Consultation submission to Ofcom:

Consultation on 870-876 MHz and 915-921 MHz, Update and Way Forward

By SCF Associates Ltd

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Table of Contents

Introduction

SCF Associates Ltd is pleased to contribute to this consultation on the future use of the 870-876 MHz and 915-921 MHz bands. This document sets out our views on what we consider are some of the key benefits and issues for licence exempt applications in this part of the spectrum. But it does not attempt to address all the issues or questions raised by the consultation at the same level of detail throughout.

The main issues covered in this response are:-

- The five questions posed by Ofcom

- The subject areas in our answer to Question 2, that is, the opportunities for economic benefits by using unlicensed bands for a smart grid, beyond smart metering and the other applications suggested by the documents seeking the re-allocation of the bands that are the focus of the consultation. The opportunities we highlight include:-

    - Social, economic and environmental benefits (e.g., fuel savings, reduction of carbon emissions, more reliable electricity supplies, etc.)

    - Future innovations and developments that the unlicensed SRD bands in the UHF range will be able to offer.

A more detailed briefing paper on certain technical issues is currently in preparation and will be delivered later.

Executive Summary

Future use of the 870-876 MHz and 915 to 921 MHz bands is an important issue and the subject of the current consultation. Demands for spectrum access are growing – in particular from industries which could contribute to the UK's prosperity. Spectrum is in especially strong demand for short range devices (SRDs). Short signal range reduces the risk of interference, making it possible to eliminate licence requirements while allowing frequency re-use by large numbers of devices. Large numbers of devices provide economies of scale, making communications technology affordable. Indeed, one of the most striking discoveries in recent decades is how much creativity is released when designers and entrepreneurs are free to develop applications not pre-defined by regulators. In this consultation, Ofcom considers allocating up to 12 MHz of spectrum to specific and nonspecific SRDs, for a variety of uses

- Management of electricity demand with wireless smart meters. This will enable far more efficient use of existing generating and distribution plant, cutting overall demand while increasing supply efficiency and reliability – the aim of what has been termed a 'smart grid'. The examples outlined here show that in other countries where it is rolled out smart grids have cut peak demand by as much as 11% to 33%. Translating this to the UK, a minimal 3% cut in peak demand would enable the UK to avoid constructing 24 new mid-range power stations.

- For the automotive industries, SRDs are used for applications ranging from tyre pressure monitoring and proximity radars to in-car entertainment

- For the alarms market, SRDs for fire and intrusion detection are crucial assets

- Logistics and manufacturing increasingly depend on SRDs, be it for parts identification and tracking by RFID or for the automation of factory processes

Social needs and benefits justify increased allocations of licence exempt spectrum for SRDs:-

- To reduce emissions of greenhouse gases (GHGs) and total energy consumption, by integrating renewable energy sources (RES) while cutting the generating capacity required for the nation, according to EU Directives

- To support smarter cities and transport which are not only greener and more economically efficient but which enable new services to citizens, from 'joined up' emergency services to streamlined travel payments – eg London's Oyster card

- Telecare of the elderly and infirm in sheltered housing, a form of social alarm, but one that may be extended in the future to remotely managed healthcare in the home

At this very moment, emission limits are biting on the electricity supply. According to the Chief Executive of Ofgem, next month the industry will be forced under two European Directives to reduce total generating capacity from coal and oil-fired generating plants. This will cut the surplus margin from 14% to 5%. In such circumstances the need for more reliable and efficient management of the electrical energy supply over the next decade will be critically important. Smart meters are needed to manage demand while integrating renewable energy sources. Applying lessons learned in the USA to the UK, a smart grid with demand response management (DR) and Distribution Automation (DA) could provide net savings worth £4.9 billion. With a further reduction in communication costs due to RF mesh networks operating at 870-876 MHz, the net benefit would rise to £6.9 billion over 20 years.

Moreover, unlicensed spectrum will trigger the next major advance for networking globally - machine-to-machine (M2M) communications, supporting innovation in applications, from wireless sensor networks to tame forest fires to pacemaker monitors reporting vital heart signs to health carers. By 2020, the economic potential of M2M and the Internet of Things (IoT) could generate benefits of more than $1.4 trillion per year[1] globally as the number of devices connected reaches 100 billion. That economic contribution is 5 times greater than the Internet today. And because unlicensed technologies are cost-effective, power-efficient and robust, they are likely to provide over 95% of these IoT connections.

This is in line with previous valuations of unlicensed spectrum, which far exceed the value of licensed spectrum. As far back as 2006, a study for Ofcom[2] showed, for licensed spectrum, an economic value for mobile services of £50Mn/MHz and for broadcasting £29Mn/MHz. Unlicensed applications such as telemetry offered £300 Mn/MHz, while RFIDs in retail were valued at £620Mn/MHz. At that time (2006) Wi-Fi and home and in-building networking were valued at £69Mn/MHz. That would be significantly higher today, as the deployment density is so much greater and a 2011 study[3] found that the economic value of spectrum use in general has increased by 25% in real terms since 2006 - to £52 billion in 2011.

[1] R. Thanki, "The Power of the Unlicensed Economy", July 2012 - http://allthingsd.com/20120710/the-power-of-the-unlicensed-economy/

[2] *The economic value of licence exempt spectrum, Final report for Ofcom*, Indepen, Aegis, Ovum (2006)

[3] "The economic value of spectrum use in the UK has increased to more than GBP50 billion (Eur60 billion) per year", Analysys Mason (21 January 2013) - http://www.analysysmason.com/About-Us/News/Insight/Economic-value-of-spectrum-Jan2013/

Our response to the consultation questions

Question 1

What other developments, in addition to the international and public sector developments we have identified, are relevant to our identification and assessment of options for release?

In sections 4.19 through 4.26 of the consultation document, Ofcom note that authorising RFID systems to operate at powers of up to 4W in the 915-921 MHz band is likely to yield substantial social and economic benefits. "Performance improvements and economies of scale" are expected mainly from the fact that RFID tags "used globally are manufactured with their centre frequencies tuned to around 915 MHz." Such tags will respond to interrogation signals transmitted in CEPT's current RFID allocation at 865-868 MHz, though with subdued power. Using frequencies closer to the tags' designed resonance – and boosting the signal strength of interrogators - will substantially improve the range, speed and reliability of tag readings, as the consultation document states.

The global database of RFID regulations compiled by the GS1 standards organization[4] supports Ofcom's observation that 915 MHz is a widely used tag frequency. So far, 20 countries have authorized the use of RFID with a maximum reader power output of 4W in at least part of the 915-921 MHz band.[5] Eight more[6] have authorized RFID in the band above 920 MHz.

It is also worth noting that in most of ITU Region 2, RFID is just one of many applications and services – licensed and licence exempt – authorised to use 915-921 MHz. Licensed radio services in this band include Fixed (primary), Radiolocation (primary in the US), Amateur and Mobile except Aero. Industrial, Scientific and Medical (ISM) devices may also use this band without licensing. The rules adopted by countries in ITU Region 2 for licence exempt uses of 915-921 MHz are usually technology and service neutral to a high degree. This provides opportunities for innovation, as seen in xG Technology's development of licence exempt cellular mobile systems using cognitive techniques in the 902-928 MHz band[7] and Apple's AirPort technology, which in 1999 introduced the public to WLANs and paved the way for Wi-Fi. Clearly there is a much greater scope for successful co-existence among diverse equipment types and network architectures in this band than Ofcom's consultation document indicates. Additional comments about the diverse uses of the 915 MHz band elsewhere are found in our answer to Question 2, below.

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[4] "Regulatory status for using RFID in the UHF spectrum," (updated to 15 February 2013) - http://www.gs1.org/docs/epcglobal/UHF_Regulations.pdf

[5] Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Israel, Japan, South Korea, Malaysia, Mexico, Panama, Peru, Philippines, Russia, South Africa, United States, Uruguay and Venezuela.

[6] Australia, Brunei Darussalam, China (including Hong Kong), New Zealand, Singapore, Taiwan, Thailand and Vietnam.

[7] "xG Technology logs orders, projects Q2 product delivery", by Donny Jackson, *Urgent Communications,* 11 February 2013 - N

Generally we agree with the conclusion of *ECC Report 181*[8] that the co-mingling of longer- and shorter-range applications is feasible in SRD bands and may result in higher levels of spectrum utilisation than the segregation of applications by power or range.

But since Ofcom's present aim is:-

> *"to identify the broad approach to release that is most likely to maximize the value to citizen and consumers from use of the band*",

the technical details of implementation are properly left for a later consultation.

[8] "Improving spectrum efficiency in SRD bands" (September 2012) - http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP181.PDF

Question 2
Do you have any additional information or analyses that could help to inform our assessment of the value that could be created through different uses of the spectrum?

1.0 - Smart metering

DECC's smart metering policy focuses on the mandated replacement of about 53 million residential and non-residential gas and electricity meters in Great Britain. A supplier-led roll-out is envisaged, with a centralised Data and Communications Company (DCC) created to support the deployed smart meters' data traffic and management needs. The business is valued by DECC as follows:

- Total Net Present Value £6,659m
- Business Net Present Value £510m

1.1.0 - The Economic Case for Smart Metering

The benefits according DECC's analysis[9] fall into eight classes:

1. With near real time information on energy consumption, consumers are expected to make energy savings through enhanced energy efficiency behaviour.

2. This reduction in energy use also implies carbon savings, in the form of reduced European Union Emission Trading Scheme (EU ETS) allowance purchases for electricity and lower emissions from gas consumption. In parallel, smart meters will allow suppliers to make a range of operational cost savings.

3. Smart metering removes the need for site visits to complete meter reads and are expected to reduce suppliers' call centre traffic, with fewer queries about estimated bills.

4. In addition, smart meters are expected to make the consumer switching process between utilities cheaper and simpler, thanks to accurate billing and more streamlined interaction between the parties involved.

5. The electricity distributors should see improved theft detection and debt management; and consumers will also be able to play a role in avoiding debt accumulation with access to accurate, near real time energy information.

6. Network operators will be able to improve electricity outage management and resolve any network failures more efficiently once a critical mass of smart meters has been rolled out; and they will be able to realise further savings from more targeted and informed investment decisions.

7. By enabling time of use (ToU) tariffs, which tend to shift a proportion of electricity generation to cheaper off-peak times, smart meters are also expected to

[9] DECC, 24 Jan 2013, *Smart meter roll-out for the domestic and small and medium non-domestic sectors (GB*), Impact Assessment, IA No: DECC0009, Final, Source of intervention: Domestic, Type of measure: Secondary legislation

generate savings both in terms of distribution and a reduction in generation capacity investment requirements.

8. The roll-out will also facilitate the development of smarter grids, although the associated benefits have not yet been quantified.

Using DECC's own figures, the breakdown of these benefits when costed is as follows for a complete UK rollout:-

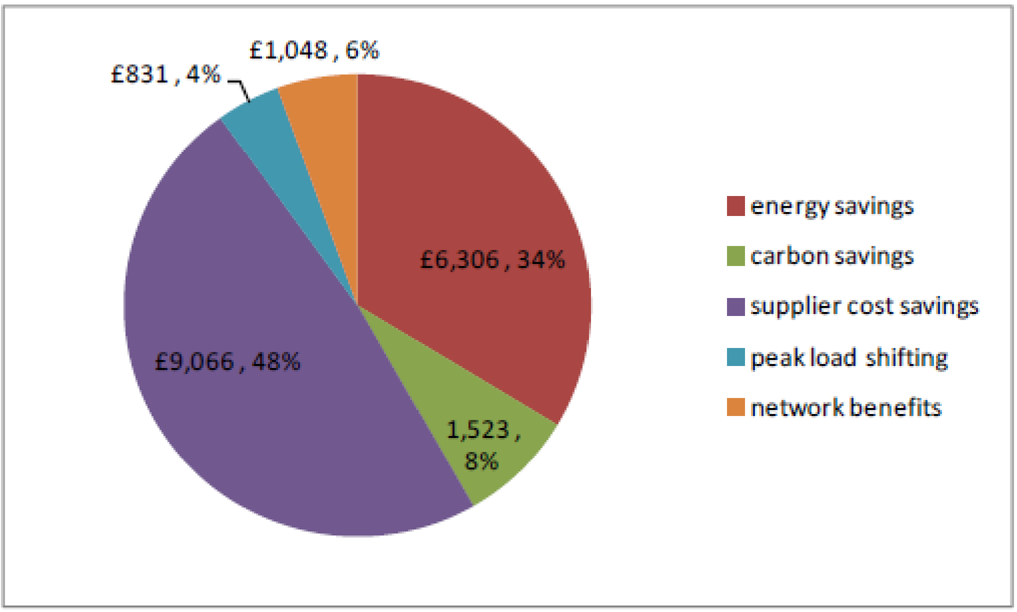


Figure 1 – The Benefits accrued from the DECC smart metering scheme

The detailed benefits accounts, developed over the last three years are as follows:-

BENEFITS (£m)	***Low***	***HIGH***	***Best estimate***
Total Transition Benefits (Constant Price)	0	0	0
Years	not defined		
Average Annual (excl. Transition) (Constant Price)	1,022	1,844	1,423
Total Benefit (Present Value)	**13,485**	**24,328**	**18,774**

Description and scale of key monetised benefits by the major groups affected are as follows:-

- Total consumer benefits: £6.3bn which includes:-
    - Savings from reduced energy consumption (£6.26bn),
    - Microgeneration (£43m) by householders.
- Total supplier benefits: £9.07bn which includes:
    - Avoided site visits (£3.37bn),
    - Reduced inquiries and customer overheads (£1.29bn),
    - Diverse other supplier economies and benefits in operations (£4.406bn)
- Total network benefits amount to £1.05bn which includes
    - Generation benefits (£794m)
    - Carbon related benefits (£1.46bn)
    - Air quality improvements (£104m) The CO_2 equivalent change in greenhouse gas emissions (in Million tonnes CO_2 equivalent) is:
        - Traded: 12.1
        - Non-traded: 25.6

Other key non-monetised benefits for the 'main affected groups' include:-

- Benefits from further development of the energy services market and the potential benefits from the development of a smart grid.

- Smart metering is likely to result in stronger competition between energy suppliers due to increased ease of consumer switching and improved information on consumption and tariffs.

- An end to estimated billing and more convenient switching between credit and pre-payment arrangements that should improve the customer experience.

Costs are broken down as follows:-

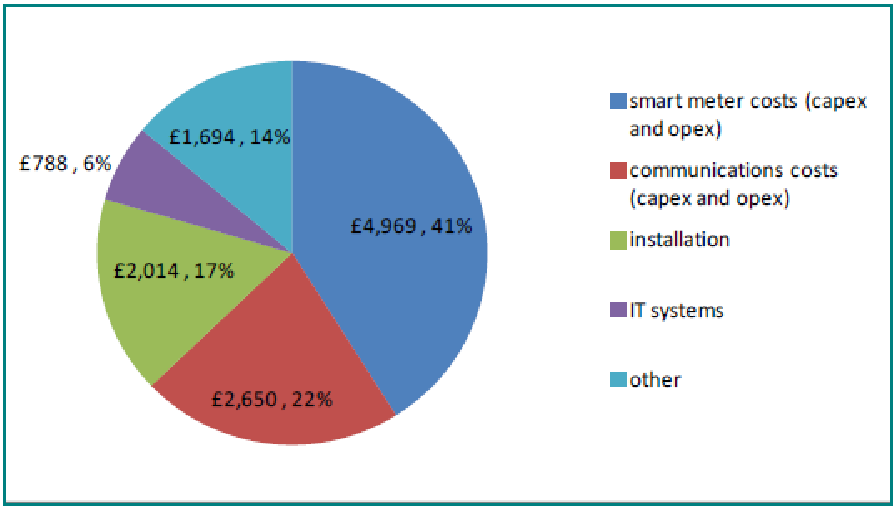


Figure 2 – The cost summary of the DECC smart metering scheme

COSTS	**£m**
Total Transition cost (Constant Price)	1,430
Years	not defined
Average Annual (excl. Transition) (Constant Price)	810
Total Cost (Present Value) Best Estimate	**12,114**

The breakdown of these costs into the main categories is:-

- Metering equipment costs with their installation and operation: £6.98bn
- Communications equipment costs: £2.65bn.
- IT systems costs: £1.24bn.
- Industry set up, disposal, energy, pavement reading inefficiency and costs associated with the Consumer Engagement Strategy: £1.24bn.

Main costs items for roll-out can be categorised as follows:-

- Energy suppliers will be required to fund the capital costs of smart meters and In-Home Displays (IHDs).
- Energy suppliers will also have to pay for the installation, operation and maintenance of this equipment plus the communications hub (which links the meter(s) in a property to the supplier via the Data Communications Company, DCC).
- Communications hubs will be provided by the DCC.
- The roll-out of smart meters also implies upfront investment in supporting IT systems and the DCC, as well as their ongoing maintenance.

- Other participants such as distribution network operators (DNOs) will also need to upgrade their systems to integrate into the smart meter network. Further costs include:-
  - The accelerated disposal of basic meters being replaced
  - The energy consumed by the smart meter equipment itself
  - Launch and support of a consumer engagement strategy.

The analysis also considers the increasingly inefficient reading of dumb meters as the roll-out progresses, otherwise known as 'pavement reading inefficiency'.

Key assumptions/sensitivities/risks in the costs and benefits analysis include:-

- Cost assumptions are adjusted for risk optimism bias
- Discount rate used is 3.5%
- Sensitivity analysis has been applied to the benefits as energy savings depend on consumers' behavioural response to information
- Numbers presented are based on the modelling assumption that the scope of the DCC will include data aggregation in the long term.
- Wireless communications are assumed to represent 22% of the total project cost with a benefits analysis based on specific HAN and WAN equipment[10], with its domestic requirements for data transfers, network architecture, etc, for a WAN communication service charge of £5.30 per premise per year.

2.0 - The Smart Electricity Grid

This section explains the benefits of a smart grid to the UK economy from a network supply perspective. These are quantified as the cost savings associated with deploying smart technologies in place of the conventional technologies of the last decades. From case studies, the section leads on to a discussion of this cost savings, one of the primary benefits that can result from a smarter electricity grid.

2.1.0 - What is a smart electricity grid?

In general the concept incorporates two core functions to advance intelligent electrical supply management, in terms of energy efficiency and sustainability for a greener economy – *demand response* and *distribution automation*. While electricity generation accounts for 40% of human-caused CO_2[11], greater use of renewables such as wind and solar requires more dynamic grid control and storage.

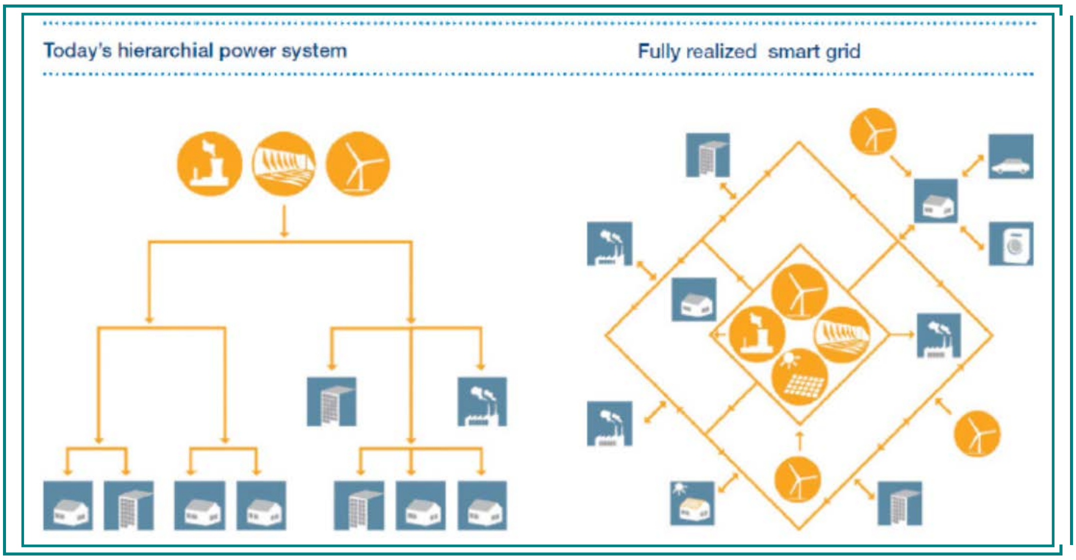
Thus Smart Grids are electricity networks that can efficiently integrate the behaviour and actions of all users connected to it — generators, consumers and those that do both — in order to ensure an economically efficient, sustainable power system with low losses and high quality and security of supply and safety . So a Smart Grid could

[10] To estimate the cost, the HAN was assumed to operate at 2.4 GHz using a variant of the Zigbee protocol, while the WAN's cost estimate is compatible with several different technical solutions. However, DECC has acknowledged that "2.4 GHz [HAN] signals will not propagate effectively in all property types," adequately covering only ~70% of properties. On the other hand, HANs operating in the UHF band "are all likely to achieve over 95% satisfactory propagation…" See "Consultation on the second version of the Smart Metering Equipment Technical Specifications", DECC Smart Metering Implementation Programme (2012) - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42953/6129-consultation-second-version-smets.pdf

[11] G. W. Arnold, *Laying the Foundation for the Electric Grid's Next 100 Years*, ETSI workshop presentation, April 5, 2011

be just considered as a “Smart Electricity System”, which encompasses both the grid and the users connected to it, and includes technical as well as non-technical (billing, operational, regulatory) building blocks.

The aim is to do all this at lower cost in capital investment and operational costs. It may incorporate smart metering, as explored in the previous section on the DECC initiative, but here we separate the two and focus on the Smart Grid for electricity.



Source: ABB, 2009

Figure 3 – Difference between today’s power system and a smart grid

Such advances enable network operators to optimise the operation of their generation resources and distribution with real-time information on demand and capability. Operators can respond immediately to changing demand and fluctuating generation patterns from renewable resources affected by local weather. Moreover a Smart Grid anticipates and avoids power disruptions caused by failure. It becomes a key component of the national electricity supply’s reliable operation.

The Smart Grid employs a range of what may be popularly termed ‘Smart technologies’ to form an advanced metering infrastructure (AMI), specifically:-

- *Demand response* (DR) systems, principally aimed at smoothing peaks in demand, to limit the maximum power demand that must be built for;
- *Distribution Automation* (DA), which is centred around grid reliability, may include, at a minimum:-
    - Systems management;
    - Transmission enhancement applications;
    - Increased reliability via networked switch reclosers that isolate and minimise the scope of outages on the distribution network;
    - Direct load control for grid reliability events;
    - Local distribution management including voltage and phase continuity through networked devices such as load tap changers or capacitor bank controllers;
    - Integration of operations, load dispatch and billing for distributed generation (DG) and renewable energy sources (RES) of electricity generation (DG/RES);
    - Advanced energy storage.

Thus the Smart Grid's transmission and distribution system employs technologies such as real-time monitoring, autonomous control, two-way communications, smart meters and energy storage.

The basis of this grid development in the UK is the regulatory and financial framework supplied by Ofgem, the regulator, through its Low Carbon Network Funds (LCNF) initiative and the follow-on Network Innovation Competition (NIC). This identified some £200bn that needs to be found over the next ten years to guarantee energy supplies in the UK. Ofgem's Electricity Market Reforms programme will be addressing the shortage of generation. However it still leaves a £32bn gap required for network investment – a significant sum in comparison with the industry's net worth, some £43bn. Ofgem's answer in economic terms is to use price models based on 'RIIO'[12], which it heralds as "*a new way to regulate energy networks.*"[13] This is expected to deliver £1bn to UK consumers over eight years[14] and stimulate over £30bn in investments needed to modernise and sustain the UK grid.

2.2.0 - Why is it important now?

Today, consumers in the UK benefit from some of the most reliable electricity distribution networks in the world. The average customer experiences just over one hour of lost supply per year[15]. This is about half the US average, and also compares favourably with many European countries. But it is about a quarter of the reliability of South Korea's advanced supply system in terms of mean time between failures and mean time to repair. This relatively strong performance by the UK supply industry is due to several factors, mainly:-

- Continuity of supply has been ensured by network planning standards that mandate a maximum of redundancy, so back-up for failure is made easier.
- Physically protected distribution networks, which may be often buried in accessible ducts, in contrast to Japan and the USA and much of the EU.
- Load despatch protection from potential overloads which limits large-scale damage – avoiding both safety issues and lengthy major repairs.
- Regulatory incentives to reduce numbers of supply interruptions and duration
- Historic growth in demand has been modest and relatively predictable.

However a primary reason for the need for a smart grid is that the last of these factors is no longer true. The way that consumers use electricity is starting to change, with increasing electricity demand – for transport in cars, trains and buses, rechargeable IT equipment and other consumer devices in both the home and office which all drive up consumption.

[12] Revenue = incentives + innovation + outputs

[13] Sean Davies (2012), *Smart grid gathers pace,* IET, Vol 7, issue 12, 17 December 2012

[14] Ofgem, *Sustainable energy networks : RIIO demands innovation and efficiency,* press release, 18 March 2011.

[15] Council of European Energy Regulators. 4th benchmarking report on quality of electricity supply.

Secondly, the UK's carbon footprint is not likely to meet the European standards for 2020 without far more careful husbandry of our generation, distribution and consumption patterns and capabilities.

Thirdly, there are movements - and corresponding policies - inciting consumers to greater respect for the environment. So there are pressures to reduce GHGs and energy consumption generally, while generating a greater proportion of renewable energy (perhaps up to 50% in the future). All require a far stronger emphasis on the efficient management of energy supplies.

2.3.0 - What types of benefits can a Smart Grid bring?

There are at least nine major economic benefits, because the aims of a smart grid are not just to inform but to control energy consumption and detect distribution anomalies, such as voltage variations. These benefits are shown in the figure below but can be grouped into three main types of advantage:-

- Operational savings - for the electrical grid and thus its users
- Fewer outages - higher reliability through anticipation of crises and failures
- Integration - of new sources, specifically distributed generation from renewable sources, and new demands, in particular electric vehicles, notably cars in cities

The selected cases illustrating the Smart Grid benefits in monetary terms in the figure below are taken from instances already rolled out and thus are outside the UK. They show what is being delivered today beyond simple meter reading. These may have social benefits as well as direct economic significance – for instance reducing electricity bills for low-income families by a greater proportion compared to middle income families.

The Range of Benefits from a Smart Electricity Grid
Nine categories of economic benefits extracted from publicly filed rate cases in the USA

Function	***Smart Grid Facility***	***Average saving, per customer***	***Highest saving measured***
Conservation voltage reduction, IVVC[16]	Distribution Automation (DA)	£174	£323 (US$488, Dominion)
Meter reading/meter ops	Automated Metering Infrastructure (AMI)	£99	£139 (210, Com Ed)
Energy Conservation	Energy Efficiency (EE)	£57	£93 (140 , BGE)
Pricing	Demand response (DR)	£48	£394 (596 BGE)
Direct Load Control (DLC)	Automated Meter Reading (AMR)	£40	£47 (69, Consumers Energy)

[16] Integrated Volt-VAR Control, deployed to reduce power wasted by reducing delivered voltage, while meeting the regulated lower limit for voltage for customer premises

Theft detection	Anti-Fraud	£34	£262 (396, BC Hydro)
Fault location, isolation & recovery with grid monitoring	Distribution Automation (DA)	£15	£38 (58, Com Ed)
Outage Detection	Automated Metering Infrastructure (AMI) and Distribution Automation (DA)	£10	£23 (34 PG&E)
Billing	Revenue Recovery	£9	£28 (42 PG&E)

Various studies have also examined Smart Grid economics in Europe[17]. For instance, European member states Denmark, Finland, Ireland Italy, Germany and Spain are all following the EU's 20/20/20 goals, but also consider a far longer term investment based on national roadmaps for energy supply and demand for their economies in 2030 and into 2050.

Great Britain is a fast mover in the field of energy services and recognises the smart grid's GDP growth potential.

2.3.1 - Analysis of the benefits from specific cases

Here we look at specific use-cases and smart grid projects for electricity supply and management. The aim here is show real experience of what a smart electricity grid can bring in terms of the economic benefits emanating from each of its various functions and capabilities.

2.3.1.1 - Use-Case 1: Demand Response Pilot

In 2010 a large USA utility, Oklahoma Gas and Electric, first deployed a demand response platform, starting with a 6000 home pilot, now rolled out to 50,000 homes and SMEs[18].

The aim was to reduce peak demand and so avoid the construction of two major power plants, each of 165 MW. To do this, the target was to shrink consumer and SME demand by 210MW over 3 years, progressively increasing savings by 70 MW each year.

This was done with an on-premises thermostat set by the customer which uses dynamic time of day (TOU) tariffs, with an in-home display of temperature and consumption, plus a customer portal for interaction and further information.

[17] V. Giordano, et al., *Smart Grid projects in Europe: lessons learned and current developments*, EC DG Joint Research Centre, Publications Office of the European Union, Luxembourg (2011).

[18] K. Tweed, "OG&E charges into 50,000 homes", *GreenTechGrid* (16 December 2011), via Silver Spring Networks

Expansion is planned to full deployment with a rollout to 120,000 customers by 2014 to get the full 210MW reduction. The cost is about US$ 300-400 per participating home but the US$60 Mn involved is far less expensive than the two new power plants totalling US$320. Results have been substantial in the 6000 home pilot with:-

Average demand reduction during peak	11%-33%
Proportion of participating homes and SMEs saving on electricity bills	98%

Note these are pilot project figures but were used to inform deployment of the production, "business-as-usual" system of 50,000 users today. On the social benefits side, customer awareness - of peak power use and energy savings - as well as customer relations, and their perception of their role in controlling their own consumption, and so the relation with the utility - has improved.

Applying the economies of peak reduction, even with a far more conservative demand saving during peak times, to the whole of the UK[19] could bring substantial savings. *An estimated projection applying this reduction across the whole of the UK shows a net saving of up to 24 peak-demand generation plants (at 165 MW capacity) in required capacity up to 2020. This economy translates to a net cost saving of approximately £250M per year, which, if accumulated to 2030 would be £6.75 Billion at current values and without future value discount.*

2.3.1.2 - Use-Case 2: Distribution Automation Benefits from Conservation Voltage Reduction (CVR)

Commonwealth Edison (ComEd) targeted 2-3% energy savings by using Integrated Volt-VAR (volt-amp reactive) Control for its CVR, while meeting the regulated limits for voltage. The overall effect is both to reduce power wasted in the customer distribution network and to cut GHG emissions.

Distribution Automation provides a reliable way to monitor the end-of-line voltages, in the distribution network between the substation and the customers, as shown below. Often in a traditional system, at the 'end of the line' from the substation voltages may dip too low. In consequence, typically, the substation voltage is set too high to compensate in such open-loop systems, in order to meet the statutory requirements at the end of the line and avoid brownouts.

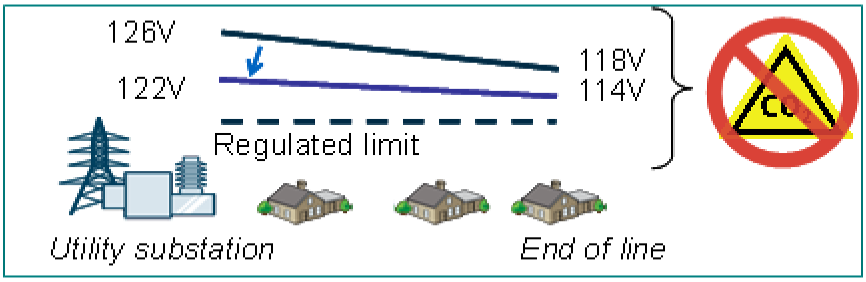


Figure 4 – Distribution automation with Conservation Voltage Regulation (CVR) reduces power consumption

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[19] Analysis using proportional estimates of UK power consumption with 3% savings relative to the peak demand, to 2020, for proportional ratios of generating capacity in the UK and USA and the numbers of customer meters. Source: Silver Spring Networks

The solution is to use the AMI to close the loop, by monitoring voltage throughout the network and then to maintain voltage at the regulated limit everywhere, ie flattening out the voltage level differences with distance. Generally a 1% voltage level reduction translates into a 1% power saving in consumption, with proportional GHG emission reductions. This reduction in consumption benefits consumers directly via reduced energy bills.

It is achieved by reducing and stabilising substation voltages, otherwise ranging (in the USA) from 126 to 122 VAC at the substation, and arriving at customer premises at 114 -118V AC to be closer to the standard regulated limit (110V AC) whatever distance each customer is from the substation.

Taking this 3% constant power reduction at a national level translates into major saving. Using a projection across the UK, the energy cost savings would amount to £400M per year approximately as well as emissions reduction of some 5M metric tons of CO_2 per year [20]. A more conservative projection – a 1% power reduction – would yield a savings of £133M per year with an emissions reduction of some 1.67M tonnes of CO_2 per year

2.3.1.3 - Use-Case 3: The more applications installed on the Smart Grid, the more benefits are realised long term

This analysis is based on a range of US case studies to show the cumulative power of smart electricity grid applications. Increasing benefits come from adding multiple functions beyond the Advanced Metering Infrastructure, specifically the functions of:-

- Distribution Automation, DA, with the majority of DA savings being from Conservation Voltage Reduction (CVR)
- Demand Response, DR
- Energy Efficiency, EE

What the analysis highlights is that an AMI is usually not enough by itself to produce a positive business case or rapid payback on investments, but requires additional functions, as shown:-

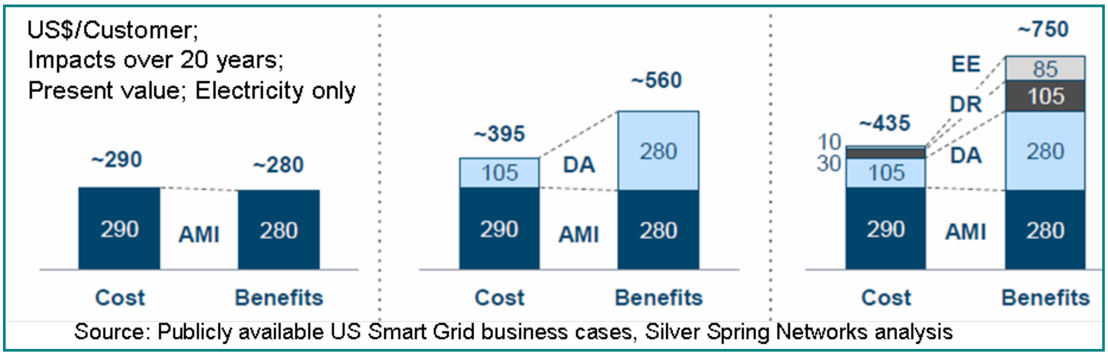

Figure 5 – Adding more capabilities makes smart infrastructure pay off

[20] Source for estimates; Commonwealth Edison and Silver Spring Networks, estimated from a USA case, proportioned for the UK, from analysis given by Navigant in a 2009 report, *Value Assessment of Distribution Automation and Conservation Voltage Reduction Programs,* for the Illinois Commerce Commission

As more applications are added, a cost benefit ratio of 0.97 for a pure AMI-only deployment becomes 1.7 – a 70% return on investment over the life of the installation in the maximum case, with DR, EE and DA added. Just adding distribution automation alone produces a 40% return.

2.3.1.4 - Use-Case 4: Advanced electricity distribution applications add extra value

One of the major drivers for the smart electricity grid is handling a new topology for generation, different to the traditional pattern of a static set of central generating stations feeding a national transmission grid at high voltage. Load dispatch for the future will have to support feed-in sources from renewables, domestic and small local power plants, varying from solar farms and offshore arrays to single wind turbines, all of which vary in electrical output with the meteorological conditions. The management of such a grid will demand far more sensing networks and actuator controls.

New demands for recharging electrical vehicles promise grid overload unless suitable real time management is available for control of the electric vehicle charging stations for non-peak-time charging. These benefits, could add significant value on top of currently deployed Smart Grid applications, as shown below:-

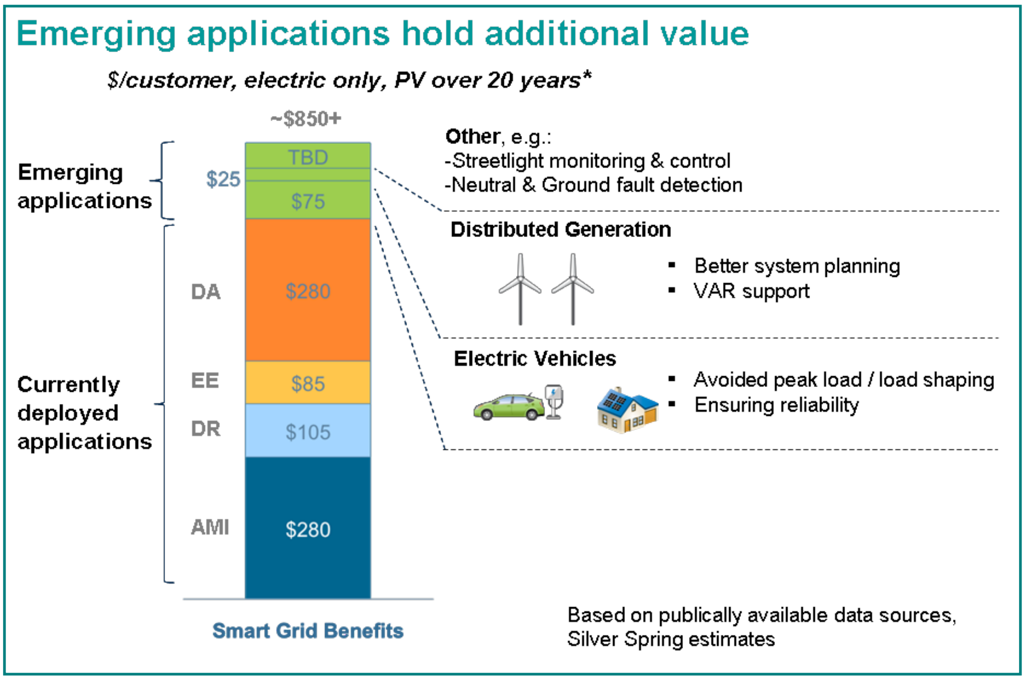

Figure 6 – Adding renewable energy sources and electric vehicles will be a future requirement, setting new patterns of demand and supply for our supply grid and requiring smarter management

Completely new applications are also appearing such as using the electricity grid to monitor ground faults due to changes in the geological structure, by measuring earthing impedance or neutral degradation. A smart grid can thus be used as a wide area sensor network for ground movements.

Further long term benefits for the customer come from fault location, isolation and supply restoration, which is performed far more quickly, reducing the mean time to repair, as well as advanced grid monitoring for transformer performance to maintain power quality.

2.3.1.5 - Use-Case 5: - overall impacts for the UK DECC smart metering project

2.3.1.5.1 - Net financial impacts of a smart electricity grid

Taking the advances explored in previous Use Cases, those benefits may be applied to the UK's DECC smart metering initiative. Impacts are estimated using a translation of benefits for DR and DA from the Use Cases in the USA.

These show that a smart grid with demand response management to reduce the peak generating capacity required and finer voltage control to meet regulatory voltage levels without waste could provide net power management savings worth some £4.9 Billion. But with the reduced costs of using an RF mesh network, in the 870-876 MHz unlicensed band[21], the net benefit would rise to £6.9 Billion.

Budget item	£Mn
Increase in benefit from Demand Response cutting demand by £250M/yr, translated from US experience for NPV over 20 years using standard NPV estimate	£1,394
Benefit of introduction of Distribution Automation with CVR ,for savings of £400Mn/yr (translated from US experience of voltage management, CVR) NPV over 20 years using standard NPV estimate	£3,927
Smart metering basic savings	£ 5,321
Costs to implement	£433
NET power supply savings	£4,888
Savings on opex communications costs as RF mesh reduces costs over mobile, over 20 years	£1,985
Net impact from benefits + savings	£ 6,873

Source: SSN (UK) Ltd. ***NB: based on the original DECC Impact Assessment. Savings may be greater as later assessments posit higher costs.***

2.3.2.0 - Summary of benefits in economic terms at a national level

2.3.2.1 - The case of the UK - employment and other impacts of the smart grid

A 2012 report analysing the UK employment potential of investment in a Smart Grid[22] concludes that it has a substantial growth-inducing benefit for the British economy.

[21] Mesh networks are particularly cost-effective in serving multi-tenant and multi-storey buildings. See the UK HAN Working Group's "Industry's Draft Technical Specifications Supporting Document: HAN Select Options" (November 2011) - https://sites.google.com/site/smdghanwg/home/papers/HANSelectOptions_SupportingDocument_Stage12.docx

[22] Ernst & Young, *Smart Grid: a race worth winning? A report on the economic benefits of smart grid*, SmartGrid GB (April 2012), available from http://www.scribd.com/doc/94198144/Smart-Grid-A-Race-Worth-Winning-a-SmartGrid-GB-Report

This comes from the £23bn that will need to be spent between now and 2050 on smart upgrades to the distribution network, with implications for employment and supply chain industry stimulation. And with national deployment for the upgrades, that would rise to £27bn. Much of the benefits accrued in this analysis depends on the assumptions regarding avoided costs, compared to a conventional (non-'Smart') energy strategy.

The smart grid is considered in isolation here, since in UK the cost/benefit of the smart grid concept is often considered separately from smart metering, being seen as a further development. Investigating the employment and broader economic impacts, this Ernst and Young study considers the smart grid costs and benefits for a £23 billion investment, based on studies for the Smart Grid Forum. However, the risks of inaction are also substantial. The results are significant, as shown below:-

Estimates of benefits

Benefits	Estimated Benefit
Direct benefits from increased activity along the supply chain	£6 billion
Indirect benefits on the purchases of intermediate inputs and capital goods and a	£5 billion
Induced impact of personal purchases of employees and business owners from additional income	£2 billion
Total	**£13 billion**
Net cost balance with an investment of £27 billion with deployment	**- £14 billion**
Risks of inaction	**Costs of risks**
Failing the carbon targets (worst case: total cost of £126 billion in net present value over the 2012 – 2050 period)	£126 billion
Faster rising cost of energy (rising extra cost of £4 billion to 2050)	£4 billion
Deteriorating network performance (assuming one 12h blackout can cost approximately £7 billion) –estimate at a rate of one every 10 years, over 37 years, to 2050, source : SCF Associates Ltd	£30 billion
Total risks of inaction, without inhibited growth, over 10 years	**£160 billion**
Net balance for investment of £27 billion, with £13 billion in benefits	**£146 billion**

Source: Ernst and Young, Smart Grid Forum (2012)

Also, there is an extra cost of inaction which is not given in the study and which we have estimated, based on the direct expenditure in the UK (£23 billion) and a low additional export potential, all at present value:-

Inhibited growth of secondary and supply chain industries and associated export potential, minimum estimate over 37 years to 2050. Source of estimate : SCF Associates Ltd	£25Bn

2.3.2.2 - It will be cheaper to upgrade the UK infrastructure to 2050 the Smart Grid way

Further analysis in the Ernst & Young report indicates that an incremental £23bn is required up to 2050 to upgrade the UK distribution network to meet demand in capacity, costs and reliability (drawn from the Smart Grid Forum early-stage research) but the process of rollout will increase this to £27bn. It also suggests that it is significantly cheaper to pursue a smart strategy relative to a conventional strategy for the future distribution network upgrades that will be required: savings from deployment of a smart grid could be £19bn (based on the same early-stage findings) some 41% of the NPV of a conventional technology approach. Importantly, savings from smart grid are projected to remain as high as £10bn even if only low levels of decarbonisation / electrification eventuate. There is a minimal downside (£0.2-£1bn) to investing early, rather than delaying a decision until 2023.

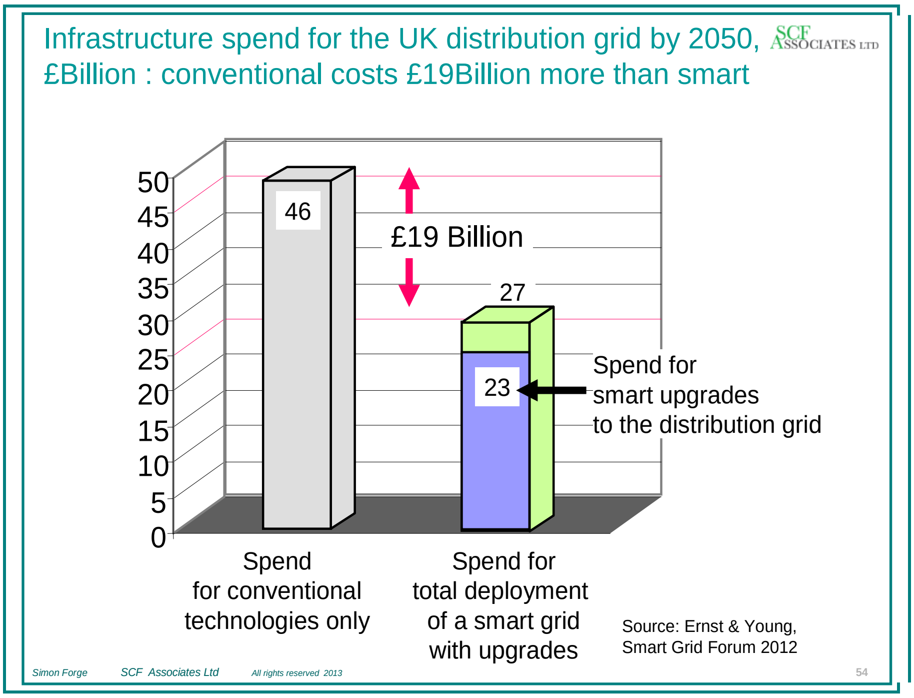

Figure 7 – The difference in infrastructure build costs favour smart grids for the long term to 2050 and present a saving of 41%

Note that the Smart Grid Forum report quoted by Ernst and Young does not explicitly quantify the value of benefits themselves. Instead it compares the cost of the two approaches for a future electricity supply grid: the first approach is by conventional technology, the second by smart technologies. Hence the net benefit is the difference in investments, capex and opex, ie the direct financial saving attributed. Other studies, such as that from EPRI (next section) suggest the savings may be greater.

2.4.0 - Does smart metering need the smart grid to succeed?

The analyses by Ernst and Young (2012) suggest that some benefits expected from smart meters and cited in the DECC smart meter rollout plan could be at risk *without the parallel development of smart grid propositions*. Indeed, some industry experts admit that the business case for smart metering alone is not compelling. However, the cumulative benefits from adding other "smart grid" applications make the business case rational Of course it is the communications infrastructure tying everything together which makes the benefits of the other applications attainable. So a timely roll out of a smart grid is essential for gaining the full range of benefits.

2.4.1 - The case of the USA: an EPRI study shows marked benefits

In 2011 EPRI, the Electric Power Research Institute published results from a long term study (to 2030) with a detailed cost-benefit analysis of smart grid implementations. Their main findings were as follows:-

Benefits

The total benefit accrued over a 20 year life of the network would be between US$1294 and US$2028 billion. However the monetised benefits for productivity of the economy seem to be taken as minimal and might be significantly higher.

Costs:

Estimated net investment requirements needed to realise a smart grid in the USA estimated as between US$338 and US$476 billion. These estimated costs considered a standard range of expenses, based on the numbers of distribution substations, kilometres of transmission lines and the incidence of vandalism. But certain costs were excluded, in particular expenses for new transmission lines, energy efficient devices and most importantly the consumer appliances and devices. Total costs for consumers might be higher than estimated in this study.

Cost to benefit ratio

A high positive balance with benefit-to-cost ratios of 2.8 to 6.0 in favour of a smart electricity grid deployment results.

A breakdown of costs and the benefits for a 20 year run is shown below:

20 year total	Low	High
COSTS of Smart Grid deployment	**(US$billion)**	
Transmission and substations	82	90
Distribution	232	339
Consumer 24 46	24	46
Net cost of investment required	**338**	**476**
BENEFITS of Smart Grid deployment	**(US$billion)**	
Productivity (real GDP)	1	1
Safety (work environment)	13	13
Environment	102	390
Capacity (peak load)	299	393
Cost of energy	330	475
Power quality	42	86
Quality of Life (comfort etc.)	74	74
Security (self-healing)	152	152
Reliability & availability	281	444
Total benefit	**1294**	**2028**
Balance	**956**	**1552**
Benefit-to-cost ratio	2.6	6.0

Source: Electric Power Research Institute, 2010

2.4.2 - The case of Denmark: again the avoided costs make the case for a smart grid, in an advanced sustainable energy economy

For a projected population of 5.7 Million in 2030, a report published in 2010 from Energinet.dk and the Danish Energy Association concludes[23] that a smart grid is the most cost effective and efficient approach to the future planning of Denmark's national power delivery infrastructure.

Note that Denmark has led the EU in wind energy use, and other renewable energy sources (RES), such as municipal heat via cogeneration. Thus their analysis shows up high variabilities, as the report's estimates are based on aggressive RES assumptions. They include a wind turbine capacity supplying 50% of Denmark's net annual demand, and also a total of electric and plug-in hybrid vehicles of around 600,000 units, and up to 300.000 individual heat pumps. For lower assumptions of RES proportions and electric vehicle demands, the estimated benefits are reduced for a smart grid infrastructure.

Investment required is estimated to be €1.3 billion in present value (DKK 9.8 billion) at an annual discount rate of 5 per cent. Costs here include rollout of the metering, as well as the control and automation on the consumer premises and in the power grid. As shown in the breakdown figures below, benefits of €1.1 billion are slightly lower than the costs, some DKK 8.2 billion, for a cost of DKK 1.6 billion overall.

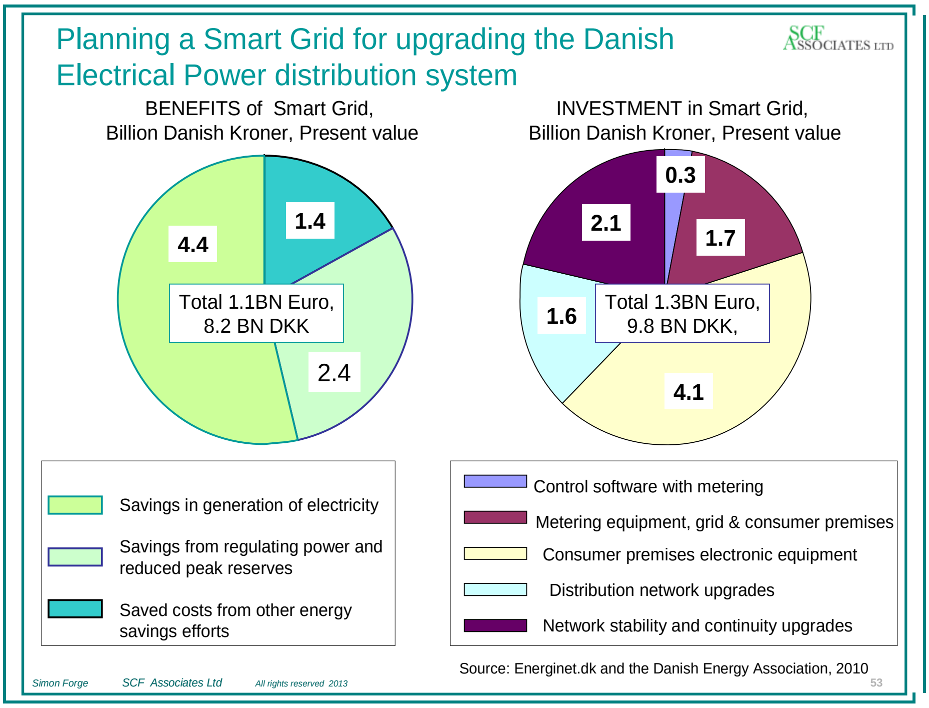

Figure 8 – Cost/benefits analysis for smart grid, before adding the avoided costs of conventional expansion strategy

However, in Denmark the conventional strategy for expansion, without a smart grid, has been estimated to cost some DKK 7.7 billion, without the additional benefits shown above. Therefore in an overall costs/benefits analysis, the smart grid strategy

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[23] Energinet.dk & Danish Energy Association, *Smart Grid in Denmark (*2010), available from: http://www.smartgridnews.com/artman/publish/Business_Lessons_Learned/Smart-grid-in-Denmark-3772.html

yields an estimated DKK 6.1 billion net benefit, due to the avoided costs of the traditional approach. *So the smart grid detailed in the report becomes the lower cost option.*

It is here we see the variability in smart grid, as with less electric/hybrid vehicle and heat pump demands, the high demand growth scenario is no longer valid. So the extra avoided costs are lower, as 74% of the extra costs come from network upgrades for reliability and capacity expansion which are not called for without the new demands.

However, both Denmark's and the EU's policy is towards energy efficiency and sustainability, which Denmark has always seen as a pillar of its industrial policy. The smart grid is an essential part of its future economy and a social support for employment and thus the upgrade of its public services it views as increasingly necessary. Moreover many EU MS are looking to Denmark and its energy strategy as a routemap for their own policy, so its planning is being monitored carefully.

2.5.0 - Macro-economic leverage effects of the Smart Grid's energy savings

However, the direct savings outlined above could be worth far more to the UK due to newly examined leverage affects on energy pricing. The 3% energy saving could be worth far more in monetary terms – perhaps 4% to 6% - in energy cost terms, when indirect impacts at a macro-economic level are taken into account.

Energy savings have a strong multiplier effect, due to their downward pressure on energy prices as demand abates. Looking at the medium/long term, to impacts apparent by 2020, shows three main effects of saving energy on energy prices:-

1. Energy efficiency policies across the EU will lead to lower fossil fuel prices,
2. Lower electricity demand will lead to lower electricity prices,
3. Infrastructure investments can be reduced, making further price savings.

A recent study from Ecofys[24] has estimated that the first effect is already substantial with energy savings in 2020 being estimated as likely to have an indirect impact on energy prices of the same order as the direct impact of the energy saving - ie *for every £1 of energy cost saving, an additional £1 could be saved by lower market prices.* Thus for the EU, while direct savings are expected to amount to €107 billion annually by 2020, the total net savings in 2020 are estimated at around €200 billion per year. Energy savings in 2030, if current ambitious energy savings continue to be pursued in the 2020-2030 period, indicate net direct energy cost savings by 2030 to of the order of €200 billion per year. Indirect energy cost savings would be of the order of €50 billion per year, a total net saving of €250 billion per year for consumers.

The impact on energy infrastructure investments would become evident in the longer term. It is important to note, however, that there will be trade-offs between the three effects - notably that more investment in certain types of infrastructure supports the use of lower cost fuels. But lower demand also means that energy infrastructure spend would tend to decline - eg *a 6% reduction removes the need for a €12 billion pipeline across Europe.*

[24] E. Molenbroek & K. Blok, *Saving energy: bringing down Europe's energy prices for 2020 and beyond*, Ecofys (2013)

Overall, the savings to 2030 could be substantial for the EU, if ambitious energy saving targets are pursued over 2020 to 2030. Net direct energy cost savings for the EU would be expected of the order of €200 billion per year and indirect energy cost savings on the order of €50 billion per year in 2030, giving €250 billion per year total net savings for consumers.

2.6.0 - Summary of benefits in social terms

The smart electrical grid may also provide social benefits, if correctly engineered in six main areas, specifically:-

- More control and better information for the customer in interfacing with the electricity providers. If carefully handled this might alleviate or compensate for the 'information asymmetry' that the service provider traditionally has over the customer. It may help the customers make wiser decisions when choosing or switching energy suppliers, because they will be better equipped to make factual comparisons.
- Sustainability – the customer is more in control of GHG emissions and of energy consumption and more responsible for the general improvement in living conditions as GHG emissions are reduced. This only becomes evident in considering economies without smart electrical infrastructures, such as China or India. There is no need to sacrifice economic growth and competitiveness to achieve climate stability - the smart electricity grid offers opportunities to achieve both increased prosperity *and* a stable climate.
- Job creation – certainly the rollout, testing and upkeep of a smart grid will generate some employment. More important will be indirect employment centred on applications that may be added to the smart grid infrastructure, such as electric vehicle charging points and renewable energy sources.
- Customer relations – information and the perception of control could improve customer views of the electrical generation and supply industry.
- Reliability and dependability of the network and thus reduction in the fears associated with lack of control over life and its processes. Note that dependence on the grid for communications increases with modern mobile devices demanding regular recharging.
- More customer control over expenditure, in ways that could in theory lower costs. We look at this further below.

2.6.1 - Smart grids benefits for lower income households

Investigation of customer spend in countries where the smart electricity grid exists (principally the USA[25]) show that energy spending takes a larger bite out of income in lower income households, so that the savings made (as a share of income) are over twice the level of middle income households, as shown below:-

[25] A. Faruqui, *et al.*, "The Impact of Dynamic Pricing on Low Income Customers", IEE Whitepaper (Updated), Brattle Institute, September 2010

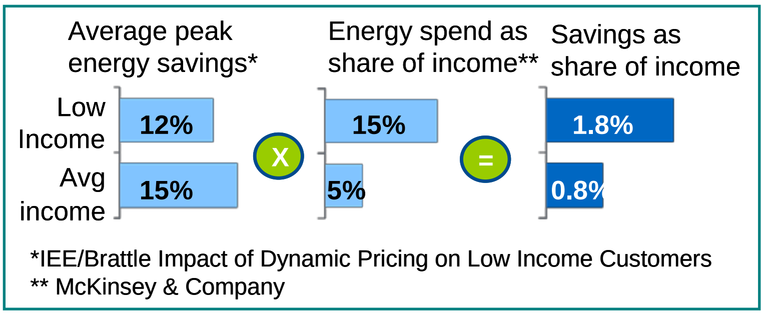


Figure 9 – Average peak energy savings and income saving for low- and average-income families in the USA

Thus the savings made have a higher proportional impact. However, this depends on energy saving programmes being widely taken up by lower income households in the UK. But it is also the case that a more capable communication network will allow the deployment of simpler and cheaper meters than the typical prepayment meters that exist today. In fact, with a smart grid, prepayment plans do not require special meters: remote disconnect/reconnect with an alert mechanism serves the same purpose less expensively and with immediate effect. The communication network also enables a variety of dynamic pricing and flexible payment options, including the activation of pre-pay and its removal, avoiding the need to change meters.

2.7.0 - In Summary

In the UK, the attraction of a smart electricity grid is growing, in order to cut consumption and provide flexible feed-in management for renewable energy sources. Energy saving is now becoming crucial at this time, in a worst case scenario, to avoid blackouts. Earlier this month (March 2013) Alistair Buchanan, chief executive of the regulator Ofgem, warned that about 10% of the UK's current generation stock will be removed from service starting next month (April 2013) to meet mandatory environmental targets defined in two European Directives, on Large Combustion Plants and Industrial Emissions[26]. The UK is committed by these legally binding treaties to reduce its carbon footprint due to coal- and oil-fired power stations.

In consequence, a smart grid may be critical in managing demand while delivering a high continuity of supply, especially during the expected switch to gas as a fuel in the short term (70% of power generation by 2020). That transfer could also require major infrastructure investments in the UK's pipeline and liquefaction infrastructure, unless electricity demand can be managed downwards.

Moreover, Ofgem's chief executive notes that within 3 years the reserve margin of generation will fall from 14% to 5% of UK capacity, requiring far more accurate and rapid control of demand and load dispatch. Longer term, the move to renewables (wind, solar, etc) for large-scale and domestic -scale levels of grid input will require more sophisticated load management, for feed-in control and billing, which only a smart grid can deliver. We believe that licence exemption is the right regulatory approach for a wireless smart grid in times of rapid change because flexibility, technical innovation and economies of scale characterise that approach. .

[26] M. Venables, "Big bills and blackouts", *Engineering & Technology*, Vol. 8, Iss. 3 (April 2013)

3.0 - Socioeconomic benefits for the UK of licence exempt applications in the 863-870 MHz band

Here we consider the benefits of allocating this band for licence exempt use, on an application-by-application basis.

3.1.0 - RFID

With an estimated 15.1 billion tags sold to date, Radio Frequency Identification (RFID) is the most widely deployed wireless application. In 2012, 3.98 billion tags were added to the global inventory, up from 2.93 billion in 2011, for a year-on-year gain of nearly 35%. 1 billion RFID labels were sold for use in retail operations in 2012 (apparel is the largest and fastest growing retail sector for RFID), along with 500 million tags for transit applications (mainly for access to mass transport systems and for automatic road toll collection). Tracking products as they move through the food distribution chain is another rapidly expanding market for RFID, driven by legislative mandates and the public's (appropriate) fear of disease, contamination, spoilage and substitution (horsemeat for beef, for example). IdTechEx sees the global spend on all forms of RFID more than tripling in the next 10 years, from $7.67 billion in 2012 to $26.19 billion in 2022.[27] The following chart forecasts the continuing proliferation in Europe of passive RFID tags, tag readers and deployment sites in major economic "verticals":[28]

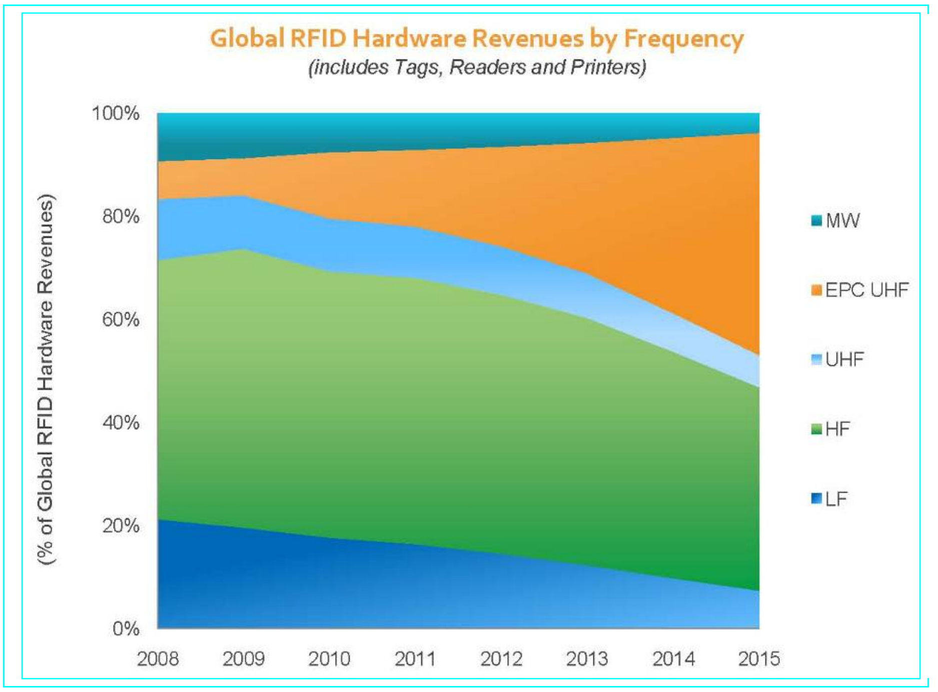
	2012			2017			2022		
Vertical	**Tags (Mn.)**	**Sites**	**Readers**	**Tags (Mn.)**	**Sites**	**Readers**	**Tags (Mn.)**	**Sites**	**Readers**
Retail & consumer goods	2270	11590	70570	13700	59900	502700	56100	206600	3440500
Automotive	50	4120	28250	200	9000	125900	500	18700	536900
Pharmaceuticals & healthcare	350	2770	12600	1700	11900	70200	6700	40600	208000
Postal & express parcel	270	950	2950	3500	3600	15100	12600	13600	52300
Aviation	60	280	5930	300	1100	51000	500	1500	160900
Other	230	11000	56000	3000	58500	397000	10300	172000	1870000
TOTALS	**3220**	**30710**	**176280**	**22400**	**144000**	**1161800**	**86700**	**453000**	**6268500**

RFID's success is due to its versatility, which in part comes from having allocations in different frequency bands. That enables it to take advantage of frequency dependent variations in signal range, penetration and absorption. The chart above does not

[27] "RFID Market Reaches $7.67 Billion in 2012 - up 17% from 2011," IdTechEx (18 July 2012) - http://www.idtechex.com/research/articles/rfid-market-reaches-7-67-billion-in-2012-up-17-from-2011-00004585.asp

[28] Data from *European passive RFID Market Sizing 2007-2022,* BRIDGE Project (2007) - http://www.bridge-project.eu/data/File/BRIDGE%20WP13%20European%20passive%20RFID%20Market%20Sizing%202007-2022.pdf

distinguish among the various bands, but the chart below shows band-by-band trends in market share for LF (<135 kHz), HF (13.56 MHz), UHF (433 MHz), EPC UHF (860-930 MHz) and MW (2.4GHz):



Source: VDC Research (2011)[29]

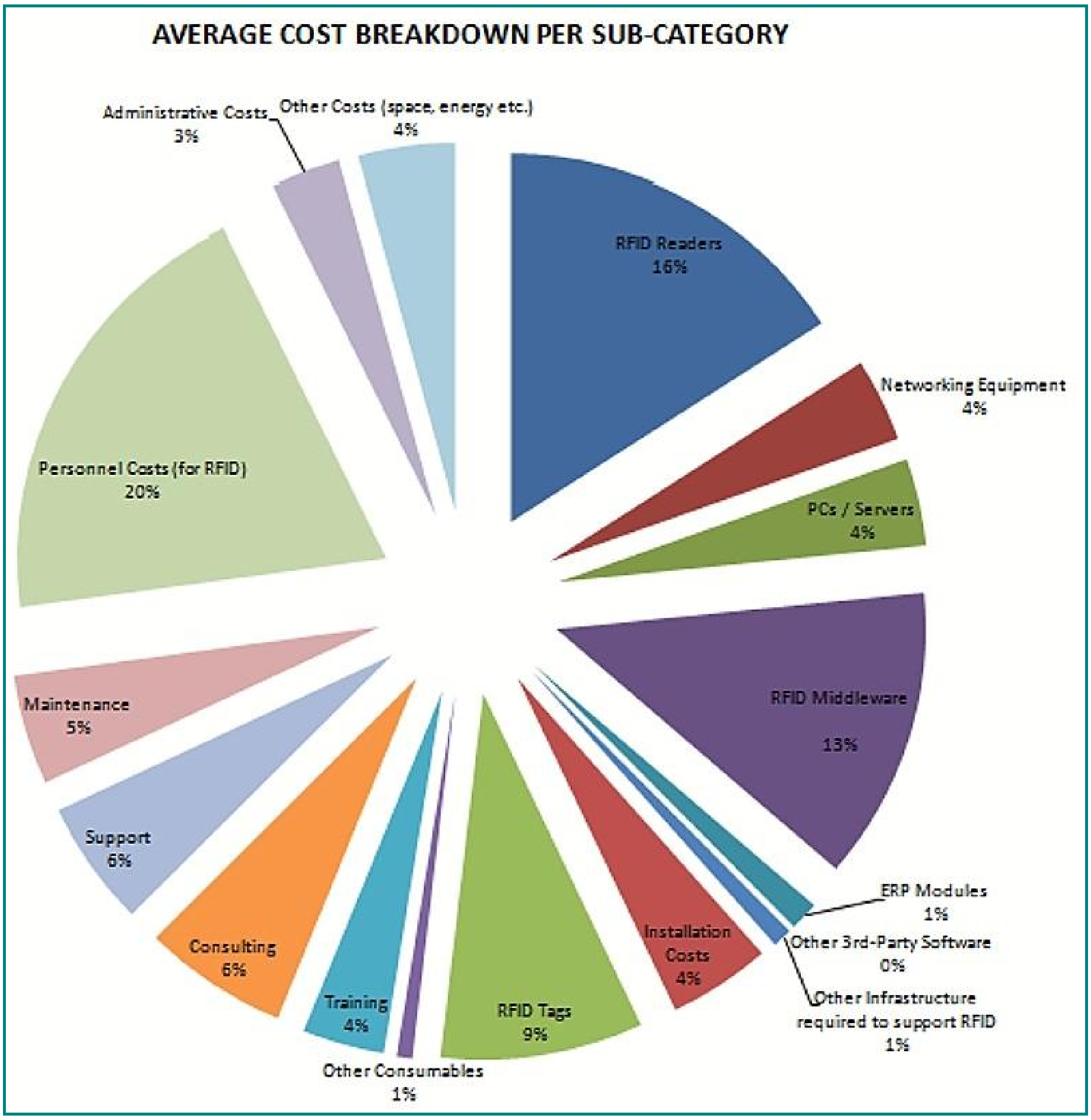
Figure 10 – EPC UHF (860-930 MHz) is rapidly expanding its share of the global RFID equipment market

EPC UHF (which is primarily used for tracking physical objects) is the fastest growing segment of a fast growing market, with a market share already exceeding 35% of the total. VDC expects it to reach 50% by 2015. Consequently, expanding the UHF spectrum for RFID must be an urgent priority. The spectrum currently available for EPC standard tags in the UK (865.6 - 867.6 MHz) is only 2 MHz, while in North and South America, 26 MHz is available (at 902 – 928 MHz).

Costs – Prices of RFID tags, printers and readers have been dropping for more than a decade but implementation is still expensive. UK RFID says the cost of a typical "system setup" starts at £15k, which might not be much for a large company but it is a substantial burden for SMEs.[30] In fact, new hardware is only a small component of the setup: 50–80% of the cost comes from the re-engineering of existing business processes and practices to accommodate RFID: changes in business data management software, staff training, outside consultants, etc. The next chart summarises the actual breakdown of the costs encountered by 8 pilot projects in an EU-funded study of RFID's return on investment for SMEs in retailing, logistics, services and manufacturing. The average cost to each pilot project of implementing RFID with open source software was €379.479.

[29] "Competing and Complementary Frequencies Changing Global RFID Landscape", VDC Research (26 July 2011) - http://blog.vdcresearch.com/autoid/2011/07/competing-and-complementary-frequencies-changing-global-rfid-landscape.html

[30] "RFID Disadvantages", UK RFID - http://ukrfid.com/business_of_RFID/rfid_disadvantages



Source: RFID-ROI-SME Project (2012)[31]

Figure 11 – Cost breakdown of RFID implementations by 8 SMEs

Benefits: A high-level summary of the RFID-ROI-SME Projects's findings is that the average return on investment for RFID in these pilots was 2.35 during the first 5 years. The average payback period was about 3 years, with some pilots achieving positive cashflow in the first year and all pilots achieving it by the 5th year. The quantifiable benefits observed included: more customers served per unit of staff time, fewer workers needed for repetitive tasks, decreased staff turnover, better visibility of operations, stocking errors reduced or eliminated, decreased losses from theft, decreased training requirements (after switchover), decreased administrative burden, etc.

[31] "ROI Studies for RFID-ROI-SME Pilot", RFID-ROI-SME Deliverable D7.3 (2012) - http://www.rfid-sme.eu/Pending%20deliverables/RFID-ROI-SME-WP7-D7.3-v1.00.pdf

3.2.0 - Automotive applications

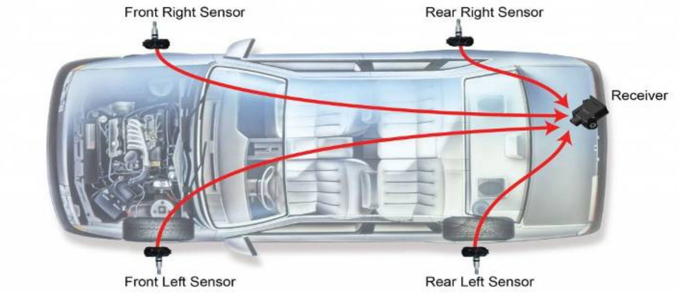
According to the European Automotive Manufacturers Association (ACEA), of the 250+ million passenger cars now operating in Europe, about 60% have at least one licence exempt short-range radio (SRR) system, and 80% of new vehicles come equipped with such systems. In the future, all road vehicles are likely to have multiple SRR systems.

Automotive SRRs are already diverse, with many dedicated bands allocated for their use: in addition to bumper proximity radars and wireless key fobs, Bluetooth connects passengers' carry-on devices to the car's entertainment centre; diagnostic data can be sent wirelessly to a repairman; truck/trailer communication systems are becoming common; car-to-car communication will soon be implemented; and tyre pressure monitoring systems (TPMS) have been mandated by the European Parliament. In this section we consider a few high value automotive applications in the 863-870 MHz band (excluding the vehicle-to-vehicle communication system that may be added to ETSI TR 102 649).

3.2.1.0 - Tyre pressure monitoring systems (TPMS)

The inflation pressure of pneumatic tyres affects a vehicle's braking distance, fuel consumption, lateral stability and tyre deterioration rate. So TPMS was developed to encourage drivers to maintain proper tyre pressure in their vehicle.

"Direct TPMS" puts sensors in or on each tyre to measure and report the tyre pressure via low-power radio to an on-board processor which controls a warning indicator on the dashboard. The data is sent in short (<20ms) bursts at start-up and at least once a minute when the vehicle is moving. In Europe the 433 MHz band is still favoured for TPMS, but the 868 MHz band has been gaining in popularity.[32] So TPMS is well-positioned to take advantage of the proposed expansion of spectrum for nonspecific SRDs in the 870-876 MHz band. And clearly it will need more spectrum: our calculations indicate that the number of direct UHF TPMS sensors in UK registered road vehicles could rise from 21.7 million in 2013 to 160 million in 2020 and possibly to 650+ million if required in all road vehicles.[33]



Source: TRW Automotive

Figure 12 – Direct TPMS

[32] I. Roufa, *et al.,* "Security and Privacy Vulnerabilities of In-Car Wireless Networks: A Tire Pressure Monitoring System Case Study" (2010) - http://ftp.cse.sc.edu/reports/drafts/ 2010-002-tpms.pdf

[33] Public acceptance of TPMS clearly depends on the development of more durable equipment with lower maintenance, service and repair costs.

3.2.1.1 - The need for tyre pressure monitoring

A 2010 survey of 38,000 cars in 9 European countries found that “71% of motorists are driving on under-inflated tyres. Bridgestone calculates that this habit is leading to the equivalent of 2 billion tons of wasted fuel [per year]. For the environment this means 4.8 million tons of additional and unnecessary CO_2 emissions annually…”[34]

“In the UK as much as £337 million of fuel is wasted each year as a result of driving on under-inflated tyres,” according to TyreSafe.[35] Severe under-inflation also jeopardizes road safety: about 12.5 million cars in the UK are driven “with potentially dangerously underinflated tyres.”[36]

In response to arguments like these, the European Parliament decided that TPMS should be installed on all passenger cars made after November 2012 and all new vehicle types registered after November 2014.[37]

3.2.1.2 - Economic and social benefits of TPMS

In 2011 the US National Highway Traffic Safety Administration analysed the effectiveness of TPMS in reducing tyre under-inflation and improving fuel efficiency. Their conclusion was that passenger cars with direct TPMS consume an average of 0.22% less fuel than cars without TPMS, for the same distance travelled; light trucks and vans equipped with direct TPMS consume 0.433% less fuel.[38] A variety of studies suggest that reducing tyre under-inflation by 1% reduces fuel consumption by 0.308%.

***Reduced fuel consumption* –** £233 million in fuel costs could be saved by UK motorists between 2013 and 2020 as the number of vehicles with TPMS rises from 5.1 to 37.5 million.[39]

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[34] “71% of motorists in Europe driving on under-inflated tyres wastes 2 billion litres of fuel a year, adding 4.8 million tons of CO_2 emissions,” Bridgestone press release, 10 March 2011 - http://www.bridgestone.eu/press/press-releases/2011/71-of-motorists-in-europe-driving-on-under-inflated-tyres-wastes-2-billion-litres-of-fuel-a-year-adding-4.8-million-tons-of-co2-emissions

[35] “Record fuel prices needn’t add ‘pressure’ to motorists”, TyreSafe Media Centre, 7 March 2012 - http://www.tyresafe.org/media-centre/latest-news/347-record-fuel-prices-needn%E2%80%99t-add-%E2%80%98pressure%E2%80%99-to-motorists

[36] Schrader Electronics, Conti-VDO & Knorr-Bremse, “Draft Cost/Benefits Analysis TPMS for M1Vehicles,” UN Economic Council for Europe, Working Party on Brakes and Running Gear (2008) - http://www.unece.org/fileadmin/DAM/trans/doc/2008/wp29grrf/TPM-03-03e.pdf

[37] Regulation (EC) No 661/2009 of the European Parliament and of the Council of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefore,” OJ L 200, 31.7.2009, pages 1-24 - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009R0661:en:NOT

[38] NHTSA (2012), page 31. There are of course fewer trucks than cars, but trucks’ share of fuel consumption and distance travelled is disproportionately large. So our cost-benefit analysis assumes TPMS reduces the fuel consumption of an average road vehicle by 0.3%.

[39] This assumes all new cars registered in the UK from 2013 onward will have TPMS, and there will continue to be about 2.5 million new vehicle registrations per year. In addition it

Reduced CO_2 emissions – Reduced fuel consumption means CO_2 emissions from road transport would also be reduced by more than 353,500 metric tons during the TPMS ramp-up period (2013-2020). The latest carbon credit price forecasts from the Department of Energy and Climate Change indicate this reduction is worth about £2.67 million. In addition, CO_2 emissions from tyre wastage are estimated at 37.5kg/tyre. So reducing tyre wear by 10% would save about 650,000 metric tons of CO_2 per year with a current carbon credit value of £3.9 million/year.[40]

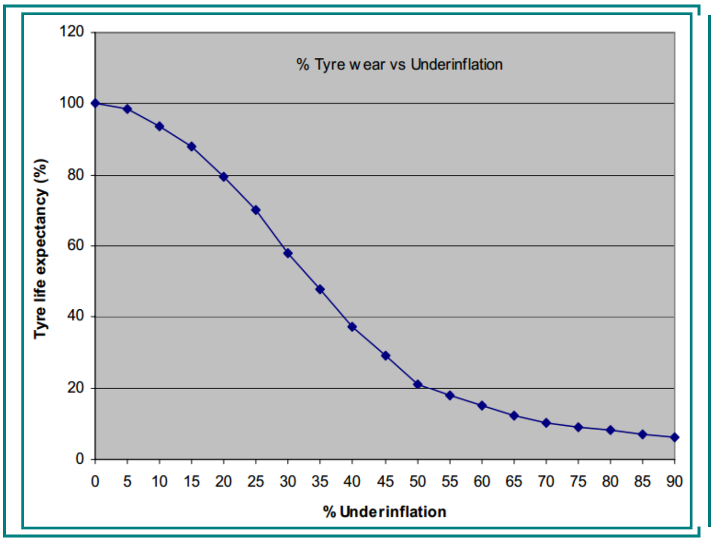

Figure 13 – The relationship between tyre under-inflation & tyre life expectancy[41]

Prolonged tyre life – According to UNECE's TPMS Task Force, tyre under-inflation of 25% causes a 30% reduction in "tyre life expectancy" (see graph above). The effect of such under-inflation is to increase the need for replacement tyres by about 13.86%. Outfitting all cars with direct TPMS would reduce the number of replacement tyres needed each year by 9.18%. Since 38.46 million replacement tyres are expected to be bought this year in the UK at an average retail price of £112.42[42], the potential savings to tyre buyers from having TPMS on all vehicles would be about £397 million per year. But since TPMS deployment is ramping up slowly, benefits of such magnitude won't be attained until next decade. Instead, we calculate the economic gain from fewer tyre replacements as £537.6 million between now and 2020, and £917.88 million more between 2020 and 2025.

Road accidents & injuries prevented – Under-inflated tyres have less lateral stability and road grip than properly inflated tyres. So their safe braking distance is reduced and they are more prone to blow-outs due to excessive sidewall flexing, which can cause catastrophic loss of vehicle control. For these reasons, the UK Department for Transport views under-inflated tyres as a contributing factor in road

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is assumed that in each year, 2.25% of previously registered vehicles will be retrofitted with TPMS, as that was the proportion reported in 2011.

[40] Schraeder *et al.* (2008)

[41] "GRRF TPMS Task Force Conclusions" (TPM-02-02, 2008), UN Economic Council for Europe, Working Party on Braking and Running Gear - http://www.unece.org/fileadmin/DAM/trans/doc/2008/wp29grrf/TPM-03-02r1e.pdf

[42] "United Kingdom Tyres Market Forecast and Opportunities, 2017", TechSci Research (October 2012) - http://www.techsciresearch.com/2044

accidents. Their most recently published annual report on road accidents cites "illegal[43], defective or under inflated" tyres as a contributing factor in accidents that killed 18 people, seriously injured 172 more and left 1,020 slightly injured in 2010.[44] The report also gives average values for the benefits of preventing such accidents. These invert "the human costs, which reflect pain, grief, suffering; the direct economic costs of lost output and the medical costs associated with road accident injuries"[45]:-

- For each fatality: £1.585 Mn
- For each serious injury: £178,160
- For each slight injury: £13,740

Multiplying these average values by the number of tyre-related casualties yields a total of £73,197,500 in losses.[46] But since under-inflation is only one of the listed factors (though it contributes to the other two), we might reduce the potential benefits of accident prevention due to TPMS by half (to £36,598,750 per year) of which 95% can be attributed to systems using licence exempt radio (£34,768,812 per year). On the other hand, these accidents represent just one year's tally.[47] In our calculation of future benefits from casualty prevention, the same ramp-up rates as for fuel savings and replacement tyres apply (along with an assumed medical cost inflation rate of 10%/year). Thus, preventing under-inflated tyre casualties generates benefits worth £32,547,424 between 2013 and 2020, and another £99,142,871 between 2021 and 2025.

3.2.1.3 - TPMS costs

There are more than a hundred different implementations of TPMS available in the UK market - most of them mutually incompatible. The diversity of units now available makes an "average" price difficult to define. But a survey of prices in the UK suggests that:-

- Individual OEM sensors cost about £30 - £40 while identical replacement versions are priced much higher.
- Retrofit systems are in the £130 - £320 price range.
- Systems for trucks and buses are about twice as costly as those for cars and vans (£300 - £350 vs. £135 - £190).

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43 "Illegal" in this context refers to tyres whose tread has worn to less than the minimum acceptable thickness – a condition that can result from under-inflation. The Tyre Industry Federation says "over 50% of car and van tyres are illegal upon replacement." (*Factbook 2011*)

44 "Road accidents and safety annual report", Department for Transport (2010), table RAS50007 (contributory factors) - http://assets.dft.gov.uk/statistics/releases/road-accidents-and-safety-annual-report-2010/rrcgb2010-04.pdf

45 "A valuation of road accidents and casualties in Great Britain in 2010" in Reported Road Casualties in Great Britain: 2010 Annual Report, UK Department for Transport (2010) - http://assets.dft.gov.uk/ statistics/releases/road-accidents-and-safety-annual-report-2010/rrcgb2010-02.pdf

46 (18 x £1,585,510) + (172 x £178,160) + (1,020 x £13,740)

47 "Industry Leader Calls for Action on 'Poorly Maintained Tires', *Tire Review* (30 November 2012) - http://www.tirereview.com/Article/107577/industry_leader_calls_for_action_on_poorly_maintained_tires.aspx

- Repair services and routine maintenance costs are expensive but highly variable in price (£200 - £700 per year).

Assuming an OEM spend of £200 by the manufacturer to install TPMS in each new vehicle registered, £200 for each new retrofit and £200 per year on average for maintenance, reprogramming and repairs (which gradually goes to zero as maintenance-free systems evolve), the cost of deploying direct TPMS is expected to be £33,801 million between now and 2025.

COSTS (millions)		BENEFITS (millions)	
Description	**2013-2025**	**Description**	**2013-2025**
OEM installation	£6,400	Reduced fuel consumption	£746
Retrofits	£4,178	Reduced CO_2 emissions	£51
Maintenance & repairs	£33,801	Fewer replacement tyres needed	£1,455
		Road accidents & injuries prevented	£132
TOTAL	**£44,379**	**TOTAL**	**£2,389**

3.2.2 - Key fobs

Originally automotive key fobs had one purpose: enabling the driver to unlock the car while approaching it (Remote Keyless Entry). Both the cost and benefit of RKE were modest.[48] But new functions can be added to a key fob by building in a data processor with expanded memory. Some of the new functions resemble smart cards: an enhanced key fob can not only interact with the vehicle, it can be used to pay for a parking space, buy gasoline or make other purchases.[49]

NXP Semiconductors in the Netherlands is promoting "smart keys" for the automobile industry. These promise substantial benefits with very little additional cost. Some suggested applications:[50]

- **Car Finder** – The key fob records the GPS coordinates of your car's most recent parking place. That can be transferred to a smartphone via NFC, which then uses a service like Google Maps to download a local street map and help you locate the car.

- **Route Planner** – Pick your destination while sitting at your home computer or tablet, then transfer the coordinates by short-range radio into the car's key fob. When you are in the car, the key will automatically upload your destination to the car's navigation system.

- **Car Status Management** – Before leaving your home or office, you can check how much fuel remains in your car for your next journey by simply waving your car key over your NFC-compliant mobile phone. And, you no

[48] RKE uses radio frequencies at 315, 413, 868 or 915 MHz.

[49] P. Lepek, "Requirements for Designing Next-generation Key Fobs," *ECN Magazine*, 28 January 2011 - http://www.ecnmag.com/articles/2011/01/requirements-designing-next-generation-key-fobs

[50] "NXP Unlocks the Potential of Multifunction Car Keys", *ECN Magazine*, 22 June 2011 - http://www.ecnmag.com/product-releases/2011/06/nxp-unlocks-potential-multifunction-car-keys

longer need to carry a paper record of your car's service history: the information is saved in your car key.

- **Car Self-Diagnosis** – Transfer diagnostic data from your car to a PC via the car key, then upload it to a service website and run a diagnostic analysis in seconds.

- **Car Personalization** – Car manufacturers can pre-fit cars with service upgrades, which can be unlocked later in the field. Obtain the unlock code from the manufacturer – for example, by making an online request or payment – and store the new features' unlock code in the car key. The new features will be activated the next time you enter the car.

3.2.3 - Vehicle-to-vehicle and roadside-to-vehicle safety communications

The need for additional allocations below 5 GHz for road transport and traffic telematic applications is increasingly discussed. Lower frequencies offer better non-line-of-sight propagation, passing around large metal vehicles and penetrating into cross-streets at intersections. They also reach farther than higher frequencies, which, at highway speeds, can increase the time a driver has to react to unexpected circumstances. A recent study of traffic accidents in Japan found that "failure to recognise a hazard in time" is responsible for 70% of all road accidents. Off the highway, the study found, 40% of all accidents happen at intersections, 14% of them during turns.[51] So "around the corner" and "longer on the highway" propagation could be harnessed to prevent accidents.

Communication of this sort would be automated and vehicle-to-vehicle, or roadside-to-vehicle, not person-to-person. The exact location of each vehicle, their speed and direction of travel, can be "broadcast" in a few milliseconds and shown on dashboard displays in nearby vehicles, along with indications that the brake or accelerator has been pressed or a turn signal activated.

Japan has allocated 755.5-764.5 MHz on a primary basis for the use of "safe driving support systems" with an "antenna power" of 10 mW per MHz of signal bandwidth.[52] This allocation is available from April 2013 and mobile units will be licence exempt.

Japan's role in the US$1.5 trillion global automobile industry is such that this new technology could begin spreading internationally quite soon, although local frequency adjustments would be needed since the "safe driving support" band is not harmonised. Indeed it is still unique to Japan.[53]

[51] Institute for Traffic Research and Data Analysis, "2004 annual statistical Report of traffic accidents", cited in "Working Document Towards a Preliminary Draft Revision Of Report ITU-R M.2228: Advanced intelligent transport systems (ITS) radiocommunications", ITU Working Party 5A Document 5A/TEMP/54 (November 2012) – http://www.itu.int/md/dologin_md.asp?lang=es&id=R12-WP5A-C-0198

[52] The assumption is that the entire band would be used as one 9 MHz channel, implying a maximum "antenna power" of 90 mW. See "700 MHz Band Intelligent Transport Systems, ARIB STD-T109 (version 1.0, English translation), February 2012 - http://www.arib.or.jp/english/html/overview/doc/5-STD-T109v1_0-E1.pdf

[53] In Europe, the 5875-5905 MHz band is reserved for safety-related ITS applications. Relevant parameters for using this band are covered by European Commission Decision 2008/671/EC. Some safety applications envisioned for this higher band are similar to Japan's concepts, but there are, as noted above, significant advantages in using UHF.

But Cisco already sees this line of development leading to new value-added services:

> "Safety coaching would be the next evolution of service opportunities. These applications would monitor driver behavior; provide scores, recommendations, and, potentially, corrections, in combination with advanced driver assist systems; and then report the number of corrections and the value of prevented crashes. Comparing an individual's safety report with those of peers, conducting safe driver competitions, and providing incentives for safe driving (with emerging 'pay how you drive' insurance premiums) would add even more value… The potential to prevent 80% of crashes and to reduce the associated cost by at least $280 per connected vehicle per year will eventually lead to mandated integration of low-latency V2V and V2I communication with ADAS and ITS, possibly toward the end of this decade".[54]

3.3.0 - Wireless audio systems

Wireless microphones, wireless audio systems, and to a lesser extent, assistive listening systems (ALS) are found in the 863 - 865 MHz sub-band.[55]

Wireless audio systems include wireless loudspeakers, wireless headsets and in-the-ear monitors – products that are used for guided tours in museums, real-time translation of foreign languages in conferences, language instruction in schools, the enjoyment of audiovisual entertainment, etc.

As for wireless microphones, in their 2010 study for Ofcom, Aegis and Ovum note that "most professional users avoid this band", considering it too crowded and thus prone to interference.[56] Nonprofessional use of wireless microphones in the 863-865 MHz band is found in churches, schools, pubs, business conference rooms, etc. Aegis and Ovum expected there to be 159,000-207,000 wireless microphones in these channels by 2013.[57]

Assistive Listening Systems (ALS) extend hearing aid technology with a short-range radio link that gives the listener untethered access to a sound source like a microphone, television or telephone. Digital signal processing may be incorporated to enhance the intelligibility of speech, suppress background noise, or reshape sound

[54] A. Mai & D. Schlesinger, "Connected Vehicles: From Building Cars to Selling Personal Travel Time Well-Spent", Cisco Internet Business Solutions Group (2011) - http://www.cisco.com/web/about/ac79/docs/mfg/Connected-Vehicles_Automotive.pdf

[55] There is also an allocation for wireless baby alarms at 864.8-865 MHz but significant market penetration has not been achieved and other bands are now more often used for this application.

[56] According to AudioTechnica, nearly 80% of the wireless microphones in the UK had been using the "light licensed" 854-862 MHz band. Many of those systems could also operate at 863-865 MHz. But since the 854-862 MHz band is now designated for cellular mobile networks, Ofcom's compensation scheme to persuade PMSE practitioners to surrender their 854-862 MHz equipment is reducing the number of professional-grade systems capable of tuning to 863-865 MHz.

[57] *Short Range Devices operating in the 863-870 MHz frequency band,* Aegis Systems Ltd. and Ovum, final report to Ofcom (2010) - http://stakeholders.ofcom.org.uk/binaries/consultations/tlc/annexes/Final_report.pdf

to overcome a listener's specific impairment. The two main use cases for ALS are: 1) *personal systems* serving one or a few auditors in a private space (a home, for example), and 2) *public systems* operating in large spaces (a theater or church, for example) to serve multiple auditors simultaneously. The latter is an alternative to the magnetic induction "telecoil" systems already widely deployed in the UK (as required by the Disability Discrimination Act 1995).

According to Deafness Research UK, almost 9 million people in the UK are deaf or have significant difficulty hearing. About 2 million have hearing aids but only 1.4 Mn use them. That suggests dissatisfaction with traditional hearing aids but ALS is still too new to have become widely deployed. Aegis and Ovum expected there to be between 209,000 and 245,000 systems deployed by 2013.[58]

Costs: "The estimated cost to the UK of untreated hearing loss in adults is €22,000,000,000".[59]

Benefits: The incorporation of radio links into audio systems adds freedom of personal movement and setup/repositioning convenience. Wireless microphones let speakers move around while projecting their voice over a larger area than unamplified sounds can reach. In the case of foreign language translations at conferences, wireless systems are a cost-effective way to promote trans-linguistic understanding and provide access to knowledge and expertise from other cultures. ALS overcomes social exclusion and isolation.

3.4.0 - Alarms

This category encompasses four main application areas: smoke and fire alarms, building intrusion and security, social alarms, and integrated systems for professional health care and emergency services. In the UK, most wireless alarms operate at 173.225 MHz, 433.92 MHz or 868.6 MHz.

3.4.1 - Social alarms

The purpose of a "social alarm" is to assist someone who might be unwell, elderly or in a fragile state of health, to call for help when they need it, or otherwise to guide them back to safety. The device usually combines a method of easy or automatic communication and a specialized sensor appropriate to the user's vulnerability or problem. For example, the alarm might sense that the person did not take their medicine on time, beeping to give them a gentle reminder - or it might send an SMS to a medical professional about the lapse. Another type of alarm might offer an easy way to call for help when the person falls down.

A "personal emergency response system" is a "first generation" telecare or "assisted living" product. It is a kind of social alarm that can be worn as a pendant or bracelet. Such devices will become increasingly sophisticated and more important as the population's average age rises. But smart phones with special apps designed for

[58] *Ibid.*

[59] The estimate includes a monetization of reduced quality of life. From "Deafness – The Facts", Deafness Research UK - http://www.deafnessresearch.org.uk/factsheets/deafness-the-facts.pdf

particular health monitoring tasks are bound to play a substantial, perhaps even a dominant, role in this field, with Bluetooth and Wi-Fi providing short-range links into mobile handsets that either record and analyse the data or upload it to cellular networks for remote patient monitoring. This is a pathway that will compete with special purpose networks in other SRD bands, such as 870-876 MHz. To some extent, then, demand for spectrum at 870 MHz from social alarms may depend on the future band conditions at 2.4 GHz.

Deloitte Life Sciences says that in 2010 the UK had 1.6 million users of social alarms, most over the age of 65, and the user base is growing about 5% per year.[60] Each UK telecare patient is spending an average of £66 on alarm installation and support from the response centres. Response centres are expected to grow into a multi-billion-pound industry by 2020, as hospitals privatise this function due to rapidly rising costs (more than 19% per year).

Costs: According to Deloitte, the UK had "a total estimated annual spend of £106 million in 2010" on social alarms and telecare. About 90% of it came from the public treasury. Annual spending is expected to reach £251 million by 2015, for a compound annual growth rate of 12.5%.

Benefits: The Department of Health's Whole Systems Demonstrator Programme is attempting to quantify the costs and benefits of telehealth, including telecare and social alarms. Preliminary results show "significant reductions in mortality" (45% fewer patients died than in the control group); emergency admissions to hospital were reduced by 20%; there were 14% fewer "bed days" for patients who sought hospital treatment voluntarily, and their "overall costs of hospital care were £1,888 less" than the control group's. However, the costs of remotely serving the telecare patients were higher than expected so no consensus has been reached regarding the cost-benefit ratio.

3.4.2 - Smoke detectors and fire alarms

According to ETSI TR 103 056, the UK market for smoke detectors and fire alarms has an annual turnover of 227 M€ (£196M) per year with annual growth of 3.3%.[61] Nearly all these alarms are mounted indoors at fixed locations. Building regulations require the installation of fire alarms and smoke detectors in public buildings, new dwellings and loft conversions.[62] While many residential alarms are "stand alone" devices – not linked in a network – the use of interlinked alarms is recommended in multi-room spaces and is required for owner-occupied buildings and two storey rented properties. Interlinking is achieved with short range radio links in licence exempt spectrum.

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[60] Deloitte Life Sciences, "United Kingdom: Primary Care: Working Differently- Telecare and Telehealth - A Game Changer for Health and Social Care" (2012) -http://www.mondaq.com/x/212788/Life+Sciences+Biotechnology/Telecare+And+Telehealth+A+Game+Changer+For+Health+And+Social+Care

[61] ETSI TR 103 056 V1.1.1 (2012-03): "Technical characteristics for SRD equipment for social alarm and alarm applications" - http://www.etsi.org/deliver/etsi_tr/103000_103099/103056/01.01.01_60/tr_103056v010101p.pdf

[62] "BS 5839 - Fire detection and fire alarm systems for buildings"

Costs – "Stand alone" battery-powered smoke detectors and fire alarms generally cost about £10. Those with built-in wireless links sell for £40 - £80. More sophisticated wireless systems, with control centres, automatic sprinkler switches, location indicators, remote test and reset capabilities, etc., can be found in large commercial buildings. These typically cost hundreds or thousands of pounds.

Benefits – The benefits of networking fire alarms often derive from the size of the facility: it is important to the survival of people in a large building that they learn as soon as possible about a fire that could block their exit. Network connectivity also enables the sending of alarm signals to a remote location – eg to the fire station, minimising the time needed for a response. Additional sources of value from connectivity may emerge with the further development of home and building automation systems.

Early warning about fire is essential to reduce property damage and offer persons at risk a chance to escape. "In 2000-2004, the death rate per 100 reported fires was 51% less in homes with working smoke alarms than in homes without this protection."[63] The UK Fire Statistics Monitor says there were 56,000 building fires between April 2011 and March 2012, but just 304 fire deaths, 187 of them in accidental dwelling fires. In addition, 4,277 people were injured by fires, 770 of them severely. The total cost of fire damage to people and property in 2008 (the most recent year for which UK statistics were found) was £3,285 Mn.[64]

These numbers are all substantially lower than were reported 10 years ago. The Government attributes the improvement to growth in fire alarm ownership: "It increased from 25% in 1989 to 86% of households reported owning a working smoke alarm in 2008."[65] If each equipped dwelling has 4 smoke detectors and the prices for both detectors and damages are held constant, then it could be said that each smoke detector installed in a dwelling between 1989 and 2008 reduced total fire damage by about £83.

3.4.3 - Building intrusion and security alarms

About 240,000 new wireless intrusion detection and security alarm systems are installed in the UK each year, 70% of them in residences.[66] Professional and high-reliability systems generally operate in the narrowband channels dedicated to alarms at 868-869 MHz, while DIY systems tend to be wideband or frequency hopping and operate in the nonspecific SRD allocations at either 433 MHz or 863-870 MHz. "Historically, most domestic alarm systems in the UK used the 433 MHz band on cost grounds but this has become increasingly prone to interference from other wireless

[63] M. Ahrens, "US experience with smoke alarms and other fire detection/alarm equipment", National Fire Protection Association (2007) - http://www.nfpa.org/assets/files/pdf/alarmexsum.pdf

[64] "The economic cost of fire: estimates for 2008", Department for Communities and Local Government (2011) - http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/ documents/corporate/pdf/1838338.pdf

[65] "Fire statistics monitor - April 2011 to March 2012", Department for Communities and Local Government (July 2012) - https://www.gov.uk/government/publications/fire-statistics-monitor-april-2011-to-march-2012

[66] ETSI TR 103 056 v.01.01.01 (2012-03) page 58 - http://www.etsi.org/deliver/etsi_tr/103000_103099/103056/01.01.01_60/tr_103056v010101p.pdf

devices… There has therefore been a marked migration to 868 MHz in recent years and virtually all new products now operate in this band," Aegis and Ovum report.[67]

But the integration of intruder detection functionality with CCTV, door entry control and building automation has begun. As a result, "The future does not look so bright for the UK intruder alarms market. The industry continues to lose share of the total security market as more clients turn to CCTV…"[68] CCTV's advantage is that it can record visual evidence to help identify and convict the intruder(s), or suggest why they entered the space without permission.

Costs – Installing wireless sensors for intruder detection is simpler and cheaper than wired units. That drives the popularity of these devices even though individual wireless units tend to be more expensive than their wired equivalents. In 2011, about £69.2 Mn. was spent in the UK on wireless building security equipment (an average of £288 per system).[69] That implies most investment went into DIY systems. Meanwhile, ONS reports that 677,000 burglaries were committed between July 2011 and June 2012.[70] The Home Office says the average cost of a burglary in a dwelling in 2011 was £3,925, while the average cost of a robbery in a commercial building was £9,372.[71] If 90% of the burglaries were in dwellings, the total annual cost to the public was £3,026 Mn.

Benefits – Deterrence is the main benefit sought from intrusion alarms. An in-depth study of Newark, New Jersey (USA) found that homes with burglar alarms are indeed less frequently burglarized. But it is difficult to quantify the deterrent because other variables have great impact (the unemployment rate, for example, as well as the alarm owner's age).[72] However, a more recent study confirmed the deterrent effect anecdotally by interviewing more than 400 incarcerated burglars: 83% said they "would try to determine if an alarm was present before attempting a burglary; …60% said the presence of an alarm would cause them to seek an alternative target; …and if a burglary was initiated and an alarm was found, half would discontinue the attempt."[73] That – and the importance of unemployment as a motivating factor – suggest that alarms might only displace rather than prevent burglaries. On the other

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[67] Aegis Systems and Ovum, *Short Range Devices operating in the 863-870 MHz frequency band,* Final Report to Ofcom (2010) - http://stakeholders.ofcom.org.uk/binaries/consultations/tlc/annexes/Final_report.pdf

[68] Mike King, "Intruder alarms market to see substantial growth in younger markets such as Brazil" (2012) - http://www.wallstreetnewshour.com/NewsStory.aspx?id=1194033

[69] Derived from the market data in ETSI TR 103 056.

[70] Office for National Statistics, "Crime in England and Wales, Year Ending June 2012" - http://www.ons.gov.uk/ons/dcp171778_283456.pdf

[71] These "costs" include property losses as well as police investigation, court and other criminal justice system costs. UK Home Office, "Revisions made to the multipliers and unit costs of crime used in the Integrated Offender Management Value for Money Toolkit" (2011) - http://www.homeoffice.gov.uk/publications/crime/reducing-reoffending/IOM-phase2-costs-multipliers

[72] S. Lee, "The Impact of Home Burglar Alarm Systems on Residential Burglaries," doctoral thesis, Rutgers University (2008), page 298 - http://www.airef.org/research/airef91808_fullreport.pdf

[73] J. B. Kuhns *et al*., "Understanding Decisions to Burglarize from the Offender's Perspective" (in press). Findings reported by Scott Goldfine in "Science Shows Alarm Systems Perform," *Security Sales & Integration*, (11 March 2013) - http://www.securitysales.com/channel/intrusion/articles/2013/03/science-shows-alarm-systems-perform.aspx

hand, the spread of intrusion alarms could have contributed to the gradual reduction in the number of burglaries shown in Home Office statistics from the past 2 decades.

3.5.0 - Building automation systems

Ten years ago, most of the equipment in this category controlled a single building feature: opening a gate, locking a door, turning off a light, etc. But the miniaturisation of actuators and the growing importance of saving energy have led to the networking and integration of controls and the creation of the “smart building” concept, which “smart metering” will soon complement. Already, “Home and Building Automation represents the main market area for non-specific SRDs”.[74] According to ETSI TR 102 649-2, a residential building automation system “typically comprises 50 nodes: 15 shutter controls, 2 garage door openers, 1 gate opener, 2 electrical door locks, 2 terrace awnings, 4 roof windows, 2-5 electrical vertical windows (ventilation control), 1 intrusion alarm, 8 heating zones and a dozen lighting terminals)”.[75]

TechNavio forecasts the global market for “smart home” network equipment to enjoy a CAGR of 35.91% from 2012 to 2016, due to “the increase in cost-effective solutions”.[76] Meanwhile, IMS Research see the global market growing from less than 20 million devices in 2012 to more than 90 million in 2017.[77] However, wireless protocols rooted in other bands than 870 MHz – Zigbee, Zwave, DECT ULE, etc. – may shape the market. But as “there is now provision for 869 MHz in the ZigBee standard, this may actually lead to increased use of this band over time”.[78]

Costs – Building energy management was said to be a £500+ million a year business in the UK in 2010, growing at a rate of 6% per year.[79] That overlaps with home and building automation, so we take the figures for BEM as a rough guide to the size of the building automation market.

Benefits – Buildings account for 41% of primary energy consumption, of which 85% is for the heating and cooling of rooms.[80] So the energy savings potential of smart building technology is large. With about 30 million buildings in the UK, 2.5 million of them non-domestic, and models developed by Siemens indicating that automation

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[74] ETSI TR 102 649-2, v.1.3.1 (2012-08): “System Reference Document for Radio Frequency Identification (RFID) and SRD equipment; Part 2: Additional spectrum requirements for UHF RFID, non-specific SRDs and specific SRDs” - http://www.etsi.org/deliver/etsi_tr/102600_102699/10264902/01.03.01_60/tr_10264902v010301p.pdf

[75] *Ibid.*

[76] “Global Smart Home Network Equipment Market 2012-2016” - http://www.technavio.com/content/global-smart-home-network-equipment-market-2012-2016

[77] “Managed Service Providers Driving Open Standards for Smart Home Connectivity”, IMS Research (2012) - http://www.imsresearch.com/press-release/Managed_Service_Providers_Driving_Open_Standards_for_Smart_Home_Connectivity

[78] Aegis and Ovum, *op cit.*

[79] K. Feddy, “Building Automation Solutions sells for £40m”, Manchester Evening News, 2 December 2010 - http://www.manchestereveningnews.co.uk/business/business-news/building-automation-solutions-sells-for-40m-904233

[80] *Building automation – impact on energy efficiency: Application per EN 15232*, Siemens - https://www.automation.siemens.com/mcms/totally-integrated-power/en/power-distribution-customers/user/Documents/Building_Automation_-_Impact_on_Energy_Efficiency.pdf

enables non-domestic buildings to achieve energy savings of 15-32% (hotels) to 27-40% (stores and warehouses), the potential benefits of home and building automation, considering only the increased energy efficiency, are likely to outweigh costs by a wide margin.[81]

3.6.0 - Conclusion

The 863-870 MHz band is recognised by CEPT's Electronic Communication Committee as a "core SRD band". It is licence exempt and fully harmonised by legally binding EU Commission Decisions: 2006/771/EC on SRDs (updated by 2010/368/EC) and 2006/804/EC for RFID. But there is diversity within the harmony, as this band is shared by many dissimilar applications, with different deployment patterns and densities, different duty cycles and social purposes. Because the band serves nonspecific SRDs, its use is not limited to specified applications. So it is not possible to compile a finite list of uses and calculate a value for each one. Rather, any list must be open ended. For this band provides space for innovation – a valuable benefit in its own right.

However, it is possible to identify existing band uses with large device populations, and to project trends to discover what applications may be popular – or outmoded – in the next decade. One might also suppose that large device populations and popularity mark the applications that people find most useful and valuable.

The largest device population in this band is undoubtedly RFID, and opening additional channels for it at 915- 921 MHz will further enhance the performance of tag readers, increase read rates, and lead Europe toward compatibility with other parts of the world. Millions of fire and intrusion detection alarms have been deployed, saving lives, reducing property losses and deterring crimes. Later in the decade, tens of millions of electricity and gas smart meters and tyre pressure monitoring systems will be deployed, driven not by popularity but by mandates for energy saving and reduced carbon and greenhouse gas emissions.

Wireless audio systems, assistive hearing systems, radio microphones and social alarms also improve the quality of life even if their economic impact is not as great as the applications cited above. But the growth of all these applications has been such that the existing allocation is overcrowded and more room is needed for expansion. That makes Ofcom's proposals for 870-876 MHz timely and welcome.

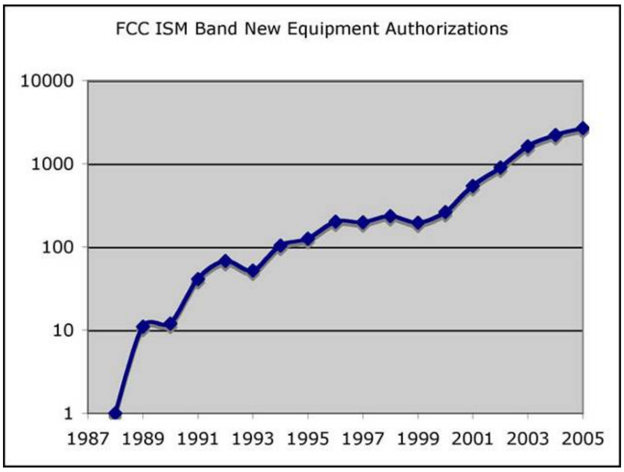
4.0 - Maximising socioeconomic benefits in the 915-921 MHz band

As part of the guard band between cellular mobile handsets and base stations, the 915-921 MHz band has been under-utilised for decades. Meanwhile, in other parts of the world, it has been a fertile seedbed for the development of licence exempt applications. It is high time that some of that fecundity finds its way to the UK.

[81] Ibid.

In 1989, the US Federal Communications Commission revised its rules for unlicensed use of the radio spectrum.[82] Generic limits on bandwidth and power replaced most application specific rules, which had little consistency and required frequent updating. An important consequence of the shift from specific to generic (application neutral) rules was that in future, the marketplace would pick which applications fill the licence free spectrum bands.

In the same rule making, the FCC also authorised the use of spread spectrum modulation for communication in bands allocated for Industrial, Scientific and Medical (ISM) applications. It had long been thought that the ISM bands were too noisy for reliable communication. But spread spectrum was resilient and the propagation at 900 MHz was excellent, so, slowly at first, but then with increasing confidence, product developers began to explore what could be done with the opportunity presented.



Source: Negus and Petrick[83]

Figure 14 – Growth in new equipment types developed in the US for the ISM bands

Two products unexpectedly emerged from the USA's 902-928 MHz band to become multi-billion-dollar global industries. A third is emerging now which might be another game-changer.

The first cordless phones appeared in the 49 MHz band in the 1980s, but moved up to 915 MHz soon after communication uses were allowed. They have since migrated to higher frequencies, but in the meantime they displaced telephones with handsets tethered by coils of wire to the base. Cordless is now the norm everywhere.

When the ISM band rules were rewritten, no one – not even those involved in drafting the changes – imagined that home WLANs would find commercial success - until Apple introduced Airport networking in 1999. As noted in our response to Question 1, above, this paved the way for Wi-Fi to develop in a higher ISM band (2.4 GHz).

[82] "In re: Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices without an Individual License, First Report and Order", 4 FCC Rcd. 3493, 4 (1989)

[83] K. Negus and A. Petrick, "History of Wireless Local Area Networks (WLANs) in the Unlicensed Bands", George Mason University Law School Conference (4 April 2008) - http://iep.gmu.edu/wp-content/uploads/2009/08/WLAN_History_Paper.pdf

And recently, xG Technologies introduced xMax, a “cognitive” cellular system that uses 900 MHz to eliminate the need to acquire an expensive mobile license. Unless cellular operators can acquire enough licensed spectrum to accommodate their customer’s growing need for bandwidth, they may have no alternative but to move into the licence exempt bands. xMax is proving that is possible.[84]

As with 863-870 MHz, generic standards for radio interfaces make it impossible to list all the applications using the 915 MHz band in the countries where it is licence exempt. But their diversity and large numbers show that Ofcom does not need to adopt technical rules to protect RFID which are any more restrictive than the FCC’s. RFID co-exists with the other denizens of 915 MHz in all parts of the world that have harmonized with those rules.

[84] R. Tehrani, “Rich takes xMax Wireless for a test drive”, TMCnet (29 September 2009) - http://blog.tmcnet.com/blog/tom-keating/wireless/rich-takes-xmax-wireless-for-a-test-drive.asp

5.0 - A Future Vision

The appearance of intelligent services as part of the (largely urban) service infrastructure has often been a somewhat idealistic vision, a subject for wishful thinking, since the 1960's and Stafford Beer's first operational research explorations. However, our mobile society – in social and technical terms - with its continued concentration in urban centres, seems to be heading inexorably towards a cross between an idealised technocentric dream or perhaps a failure in Orwellian mismanagement, destined to be quickly rejected. But now we have the digital intelligence at low cost and the unwired communications links, via SRDs and longer range wireless. So how can it evolve in a simple, practical way that has real benefits for ordinary people?

If such a smart environment were well designed, what we might envisage is a cascade of more intelligent management structures and systems that operate at different levels of granularity, starting with one household or person, up to a whole city and then beyond into the whole country and region. These would interwork through a clustering of systems. One view of this is shown below. It starts at the level of the meter in a house for measuring electricity, then to a home area network, then a smart energy grid. That may also be a first step towards managing large buildings and campuses, together the elements that form a complete city:-

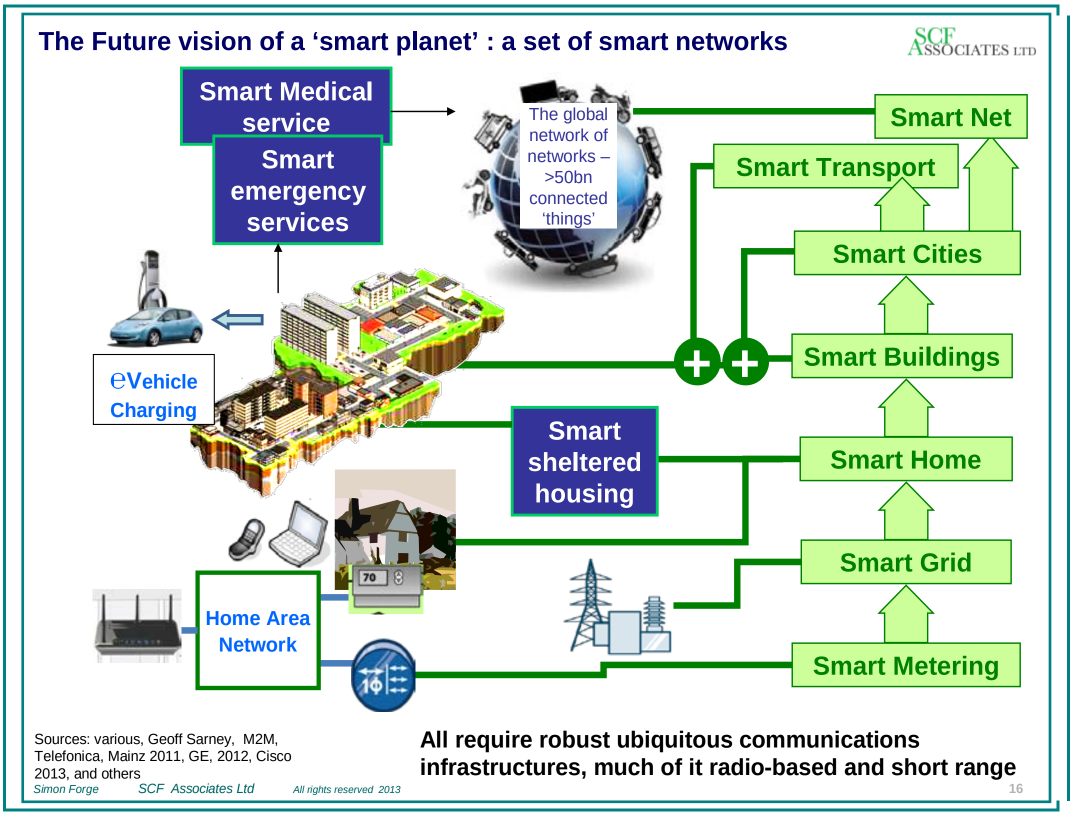


Figure 15 - A vision of layers of infrastructure to support 'smart environments'

The several layers shown above eventually form the smart city. Now we examine each layer in turn, including some that are oriented to vertical industries, such as logistics networks and support for additional utilities – such as water - as well as care and health services, smart transport and smart vehicles.

5.1.0 - An infrastructure for the future is now emerging, in which SRDs are a key component

For the future, we can see an infrastructure emerging which has a layered structure of added value benefits, based on licence exempt bands for communications:-

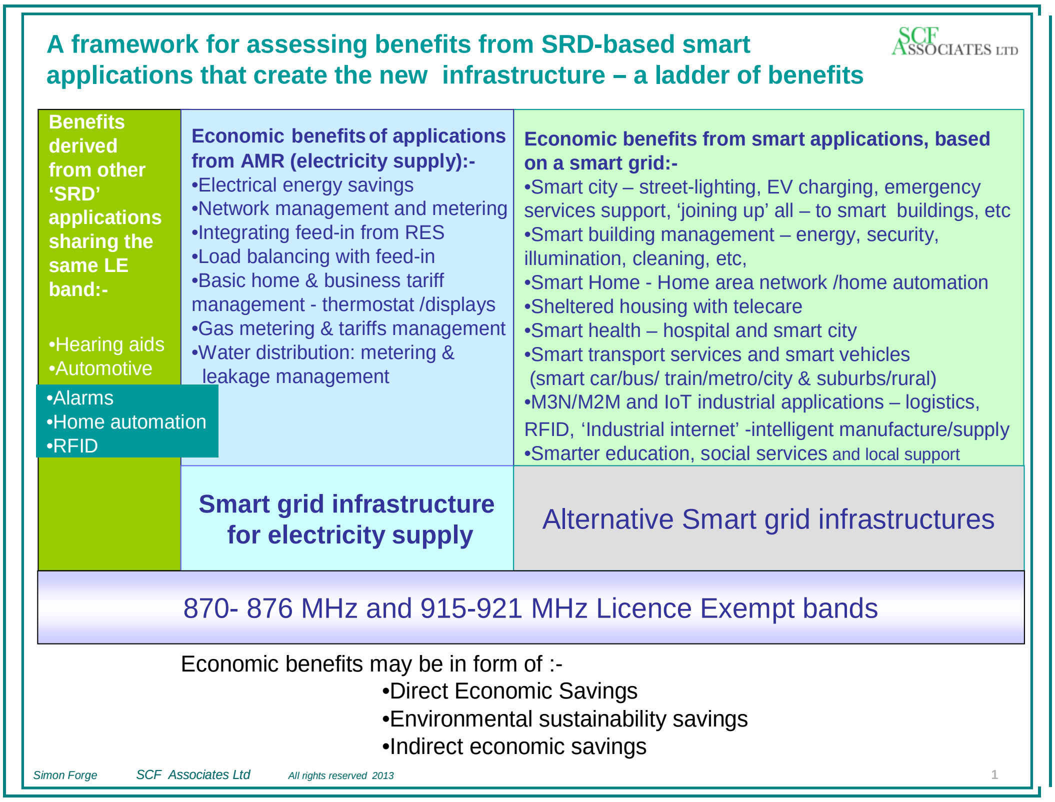


Figure 16 – The benefits structure of a smart ubiquitous environment based on SRDs

We now examine seven key areas for building the smart environment:-

5.1.1 - Smart city: 'joining up' smart buildings, street-lighting, electric vehicle charging and support for emergency services

80% of the EU lives in cities, producing 75% of the CO_2, consuming 75% of Europe's energy[85] and producing 85% of GDP. Three levels of interaction are envisaged by the majority of current smart city projects globally – citizens, ecosystems, and the functional urban infrastructures of energy, lighting, transport, water, etc, all based on real-time data collection. The source of this advance is the use of ICTs to control each aspect in a 'metropolitan area machine to machine network' (or M3N) with sensors and actuators.

Such cities need a smart energy grid and also local and global communications connectivity including ubiquitous broadband. This infrastructure can host services for advanced emergency response, sheltered housing for a "hospital in the home" as

[85] Mario Compulargo, European Commission, DG CONNECT, Director, Emerging Technologies and Infrastructures, *Smart Cities and the future internet*, presentation, January 2012, Eurocities Workshop

well as advanced health, while also supporting the city's major industries. One industrial example of this is the Korean container port of Busan:-

The smart port of Busan - the 'Green u-City'

Busan, on the southern coast of Korea, with its 4 million inhabitants, has become Korea's 'Ubiquitous technology port' and the fifth largest container port globally today.

The whole city has become connected and highly efficient for container handling by installing various SRD wireless sensor networks for RFIDs and vehicle traffic management as well as the running of the container port with Wi-Fi and Zigbee. In the long-term, the aim is to become a logistics hub for north-east Asia. To compete with low-cost Chinese ports and high-tech Singapore, it needed a far more advanced infrastructure. A budget of US$ 1 billion (1 trillion won) has been spent since 2005 in a venture with KT to make all of Busan connected and web-accessible – the initial rollout was in place for the ASEAN summit conference of 2005.

First investments were in container tracking, by installing the networks for RFID sensor monitoring of containers equipped with smart tags as they pass to and from the 30-berth harbour. Transport efficiency and manufacturing supply chains were the next targets for ubiquitous sensor networks, with a U-traffic plan to manage road congestion to the port and for supply chain management, first deployed at the local Renault-Samsung factory, a plan called U-Automotive.

Original targets expected for economic payback from the 'smart port' investments over 10 years since 2005 are estimated as between US$ 4.6 and 5.3 billion (4.6 - 5.3 trillion won) with increased port employment by 2010. City-wide efficiency gains in traffic flow, etc., were expected to be worth some US$ 15.3 billion, creating 160 jobs. KT sees Busan as a test bed for a new technology and business model for use elsewhere in Korea.

Access to government services for citizens via smartphones and tablets are also part of the U-Government plan for urban services with a US$ 300 million budget. The citizen's smart infrastructure combines SRD sensor and broadband networks, M2M, WLAN, NFC and RFID technologies. Citizens can benefit from services designed to improve vocational and academic learning via interactive video sessions for mentoring. Expanded free education for low income community residents and students aims to erase the social divide. Other services are aimed at reducing health care costs, especially for low income residents and elderly people living alone. A particular aim is to improve access to care services for chronic diseases, reducing visits to hospitals. Specialised information services are also aimed at participatory urban regeneration projects, and stimulating revenue creation opportunities. At the same time Busan plans to reduce CO_2 emissions by 3000 metric tons by 2020, via energy demand management by its consumers. Their aim is to emit 60% less than other newly-developed Korean cities that lack its Green u-City services. Sources: GSMA, KT, Cisco; Financial Times[86]

[86] A. Fifield, "South Korea: Busan Green u-City", GSMA, KT, Cisco (2012); "*Busan looks to a ubiquitous future" Financial Times*, 22 April 2005

5.1.2 - Smart building management: energy, security, illumination, cleaning, etc.

Smart buildings host an array of networked devices that monitor and control the facility's services (mechanical systems, electronics, HVAC, and lighting) to achieve greater energy efficiencies and cost savings, while improving the users' experience. This takes the home area network (HAN) and building automation to a new level of integration.

Automatic control of total energy consumption and the incorporation of back-up power supplies, eg for a data centre, are part of the principal functions expected. Other major systems that turn the inanimate building into an almost living organism include internal communication networks, lift safety systems and fire alarm networks that automatically trigger sprinklers when needed. Distributed antenna systems may be included to support wireless voice telephony and video plus electronic whiteboard networks for large office complexes. Most large buildings will also have security monitoring – with CCTV, motion detectors and door lock controls as well as sensors to turn off lights when no one is in the room. Such advances may include robotic systems – indoor and outdoor vacuum cleaners, as in the Norman Foster HSBC building in Hong Kong – with its automatic swivelling mirrors to direct daylight into the atrium for natural lighting, thereby reducing electricity consumption.

All of these advances depend on distributed sensor networks and short-range wireless links for customisable signalling to control centres, and wireless local area networks for person-to-person communications. Smart buildings reap savings from sharing their network infrastructure across multiple functions.

In its assessment of future Internet uses Cisco attributes a global value of $349 billion from 2013 to 2022 due to smart buildings.

5.1.3 - A Smart Infrastructure for additional utilities: Smart Water networks (SWAN)

When it comes to utility network automation, the electricity and gas sectors, are 10-20 years ahead of the water sector, which on a global basis is worth in excess of $500 billion annually. Smart Water networks (sometimes abbreviated to 'Swan') are the next step in managing demand and enhancing stability of supply. Strains on the water industry are mounting, with challenges from climate change, population growth and new patterns of usage.

Global warming is starting to disrupt rainfall patterns, increasing the frequency of flash floods and droughts. At a time when new investments are needed to improve the resilience of water systems, 20% to 60% of the potable water supply is still lost through leakage. Increasing supply network automation could address water shortage issues faster and at a fraction of the cost of new reservoirs and desalination plants. This would require sensor networks with actuators, most probably connected by radio, in order to reduce pressure bursts which cause new leaks.

Worldwide annual opex for water and wastewater utilities stood at about £143 billion ($222 billion) in 2010. Smart water networks could reduce that by up to 30%, an annual saving of some £43 billion, according to Schneider Electric in France.

Water utility leakage rates are high in the UK, with losses of 3.36 billion litres / day in 2010-2011. The largest utility, Thames Water, experienced 26% loss of its potable water production in 2010-2011[87]. Thus building Swan networks in the UK would produce a higher return than building new treatment plants. But only now is that possible. A decade ago, adding pressure management and flow control to the water system would have been too expensive. The technology was available, but it required too much customisation.[88] However, if water can take advantage of the smart grid deployed for electricity and gas, it would be affordable.

Swan Case study - City of Calgary

In Canada, the City of Calgary's water system delivers 450,000m^3/day of potable water to 1.1 million residents and thousands of businesses. The system is divided into 40 Pressure Managed Areas (PMAs) with 4,500km of pipes. A new water loss management programme reduced leakage to approximately 10%, but water is still scarce in the region. To further reduce losses, the City is investigating Swan systems. Starting in 2010, they pilot tested active pressure management in two residential PMAs, using programmable logic controllers (PLCs) and communications links to the pressure regulation valves (PRVs) to monitor demand and control pressure. The results have been positive - a 20% (10,000m^3/day reduction in leakage, equivalent to a daily saving of Can$10,000, or about Can$ 35Mn over a 10 year amortisation period. There are over 200 PRVs in the Calgary distribution system that would have to be retrofitted at a cost of approximately Can$25,000 per chamber, for a total of Can$5 million, plus management software. The net 10-year ROI is 700 %. Source: Swan's Way[89]

Naturally a further step is to integrate gas into the water and electricity smart grids for meter reading, tariff management and peak demand reductions, all as a single system, and in the future sharing a single local response and control network.

5.1.4.0 - Sheltered housing with telecare: supporting the frail and elderly in the home

In the UK by 2020 more than half the population will be over 50. Across the developed world, the population above 60 years has expanded from 99 million in 1950 to 248 million in 2000, and is expected to be 298 million in the year 2050.[90].

However, it is the 'fourth age', above 70 or 80 years, that will in the future be the most intensive users of advanced ICTs, especially short-range wireless. Ageing of the population is expected to increase the cost of health care but in fact age is not as important as proximity to death. For it is the extreme decline in health just before death that drives up health care costs the most.[91].
Nevertheless, there is tremendous scope to improve support for the growing number of families and older people, as and when they need more help, and some of the

[87] BBC News, 5 April 2012 – http://www.bbc.co.uk/news/uk-17622837

[88] Telvent Water Product Centre

[89] SWAN's Way – in search of lost water, Volume 12, Issue 6 (June 2011)

[90] SCF Associates Ltd, "The Future of the Family to 2030 – A Scoping Report", OECD International Futures Programme, *The Role of ICTs in Shaping the Family of the Future*, Dec. 2008

[91] A. Gray, "Population ageing and health care expenditure", *Ageing Horizons*, No. 2 (2005) - http://www.ageing.ox.ac.uk/ageinghorizons/thematic%20issues/healthcare/papers%20healthcare/pdf%20files/gray%20issue%202%202005.pdf

added support can reduce the much higher costs of delaying the start of treatment. For example, if cancer is detected as soon as it forms, non-invasively, for a monitoring cost of under €50 per year, the need for debilitating and expensive chemotherapy can be reduced. The same is true for heart ailments.

Care of the elderly and infirm at home is not only a less costly option than hospital stays, but it is often more pleasant for the patient and their family. "Smart sheltered housing" makes it an option for those less able to manage on their own. Doors, curtains, central heating, lights etc, can be operated by remote control, while sensors monitor blood sugar and blood pressure, medicine taking, etc. to ensure that all is safe and normal.

The aging demography will tend to push radio communications towards new uses, such as body area networks. Support will generally become more sophisticated, using various sensor networks and even robotics, but it must also be widely available and low-cost.

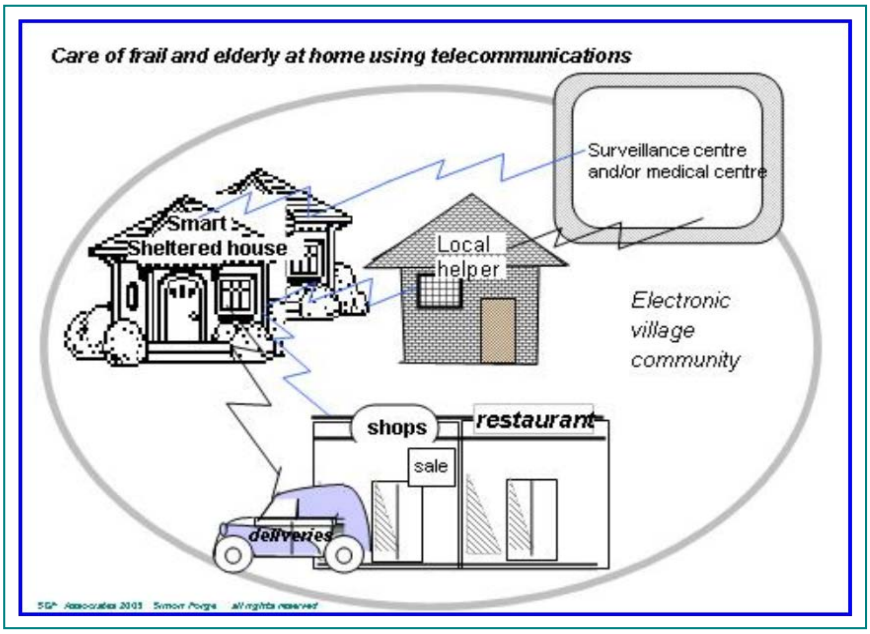


Figure 17 – ICT organisational capabilities for sheltered housing support services in an ‘electronic village community’

In California, Intel is investigating memory loss due to diseases such as Alzheimer’s, with its Proactive Health Strategic Research programme, Its systems are based on wireless sensor networks for the assessment of everyday activities, in order to detect sudden cognitive decline. From the prototype systems, Intel’s Center for Aging Services Technology has found that a loss of cognitive abilities can provoke social inactivity, due to memory loss of friends and relations, which leads into depression, accelerating the decline of health.

Such trends in demand for support services and devices for the elderly and in health care are likely to seed different and new extensions of current infrastructures. Much will be based on SRDs in licence exempt bands – for the parts of life cellular mobile cannot reach – or reach cost effectively. Thus future care for the aged and frail will depend on turning the home into an intelligent support system using assistive technologies in 5 key areas:-

Turning the home into an intelligent health support system

- An infrastructure for managing care in the home, to avoid future systematic overload of the hospital system, with real-time systems that give rapid indication for crisis prevention.
- Better care provision at lower cost, for a population segment which is typically the most expensive to treat but in a preventive approach, and in a ubiquitous manner – the home, the car, the workplace – for maintaining physical fitness, early problem detection and diagnosis, maintaining social activity and cognitive engagement.
- Consumerisation of health care, away from the physician towards the person in care and the family/community network[92] who provide support links. Telemedicine and ubiquitous care for the aged can shift the emphasis from after the fact cures to prevention, using real time diagnostics and alerts.
- Support for the autonomy of the individual to control and enjoy their own environment.
- Linking the large number of computers that will be used in future home health systems, with machine to machine communications

Below are some examples of simpler assistive technologies employed in UK projects:

Functions of assistive ICTs in Sheltered Housing for the elderly: many functions are connected via SRD to a home communications hub that has remote links

- *Audible Reminders*- Voice emulation devices for reminding occupants of important dates or times. Useful for medication and doctor's appointments.
- *Pill dispenser* – a 'Carousel' generates a gentle reminder that medication needs to be taken, within a specified timeframe, else an alarm call can be triggered via SRD.
- *Touchscreen Interface* – Enables devices to be remotely controlled by pressing a picture on a screen. (ie turning on heating, locking/opening doors, opening windows).
- *Pressure Pads/ Lighting Controls* - Located under carpets to monitor activity in the home via SRD links. The pads show occupants' movement about the house and can trigger other appliances, eg lights. Lights can be programmed to react to personal requirements, such as getting out of bed at night to go to the bathroom or in emergency situations, eg fire.
- *Door Entry System* – If the door bell rings, the television comes on (if not already on) and shows who is at the door via a video link. The door can then be opened remotely.
- *SRD Bathroom Controls* – Washbasin taps, toilet flush and shower operation via 'no-touch' NFC sensors. The control system times the water flow to prevent potential flooding, while water is thermostatically regulated to avoid scalding. The toilet flush monitors activity levels of the occupant and may also trigger effluent monitoring for a medical analysis, with results relayed via SRD to a storage hub.
- *Video monitoring* – constant links to remote centre may survey extremely frail people, for cases of fall, sudden attacks/seizures etc.
- *Heat/ Smoke Detectors* – Heat detectors are located in the kitchen to monitor excessive heat output (eg cooker left on for a prolonged period). Can interact via short-range wireless links with smoke alarm and other equipment in emergency situations, including unlocking and opening doors, switching on extractor fans and cutting off gas/electricity to appliances.
- *Fridge / Freezer Defrost Alarm* – Monitors core temperature of cold appliances to warn of defrost due to a fault, such as a door being left open.
- *Heating Controls* – Temperature regulation in each room with a thermostat, linked to motorised radiator valve wirelessly.
- *Keyless Doorlocks* – Doors can be unlocked by SRD key fob.
- *Central Locking* – Before leaving the house a green light at the front door will signal that all the windows are shut and the back door locked. A red light signals an insecurity.
- *Automation Control Centre* – for wireless control of the home environment and household items – audio-visual equipment, telephones and all of the above systems, integrating assistive technologies.
- *Motorised Windows/ Window sensors/ Curtain Motors* – Windows and curtains can be opened or closed by use of either a radio remote control or by wall switches. External twilight sensors will allow curtains to close automatically at dusk. Windows can also be programmed to close when heating comes on, when the property is empty, or if external temperatures fall below the pre-set threshold.

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[92] E. Dishman, "Inventing wellness systems for aging in place", *IEEE Computer*, Vol. 37, No. 5 (2004), p. 34.

For those with severe disabilities, the systems above for an assisted sheltered dwelling are becoming available in the UK through the National Health Service. The cost of 2-3 these assistive technologies is less than £2,000 per home.

5.1.4.1 - The overall economic effects

These kinds of advances will increase the number of people who can live without constant in-person medical supervision. Such systems will increase independent life expectancy and so lengthen working life. The economic impacts are likely to be significant, though hard to price, including:-

- Lessening the need for state subsidy of elderly care
- Home care environments are conducive to knowledge work. This suggests a new market for distance learning late in life – to launch a new career, satisfy curiosity or amuse. We may have to stop thinking of education as primarily for the young.
- Teleworkers may remain employable long after they reach what is regarded today as retirement age. They could dominate those professions that call for experience and judgment.

5.1.4.2 - Implications for social benefits

We anticipate two key effects at a family-structure level:-

- Incorporation of older generations back into the family, so multigenerational households reappear. Grandparents taking care of younger children will enable both parents to work.

- Similarly, family members previously engaged in full-time or part-time care of an elderly family member can pursue other activities, especially employment. As this burden has in the recent past fallen disproportionately on women, they may be freer to seek work outside the home, thereby raising total family income. In the UK there are over 6 million unpaid carers, ie family and friends, equivalent to 11% of the population over 5 years (NSO, 2006). Some 5% of carers were over 85 years themselves, while 114,000 carers were children aged 5 to 15 years.

5.1.5 - Smart health and the smart hospital in the smart city: melding the hospital with the smart home

Over the last three decades, the UK has examined health care as a unified system, attempting to form a 'joined up' organisation of care for the patient across all levels and intensities, from home to clinic to hospital. At the centre of this is the 'smart hospital'. Connected healthcare and patient monitoring were explored in the section above in extending the care systems into the (sheltered) home. The smart hospital is a hub for emergency and more intensive care, dependent for its "intelligence" on two interrelated systems:-

- The smart building, described above, which in addition to its other functions, can act against infectious diseases which may cluster in ventilation and water systems (MSRA and Legionnaires types of disease) or on building surfaces; and

- Medical systems that take full advantage of patient identification and asset tracking. RFID has been shown to reduce staff errors in the distribution of medicines and speed up access to medical histories, which can, in an emergency, make the difference between life and death. It also supports more efficient use of resources, making equipment and specialized supplies easier to locate, reducing the need for redundant inventories

In between these two is the concept of the ‘smart ward’. In such wards, vital information, such as allergic reactions, or prescribed medication is displayed on a screen above each patient along with any other vital information for treatment. This display is triggered by an RFID equipped identification badge worn by nurses and doctors, which activates information support systems as they enter the ward or approach a bed, providing patient-specific information needed by that caregiver. This system significantly reduces the time needed to understand the patient’s condition, prevents errors in treatment, and reduces the time needed to document tasks by 60%. Such wards may also have a schedule screen, for patients to know who will be caring for them when, and they can even gain access to educational information about their problem and treatment.

Although there was initially some apprehension about using unlicensed radio frequency devices in hospitals, a consensus seems to have emerged that the risks are vastly exceeded by the benefits. Large volumes of mission-critical data now routinely move through WLANs, which are replacing wired and licensed wireless systems. It is now widely appreciated that many lapses and inefficiencies in healthcare are due to the difficulty of getting information exactly where and when it needed. Ubiquitous wireless networks and short-range devices go a long way toward eliminating such problems.

5.1.6 - Smart transport services and smart vehicles (smart car/bus/train/ metro/city & suburbs/rural)

The future of transport is not just a set of enhancements to existing different modes of transport. The future lies in systems which put the users, rather than the vehicle or driver, or the traffic in general, at the centre of the transport strategy, considered as a holistic system.

Logistics planning already entertains such procedures, especially for freight. For instance, Dutch and Japanese analyses of freight deliveries in dense urban situations identified night or very early morning delivery as optimal because road traffic is lighter, and they proposed the use of electric trucks to reduce noise. Shifting delivery times to the “off hours” reduces daytime traffic congestion since delivery trucks no longer block busy roads as they load and unload their goods.[93]

Such plans require vehicle location monitoring and SRDs have a key role to play, providing the smart city with intelligent transport and smarter parking. Vehicle monitoring systems (which increasingly exploit the Bluetooth signals of mobile phones carried by passengers and drivers) make it possible to observe traffic flow in real time, while other systems identify specific vehicles disrupting the flow. Estimates of arrival and journey times, anticipation of delays and proactively coordinating

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[93] *The Macro-economic effects of near-zero tariff telecommunications*, SCF Associates Ltd, 1999

transport resources to optimise the movement of goods and people through the smart city is becoming more effective and affordable. .

Transport systems are already becoming dependent on the use of SRDs, especially RFID for:-

- Managing recharging points for electric cars and pools of shared vehicles.
- Access and billing for car parks, toll roads and public conveyances.
- Helping drivers find available parking spaces (up to 30% of city traffic is caused by drivers looking for parking places[94])
- Issuing electronic passes ('tickets') when a passenger arrives in a rail or air terminal
- Opening and closing priority lanes for taxis and buses
- Optimal routing for shared fare vehicles in which a bus effectively becomes a taxi offering point to point journeys for the needs of its particular passengers. Interactions with the vehicles at the scene of an accident – eg the car involved automatically signals an incident and calls the emergency services.

5.1.7 Future M3N: Metropolitan Mesh Machine Networks and M2M

The first concepts of metropolitan mesh machine networks (M3N) have been of sensing nodes for monitoring a wide range of physical data in the urban (or rural) context. These include meteorological data such as temperature, pressure, humidity, UV index, wind strength and direction, and light/visibility levels. Sensor networks for pollution levels are also an important application, mainly for particles and gases (sulphur dioxide, carbon monoxide, ozone, nitrogen oxide, CO_2, methane) and for ground and water contamination, eg by heavy metals (e.g. mercury), pH levels, radioactivity, etc. Further environment data, such as levels of allergens (pollen, dust), electromagnetic pollution (solar activity) and noise may be monitored by M3N sensors. Their development also forms a part of the wider concept, sometimes termed the Internet of Things (IoT) for development of networks of objects, as an adjunct to the existing internet. These are now being pursued by various industry sectors, to enable connected objects to converse with other objects (machine to machine, M2M) or with human users, commonly via licence exempt radio communications.

M3N arrays can also be used for sensors in addition to utility services, for municipal consumption of gas, water, electricity, etc. Input data is relayed via the mesh to processing nodes or centres which may then trigger appropriate actuators. Actuator nodes are capable of controlling smart city services and devices (such as street lights or traffic lights for controlling traffic flow).

In the future, M3Ns – could provide an adjunct to expand the infrastructure, in order to interconnect a number of networks across the city, especially if they can interface to the smart electricity grid, and its extensions for water and gas.

This would expand the range of physical parameters monitored, to city services like emergency response, security, public transportation, parking and road management. However, the bandwidth requirements foreseen by ETSI in TR 103 055 v.1.1.1 (eg a data volume of 600 Mbytes per day, traffic predominantly in the uplink direction, and

[94] IBM global parking survey, 2011, with average time to find a space being 20 minutes globally

end-points operating on battery, with the restricted power levels, duty cycles, capacity and range which that entails) may not be enough to support all the applications visible on the horizon.

Unlicensed spectrum will trigger a the next major advance for networking globally and the internet: the rise of machine-to-machine (M2M) communications, enabling widespread innovation in applications, from wireless sensor alert networks for forest fires to pacemaker monitors reporting vital signs to health carers. The number of intelligent connected devices is growing quickly, and is likely to exceed 100 billion by 2020, potentially generating an economic contribution of more than $1.4 trillion per year — five times greater than the Internet today.

Thus technologies using unlicensed spectrum are set to provide 95% of these The M3N’s connections, as unlicensed technologies are cost-effective, power-efficient and provide users fine-grained control over the networks and infrastructure they deploy. Moreover, the alternative notion of licensing for the high numbers of devices and links involved would become an unworkable absurdity in practice, given the finite budgets and person-hours available to regulatory authorities like Ofcom.

Question 3

Do you agree with our proposal to release 870-876 MHz / 915 -921 MHz for licence exempt SRD and RFID applications if Government releases 870-872 MHz / 915-917 MHz?

Yes, we agree.

The licence exempt applications proposed by Ofcom for utilisation in these bands are of substantial socio-economic value. This is demonstrated by the numerous applications dependent on SRD and RFID use and their increasing significance for everyday life (as examined in our response to Question 2).

The primary questions are:-

- “are these the best uses of these bands”?
- “can they coexist with ER-GSM, in the 873-876 and 918-921 MHz ranges?

Since Ofcom says there is no immediate plan to authorize ER-GSM, and in any case, it might only be needed in a few large switching centres and along the high-speed rail line to continental Europe, co-existence with ER-GSM should not be a decisive test for the deployability of SRDs and RFID throughout the UK.

Question 4

Do you agree with our proposal to release 872-876 MHz / 917-921 MHz for licence exempt SRD and RFID applications if Government does not release 870-872 MHz / 915-917 MHz?

Ofcom notes that in implementing the release it will need to be clear whether the 2x2 MHz of spectrum at 870-872, 915-917 MHz currently managed by Government is also to be released.

Our view is that the extra 2MHz at 870MHz and at 915MHz is most useful but does not eliminate the value of applications likely to come to market in the remaining spectrum.

Certainly the promised benefits of new applications on licence exempt bands could be reduced if less spectrum were made available.

Following discussions in Government, if a positive decision becomes clear in a timely manner it will certainly act as a near-term catalyst for new licence exempt SRD applications, as discussed above.

Question 5

Do you have a view on the sequencing and timing of Ofcom's next steps if the spectrum is released for licence exempt SRD and RFID applications?

It is most important not to let the schedule proposed in Table 1.1 of the consultation document slip. Indeed, it should be accelerated if possible. This spectrum has been under-utilised for more than a decade. The benefits foregone – and opportunity cost incurred – are huge. Had the spectrum been released earlier, vast amounts of societal value could have been unlocked in the areas of smart metering and the other smart applications described in this response. Further delay or deliberation regarding this band will postpone the innovations that will surely occur by exploiting 870 / 915 MHz.

Who we are

SCF Associates Ltd

SCF Associates Ltd is a specialised research firm focusing on strategy, technology, socio-economics and policy, mainly in the telecommunications and information industries. Formed in 1998, as a private limited company registered in the UK, we have delivered a variety of assignments, with much of the work being in the public sector and some published openly. The core strength is in exploring the economic and social impacts of technological innovation over the medium to long term through both qualitative and quantitative methods. The focus is on high technology industries, exploring mid-term and long-term future strategy, frequently using scenario planning. Subject areas examined range from innovative spectrum management to design of a future internet from a human factors perspective, an architecture for the Internet of Things, green data centres, to the impacts of ICTs on the family, and future innovations in robotics. We focus on combining the technical side with the economic and human factors. We have also carried out specialist assignments in the private sector, at times under conditions of non-disclosure. Based on experience gathered over the past two decades, the company has developed its own approach to scenario construction – Scenario Construction for Forecasting. We frequently use this technique, combined with other novel economic modelling methods for long term quantitative impact assessments, to illustrate potential socio-economic outcomes of technological change. In so doing, we help clients to formulate appropriate strategies and policies.

Simon Forge has worked for over 25 years in the information industries. He is director of SCF Associates Ltd. He has produced a range of studies on novel approaches to spectrum management for the European Commission and for national regulators in Asia and Europe, most recently a study on sharing spectrum. His latest publication is on the strategic impacts for MNOs, broadcasters and other spectrum users of the release of the 700MHz band. He is a Chartered Engineer and holds degrees in Control Engineering and Digital Signal Processing from the University of Sussex, UK (BSc, MSc, PhD).
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Robert Horvitz is the founder and director of the Open Spectrum Foundation, a not-for-profit policy research project based in the Netherlands. A specialist in licence exempt spectrum, he has worked with Open Spectrum UK on Ofcom consultation responses in the past. He also co-authored SCF Associates Ltd's 2012 study for the European Commission on the value of shared spectrum access.

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