Chapter 7
Direct and Indirect Effects of Mobile Networks on CO_2 Emissions: A German Case Study

Bernd Sörries

Introduction

During the past years, mobile services have profoundly changed daily life and work. Mobile services are ubiquitously available today. There are more than four billion subscriptions to the networks worldwide. The price of the "mobile success story" is a growing carbon footprint of mobile communication at a time when especially politicians have accepted climate change as a major threat to be addressed by all stakeholders of an economy. Although some studies on the ecological impact of information and communication technologies (ICT) have been published (e.g. Erdmann/Hilty 2010), much of the debate has been centered on its negative energy impact (Masanet/Matthews 2010, 688). Also there are only a few (national) case studies revealing empirical data on the positive and negative environmental impacts related to mobile communication (e.g. Malmodin 2010; Malmodin et al. 2010; Biczók et al. 2011).

This study tries to fill the gap by providing an analysis of the ecological impact of mobile networks in Germany. It raises the following questions: What are the CO_2 emissions of German mobile networks? What are the contributions of wireless technologies/networks and Mobile Network Operators (MNOs) to deal with the daunting climate challenge?

To investigate the ecological impact, one can distinguish between direct and indirect effects on greenhouse gas emissions. The direct impact derives mainly from the electricity use of network components (e.g. base stations). The indirect impact consists of those applications enabled by mobile networks which have the potential to reduce greenhouse gas emissions. Very prominent examples in this sense are "Smart Grids" and "Smart Meters." Smart Grids aim at improving efficiency of

B. Sörries (✉)
Forschungsstelle für Mobiles Internet am ITM, Leonardo Campus 9, 48149, Münster, Germany
e-mail: soerries@uni-muenster.de

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Table 7.1 Areas/applications where ICTs have an enabling functionality

Health	Transport	Utilities/smart grids	Smart work
Remote diagnosis and monitoring	Car navigation	80% of homes to have smart electricity meters by 2020	Teleworking, tele-commuting
Self-diagnosis	Intelligent traffic management	Smart Grids to match energy demand with production	Smart meeting (virtual or telepresence/ meeting/conference
Clinical info system	Road enforcement		Virtual office
Medical records	Container tracking		
	Emergency vehicle notification		

Source: Nagpal (2011)

electricity grids through active monitoring and reducing reliance on centralized electricity production (e.g. Scott 2009). Smart Meters are designed to provide utility customers with real-time information about their energy consumption. Both components of a new energy infrastructure facilitate the share of renewable energy sources in total electricity production and consumption.

In sum, the paper comes to the conclusion that the direct, mainly negative impact of mobile networks on climate change can be compensated by new, innovative applications helping to improve energy efficiency. Mobile technologies therefore can be a vital tool to tackle climate change.

Information and Communication Technologies and Greenhouse Gas Emissions

Growing and fast developing ICTs are cross-sectional technologies from which substantial contributions to national programs are expected to reduce greenhouse gas emissions (Bundesregierung 2002). First, ICTs help to spread information about climate change. That applies in particular to mobile services that are available almost anywhere and anytime in the world. In the second place supporters of ICTs refer to new applications which can for example substitute travel, or reduce energy consumption or material demand (e.g. Hilty et al. 2006). In that respect ICTs support the reduction of carbon dioxide (CO_2). Whether ICTs at large and wireless technologies in particular have positive or negative environmental impacts depends on the interdependency of the following effects (e. g. Erdmann/Hilty 2010, 825):

1. Direct effect (or first order effect): The production and the use of ICT components cause greenhouse gas emissions. In 2009 OECD estimated the ICT's own carbon footprint to be 2% of the total CO_2 emissions (OECD 2009, 5). Thus, the assessment of the direct impact of mobile networks requires the analysis of the lifecycle of hardware used in the networks.

2. Enabling effect (or second order effect): ICTs are constantly being reinvented and improved. Innovation in ICT enables a variety of new applications making processes in organizations or daily life more efficient and interrelated (e.g. Picot/Schmid 2009). As a consequence those applications may stop the waste of resources and therefore reduce greenhouse gas emissions. In this respect ICTs in general and mobile networks in particular enable solutions contributing to a more sustainable growth. However, it has taken into account that gains of efficiency might be used for new business opportunities which in turn produce new greenhouse gas emissions.
3. Systemic effect (or third-order effect): This third-order effect is linked to the above mentioned enabling functionality of ICTs. In the event that mobile-enabled applications are widely accepted and used, they have the potential to influence customs of users or the way organizations structure their procedures. An example of the systemic effect can be seen in the growing portion of households being disconnected to fixed line networks. Here users prefer personalized mobile communication systems.

How some of these effects materialize with regard to mobile networks is explained in the following sections.

Electricity Consumption of Mobile Networks: The Direct Environmental Impact

Global Impact of Mobile Networks

To estimate the carbon footprint of mobile networks, one has to analyze the different phases of their lifecycle (e.g. Malmodin et al. 2010). Of particular importance are manufacturing, distribution, and use of products required in a mobile network. The CO_2 emissions depend on both the penetration of products and the use of them. Whereas the demand for “mobile voice” determined the size of the networks in the early phase of mobile communication, mobile data services are now the key input parameter for network planning. The volume of mobile data has grown exponentially in the last years (for Germany see Bundesnetzagentur 2011a, 90) and there is no doubt that this development will last in the years to come (Cisco 2012). It is forecasted that mobile networks will carry 17% of total IP-traffic in 2020 (Biczók et al. 2011, 8). In light of this development MNOs are constantly compelled to extend their infrastructures. As a result, the direct environmental impact becomes grave. Biczók et al. (2011, 6) predicted in their study that in view of the increasing demand for mobile data services the mobile ecosystem will cause 0.4% of the global CO_2 emissions in 2020, which means two times more than in 2007.

Due to a lack of empirical data required for a complete lifecycle assessment of mobile communication in Germany, the case study focused merely on one but critical phase of the lifecycle: the operation of the networks. In this phase approximately 40% of the total carbon footprint of mobile communication including mobile devices manufacturing as well as data centers and activities of MNOs are produced (Biczók et al. 2011, 12).

Electricity Use and Carbon Footprint of Mobile Networks in Germany

Status of Mobile Networks in Germany

In Germany the four mobile networks are being operated by Telekom Deutschland (formerly T-Mobile), Vodafone, E-Plus, and Telefonica (formerly O_2). The MNOs have deployed up to three different wireless access technologies: GSM (Global System for Mobile Communications), UMTS (Universal Mobile Telecommunications System), and LTE (Long Term Evolution).

The spine of the wireless infrastructure is still GSM, which the operators started with in the early 1990s. GSM primarily serves the mobile telephone system. The networks cover almost 100% of the country (indoor and outdoor). After the auctioning of UMTS licenses in 2000, the MNOs started deploying their second radio access technology which in comparison to GSM does not cover the whole country. According to the German regulatory authority (Bundesnetzagentur), between 65 and 80% of the population nowadays has access to the UMTS networks. In terms of nationwide coverage that means up to 53% in the first quarter of 2011 (Bundesnetzagentur 2011b, 56). Even though the average revenue per customer is constantly decreasing, cost pressure remains high (e.g. Büllingen et al. 2010, 5ff), three of four MNOs started deploying the third radio access infrastructure: LTE. This technology provides higher bandwidth and lower costs per megabit. The rollout started at the end of 2010.

Electricity Consumption in the Access Networks

A mobile network is comprised of a large scale of different components. By far, mobile base stations (share of 97% on total equipment in GSM) predominate over other hardware like mobile switching centers (0.8%) or base station controllers (2.2%) (Mohr et al. 2009, 12). In order to estimate the electricity use of the total networks, the exact number of the components and their power drain must be known. There are some studies available dealing with those figures (Fraunhofer-Institut 2009; Mohr et al. 2009). However, some of their assumptions are rough and unproven. For the purpose of the study, data from the SMART 2020 study (GESI 2009) and from a German MNO were taken.

The main driver of energy consumption is the number of base stations deployed. The base stations account for 85–90% of total electricity use in a mobile network (e.g. GESI 2009, 25).[1]

Assessing the number of base stations is not an easy task. The German regulatory authority provided some figures. But the released figures are not consistent. According to the annual report of 2010, the mobile operators ran 110,000 base stations (Bundesnetzagentur 2011a, 90). Another statistic counted 126,000 (Bundesnetzagentur 2011b, 56). The EMF database which shows the number of sites with one or more base stations per site revealed 161,897 base stations (status March 2011).

In order to validate the different figures it is worthwhile to take some data provided by the operators themselves. Unfortunately, only two MNOs made the number of base station public. According to the mother company of E-Plus (KPN 2011a, 23), E-Plus had 26,680 base stations in its network at the end of 2010 (19.005 for GSM, 7.675 for UMTS). Telefonica published on its website the number of 27,000 base stations for the same period (17,000 for GSM, 10,000 for UMTS). Telekom Deutschland and Vodafone have not made figures publically available, therefore estimations are necessary.

If one uses the first figure of the regulator (110,000) as a starting point, Telekom Deutschland and Vodafone would have 28,160 base stations each, provided both operators have an equal amount of hardware in their networks. This figure does not really look reliable because of historical circumstances (time of market entry, frequencies assigned) and differences in quality of service among the MNOs (e.g. Gerpott 2008). One can fairly expect that the market leaders Telekom Deutschland and Vodafone must have deployed more base stations than their competitors.

If one takes 161,897 as the baseline for the calculation, the outcome is not reliable either. In this scenario Telekom Deutschland and Vodafone would have had more than 54,000 base stations, two times more than the other mobile operators. Although there are differences in quality of service and network coverage, the number of 54,000 base stations appears too high. This assumption is backed by the outcome of cost-based regulation of mobile termination charges. Hereby, in a simplified view, the regulated charges are output variables of the network investments (mainly in base stations) of each MNO and its volume of voice traffic. For several years, the mobile termination charges have been subject of regulation. Due to the assignment of different frequencies (900 and 1,800 MHz) and different times of market entry,[2] there was a spread between the termination rates of Telekom Deutschland and Vodafone on one side and the followers E-Plus and Telefonica on the other side. However, since 2006 the spread has become smaller. Currently the regulated wholesale rates for all four mobile operators are more or less equal (Coppik/Herrmann 2011). Given that E-Plus' and Telekom Deutschland's shares of voice traffic differed only by 1% point in 2009

[1] The first figure, 85%, was measured by the MNO.

[2] Telekom Deutschland and Vodafone launched their services in 1992. E-Plus entered the market in 1994. Telefonica completed the picture in 1998.

(Sörries 2010, 69), an almost equal termination rate indicates that a distinction in the number of base stations by the factor two is not realistic.

To get a valid estimation of base stations operated by all MNOs one can however refer to cost-based regulation of mobile termination rates in Germany. In 2006 a model was developed to determine the number of base stations an efficient MNO had to operate to handle a certain amount of voice traffic (Brinkmann et al. 2006). The model calculated 15,069 base stations for an operator with a market share of 13% (E-Plus market share in 2006) and 20,304 base stations for an operator with a market share of about 38% (like Telekom Deutschland). These figures corresponded to the available public data at that time. Provided the MNOs invested in line with their networks, the current number of base stations for Telekom Deutschland and Vodafone can be calculated. According to this model, both operators ran approximately 35,948 base stations each in 2010. That leads to the sum of 125,576 base stations in 2010. Therefore the last figure of the regulator—126,000—seems to be valid.

The electricity use of 126,000 base stations can be calculated as follows: according to the empirical data of an MNO, a GSM base station consumes on average 12,000 kWh per annum. Therefore it has a power consumption of 1,370 W. The Fraunhofer-Institute referred in its study to a power consumption of 1,727 W (Fraunhofer-Institut 2009, 150). An additional UMTS base station at the same site increases the electricity consumption by 7,000 kWh/a. A combined GSM/UMTS site therefore consumes 19,000 kWh/a.

Provided that the share of UMTS base stations at Telekom Deutschland and Vodafone corresponds to the average of 40% of the total base stations (Bundesnetzagentur 2011a, 90), there were 46,322 UMTS base stations in Germany in 2010. Before the model can be fed with these data, one additional assumption must be made: UMTS base stations are usually deployed at GSM sites. As a result, the total electricity consumption of all base stations is approximately 1.28 TWh/a. With the figure of the SMART 2020 study, whereby the radio access network has a share of 90% of the total network, the total electricity use of the mobile networks in Germany is approximately 1.42 TWh/a. Using 85% as the relevant figure for the electricity consumption of base stations, the corresponding figure is 1.50 TWh/a; converted into subscriber or sold SIM card that means approximately 13 kWh/SIM card.

Against the background of the electricity consumption of the mobile networks, one can calculate the carbon footprint. Applying 0.61 kg-CO_2/kWh the mobile networks have a direct environmental effect of about 863,995 t CO_2 to 914,818 t CO_2. Once again, converted into sold SIM cards, mobile networks stood for 8 kg CO_2/SIM card.

Options to Reduce CO_2 Emissions

Relevance of the Regulatory Framework

Before technical aspects to reduce electricity consumption are analyzed, it is worthwhile to mention that the regulatory framework can also contribute to a more climate friendly mobile infrastructure.

The MNOs are constantly facing a growing demand for mobile data services. To cope with the demand, they have to increase their network capacities. An increase in capacity can either be done by additional sites and base stations or by the use of new frequencies. In the latter case, no additional sites and equipment are needed.

In light of the increasing demand and due to "free" spectrum, the German regulatory authority auctioned new frequencies in 2010. The amount of spectrum (360 MHz) sold in the auction was bigger than the spectrum assigned to MNOs prior to the auction. With the new spectrum, the MNOs are not forced to look for new sites in a mid-term perspective. That helps to reduce costs and greenhouse gas emissions. In the event that further frequencies are desperately needed, and some MNOs have already claimed that in public,[3] the regulator should take into account that the energy balance of frequencies below 1 GHz is better than the energy balance of frequencies above 1 GHz. The reason for the difference in balance rests with the propagation characteristics of frequencies. They differ significantly (see Vodafone 2006).

Relevance of Competitive Strategies

The MNOs pursue different corporate strategies to assure competitive advantages in the retail and wholesale markets. With Porter (1985) three generic strategies can be distinguished: cost leadership, differentiation, and focus strategies. Especially those MNOs who first entered the market in the 1990s focused primarily on differentiation. The quality of the network was here the key parameter to attract customers and gain market share. As a consequence, these MNOs have always invested heavily and to an early point in time in new infrastructure. This is done irrespective of the fact that either hardware is premature or the number of available handsets is very limited. The early introduction of new radio access infrastructure promises first mover advantages and therefore aims at upgrading the brands of the MNOs and locks in customers who are in favor of new technologies. The introduction of UMTS in the German market provides a good example for the ambiguity of this type of strategy. The market leaders tried to outperform their competitors by offering new UMTS services as soon as possible and to a larger extent.[4] Still in terms of UMTS coverage, there are differences among the MNOs. The first mover, however, had to make the experience that the lifetime of the first deployed network hardware was considerably shorter than it was with hardware delivered at a later stage. Furthermore, it took years before UMTS flourished (Sörries 2010, 39). Therefore the (environmental) price of being the first in the market was to waste more resources.

Does the same development occur with the current roll-out of LTE once again? The answer is twofold. First, some of the frequencies[5] which are being used for LTE

[3] News on www.teltarif.de (dated 21.1.2012).

[4] T-Mobile launched UMTS services in January 2004. Vodafone followed 1 month later. E-Plus and Telefonica launched their services during summer 2004.

[5] In the 800 MHz band.

services have been assigned with tight coverage obligations. The MNOs must first provide access to LTE networks in communes with no or less developed broadband infrastructure. In doing so, the MNOs support the government's target to close the digital gap between urban and rural areas. In that regard, LTE provides a positive effect on societal welfare. Secondly, the positive effect of the LTE roll-out is constrained to some extend by the fact that until now only a few LTE handsets (including sticks for laptop use) are available. Therefore it is not unreasonable to state that those MNOs pursuing the strategy to be as fast as possible, ready to offer new services, want primarily to improve their brand in the first phase of the technology lifecycle. They try to maintain or increase the loyalty of those customers who have a strong interest in using the most advanced technologies. As a consequence, in the first phase of the LTE lifecycle only a small portion of customers make use of the new infrastructure. With respect to more sustainability in the sector, this kind of strategy can be criticized because it tends to waste resources.

If MNOs adopt a cost leadership strategy, they are forced to wait until the hardware for new technologies is more advanced, cheaper, and the retail products for the mass market are available. This strategy fits better with programs to reduce the consumption of raw materials and greenhouse gas emissions. However, the follower applying a cost leadership strategy needs a first mover in the market who is willing to pave the way for new technologies.

Technical Measures to Reduce Consumption of Electricity

From a technical point of view, there are a variety of options to reduce the consumption of electricity in the mobile networks. The cooling of network components can be subject of technical measures as well as the optimized transmitting of signals (e.g. Mohr et al. 2009). A pilot with innovative cooling systems exhibited that with such an innovation, the use of electricity can be reduced by around 90%.[6] Furthermore, E-Plus is currently conducting a pilot with a base station using only renewable energy sources (sun, wind, regenerative fuel cells). In such a system, the operation of the base station does not issue any carbon dioxide at all. Due to the potential of such a technology, it should be discussed whether and how through policy frameworks the government could incentivize such innovation and action. This pilot shows how MNOs may facilitate a more sustainable development in the mobile market.

Besides technology-driven improvements, the MNOs regularly renew their network equipment. Older, less efficient base stations are replaced by newer, more efficient base stations. With these activities the MNOs have saved some million kWh in the last years (e.g. Vodafone 2009). The new infrastructure has helped the MNOs to bring energy consumption and operational costs down.

[6] Press release of Ventfair dated of 18.05.2011.

The network-related activities of the MNOs are completed by the goal to increase the share of renewable energies on the total energy consumption. Currently, the share is between 30 and 60% (see Telefónica 2010, 20 ff; KPN 2011b, 10; Vodafone 2009, 29; Deutsche Telekom 2011, 29).[7]

The Enabling and Systemic Effect: Mobile Enabled Application

Although the mobile telephone system still prevails over all other mobile services, it is obvious that mobile data applications used across all sectors of the economy have become more popular. Mobile data applications can be found in the health, transport/logistic, and energy sector to name only a few. At the sixth IT-Summit of the Federal Government and the German ICT sector, the ICT's transformational role in the innovation and redesign of business models was widely acknowledged.[8] It is expected that with innovative mobile business solutions and Machine-to-Machine applications, wireless technologies may be a driver of structural changes across the economy.

Some of the new applications have the potential to support the political targeted decline in greenhouse gas emissions of about 20% by 2020 in the European Union. A study released by Accenture and Vodafone (2009) draw the conclusion that through the use of mobile-enabled applications approximately 113 Mt CO_2e in 2020 could be saved in the EU. Among others, applications like Smart Grids in the energy sector and Smart Logistics are identified to deliver a major contribution to this saving of carbon dioxide. These areas of applications are analyzed in more detail in the next section of the chapter.

Wireless Technologies and Smart Grids

Renewable energy sources characterized by a volatility of production, the decentralized input of renewable energy as well as the targeted self-regulation of customer's energy consumption make substantial, structural changes in the energy infrastructure inevitable. To secure a stable energy supply, the current energy networks must be updated with ICTs making remote control of the local networks feasible (e.g. Wissner 2009). These "intelligent energy networks" or "Smart Grids" could provide the following function: "Smart Grids can manage direct interaction and communication among consumers, households or companies, other grid users and energy suppliers" (European Commission 2011, 2). But Smart Grids alone will not be in the position to manage the challenges. Smart Grids can fulfill the Commission's

[7] Without RECS certificates. With RECS certificates Deutsche Telekom consumes to 100% "green energy."

[8] See press release to the sixth IT-summit in December 2011, www.it-gipfel.de.

broad expectation only if the way how metering in the households and companies is done changes. Today, standard electricity meters that are deployed in households lack the required feedback capabilities that are necessary to (1) balance supply and demand of energy, (2) increase energy awareness of customers, and (3) influence customers' behavior. Smart Meters consisting of a communication interface turn customers from passive into an active mode in the energy market. Knowing the consumption is the first step to adjust consumption patterns. Therefore, the Smart Meter could be seen as the nucleus of new market places for energy and as an integral part of the new network infrastructure.

The Smart Meter is legally promoted by European law. According to the directive 2009/72/EC, Member States shall ensure the implementation of intelligent metering systems assisting the active participation of consumers in the electricity supply market. The implementation of those metering systems may be subject to an economic assessment of all the long-term costs and benefits to the market and the individual consumer. The assessment should further answer questions like which form of intelligent metering is economically reasonable and cost-effective and which timeframe is feasible for their distribution. Where roll-out of Smart Meters is assessed positively, at least 80% of consumers shall be equipped with a Smart Meter. Some Member States have already taken the decision to even go beyond this threshold. In the UK for example all "old" meters in households will be replaced by 2020 (Kearney 2010). In Germany the roll-out is subject to the above mentioned economic assessment. It must be finalized until Sept.3, 2012 (Annex 1 Directive 2009/72/EC). However, since 2011 the federal law rules that households and undertakings with an electricity consumption of more than 6,000 kWh/a shall be equipped with a Smart Meter (§ 21c EnWG). Whether this threshold will stand in the future remains unclear. Some pilots conducted in Germany suggest that even for households with less than 6,000 kWh, the Smart Meter could reduce electricity consumption of about 5–15% (e.g. Bundesnetzagentur 2010). Furthermore, the economic assessments already carried out in other Member States recommended nationwide installments of Smart Meters (e.g. PWC 2010). Although questions still arise how the new system should look like, what kind of functions Smart Grids and Smart Meters should have (e.g. Appelrath et al. 2012), what the role of regulation should be, and whether consumers are going to embrace the new infrastructure, it appears that in Germany Smart Meters and Smart Grids will characterize the new energy infrastructure at least in the mid-term perspective. If nevertheless that is not the case one can hardly imagine how the share of "green energy" in total energy consumption can be increased.[9]

To make Smart Grids and Smart Meters work, Machine-to-Machine communication can be used. In theory almost all existing telecommunication technologies and public networks are equipped to support utilities to install the new infrastructure. Due to the nationwide availability and comparable low costs wireless technologies

[9] Essential prerequisites for a successful installment of Smart Grids and Smart Meters are specifications with regard to data protection and data security.

are very often chosen to run pilots in Germany, In that sense, the utilities pursue a very pragmatic way to test Smart Grids and Smart Meters.[10] That applies primarily for GSM and CDMA. One can expect that due to availability, costs and reliability wireless technologies (e.g. GSM, LTE, CDMA) remain attractive for Smart Grids in the future. Also interest groups of the energy sector show interest in getting exclusive spectrum assignment for Smart Grid purposes (e.g., Kilbourne/Bender 2010). It is therefore not far-fetched to say that mobile networks are going to play out their enabling functionality in the energy market to a greater extent in the future.

In order to estimate the enabling effect of mobile networks in Germany, one can assume that on average households with a Smart Meter reduce electricity use by about 5%. Complying with the law, experts estimate that 15% of all households (44 millions) must get a Smart Meter. Since the average electricity consumption of these households is not publically known, the calculation is fed with the lowest level, 6,000 kWh/a. As a result, Smart Grids together with Smart Meters scale down electricity consumption by 1.98 TWh/a. This saving of electricity is reduced by the electricity consumption of the used Smart Meters. Here it is estimated that a Smart Meter consumes 1,576 kWh/a (PWC 2010, 31). Therefore the new infrastructure decreases electricity consumption of about 1.86 TWh/a. Provided that only 50% of the Smart Meters communicate wirelessly, mobile networks could help reduce CO_2 emission of about 572,175 t per annum (0.9 TW-h/a × 0.61 kg/CO_2). In the event that Germany goes for the 80% threshold laid down in the respective EC directive, the total CO_2 emissions of the mobile networks can be compensated by Smart Grids and Smart Meters.

Furthermore some pilots show that consumers with a Smart Meter tend to adjust their electricity consumption to the level of supply. If green energy is scarce, they postpone energy use, wherever they can. Herewith, the new application shows the systemic effect of ICTs.

Mobile Networks and Logistics

Transport and logistics stand for approximately 23 of total global CO_2 emissions.[11] To combat climate change, this sector must provide substantial reductions in greenhouse gas emissions. Because mobility plays an important role in the sector, mobile-enabled applications might facilitate the development of more climate friendly transports and logistics. The variety of areas where mobile applications improve efficiency in processes or organizations is great. For example centralized tracking systems feed data to a fleet management system which aims to optimize speed and

[10] With regard to a Smart Meter, no wiring in households is needed if wireless technologies are chosen.

[11] See http://www.ipcc-wg3.de/publications/assessment-reports/ar4/working-group-iii-fourth-assessment-report.

routing. With a loading optimization system, a monitoring of the loading is possible and thus it is easier to make use of spare capacity. Other applications can be used with regard to onboard telematics and remote supply control (e.g., GESI 2009, 40). Even without highly sophisticated (future) applications, the use of mobile telephone systems and text messages helped to avoid CO_2 emissions. These basic services made the management of vehicles more efficient because unloaded drives could be reduced. Hence, either the use of fuel was reduced or the loading was optimized. A study conducted in 2006 revealed that mobile networks had saved 137,000 t CO_2 emission in the German transport branch in 2005 (Gerlach et al. 2006, 56). The authors of the study expected that in 2020 this amount will increase up to 270,000 t CO_2. Therefore, mobile networks have already enabled undertakings in transport and logistics to bring emissions down. One can expect that this positive effect will apply in the future as well.

Summary and Outlook

ICTs and wireless networks can be seen as vital tools to gain both more efficiency in processes and organizations and more innovations across the economy. They enable new applications which lead to a more efficient use of energy. These new applications have the potential to contribute to a more sustainable growth of the economy. This development should be further promoted. Smart Grids, Smart Meters as well as Smart Logistics or applications in the health sector are areas where wireless technologies can be used to accelerate the required structural changes. Here, more transparency about the benefits of mobile applications is needed to avoid market entry barriers.

This study gives some empirical evidence that the reduction of CO_2 emissions is ranked very highly on the agenda of all mobile operators in Germany. Their activities are to a certain degree related to the transformational role ICT can play across the economy. Furthermore, the source of their activities is due to cost saving potentials which can be reached with more efficient networks. Since competition in the retail markets is fierce, all MNOs strengthen their activities to reduce operational expenditures. Future policy towards a more sustainable growth should follow this line. For example it should be discussed whether it is necessary to deploy the new access infrastructure LTE four times in Germany. New ways of cooperation (infrastructure sharing, shared use of frequencies in rural areas), of course along the provisions of the antitrust law, should be investigated. That could help to decrease costs and confine CO_2 emissions. Last, but not least, the influence of the regulatory framework on CO_2 emissions should not be denied.

Although the increase in traffic volume leads to an enlargement of the infrastructure, mobile networks together with new data-based applications are less of a problem with regard to policies aimed at tackling climate change.

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