Utility Spectrum Options Call for Input

1.0 Executive Summary

The Energy Networks Association Strategic Telecommunications Group (ENA-STG) and the Joint Radio Company (JRC) welcome the opportunity to provide this joint input to the Ofcom Utility Spectrum Options Call for Input. In terms of the profound transition that is underway within the UK Energy Sector Ofcom has correctly identified the dramatic changes to the energy supply and demand context being led by Government Policy – notably the programme to deliver 'Net Zero.' Whilst from an energy system perspective Ofcom has emphasised the changes underway in the Electricity context it is also important to acknowledge the considerable transformation anticipated in the gas context, in particular the plans being developed for Hydrogen as a green alternative to natural gas which will bring significant complexity to the operating model of the gas network operators and add to the need for enhanced operational control capability.

Noting the spectrum options under consideration we welcome the emphasis placed on sub 1 GHz spectrum options aligned to 3GPP designated bands. The approach adopted to assess the suitability of the bands is very constructive and addresses the core considerations. We recognise that with any bands there will be constraints and complexities to be worked through and Ofcom have successfully identified the aspects to be addressed. In terms of the sub 1-GHz frequency options the ENA-STG Members and JRC have undertaken extensive studies / analysis to establish the performance / capability of the LTE technology relative to the existing and known future use cases from an enhanced operational control perspective and have responded in detail on the individual bands. To this end we note that the sub 1-GHz bands are well aligned to the needs of the Energy Network Operators and therefore encourage Ofcom to further explore the potential for these bands to be made available to enable the 'Net Zero' transition. For the 1900MHz band we encourage Ofcom to continue with the initiative underway to recover this spectrum and redeploy it noting that it has the potential to be complementary to the sub 1-GHz spectrum over the long term to address the operational needs of urban areas where asset density will be high and the OT network will be capacity constrained. For the spectrum at 800 MHz we suggest that this spectrum be de-prioritised for future work as it is not currently designated a 3GPP band.

From a coverage perspective we note Ofcom's perspective that there is little difference between the propagation performance of the 700 MHz spectrum band relative to the 400 bands particularly when the 700MHz network design has been optimised. Whilst our analysis suggests that there is a modest underperformance relative to the 400 MHz bands we would need to explore whether the optimisation options were appropriate / relevant to the operational roll-out of the solution – in particular noting that the performance of the radio network is intended to always guarantee performance at the edge and we are keen to work with Ofcom to refine the understanding of coverage and performance from the perspective of guaranteeing connectivity to the edge device.

From a capacity perspective we note Ofcom's approach to approximate use cases to allow it to establish the spectrum requirements. We believe that as a first approximation this is a sensible approach. To establish the real-world performance of the LTE system a trial network has been deployed in the Taunton area which has been used to demonstrate the capability of the system to support a range of applications / use cases, including remote video. This active deployment of the LTE solution running live applications has confirmed that the minimum frequency allocation that would be appropriate to address the known use -cases / applications specific to the Energy sector would be 2 x 3 MHz.

UK Economic Development is predicated on robust and resilient energy supplies – for an increasingly dynamic energy supply system operational communications will have a crucial role in balancing supply and demand and ensuring stability of the energy networks whilst facilitating increased supply from

Distributed Energy Resources (DERs) and the expansion of demand from Electric Vehicles (EVs)[1]. This functionality will be enabled by the widespread deployment of active, resilient control systems with enhanced and resilient data communications key to managing these energy flows. To this end, secure and expanded access to dedicated radio spectrum for Energy Utility Networks is a critical component of their future operating model and to enabling the 'Smart Grid' that is central to the UK Government's ambitions for a 'Net Zero' future. In this context it is worth acknowledging the significant near-term policy outcomes that have been established in UK law, notably;

- Sale of new petrol and diesel vehicles to be banned from 2030, with hybrids to follow in 2035, *leading to a greater dependency on Electricity;*
- Gas boilers to be banned from new housing in 2025, and households will no longer be able to buy gas boilers from 2035, *leading to an increased dependency on Electricity;*
- Net Zero Power System 2035 (subject to security of supply), *much more Distributed Energy Resources (Renewables) typically embedded below the Transmission Layer and intermittent.*

To facilitate these outcomes the Energy System will need to pivot from fossil fuels to Renewables as demand swings to an increasing dependency on electricity. This profound change to the demand context will be dependent a more adaptable and flexible Energy System, subject to enhanced operational control and integrity. Ofcom has made good progress in establishing the key criteria specific to addressing the spectrum access needs of this profound system change – but noting that the above outcomes are dependent on fundamental system change we encourage Ofcom to recognise the urgency with which this spectrum access arrangement needs to be progressed. The climate change driven extreme weather events[2] of 2023 are a stark reminder of the significance and urgency of this work.

[1] Need for Increased Spectrum Allocation and Investment in Operational Telecommunications (OT) to Support Electricity Networks to facilitate the 'Net Zero' transition, Position Statement of the Energy Networks Association Strategic Telecommunications Group, Jan 2019 Electricity Networks Brochure (LINKED) jan (energynetworks.org)

[2] The world's most extreme weather events in 2023 https://www.theweek.co.uk/news/environment/960113/the-worlds-most-extreme-weather-events-in-2023

2.0 Background

The Energy Networks Association (ENA, www.energynetworks.org)

Energy Networks Association (ENA) represents the 'wires and pipes' transmission and distribution network operators for gas and electricity in the UK and Ireland. Our members control and maintain the critical national infrastructure that delivers these vital services into our homes and businesses.

ENA's overriding goals are to promote the UK and Ireland energy networks ensuring our networks are the safest, most reliable, most efficient, and sustainable in the world. We influence decision-makers on issues that are important to our members. These include:

- Regulation and the wider representation in UK, Ireland and the rest of Europe.
- Cost-efficient engineering services and related businesses for the benefit of members.
- Safety, health and environment across the gas and electricity industries.
- The development and deployment of smart technology.

As the voice of the energy networks sector ENA acts as a strategic focus and channel of communication for the industry. We promote the interests and good standing of the industry and provide a forum of discussion among company members.

The ENA-STG (Strategic Telecommunications Group) provides opportunities to exchange information and best practice in the key elements of telecommunications[3] in electricity and gas distribution networks.

The Joint Radio Company (JRC, www.jrc.co.uk)

Joint Radio Company Ltd is a wholly owned joint venture between the UK electricity and gas industries specifically created to manage the radio spectrum allocations for these industries used to support operational, safety and emergency communications.

JRC manages blocks of VHF and UHF spectrum for Private Business Radio applications, telemetry & telecontrol services and network operations. JRC created and manages a national cellular plan for co-ordinating frequency assignments for several large radio networks in the UK.

The VHF and UHF frequency allocations managed by JRC support telecommunications networks to keep the electricity and gas industries in touch with their field engineers and remote assets. These networks provide comprehensive geographical coverage to support installation, maintenance, operation and repair of plant in all weather conditions on 24 hour/365 days per year basis.

JRC's Scanning Telemetry Service is used by radio based Supervisory Control And Data Acquisition (SCADA) networks which control and monitor safety critical gas and electricity industry plant and equipment throughout the country. These networks provide resilient and reliable communications at all times to unmanned sites and plant in remote locations to maintain the integrity of the UK's energy generation, transmission and distribution.

JRC also manages microwave fixed link and satellite licences on behalf of the utility sector.

JRC supports the European Utility Telecommunications Council's Radio Spectrum Group, and participates in other global utility telecom organisations. JRC participates in European Telecommunications Standards Institute (ETSI) working groups developing new radio standards, and European telecommunications regulatory groups and workshops.

JRC works with the Energy Networks Association's Future Energy Networks Groups assessing ICT implications of Smart Networks, Smart Grids & Smart Meters, is an active member of the Energy Networks Association Strategic Telecoms Group and is an acknowledged knowledge source for cyber-security in respect of radio networks.

[3] Operational telecommunications – Energy Networks Association (ENA)

3.0 The Broader Context:

The 'Net Zero' Transition and the need for enhanced visibility and control of Energy Network Assets

3.1 Introduction

UK Energy Networks are undertaking a transition from centralised energy generation to a model where energy generation is distributed via a larger and more diverse range of generation sources resulting in a shift from a passive to an active or "Smart Grid" where energy flows in two directions. This shift to an active and distributed grid demands a greater level of intelligence and interconnectivity (sensors, communications and control) and automation across the entire distribution network, to ensure co-ordination, efficiency, responsiveness, safety, security and resilience of supply.

Figure: A vision of the new Smart Grid infrastructure with greater diversity and interconnectivity

Source: European Commission

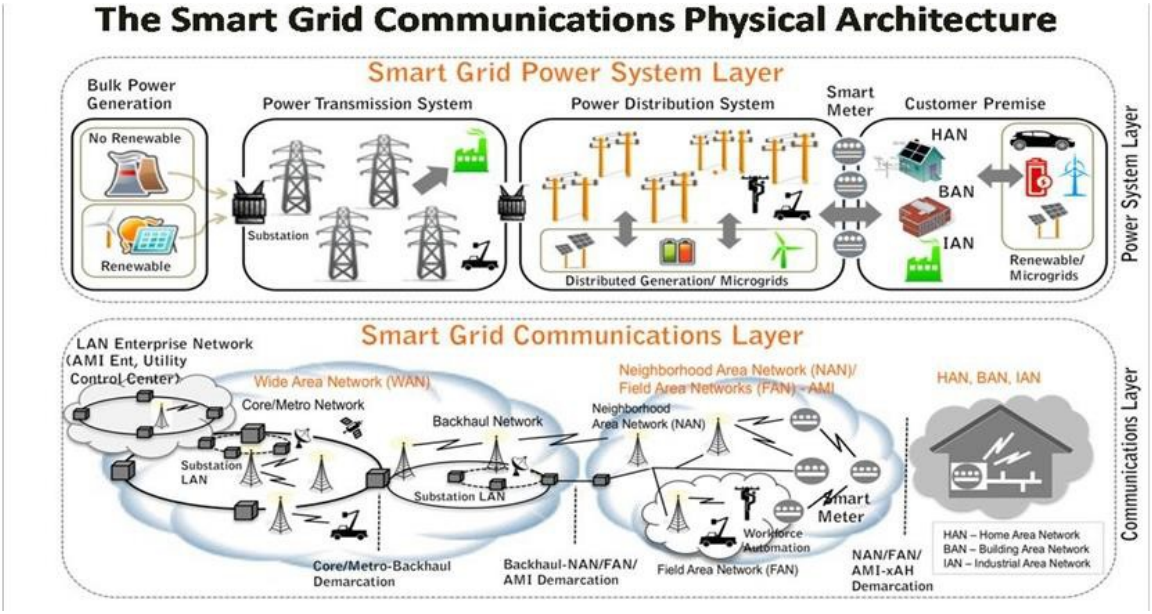
3.2 The need for Enhanced Operational Control is a product of the Change in the Supply and Demand Context

Historically, energy networks have largely been passive composed of only a small number of active control components at the High Voltage layer (i.e. above 33,000 volts). The operational telecommunications systems used in these systems have typically been narrowband, employing a mixture of wired and wireless connectivity solutions. In the case of wireless connectivity, a relatively limited amount of radio spectrum has been utilised to date to support these legacy needs. The centralised or 'top down' approach of energy supply required no visibility for control purposes of what was happening at the edges of the network (Low Voltage - LV) and relatively limited visibility at Medium Voltage (MV). However, as the UK's energy networks become more dynamic both from a supply and demand perspective – incorporating distributed generation and storage alongside the adoption of high energy-consumption but low carbon emitting technologies like electric vehicles and heat pumps – there is an increased need for active control. For electricity this will require control components within the medium and low voltage layers – effectively turning the monitoring and control (and connectivity) hierarchy upside down. I.e. rather than requiring connectivity at low data rate to a small number of very large, centralised, critical assets, the future scenario will require higher bandwidth connections to a much larger number (100 x) of distributed assets each of which will play a critical part in the future network (individually & collectively) with the number of wireless

connections expected to grow significantly leveraging their cost effectiveness and flexibility. Within the Gas networks additional capability is required as hydrogen and other green gases are added to the mix of the energy system.

This significant increase in the number of connected assets will result in a dramatic increase in data flows necessary to operate the energy system in real time, requiring a corresponding expansion in the need for connectivity including use of radio spectrum-based solutions.

Figure: IEEE graphic of the Smart Grid Power Layer overlaid on the telecoms layer



Source: IEEE

3.3 Enabling a Dynamic Energy Supply Solution through enhanced Operational Telecommunications Capability

Wireless based communication systems have always been a critical component of the operational Command and Control systems of the Energy Networks. The need for enhanced operational communications solutions has been under review for the past 5 years or more both in the UK and Internationally. In the UK, Ofcom's project 'Strategic Review of Utility Operators Spectrum Requirements' has been a significant development which has been contributed to by Joint Radio Company[4] and ENA-STG[5]. With this Call for Input Ofcom have taken a significant step towards addressing the future Operational Telecommunications requirements of the UK Energy Sector. It is also important to acknowledge that Government departments, The Department for Science, Innovation and Technology (DSIT) and The Department for Energy Security and Net Zero (DESNZ), are actively engaged in responding to the developing needs of the Energy Network Operators through the 'Net Zero' transition programme. One common theme that regularly needs to be addressed when exploring the needs of the Energy Network Operators with policy makers is the limitations[6] of publicly available communications services to address the critical operational needs of the sector, i.e. resilience to mains power failure, reach, guaranteed QoS and availability, etc. To this end JRC commissioned research by Gemserv[7] to establish the potential benefits and costs of an enhanced operational control solution via three different approaches: fibre, public cellular and private wireless. The Gemserv analysis clearly demonstrates the private wireless solution to be the most cost effective

[4] Joint Radio Company a joint venture between National Grid and the Energy Networks Association

[5] ENA-STG, Energy Networks Association Strategic Telecommunications Group

[6] 'Operational Control of Mission Critical Networks and the Service Limitations of Public Mobile Networks (JRC White Paper)' https://www.jrc.co.uk/Plugin/Publications/assets/pdf/ICT-Operational-Control-of-Mission.pdf

[7] 'Economic rationale for enabling Smart Grid functionality of the UK energy system via a Private Radio Frequency based enhanced Operational Communications Solution,' Gemserv, 19 November 2021. https://www.jrc.co.uk/Plugin/Publications/assets/pdf/ICT-Economic-rationale-for-enabling-Smart.pdf

and capable option at a cost one twelfth of the benefit that would be realised – an annual net saving of £25 on every household's energy bills. JRC and the ENA-STG are committed to working closely with Policy Makers to ensure that the appropriate Policy Interventions are enabled, e.g. dedicated spectrum access to facilitate the 'Net Zero' transition. It is noteworthy that this study did not include analysis of the avoided costs of the 'do nothing' scenario – i.e. simply building a much larger passive or 'dumb' network. It is anticipated that if those costs were factored in then the saving per household would be many times greater than the £25 indicated. Separately, It has been estimated[8] that without a smarter solution, the UK could need to invest between £10 Billion and 15 Billion per year reinforcing the passive network.

3.4 'Net-Zero' Prioritised by UK Government

Government policy which has been enshrined in law is driving significant change in terms of the UK Energy System;

- Ban of the sale of combustion engine vehicles from 2030[9] and hybrid vehicles from 2035[10]
- Gas boilers to be banned from new housing in 2025, and households will no longer be able to buy gas boilers from 2035[11]
- Focus on green Hydrogen as an alternative heat source to Natural Gas[12];
- Net Zero power system by 2035[13].

Such profound market changes will be dependent on the energy networks being able to dynamically control energy flows dynamically from Distributed Energy Resources to Electric Vehicles and other low carbon technologies, e.g. Heat Pumps, with the number of EVs alone forecast to grow to 11m by the end of the decade. Independent of the opportunity that is afforded by access to spectrum, as has been enabled in Ireland, Germany, Poland, Spain, etc.[14], the UK Energy Network Operators will be unable to deploy a dedicated and shared resilient communications layer to enable the 'Smart Grid' functionality that is essential to deliver 'Net Zero,' in particular the provision of resilient operational control telecommunications capability to assets within the Low Voltage (LV) layer of the DNO Networks. In addition, we note the World Economic Forum in their recent publication[15],

Alongside the above Energy Policy related Government interventions it is also worth noting the recent spectrum policy statements from Government specific to the needs of the Energy Sector;

- In April this year, the Department for Science, Innovation & Technology published their long-awaited radio spectrum policy statement. In this statement, the Government officially recognised that radio spectrum will play an important role in enabling the digital connectivity needed for future low carbon energy networks. The statement details that the UK is

  > *"..moving towards a smarter, more flexible and more integrated energy system which will require significantly enhanced connectivity and digitalization throughout the network to support the coordination, automation and control of energy network assets Certain communications functions may require enhanced power resilience and reliability. If meeting these or other requirements is best served by private wireless networks, the identification of suitable and sufficient spectrum may be necessary".*

  Importantly, the Department says that they are

[8] https://eandt.theiet.org/content/articles/2022/09/analysis-is-the-electricity-network-ready-for-an-ev-revolution/

[9] https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

[10] https://www.gov.uk/government/news/government-takes-historic-step-towards-net-zero-with-end-of-sale-of-new-petrol-and-diesel-cars-by-2030

[11] https://www.gov.uk/government/publications/heat-and-buildings-strategy

[12] https://www.gov.uk/government/publications/uk-hydrogen-strategy

[13] https://www.gov.uk/government/news/plans-unveiled-to-decarbonise-uk-power-system-by-2035

[14] https://www.comreg.ie/comreg-completes-the-400-mhz-spectrum-award/, https://450alliance.org/ericsson-chosen-to-deliver-ran-and-core-network-solutions-for-pges-lte450-mission-critical-network/ , https://450alliance.org/nokia-chosen-by-450connect-to-supply-network-technology-for-lte450-critical-infrastructure-network-in-germany/, https://www.boe.es/buscar/doc.php?id=BOE-A-2020-8286

[15] https://www.weforum.org/reports/future-series-cybersecurity-emerging-technology-and-systemic-risk

"working closely with the Department for Energy Security and Net Zero, Ofcom and Ofgem to assess the energy (and wider utility) sector's communications requirements and ensure that timely decisions are taken on any resulting spectrum needs".

- Alongside this Policy Statement in April 2023, the Department published the UK Wireless Infrastructure Strategy. The document recognises how the shift to Net Zero is increasing the need for increased monitoring, control, protection and automation across the entire network. It states that a

  "significant component of the increased connectivity requirement of electricity DNOs is likely to need to be addressed by private wireless networks – particularly to cover critical monitoring, control and teleprotection functions which require high levels of availability and power independence over a number of days".

  The strategy document goes on to say,

  "Alongside the Department for Energy Security and Net Zero, and as part of the Energy Digitalisation Strategy, we will continue to encourage collaboration between telecoms and utilities providers to support the digitalisation of the energy sector".

Following these developments, the Department for Energy Security and Net Zero announced a review of the communication options available to address the requirement for a robust and resilient smart energy grid.

The review will look at technical viability and financial costs of a range of communication options, supporting the use cases for the energy sector as it transitions to Net Zero, including the potential requirement for radio spectrum access.

Finally, it is worth noting that Ofgem in their RIIO-ED2 final determination,[16] which defines the regulatory funding mechanism and obligations applicable to the GB Distribution Network Operators (DNOs), acknowledged the potential for spectrum access during the ED2 Period and advised that the Digitalisation re-opener mechanism would be the appropriate funding mechanism to use.

These are very welcome developments. Both the Government and the Regulator (Ofgem) recognise the potential role that dedicated radio spectrum access can play in delivering the Energy System Transition and 'Net Zero.'

[16] Page 212 Para. 6.275, https://www.ofgem.gov.uk/sites/default/files/2022-11/RIIO-ED2%20Final%20Determinations%20Core%20Methodology.pdf

4.0 JRC's Detailed Response to Questions

Question 1: Have we correctly identified the key changes in the utilities sector that could lead to additional spectrum requirements?

JRC Response

Confidential? No.

Ofcom have acknowledged the Energy Transition and the significant changes anticipated to the supply and demand of electricity in the UK which will lead to the need for enhanced operational control of the electricity networks referencing the original narrative document prepared by the ENA-STG in 2018 which was based solely on input by the Distribution Network Operator. As the 'Net Zero' policy landscape has developed the ENA-STG has revised the narrative document[17] to acknowledge the needs of the gas sector to acknowledge the potential role of Hydrogen[18] and with it the importance of enhanced visibility and control over gas network assets for real-time monitoring of gas mixture. It is important to emphasise here as outlined in the narrative document that the Energy Network Operators have traditionally used private networks designed to address the operational needs of the Energy Sector, in particular the regulatory obligations imposed on the network operators to be able to maintain operational integrity even when mains power has ceased. The operational communications enable critical system functionality of the networks allowing outages to be responded to and rectified in line with regulatory response times. Furthermore, the Storm Arwen review noted the DNOs private OT systems were able to maintain function when all public communications networks were taken out by the storm. As we move towards an economy that is increasingly dependent on secure and reliable electricity supply it is imperative that the energy network operators are afforded access to spectrum access to enable the smart grid transition based on enhanced operational capability.

Question 2: What alternative communication solutions might play a role in meeting the future operational communication needs of the utilities sector, alongside or instead of additional spectrum for a private network?

JRC Response

Confidential? No.

The energy networks have deployed a broad range of communications technologies to facilitate their operating model over the last 50 years leveraging both public and private solutions subject to the functionality, availability, and cost of the solution. There are profound capability gaps of the commercially available platforms, i.e. coverage, availability, reliability, QoS, etc., in terms of serving the critical operational use cases that are central to the operational integrity of the Energy Networks, e.g. Automation Solutions, 'smart' Active Network Management (ANM), Distributed Energy Resource Connections and enabling Electricity System Restoration. The choice of communications solution for these critical applications / use cases is dependent on guaranteed functionality including power resilience in the event that mains power is lost. To ensure critical system functionality, i.e. resilience and security, the Energy Network Operators have historically deployed private networks involving fixed fibre, fixed links and wide area radio networks to enable SCADA[19] system functionality to remote assets. The radio spectrum that has afforded this functionality is dedicated to the Energy Networks requirements in the 450-470 MHz range but is limited to 2 x 1 MHz and 12.5 kHz channel width and hence not capable of addressing the substantial increase in connected assets and traffic requirements associated with smart grid functionality. Therefore, deployment of a National Private shared utility LTE network has been prioritised to address the discrete use cases of UK Utilities including secure and resilient wide area voice. Such a solution would afford scale economies to the difficult to serve and high

[17] Energy Networks Association revised ENA-STG Narrative, March 2022. https://www.energynetworks.org/publications/stg-spectrum-narrative-document

[18] A hydrogen vision for the UK, April 2023, https://cdn.prgloo.com/media/7d00b2386ec0400ab38308972232b524.pdf

[19] Supervisory Control and Data Acquisition (SCADA) is a control system architecture comprising computers, networked data communications and graphical user interfaces for high-level supervision of machines and processes maintaining efficiency by collecting and processing real-time data.

resilience needs of the UK Energy Network Operators ensuring a cost-effective outcome where the costs are spread across all UK Network Operators (Electricity, Gas and Water). Noting that Mobile Networks have not been designed with a guaranteed level of power autonomy, whilst power resilience will have been deployed to the core network and switches, the radio base stations rarely have power resilience deployed as noted by Vodafone at the joint Energy Networks / Telecoms working group hosted by DSIT. Furthermore, we understand that power resilience has only been targeted at a relatively small proportion, circa 20% of Base Stations, for the Emergency Services Network (ESN), due to the challenging economics of additional roll out and the inherent logistical challenges of locating power back-up for roof-top systems, monopoles, street works etc. In summary, Commercial Mobile Networks have not been designed to have power resilience and it would be impractical and uneconomic to retrofit in many locations. Furthermore, Commercial Operators target their services to population coverage rather than the needs of the Network Operators and they have no imperative or regulatory requirement to serve the needs of infrastructure operators in remote / difficult to serve locations of little economic value to them.

Gemserv[20] in their economic analysis explore the potential for alternative technologies to address the critical 'smart grid' operational communications requirements of the Energy Network Operators. The technologies analysed were; fixed fibre, public mobile and private radio network. Gemserv observe that the increased functionality and performance that will be realised through an enhanced operational control capability is outlined below;

- *Managing more granular data from more network assets regarding the operation of their networks, to gain visibility of network utilisation and facilitate more effective network planning, operation and enhanced asset utilisation.*
- *Enabling the near real time ability to reconfigure parts of the network to better manage energy flows, or to isolate faults, etc.*
- *Real time operational technology to protect the network in fault circumstances.*
- *Receiving and acting upon alerts from network assets to warn of potential and actual network faults.*
- *Communicating with generation, storage or consumption for system balancing or voltage management.*
- *The opportunity to use embedded generation to facilitate the Electricity Restoration Process.*
- *Enable local market mechanisms to be established for energy provision.*
- *Establish mechanisms for balancing locally.*

Gemserv's analysis notes that the Private Radio solution is the most cost-effective solution (subject to spectrum access) at £960m, the Commercial Mobile solution was estimated to cost £2.4bn[21] whilst the fixed fibre alternative proved to be uneconomic, i.e. cost more than the savings to be realised.

Last Mile Connectivity – Economics of New Wireless (Private LTE) versus New Fibre

A simple approximation of the economics of a private wireless solution relative to a fixed alternative considers the cost of new fibre deployment.[22] The DNO Private LTE analysis undertaken by JRC allows us to determine the appropriate number of assets that can be served by an individual LTE base station - see analysis provided below which is an extract from Annex 2 of the ENA-STG input[23]. The maximum number of outstations per sector would be 300-350, but over a significant mixed area we might expect the average to be half that, i.e. 150-175 per sector to support the rate of response needed to ensure the operational integrity of the network. We understand the typical costs for a LTE Base Station deployment including a 3 sector antenna system to be £57,500 and hence the 'last mile' connectivity

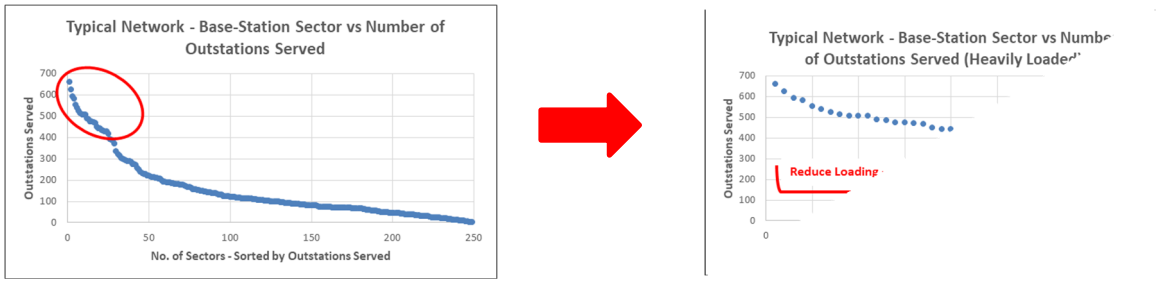
[20] Gemserv Study: Economic rationale for enabling Smart Grid functionality of the UK energy system via a Private Radio Frequency-based enhanced Operational Communications Solution https://www.jrc.co.uk/Plugin/Publications/assets/pdf/ICT-Economic-rationale-for-enabling-Smart.pdf

[21] The Commercial Mobile solution is dependent on the deployment of power back-up solutions, i.e. UPS / Generators, to Base Stations it is anticipated that for the majority of Base Stations this will not be physically possible due to lack of land, physical security and consent.

[22] BT quote to a DNO a new fibre run cost £57.3k per km at 2015 prices.

[23] ENA-STG Response to Ofcom Spectrum for Utilities Questions FINAL.docx, 07 May 2020

cost per asset per Base Station would be £109 - £127. Alternatively, it is possible to connect up to 525 assets via the Private LTE wireless solution for the equivalent cost of 1 km of fibre run.



Noting that the Energy Network Operators both Gas and Electricity are obliged by Ofgem through the regulatory framework to ensure that the cost to the end consumer is minimised and hence the Private LTE solution (subject to spectrum access) being orders of magnitude cheaper than new fibre as a 'last mile' solution would be prioritised.

Question 3: Are there any other spectrum bands we should consider for use by utilities?

JRC Response

Confidential? No.

Ofcom have captured the relevant bands in particular the frequency options below 1 GHz that are aligned to 3GPP bands and hence offer the potential for a significant ecosystem of devices Internationally. The other frequency range that may have relevance in the future is the 380-400 MHz range whilst this is currently occupied by voice communications for the PPDR community once they have transitioned to the broadband solutions under deployment with the Emergency Services Network (ESN) it is anticipated that the legacy Tetra capability will be withdrawn freeing up the spectrum at 380 – 400 MHz.

Question 4: Do you have any comments on the three bandwidths we have considered that might be necessary to support a private network for utilities? Please reference our capacity analysis in annex 7 where relevant.

JRC Response

Confidential? No.

Whilst 2 x 1.4MHz (FDD) channel width is the minimum possible width from an LTE perspective and could in principle accommodate some degree of functionality both data connectivity and voice the extensive analysis undertaken by JRC and National Grid Electricity Distribution (NGED)[24] has demonstrated that the minimum spectrum requirement is 2 x 3MHz (FDD) or 1 x 5 MHz (TDD). The detailed radio design was intended to facilitate connectivity to the vast majority of NGED's distribution substations (circa 200,000) to enable a range of outcomes as summarised below aligned to its regulatory obligations;

- *Connect more embedded electricity generation into the distribution network whereas previously generation was usually connected into the transmission network;*
- *Reduce the costs associated with connecting generation to the distribution network to encourage more renewable generation which is often located in places with insufficient network capacity to carry the load;*
- *Facilitate demand management to enable loads to be connected flexibly to the network to avoid the costs of re-enforcing the electricity network and building expensive peak power generation plant;*
- *Enable new demands to be managed as we move towards a zero-carbon economy with the electrification of transport and heat, plus new innovative demands in the electricity network;*

[24] Ofgem funded Network Innovation Allowance Next Generation Wireless Telecoms Analysis, 22 January 2020. https://www.jrc.co.uk/Plugin/Publications/assets/pdf/ICT-Final-Report-published-after.pdf

- *Improve the reliability and quality of electricity supplies as we become a digital nation ever more dependent on a reliable supply of electricity;*
- *Ensure a sustainable and affordable supply of electricity for consumers and the economy;*
- *Enhance asset life and reduce maintenance costs through more intelligent monitoring of infrastructure; and*
- *Enable innovative new market mechanisms to flourish.*

To further develop NGED's / JRC's understanding / expertise with LTE system capability a trial network was deployed to refine the technical understanding of the actual propagation / performance characteristics of LTE in the real world,[25]

Core System Performance Objectives

The core system performance objectives and outcomes of this Ofgem Innovation funded project are summarised below:

- *Confirmation that LTE is a suitable solution for providing data and voice communications for the energy industry;*
- *Confirmation on bandwidth requirements;*
- *Confirmation on types of data that can be passed over an LTE system;*
- *Calibration of propagation predictions and performance in a multi-site environment;*
- *Seamless interoperability of multi-vendor CPE and EPC equipment;*
- *Testing of mobile and handheld device connectivity including Wi-Fi;*
- *Robust modulation techniques capable of performing in challenging RF environments;*
- *Ability to support ever-changing cyber security threat landscape; and*
- *Potential to support independent traffic streams over a single Radio Access Network (RAN);*

Outcomes

- *The distribution of measured vs predicted signal levels for each sector (eNodeB) matched expectations. This allowed the correct RF performance of the installed network to be confirmed and concluded that the actual received signal levels closely align with the respective received signal level predictions generated;*
- *The project successfully integrated multi-vendor CPE's seamlessly with existing RAN and core components;*
- *The project successfully connected Mission Critical Push to Talk (MCPTT), and fixed telephony Voice, over IP (VOIP) equipment across the LTE network. Inter-system test calls, including mobile voice and mobile video connectivity via Wi-Fi connections to the CPE, were also established;*
- *The project has demonstrated that LTE is a suitable solution to provide a diverse range of services / applications to address the expanding operational communications needs of the Energy Network Operators. The trial network successfully carried voice, data, and video from a number of substations back to the central test lab, connected to various application servers. In addition, testing and analysis was carried out to evaluate traffic flows and resource usage, alongside the demonstration of traffic shaping techniques such as Quality of Service (QOS) and priority queueing;*
- *Bandwidth requirements – the LTE system was configured to operate in a 2 x 3 MHz FDD channel. Evaluation of channel usage and bandwidth requirements was undertaken and concluded that 2 x 3MHz is an absolute minimum bandwidth necessary to address the operational communications system requirements of NGED; and*
- *It was demonstrated that the LTE system was able to carry a diverse range of data based applications including, H.264 compressed video, SIP's and VOIP telephony, MCPTT voice, DNP3*

[25] https://www.nationalgrid.co.uk/downloads-view-reciteme/596479

and IEC870-5-104 SCADA data, Simple Network Management Protocol (SNMP), Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) data streams, Hypertext Transfer Protocol (HTTP) and Hypertext Transfer Protocol Secure (HTTPS), and File Transfer Protocol /Secure File Transfer Protocol (FTP/SFTP) file transfers.

- *It was demonstrated that the LTE solution could very significantly outperform narrow band systems in terms of robust communication in a wide range of non-ideal RF conditions (mainly due to OFDM modulation techniques). Several of the remote sites in the LTE trial could not be connected at all by legacy narrow band solutions in the same frequency band.*

Considering the above extensive and detailed work that has been undertaken from an Energy Networks Operator perspective the minimum spectrum allocation to address the operational communications needs would be 2 x 3 MHz based on the current 'known' applications and use cases.

In terms of Ofcom's analysis we note the higher bandwidth requirements associated with the application 'CCTV' and whilst remote video monitoring has been demonstrated on an isolated basis in the Taunton Trial it has not been considered a core application at this time – hence the observation regarding 2 x 3MHz of spectrum. If such a bandwidth hungry application were to be required on a widespread basis in the future, i.e. "CCTV" could be considered a proxy for such a potential future bandwidth hungry application then clearly the bandwidth requirements of the Energy Network Operators would be in excess of the 2 x 3 MHz that has been established through this work and worthy of consideration. Furthermore, the work undertaken here whilst focused on the extensive operational communications needs of a DNO it is anticipated that the 2 x 3 MHz would also be able to accommodate the OT requirements of the Gas community noting that their requirements are anticipated to be modest in comparison. However, as we do not have visibility of the requirements of the Water sector, we are not able to judge whether their requirements would be accommodated and hence should be considered outside of this 2 x 3 MHz minimum. Nevertheless, we are keen to work with the Water sector alongside Ofcom to better understand their requirements and whether they can also be accommodated within the minimum identified of 2 x 3 MHz.

Question 5: Do you have any comments on our approach to examining each potential candidate spectrum band, including the factors relevant to assessing suitability, and the capacity and coverage analysis provided in annexes 7 and 8?

JRC Response

Confidential? No

The approach adopted by Ofcom to assess the viability of the candidate bands to address the operational telecommunications needs of the Energy Network Operators at a macro level picks out the key criteria. However, there are some subtle micro-level factors worthy of consideration when exploring the individual bands which we note against the specific criteria. When considering bands such as the 450-470 MHz band from an existing uses / utilisation perspective there would be merit in revisiting and updating the previous analysis undertaken to ensure that the perceived complexity of any possible re-plan of the band is informed by the latest usage data. One of the principle drivers behind the pre-disposition towards 3GPP designated bands is that this will afford two fundamental benefits, (i) that there will be an International device ecosystem that will drive scale economies; and (ii) the adoption of an Internationally aligned standard will allow the Energy Network Operators to be in control of Technology Risk over the long term with the scope for the Industry to benefit from technology enhancements as the standard evolves over time.

Additionally, Ofcom's coverage analysis appears to only consider downlink connectivity (base station to edge device UE) whereas the asymmetry of base station to UE transmit power will generally result in the uplink direction being the determining factor in useful coverage radius. We acknowledge that currently there is work underway in 3GPP to create a higher power class of UE for industrial uses which may partially address this in due course.

Appraisal of specific criteria by band relative to Ofcom's Perspective;

400MHz (NI only), 2 x 3 MHz as a minimum will need to be accessible, refer to response to Question 4, hence we encourage Ofcom to consider how to address the co-ordination risk inherent in this option.

Perspective	Equipment ecosystem	What needs to happen to enable use for a private network	Preliminary view of associated costs	Illustrative timing for accessing the band
Ofcom Perspective	• Widely available (and increasing) LTE and utilities specific equipment	• To access lower 2x2 MHz pair - share / coordinate with PSNI's current limited use, otherwise depends on whether PSNI ceases using the band in future • To access upper 2x2 MHz pair - commercial arrangements (i.e. through spectrum trading or leasing) with current licensees (Arqiva / Airwave) • To access either or both lower and upper pairs - work with MOD to understand arrangements necessary (if any) to protect Fylingdales radar, and other MOD use	• Lowest site build costs • Lower equipment costs; • Uncertain if any migration costs.	• **Lower pair** - <5 years if able to share, or if PSNI ceases use; • **Upper pair** - <5 years if agree commercial access with Arqiva / Airwave.
JRC / ENA-STG Perspective	Agreed and alignment to the solution in RoI but would not benefit from the scale of demand in GB market.[26]	• We have only limited visibility of the PSNI use and that the spectrum access affords flexibility for roaming activities. From a co-existence perspective we encourage Ofcom to engage directly with PSNI to determine how much spectrum the system requires and whether this would accommodate 2 x 1.4 MHz to be accessed for 'smart grid' developments. There may also be merit in reviewing whether the PSNI application could in due course be migrated to the Private LTE solution and thereby removing the constraint on the lower pair; • Availability of the upper pair as has been noted by Ofcom will be subject to agreeing a Trade with the licence holder. In addition, there may be a requirement for Ofcom to consult on a variation to the licence to accommodate the trade of an area licence in NI. • Fylingdales radar / other MOD use. Need to confirm that this is not a constraint. Noting it may have implications for RoI.	• Agree on site build and equipment costs; • Migration costs would be subject to whether PSNI could accommodate co-existence / are able to migrate the application. In addition, the migration costs would include the cost any trade with Arqiva / Airwave.	• **Lower pair**, < 5 years if PSNI are able to share or if PSNI cease use although they have indicated the need for capability at least until they have their 'ESN' alternative. • **Upper pair**, subject to timing for trade and any regulatory changes.

[26] 450 Alliance, 'Annual Device Report' https://450alliance.org/wp-content/uploads/2020/04/450Alliance-annual-device-update-P-rev-A.pdf

450MHz, up to 2 x 5 MHz FDD.

Perspective	Equipment ecosystem	What needs to happen to enable use for a private network	Preliminary view of associated costs	Illustrative timing for accessing the band
Ofcom Perspective	• Widely available (and increasing) LTE and utilities specific equipment	• Consider changes to the spectrum environment since 2017 • Comprehensively assess technical feasibility, cost and benefits of any proposed replan, including the implications for existing users • Consider coexistence arrangements for adjacent Fylingdales radar • For partial replan – migrate some narrowband users. Study extent of filtering and frequency separation required; • For full replan – replan all narrowband users to align with harmonised band plan	• Similar site and equipment costs as 400 MHz band • Significant costs from migrating (some or all) incumbent users	• >5 years for band availability depending on scale and complexity of replan • Certainty of access to the band could be < 5years
JRC / ENA-STG Perspective	Agree mission critical deployments (Utilities and PPDR) are underway in multiple territories with support from multiple highly credible hardware vendors;[27]	• We encourage Ofcom to consider changes to the spectrum environment since 2017 in light of our response to Question 8 and also to establish the extent to which the band is currently used. In particular we feel that the view of LTE as a 'noisy neighbour' in the RF domain warrants renewed study and measurement as the roll off performance of modern LTE systems exceeds specifications[28]. • Agree with the need to assess the viability of a re-plan based on up to date information on current use and future trends; • Co-existence arrangements with Fylingdales will need to be considered in the context of the re-plan and the potential frequency separation between the 'smart grid' solution and the Fylingdales use. • Note the proposed analysis regarding filtering and frequency separation to accommodate a partial re-plan. • A full re-plan has the potential to 'future proof' the band and potentially liberate additional capability	• Agree on site build and equipment costs; • Migration costs would be subject to an up to date understanding of the incumbent use and any costs likely to align with the migration, noting that there may be long term issues of viability of the band.	• > 5years / > 10 years dependent on the extent of the band re-plan. • Agree that certainty of access to the band could be < 5years.

[27] 450 Alliance, 'Annual Device Report' https://450alliance.org/wp-content/uploads/2023/05/450Alliance-annual-equipment-update-2023-P-rev-FINAL.pdf

[28]

700MHz, up to 2 x 3 MHz FDD.

Perspective	Equipment ecosystem	What needs to happen to enable use for a private network	Preliminary view of associated costs	Illustrative timing for accessing the band
Ofcom Perspective	• PPDR device availability increasing but not yet any utilities specific equipment	• Prospective users of band and SDL licensee (EE) to identify commercial and/or technical opportunities for mitigating interference risks, including utilities base stations resilience to SDL transmissions • Utilities to work with manufacturers to develop suitable equipment • Resolve any potential competing demand for the spectrum through sharing arrangements or an Ofcom process to determine optimal use.	• Limited increase on the lowest site build costs of 400/450MHz bands • Higher bespoke equipment costs	• < 5 years as no incumbent users.
JRC / ENA-STG Perspective	• PPDR device development aligns with the needs of Energy Network Operators. Already developing device eco-system as other countries in Europe[29] prepare / are deploying PPDR solutions. Nine[30] utility equipment vendors have confirmed hardware capability to support this band in their current range of ruggedised IEDs & RTUs	• Measures for co-existence of the band with adjacent SDL service to be explored. Testing is underway to better understand the risk / harm. • Vendors are actively developing the device eco-system and once there is greater certainty over access for UK Energy Network Operators the supply chain will respond accordingly. • We have noted the need for a minimum 2 x 3 MHz to address the current use cases / applications specific to the Energy Network Operators and are keen to work with Ofcom and the other relevant Utilities to better understand how their operational needs could be accommodated. **SDL Status in Europe** • A fragmented approach in Member States towards award / release of the 700 MHz band SDL. The SDL block has been awarded in 3 Member States[31], awarded for PPDR in 3 Member States[32], not included in the award of the 700 MHz band for 8 Member States[33] whilst the remaining MSs have no current plans to progress SDL. • No device eco-system for SDL[34] as noted in the CEPT report. • The fragmented access arrangements for 700 MHz SDL cast doubt on whether the system will be meaningfully deployed.	• Agree on site build and equipment costs subject to acknowledging that the scope for optimising the 700 MHz radio design may be limited by the basis of the connection and also the real world performance of the antenna at the outstation. • Equipment costs are anticipated to align with the 400 MHz Bands	• Certainty, circa 1 year • Access, circa 2 years noting the urgency with which the Energy Network Operators have to deliver against Government Policy objectives.

[29] Spain, France, Greece and Germany

[30]

[31] Latvia, Switzerland and Denmark, https://www.spectrum-tracker.com

[32] France, Germany and Spain. https://www.spectrum-tracker.com

[33] Austria, Belgium, Estonia, Hungary, Lithuania, Luxembourg, Portugal and Netherlands. https://www.spectrum-tracker.com

[34] Compendium of information relating to spectrum use, needs, sharing and compatibility within the 470 – 960 MHz frequency band, https://www.cept.org/Documents/cpg-ptd/77816/ptd-23-026-annex-iv-05_draft-cept-brief-associated-compendium-of-information, pg 4 section 1.1.3 IMT.

800/900MHz (NI Only), up to 2 x 3 MHz FDD.

Perspective	Equipment ecosystem	What needs to happen to enable use for a private network	Preliminary view of associated costs	Illustrative timing for accessing the band
Ofcom Perspective	• No 4G/LTE or 5G. Harmonised for GSM-R / FRMCS	• Utilities to work with manufacturers to develop suitable equipment • Resolve any potential competing demand for the spectrum through sharing arrangements or an Ofcom process to determine optimal use	• Similar to 700 MHz	• < 5 years as no incumbent users.
JRC / ENA-STG Perspective	• Not a 3GPP Designated band hence no international co-ordination	• No scale economies to be realised due to lack of international harmonisation; • No device eco-system.	• No International co-ordination and 3GPP alignment hence Network equipment and device ecosystem does not exist hence time and cost would be excessive.	• < 5 years for spectrum access. • > 10 years for equipment subject to significant UK investment.

1900MHz, up to 15 MHz TDD.

Perspective	Equipment ecosystem	What needs to happen to enable use for a private network	Preliminary view of associated costs	Illustrative timing for accessing the band
Ofcom Perspective	• Limited LTE equipment (not utilities specific) • 1900-1910 harmonised for FRMCS	• Mobile base station receivers above 1920 need sufficient selectivity • Utilities to work with manufacturers to develop suitable equipment • Subject to the outcome of our 1900 MHz consultation, potential process to revoke existing licensees and subsequently reallocate spectrum, taking account of any potential for competing demand and sharing between new users.	• Highest initial site build and operating costs • Higher bespoke equipment costs	• >5 years. If licences are revoked, subject to reallocation process, potential to deploy within 5year notice period if spectrum unused
JRC / ENA-STG Perspective	• A 3GPP Designated band but no device ecosystem and not Internationally harmonised for Utility use.	• Subject to release by MNOs • Technical limitations on use constrain its usefulness for Energy Network Operators • International harmonisation of Utility use to drive market for device development; • Co-ordination of Utility use within the band across Europe as a minimum. • Co-ordination with rail sector (if possible) would introduce further technical and regulatory challenges and complexity around GSM-R migration	• High network costs; • Device costs subject to international harmonisation for this use	• Timing of release difficult to judge as no precedent. • > 10 years for equipment subject to significant UK investment. .

Appraisal of Ofcom's Spectrum capacity scenarios model - Annex 7

Initial Observations – Ofcom's approach explores the number of connections / concurrent streams that could be accommodated by a base station sector against three discrete applications, i.e. Data Monitoring & Control, Voice Calls, Video Streams. Whilst in the detailed technical studies and field trials undertaken, we have sought to establish the range and diversity of use cases / applications that can be accommodated which would appear to align well with those characterised by Ofcom it is difficult to do a straight comparison. Nevertheless, the service data rates applied by Ofcom are in alignment with those expected by JRC, we make specific observations against the three categories as follows -

Data Monitoring and Control

This category represents by far the largest volume of predicted connections. The average range of 600 – 1280 bps assumed by Ofcom is reasonable when the Energy Network is in a stable, quiescent state. However, the ratio of peak to average data rate also needs to be considered. During a fault scenario it is possible that RTUs and IEDs (Remote Telemetry Units and Intelligent Electrical Devices) could have peak data rates of between 20 and 50 kb/s. This would be sustainable for a localised fault affecting just one device or one substation but in a storm event it is possible that many devices simultaneously will require a significant increase communications throughput in order to rapidly address the faults. These rates are indicated in the table below -

Network characteristics[35]

Application	Bandwidth	Latency	Reliability	Security
AMI	10-100 kbit/s/node, 500 kbit/s for backhaul	2-15 sec	99-99.99%	High
Demand Response	14 kbit/s – 100 kbit/s per node/device	500 ms-several minutes	99-99.99%	High
Wide Area Situational Awareness	600-1 500 kbit/s	20 ms-200 ms	99.999-99.9999%	High
Distribution Energy Resources and Storage	9.6-56 kbit/s	20 ms-15 sec	99-99.99%	High
Electric Transportation	9.6-56 kbit/s, 100 kbit/s is a good target	2 sec-5 min	99-99.99%	Relatively high
Distribution Grid Management	9.6-100 kbit/s	100 ms-2 sec	99-99.999%	High

It is a reasonable assumption that the majority of data traffic can be scheduled within a certain tolerance in terms of timing. The implementation of IEEE 802.1 p / q QOS and COS parameters will ensure that critical data is prioritised through the RAN, EPC and eventually to the SCADA front end processor (FEP).

Voice Calls

We agree that the use of standard data rate figures ETSI and 3GPP around audio codecs is reasonable and also that the number of simultaneous calls in one area is unlikely to exceed the numbers estimated by Ofcom.

Video Streams

JRC agree that it is unreasonable to expect that a private LTE network for utilities will be capable of continuously carrying multiple video streams. However, we note that the majority of video use (likely to be for security purposes and / or equipment damage) could be very effectively satisfied with a very

[35] Telecommunication Networks for the Smart Grid (2016), Alberto Sendin, Miguel A. Sanchez-Fornie, Inigo Berganza, Javier Simon, Iker Urrutia, Artech House.

slow frame rate (<= 1 frame per second) which is triggered for just a few seconds when an event occurs.) We believe therefore that although not capable of supporting continuous CCTV operation, an LTE network would be capable of supporting very valuable visual confirmation of intruders and / or equipment failure.

Spectral Efficiency

The acknowledgement that utility networks are uplink centric rather than downlink is valuable. This is important when considering the spectral efficiency figures and applying 0.4 bps / Hz tackles three key factors;

- *i) A large percentage of UE devices are likely to be close to the edge of the coverage area of a cell and therefore operating at lower modulation rates with resultant poorer efficiency.*
- *ii) Edge devices have considerably less power than base station transmitters – the majority are limited to 'Power Class 3' (23dBm) although there is a work item in 3GPP to eventually create a higher power class (31dBm) https://www.3gpp.org/technologies/high-power-ues*
- *iii) Many edge devices will be located in obstructed locations and will have sub-optimal RF paths. As a result, they will be unlikely to be operating at anything more than 16 QAM.*

Overall, we are satisfied with the assumption of an overall spectrum efficiency of 0.4 bps / Hz although we are concerned about the assumption of reciprocal coverage in both up and downlink directions (covered in more detail in our assessment of section A8 – Coverage Analysis)

Appraisal of Ofcom's approach to Coverage analysis – Annex 8

JRC observe that drawing conclusions based on single site coverage is not ideal. The whole topic of resilience from being served by multiple paths cannot be addressed and the impact of adopting higher frequencies is a likely reduction in resilience, as site by site coverage areas are less likely to overlap. Noting that the single site coverage is for download, whilst we are concerned about upload performance / reliability. To this end, the gain of up to 34% area by comparing the 700 MHz base station with 3dB power increase against 450 MHz, with no other changes is at odds with both our radio planning work and our field trials. The increase in free space loss (3.8dB) is not even offset by the 3dB power increase. If 3GPP are considering a 3dB increase in UE power, this will help the Uplink on all frequencies. With increasing frequency, it is likely that higher gain antennas can be used at base stations and possibly outstations, however this must be partially offset by increased feeder losses. For one DNO study, we compared 415 MHz with 740 MHz for a 136-site network. The increased propagation loss (450 MHz to 740 MHz) would amount to 5dB, and this is offset by a 5dB base station antenna gain and an extra 1dB of feeder loss, so a net loss of 1dB. The overall coverage (site served) dropped by around 7%. From an operational design perspective this result for a multisite solution is more realistic. Noting that Ofcom in their analysis explore how the coverage of a 700 MHz design could be enhanced / optimised to approach that of non-optimised 450MHz design. Whilst this is potentially technically feasible it is not necessarily deployable based on our experience of the physical / security constraints that apply when deploying outstation systems, in particular the form factor of the antenna system and installation.

JRC also note that the use of a single omni directional antenna is not consistent with what we would expect to see in the real world where it is far more likely that a 3 or 4 sector deployment would be implemented (the NGED trial in Taunton comprised 3 sectors). This has an impact on EIRP and also brings into play the topic of intra-site (inter cell) interference requiring further co-ordination and impacting coverage predictions. Although we recognise that higher antenna heights and additional transmit powers will broadly improve coverage, JRC encourage Ofcom to undertake further analysis with refined input parameters which would create more accurate modelling of total number of base stations required (and hence the economics of the frequency options). An accurate understanding of this will be critical when the Energy Network Operators establish the funding arrangement with Ofgem and also when undertaking a cost-benefit analysis associated with re-arranging the 450 MHz band.

To this end, JRC's detailed radio planning analysis has indicated between 20 and 50%[36] increase in the number of base stations for a 700MHz network relative to a 400MHz design, subject to local terrain, would be necessary to guarantee system performance. The implications of this from a network investment perspective would be circa £19m - £47m on top of the total investment noted in the Gemserv study for a private radio solution.

Appraisal of Ofcom's assessment of Coexistence for adjacent spectrum users in the 450 MHz band – Annex 9

We welcome Ofcom's approach to consider options for co-existence of existing narrow band users (without migration) alongside an LTE system. As indicated by Ofcom, such a solution would require further technical assessment. In particular, we encourage Ofcom to consider the following aspects in their assessment;

i) The potential for interference is subject to quite historic information. It is JRC's understanding that the majority of LTE (and narrow band) equipment currently on the market significantly out-performs the standards as originally established[37]. It would therefore be possible through a combination of measurement and analysis to determine the extent to which the co-existence arrangements may be more straightforward and hence less complex to address than envisaged, e.g. guard bands of 1 or 2 MHz may not be necessary.

ii) Noting that it is possible to suppress a number of sub-carriers in an LTE system this may prove a useful option for simplifying co-existence as part of any Replan by temporarily narrowing or 'notching out' spot frequencies of concern;

iii) Further analysis of the use / occupancy by the Business Radio community of the 450 – 470 MHz band (including a possible measurement campaign) is to be encouraged as we understand that many users, assumed to be potential victims of interference, are no longer active in the band.

iv) In conjunction with the above item we anticipate that some large geographic areas of the UK (notably Scotland) have extremely little active BR systems deployed and hence it would be possible to commence LTE deployments in those areas with negligible risk of interference to other users.

v) The Energy Network Operators and the Water Network Operators are likely to be by far the largest user of BR in 450-470 MHz (Scanning Telemetry, ST). If, following an audit of other active users in the band it transpires that Utility ST is the largest user base then that presents a potential opportunity in terms of any migration out of the band.

Question 6: Do you have any comments on our overview of the 400 MHz band in NI? Please consider the specific factors we have discussed in your response.

JRC Response

Confidential? No.

This band would align with the spectrum award in the Republic of Ireland and presents the potential for an 'Island of Ireland' solution which may be desirable from a policy perspective. Nevertheless, this band does present a co-ordination risk in that agreement would need to be secured with Arqiva / Airwave to the lower 2 MHz alongside an access arrangement to the upper 2 MHz with the PSNI – neither of these outcomes are a given and present considerable risk / uncertainty to the long term access and viability of the band for this application. In terms of the Arqiva / Airwave block in the event that a trade was to be forthcoming there may need to be regulatory action to vary the licence to enable the trade in NI only. Our understanding of the PSNI use of the band is that they will continue to have a need for this until at least 2028. Furthermore, it is understood that they require flexibility to be able to actively deploy the solution anywhere in Northern Ireland and this will likely present challenges from a co-existence / co-ordination perspective – we encourage Ofcom to liaise with PSNI to establish the extent to which there may be the potential for co-existence. In terms of the potential opportunity to migrate the system out of the band there may be merit in exploring whether the solution could be

[36] https://www.jrc.co.uk/Plugin/Publications/assets/pdf/ICT-Final-Report-published-after.pdf page 41-42.

[37] Refer to Annex I for Spectrum Analyser plots of LTE equipment performance associated with the NGED Trials at Taunton and Portishead.

accommodated within the Private LTE solution to be deployed by the Energy Network operators which might ease the availability of the PSNI 2 x 2 MHz.

JRC are aware that the 400 km exclusion zone associated with Fylingdales has been in existence for many decades and whilst we recognise the importance of this radar in a military context we encourage Ofcom to consider whether this exclusion could be reviewed in light of both advances in technology since the radar was originally constructed and also the measurements carried out by Ofcom and MOD associated with the first NGED LTE trial in Portishead in 2017-2018, noting that the trial operated in the 410 MHz range. We are also aware that a specific arrangement was made with Arqiva / DCC for the deployment of smart metering in the areas surrounding Fylingdales and we would be interested to understand in more detail how that solution was accomplished. In particular, Northern Ireland could benefit significantly from a utility network using spectrum in the same band as the ESBN network solution in the Republic of Ireland, presumably the province is distant enough from the radar to not be constrained by any exclusion criteria.

Question 7: Do you have any comments on our overview of the 450 MHz band in GB and NI? Please consider the specific factors we have discussed (including the coexistence analysis in annex 9) in your response.

JRC Response

Confidential? No.

The 450 MHz band is the 'sweet spot' from an Energy Network Operators perspective with existing legacy analogue systems in the band and power resilient infrastructure deployed for the OT system capability in place. To facilitate the migration of the narrow band systems out of this frequency range there will need to be additional spectrum in excess of that already occupied to allow for parallel running during the deployment of the Private LTE solution.

The adoption of Wideband – Private LTE solutions In Europe

The use of 450 – 470 MHz LTE technology is rapidly evolving throughout Europe. it is already in use in Poland by power company PGE, Germany by 450 Connect (Utilities) and Spain (Ministry of Interior for national PPDR network). In the Netherlands tentative agreement has now been reached to allow the Utility Connect to expand their holding from 2 x 1.25 MHz to 2 x 3MHz to allow the migration from existing CDMA networks to LTE (the suggested period of the license will run to 2050). In France, ARCEP have recently consulted on migration to LTE services in the same frequency band – it does seem likely that with both of its large neighbours (Spain and Germany) deploying 450 MHz LTE that France will adopt the same approach. Combining all of these high-power aggregate LTE transmissions together is extremely likely to cause interference to legacy narrow band business radio use in the UK, even during normal propagation scenarios and the absence of propagation 'lifts'. The problem will be further exacerbated by the long-standing misalignment of TX Hi / Lo status in the UK with respect to the rest of Europe. Ofcom have previously explored this issue in the analysis undertaken by Aegis[38] in 2014 which considers the potential for interference from wideband systems deployed in France and the Netherlands and which noted;

> 'This "new" interference is wideband and more challenging / impossible to escape from than the individual channel interference cases experienced in the past. Worsening the situation is that it is not the individual mobile that is suffering interference and unable to communicate but the base station receiver rendering the whole network of very little use.
>
> Clearly any networks that are safety or business critical cannot be operated on frequencies where there is likely to be a loss of communications for any period of time. It has also been noted by some users that it is important that when a critical transmission is sent it must arrive at once without the need for multiple re-transmissions. Therefore, with the potential for increasing use of the bands in Europe, in particular to provide high power

[38] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/51637/aegis-report.pdf, UHF 1 & 2 Future Demand Final Report. Extract from 3.4.4.3 page 55.

wideband and broadband services (see Annex C), there is a need to investigate whether band reversal would help alleviate the impact of interference.'

In summary, if nothing is done to address the band reversal and fragmentation then over the next decade the band is likely to become unusable for mission critical connectivity such as that which is required by JRC's members.

Question 8: Do you consider that changes in the spectrum environment for the 450 MHz band mean that there is a case for re-examining whether this band should be reconfigured in the UK to align with the harmonised band plan?

JRC Response

Confidential? No

We have serious reservations regarding the long-term viability of the band to accommodate the existing services as noted in response to Q. 7 above, including the significant deployment of critical narrowband systems on which the Energy Network Operators depend for operational integrity, in the 450 – 470 MHz band due to the reverse nature of the channel plan relative to that of mainland Europe and the potential for wide-band / broadband LTE system deployments in the UK's near neighbours. Recently the Netherlands National Regulatory Authority (NRA)[39] has consulted on plans to extend the licence time frame for CDMA use of the band alongside the potential for a migration to LTE functionality in the future to address the developing requirements of 'smart grid' developments in the country. Whilst the French NRA ARCEP recently undertook a multi-band consultation[40] which included the 450 – 470 MHz range to explore the potential future deployment options for this band exploring the potential for LTE technology. If the above anticipated change of use of the band in adjacent countries were to materialise then there will be a wholesale degradation of the existing narrowband systems in the band, because narrowband use will be concentrated in the same blocks as used in the UK potentially resulting in a sterilisation of the band to the services currently present. In the case of the existing Energy Network Operators use this would result in a forced migration out of the band as they would be unable to tolerate the risk of widespread disruption of their existing systems.

In light of the above and Ofcom's duties to ensure the optimum and efficient use of the electromagnetic spectrum it would seem appropriate for Ofcom to re-examine whether this band should be reconfigured in the UK to align with the harmonised band plan.

Question 9: Do you have any comments on our overview of the 700 MHz band in GB and NI? Please consider the specific factors we have discussed in your response.

JRC Response

Confidential? No.

We welcome Ofcom's inclusion of this band as a potential option to address the enhanced Operational Telecommunications needs of the Energy Network Operators. Ofcom note that this is a PPDR band but acknowledge that it could also potentially be adopted for the Energy Network Operators requirements. It is worth noting that many of the same arguments used to justify a dedicated allocation for PPDR use have parallels with the energy sector requirement, i.e. the need to migrate away from legacy narrow band solutions to future proof broadband connectivity based on 3GPP / LTE. The aspects of system security, ubiquitous coverage (including indoor), ecosystem support and power autonomy are common to both Utilities and PPDR sectors – the requirement of both sectors is mission critical. Furthermore, the Energy Network Operators have acknowledged that this is a potential option for the sector for some time[41] noting that it is sub 1-GHz with good propagation characteristics, is a 3GPP band, has a developing eco-system of PPDR equipment which aligns well with the needs of the Energy Network

[39] https://www.internetconsultatie.nl/nfpwijzigingpamr2/document/11317

[40] Préparer le futur des réseaux mobiles - Consultation publique du 23 mai au 23 septembre 2022 (arcep.fr)

[41] Next Generation Wireless Telecoms, Ofgem funded Innovation Project undertaken by Western Power Distribution, 2020, pg. 40. https://www.jrc.co.uk/Plugin/Publications/assets/pdf/ICT-Final-Report-published-after.pdf

Operators and is being made available for PPDR across Europe. In our response[42] to Ofcom's PSNI consultation we noted the potential for alignment between the critical communications requirements of PSNI and those of CNI operators such as Northern Ireland Electricity Networks and Northern Ireland Water and hence the potential for a 'win-win,' where the PPDR community would be able to benefit from a more robust and resilient OT solution to address their critical communication needs. Ofcom have noted concerns with regard to coexistence with the adjacent Supplemental Downlink (SDL) system, we anticipate that the correct design and deployment of a Private LTE network for the Energy Network Operators would be possible to minimise disruption to the adjacent SDL service[43]. Independent of the clear importance of establishing a robust co-existence arrangement with the adjacent SDL service it is worth exploring to what extent the SDL arrangement is being pursued across Europe as this will have a significant bearing on whether a device eco-system is established to enable the service to be launched. To this end we have noted the Status of SDL in Europe in the 700 MHz table response to Q. 5 which demonstrates the fragmented / disjointed approach across Europe to the licensing of the centre gap, with SDL only licensed in a limited number of countries (3). In addition, the CEPT-CPG report[44] states that there are no devices available that are compatible with the SDL service.

> ***While there are NO consumer devices supporting the 700 MHz SDL service we have confirmation from 9 major equipment vendors indicating that there are 700 MHz Utility grade products already supporting band 68 / band 28.***

Overall, the 700 MHz band has the potential to address the immediate needs of the Energy Network Operators to enable enhanced operational control noting that it is;

- *Currently clear of other users and free to be allocated, Ofcom has full discretion over its future use;*
- *The spectrum available aligns well with the minimum requirement identified of 2 x 3 MHz.*
- *A 3GPP band with a developing device eco-system which aligns with the operational requirements of Energy Network Operators; and*
- *Expanding adoption of and deployment of 700 MHz networks for PPDR and M2M applications in Europe*

We therefore encourage Ofcom to prioritise this band in their further work and we are keen to work with Ofcom to address any issues that might impact early release.

Question 10: Do you have any comments on our overview of the 800/900 MHz band in NI? Please consider the specific factors we have discussed in your response.

JRC Response

Confidential? No.

We note that this frequency range does not align with a 3GPP band plan and as one of the key criteria for relevant bands is alignment to a 3GPP band with an established ecosystem of devices we would not prioritise this band as a spectrum option to address Utility Operational Communications requirements.

Question 11: Do you have any comments on our overview of the 1900 MHz band in GB and NI? Please consider the specific factors we have discussed in your response.

JRC Response

Confidential? No.

We refer Ofcom to the JRC response[45] to the consultation issued earlier this year and note that spectrum at this frequency range would be seen as complementary to priority spectrum (sub 1GHz)

[42] https://www.ofcom.org.uk/__data/assets/pdf_file/0025/249019/jrc.pdf
[43] Technical work is underway with NGED & JRC to understanding the optimise the co-existence arrangements.
[44] Compendium of information relating to spectrum use, needs, sharing and compatibility within the 470 – 960 MHz frequency band, https://www.cept.org/Documents/cpg-ptd/77816/ptd-23-026-annex-iv-05_draft-cept-brief-associated-compendium-of-information, pg 4 section 1.1.3 IMT.
[45] https://www.ofcom.org.uk/__data/assets/pdf_file/0033/262797/joint-radio-company-ltd.pdf

essential to establish cost effective and robust wide area operational communications coverage, subject to;

- *The spectrum being released by the Mobile Network Operators;*
- *The establishment of an appropriate ecosystem of hardware vendors for the frequency range under consideration. JRC would encourage Ofcom to seek to co-ordinate within the CEPT framework to secure a common approach to this band across Europe which would lead to the development of a much broader eco-system than would be possible if this approach was limited to the UK only; and*
- *Technical studies to understand how / whether the spectrum 1910-1920 MHz might be deployed in a utility context given that there are technical constraints on the upper 5 MHz. The usefulness of the spectrum and potential functionality / services that might be possible will be severely constrained if the spectrum must be divided into two 5 MHz channels – one for low power and one for high power – or used as a contiguous 10 MHz channel, but only at low power to respect the coordination constraints on the top 5 MHz.*

The timelines associated with above activities will be protracted and with no certainty of a positive outcome and hence we would not consider the spectrum at 1900 MHz a priority band for Ofcom to focus on to address the urgent spectrum access needs of the Energy Network Operators

Question 12: Which band(s) do you consider we should examine further with a view to developing consultation proposals to enable their use in a private network, if this were needed? Please reference the factors we have considered where appropriate and provide separate answers for GB and NI if relevant.

JRC Response

Confidential? No.

The Energy Network Operators' focus is the sub 1-GHz bands, and these should become the focus of more detailed work to be undertaken by Ofcom to inform the anticipated consultation process that will follow this Call for Input. With regard to the individual options we note the following;

- ***450-470MHz band**; This is the 'sweet-spot' spectrum, currently leveraged by the Energy Network Operators for legacy analogue narrowband systems and hence has established infrastructure assets (including power autonomy) to be leveraged for a LTE system deployment. It is aligned to 3GPP bands and has a developing ecosystem of devices*. Noting the fundamental challenges associated with the existing configuration of this band plan relative to Europe and the range of uses in the band. Whilst, these complexities will inevitably lead to a long time frame, as noted by Ofcom > 5 years, we encourage Ofcom to undertake further work specific to this band to assess its viability for Energy Network use as per our response to Question 8. This band has the potential to enable a Nationwide (including NI) capability to address the operational communications needs of all Energy Network Operators and hence maximise the scale economies from a CPE perspective.
- ***700 MHz band**; Noting the specific policy outcomes targeted by Government, referenced in section 3.4, we encourage Ofcom to recognise the urgency of spectrum access to enable the policy outcomes and as such the importance of early spectrum access. To this end Ofcom can enable access to the 700 MHz band, a 3GPP designated band with an existing ecosystem, at the earliest opportunity, subject to the consultation process planned.* This band has the potential to enable a Nationwide (including NI) capability to address the operational communications needs of all Energy Network Operators and hence maximise the scale economies from a CPE perspective. *This band should therefore be a priority band for further consideration;*
- ***400MHz band (NI)**; Noting that this band is a 3GPP designated band and aligns with the solution being deployed in the Republic of Ireland it has the appropriate characteristics to satisfy the operational communications needs of Energy Network Operators in Northern*

Ireland. Notwithstanding the regulatory constraints associated with it being currently licensed to third parties. Whilst this will not afford the scale economies anticipated with the two other sub -1-GHz bands we still believe that this band is worthy of further consideration;

- ***1900 MHz band**; This has the potential to be a complementary Nationwide 3GPP solution in addition to the sub-1GHz spectrum options subject to it being released by the MNOs, an ecosystem developed, and technical limitations addressed. As such we encourage Ofcom to progress the activity already underway regarding this band; and*
- ***800 MHz band;** this is not a 3GPP band and as such does not align with our priority requirements, we therefore suggest that this band is not included in further work.*