Carbon Connections:

Quantifying mobile's role in tackling climate change

July 2009

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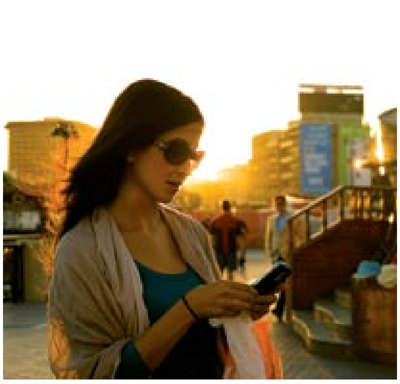


Authors

Vodafone

Vodafone Group Plc is the world's leading international mobile communications group. It has a significant presence in Europe, the Middle East, Africa, Asia Pacific and the US through the Company's subsidiary undertakings, joint ventures, associated undertakings and investments.

Vodafone provides voice and data communications services, including voice calls, SMS text messaging, MMS picture and video messaging, internet access and other data services. Increasingly, Vodafone offers integrated mobile and PC communication services – wirelessly through 3G and HSPA services – and via fixed-line broadband. Vodafone offers a comprehensive range of products to support machine-to-machine (M2M) smart services and facilitate secure, high performance remote working.

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Accenture

Accenture is a global management consulting, technology services and outsourcing company. Combining unparalleled experience, comprehensive capabilities across all industries and business functions, and extensive research on the world's most successful companies, Accenture collaborates with clients to help them become high-performance businesses and governments. With approximately 177,000 people serving clients in more than 120 countries, the company generated net revenues of $23.39 billion for the fiscal year ended 31 August 2008.

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Foreword from Vittorio Colao, Vodafone Group Chief Executive Officer

Tackling climate change is a huge challenge for the world, and one where the mobile telecommunications industry can make a great contribution.

Every business must reduce its carbon impact, and the innovative use of mobile technology can help to create a low-carbon economy. The need to reduce greenhouse gas emissions is a significant business opportunity for many companies in our industry and beyond. Smart products and services will save customers money as well as helping to reduce emissions, so they will be increasingly attractive as the cost of carbon rises in the coming years.

There has been a lot of discussion of the potential for ICT, but little detailed quantification of how much can be achieved and how much it might be worth for energy users. The findings of this report are based on detailed, quantified assessments of 13 wireless opportunities and should be of interest to decision makers in many industries, as well as government and environmental groups.

This report shows that in 2020 these 13 specific opportunities, supported by mobile services, could save 2.4% of expected EU emissions – 113 million tonnes of CO_2e, equivalent to saving 18% of UK emissions in 2008. This would save €43 billion in energy costs alone and would require a billion mobile connections, 87% of which are machine-to-machine (M2M), connecting one piece of equipment wirelessly with another.

Reports such as this are effective only if they stimulate action by business, governments and other players. It is important to recognise that whilst the billion connections identified in this research will themselves use energy and result in emissions, the payback in terms of emissions avoided is compelling.

Vodafone and other innovative businesses can play their parts but policymakers must make the carbon connection between ICT and climate change, and construct policy frameworks that incentivise the investment and actions necessary to create smart wireless communications and which encourage cross-industry collaboration. With the right approach, there is a clear win-win-win for business, society and the environment.

Vittorio Colao, Vodafone Group Chief Executive Officer

"Tackling climate change is a huge challenge for the world, and one where the mobile telecommunications industry can make a great contribution."
Vittorio Colao, Vodafone Group Chief Executive Officer

Foreword from Mark Foster, Accenture Group Chief Executive – Management Consulting & Integrated Markets

The communications industry has been at the heart of the transition to a globalised economy. It has played a transformational role in the innovation and redesign of business models across all industry sectors in the digital era and will continue to be a catalyst for further reconfiguration of industries and their value chains in the period ahead.

Today we face the onset of a new era and the unprecedented global challenge of climate change. Leading scientists and experts predict that global emissions need to be stabilised by 2015 to prevent reaching potentially irreversible levels. But to date, the targeted decline in greenhouse gas emissions has yet to materialise. There is a clear and immediate imperative to take further steps to reduce global emissions and the communications industry will yet again play a pivotal role.

It is in this context that Vodafone and Accenture have worked together to better understand the transformational role that the communications industry can play in enabling the low carbon economy and quantify its potential impact and benefits. Industry leaders such as Vodafone, and the mobile telecoms sector as a whole, can both reduce their own carbon footprint and, more importantly, enable the reduction of carbon emissions in other sectors.

This joint report outlines how the mobile industry can begin shifting from strategy to execution in driving both carbon abatement and cost reductions for its business customers through the use of mobility solutions and machine-to-machine connected intelligent ICT. Together we have identified 13 opportunities that could enable a potentially game-changing prize for society and the sector across the EU-25 countries by 2020 – a prize that includes carbon abatement of 113 Mt CO_2e, energy savings of €43 billion per annum and 1 billion new connections.

The findings and recommendations provide a robust foundation for policymakers, regulators and industry leaders to shape the market incentives to unleash the enormous innovation potential of the mobile communications industry to help transition to a new era: a low carbon economy.

Mark Foster, Accenture Group Chief Executive – Management Consulting & Integrated Markets

"There is a clear and immediate imperative to take further steps to reduce global emissions and the communications industry will yet again play a pivotal role by enabling the transition to a low carbon economy."
Mark Foster, Accenture Group Chief Executive – Management Consulting & Integrated Markets

Executive summary

The 13 wireless telecommunications opportunities identified in this report have the potential to reduce carbon emissions by 113 Mt CO2e[1] a year and cut associated energy costs by €43 billion across the EU-25 countries in 2020. These carbon savings represent 2.4% of expected EU emissions for 2020. To achieve these savings, 1 billion mobile connections are required.

ICT can make a major contribution to tackling climate change by eliminating the need for physical products or activities through the effective use of ICT products or services, and enabling 'smart' applications that improve energy efficiency through real-time monitoring and control of processes. Wireless telecommunications enable this to be done remotely and on the move using cellular connections. Machine-to-machine (M2M) communications will play a key part.

By 2020, EU emissions are projected to decrease by 8.8% from 1990 levels assuming business as usual.[2] The carbon emissions savings identified in this study represent 2.4% of expected EU emissions in 2020, bringing the total decrease to 11% by 2020 from the 1990 level – helping the EU move closer to its 20% reduction target. The associated €43 billion potential saving cited in this report is derived from the reduction in energy costs only and does not include other related potential cost savings. These savings are calculated by investigating 13 specific opportunities and therefore only focus on a fraction of the full potential of wireless smart services to reduce emissions.

The quantitative research models that underpin the analysis are based on the characteristics of each industry (such as fleet sizes for the logistics and transport sector) and specific criteria (such as local fuel or electricity prices) for each individual country assessed, rather than using aggregate data. This approach sets the findings apart from previous studies and increases the accuracy of the results. The extensive segmentation of the addressable market for carbon reduction opportunities (e.g. only freight companies with a certain fleet size could implement central tracking systems) yields lower carbon and cost savings estimates if compared to previously published reports on this subject.

Opportunities

Of the wider range of possible opportunities for wireless telecoms to reduce carbon emissions and energy costs, 13 opportunities in five key areas were shortlisted and assessed to analyse potential emissions abatements and associated energy cost savings:

- **Dematerialisation** – replacing physical goods, processes or travel with 'virtual' alternatives, such as video-conferencing or e-commerce (online shopping):
  - **Mobile telepresence** – connecting 'virtual meeting rooms' to mobile devices would allow workers to join conferences from anywhere
  - **Virtual office** – using wireless telecommunications products means people can work remotely or from home
  - **Mobile delivery notifications for e-commerce** – businesses can use mobile communications to contact customers for more efficient order placement and delivery.
- **Smart grid** – improving efficiency of electricity grids through active monitoring and reducing reliance on centralised electricity production:

1 All carbon savings in this report are calculated in tonnes of carbon dioxide equivalent (CO_2e). This includes all greenhouse gases, not just carbon dioxide

2 Estimate based on trend of Europe's emission levels from 1990 to 2006. EEA, Greenhouse gas emission trends and projections in Europe 2008, Report No 5/2008

- **Energy network monitoring** – wireless devices monitor losses and load capacity of the electricity transmission and distribution network
- **Smart meter: micro-power generation** – smart meters support the sale of energy generated locally to utility companies for distribution in the locality
- **Smart meter: grid loading optimisation** – smart meters encourage end users to adjust daily electricity use and smooth consumption peaks, allowing energy providers to optimise grid loading.

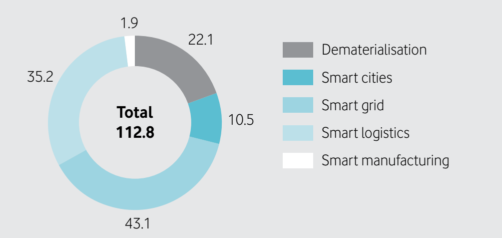
- **Smart logistics** – monitoring and tracking vehicles and their loads to improve the efficiency of logistics operations by utilising vehicles more fully:
  - **Centralised tracking** – wireless vehicle tracking devices feed data to a central fleet management system to optimise speeds and routing (for large freight companies)
  - **Decentralised tracking** – onboard tracking devices communicate wirelessly with nearby vehicles to adjust speed and routing (for smaller freight companies)
  - **Loading optimisation** – monitoring devices communicate vehicles' loading status to make use of spare capacity through re-routing
  - **Onboard telematics** – data from vehicle sensors are used to plan predictive maintenance and encourage fuel-efficient driving
  - **Remote supply control** – devices monitoring stock levels in vending machines can be linked wirelessly to suppliers for more efficient deliveries.

- **Smart cities** – improving traffic and utilities management:
  - **Synchronised traffic and alert system** – a monitoring system autonomously synchronises traffic lights and notification boards, optimising traffic flow and reducing congestion.

- **Smart manufacturing** – synchronising manufacturing operations and incorporating communication modules in manufactured products:
  - **High-value product remote monitoring module** – a communication module is incorporated within high-value products (for examples, see the basis of analysis on page 28) and transmits the status of the product to the maintenance provider, enabling predictive maintenance.

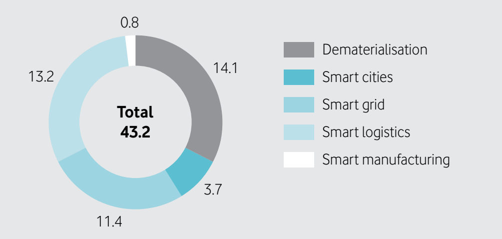
Key findings

Figure 1. Total carbon abatement potential for all modelled opportunities (EU-25; 2020)



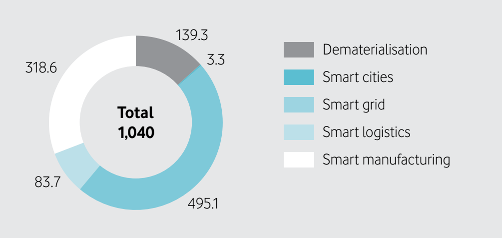
Carbon savings (Mt CO_2e)

Figure 2. Total cost saving potential for all modelled opportunities (EU-25; 2020)



Energy cost savings (€ billion)

Figure 3. Total connections required for all modelled opportunities (EU-25; 2020)



Connections (million)

Opportunity	Carbon abatement potential for EU-25 in 2020 (Mt CO_2e)	Energy cost savings (€ billion)	Total connections required to achieve these savings (million)
Dematerialisation	22.1	14.1	139.3
Smart grid	43.1	11.4	495.1
Smart logistics	35.2	13.2	83.7
Smart cities	10.5	3.7	3.3
Smart manufacturing	1.9	0.8	318.6
Total	**113**	**43**	**1,040**

The 13 opportunities identified in this study have the potential to reduce carbon emissions by 113 Mt CO_2e and energy costs by €43 billion a year in 2020 across EU-25 countries. Of these opportunities, smart grid and smart logistics represent the largest potential, with 70% of the identified carbon savings.

Smart applications enabled by wireless M2M connectivity represent 80% of the total carbon savings identified in this report, and the remaining 20% can be achieved through dematerialisation.

Delivering these smart solutions will come at a cost for energy users, requiring investment in hardware and software to be enabled by wireless connectivity. The 1 billion connections needed to achieve these savings will also require investment, but present a clear business opportunity for telecoms companies. Although we have not quantified the increase in emissions from providing the network capacity needed in this study, we expect this to be small compared with the scale of the opportunities presented – approximately 17% of the identified savings based on previous analysis of the ICT sector as a whole.[3]

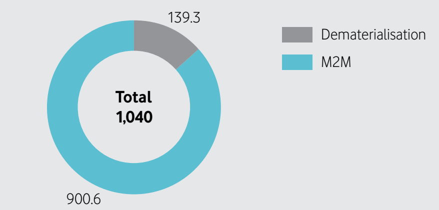
The primary scope of this report is the potential for carbon and energy cost savings in the EU-25 countries by 2020. We also looked at Australia and India in the areas where significant savings could be achieved. For example, smart grid opportunities in India could save more than 80 Mt CO_2e – nearly double that of all EU-25 countries combined – by reducing energy losses in transmission and distribution (currently nearly 25% of India's electricity production) and promoting decentralised energy production.

Incentives and potential barriers

Some of the opportunities identified, particularly smart grid and smart cities, demand relatively high capital expenditure and would take a number of years to deploy. However, these opportunities yield significant returns over the longer term – €11.4 billion a year for smart grid alone. Other opportunities such as virtual office require relatively small investment with rapid payback. Accenture achieved a 300% to 500% return on the monthly operating costs of its 30 telepresence terminals through significant savings in business travel.[4]

The business case for other industries to invest in wireless ICT solutions would be strengthened by a rising cost of carbon emissions (already €16 per tonne[5]), which could be achieved through the strengthening and extension of market-based cap-and-trade mechanisms such as the EU Emissions Trading Scheme.

Figure 4. Total connections grouped by M2M and dematerialisation (EU-25; 2020)



Connections (million)

3 Emissions from the ICT industry as a whole are projected to increase from 2% to 3% of global emissions to enable a 15% reduction from other industries, SMART 2020, Climate Group 2008

4 BTNonline Corporate Travel Intelligence, Accenture Realizing Significant Savings Through TelePresence, 2009

5 May 2009 figure, European Climate Exchange and Energy Information Administration

Smart grids and smart logistics often require the technology used to be compatible with companies and network providers across different countries. Technology and telecommunication providers and affected industries would need to collaborate effectively and agree common operating standards to accelerate adoption. In addition, sufficient next generation network coverage and bandwidth must be available to enable the 1 billion connections required to achieve the savings.

As well as providing significant potential savings in carbon emissions and energy costs, the opportunities identified in this report offer many additional benefits – ranging from more reliable vehicles and machinery achieved through predictive maintenance, to reduced office requirements and less time wasted commuting. These are outlined in the findings section of this report, together with potential barriers (see page 11).

Recommendations

We make a series of recommendations for governments and industry to promote development and deployment of wireless telecoms to reduce carbon emissions.

Governments should work with industry to:

- Deliver an appropriate price for carbon, for example by exploring appropriate opportunities to extend emissions trading schemes and progressively decrease free carbon allowances. This is the key factor in encouraging uptake of ICT emissions reduction opportunities, and would provide greater transparency and certainty to enable rational investment decisions
- Stimulate investment in smart ICT solutions through appropriate subsidies or legislation to increase the adoption rate of smart technology. For example, regulation could require the integration of M2M modules into high-value capital equipment or explore more definitive timetables for the roll-out of smart grid solutions to ensure widespread uptake and diffusion of the technology[6]
- Work with ICT providers and targeted industry sectors to promote interoperability and standardisation of services to enable wide-scale deployment across different countries and industries
- Establish best practice projects to benchmark and showcase the potential of smart ICT solutions
- Support further detailed research of carbon reduction opportunities for specific countries or industry segments to assess the technical feasibility and anticipated capital expenditure requirements
- Promote cap-and-trade and offset mechanisms that result in the transfer of ICT technology to developing countries.

6 Accelerating Smart Grid Investment, World Economic Forum and Accenture, 15 July 2009

Introduction

Smart energy saving with wireless telecommunications

Climate change is now widely accepted as a major threat that must be addressed urgently. It is clear that substantial and swift reductions in greenhouse gas emissions are essential to avoid widespread danger to people, habitats and the global economy.[7] Global emissions need to stabilise by 2015 and fall by 50% below 2000 levels by 2050, even as the population increases and economic development continues.

Wireless telecommunications can make a significant contribution to this daunting challenge. It has been estimated that the ICT industry as a whole could save 15% of predicted greenhouse gas emissions in 2020[8] and wireless applications can play a significant part. At the same time, the industry's products and services will continue to increase productivity and support economic development – the projected 15% reduction in emissions stems from energy savings worth €600 billion.

ICT's contribution to energy reduction is especially important because the potential emissions savings are five times the industry's own footprint.[9] Energy savings will come partly by replacing physical products or activities with 'virtual' ones, as in video-conferencing.

ICT can also cut energy consumption by supporting active monitoring and control of processes. Active monitoring improves energy efficiency by optimising process performance, and wireless telecoms enables remote monitoring through machine-to-machine (M2M) 'smart services' using cellular connections.

Smart M2M communications are a growing area in wireless telecommunications and are behind 80% of the total carbon savings identified in this report. M2M enables one device to communicate its status continually or sequentially to another device, often linked to a central management system (see Figure 5, on page 10). An example would be a truck communicating its position to a central fleet management system that calculates the optimal route and speed, helping to cut fuel consumption. Communication through a SIM card eliminates the need to integrate with a fixed-line network, providing greater flexibility.

7 See, for example, Intergovernmental Panel on Climate Change's (IPCC) 2007 Synthesis Report, Stern Review on the Economics of Climate Change, HM Treasury 2006

8 SMART 2020, GeSI and The Climate Group 2008

9 SMART 2020, GeSI and The Climate Group 2008

10 David Clark (Senior Research Scientist, MIT) quoted in The Economist, Telecoms – A world of connections, 2007

More and more industry sectors are integrating M2M smart services in monitoring and control systems. As many as a trillion networked devices could be in use by 2020[10], potentially revolutionising many key areas including transport, energy consumption and manufacturing processes. A number of significant smart opportunities using M2M connections are already under way, for example:

- The EU Commission has launched the Intelligent Transport Systems Action Plan to promote a shift of freight transport to less carbon-intensive modes[11]
- Xcel Energy, Accenture, and product specialists are working together to build the first smart grid city solution in North America, aiming for a 10% decrease in overall energy consumption.[12]

We estimate that in the 25 EU countries (EU-25), the 13 specific opportunities shortlisted and assessed in this report could avoid 113 Mt carbon emissions per year by 2020. This represents 2.4% of predicted EU emissions by 2020 in a business as usual scenario. The energy saved would be worth €43 billion. These are conservative estimates and relate only to the 13 specific opportunities studied.

To achieve these savings, a billion mobile connections would be required – this is around five times the number of existing mobile voice connections in Western Europe,[13] although almost 87% of the connections required would be M2M. This presents a significant opportunity for telecoms companies.

The business case for other industries to invest in wireless ICT solutions would be strengthened by a rising cost of carbon emissions, as market-based measures such as the European Union Emissions Trading Scheme (EU-ETS) are strengthened and extended (see box). The EU-ETS is eventually expected to cover more than half of all EU carbon emissions[14] and the traded price is expected to rise from the May 2009 level of €16 per tonne. Even that price would add between 5% and 16% to today's prices of oil-based fuels.[15]

A unique quantified analysis

This report focuses on wireless telecommunications, tightening the focus of the broader SMART 2020 study of the whole ICT sector. Our aim is to highlight the potential applications in which mobile technology can help other industries to cut carbon emissions. We identify the associated energy cost savings, technical requirements, regulatory and market incentives and barriers.

The focus is on Europe because of Vodafone's strong presence, especially in Germany, Italy, Spain and the UK. There is also a clear drive from the EU Commission for advanced ICT solutions to transform energy efficiency [17] as part of its objective to cut emissions to 20% below the 1990 level by 2020. The availability of robust and accurate data for all European countries from Eurostat also allows accurate carbon and cost models to be developed and validated. In addition, we include findings on India and Australia, where Vodafone has a strong presence and where there is a clear business case.

We have built a robust quantitative assessment of the potential savings in carbon emissions and energy costs, and the number of connections required for the main opportunities. We began with five key areas:

- **Dematerialisation** – replacing physical goods, processes or travel with 'virtual' alternatives, such as video-conferencing or e-commerce (online shopping)
- **Smart grid** – improving efficiency of electricity grids through active monitoring and reducing reliance on centralised electricity production

EU Emissions Trading Scheme (EU-ETS)

Industry sectors such as chemicals production and energy generation are now covered by the EU-ETS and the scheme is being extended to many others, including aviation by 2012. Companies in the scheme must buy carbon permits covering their emissions and this will be a significant change to the cost-valuation models many companies currently use, affecting buying and investment decisions. Applying an emission trading scheme to the freight sector, for example, may significantly influence the choice of transport modes based on their carbon intensity.

In 2007, $64 billion worth of carbon permits were traded worldwide with 1.6 Gt of CO_2e traded to the tune of €28 billion in the EU-ETS alone. Overall the carbon commodities market is forecast to be worth up to $3 trillion by 2020.

Currently, a significant proportion of emission allowances are provided free but this will progressively be replaced by auctioning from 2013, with all free allowances expected to be replaced by auctioned permits by 2020.[16]

11 EU Parliament, Intelligent Transport Systems and Services report, 2008

12 Accenture, EALA Strategy Connect, 2008

13 Based on a total of 214 million voice cellular connections in Western Europe in 2009. IDC, Forecast: Mobile Services, Western Europe, 2003–2012

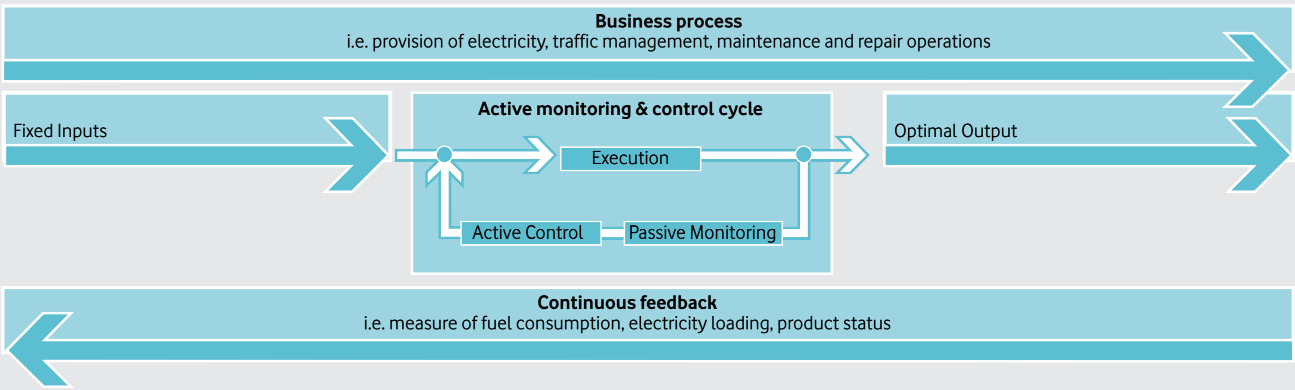
14 Janaki Ramakrishnan, International Environmental Science Centre

15 WEF, Supply Chain Decarbonisation, 2009

16 Financial Times, Domination of Carbon Trading, 2008

17 EU communiqué, mobilising information and communication technologies to facilitate the transition to an energy efficient, low carbon economy, COM(2009) 111 final (12/03/2009)

Figure 5. The 'smart' approach to business process optimisation



- **Smart logistics** – monitoring and tracking vehicles and their loads to improve the efficiency of logistics operations by utilising vehicles more fully
- **Smart cities** – improving traffic and utilities management
- **Smart manufacturing** – synchronising manufacturing operations and incorporating communication modules in manufactured products.

There are many options within these five areas and initially we examined 29 applications (see Appendix 1, page 34), chosen on the basis of:

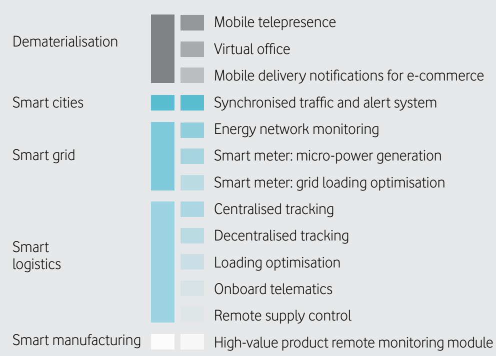
- Carbon abatement potential, based on SMART 2020 and World Economic Forum findings
- Addressable market based on industry segmentation and historical spend on ICT wireless products or services[18]
- Qualitative assessment of feasibility and attractiveness to customers and telecommunications providers.

From this analysis, 13 specific wireless carbon reduction opportunities were shortlisted (Figure 6) to explore in depth. For each of these, detailed models were developed to compute the energy cost savings, carbon abatement potential, and the number of mobile connections required for the selected countries (see Appendix 1 for details of the methodology).

To increase the accuracy of the findings, each model relies on the sophisticated segmentation of key inputs (for example, only road freight companies with over 20 trucks would implement centralised tracking systems) and detailed country-specific data (such as fuel prices). For instance, the addressable market for smart logistics is determined based on the data for the number, type and size of vehicles per company. In addition, specific emissions factors for each type of vehicle and country-specific fuel prices are used to accurately compute the savings. This approach sets the findings apart from previous studies and provides more realistic figures for the estimated carbon and cost savings.

The assessment of emission reductions is a gross figure, representing the total savings from using the mobile opportunities. It does not account for the additional energy and emissions associated with the required mobile network capacity, which would reduce the overall energy savings and emissions reduction. Nor does it allow for savings already being delivered by early adopters of some of the opportunities outlined.

Figure 6. List of modelled opportunities



18 IDC, Worldwide and US wireless infrastructure and application service spending 2005–10, 2005

Findings

By 2020, EU emissions are projected to decrease by 8.8% from 1990 levels assuming business as usual.[19] The EU will not meet its 20% reduction target without improving the energy efficiency of business processes and operations. The carbon emissions savings from the 13 opportunities identified in this study could reduce emissions in 2020 by a further 2.4%, bringing the total reduction to 11% from the 1990 level.

Of the wider range of possible opportunities for wireless telecoms to reduce carbon emissions and energy costs, 13 opportunities in five key areas were shortlisted and assessed. This section outlines the findings of the analysis in each of these five areas:

- Dematerialisation: 22.1 Mt CO_2e; €14.1 billion
- Smart grid: 43.1 Mt CO_2e; €11.4 billion
- Smart logistics: 35.2 Mt CO_2e; €13.2 billion
- Smart cities: 10.5 Mt CO_2e; €3.7 billion.
- Smart manufacturing: 1.9 Mt CO_2e; €0.8 billion

Overall, the wireless telecoms applications modelled in this study could reduce carbon emissions by 113 Mt CO_2e in 2020 across EU-25 countries. The associated €43 billion potential saving is derived from the reduction in energy costs only and does not include other related potential cost savings.

To achieve these savings, 1 billion mobile connections would be required. Delivering these connections will come at a cost. Emissions from the ICT industry as a whole are projected to increase from 2% to 3% of global emissions in order to enable a 15% reduction from other industries.[20] We have not quantified the increase in emissions from providing the network capacity needed in this study, but we expect it to be approximately 17% of the identified savings based on previous analysis of the ICT sector as a whole.[21]

Key findings

Figure 7. Total carbon abatement potential for all modelled opportunities (EU-25; 2020)

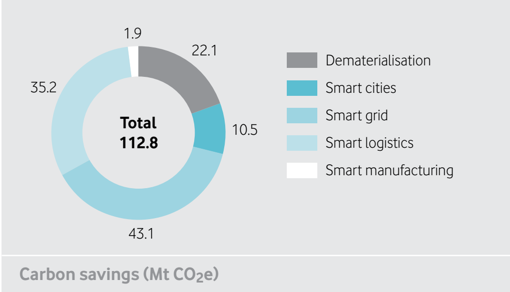


Figure 8. Total cost saving potential for all modelled opportunities (EU-25; 2020)

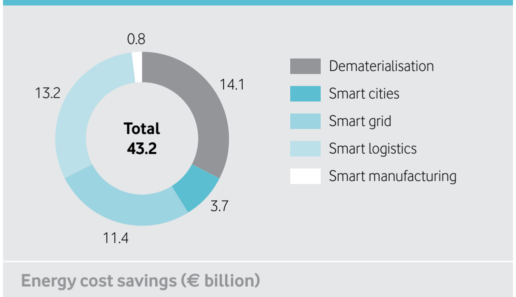
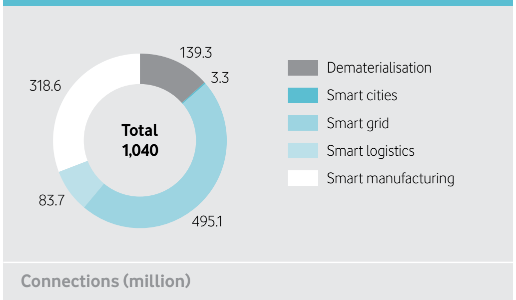


Figure 9. Total connections required for all modelled opportunities (EU-25; 2020)



19 Estimate based on trend of Europe's emission levels from 1990 to 2006. EEA, Greenhouse gas emission trends and projections in Europe 2008, Report No 5/2008

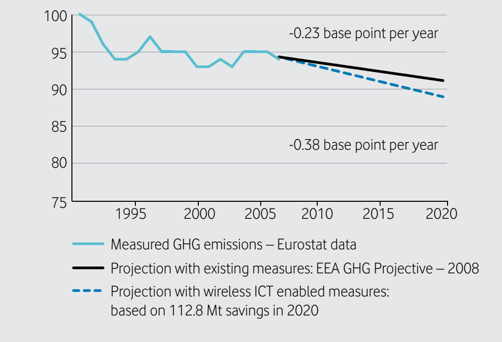
20 SMART 2020, Climate Group 2008

21 Derived from SMART 2020, Climate Group, 2008

These opportunities to reduce emissions can also be extended to other countries. Our analysis also covers Australia and India in the areas that can make a significant difference in those countries compared with Europe, particularly smart grid and smart logistics.

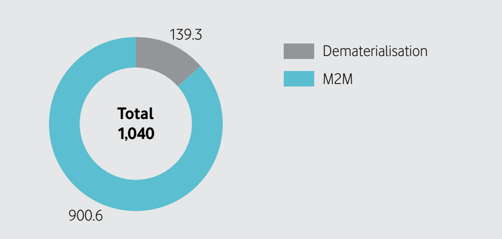
Additional benefits and potential barriers are outlined for each of the specific opportunities. High-level incentives and barriers are covered in the Recommendations section (see page 31).

Figure 10. Projected 2020 greenhouse gas emissions in Europe based on findings



Index 100 = base year emissions

Figure 11. Total connections grouped by M2M and dematerialisation (EU-25; 2020)



Connections (million)

Dematerialisation

Potential savings in 2020:
Carbon: 22.1 Mt CO_2e
Energy costs: €14.1 billion

Dematerialisation is the substitution of physical products and activities with low-carbon 'virtual' alternatives. The main benefit is to reduce travel – for example meeting via video or teleconference rather than travelling to meet in person, working from home rather than commuting to the office, and shopping online to reduce individual consumers' trips to stores.

Dematerialisation using the wireless telecoms applications modelled in this study can reduce 2020 emissions in the EU by 22.1 Mt CO_2e, saving €14.1 billion.

This study focuses on three opportunities that could cut emissions through dematerialisation:

1. **Mobile telepresence:** Connecting 'virtual meeting rooms' to smart phones via 3G or next generation access networks could increase the use of telepresence by allowing workers to join the conference from almost anywhere using mobile devices
2. **Virtual office:** Using wireless telecommunications products to create a virtual office means people can work remotely and from home, reducing travel and office space needs
3. **Mobile delivery notifications for e-commerce:** Businesses can use mobile communications to connect efficiently with their customers, enabling more efficient order placement and delivery.

Mobile telepresence

Potential savings in 2020:
Carbon: 1.4 Mt CO_2e
Energy costs: €4.7 billion

The telepresence market is expected to continue growing rapidly – by 265% in 2009 and up to 90% in 2012.[23]

This technology can cut costs significantly by reducing business travel: Cisco Systems, for example, saved $45 million in 2007 by using the company's network of 170 telepresence terminals to hold 28,000 meetings virtually instead of travelling.[24] Accenture achieved a 300% to 500% return on the monthly operating costs of its 30 telepresence terminals through significant savings in business travel.[25]

It is not yet possible to access telepresence conferences using mobile devices but this is expected to change. Advances in mobile technology could increase use of telepresence by enabling workers to access conferences remotely using smart phones, netbooks or laptops with high bandwidth 3G or next generation access networks. The ICT sector should accelerate the development of mobile telepresence access, particularly as mobile telecommunications move towards converged offerings and with the deployment of next generation access networks such as LTE and WiMax.

Basis of the analysis

The analysis of mobile telepresence and the virtual office is modelled on the business activities service sector, which is most likely to deploy flexible working schemes in the EU-25 countries.

For mobile delivery notifications, the analysis is based on domestic households in the EU-25 countries, although this could also be extended to small businesses.

Additional assumptions include:

- A logarithmic growth of the telepresence market past the 2012 IDC projection [22]
- A third of the audience will access telepresence terminals remotely
- Linear growth of the demand for e-commerce based on current demand data
- Employees will telecommute one day a week on average
- Only cars are taken into account when computing savings from commuting to the work place and shopping trips
- E-commerce will be extended to products which are regularly purchased through individual shopping trips such as clothes, sports goods, food, groceries and household goods.

For more detailed parameters, see Appendix 2 (page 37).

22 IDC, Telepresence, Miracle or Mirage?, 2009

23 Growth measured by number of terminals sold each year. IDC, Worldwide Telepresence 2008–2012 Forecast and Analysis, 2008

24 IDC, Telepresence, Miracle or Mirage?, 2009

25 BTNonline Corporate Travel Intelligence, Accenture Realizing Significant Savings Through TelePresence, 2009

Assuming that around a third of users will access conferences via mobile, telepresence offers potential carbon savings of 1.4 Mt CO_2e and energy cost savings of up to €4.7 billion a year in the business activities service sector across EU-25 countries by 2020.

Additional benefits:
- Reduce business travel costs
- Eliminate the need to be physically present in telepresence rooms
- Increase productivity by minimising time spent travelling
- Reduce investment in telepresence terminals with some users accessing conferences via mobile devices.

Potential barriers:
- High bandwidth required for telepresence means adequate next generation access network must be available to offer access via mobile
- High cost of telepresence terminals (from $80,000 to more than $300,000[26] for Cisco's range of products) means that only large companies are likely to make the initial investment.

Virtual office

Potential savings in 2020:
Carbon: 18.2 Mt CO_2e
Energy costs: €8.1 billion

An increasing number of business people are using wireless telecommunications products to work remotely. In the US, for example, around 11% of the total workforce already telecommutes at least one day a month.[27]

Wireless telecommunications products – such as mobile email, secure access to applications via mobile phones, mobile broadband cards or USB dongles – can be used together to create a virtual office. By enabling remote and home working (or 'telecommuting'), the virtual office cuts emissions and costs from commuting to a physical office location.[28]

Office space and energy requirements for companies are also reduced. However, emissions reductions here are effectively cancelled out because employees still need to heat and power their alternative locations (usually their homes). In the UK, for example, where the business activities service sector is large, for each kWh saved from building operations, 1.15 kWh is generated from working at home.[29] Therefore, the real savings come from reduced travel.

The virtual office has the potential to reduce emissions by 18.2 Mt CO_2e and cut energy costs by €8.1 billion a year in the business activities service sector across EU-25 countries in 2020.

Additional benefits:
- Reduce office space requirements
- Decrease time as well as costs and emissions from business travel and commuting
- Reduce wired landline infrastructure requirements
- Relatively small investment required for existing virtual office products.

26 www.cisco.com, Marthin De Beer (vice president and general manager, Cisco Group), 2006

27 Estimate from the Bureau of Labor Statistics, WorldatWork, Telework Trendlines 2009

28 There is a net reduction in emissions from travel even though public transport will still be running

29 Derived from Eurostat database, extracted from our analysis

Potential barriers:

- Need to change company culture of working together in a physical office
- Employee resistance to working remotely
- Working from home may not be viable in certain industry sectors, such as retail or manufacturing.

Mobile delivery notifications for e-commerce

Potential savings in 2020:
Carbon: 2.5 Mt CO_2e
Energy costs: €1.3 billion

Online ordering and home delivery from retail and wholesale outlets can substantially reduce emissions from shopping trips by individual consumers. Although the distance travelled by delivery trucks will increase, each trip can make multiple deliveries, resulting in a net reduction in distance travelled.

E-commerce is already well established and growing at 8% [30] a year in EU-25 countries. Offering customers reliable and accurate notifications about the status and timing of deliveries via their mobile phone could make regular online shopping a more attractive option for consumers for a wider range of products, such as clothes, sports goods, food, groceries and household goods. These notifications make delivery times more predictable, enabling customers to plan their schedules accordingly and reduce time wasted waiting for deliveries. This in turn reduces emissions from abortive delivery attempts and individual shopping trips.

Extending the range of products regularly ordered online through reliable mobile delivery notifications offers potential emissions reductions of 2.5 Mt CO_2e a year and energy cost savings of €1.3 billion across EU-25 countries by 2020. To achieve these savings, platforms must be developed that provide robust, reliable orders and notifications for e-commerce.

Additional benefits:

- Reduce retail building floor space and associated operating expenses
- Reduce customer time wasted waiting for deliveries with reliable mobile delivery notification
- Manage retail supply chains more efficiently with advanced notice of consumer demand.

Country analysis

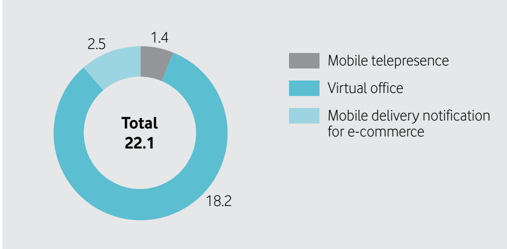
Cost savings are dependent on the price of fuel (for road, rail or air travel) and electricity (for office electricity use), as well as other factors such as the number of employees in the business activities service sector and the share of households using e-commerce. Given these factors, France, Germany, Spain and the UK are likely to achieve the greatest carbon reductions from dematerialisation in the EU.

Countries with a large share of their population in the business activities service sector, such as the UK with 7%, (see Figure 29, page 36) or with a large total workforce in that sector, such as Germany with 4 million, represent the largest potential for the number of employees likely to telecommute (Figure 15).

Key findings for EU-25 countries in 2020

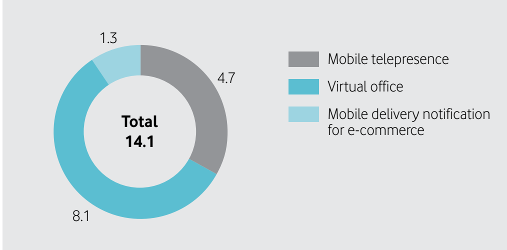
- **Total carbon abatement potential:** 22.1 Mt CO_2e (Figure 12)
- **Total energy cost savings potential:** €14.1 billion (Figure 13)
- **Total connections required to achieve these savings:** 139.3 million (Figure 14)

Figure 12. Dematerialisation carbon abatement potential (EU-25; 2020)



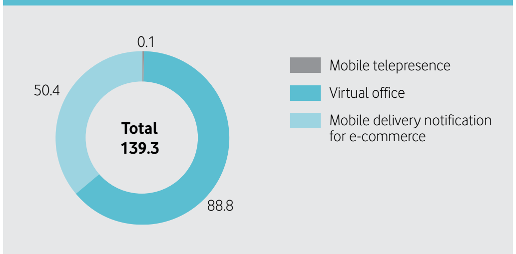
Carbon savings (Mt CO_2e)

Figure 13. Dematerialisation energy cost reduction potential (EU-25; 2020)



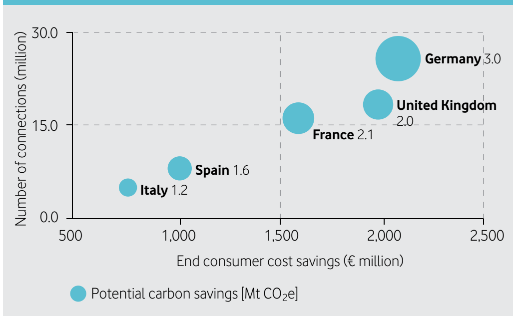
Energy cost savings (€ billion)

Figure 14. Dematerialisation – required connections (EU-25; 2020)



Connections (million)

Figure 15. Comparison of the 2020 savings potential of the three combined dematerialisation opportunities for a selection of EU-25 countries



Potential savings (€million) and required connections (million)

30 Eurostat average for EU-25 countries, 2008

Smart grid

Potential savings in 2020:
Carbon: 43.1 Mt CO_2e
Energy costs: €11.4 billion

Most existing electricity grids are inefficient and outdated, with few major upgrades over the past 30 years. Smart grids can deliver energy more efficiently by using wireless ICT to enable communication between the energy provider and intermediate points on the grid or end users of energy.

The smart grid innovations modelled in this study could help electricity providers to reduce annual EU carbon emissions by up to 43.1 Mt CO_2e and save €11.4 billion per annum by 2020. To achieve these savings, 495.1 million M2M connections would be required.

Wireless telecommunications providers are well positioned to provide the M2M communications required for smart grids, with extensive cellular General Packet Radio Service (GPRS) network coverage. For example, the UK government aims to replace all standard meters with smart meters by 2020, connecting around 23 million households.[31] GPRS already covers 98% of all UK households 'to the door'. However, only 70% of UK households have coverage to their meter cupboard. [32]

This study focuses on three key smart grid opportunities to improve the efficiency of transmission and distribution networks, and of end-consumer electricity use:

1. **Energy network monitoring:** Wireless devices monitor losses and load capacity of the electricity transmission and distribution network. This helps to locate network losses and minimise energy shortages and power outages
2. **Smart meter: micro-power generation:** Smart meters enable two-way electricity flow in urban grids. This promotes the sale of electricity from small-scale renewable generators to utility companies for local distribution, reducing reliance on centrally generated power
3. **Smart meter: grid loading optimisation:** Using smart meters to promote more efficient energy use and encourage off-peak electricity use by consumers. This helps to smooth peaks in demand, allowing energy providers to optimise grid loading.

Energy network monitoring

Potential savings in 2020:
Carbon: 16.4 Mt CO_2e
Energy costs: €4.2 billion

In Europe, approximately 8%[33] of electricity is lost during transmission and distribution, and the proportion is much greater in developing countries. In India, for example, nearly a quarter of energy produced is lost,[34] costing an estimated €39 billion a year.[35]

Wirelessly connected devices deployed across the distribution network allow electricity providers to monitor network losses, load capacity and line usage. This does not directly reduce losses, but it helps utility companies to optimise daily loading requirements and identify ways to improve the efficiency of the grid.

i

Basis of the analysis

For energy transmission and distribution network monitoring, it is assumed:

- Grid size is proportional to size of road network
- 10 monitoring devices per km in high density areas and one in low density areas.

The analysis of micro-power generation and grid loading optimisation opportunities using smart meters is based on domestic households only.

For more detailed parameters, see Appendix 2 (page 37).

31 UK Department of energy and climate change, Consultation on Smart Metering for Electricity and Gas, 2009

32 Accenture, high-level assessment of smart meter technology in the UK, 2008

33 Eurostat data for 2007

34 International Energy Agency, Statistics on India's energy sector

35 Using average price S2 – 2008 in India 0.08€/MWh

The loading voltage and intensity at various points on the grid is communicated to a central management system via an M2M cellular connection. By monitoring this, electricity drops, power outages and illegal electricity connections can be easily identified and located, leading to the dispatch of maintenance and engineering staff for repairs quickly and only when needed.

Additional benefits:

- Reduce maintenance and field engineering requirements
- Identify power outages and peak loading locations remotely in real time
- Reduce the number of CO_2e permits required for electricity companies regulated by the EU Emissions Trading Scheme (EU-ETS)
- Flexible add-on to the grid.

Smart meter: micro-power generation

Potential savings in 2020:
Carbon: 23.5 Mt CO_2e
Energy costs: €6.4 billion

Energy generated locally, both by households and by small-scale renewable generators (powered by solar or wind, for example), can be fed into the grid and sold to utility companies for local use. This reduces energy losses associated with transmission and distribution of centrally generated power sent over long distances.

Smart meters can promote these transactions by enabling utility companies to monitor remotely the amount of electricity fed into the grid from individual locations. Each meter is connected to the utility company via an M2M cellular connection, periodically transmitting data on consumption and excess in capacity.

Micro-power generation[36] requires initial investment by domestic households to install generators powered by renewables. National and local governments in Europe are providing strong incentives to support smart grid initiatives. In France, for example, interest-free loans of up to €30,000 are available to households for implementing micro-energy solutions such as geothermal or heat pumps.[37] It is estimated that in 12 industrial countries a sixth of electricity originates from micro-power generation.[38]

Additional benefits:

- Enable electricity providers to distribute locally generated electricity to neighbouring consumers, reducing energy losses from transporting power over long distances
- Reduce household electricity bills with excess energy sold to the utilities company
- Decrease reliance on carbon-intensive energy production by promoting small-scale renewables
- Improve national energy security and reduce reliance on fossil fuel.

Potential barriers:

- Capital expenditure required by consumers to invest in renewable generators and uncertainty over future fuel costs
- Need to change mindset of public from energy consumer to energy producer.

36 This includes waste-heat or gas-fired cogeneration, wind and solar power, geothermal, small hydro, and waste- or biomass-fuelled plants

37 www.ecocitoyens.ademe.fr, 2009

38 McKinsey, Using energy more efficiently: An interview with the Rocky Mountain Institute's Amory Lovins, 2008

Smart meter: grid loading optimisation

Potential savings in 2020:
Carbon: 3.2 Mt CO_2e
Energy costs: €834 million

Smart meters provide accurate data on energy use, enabling consumers to adjust their daily usage patterns. This can help to smooth peaks in energy demand, particularly when combined with variable pricing offered by the energy provider. As a result, overall energy requirements are lower as extra capacity is not needed to provide back-up during periods of peak demand.

Software connected to smart meters can display key metrics on energy use in real-time together with tips for householders to reduce consumption at peak times and cut bills by using more energy at off-peak rates. This capability is enabled by two-way communication between the energy provider and the end consumer via an M2M cellular connection.

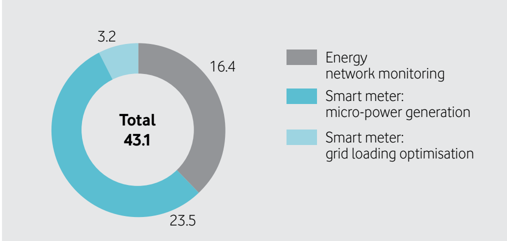
Additional benefits:

- Enable consumers to choose when to use electricity and reduce their bills by providing data on energy use combined with variable pricing
- Smooth peaks in demand for electricity by changing consumer behaviour, minimising transmission peak losses for energy providers
- Save on carbon permits for electricity providers regulated by cap-and-trade schemes (such as EU-ETS).

Key findings for EU-25 countries in 2020

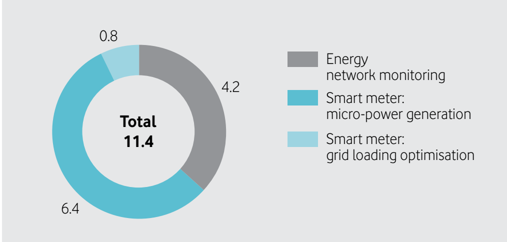
- **Total carbon abatement potential:** 43.1 Mt CO_2e (Figure 16)
- **Total end-consumer electricity cost savings:** €11.4 billion (Figure 17)
- **Total connections required to achieve these savings:** 495.1 million (Figure 18)

Figure 16. Smart grid carbon abatement potential (EU-25; 2020)



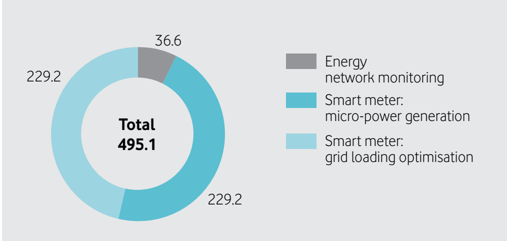
Carbon savings (Mt CO_2e)

Figure 17. Smart grid electricity cost reduction potential (EU-25; 2020)



Energy cost savings (€ billion)

Figure 18. Smart grid – required connections (EU-25; 2020)



Connections (million)

In practice: Smart meters in the UK

Bglobal's energy management system will enable Vodafone to cut carbon emissions and save at least £2 million a year on its energy bills by installing smart metering at base station sites in the UK.

Automated meter reading equipment provides a reading every 30 minutes and the data is transmitted over the Vodafone network to Bglobal's central data centre. Real-time data from smart meters enables Vodafone to monitor and put in place measures to reduce energy use, cutting costs and carbon emissions.

This data can be used to identify and prioritise sites with higher energy usage for energy-saving measures. These include replacing air conditioning with energy-efficient free cooling (using fresh air), which will save more than £1 million a year.

Electricity to run Vodafone's 12,000 UK base stations costs around £20 million a year. Bills have previously been estimated for these sites as most are unmanned with restricted access, making it difficult to read meters manually. By providing accurate readings from smart meters to its energy provider, Vodafone will save 10% a year on electricity bills. Monitoring energy use remotely also eliminates the need for staff to access base stations for meter readings at a cost of between £50 and £100 per visit.

The cost savings enabled by smart meters mean that Vodafone UK will recoup its initial investment in less than a year.

Country analysis

Europe

The potential for smart grid to achieve significant reductions in emissions depends on the carbon intensity of energy production in each country. For example, the carbon abatement potential in France, where nearly three-quarters of electricity is generated from nuclear power,[39] is 85% smaller than the UK (Figure 19). However, the corresponding electricity cost savings only differ by 30%.

India

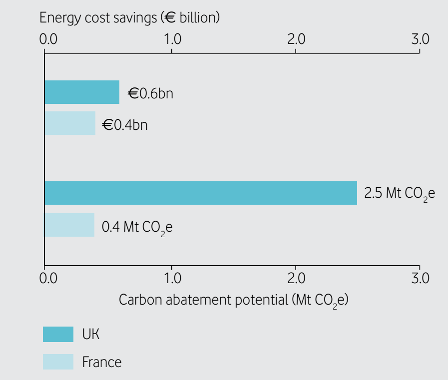
With 25% of produced electricity lost[40] during transmission and distribution, potential savings in India are significant. Smart grid opportunities in India could achieve a total potential abatement of more than 80 Mt CO_2e, nearly double that of all EU-25 countries combined. By focusing only on improving the efficiency of the grid through energy transmission and distribution network monitoring, projected savings in India are more than three times greater than all EU-25 countries combined (Figure 20). This presents potential cost savings of €6 billion, making a strong business case to upgrade the grid in India.

India can also benefit from the large volume of green technology transfers it receives from carbon offsets to implement smart grid solutions. India already has low-carbon and environmental goods and services (LCEGS) with a market value of £191 billion, representing 6% of the £3,046 billion global market.[41] Shifting the investment in LCEGS to ICT green solutions could help India finance the required capital expenditure.

Australia

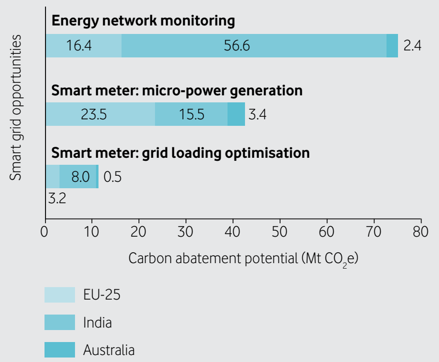
Australia's carbon intensive energy production sector, stimulated by high household consumption per capita (almost 10 tonnes CO_2e/capita)[42], could use smart grid initiatives to reduce its carbon footprint by 6.4 Mt CO_2e a year in 2020. This represents 15% of the achievable savings in EU-25 although Australia's population is only 5% of the EU-25 countries.

Figure 19. Comparison of the 2020 carbon abatement and energy cost saving potential for the energy network monitoring opportunity in the UK and France



Smart grid: energy network monitoring (2020)

Figure 20. Comparison of the 2020 carbon abatement potential for each smart grid opportunity in EU-25, India and Australia



Smart grid 2020

India

- **Total carbon abatement potential:** 80.1 Mt CO_2e (Figure 20)
- **Total end-consumer electricity cost savings:** €8.6 billion
- **Total connections required to achieve these savings:** 1,942 million

Australia

- **Total carbon abatement potential:** 6.4 Mt CO_2e (Figure 20)
- **Total end-consumer electricity cost savings:** €0.8 billion
- **Total connections required to achieve these savings:** 26.8 million

39 72%. Derived from Eurostat data, 2007

40 Derived from statistics of the International Energy Agency for India's energy sector

41 Financial Express, India emerges as third largest market in low-carbon and green goods & services, 2009

42 Derived from statistics of the International Energy Agency for Australia's energy sector

Smart logistics

Potential savings in 2020:
Carbon: 35.2 Mt CO_2e
Energy costs: €13.2 billion

Transport and logistics operations have high carbon intensity because they rely largely on fossil fuels. The logistics and freight transport sector accounts for around 5.5% of global emissions,[43] but these can be cut by addressing inefficiencies. For example, articulated freight trucks in the UK (which carry the largest share of national freight) are less than half full on average.[44]

Wireless telecoms can help to improve the efficiency of logistics and transport by cutting journey times and reducing the number of trips. Delays can be reduced by redesigning distribution networks dynamically to take advantage of the best routes and transport modes. The length of journeys can be reduced by improving vehicle loading and having up to date information about the status of goods. By remotely monitoring vehicles' status and increasing the use of telematics data, the lifespan and utilisation rates of vehicles can be increased, reducing the number of trucks required in the fleet.

The study focuses on five areas where wireless technology can achieve the biggest reductions in carbon emissions and costs:

1. **Centralised tracking:** Wireless vehicle tracking devices feed data to centralised fleet management software to optimise speeds and routing of vehicles (for large freight companies with more than 20 vehicles)
2. **Decentralised tracking:** Onboard tracking devices communicate wirelessly with nearby vehicles in the fleet to adjust speed and routing (for smaller freight companies with between five and 20 vehicles)
3. **Loading optimisation:** Monitoring devices communicate the loading status of vehicles, enabling logistics companies to make use of spare loading capacity by rerouting vehicles
4. **Onboard telematics:** Data from sensors on the vehicle are used to plan predictive maintenance to increase the lifespan and utilisation rate of vehicles (by reducing downtime)
5. **Remote supply control:** Devices monitoring supply levels in vending machines can be linked wirelessly to suppliers for more efficient planning of deliveries.

Smart logistics could significantly improve the energy efficiency of freight fleets – and reduce associated operating costs – by increasing the intensity of freight operations (in tonne.km) and reducing the total number of kilometres travelled by trucks (in vehicle.km).

The smart logistics opportunities identified in this study could reduce emissions by 35.2 Mt CO_2e and cut fuel costs by €13.2 billion across the logistics and transport sector in EU-25 countries in 2020.

Basis of analysis

The analysis considers road freight only.

It assumes:

- Centralised tracking systems are used by companies with at least 20 vehicles
- Decentralised tracking systems are used by companies with five to 20 vehicles
- Onboard telematics apply to companies with more than 10 vehicles
- Trips for daily resupply operations could be cut by 35% for remote supply control.

The intensity of freight operations is calculated in tonne.km (weight multiplied by distance travelled) and the total number of kilometres travelled by trucks is calculated in vehicle.km (number of trucks multiplied by distance travelled).

The number of vending machines in operation is derived from the number of machines sold per year in Europe.

For more detailed parameters, see Appendix 2 (page 37).

43 This does not include personal transport. WEF and Accenture, Supply Chain Decarbonization, using OECD data, 2009

44 Articulated trucks with loading capacity below 33 and above 3.5 tonnes are 57% empty on average in the UK. DEFRA, 2008 Guidelines to Defra's GHG Conversion Factors, 2008

The significant investment required to install telematics and centralised fleet management systems may limit uptake of this opportunity to large freight companies. However, decentralised tracking may provide a better option for small freight companies. A platform for fleet management should be developed to facilitate smart logistics by enabling interoperability and synergies between small and large freight operators.

Centralised tracking

Potential savings in 2020:
Carbon: 23.4 Mt CO_2e
Energy costs: €8.9 billion

A centralised fleet tracking system means that large logistics and transport companies (with at least 20 vehicles) can optimise routing, reduce delays and reroute shipments in real time. An M2M device fitted on each vehicle uses GPS to communicate position, speed and direction to a central tracking system via a cellular connection. This data, together with traffic information, can be used to calculate the most efficient route or vehicle speed to allow additional loads to be picked up along the way.

Additional benefits:

- Reduce the distance travelled and associated fuel consumption through re-routing
- Decrease idling time through speed control and co-ordination of deliveries
- Reduce the size of fleets (and associated operating expenses) by making more efficient use of each vehicle.

Potential barriers:

- High capital expenditure required for tracking systems applied to large transport fleets
- Interoperability of onboard systems is necessary to roll out centralised tracking systems on a large scale.

Decentralised tracking

Potential savings in 2020:
Carbon: 5.3 Mt CO_2e
Energy costs: €2.0 billion

An onboard tracking system suited to smaller logistics companies (with between five and 20 vehicles) enables communications between vehicles in a fleet without the need for a central hub. Drivers can adjust their routes to optimise delivery planning based on the relative location, speed and destination of the other vehicles of the fleet, which are communicated via M2M cellular connections.

Compared to centralised tracking, which requires the installation and integration of a central tracking hub as well as retrofitting a large fleet of trucks, the decentralised nature of this opportunity means the initial investment in a central hub is not required, making it cheaper and therefore more attractive to smaller companies.

Additional benefits:
- Reduce the distance travelled and associated fuel consumption through re-routing
- Decrease idling time through speed control and co-ordination of deliveries
- Relatively small investment compared with centralised tracking.

Loading optimisation

Potential savings in 2020:
Carbon: 4.9 Mt CO_2e
Energy costs: €1.8 billion

The loading capacity of each vehicle can be monitored remotely using an onboard device that measures the load's weight or volume combined with an M2M connection to a central fleet management system. This means a vehicle's speed or route can be adjusted to make use of spare capacity. The load weight or volume can be measured using embedded radio frequency identification (RFID) chips or through active monitoring sensors in the vehicle.

Additional benefits:
- Reduce fleet size and associated capital expenditure on vehicles
- Reduce operating expenses by cutting fuel consumption per product transported.

Potential barriers:
- More complicated to implement than a tracking system as complex sensor assemblies are required to measure load weight or volume.

Onboard telematics

Potential savings in 2020:
Carbon: 1.5 Mt CO_2e
Energy costs: €392 million

Telematics data – such as fuel consumption, temperature or status of engine components – can be collected from an onboard computer or a series of vehicle sensors and communicated wirelessly via an M2M device. Central fleet management systems can then monitor the status, efficiency and safety of vehicles remotely.

Remote monitoring of vehicles can flag up problems before the driver is aware of them and allows fleet managers to schedule predictive maintenance. This could increase the utilisation rate of fleet vehicles by reducing downtime, helping to cut maintenance costs by 5 to 15%.[45]

Additional benefits:
- Encourage more fuel efficient driving behaviour
- Extend vehicle life (reducing associated investment) through predictive maintenance
- Utilise fleets more efficiently
- Reduce insurance premiums (by an estimated 5%).[46]

45 Accenture, Green Fleet Management through Wireless, 2008
46 Accenture, Green Fleet Management through Wireless, 2008

Potential barriers:

- Interoperability of onboard systems is necessary to roll out smart logistics on a large scale
- High capital expenditure is required for the integration of telematics in large transport fleets
- Onboard telematics can be fully integrated in new vehicles, but retrofitting in older vehicles would be technically difficult and costly.

Remote supply control

Potential savings in 2020:
Carbon: 0.1 Mt CO_2e
Energy costs: €39.0 million

Supplies in vending machines and other units can be monitored remotely using embedded sensors that communicate stock levels to suppliers via a wireless M2M connection. This enables the supplier to improve the efficiency of deliveries by restocking only when needed, while avoiding product shortages.

Additional benefits:

- Reduce transport and delivery requirements by restocking only when needed
- Track and plan for demand peaks, reducing the risk of stock running out
- Optimise inventory levels and reduce working capital requirements.

Key findings for road freight transport in 2020 EU-25

- **Total carbon abatement potential:** 35.2 Mt CO_2e (Figure 21)
- **Total fuel procurement cost savings potential:** €13.2 billion (Figure 22)
- **Total connections required to achieve these savings:** 83.7 million (Figure 23)

Figure 21. Smart logistics carbon abatement potential (EU-25; 2020)

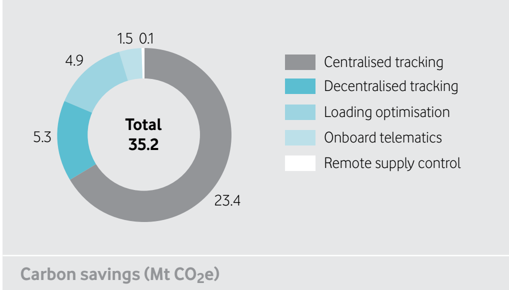


Figure 22. Smart logistics fuel procurement cost reduction potential (EU-25; 2020)

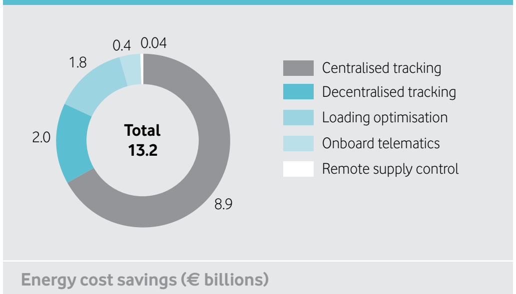
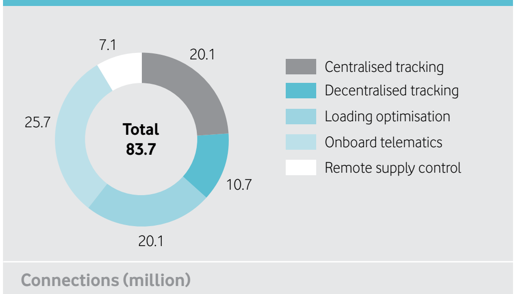


Figure 23. Smart logistics – required connections (EU-25; 2020)



Australia

- **Total carbon abatement potential:** 2.4 Mt CO_2e
- **Total fuel procurement cost savings potential:** €839.2 million
- **Total connections required to achieve these savings:** 740,976

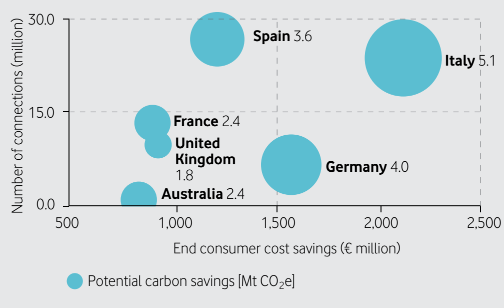
Country analysis

Europe

EU countries with large numbers of freight vehicles are strong potential markets for M2M-enabled fleet management systems (Figure 24). Potential energy cost savings and corresponding carbon savings depend on the nature of the freight sector in each country. For example, France and Italy have the largest number of freight vehicles, but cost and carbon savings are also dependent on the volume of freight (tonne.km) and the number of truck kilometres travelled (vehicle.km).

Germany has the largest volume of freight transported, with 343,000 million tonne.km[47] of road freight per year, but is not associated with the greatest savings because its freight sector is also more efficient, with a relatively high average utilisation rate of 133,380 tonne.km per vehicle per year. Italy shows the strongest potential for smart logistics solutions, with potential savings of €2 billion in fuel costs and 5.1 Mt CO_2e in carbon emissions a year by 2020.

Figure 24. Potential savings and required connections for smart logistics opportunities for a selection of countries in 2020



Potential savings (€million), required connections (million) and potential carbon savings (Mt CO_2e)

Australia

Australia was included in our analysis for smart logistics because of its strong reliance on road freight and the high intensity of its freight sector, mainly because of the large distances that must be covered. Australia's freight intensity is 476,749 tonne.km per vehicle per year, 3.6 times that of Germany[48]. Smart logistics could enable total potential carbon savings of 2.4 Mt CO_2e and fuel cost savings of €839.2 million in Australia.

In practice: Smart logistics in the UK

Isotrak's fleet management systems are helping UK businesses cut fuel costs and CO_2 emissions, reduce fleet size and save time by enabling smart logistics.

The company's Active Transport Management System combines satellite tracking and onboard telematics data sent over the Vodafone mobile network using standard SIM cards. This enables businesses to monitor their fleets remotely and plan more efficient logistics based on where vehicles travel, what they carry and how they are driven. By changing driving styles, for example, fuel efficiency can be improved by 5–15%.

In the UK, over 80% of all groceries, half of all road fuel and all residential mail are transported on trucks equipped with Isotrak systems. Isotrak expects to have connected 30,000 vehicles by the end of 2009. Among its customers are leading logistics companies and the UK's biggest supermarkets, including Asda, Tesco and Sainsbury's.

The Asda fleet has already saved 18 million road miles — the equivalent to 28,000 tonnes of carbon dioxide – and cut fuel costs by 23% over three years using Isotrak's system. Asda drivers have changed their behaviour to improve fuel efficiency by 6.6%, and the system is also enabling the supermarket to 'backhaul' more waste and recyclable materials between stores and distribution centres, minimising the number of trucks running without full loads.

47 Tonne.km is the standard unit for freight volume resulting from the multiplication of a load in tonnes by the distance travelled in kilometres. 2009 projection based on 2007 Eurostat data

48 Australian Bureau of Statistics, 2008 Year Book Australia

Smart cities

Synchronised traffic and alert system

Potential savings in 2020:
Carbon: 10.5 Mt CO_2e
Energy costs: €3.7 billion

Creating 'smart' cities through monitoring and control systems that promote energy efficiency could deliver significant environmental benefits. Wireless telecoms could help to reduce emissions by:

- **Improving urban traffic management:** Urban monitoring and control systems that network traffic lights, notification boards and auxiliary systems enable dynamic rerouting of traffic to reduce congestion
- **Monitoring utilities to improve efficiency:** Remote monitoring of utilities such as water improves planning, reduces losses and optimises maintenance (for electricity, see the smart grid section of this report).

The study focuses on the opportunity for wireless telecoms to improve traffic flow and reduce road congestion by connecting traffic monitoring sensors to traffic lights. Wireless monitoring devices installed at key road intersections would connect traffic sensors (such as cameras), traffic lights and electronic notice boards. Combined with a traffic management platform, these devices enable traffic lights and notices to change automatically in response to data from sensors.

Reducing congestion to increase the average speed of traffic by 20% in urban areas from 40 to 48 km/hour could reduce emissions by an estimated 5%.[49] The analysis found that using wireless telecoms to reduce congestion could cut emissions by 10.5 Mt CO_2e and save €3.7 billion in fuel costs across EU-25 countries in 2020. Decreasing road congestion could also improve air quality in urban areas.

In addition to the environmental benefits, governments and local authorities investing in smart cities could boost their economies. A £5 billion investment in intelligent transport systems in the UK, for example, could create or retain an estimated 188,500 jobs for a year.[50]

Basis of analysis

The analysis of synchronised traffic and alert systems covers urban areas only. It assumes:

- 10 traffic monitoring module units per km in urban areas
- Average traffic speed will increase by 20%
- A linear correlation between the increase in average speed and decrease in emissions.

For more detailed parameters, see Appendix 2 (page 37).

49 Ministry of Economy, Trade and Industry, Japan, International Meeting on Mid-Long Term Strategy for Climate Change, June 2008

50 London School of Economics Enterprise LTD & The Information Technology and Innovation Foundation, The UK's Digital Road to Recovery, 2009

Local authorities should investigate the results from existing pilot programmes and use the lessons learned in the course of deploying trials of their own.

Additional benefits:

- Decrease pollution levels in urban areas and improve air quality
- Increase local revenues by coupling intelligent traffic monitoring systems with congestion charging schemes to prevent 'rebound' effects (see barriers below).

Potential barriers:

- High capital expenditure to install and fully integrate autonomous traffic control systems
- Improvements in traffic flow could create a 'rebound' effect by increasing road use, negating the benefits.

Country analysis

Cost and environmental savings are proportional to the volume of vehicles in urban areas of each country. Countries with the largest volumes of vehicles – such as Italy, Germany and Spain – offer the greatest carbon and cost savings potential (Figure 25):

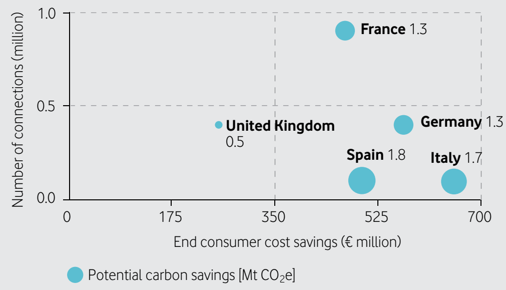
- Spain: 1.8 Mt CO_2e and €499 million
- Italy: 1.7 Mt CO_2e and €656 million
- Germany: 1.3 Mt CO_2e and €570 million.

The number of connections generated by smart traffic systems is proportional to the size of the network in high-density zones. France would need the most connections as it has the biggest road network in the EU, with 618,928 km in high density areas.[51]

Key findings for EU-25 countries in 2020

- **Total carbon abatement potential:** 10.5 Mt CO_2e
- **Total fuel procurement cost savings potential:** €3.7 billion
- **Total connections required to achieve these savings:** 3.3 million

Figure 25. Comparison of the 2020 savings potential of synchronised traffic and alert system for a selection of EU-25 countries



Potential savings (€million), required connections (million) and potential carbon savings (Mt CO_2e)

51 2009 projection based on 2005 Eurostat data

Smart manufacturing

High-value product remote monitoring module

Potential savings in 2020:
Carbon: 1.9 Mt CO_2e
Energy costs: €832.2 million

Smart wireless communications can help to achieve improvements in manufacturing efficiency that could deliver significant benefits in emissions savings. Industrial activity is the third largest source of emissions, accounting for 18% of the total in 2005.[52] Around 62 million high-value manufacturing machines are produced each year in Europe alone (see the basis of analysis for further details), each of which requires regular maintenance, adding to the costs and emissions associated with manufacture.

Smart wireless ICT can be used to:

- **Increase manufacturing process efficiency** – by automating communications between production sub processes
- **Support predictive maintenance** – by remotely monitoring machinery to improve maintenance planning and overall service management
- **Optimise order fulfilment** – by integrating order capture in production planning, output and dispatch, and increasing the intensity of batch production to reduce continuous production.

The study focuses on the specific opportunity to reduce carbon emissions from manufacturing by enabling predictive maintenance of high-value machinery as this opportunity would strongly rely on wireless telecommunications. Most of these machines already have built-in computers to monitor their operational status. It would be relatively easy to integrate a cellular M2M communication module into these devices to transmit data securely to maintenance providers, enabling them to monitor machinery remotely and prevent unnecessary field maintenance trips.

Wireless telecoms used in this way to reduce fuel use required for maintenance trips could lead to a 1.9 Mt CO_2e reduction in emissions and cut fuel costs by €832.2 million across EU-25 countries in 2020. By improving the efficiency of maintenance, manufacturers could cut operating costs and maintenance service providers could manage a higher volume of products. To achieve these savings, 318.6 million M2M connections would be required.

Basis of analysis

The analysis is based on the reduction in fuel use required for maintenance trips, decreasing related emissions and costs. Only the manufacturing goods in the following categories were selected:

- Industrial mechanical machinery
- Industrial electrical machinery
- Electro-magnetic machines.

The minimum threshold value to select high value manufactured products is set at €50,000.

For more detailed parameters, see Appendix 2 (page 37).

52 OECD, Environmental Data Compendium, 2005

Additional benefits:

- Extend the life of machines by improving predictive maintenance
- Reduce insurance premiums through continual monitoring of machinery
- Low capital expenditure as M2M communications modules can be integrated relatively easily into existing built-in computers on most high-value machinery.

Potential barriers:

- The destination of machinery must be known to install compatible M2M modules at the point of manufacture, unless a global M2M platform is established with a SIM card that operates worldwide.

Country analysis

Germany has the largest manufacturing output in Europe with a forecasted output of 221 million high-value products in 2020 – over 200% more than all other EU-25 countries combined (Figure 26).

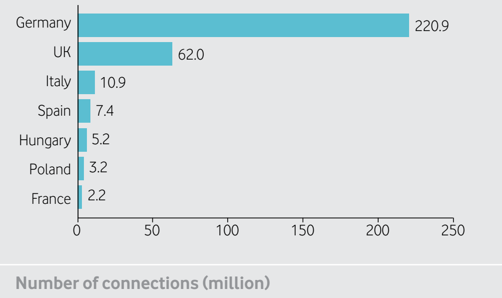
Our calculations on the reduction in field maintenance trips are based on the country where products were manufactured. However, as most products manufactured in Germany are exported, the potential environmental and cost savings may vary depending on the intensity of electricity production and the cost of fuel in destination countries.

Specific operating markets, such as Germany, are highly attractive based on the volume of high-value machines they produce. It is likely that countries with similar manufacturing levels, such as China or the US, have a similar market potential.

Key findings for EU-25 countries in 2020

- **Total carbon abatement potential:** 1.9 Mt CO_2e
- **Total fuel procurement cost savings potential:** €832.2 million
- **Total connections required to achieve these savings:** 318.6 million

Figure 26. Comparison of projected 2020 manufacturing output of high-value products for Germany and other EU-25 countries



Incentives and potential barriers

Some of the opportunities identified, particularly smart grid and smart cities, demand relatively high capital expenditure and would take a number of years to deploy. However, these opportunities yield significant returns over the longer term – €11.4 billion a year for smart grid alone. Other opportunities such as virtual office require relatively small investment with rapid payback, whereas the significant investment required to install telematics and centralised tracking systems may mean that although larger companies can recoup this expenditure, incentives for very small companies may not be substantial enough.

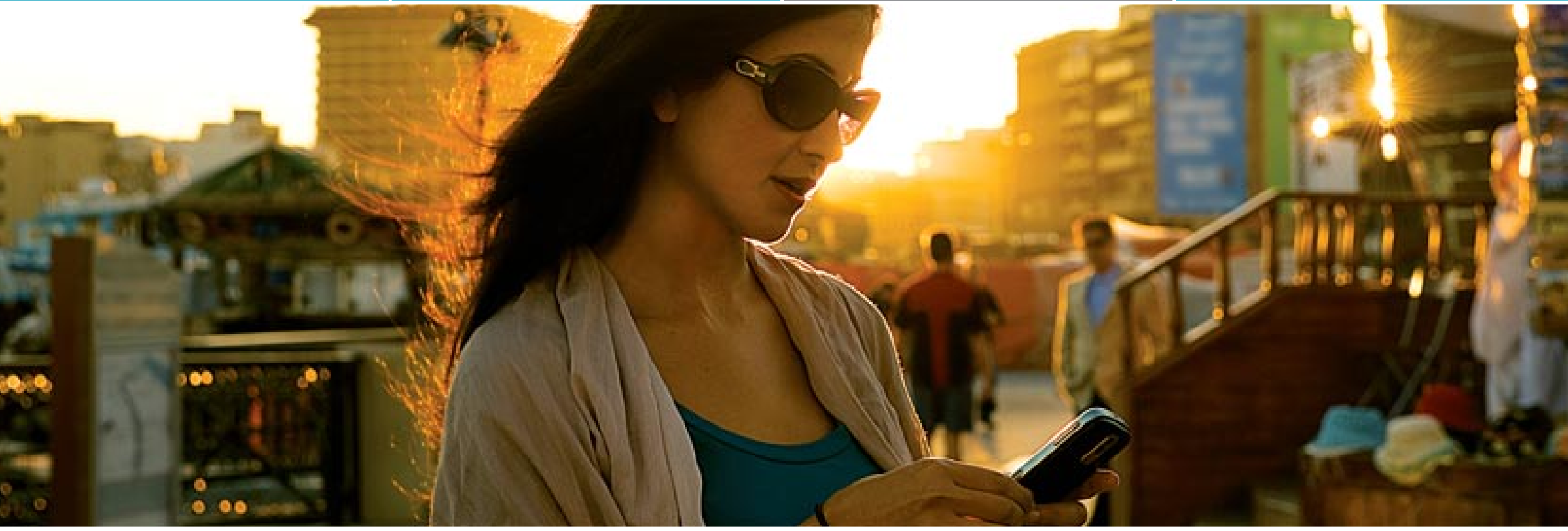
The business case for other industries to invest in wireless ICT solutions would be enhanced by a rising cost of carbon emissions (already €16 per tonne[53]), which could be achieved through the strengthening and extension of market-based measures such as the EU Emissions Trading Scheme. Smart logistics could save transport companies €563 million in carbon permits in 2020, as the EU Emissions Trading Scheme is likely to be extended to the freight sector. Smart meters could also help organisations meet their obligations under environmental regulations, such as the UK Carbon Reduction Commitment. Other incentives include the additional benefits offered by specific opportunities (see Findings, pages 11–29).

Smart grids and smart logistics often require the technology used to be compatible with companies and network providers across different countries. Targeted industries, system integrators, technology and telecom providers would need to collaborate effectively and agree common operating standards to accelerate adoption. The EU Commission is urging member states to agree to a minimum level of functionality[54] for smart meters to support the interoperability of grids and electricity providers across Europe. Currently few markets have set hard targets for the implementation of smart grid technologies such as smart meters.

Sufficient next generation network coverage and bandwidth must be available to enable the 1 billion mobile connections (87% of these M2M) required to achieve the savings identified in this report. In addition, the licensing of mobile infrastructure assets must recognise the longer lifecycle of an M2M SIM (compared with a person-to-person [P2P] communications SIM) and infrastructure investment must be planned on a longer term horizon.

Both governments and industry have an important role to play in overcoming these potential barriers (see Recommendations, page 31).

53 May 2009 figure
54 EU communiqué, COM (2009) 111 final (12/03/2009)



Recommendations

This study demonstrates clear opportunities for wireless telecoms to enable significant emissions reductions across the EU and beyond.

Governments have an important role in creating the policy framework to stimulate uptake of these technologies.

The industry sectors that would be instrumental in developing and using wireless ICT also have an important role to play in order to realise the greatest carbon reduction opportunities. These sectors include:

- ICT (to develop the technology and provide the connections required)
- Logistics and transport (for smart logistics)
- Utilities (for smart grid)
- Manufacturing and managed maintenance services (for smart manufacturing)
- Business activities service (for dematerialisation).

Other industries may not experience such significant savings, but could still achieve cost-effective savings with smart ICT products or services by, for example, substituting commuting with virtual office products.

Here we outline a series of recommendations for governments and industry to accelerate the development and implementation of these opportunities.

• Deliver an effective price for carbon
Governments should explore appropriate opportunities to extend emissions trading schemes to allow companies to adjust over time to the inclusion of carbon as a priced commodity in cost valuation models. Progressively reducing free carbon allowances will gradually drive up the price of carbon, encouraging companies to be more proactive in addressing energy efficiency and, where relevant, to implement wireless telecoms solutions that enable carbon abatements.

• Develop regulatory frameworks that incentivise investment in smart technologies
Governments could consider regulatory measures which will help to drive the adoption of smart technologies, in support of a higher price for carbon. For example, in the area of smart grids, and more precisely smart metering, governments could explore more explicit timetables for the implementation of smart grid technologies to

help accelerate the roll-out of smart meters, or consider the mandatory introduction of M2M modules into certain high value capital equipment and commercial logistics vehicles to ensure widespread diffusion of the technology.

At the same time, it is likely that M2M SIMs will have longer lifecycles than P2P SIMs and the planning of investment, and the licensing of mobile network infrastructure, may need to be undertaken over longer time horizons.

• Promote interoperability and standardisation
Interoperability and standardisation of services is essential to extend the use of wireless ICT for emissions reductions across different countries and different industries. The EU must work in partnership with ICT providers and other relevant industry sectors, to develop standards for operating and compatibility, in particular for:

- Smart meters
- Traffic management systems
- Embedded M2M modules in tradable products.

• Facilitate the formation of consortia for major smart opportunities
Large scale carbon reduction opportunities, such as smart grids, are complex systems which cannot be implemented by single players. They require input from a number of service and technology providers, and often demand significant capital expenditure. Governments must incentivise the formation of industry consortia to realise these opportunities.

In the UK, for example, the government has launched a consultation process to replace all standard meters with smart meters.[55] This process allows the various stakeholders to clearly identify and take ownership of specific tasks required to achieve this.

• Conduct further detailed research into specific emission reduction opportunities through smart ICT services
Geographical, functional and industrial segmentation in the analysis significantly increased the accuracy of the findings. We recommend industry sectors conduct further detailed assessments of carbon reduction opportunities for specific countries and industry segments.

For example, given the potential size of energy savings which could be achieved by rolling out smart grid in India (107 TWh in 2020), there is a clear need for additional research and analysis of the inefficiencies, to further substantiate and pinpoint the potential environmental and cost savings from implementing smart grid initiatives.

• Provide tax incentives for wireless ICT technology research and development
The capital expenditure required for carbon reduction opportunities can be significant. Therefore, it is important for governments to stimulate investment in wireless telecoms infrastructure through tax incentives and grants.

The EU plans to provide €200 million of funding for eco-innovation projects between 2008 and 2013. The Seventh Framework Programme (FP7), launched in 2007, allocates €54 million for research into ICT for environmental management and energy efficiency. [56]

55 UK Department of Energy and Climate Change, Consultation on Smart Metering for Electricity and Gas, 2009

56 EU Commission, Seventh Framework Programme, 2007–08

- **Evaluate both technical feasibility of potential opportunities and anticipated capital expenditure requirements through pilot projects and case studies**

The business case for investment in smart ICT solutions will be strengthened through the implementation of pilot projects. These projects would help to substantiate the savings as well as improve the understanding of the scale of the upfront investment required.

This study has modelled the benefits of carbon reduction opportunities for industries but has not assessed the capital expenditure required by companies to finance the opportunities. CAPEX requirements are often very specific to companies for opportunities such as dematerialisation or smart logistics or must be evaluated on a cross-industry basis for opportunities such as smart grids.

- **Promote cap-and-trade and offset mechanisms that result in the transfer of ICT technology to developing countries**

Governments should promote the transfer of ICT technology through carbon offsets and low-carbon and environmental goods and services (LCEGS) that can enable emissions reductions in developing countries. This could achieve considerable gains in energy efficiency without imposing caps on emissions in developing countries that could hamper economic growth.

Appendix 1: Research methodology

Selecting the target opportunities

We carried out a detailed assessment of 13 carbon reduction opportunities in five broad categories. Dematerialisation is one category, where wireless mobile products and services are already replacing physical goods, processes or travel. The other four categories were identified as having high potential in the SMART 2020 report and the 2009 ICT and Supply Chain Decarbonisation reports by the World Economic Forum:

- Smart grid
- Smart logistics
- Smart cities
- Smart manufacturing .

For each of these five categories we identified specific wireless telecoms opportunities that could result in significant carbon abatement. We began with a shortlist of 29 drawn from the findings of various studies, pilot programmes and commercially available solutions, and narrowed this down to the 13 most attractive opportunities (Figure 27) based on:

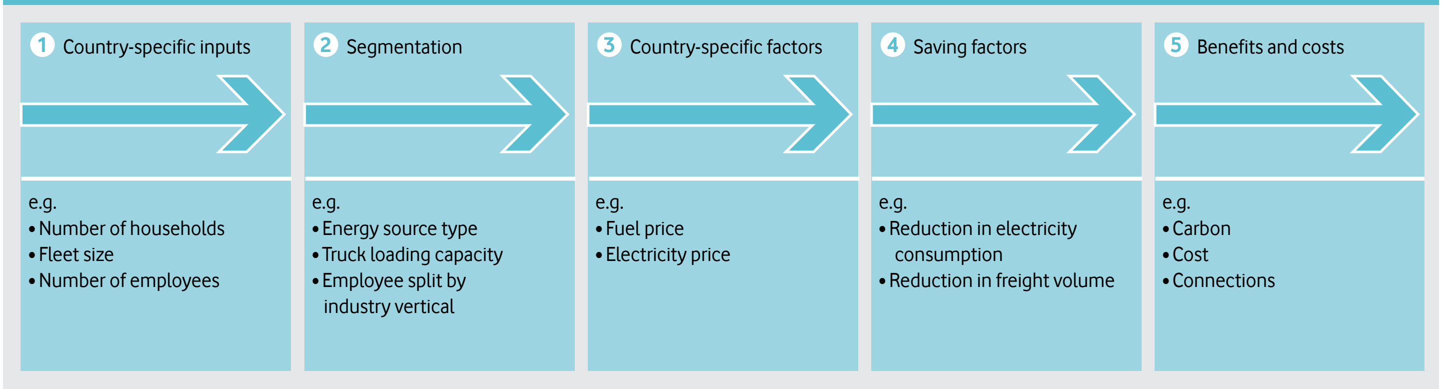
- Carbon abatement potential according to the SMART 2020 and World Economic Forum findings
- Qualitative assessment of feasibility and attractiveness to customers and telecommunications providers
- Addressable market based on industry segmentation and historical spend on ICT wireless products or services. [57]

57 IDC, Worldwide and US wireless infrastructure and application service spending 2005–10, 2005

Figure 27. List of 29 wireless ICT opportunities. The 13 shortlisted opportunities analysed in this study are highlighted.

- **Dematerialisation**
  - **E-commerce**
    - **Mobile delivery notification for e-commerce** – Linking businesses to their customers for order placement and delivery notifications
    - **Mobile media data management** – Software to enable purchase, storage and reading of any media from mobile phones to eliminate use of physical CDs or DVDs
  - **Green IT**
    - **e-invoice** – Invoices can be sent directly to a mobile phone and paid or acknowledged via SMS message
    - **RFID enabled e-ticket** – Passive RFID-enabled devices (mobile phone or cards) enable commuters to use a 'touch and go' action, eliminating the need for paper tickets
    - **Mobile power management** – Designed for mobile phones to turn off unused modules and enable wactive stand-by hibernation power savings
    - **Decentralised back-up servers** – Office and sensitive data for mobile workers can be backed up on any third-party server, using mobile back-up services
  - **Virtual office**
    - **Mobile telepresence** – Access telepresence terminals via mobile phone
    - **Virtual office (combined products/services for remote working)** – Use wireless ICT products together to enable people to work remotely, reducing travel and office space needs
- **Smart Manufacturing**
  - **E-commerce**
    - **On-demand manufacturing** – Customer orders (via mobile phones or PCs) are directly routed to producers, enabling production to be accurately scaled based on order volume and delivery requirements
  - **Industry**
    - **Manufacturing synchronisation** – Wireless communication between manufacturing processes improves efficiency by synchronising the manufacturing production chain
    - **High-value product monitoring module** – Incorporating communication modules within high-value machines during manufacture enables predictive maintenance
- **Smart Grid**
  - **Power consumption**
    - **Smart meter: grid loading optimisation** – Smart meters enable the end user to adjust daily consumption usage (e.g. according to variable price)
    - **Smart meter: customise energy sourcing** – Smart meters enable the end user to choose energy provider and energy source type
  - **Power delivery**
    - **Energy network monitoring** – Wirelessly linked devices used to monitor the electricity distribution network's losses and load capacity
  - **Power generation**
    - **Smart meter: micro-power generation** – Locally generated energy sold to energy providers through smart meters, providing energy to locality
- **Smart Cities**
  - **Traffic management**
    - **Synchronised traffic and alert system** – Wireless modules located at road intersections are used to optimise traffic fluidity and reduce congestion
  - **Utilities**
    - **Water supply micro monitoring** – Sensor to detect pipe bursts, leaks and other losses to minimise wasted water and energy requirements from pumping and treatment plants
    - **Smart meter: water consumption** – Smart water meter coupled with electric smart meter to monitor water consumption and recycling
- **Smart Logistics**
  - **Fleet management**
    - **Loading optimisation** – Fleet management systems used to re-route freight vehicles based on spare loading capacity to utilise vehicles more fully
    - **Centralised tracking** – A centralised system to monitor vehicles within the fleet and use software to adjust vehicle speed and optimise routes
    - **Decentralised tracking** – An onboard tracking system that communicates with other vehicles within the fleet to adjust speed and route
    - **Onboard modal switch terminal** – A module which defines the optimal transportation mode for a shipment based on carbon and physical costs
    - **Onboard telematics** – Onboard monitoring module linked to sensors which allows predictive maintenance
  - **Warehousing**
    - **Mobile delivery notification (logistics and infrastructure)** – Based on the load's location, an SMS alert is sent to the receiver to notify that the delivery is imminent
    - **RFID enabled goods quality tracking** – The status of goods is transmitted using RFID tags on goods and a SIM enabled communication device
    - **Remote supply control** – Remote monitoring of supply levels and inventory (e.g. in vending machines)
    - **RFID enabled warehouse management** – Asset inventory using RFID receptors in warehouses to report incoming/outgoing/sorted assets allowing optimised floor space and access location
- **Smart Buildings**
  - **Building management system**
    - **Globalised building management system** – Third party providers wirelessly receive and manage building data from various sites
    - **Building monitoring system** – Control systems are used to minimise energy requirements using active sensors to monitor light, humidity and temperature

Figure 28. Carbon opportunity assessment methodology

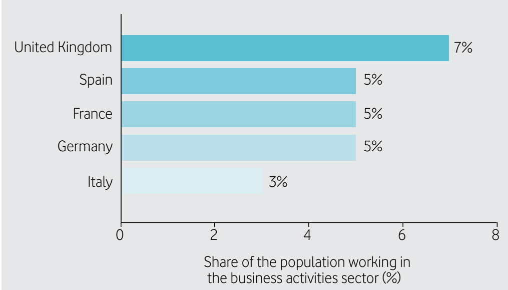


Detailed assessment

For each of the 13 opportunities, we developed detailed models for the selected countries to compute 2020 figures for cost savings, carbon abatement potential, and the number of mobile connections. Figure 28 summarises the methodology. The models are all country specific, which is essential to determine the results for each market because countries have very different characteristics. The benefits of this approach are highlighted when comparing countries with very different characteristics. This is highlighted in the graphs in Figures 29, 30 and 31 which rely on the same data that we have used to estimate carbon and cost savings.

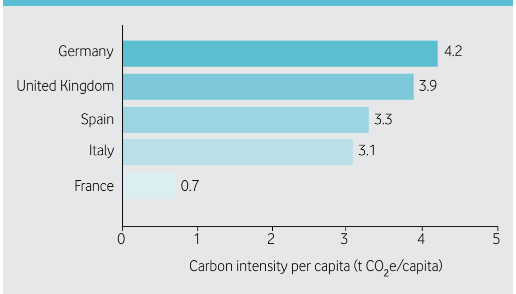
The detailed analysis is also based on industry specifics in each country. For example, the smart logistics analysis uses data broken down to consider the number, type and size of vehicles per company combined with country-specific fuel prices and emissions factors per type of vehicle. Similar variations can be seen across all the inputs to this study and are reflected in the results, setting the findings apart from previous studies because of their specificity.

Figure 29. Share of the population working in the business activities service sector



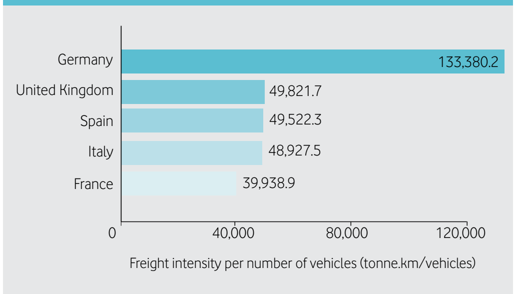
Proportion of the population (percentage)

Figure 30. Carbon intensity per capita



Emissions from energy production per capita (tonnes CO_2e/capita)

Figure 31. Freight intensity



Freight volume per number of vehicles (tonne.km/vehicles)

Appendix 2: Basis of analysis

Opportunity	Assumptions	Inputs	Segmentation	Factors
Dematerialisation				
Mobile telepresence	• Assume a logarithmic growth of the telepresence market past the 2012 IDC projection • No country-specific geographical split for this opportunity, only Europe in scope • Assume negative growth of Europe's market share past 2013 • Assume 1/3 of the audience will access the Telepresence terminal remotely	• Number of telepresence terminals worldwide	• Market split by continents • Telepresence bandwidth requirements by service providers • Market share by service providers	• Number of meetings held per year • Number of seats per terminal • Average cost savings per terminal • Average emissions savings per terminal
Virtual office	• Only cars are taken into account when computing savings from commuting to the work place • Only employees working in the business activities service sector are taken into account • Assume employees will telecommute one day a week on average	• Number of employees in the service sector	• Number of employees per industry vertical • Electricity production source split • Car motor type split • Electricity consumption split by industry and households	• Number of business days working from home • Share of building emissions proportional to employee number • Fuel price by motor type • Electricity price • Share of employees driving to work • Average commuting journey length • Car fuel consumption per motor type
Mobile delivery notifications for e-commerce	• Only cars are taken into account when computing savings from shopping trips • Growth in number of households is computed based on historical data for years 2000/2001/2002 • Assume linear growth of the demand for e-commerce based on current demand data • Only households are in scope	• Number of households	• Share of households purchasing via internet by type of products and services • Passenger car motor type • Delivery truck motor type	• Average distance travelled for shopping trips • Number of shopping trips per year • Fuel price per motor type • Electricity price • Number of drops per delivery truck

Opportunity	Assumptions	Inputs	Segmentation	Factors
Smart grid				
Energy network monitoring	• Grid size is proportional to size of road network • Electricity price is based on 2007 S01 • Assume 10 monitoring devices per km in high density areas and 1 in low	• Grid size (km) • Total energy production • Total transmission losses	• Electricity source type • Split in nature of electricity loss	• Reduction factor for electricity losses • Electricity price • Emission factor per electricity source type
Smart meter: micro-power generation	• Electricity price is based on 2007 S01 • Only households are in scope	• Number of households • Energy consumption by households • Total transmission losses	• Electricity source type • Split in nature of electricity losses • Split in end usage of electricity	• Share of household electricity consumption • Share of non-physical electricity loss • Share of produced micro-electricity • Electricity price • Emission factor per electricity source type
Smart meter: grid loading optimisation	• Only households are in scope • Electricity price is based on 2007 S01	• Number of households • Energy consumption by households • Total transmission losses	• Electricity source type • Split in nature of electricity losses • Split in end usage of electricity	• Share of household electricity consumption • Share of electricity loss removed from peak loading • Electricity price • Emission factor per electricity source type
Smart logistics				
Centralised tracking	• Only road freight is taken into account • Only applies to companies which have 20+ vehicles	• Number of tonne.km of road freight • Number of road freight vehicles	• Vehicle loading capacity • Company size by number of vehicles • Freight volume savings from network optimisation (in tonne.km) • Vehicle motor type	• Fuel price by motor type • Fuel consumption by vehicle size • Emission factor by vehicle size
Decentralised tracking	• Only road freight is taken into account • Applies to companies with 5–20 vehicles	• Number of tonne.km of road freight • Number of road freight vehicles	• Vehicle loading capacity • Company size by number of vehicles • Freight volume savings from network optimisation (in tonne.km) • Vehicle motor type	• Fuel price by motor type • Fuel consumption by vehicle size • Emission factor by vehicle size
Loading optimisation	• Only road freight is taken into account • Applies to companies with 20+ vehicles	• Number of vehicle.km of road freight • Number of road freight vehicles	• Vehicle loading capacity • Company sizes by number of vehicles • Vehicle motor type	• Increase in vehicle loading factor • Average loading capacity by vehicle type • Fuel price by motor type • Fuel consumption by vehicle type • Emission factor by loading percentage and vehicle size • Reduction in vehicle.km

Opportunity	Assumptions	Inputs	Segmentation	Factors
Smart logistics continued				
Onboard telematics	• Only road freight is taken into account • Applies to companies with 10+ vehicles	• Number of existing road freight vehicles • Number of new road freight vehicle registrations	• Vehicle loading capacity • Company sizes by number of vehicles • Vehicle motor type	• Fuel price by motor type • Fuel consumption by vehicle size • Emission factor by vehicle size • Average vehicle downtime • Reduction in downtime factor • Increase in vehicle lifespan factor
Remote supply control	• Number of vending machines in operation is derived from number of machines sold per year in Europe • Assume 35% of the trips could be removed from daily re-supply operations	• Number of vending machines in operation	• Vending machine sales growth by machine type • Light utility truck motor type	• Number of machines re-supplied per day • Average distance travelled per day for re-supply • Share of re-supply trips removed • Fuel consumption per vehicle motor type • Emissions factor per vehicle type
Smart cities				
Synchronised traffic and alert system	• 10 traffic monitoring module units per km in urban areas • Average traffic speed to increase by 20% • Linear correlation between the increase in speed and decrease in emissions • Only consider urban areas	• Length of the road network excluding highways • Number of vehicles in active circulation	• Road category type (local, regional, provincial) • Urban vehicle type • Motor type by vehicle type	• Average distance travelled per year • Share of distance travelled in urban areas • Average speed in urban areas • Emissions factor per speed unit • Fuel price by motor type • Emissions factor by vehicle type
Smart manufacturing				

High-value product monitoring module	• Only the manufacturing goods in the following categories were selected:
	  • Industrial mechanical machinery
	  • Industrial electrical machinery
	  • Electro-magnetic machines
	• Output growth in manufactured products is based on EU-25 growth in manufacturing
	• The minimum threshold value to select high value manufactured products is set to €50,000
		• Number of manufactured goods produced per year	• Type of manufactured goods
			• Light utility truck motor type
				• Emissions factors per vehicle motor type
				• Fuel consumption per vehicle motor type
				• Number of field maintenance routine check operations per year
				• Average distance travelled per field operation

Appendix 3: Glossary

BAU
Business as usual

Business activities service sector
Subset of the service industry sector concerned with providing knowledge-intensive inputs to business processes of organisations. Some examples include:

- Hardware consultancy
- Software consultancy
- Research and experimental development on social sciences and humanities
- Legal activities
- Business and management consultancy activities
- Advertising
- Market research and public opinion polling

CO_2e
Carbon dioxide equivalent: expression of greenhouse gas emissions in comparative units of carbon dioxide emissions

Dematerialisation
Replacing physical goods, processes or travel with 'virtual' alternatives, such as video-conferencing or e-commerce (online shopping)

e-Commerce
Purchasing and selling products or services over the internet

EU-25
The 25 European member countries of the European Union, before the accession of Romania and Bulgaria in January 2007

GHG
Greenhouse gases including water vapour, carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbons

ICT
Information and communication technology: combination of devices and services that capture, transmit and display information electronically

M2M
Machine-to-machine connectivity allowing the two-way communication of data between machines

Mega-tonne (Mt)
1,000,000 tonnes

Peak loading
Status of electricity distribution network when electricity demand is the greatest

RFID
Radio frequency identification: automatic identification and data capture method, relying on storing and remotely retrieving data

Smart cities
Application of ICT products and services to improve traffic and utilities management

Smart grid
Improving efficiency of electricity grids through active monitoring and reducing reliance on centralised electricity production

Smart logistics
Monitoring and tracking vehicles and their loads to improve the efficiency of logistics operations by utilising vehicles more fully

Smart manufacturing
Synchronising manufacturing operations and incorporating communication modules in manufactured products

Technology transfer
The exchange of knowledge, hardware, software and goods among stakeholders that leads to the spreading and adoption of technology

Telecommuting
Replacing commuting by rail, car or other daily commuting transportation modes with working from home

Tonne.km
Standard unit resulting from the multiplication of a payload in tonnes by a distance travelled in km

Vehicle.km
Unit of measurement that represents the movement of a vehicle over one kilometre

Appendix 4: Further reading

Accenture Research: Achieving High Performance in an Era of Climate Change

www.accenture.com/Global/Research_and_Insights/Policy_And_Corporate_ Affairs/AchievingChange.htm

Accenture Sustainability micro site
https://microsite.accenture.com/sustainability/

Accenture Sustainability Practice
www.accenture.com/sustainability/

SMART 2020
www.smart2020.org

VF Corporate Responsibility Site
www.vodafone.com/start/responsibility.html

Vodafone CR Reports
www.vodafone.com/start/responsibility/publications_faqs.html

World Economic Forum and Accenture: Supply Chain Decarbonization
www.weforum.org/pdf/ip/SupplyChainDecarbonization.pdf

Forward-looking statements

This document contains forward-looking statements within the meaning of the US Private Securities Litigation Reform Act of 1995 with respect to Vodafone's financial condition, results of operations, business and strategy. In particular certain forward-looking statements relate to plans to reduce carbon emissions and any associated cost savings which may be achieved. Some of the factors which may cause actual carbon-emission projections and cost savings to differ from these forward-looking statements include, but are not limited to, a lack of cross-industry collaboration, insufficient infrastructure investment and the absence of a regulatory environment that incentivises industry investment and collaboration, as well as factors discussed in 'Incentives and potential barriers' on page 30 of this document and Appendix 1: Research methodology' on pages 34 to 36 of this document. Furthermore, a review of the reasons why Vodafone's actual financial and operational results may differ materially from the expectations disclosed or implied within any forward-looking statements made herein can be found in Vodafone's 2009 Annual Report under 'Principal risk factors and uncertainties' on pages 38 and 39. All subsequent written or oral forward-looking statements attributable to Vodafone or any member of Vodafone Group Plc or any persons acting on their behalf are expressly qualified in their entirety by the factors referred to above. No assurances can be given that the forward-looking statements in this document will be realised. Subject to compliance with applicable law and regulations, Vodafone does not intend to update these forward-looking statements and does not undertake any obligation to do so.

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