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GLOBAL e-SUSTAINABILITY INITIATIVE

Mobile Carbon Impact

How mobile communications technology is enabling carbon emissions reduction

Prepared for GeSI by CARBON TRUST

GSMA Latam webinar

29 November 2016

What is the GeSI Mobile Carbon Impact report about?

- Assessment of what the carbon abatement (enabling effect) from mobile is **now** (based on 2015 data → report released in December 2015)
- **Detailed** bottom-up calculation
  - 100 mechanisms identified, 60 mechanisms analysed in detail
- Carbon abatement measurement for **M2M** and **consumer behavioural changes**

Scope:

- Impact from **mobile only**
- Europe and USA
- No rebound effects considered
- However, generally a conservative approach was taken to calculating the carbon abatement

Key Findings

The carbon emissions abatement enabled by mobile communications technology is approximately

5X greater

than the carbon emissions from mobile networks.

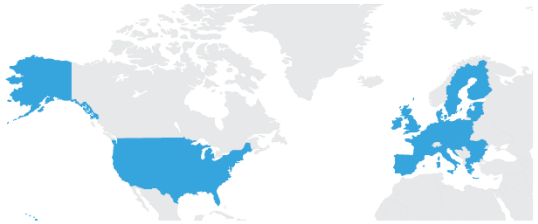
Carbon emissions from mobile networks

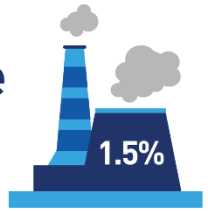
Carbon emissions abatement enabled by mobile communications technology

Mobile communications technology is currently enabling the

reduction of 180 million tonnes of CO_2e a year

in the USA and Europe.





and equivalent to 1.5% of all greenhouse gas emissions from the USA and Europe.

This amount is greater than the annual carbon emissions from the Netherlands.

There is expected to be

3X

Increase in carbon abatement over the next five years.

(to about 500 million tonnes of carbon emissions per year for USA and Europe), given current projections of the increase in deployment of M2M technologies.

Mobile users are willing to adopt behaviours to help reduce their carbon emissions.

International consumer research shows high levels of willingness for smartphone users to adopt behaviours that will result in reduced personal carbon emissions, enabled by functions or apps on their mobile devices.

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Methodology overview

- 10 categories
- 100 mechanisms identified
- 60 mechanisms analysed in detail
- Analysis for UK, Germany, Spain, France, USA, and Europe
- Global consumer survey to integrate available data
  - 4,000 smartphone users
  - USA, UK, Spain, South Korea, and Mexico
- Each mechanism:
  - Calculation methodology developed
  - Specific studies or assumptions used
  - Carbon abatement factor
  - Volume data
    - (e.g. M2M connections, number of smartphones, people using an application)

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Methodology examples

Building energy management systems for commercial buildings using smart meters

The carbon abatement is from the reduction in energy use in commercial buildings from energy management systems. This is enabled through the provision of smart meters to collect energy data. The smart meters are connected using M2M technology, the assumption being that each M2M connection represents one smart meter.

Volume factor: number of smart meters used for such systems today = number of M2M connections

Data source: number of business smart meter M2M connections from Machina Research (these are factored to only include the connections related to mobile).

Carbon abatement factor: carbon reduction per smart meter. This is derived from case studies (e.g. Vodafone ASB bank case study, and case studies in the Better Buildings Partnership "Better Metering Toolkit"). These give energy savings of between 7.5% and 25%. A mid-range value of 14% has been assumed. Combined with the typical number of smart meters per floor area, and typical energy consumption per floor area, an energy saving and therefore carbon saving per smart meter can be derived.

Fleet vehicle driver behaviour improvement

The carbon abatement is from the reduction in fuel use due to improved driver behaviour. This is the result of both feedback on driving performance (e.g. speed, acceleration, braking, cornering) from telematics enabled through M2M technology, and management intervention to encourage better driving techniques (e.g. training, incentives, scorecards).

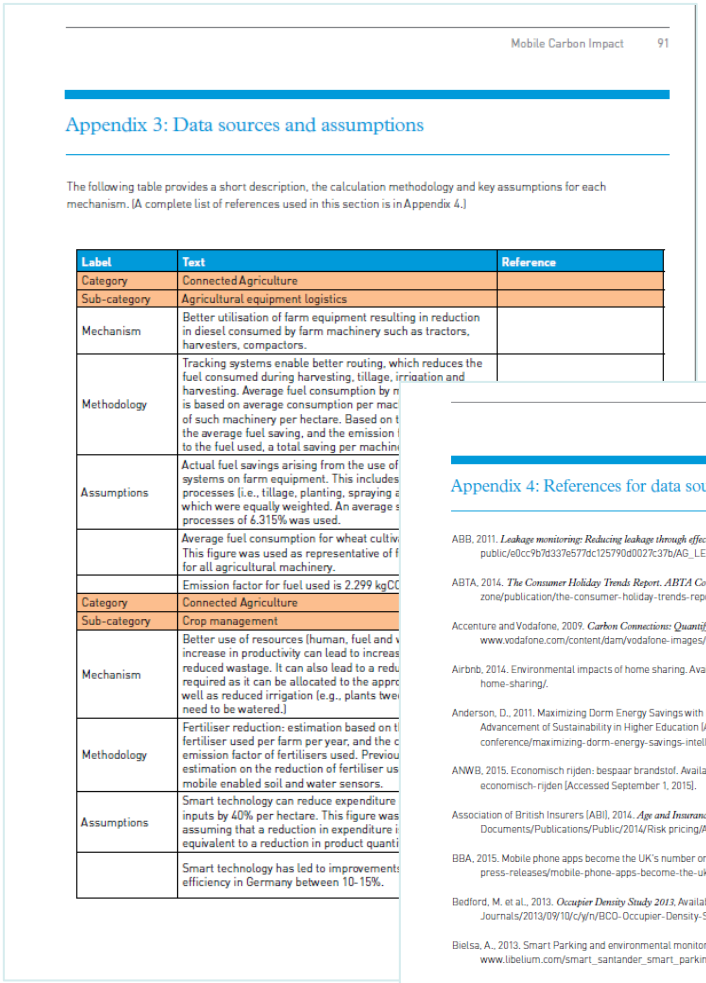
Volume factor: number of connected vehicles = number of M2M connections

Data source: number of fleet management M2M connections from Machina Research.

Carbon abatement factor: carbon reduction per vehicle. This is derived from various studies that give a range of 5% to 20% for the fuel saving factor, depending on the level of intervention. A mid-range value of 10% as typical has been assumed. This is combined with average vehicle emissions per km (from Defra emission factors), and typical annual distance for vehicles (available from national statistics). A mix of vehicle types is assumed (20% car, 60% LGV, 20% HGV) based on typical split of M2M connections for fleet management, which is from Carbon Trust analysis of source data.

Methodology documentation

- Full description of methodology (Appendix 1)
- All assumptions documented in detail for each of the 60 mechanisms including source references for data (Appendices 3 & 4)
- Additional GeSI-member-only deliverable: Carbon Abatement Calculation Handbook (completed in early 2016): provides list of factors, assumptions, and how to apply these



Appendix 3: Data sources and assumptions

The following table provides a short description, the calculation methodology and key assumptions for each mechanism. (A complete list of references used in this section is in Appendix 4.)

Label	Text	Reference
Category	Connected Agriculture	
Sub-category	Agricultural equipment logistics	
Mechanism	Better utilisation of farm equipment resulting in reduction in diesel consumed by farm machinery such as tractors, harvesters, compactors.	
Methodology	Tracking systems enable better routing, which reduces the fuel consumed during harvesting, tillage, irrigation and harvesting. Average fuel consumption by n is based on average consumption per mac of such machinery per hectare. Based on t the average fuel saving, and the emission f to the fuel used, a total saving per machin	
Assumptions	Actual fuel savings arising from the use of systems on farm equipment. This includes processes (i.e., tillage, planting, spraying a which were equally weighted. An average s processes of 6.315% was used.	
	Average fuel consumption for wheat cultiv This figure was used as representative of f for all agricultural machinery.	
	Emission factor for fuel used is 2.299 kgCO	
Category	Connected Agriculture	
Sub-category	Crop management	
Mechanism	Better use of resources (human, fuel and v increase in productivity can lead to increas reduced wastage. It can also lead to a redu required as it can be allocated to the appro well as reduced irrigation (e.g., plants twe need to be watered.)	
Methodology	Fertiliser reduction: estimation based on t fertiliser used per farm per year, and the c emission factor of fertilisers used. Previou estimation on the reduction of fertiliser us mobile enabled soil and water sensors.	
Assumptions	Smart technology can reduce expenditure inputs by 40% per hectare. This figure was assuming that a reduction in expenditure i equivalent to a reduction in product quanti	
	Smart technology has led to improvements efficiency in Germany between 10-15%.	

Appendix 4: References for data sources and assumptions

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Rebound effects and uncertainty

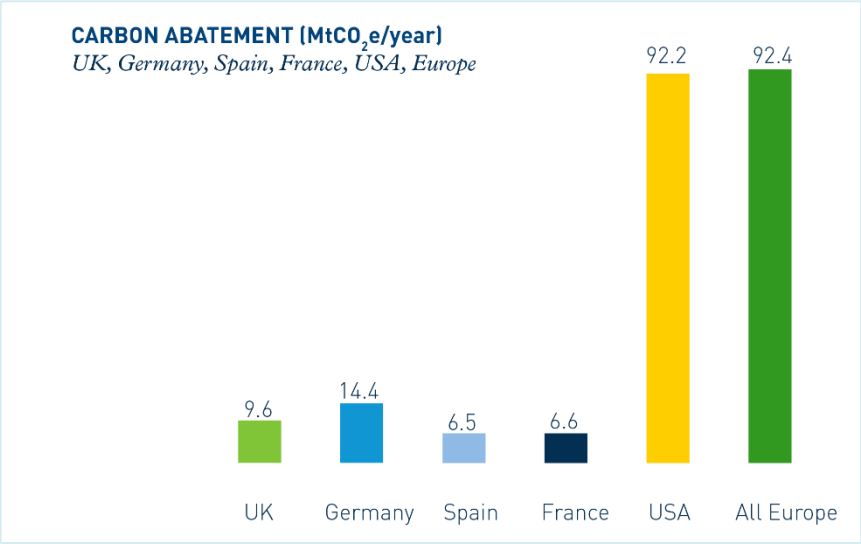
Rebound effects

- Generally difficult to quantify, and thus not calculated
- Additional activities resulting from the mechanism
  - Examples:
  - Working from home – energy to heat the home
  - Smart parking – additional car journeys into cities
  - Friends and family calls – encourage additional visits
  - Mobile shopping – home delivery emissions, increase in shopping activity
- Reallocation of resources
  - E.g. money from household energy saving spent on additional travel for holidays

Uncertainty

- Results are highly dependent on saving factors and other assumptions
- Conservative factors selected if there was a range of factors to choose from

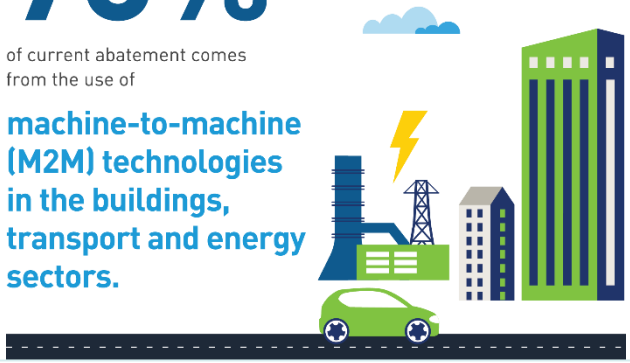
Results

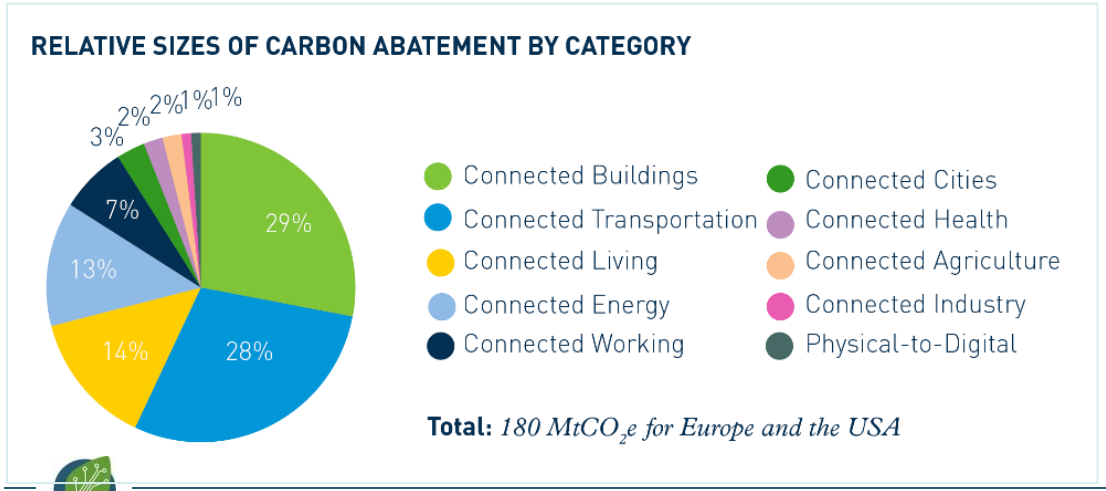


70%

of current abatement comes from the use of

machine-to-machine (M2M) technologies in the buildings, transport and energy sectors.





20%

of current abatement comes from the use of

mobile devices to enable behavioural changes in lifestyle and working patterns.

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Connected Agriculture

(2% of total)

- **Enhanced agricultural equipment logistics:** *more efficient operational use of farm machinery such as tractors, harvesters and compactors results in a reduction in fuel use through automatic machine setting, autonomous guidance, steering systems and telemetry.*
- **Improved crop management:** *providing information to farmers, controlling irrigation remotely and monitoring soil conditions to allow for less use of fertiliser, which can result in an overall increase in productivity and yields alongside reduced wastage.*

CARBON EMISSIONS FROM CONNECTED AGRICULTURE ABATEMENT[16] (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Agriculture	**53,000**	**125,000**	**28,000**	**170,000**	**2,125,000**	**1,043,000**
Agricultural equipment logistics	5,000	12,000	7,000	22,000	235,000	121,000
Crop management	48,000	113,000	21,000	149,000	1,890,000	923,000

Connected Buildings (1/2)

(29% of total)

Connected Buildings

- **Advanced building energy management systems:** *automated energy management systems using smart meters, which track energy use and provide information that allows optimised use of electricity and heating, resulting in energy savings.*
- **Improved HVAC (heating, ventilation and air conditioning) controls:** *more effective monitoring and control of HVAC systems using connected sensors, including automatic response to occupancy levels of areas within buildings, leading to overall reductions in building energy consumption.*
- **Smart meter installation:** *providing greater visibility through detailed monitoring of energy and water use raises awareness of where savings can be achieved, helping to positively encourage energy saving behaviour.*

CARBON EMISSIONS ABATEMENT FROM CONNECTED BUILDINGS (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Buildings	2,916,000	1,148,000	2,120,000	754,000	32,300,000	21,333,000

Connected Buildings (2/2)

(29% of total)

Connected Buildings

CARBON EMISSIONS ABATEMENT FROM CONNECTED BUILDINGS (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Buildings	**2,916,000**	**1,148,000**	**2,120,000**	**754,000**	**32,300,000**	**21,333,000**
Building energy management systems (electricity commercial)	470,000	78,000	1,079,000	19,000	7,716,000	5,347,000
Building energy management systems (gas commercial)	1,001,000	22,000	39,000	22,000	1,421,000	4,281,000
HVAC control - commercial buildings	1,211,000	971,000	670,000	685,000	12,724,000	8,722,000
HVAC control - residential buildings	29,000	31,000	7,000	11,000	395,000	146,000
Smart meters - water commercial	50	250	1,000	230	9,000	6,000
Smart meters - water residential	30	80	470	110	9,000	2,000
Smart meters (electricity residential)	109,000	44,000	318,000	15,000	9,849,000	2,557,000
Smart meters (gas residential)	95,000	2,000	5,000	2,000	175,000	273,000

Connected Cities (1/2)

(3% of total)

Connected Cities

- **Parking space monitoring:** *tracking car parking space availability can provide information or feedback to vehicles helping to route them towards available spaces, which saves fuel use from driving around looking for spaces.*
- **On-demand refuse connection (smart bins):** *using smart bins that are able to report when they are in need of emptying can help to make refuse collection more efficient, allowing for the optimisation of routes used and avoiding fuel use from unnecessary collections.*
- **Intelligent street lighting:** *energy demand for street lighting is being reduced thanks to new lamps that contain sensors and can be controlled remotely in order to switch off or dim lighting when it is not required, saving electricity use.*
- **Smart traffic management:** *with remote monitoring of traffic conditions, mobile technology can be used to dynamically change road signs or traffic signals in order to avoid congestion or curb excessive speed, give preference to public transportation, or to enforce a congestion charging policy, helping to avoid additional fuel use from vehicles.*

CARBON EMISSIONS ABATEMENT FROM CONNECTED CITIES[21] (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Cities	435,000	498,000	226,000	383,000	1,990,000	3,018,000

Connected Cities (2/2)

(3% of total)

Connected Cities

CARBON EMISSIONS ABATEMENT FROM CONNECTED CITIES[21] (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Cities	**435,000**	**498,000**	**226,000**	**383,000**	**1,990,000**	**3,018,000**
Parking space monitoring	9,000	12,000	6,000	12,000	260,000	74,000
Smart bins	20	20	10	10	70	100
Street lighting	108,000	42,000	8,000	5,000	31,000	202,000
Traffic congestion management	38,000	61,000	40,000	45,000	212,000	403,000
Traffic congestion monitoring (road signs)	149,000	204,000	92,000	170,000	372,000	1,281,000
Traffic congestion monitoring (traffic lights)	131,000	179,000	81,000	150,000	1,116,000	1,057,000

Connected Energy (1/2)

(13% of total)

- **Electric vehicle infrastructure:** *mobile has an important role to play in supporting the use of electric vehicles, enabling charging point connection to electricity grids, and helping to facilitate the transition to low carbon transportation.*
- **Connection of decentralised energy generation (microgeneration):** *enabling low carbon microgeneration of energy by individuals and businesses to be exported to the grid by communicating capacity and pricing, as well as facilitating payment. Technologies assessed include combined heat and power (CHP), solar photovoltaics and wind turbines.*
- **Managed smart grids:** *by monitoring the distribution of an electricity or gas network, utilities can identify points of loss and improve efficiency.*

CARBON EMISSIONS ABATEMENT FROM CONNECTED ENERGY (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Energy	1,536,000	5,255,000	939,000	221,000	9,265,000	15,523,000

Connected Energy (2/2)

(13% of total)

Connected Energy

CARBON EMISSIONS ABATEMENT FROM CONNECTED ENERGY (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Energy	**1,536,000**	**5,255,000**	**939,000**	**221,000**	**9,265,000**	**15,523,000**
Electric vehicle connection	840	1,000	650	3,000	1,000	11,000
Micro-generation (CHP business)	40	80	9	5	180	180
Micro-generation (CHP residential)	7	10	2	1	50	40
Micro-generation (solar business)	458,000	3,340,000	517,000	125,000	1,817,000	8,711,000
Micro-generation (solar residential)	426,000	1,441,000	210,000	51,000	747,000	3,797,000
Micro-generation (wind business)	470,000	286,000	82,000	6,000	3,623,000	1,445,000
Micro-generation (wind residential)	58,000	45,000	8,000	990	347,000	165,000
Smart Grids - electric network management	98,000	114,000	102,000	19,000	2,434,000	1,117,000
Smart Grids - gas network management	25,000	28,000	19,000	15,000	296,000	277,000

Connected Health
(2% of total)

- **Smart home care:** *monitoring chronic or high risk patients at home with mobile technology can avoid repeated car journeys to hospital by the patient, or by health professionals to the patient's home, as well as provide better pre-emptive medical intervention to reduce the total number of days spent in hospital.*

- **Connected out of hospital care:** *remote monitoring and assisted living for patients out of hospital (compared to no remote monitoring) helps to reduce the number of days needed to be spent by patients in hospital and can help to avoid additional journeys and reduce resource consumption per patient.*

CARBON EMISSIONS ABATEMENT FROM CONNECTED HEALTH (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Health	**47,000**	**89,000**	**29,000**	**51,000**	**3,540,000**	**406,000**
Smart Health - home care	43,000	82,000	26,000	46,000	3,361,000	372,000
Smart Health - out of hospital care	4,000	7,000	3,000	4,000	179,000	33,000

Connected Industry (1/2)

(1% of total)

- **Automating industrial processes:** *the use of M2M connections helps to improve the efficiency and productivity of industrial processes, helping to reduce energy consumption.*
- **Field force automation:** *improved connectivity helps to increase productivity and reduce travel by mobile work teams, reducing overall vehicle fuel use.*
- **Improved supply chain and inventory management:** *mobile can be used to monitor goods and equipment helping to improve efficiency in logistics and reduce wastage, particularly for perishable goods. This includes connected vending machines that can be remotely monitored, improving the logistics for restocking.*
- **Enabling cashless payment (point of sale):** *mobile is used to facilitate payment at point of sale, helping the economy to use less physical cash and to avoid fuel use from its production and transportation.*
- **Enhanced detection of inefficiency (water grid):** *sensors can help to identify areas of loss and enable rapid repairs, preventing unnecessary resource use, for example where utilities are able to use mobile to detect leaks in the water grid.*[25]

CARBON EMISSIONS ABATEMENT FROM CONNECTED ENERGY (tCO_2e/year)

CARBON EMISSIONS ABATEMENT FROM CONNECTED INDUSTRY (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Industry	88,000	196,000	65,000	32,000	1,837,000	808,000

Connected Industry (2/2)

(1% of total)

Connected Industry

CARBON EMISSIONS ABATEMENT FROM CONNECTED INDUSTRY (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Industry	**88,000**	**196,000**	**65,000**	**32,000**	**1,837,000**	**808,000**
Automation in industrial processes	37,000	92,000	20,000	7,000	324,000	319,000
Field force automation	5,000	5,000	5,000	7,000	101,000	30,000
Supply chain management	4,000	5,000	3,000	4,000	23,000	44,000
Inventory management	37,000	85,000	32,000	8,000	1,309,000	364,000
Vending machines	6,000	9,000	5,000	6,000	79,000	47,000
Point of sale	290	170	270	310	2,000	3,000
Water grid - leak detection	1	10	3	3	50	40

Connected Living (1/2)

(14% of total)

- **Enabling the sharing economy:** *mobile apps are helping to overcome barriers which were preventing direct peer-to-peer sharing or exchange, for example by renting goods, finding new owners for unwanted goods, sharing car journeys or offering unused space for accommodation.*
- **Keeping in touch virtually (friends and family):** *the use of mobile devices to connect with family and friends through voice and video calling can help to reduce the frequency of travel to visit them, avoiding the associated transportation emissions.*
- **Remote access to goods and services (mobile banking and shopping):** *mobile access can avoid journeys to retail locations in order to shop for goods or access services such as banking.*
- **Smart home control:** *smartphones can be used to remotely operate appliances, heating and cooling within the home, helping to reduce electricity and gas demand.*
- **Improving route planning and eco-driving:** *map or satnav apps on smartphones can be used to plan journeys more efficiently, minimising the distance to travel and avoiding traffic. Similarly, eco-driving apps can minimise fuel use by providing guidance and supporting behaviour change.*

CARBON EMISSIONS ABATEMENT FROM CONNECTED LIVING (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Living	1,259,000	1,412,000	1,079,000	1,163,000	8,889,000	16,123,000

Connected Living (2/2)

(14% of total)

CARBON EMISSIONS ABATEMENT FROM CONNECTED LIVING (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Living	**1,259,000**	**1,412,000**	**1,079,000**	**1,163,000**	**8,889,000**	**16,123,000**
Accommodation sharing	262,000	276,000	274,000	240,000	928,000	3,583,000
Ride sharing	47,000	47,000	39,000	41,000	219,000	586,000
Sharing economy (goods sharing)	96,000	74,000	56,000	64,000	398,000	955,000
Avoiding social journeys (friends & family)	410,000	571,000	459,000	496,000	2,748,000	6,625,000
Mobile banking	178,000	225,000	130,000	184,000	1,733,000	2,067,000
Mobile shopping	37,000	31,000	3,000	12,000	347,000	153,000
Smart homes	104,000	54,000	21,000	19,000	1,562,000	599,000
Use of mobile as a satnav	101,000	116,000	81,000	90,000	848,000	1,304,000
Eco-driving	24,000	19,000	16,000	17,000	108,000	252,000

Connected Transportation (1/2)

(28% of total)

Connected Transportation

- **Enabling smarter logistics:** *mobile technology can optimise multi-modal land and sea fleets so that they operate more efficiently through better routing, avoiding areas of travel, optimising vehicle loads and improving the fuel efficiency of road vehicles.*
  (Includes: Fleet vehicle driver behaviour improvement, Smart Logistics - efficient routing & fleet management, Smart Logistics - loading optimisation, Sea fleet)

- **Reducing the impact of breakdowns:** *mobile technology can optimise multi-modal land and sea fleets so that they operate more efficiently through better routing, avoiding areas of travel, optimising vehicle loads and improving the fuel efficiency of road vehicles.*
  (Includes: Fleet vehicle driver behaviour improvement, Smart Logistics - efficient routing & fleet management, Smart Logistics - loading optimisation, Sea fleet)

- **Changing individual transport choices and driving behaviour:** *mobile connectivity can help individuals to make lower carbon transport decisions in various ways, such as: improved route guidance using satellite navigation; supporting access to on-demand car sharing services through car clubs; helping improve public transport user experience with mobile ticketing and better journey planning; and enabling insurance policies that actively monitor driving to reduce premium costs for safer, more fuel efficient driving.*
  (Includes: Satellite navigation, Car sharing (car clubs), Usability of public transport, Usage based car insurance)

CARBON EMISSIONS ABATEMENT FROM CONNECTED TRANSPORTATION (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Transportation	2,340,000	4,255,000	1,197,000	2,709,000	24,756,000	26,173,000

Connected Transportation (2/2)

(28% of total)

CARBON EMISSIONS ABATEMENT FROM CONNECTED TRANSPORTATION (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Transportation	**2,340,000**	**4,255,000**	**1,197,000**	**2,709,000**	**24,756,000**	**26,173,000**
Fleet vehicle driver behaviour improvement	803,000	1,060,000	203,000	1,314,000	10,059,000	5,800,000
Smart Logistics - efficient routing & fleet management	293,000	315,000	65,000	495,000	3,259,000	1,973,000
Smart Logistics - loading optimisation	117,000	126,000	26,000	198,000	1,303,000	789,000
Sea fleet	309,000	1,803,000	116,000	109,000	517,000	8,183,000
Remote vehicle condition monitoring	100	150	50	120	990	900
Roadside assistance	20	40	20	30	140	240
Satellite navigation	23,000	23,000	6,000	31,000	27,000	184,000
Car sharing (car clubs)	86,000	309,000	86,000	86,000	341,000	589,000
Usability of public transport	536,000	466,000	567,000	364,000	8,075,000	6,556,000
Usage based car insurance	173,000	154,000	127,000	111,000	1,174,000	2,097,000

Connected Working
(7% of total)

- **Reducing business travel (audio conferencing):** *it is possible to reduce fuel use from business travel with audio and video connectivity through mobile, as well as access to collaborative working software.*
- **Enabling home working:** *improved connectivity helps to increase productivity and reduce travel by mobile work teams, reducing overall vehicle fuel use.*

CARBON EMISSIONS ABATEMENT FROM CONNECTED WORKING (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Connected Working	**810,000**	**1,340,000**	**759,000**	**1,084,000**	**6,714,000**	**7,096,000**
Audio conferencing	207,000	55,000	6,000	66,000	1,680,000	404,000
Working from home	603,000	1,284,000	754,000	1,018,000	5,034,000	6,692,000

Physical-to-Digital
(1% of total)

- **Reducing business travel (audio conferencing):** *it is possible to reduce fuel use from business travel with audio and video connectivity through mobile, as well as access to collaborative working software.*
- **Enabling home working:** *improved connectivity helps to increase productivity and reduce travel by mobile work teams, reducing overall vehicle fuel use.*

CARBON EMISSIONS ABATEMENT FROM PHYSICAL-TO-DIGITAL (tCO_2e/year)

	UK	Germany	Spain	France	USA	Europe
Physical-to-Digital	**90,000**	**109,000**	**72,000**	**63,000**	**743,000**	**891,000**
Multi-functional device	9,000	41,000	66,000	36,000	132,000	556,000
Newspapers, music, DVD, storage.	81,000	68,000	7,000	27,000	611,000	335,000

Conclusions

- **Enabling technology:** *there is a need to invest in innovative or disruptive new technologies that enable better, low-energy access to mobile communications, as well as creating the enabling network infrastructure for connections around the world.*
- **Implementing solutions:** *businesses and governments need to adopt and scale up the mechanisms that are effective in reducing carbon emissions today, as well as exploring novel uses for mobile communications technology that can achieve further reductions.*
- **Policy landscape:** *governments can accelerate progress by supporting common standards and developing appropriate regulatory oversight, as well as advancing deployment by the use of incentives and disincentives, such as support for improved connectivity or putting a strong price on carbon emissions through cap-and-trade schemes and taxes.*
- **Changing behaviour:** *there is a significant opportunity to use mobile to support organisations and individuals by developing simple, useful tools that offer lower carbon options and services.*

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