outage, buffering will be enabled prior to the DSP being taken down. In the case of unplanned outages, the CGI support team will determine whether buffering is advisable and, if so, enable it. Some message loss is, therefore, possible during the initial period of the unplanned outage. For buffering to be available, the buffering component must be unaffected by the unplanned outage impacting the DSP. In the event of the loss of a data centre, this may require messages to be diverted to the buffering component in the secondary site. Routing of messages to this standby component would be prioritised over the failover of other DSP components but would, inevitably lead to some message loss during the switch.

- Ahead of this Technical Paper being issued, it was previously noted that there are several known Defects, Incidents or Problems which are being investigated as part of the current agreement to Run and operate the service. These items will follow the standard in-life Incident, Defect and Problem Management approach through to resolution in line with the agreed KPI's and SLA's.

- The POA Programme has a Testing Project whose objective is to test and find the root cause of the problems.

- Appendix A – Power Alert Data Analysis contains an analysis of the investigations to date and also contains information on existing incidents currently being reviewed.

- Appendix D – Known Incidents Identified by DCC, contains a description of incidents identified by DCC in relation to power alerts. These are currently under investigation as part of Project C in the Programme.

4 As Is System Overview

The current implementation for managing power alert messages is as follows:

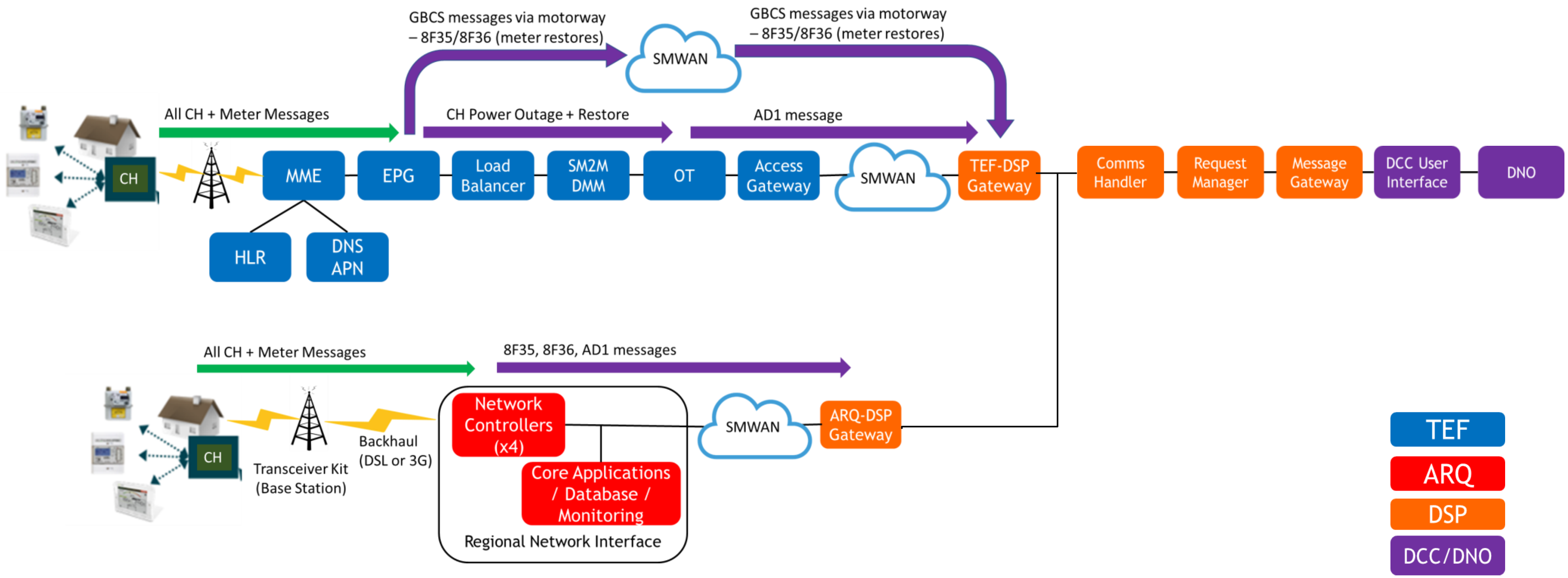


Figure 1 POA/PRA Journey Overview

Component	Owner	Description
CH	TEF ARQ	Communications Hub. Device to handle communications between smart meters and service providers
MME	TEF	Mobility Management Entity. Also known as Serving GPRS Support Node (SGSN). This manages the network sessions of the CHs
HLR	TEF	Home Location Register. Supports reconnection of CHs
DNS APN	TEF	Domain Name Service Access Point Name. Facilitates data network communications
EPG	TEF	Evolved Packet Gateway. Also known as Gateway GPRS Support Node (GGSN). Facilitates network transmission of CH data
Load Balancer	TEF	Processes inbound CH messages and controls the flow of messages into the downstream system
SM2M DMM	TEF	Smart Machine to Machine Device Monitoring and Management. Manages CH communications. Will process power alerts and pass on to Orchestration system
OT	TEF	Orchestration System. Determines confirmed power outage messages and generates the AD1 message
Access Gateway	TEF	Security gateway system which manages interactions with the DSP gateway
SMWAN	TEF ARQ CGI	Service Management Wide Area Network. Network used to transmit messages between service providers
TEF-DSP Gateway	CGI	Telefónica-DSP gateway
ARQ-DSP Gateway	CGI	Arqiva-DSP gateway
TK	ARQ	Transceiver Kit. Base station which facilitates communication from the CH to the rest of the network
Regional NW Interface (RNI)	ARQ	Regional Network Interface. Gathers and processes network data. Consists of network controllers and supporting systems such as monitoring components
Comms Handler	CGI	Communications Handler. Manages the queue for message processing
Request Manager	CGI	Request Manager. Handles business logic, validation, post-processing requirements
Message Gateway	CGI	Message Gateway. Responsible for delivering messages to Users
DCC User Interface	DCC	DCC Interface. Demarcation point between DSP and DCC
DNO		Distribution Network Operators. Will receive power alert messages

Table 5 Smart Metering System Components

For reference, please also note the following terms used in the diagram above:

Term	Meaning
8F35	Power Restoration Alert (PRA) from the electric meter (8F35 is the GBCS message code). This is generated regardless of the duration of the power outage.
8F36	Power Restoration Alert (PRA) from the electric meter where the restore occurs more than 3 minutes from the outage (8F36 is the GBCS message code).
AD1	Confirmed power outage messages for outages of greater than 3 minutes. This is based on power outage messages from the CH rather than meter outage messages.
Motorway	A collection of CSP/DSP components employed in processing Service Requests, DCC Alerts and Device Alerts which go via SMWAN traffic onto the DSP. The 8F35 and 8F36 messages are not processed by Telefónica IT systems.

Table 6 Key Definitions

The systems have been designed to meet the core requirements set out by the DCC. For the CSPs, the key requirements are set out in section 2.2 of the contract (refer to “section 13 Appendix B – CSP Contract Extracts” for excerpts from the CSP contracts). This states that where up to 50 premises are impacted by a single outage event, 100% of alerts should be reported. Where an incident comprises more than 50 outages, 100% of the initial 50 outages shall be reported plus 25% of the outages over and above the initial 50. The CSPs are not obliged to deliver more than 5,000 alerts relating to the same outage event but they are obliged to deliver all restore alerts. This is also covered in the document referenced: **Power Alerts Project Briefing Paper [R4].**

4.1 Summary of core DNO Requirements against As Is Capability

Based on the As Is overview of the service providers described above, this section provides a view of how the current implementations of the service provider platforms perform against the core DNO requirements. The core DNO requirements with a brief description of what they entail are as follows:

Ref	Definition	Description
POA.1	POA for all outages > 3 minutes	Supply all AD1s with no message loss
POA.2	POAs delivered < 5 minutes	AD1s to be delivered within 5 minutes from the time outage occurred to when it is delivered to DNOs
POA.3	POAs must be reliable	There should be reliable delivery of AD1s

Ref	Definition	Description
POA.4	POAs must be trustworthy	Messages should be accurate and not result in false positives (i.e. AD1 sent without an actual power outage) or false negatives (i.e. power outage without an AD1 sent)
POA.5	POAs must be consistent	AD1s should be consistent between meter types, CH types and CSP regions
PRA.1	All PRAs required	Supply all 8F35/8F36 messages with no message loss
PRA.2	PRAs delivered in < 1 min	8F35/8F36 messages to be delivered within 1 minute from the time it was generated by the ESME to when it is delivered to DNOs
PRA.3	PRAs must be consistent	8F35/8F36 messages should be consistent between meter types, CH types and CSP regions
PRA.4*	PRAs must be trustworthy	Messages should be accurate and not result in false positives (i.e. 8F35/8F36 sent without an actual power restore) or false negatives (i.e. power restore without a 8F35/8F36 sent)
GEN.1*	No loss of PRAs/POAs during planned outages	AD1s, 8F35, 8F36 messages retained for later processing when planned system outages occur under system maintenance windows
GEN.2*	No loss of PRAs/POAs during unplanned outages	AD1s, 8F35, 8F36 messages retained for later processing when unplanned system outages occur

Table 7 DNO Requirements

* Note that these requirements do not form part of the list of requirements contained in the "Power Outage and Power Restoration Alerts DNO Requirements" paper presented to the ENA Smart Metering Steering Group on the 7th October 2019 but have been added by the service providers. The DNO requirements are captured in the annex of reference document: **DP096-DNO POAs Modification Report [R4].**

The following table provide an overview of the current capabilities

Req	Description	DSP Current capability		TEF Current capability		ARQ Current capability	
POA.1	POA for all outages > 3min	12,000	TPM	5,000	TPM	5,000	TPM
POA.2	POAs delivered in < 5min	0.0048	mins	6-13	mins	3-12	mins
POA.3	POA must be reliable	12,000	TPM	5,000	TPM	5,000	TPM
POA.4	POAs must be trustworthy^	N/A		N/A		N/A	
POA.5	POAs must be consistent*	N/A		*		*	
PRA.1	All PRAs required	96,000	TPM	200,000	TPM	35,000	TPM
PRA.2	PRAs delivered in <1min	0.00042	mins	<1-3.5#	mins	3-37	mins
PRA.3	PRAs must be consistent*	N/A		*		*	
PRA.4	PRAs must be trustworthy^	N/A		N/A		N/A	
GEN.1	No loss of PRAs/POAs during planned outage	Potential Loss during maintenance window		Potential Loss during maintenance window		Potential Loss during maintenance window	
GEN.2	No loss of PRAs/POAs during unplanned outage	4 hour RTO		4 hour RTO		4 hour RTO	

Table 8 Service Provider Current Capabilities

Note in the table above, TPM refers to transactions per minute and RTO refers to Recovery Time Objective, which is the length of time it can take to recover from an unplanned outage.

^ For POA.4 and PRA.4 (trustworthiness of POAs/PRAs), there are no measures available to record against these. There are investigations underway to validate if there may be false positives or false negative power alert scenarios as described in "Appendix A – Power Alert Data Analysis"

* For POA.5 and PRA.5, POAs/PRAs must be consistent, this refers to consistency between meter types, CH types and CSP regions. This cannot be measured against individual service providers and needs to be assessed across the end to end implementation across service providers. The service providers do not have control of the meter types so consistency cannot be measure against these. For CH types, Telefónica has two CH vendors that are used and the functionality is consistent between these. For consistency between CSPs, there are differences between the way POAs and PRAs are sent to the DSP (e.g. Arqiva can send up to 3 alerts for POAs but Telefónica does not) but the DSP has some functionality in place (e.g. de-duplication) so that the data that is sent to the DNOs is sent in a consistent manner across CSPs. However, due to differing system implementations, CSPs have differing durations of sending POAs/PRAs and message throughput rates. In the case of the CSP North region, there are known incidents where the DNOs have duplicate AD1s which is normally caused by the duplicate AD1s arriving outside of Arqiva and CGI's de-duplication window. The delays themselves are caused by issues such as line faults.

When the CH is attached to the network and is able to transmit the message, it takes a few seconds only. In the event that the CH has to shut down due to lack of mains power, the ESME on power restore will need to wait for the CH to reboot and reattach to the network which will take more than 1.5-3.5 minutes.

4.2 Telefónica CSP System Overview

Under the Telefónica implementation, all CHs (including gateway hubs and gateway attached hubs) and meter messages flow from the premise to the MME network component and EPG. At this point, the message flows diverge.

- ESME power restore messages, 8F35 and 8F36, are passed to the DSP via "motorway" or SMWAN traffic and onto the Telefónica-DSP message gateway. These messages are transported but not processed by Telefónica systems.
- Other message types, such as the CH power outage alert and CH power restore alert messages are passed onto the Smart M2M DMM system.

Internally to Telefónica, a load balancer currently sits in front of SM2M DMM and this has message throttling in place to protect the Smart M2M DMM and downstream systems from receiving a surge of messages during a large power outage event or a large number of CHs having power restored. The throttling to power outage alerts only applies if an outage affecting more than 34,000 households occurs. (It is applied above 2,267 transactions per second over the 15 second randomisation period that Telefónica CHs use to send power outage alerts). For CH power restore alerts throttling only occurs at outages affecting more than 226,700 households. (Due to a larger 100 second randomisation window). In the extremely rare event of an outage this large occurring in exactly the same 15 seconds as a secondary outage this can effect outage alerts of the secondary outage as throttling means that messages in excess of the threshold will be dropped and discarded. From the load balancer, messages will then flow through into the Smart M2M DMM system which in turn passes these messages onto the Orchestration (OT) system.

The OT system has the responsibility of determining which power outage messages received constitute an AD1 message (i.e. a power outage without a corresponding restore within 3 minutes from the outage). This is done via a timer which waits for corresponding power restore messages. In the event a power restore message is not received in time, OT generates the AD1 message, which is then passed on to the TEF-DSP message gateway via the Telefónica Access Gateway system (which is a security gateway).

Although the criteria for a confirmed power outage is any outage without a restore in 3 minutes, the OT system has to wait longer than 3 minutes to determine if there is a corresponding restore alert message available. This is to take into account circumstances where a power outage lasts longer than the capacity of the CH to stay powered on without mains power but less than 3 minutes. The CH can last from 20 seconds up to 2 minutes (dependent on various factors such as the age of the meter) before it needs to power down.

Step	Item	Time
1	Waiting time to confirm Power Outage Alert	3 minutes
2	CH boot time	Between 1 and 1.5 minutes
3	Re-connection algorithm to control the load of a high number of devices simultaneously connecting to the radio network	Between 0.33 minutes (20 seconds) and 2 minutes with option to expand to 10 minutes
4	Establish PDP context (enable data transmission), various transit hops and processing times	0.5 minutes
5	Hysteresis to check for confirmed outages and sending to DSP via the Access Gateway	1 minute
	Total	**6-8 minutes**

Table 9 Telefónica POA Processing Times

When the power supply is restored, the CH needs between 60 and 90 seconds to reboot and then based on the re-connection algorithm, it can take between 20 seconds to 2 minutes to reattach to the network. The CH power restore message can then take about 30 seconds before it reaches the OT system. The OT system therefore needs to wait for 5-7 minutes from the start of the power outage (depending on the re-connection algorithm) before confirming a power outage. It can take a further 1 minute to transmit the AD1 message onto the DSP which brings the total to 8 minutes. This is the maximum time for small or medium sized power outage scenarios. For power outage scenarios where there are more than 5,000 simultaneous power alert messages, it will take longer to pass these messages onto the DSP due to the CSP-DSP throttling in place.

The CH network reattach time varies as there is an algorithm in place to protect Telefónica's network infrastructure by preventing large scale simultaneous network reattachments. The algorithm reserves the first 20 seconds of the 120 second window to allow mesh CHs to attach to the network. The next 100 seconds is split into 10 slots of 10 seconds each to allow batches of CHs to attach to the network. The appropriate slot is determined using a 4 byte least significant byte (LSB) of the CH GUID converted from hexadecimal to decimal.

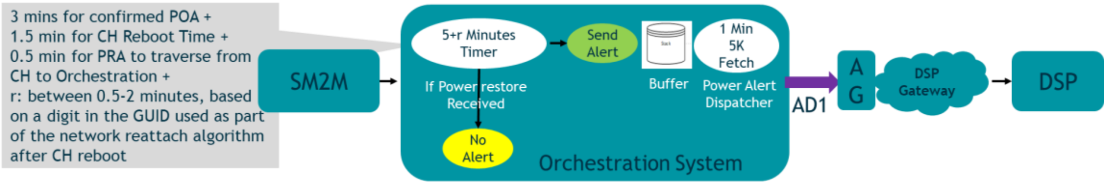


Figure 2 Telefónica System View for POAs

Once a power outage is confirmed, the messages are stored in a buffer and are handled in batches to send out to the DSP. It will fetch the messages in the buffer every minute (up to a maximum of 5000 messages) to process the batch. The OT system transmits each AD1 message using an API call to the AG system.

There is also a throttling mechanism in place between the Telefónica systems and the DSP gateway which is currently at 5,000 messages per minute. This means that in the event of a large outage, there will be a delay in sending some of the messages through the gateway to meet the throttling requirement.

Based on the above flows, the confirmed power outage messages will typically take 6-8 minutes from the time the power outage occurred to the time the time it is sent to the DSP. When processing larger volumes of messages during large outages (exceeding 5,000 premises), some messages can take longer to get through. This also applies to separate unrelated power outages that happen within that same minute. A last in-first out method is currently applied in aid of processing any secondary outage alerts. For power restore messages generated by the ESME, given that there is no processing required for these by the IT systems and they are transmitted directly from the CHs to the DSPs, these will typically take only a few seconds to traverse once connectivity is established.

The overall solution is currently achieving the agreed PM12.1 and PM12.2 performance measures as defined in the baselined Contract Schedules 2.1 and 2.2 (these measure the percentage of POAs successfully delivered – refer to Appendix B for details of the performance measures for the CSPs and the contract extracts). In the last twelve months, there has been only one instance where Telefónica did not fully meet both these performance measures. This was due to extraordinary circumstances.

4.2.1 Unhappy Path Scenarios

There are several scenarios where messages do not flow through via the "normal" or happy path. These will then result in messages getting delayed or not getting transmitted at all. The scenarios are outlined below.

Radio Access Network (RAN) Level Outages

This is where the CH is unable to communicate with the Telefónica cellular network (RAN). The following scenarios can affect the cellular access:

a) There is a local RAN outage, due to maintenance or a fault
b) There is a RAN outage due to the power outage;
   The RAN is made up of macro sites and microcells. Macro sites provide the main coverage and have a battery backup. Non-macro sites, i.e. microcells located on the side of buildings, stadiums etc. do not have battery backup but these are also under cellular coverage of a macro site. There are a small percentage of macro sites where battery backup is not possible due to practical reasons such as space.
c) Coverage is affected due to atmospheric or other circumstances

The effect of RAN outages on power alerts is:

- For Toshiba CHs, any messages will be lost during shutting down. This results in the CH power outage alert being lost. Power outage restore messages to the DSP and the CH are held and will be sent once connectivity to the RAN is re-established. The end result of this is that no AD1 will be generated but 8F35/36 will still be sent though it may be delayed.
- For WNC, messages are written into non-volatile memory and will be available when the CH restarts. So the WNC CHs will attempt to resend a CH power outage alert as well as the power restore alert when power is restored. Both these are then held until connectivity to the RAN is re-established. The ultimate end result here is a delay in AD1 and 8F35/36 delivery to the DSP.

DSP Outages

As shown in "Figure 1 POA/PRA Journey Overview", there are two message types sent to the DSP, 8F35/8F35 ESME power restore messages and AD1 power outage messages.

For 8F35/8F36 messages, if there is no response or a failure response from the DSP when attempting to send, the CH will attempt to retry sending the message after 30, 60 and 300 seconds. If the CH is unsuccessful after all four attempts, there will be no further retry attempts and the message is lost.

For AD1 messages, the OT system will send the message via the Access Gateway and will make 3 send attempts at 10 second intervals before registering a failure. The message will not be resent beyond this time.

The same rules above apply if the DSP is not available due to planned maintenance or there is an unplanned outage affecting the ability of the DSP to receive AD1s and 8F35/36s.

SM2M DMM System Unavailable

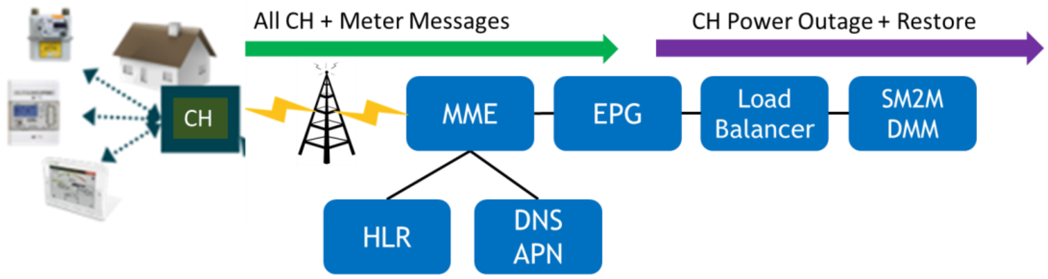


Figure 3 Message Flow to SM2M DMM

The SM2M DMM system manages interactions with the CH. As indicated in the above diagram, the SM2M DMM system receives the CH power outage and CH power restore messages.

If the CH attempts to send a CH power outage message to SM2M DMM and it is not available, there will be no further retry attempts. This is because if the CH has no power, it will start the process of shutting down as soon as possible.

If the CH attempts to send a CH power restore message to SM2M DMM and it is not available, the CH will attempt to resend the message at 30, 60 and 300 seconds. There will be no further retry attempts.

The above will be applicable for both planned and unplanned outages of the system.

OT System Unavailable

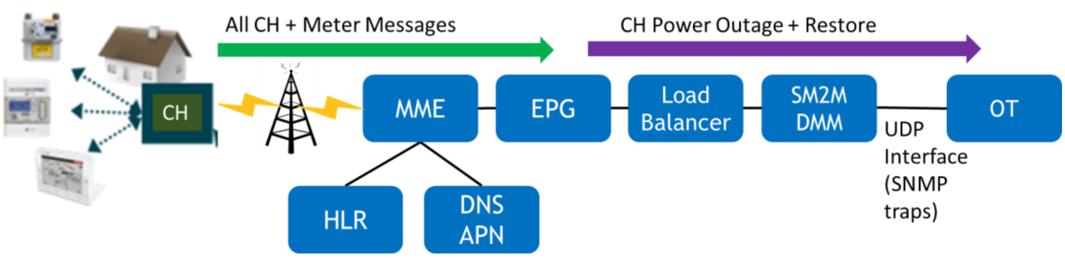


Figure 4 Message Flow to Orchestration System

The Orchestration (OT) system works out which CH power outage messages constitute a power outage lasting longer than 3 minutes and generates an

AD1 message that goes out to the DSP. SM2M DMM sends the CH power alert messages to OT for processing and this is done via a UDP (User Datagram Protocol) interface which works on a fire and forget policy. Essentially, this type of interface messaging has high performance capability but does not have a capability of confirming receipt of the message to enable retries. The source system is not aware if there are any transmission failures when it sends the message through. Therefore, if for any reason, there is a message failure between SM2M DMM and OT, the message is lost. This is applicable to both planned and unplanned outages of the OT system.

Planned outages are normally agreed with DCC in advance so DCC is aware of any planned outages. In the case of unplanned outages, incident tickets are raised and these are shared with DCC as per normal process.

4.3 Arqiva CSP System Overview

The Arqiva implementation progresses the power outage AD1 messages and the power restore 8F35/8F36 messages via different channels.

4.3.1 Power Outage alerts from Communications Hubs

On a power outage, the Communications Hub closes down HAN communication and other auxiliary functions. Power to the CH is maintained via internal super capacitors. The behaviour of a CH on power outage is defined below:

- CH waits for 3 minutes to filter out momentary outages which may occur under normal operations.
- After 3 minutes, the CH will attempt to send 3 outage alerts in three different time windows. Within each time window, the actual time of alert transmission is randomised to minimise the risk of collision.
    - First alert is raised within 45 seconds
    - Second alert is generated in the span of next 4 minutes
    - Third alert is generated in the span of next 4 minutes
    - There is sufficient charge in the super capacitors to maintain power for the three alert transmissions

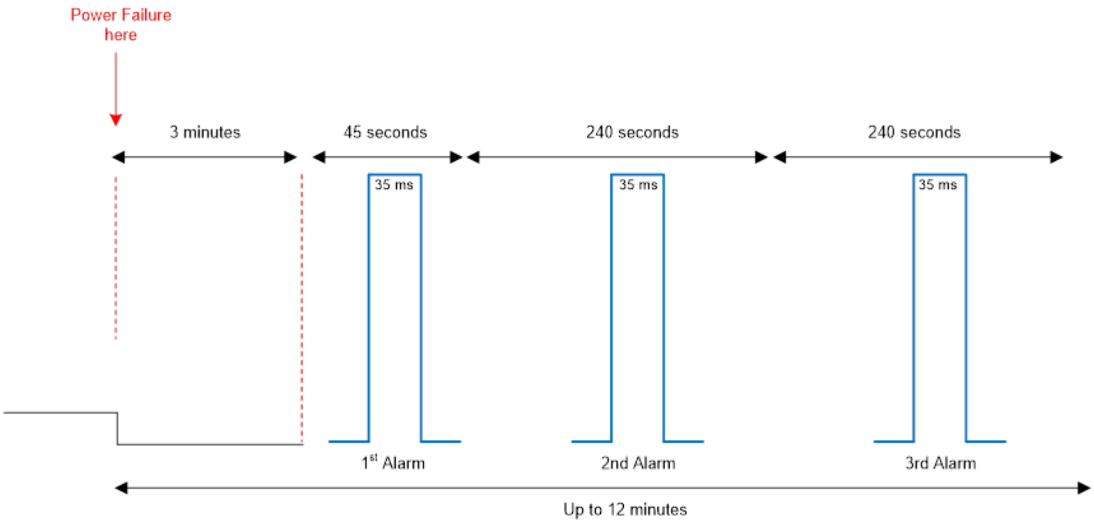


Figure 5 Outage Alert in normal mode

For power restore alerts from ESME devices, generated outage alerts are GBCS messages of type SME A.C. (Message Code: 0x0067). Once these alerts are generated and sent through the HAN Interface to the CH, the CH will buffer this alert until it is ready to send this over SMWAN.

The CH sends this critical message alert over the normal traffic channel by sending a Request to Send (RTS) to the Regional Network Interface (RNI) indicating a message is waiting to be collected.

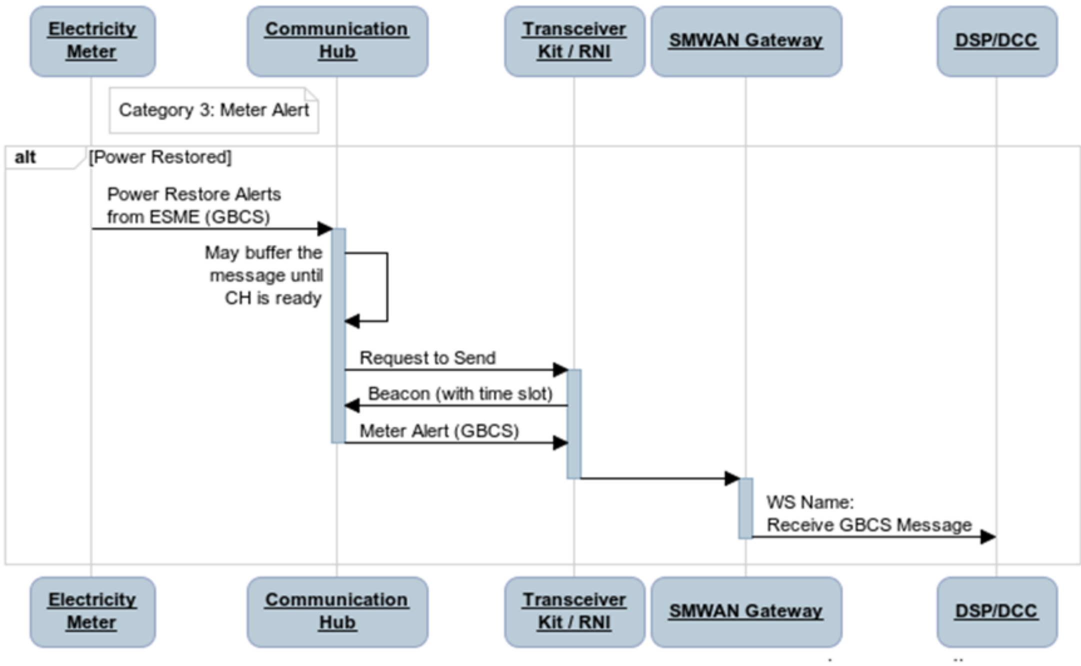


Figure 6 ESME Outage Alert Transmission

Following the RTS, CH receives the beacon (RTS Response) with a timeslot to send the alert data to RNI.

As these ESME alerts are GBCS messages transmitted as a poll/response mechanism, once the alert message is received by the CH, it will be transmitted to the RNI. The RNI will then submit these ESME alerts to SMWAN Gateway using the "*Receive GBCS Message*" web service.

The overall solution is currently achieving the agreed PM12.1 and PM12.2 performance measures as defined in the baselined Contract Schedules 2.1 and 2.2 (these measure the percentage of POAs successfully delivered – refer to Appendix B for details of the performance measures for the CSPs and the contract extracts). In the last twelve months, there have been three instances where Arqiva did not fully meet both these performance measures. This was due to extraordinary circumstances.

4.3.2 Unhappy Path Scenarios

The scenarios for unhappy paths are outlined below.

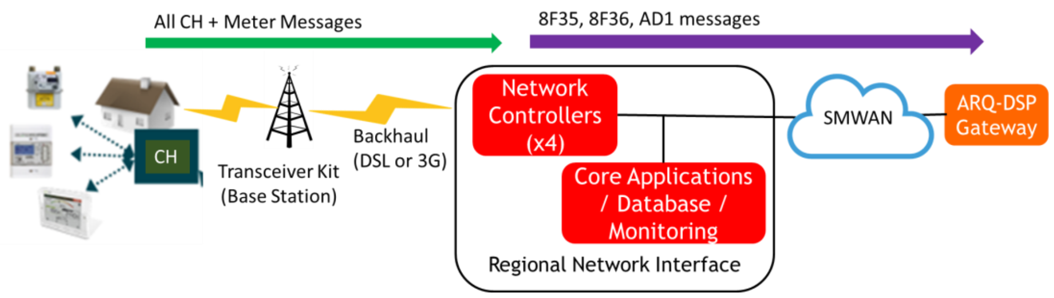


Figure 7 Arqiva CSP Message Flow

Comms Hub not available

The ESME generated 8F35 and 8F36 restoration alerts are transferred over the air from the meter to the CH. On power restoration the CH takes up to 3 minutes to reboot. If an EMSE alert is transmitted before the CH has rebooted then the alert will be lost at this point in the process and will not be retried.

Transceiver Kit not available

The CH will attempt to send AD1 messages following the three alert windows described above. Any Transceiver Kits which are within range of the CH can pick up AD1 alerts from any CH. Although there is provision for coverage from multiple TKs being within reach of a CH, there may be situations where the message is not picked up by any TK (may be due to an existing fault at the TK site). This will result in a message getting lost as the CH sends AD1 messages under a fire and forget policy.

For 8F35 and 8F36 power restore alerts, the CH will retry sending of the RTS message (the retry window lasts for up to an hour) until allocated a timeslot via a beacon. If no beacon is received then the RTS is resent over increasing back off windows. At the end of the windows the alert is lost.

RNI not available

This scenario is where the transceiver kit is able to pick up the CH message but is unable to pass the message on to the regional network interface. The transceiver kit does have buffering capability and will therefore attempt resends of messages. Buffering on the TK is limited by the disk space available but depending on the rate at which messages are arriving at the TK, it is normally enough for a few hours of storage.

Although buffering at the TK is available the reintroduction of these messages is interleaved with live over the air messages once the connection to the RNI is re-established. This can lead to significantly delayed messages being passed through to the DSP, well outside of the deduplication window. Buffering at the TK is only intended to support momentary lapses in connectivity to the RNI rather than prolonged interruptions.

Duplicate AD1 messages

This is linked to the scenario where a message from the CH is picked up by multiple transceiver kits but there are issues with RNI connectivity. Part of a role of the RNI is to de-duplicate any messages that are picked up by multiple transceiver kits (this currently occurs over a 3 second window to cater for variances in backhaul delivery times between sites). In this scenario, one TK has an established RNI connection and is therefore able to pass the message on to the RNI. However, the other TK does not have RNI connectivity and it takes a long time to re-establish connectivity. Once connectivity is re-established, the delayed AD1 message is sent. However, due to the length of delay in the AD1 messages being sent to the RNI, it is unable to perform any de-duplication and therefore the same AD1 message is sent twice to the DSP. The DSP does not perform de-duplication in this instance as it assumes that the RNI would have already performed this activity.

DSP not available

If an AD1 message is forwarded onto the DSP gateway and the message transfer is unsuccessful, there will be a retry performed 5 and 10 seconds after the original attempt. If after these attempts the message is still unsent, the message is dropped.

4.3.3 Current Performance

Current performance on Arqiva systems is described below for a small and large scale outage scenarios. The performance is given at the single radio cell level and can be applied to multiple cells in parallel for larger outages. For larger multi-cell scenarios, the total throughput may exceed the 5,000 per minute alert throttle between the CSP and DSP at which point AD1s will begin to buffer at the Arqiva-DSP gateway.

The below examples have been chosen to illustrate a common small scale outage, typically seen thousands of times a year across the UK and a rare large event seen less frequently in a year.

Example Case One: 50 premise outage, single cell (DNO Scenario C)

For a smaller outage affecting 50 premises which all reside within a single cell of the Arqiva system, the performance for each alert type would typically be as follows:

- AD1s

  AD1 alerts would begin transmission after 3 minutes of outage, following the three transmission windows. Where over the air collision occurs, some packets may be lost during each window. However, statistically it is unlikely that the same alerts would be lost over all three windows.

  After 5 minutes (3 minutes to confirm the outage and 2 minutes of alert delivery) typically 95%[8] of alerts will be delivered. The remaining alerts are expected to be retransmitted during the second and third windows. The bulk of alerts would arrive between 3-4 minutes, typically 94%. Between 4-5 minutes, 95% of the alerts would be received.

- 8F35 and 8F36 alerts

  On restoration of power to all premises the CH will begin rebooting which can take up to 3 minutes. 8F35 and 8F36 alerts will be passed from the ESME to the CH[9] and held in its internal memory. Any CH with a GBCS alert held in memory will begin sending RTS messages immediately and beacons will be allocated as the RTS messages are processed by the RNI. As the CH takes up to three minutes to boot up, the alerts would typically take around 5 minutes to pass through the system back to the DSP.

Example Case 2: 30,000 premise outage, three cells (DNO Scenario F)

For a larger outage affecting 30,000 premises spread over multiple cells, performance for the two alert types would typically be as follows:

- AD1s

  AD1 alerts begin transmission after the three minute hold off period to confirm the outage. Assuming that the 30,000 alerts are across a minimum of three Arqiva cells equally loaded with 10,000 premises in each, the initial 45 second alert window would experience higher levels

[8] Not accounting for CHs operating in Buddy mode, typically 5% of the network. Buddy mode is where CH which are out of range of the network communicate via CHs that are connected to the network (the buddy). For a standalone site with no overlapping coverage from neighbouring sites and connected to the RNI with DSL backhaul.

[9] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers. Single traffic channel per cell.

of message collision. Delivery of alerts will improve over the two 240 second windows.
After 5 minutes total since the outage, typically it would be expected that 52%[10] of alerts would be delivered. At the end of the three windows (705 seconds after the power is lost) typically around 93% of devices alerts will have delivered.
At this volume, the 5000 per minute throttle to the DSP would be breached and alerts would begin buffering before sending. The above delivery percentages refer to the percentage delivered to the gateway, at which point they would be sent at 5000/minute. Note that the messages sent through the Arqiva gateway to DSP will include duplicate AD1 alerts. After deduplication by the DSP, the number of alerts sent to the DNOs would be less than 5,000/minute.

- 8F35 and 8F36 alerts

  ESME alerts will again be passed up to the CH[11] and the CH will generate RTS messages. Initially the high contention for the RTS channel will result in message collisions and not all RTS messages will be received successfully. The RTS back off routine will result in reduced contention between devices and improve delivery to the TK, at which point UL messaging timeslots will be allocated via a beacon for the transmission of the GBCS alerts.[12]

4.4 DSP System Overview

The DSP receives PRAs and POAs via separate channels. PRAs are received as GBCS alerts and are processed with all other GBCS traffic. Power outages are received via a dedicated power outage alert URL as HTTP messages. There are separate CSP gateways for Telefónica and Arqiva and there are two gateways for each CSP to allow for load balancing. This is illustrated in Figure 8, below.

[10] Assumptions: Three cells providing coverage to 10,000 premises each, split over two alert channels in each cell. Each cell contains 500 (5%) out of range (ORD) devices connected through buddy mode which are lost. the Three sites have DSL backhaul. Macro diversity of 2 providing some additional coverage from neighbouring sites into the outage area.

[11] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers.

[12] Assuming successful beacon allocation the maximum GBCS alert delivery rate is 2 messages per second per channel per cell. In this case up to 8 alerts per second in each cell will be delivered taking approximately 45 minutes to fully deliver all 8F35 and 8F36s.

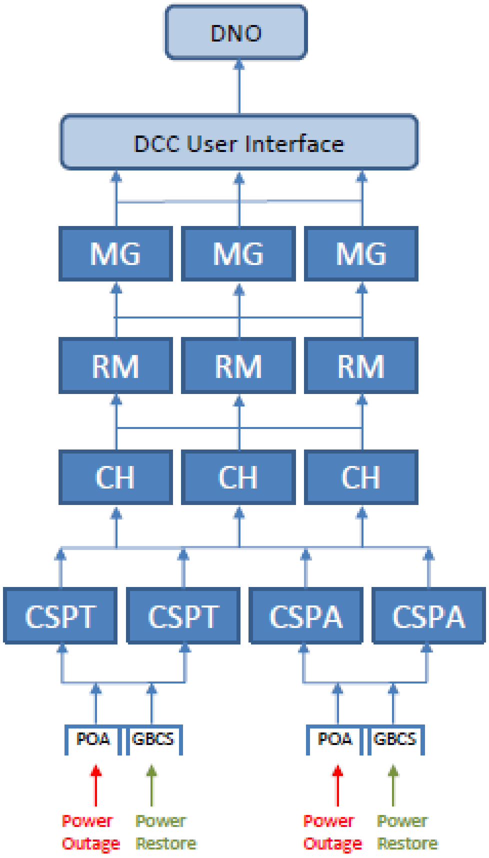


Figure 8 DSP System View

Component	Description
CSPT	Telefónica CSP message gateway
CSPA	Arqiva CSP message gateway
CH	Communications Handler. Manages the queue for message processing
RM	Request Manager. Handles business logic, validation, post-processing requirements
MG	Message Gateway. Responsible for delivering messages to Users
DCC User Interface	DCC Interface. Demarcation point between DSP and DCC

Table 10 DSP Components

In the case of POAs received from Arqiva, there is logic in place to perform de-duplication to remove the duplicate POAs that arise from each CH attempting to send an outage message three times. The DSP records the outage time from the first POA from a CH and rejects subsequent POAs from the same CH containing the same outage time. The length of time for which the DSP 'remembers' an outage is configurable and currently set to 2 hours.

Messages received from the gateways are processed northbound via shared DSP motorway lanes. There is no data manipulation of PRAs but POAs are converted into a number of DCC Alert AD1 alerts, depending on the SMETS2 Installation. DCC Alert AD1s are sent to the following recipients (if present):

- EIS - Electricity Import Supplier
- GIS - Gas Import Supplier
- ENO - Electricity Network Operator
- GNO - Gas Network Operator

A typical dual fuel SMETS2 Installation will give rise to 4 DCC Alert AD1s (AD1s being sent to the EIS, GIS, ENO and GNO). Similarly, DCC Alert AD1s for a typical single fuel site will give rise to 2 AD1s (one to the Supplier and one to the Network Operator). DCC Alert AD1s are sent for each ESME and GSME on the HAN, therefore, SMETS2 Installations with multiple ESMEs according to the Smart Metering Inventory in DSP will give rise to a DCC Alert AD1 to the registered EIS and ENO for each ESME associated with the HAN. The inventory may reflect actual installed ESMEs, but in some cases there are misleading entries in the inventory due to failed meter installations for which the supplier has not sent a Decommission Device Service Request.

POAs and PRAs are forwarded to the DCC User Interface for delivery to DCC Users over the DCC User Gateway. Should a DNO use a DCC service provider to connect to the DCC, there will be additional transmission required of the POA/PRA between the DCC Service provider and the DNO.

CGI currently has no contractual SLA specific to POAs or PRAs, but does have a general ‘DSP Alert Response Time’ target of 4 seconds for processing of all Alerts. Analysis of POAs and PRAs processed for the period 9th to 15th June 2020 inclusive demonstrated that CGI met this SLA for 99.99% of the POAs and PRAs processed, processing AD1s in an average of 0.288 seconds and 8F35s/8F36s in an average of 0.025 seconds (refer to section 12.3 DSP PRA/POA Processing Time for further details). The maximum volumes of POAs and PRAs that the DSP systems can handle, based on current performance testing and capacity planning, is 12,000 POAs/minute and 96,000 PRAs/minute under normal operating conditions, noting however that this capacity is shared between the 2 CSPs. This is sufficient to cope with 4 of the 8 DNO scenarios (refer to Table 20: Current and enhanced DSP capability to meet DNO scenarios).

4.4.1 Unhappy Path Scenarios

The scenarios for unhappy paths are outlined below.

DCC User Interface Not Available

The DSP will forward on messages via the DCC User Interface for the DNOs to consume. In the event there is no response, the DSP will perform three retries every 60 seconds and thereafter will attempt a retry every 2 hours up until 48 hours. Beyond that, if the message still cannot get through, the message will be dropped.

DSP Gateway Not Available

In the event that the DSP cannot receive messages from the CSP due to unavailability of DSP systems, there will be several attempts made by the CSP during a short period but if still unsuccessful, these messages will be lost. This can occur during planned or unplanned DSP outages. The DSP has planned outages for maintenance that typically last 4 hours. Note that there was previously a DCC Change Request (CR1090) which aimed to address loss of messages during planned DSP outages but this Change Request was withdrawn.

Message volumes exceeding DSP thresholds

The DSP systems have load balancing servers which monitor the volume of messages received from the CSPs. If the volume of messages from a CSP exceeds a configured threshold, the CSP will receive an error response. This may trigger the CSP to retry sending the message but, if a similar response is received from the DSP systems, it will eventually lead to messages being dropped.

Arqiva POA duplicates delivered more than 2 hours after the outage

As described above, the DSP currently applies business logic to de-duplicate multiple POAs arising from the three attempts each Arqiva CH makes to send a POA. The buffer used by the DSP for ‘remembering’ previously processed POAs is currently set to 2 hours. If a duplicate POA arrives more than 2 hours after receipt of its first sibling, it will not be recognised as a duplicate by the DSP and will be forwarded to its recipients as an AD1.

5 To Be Solution Options

Based on the DNO requirements, it is noted that there are enhancement opportunities identified by Telefónica, CGI and Arqiva to improve how and when power outage alerts (POAs) and Power Restorations Alerts (PRAs) are received by them. Telefónica and Arqiva have identified potential enhancements which could be introduced to improve the speed of POA/PRAs and overall volume of alerts being sent to DNOs. CGI has identified 6 options for improving the volume of POAs/PRAs the DSP can handle and a further 2 enhancements aimed at addressing other DNO requirements.

In summary:

- **POA.1 and POA.3 (delivery of all AD1 messages)**
  - The current capacity for DSP capability based on normal operating conditions can cater for 12,000 TPM shared across both CSP's - whereas the comparable TPM for Arqiva and Telefónica performance is deemed to be at 5,000 presently. There are available enhancements by Arqiva and Telefónica to uplift this to 35,000 and 30,000 through Option 4 and Option 3 respectively, which if selected would need to drive a corresponding DSP option being selected to increase capacity
  - Even through the introduction of the denoted Arqiva enhancements, the uplifted TPM volume is not expected to improve throughput significantly. It is only during outage scenarios where there are large volumes of alerts that occur around the same time that the current throttling is the limiting factor in alert delivery time. Enhancement through Arqiva Option 4 would only be visible to the DNOs during outages >20,000 premises. At outages of >20,000 premises, the DNOs would receive 20-30% of POAs.

- **POA.2 (delivery of AD1s < 5 minutes)**
  - Based on the assessment of this requirement, there is only one available solution enhancement to meet the average time for a POA to traverse from the Device to the DNO's within the designated five minute window (Telefónica option 3, Network Evolution CH with super capacitor). However, this will only be applicable to premises that use the new CH. Premises with 2G/3G CHs will not encounter quicker delivery of AD1s. The other Telefónica options and Arqiva (Option 2a) will reduce the current average durations. The reductions in durations vary based on the solution option and the volumes of outages. Further details are provided under each solution option. Based on historical analysis of DSP Production performance, the time taken for the DSP to process POAs and PRAs is 0.288 and 0.025 seconds, respectively. Given that these processing times are less than 0.05% of DNO target times for delivery of POAs

and PRAs, there is little benefit attempting to reduce DSP processing times.

- **POA.4 (POAs are trustworthy)**
  - This requirement is to eliminate false positives or negatives with POAs. For Telefónica, options 1 and 2, a reduction in message loss (specifically CH power restore alerts), will reduce the chances of AD1s being sent for outages under 3 minutes. Option 3 (Network Evolution CH with super capacitor) will allow the CH to directly work out when an AD1 message should be sent thereby making improvements overall in this area.
  - Arqiva duplicates can cause duplicate POAs to DNOs and there is a solution proposed to address this (backhaul resilience option).
  - There are indications based on the data supplied by the DSP for June 2020, that there is misalignment in the volumes of POAs and PRAs that are being sent to the DNOs (refer to "Appendix A – Power Alert Data Analysis" for further details). This is currently being analysed to determine the root cause and could result in incidents being raised to address these issues.
  - There is an issue that ESME firmware updates cause POAs which do not represent actual outages. This is not controlled by the service providers and no options are proposed to address this particular issue.
  - DNOs will not receive POAs for gas-only SMETS2 HANs (or any SMETS1 HANs, though that is a known limitation). There are no solution options available to address this issue but is raised for awareness.

- **POA.5 (AD1s must be consistent)**
  - This requirement indicates that AD1s should be consistent across meter types, CH types and CSPs. The service providers do not have control over the meters and therefore there are no solutions proposed to address this. From a CH perspective, Telefónica uses two vendors and the functionality is consistent. In addition, mesh and non-mesh CH types are consistent from a POA/PRA perspective so there is no solution required to address this.
  - From a CSP perspective, there are differences such as the duration of time to deliver POAs and the throughput. The solution options offered do offer improvements in the delivery times and improved throughput rates which will improve consistency between CSPs. However, due to the different implementations of the CSP systems, it will not be completely consistent.

- **PRA.1 (delivery of all PRAs)**
  - The assessment has identified that the current TPM in place is 96,000 by the DSP and 200,000 by Telefónica – with Arqiva presently limited to the max alert rate of circa 35,000 TPM.

Arqiva are proposing two options to streamline this, DSP are proposing four options to increase the limit to 192,000 TPM and Telefónica do not believe any improvements are needed to meet this requirement

- **PRA.2 (PRAs delivered < 1 min)**
    - For the DSP, the current solution meets the 1 minute requirement. For Telefónica, PRAs can be delivered under 1 minute provided the CH is connected to the network. If the CH needs to reboot due to lack of power, it will take longer than 1 minute after power is restored, taking into account the CH reboot time and the time required for the CH to reattach to the network (the total time can range from 1.5-3.5 minutes). For Arqiva, the throughput of PRAs is limited to 2 per second per channel per cell. For a maximum loaded cell the average time for delivery of 50% of 8F35 and 8F36 alerts would be 24 mins. None of the proposed Arqiva solutions will reduce the time for a maximum sized outage to less than 1 minute, due to the time required for the CH to reboot after power is restored (this takes up to 3 minutes) – and DSP and Telefónica are not proposing any solution enhancements.

- **PRA.3 (PRAs are consistent)**
    - As per POA.5 (POAs are consistent), there are solutions to improve delivery times and throughput of PRAs which will improve consistency between CSPs. However, due to the different implementations of the CSP systems, it will not be completely consistent.
    - Note that if the Arqiva Option 1 is introduced, this requirement would be breached and consistency between CSPs will be reduced.

- **PRA.4 (PRAs are trustworthy)**
    - CGI has proposed three enhancements aimed at improving the trustworthiness of PRAs. Two aim to improve the quality of PRAs by prioritising delivery of POAs/PRAs that provide the most useful information to DNOs. The third aims to remove large volumes of spurious PRAs generated by a small number of defective ESMEs.

- **GEN.1 (No loss of PRAs/POAs during planned outages)**
    - Telefónica has proposed two options to address the issues of lost POAs during planned outages. There are no solution options from Telefónica for PRAs lost during planned DSP outages as this is via a different interface.
    - CGI has proposed an enhancement for introducing buffering of messages during planned outages.
    - Arqiva has proposed an enhancement for introducing buffering of messages in the CSP-DSP interface.

- **GEN.2 (No loss of PRAs/POAs during unplanned outages)**
    - Telefónica has proposed two options to address the issues of lost POAs during unplanned outages. There are no solution options from Telefónica for PRAs lost during unplanned DSP outages as this is via a different interface.
    - Arqiva's enhancement for introducing buffering of messages in the CSP-DSP interface covers unplanned outages of the DSP as well.

Details of the options proposed by the service providers are described below. These options take into account the core DNO requirements and the various outage scenarios that need to be addressed. These are listed below with the assumed maximum simultaneous alert volumes that are expected to incur.

Scenario	Description	Assumed Maximum Simultaneous Outage Volumes	Assumed Maximum Simultaneous Restore Volumes
C	Overhead power line comes down. 30 homes in a village are taken off supply as are 15-20 local supply points at neighbouring farms	50	50
A/B	Single 5000 property outage (A - TEF region / B - ARQ region)	5,000	5,000
D	Substation damaged - 5,000 lose power simultaneously	5,000	5,000
G	Storm travelling West to East knocks out a total of 100,000 MPAN's over a 20-hour period on average 5,000 homes an hour with a mix of high volt and low voltage. Due to re-routing, alerts may be generated and restored within the 3 minutes	5,000	7,500[13]
H	Storm travelling South to North from Bristol to Glasgow affecting 100,000 MPAN's over 7 hours to include 20,000 simultaneous supply points in Birmingham, 15,000 in Manchester and 65,000 being a mix of high voltage / low voltage in other cities, towns and villages	20,000	20,000
E	20,000 homes in a major city lose power within 30 seconds a smaller power event occurs meaning the loss of power occurs in a different part of the same SP region (e.g. 20,000 homes in London – 6 homes in Western Super Mare)	20,006	20,006

[13] assumes restores are split: 50% < 3 mins (8F35 only), 50% > 3 mins (8F35/36) i.e. 5000 x 8F35s / 2500 x 8F36s

Scenario	Description	Assumed Maximum Simultaneous Outage Volumes	Assumed Maximum Simultaneous Restore Volumes
F	An event knocks down a high voltage cable in a major city (as per DNO discussions assumed to be scenario for outage of 30,000 properties)	30,000	30,000
I	Transmission Line Failures	200,000	50,000

Table 11 DNO Scenarios with Volumes

The following additional assumptions are as follows:

- In each outage scenario, there will be a mixture of SMETS1 and SMETS2 type meters. Based on current volumes the breakdown of SMETS1 to SMETS2 meters is 33% SMETS1 and 67% SMETS2. However, for the purposes of analysis done in this paper, the volumes of these are assumed to be 10% SMETS1 meters and 90% SMETS2 meters to allow for concentrations of SMETS2 installations. Given that the bulk of SMETS1 meters do not provide power alerts, we can expect 90% of the above volumes to result in power alerts. This is more prevalent in the larger outage scenarios.
- The simultaneous outage volumes refer to volumes of alerts that the service providers would expect to receive in the space of a single minute.

5.1 Service Provider Options

5.1.1 Telefónica CSP Implementation Option Descriptions

Overview of Options

The options provided by Telefónica are focused on improvements to the power outage messages (AD1). In terms of the meter PRAs (8F35 and 8F36 messages), the current functionality provided by Telefónica is able to transmit these messages very quickly and reliably to the DSP, under the scenarios where the CH is attached to the network, so there is not a need to make changes to this particular message flow. There will still be a potential issue in situations where the DSP is unavailable (e.g. due to planned maintenance) as in those circumstances the messages will not get transmitted. Due to the nature of the way the interface for transmitting GBCS messages to the DSP is implemented, there is no capability in place for undertaking resending of messages over a long period for situations where the message transmission failed. There are three retries which stretch out over a period of five minutes overall. The DSP has a solution option suggested for capturing alerts from Telefónica during planned outages for future processing but this covers only the interface for dealing with POAs and does not cover the PRA interface. Similarly, Telefónica has options for storing POAs for future processing in situations where there are planned or unplanned outages at the DSP but it does not cover PRAs.

For POAs, the main focus areas are to ensure greater throughput of POAs sent to the DSP under large outage scenarios, reduction of time taken to process POAs as it traverses through the Telefónica systems onto the DSP and also to improve the reliability/trustworthiness of the POAs. Addressing reliability/trustworthiness of POAs would be done by minimising any message losses that may occur as the alerts traverse through the various systems. Although based on previous analysis on Telefónica systems there was no evidence found that any POAs were lost, the data supplied by the DSP for June 2020 indicates there are some discrepancies in the POA and PRA data (see "Appendix A – Power Alert Data Analysis"). Some analysis has been done on this data and is covered in this paper but further work is required to clearly identify root causes of these discrepancies. The discrepancies could potentially be due to a number of factors such as issues with specific ESMEs or CHs installed, firmware updates on the CHs or ESMEs resulting in spurious POAs/PRAs or some other issues. Issues with specific ESMEs or CHs cannot be resolved by enhancement options but the enhancements can address other issues such as ensuring that even under some small volume scenarios, no POAs and PRAs are lost during processing.

There are 4 options provided in this paper:

1. Improvements in existing systems for POA/PRA processing
2. Cloud based micro service for POA/PRA processing
3. Introduction of a Network Evolution CH with super capacitor
4. CH firmware updates and network infrastructure enhancements

Based on the above options, option 4 was investigated and is not deemed to be a viable option to take forward due to large investments in 2G/3G network infrastructure which is considered legacy infrastructure. It has been included for completeness as it has been discussed with DCC and DNOs in the past.

For the remaining 3 options, the below table is provided to help with understanding what the different options will achieve.

Option	Increases throughput of POAs for new power outages to DNOs	Increases throughput of PRAs to DNOs following a power outage	Reduces processing time of POAs	POAs delivered in under 5 minutes	Improves the quality of POAs/PRAs received by DNOs	Improved scalability for future volume growth	Avoids lost POAs during planned/unplanned maintenance
1 – Existing IT System Enhancements	✓		✓		✓		✓
2 – Cloud Based Micro service	✓		✓		✓	✓	✓

Option	Increases throughput of POAs for new power outages to DNOs	Increases throughput of PRAs to DNOs following a power outage	Reduces processing time of POAs	POAs delivered in under 5 minutes	Improves the quality of POAs/PRAs received by DNOs	Improved scalability for future volume growth	Avoids lost POAs during planned/unplanned maintenance
3 - Network Evolution Comms Hub with Super capacitor	✓		✓	✓	✓	✓	✓

Table 12 Telefónica Options Feature Benefits

Some of the above would have varying degrees of the improvements that these options will deliver. These will be described further in the sections below.

TEF.1 – Existing IT System Enhancements for POA/PRA processing

This option is looking to optimise the functionality currently provided by the existing systems to reduce the time it takes overall to process AD1 messages and to reduce the occurrences of messages being dropped while traversing through the various systems. The option covers a number of changes amalgamated together which on their own would have addressed certain DNO requirements but not most of them. Therefore, the changes have been combined to improve coverage of addressing the DNO requirements. This solution option includes a buffering capability to minimise message losses during planned and unplanned outages of systems. The message buffering capability involves using the Kafka messaging system to transfer data between systems.

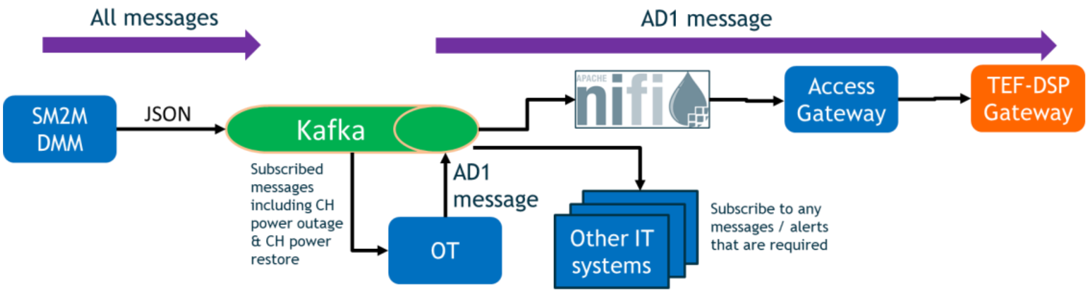


Figure 9 Telefónica Option 1 Overview

In the current functionality, the interface between SM2M DMM and OT is a UDP type interface which can potentially result in message loss as it does not provide guaranteed delivery capabilities. Using Kafka will allow messages from SM2M DMM to be published on to the Kafka topic and allow systems to subscribe to that topic and pick up the message types they need. This implementation also offers performance benefits to OT since it reduces the volume of messages it has to deal with. Currently, it receives all messages from SM2M DMM when in many cases, it just forwards these messages onto downstream systems. With this implementation OT only picks up the messages it needs for processing, including CH power outage and CH power restore alerts.

Once OT determines if a CH power outage alert has lasted longer than 3 minutes, it will publish the AD1 message back onto Kafka. There will be another component, Nifi, which will consume the AD1 message from Kafka and send the message onto the DSP. By making use of this capability for sending AD1s, messages can be retained for later processing in the event that the message send failed (e.g. due to a planned outage at the DSP).

Based on the above implementation, we can analyse the performance against 2 outage scenarios:

- Scenario A – Single 5000 property outage in a Telefónica region
  - **AD1 Messages**
    - There will be 5,000 CH power outage messages sent over 15 seconds
    - These outage messages will be passed onto the SM2M system and then OT via Kafka within a few seconds
    - OT will hold onto these messages and wait 5 to 7 minutes for associated power restore messages. This is based on the reattach algorithm used for CH reattaching to the network after a CH reboot. The time OT will wait for the corresponding CH power restore alert will be linked to the GUID of the CH.
    - If power is restored within 3 minutes, CH Power Restore Alerts will arrive at OT within 7 minutes and OT cancels the outage
    - If power is restored after a period of 3 minutes, OT will not receive the CH PRAs within 5 to 7 minutes. Therefore, OT marks the outage as confirmed and publishes the AD1 to the Kafka queue. This will be picked up by Nifi and sent to the DSP within a few seconds
    - The length of time OT waits is dependent on the GUID of the CH and therefore some AD1s are sent just after the 5 minute mark and for some it has to wait 7 minutes
    - If the Nifi system attempts to send the message to the DSP and the message send fails due to DSP unplanned or planned outages, the message will be held in the Kafka queue in order for Nifi to try and send again at a later time once the DSP is available
  - **8F35/8F36 Messages**
    - When power is restored to the meter, if the CH has not shutdown, the 8F35 message will be transmitted to the DSP within 1 minute
    - If the CH has shutdown, the CH will need to restart and reattach to the network and will then transmit the 8F35/8F36 message to the DSP within 1 minute. The time required for the CH to restart and reattach can be up

to 3.5 minutes (1.5 minutes to reboot and up to 2 minutes using the network reattach algorithm). Also, there would be some time required for the ESME to restart and connect to the CH after the power is restored in order to transmit the 8F35/8F36 message

- Scenario E – 20,000 homes lose power and within 30 seconds a smaller power event occurs in a different part of the same SP region
  - **AD1 Messages**
    - There will be 20,000 CH power outage messages sent over 15 seconds
    - These outage messages will be passed onto the SM2M system and then OT via Kafka within 2 minutes
    - 30 seconds later, power is then lost to the 6 homes and the power outage messages related to these 6 homes will be queued behind the 20,000 outage alerts
    - OT will hold onto these messages and wait 5 to 7 minutes for associated power restore messages. As described above, the time OT waits for the corresponding CH PRA is based on the network reattach algorithm and is dependent on the CH GUID
    - If power is restored to all 20,006 premises within 3 minutes, CH Power Restore Alerts will arrive at OT within 7 minutes and OT cancels the outage
    - If power is restored to all 20,006 premises after a period of 3 minutes, OT will not receive the CH PRAs within 5 to 7 minutes. Therefore, OT marks the outage as confirmed and publishes the AD1 to the Kafka queue. This will be picked up by Nifi and sent to the DSP within 2 minutes. This is based on the Access Gateway system processing up to 15,000 transactions per minute
    - The length of time OT waits is dependent on the GUID of the CH and therefore some AD1s are sent just after the 5 minute mark and for some it has to wait 7 minutes
    - Given that the power outage for the 6 premises occurred 30 seconds after the outage of the 20,000 premises, it does mean that a large portion of the AD1 messages related to the 20,000 premises will be processed first. However, this does not mean that the AD1 messages related to the 6 premises will only be sent after the AD1 messages for the 20,000 premises are cleared first. The AD1 messages related to the 6 premises will be intermixed with the messages related to the 20,000 premises as all the messages sent will be staggered based on the GUID of the CHs.
    - The last of these AD1s will delivered to the DSP in 8 minutes
  - **8F35/8F36 Messages**

- This will perform in the same way as the 8F35/8F36 messages under scenario A

In summary, key benefits of this option are as follows:

Key Benefits	Improvement Made?	Additional Information
Increases throughput of POAs for new power outages to DNOs. Requires alignment with DSP to adjust throttling	✓	From 5000 TPM to 15000 TPM
Increases throughput of PRAs to DNOs following a power outage		No change
Reduces processing time of POAs	✓	Reduced by 1 minute
POAs delivered in under 5 minutes		Only achievable with the Next Gen CH solution option
Improves the quality of POAs/PRAs received by DNOs	✓	Reduced chance of message loss resulting in increased reliability of POAs/PRAs
Improved scalability for future volume growth		Will require standard hardware investment or software updates to improve capacity
Avoids lost POAs during planned/unplanned maintenance	✓	Message buffering in place

Table 13 Telefónica Option 1 Benefits

TEF.2 – Cloud Based Micro service

This option is a module to process power alerts and determine if a power outage received constitutes a confirmed power outage over 3 minutes in duration and then sends out an AD1 message to the DSP. Power alert messages will be diverted from the existing system process which goes via the SM2M DMM and OT systems to the micro service. The benefit of this option is a greater ability to handle a larger volume of messages than the current systems can process and to reduce the chances of messages being lost while the messages flow through multiple systems. Given the fact that the micro service is cloud based making use of the Platform as a Service (PaaS) capability, it is also going to be implemented in a high availability configuration which means that the service will be able process power alerts during maintenance windows as well. There will also be a capability in place to buffer AD1 messages in case the DSP is unavailable due to planned or unplanned outages.

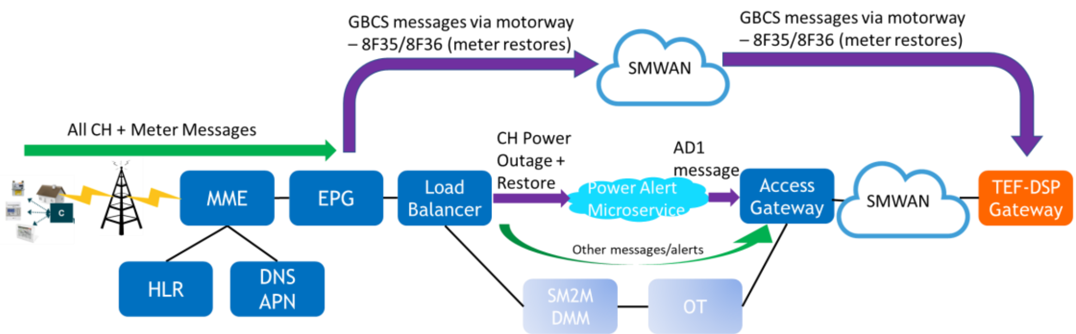


Figure 10 Telefónica Option 2 Overview

In terms of connectivity of the micro service with the DSP, several options were considered such as integration with the DSP on the cloud using a data streaming method to transfer data. Based on discussions with the DSP which included designers and security teams, it was determined that it was best for now to implement a solution which did not impact the current CSP-DSP interface and therefore this option will make use of the current API functionality that the DSP exposes to consume AD1 messages. Some of the reasons behind this decision was that cloud based traffic would have to be diverted into the DCC gamma network, whose security levels were not as high as the SMWAN network which would have meant making a large number of changes to the gamma network capability as well the fact that the DCC was looking into cloud based capabilities at a later point in time as part of the network evolution programme. This implementation would be a step in the right direction towards that evolution and in the future alternative integration options with the DSP can then be employed.

In summary, key benefits of this option are:

- Reduction in the E2E journey time of POAs by 1 minute (from 8 minutes to 7 minutes). This means the range of times AD1 messages will be sent will be 5 to 7 minutes for small to medium sized outages up to around 5,000 premises experiencing outages at the same time. A view of AD1 message times based on outage scenarios is shown in “Table 16 Telefónica Options against DNO Scenarios”
- Greater throughput of POAs, going from 5,000 TPM to 15,000 TPM (reduction in queuing during large outages). This requires agreement with the DSP to reduce the throttling of messages at the gateway in order to achieve greater performance
- Ability to retain POAs for later processing during planned and unplanned outages on the DSP
- High availability solution in the cloud which minimises any outages for maintenance, resulting in minimising any messages lost
- Ease of future scaling of the capability as volumes increase
- Progression towards more cloud based micro services being implemented in the future

TEF.3 – Network Evolution Comms Hub with Super capacitor

This option is to introduce a next generation CH which not only has 4G capability but will also have a capability of remaining powered on without mains power for longer than three minutes. In that instance, the CH itself can establish if a power outage lasts longer than three minutes and therefore can transmit the AD1 message directly via a similar route to the 8F35 and 8F36 messages. This will then allow for the message to be transmitted to the DSP in under a minute (provided there is no DSP outage) and can be transmitted reliably.

DCC is looking to make use of 4G CHs as part of the network evolution programme and costs for the 4G CHs have been provided by Telefónica separately. It should be noted though that any CH costs provided previously do not include the enhanced capability to remain powered on for longer than three minutes in case of a power outage. Also, this solution will only be valid for new CHs and will not improve the message transfer rate of existing 2G/3G CHs. By the time a decision is made on new CHs and when these hubs start rolling out (earliest time is estimated to be 2022), there may already be around five million 2G/3G CHs deployed within the south and central regions. DCC may want to consider solutions such as using these new CHs as proxies for the older CHs whereby if a new 4G CH indicates a confirmed power outage and it is in the same area as an existing 2G/3G CH, then it can be deduced that the older CHs are also out of power. The AD1 messages for the older CHs will eventually arrive to the DNOs but the AD1s from the 4G CHs will arrive sooner. This type of proxy solution will only become viable once there are a sufficient volumes of new CHs deployed in the majority of areas across the country.

TEF.4 – Firmware and Network Infrastructure Updates

The aim of this option is to reduce the time it takes end to end for power alert messages to traverse through the CSP systems. Note that this option has been discussed in previous iterations of POA/PRA analysis but has been analysed again based on current developments. It is not deemed to be a viable option (the reasons for this are described below) but has been included for completeness.

In the current implementation, a significant amount of time is taken by the OT system to wait for power restore messages that may come through as a result of a CH having to shut down, reboot once power is restored, reattach to the network and transmit the power restore message. The time taken for a CH once power is restored after it shuts down is as follows:

Comms Hub boot time	up to 90 secs
Re-connection algorithm to control the load of a high number of devices simultaneously connecting to the radio network	up to 2 mins with option to expand to 10 mins

These times above are over and above the 3 minutes the OT system needs to wait in order to determine whether a power outage constitutes a power outage longer than 3 minutes. This option is looking to reduce the above times so that the AD1 messages can get passed on to the DNOs quicker.

As explained in section “4.2 Telefónica CSP System Overview”, the Network elements involved in the delivery of the SMIP service need to be protected in scenarios where large volumes of alerts can be generated. Due to the nature of SMIP where there are millions of devices interfacing with the TEF Network great care needs to be taken with defining Communication Hub behaviour. Designs need to avoid scenarios where alert storms are generated or simultaneous mass attaches to the Telefónica network can occur. This risks deteriorating or even disabling the Telefónica network, impacting both mobile customers as well as the delivery of the end to end smart metering service.

From discussions with DNO stakeholders in conjunction with DCC, the assumption is that the service provider systems should cope with levels of national grid transmission failures which are outlined as follows:

Type of Incident	Customer Number affected (Typical)	Frequency of incident	Comments
National Grid Transmission System	1-200,000 customers	Average 9 per annum (3 to 16 typically per annum)	On average these incidents last 60mins but are very dependent on the circumstances. The average of 9 incidents per annum includes incidents affecting small numbers of very large industrial/commercial customers (i.e. some of these incidents do not affect domestic customers). On occasions the transmission system will experience very short interruptions (lasting a few seconds) which would result in simultaneous restorations of 1-200,000 customers. Such events are likely to be too short to be detected by the communications hub.

Table 14 National Grid Transmission Failure Overview

Based on the above, the maximum outage size that will be considered in analysis work is one affecting 200,000 households/communication hubs, as it is an event that is expected to occur several times a year. Larger outages are expected to occur less than yearly. Considered against the SMETS1 meter roll out which is close to 7 million and the potential SMETS2 numbers, Telefónica assumes that full roll out means that eventually no more than 66% of households will be on SMETS2. So the above single outage size will result in 132,000 outage alerts for the CSPs. Alerts will arrive randomised over 15 seconds so result in a rate of 8800 transactions per second. Larger but very rare outages will be impacted by longer processing times and when these occur may result in outage alerts being dropped.

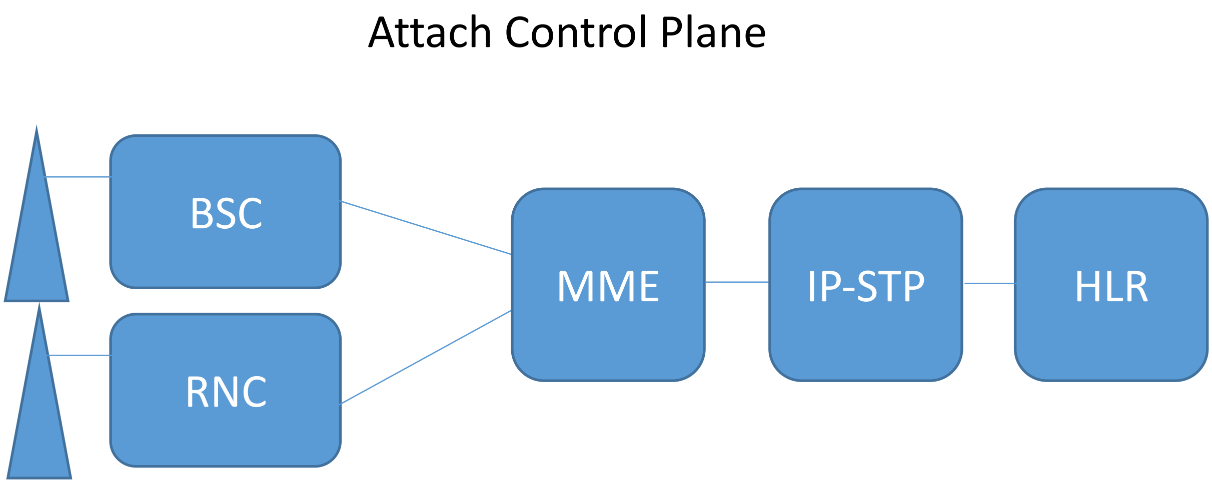
Based on information in "Appendix C – National Grid letter to Telefónica – Black Start Worst Case Scenario", Telefónica assumes that the most extreme scenario for power restoration is one from a nationwide black start. The letter advises Telefónica that the rate that households will have power restored at is a maximum of 350,000 homes in any 5 minutes. Considering the spread between SMETS1 and SMETS2 at 66% this works out at 231,000 households with a SMETS2 meter. So a maximum of 231,000 communication hubs will be reattaching to the Telefónica network in any 5 minute period. **If this power restore rate is exceeded then this will put the Telefónica network at risk.**

In terms of requirements to reduce the overall duration of the network re-attach timer, also referred to as dither, from the current period of two minutes, many network components need to be considered.

The background to this timer is that the Telefónica service was initially setup with a 10 minute re-attach timer based on forecasts. At the request of the DCC, this was subsequently agreed to be reduced during early roll out to 2 minutes with the proviso that it could be increased again as communication hubs roll out increased. Thus far there has not been a need to do so but the 2 minutes cannot be considered to be permanent, it will be reviewed as use of the network by smart meters increases. The network re-attach timer is there to protect the Telefónica network when the grid recovers from a large power outage. In that scenario many CH will need to re-attach to the Telefónica network when their power is restored. The rate this is done at is controlled by the grid operators. In order to throttle the CH attach rate the timer helps spread the attaches to the Telefónica network. The network optimisation option explores what changes are needed to reduce the network re-attach timer from the current 120 seconds to 70 seconds for each element in the control plane. This means increasing the maximum attach rate of 2310 to 3850 transactions per second.

5.1.1.1.1 Radio Access Network

The RAN covers all equipment from radio masts to the packet core. The RAN is used for both mobile subscribers as well as smart metering. The network elements involved are the following:



Activate Control Plane and DNS

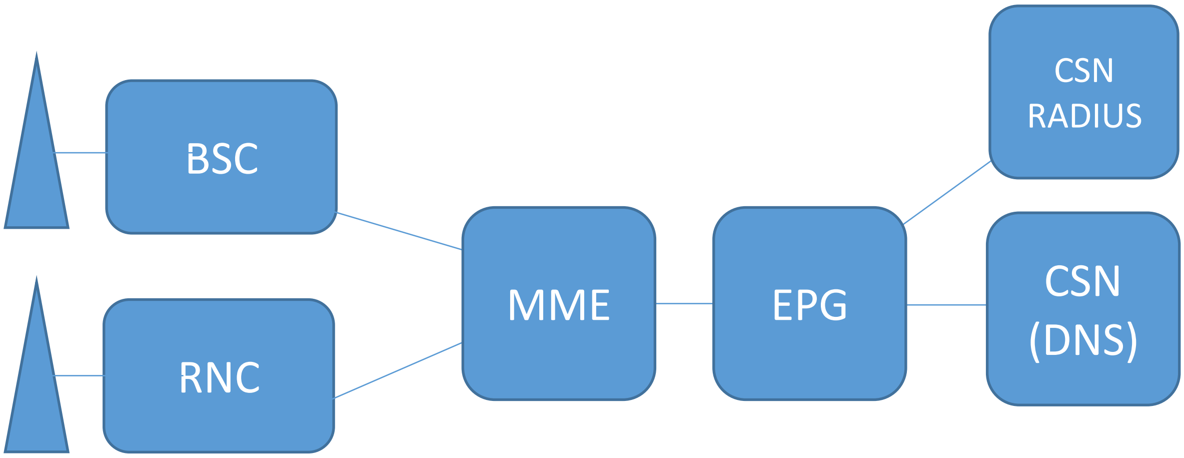


Figure 11 Radio Access Network

Component	Description	Function
BSC	Base Station Controller	Radio resource management
RNC	Radio Network Controller	Radio resource management
MME	Mobility Management Entity	Also known as Serving GPRS Support Node (SGSN). Represents the control plane and provides devices with access
IP-STP	IP Signalling Transfer Point	Network aggregation point
HLR	Home Location Register	Holds subscriber information and is needed for attaching to the network.
EPG	Evolved Packet Gateway	Main node in Evolved Packet Core
CSN	Telefónica Network	Secure Section of Network

Figure 12 RAN Component Overview

The communication hubs are connected via masts to either a BSC or an RNC depending on the traffic type (2G/3G). The *Base Station Controller* (BSC) is in control of and supervises a number of Base Transceiver Stations (BTS). The BSC is responsible for the allocation of radio resources to a mobile call and for the handovers that are made between base stations under his control.

A *Radio Network Controller* (RNC) is a governing element in the UMTS radio access network (UTRAN) and is responsible for controlling the Nodes that are connected to it. The RNC carries out radio resource management, some mobility management functions and encrypts data before it is sent.

Due to the geographic nature of power outages it means that a medium sized power outage may actually put significant load on local infrastructure of the RAN. However, the main concern is the impact of the attach rate that a black start power restore can generate and how this impacts the RNC. The vast majority of nodes will be connected via RNC as the percentage of communication hubs connected to 2G is very small.

The RNCs have a fixed registration capacity and exceeding it will mean requests are backed off and retried. In a signalling storm this will see requests backed off multiple times. In order to support the 3850 transactions per second attach rate that the network attach timer reduction dictates a doubling of the number of RNCs is required at significant cost. There are many RNCs sites in use that would all need to be upgraded. Even if the RNC improvements were to be put in place we would then be likely to hit processing limitations of the base stations at the higher attach rates of recovery of an extreme power outage. This would result in alerts either getting lost or ending up being backed off and retried, delaying their delivery. Improvements in the RAN here would also be extensive and costly to implement.

5.1.1.1.2 MME

The MME (SGSN) is used for both mobile subscribers as well as smart metering. The serving GPRS Support Node (SGSN) is responsible for the delivery of data packets from and to the subscribers within its service area. Its tasks include packet routing and mobility management (attaches and detaches) as well as many other functions. The 3850 transactions per second attach rate seen during a black start scenario taking place would make up a significant part of the total 'normal' traffic that the MME processes. This therefore means that the MMEs would need to be increased in each deployment by around a third. Associated design, project and deployment work will also need to be considered. Even with this additional hardware a black start re-attach scenario would still be challenging to support.

5.1.1.1.3 IP-STP

The IP-STP is used for both mobile subscribers as well as smart meters. IP-STPs simply route traffic that they are sent and do so within a few milliseconds. After analysing the routing digits it decides where to send traffic. IP-STP capacity vastly exceeds the attach rates that an extreme outage would generate over either 120 seconds to 70 seconds.

5.1.1.1.4 HLR

The HLRs we use are bespoke to smart metering but they do share a common interface with the MMEs for both mobile subscribers as well as for smart metering which is the limiting factor. The Home Location Register is a database that contains details of each communication hubs mobile subscription authorised to use the TEF network. It stores details of each SIM card issued and its unique IMSI number. The current HLRs cannot support a sufficient size increase in attach rates of 3850 transactions per second to shorten the network attach timer. There is a project delivering new smart metering HLRs planned for 2021. These can support the re-attach rates required with limited headroom. Roll out of the new HLRs including a sufficiently large subscriber migration are at least 12 months away.

5.1.1.1.5 EPG

The EPGs Telefónica uses are bespoke to smart metering. The Evolved Packet Gateway provides connectivity to the communication hubs with Serving Gateway, PDN Gateway, User Plane Function and Traffic Detection functionality for GSM, WCDMA, LTE, 5G, Wi-Fi and CDMA interworking, allowing for seamless transitions between different access types.
Ericsson (Telefónica supplier) has modelled the 3850 activations /second on the EPG to support the reduction in the re-attach timer and confirmed that the current EPG deployment can support the necessary rates. There is activation rate throttling that would need to be reviewed and adjusted. It is also essential that the load would need to be tested for which a new tool is required. This new tool is expected to confirm it can indeed be supported.

5.1.1.1.6 Conclusion

Achieving a reduction in the network re-attach timer that applies following a power outage is challenging. Some of the systems impacted by the high attach rates that take place following extreme power outages have improved over recent times and can support the rates needed to bring in a reduction. Other systems such as HLR, have improvements scheduled for 2021/2022 which will then enable them to support the higher rates. However, the Radio Access Network is one area where the capacity remains unchanged and even though we are still running with the 2 minute timer, this is where the original 10 minute re-attach timer was calculated as a safe value. Upgrading the RAN would be extensive, geographically spread and carry a very high cost. Making these kind of improvements on 3G, a radio technology that is becoming legacy, is an option that Telefónica does not support and therefore, this option is not viable. Instead, Telefónica suggests that 4G is explored further as an option and specifically how this could be setup to reduce signalling load.

Estimated impact of enhancements

The table below sets out the estimated impact of the proposed Telefónica enhancements. The colours in the grid indicate the level of impact (compared to the current capability) against each core DNO requirement for the proposed options:

Key:	No Change	Some Improvement	Significant Improvement

Req.	DNO Requirement	Option 0 Current capability		Option 1 Combined IT Updates	Option 2 Cloud Based Micro service	Option 3 Network Evolution CH	Option 4 CH FW change & NW updates
POA.1	POA for all outages > 3min[14]	5,000	TPM	15,000	15,000	30,000 (only for Next Gen CHs)	5,000
POA.2	POAs delivered in < 5min[15]	8	mins	7	7	4 (only for Next Gen CHs)	7
POA.3	POA must be reliable	5,000	TPM	15,000	15,000	30,000 (only for Next Gen CHs)	5,000
POA.4	POAs must be trustworthy	N/A		N/A	N/A	N/A	N/A
POA.5	POAs must be consistent	N/A		N/A	N/A	N/A	N/A
PRA.1	All PRAs required	200,000	TPM	200,000	200,000	200,000	200,000

[14] Any throughput volumes require alignment with the DSPs to ensure there is no message loss

[15] The time taken is expressed under normal levels. In high volume outage scenarios, the time taken can be longer to deliver AD1s

Req.	DNO Requirement	Option 0 Current capability		Option 1 Combined IT Updates	Option 2 Cloud Based Micro service	Option 3 Network Evolution CH	Option 4 CH FW change & NW updates
PRA.2	PRAs delivered in <1min	<1	mins	<1	<1	<1	<1
PRA.3	PRAs must be consistent	N/A		N/A	N/A	N/A	N/A
PRA.4	PRAs must be trustworthy	N/A		N/A	N/A	N/A	N/A
GEN.1	No loss of PRAs/POAs during planned outage	Potential POA/PRA loss during maintenance window (TEF and DSP systems)		Potential POA/PRA loss during SM2M maintenance only. POAs queued for later processing for OT and DSP maintenance. PRA loss if DSP not available	No loss - POAs are queued for later processing / PRA loss if DSP not available	Loss if DSP is not available. No loss from TEF systems outage	Potential loss during maintenance window (TEF and DSP systems)
GEN.2	No loss of PRAs/POAs during unplanned outage	4 hour RTO		4 hour RTO	4 hour RTO	4 hour RTO	4 hour RTO

Table 15 Telefónica Options Overview

Note the following:

* Requires alignment with DSP

^ Time taken can be higher when dealing with higher alert volumes (>10000/min)

“This option is not considered viable by Telefónica

Option 1 is mutually exclusive with option 2

Option 3 is compatible with any option

The table below shows the performance of the solution options against the various outage scenarios (ordered by maximum simultaneous volumes of outages that can be triggered within 1 minute). It is assessed from the perspective of the length of time in minutes for delivery of all AD1s and is expressed in a range of minutes. Given that option 4 – CH firmware updates and network infrastructure updates is not considered a viable option by Telefónica, it has not been shown in the table.

For PRAs, there is not expected to be any change in the way messages are handled. These should all be delivered in under a minute and there should not be any message loss incurred. Note as indicated previously, if a CH has to reboot and re-attach to the network, there is time required for that to take place (which is more than one minute) and then the CH can deliver the message in under 1 minute. Also there would be time required for the ESME itself to reboot and connect to the CH before it can transmit the 8F35/8F36 messages.

Key:	Some Improvement	Significant Improvement

		Message volumes		AD1 delivery time range (in minutes)			
Scenario	**Description**	**Max Simultaneous Outages**	**Max Simultaneous Restores**	**Current**	**1. Improvements in existing system**	**2. Cloud Based Micro service**	**3. Network Evolution CH**
C	Overhead power line comes down. 30 homes in a village are taken off supply as are 15-20 local supply points at neighbouring farms	50	50	6-8	5-7	5-7	4
A/B	Single 5000 property outage (A - TEF region / B - ARQ region)	5,000	5,000	6-8	5-7	5-7	4
D	Substation damaged - 5,000 lose power simultaneously	5,000	5,000	6-8	5-7	5-7	4

		Message volumes		AD1 delivery time range (in minutes)			
Scenario	Description	Max Simultaneous Outages	Max Simultaneous Restores	Current	1. Improvements in existing system	2. Cloud Based Micro service	3. Network Evolution CH
G	Storm travelling West to East knocks out a total of 100,000 MPAN's over a 20-hour period on average 5,000 homes an hour with a mix of high volt and low voltage. Due to re-routing, alerts may be generated and restored within the 3 minutes	5,000	7,500	6-8	5-7	5-7	4
H	Storm travelling South to East from Bristol to Glasgow affecting 100,000 MPAN's over 7 hours to include 20,000 simultaneous supply points in Birmingham, 15,000 in Manchester and 65,000 being a mix of high voltage / low voltage in other cities, towns and villages	20,000	20,000	6-11	5-10	5-8	4
E	20,000 homes in a major city lose power within 30 seconds a smaller power event occurs meaning the loss of power occurs in a different part of the same SP region (e.g. 20,000 homes in London – 6 homes in Western Super Mare)	20,006	20,006	6-11	5-10	5-8	4
F	An event knocks down a high voltage cable in a major city (as per DNO discussions assumed to be scenario for outage of 30,000 properties)	30,000	30,000	6-13	5-12	5-8	4
I	Transmission Line Failures[16]	200,000	50,000	6-14	5-13	5-8	4-8

Table 16 Telefónica Options against DNO Scenarios

[16] With transmission line failures, it is expected that if there are 200,000 simultaneous POAs that get raised by the CHs, only 34,000 of these will get through to the Telefónica systems for processing due to the system throttling in place. The rest of the messages will get dropped. The time ranges indicated are for the 34,000 POAs that get processed

5.1.2 Arqiva CSP Implementation Option Descriptions

Based on the current implementation, a number of areas of improvement have been identified. The following section outlines where the improvements could be made and highlights the potential improvements against two key use cases:

- Smaller outages affecting 50 premises which all reside within a single cell of the Arqiva system
- Larger outages affecting 30,000 premises spread over multiple cells

ARQ.1 – Reinstate Comms Hub Restoration Alerts

Within the Arqiva system there is an additional alert generated by the CH on restoration of power. At present this alert is suppressed within the core of the Arqiva system and not forwarded on to the DSP. The CH restoration alert follows the same messaging process as the AD1 alert described above, without the 3-minute hold off period for confirmation of an outage (i.e. these alerts are generated for outages of any duration). There alerts are sent randomly over 3 windows of 45 seconds, 240 seconds and 240 seconds.

For the vast majority of outages, the performance of these alerts is such that the DNOs would receive a significant proportion of alerts within the first 45 second window after the CH reboots. In larger outages, this restoration alert provides a significantly quicker notification of power restoration in an area than the 8F35 and 8F36 messages.

It is recommended that the 8F35 and 8F36 messages are maintained as a slower but more reliable confirmation of the power restoration for all premises for reporting purposes.

Note that this option would require significant change to both the DSP system and DUIS in order to reinstate the previously removed alert. The additional work required to process the CH PRA beyond Arqiva has not been factored into this solution option.

Advantages

- Significant improvement in PRA delivery time
- PRA generated independent of ESME that the CH is attached to. This means that DCC would be in control of these alerts rather than dependent on ESME manufacturers and associated firmware

Disadvantage

- Additional PRA message type that was previously removed, requiring change to DSP, DUIS and DNOs
- Additional PRA message will be sent through the DSP gateway, causing a reduction in overall capacity (this is more of an issue for larger volume outage scenarios)
- Cannot guarantee delivery of all PRAs
- Added inconsistency between CSPs (note for Telefónica, 8F35 and 8F36 alerts are delivered quicker than CH power restore alerts and

therefore there is little benefit in providing this alert from Telefónica CHs)

5.1.2.1.1 Example Case One: 50 Premise outage, single cell

Reinstating the CH restoration alert adds to the current performance as follows:

- AD1s and CH Restoration Alerts

  CH Restoration alerts follow the same mechanism as the AD1s. The additional restoration alerts will be delivered in the same timescale as the AD1s in the current implementation (95% after 5 minutes total[17])

- 8F35 and 8F36 alerts

  There will be no change in the performance of 8F35 and 8F36 alerts.

5.1.2.1.2 Example Case Two: 30,000 Premise outage, three cells

For a larger outage affecting 30,000 premises spread over multiple cells, performance for the two alert types would typically be as follows:

- AD1s and CH Restoration Alerts

  CH Restoration alerts follow the same mechanism as the AD1s. The additional restoration alerts will be delivered in the same timescale as the AD1s in the current implementation (52% after 5 minutes total, 94% after all three alert windows[18]). At these volumes, the current throttle limit will be breached delaying alert delivery.

- 8F35 and 8F36 alerts

  There will be no change in the performance of 8F35 and 8F36 alerts.

ARQ.2 – Increase Traffic Channels in a cell

A limiting factor in the speed at which alerts are delivered is the contention between CHs for the available channel resource. Utilising additional channels in a cell would reduce the loading of CHs on a single channel, increasing throughput and reducing the risk of over the air collision of the ALOHA based AD1.

[17] Assumptions: Not accounting for CHs operating in Buddy mode, typically 5% of the network. For a site with DSL backhaul.

[18] Assumptions: Three cells providing coverage to 10,000 premises each. Each cell contains 500 (5%) out of range (ORD) devices connected through buddy mode which are lost. Both sites have DSL backhaul

The CH and ESME alerts are carried over two different channel types. This improvement option could be implemented on just one channel type to improve performance for either alert type, or on both channel types.

ARQ.2a – Increased Alert Channels

Increasing the number of alert channels only would provide improvement to the CH generated AD1s. In the current solution, there are up to two common alert channels across all cells. Implementing up to 4 alert channels in some or all cells and assigning CHs randomly between them would provide an increase in throughput compared to the current solution.

Advantages

- Improvement in POA delivery time

Disadvantage

- Knock on impact increases cost when applying across the network

5.1.2.1.3 Example Case One: 50 Premise outage, single cell

- AD1s and CH Restoration Alerts
  AD1 alerts would follow the same process as the current implementation, split over two channels. With half the number of devices contending for the resource, typical performance would be for 96% of alerts to be delivered within 5 minutes of the outage and the remaining alerts delivered over the second and third windows.[19]

- 8F35 and 8F36 alerts

  There will be no change in the performance of 8F35 and 8F36 alerts.

5.1.2.1.4 Example Case Two: 30,000 Premise outage, three cells

- AD1s and CH Restoration Alerts

  AD1 alerts would follow the same process as the current implementation, split over an additional two channels (four total in a cell). Typical performance would be for around 76% of alerts to be delivered within 5 minutes of the power outage increasing to around 95% at the end of the three alert windows.[20] With this increased throughput, the 5000 per minute limit would again be reached and alerts buffered and delayed.

- 8F35 and 8F36 alerts

  There will be no change in the performance of 8F35 and 8F36 alerts.

[19] Assumptions: CHs involved in the outage are spread over the two alert channels evenly. Not accounting for CHs operating in Buddy mode, typically 5% of the network. Both sites have DSL backhaul.

[20] Assumptions: 2 cells providing coverage to 10,000 premises each. Each cell contains 500 (5%) out of range (ORD) devices connected through buddy mode which are lost. For a site with DSL backhaul

ARQ.2b – Increased Bulk Traffic Channels

Increasing the bulk traffic channels in a cell would reduce the number of CHs competing for the resource in a large restoration event. This would increase the throughput of 8F35 and 8F36 restoration messages.

Advantages

- Small improvement in PRA delivery time

Disadvantage

- Significant cost

5.1.2.1.5 Example Case One: 50 Premise outage, single cell

- AD1s and CH Restoration Alerts

  There will be no change in the performance of AD1 alerts.

- 8F35 and 8F36 alerts

  ESME alerts will follow the same process as the current implementation, split over two channels. The additional channel will increase the throughput for GBCS alert delivery reducing the minimum time required to deliver all alerts to around 4 minutes after power is restored to the CH[21].

5.1.2.1.6 Example Case Two: 30,000 Premise outage, three cells

- AD1s and CH Restoration Alerts

  There will be no change in the performance of AD1 alerts.

- 8F35 and 8F36 alerts
  ESME alerts will follow the same process as the current implementation, split over an additional channel. The additional channel will increase the throughput for GBCS alert delivery reducing the time required to fully deliver all 8F35 and 8F36 alerts to around 37 minutes[22].

ARQ.3 – 3G Backhaul Resilience

In the current network there are a number of sites which use 3G backhaul to pass messages to and from the core network. In the long term, the majority of sites will be migrated over to DSL backhaul where available. Those sites

[21] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers. Assumes a total of two traffic channels in use in the cell. Maximum rate assumes no other messaging required.

[22] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers. Assumes a total of five traffic channels in use in each cell. Maximum rate assumes no other messaging required.

which have been designed as permanent 3G backhaul sites suffer when the 3G service from the mobile network operator goes down.

The 3G routers used in these sites have the option to include a secondary SIM as an alternate connection for resilience during a mobile network outage. It should be noted that not all sites are in locations served by a secondary mobile network operator. Furthermore, the resilience of the mobile network operators' sites is unknown to Arqiva and both networks could be lost during an outage.

Advantages

- Reduction in delayed and duplicate alerts

Disadvantage

- May require dedicated PR to establish feasibility

5.1.2.1.7 Example Case One: 50 Premise outage, single cell

- AD1s and CH Restoration Alerts

  There will be no change in the over the air performance of the AD1 alerts. For sites where at least one of the 3G connections remains active alerts will continue to be returned to the core network as they are in the current solution within the window for deduplication, reducing the number of significantly delayed AD1s. Sites with no alternate 3G connection will continue to queue messages at the TK and send them once backhaul is re-established.[23]

- 8F35 and 8F36 alerts

  There will be no change in the over the air performance of the 8F35 and 8F36 alerts. For sites where at least one of the 3G connections remains active, alerts will continue to be returned to the core network as they are in the current solution within the window for deduplication, reducing the number of significantly delayed ESME alerts. Sites with no alternate 3G connection will continue to queue messages at the TK and send them once backhaul is re-established.[24]

5.1.2.1.8 Example Case Two: 30,000 Premise outage, three cells

- AD1s and CH Restoration Alerts

  There will be no change in the over the air performance of the AD1 alerts. For sites where at least one of the 3G connections remains active, alerts will continue to be returned to the core network as they are in the current solution within the window for deduplication, reducing the number of significantly delayed AD1s. Sites with no alternate 3G

[23] Assumptions: Not accounting for CHs operating in Buddy mode, typically 5% of the network. For a site currently using 3G as the method of backhaul.

[24] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers. For a site currently using 3G as the method of backhaul.

connection will continue to queue messages at the TK and send them once backhaul is re-established.[25]

- 8F35 and 8F36 alerts

  There will be no change in the over the air performance of the 8F35 and 8F36 alerts. For sites where at least one of the 3G connections remains active, alerts will continue to be returned to the core network as they are in the current solution within the window for deduplication, reducing the number of significantly delayed ESME alerts. Sites with no alternate 3G connection will continue to queue messages at the TK and send them once backhaul is re-established.[26]

ARQ.4 – Relaxed Throttle Between the CSP and DSP

At present there is a defined throttle between the CSP and DSP to prevent a surge in AD1 messages overloading the DSP network. The throttle is currently configured to a maximum of 5,000 messages in a rolling minute window. For larger outages this can result in a delay in delivering the AD1 alerts to the DNOs, despite the over the air delivery being completed. Where there are three AD1 alerts sent by each CH, some of the messages in the 5,000 will be duplicates of an outage already known to the DNOs. Where the DSP filters these duplicates, less than 5,000 alerts per minute will be delivered to the DNOs.

Relaxing the throttle would enable faster clearing of alerts and crucially reduce blocking of further outage alerts from a different incident behind a large outage in the buffer at the gateway. At present the upper limit of throughput is conservatively estimated to be c. 35,000 transactions per minute.

In a large outage over multiple cells the 5,000 messages per minute threshold is easily breached, particularly as three alerts are transmitted per CH. Note that for this reason, when implementing several of the other solutions which improve throughput of alerts, an element of option ARQ.4 should be considered in parallel.

Advantages

- Reduces the chance of blocking smaller outage alerts volumes behind a large outage in progress

Disadvantage

- Possible oversize of infrastructure for rarely occurring outage sizes

5.1.2.1.9 Example Case One: 50 Premise outage, single cell

[25] Assumptions: Three cells providing coverage to 10,000 premises each. Each cell contains 500 (5%) out of range (ORD) devices connected through buddy mode which are lost. Both sites have 3G backhaul.

[26] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers.

- AD1s and CH Restoration Alerts

  There will be no change in AD1 alert performance for an isolated outage of this size as the current throttle limit is not reached.[27]

- 8F35 and 8F36 alerts

  No change from current performance.[28]

5.1.2.1.10 Example Case Two: 30,000 Premise outage, three cells

- AD1s and CH Restoration Alerts
  With the current maximum rate a scenario of this size would result in alerts being throttled (when including background levels of alerts across the network) the relaxed throttle would allow AD1 alerts for an outage of this scale to clear as they are received. Without buffering alerts for an outage of this scale, the chance of blocking a secondary outage elsewhere in the network is reduced.[29]

- 8F35 and 8F36 alerts

  No change from current performance. Throttle limit is not reached until a significantly larger outage scenario.[30]

ARQ.5 – Buffering alerts at the CSP – DSP Gateway

Implementing a monitor and buffer solution at the CSP – DSP gateway would allow Arqiva to hold messages providing resilience when the DSP connection is down, covering both planned or unplanned outages. The proposed buffer would be part of the Arqiva gateway and would need to be appropriately sized to handle typical message throughput for the duration of any DSP scheduled outages at a minimum.

On restoration of the connection to the DSP the buffer would need to be cleared in an agreed controlled manor to avoid overloading the DSP systems.

Advantages

- Reduced message losses during planned and unplanned DSP outages

Disadvantage

- Buffered alerts will arrive well beyond the DNOs required timescales

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[27] Assumptions: Not accounting for CHs operating in Buddy mode, typically 5% of the network. For a site with DSL backhaul.

[28] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers.

[29] Assumptions: Three cells providing coverage to 10,000 premises each. Each cell contains 500 (5%) out of range (ORD) devices connected through buddy mode which are lost. Both sites have DSL backhaul.

[30] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers.

5.1.2.1.11 Example Case One: 50 Premise outage, single cell

- AD1s and CH Restoration Alerts

  No change in over the air performance of AD1s. Buffering at the gateway will ensure delayed delivery once the DSP connection is restored, rather than loss of messages.[31]

- 8F35 and 8F36 alerts

  No change in over the air performance of ESME alerts. Buffering at the gateway will ensure delayed delivery once the DSP connection is restored, rather than loss of messages.[32]

5.1.2.1.12 Example Case Two: 30,000 Premise outage, three cells

- AD1s and CH Restoration Alerts

  No change in over the air performance of AD1s. Buffering at the gateway will ensure delayed delivery once the DSP connection is restored, rather than loss of messages.[33]

- 8F35 and 8F36 alerts

  No change in over the air performance of ESME alerts. Buffering at the gateway will ensure delayed delivery once the DSP connection is restored, rather than loss of messages.[34]

ARQ.6 – Deduplication at the CSP – DSP Gateway

Although some immediate message deduplication takes place in the network controllers at the front end of the Arqiva RNI, this is only intended to cover duplicates received by neighbouring base stations which arrive within a short timeframe. Where duplicate alerts are significantly delayed, for example due to the 3G backhaul being lost during the outage, a longer period of deduplication needs to be applied.

By applying the same deduplication method to the gateway, additional longer interval deduplication could be performed at the exit point from the Arqiva system. The exact deduplication window would need to be defined based on a combination of load on the system and typical delayed message durations.

[31] Assumptions: Not accounting for CHs operating in Buddy mode, typically 5% of the network. For a site with DSL backhaul.

[32] *Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers.

[33] Assumptions: Three cells providing coverage to 10,000 premises each. Each cell contains 500 (5%) out of range (ORD) devices connected through buddy mode which are lost. Both sites have DSL backhaul.

[34] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers.

Advantages

- Reduced the number of duplicate alerts being sent significantly after outages occur

Disadvantage

- The deduplication window will be finite in size and does not prevent delayed alerts in exceptional circumstances

5.1.2.1.13 Example Case One: 50 Premise outage, single cell

- AD1s and CH Restoration Alerts

  Any delayed AD1 alerts due to loss of 3G connectivity will be de duplicated at the CSP gateway.[35]

- 8F35 and 8F36 alerts

  Any delayed 8F35 and 8F36 alerts due to loss of 3G connectivity will be de duplicated at the CSP gateway.[36]

5.1.2.1.14 Example Case Two: 30,000 Premise outage, three cells

- AD1s and CH Restoration Alerts

  Any delayed AD1 alerts due to loss of 3G connectivity will be de duplicated at the CSP gateway.[37]

- 8F35 and 8F36 alerts

  Any delayed 8F35 and 8F36 alerts due to loss of 3G connectivity will be de duplicated at the CSP gateway.[38]

[35] Assumptions: Not accounting for CHs operating in Buddy mode, typically 5% of the network. For a site with 3G backhaul where power is restored within the deduplication window.

[36] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers. For a site with 3G backhaul where power is restored within the deduplication window.

[37] Assumptions: Some duplicates are picked up by neighbouring 3G sites which connectivity had restored within the deduplication window.

[38] Assumptions: ESME alerts are delivered to the CH successfully. Currently there are known issues with some meter manufacturers. For a site with 3G backhaul where power is restored within the deduplication window.

Estimated impact of enhancements

The table below sets out the estimated impact of the proposed Arqiva enhancements. Numbers quoted are for a single maximum loaded cell of 10,000 CHs.

Key:	No Change	Improvement

Req.	DNO Req.	Option 0 Current capability		Option 1 Reinstate CH PRA	Option 2a Additional Channels (Alert Channel)	Option 2b Additional Channels (Bulk Channel)	Option 3 Improved Backhaul Resilience	Option 4 Increase 5k / min Throttle	Option 5 Buffer at CSP - DSP Gateway	Option 6 De duplicate at CSP - DSP Gateway
POA.1	POA for all outages > 3min	5,000	TPM	Up to 5,000	Up to 5,000	Up to 5,000	Up to 5,000	Up to 35,000 (for outages >100K)[39]	Up to 5,000	Up to 5,000
POA.2	POAs delivered in < 5min	5	mins	5	4	5	5	5	5	5
POA.3	POA must be reliable	5,000	TPM	Up to 5,000	Up to 5,000	Up to 5,000	Up to 5,000	Up to 35,000 (for outages >100K)[40]	Up to 5,000	Up to 5,000

[39] A rate of 35,000 messages per minute would only be reached in very large power outage scenarios involving over 100,000 premises. The message rate will be the same as current performance for power outages involving a lower number of premises.

[40] A rate of 35,000 messages per minute would only be reached in very large power outage scenarios involving over 100,000 premises. The message rate will be the same as current performance for power outages involving a lower number of premises.

Req.	DNO Req.	Option 0 Current capability		Option 1 Reinstate CH PRA	Option 2a Additional Channels (Alert Channel)	Option 2b Additional Channels (Bulk Channel)	Option 3 Improved Backhaul Resilience	Option 4 Increase 5k / min Throttle	Option 5 Buffer at CSP - DSP Gateway	Option 6 De duplicate at CSP - DSP Gateway
POA.4	POAs must be trustworthy			POAs are only generated for outages >3 minutes	POAs are only generated for outages >3 minutes	POAs are only generated for outages >3 minutes	POAs are only generated for outages >3 minutes	POAs are only generated for outages >3 minutes	POAs are only generated for outages >3 minutes	POAs are only generated for outages >3 minutes
POA.5	POAs must be consistent			No change	No change	No change	No change	No change	No change	Reduced delayed duplicate alerts
PRA.1	All PRAs required	35,000	TPM	35,000 for 8F35 and 8F36. 5,000 for CH PRA	No Change in 8F35 and 8F36 alert delivery	No Change in 8F35 and 8F36 alert delivery	No Change in 8F35 and 8F36 alert delivery. Reduction in severely delayed alerts where backhaul is maintained	No Change in 8F35 and 8F36 alert delivery	No Change in 8F35 and 8F36 alert delivery	No Change in 8F35 and 8F36 alert delivery. Reduction in severely delayed alerts where duplicate is removed
PRA.2	PRAs delivered in <1min	24	mins	5	24	20	24	24	24	24
PRA.3	PRAs must be consistent			Additional alert type from ARQ only. CSPs	No change	No change	No change	No change	No change	No change

Req.	DNO Req.	Option 0		Option 1	Option 2a	Option 2b	Option 3	Option 4	Option 5	Option 6
		Current capability		Reinstate CH PRA	Additional Channels (Alert Channel)	Additional Channels (Bulk Channel)	Improved Backhaul Resilience	Increase 5k / min Throttle	Buffer at CSP - DSP Gateway	De duplicate at CSP - DSP Gateway
				Closer in PRA notification timing						
PRA.4	PRAs must be trustworthy			Additional CH PRA does not change current implementation	8F36 is only generated on outage >3 minutes	8F36 is only generated on outage >3 minutes	8F36 is only generated on outage >3 minutes	8F36 is only generated on outage >3 minutes	8F36 is only generated on outage >3 minutes	8F36 is only generated on outage >3 minutes
GEN.1	No loss of PRAs/POAs during planned outage			Alerts lost during maintenance windows	Alerts lost during maintenance windows	Alerts lost during maintenance windows	Alerts lost during maintenance windows	Alerts lost during maintenance windows	Alerts buffered during DSP maintenance windows	Alerts lost during maintenance windows
GEN.2	No loss of PRAs/POAs during unplanned outage			Alerts lost during unplanned outages	Alerts lost during unplanned outages	Alerts lost during unplanned outages	Alerts lost during unplanned outages and delayed during 3G outages	Alerts lost during unplanned outages	Alerts buffered during unplanned DSP outages	Alerts lost during unplanned outages

Table 17 Arqiva Options Overview

5.1.3 DSP Implementation Option Descriptions

Overview of Options

Based on historical analysis of DSP Production performance, the time taken for the DSP to process POAs and PRAs is 0.288 and 0.025 seconds, respectively. Given that these processing times are less than 0.05% of DNO target times for delivery of POAs and PRAs, there is little benefit attempting to reduce DSP processing times.

There are, however, limitations on the volumes of POAs and PRAs that can be processed by the DSP given the infrastructure on which it is currently deployed. We estimate that, under normal operating conditions, these limitations are 12,000 POAs per minute and 96,000 PRAs per minute. We have arrived at these numbers based on previous performance testing and the assumption that our capacity planning aims to ensure that there is always sufficient spare capacity to accommodate the loss of a motorway (the name given to a collection of DSP components employed in processing Service Requests, DCC Alerts and Device Alerts). Under normal operating conditions (i.e. assuming no DSP outages), this spare motorway could be employed to process the POAs and PRAs associated with a network outage. However, were a network outage to coincide with a DSP outage, these limits would be reduced.

If POA/PRA volumes exceed available capacity, this may result in longer processing times (impacting POA.1 and PRA.2) and/or the loss of POAs/PRAs (impacting POA.3 and PRA.1).

Since some of the outage scenarios identified by the DNOs would result in POA and PRA volumes in excess of the DSP's current capacity, we have considered a number of possible enhancements for increasing the volumes of POAs and PRAs the DSP can handle. In doing so, we have also considered ways in which DSP resource can be reserved for POAs/PRAs to ensure that it is always available, regardless of other DCC User activity or outages of DSP components.

As a precursor to any attempt at increasing POA capacity, we have identified a number of relatively minor code optimisations to accommodate current operating conditions which weren't foreseen at the time the DSP was built. These include the failure of GNOs to become DCC Users and the prevalence of SMETS2 Installations comprising multiple ESMEs and GSMEs (often resulting from failed installations which leave 'ghost' Devices registered in the Smart Metering Inventory). Both cases result in the generation of unnecessary AD1s which could be avoided through the addition of relatively simple business logic. We propose that this enhancement forms part of any software changes made to improve DSP performance since the benefits it realises are magnified by subsequent enhancements.

Six of the enhancement options we are proposing are designed to increase the volume of POAs/PRAs the DSP can process. Another two enhancement options address other stated DNO requirements.

The Table 18, below is provided to help with understanding what the different options will achieve.

Option	Increases throughput of POAs for new power outages to DNOs	Increases throughput of PRAs to DNOs following a power outage	Increases total throughput within DSP	Separates POA/PRA traffic from other messages within DSP	Improves the quality of POAs/PRAs received by DNOs	Filters out spurious PRAs	Avoids lost POAs & PRAs during planned maintenance
1 – Provision of new shared Infrastructure	✓	✓	✓				
2 – Prioritising POAs and PRAs over other northbound traffic	✓	✓					
3 - New dedicated resources for POAs and PRAs	✓	✓	✓	✓			
4 – Cloud-based Dedicated DNO POA/PRA resources	✓	✓	✓	✓			
5 – Prioritisation within POAs and PRAs by Postcode/ Time	✓	✓	✓		✓		
6 – Prioritisation within POAs and PRAs by Canary Indicators	✓	✓	✓		✓		
7a – Reduce Spurious PRAs: Traffic management						✓	
7b – Reduce Spurious PRAs: Blocklist						✓	
8 - Buffering During DSP Planned Maintenance							✓

Table 18: Impact of DSP enhancements on handling of POAs/PRAs

DSP.1 – Provision POAs/PRAs on New Shared Infrastructure

This is intended to provide additional shared DSP capacity, increasing processing capacity in order to leave a greater margin available for use in power outages.

This option provides a new set of the primary servers used for expansion of shared motorway resources, namely the CH (Communications Handler), RM and MG tiers. This is illustrated in Figure 13, below.

As the new motorway resources will add to the shared infrastructure, the new capacity would be available to other types of usage as well as POAs and PRAs, rather than reserved solely for use in power outages, but the increased headroom means that in typical circumstances more resources would be available for POAs and PRAs. This would be significant in a major power outage.

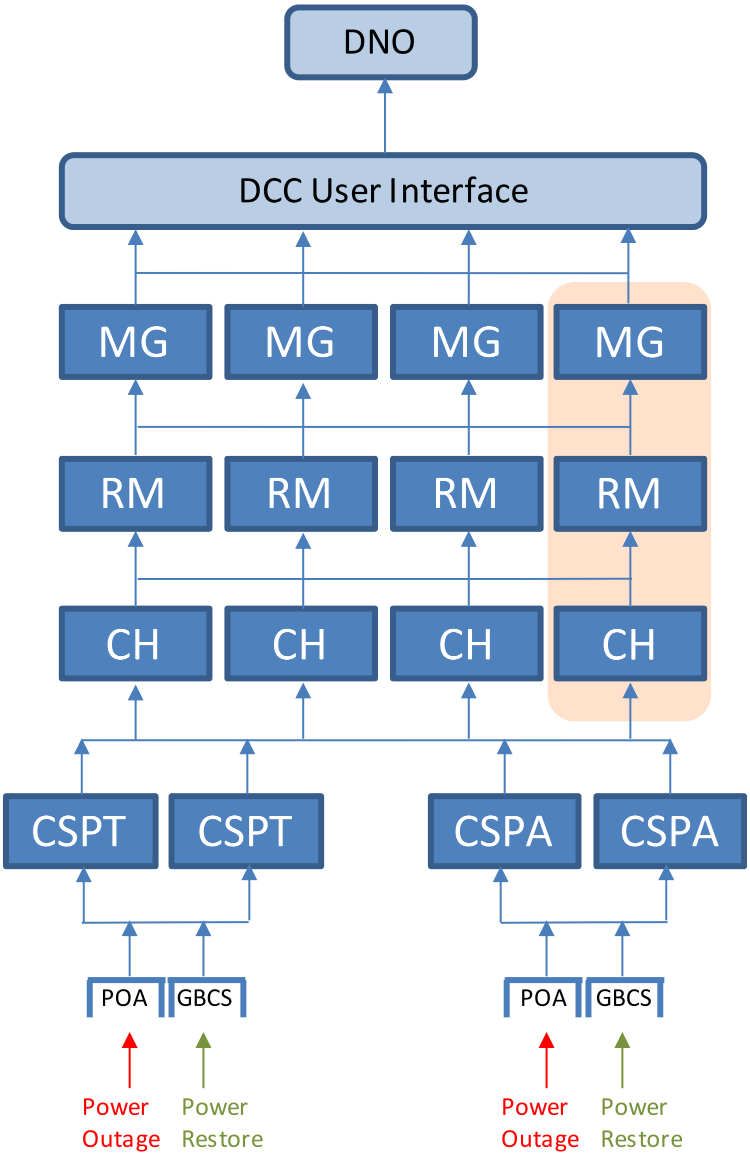


Figure 13 Option 1 Provision of New Shared Infrastructure

Advantages

- Additional capacity is likely to be available to process POAs/PRAs in the event of network outages.
- All DCC Users benefit from the additional capacity provided.

Drawbacks

- Since additional capacity is shared amongst all DCC Users, it may not be available for processing POAs/PRAs at time of network outages.

DSP.2 – Prioritising POAs and PRAs over other northbound traffic

This option will establish mechanisms for giving preference to POAs and PRAs above all other northbound traffic. Rather than queuing behind other Alert types and Service Request Responses, POAs and PRAs where present will be serviced and delivered first, meaning that at times of very high POA and PRA volumes due to major outages, all of DSP's northbound resources will be devoted to delivering them.

This will be achieved by the provision of new queuing mechanisms, with the addition of at least one high priority queue, or a hierarchy of additional queues could be used, e.g. POAs could be prioritised over PRAs, and/or 8F36s could be prioritised over 8F35s. This option is illustrated in Figure 14, below.

This increases the capacity of the DSP that is used by POAs and PRAs when needed, which would be significant in a major power outage, while enabling capacity to be used for other types of northbound message most of the time.

This option also includes prioritisation to deliver DCC Alert AD1s to DNOs ahead of delivery to other User roles (suppliers and gas network operators), since speed of delivery of these alerts is less critical to other User roles

In addition, this option will include rationalisation of the generation of DCC Alert AD1s. The current requirement is that DCC Alert AD1s should be generated for both supplier and network operator of every meter associated with a Comms Hub. Rationalisation will include not generating alerts for GNOs where the registered GNO is not a DCC User (currently the case for all MPRNs) and only generating one alert for the DNO in cases where there are multiple meters (which could be the result of failed installations, or could be because of multiple physical electricity meters).

Reduction of the number of DCC Alert AD1s to be generated would reduce the total demand on DSP systems during power outages.

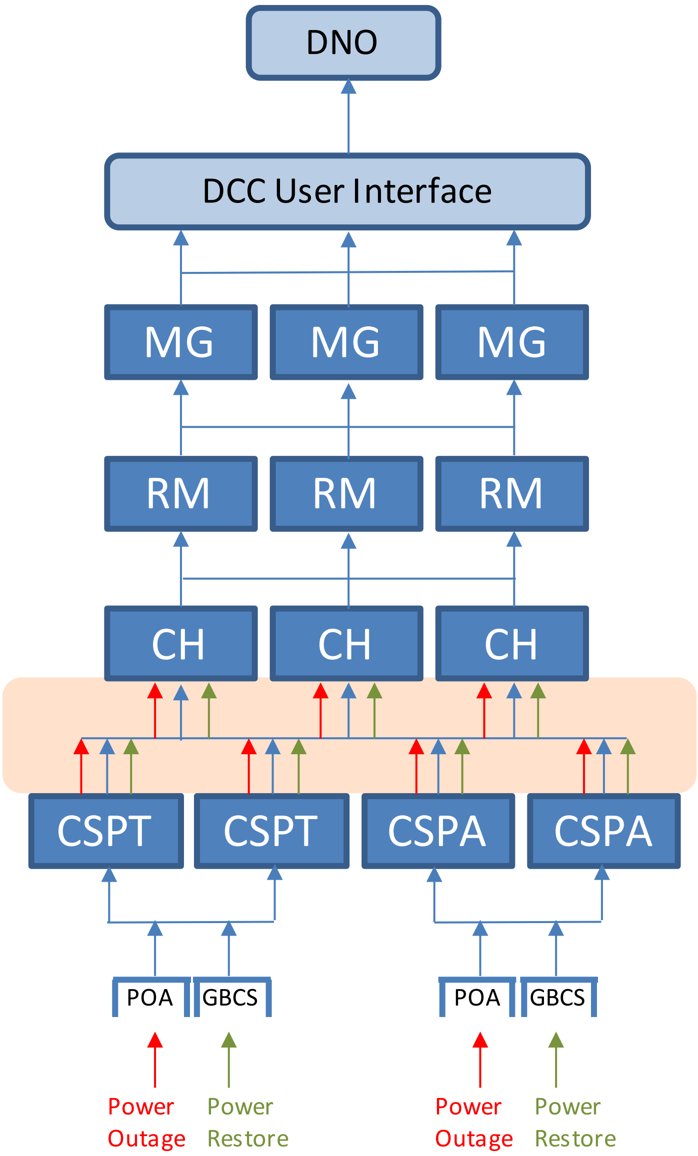


Figure 14 Option 2 Prioritising POAs and PRAs over other northbound traffic

Advantages

- No new infrastructure is required (software change only).
- At times of network outage, all DSP northbound resources will be available for processing POAs/PRAs.

Drawbacks

- Since all DSP northbound resources will be devoted to processing of POAs/PRAs, other DCC Services will be impacted affecting other DCC Users.

DSP.3 – New Dedicated Resources for POAs and PRAs

This option is intended to provide additional DSP capacity dedicated to POAs and PRAs, separated from motorway lane capacity used for other purposes.

Separation provides the benefit that capacity required for POAs and PRAs can be provided in isolation, to ensure it is available when needed, and without having an impact on other DCC Services.

New infrastructure resources will be provided, and configuration will ensure that they are used only for POAs and PRAs.

Since the infrastructure will be dedicated, it will be necessary to provide two new sets, for resilience. The new resources will be combined, which means that at all times at least one motorway lane and other resources will be available, and most of the time two motorway lanes will be available exclusively for POA and PRA use.

In this option, a resilient pair of sets of the primary servers used for expansion of shared motorway resources will be provided, namely the CH, RM and MG tiers, and dedicated CSP gateway infrastructure as well, providing additional separation from other traffic.

The dedication of resources would be achieved by routing of POAs and PRAs during a stage of processing messages arriving from the CSPs, prior to the CSP Gateway tier. This is illustrated in Figure 15, below.

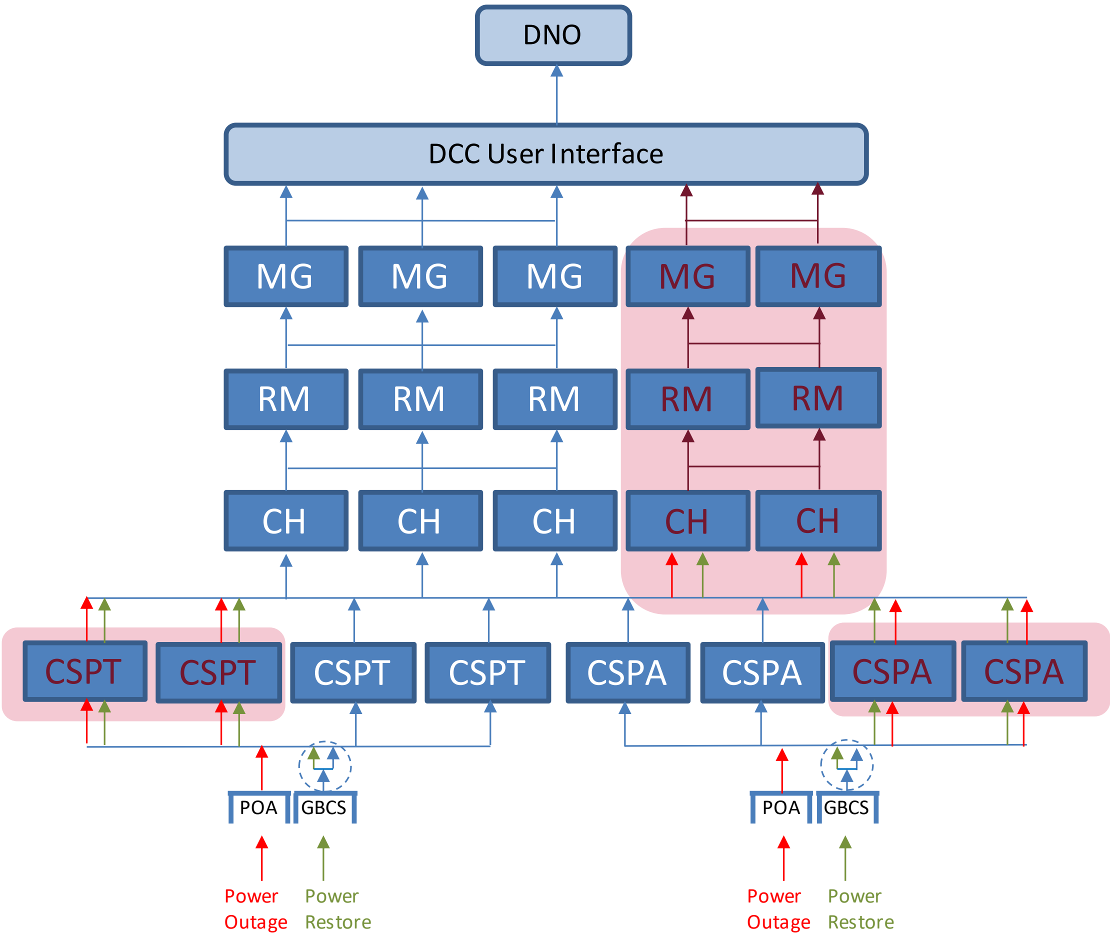


Figure 15 Option 3 New Dedicated Resources for POAs and PRAs

Advantages

- Resilient, dedicated DSP capacity is reserved exclusively for use in processing DNO POAs/PRAs.
- Since DNO POA/PRA processing is performed on new DNO-dedicated infrastructure, other DCC Services (and DCC Users) are unaffected.

Drawbacks

- Sufficient dedicated DSP capacity must be added to cope with the largest DNO scenario.
- Dedicated DNO POA/PRA capacity will remain unused for the majority of the time.

DSP.4 – Cloud Deployment of New Dedicated Resources

Where new infrastructure is to be provided, this could be deployed as cloud-based rather than on premise.

The dedicated motorway lane(s) and CSP Gateways could be deployed in the cloud to give greater flexibility in scalability. This is illustrated in Figure 16, below.

A certain amount of capacity would need to be always available, since AWS proof of concept activities have shown it can take several minutes for auto scaling to add resources. This may result in a significant percentage of the total capacity required to manage significant outages being made permanently available, reducing any Pay-As-You-Go benefits of auto-scaling in the cloud.

Note that DCC have stated that this option will not be progressed within the DNO programme but could be considered as part of DCC's Network Evolution programme.

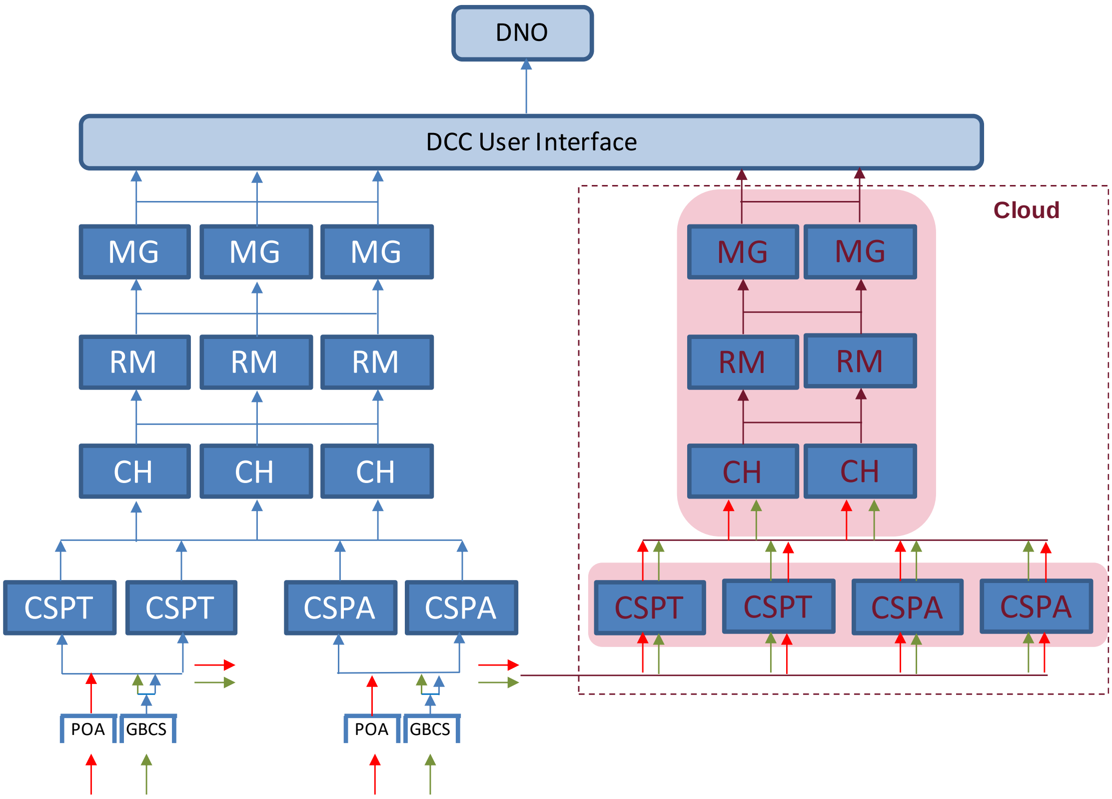


Figure 16 Cloud Deployment of New Dedicated Resources

Advantages

- Resilient, dedicated DSP capacity is reserved exclusively for use in processing DNO POAs/PRAs.
- Since DNO POA/PRA processing is performed on new DNO-dedicated infrastructure, other DCC Services (and DCC Users) are unaffected.
- DSP capacity can auto-scale in response to fluctuating outage demands.
- Aligns with DCC's cloud-based strategy.

Drawbacks

- Moving motorways to the cloud will require additional security measures and DCC security approval.
- Depending on speed of cloud-base auto-scaling, a large capacity of cloud infrastructure may need to be made permanently available to provide sub-minute response times, thus negating the Pay-As-You-Go benefits of cloud-based solutions.
- Dedicated DNO POA/PRA capacity will remain unused for the majority of the time.

DSP.5 – Prioritisation within POAs and PRAs by Postcode/Time

This option prioritises delivery of DNO POAs/PRAs by the DSP based on their location and outage time. The intention is to prioritise POAs/PRAs pertaining to new network outages over those related to outages which have already been notified to the DNO. Since the DSP has no knowledge of a SMETS2 Installation's location on the DNO's network, postcode sector would be used as a surrogate. By combining this with the time the outage occurred, it is hoped that POAs/PRAs relating to the same network outage can be identified by virtue of their geographic and temporal proximity.

This option helps to address the DNO's requirements POA.4 and PRA.4 ("Alerts must be trustworthy") by focusing on delivery of POAs/PRAs likely to provide outage information not already known to the DNO. Smoothing the delivery of POAs/PRAs also has the advantage of reducing DNO POA/PRA processing requirements. By queuing POAs/PRAs relating to notified postcode sectors for slower delivery, this option meets the DNO's requirements POA.3 ("POAs must be reliable") and PRA.1 ("All PRAs required"), however, a variation would be to discard "duplicate" POAs/PRAs, thus further reducing DNO POA/PRA processing requirements.

Option 6, Canary has similar goals but takes a different approach.

It has been noted that DNOs have expressed a preference for this type of prioritisation to be applied by the CSPs at the network level. However, prioritisation at the DSP has been considered as a possible alternative. Prioritisation in the DSP has some advantages such as being able to apply per-DNO prioritisation in a way that would not be feasible for a CSP to ensure that prioritisation would only apply within alerts intended for the same DNO.

Advantages

- No new infrastructure is required (software change only).
- POAs/PRAs relating to new network outages are prioritised to provide DNOs with 'higher quality' POAs/PRAs.

Drawbacks

- Use of postcode sector/outage time to distinguish between POAs/PRAs resulting from different network outages is an approximation.
- Prioritisation of DNO POAs/PRAs over other northbound traffic means that DCC Services to other DCC Users is likely to be affected.

DSP.6 – Prioritisation within POAs and PRAs by Canary Indicators

As with Option 5, this option focuses on prioritising delivery of POAs/PRAs associated with MPANs that a DNO has identified as being a significant indicators of the health of the network.

In this option, DNOs would identify key SMETS2 Installations which, by virtue of their location on the network, provide key information as to the health of the network and the likely location of a network outage. The DSP would then prioritise delivery of POAs/PRAs relating to these key SMETS2 Installations over POAs/PRAs from other SMETS2 Installations. This option would require the DNOs to identify key SMETS2 Installations and communicate these to the DSP, both initially and in response to any changes resulting, for example, through re-configurations of the network. There are several methods by which this may be achieved and we would aim to support the least onerous and most flexible solution following dialogue with the DNOs.

This option helps to address the DNO's requirements POA.4 and PRA.4 ("Alerts must be trustworthy") by prioritising delivery of those POAs/PRAs which provide the most valuable information in determining the location and extent of an outage. As with Option 5, queuing POAs/PRAs relating to other SMETS2 Installations for slower delivery meets the DNO's requirements POA.3 ("POAs must be reliable") and PRA.1 ("All PRAs required") and reduces DNO PRA/POA processing requirements by smoothing POA/PRA delivery.

As with Option 5, the primary expectation is that all POAs and PRAs would be delivered, in which case this option is concerned only prioritising delivery of those Alerts of most value to the DNO at the expense of slower delivery of the remainder. However, the same approach could also be used to dump large numbers of POAs regarded as superfluous.

Advantages

- No new infrastructure is required (software change only).
- DNOs can prioritise delivery of POAs/PRAs for MPANs selected based on their network location.
- Option can help address prevalence of SMETS1 Installations by allowing DNOs to prioritise SMETS2 Installations located in SMETS1 Installations as indicators of SMETS1 customer's network status.

Drawbacks

- Selection of representative MPANs may require network information not currently available to a DNO (e.g. Phase).
- DSP will need to be informed of priority MPAN selection, both initially and in response to any changes (e.g. network re-configuration) which requires additional effort from the DNOs.
- Prioritisation of DNO POAs/PRAs over other northbound traffic means that DCC Services to other DCC Users is likely to be affected.

DSP.7 – Reduce Spurious PRAs

There are two sub-options which would reduce incidence of spurious PRAs. Note that the primary purpose of these implementations would be to reduce the background level of spurious Alerts which mask Alerts caused by low-volume real power outages. As an example, analysis of PRAs received by the DSP between 09 and 15 July 2020, inclusive revealed one ESME was generating an average of 10,832 8F35s per day.

Though having an appreciable impact on background outages, the impact of spurious PRAs diminishes as network outage events increase in size.

DSP.7a Change the exclusion list for alert traffic management

Data Communications Company

Option 7a is a simple enhancement which involves requesting the Operations Group to remove 8F35s and 8F36s from the SECMP0062 exemption list of Alert Codes so that northbound application traffic management alert storm protection is applied to PRAs. This will have the effect of consolidating PRAs in excess of the Alert Code Specific Threshold (currently set at 20) for a specific Device consolidated down to 1 in 500 or 1 per day for each Alert Code, thus dramatically reducing the volume of spurious PRAs received by a DNO.

Advantages

- Very simple enhancement.
- Appreciable impact on background levels of PRA.

Drawbacks

- Benefits diminish with size of outage scenario.

DSP.7b Introduce a block list for specific rogue devices

Option 7b uses a more targeted approach whereby a block list of specific ESME Devices known to generate spurious PRAs would be maintained, and PRAs from those Devices would be suppressed,

Current analysis suggests that either of these enhancements would reduce the volume of spurious PRAs received by a DNO by between 10% and 20%.

Advantages

- Relatively simple enhancement.
- Appreciable impact on background levels of PRA.

Drawbacks

- Benefits diminish with size of outage scenario.

DSP.8 – Buffering During DSP Planned Maintenance

Although the DCC is meeting SLAs for planned maintenance and other release activities, messages, including POAs and PRAs, are typically lost during the maintenance period (which can last up to 6 hours).

A solution has been specified previously (as CR1090) for buffering during planned maintenance periods, though not implemented. Implementation of this is suggested as an option to avoid POAs and PRAs being lost during planned maintenance. Note that they will not be delivered until after normal service resumes following the end of the planned maintenance period.

To handle storage of northbound messages during a production uplift outage, DSP will build a new component called the SMWAN Message Buffer. This will be independent of the rest of the DSP solution and will be deployed on its own hardware. The way in which it relates to existing DSP solution components is shown in the diagram below. There will be two SMWAN Message Buffer components to ensure operational consistency – one for Arqiva and one for Telefónica. This is illustrated in Figure 17, below.

As part of preparing for a DSP planned maintenance period, messages will be routed away from normal DSP components to the SMWAN Message Buffers, from which they will be routed back to DSP at the end of the maintenance period. There will be no use made of the SMWAN Message Buffers during normal DSP service.

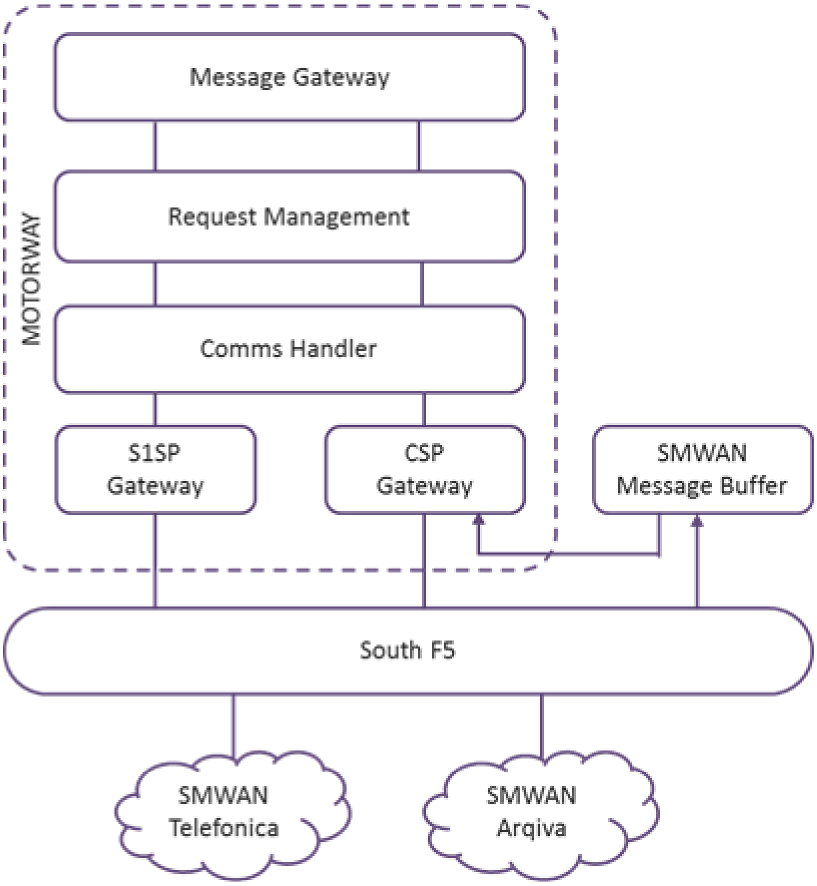


Figure 17 Option 8 Buffering During DSP Planned Maintenance

Advantages

- PRAs/POAs will not be lost during a planned DSP outage.

Drawbacks

- Buffered PRAs/POAs will be delivered on recovery of DSP and could be up to 6 hours late.

Estimated impact of enhancements

The table below sets out the estimated impact of the 8 proposed DSP enhancements.

Key:	No Change	Improvement

Req.	DNO Requirement	Option 0		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7a/7b	Option 8
		Current capability		General Uplift	Message Type Prioritisation	Dedicated Resilient MWL	Dedicated MWL (cloud)	Geographic/ Time Prioritisation	"Canary"	PRA Northbound Traffic Mgmt	DSP Buffer for Planned Outages
POA.1	POA for all outages > 3min	12,000	TPM	24,000	24,000	24,000	24,000	24,000	24,000	12,000	12,000
POA.2	POAs delivered in < 5min	0.0048	mins	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048[41]
POA.3	POA must be reliable	12,000	TPM	24,000	24,000	24,000	24,000	24,000	24,000	12,000	12,000
POA.4	POAs must be trustworthy	N/A		N/A	N/A	N/A	N/A	'Higher quality' POAs/PRAs	'Higher quality' POAs/PRAs	N/A	N/A
POA.5	POAs must be consistent	Dependent on meter, CH and CSP		Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP
PRA.1	All PRAs required	96,000	TPM	192,000	192,000	192,000	192,000	96,000	96,000	96,000	96,000
PRA.2	PRAs delivered in <1min	0.0004	mins	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004[42]
PRA.3	PRAs must be consistent	Dependent on meter, CH and CSP		Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP	Dep on meter, CH and CSP

[41] Whilst Option 8 will have no impact on delivery times of POAs/PRAs under normal operation, POAs/PRAs generated during a planned outage may be received up to 6 hours late.

[42] Whilst Option 8 will have no impact on delivery times of POAs/PRAs under normal operation, POAs/PRAs generated during a planned outage may be received up to 6 hours late.

Req.	DNO Requirement	Option 0 Current capability		Option 1 General Uplift	Option 2 Message Type Prioritisation	Option 3 Dedicated Resilient MWL	Option 4 Dedicated MWL (cloud)	Option 5 Geographic/ Time Prioritisation	Option 6 "Canary"	Option 7a/7b PRA Northbound Traffic Mgmt	Option 8 DSP Buffer for Planned Outages
PRA.4	PRAs must be trustworthy	N/A		N/A	N/A	N/A	N/A	'Higher quality' POAs/PRAs	'Higher quality' POAs/PRAs	10-20% reduction in PRA volume	N/A
GEN.1	No loss of PRAs/POAs during planned outage	Loss during maintenance window		Loss during maintenance window	Loss during maintenance window	Loss during maintenance window	Loss during maintenance window	Loss during maintenance window	Loss during maintenance window	Loss during maintenance window	No loss during maintenance windows
GEN.2	No loss of PRAs/POAs during unplanned outage	4 hour RTO		4 hour RTO	4 hour RTO	4 hour RTO	4 hour RTO	4 hour RTO	4 hour RTO	4 hour RTO	4 hour RTO

Table 19 Estimated impact of DSP enhancements

Please note that:

- Options 1, 3 and 4 are mutually exclusive.
- Volumes quoted assume normal DSP operation (i.e. that capacity reserved to cope with DSP outages is not being used).
- POA.5 and PRA.3 (consistency) is dependent on consistency in behaviour between ESMEs, Comms Hubs and CSPs and is not, therefore, relevant to the DSP.

Table 20, below, shows whether the current DSP capacity and enhanced capacity for each proposed option meets the DNO requirements for POA/PRA delivery[43] under each of the DNO-specified scenarios.

Key:	Scenario is supported	Supported with addition of two motorway lanes	Scenario not supported

[43] POA.1, POA.2, POA.3, PRA, 1 and PRA.2.

Scenario	Description	Max Simultaneous Outages	Max Simultaneous Restores	Max Simultaneous SMETS2 POAs	Max Simultaneous SMETS2 PRAs	Current	1. General Uplift	2. Message Type Prioritisation	3. Dedicated Resilient MWL	4. Dedicated MWL (cloud)
C	Overhead power line comes down. 30 homes in a village are taken off supply as are 15-20 local supply points at neighbouring farms	50	50	45	45	Yes	Yes	Yes	Yes	Yes
A/B	Single 5000 property outage (A - TEF region / B - ARQ region)	5,000	5,000	4,500	4,500	Yes	Yes	Yes	Yes	Yes
D	Substation damaged - 5,000 lose power simultaneously	5,000	5,000	4,500	4,500	Yes	Yes	Yes	Yes	Yes
G	Storm travelling West to East knocks out a total of 100,000 MPAN's over a 20-hour period on average 5,000 homes an hour with a mix of high volt and low voltage. Due to re-routing, alerts may be generated and restored within the 3 minutes	5,000	7,500	4,500	6,750	Yes	Yes	Yes	Yes	Yes
H	Storm travelling South to East from Bristol to Glasgow affecting 100,000 MPAN's over 7 hours to include 20,000 simultaneous supply points in Birmingham, 15,000 in Manchester and 65,000 being a mix of high voltage / low voltage in other cities, towns and villages	20,000	20,000	18,000	18,000	No	Yes	Yes	Yes	Yes
E	20,000 homes in a major city lose power within 30 seconds a smaller power event occurs meaning the loss of power occurs in a different part of the same SP region (e.g. 20,000 homes in London – 6 homes in Western Super Mare)	20,006	20,006	18,005	18,005	No	Yes	Yes	Yes	Yes
F	An event knocks down a high voltage cable in a major city (as per DNO discussions assumed to be scenario for outage of 30,000 properties)	30,000	30,000	27,000	27,000	No	Yes[44]	No	Yes[45]	Yes
I	Transmission Line Failures	200,000	50,000	180,000	45,000	No	No[46]	No	No[47]	Yes

Table 20: Current and enhanced DSP capability to meet DNO scenarios

[44] General uplift will accommodate this scenario under normal DSP operating conditions but would require two additional motorway lanes, rather than one.

[45] Dedicated resilient MWL will accommodate this scenario under normal DSP operating conditions but would require three additional motorway lanes, rather than two

[46] Whilst it is technically feasible to provide sufficient motorway lanes to cope with these transaction volumes, the quantity of infrastructure required makes this solution commercially untenable.

[47] Whilst it is technically feasible to provide sufficient motorway lanes to cope with these transaction volumes, the quantity of infrastructure required makes this solution commercially untenable.

This figures in Table 20 are based on the following assumptions:

1. “Simultaneous” POAs/PRAs are received over the course of a minute.
2. Simultaneous outages do not occur in parallel with simultaneous restorations (i.e. processing of POAs and PRAs relating to outages described in the scenarios does not happen at the same time).
3. For enhancement options involving prioritisation that do not include dedicated DNO resources (i.e. option 2, 5 and 6), SLAs for delivery of “non-priority” POAs/PRAs are unlikely to be met.
4. Given the prevalence of SMETS1 Installations, the number of SMETS2 POAs/PRAs resulting from the number of properties experiencing an outage has been reduced by 10% rather than 33% to allow for concentrations of SMETS2 Installations.

5.2 Recommendation

Based on the analysis and the expected benefits as set out in precursor sub-sections contained with Section 5, the following options are recommended:

Level	Telefónica	CGI	Arqiva
One	Option 2 – Cloud Based Micro Service Option 3 - Network Evolution Comms Hub with Super capacitor	No recommendation	Option 2a – Additional Channels (Alert Channel) Option 4 – Increase 5k/min Throttling
Two	Option 1 – Existing IT System Enhancements	No recommendation	Option 1 – Reinstate CH PRA

Table 21 Options Recommendations Overview

The recommendation has been broken down into two levels based on prioritisation and the value which each option could bring to the DNO's.

Please note that:

- Telefónica Option 4 (Firmware and Network Infrastructure updates) is not deemed viable due to investment, technology roadmap considerations and indicative delivery timeline.
- Arqiva Option 1 is deemed not viable on the basis of previous DNO/DCC decision to remove CH PRA and that it would contradict PRA.3 but it has been included on the basis of the benefit which it could offer
- CGI is not in a position to make a recommendation as to the enhancement(s) to be implemented as the decision is dependent on:
    - the choice of CSP enhancements;
    - the priorities placed by the DNOs on their stated requirements;
    - the acceptability of the effect that some options may have on other DCC Users

5.3 Breakdown

The following solution enhancement options have been proposed by the three parties:

Telefónica	CGI	Arqiva
1. Existing IT System Enhancements	1. General Uplift	1. Reinstate CH PRA
2. Cloud Based Micro Service	2. Message Type Prioritisation	2a. Additional Channels (Alert Channel)
3. Network Evolution Comms Hub with Super capacitor	3. Dedicated Resilient MWL	2b. Additional Channels (Bulk Channel)
4. Firmware and Network Infrastructure Updates	4. Dedicated MWL (cloud)	3. Improved Backhaul Resilience
	5. Geographic/Time Prioritisation	4. Increase 5k / min Throttle
	6. “Canary”	5. Buffer at CSP - DSP Gateway
	7a/7b. PRA Northbound Traffic Management	6. De-duplicate at CSP - DSP Gateway
	8. DSP Buffer for Planned Outages	

Table 22 Service Provider Enhancement Options Summary

Please note that the DSP Options 3, 4, 5 and 6 require DSP Option 2 as a pre-requisite.

In addition, if Telefónica Option 1 or 2 is selected, there is no need to introduce DSP Option 8.

Any other option is deemed to be independent of one another and can be introduced independently.

6 Responses to DNO Questions

This section sets out the response to the 43 proposed questions. Unless denoted otherwise, the responses below cover all the service providers.

Q1 End to end system behaviour up to DNO systems needs to be considered in the Study.

Yes, this has been considered and is included in this study. Please refer to “section 4 As Is System Overview” for current behaviour.

Q2 Need to cover all constraints on the DCC end to end system which impact; Power Outage Alerts and Power Restoration Alerts.

Please refer to “section 4 As Is System Overview” for current behaviour which includes constraints in the system.

Q3 What is the current POA/PRA performance measurement methodology and what is the current reporting to Industry / BEIS / DNOs? Does it meet DNO requirements?

Currently AD1s are reported to DCC on PM12.1 (power loss events impacting 50 or less Comms Hubs) and PM12.2 (power loss events greater than 50 Comms Hubs). These are collated at DCC and reported out on PM001 to the SEC Operations Group. It does not measure from the time the power was lost to the comms hub. Restore alerts are not recorded separate from other alerts and are included as part of the category 3 alerts which are also reported out on PM001.

This does not meet the DNO requirements and a workshop was held with DNO delegates to gather timing, frequency and detail of reporting. This is covered separately as part of the wider DNO enhancements.

Q4 What are the exclusions in the current systems i.e. buddy CHs, masts without backup etc.?

	Comment	Impact
TEF	A power outage may in rare cases affect the local infrastructure of the cellular network (Radio Access Network). The RAN is made up of macro sites and microcells. Macro sites provide the main coverage and have a battery backup. Non-macro sites, i.e. microcells located on the side of buildings, stadiums etc. do not have battery backup but these are also under cellular coverage of a macro site. There are a small percentage of macro sites where battery backup is not possible due to practical reasons such as space	Small percentage

	Comment	Impact
ARQ	Comms Hubs (CHs) which are unable to communicate with the Arqiva network directly may communicate via a direct connecting CH in Buddy Mode. The device which cannot directly communicate with the network is termed an Out of Range Device (ORD). The CH which relays the messages between the network and the ORD is known as the Buddy. CHs operating in Buddy Mode are expected to represent around 5% of the total estate at the end of deployment. In a power outage, if the Buddy device loses power then it will not relay messages from the ORD. With respect to power outages there are three scenarios related to buddy mode. 1. Power is lost to the buddy device only 2. Power is lost to the ORD device only 3. Power is lost to both devices In scenario 1 the power outage alerts from the Buddy will be sent to the network following the usual process. In scenario 2 the power outage alerts are received by the Buddy device and relayed to the network. In scenario 3 the power outage alerts from the Buddy device will be sent to the network following the usual process. However, to conserve power, the Buddy device will not forward the power outage alerts from the ORD. Once power is restored to the Buddy CH, it will resume relaying messages from the ORD including power restoration alerts. Where 3G backhaul is provided from a site, the 3G network may also be lost during an outage. While connectivity is down alerts will be buffered at the TK and interleaved with live messages once connectivity is restored.	5% of total CH estate
DSP	There are no known exclusions in the current systems	n/a

Q5 How do the systems handle POA/PRA alerts during DCC and User downtime? Are there areas for improvement? What are the improvement options and estimated cost of delivery?

Service provider systems typically use retry strategies to send alerts if there are failures during the send.

POAs are not retried due to the Communication Hub only having a limited time it can sustain itself following loss of power.

For 8F35/8F36 messages, if there is no response or a failure response from the DSP when attempting to send, the CH will attempt to retry sending the message after 30, 60 and 300 seconds.

Different unhappy path scenarios are described in "section 4.2.1 Unhappy Path Scenarios". Currently there is no coverage in place for planned outages where messages can get lost during maintenance windows.

Improvement options specified under "section 5 To Be Solution Options"have solutions to address this issue and consist of:

	Option	Impact
TEF	TEF.1 - Improvements in existing systems TEF.2 - Cloud based micro service TEF.3 – Network Evolution CH with super capacitor	Reduction in message loss
ARQ	ARQ.5 - Buffering alerts at the CSP-DSP gateway	Reduction in message loss
DSP	DSP.8 - Buffering during DSP planned Maintenance	Reduction in message loss

Costs for these options will be supplied under separate documents along with this paper.

Q6 If it is decided to change the systems to enhance the POA/PRA performance how will this be raised with industry? Who pays for the enhancement? Would this follow the SEC modification process?

This will be raised as a SEC modification and will therefore follow the SEC modification process.

Q7 It is noted that the Arqiva solution may mask (by delay in sending alerts) smaller faults in other geographic regions in the event of a large fault occurring elsewhere. This is less than optimal from a DNO perspective and needs to be considered in any revised proposal. With options to improve this limitation and estimated costs and time to deliver included.

	Comment	Impact
ARQ	At present there is a throttle between the CSP and DSP to limit the maximum throughput of messages to 5,000 power outage alerts per minute. For outages generating greater than 5,000 outage alerts per minute, the additional alerts will be buffered and sent at the maximum rate until cleared. If a smaller outage alert occurs shortly after a larger outage this can in theory block the alerts from the smaller outage until the buffer clears. Some of the solution options specified under "section 5.1.2 Arqiva CSP Implementation Option Descriptions" do have solutions to address this issue. Costs for these options will be supplied under separate documents along with this paper.	Large outage = delayed AD1s

	Comment	Impact
TEF	There is currently a throttle between the CSP and DSP to limit the maximum throughput of messages to 5,000 power outage alerts per minute impacts as described above. DSP enhancements to increase throughput of POAs will enable the current limit of 5,000 to be raised.	Large outage = delayed AD1s
DSP	There is currently a throttle between the CSP and DSP to limit the maximum throughput of messages to 5,000 power outage alerts per minute impacts as described above. DSP enhancements to increase throughput of POAs will enable the current limit of 5,000 to be raised.	Large outage = delayed AD1s

Options to improve are:

	Option	Impact
TEF	TEF.1 - Improvements in existing systems	Increased alert throughput
ARQ	ARQ.4 – Relax throttle between CSP and DSP	Increased alert throughput
DSP	DSP.1 – Provision of new shared infrastructure DSP.2 – Prioritising POAs and PRAs over other northbound traffic DSP.3 – New dedicated resources for POAS and PRAs DSP.4 – Cloud-based Dedicated DNO POA/PRA resources	Increased alert throughput
	DSP.5 – Prioritisation within POAs and PRAs by Postcode/Time DSP.6 - Prioritisation within POAs and PRAs by Canary indicators	Prioritise POAs/PRAs pertaining to new network outages over those related to outages which have already been notified to the DNO

Q8 Due to the change in the number of SMET 2+ versus SMETS 1 meters installed against what was assumed in the SMART business case DNOs will never receive alerts from all homes for any outage which needs to be consider in DNO requirements and revised proposal. The study needs to look into options that might be available to mitigate this position.

The fact that the vast majority of SMETS1 Installations do not generate POAs/PRAs is not something that can be directly addressed by the DSP or

CSPs. However, the DSP's "Canary" enhancement option (as described in "section 5.1.3 DSP Implementation Option Descriptions") does allow DNOs to prioritise delivery of POAs/PRAs from SMETS2 Installations located in areas of heavy SMETS1 Installation deployment, thus providing indicators of outages on these parts of the network.

Q9 What are the constraints in the DSP systems regarding POAs and PRAs from a delivery time scale and volume perspective?

	Comment	Impact
TEF	n/a	n/a
ARQ	n/a	n/a
DSP	Under normal operating conditions (i.e. assuming no DSP outages), the average processing times of POAs and PRAs are 0.288 and 0.025 seconds respectively and maximum processing rates are 12,000 and 96,000 messages per minute for POAs and PRAs respectively. There are volume constraints that apply to the aggregate POAs/PRAs received from both CSPs and that there is a maximum rate for POAs defined for each CSP defined in a Code of Connection. For volumes above these, some POAs/PRAs may get lost and/or take a longer time to be delivered. Note that the maximum DSP rate specified above for delivering POAs assumes there are no PRAs at the same time, and vice versa. Six DSP enhancements have been proposed for increasing the throughput of POAs and PRAs.	Large outage = delayed AD1s, 8F35s & 8F36s

Q10 What are the constraints in the CSP Arqiva systems regarding POAs and PRAs from a delivery time scale and volume perspective?

	Comment	Impact
TEF	n/a	n/a

	Comment	Impact
ARQ	Within the Arqiva system the AD1s and ESME alerts are delivered following two different message processes (described in more detail in “section 4.3 Arqiva CSP System Overview”). For AD1 alerts, throughput of the alert channel within a cell will depend on the number of alerts transmitted. Where the alerts are randomised over each window there is the chance that multiple alerts are transmitted at the same time and collide, causing messages to be lost. The more alerts transmitted within a time window the higher the chances of over the air collision. For the ESME alert process, CHs are allocated uplink timeslots to send the alerts in. The maximum throughput for a single channel in a cell is 2 alerts per second. For cells with higher CH loading, multiple traffic channels are used to maintain overall throughput. Typical maximum loading of a cell will be around 10,000 CHs at the end of CH roll out, with around 2,500 CHs per channel.	Large outage = delayed AD1s, 8F35s & 8F36s
DSP	n/a	n/a

Q11 What are the constraints in the CSP Telefónica systems regarding POAs and PRAs from a delivery time scale and volume perspective?

	Comment	Impact
TEF	The full constraints are covered in "section 4.2 Telefónica CSP System Overview". From a delivery timescale perspective, confirmed power outages are determined from receiving an outage alert and not receiving a restore alert within a given time. This time is based on: • Comms Hub boot time 90 seconds • Network attach of between 20-120 seconds • Various network hops and process time adding up to 30 seconds • Orchestration system processes which gather AD1 messages and sends a batch of messages from the message buffer once a minute From a volume perspective, alerts get throttled for outages messages received exceeding 34,000 to protect SM2M and downstream systems. The CSP-DSP interface is currently restricted to 5000 alerts/minute. Also, the current implementation does not have provision for managing power alert notifications during planned maintenance periods (including DSP maintenance periods) and these will result in notifications not going through to the DNOs. The solution options specified under "section 5 Options" include solutions to address these issues. Costs for these options will be supplied under separate documents along with this paper	Large outage = delayed AD1s
ARQ	n/a	n/a
DSP	n/a	n/a

Q12 What are the POA and PRA alert service levels that DNOs currently get and experience from CSPs and DSP systems? How and when is this reported?

SLAs are normally reported in a monthly service reporting pack to the DCC.

SLAs are described in the PMA (Performance Measurement Methodology). POAs are reported under performance measures PM12.1 and 12.2.

PM12.1 reports on outages for 50 communication hubs or fewer and is calculated as power outages alerts sent/power outage alerts received,

PM12.2 reports on outages greater than 50 communication hubs and is calculated as power outages alerts sent/power outage alerts received>50 and =< 5000,

There are currently no bespoke SLAs for the delivery of PRAs. Further details on the PM reports and service levels are available in "Appendix B – CSP Contract Extracts".

	Comment	Impact
TEF	For both PM12.1 and PM12.2, the target SLA is 98% and minimum SLA is 96%. Since January 2019, in the CSP South region, there have been 2 reported failure months – January 2019 and August 2019 for PM12.1 and January 2019 and August 2019 for PM12.2. Similarly, for the CSP Central region, there have been 2 reported failure months – January 2019 and August 2019 for PM12.1 and July 2019 and August 2019 for PM12.2.	n/a
ARQ	Under both PM12.1 and PM12.2, the target SLA is 99% and minimum SLA is 96%. Since January 2019, in the CSP North region there have been three instances where the target SLA was not met – May 2019, May 2020 and June 2020. In all three cases the minimum SLA was still maintained.	n/a
DSP	Generic alert delivery SLAs apply. Analysis has shown that DSP meets this SLA for 99.99% of POAs/PRAs.	n/a

Q13 Can CSPs add an element of 'location awareness' into their processing (derived from identifying the receiving base station or cellular tower location) and therefore could protect DNOs from very large outages affecting one area whilst not impacting traffic from other areas? If this could be achieved can it guarantee near 100% delivery of small and isolated faults whilst also giving the DNOs enough notice of larger network event without needing to send every single alert for large events? How would this be delivered at what costs and delivery timescales?

Whilst technically possible this would add processing overhead to the typical 'day to day' performance, where large outages are uncommon. Furthermore, the CSPs have no correlation between CHs and DNO network topology or boundaries between DNOs which fall within a single cell. Prioritisation also cannot take place until a significant number of alerts have been read. CSPs do have location awareness through the Radio Access Network by means of cell ids but these can cover varying degrees of geographical areas and will have a different topology to the grid. Any processing which takes place geographically has the potential to remove desired alerts not just those relating to a known outage.

Further work on this is required to ascertain what further data can be provided by SU's / DNO's to allowing location based tracking to be implemented at a level to allow this to be carried out by service providers and to maintain a trustworthy service.

Q14 DNOs require a Power Outage Alert for all outages of power to the meter which are longer than 3 minutes to be sent to the DNO

can this be delivered if not why not? What are the options and cost estimate and delivery timescale?

	Comment	Impact
TEF	There is a throttle in place on the load balancers that deliver CH alerts to the SM2M DMM system. This protects SM2M DMM and downstream systems from an alert flood if an outage occurs exceeding 34,000 households. It is applied when the alerts exceed 2267 transactions per second (alerts are randomised over 15secs). For outages smaller than 34,000 households, no alerts will intentionally be dropped.	Large outage >34k = dropped AD1s
ARQ	POAs are sent as a last gasp type message from the CHs and are not acknowledged. To improve the probability of successful delivery, three alerts are sent from each CH. During large outages, some messages are lost due to over the air collisions and all three alerts for a particular CH can in theory be lost. There are enhancement options which aim to reduce the chance of over the air message collisions occurring, improving the reliability in larger outages.	Large outage = dropped AD1s
DSP	There is also message throttling in place at the CSP-DSP gateway of 5,000 messages per minute. DSP enhancements to increase throughput of POAs will enable the current limit of 5,000 to be raised.	Large outage = delayed AD1s

The solution options specified under “section 5 Options” include solutions to address the above issues. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
TEF	TEF.1 – Improvements in existing systems TEF.2 – Cloud Based micro service TEF.3 – Network Evolution CH with super capacitor	No dropped AD1s
ARQ	ARQ.4 – Relaxed throttle between CSP and DSP	No dropped AD1s
DSP	DSP.1 - Provision of new shared Infrastructure DSP.2 - Prioritising POAs and PRAs over other northbound traffic DSP.3 - New dedicated resources for POAs and PRAs DSP.4 - Cloud-based Dedicated DNO POA/PRA resources DSP.5 – Prioritisation within POAs and PRAs by Postcode/Time DSP.6 - Prioritisation within POAs and PRAs by Canary indicators	Increased throughput of AD1s

Q15 The DNOs require the Power Outage Alert to be delivered promptly, arriving at the DNO systems within 5 minutes of the start of the power outage (i.e. 2 minutes after the start of the Power Outage Event, which starts 3 minute after the start of the power outage) can this be delivered if not why not? What are the options and cost estimate and delivery timescale?

	Comment	Impact
TEF	The 5 minute delivery time from the start of the power outage (including the 3 minute wait time to confirm the outage) cannot currently be achieved, due to several reasons including the time it takes to process the outage alert and also the time required to wait for possible power restore alerts that may arrive after the CH reboots and reattaches to the network. This is described in more detail under "section 4.2 Telefónica CSP System Overview".	AD1s take up to 8mins
ARQ	There are 3 alerts sent for AD1s. The length of time it takes to deliver these varies based on several factors such as the volume of outages and number of cells that support the transmission of these alerts. After the first alert window, which is sent within the DNO requirement of 5 minutes, a certain percentage of the AD1 alerts will be delivered with additional AD1 alerts delivered within the subsequent alert windows. This is covered in more detail in "section 4.3.3 Current Performance".	>50% of AD1s are delivered within 5 minutes
DSP	Analysis has shown that the average DSP processing time for POAs/PRAs is 0.02 seconds (please refer to Appendix A: DSP PRA/POA). Since this represents less than 0.01% of the 5 minute target, DSP processing is not considered to be on the critical path for achieving this requirement.	All alerts processed within 4 seconds

The options specified under "section 5 Options" include solutions to address this issue. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
TEF	TEF.3 – Network Evolution CH with super capacitor	Faster AD1 delivery
ARQ	ARQ.2a – Increased alert channels	Faster AD1 delivery
DSP	n/a	n/a

Q16 Can the Power Outage Alert be reliable and dependable? How can reliable and dependable be defined and measured?

It is assumed that reliability of POAs is defined as successful delivery of all power alerts longer than 3 minutes (AD1 alerts). Dependable is assumed to mean trustworthy alerts where there are no false positive or negative messages.

	Comment	Impact

TEF	Under the Telefónica implementation, reliable and dependable delivery of power outage information is affected by:
	• OUTAGE
	    ○ CH triggering the outage alert using a send and forget method
	    RAN and packet Core delivering the outage alert to the SM2M DMM system.
	    ○ SM2M DMM passing the outage alert to the Orchestration system via a UDP interface.
	    ○ Systems downtime
	• RESTORE
	    ○ ESME triggering the restore alert
	    ○ CH forwarding the ESME restore alert to DSP
	    ○ CH triggering the CH restore alert
	    ○ RAN and packet Core delivering the restore alert to SM2M
	    ○ SM2M processing the restore alert to the Orchestration system via a UDP interface.
	    ○ Orchestration system generating the AD1 correctly and sending to DSP
	    ○ All systems being available
	
	Known reasons why an AD1 might not get triggered:
	For large outages, there is a throttle in place of 2267 transactions per second or an outage of 34,000, to protect downstream systems.
		n/a

ARQ	There are known instances where AD1 alerts are lost. The AD1 alerts are considered to be dependable as CHs only generate POAs when power has been interrupted for at least 3 minutes.	n/a
DSP	For the unusual cases where there are gas-only SMETS2 installations, when DSP receives a power outage alert from the Comms Hub via the CSP, it will attempt to find the MPAN(s) of the associated electricity meter(s), but for gas-only installations there will not be one. As the MPAN is used in order to know which DNO to send the DCC Alert AD1 to, and also the DUIS DCC Alert AD1 structure requires an MPAN, it is not feasible for DSP to send a DCC Alert AD1 to the DNO. Currently approximately 5% of SMETS2 installations are gas-only, though this proportion is expected to decrease as the smart meter rollout continues.	n/a

Data Communications Company

Using data provided by the DSP a full review is currently underway of outage and restore alert processing with the aim to identify weaknesses in the above areas. Appendix A shows Power Alert data analysis.

There are also other DCC CRs that are currently being progressed to measure and assess the service provider systems. CR1349 will cover POA/PRA reporting and PR1227 will cover end to end testing of POA/PRA.

Q17 The DNOs require the format, reliability and behaviour of Power Outage Alert to be consistent between all Meter types and Comms Hub types and CSPs can this be delivered? How can consistence be defined and measured?

Alerts are currently consistent between CSPs and are of the same format although do not necessarily have the same reliability. Arqiva alerts can be lost due to over the air collision of messages. Telefónica alerts may potentially be lost while traversing between systems. There is general consistency between CH types in terms of delivery of the POAs.

Using data provided by the DSP, a full review is currently underway of outage and restore alert processing with the aim to identify weaknesses in the above areas, including analysing whether there are any inconsistencies between CH types and meter types.

Q18 The DNOs require the Power Restoration Alert to be delivered promptly, arriving at the DNO systems within 1 minute following the restoration of the power supply to the meter is this requirement being met? If not, how can it be achieved at what cost?

	Comment	Impact
TEF	Power Restoration Alerts are generated by the ESME and sent to the CH. If during a grid outage, power is restored before the communication hub supercapacitor (backup power) expires then ESME Power Restoration Alerts (8F35 and 8F36) will be sent immediately and reach the DSP within 1 minute. If the communication hub has to shut down due to the super capacitor expiry, it will take longer to transmit the power restoration alert. The communication hub will take around 90 seconds to reboot itself and a further 20 to 120 seconds before it re-attaches itself to the Telefónica network. Once it has attached, it is able to forward the Power Restoration Alert which will reach the DSP within a minute. A communication hub supercapacitor is expected to last at least 20 seconds but could last up to 2 minutes. If the CH has to reboot, then there are no solutions currently available from the Telefónica side to transmit the PRA within a minute due to the constraints of the CH.	PRAs take between <1min to 4mins

	Comment	Impact
ARQ	Power Restoration Alerts are generated by the ESME and sent to the CH. On power restoration the CH reboots, taking up to 3 minutes. At present there are known to be ESMEs which transmit the GBCS alerts before the CH has finished booting. With no message retry mechanism from the meter these messages are currently lost. PR1227 is aimed at identifying the meters which suffer from above issue. Once the CH has rebooted after power restoration any successfully received PRAs will be uploaded to the network at a maximum rate of 2 messages per channel per cell. Some of the options in “section 5.1.2 Arqiva CSP Implementation Option Descriptions” aim to improve the throughput of ESME alerts once they reach the CH.	PRAs sent at a rate of 2 per second per channel in a cell. For the maximum loading of a channel PRAs can take 45 minutes to send
DSP	Analysis has shown that the average DSP processing time for PRAs is 0.025 seconds (please refer to Appendix A: DSP PRA/POA SLAs). Since this represents 0.042% of the 1 minute target, DSP processing is no considered to be on the critical path for achieving this requirement.	4secs

Q19 DNOs require Power Restoration Alerts for all outages of power to the meter (i.e. those lasting less than 3 minutes and those lasting more than 3 minutes) to be sent to the DNO are the system meeting this requirement? If not, how can it be met at what cost?

	Comment	Impact
TEF	Power Restoration Alerts are sent directly from the CH to the DSP traversing only the Radio Access Network and the Telefónica Network interface to the DSP. All 8F35s and 8F36s are due to be sent to the DSP. There is high availability on the network links so in general the exceptional situations where these alerts are not delivered would be: ○ CH issue ○ CH to RAN connectivity issue ○ When there are unplanned or planned outages on the DSP systems	All PRAs sent

	Comment	Impact
ARQ	The Arqiva CH will maintain power for the 3 minutes required to identify power outages due to the charge in the supercapacitor. On loss of power the CH processor drops into a low power state to preserve capacitor charge. Where power is restored within this time the CH reboots taking up to 3 minutes. After rebooting, any ESME alerts sent to the CH will be uploaded to the network with a maximum rate of 2 alerts per channel per cell. Where power is restored after an outage longer than 3 minutes the CH will again reboot taking up to 3 minutes. After rebooting, any ESME alerts sent to the CH will be uploaded to the network with a maximum rate of 2 alerts per channel per cell. Some of the options in "section 5.1.2 Arqiva CSP Implementation Option Descriptions" aim to improve the throughput of ESME alerts once they reach the CH.	All PRAs sent assuming success before the end of the RTS back off window
DSP	Under normal operating conditions (i.e. assuming no DSP outages), the average processing times of POAs and PRAs are 0.288 and 0.025 seconds respectively and maximum processing rates are 12,000 and 96,000 messages per minute for POAs and PRAs respectively. There are volume constraints that apply to the aggregate POAs/PRAs received from both CSPs and that there is a maximum rate for POAs defined for each CSP defined in a Code of Connection. For volumes above these, some POAs/PRAs may get lost and/or take a longer time to be delivered. Note that the maximum DSP rate specified above for delivering POAs assumes there are no PRAs at the same time, and vice versa. Six DSP enhancements have been proposed for increasing the throughput of POAs and PRAs	All PRAs sent

Using data provided by the DSP a full review is currently underway of outage and restore alert processing with the aim to identify weaknesses in the above areas.

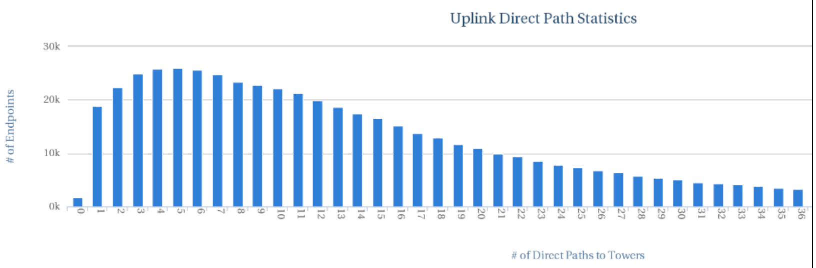
The solution options specified under "section 5 Options" include solutions to address the above issues. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
DSP	DSP.1 - Provision of new shared Infrastructure DSP.2 - Prioritising POAs and PRAs over other northbound traffic DSP.3 - New dedicated resources for POAs and PRAs DSP.4 - Cloud-based Dedicated DNO POA/PRA resources DSP.5 – Prioritisation within POAs and PRAs by Postcode/Time DSP.6 - Prioritisation within POAs and PRAs by Canary indicators	Increased throughput of AD1s

Q20 How does the CSPs and DSP system deal with an outage scenario of a single 5000 property outage? Can this be enhanced, how at what cost and timescale?

The assumption is that all 5,000 homes have power restored simultaneously.

	Comment	Impact
TEF	When power is lost, 5,000 outage alerts are sent over 15 seconds. They are delivered to the Orchestration Tool (OT) within a few seconds at which point it holds these messages and awaits restore alerts. If power is restored within 3 minutes: • CHs that are not powered down send restore alerts randomised over 30 seconds • CHs that are powered down boot up and follow network attach procedure • OT waits for up to 7 minutes for the restore alerts • OT cancels the outage If power is restored after a period of 3 minutes: • OT waits for up to 7 minutes for the restore alerts • When a PRA is not received, OT marks the outage as confirmed and queues up the AD1 • AD1 is sent to DSP when the once a minute OT batch process picks it up. • 5,000 AD1s are sent to DSP spread over 1 minute. The total time from outage to delivery of final alerts to DSP is approximately 8 minutes.	AD1s sent to DSP within 8mins 8F36s sent to DSP within 4mins

	Comment	Impact
ARQ	We can analyse this based on assuming the worst case where all 5,000 CHs are within a single cell of the Arqiva system and with 5% of the cell connected through buddy mode and no additional coverage provided by neighbouring sites. The CHs will begin sending POAs once the outage time reaches 3 minutes. Three alerts are transmitted from each CH dithered over a 45s, 240s and 240s window respectively. In the above scenario, statistically around 31% of alerts will be delivered within 5 minutes (2 minutes after the outage is confirmed). This will rise to around 86% of CHs alerts at the end of the third window a total of 11m 45s after the outage occurred (8m 45 after outage confirmation). Typically, an outage of this size would occur in a location where overlapping coverage from neighbouring sites is provided. With some overlapping coverage provided by a single additional site then the number of CHs alerts expected to be received at 5m and 11m 45s would be around 52% and 94% respectively. At present there are around 3% of CHs which are only served by a single site. The vast majority of CHs have additional coverage provided by multiple neighbouring sites. The number of sites which provide overlapping coverage varies by geographic area and install location. With each increasing uplink path available the chance of successfully receiving a given power outage alert increases. In very large outage scenarios, the availability of neighbouring sites is reduced. For the current installed CH estate, the below graph shows the number of uplink paths available to each CH demonstrating the level of overlapping coverage in the network:  **Figure 18 Uplink Direct Path Statistics**	94% of AD1s sent to DSP in 11m45s
DSP	DSP processes all AD1s and 8F35 and 8F36s within 4 seconds	AD1s forwarded within 4 seconds

Solution options specified under “section 5 To Be Solution Options“ address aspects of this, including the length time it takes for DNO to receive these alerts. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
TEF	TEF.3 – Network Evolution CH with supercapacitor	Faster AD1 delivery
ARQ	ARQ.2a – Increased alert channels	Faster AD1 delivery
DSP	n/a	n/a

Q21 How does the CSPs and DSP system deal with an outage scenario an overhead power line comes down (possibly hit by a car), 30 homes in a village are taken off supply as are 15-20 local supply points at neighbouring farms? Can this be enhanced, how at what cost and timescale?

The assumption is that all 50 homes have power restored simultaneously.

	Comment	Impact
TEF	This would work in the same way as described in Q20	AD1s sent to DSP within 8mins 8F36s sent to DSP within 4mins
ARQ	We can analyse this based on assuming the worst case where all 50 CHs are within a single cell of the Arqiva system and with 5% of the cell connected through buddy mode and no additional coverage provided by neighbouring sites. After 5 minutes, statistically around 91% of CHs alerts will have been delivered rising to around 95% after 11m 45s	95% delivery after 11m45s
DSP	DSP processes all AD1s and 8F35 and 8F36s within 4 seconds	AD1s forwarded within 4 seconds

Q22 How does the CSPs and DSP system deal with an outage scenario of 30,000 property outage. Can this be enhanced, how at what cost and timescale?

The assumption is that all 30,000 homes have power restored simultaneously.

	Comment	Impact
TEF	When power is lost, 30,000 outage alerts are sent over 15 seconds. They are delivered to the Orchestration Tool (OT) within a few seconds at which point it holds these messages and awaits restore alerts. If power is restored within 3 minutes: • CHs that are not powered down send restore alerts randomised over 30 seconds • CHs that are powered down boot up and follow network attach procedure • OT waits for up to 7 minutes for the restore alerts • OT cancels the outage If power is restored after a period of 3 minutes: • OT waits for up to 7 minutes for the restore alerts • When a PRA is not received, OT marks the outage as confirmed and queues up the AD1 • AD1 is sent to DSP when the once a minute OT batch process picks it up. • 30,000 AD1s are sent to DSP spread over a 6 minute period The total time from outage to delivery of final alerts to DSP is approximately 13 minutes.	AD1s sent to DSP within 13mins 8F36s sent to DSP within 4mins
ARQ	We can analyse this based on assuming the worst case where all 30,000 CHs are spread across three cells of the Arqiva system, 10,000 in each cell. 5% of the cell connected through buddy mode and additional coverage provided by a single neighbouring site. After 5 minutes statistically around 52% of CHs alerts will have been delivered rising to around 94% after 11m 45s. For an outage of this size the contribution from neighbouring sites is likely to be higher than just a single neighbouring site. Where there are two additional sites providing overlapping coverage into each cell the number of CHs alerts expected to be received at 5m and 11m 45 rises to around 66% and 95% respectively.	95% of AD1s sent to DSP in 11m45s
DSP	Under normal operating conditions, the DSP can process a maximum of 12,000 POAs per minute and 96,000 PRAs per minute. Six DSP enhancements have been proposed for increasing the throughput of POAs/PRAs.	Higher volumes of POAs

Solution options specified under “section 5 To Be Solution Options“ address aspects of this, including the length time it takes for DNO to receive these alerts. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
TEF	TEF.3 – Network Evolution CH with supercapacitor	Faster AD1 delivery
ARQ	ARQ.2a – Increased alert channels	Faster AD1 delivery
DSP	DSP.1 - Provision of new shared Infrastructure DSP.2 - Prioritising POAs and PRAs over other northbound traffic DSP.3 - New dedicated resources for POAs and PRAs DSP.4 - Cloud-based Dedicated DNO POA/PRA resources DSP.5 – Prioritisation within POAs and PRAs by Postcode/Time DSP.6 - Prioritisation within POAs and PRAs by Canary indicators	Increased throughput of AD1s

Q23 DNOs expect the introduction of Smart Metering to deliver notifications within one or two minutes after a supply interruption has lasted longer than 3 minutes (a power outage is defined as a supply interruption lasting three minutes or more), as well as instantaneous notifications when power is restored how can this expectation be met? Can this be enhanced, how at what cost and timescale?

Duplicated. See Q15 and Q19

Q24 How does the CSPs and DSP systems deal with an outage scenario of 20,000 homes in a major city lose power within 30 seconds a smaller power event occurs meaning the loss of power occurs in a different part of the same SP region (e.g. 20,000 homes in London – 6 homes in Western Super Mare). Can this be enhanced, how at what cost and timescale?

The assumption is that all 20,006 homes have power restored simultaneously.

	Comment	Impact
TEF	When power is lost, 20,000 outage alerts are sent randomised over 15 seconds. They are delivered to the Orchestration Tool (OT) in around two minutes at which point it holds these messages and awaits restore alerts. 30 seconds later, power is then lost to the 6 homes and the power outage messages related to these 6 homes will be queued behind the 20,000 outage alerts. There are different scenarios involved here:	
	Scenario 1 If power is restored to all 20,006 CHs within 3 minutes: • CHs not powered down send a restore alerts randomised over 30secs • CHs powered down boot up and follow network attach procedure • OT waits the for up to 7mins for the restore alerts • OT cancels the outages	**Scen 1** No AD1s sent 8F35s sent to DSP within 4mins
	Scenario 2 If power is restored to all 20,006 CHs after 3 minutes: • OT waits for up to 7 minutes for the restore alerts • When power restore alerts are not received during this time, OT marks the outage as confirmed, queues up the AD1 • AD1 is sent to DSP when the once a minute OT batch process picks it up • 20,006 AD1s are sent to DSP over a 5 minute period	**Scen 2** AD1s sent to DSP within 12mins 8F36s sent to DSP within 4mins
	Scenario 3 If power is restored to the 20,000 CHs after 3 minutes and power is restored to the 6 CHs within 3 minutes • CHs not powered down send restore alerts randomised over 30 seconds • CHs powered down boot up and follow network attach procedure • OT waits for up to 7 minutes for the 20,000 restore alerts • When not received, OT marks the outage as confirmed, queues up the AD1 • OT waits the for up to 7 minutes for the 6 restore alerts • OT cancels the 6 outages • AD1s are sent to DSP when the once a minute OT batch process picks it up • 20,000 AD1s are sent to DSP over a 4 minute period • Total time from outage to delivery of final alert to DSP is 11 minutes.	**Scen 3** AD1s sent to DSP within 11mins 8F36s sent to DSP within 4mins

	Comment	Impact
ARQ	We can analyse this based on assuming the worst case where all 20,000 CHs are spread across two cells of the Arqiva system, 10,000 in each cell. 5% of the cell connected through buddy mode and additional coverage provided by a single neighbouring site. Assuming the 6 devices are not connected through buddy mode. Assuming the worst case where the 20,000 CHs are spread across two cells of the Arqiva system, 10,000 in each cell. 5% of the cell connected through buddy mode and additional coverage provided by a single neighbouring site. The additional 6 devices are not connected through buddy mode. After 5 minutes statistically around 52% of CHs alerts from the first outage will have been delivered rising to around 94% after 11m 45s. Where power is lost to the 6 premises at the 30 second mark alerts will be interleaved with the larger outage. As the first outage is expected to deliver 52% of CHs alerts within a 2 minute window (3-5 minutes after power is lost) this does not reach the current limit of the CSP – DSP 5000 per minute throttle. As such the 6 alerts from the second outage will be sent to DSP as soon as they are received by the network without additional processing delay, typically within 4 minutes of power being lost.	94% of AD1s sent to DSP in 11m45s
DSP	Under normal operating conditions, the DSP can process a maximum of 12,000 POAs per minute and 96,000 PRAs per minute. Six DSP enhancements have been proposed for increasing the throughput of POAs/PRAs.	Higher volumes of POAs

Solution options specified under “section 5 To Be Solution Options“ address aspects of this, including the length time it takes for DNO to receive these alerts. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
TEF	TEF.3 – Network Evolution CH with supercapacitor	Faster AD1 delivery
ARQ	ARQ.2a – Increased alert channels	Faster AD1 delivery
DSP	DSP.1 - Provision of new shared Infrastructure DSP.2 - Prioritising POAs and PRAs over other northbound traffic DSP.3 - New dedicated resources for POAs and PRAs DSP.4 - Cloud-based Dedicated DNO POA/PRA resources DSP.5 – Prioritisation within POAs and PRAs by Postcode/Time DSP.6 - Prioritisation within POAs and PRAs by Canary indicators	Increased throughput of AD1s

Q25 How does the CSPs and DSP systems deal with an outage scenario of an event knocks down a high voltage cable in a major city. Can this be enhanced, how at what cost and timescale?

Duplicate. DCC have confirmed that this is the same scenario as Q23, and outage size assumed is 30,000.

Q26 How does the CSPs and DSP systems deal with an outage scenario of a storm travelling West to East knocks out a total of 100,000 MPAN's over a 20-hour period on average 5,000 homes an hour with a mix of high volt and low voltage. Due to re-routing, alerts may be generated and restored within the 3 minutes. Can this be enhanced, how at what cost and timescale?

The largest single outage size quoted here is 5,000.

	Comment	Impact
TEF	When power is lost, 5,000 outage alerts are sent over 15 seconds. They are delivered to the Orchestration Tool (OT) within a few seconds at which point it holds these messages and awaits restore alerts. If power is restored within 3 minutes: • CHs that are not powered down send restore alerts randomised over 30 seconds • CHs that are powered down boot up and follow network attach procedure • OT waits for up to 7 minutes for the restore alerts • OT cancels the outage If power is restored after a period of 3 minutes: • OT waits for up to 7 minutes for the restore alerts • When a PRA is not received, OT marks the outage as confirmed and queues up the AD1 • AD1 is sent to DSP when the once a minute OT batch process picks it up. • 5,000 AD1s are sent to DSP spread over 1 minute. The total time from outage to delivery of final alerts to DSP is approximately 8 minutes. This cycle repeats for each outage. If 2 outages of 5,000 coincide then Telefónica will treat this as a single outage of 10,000. If half are restored within 3 minutes then no AD1 will be generated for these.	AD1s sent to DSP within 8mins 8F36s sent to DSP within 4mins

	Comment	Impact
ARQ	We can analyse this based on assuming the worst case where all 5000 CHs are within a single cell of the Arqiva system with 5% of the cell connected through buddy mode and no additional coverage provided by neighbouring sites. The CHs will begin sending POAs once the outage time reaches 3 minutes. Three alerts are transmitted from each CH dithered over a 45s, 240s and 240s window respectively. In the above scenario, statistically around 31% of alerts will be delivered within 5 minutes (2 minutes after the outage is confirmed). This will rise to around 86% of CHs alerts at the end of the third window a total of 11m 45s after the outage occurred (8m 45 after outage confirmation). Typically, an outage of this size would occur in a location where overlapping coverage from neighbouring sites is provided. With some overlapping coverage provided by a single additional site then the number of CHs expected to be received at 5m and 11m 45s would be around 52% and 94% respectively. This cycle repeats for each outage. If two outages of 5,000 coincide, Arqiva will treat this as a single outage of 10,000 where the performance for a worst-case single cell outage is described in question 22.	94% of AD1s sent to DSP in 11m45s
DSP	Under normal operating conditions, the DSP can process a maximum of 12,000 POAs per minute and 96,000 PRAs per minute. Six DSP enhancements have been proposed for increasing the throughput of POAs/PRAs.	Higher volumes of POAs

Solution options specified under "section 5 To Be Solution Options" address aspects of this, including the length time it takes for DNO to receive these alerts. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
TEF	TEF.3 – Network Evolution CH with supercapacitor	Faster AD1 delivery
ARQ	ARQ.2a – Increased alert channels	Faster AD1 delivery
DSP	DSP.1 - Provision of new shared Infrastructure DSP.2 - Prioritising POAs and PRAs over other northbound traffic DSP.3 - New dedicated resources for POAs and PRAs DSP.4 - Cloud-based Dedicated DNO POA/PRA resources DSP.5 – Prioritisation within POAs and PRAs by Postcode/Time DSP.6 - Prioritisation within POAs and PRAs by Canary indicators	Increased throughput of AD1s

Q27 How does the CSPs and DSP systems deal with an outage scenario of storm travelling South to North from Bristol to Glasgow affecting 100,000 MPAN's over 7 hours to include 20,000 simultaneous supply points in Birmingham, 15,000 in Manchester and 65,000 being a mix of High Voltage/Low Voltage in other cities, towns and villages. Can this be enhanced, how at what cost and timescale?

The largest single outage size quoted here is 20,000.

	Comment	Impact
TEF	When power is lost, 20,000 outage alerts are sent over 15 seconds. They are delivered to the Orchestration Tool (OT) within a few seconds at which point it holds these messages and awaits restore alerts. If power is restored within 3 minutes: • CHs that are not powered down send restore alerts randomised over 30 seconds • CHs that are powered down boot up and follow network attach procedure • OT waits for up to 7 minutes for the restore alerts • OT cancels the outage If power is restored after a period of 3 minutes: • OT waits for up to 7 minutes for the restore alerts • When a PRA is not received, OT marks the outage as confirmed and queues up the AD1 • AD1 is sent to DSP when the once a minute OT batch process picks it up. • 5,000 AD1s are sent to DSP spread over 1 minute. The total time from outage to delivery of final alerts to DSP is approximately 8 minutes. This cycle repeats for each outage. If 2 outages coincide then Telefónica will treat these as a single outage of the sum of both. Only when the total number of CHs affected exceeds 34,000 will throttling of power outage alerts take place.	AD1s sent to DSP within 11mins 8F36s sent to DSP within 4mins
ARQ	The performance for this size outage is as described in question 22. This cycle will repeat over the course of the outage. Where multiple outages occur at the same time, the current 5,000 per minute throttle to the DSP could be exceeded leading to delays in alerts being delivered to the DNOs.	94% of AD1s sent to DSP in 11m45s
DSP	Under normal operating conditions, the DSP can process a maximum of 12,000 POAs per minute and 96,000 PRAs per minute. Six DSP enhancements have been proposed for increasing the throughput of POAs/PRAs.	Higher volumes of POAs

Solution options specified under "section 5 To Be Solution Options" address aspects of this, including the length time it takes for DNO to receive these alerts. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
TEF	TEF.3 – Network Evolution CH with supercapacitor	Faster AD1 delivery
ARQ	ARQ.2a – Increased alert channels	Faster AD1 delivery
DSP	DSP.1 - Provision of new shared Infrastructure DSP.2 - Prioritising POAs and PRAs over other northbound traffic DSP.3 - New dedicated resources for POAs and PRAs DSP.4 - Cloud-based Dedicated DNO POA/PRA resources DSP.5 – Prioritisation within POAs and PRAs by Postcode/Time DSP.6 - Prioritisation within POAs and PRAs by Canary indicators	Increased throughput of AD1s

Q28 Are there any open defects with CHs that is causing issues with POA and PRA? What are they and what are the fix dates?

	Comment	Impact
TEF	There are no known open defects where the root cause has been specifically related to POAs/PRAs. Several incidents have been raised which require further investigation on CHs/ESMEs in specific premises.	n/a
ARQ	No open defects, however the problem with ESME messages being lost while the CH is still rebooting is under review. The missing data includes FW activation alerts from the ESME (outside the scope of this project) and power restore alerts from the ESMEs. A fix would involve a change to the way in which the ESME transmits the alert to introduce a similar retry strategy to that which already exists for messages going from the CH to other HAN devices. No fix date set.	n/a
DSP	There are no known open defects	n/a

The work planned under DCC PR1227 (related to testing of power alerts capability) may identify some issues which will need to be addressed.

Q29 Is the CSP DSP systems sized to meet the DCC obligation to deliver POA and PRA service to DNOs? If not, what is the size of the gap and where is the gap? Can this be enhanced, how at what cost and timescale?

For the service providers, the systems are sized to deliver a power outage service that will grow as the CH roll out increases. Please refer to “section 4 As Is System Overview” in the paper which provides details of the current service implementation. There are significant technical and financial barriers to meet the DCC obligation to the DNOs. Options as to how these can be met in part are provided in the paper. Please refer to "section 5 To Be Solution Options" for details.

Q30 What is the length of the dither within the Comms Hub which delays the POA and can it be reduced and by how much? At what costs? How long to implement?

	Comment	Impact
TEF	The current length of the dither within the CH is up to 2 minutes further covered in "section 4.2 Telefónica CSP System Overview". For options to reduce this, it is covered in "section 5 To Be Solution Options". Costs for these options will be supplied under separate documents along with this paper.	2mins
ARQ	A dither is used to randomise alert transmissions over the three alert windows. The shorter 45s window has been chosen to optimise delivery for smaller outages while the longer 240s windows are intended to improve performance for larger outages. There is no scope to change the alert windows.	4mins
DSP	n/a	n/a

Q31 Are there any infrastructure limitations with CSPs and DSP systems which delay POA and PRAs and volumes sent to DNOs? Can this be enhanced, how at what cost and timescale?

For Telefónica and Arqiva, the delivery of POAs and PRAs is reliant on the Radio Access Network as well as smart metering systems involved. For the DSP, the time taken to deliver messages at its end is very short and improvement options are available to increase the volumes of messages delivered in that duration.

The options offered in the paper provide ways of improving upon this service and some of the options are addressing infrastructure limitations, covered in "section 5 To Be Solution Options". Costs for these options will be supplied under separate documents along with this paper.

	Option	Impacted requirement
TEF	TEF.1 – Improvements in existing systems TEF.2 – Cloud based micro service	POA.1, POA.2, POA.5, GEN.1, GEN.2
ARQ	Options do not cover infrastructure	n/a
DSP	DSP.1 – Provision of new shared infrastructure DSP.3 – Provision of new DNO dedicated infrastructure	POA.1, POA.3, PRA.1,

Q32 What is the impact of 5G on POA PRA deliver in the future?

This is relevant for the Telefónica implementation only.

5G includes Ultra Reliable Low Latency solutions but these are designed for machine to machine (M2M) applications such as driverless robots and cars. For now, 5G is reliant on 4G for all connection control aspects so only offers increased bandwidth which is not of benefit to POA/PRA.

4G offers better control of attach rates during a power restore and offers the opportunity to redesign the deactivate/detach/attach/activate process in order to reduce the signalling load and increase the attach throughput of communication hubs. It may also provide opportunity for CH hardware changes that help identify confirmed power outages quicker.

Q33 How does the CSP/DSP systems operate in a Black Start scenario? What are the options to make improvements? At what costs?

Based on discussions with DCC and DNO representatives, catering for a nationwide/blackstart scenario would be a very complex and costly change on the CSP/DSP implementation for something that is relatively rare. Therefore, this paper is focused on dealing with outages up to the national grid transmission failure level which is described below:

Type of Incident	Customer Number affected (Typical)	Frequency of incident	Comments
National Grid Transmission System	1-200,000 customers	Average 9 per annum (3 to 16 typically per annum)	On average these incidents last 60mins but are very dependent on the circumstances. The average of 9 incidents per annum includes incidents affecting small numbers of very large industrial/commercial customers (i.e. some of these incidents do not affect domestic customers). On occasions the transmission system will experience very short interruptions (lasting a few seconds) which would result in simultaneous restorations of 1-200,000 customers. Such events are likely to be too short to be detected by the communications hub.

Based on the volumes of outages and restores that may occur with a black start scenario, there will be some power alert messages lost due to the network and system level protection mechanisms put in place by the service providers.

Q34 Are the environment that the CHs are deployed into behaving as predicted? If not can this be enhanced, how at what cost and timescale?

For Telefónica and Arqiva, there are currently no known environment issues.

Q35 Are the devices and network on which they operate behave as expected for POA and PRA processing? Can this be enhanced, how at what cost and timescale?

Using data provided by the DSP, a full review is currently underway of outage and restore alert processing with the aim to identify weaknesses in the processing of outages.

Q36 Are the operational assumption and parameters correct for POA and PRA processing? Can this be enhanced, how at what cost and timescale?

Using data provided by the DSP, a full review is currently underway of outage and restore alert processing with the aim to identify weaknesses in the processing of outages.

Q37 Can the throttling of alerts at the CSPs be changed to improve the timing of AD1s being sent to DNOs? What are the options and improvements likely? What would be the costs and timescale to make the changes?

	Comment	Impact
TEF	The implementation uses throttling for CH POAs and PORs to protect systems from a large outage alert storm. This is set at an outage size of 34,000. Without this throttle the entire TEF smart metering service could be at risk so it cannot be adjusted without additional capacity first being made available. A 2nd throttle between the CSP and DSP systems is set at 5000/minute to manage load on the DSP	5000/min
ARQ	A throttle between the CSP and DSP systems is set at 5000/minute to manage load on the DSP	5000/min
DSP	Options to increase the throughput can be found in section 5 “To Be Solutions Options”	

For all service providers, relaxing the throttle between the CSP and DSP systems would improve the throughput of large alert storms, which will result in more alerts being delivered to the DNO during the same length of time

Solution options specified under “section 5 Options” address aspects of this. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
TEF	TEF.1 – Improvements in existing systems TEF.2 – Cloud Based micro service	Increased throughput of AD1s

	Option	Impact
ARQ	ARQ.4 – Relaxed throttle between CSP and DSP	Increased throughput of AD1s
DSP	DSP.1 - Provision of new shared Infrastructure DSP.2 - Prioritising POAs and PRAs over other northbound traffic DSP.3 - New dedicated resources for POAs and PRAs DSP.4 - Cloud-based Dedicated DNO POA/PRA resources DSP.5 – Prioritisation within POAs and PRAs by Postcode/Time DSP.6 - Prioritisation within POAs and PRAs by Canary indicators	Increased throughput of AD1s

Q38 Do alerts get lost? What are the scenarios if alerts are lost and how can this be prevented? At what cost and timelines?

The current service provider systems will experience loss of messages due to planned outages for system maintenance.

	Comment	Impact
TEF	There are places where in theory alerts can get lost though analysis previously made does not suggest these are material. These are described in more detail in “section 4.2 Telefónica CSP System Overview”.	Not material
ARQ	AD1 alerts are sent without acknowledgement. It is possible that all three alerts are not received by any site and the alert is lost. Messages lost due to buddy mode are described in question 4. ESME generated meter alerts are currently lost for some ESME manufacturers. Testing as part of PR1227 will identify these meters	Small losses possible
DSP	POAs/PRAs are currently lost during DSP planned and unplanned outages. Planned outages typically last for 4 hours.	Losses during planned / unplanned outages

Options to address these issues are covered in “section 5 To Be Solution Options”. Costs for these options will be supplied under separate documents along with this paper.

	Option	Impact
TEF	TEF.1 – Improvements in existing systems	More reliable alert handling
ARQ	ARQ.5 – Buffering alerts at the CSP-DSP gateway	More reliable alert handling

	Option	Impact
DSP	DSP.8 - DSP Buffer for Planned Outages	Prevents loss of POAs/PRAs during DSP planned outages

Q39 Are there scenarios where DNOs get 8F36 but don't get an AD1? If yes what is the cause of this and what is the fix and timescale?

Using data provided by the DSP a full review is currently underway of outage and restore alert processing with the aim to identify weaknesses in the processing of outages.

	Comment	Impact
TEF	A known scenario where this may occur is for an outage impacting more than 34,000 Communication Hubs. A cellular access issue could also cause this for Toshiba communication hubs. (See section 4.2.1 Unhappy Path Scenarios) Note a review of outage alert processing is also taking place.	Extremely large outage
ARQ	As described in question 38, it is possible that the AD1 alert is lost. The 8F36 alert follows a retry process and its delivery is therefore more reliable. Typically for small to medium sized outages the number of lost AD1s will be minimal. For larger outages the chance of losing the AD1 is increased and is described in the scenario in question 22. Solution options to improve message throughput would reduce the number of AD1 which are lost due to over the air collision of messages. This is covered in "section 5 To Be Solution Options". Costs for these options will be supplied under separate documents along with this paper.	More likely for larger outages
DSP	No losses expected in normal operation	No losses expected

Q40 The DNOs' expectation is that all outage alerts will be delivered as had previously been agreed with DCC and CSPs at industry meetings during 2013/14. The CSPs and DCC agreed to provide all alerts because CSPs would otherwise struggle to differentiate between different DNO network incidents therefore not being able to cap the maximum number of alerts per incident (i.e. 50) as set out in the service level details contained in their respective contracts. Furthermore, DNOs were never consulted on the final alert volume cap for the service levels and would never have agreed to a cap of 50 if they had been consulted. How can this expectation be met?

Duplicate of Q14

Q41 Previously via workshops it was discussed that a series of realignment steps which DCC and Telefónica believe will provide

adequate support to DNOs business case fulfilment which included work on Dithered Network Attach, Rollout dependant Dither improvement and Dither Zeroed set by Incident/SR. What is status of these realignment steps?

A full review of the network re-attach timer or dither has been performed as part of PR1226. Details of this are in "section 5.1.1 Telefónica CSP Implementation Option Descriptions". This has established that it is not viable to reduce the Telefónica dither time.

Q42 Previously there was discussions on increasing the Telefónica core network infrastructure, adding more SGSNs, GGSNs and HLRs may improve performance of alerts is this still a viable option?

A full review of the network re-attach timer or dither has been performed as part of PR1226 and investigates what infrastructure changes are required to achieve this. Details of this are in "section 5.1.1 Telefónica CSP Implementation Option Descriptions". This has established that it is not viable to reduce the Telefónica dither time.

The dither time was originally set at 10 minutes and the reduction to 2 minutes was a temporary concession at the start of roll out. This has been covered in the reference document "**Power Alerts Project Briefing Paper [R2]**".

Q43 Previously Arqiva presented eight enhancement options that could increase the throughput of Power Outage and Restoration alerts through the Arqiva SMWAN. These options are presented in an order whereby they build consecutively on the previous stages. These were,

1. Modifications to the RTS time windows.

2. The addition of a second RTS channel

3. The addition of a second Alarm channel

4. The addition of a further two RTS channels (total of four).

5. The addition of a further two Alarm channels (total of four).

6. Mixed modulation schemes on the RTS and Alarm.

7. Higher bandwidth RTS and Alarm channels. 8 Additional sites to reduce maximum Comms Hub density (across entire network).

Are any of these still options and at what costs and timescales?

The above options were initially suggested significantly earlier in the project and not all of them are still applicable.
Option 1 was implemented to improve the throughput of request to send (RTS) messages. This has already improved the 8F35 and 8F36 delivery timescales in larger outages.
Options 2 and 3 are covered in the solution options under "section 5.1.2 Arqiva CSP Implementation Option Descriptions". Costs for these options will be supplied under separate documents along with this paper.

Option 4 is now removed, the current RTS channel capacity is well above what can be supported on the traffic channel in each cell so no further benefit can be realised.

Option 5 is an extension of option 3 and would be preferable particularly in conjunction with the reinstating of CH power restoration alerts.

Options 6, 7 and 8 are withdrawn.

7 Enhancements Plan

Based on the integrated planning sessions, the following timelines have been identified for each option, starting from the point in which CAN approval is issued and only through to PIT Exit:

7.1 Telefónica Indicative Delivery Timeline Overview

Based on the indicative Delivery Planning, the following timeframe for the introduction of the identified enhancement options by Telefónica is proposed:

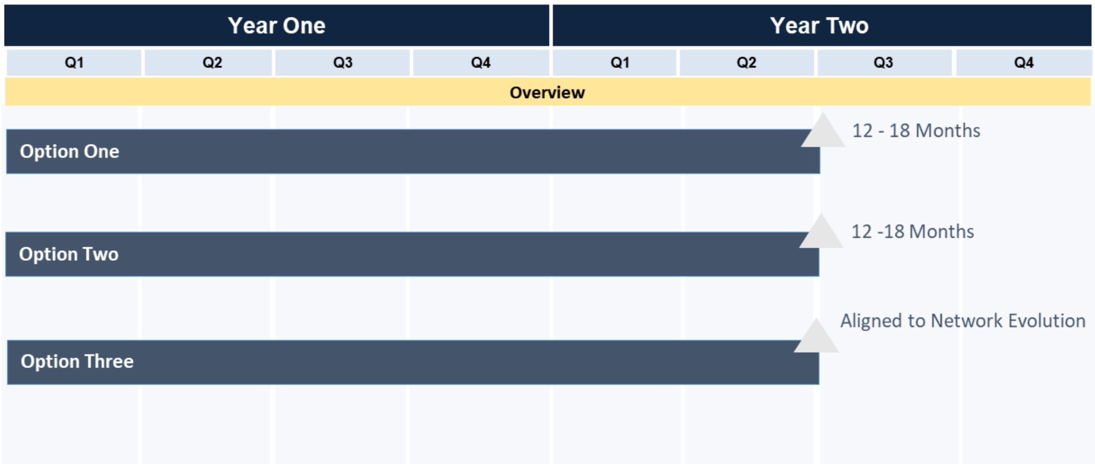


Figure 19 Telefónica Indicative Delivery Timelines

Please note that:

- On the basis that Option Four is not viable, no timeline is provided
- This timeline is up to the forecasted up to PIT exit

Telefónica	Indicative Delivery Timeline
1. Existing IT System Enhancements	12 – 18 months
2. Cloud Based Micro Service	12 – 18 months
3. Network Evolution CH with Super-Capacitor	Aligned to Network Evolution
4. Current CH Small Change & Network Capacity Uplift	Not Applicable

Table 23 Telefónica Indicative Delivery Timeframe

7.2 Arqiva Indicative Delivery Timeline Overview

Based on the indicative Delivery Planning, the following timeframe for the introduction of the identified enhancement options by Arqiva is proposed:

Figure 20 Arqiva Indicative Delivery Timelines

Arqiva	Indicative Delivery Timeline
1. Reinstate CH PRA	1 – 3 months
2a. Additional Channels (Alert Channel)	3 - 12 Months
2b. Additional Channels (Bulk Channel)	3 - 12 Months
3. Improved Backhaul Resilience	3 - 12 Months
4. Increase 5k / min Throttle	3 - 12 Months
5. Buffer at CSP - DSP Gateway	12 months +
6. De-duplicate at CSP - DSP Gateway	12 months +

Table 24 Arqiva Indicative Delivery Timeframe

7.3 CGI Indicative Delivery Timeline Overview

Based on the indicative Delivery Planning, the following timeframe for the introduction of the identified enhancement options by CGI is proposed:

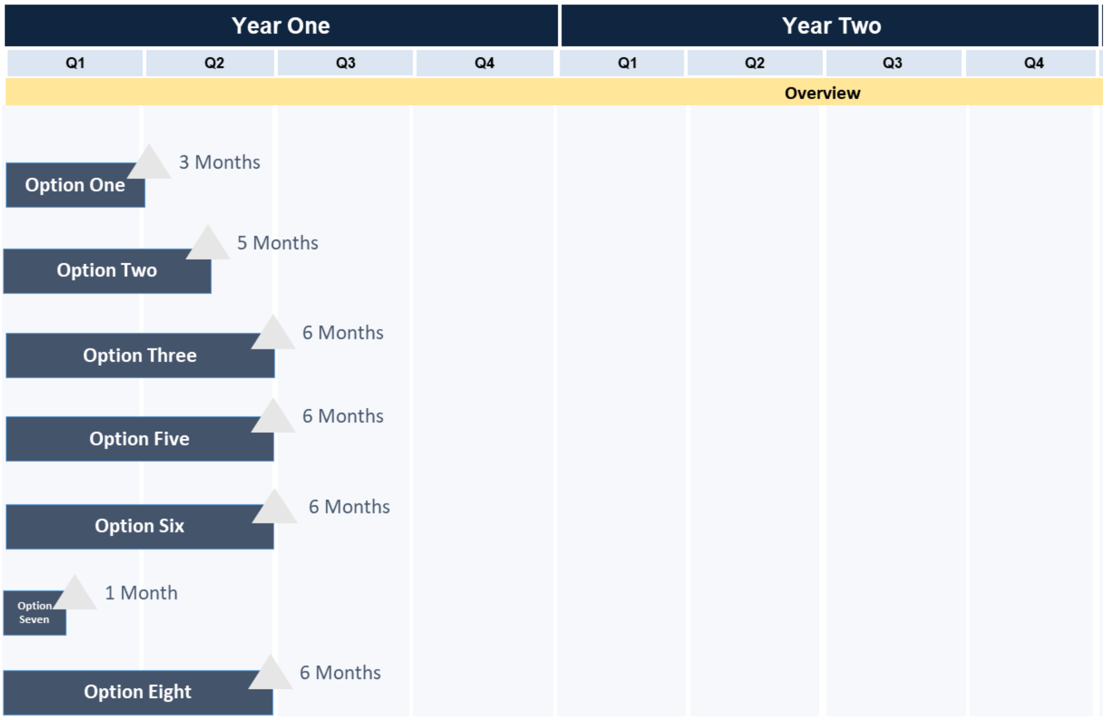


Figure 21 CGI Indicative Delivery Timelines

CGI	Indicative Delivery Timeline
1. General Uplift	3 months
2. Message Type Prioritisation	5 months
3. Dedicated Resilient MWL	6 months
4. Dedicated MWL (cloud)	Not Provided
5. Geographic/Time Prioritisation	6 months
6. “Canary”	6 months
7a/7b. PRA Northbound Traffic Management	1 months
8. DSP Buffer for Planned Outages	6 months

Table 25 CGI Indicative Delivery Timeframe

The timescales provided are approximate and for PIT-complete only. For the avoidance of doubt, the timescales exclude time to develop a Full Impact Assessment, subsequent commercial agreement and all post PIT phases (SIT, UIT and Transition to operations activities). These timescales are based on the changes being implemented independently.

Where a number of changes are aggregated into a single release, the period to implement all changes may change the overall implementation time to PIT complete. Further, Production deployment timescales may need to be aligned to a maintenance release.

However, considering the current DCC DNO Programme Plan to issue the CAN for Project D in December 2020, which is believed to be the agreed vehicle to introduce any agreed solution enhancement – there may be an opportunity to launch these as part of any planned November 2021, June 2022 and November 2022 major releases.

As part of ‘Project D’, it is suggested that investment into the DNO solution’s is considered to process any expected increase of volume of data based on the DCC Rollout Forecast

8 RAID

The following RAID items have been identified as part of the creation of this Technical Paper

8.1 Assumptions

The following assumptions have been made and should any assumption prove to be incorrect or invalid, Telefónica reserves the right to revaluate the Technical Paper. The table below contains a summary of the assumptions:

Reference	Assumption	Status
A-001	Any Solution Option, ROM Costs and Delivery Timescales provided are indicative and are subject to a DCC CR being raised to enable a full Impact Assessment to take place	Open
A-002	Outage Scenario specific assumptions relating to Network Topography and Cell loading are valid	Open
A-003	There are SMETS 1 meters already deployed, reducing potential SMETS 2 install levels in a given cell.	Open
A-004	Arqiva assume that 5% of Install base are communicating in Buddy mode.	Open
A-005	Maximum loading per traffic channel of 2,500 CHs	Open
A-006	Background / rest of network message throughput level, during large outages, is not accounted for in the modelled performance	Open
A-007	Outage Scenario specific assumptions relating to Macro diversity levels for the affected CHs are valid	Open
A-008	Arqiva assumes that there is maximum loading per cell of 10,000 CH’s	Open
A-009	Arqiva & Telefónica assumes there is no change to current SLAs	Open
A-010	The seven DNO requirements are based on SEC modification request DP096	Open
A-011	When calculating DSP capacity in relation to the DNO scenarios, it is assumed that simultaneous outages and simultaneous restorations do not happen concurrently.	Open

Reference	Assumption	Status
A-012	The definition of “simultaneous” in the context of a simultaneous outage/restoration of properties means POAs/PRAs received over the course of a minute.	Open
A-013	When calculating DSP capacity, the number of properties involved in DNO scenarios has been reduced by 10% to allow for the present of SMETS1 Installations. A 10% reduction has been used in preference to a 33% reduction (reflecting the national proportion of SMETS1 Installations) to allow for concentrations of SMETS2 Installations.	Open
A-014	DSP capacities quoted and used in determining DSP response against the DNO scenarios assumes normal operating conditions (i.e. no DSP outages at the time the scenario occurred).	Open
A-015	It is not possible to estimate the percentage of 3-phase SMETS2 ESMEs from data held within the DSP so scenario forecasts have not taken into account the additional PRAs that a 3-phase SMETS2 ESME could generate (i.e. one per lost phase). Any estimate of the percentage of Profile Class 1 to 4 MPANs with 3-phase connections that the DNOs could provide will be incorporated in future forecasting.	Open

8.2 Dependencies

Telefónica has identified the following dependencies in producing this Technical Paper:

Reference	Org	Dependency	Implication if dependency is not met	Status
D-001	TEF	Telefónica wish to highlight our continued compliance with the existing Performance Measures (PMs) relating to Power Outages contained in Schedule 2.2 of our Agreement with DCC.	However, in the event that the DCC wishes to introduce or amend the existing PMs relating to Power Outages as part of proceeding with one or more of the Delivery Options contained within this Technical Paper, the new PMs would need to be mutually agreed by both parties via an approved Impact Assessment and the production of a Contract Authorisation Notice (CAN).	Open
D-002	TEF ARQ	PR1227 identifies and removes issues with ESME generated alerts being lost.	The Power Restoration Alert Performance quoted in the report is no longer valid.	Open
D-002	TEF ARQ	Reducing alert throttling requires DSP collaboration.	Arqiva would not be able to relax the throttle, therefore slower Alert delivery for large Outages.	Open
D-003	TEF ARQ CGI	Performance Testing will be required for any of the agreed solution enhancements	To validate any of the proposed timing benefits	Open
D-004	TEF ARQ CGI	The planned testing under PR1227 is needed to test the pre-agreed CHs and ESME combinations to prove AD1, 8F35 and 8F36 alert behaviour (including OTA firmware upgrade impact on alerts).	To identify defects with either CHs or ESMEs and fix and retest, plus test and identify root cause of why DNOs can't communicate with ESMEs	Open

8.3 Risks

The Technical Paper has identified the following risks:

Reference	Org	Risk	Status
R-001	ARQ	As a direct consequence of Government Guidance and Statute relating to the COVID-19 pandemic, there may be an impact on timescales. ASML will take all reasonable steps to mitigate the impact that restrictions on movement and social distancing might have on the programme. If delay is anticipated, ASML will work with DCC to reach a commercial agreement as to the treatment of any such delays under the Agreement.	Open
R-002	TEF ARQ	For very large outage scenarios such as black start, the system will inevitably be overloaded and performance at these levels cannot be guaranteed to fit with modelling	Open
R-003	ARQ	Unavailability of spectrum to purchase and deploy additional channels.	Open
R-004	TEF ARQ	Performance for alert delivery based on modelling only.	Open
R-005	TEF	The current network re-attach timer (or dither) was reduced from 10 minutes to 2 minutes on a temporary basis during the first 2 years of roll out. Periodic reviews will assess the impact this has on the Telefónica radio network and may result in the timer being increased backup from the current 2 minutes.	Open

8.4 Issues

The Technical Paper has identified the following potential issues to delivery of the solution described in the CR:

Reference	Description	Status
I-001	Telefónica Option Four (Firmware and Network Infrastructure Updates) has been included for completeness, but this is not a viable option that can be taken forward under Project D	Open
I-002	Known issue with some meter manufacturers where ESME generated alerts are lost before reaching the CH.	Open

Reference	Description	Status
I-003	TK backspool issue leading to significantly delayed alerts – patch now rolled out to all TKs. This Issue has been patched since the Data used in this paper was produced, and is no longer relevant from an Arqiva perspective	Open
I-004	There is a known issue with a small number of ESMEs generating very large volumes of spurious 8F35s and 8F36s. The DSP has proposed an enhancement (DSP Option 7) to help address this.	Open

9 Commercial Information (confidential documentation provided separately)

The commercial response with regards to any estimated costing has been provided separately.

The key points related to the commercial response from a Telefónica perspective can be found below:

- The ROMs supplied under separate cover are indicative and should not be construed to represent a formal quote for delivery. As such, the ROMs do not represent formal offers which are capable of acceptance.
- In the event that the DCC elects to proceed with one or more of the Solution Options, then Telefónica require a separate commercial vehicle in the form of a Change Request to underpin their delivery. Prior to the mobilisation of Telefónica resources, advance commercial cover in the form of a DCC Purchase Order is required.
- Please note the ROMs submitted separately in conjunction with this Technical Paper shall remain valid for a period of 45 calendar days from the date of the Technical Paper submission to the DCC.
- Telefónica's ROM pricing is quoted in pound sterling and is exclusive of VAT, with exception to the Network Evolution CH with Super capacitor option (which is quoted in US dollars),

Note: CGI and Arqiva will supply commercial related terms and conditions alongside their ROM costs.

10 Next Steps

The next steps are:

Present Paper to ENA/BEIS/DNOs: 14th August 2020.

DNOs consultation: 14th August 2020 to 30th September 2020.

Presentation to TABSAC: Date to be confirmed.

Agree Project D scope: 16th October 2020

11 Glossary

Acronym	Definition	Meaning
8F35		Power restore message from the electric meter (8F35 is the GBCS message code). This is generated regardless of the duration of the power outage.
8F36		Power restore message from the electric meter where the restore occurs more than 3 minutes from the outage (8F36 is the GBCS message code)
Access Gateway		Security gateway which manages interactions with the DSP gateway
AD1		Confirmed power outage message greater than 3 minutes. This is based on power outage messages from the CH rather than meter outage messages.
API	Application Programme Interface	System interface which defines interactions between multiple software intermediaries.
ARQ-DSP Gateway		Message gateway between Arqiva and DSP systems
BEIS	Department for Business, Energy & Industrial Strategy	
BSC	Base Station Controller	Provides radio access network resource management
BTS	Base Transceiver Station	Equipment that facilitates wireless communication between user equipment and a network
CDMA	Code-Division Multiple Access	A channel access method used by various radio communication technologies
CH	Communications Hub (or Comms. Hub)	Device to handle communications between smart meters and service providers (note most of this document will refer to CH as Communications Hub)
CH	Communications Handler (or Comms. Handler)	DSP component that manages the queue for message processing (note most of this document will refer to CH as Communications Hub unless specifically referring to the DSP component system)
CSP	Communication Service Provider	These cover Telefónica and Arqiva

Acronym	Definition	Meaning
DCC User Interface		Demarcation point between DSP and DCC
DNO	Distribution Network Operator	Organisation that is responsible for the distribution of electricity from the national transmission grid to premises
DNS APN	Domain Name System Access Point Name	Address of the DNS
DSL	Digital Subscriber Line	Method of data transmission over fixed line
DSP	Data Service Provider	This covers CGI
EIS	Electricity Import Supplier	
ENA	Electricity Network Association	
ENO	Electricity Network Operator	
EPG	Evolved Packet Gateway	Also known as Gateway GPRS Support Node (GGSN). Facilitates network transmission of CH data
ESME	Electric Smart Metering Equipment	Electricity smart meter
GBCS	Great Britain Companion Specification	Describes the detailed requirements for communications between Smart Metering Devices and DCC
GIS	Gas Import Supplier	
GNO	Gas Network Operator	
GSM	Global System for Mobile communication	Digital mobile network
GUID	Globally Unique Identifier	Usually used to refer to the unique identifier of the communications hub
HAN	Home Area Network	Allows for connectivity between the communications hub and other devices such as smart meters, handheld devices, etc.
HLR	Home Location Register	Supports reconnection of CHs
HTTP	Hypertext Transfer Protocol	Application-layer protocol for transmitting documents, such as HTML
IMSI	International Mobile Subscriber Identity	A unique number identifying a GSM subscriber
IS-STP	IP Signalling Transfer Point	Network aggregation point
Load Balancer		Manages the data load of inbound messages (sometimes referred to as F5)
LSB	Least Significant Byte	Smallest byte. In this paper it refers to the smallest byte of the CH GUID to determine when the CH can attach to the network
LTE	Long Term Evolution	Commonly used to refer to 4G

Acronym	Definition	Meaning
MG	Message Gateway	Responsible for delivering messages to Users
MME	Mobility Management Entity	Also known as Serving GPRS Support Node (SGSN). This manages the network sessions of the CHs
ORD	Out of Range Device	Device is out of range and cannot transmit messages
OT	Orchestration Tool	TEF Orchestration System. Determines confirmed power outage messages and generates the AD1 message
PDN	Packet Data Network	A network that provides data services. Packet switching is a mode of data transmission in which a message is broken into a number of parts that are sent independently, over whatever route is optimum for each packet, and reassembled at the destination
PM	Performance Measure	Reports supplied by service providers to indicate levels of service
POA	Power Outage Alert	These are power outage alerts from both the meters and the communications hubs when there is a loss of power
PRA	Power Restore Alerts	These are power restore alerts from both the meters and the communications hubs when mains power is restored
RAID	Risks, Assumptions, Issues, Dependencies	
RAN	Radio Access Network	Communications network used for 2G/3G
RM	Request Manager	Handles business logic, validation, post-processing requirements
RNC	Radio Network Controller	Radio resource management
RNI	Regional Network Interface	Gathers and processes network data. Consists of network controllers and supporting systems such as monitoring components
RTS	Request To Send	Message alert from the communications hub to the regional network interface to indicate a message is waiting to be collected

Acronym	Definition	Meaning
SEC	Smart Energy Code	Agreement which defines the rights and obligations of energy suppliers, network operators and other relevant parties involved in the end to end management of smart metering in Great Britain
SLA	Service Level Agreement	Agreement between parties on the level of service agreed to be provided
SM2M DMM	Smart Machine to Machine Device Monitoring and Management	TEF system to manage CH communications. Will process power alerts and pass on to Orchestration system
SME	Subject Matter Expert	
SMETS	Smart Meter Equipment Technical Specifications	Industry specification for smart meters
SMWAN	Service Management Wide Area Network	Network to facilitate data transfer between CSPs and DSP
SP	Service Provider	Covers CGI, Arqiva and Telefónica
TEF-DSP Gateway		Message gateway between Telefónica and DSP systems
TK	Transceiver Kit	Base station which facilitates communication from the CH to the rest of the network
TPM	Transactions per minute	Number of transactions/messages a system can process in a minute
TPS	Transactions per second	Number of transactions/messages a system can process in a second
UDP	User Datagram Protocol	Communications protocol that is primarily used for establishing low-latency and loss-tolerating connections between applications
UL	Uplink	Message transfer up to the network
UMTS	Universal Mobile Telecommunications Service	3rd generation mobile cellular system based on GSM
URL	Uniform Resource Locator	Web address
UTRAN	UMTS Terrestrial Radio Access Network	Radio access network to support 3G
WCDMA	Wideband Code Division Multiple Access	A 3G standard
WNC	Wistron NeWeb Corporation	Supplier of CHs for the CSP Central and South regions

12 Appendix A – Power Alert Data Analysis

This section provides some analysis of POA/PRA data by the service providers based on data supplied by the DSP for the week of 9th-15th June 2020.

The information covered indicates volumes of 8F35, 8F36 and AD1 messages processed by the service providers and sent across to DNOs with some performance data. It also shows some mismatches in volumes of 8F36 messages and AD1 messages which in most cases should be aligned and various combinations of 8F35, 8F36 and AD1 which show unexpected behaviour.

A deeper dive analysis was conducted by the CSPs based on the data for one particular day in this range (14th June 2020) in which findings are reported below. It does indicate that further analysis is required on POAs and PRAs and any findings from DCC CR1349 (POA/PRA reporting capability) and DCC PR1227 (POA/PRA E2E testing) will supply further information to help aid the analysis overall. The consolidated data from these various activities will support in determining the root cause of the mismatches in alerts experienced by the DNOs so that specific issues can be addressed.

12.1 Key findings

The key findings from this analysis are as follows:

- Typical 'background' POA/PRA volume over this period was ~4,000 POAs/PRAs per hour
- Over 80% of POAs/PRAs were 8F35s
- The ratio of received 8F35s to 8F36s suggests that the ratio of outages of <3 minutes to those of >3 minutes is ~16:1
- PRAs from SMETS1 Devices accounted for 0.1% of total PRAs and were attributable to a single ESME model/firmware combination
- 10-20% of PRAs come from 0.1% of ESMEs generating in excess of 100 Alerts per day
- Average processing DSP processing times for POAs/PRAs was <0.02 seconds with DSP SLAs being met 99.99% of the time
- 5% of POAs received from Arqiva take more than 12 minutes to arrive, 3% taking more than 7 days.

The combinations of POAs/PRAs associated to individual MPxNs on any given day is difficult to explain (e.g. significant volumes of solitary AD1s, very low volumes of AD1/8F35/8F36 combinations)

12.2 PRA/POA volumes for 9-15 June 2020

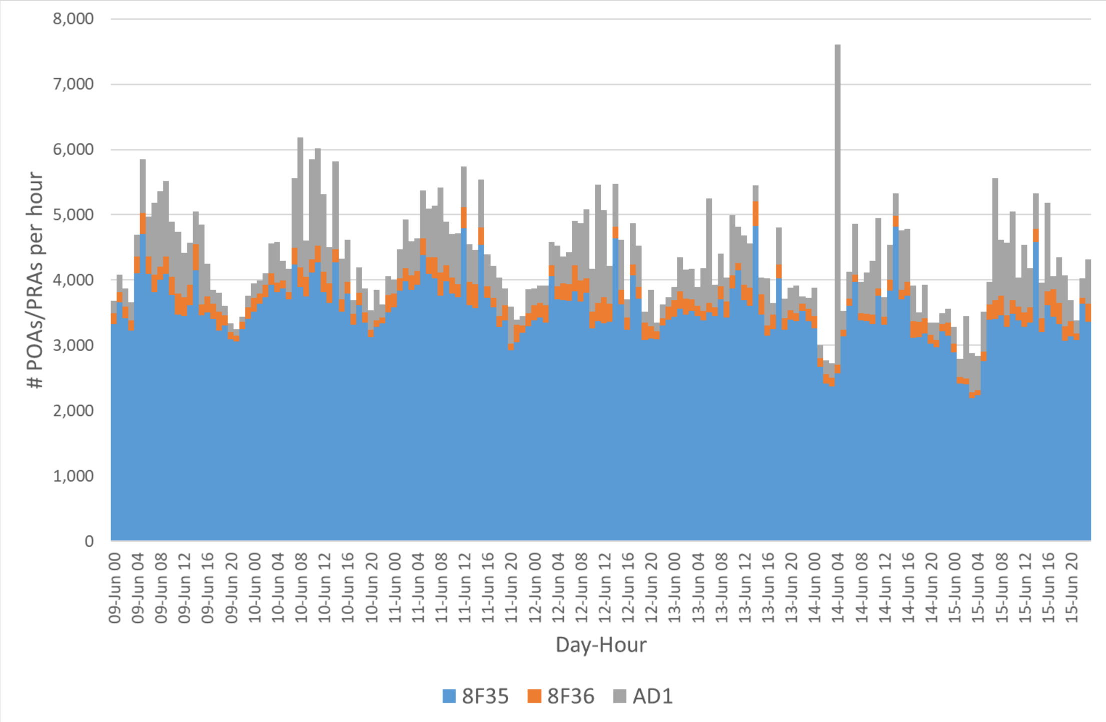


Figure 22 Hourly Volumes for 9th-15th June 2020

This graph shows the hourly volumes of POAs (AD1s) produced and PRAs (8F35s and 8F36s) received over the period 09 June 2020 to 15 June 2020. There were 707,367 POAs/PRAs logged during that period. Note that DSP typically generates four AD1s for each >3min outage notification as AD1s need to be sent to both Supplier and Network Operator for both gas and electricity (in the case of a dual fuel site). The spike in AD1s shown at ~04:00 on 14 June may be due to an ESME firmware activation since there is no associated spike in 8F36s.

12.3 DSP PRA/POA Processing Time

Alert Type	Average DSP processing time (secs)
8F35	0.025
8F36	0.025
AD1	0.288[48]

Table 26 DSP PRA/POA Processing Time

[48] This figure has been produced by adding an estimate to logged times in order to produce a representative figure for DSP processing time. The calculated average time from the Service Audit Trail is 0.009s; however, that is the SLA time, which for a DCC Alert starts from the generation of the Alert, so it does not take into account the full DSP processing time starting from receiving the CSP AD1. Although that is not ordinarily recorded, a small sample of AD1 processing was examined in more detail in order to produce an estimate of the additional processing time within DSP; this produced an average of 0.279s for adding to the defined SLA time measurement.

Alert Type	Pass	Fail	% Pass	% Fail
8F35	595,455	61	99.990%	0.010%
8F36	34,697	3	99.991%	0.009%
AD1	77,149	2	99.997%	0.003%
Total/Avg	707,301	66	99.991%	0.009%

Table 27 DSP Pass/Fail Rate by Alert Type

The tables above indicate the DSP processing times for the PRAs logged between 09 June 2020 and 15 June 2020 and SLA times for POAs. The average SLA pass rate was 99.991%.

12.4 ENO Retries

The charts below show delivery attempts made to the DNOs over this period.

The graph below shows the total number of POAs/PRAs sent to each DNO, the colours indicate the number of retries required in the delivery. The blue colour at the left of the bar denotes a single attempt with each subsequent colour representing a different number of re-tries up to the maximum of 96 (show as pale green at the far right of the bar). DNO2 can be seen to require extensive retries but significant retries can also be seen for DNOs 5, 11, 12, 13 and 14.

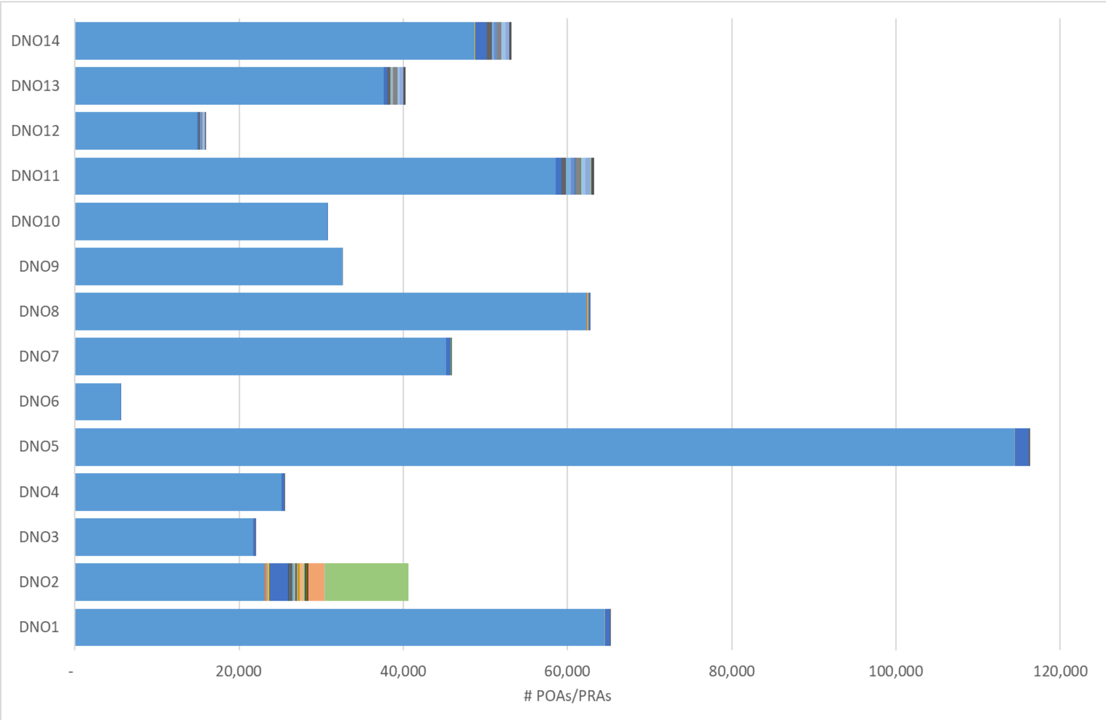


Figure 23 POA/PRA delivery attempts by DNO

The graph below shows the total number of POAs/PRAs sent to each DNO, the colours indicating whether delivery was successful or not. Blue denotes success, orange denotes failure. There is an appreciable failure rate in delivery of POAs/PRAs to DNO2. All other DNOs experienced no failures (though several retries) other than DNO11 which also experienced some failures.

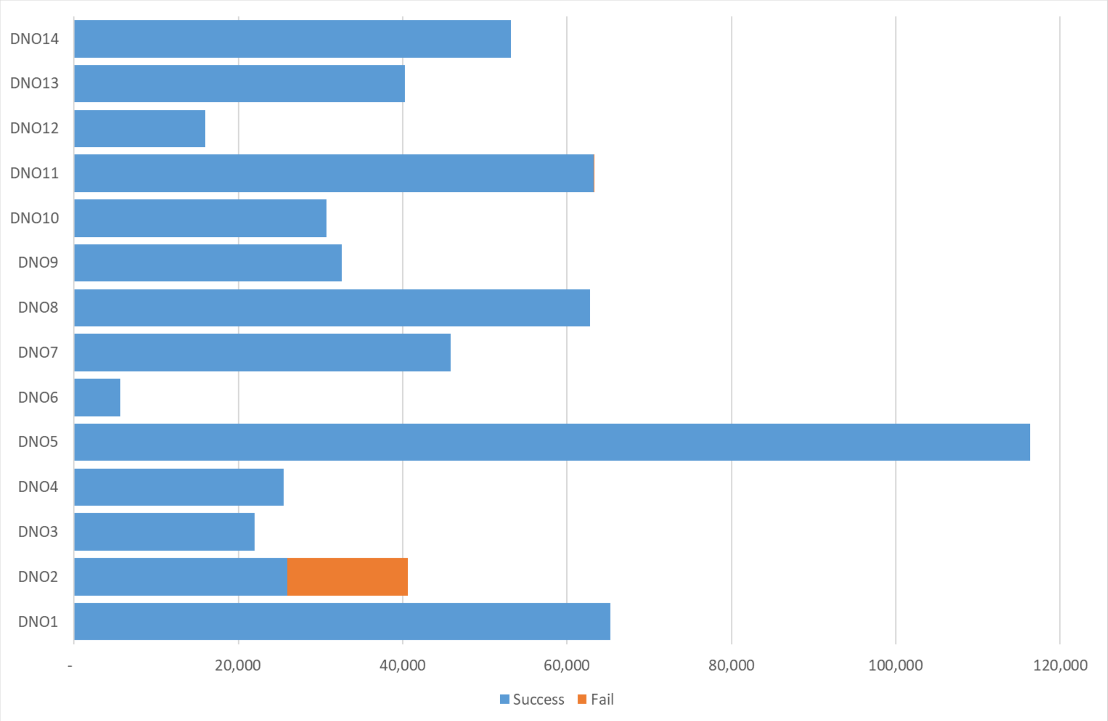


Figure 24 POA/PRA delivery successes by DNO

12.5 % POA/PRA of Total Message Volume

The graph below shows the number of POAs/PRAs as a percentage of all messages sent/received over the 7 day analysis period, broken down by CSP. It shows that a small percentage of PRAs (8F35s) come from the S1SP SMETS1 estate. However, these are attributable to 650 Devices sharing a single Model-Firmware combination (56780201-3465317). The POAs/PRAs attributable to the 'blank' CSP are likely to be due to Comms Hubs which have been incorrectly de-commissioned (i.e. are not market as 'commissioned' in the DSP but are still generating Alerts on the network.

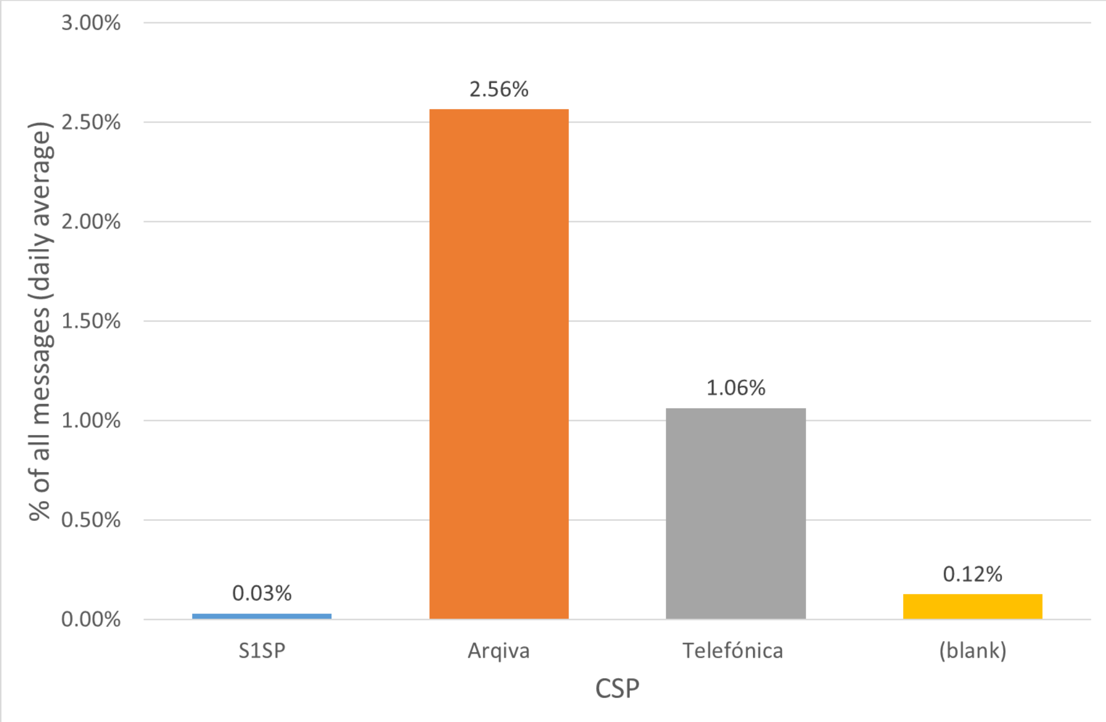


Figure 25 Volumes of Alerts by CSP

12.6 Spurious POAs/PRAs

This graph shows the impact of applying SECMP0062 to POAs/PRAs. The bars on the left show the number of MPxNs generating, on average, <20 POAs/PRAs per day and the number of POAs/PRAs these MPxNs generated. The bars of the right show the same thing for MPxNs generating, on average, >=20 POAs/PRAs per day.

This shows that a very small number of Devices (0.1% of those generating POAs/PRAs over the analysis period) are responsible for a significant volume (15%) of all POAs/PRAs generated over the same period.

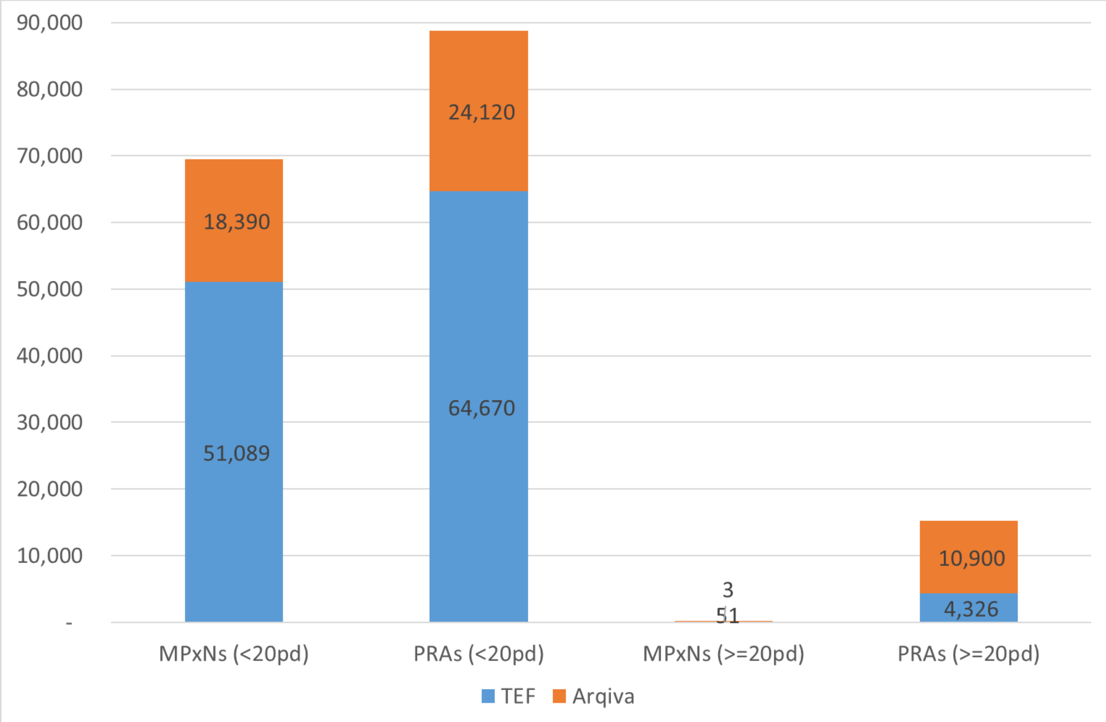


Figure 26 Volume of Spurious POAs/PRAs

From the above graph:

- 74,514 MPxNs generating <20 POAs/PRAs are responsible for 88,790 POAs/PRAs
- 54 MPxNs generating >20 POAs/PRAs per day are responsible for 15,226 POAs/PRAs
- The majority (88%) of these are 8F35s
- 0.1% of MPxNs are responsible for 15% of POAs/PRAs
- One particular ESME (MPAN = 2333350596013) is generating an average of 10,832 8F35s per day

12.7 Alert Type combinations – Telefónica CSP

This graph shows a breakdown of MPxNs for the Telefónica regions based on the daily average combination of POAs/PRAs generated for each MPxN.

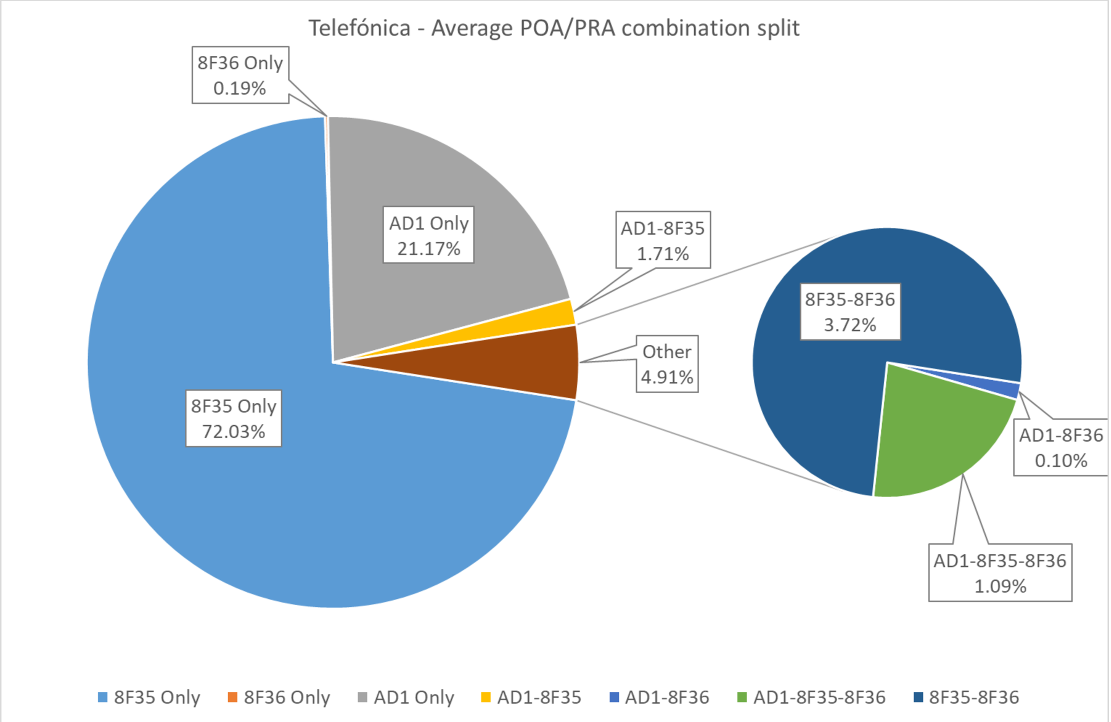


Figure 27 Telefónica POA/PRA Combination Split

Key points from the graph above are the following:

- 72% of MPANs generate a solitary 8F35
- For outages of 3 minutes duration or more that occur and complete within the same day, the expectation would be to see one 8F35, one 8F36 and two AD1s for a single fuel site and one 8F35, one 8F36 and four AD1s for a dual fuel site. This is based on a BEIS clarification of interpretation of SMETS which stipulated that restoration if an outage of >3 mins should result in the generation of an 8F35 <u>and</u> an 8F36 and the fact that the DSP informs both the primary Supplier and Network Operator of outages of >3 mins duration for both gas and electricity (i.e. resulting in two AD1s per affected fuel).
- 21% of MPANs generate a solitary AD1. This may be attributable to firmware updates to ESMEs which reboot during firmware activation, thus causing the CH to trigger an AD1 in the absence of an 8F35 or 8F36. This needs to be verified by more analysis of the Model-Firmware combinations of affected ESMEs and their receipt of SRV11.3s during the day of the outage. Another contributory factor could be gas only SMETS2 Installations. Initial analysis of the currently deployed SMETS2 estate indicates that gas only SMETS2 Installations account for ~5% of SMETS2 Installations.

12.7.1 Telefónica CSP Analysis

Overview

Based on the Telefónica analysis conducted with provided DSP data, the initial findings have identified two problem areas with sets that are causing a high number of outages:

- CSP figures indicate a higher number of sets in non-normal operating conditions (($\geq$ 20 POA per day) when compared to DSP figures (134 units in TEF analysis vs 51 units in DSP average)
- 17% of AD1 alerts generated are sourced from installations in Non normal operating conditions

As a priority, it is recommended that the impacted individual sets are subject to a site visit which is conducted to introduce a correction.

Further analysis was also conducted into the normalized sample in order to identify structural root causes. This has pointed to an un-matching number of meter alerts vs CSP originated/recorded alerts:

- 94.6% of normalized sample have no 8F36 alert.
- 80.7% of normalized sample have no 8F35 alert.

Due to the sum aggregation applied to the data, an additional check was performed on single long power outages present in the normalized sample that points to a very low rate of what can be considered E2E success on power outage alert management:

- Only 3.2% of sets in a normalized sample with a single long power outage on 14th June do present a correspondent 8F35 and 8F36 as expected

Telefónica has summarized the possible root causes, however, from the available data it is not possible to deep dive on each of the specific root causes. Although, based on available data to prioritize problems, it is suggested that:

- Priority 1: unmatched alerts may be due to meter inability to send the alerts or power outage not occurring in premise (80% best success rate of meter alert delivery to DSP in normalized sample)
- Priority 2: AD1 alerts may be false positives

Known Problem Records

The following next steps are suggested:

- Improvement on problem management/problem framework and alignment on data captures as incidents occur (DNO > DSP > CSP)
- AD1 reliability is dependent on how accurate DMM Power Outage Alerts and Power Outage Restores are so additional and independent work on 8F35 and 8F36 against DMM outage/restore is needed with access to timestamps in payloads of these alerts

- Future work on data analysis not only needs a more comprehensive data set not only in term of quality of data, but also duration. A single day in analysis may not be representative
- To undertake testing as part of PR1227 that will provide further insights from the planned testing.

In advance of this paper being produced, the following Problem Records were known:

- PBI000008989186 - POA Alerts (WFL 180 db table fragmentation issue)
  - No impact to DNO
  - TEF Power Outage Alert may not be stored in CHDB when table fragmentation issue occurs (low probability)
- PBI000009010789 - Difference between received Power Outage messages and SNMP traps
  - There is a rare likelihood of occurrence on:
    - Missed AD1 when not processing power outage alert
    - False Positives when not processing power restore alert
  - This was only linked into 1 Incident – TEF INC INC000004068628

These are already being proactively addressed.

There are other open incidents:

Incidents	Description
INC000004131805 - Multiple AD1 alerts INC000004127503 - Multiple AD1 alerts INC000004131713 - Multiple AD1 alerts INC000004165469 - Multiple AD1 alerts	These incidents are similar and relate to multiple AD1 alerts being generated from a premise. The key next step is for a site visit to be arranged to assess the issue and supply a resolution
INC000004105064 - Multiple Power Outage and Restores	There are recurring low RMS voltage alarms from ESMEs, after which the CH undergoes recurring power outages/ restores. The key next step is for a site visit to be arranged to assess the issue and to advise why the ESMEs are sending low power alerts

Table 28 Telefónica Incidents Overview

Please also note that there are no other relevant Incident or Defects that should be referenced at this time.

Activities Performed by Telefónica during analysis

The dataset supplied by the DSP was complemented with Telefónica data for the identified AD1 events on June 14th to facilitate the analysis taking place.

The following sources were considered in analysis:

- CH database (CHDB) for CH power outage alerts – this data is passed onto CHDB by the Orchestration (OT) system (captured in OIWFL083)[49]
- CH database (CHDB) for CH power restore alerts – this data is passed onto CHDB by the Orchestration (OT) system
- CHDB AD1 alerts – this data is passed onto CHDB by the Orchestration (OT) system
- Orchestration (OT) system logs
- PM12.x reports for June – this contains details of the CH type and manufacturer

Some data manipulation was performed on this data to assist in understanding the information better. Key steps included:

- Data exclusion due to data inconsistency or non-normal operating conditions in order to obtain a normalized set
- Analysis on normalized set
- Analysis on simplified set with single AD1 in sample to allow 1-1 correlation to Telefónica POAs and meter 8F35/8F36 alerts

Context based on DSP data Analysis

The DSP analysis was conducted on data captured between 9th June and 15th June, comprising a total of 707,367 messages during this period.

The DSP analysis identified that the majority of the traffic related to power outage/restore messages is particular to short power outages, which equates to 88% of traffic volume. Whether these are true short outages should be questioned considering the available data.

Figure 28 has an aggregated count of devices, alert volume and a calculated ratio of alerts/device depending on number of events per day observed in that period.

For clarity, more than 20 events a day is deemed as an abnormal behaviour. An average ratio of alert per device across 51 devices in this bucket is a good pointer this is not induced by grid related problems but is very likely caused by faulty devices or installation problems. 51 devices account for 4326 power outages in a single day, with an average of almost 85 outages in a single day.

[49] OIWFL083 is OI/OT workflow which sends AD1 alert to DSP

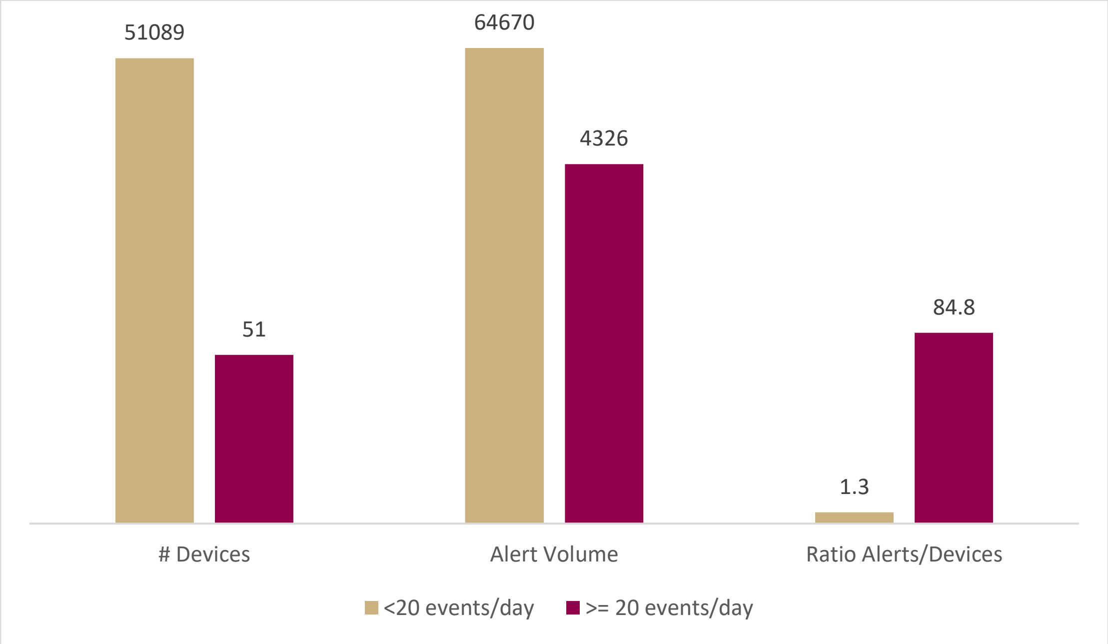


Figure 28 Count of MPANs and Power Outage/Restore Related Alerts splitting on daily count of alerts (less/over 20 alerts/day)

72% of alerts correspond to occurrences where only 8F35 alert is captured at DSP level, but a breakdown on MPANs generating power outages show several of these short power outages are unlikely to be true grid outages.

DSP identified an unmatched number of alerts, i.e. from all related power outage traffic volume, in which 21% corresponds to AD1 alerts unmatched with an 8F36. In a lesser extent and on a more positive note, there is a very small proportion of 8F36 alerts without a corresponding AD1. However, less than 1.2% of AD1 alerts are matched with 8F36 alerts.

It is also worth to note that 1.7% of Telefónica AD1s point to be false positives, i.e. AD1 occurs in conjunction to 8F35 alert.

Telefónica data analysis focused on a subset of Data DSP created with AD1 alerts to investigate further the two last referred observations.

Preliminary analysis, observations and exclusions

The data analysis focused on the identification of AD1 alerts from Telefónica across the E2E journey, including the count of Telefónica Power Outage Alerts and Telefónica Power Outage Restores.

Table 29 provides a high-level summary of the available data:

Count of CH GUID	Total AD1 (DSP)[50]	Total 8F35 (DSP)[51]	Total 8F36 (DSP)[52]	Total CHDB TEF POA	Total CHDB AD1	Total AD1 OIWF L083
3,223	13,032	1,153	832	21,711	3,756	3,730

Table 29 Summary on analysed sample of DSP reported AD1 Alerts

From the previous table, it is immediately perceptible a high ratio of power outage alerts captured in Telefónica per CH. As per DSP analysis, the data was split in Telefónica end capturing CHs exhibiting less and more than 20 power losses per day. A similar analysis is captured in Figure 29, but in relation to Telefónica Power Outage alerts captured in SM2M/OT.

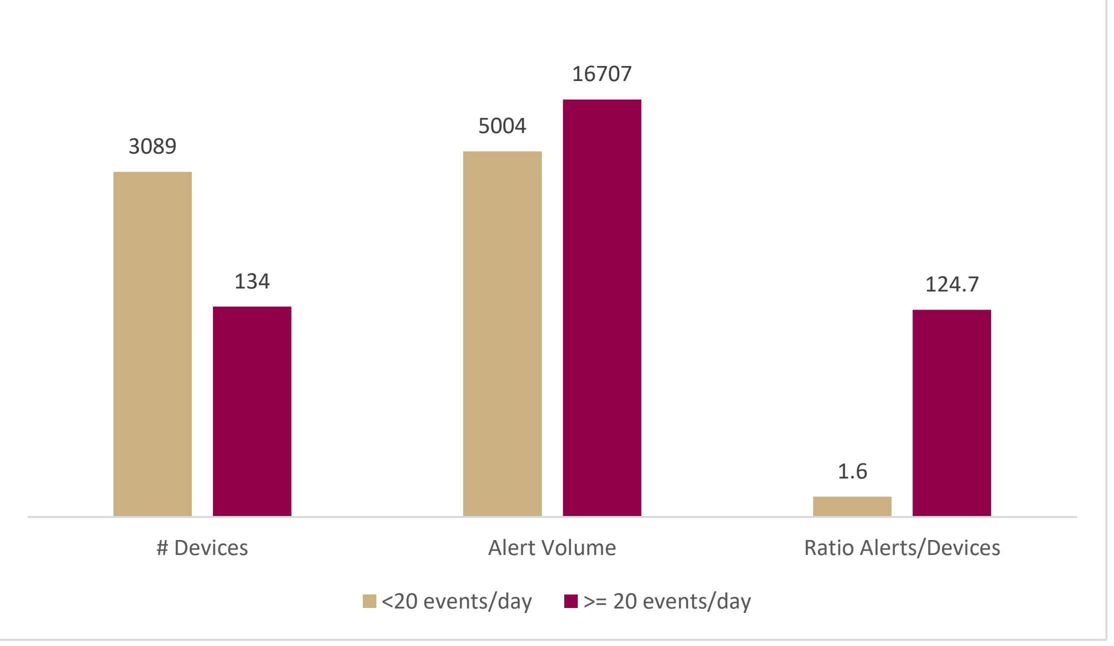


Figure 29 Count of CHFs and TEF Power Outage Alerts splitting on daily count of alerts (less/over 20 alerts/day) recorded on CSP.

CSP figures for 14th June against DSP figures for a period comprising 9th June to 15th June, by comparing Figure 28 and Figure 29 point to:

1) TEF is capturing a higher number of power outages from their Comms Hubs when compared to 8F35 volume on DSP
2) There is a higher number of sets exhibiting more than 20 power outages a day when this is captured from CHF side

[50] This is based on AD1 data supplied by CGI which identified 3,223 unique CH GUIDs and a total of 13032 AD1s. Note that a CH POA typically causes a generation of 4 DCC Alert AD1s

[51] This is based on a subset of the 8F35 alert data supplied by the DSP where the alerts relating to the 3,223 unique CH GUIDs were cross referenced with CH GUIDs in the DSP supplied AD1 alerts

[52] This is based on a subset of the 8F36 alert data supplied by the DSP where the alerts relating to the 3,223 unique CH GUIDs were cross referenced with CH GUIDs in the DSP supplied AD1 alerts

This is not however a definitive conclusion that can be reached from this data, as a like for like data set needs to be analysed, but it is enough to identify a set of problems which emerge in sets with a high number of power outages per day, constituting Data Problem 1 which is summarized in the box below:

Data Problem #1: 134 devices exhibit at least 20 POA alerts for day in analysis, with a ratio of 124.7 alerts/day.

Discussed root causes (not exhaustive)
This problem is vastly caused by a small number of devices exhibiting an abnormal high rate of outages.

4.2% of sample to be excluded due to highly abnormal conditions to be checked in premises. It is important to note this accounts for 17.4% of all AD1s in provided sample.

A secondary problem identified in data is an un-matching number of AD1 alerts captured on DSP end and CSP end, which most likely points to data quality issues, gaps or extraction problems, as the AD1 alert was received in DSP end. In summary:

Data Problem #2: 95 CHF devices for which DSP sent an AD1 alert were not matched in log capturing OIWFL083 nor it is matching a record in CHDB

2.9% of sample to be excluded due to data being inconsistent between CSP/DSP

Observed root causes
Device is not a CHF (F8-E5-CF-00-00-43-F2-46)

Discussed root causes (not exhaustive)
UTC vs BST timestamp created a gap in extracts from DSP and CSP Errors in log extraction/manipulation, using a start time that is not concurrent with time AD1 alert was sent from TEF AG to DSP

Analysis below is conducted further excluding the devices identified in Data Problem 1 and Data Problem 2. Table 30 updates values captured in Table 29 with this exclusion:

Count of CH GUID	Total AD1 (DSP)	Total 8F35 (DSP)	Total 8F36 (DSP)	Total CHDB TEF POA	Total CHDB AD1	Total AD1 OIWF L083
2,994	10,595	950	280	5,002	3,172	3,140

Table 30 Summary on analysed sample of DSP reported AD1 Alerts, excluding Smart Meter Sets exhibiting 20 or more power outages in analysed day.

Problems observed in normalized data set

Alert volumes in Table 30 show an unbalanced number of alerts between CSP end and DSP end. Meter supply restore alerts are in reduced number against Telefónica observed outages, this is the reasoning captured on observed data problems. Please see below:

Data Problem 3: TEF AD1 alerts are unmatched with 8F36 alerts. 2832 sets with a registered AD1 alert have no 8F36 alert on DSP end.

94.6% of normalized sample have no 8F36 alert.

Possible root causes grouped by possible scenarios is presented in Table 31 *due to complexity of this case.*

Observations in data:
Out of these 2832 sets without 8F36, it is observed that an 8F35 was received in 445 sets. This implicitly points to meters ability of sending out alerts on outage and a potentially AD1 false positive, which can't be confirmed on data sets provided. Further investigation is needed on accuracy of timestamps between DMM power outage/restore alerts against meter 8F35 alerts for these cases.

Based on the data analysis, the following scenarios are also considered to be applicable for the specific root causes of the quoted problems:

Scenario	Possible Root Causes Discussed
Scenario 1 No outage occurred in premise	- Installation problem causing poor power supply conditions to Comms Hub - Meter firmware activation or reboot causing power loss on Comms Hub - On site procedures (Comms Hub power cycling)
Scenario 2 AD1 is a false positive	- TEF processing of DMM power restore alert is delayed - DMM power restore alert is lost in network - DMM power restore alert is not sent - Inaccurate timestamp on either DMM power outage alert or DMM power restore alert
Scenario 3 Confirmed outage but alert is not received	- Alert is sent from meter without resiliency - Alert is not sent from meter - Comms hub does not buffer/send out alert once WAN connectivity is established

Table 31 Scenarios and discussed possible root causes for Data Problem 3 (TEF AD1 alerts unmatched with 8F36 alert).

A similar analysis was conducted in alignment of AD1 alerts and generated 8F35 alerts, allowing identification of described below:

Data Problem 4: TEF AD1 alerts are unmatched with 8F35 alerts. 2416 sets with a registered AD1 alert have no 8F35 alert on DSP end.

80.7% of normalized sample have no 8F35 alert.

Possible root presented in Table 31 *for scenario 1 and 3 are valid for this observation.*

Observations in data:
Out of these 2832 sets without 8F36, it is observed that an 8F35 was received in 445 sets. This implicitly points to meters ability of sending out alerts on outage and a potentially AD1 false positive, which can't be confirmed on data sets provided. Further investigation is needed on accuracy of timestamps between DMM power outage/restore alerts against meter 8F35 alerts for these cases.

TEF attempted to conduct an additional analysis correlating volume of 8F35 alerts in comparison with DMM power outage alerts, however the same showed to be invalid, as presented 8F35s were captured from DSP end against received AD1 alerts, so it is uncertain how to proceed with these aggregated volumes of 8F35 alerts. This part of the review has been paused under this specific paper.

Furthermore, to assess quality of DMM power outage and power restore alerts, ESME alert payloads are required to compare timestamp accuracy.

A simplification in analysis is proposed by using a sample with single long power outages, which allow to analyse a 1 to 1 correlation of all alerts (AD1, 8F35 and 8F36).

Other issues identified are that the Total number of AD1 alerts captured on DSP includes all AD1s sent to different service users. This alert is ought to be sent to Electricity Supplier, Electricity DNO, Gas Supplier and Gas DNO. Therefore, there should be a factor of 2 or 4 in relation to AD1 alerts sent from TEF Access Gateway to CSP Management Gateway, depending on whether it is a dual fuel or a single fuel install. The ratio in the sample is 3.5, which if within the expected range. However, it is observed in sample several sets exhibit a different multiplier factor, this constitutes **Data Problem #5**. It is also worth to refer that for TEF analysis a better point of capture is at CSP Management Gateway to allow problem segregation between CSP and DSP.

Data Problem 5: in 11 cases out of the single long power outages from normalized sample, ratio on AD1 alerts stored in CHDB are not matched in a factor of 2 or 4 on alerts sent from DSP to service users.

0.5% of single long power outages show DSP number of alerts sent to service user is not matching a 2 or 4

Discussed root causes (not exhaustive)
-Registration issues
-Certificates misalignment
-Multiple ESMEs per premise/Comms Hub
-TEF AD1 alert not stored in CHDB

12.7.2 Problems observed in single long power outages in normalized sample

As proposed above, there is a reasonable and sizeable sample of single long power outages registered on 14th June, this data is presented in Table 32.

Count of CH GUID	Total AD1 (DSP)	Total 8F35 (DSP)	Total 8F36 (DSP)	Total CHDB TEF POA	Total CHDB AD1	Total AD1 OIWF L083
2,234	7,645	259	100	2,234	2,234	2,215

Table 32 Summary on analysed sample of DSP reporting a single AD1 alert from normalized sample.

Data Problem 5: On single AD1 alerts received on DSP, TEF power outage alert are unmatched on DSP with meter alerts. In a total of 2234 in normalized set with a single long power outage, only 72 sets present both 8F35 and 8F36 alerts as expected.

3.2% of normalized sample in a scenario of a single long power outage have meter alerts recorded in DSP end.

Possible root causes are identical to scenarios explained in Table 31*.*

Other observations in data:
In 215 of cases, at least one of the alerts is received on DSP, which implies meter ability to send the alert out in a very small proportion of cases:
-There are 187 cases where 8F35 is received without 8F36 (8.4% of single AD1s)
- There are 28 cases where 8F36 is received without 8F35 (1.3% of single AD1s)

Next Steps

Telefónica has systematized root causes and has been able to provide a summary of this based on the available data. However, it has not been possible to complete the exercise of quantifying each root cause with the available data.

On the data captured and analysed, an educated guess on expected rate of occurrence of root causes may allow to prioritize effort, according to the observed rate of occurrence

- Up to 80% of unmatched alerts may be due to meter inability to send the alerts or to situations where outage did not occur (best success rate of meter alert delivery to DSP in normalized sample)
- Up to 8% of AD1 alerts may be false positives (presence of 8F35 and no 8F36 in single long power outages)

Planned lab investigation is the suggested approach to investigate unmatched alerts, but analysis on meter types and identifying concurrent events such as firmware upgrades, meter reboots and Comms Hub power cycling should be captured in data to allow a separation in what can be a structural problem regarding ability to send alert vs scenarios where power outage is not occurring in premise.

Data captures set for this piece of work lack detail in order to investigate AD1 false positives. Timestamps are an essential part of the work to validate alerts. AD1 reliability is dependent on how accurate DMM Power Outage Alerts and Power Outage Restores are so additional and independent work on 8F35 and 8F36 against DMM outage/restore is needed.

In addition, a single day was observed in Telefónica. A more comprehensive sample should be aimed, in quality and duration.

On a final note, number of problem records is nowhere matching the size of the problem reported with E2E power outage behaviour. It is suggested that a framework definition is introduced for these problems and agreement on how to capture incidents and support data to enrich these problems – alongside the introduction of any solution enhancements in line with the DNO requirements.

12.8 Alert Type combinations – Arqiva CSP

This graph shows a breakdown of MPxNs for the Arqiva region based on the daily average combination of POAs/PRAs generated for each MPxN.

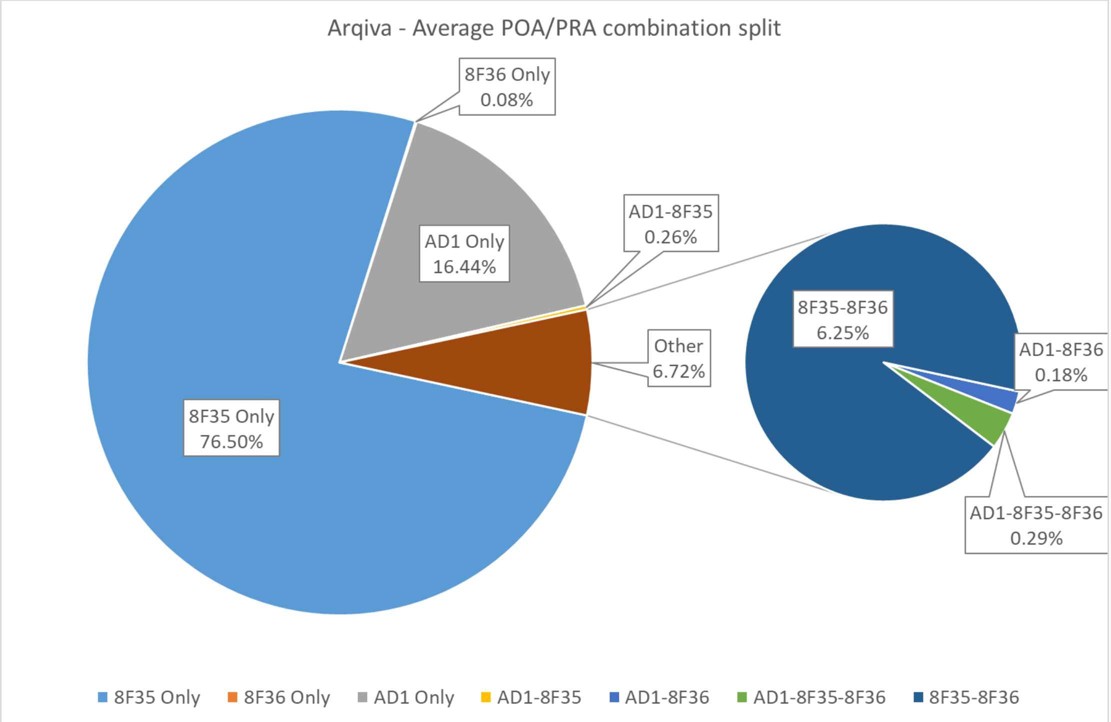


Figure 30 Arqiva POA/PRA Combinations

Key points from the graph above are the following:

- 77% of MPANs generate a solitary 8F35. If DNOs agree that timely delivery of 8F35s (indicating an outage of less than 3 minutes in duration) are of less importance than AD1s/8F36s (denoting outages of 3 minutes or more), this would reduce the POA/PRA estate requiring timely delivery to less than a quarter under 'normal' conditions.
- For outages of 3 minutes duration or more that occur and complete within the same day, the expectation would be to see one 8F35, one 8F36 and up to three AD1s sent to the DSP. Where more than one AD1 alert is sent to the DSP, deduplication within the DSP system will result in a single AD1 alert being processed by the DSP, generating up to 2 AD1s for single fuel and up to 4 AD1s for dual fuel installations.
- 16% of MPANs generate a solitary AD1. This may be attributable in part due to specific ESMEs generating and sending the 8F35 and 8F36 alerts whilst the CH is rebooting after power restoration. In this scenario the CH HAN receiver is not enabled at the time that the ESME transmits and the 8F35 and 8F36 alerts are lost. A change to the messaging protocol used by the ESME to include an acknowledgement or retry mechanism would be required to prevent these messages being lost.
- A small percentage of solitary AD1 alerts may also be attributed to firmware updates to ESMEs which interrupt power supplied to the CH during firmware activation, thus causing the CH to trigger an AD1 in the absence of an 8F35 or 8F36. This needs to be verified by more analysis of the Model-Firmware combinations of affected ESMEs and their receipt of SRV11.3s during the day of the outage.
- The 6% of power outage events which generate both an 8F35 and 8F36 without an AD1 can primarily be attributed to one of three factors.

  - A significant delay in delivering the successful AD1 alerts back to the core network
  - Devices in the outage include both CHs operating in buddy mode (the Out of Range Device and the corresponding Buddy)
  - The AD1 alert being lost due to message collisions over all three alert windows
- Based on the window of data analysed the vast majority of missing AD1 alerts fall under the first of the above categories, being delivered significantly delayed. Analysis of the origin of significantly delayed alerts highlighted specific sites within the network experiencing problems with backhaul connectivity as described in the unhappy path scenarios. Where RNI connectivity is unavailable messages at the TK are buffered and interleaved with live messages once connectivity is re-established.
- An issue had previously been identified with the TK buffering process which was exacerbating the problem of messages being delayed at the TK. At the time that the data was collected a patch for the existing issue was in the process of being rolled out to the network. Since that time all sites in the network have been patched and as such Arqiva expects fewer issues with significantly delayed messages being reported. Note that this patch does not change the fundamental TK buffering and buffer clearing process. It is still feasible that messages buffered at the TK will arrive significantly after the event due to intermittent backhaul connections.
- During recent months, government restrictions have prevented access to a number of sites with known RNI connectivity issues requiring BT maintenance to the DSL line. As a result there has been an increase in the number of messages arriving significantly after the outage event.

12.9 Arqiva POA Times from Outage to Receipt by DSP

This graph shows the delay between the power being lost and a corresponding POA arriving at the DSP. This data is extracted from a log introduced as part of the DSP Change Request for de-duplication of AD1s received from Arqiva. As such it contains up to three alerts produced by each CH in an outage. Arqiva CHs generate three outage Alerts:

- The first is generated between 180 seconds (3 minutes) and 225 seconds (3 minutes 45 seconds) after the outage
- The second is generated between 225 seconds (3 minutes 45 seconds) and 465 seconds (7 minutes 45 seconds) after the outage
- The third is generated between 465 seconds (7 minutes 45 seconds) and 705 seconds (11 minutes 45 seconds) after the outage

Under typical daily volumes the alert from the first 45 second window is almost always received, followed later by the subsequent duplicate alerts from the second and third windows.

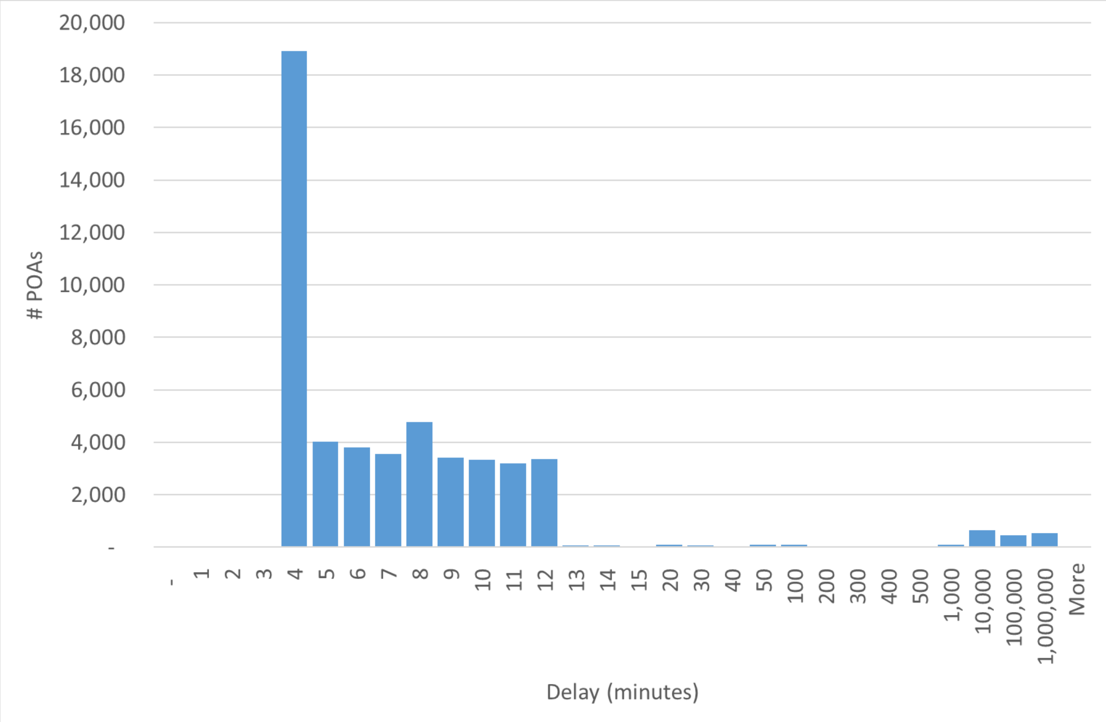


Figure 31 Arqiva POA Delivery Times

In the table below analysis of the alerts have been split between those delivered within the expected windows and those which arrived at the DSP after a delay. 95% of all alerts over the analysis period were delivered within the expected windows, with the average of all alerts before deduplication being 6 minutes after loss of power. As discussed previously the first alert to arrive at the DSP is typically within the 45 second window after confirmation of the outage and would generate the AD1 that is sent to the DNOs at that time.

Alert Delivery Time	No. Alerts	Average Delay (mins)	Average Delay (days)	Percentage of Alerts in sample
< 11 min 45 sec	48,412	6	0	95%
>11 min 45 sec	2,344	44,447	31	5%
All alerts	50,756	2,058	1.4	100%

Table 33 Arqiva Alert Times

The AD1 de-duplication change logs the time of each outage notification received and looks to see if an outage notification has been generated by the same CH within a configurable time period. If so, the outage notification is rejected as a duplicate of a previously received outage notification. The DSP retains knowledge of outage notifications received from Arqiva for a specified period. If a duplicate is received after a period longer than the specified period, DSP fails to recognise it as a duplicate and sends it on. DSP retains a log of de-duplication activity for a period of a month. This data is based on an analysis of the log spanning the period 17 May 2020 to 18 June 2020 during which 50,756 POAs were processed.

POAs with up to an 11 minute 45 second delay are to be expected. POAs with a delay longer than 11 minutes 45 seconds (5% of those processed) are not and are most likely due to problems with intermittent connectivity between TKs and the RNI as covered above. These alerts that are longer than 11 minutes 45 seconds are likely to be duplicate alerts but this cannot be assumed since there are scenarios where the delayed alert was picked up by a single site and transmitted late.

13 Appendix B – CSP Contract Extracts

Power Outage Alerts
- CSP Contract Extrac

14 Appendix C – National Grid letter to Telefónica – Black Start Worst Case Scenario

Telefonica letter _v3.pdf

15 Appendix D – Known Incidents Identified by DCC

The items below identify known issues related to POAs and PRAs, namely:

- AD1s
- 8F35
- 8F36

These issues will be tested further as part of PR1227 (E2E POA & PRA Testing by Telefónica, Arqiva and CGI) which aims to test the alerts, identify root causes and fix paths.

1. AD1 received and device becomes unresponsive/can no longer be communicated with
2. AD1 received but no SMART meter at the property
3. AD1 received but no N16 and/or N42
4. AD1 received but customer on supply
5. AD1s received multiple restore alerts received
6. AD1s received too early (part 1)
7. AD1s received too early (part 2) - AD1 is received with a time stamp in the future
8. AD1s being received too late - POAs have been received after 7 minutes but some are over an hour and up to 24 hours after the time stamp
9. Duplicate AD1s being received in CSPN - Some AD1s are received by DNOs several hours after the original and outside of the time used for DSP to check
10. Duplicate alerts with different headers
11. 8F35/8F36 being received with no correlating AD1
12. Multiple AD1s being received
13. Multiple PRA being received following an AD1

16 Appendix E – Telefónica Network Resilience Information

In the event of power outages that may impact the network infrastructure in the CSP central and south regions, here are details of the network configuration.

Backup for cell sites are provided through two mechanisms: site coverage overlap and power backup:

- All cell sites are designed with power backup by default – they will have batteries / alternative power sources installed that provide 10 minute backups to cover power dips / short outages only. There will be a few sites which will not have power backup - these will include cell towers providing coverage extensions within specific buildings / venues.
- The network is designed with coverage overlap across the tower network. For example, in East Anglia, the network topography has a 40% coverage overlap across sites

Additional information regarding the network infrastructure is also included in the response to question 4 under “section 6 Responses to DNO Questions”.

17 Appendix F – Enhancement Option Costing's

Below is the enhancement options with ROM costs however it excludes post PIT implementation costs which depend on the delivery channel. All costs quoted below are indicative only and are subject to a CR being raised and Full Impact Assessments being conducted.

16.1 Arqiva enhancement Options and Indicative Costs

Arqiva Option 1 - Reinstate CH Restoration Alerts
ROM cost of £ X
The cost for this change is based on making the Arqiva change only. Changes to DSP and DUIS would also be required.

Arqiva Option 2 – Increase Traffic Channels
ROM cost of £ £X - £X Million but could go as high as £X - £Xmillion
The cost for this Change will vary depending on the number of Traffic Channels purchased. At the low end the cost is for approx. 3 to 5 channels with the high end 15 – 20. If more channels are needed, then the cost would increase even further.

Arqiva Option 3 – 3G Backhaul Resilience
Due to the complexity of this change and the work required to produce a ROM cost for this enhancement, we would need to conduct an Impact assessment to provide a ROM cost.

Arqiva Option 4 – Relaxed throttle Between the CSP and DSP
ROM cost of £ X
This is based on general uplift of the current throttle maintaining the existing infrastructure, anything more and costs would scale up quickly and require more work. If this was the case costs could end up in the £X million range.

Arqiva Option 5 – Buffering alerts at the Gateway
ROM cost of £ X million

Arqiva Option 6 – Deduplication at the CSP – DSP Gateway
Due to the complexity of this change and the work required to produce a ROM cost for this enhancement, we would need to conduct an Impact assessment to provide a ROM cost.

16.2 Telefonica enhancement options and Indicative costs

Telefonica Option 1 - Existing IT System Enhancements for POA/PRA processing
ROM cost of ££Xm -£Xm (Setup) / £Xk -£Xk Per Annum (OPEX)

Telefonica Option 2 - Cloud Based Micro Service

£Xm -£Xm (Setup)
£Xk -£Xk per Annum (OPEX)

Option 3 - Network Evolution Comms Hub with Super-Capacitor

$X to $X per unit (USD)

Telefonica Option 4 - Firmware and Network Infrastructure Updates
~£Xm -~£Xm

16.3 DSP Enhancement options and Indicative costs

DSP Option 1 - Provision of New Infrastructure
ROM £Xk - £Xk

DSP Option 2 - Prioritisation Capability
£Xk - £Xm

DSP Option 3 - Dedicated Infrastructure Resources
£Xk - £Xk

DSP Option 4 - Cloud Based Deployment
TBD

DSP Option 5 - Prioritisation within Alert Types (Postcode + TPB)
£Xk - £Xk

DSP Option 6 - Prioritisation within Alert Types (Canary)
£Xk - £Xk

DSP Option 7 - Reduce Spurious PRAs
£X - £Xk

DSP Option 8 - V1.1 Submission of CR1090 - Data Retention Improvements
£Xk - £Xm

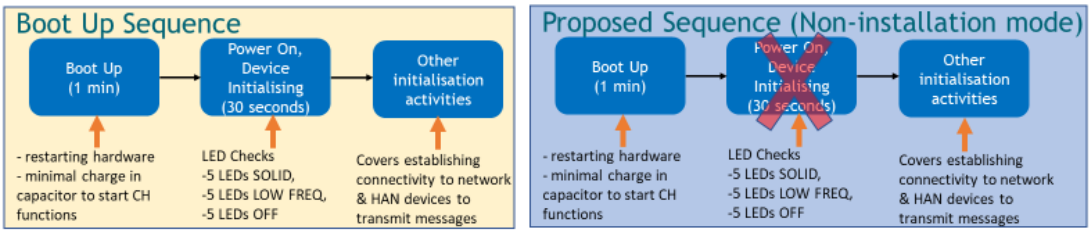
DSP Option 9 - Additional Work: Performance Testing
£Xk - £Xk

END.

Appendix G
Additional Telefonica and Arqiva Enhancement

See below additional enhancement options:

Telefonica - T6 - Reduction in CH Re-Boot Time



- **Skip power on, device initialisation step, saving 30 seconds (Boot time reduction from 90 secs to 60 secs)**
- This sequence is specific to non-installation mode (Existing sequence used for installation mode)
- Updates required for both Toshiba and WNC for alignment
- This change would apply to mesh and non-mesh CHs
- **Delivery time of AD1s and 8F35/8F36 messages will be reduced by 30 seconds**

Telefonica - T7 - Dither Reduction

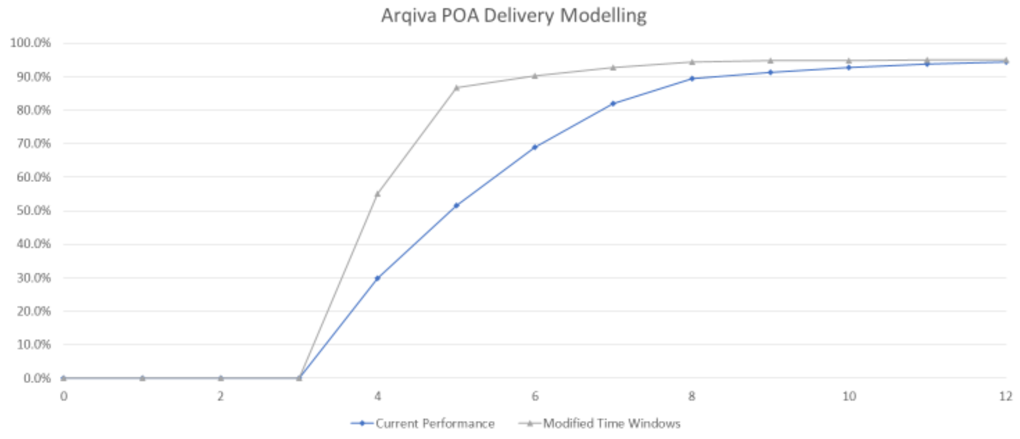
- This option is to reduce the overall time taken for all impacted CHs in a power outage to send messages once power is restored, by adjusting the network re-attach timer.
- The network re-attach timer is in place to protect Telefónica's network infrastructure by preventing large scale simultaneous network reattachments. This can occur after a large power outage which causes CHs to reboot once power is restored and reattach to the network.
- The network re-attach timer prioritises mesh enabled comms hubs in order to allow leaf mesh comms hubs gateways to connect to following an outage
- The network re-attach timer then switches to non mesh and randomises all remaining attaches
- Current algorithm is as follows:
  - 0 - 20 seconds – Mesh CH reattachments
  - 20 - 120 seconds – 10 slots of 10 seconds each for batches of non-mesh CH to reattach
- Removal of a short gap (10 seconds) between the switchover from mesh to non-mesh comms hubs
- **This reduces the network re-attach timer by 10 secs from 120 secs to 110 secs**

Arqiva – A7 – Modify time window

- Modified time window
  - Change first CH POA alert window to 120 seconds to align with 5 minute total elapsed time
  - Reduce second and third alert windows to 200 and 205 seconds respectively
  - By modifying the time windows over which the CH transmits its POA Arqiva can deliver a greater number of alerts at the 5 minute interval when considering the 30,000 size outage
  - The trade off is that for >99% of annual outages alert delivery is slower

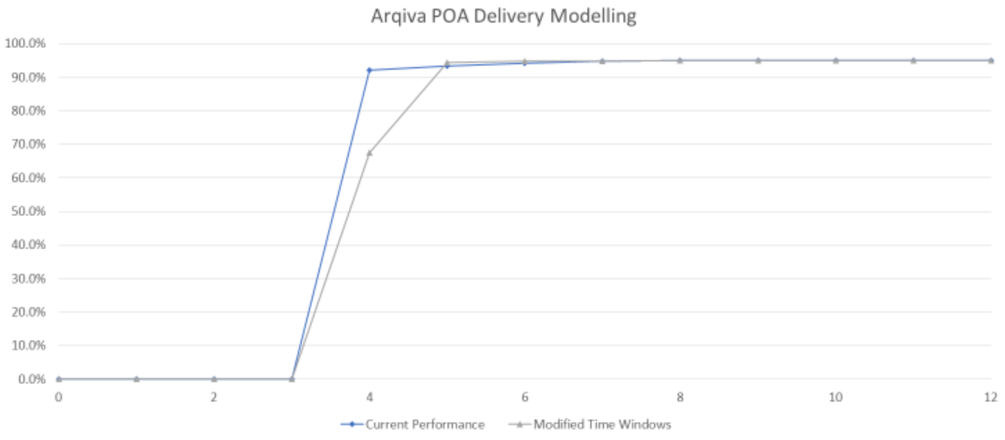
3

Arqiva - 30,000 CH Outage



4

Arqiva - 1,000 CH Outage



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Appendix H

Additional Scenario Analysis

Central South Performance Enhancement Mapping to DNO Scenarios

		Message volumes		AD1 delivery time range (in minutes)			PRA delivery time range (in minutes) (outages > 20s)		
Scenario	Description	Max Simultaneous Outages	Max Simultaneous Restores	Current	A. High Perf Enhancement	B. Max Perf Enhancement	Current	A. High Perf Enhancement	B. Max Perf Enhancement
C	Overhead power line comes down. 30 homes in a village are taken off supply as are 15-20 local supply points at neighbouring farms	50	50	6-8	5-7	4.5-6.5	1.5-3.5	1.5-3.5	1-3
A/B	Single 5000 property outage (A - TEF region / B - ARQ region)	5,000	5,000	6-8	5-7	4.5-6.5	1.5-3.5	1.5-3.5	1-3
D	Substation damaged - 5,000 lose power simultaneously	5,000	5,000	6-8	5-7	4.5-6.5	1.5-3.5	1.5-3.5	1-3
G	Storm travelling West to East knocks out a total of 100,000 MPAN's over a 20-hour period on average 5,000 homes an hour with a mix of high volt and low voltage. Due to re-routing, alerts may be generated and restored within the 3 minutes	5,000	7,500	6-8	5-7	4.5-6.5	1.5-3.5	1.5-3.5	1-3
H	Storm travelling South to East from Bristol to Glasgow affecting 100,000 MPAN's over 7 hours to include 20,000 simultaneous supply points in Birmingham, 15,000 in Manchester and 65,000 being a mix of high voltage / low voltage in other cities, towns and villages	20,000	20,000	6-11	5-8	4.5-7.5	1.5-3.5	1.5-3.5	1-3
E	20,000 homes in a major city lose power within 30 seconds a smaller power event occurs meaning the loss of power occurs in a different part of the same SP region (e.g. 20,000 homes in London – 6 homes in Western Super Mare)	20,006	20,006	6-11	5-8	4.5-7.5	1.5-3.5	1.5-3.5	1-3
F	An event knocks down a high voltage cable in a major city (as per DNO discussions assumed to be scenario for outage of 30,000 properties)	30,000	30,000	6-13	5-8	4.5-7.5	1.5-3.5	1.5-3.5	1-3
I	Transmission Line Failures (only 34,000 POA messages are processed due to throttling measures put in place in the systems)	200,000	50,000	6-14	5-8	4.5-8	1.5-3.5	1.5-3.5	1-3

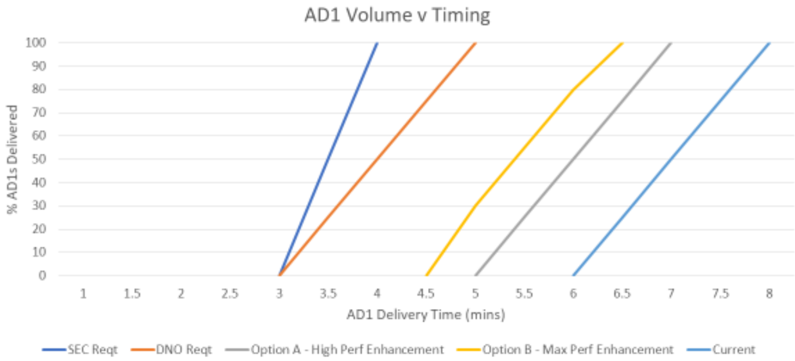
North Region Performance Enhancement Mapping to DNO Scenarios

Scenario	Current	Option A			Option B
		Change 2 PRA from CH	Change 3 + Alert Channel	Change 4 Relax throttle	Change 8 CH processing time
Scenario A&B. **Single 5000 property outage** **(A - TEF region / B - ARQ region)**	POA: 52% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins	New PRA: 52% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins	POA: 76% in 5 mins 95% in 12 mins 8F35/8F36: 45 mins	No Change	POA: 55% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins
Scenario C. **Overhead power line comes down. 30 homes in a village are taken off supply as are 15-20 local supply points at neighbouring farms**	POA: <4 min 8F35/8F36: <4 min	New PRA: <4 min 8F35/8F36: <4 min	POA: <4 min 8F35/8F36: <4 min	No Change	POA: <5 min 8F35/8F36: <5 min
Scenario D. **Substation damaged - 5,000 lose power simultaneously**	POA: 52% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins	New PRA: 52% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins	POA: 76% in 5 mins 95% in 12 mins 8F35/8F36: 45 mins	No Change	POA: 55% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins
Scenario E. **20,000 homes in a major city lose power within 30 seconds a smaller power event occurs meaning the loss of power occurs in a different part of the same SP region (e.g. 20,000 homes in London – 6 homes in Western Super Mare)**	20,000 Outage POA: 31% in 5 mins 94% in 15 mins 8F35/8F36: 45 mins 6 Outage POA: <4 min 8F35/8F36: <4 min	New PRA: 31% in 5 mins (52% in 5 mins with Change 4) 94% in 15 mins (94% in 12 mins with Change 4) 8F35/8F36: 45 mins	POA: 31% in 5 mins (76% in 5 mins with Change 4) 95% in 15 mins (95% in 12 mins with Change 4) 8F35/8F36: 45 mins	Reduced risk of blocking messages during large outages. At 5000 per min throttle begins to impact for single outages around 20k in size with current alert channel count. Higher throughput of change 3 would mandate this change.	POA (assumes Change 4 implemented): 55% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins

North Region Performance Enhancement Mapping to DNO Scenarios

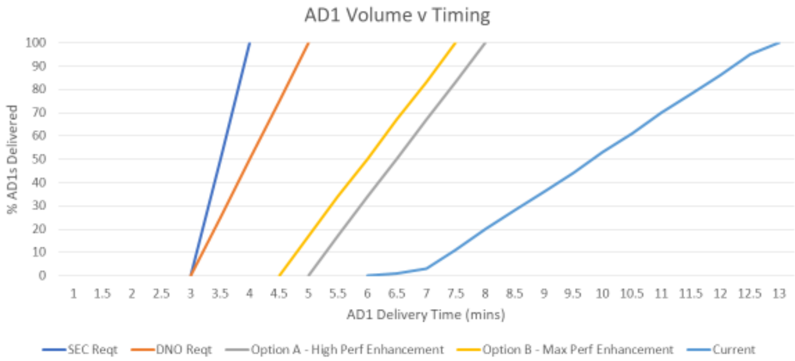
Scenario	Current	Option A			Option B
		Change 2 PRA from CH	Change 3 + Alert Channel	Change 4 Relax throttle	Change 8 CH processing time
Scenario F. **An event knocks down a high voltage cable in a major city (as per DNO discussions assumed to be scenario for outage of 30,000 properties)**	POA: 31% in 5 mins 94% in 15 mins 8F35/8F36: 45 mins	New PRA: 31% in 5 mins (52% in 5 mins with Change 4) 94% in 15 mins (94% in 12 mins with Change 4) 8F35/8F36: 45 mins	POA: 31% in 5 mins (76% in 5 mins with Change 4) 95% in 15 mins (95% in 12 mins with Change 4) 8F35/8F36: 45 mins	Reduced risk of blocking messages during large outages. At 5000 per min throttle begins to impact for outages around 20k in size with current alert channel count. Higher throughput of change 3 would mandate this change.	POA (assumes Change 4 implemented): 55% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins
Scenario G. **Storm travelling West to East knocks out a total of 100,000 MPAN's over a 20-hour period on average 5,000 homes an hour with a mix of high volt and low voltage. Due to re-routing, alerts may be generated and restored within the 3 minutes**	POA: 52% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins	New PRA: 52% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins	POA: 76% in 5 mins 95% in 12 mins 8F35/8F36: 45 mins	No Change	POA: 55% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins
Scenario H. **Storm travelling South to East from Bristol to Glasgow affecting 100,000 MPAN's over 7 hours to include 20,000 simultaneous supply points in Birmingham, 15,000 in Manchester and 65,000 being a mix of high voltage / low voltage in other cities, towns and villages**	POA: 31% in 5 mins 94% in 15 mins 8F35/8F36: 45 mins	New PRA: 31% in 5 mins (52% in 5 mins with Change 4) 94% in 15 mins (94% in 12 mins with Change 4) 8F35/8F36: 45 mins	POA: 31% in 5 mins (76% in 5 mins with Change 4) 95% in 15 mins (95% in 12 mins with Change 4) 8F35/8F36: 45 mins	Reduced risk of blocking messages during large outages. At 5000 per min throttle begins to impact for outages around 20k in size with current alert channel count. Higher throughput of change 3 would mandate this change.	POA (assumes Change 4 implemented): 55% in 5 mins 94% in 12 mins 8F35/8F36: 45 mins
Scenario I. **Transmission Line Failures**	Unknown. Not modelled during PR1226	Unknown. Not modelled during PR1226	Unknown. Not modelled during PR1226	Unknown. Not modelled during PR1226	Unknown. Not modelled during PR1226

Table 1- POA delivery period and volumes for Central South Regions for scenarios A,B,C,D,G (up to 5000 simultaneous outages)



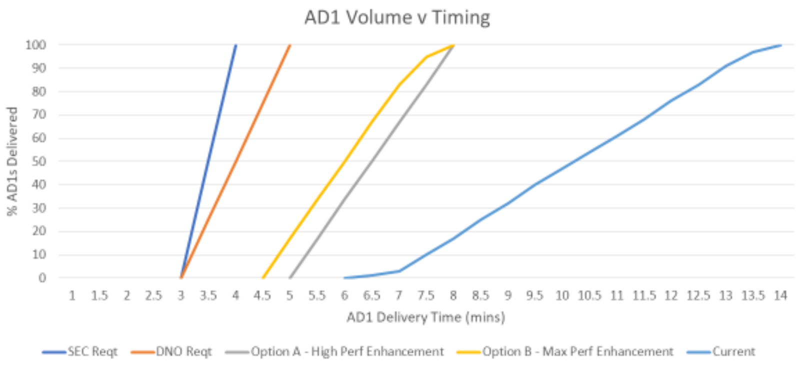
- Option B – Max Perf Enhancement for 2G/3G CH covers combined microservices, reduction in CH reboot times and reduction of dither algorithm.
- For Option B, system needs to wait approx. 4 mins to ensure there are no CH power restore messages arriving before sending out the AD1s. A CH power restore message arriving within 4 mins of the CH power outage message is actually a power outage that lasts < 3 mins and is therefore not an AD1. This takes into account CH reboot, network re-attach and message transmission time.

Table 2 - POA delivery period and volumes for Central South Regions for scenarios E,F,H (up to 30000 simultaneous outages)



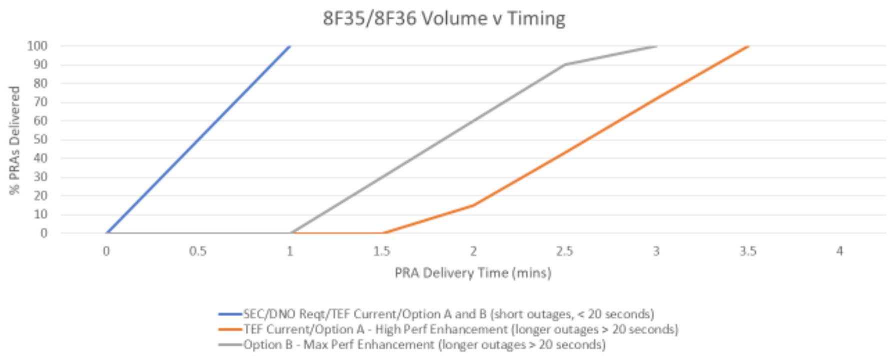
- Option B – Max Perf Enhancement for 2G/3G CH covers combined microservices, reduction in CH reboot times and reduction of dither algorithm.
- For Option B, system needs to wait approx. 4 mins to ensure there are no CH power restore messages arriving before sending out the AD1s. A CH power restore message arriving within 4 mins of the CH power outage message is actually a power outage that lasts < 3 mins and is therefore not an AD1. This takes into account CH reboot, network re-attach and message transmission time.

Table 3 - POA delivery period and volumes for Central South Regions for scenario I (up to 200,000 simultaneous outages, capped at 34,000 POAs for processing due to system throttling)



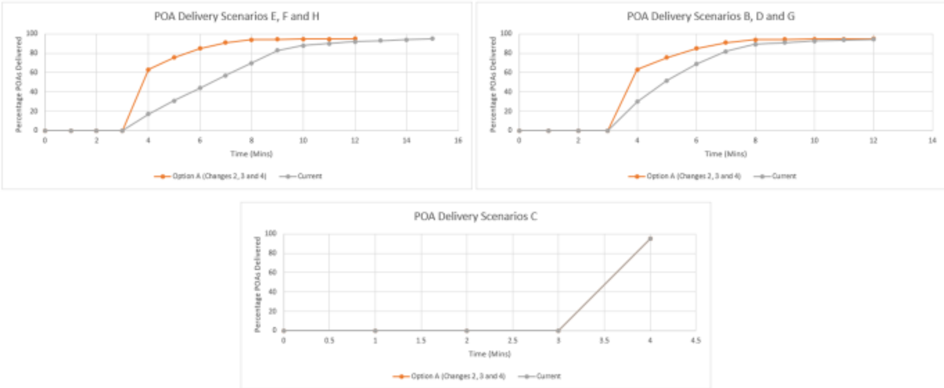
- Option B – Max Perf Enhancement for 2G/3G CH covers combined microservices, reduction in CH reboot times and reduction of dither algorithm.
- For Option B, system needs to wait approx. 4 mins to ensure there are no CH power restore messages arriving before sending out the AD1s. A CH power restore message arriving within 4 mins of the CH power outage message is actually a power outage that lasts < 3 mins and is therefore not an AD1. This takes into account CH reboot, network re-attach and message transmission time.

Table 4 - PRA (8F35/8F36) delivery period and volumes for Central South Regions (all scenarios)



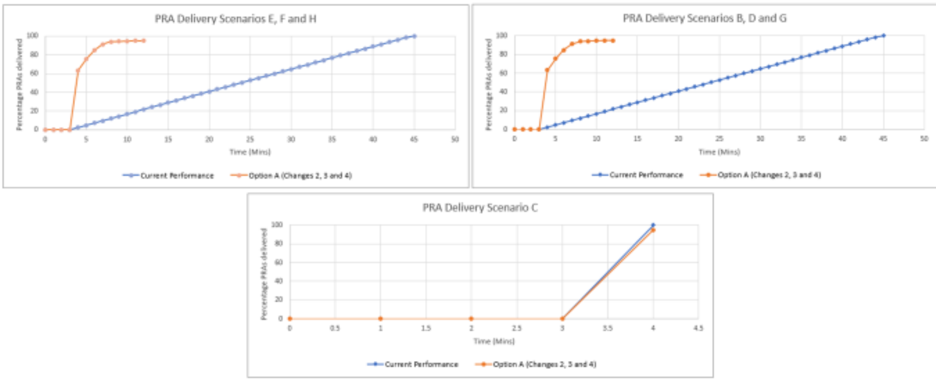
- When power outage occurs, CH can stay on for about 20 seconds before shutdown occurs. Currently, once CH shuts down, 1.5 minutes is required for CH to reboot followed by network re-attach algorithm ranging from 0 – 2 minutes to connect.
- Currently, first 20 seconds of the re-attach algorithm is dedicated to mesh enabled CHs, followed by 100 seconds split into 10 x 10 second slots for the remaining non-mesh CHs. These are evenly split as it uses a single digit based on the CH GUID to determine which CHs can attach.
- Enhancements under Option B involve 40 seconds savings covering 30 seconds reduction in CH reboot time plus 10 seconds reduction in the re-attach algorithm (dither reduction)

Table 5 -7 North Region Performance Enhancement Mapping to DNO Scenarios



Notes: Alert delivery based on modelled performance only. Scenarios B, C, D and G current performance assumed to stay below current 5000 per min throttle. Option B not shown as performance change is minimal.

Table 8 – 10 North Region Performance Enhancement Mapping to DNO Scenarios



Notes: Option A Change 2 introduces the CH PRA. PRA delivery is in addition to current 8F35 and 8F36 alerts and requires DSP to support the message. Based on modelled performance only. Scenarios B, D and G current performance assumes worst case single cell loading. Option B not shown as performance change is minimal.

18 Appendix I – Revised costs for recommended Option 3a & 3b.

Below are the ROM costs, and costs to prepare the FIA for the improvements associated to the recommended option 3, a & b. (As described in the DCC Recommendations Paper version 3 and MP096 Request for information document.) The ROM costs excludes post PIT implementation costs which depend on the delivery channel. All costs quoted below are indicative only and are subject to Full Impact Assessments being conducted.

		Option A	Option B
Title	Cost to Prep FIA	ROM costs	
Cloud Based Micro service	£X	£x	£x
CH Reboot	£X		£x £x
Reduce the CH dither	£X		£x £x
Additional alert channel	£X	£x	£x
Relax Alert Throttling	£X	£x	£x
Modify CH time window	£X		£x
PRA from the CH	£X	£X	£X
Send PRA from the CH	£X		£X
Additional motorway	£X	£X	£X

ROM Total	£X	£X
Prep FIA Costs	£X	£X