



Smart Grid Systems and Other Radio Systems suitable for Utility Operations, and their long-term spectrum requirements

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Contents

Intellectual Property Rights	4
Foreword.....	4
Modal verbs terminology.....	4
Executive summary	4
Introduction	5
1 Scope	7
2 References	7
2.1 Normative references	7
2.2 Informative references.....	7
3 Definitions, symbols and abbreviations	9
3.1 Definitions.....	9
3.2 Symbols.....	9
3.3 Abbreviations	10
4 Utility operations requirements	12
5 Existing and potential utility operations technologies.....	19
5.1 Data systems.....	19
5.2 High-definition Real-time Video.....	21
5.3 Other Utility Operations Radio Systems	21
6 Long-term spectrum requirements for utility operations.....	22
7 Conclusion.....	23
Annex A: Simple Electricity Grid Network.....	24
Annex B: Electricity Grid control and monitoring.....	27
B.0 Background	27
B.1 Point-to-multipoint systems	27
B.2 Point-to-point systems.....	28
B.3 Point-to-point and Point-to-multipoint technical details	29
History	31

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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Executive summary

The present document highlights the future requirements for the mission critical real-time systems, e.g. Smart Grids, that are necessary to meet Europe's need for the "*reliable provision of electricity wherever and whenever it is required*". It also emphasises that almost all of Europe's businesses are dependent on electricity, and/or gas (gas may also be used to generate electricity), to enable them to supply the goods and/or services to Europe's citizens and consumers.

Article 194 of the Treaty on the Functioning of the European Union [i.1] (TFEU/Treaty of Rome) sets out that the aim of EU Energy policy is to "*ensure security of energy supply in the Union*", i.e. to ensure that energy (including electricity) is available to all when needed, and while doing so "*promote energy efficiency and energy saving and the development of new and renewable forms of energy*". Smart Electricity Grids will be used to distribute and control these energy efficient/saving networks.

The present document builds on the Smart Grids Co-ordination Group Technical Report Reference Architecture for the Smart Grid [i.2] (RASG) in that it highlights that real-time mission critical Smart Grid systems typically need to be resilient, sometimes requiring best practice resilience [i.3]. By contrast best-effort, non-real-time, Smart Meter systems typically do not need to be resilient. This should clarify which of the systems mentioned within the RASG [i.2] may be suitable for Smart Grid systems and which may only be suitable for Smart Meter systems.

In line with the requirement of Mandate M/462 [i.25] to enable efficient energy use in fixed and mobile information and communication networks, the present document also highlights the power efficiencies of using 12,5 and 25 kHz narrow band equipment versus, say, 150 kHz wideband and MHz-wide broadband equipment.

The present document also highlights that there may be options for the existing ETSI standards suitable for low data rate electricity grid systems, e.g. 9,6 kbit/s within 12,5 kHz narrow band channels, to be updated to enable higher data rates, e.g. 64 kbit/s within 25 kHz channels, for use by Smart Grid systems.

The present document supports the RASG recommendation [i.2] that: "*deployment constraints mandate the need for both wire-line and wireless communications. Utility access to wireless network resources is necessary. Where spectrum is allocated for use by utility networks, this will help progress the Smart Grid deployments ensuring the standard work and products take into account the allocated spectrum for utilities.*" It should be noted that there may be significant differences between the enhanced requirements of critical infrastructure utility (CIU) networks, such as those used by the electricity utilities, and the lesser requirements of non-critical infrastructure utility networks.

The present document highlights that when a radio link is used as the diversity route for another link, e.g. wired, the radio link needs to work immediately when required and continue to work despite any power disruptions, etc.

The present document highlights that Utility Operations have ~50 years of experience in designing, installing, operating, and maintaining resilient machine to machine (RM2M) systems such as those used to supervise and control electricity grids. The present document suggests that, whereas Member States are expected to provide an average of 1 200 MHz for IMT systems, the average spectrum requirements for Critical Infrastructure Utility Operations Networks, including Smart Grids, is likely to be ~1,5 percent of that for IMT systems.

Noting that, regarding spectrum for International Mobile Telecommunications (IMT) broadband use, "*the RSPG recommends that future discussions on spectrum management decisions avoid setting an arbitrary amount of spectrum to be harmonised*" [i.23]. It is expected that the evidence based identification of 18 MHz of spectrum within the VHF, 400 MHz UHF and 1,4 GHz bands will be seen as a realistic figure rather than an arbitrary one.

The details of the future spectrum requirements will be expanded within ETSI TR 103 492 [i.26].

Introduction

The present document has been developed to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Posts and Telecommunications Administrations (CEPT).

Almost every service or product offered to Europe's citizens and consumers relies directly or indirectly on the reliable provision of electricity and/or gas (gas can also be used to generate electricity) by Europe's Utility Operations. The European Commission, within its Energy Strategy [i.4], fully recognises and supports the important requirement for "*secure energy supplies to ensure the reliable provision of energy whenever and wherever needed*".

The European Commission's 2030 policy framework seeks to de-carbonise the energy system. The framework encourages the electrification of heat and transport, as well as the connection of more intermittent generation. As these policies take effect, the electricity system will become more complex to plan, control and balance. More flexibility will be needed to ensure that the energy system is able to cope with the future challenges. It will be key to delivering an affordable and climate-friendly energy system [i.5]. Natural disasters, terrorist attacks, and criminal activity can all disrupt the critical energy infrastructure Europeans depend on. While national authorities are primarily responsible for the protection of energy facilities such as power plants and transmission lines, energy disruptions can be felt across national borders. The EC considers that, inter alia, energy infrastructures and facilities for the generation and transmission of electricity in respect of supply electricity between member states are European Critical Infrastructures [i.6] (ECI). Likewise, Gas production, refining, treatment, storage and transmission by pipelines, and liquid natural gas (LNG) terminals, are considered to be ECI.

The EC's European Programme for Critical Infrastructure Protection [i.7] (EPCIP) identifies that "*European Critical Infrastructures (ECI) constitute those designated critical infrastructures which are of the highest importance for the Community and which if disrupted or destroyed would affect two or more Member States, or a single Member State if the critical infrastructure is located in another Member State. The identification and designation of National Critical Infrastructures is defined by a Member State according to predefined national criteria. With due regard to existing Community competences, the responsibility for protecting National Critical Infrastructures falls on the NCI owners/operators and on the Member States*".

The EC Directive 2008/114/EC on European Critical Infrastructures [i.8] fully recognises that the "*infrastructures and facilities for generation and transmission of electricity in respect of supply electricity*" is part of each member state's critical infrastructure. This criticality is emphasised by the European Commissions' acknowledgement of the continued requirement for electricity grids to have Resilience to ensure critical infrastructure protection (CIP). It should be noted that there may be significant differences between the enhanced requirements of critical infrastructure utility (CIU) networks, such as those used by the electricity utilities, and the lesser requirements of non-critical infrastructure utility networks.

Indeed, the importance of Smart Grid electricity is such that the EC has created the M/490 EN Smart Grid Mandate [i.9]. This is the "Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment". The objective of this mandate was/is to develop or update a set of consistent standards within a common European framework that integrates a variety of digital computing and communication technologies and electrical architectures, and associated processes and services that will achieve interoperability and will enable or facilitate the implementation in Europe of the different high level Smart Grid services. It should be noted that two of the high-level services the Smart Grids Task Force defined are "*enhancing efficiency in day-to-day grid operation*" and "*ensuring network security, system control and quality of supply*". It should also be noted that there are options for the existing 12,5 and 25 kHz narrow band grid systems to use higher data rate systems, e.g. 64 kbit/s in 25 kHz. This will enable any higher data rate Smart Grid systems the option to continue to use 12,5 and 25 kHz narrow bandwidth channels rather than having to move unnecessarily to, say, 150 kHz wideband systems or MHz broadband systems.

The need for reliable, secure, and resilient network operation is an over-riding influence on the choice of technologies or service provision model in some instances. The increasing number of attacks on utility monitoring and control systems makes it increasingly important for Utility Operations systems to be protected against intrusion. Fortunately, Utility Operations have circa 55 years of experience in designing, installing, operating, and maintaining resilient machine to machine (RM2M) systems. During this time, experience has proven that a simple solution to potential external attacks is to ensure that there is an "air gap" between critical utility control networks and the public networks to guarantee secure and reliable operation of the former.

The present document highlights which types of self-managed Resilient Machine to Machine (RM2M) system technologies and self-managed Machine to Machine (M2M) system technologies are currently being used for Utility Operations, and their spectrum requirements.

It is important to note that utility communications systems are typically incorporated for safety, security, system monitoring & control and not for economic gain. Ownership, or self-licensing, is seen as a cost effective method of accessing spectrum. It also ensures that the systems will work exactly as they are designed/intended to rather than risking using adapted generic systems that rely on a supplier meeting key performance indicators (KPI) even during extreme conditions, e.g. coverage during storms to remote rural locations with major power outages.

In considering these requirements, it should be noted that future Critical Infrastructure Utility Operations spectrum requirements are expected to be very limited compared with the spectrum requirements of, for example, broadband public mobile systems. Indeed, the European Utility Telecom Council (EUTC) spectrum proposal identified a potential requirement for 6 MHz of licensed 400 MHz UHF and 10 MHz of 1,4 GHz spectrum for Smart Grid utility operations. This potential requirement may be considered minimal in contrast to the 1 200 MHz of spectrum proposed for public mobile broadband data in the European Radio Spectrum Policy Programme (RSPP).

It will be seen that in some cases, with the current absence of suitable licensed spectrum, utility operational systems may need to use alternative wireless solutions, but this does not necessarily indicate their suitability in the long-term.

The present document notes that the European Common Allocation Table shows 450 MHz to 470 MHz is identified for use by narrow band mobile systems complying with, for example, ETSI EN 300 086 [i.10], ETSI EN 300 113 [i.11], ETSI EN 301 166 [i.21], and ETSI EN 302 561 [i.13].

NOTE: The UK power utilities use 12,5 kHz narrow band UHF systems that operate within the technical requirements of ETSI EN 300 113 [i.11] and with no detrimental impact to adjacent 12,5 kHz narrow band private mobile radio users.)

The present document also notes ITU footnote RR No. 5.286AA [i.14]: "*The band 450-470 MHz is identified for use by administrations wishing to implement International Mobile Telecommunications (IMT). See Resolution 224 (Rev.WRC-07). This identification does not preclude the use of this band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations. (WRC-07)*".

1 Scope

The present document considers:

- 1) systems suitable for Critical Infrastructure Utility Operations Smart Grids;
- 2) the essential requirements for systems suitable for other Utility Operations radio systems;
- 3) the long-term spectrum requirements for Utilities.

The present document identifies the functional requirements for existing and future radio systems for critical infrastructure utility operators, e.g. electricity and gas, and associated implications for spectrum requirements. Requirements for Smart Cities or Smart Homes are not within the scope of the present document. The present document does not contain any spectrum requests. It is envisaged that a further Technical Report (TR) will be developed complementing the present document and providing a formal System Reference Document for CEPT to consider.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] "Treaty on the Functioning of the European Union" (Treaty of Rome).

NOTE: Available at <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN>.

[i.2] CEN-CENELEC-ETSI Smart Grid Coordination Group: "Smart Grid Reference Architecture".

NOTE: Available at http://ec.europa.eu/energy/sites/ener/files/documents/xpert_group1_reference_architecture.pdf.

[i.3] CPNI: "Telecommunications Resilience Good Practice Guide", Version 4.

NOTE: Available at http://www.cpni.gov.uk/documents/publications/undated_pubs/1001002-guide_to_telecomms_resilience_v4.pdf

[i.4] EC Energy Strategy.

NOTE: Available at <https://ec.europa.eu/energy/en/topics/energy-strategy>.

[i.5] Smart Grid Task Force report: "Regulatory Recommendations for the Deployment of Flexibility".

NOTE: Available at <http://ec.europa.eu/energy/sites/ener/files/documents/EG3%20Final%20-%20January%202015.pdf>.

[i.6] Council Directive 2008/114/EC on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection.

NOTE: Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:345:0075:0082:EN:PDF>.

- [i.7] European Programme for Critical Infrastructure Protection.
- NOTE: Available at <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3A133260>.
- [i.8] Council Directive 2008/114/EC on European Critical Infrastructures Annex 1.
- NOTE: Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:345:0075:0082:EN:PDF>.
- [i.9] EC M/490 EN Smart Grid Mandate.
- NOTE: Available at <ftp://ftp.cencenelec.eu/CENELEC/Smartgrid/M490.pdf>.
- [i.10] ETSI EN 300 086: "Land Mobile Service; Radio equipment with an internal or external RF connector intended primarily for analogue speech; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".
- [i.11] ETSI EN 300 113: "Land Mobile Service; Radio equipment intended for the transmission of data (and/or speech) using constant or non-constant envelope modulation and having an antenna connector; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".
- [i.12] ETSI EN 302 426: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Harmonized EN for CDMA spread spectrum Repeaters operating in the 450 MHz cellular band (CDMA450) and the 410 MHz, 450 MHz and 870 MHz PAMR bands (CDMA-PAMR) covering essential requirements of article 3.2 of the R&TTE Directive".
- [i.13] ETSI EN 302 561: "Land Mobile Service; Radio equipment using constant or non-constant envelope modulation operating in a channel bandwidth of 25 kHz, 50 kHz, 100 kHz or 150 kHz; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".
- [i.14] ITU Radio Regulations footnote No. 5.286AA.
- [i.15] EUTC position paper: "Spectrum needs for Utilities"
- NOTE: Available at <http://utc.org/europe/wp-content/uploads/sites/4/2016/04/EUTC-Spectrum-Position-Paper.pdf>.
- [i.16] IEC 61850: "Power Utility Automation".
- [i.17] Ofcom (UK) MPT1411: "Performance Specifications and Frequency Assignment Criteria for Private Fixed Mobile Equipment for Telemetry and Telecontrol Purposes Operating in the Bands 457.5 to 458.5 MHz and 463.0 to 464.0 MHz". (January 1995).
- [i.18] Ofcom (UK) OfW49: "Fixed Point-to-Point and Point-to- Multipoint Scanning Telemetry Radio Services with Analogue Modulation Operating in the Frequency Ranges 457.5 to 458.5 MHz paired with 463.0 to 464.0 MHz".
- NOTE: Available at http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/tfac/tfac_ofw49.pdf.
- [i.19] British Radiocommunications Agency MPT1327: "Trunked Private Mobile Radio Systems".
- [i.20] ScottishPower press release 16th February 2012.
- NOTE: Available at http://www.scottishpower.com/news/pages/scottishpower_and_national_grid_award_contracts_to_deliver_major_electricity_grid_upgrade.asp
- [i.21] ETSI EN 301 166: "Radio equipment for analogue and/or digital communication (speech and/or data) and operating on narrow band channels and having an antenna connector".
- [i.22] Telent Study for UK Energy Networks Association (ENA).
- [i.23] European Commission Radio Spectrum Policy Group: "RSPG Opinion on the implementation of the current RSPG and its revision to address the next period".
- NOTE: Available at https://circabc.europa.eu/d/a/workspace/SpacesStore/4709f36a-f27b-4850-a19b-95df0154d5aa/FRSPG16-006final_RSPG_opinion.pdf.

[i.24] Joint Radio Committee history.

NOTE: Available at <http://www.jrc.co.uk/about-us/history>.

[i.25] EC M/462 Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of ICT to enable efficient energy use in fixed and mobile information and communication networks.

[i.26] ETSI TR 103 492: " System Reference document (SRdoc); Critical Infrastructure Utility Operations requirements for Smart Grid systems, other radio systems, and future radio spectrum access arrangements below 1,5 GHz".

[i.27] ETSI TS 102 361: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical Requirements for Digital Mobile Radio (DMR)".

[i.28] ETSI TS 102 490: "Intelligent Transport Systems (ITS); Security; ITS communications security architecture and security management".

[i.29] ETSI TS 102 658: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Private Mobile Radio (dPMR) using FDMA with a channel spacing of 6,25 kHz".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

400 MHz UHF band: spectrum within the range 380 MHz to 470 MHz

best practice resilience: measures that can be taken to guarantee resilience, irrespective of cost [i.3]

broadband: channel widths of 1 300 kHz and greater

good practice resilience: measures which can be taken to provide a degree of resilience commensurate with the Corporate risk strategy [i.3]

Machine to Machine (M2M) systems: any past, existing, or future wireless, wired, fibre, or combination of technologies that enable connected devices to exchange information and perform actions typically without the manual assistance of humans

narrow band: channel widths of 6,25 kHz, 12,5 kHz and 25 kHz

Resilient Machine to Machine (RM2M) systems: any suitably enhanced/hardened past, existing, or future wireless, wired, fibre, or combination of technologies that enable connected devices to exchange information and perform actions typically without the manual assistance of humans

upload centric: remote communication point that primarily transmits data to a central point rather than primarily receives data from a central point

NOTE: This is opposite to a typical public mobile system.

wide band: 50 kHz to 14 300 kHz channel widths

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dBi	dB gain with respect to an isotropic radiator
dBW	dB gain with respect to one watt
kHz	Kilo Hertz
MHz	Mega Hertz
N _{RX}	Receiver noise power density typical

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BER	Bit Error Rate
CENELEC	European Committee for Electro-technical Standardisation
CCTV	Closed-Circuit TeleVision
CDMA	Code Division Multiple Access
CEPT	European Conference of Posts and Telecommunications Administrations
CIU	Critical Infrastructure Utilities
CIP	Critical Infrastructure Protection
DMR	Digital Mobile Radio

NOTE: 12,5 kHz digital radio technology as defined in ETSI TS 102 361 [i.27].

dPMR Digital Private Mobile Radio

NOTE: 6,25 kHz digital radio technology as defined in ETSI TS 102 490 [i.28] and ETSI TS 102 658 [i.29].

EC	European Commission
ECC	Electronic Communications Committee
ECI	European Critical Infrastructures
EHV	Extra High Voltage

NOTE: 275 kV and 400 kV.

e.i.r.p.	Effective Isotropically Radiated Power
EPCIP	European Programme for Critical Infrastructure Protection
ESO	European Standardisation Organisations
ETSI	European Telecommunications Standards Institute
EU	European Union
EUTC	European Utilities Telecom Council
FM	Frequency Modulation
FS	Fixed Services
FSK	Frequency Shift Keying
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HV	High Voltage

NOTE: 11 kV, 33 kV, 66 kV and 132 kV.

IEC	International Electro-technical Commission
IMT	International Mobile Telecommunications
ITU-R	International Telecommunications Union - Radiocommunications
KPI	Key Performance Indicator
LNG	Liquefied Natural Gas
LTE	Long Term Evolution
LV	Low Voltage

NOTE: 230 volts and 400 volts.

M2M	Machine to Machine
MW	Mega Watt
NB-IoT	Narrow Band Internet of Things

NOTE: 180 kHz channel width.

NB-LTE Narrow Band Long Term Evolution

NOTE: 200 kHz channel width.

NCI	National Critical Infrastructures
P25	Project 25
PBR	Private Broadband Radio

PLC Power Line Communications
 PMR Private Mobile Radio (ITU definition)

NOTE: Also known as Professional Mobile Radio.

PMP Point to Multi-Point
 PP Point to Point
 QoS Quality of Service
 QPSK Quadrature Phase Shift Keying
 RASG Reference Architecture for the Smart Grid
 RM2M Resilient Machine to Machine
 RSPG Radio Spectrum Policy Group
 RSPP Radio Spectrum Policy Programme
 SCADA Supervisory Control And Data Acquisition
 SINAD (signal + noise + distortion) / (noise + distortion) ratio
 SR Systems Reference document
 ST Scanning Telemetry
 TDMA Time Division Multiple Access
 TEDS TETRA Enhanced Data Service
 TETRA TERrestrial Trunked RADio
 TFEU Treaty on the Functioning of the European Union (The Treaty of Rome)
 TR Technical Report
 Tx Transmit
 UHF Ultra High Frequency (300 to 3,000 MHz)
 UON Utility Operations Networks
 VHF Very High Frequency (30 to 300 MHz)

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