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From Workplace to Anyplace

Assessing the global opportunities to reduce greenhouse gas emissions with virtual meetings and telecommuting

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Preface

All too often the discussion about reduction of greenhouse gases is caught in an old dichotomy where increased quality of life is presented as if it is in conflict with the need to move away from a dependency on fossil fuel. Today new and innovative solutions exist that can both provide a better quality of life and contribute to dramatically reduced emissions. These solutions are particularly important but also challenging when approaching the climate challenge from a global perspective, because the need to help billions of people move quickly out of poverty and the need to provide solutions that can help people in the developed world to reduce their ecological footprint must be supported at the same time.

Two of the most interesting and innovative climate solutions that can contribute to a higher quality of life and decreased ecological footprint are virtual meetings and telecommuting. Lately these solutions have begun to be used on a wider scale, but the potential is enormous and has not yet been recognized, as this report shows. Increasing virtual meetings and telecommuting today could, without any dramatic measures, help to save more than 3 billion tons of CO_2 emissions in a few decades; this is equivalent to approximately half of the current US CO_2 emissions. The key to tap into the real potential lies in collaboration between governments and business, as well as collaboration between OECD and emerging economies such as China and India. Hopefully this report can help inspire concrete actions, as there is no reason to wait before we embark on an innovative low-carbon development path – a path that embraces innovation, equity, and leadership. This report shows that we can do it if we want to. Now is the time for action.

Dennis Pamlin, Global Policy Advisor, WWF Sweden
March 2009

Executive summary

This report focuses on the opportunities to reduce the greenhouse gas (GHG) emissions in work-related contexts, thanks to the deployment of IT solutions that enable one or more individuals to work or collaborate remotely. In particular the report analyzes the potential associated with teleworking and virtual meetings to reduce carbon emissions from daily commuting by car and business air travel, and the conditions under which such potential could be realized. The goal of the report is to gain an understanding of the scale of the opportunities available while identifying the key drivers that may enable or hinder the full achievement of such opportunities. By analyzing different trajectories of possible future developments, this report provides insight into a future in which maximum GHG emission reductions could be achieved.

The premise for the analysis is that IT is best seen as a catalyst that can either be used in ways that reduce our environmental footprint or can be deployed within systems that ultimately result in an increased environmental footprint. Because the policy and economic environment in which IT technology is deployed largely determines its net impact on GHG emissions, this report outlines four scenarios for possible future developments, characterized by different roles and attitudes in policy makers and IT industry (see table below).

The first part of the report provides a background on current trends in teleworking and virtual meetings in key regions around the world. This is followed by the description of four potential "future worlds" that would result in different outcomes for global GHG emissions. The final part of the report discusses the policies and strategies that can be deployed jointly, by policy makers and IT providers and users, to foster the adoption of solutions such as teleworking and virtual meetings and to maximize their benefits in terms of GHG emission reductions.

		IT industry behavior	
Overview of "future worlds"		IT industry and users do not address energy and climate change issues specifically	IT industry and users aggressively pursue and offer climate friendly solutions
Policy domain	Effective climate change policy, including support for low-carbon IT solutions	**Policy world**	**Smart world**
Policy domain	Weak climate change policy, ignoring the role of low-carbon IT	**Carbon world**	**Tech world**

Table 1. Overview of future worlds

Strategic choices of policy makers and enterprises will determine which future world we will live in. The different future worlds analyzed in the report do not represent forecasts of future development; they represent instead a portfolio of options available to the global community.

For each of the possible trajectories, the GHG emissions associated with business air travel and car commuting are estimated quantitatively to contrast and compare different future worlds, and to analyze the reduction in GHG emissions that may be enabled by IT through virtual meetings and telecommuting.

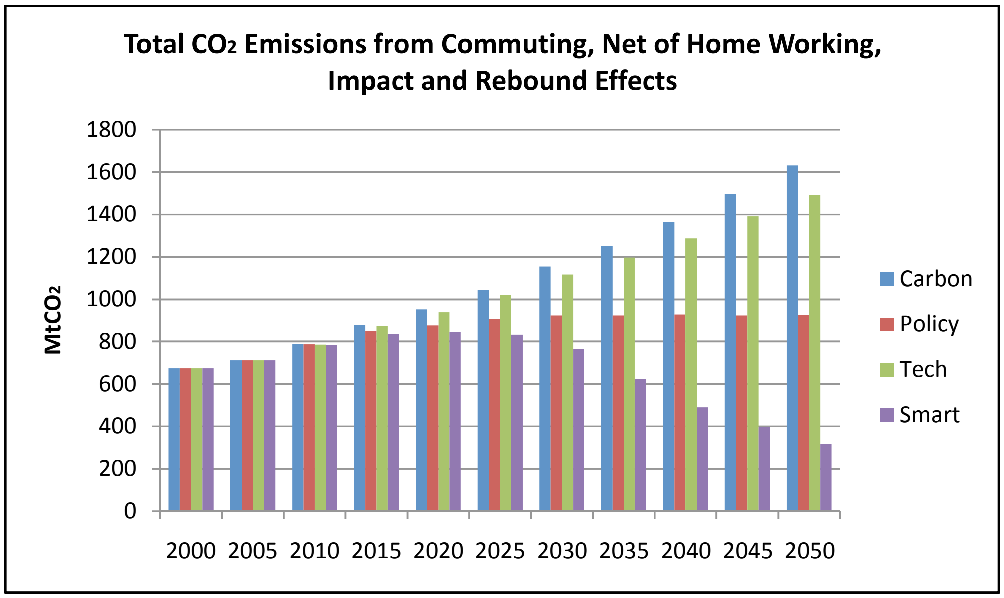
Utilizing different projections of future worlds, the report analyzes not only the direct effect of these technologies but also different types of indirect effects from the uptake of these technologies that can result in both decreased and increased GHG emissions. These can be characterized in two ways:

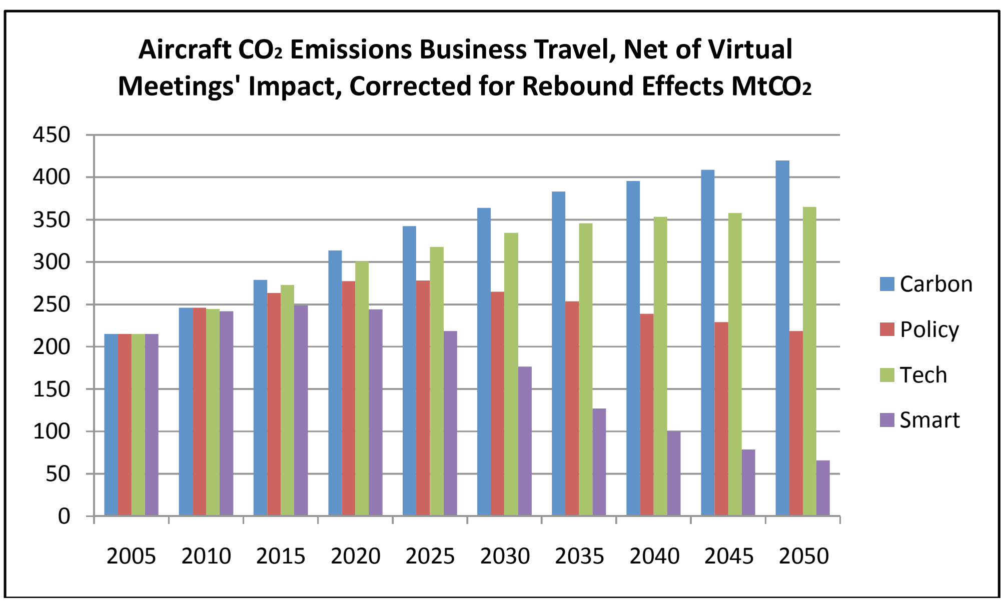
- Low-carbon feedback, if a solution that directly leads to GHG emission reductions also generates changes in behavior, economic activities, processes, or societal organizations that in turn lead to additional GHG reductions.
- High-carbon feedback, if a solution that directly leads to GHG emission reductions also leads to changes in behavior, economic activities, processes, or societal organizations that in turn lead to additional GHG emissions, which may negate, in full or partially, the GHG emission reductions initially/directly achieved.

Key findings

- The analysis highlights that the volume of GHG emission reductions potentially delivered by teleworking is larger than the volume potentially delivered by virtual meetings (see graphs below). Teleworking is not the same as "home work"; increasingly people work in various locations outside the workplace.
- Maximum benefits can be achieved in a smart world where both policy makers and private-sector companies produce and use IT 1) work together to leverage teleworking and virtual meeting solutions as tools to deliver GHG emission reductions while 2) implementing strategies that reduce the risks of negative rebound effects and increase the opportunities to achieve virtual cycles of low-carbon feedback (see table 2, below). For example, this might occur where the gains from increased use of low-carbon IT solutions trigger further actions that reduce GHG emissions. (Increased use of teleworking can, for example, increase connectivity and make it easier for people to have a smart house or to buy local goods online instead of driving to a supermarket to buy goods with a high carbon footprint).
- The difference in emission savings between the carbon world (lowest savings overall) and the smart world (highest savings overall) is significant – e.g., for teleworking about 1 billion tons of CO_2 emissions differentiate the two scenarios in year 2030 (approximately equivalent to the total current CO_2 emissions from UK and Italy combined) and almost 3.5 billion tons in year 2050 (almost as much as the EU's total CO_2 emissions or more than half of the US's current CO_2 emissions).
- The other three future worlds do not deliver carbon reductions as significant as those offered by the smart world because 1) they assume a lower uptake of teleworking and virtual meetings or 2) the gains from increased use of low-carbon IT solutions are offset by other actions that ultimately increase GHG emissions (i.e., negative rebound effects). For example, the increased use of teleworking can result in people buying bigger cars and driving more or even longer distances than they did when they were commuting to the office, or in them applying savings from reduced commuting to high-carbon goods and services such as vacations that require long flights.
- Instead of looking at rebound effects as something negative, it is important to recognize that in the right policy environment, rebound effects can help reduce the emissions even further, a situation known as low-carbon feedback. Virtuous cycles of low-carbon feedback can only be achieved when policy makers, IT users, and the IT industry work together to deploy appropriate policy measures and strategies.

- Whereas OECD countries may deliver the majority of GHG emission reductions in the short term, developing and emerging countries can provide a growing share of future reductions and will, from about year 2030, deliver the majority of new emission reductions. Teleworking alone could achieve over 1.3 billion tons of reductions in developing countries between 2030 and 2050 (421 $MtCO_2$ in China alone) compared to 876 $MtCO_2$ in OECD countries for the same time period.
- A webcam-equipped laptop and mobile and wireless connectivity, as well as effective and secure software, are the key technical requirements for teleworking. These solutions already exist, and the sooner a broad deployment can take place the faster significant reductions can be achieved. A critical factor to support broad deployment is organizational buy-in for teleworking.
- Despite the rebound effects, the prevalent consensus in the literature is that overall telecommuting reduces the distance traveled and the GHG emissions that result from transportation.





Graph 1: CO_2 emissions from commuting and business air travel in projections of future worlds.

Policies and strategies

There are several no-regret solutions that can be implemented in a relatively short time frame, such as leveraging of procurement practices and disseminating best-practice cases.

Most of these activities are most effectively undertaken with the active participation of both the public and private sector, as highlighted by the table below:

	Public sector	IT industry	Leading IT Users (Trendsetters)
Ensure broadband infrastructure	Regulatory framework and incentives*	Direct investment***	
Build knowledge and capacity on IT use to reduce GHG emissions	"Core business" of the public sector***	Most knowledgeable on technology and its uses***	Direct experience and practical insight***
Remove regulatory barriers	Assess and revise regulation***	Identify barriers and propose solutions**	Identify barriers and propose solutions**
Leverage procurement to support GHG reductions with low-carbon feedback	***	**	**
Articulate methodologies for data collection and analysis	For dissemination and standardization*	Work with customers and facilitate***	Direct application and standard development***
Systematically assess the GHG impact of IT solutions (including rebound effects)	For macro-level analyses***	Systematically assess the impact of products and services***	Gain direct experience and practical insight***
Set up data collection systems	Macro level and to create standards***	Embed data collection and communication capabilities in IT***	Implement company- and supply-chain-wide systems***
Disseminate best practices	Country level***	With customers and policy makers***	With peers, suppliers, and policy makers***
Introduce policies that channel resources towards creating low-carbon feedback	Assess and develop appropriate policies***	Provide advice and explore solutions**	Provide advice and explore solutions**
Technology development and tailoring to developing countries	Provide support and knowledge***	Develop technologies***	Help articulate requirements***
Capacity building and dissemination in developing countries	Support with tools and funding instruments***	Work with local and suppliers and customers***	Work with local suppliers and customers***

* Limited role   ** Medium important role   *** Important role

Table 2: Policies and strategies to reduce GHG emissions with IT and generate low-carbon feedback in relation to different stakeholders (The notes in each column provide a short explanation of the role of different stakeholders.)

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By jointly working towards the implementation of these strategies, policy makers and private-sector companies may enable IT applications, such as the ones supporting teleworking and virtual meetings, to gain a broader acceptance and use in society. They would deliver greater GHG emission reductions while liberating resources and providing models that can help reduce GHG emissions more broadly, thus fostering low-carbon feedback. If this potential is fully tapped, the GHG emission reductions can be dramatic.

To illustrate the different options, WWF has developed a web tool that makes it is possible to explore the possible outcomes.[1]

Key recommendations

- Develop rigorous, transparent methodologies to evaluate the emission reductions achieved with IT solutions and disclose use and potential savings information.
- IT companies must themselves use virtual meetings and support teleworking – a must to be able to demonstrate that IT companies believe in their own solutions.
- Ensure improved infrastructure both for virtual meetings and teleworking – cities should include teleworking in their transport strategies and ensure that connectivity is possible from all relevant places.
- Low-carbon IT solutions must be included in climate change strategies and specifically in transport and infrastructure policy processes.
- Articulate and introduce policies that eliminate negative rebound effects and promote virtuous cycles of low-carbon feedback – e.g., when resources (time or money) are liberated, automatically provide incentives for those resources to be invested in ways that lead to reductions in GHG emissions and support further reductions.
- Assess existing subsidies for high-carbon services (e.g., subsidies for car ownership, increased taxation on rooms where teleworking can take place, and tax-financed investments in infrastructure that encourage increased use of cars and planes) and develop systems that allow for a technology-neutral competition to provide similar services.

[1] See www.panda.org/ict for a link to the tool.

Introduction

This report focuses on two applications of IT: teleworking and virtual meetings. They may lead to a reduction in the demand for commute- and business-related travel and the associated GHG emissions.

- *Teleworking,* is defined as performing work, either for an outside employer or through self-employment, at home or from any remote location (e.g., away from the office or any other "traditional" workplace).
- *Virtual meetings,* also known as *teleconferencing*, are defined as work-related meetings involving two or more geographically separated locations and enabled by the use of telecommunication applications, in which communication may be exclusively audio (*audioconferencing*), audio and video (*videoconferencing*), or enabled by the web (*web conferencing*).[2]

Utilizing different projections of future worlds, this report analyzes not only the direct effect of these applications but also different types of indirect effects from their uptake that can result in both increased and reduced GHG emissions. Such dynamics are here defined as

- low-carbon feedback, if a solution that directly leads to GHG emission reductions also generates changes in behavior, economic activities, processes, or societal organizations that in turn lead to additional GHG reductions, and
- high-carbon feedback, if a solution that directly leads to GHG emission reductions also leads to changes in behavior, economic activities, processes, or societal organizations that in turn lead to additional GHG emissions, which may negate, in full or partially, the GHG emission reductions initially/directly achieved.

The insight gained with this analysis can hopefully help policy makers and companies articulate policies and strategies that maximize the GHG emission reductions achieved with IT.

The report is organized in the following sections:

Section 2 provides **background** on the IT solutions that are the focus of this report by defining the subject of the analysis; illustrating drivers, uses, and trends; and discussing the conceptual link between these IT solutions and GHG emissions.

The approach of this report is to assess the possible impact of teleworking and virtual meetings on GHG emissions under different trajectories of future developments. Section 3 will therefore provide a **description of the possible futures,** or future worlds, that are analyzed and discussed in this report. They do not represent forecasts of future development but are qualitative representations.

For each of the possible trajectories the **GHG emissions** associated with business air travel and car commuting have been **estimated quantitatively** to contrast and compare IT-enabled reductions in the different future worlds, through virtual meetings and telecommuting. The results of this analysis are presented in sections 4 and 5. Section 4 describes the methodology used to model GHG emissions, while section 5 discusses the results of the simulations undertaken.

The analysis highlights the key role that policy makers and the IT industry can play in realizing a future that fully leverages IT to reduce GHG emissions from business travel and car commuting. Therefore it will

[2] Among the other ICT applications not discussed in this report, one of the most interesting and popular is known as *webcasting* (i.e., "broadcasting" over the Internet), which refers to a non-interactive, "one-to-many" (as opposed to "one-to-one") form of communication. Webcasting is used extensively in the commercial sector for investor relations presentations and e-learning, and for related communications activities.

be critical to implement **policies and strategies** that maximize the effectiveness/efficiency of IT solutions (in terms of GHG emission reductions) and their deployment. Such complementary policies and strategies are discussed in section 6.

The document concludes – in section 7 – with a **summary** of the main results reached, their significance, and the implications for future activities.

A number of **appendices** are included with additional background information and analytical details.

1 Background

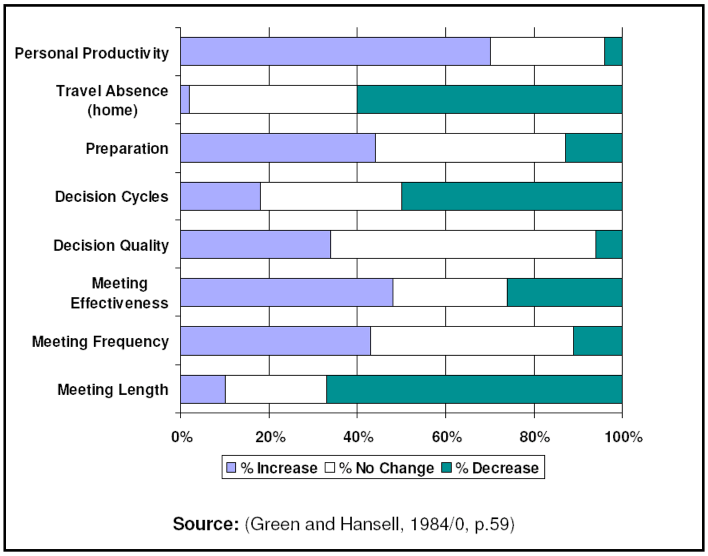
Information and communication technologies (IT/ICT) provide a broad range of solutions to both public and private organizations and businesses, particularly in the service industry. Seen from a climate change perspective, these solutions are interesting, as they can reduce the need to travel for work-related purposes, thus enabling a reduction in GHG emissions from transportation. Moreover, these solutions can potentially support further reductions in GHG emissions in other parts of society if complementary measures are put in place, i.e., they could be instrumental in achieving *low-carbon feedback.*[3]

In addition to their potential contribution to GHG emission reductions, both teleworking and teleconferencing are increasingly perceived by companies as productivity and efficiency enhancers, as they show benefits not only in terms of cost reduction and environmental performance but also in terms of increased economic performance and social benefits. For example, utilizing a detailed questionnaire with its employees, AT&T established that the implementation of telecommuting practices within its company was associated with an increase in productivity and job satisfaction among telecommuters. Moreover, AT&T estimated that telecommuters saved about 5.1 million gallons of gasoline (equivalent to about 44,000 metric tons of avoided vehicle emissions).[4]

Productivity improvements were also identified as key benefits of virtual meetings, as highlighted in the graph below from an early study on videoconferencing. Similar benefits were reported by Roy and Filistrault (1998), who, based on a survey conducted among business travelers, concluded that teleconferencing can accelerate decision making by rapidly linking key players. Finally, Hopkinson et al. (2003), in their survey of BT employees, found that 82 percent felt that teleconferencing had improved their work performance, including 44 percent who felt this improvement was considerable.

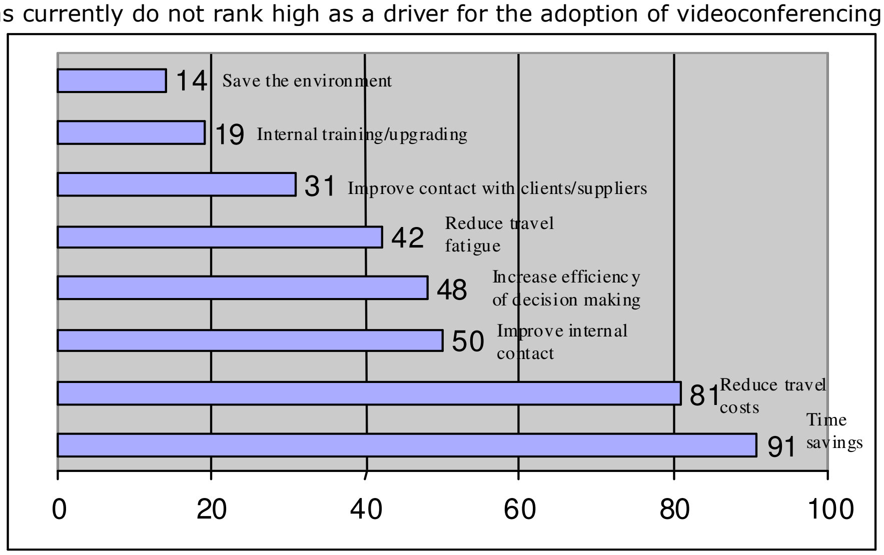
[3] Conversely, if surrounding conditions are unfavorable, GHG emission reductions initially achieved by teleworking or virtual meetings may be counterbalanced by secondary effects that led to higher GHG emissions, a situation that may even lead to net increases in carbon emissions. These situations may be defined as high-carbon feedback. Low- and high-carbon feedback will be further discussed in section 1.4 and in the chapters below.

[4] AT&T, 2002; AT&T, 1997.



Graph 2: Effects of videoconferencing on meetings.

In a more recent study, Denstadli (2004) tried to identify and rank the main factors that lead certain businesses to choose videoconferencing over physical travel (see graph below). According to the survey conducted by Denstadli (2004), videoconferencing allows for substantial reduction of travel costs and offers the benefit of related time savings. At the same time, through videoconferencing, more frequent meetings with more participants – who otherwise would not have traveled – can take place at a considerably lower cost. This means that more people with different backgrounds and perspectives can be brought to the "virtual table," enriching the discussion and leading, eventually, to a more informed decision. Moreover, some studies (e.g., Duarte and Snyder, 2001) have shown that participants in virtual meetings tend to be very concentrated and focused, enhancing the effectiveness of the decision-making process, in line with the findings of the study by Roy and Filistrault (1998). Another important feature of virtual meetings lies in the fact that they can be recorded, giving participants the possibility to summarize and analyze the discussion afterwards. Interestingly Denstadli's survey also highlights that environmental considerations currently do not rank high as a driver for the adoption of videoconferencing solutions.



Graph 3. Reasons for adopting videoconferencing. Source: Denstadli (2004).

The number of businesses which use these applications either regularly or occasionally has grown significantly in the last few years. In addition, the frequency with which these applications have been used has intensified as well. The sections that follow will discuss recent trends and dynamics in further detail.

1.1 Teleworking

1.1.1 Teleworking – Data availability and data-collection issues

Data on the penetration of ICT applications in the workplace and on their impact on commuting are relatively scarce.

Regular statistical data on teleworking are not currently collected, other than in a few countries. Occasional sample surveys and estimates are available for some countries, typically in North America, Europe, or Japan. Data are particularly scarce for developing and emerging countries, where typically no data is available. For some countries, however, such as the US and members of the EU, data on the share of teleworking by sector and/or occupation are available.

Existing statistical surveys, however, often produce results that are not comparable due to the lack of standard definitions. Some surveys, for example, focus on teleworkers as a whole, while others differentiate or restrict their focus to teleworkers that work from home (home workers), utilize ICT technologies in their work, or must utilize ICT technologies to work (TC teleworkers). The figure below provides a graphical representation of various types of teleworkers that can be identified and that may be the focus of statistical surveys.

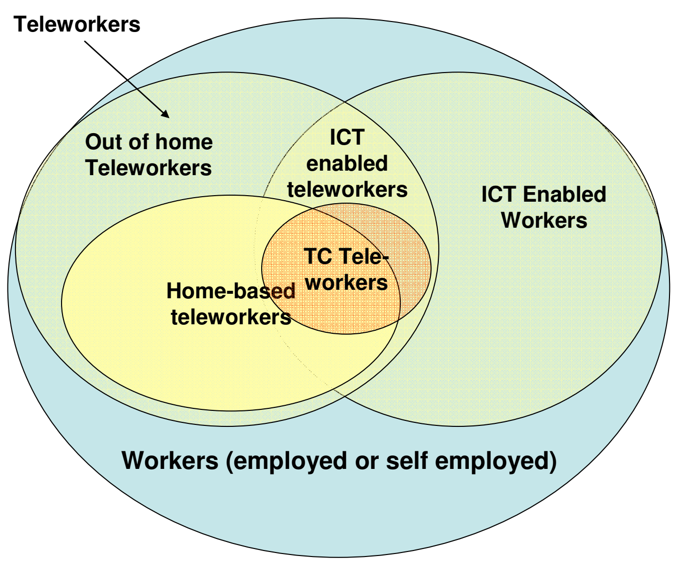


Figure 1: Different types of teleworkers.
Note: The relative size of the circles does not reflect the relative size of different groups.

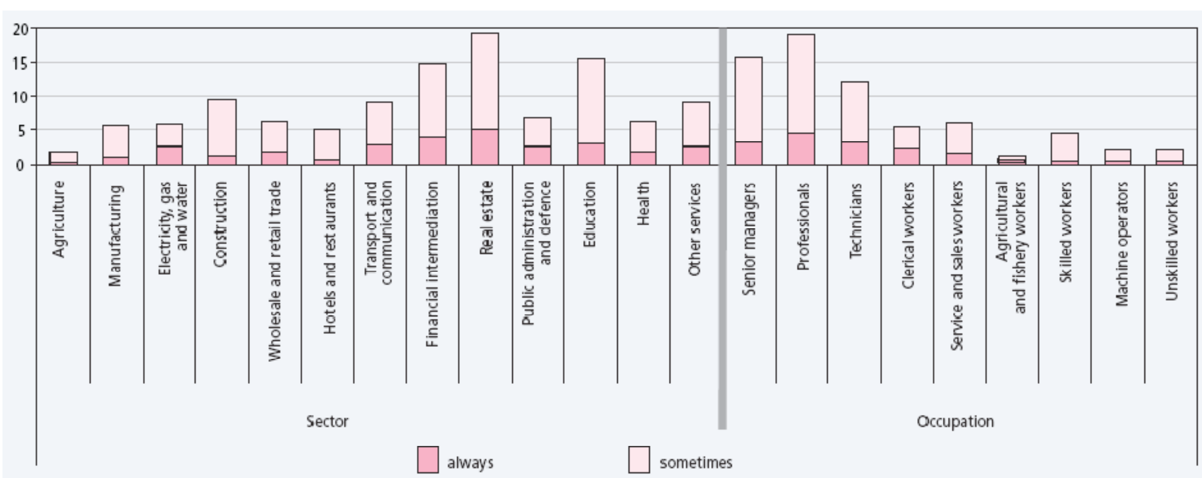
An additional limitation of existing data on teleworking is that questionnaire designs often fail to capture important information, such as the number of days teleworked each month or week by respondents falling under the category of teleworkers.

Despite differences in definitions, methodologies, and estimations we can, however, draw some preliminary conclusions, which are discussed below.

1.1.2 Teleworking – Penetration

The rate of penetration of teleworking and teleconferencing into the working environment is not uniform across countries, due to different economic, technological, and policy contexts. According to WorldatWork (2008), in 2005 there were in the US around 26.1 million teleworkers (defined as those teleworking at least once a month), corresponding to 17.5 percent of the total workforce. Among these, 16.2 million were classified as "contract teleworkers," while 12.4 million were "employee teleworkers."[5] Out of the total 26.1 million US teleworkers in 2005, 22.2 million workers were teleworking at least once per week, with 12.2 million teleworking almost every day (full time). In the EU, according to the European Working Conditions Observatory (2007), the percentage of teleworkers (teleworking at least once a month) was around 8 percent of the total workforce, while only 2 percent telework every day (full time), with the highest proportion of teleworking in the Scandinavian countries and the Netherlands and the lowest in southern European countries. Finally, Gartner (2005) reports that in Japan teleworkers accounted for 6.6 percent of the workforce in 2000.

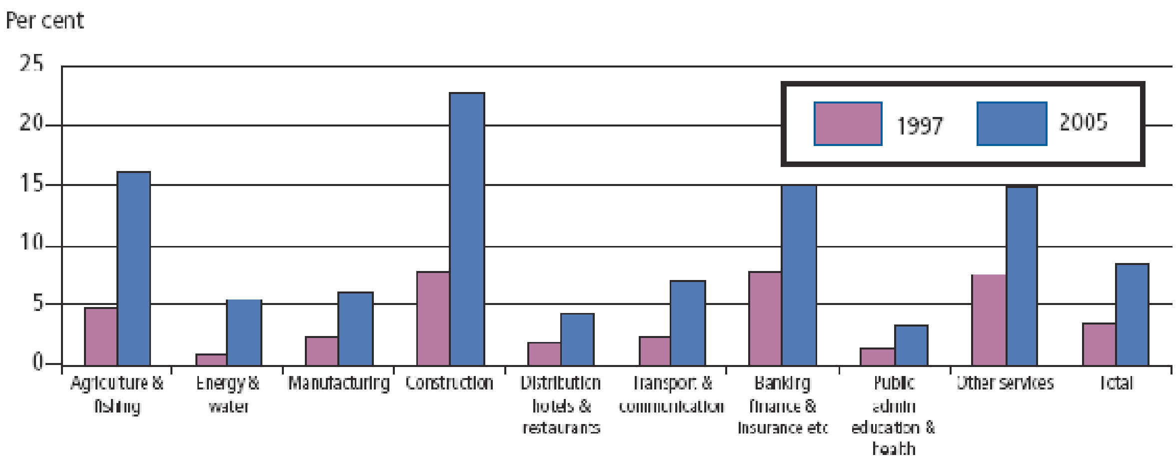
The use of teleworking depends on the occupation level of employees. In most cases, all else being equal, top managers, senior officials, and professionals, as well as people in skilled-trade occupations, all of whom have a higher degree of control over their activities compared to the average employee, tend to use these applications more often. For the EU-27, for example, among professional, managerial, and technical occupations, this share is well above 10 percent (see graph below).



Graph 4: Teleworking by sector in the EU, source: European Working Conditions Observatory (2007).

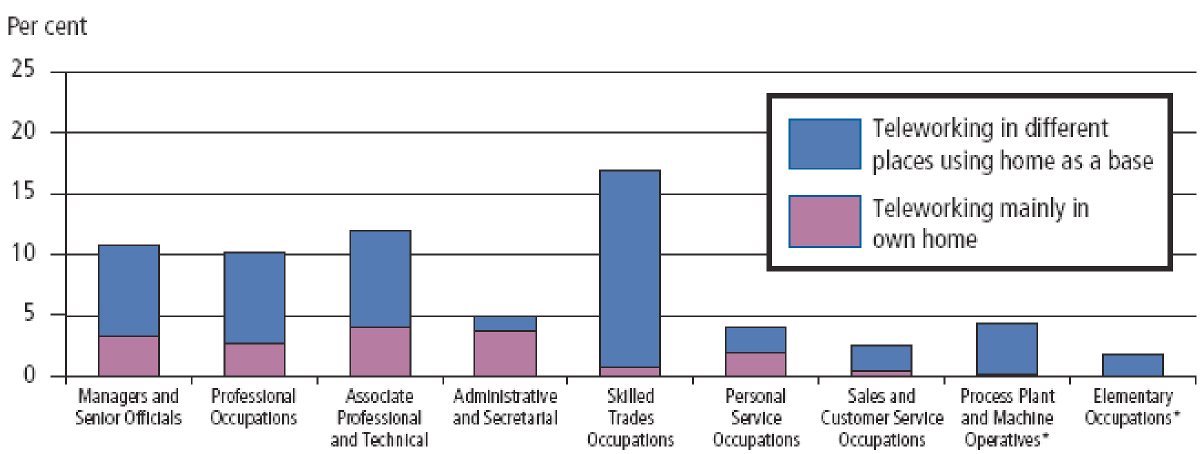
As highlighted by the graph above, the implementation of teleworking is not uniform across sectors. Typically, the highest implementation occurs in the most knowledge-intensive industries within the service sector of economically and technologically advanced countries. Some traditional sectors, however, may have high adoption rates. This is the case in the construction sector in the EU-27, and also of agriculture and fishing in countries such as the UK (see graph below).

[5] WorldatWork (2007) defined a "contract teleworker" as "a self-employed individual who works remotely at least one day per month during normal business hours" and an "employee teleworker" as "a regular employee (full or part time) who works remotely at least one day per month during normal business hours."



Graph 5: Teleworking by sector in the UK, source: National Statistics for UK (2005).

As shown in the graph below, while some teleworkers work from home (home workers), a significant proportion, especially among skilled trades, work from other locations besides their homes.



Graph 6: Teleworking from home and from different places in the UK, source: National Statistics UK (2005).

Regarding the remote locations from which teleworking may be carried out, data for the US suggests that, although the home is still the most common location for teleworkers to conduct their work, a growing number of them work from various other locations. In particular, according to a survey conducted by WorldatWork (2007), 24.6 million people conducted work from a customer or client's place of business in the month preceding the survey, 20.2 million conducted work from a café or restaurant, 17.8 million did so from a hotel or motel, and 11.5 million worked from a park or an outdoor location. Finally, a considerable number of people conducted work using a telephone and/or a PC while traveling (24 million in the car; 10.6 million on an airplane, train, or subway; and 9.1 million in an airport, train depot, or subway platform).

UK data also show other interesting trends. Between 2000 and 2005, for instance, the share of home workers using a telephone and computer to carry out their work (IT-enabled teleworkers) increased quite significantly (up to 77 percent), and, among them, the proportion who could not work from home without using both a telephone and computer (so-called "TC teleworkers") increased as well (reaching 87 percent in 2005)[6]

Differences in behavior between different groups of teleworkers may have significant implications in terms of GHG emission reductions achieved via teleworking (e.g., because of different teleworking and traveling schedules of different groups). Currently, however, the information available about the behavior of different groups, and in particular about people working outside their homes, is insufficient to draw firm conclusions. Despite these limitations, a number of studies, typically case-study-based or focusing on individual countries, have attempted to estimate the impact of teleworking on transportation and GHG emissions (see table below).

Focusing on the US market as a whole, the Consumer Electronics Association estimated that about 3.9 million Americans currently telecommute and that telecommuters save between 17 and 23 kg of CO_2 emissions a day. Thus the CEA estimates that currently US telecommuters avoid emitting between 10 and 14 million tons of CO_2 per annum.
Looking at existing and potential adoption of telecommuting, the American Consumers Institute envisions that an additional 10 percent of the US workforce could begin telecommuting over a 10-year period. Considering only benefits deriving from the reduction of car commuting, the ACI estimates that such change would allow the US economy to save about $96.5 billion each year, reducing gasoline use by 16.6 billion liters and CO_2 emissions by 38.5 million tons.[7]
In the UK, a pilot survey undertaken by BT indicated that, on average, home-workers eliminated 3,149 miles (about 5,000 km) of home-to-office travel, most of which would have been by car rather than by public transport. Respondents were also asked if they had increased leisure journeys: only seven out of the 43 home workers interviewed said they had, and the increased mileage was low in relation to the savings from home-office travel.[8]
In simulating the impact on traffic congestion, NERA Economic Consulting's "conservative assumption" on car commuting is that compared to a business-as-usual scenario, home workers will enable a 10 percent reduction in traffic in 2005 and 15 percent in 2010, with a noticeable impact on traffic congestion[9].
Discussing potential aggregate savings at European level, and citing a study by the European Telecommunications Network Operators Association (ETNO) and the World Wildlife Fund, the American Electronics Association (AeA) notes that if just 10 percent of the EU employees became flexi-workers 22 million tons of CO_2 might be saved annually[10].

Table 3. Summary of studies estimating teleworking impact on GHG emissions

Thus, both US and European studies point out that teleworking can potentially enable millions of tons in travel-related GHG emission reductions.

Several authors, however, pointed at a number of indirect, rebound effects that may reduce the positive impact of telecommuting on traffic levels and GHG emissions. In particular potential traffic (and GHG emissions) increases have been associated with:

- latent demand from people who decide to travel as congestion, thanks to telecommuting, decreases:
- leisure travel from telecommuters that take advantage of the commuting time saved thanks to telecommuting; and
- increased urban sprawl, facilitated by the diminished need to live in proximity to offices.

[6] National Statistics UK, 2005

[7] Joseph Fuhr and Stephen Pociask. "Broadband services: economic and environmental benefits," The American Consumer Institute, October, 2007.

[8] Motors and Modems Revisited: The Role of Technology in Reducing Travel Demands and Traffic Congestion. John Dodgson, Jonathan Pacey and Michael Begg. NERA, London, May 2000.

[9] Op.cit.

[10] AeA 2007 – John A. "Skip" Laitner, Karen Ehrhard-Martinez Advanced Electronics and Information Technologies: The Innovation-Led Climate Change Solution.

Despite the recognition of these dynamics, the prevalent consensus in the literature is that, overall, telecommuting reduces the distance traveled and the GHG emissions deriving from transportation. The debate on the size and kind of rebound impact remains open. It is clear, however, that the size and kind of possible rebound effects depend on the cultural, economic, and policy framework in which telecommuting is deployed, e.g., in an environment in which lack of urban planning does not encourage mixed-use living, telecommuting may lead to increasing sprawl and additional leisure- and chore-related travel. Flanking policies and measures can therefore maximize the impact of telecommuting and minimize the negative rebound effect and support low-carbon feedback.

1.1.3 Teleworking – Existing barriers and growth potential

Whereas current adoption of teleworking is typically limited to a small percentage of workers, it appears that a broader number of workers are potentially interested in this application. A high level of interest is present both among those already employed (see table below) and among those currently unemployed (see appendix 3). This level of interest should be considered high, relative to the fact that support and commercial push for teleworking are not high and few role models that successfully have implemented teleworking solutions are well known.

	Interested in permanent home-based telework	Interested in alternating home-based telework	Interested in centre-based telework	Interested in any of these types of telework
AUSTRIA	45.2	59.8	53.9	70.3
BELGIUM	43.7	53.0	68.8	77.1
DENMARK	39.1	54.1	66.2	78.6
FINLAND	44.4	66.0	56.6	75.4
FRANCE	28.7	37.1	43.0	54.1
GERMANY	41.8	58.1	61.1	75.5
GREECE	35.7	40.5	50.0	53.7
IRELAND	50.8	57.7	51.7	68.9
ITALY	45.4	50.2	59.2	69.0
LUXEMBOURG	40.6	56.1	64.7	74.7
NETHERLANDS	44.2	68.5	64.1	74.7
PORTUGAL	22.9	24.8	34.7	39.8
SPAIN	41.7	45.6	46.1	59.6
SWEDEN	43.3	60.6	45.6	67.3
U.K.	41.5	55.7	54.9	65.3
EU	40.1	51.5	54.5	66.5
CH	34.8	44.8	51.2	63.5
USA	50.5	61.7	61.6	73.3

Table 4: Employed people interested in teleworking, source: Gareis (2002).

The set of potential teleworkers may be even larger if one considers the functional activities of different workers and their actual connection to a physical space.

The commission of the European Communities, for example, has estimated that roughly 50 percent of all employment is not bound to a specific geographical location. In the US, the number of so-called information workers, which account for around half of the total workforce (with this figure expected to grow up to 70 percent), has been used as an indicator of the potential growth of teleworking. However, not all information workers consider themselves potential teleworkers. According to a number of surveys that have been conducted, between 20 and 82 percent of information workers either believe they cannot telework or are not willing to do so under current circumstances. If the results of two empirical US surveys by Mokhtarian, which suggest that information workers who are unable or unwilling to telework represent 40 percent of the total, are taken as representative, this implies that currently 30 percent of the labor force could and would like to telework (60 percent out of 50 percent of the total labor force) (Arnfalk 1999). It must be noted, however, that the broad range of responses provided to these surveys may signal lack of clarity among respondents about the implications, benefits, and drawbacks of teleworking.

Surrounding conditions play a key role in determining both the potential for teleworking and its actual utilization. Today, despite the high level of interest for teleworking expressed by most employees, as well as by a growing number of employers, the share of teleworkers is still relatively low in most countries. This is due to a combination of factors, including technological and economic barriers, legal and administrative barriers (such as lack of permission to telework from the company or lack of approval from the superior), and the perceived need for physical presence and face-to-face interaction in a number of jobs. The results of a survey conducted in the EU-15 on the reasons for not teleworking are reported in the table below.

Teleworking already (at least one full working day per week)	**2.1**		
Not teleworking already (or less than one full working day per week) or DK	**97.9**		
thereof (100%):			
Job is feasible for telework		*28.0*	
Job is not feasible for telework		*67.3*	
*thereof (100%): Main reason (multiple answers)**			
Company does not permit telework			*13.6*
Superior does not approve of telework			*5.3*
Job requires face-to-face contact with customers, colleagues or other persons			*64.8*
Job requires access to machines or other things which cannot be accessed from home			*47.7*
Other reasons			*8.0*
Reasons: DK			*1.3*
Feasibility: DK, missing data		*4.7*	
Total	**100**	*100*	

Table 5: Reasons to telework or not to telework, source: Gareis (2002).

Despite existing barriers it is to be expected that, with the continuation of existing trends, a larger proportion of people will be able or willing to telework in the future, due to several drivers, as discussed in section 1.3 below. The speed of development, however, and the impact that such development may have on GHG emissions will vary significantly, depending on the behavior of key players such as IT producers and users and policy makers. These aspects will be discussed in more detail in sections 2 and 3 below.

1.2 Virtual meetings

1.2.1 Virtual meetings – Data availability and data-collection issues

The background research undertaken for this project highlighted that currently there is no systematic effort to collect statistical data about the adoption of virtual meetings. Statistical data examining virtual meetings is therefore even scarcer than for teleworking. This is surprising, given how much virtual meeting technologies are promoted by many IT companies as important business solutions.

A number of studies, based on case studies, have analyzed various themes associated with virtual meetings such as user behavior; technology performance; or, as in the studies that will be highlighted below, impact on travel behavior and CO_2 emissions. These occasional surveys and studies vary significantly in terms of goals, scope, and approach. As these studies are based on anecdotal evidence, they fail to provide rigorous statistical data on the adoption of virtual meetings in the workplace and on the associated impact on business travel at an aggregated level, whether by country or even by industrial sector.

1.2.2 Virtual meetings – Existing literature

Since the introduction of the telephone and, later, of the Picturephone by Bell Labs at the World Expo in 1964, a number of studies have speculated that teleconferencing would lower or even replace the need for business travel. For example, a letter to the editors of the *Times* dated May 10, 1879, opines that the invention of the telephone *"could replace the rapid journeying which wearied the businessman of today."* Quite similarly, in 1969, Kjellstrom wrote, *"By 1975 we will no longer need to spend time in face-to-face meetings. Thanks to computer terminals and picture telephony, we will be able to meet electronically from our office chairs"* (Arnfalk, 2002).

Over the last couple of decades, the introduction of personal computers and of the Internet in the workplace, combined with the more recent spread of broadband, has spurred a renewed interest among researchers, who have focused their attention on specific types of teleconferencing such as videoconferencing and, more recently, web conferencing. A sample of studies is provided in the table below.

Source	Finding
BT trial 1983–1986 (Bennison 1998)	Eighty-seven percent of respondents felt that teleconferencing reduced their need to travel.
SCAG meeting (Mokhtarian 1988)	• Total vehicle miles increased by 29 percent by replacing a regional meeting for a teleconference, as shorter distances to teleconference facilities were outweighed by increased attendance. • Travel in peak-hour, congested conditions was replaced by travel in off-peak, less congested conditions. • A total of 1.8 percent of all business travel may currently be substituted by teleconferencing.
Canadian employees (Redekop 1994)	Twenty-five percent of respondents made fewer business trips due to communication technologies in 1992, and 28 percent did so in 1994.
Cook and Haver (1994)	• It was argued that a 25 percent replacement of business travel by air was going to take place in the US by 2010.
Canadian business travelers (Roy and Filistrault 1998)	• A total of 24.2 percent said they were traveling less often as a result of company policy to increase utilization of teleconferencing. • Of those participating in at least one videoconference in the previous year, users stated that videoconferencing had been a substitute for an air trip in 45 percent of the cases. • As much as 1.8 percent of all business travel may currently be substituted by teleconferencing.
Epson Telecentre (SustainIT undated, Bibby 2000)	A telecenter with eight desks was estimated to save 30,000 vehicle miles per annum (3,750 miles per desk).
Tetrapak (Arnfalk 2002)	Business travel could be reduced by 10 percent due to videoconferencing.
Telia (Arnfalk 2002)	Between 1997 and 2000, business travel by air was reduced by over a third, partly due to more virtual meetings (particularly audioconferencing).
Survey of four Swedish companies (Arnfalk 2002)	• Forty-five to 61 percent respondents said videoconferencing had reduced their own travel. • Fifteen to 25 percent said it had reduced other people's travel. • Seventeen to 20 percent said it had only had a minor effect. • One to 3 percent said it had increased their travel.
Hopkinson et al 2003	• Seventy-one percent of respondents said their last conference call had replaced a meeting (with 52 percent of respondents stating that this was "definitively the case"), while 5 percent stated that it had generated a meeting. • A half million car/van trips and 51–59 million miles of travel saved for 108,000 people (approximately five trips and 450–550 miles per person per year). • Forty-six percent avoided trips that would have taken place during peak periods. • Ten to 11 percent saw a reduction in business mileage.
Mason Williams (2004)	Video meeting equipment has allowed travel costs to drop by a third.
HP 2008	Case study of Halo telepresence solution applied to a HP team responsible for transferring manufacturing responsibility for an HP product from Oregon to Singapore: • cut an estimated 44 international employee trips from the project and • prevented about 145 metric tons of carbon emissions from being released into the environment.

Table 6*: Scale and impact of teleconferencing,* source Cairns S**,** Sloman L**,** Newson C**,** Anable J**, Kirkbride A & Goodwin P (2004) 'Smarter Choices – Changing the Way We Travel**

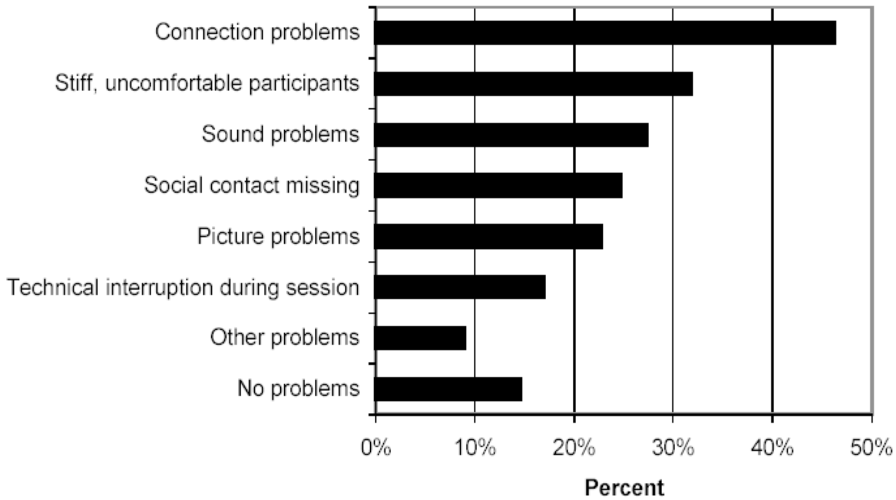
As with teleworking, the estimated benefits of virtual meetings may vary depending on the assumptions made on the potential rebound effects generated. Typically, more prudent estimates highlight that besides substitution, two other possible effects of virtual meetings on travel can be identified:

- Supplementation: Virtual communication supplements physical travel, which continues to take place.
- Generation: Virtual communication leads to more numerous and remote contacts and businesses, stimulating and generating more demand for travel.

For instance, according to some authors, such as Denstadli (2004), videoconferencing may cause a "travel shifting," from internal company meetings and routine contacts to external, business-development-related meetings. In other words, travel costs and time saved for internal meetings thanks to the use of tele- and videoconferencing may free time and resources for more strategic external meetings. Although this may have positive effects in terms of business development, it may neutralize or even reverse the reduction in physical travel to attend internal meetings. Other travel-generation effects were found by Mokhtarian (2003), according to whom videoconference-based meetings of the South California Association of Government resulted in greater overall miles traveled, as the average number of attendees, who had to travel in order to join the virtual meetings at their local hubs, rose. Finally, with improved IT applications such as tele- and videoconferencing, the geographic scope of businesses may expand, enabling companies to establish offices and operations in remote locations based on resource-efficiency considerations. All else being equal, this would generate new demand for interaction, both virtual (through teleconferencing) and physical, creating the need for additional travel. In a survey conducted by Barclaycard Business and Future Foundation (2007) among UK businesses, 13 percent of those who responded said that they were traveling more than in the previous year, and indicated that this was due to the growing need for face-to-face meetings. As concluded by Barclaycard Business and Future Foundation (2007), "Business across international borders incurs issues such as cultural or language barriers and incompatible time zones, all of which are better overcome with face-to-face contact." Finally, Arnfalk (2002), highlighted that a certain number of meetings that were held via teleconference would not have happened otherwise and/or fewer people would have traveled to attend it. According to a survey he conducted, almost one-fifth of respondents had participated in virtual meetings they would not otherwise have traveled to. It is reasonable to assume, therefore, that the cultural, economic, and policy framework in which such meetings take place will likely affect the ultimate impact on GHG emissions, while technological factors will affect usage rates and patterns.

1.2.3 Virtual meetings – Existing barriers and growth potential

Typical challenges for virtual meetings derive from the limitations that a work interaction mediated by an IT device may bring to meeting participants. This is more evident with audioconferences, when the communication is constrained to verbal-only, but it is also present in more sophisticated solutions, such as videoconferencing or web conferencing, when visual interaction is also present and more tools enable richer interactions. Earlier studies highlighted some of these barriers, as shown in the graph below.



Graph 7. Problems with videoconferencing in four Swedish organizations. Adapted from Arnfalk (1999).

Technological development continues to improve functionalities and enable richer IT-mediated interactions. A number of barriers, however, are not completely overcome yet. For example, the following:

- Despite the significant expansion and enhancement of IT infrastructures over the past few years, in emerging economies and developing countries such infrastructures are still inadequate. Problems may follow in terms of lack of bandwidth, connection reliability, security, or loss of data. In the case of multinational companies and organizations with operations in these countries, this can represent a major obstacle to the use of IT applications for internal meetings, which account for a large share of travel in these types of entities.
- There are problems of accessibility, both in terms of costs and know-how. This is the case with videoconferencing. Despite the substantial decrease in the costs of videoconferencing equipment and services, this technology still requires, in order to achieve very high performance, an initial investment that many small and medium businesses cannot afford. This aspect, coupled with the lack of adequate technological know-how that affects many small and medium enterprises (SMEs), has limited the development of this technology on a large scale.
- Cultural, organizational, and psychological barriers may also limit adoption, as changes in "the way business is done" may be seen as unneeded, inappropriate, or costly.

An important aspect that will influence the long-term dissemination and utilization of virtual meetings is the degree to which they will (be perceived to) lack the human/social interaction needed to perform specific work-related tasks. According to Arnfalk (2002), for example, business travel can have three main purposes:

- Provide access to customers, suppliers, partners, and colleagues, or to products, instruments, etc.
- Yield values: revenue, information, knowledge, skills, collaboration, etc.
- Provide intangible values: trust, confidence, interest, pleasure, gratitude, etc.

IT-enabled virtual meetings may already perform some of these functions relatively well. Others, however, present bigger challenges, especially those that require a high dose of "social presence," such as kickoff and kick-out meetings, which typically provide intangible values such as trust, confidence, interest, etc.

1.3 Outlook – Teleworking and virtual meetings

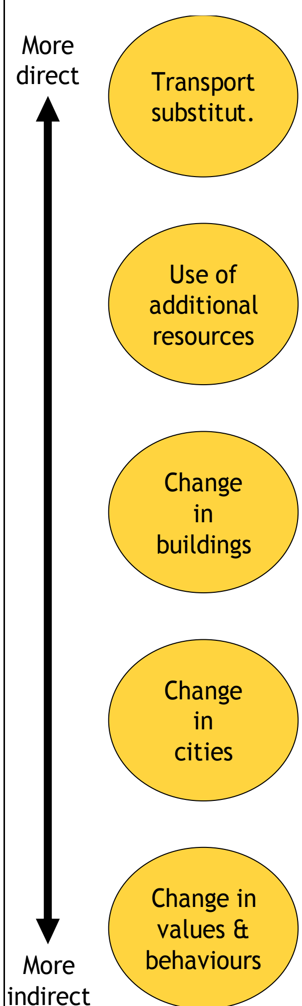
The growing penetration of both teleworking and teleconferencing in the workplace has been prompted by a number of factors, which will likely continue in the coming years and decades. For example, consider the following:

- The reliability and affordability of IT applications such as teleworking and teleconferencing have improved considerably in the past few years, coupled with ever-improving functionalities. This technological progress is expected to continue in the future, allowing more reliable, high-quality, and interactive communications and exchanges among users.
- Structural changes in the economy (such as a growing proportion of service-sector and knowledge workers over the total workforce) can broaden the pool of workers that can use teleworking or virtual meetings. Significant growth is likely in emerging economies and developing countries, where the service sector currently represents a smaller proportion of the economy as compared to developed countries. These areas will likely grow significantly over the next few decades.
- Technological improvements may also enable better man-machine and machine-machine interaction, which may allow the deployment of IT solutions in a broader set of sectors, also enabling a greater set of professions and people to utilize virtual meetings and teleworking.
- Transportation and energy costs have seen an upward trend and such costs are likely to further increase in the future, especially if the true costs of fossil fuel emissions (including externalities) are charged to the transportation sector.
- Several companies around the world have committed to GHG-emission-reduction strategies, partly in response to the climate change mitigation targets adopted by a number of governments, particularly under the Kyoto Protocol.

Undoubtedly a growing use of teleworking and teleconferencing will have an impact on transportation and associated GHG emissions. The net impact achieved, however, may vary significantly, as several factors influence both direct and indirect (rebound) emissions, as illustrated in the following section.

1.4 Paths of GHG impact for teleworking and teleconferencing

By limiting the need to travel for work or meetings teleworking and virtual meetings can potentially provide a positive contribution in the effort to reduce GHG emissions. These IT solutions, however, can impact GHG emissions through multiple channels, both directly and indirectly. From the point of view of climate change, some solutions may lead to further emission reductions (creating virtuous cycles of GHG emission reductions) while others may lead to increased emissions (creating negative rebound effects that can negate in whole or in part the initial reductions achieved). The table below provides an illustration of these dynamics. Solutions that lead to reductions in GHG emissions are written in green; those that lead to increases in GHG emissions are written in black.



Solutions Leading to <u>Reductions</u> in GHG Emissions	Solutions Leading to <u>Increases</u> in GHG Emissions
Reduced commuting or work-related travel reduces CO_2 emissions.	The use of IT equipment to support work and interaction from home uses electricity, which produces CO_2 emissions.
Less or more efficient use of IT equipment in an office may reduce electricity use and related CO_2 emissions.	Teleworkers may consume more energy at home for heating and lighting.
Employees may consume less energy at work for heating and lighting.	People who avoid commuting or business travels may have additional time available, which may lead to additional travel for personal chores or leisure, which increases GHG emissions.
Avoiding trips reduces costs, which provides additional income or profits, which in turn lead to consumption or investment in products and services that also generate a reduction in GHG emissions. (This would be the case if culture, economics, and policies channel expenditures towards low-carbon lifestyles and consumptions.)	Avoiding trips reduces costs, which provides additional income or profits, which in turn lead to consumption or investment in goods or services with large carbon footprints. (This would be the case if culture, economics, and policies encourage expenditures that lead to GHG emissions.)
Companies where a significant number of employees work from home may be able to reduce their office space and the associated electricity and heat use.	Workers who work at home may want bigger homes to accommodate the home office, which may increase energy use.
People who have the opportunity to telework may be inclined to move further away from their offices, thus over time having an incentive to almost never travel to the office, which decreases GHG emissions	People who have the opportunity to telework may be inclined to move further away from their offices, thus traveling longer when going to the offices, which increases GHG emissions.
The ability to work with people in virtual spaces may extend a network of relationships to places that are further and further away. This may lead to (as virtual meetings become so common that it is impossible to meet everyone) a decrease in the urge to physically meet.	The ability to work with people in virtual spaces may extend a network of relationships to places that are further and further away. This may lead to in-person trips in areas that would not otherwise be a travel destination, thus increasing GHG emissions.
People who avoid commuting or business travels may get rid of the car and/or change their lifestyle, which may lead to reduced travel for personal chores or leisure, which decreases GHG emissions.	
Working from home may lead to stronger roots in an area and within a community, which may lead to less traveling and more local consumption and less GHG emissions (direct positive rebound effect).	
If telecommuting and virtual meetings are explicitly associated with environmental benefits, people may transfer such values from the work environment to other environments, which will decrease GHG emissions.	

Table 7: Teleworking and virtual meetings, direct and indirect impact on GHG emissions.

For most of the variables and relationships mentioned above, the data currently available is extremely scarce. Understanding and quantifying the existing and possible impact of teleworking and virtual meetings on GHG emissions therefore involves significant challenges.

It must also be said, however, that targeted policies and strategies can greatly affect most of the variables and relationships mentioned above. To a significant extent, therefore, when considering the opportunities for reductions in GHG emissions through telecommuting and virtual meetings, one can ask the question, "What conditions can be created to maximize GHG emission reductions, and what should be done to avoid risks of GHG emissions increase?"

This question underlies this report. The sections below adopt an approach to investigate possible future trajectories, discuss key drivers and sensitivities, and identify policies and strategies that can help maximize the climate benefits of the low-carbon IT solutions under investigation.

2 Future worlds

As highlighted in section 2, there are numerous variables that may affect the implementation of IT solutions for remote collaboration and remote working, and there are multiple channels through which such technologies can affect GHG emissions, both directly and indirectly, with various degree of impact per channel. Thus several possible futures can be imagined, in which the interplay of these variables leads to dramatically different results.

Three key players appear to have a significant degree of influence on most of the relevant variables: the IT industry, customers that adopt IT products to reduce travel (IT users), and policy makers. The IT industry has a great degree of influence on how IT technologies are developed, marketed, and used. Factors controlled by the IT industry include decisions such as when new products are developed, whether climate change benefits are part of the product's requirements and conveyed to users, whether to encourage system implementation to include an effort to reduce GHG emissions, and whether to encourage governmental policy development regarding climate change and infrastructure development.

IT users can formulate strategies and demands on both the IT industry and policy makers. They may deploy IT to consciously reduce their GHG footprint or may be unaware of this potential (or unwilling/unable to act) and so use IT in ways that further increase their GHG emissions.

Policy makers can articulate policies that affect the adoption of IT and the impact IT can have on GHG emissions through different channels. For instance, policy makers can implement policies that promote the use of IT, favor IT solutions with the highest environmental benefit, adopt a service perspective, allow IT solutions to be compared with traditional ways of providing the service such as flying or driving by car, reduce or increase the ability of workers to work remotely, promote a sustainable or unsustainable use of additional resources (time or money) that are made available by efficiency gains, etc.

Considering different behaviors from these key players, this report illustrates and analyzes four possible futures:

- No one takes the lead and society develops on a business-as-usual pattern [carbon world].
- The policy domain delivers effective climate change policies, but IT suppliers and users are not proactive at addressing climate change problems. This would be a scenario with

ambitious targets compared to today, resulting in significant, but still incremental, improvements [policy world].

- The IT industry and IT users show a commitment to implement low-carbon IT solutions, while policy makers are ineffective at targeting climate change. This scenario is in many ways an extreme scenario that is meant to illustrate what happens if no overall framework exists [tech world].
- Key players in the IT industry, IT users, and policy makers come together and support the use of low-carbon IT solutions and the creation of a framework that support low-carbon feedback that contributes to accelerated emission reductions [smart world].

The four possible futures are summarized in the table below.

		IT industry behavior	
		IT industry and users do not address energy and climate change issues specifically	IT industry and users aggressively pursue and offer climate-friendly solutions
Policy domain	Effective climate change policy, including support for low-carbon IT solutions	**Policy world**	**Smart world**
	Weak climate change policy, ignoring the role of low-carbon IT	**Carbon world**	**Tech world**

Table 8. Each of these possible futures is described in more detail below.

2.1 Carbon world

A carbon world represents a world in which both policy makers and industry are not willing or able to effectively address climate change issues. In this world, past trends, behaviors, and development models are maintained. Businesses require employees to mostly work in centralized offices or factories. Face-to-face meetings remain the prevalent way to interact. Labor relations focus on process control (as opposed to outcome). Ownership of private vehicles is a status symbol in developing countries and developed countries alike, and is a necessity in many countries that do not offer alternatives to private vehicle transportation. By and large the energy systems used in society (including transportation) are fossil-fuel-based and show a limited increase in efficiency over time. IT technologies (based on incremental improvements of current – 2008 – technologies) support a steady growth in teleworking and virtual meetings, but there is no specific focus on achieving reductions in GHG emissions with such applications.

2.2 Policy world

Policy makers drive climate change action in the policy world, while the IT industry and the private sector focus on meeting regulatory requirements. Climate change policy targets traditional activities such as energy production and energy efficiency in buildings and in energy-intensive industries. Overall economies and societies become less dependent on fossil fuels and reduce their GHG emissions. The policies in place, however, are not effective at leveraging IT to reduce GHG emissions. Stimuli to adopt IT solutions that reduce GHG emissions are indirect or feeble.

2.3 Tech world

The tech world is a mirror image of the policy world. In this world, policy makers are unable to find the consensus needed to seriously tackle climate change. The IT industry, on the other hand, develops and directs technology towards reducing GHG emissions. When IT is the core component of a service (e.g., teleworking or virtual meetings), direct reductions in GHG emissions are achieved. When IT is deployed as a subcomponent of a wider system (e.g., in energy or transportation systems), IT-enabled improvements are generally utilized to increase performance without decreasing energy consumption and emissions. In both cases, additional resources (time and money) made available by the efficiency gains deriving from IT use are spent in goods, services, and activities that lead to further GHG emissions, thus generating negative rebound effects. In this world IT *swims against the current* as the efficiency gains and GHG emission reductions potentially enabled by IT are counterbalanced by a general socioeconomic setting that is not conducive to deeper GHG emission reductions.

2.4 Smart world

In the smart world, policy makers and the IT industry converge on the goal of reducing GHG emissions. Effective collaboration takes place and IT is a critical component in the portfolio of solutions devised by societies to eliminate the effects of climate change.

Together, policy makers and the IT industry seek to activate virtuous cycles of low-carbon feedback, which promote and leverage innovation in which IT is a key enabler. As low-carbon feedback loops unfold, transformative changes can take place at all levels of society, leading to reductions in GHG emissions across a broad range of activities. Virtual meetings and telecommuting are two of the many solutions that enable dramatic reductions of GHG emissions.

Low-carbon feedback – Making transformative emission reductions a reality[11]

Most scenarios and policy suggestions focus on incremental changes that lead to reduction in GHG emissions, which generally follow a linear path and are based on improvements to existing technologies (typically in the energy sector) and socioeconomic structures. Yet such changes are insufficient to achieve the GHG emission reductions that are necessary to avoid serious damages from climate change. A transformative change that results in accelerated GHG emission reductions is needed. While it is easier to advocate a path of transformative change, history shows that such changes are difficult to realize, as rapid shifts require new stakeholders to emerge. IT technologies, together with other advanced, nontypical energy solutions, such as integrated solar/LED/battery solutions, may play a key role in achieving such transformative changes. Vision and smart strategies from governments and private-sector companies leveraging IT technologies can enable emission reduction paths that lead to transformations, which in turn produce further GHG emission reductions, thus generating virtuous cycles of low-carbon feedback. An example is provided below.

Public authorities adopt e-government solutions across the board, coupled with a transformation of their back offices, which involves a generalized use of remote working solutions. Laws that hinder the adoption of remote working solutions are amended, while incentives are provided to companies that reduce GHG emissions with a smart use of IT (along with other, more traditional, strategies). Broadband access is generalized and communication and capacity-building campaigns are rolled out throughout society to increase the acceptance and adoption of virtual meetings and telecommuting.

An increase in virtual meetings and telecommuting, coupled with targeted communication and incentive schemes, leads to an increasing demand for smart buildings and a broader use of IT to obtain products or services (e-commerce, e-government, e-health, etc.).

The growing demand for e-commerce and e-services enables more companies to adopt telecommuting solutions for their employees and make their offices virtual as the initial demand generates a better infrastructure for additional services. In turn, with more people working from home and using the Internet to buy products and services, transportation patterns change while the need for private ownership of a vehicle decreases. Public authorities favor these trends through urban planning, creating more mixed-use communities (IT tools enable public authorities to undertake smart urban planning). Additional policies are adopted to reduce unnecessary travel and to promote public transport (e.g., real-time pricing for car pollution, enabled by IT).

As mixed-use communities increase in number, awareness and knowledge also increases in the wider society. Policy makers promote these trends with communication campaigns. As a result, people demand more policies that leverage technology to increase quality of life and reduce GHG emissions, and entire cities and countries become "smarter."

[11] The low-carbon and high-carbon feedback is developed further in the WWF report "The first global strategy for CO2 reductions with IT: A billion tons of CO_2 reductions and beyond through transformative change," available at www.panda.org/ict.

3 Quantitative analysis – Methodology

This report includes a quantitative analysis by geographic regions to estimate the GHG emissions that may take place in the different worlds described above, and focuses on the GHG emissions associated with business air travel and car-based commuting.[12]

The quantification approach is illustrated by the figure below.

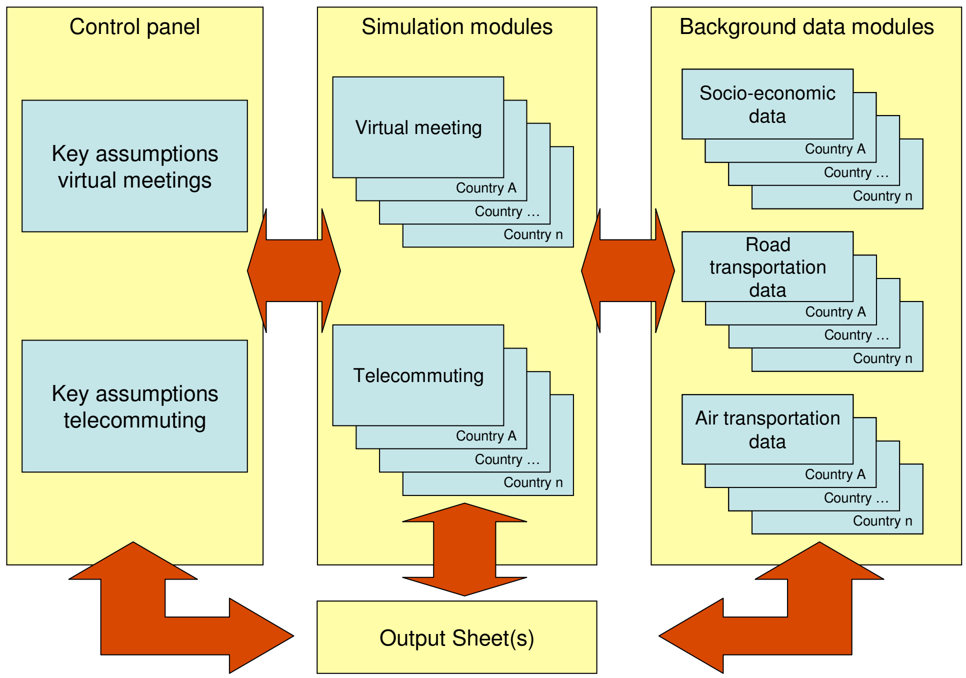


Figure 2. Quantitative analysis of GHG emissions

Background data were collected on socioeconomic indicators (e.g., population, income and occupation by sector), road transport (car ownership rates, average kilometers traveled, average fuel efficiency, commuting data, etc.), and air transport (total kilometers of air travel, business travel as a percentage of the total, average fuel consumptions per kilometer traveled, etc.).

For this background data, official statistics were used from various sources published by international organizations such as the Organization for Economic Cooperation and Development (OECD), the International Energy Agency (IEA), and the United Nations. For country-level data, official national statistics were used as well. Further details on the specific sources used for each set of data are provided in the annex to this report, as well as in the bibliography.

The background data informed the simulation modules, which projected socioeconomic activities and GHG emissions for the four worlds under investigation. In order to perform the simulations, key assumptions were devised for each of the four scenarios modeled. Such

[12] The focus of the analysis was on business air travel, as is it is one of the fastest-growing sources of GHG emissions. Other possible effects, such as changes in GHG emissions deriving from business travel undertaken by car or train (i.e., not business air travel), were not quantified. The analysis undertaken in section 5 will therefore provide an underestimate of the potential impact of ICT on business travel as a whole.

assumptions, and their rationale, are described in more detail in section 3.1 (below) and in the appendix.

3.1 Key assumptions – Approach

The table below summarizes the main variables used in the simulation model and illustrates the approach followed in selecting the key model assumptions. The table provides a description of the main assumptions utilized in the model. More detailed information on the numerical values utilized in the simulation is provided in the appendix.

Commuting

	Carbon world	Policy world	Tech world	Smart world
Car ownership rate prior to teleworking	Based on past trends and GDP growth projections	Lower than carbon world	Same as in carbon world	Lower than policy world
% home workers	Future growth based on historic penetration and perceived long- term penetration potential in a carbon world	Marginally higher than in carbon world	Higher than policy world	Higher than tech world
Energy efficiency in vehicles	Based on past trends	Higher efficiency gains than in carbon world	Same efficiency gains as carbon world	Same efficiency gains as policy world
Additional electricity used by the IT solutions that enable IT	Following historic development	Lower than carbon world	Lower than policy world	Same as tech world
Electricity grid GHG emissions	Grid emission data with some decrease over time	Lower than carbon world	Same as carbon world	Same as policy world (could be lower)
Additional travel for leisure and chores (direct rebound effect)	Based on historical data and constant over time	Lower than carbon world	Same as carbon world	Lower than policy world
Number of home workers giving up their vehicle	Zero	Slight reduction	Zero	Higher than in policy world and growing over time
Indirect rebound effect[13]	Additional GHG emissions deriving from additional disposable income or profits; decreasing over time as for past trends	Lower than carbon world	Same as carbon world	Lower than policy world, and as virtuous cycles of low-carbon feedback result in further GHG reductions

Table 9: Summary assumptions, commuting.

[13] The GHG emissions associated with the expenditure of the additional economic resources made available by teleworking were used as a combined indicator for several indirect effects, such as purchases of goods or services, home improvements/investments/moves, and changes in lifestyles and values. As discussed in section 1.4, each of these activities may be associated with increased or decreased GHG emissions.

For some of the key assumptions utilized in the model, and for selected countries (USA, EU, China), the numerical values for year 2030 are reported in the tables below.

Table 10: USA Commuting—2030

	Historical 2005	Carbon world	Policy world	Tech world	Smart world
Teleworkers as % of car commuters	17%	30%	33%	41%	46%
Telecommuting days per week	2.70	2.84	2.92	3.24	3.50
Average reduction in km traveled by teleworkers	2,566	2,643	2,475	3,019	2,965
Average fuel economy for cars (L/100 km) (calculated)	11.6	11.1	10.3	11.1	10.3
Electricity used by teleworking devices per hour of teleworking (kWh)	0.05	0.05	0.04	0.02	0.02
Grid emission factor (kgCO_2/kWh)	0.52	0.52	0.33	0.52	0.33
Direct rebound effect (increase in km traveled as % of km saved with teleworking)	25%	25%	15%	25%	5%
% teleworkers giving up their vehicle	0%	1.1%	2.2%	1.1%	23.3%
Indirect rebound effect – kg CO_2 emissions per $ saved by teleworkers (and spent on goods or services)	0.64	0.56	0.34	0.56	0

Table 11: EU Commuting—2030

	Historical 2005	Carbon world	Policy world	Tech world	Smart world
Teleworkers as % of car commuters	8%	25%	29%	37%	42%
Telecommuting days per week	1.00	1.72	2.00	2.22	2.95
Average reduction in km traveled by teleworkers	750	1,244	1,314	1,603	1,939
Average fuel economy for cars Average cars on road fuel economy (L/100 km) (calculated)	7.8	7.0	6.5	7.0	6.5
Electricity used by teleworking devices per hour of teleworking (kWh)	0.05	0.05	0.04	0.02	0.02
Grid emission factor (kgCO_2/kWh)	0.35	0.35	0.18	0.35	0.18
Direct rebound effect (increase in km traveled as % of km saved with teleworking)	25%	25%	15%	25%	5%
% teleworkers giving up their vehicle	0%	1.1%	2.2%	1.1%	23.3%
Indirect rebound effect – kg CO_2 emissions per $ saved by teleworkers (and spent on goods or services)	0.39	0.34	0.20	0.34	(0.1)

Table 12: China Commuting—2030

	Historical 2005	Carbon world	Policy world	Tech world	Smart world
Teleworkers as % of car commuters	4%	15%	18%	24%	32%
Telecommuting days per week	1.00	1.72	1.75	1.94	2.50
Average reduction in km traveled by teleworkers	900	1,454	1,345	1,955	1,921
Average fuel economy for cars Average cars on road fuel economy (L/100 km) (calculated)	11.4	10.1	9.1	10.1	9.1
Electricity used by teleworking devices per hour of teleworking (kWh)	0.05	0.05	0.04	0.02	0.02
Grid emission factor (kgCO_2/kWh)	0.79	0.79	0.62	0.79	0.62
Direct rebound effect (increase in km traveled as % of km saved with teleworking)	25%	25%	15%	25%	5%
% teleworkers giving up their vehicle	0%	1.1%	2.2%	1.1%	51.7%
Indirect rebound effect – kg CO_2 emissions per $ saved by teleworkers (and spent on goods or services)	0.90	0.75	0.53	0.75	0.2

Table 13: Business-related Air Travel

	Carbon world	Policy world	Tech world	Smart world
Km traveled prior to virtual meetings	Projections from several sources	Lower than carbon world	Higher than in carbon world	Lower than policy world
% reduction in km traveled due to virtual meetings	Based on historical data and a slow growth	Marginally higher than carbon world	Higher than policy world	Higher than tech world
Energy efficiency in airplanes	Baseline on past trends	Higher efficiency gains than carbon world	Same efficiency gains as carbon world	Same efficiency gains as policy world
Additional electricity used by the IT solutions that enable IT	Following current trends	Lower than carbon world	Lower than policy world	Same or lower than in policy world
Electricity grid GHG emissions	Grid emission data with some decrease over time	Lower than carbon world	Same as carbon world	Same as policy world (could be lower)
Direct rebound effects	Based on historical data and constant over time	Lower than in carbon world	Higher than carbon world (high-carbon feedback)	Lower than policy world
Indirect rebound effects	Based on the GHG intensity of the economy; decreasing over time, as for past trend	Lower than carbon world	Same as carbon world	Lower than policy world, with further reductions of GHG emissions over time as virtuous cycles of low-carbon feedback are achieved

For some of the key assumptions utilized in the model, and for selected countries (USA, EU, China), the numerical values for year 2030 are reported in the tables below.

Table 14: USA Virtual Meetings—2030

	Historical 2005	Carbon world	Policy world	Tech world	Smart world
Business travel avoided thanks to virtual meetings (%)	8%	27%	30%	50%	66%
Additional electricity used per hour of virtual meeting (kWh)	2.43	2.43	1.94	0.85	0.49
Grid emission factor ($kgCO_2/kWh$)	0.52	0.52	0.33	0.52	0.33
Negative rebound effect as % of km initially saved by virtual meetings	25%	25%	10%	25%	
Indirect rebound effect – kg CO_2 emissions per $ saved by teleworkers (and spent on goods or services)	0.64	0.56	0.34	0.56	0

Table 15: EU Virtual Meetings—2030

	Historical 2005	Carbon world	Policy world	Tech world	Smart world
Business travel avoided thanks to virtual meetings (%)	5%	22%	29%	44%	64%
Additional electricity used per hour of virtual meeting (kWh)	2.43	2.43	1.94	0.85	0.49
Grid emission factor ($kgCO_2/kWh$)	0.35	0.35	0.18	0.35	0.18
Negative rebound effect as % of km initially saved by virtual meetings	25%	25%	10%	25%	5%
Indirect rebound effect – kg CO_2 emissions per $ saved by virtual meetings (and spent on goods or services)	0.39	0.34	0.20	0.34	(0.1)

Table 16: China Virtual Meetings—2030

	Historical 2005	Carbon world	Policy world	Tech world	Smart world
Business travel avoided thanks to virtual meetings (%)	1%	17%	19%	24%	37%
Additional electricity used per hour of virtual meeting (kWh)	2.43	2.43	1.94	0.85	0.49
Grid emission factor ($kgCO_2/kWh$)	0.79	0.79	0.62	0.79	0.62
Negative rebound effect as % of km initially saved by virtual meetings	25%	25%	10%	25%	5%
Indirect rebound effect – kg CO_2 emissions per $ saved by virtual meetings (and spent on goods or services)	0.90	0.75	0.53	0.75	0.2

The quantification model entails several tables with input data and assumptions for each geographic area analyzed and for the time period until 2050. Key assumptions tables are reported and discussed in the appendix.

4 Quantitative analysis – Simulation results and discussion

The approach described above enabled the simulation of various paths of development with corresponding calculations of the possible impact on CO_2 emissions.

For each of the worlds, the simulations undertaken project several emission paths, including

- "baseline" GHG emissions that would occur, in different worlds, in the absence of any teleworking or virtual meetings;
- GHG emissions net of the direct impact of teleworking or virtual meetings (i.e., only accounting for the reduction in commuting travel, without considering any rebound effect, positive or negative), with and without a correction for GHG emissions associated with the electricity used by IT devices; and
- GHG emissions net of the impact of teleworking or virtual meetings and of relevant rebound effects deriving from the availability of additional time or income.

Thus the analysis allows for comparisons between different worlds (e.g., to contrast commuting emissions in two different worlds) and within individual worlds (e.g., to air-travel emissions net of direct virtual-meeting impact with air-travel emissions that are also corrected for different rebound effects).

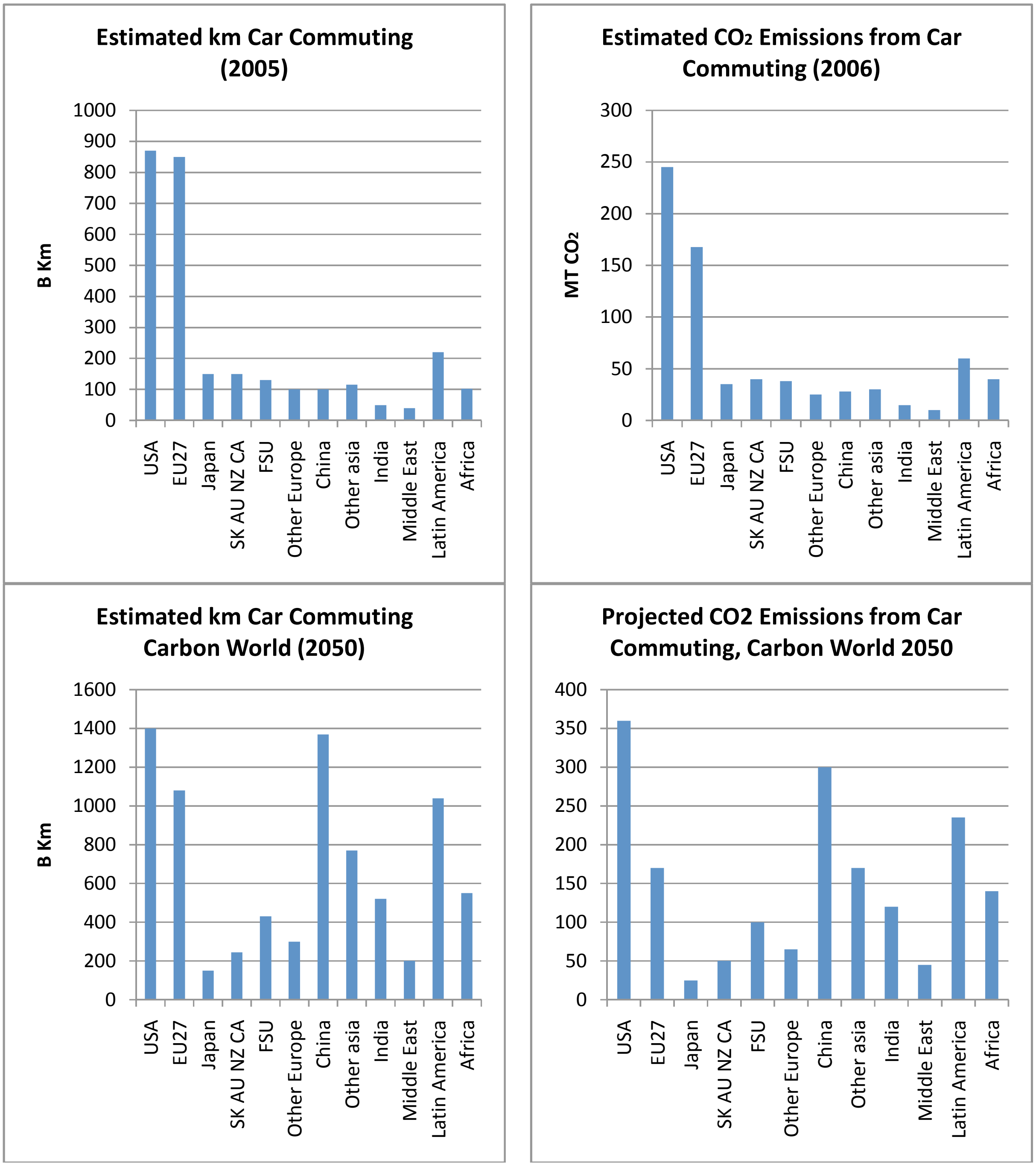
Key findings are reported and discussed below.

4.1 Teleworking

For teleworking, the analysis focused on modeling the possible reductions in CO_2 emissions deriving from the teleworkers' reduced use of privately owned cars for commuting purposes. Possible positive and negative rebound effects are also considered in the analysis, in terms of additional kilometers traveled for chores or leisure and from increasing/decreasing emissions deriving from the use of disposable income or profits made available by transportation savings. Possible reductions in the emissions generated by public transportation, on the other hand, are not considered in the analysis, under the conservative assumption that the number of public transportation vehicles, which are used to transport commuters, would not decrease even if a significant proportion of workers worked from somewhere other than the office.

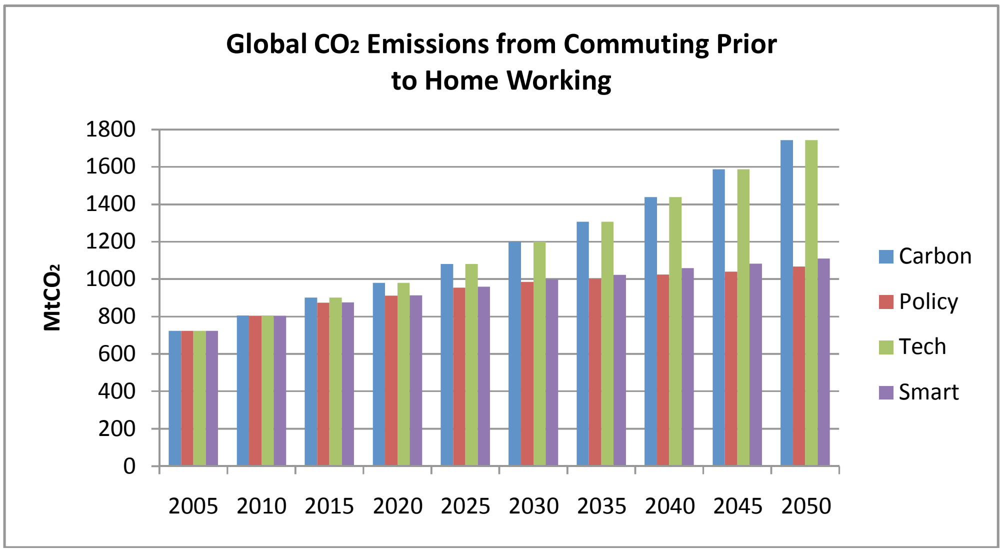
Commuting is currently estimated to represent between 27 and 50 percent of overall kilometers traveled, and emissions produced, by privately owned cars, depending on the region.[14] Typically between 3,000 and 5,000 kilometers per annum per vehicle are due to commuting, leading to overall emissions at global scale of about 800 $MtCO_2$ (2005 data), as compared to a total from privately owned cars of about 2,600 $MtCO_2$. Current projections for increases in car ownership would lead to a significant growth in distance traveled, and associated emissions, especially in rapidly growing and developing countries. This is highlighted in the graphs below, illustrating the projections of the carbon world.

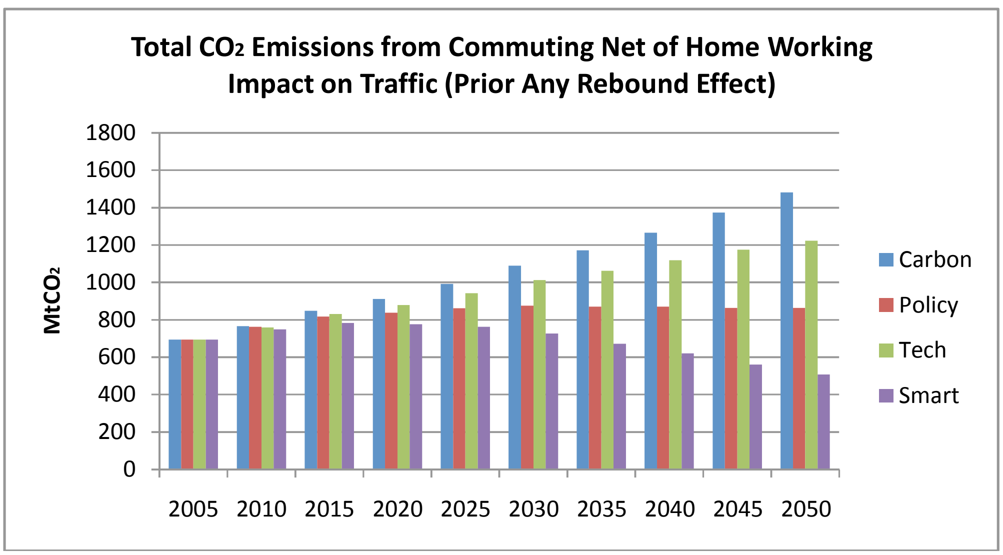
[14] Detailed data on commuting behavior are not readily available for many countries, especially less developed ones. Wealthier regions with higher disposable incomes, shorter working weeks, and better public transportation systems typically show a higher proportion of leisure travel.

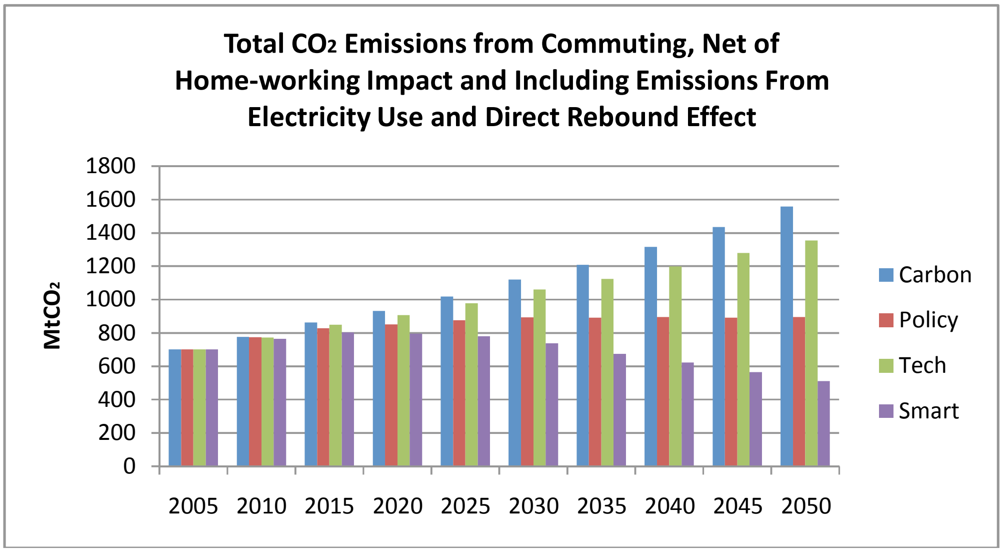


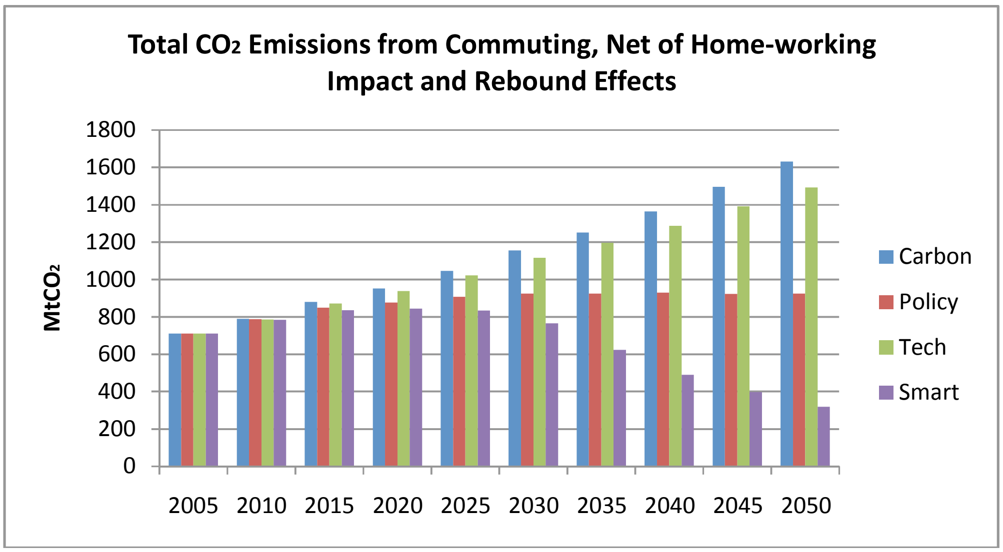
Graph 8: Kilometers of car commuting and CO_2 emissions carbon world, 2005 and 2050.

Comparing projections for commuting-related car emissions for the four worlds suggests that, worldwide, in the absence of teleworking, GHG emissions would continue to grow on a relatively steady linear trend in the carbon and tech worlds, and at a lower rate in the policy and smart worlds (see graphs below). If the net impact of home working is added, all projections result in a reduction in GHG emissions, which is limited in carbon world, moderate in both the policy and tech worlds, and more dramatic in the smart world. Specifically, the impact of home working on commuting emissions from cars would result in a reduction in the growth trend in a carbon and tech world, would achieve a stabilization of emissions in a policy world, and would only deliver an overall reduction in emissions in a smart world. When rebound effects are accounted for in both the carbon and tech worlds, the initial reductions in transportation emissions are partially counterbalanced by additional emissions deriving from electricity use (minimal impact), increasing travel from leisure and chores, and additional GHG-generating expenditures. This indicates that in the absence on aggressive policy, current trends of emission growth would not be effectively mitigated. This also highlights that even if the IT industry focuses on devising solutions to reduce CO_2 emissions (tech world), the overall outcome would not be a net reduction in commuting emissions if the broader socioeconomic environment in which the IT industry operates fails substantially at the task of tackling global warming.





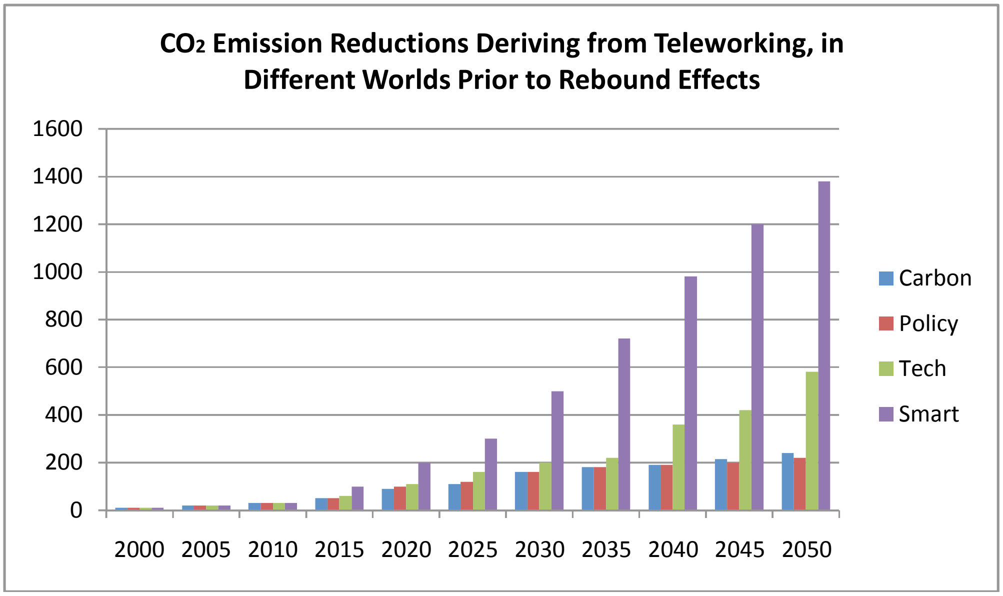


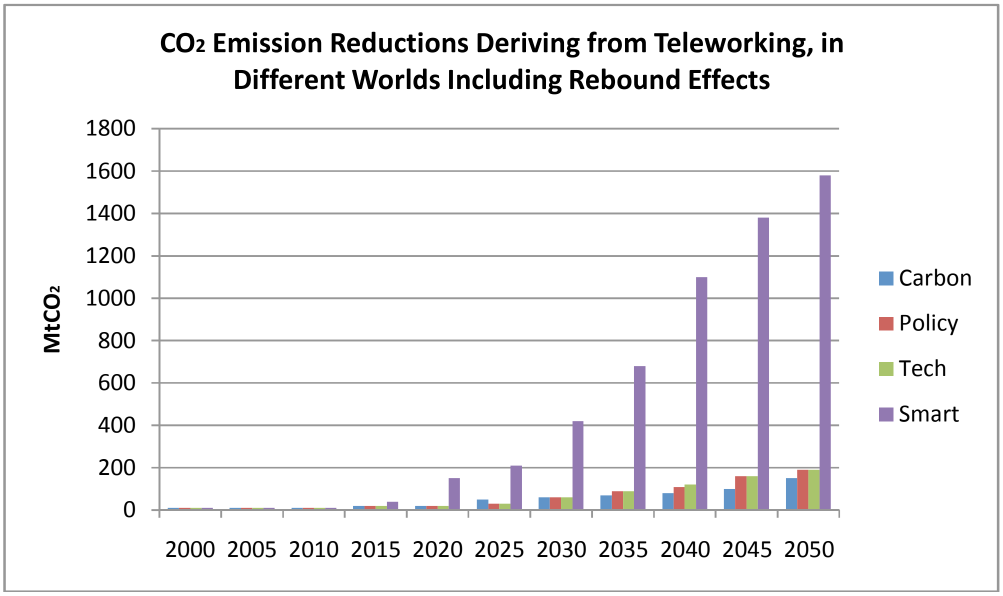


Graph 9: CO_2 from commuting and rebound effects in different worlds.

A closer look at the CO_2 emission reductions that teleworking can generate within different worlds, however, reveals that home working can provide a larger contribution in terms of GHG emission reductions in both smart and tech worlds, as compared to the carbon and policy worlds. This indicates that whereas in a policy world a larger share of the emission reductions achieved could be attributed to policies (which lead to an increased use of IT solutions but also reduce their GHG impact), when such policies are lacking, the active engagement of the IT industry can play a significant role. This holds true if rebound effects are taken into account. When considering both direct emission reductions and direct rebound effects, about 197 $MtCO_2$ would be saved in 2030 by a proactive IT industry, compared to a savings of 117 $MtCO_2$ without such engagement. Even if stringent indirect rebound effects are simulated, the tech world would outperform the carbon world by over 41 $MtCO_2$ by 2030, delivering total emission reductions of about 93 $MtCO_2$, and by over 152 $MtCO_2$ by 2050, delivering total emission reductions of about 286 $MtCO_2$. The greatest impact in terms of GHG emission reductions enabled by teleworking, however, would be achieved in a smart world, where total emission reductions of 455 $MtCO_2$ and 1575 $MtCO_2$ would be achieved in 2030 and 2050, respectively. In smart world, indirect rebound effects would produce an increase in GHG emissions in 2030 (of about 38 $MtCO_2$) and a decrease (of about 191 $MtCO_2$)

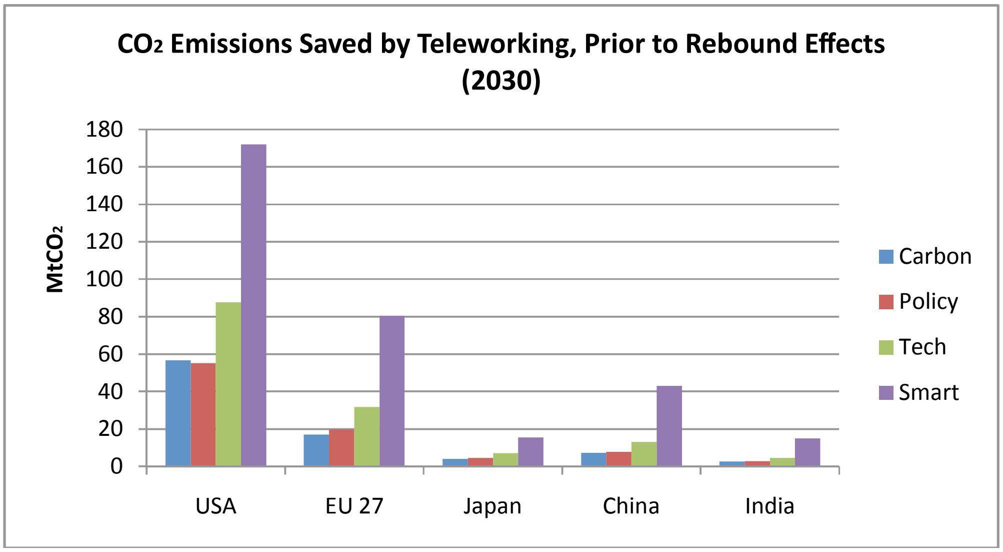
in 2050. This is due to the fact that over the 2030–2050 period, a growing number of regions are assumed to deploy policies and strategies that can effectively channel the additional economic resources generated by the reduction in transportation costs enabled by teleworking into activities that lead to further reductions of GHG emissions.

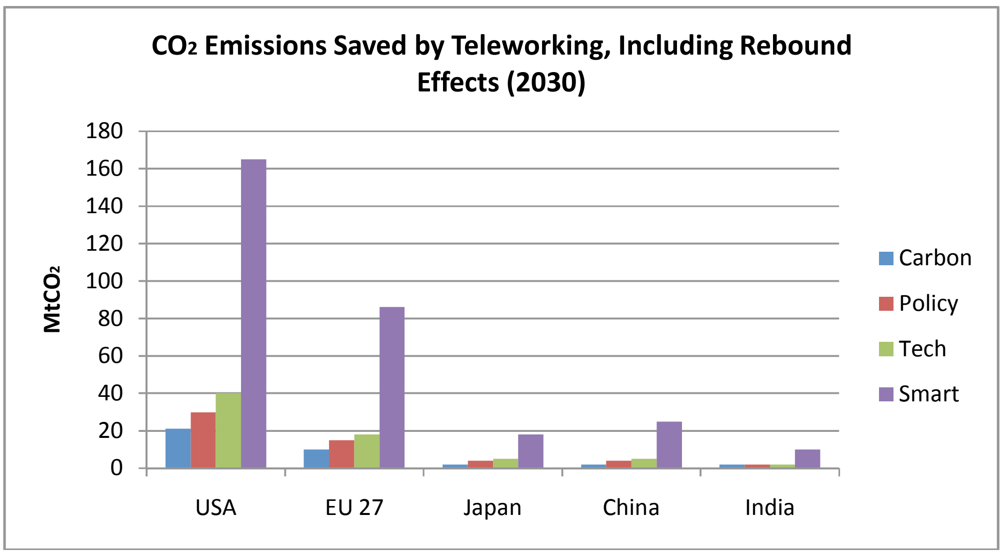


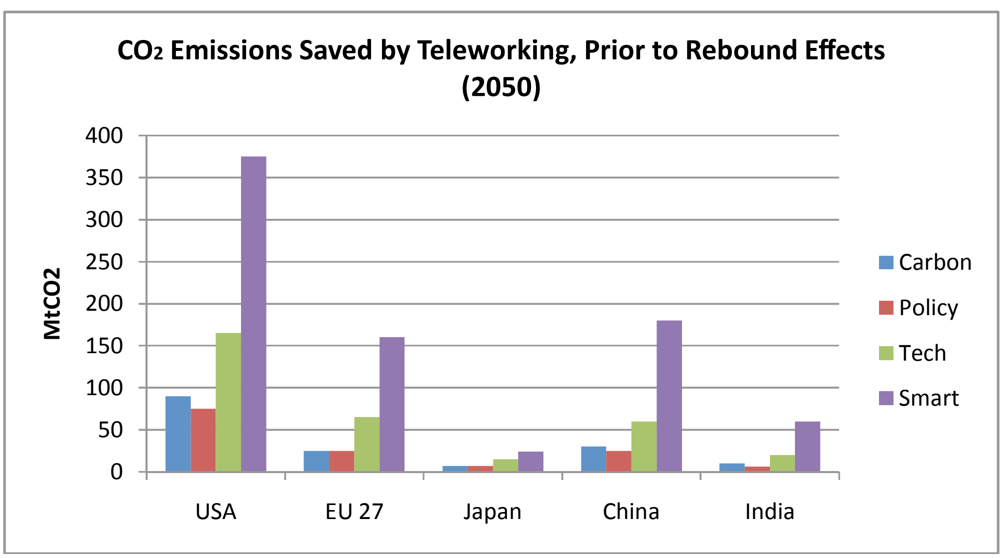


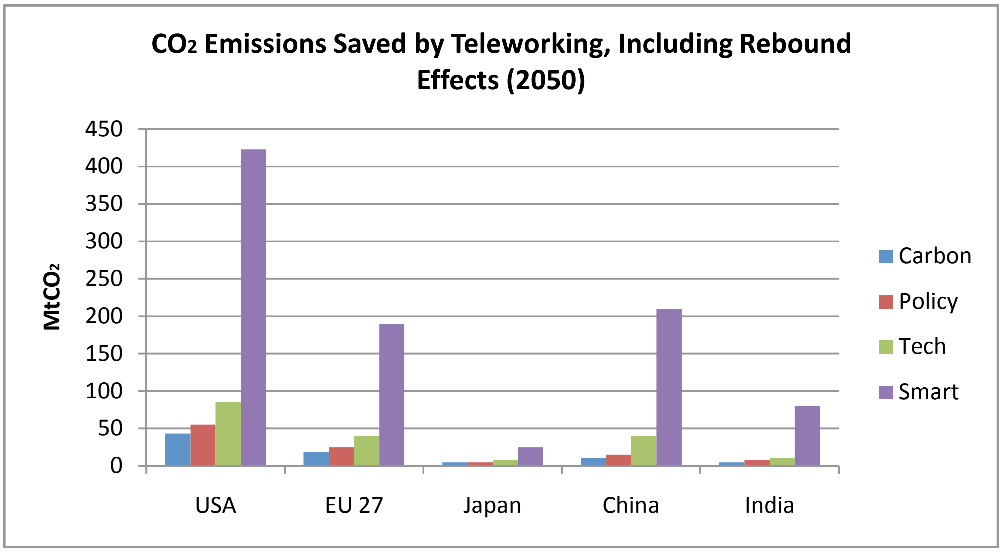
Graph 10: CO_2 emission reductions from teleworking in different worlds.

A breakdown by region shows that within each world teleworking generates the greatest reductions in emissions in OECD countries, regardless of the future world simulated in the projection. This reflects both the higher numbers of knowledge workers in OECD countries and the greater penetration of privately owned vehicles. Over time, however, the potential impact of teleworking becomes significant in developing countries as well, as shown by the 2050 projections reported below.


CO₂ Emissions Saved by Teleworking, Prior to Rebound Effects (2030)
MtCO₂
180
160
140
120
100
80
60
40
20
0
USA
EU 27
Japan
China
India
Carbon
Policy
Tech
Smart

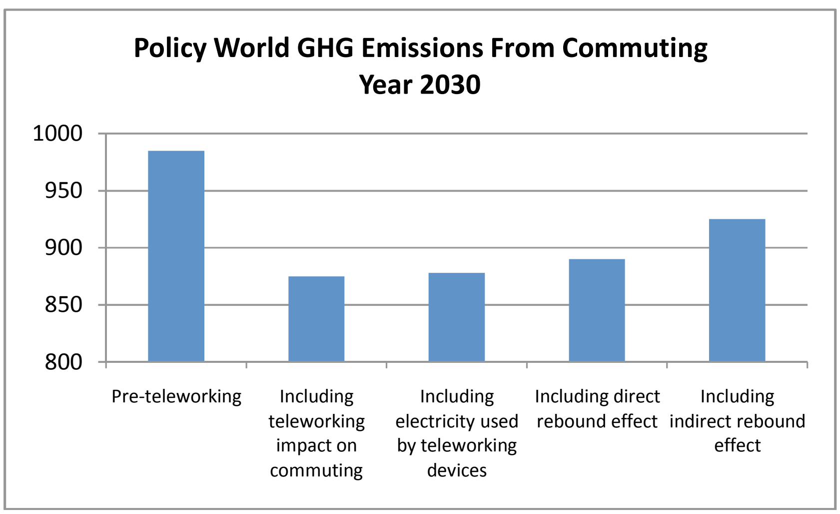

CO₂ Emissions Saved by Teleworking, Including Rebound Effects (2030)
MtCO₂
180
160
140
120
100
80
60
40
20
0
USA
EU 27
Japan
China
India
Carbon
Policy
Tech
Smart

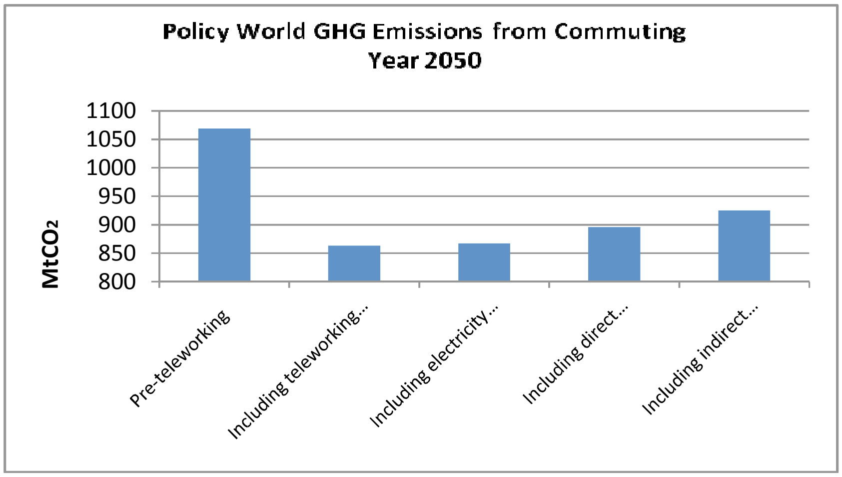

CO₂ Emissions Saved by Teleworking, Prior to Rebound Effects (2050)
MtCO2
400
350
300
250
200
150
100
50
0
USA
EU 27
Japan
China
India
Carbon
Policy
Tech
Smart

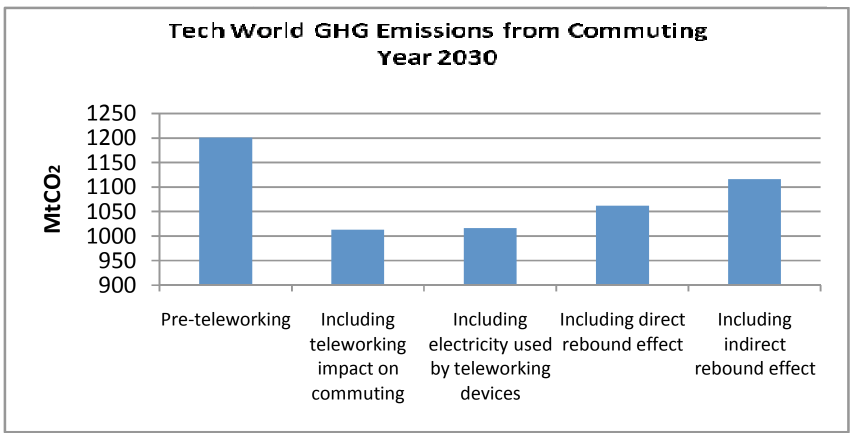


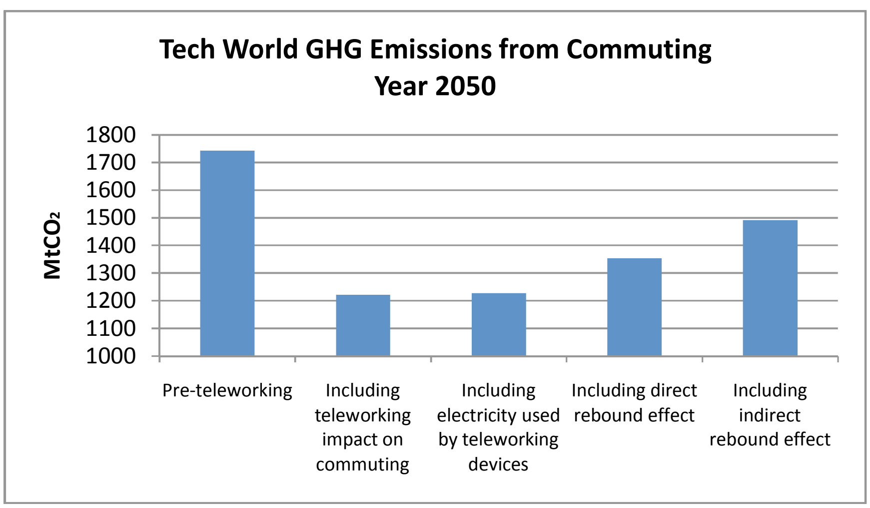
Graph 11: CO_2 emission reductions enabled by teleworking in different regions.

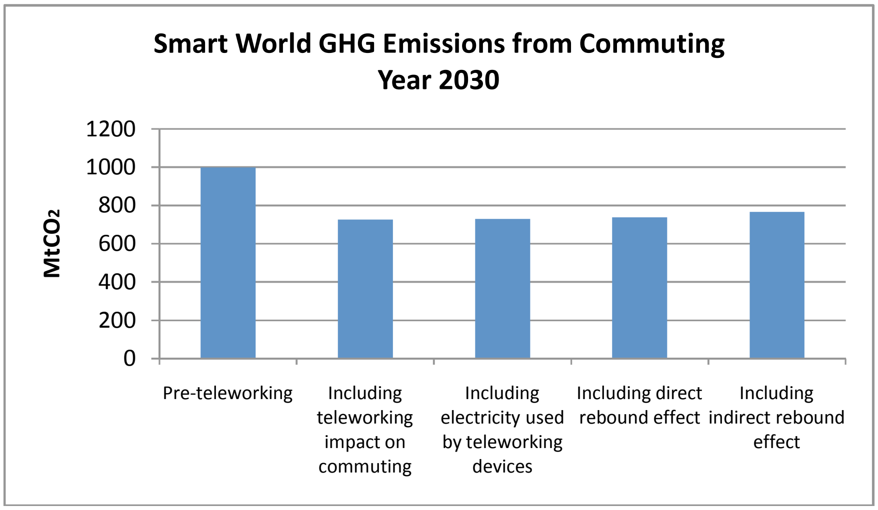
Even considering potential rebound effects, teleworking leads to reductions in GHG emission in all worlds. However, in projections such as for the carbon world, which assumes lower efficiency in IT equipment, the net impact on CO_2 emissions will be significantly reduced, as higher rates of CO_2 emissions associated with electricity production and greater rebound effects deriving from the additional resources (time and money) made available by teleworking need to be taken into consideration. The graphs below provide further detail on the impact that various rebound effects can have on the emission reductions generated by teleworking.

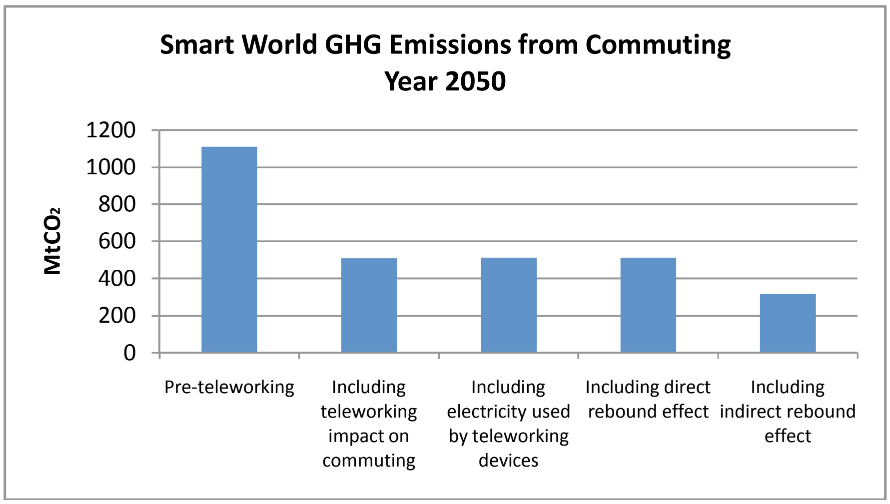



Policy World GHG Emissions from Commuting
Year 2050
MtCO2
1100
1050
1000
950
900
850
800
Pre-teleworking
Including teleworking...
Including electricity...
Including direct...
Including indirect...


Tech World GHG Emissions from Commuting
Year 2030
MtCO2
1250
1200
1150
1100
1050
1000
950
900
Pre-teleworking
Including teleworking impact on commuting
Including electricity used by teleworking devices
Including direct rebound effect
Including indirect rebound effect

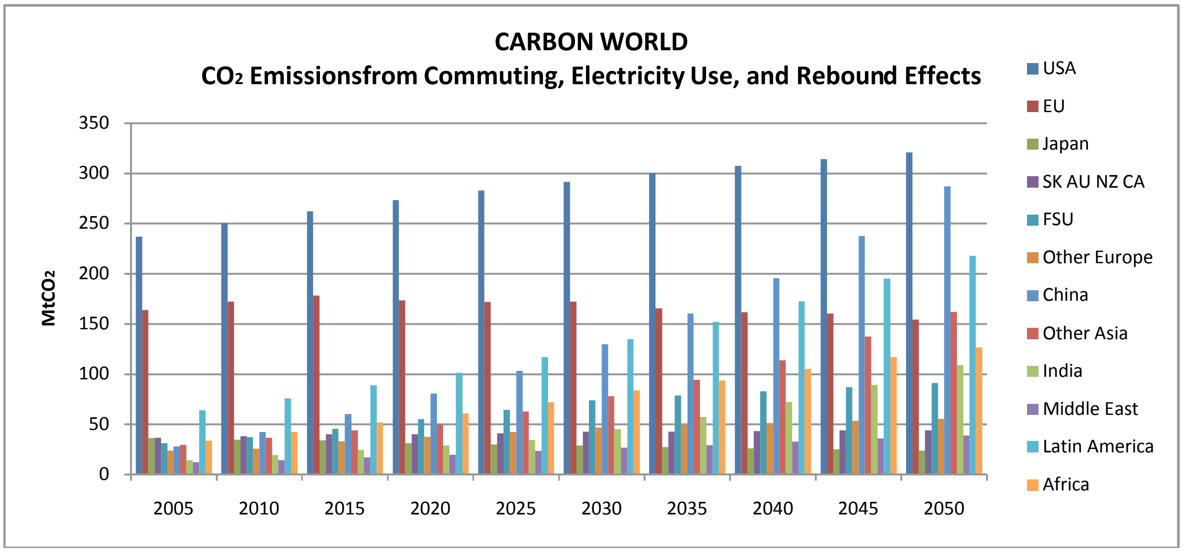

Tech World GHG Emissions from Commuting
Year 2050
MtCO2
1800
1700
1600
1500
1400
1300
1200
1100
1000
Pre-teleworking
Including teleworking impact on commuting
Including electricity used by teleworking devices
Including direct rebound effect
Including indirect rebound effect



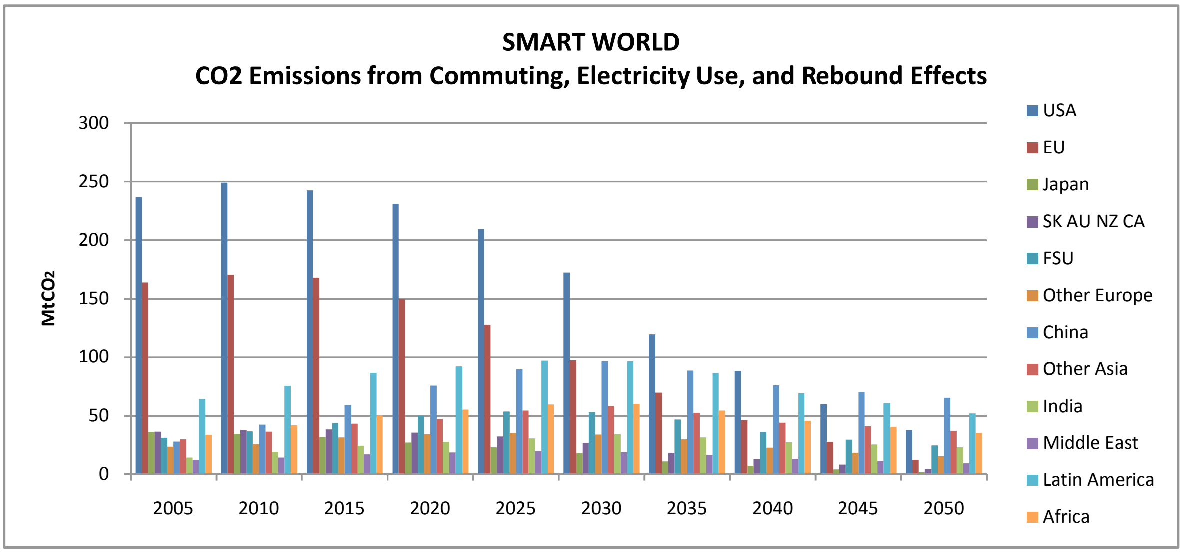


Graph 12: CO_2 emissions with teleworking and various rebound effects worldwide 2030 and 2050.

A comparison of net emissions over time in the smart and carbon worlds highlights how the combined action of policy makers and IT industry leads CO_2 emissions to peak between 2010 and 2015 in developed countries while dramatically slowing down the projected growth in developing countries, where a peak in emissions is reached around 2030, followed by a decline in net emissions.

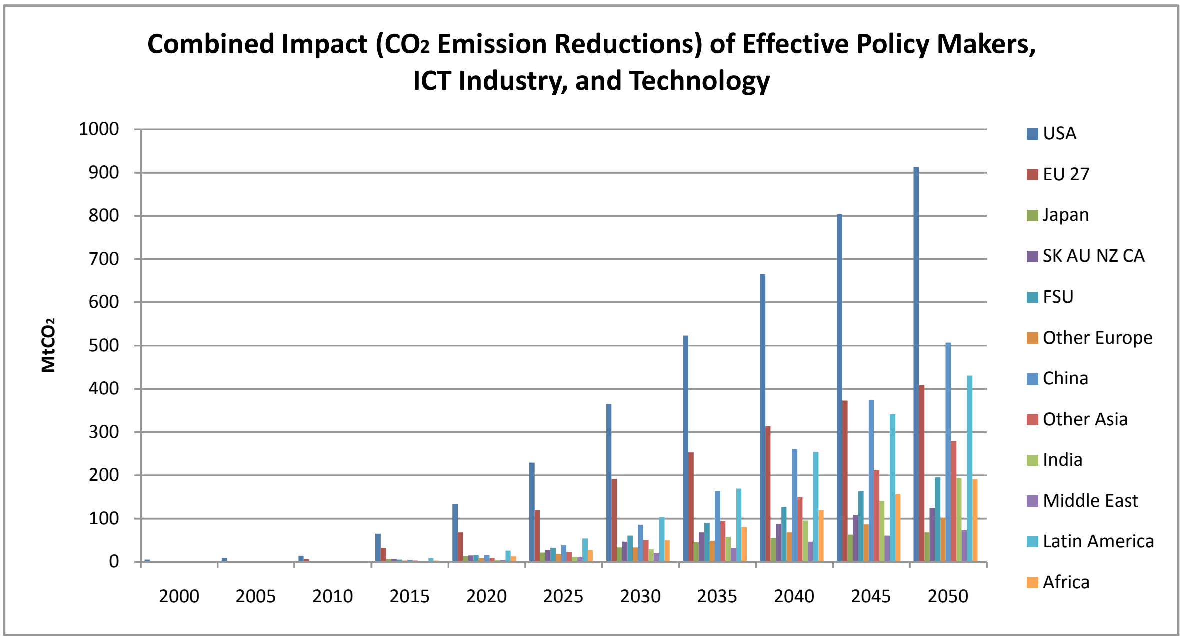


Graph 13. 2005–2050 CO_2 emission from commuting, electricity use, and rebound effects in a carbon world.



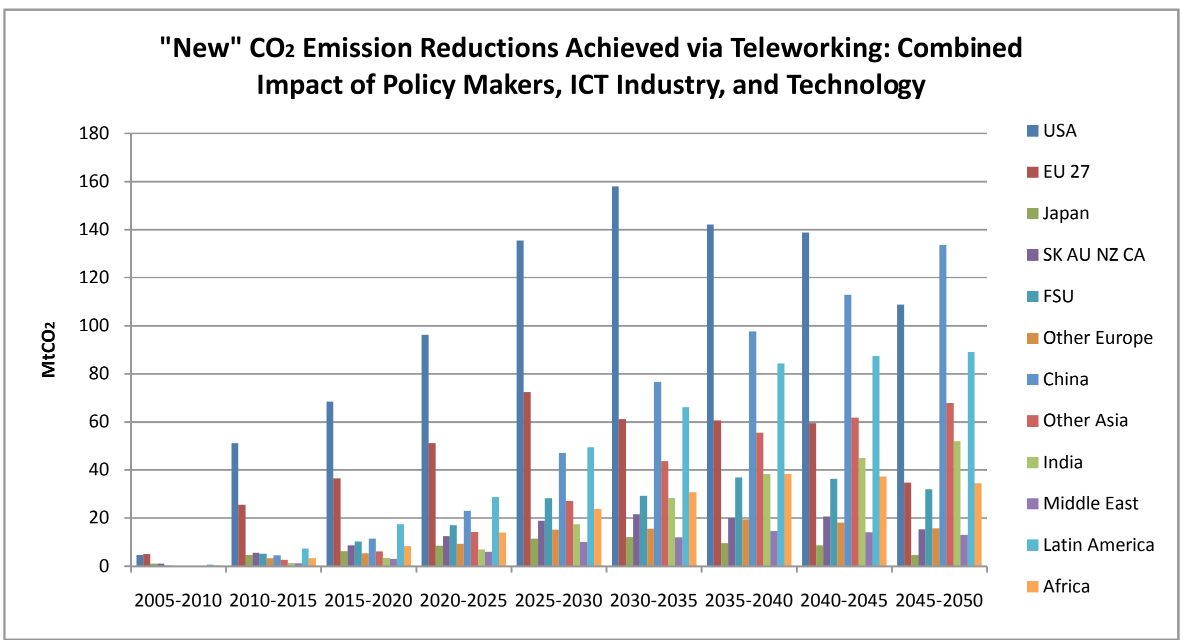
Graph 14: 2005–2050 CO_2 emissions from commuting, electricity use, and rebound effects in a smart world.

Comparing the CO_2 emissions of a carbon world pre-telecommuting to those of a smart world, including the impact of teleworking, provides a measure of the overall impact that active and effective policy makers and an engaged IT industry can achieve with technology (see graph below).



Graph 15: Combined impact of effective policy makers, IT industry, and technology.

The graph highlights that overall almost 3.5 billion tons of CO_2 emissions can be saved in 2050. Whereas the largest contribution to such savings will come from OECD countries, over time significant emission reductions are also generated in developing and emerging countries. This dynamic is even more evident when looking at the new savings (i.e., increases of CO_2 emission reductions compared to the previous period) generated in any given period (see below).



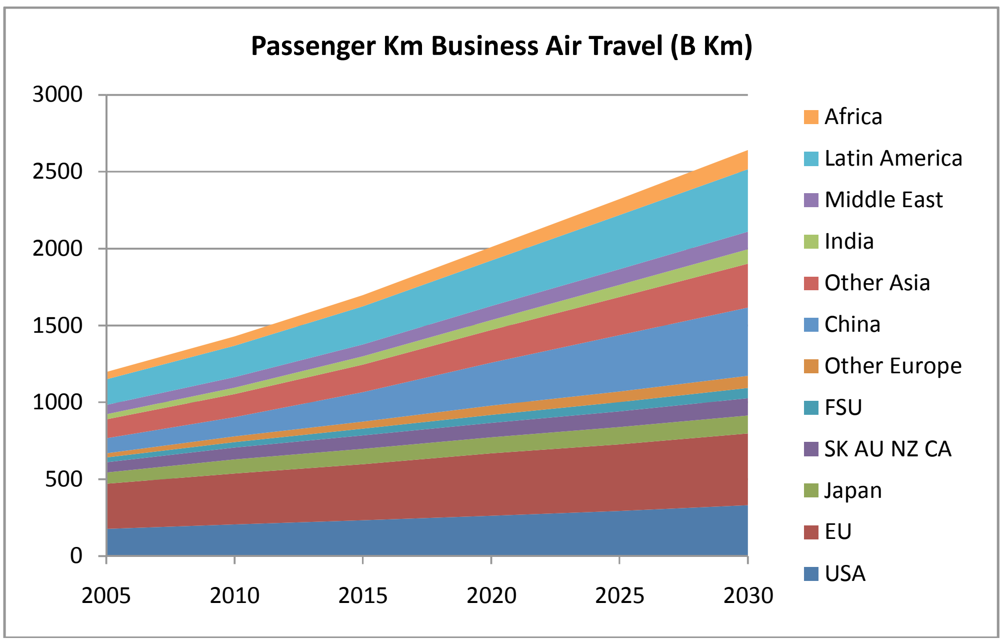
Graph 16: New CO_2 emission reductions by country over time—combined impact of effective policy makers, IT industry, and technology.

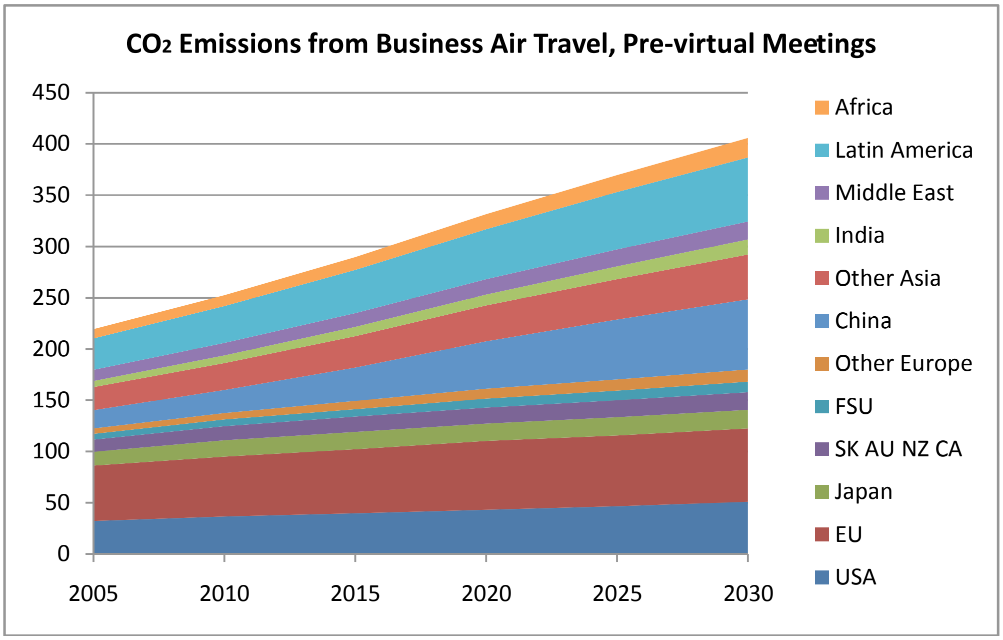
As highlighted above, while new savings peak in OECD countries between 2025 and 2035, developing and emerging countries from Asia and Latin America provide a growing proportion of the additional savings achieved, delivering the majority of new savings starting from about 2030. This insight can provide useful guidance to both policy makers and the IT industry in terms of focus for action and timing.

It must be pointed out that uncertainty associated with the analysis undertaken must be considered high, as relevant data is currently missing in a number of areas. Despite this limitation, however, the analysis highlights that combined actions of policy makers and the IT industry can deliver results that are dramatically superior in terms of GHG emission reductions achieved. The analysis also shows that whereas OECD countries will likely deliver the majority of emission reductions in the short term, developing and emerging countries will play a preponderant role over time.

Virtual meetings

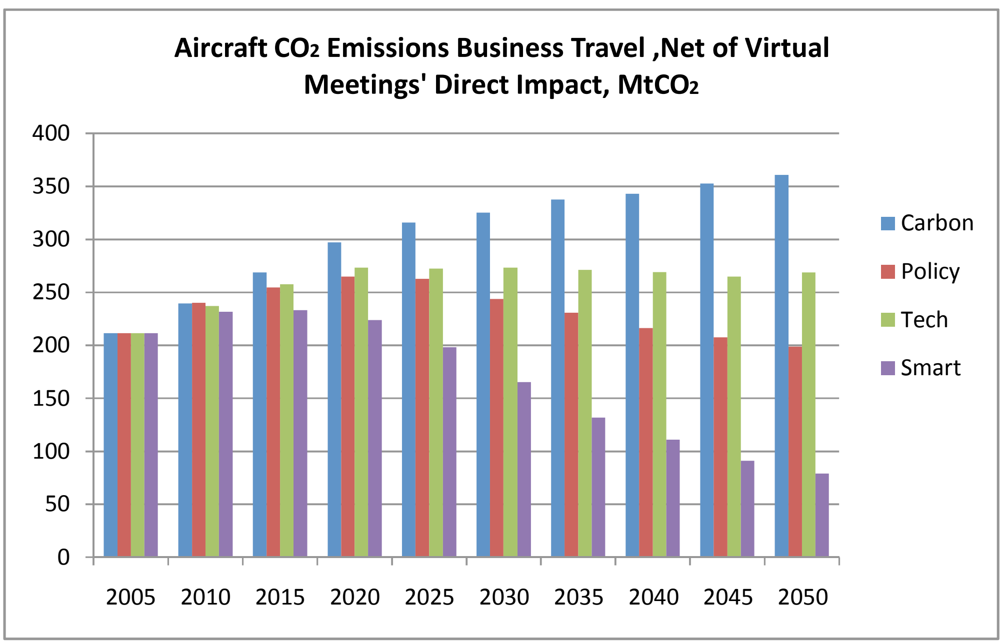
To quantify the possible GHG benefits of virtual meetings, the analysis focused on business air travel, as this activity can most clearly be targeted for substitution by virtual-meeting solutions, and because air travel is a growing source of CO_2 emissions and thus a topic of concern in the climate policy debate (see below.

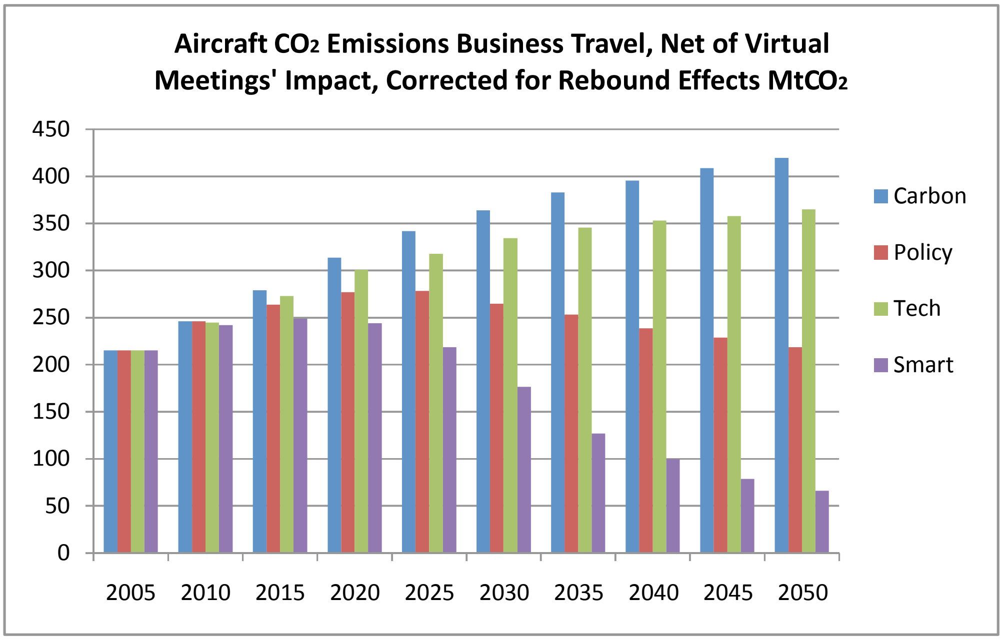




Graph 17: Business air travel, kilometers traveled, and associated CO_2 emissions.

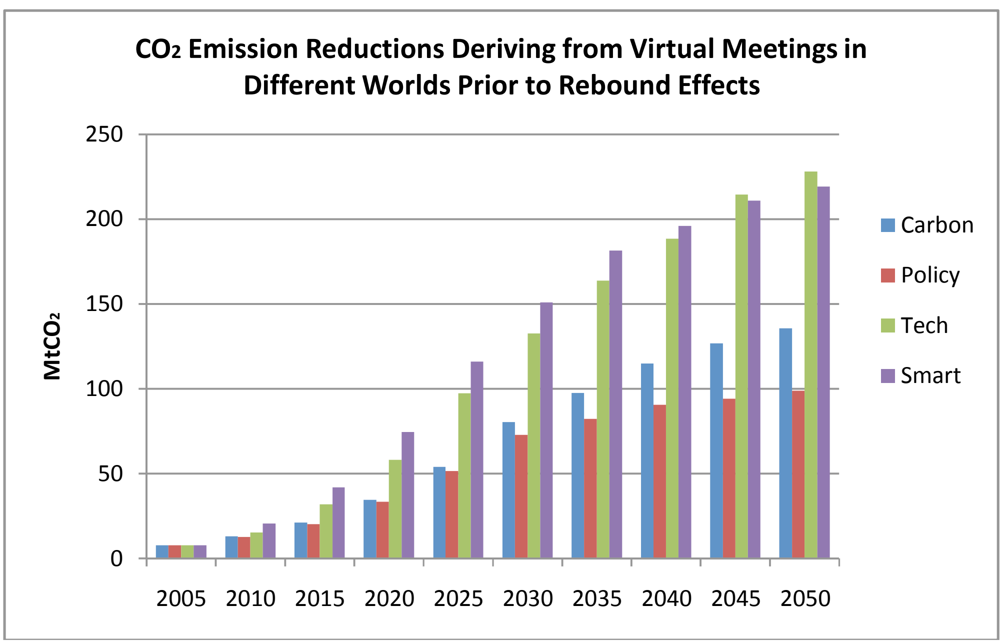
As virtual meetings can also substitute shorter trips that would not occur via airplane, the projections discussed below can be considered conservative. As with telecommuting, in addition to direct emission reduction generated by virtual meetings, possible rebound effects are also considered in the analysis. The graphs below highlighted the total CO_2 emissions projected for business travel in the different worlds analyzed.

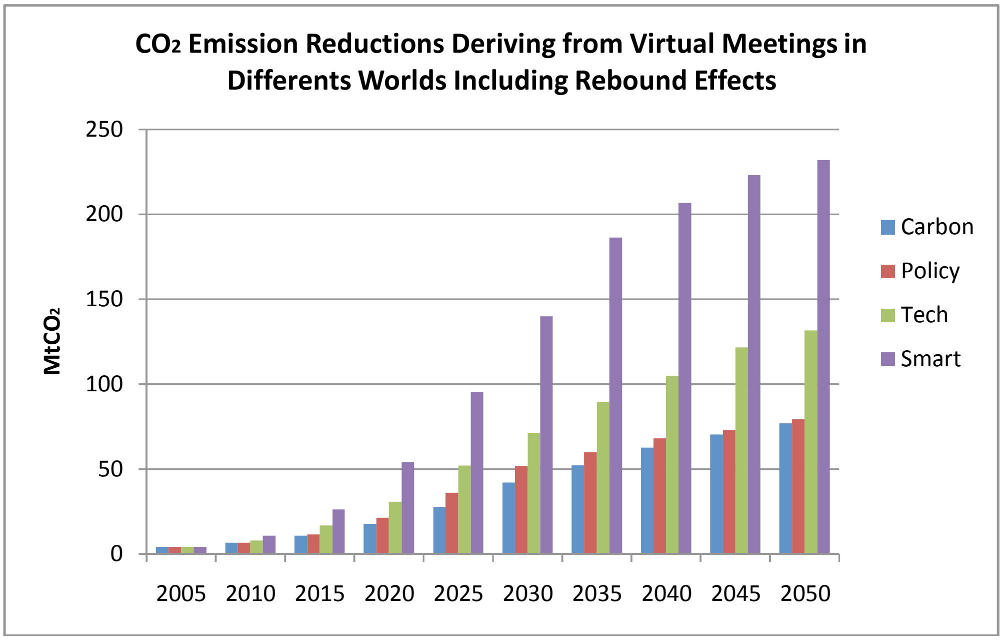




Graph 18: CO_2 emissions from aircraft business travel in different worlds.

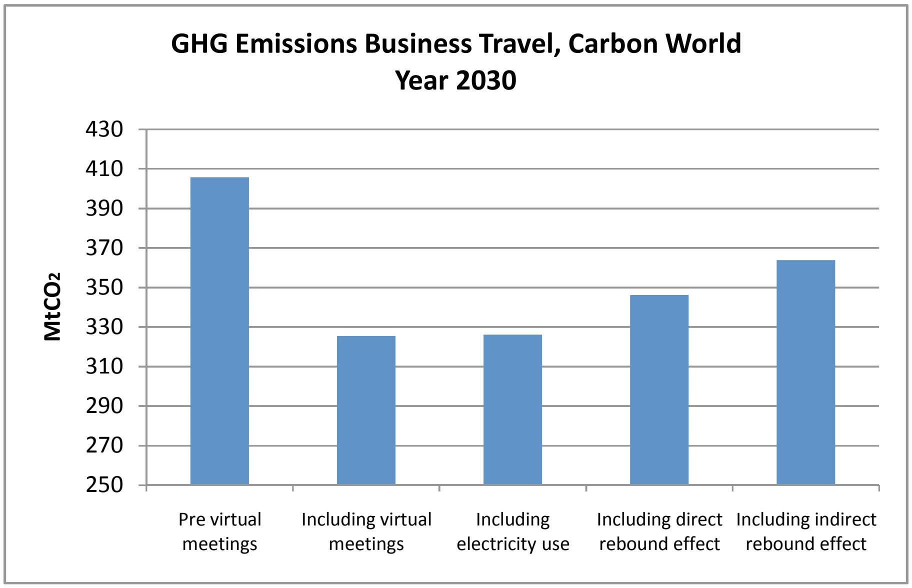
In both a carbon and a tech world, business air-travel emissions would continue to grow despite the mitigating impact of virtual meetings. In the policy and smart worlds, however, emissions from business travel would be reduced. In a tech world, in the absence of policy leadership, the IT industry could play a significant role, as a higher adoption of virtual meetings (driven by the IT industry) coupled with a relatively inefficient transport sector (caused by lack of strong climate change policy) would lead to significant gross reductions in emissions (see graphs below, left). Unfortunately, lack of strong climate change policies would also mean the presence of significant negative rebound effects, which would counterbalance a significant proportion of the direct gains achieved with virtual meetings (graphs below).

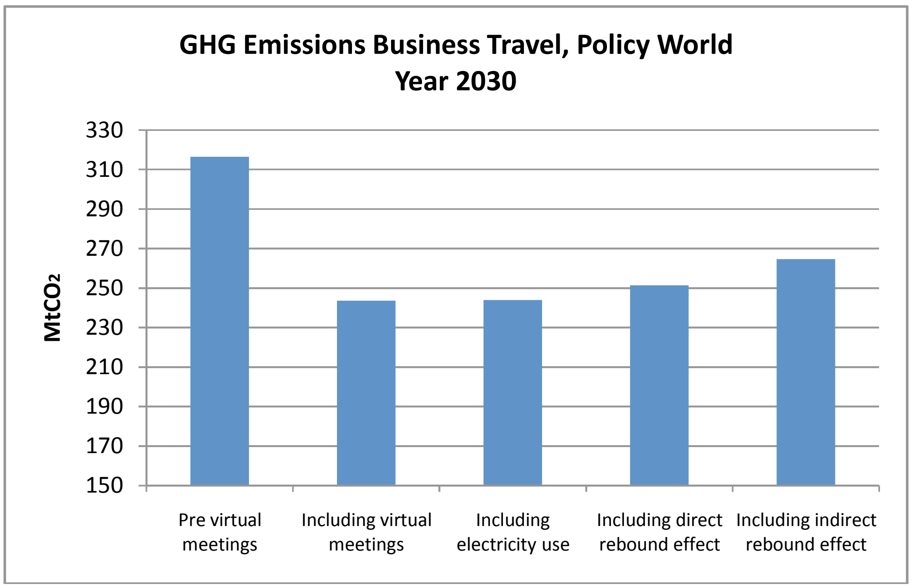


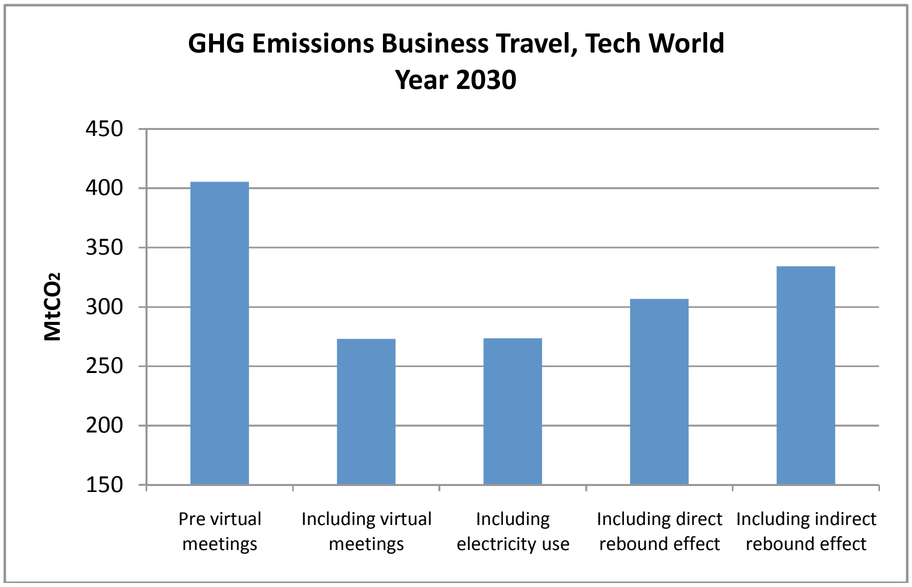


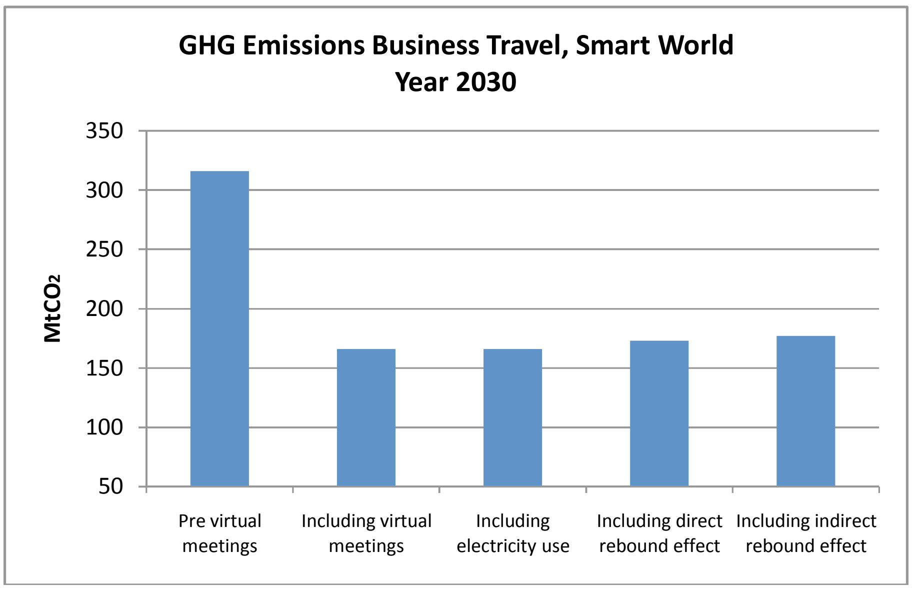
Graph 19: CO_2 emission reductions from virtual meetings within different worlds.

The graphs below provide further detail on the impact that various rebound effects can have on the emission reductions generated by virtual meetings.


GHG Emissions Business Travel, Carbon World
Year 2030
MtCO2
430
410
390
370
350
330
310
290
270
250
Pre virtual meetings
Including virtual meetings
Including electricity use
Including direct rebound effect
Including indirect rebound effect

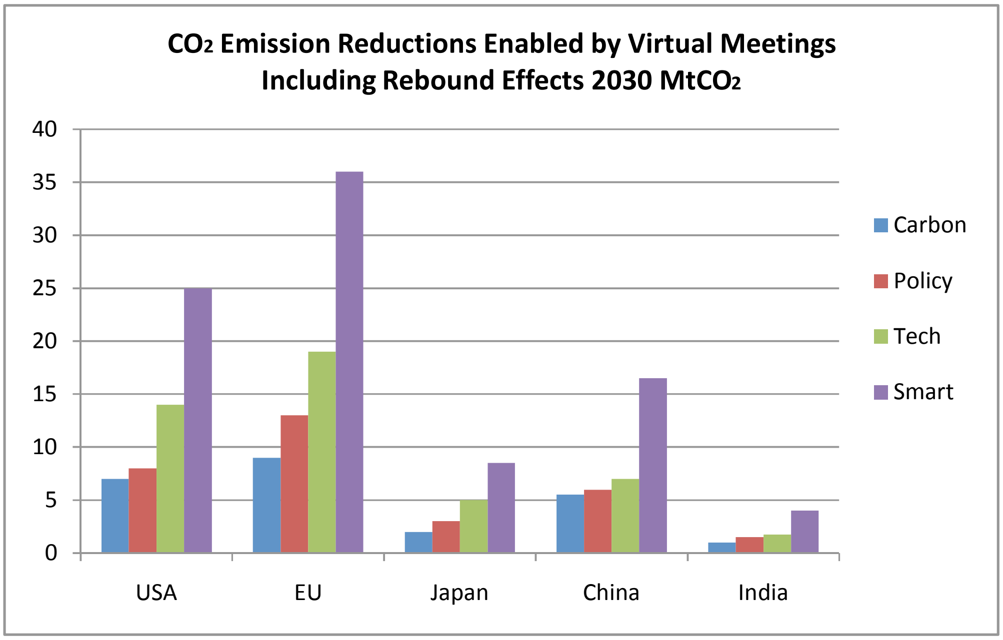

GHG Emissions Business Travel, Policy World
Year 2030
MtCO2
330
310
290
270
250
230
210
190
170
150
Pre virtual meetings
Including virtual meetings
Including electricity use
Including direct rebound effect
Including indirect rebound effect

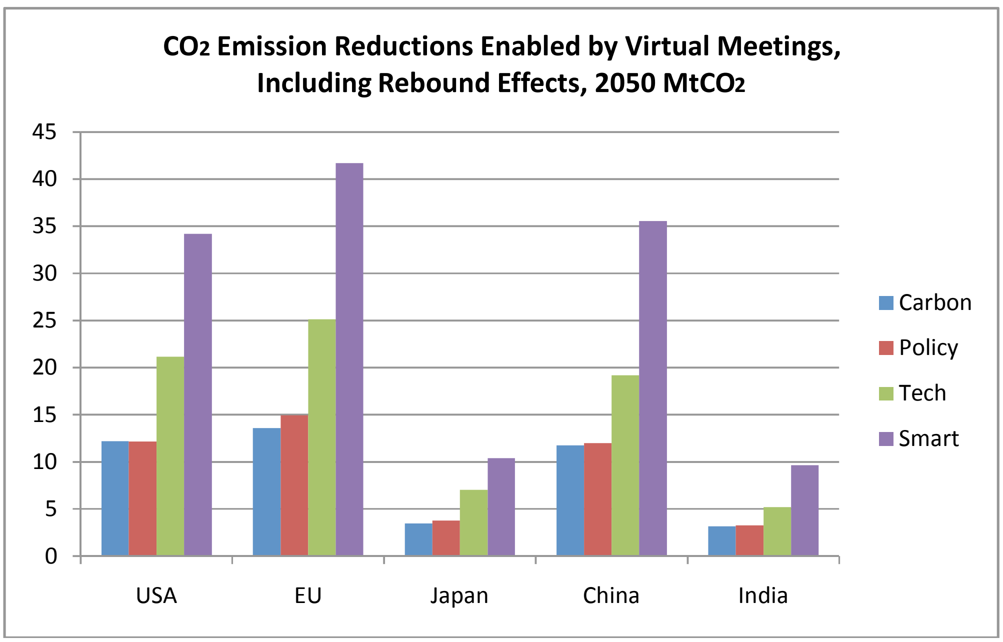




Graph 20: Virtual meetings' impact, including different rebound effects in different worlds, 2030.

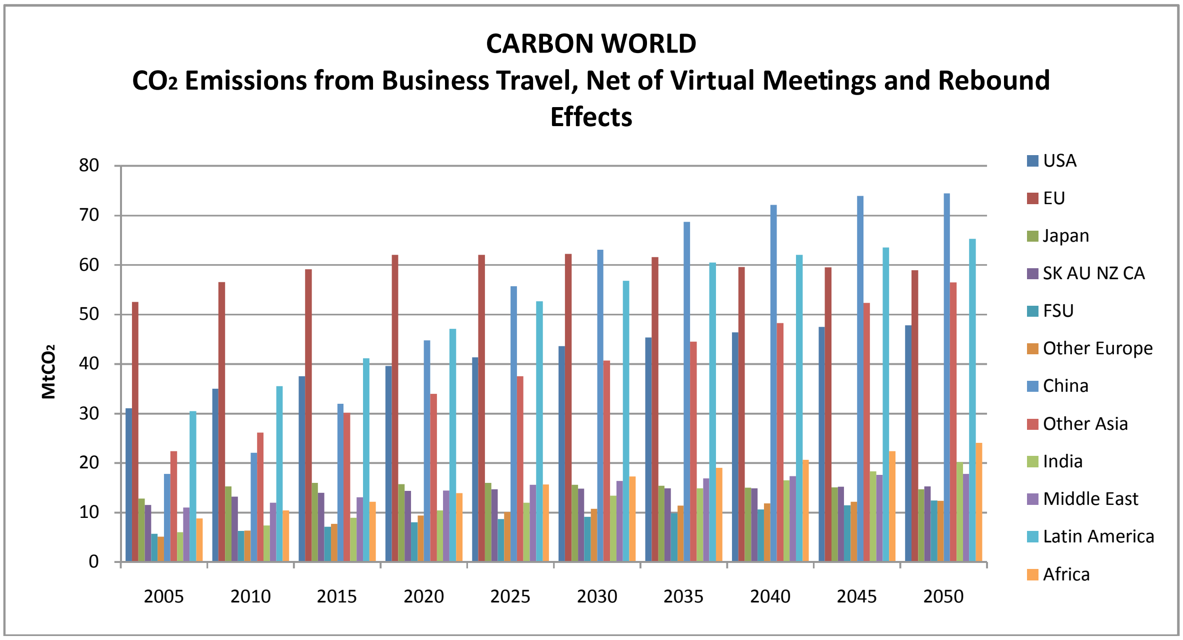
Despite air travel's faster growth in developing countries, the projections indicate that a larger share of CO_2 emission reductions may be achieved in developed countries. As with telecommuting, this can be explained by a greater number of business travelers and by an economic specialization in sectors that are more suitable for an adoption of virtual-meeting solutions (at least in the short and medium term) in OECD economies. As with telecommuting, over time a significant volume of emission reductions will become possible in developing countries (see graphs below).



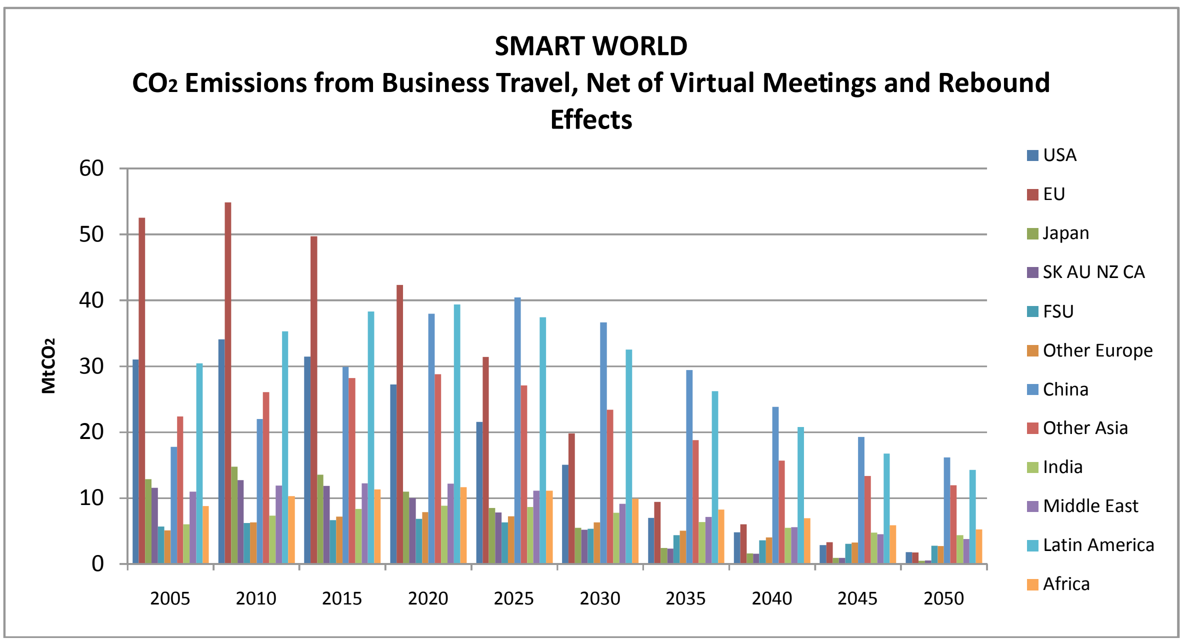


Graph 21: CO_2 emission reductions enabled by virtual meetings by region.

As highlighted by the two graphs below, a smart world would initially generate emission reductions by reducing the emissions associated with business travel in OECD countries, but continue to show growth in developing countries. From about 2020 to 2025, emissions deriving from business travel would then decrease in developing countries as well, including China.



Graph 22: CO_2 emissions over time from business travel, net of virtual meetings and rebound effects, carbon world.



Graph 23: CO_2 emissions over time from business travel, net of virtual meetings and rebound effects, smart world.

As highlighted in section 1.2 above, statistical data on virtual meetings is not collected, while existing case study analyses are based on a variety of approaches, methodologies, and data sets, and typically focus on individual companies. The uncertainties associated with the estimates provided above are therefore high. The simulations, however, provide useful indications on the size of the emission reductions that could potentially be achieved. They also provide insight on the negative rebound effects that can potentially occur in the absence of effective climate change policies. Public policies and strategies will therefore be the focus of our next section.

5 Policies and strategies

The analysis undertaken above illustrates how different behaviors from private-sector companies supplying and using IT, as well as from policy makers, can lead to dramatically different outcomes in terms of the potential impact of teleworking and virtual meetings on GHG emissions.

The opportunities to reduce GHG reductions offered by teleworking and virtual meetings will not be harvested automatically, as, by improving efficiency and productivity, these solutions also deliver more free time to workers, higher profits to companies, and higher disposable income. The use of these additional resources can lead to higher GHG emissions that negate initial gains. The size of this rebound effect will depend on technological and economic development and on the broader strategies and policies that societies and businesses will pursue.

The projections illustrated in section 4 highlight the importance of a combined effort from both the private and the public sectors. Such combined effort can play a key role in eliminating existing barriers for the implementation of teleworking and virtual-meeting solutions, in reducing the negative feedback that may occur when additional resources are made available by such solutions, and in activating virtuous cycles that leverage these IT solutions to further decrease GHG emissions (see box below).

Activating virtuous cycles

Virtuous cycles can be activated when the implementation/use of an IT solution that reduces GHG emissions

- makes it easier for more of the same solution to be deployed;
- leads to a higher use of complementary IT solutions that also achieve GHG emission reductions;
- leads to a broader adoption of organizational structures and processes that require fewer GHG emissions; and
- fosters a culture and behaviors that drive society towards lower GHG emissions.

Currently there is a limited understanding on how private-sector companies and public authorities can work together to fully achieve these goals, as there is insufficient insight on the various feedback loops that teleworking and virtual meetings can generate. Despite these limitations, a number of no-regret strategies appear to be present. They include the following:

- Deploy the broadband infrastructure needed to enable IT applications that reduce GHG emissions, thus offering an alternative to infrastructures that, by their nature, lead to additional GHG emissions (this move not only promotes teleworking and virtual meetings but also supports other IT solutions that can reduce GHG emissions)
- Explicitly link the adoption of teleworking and virtual meetings with the need to reduce GHG emissions, increasing awareness on the GHG opportunities and risks associated with these two solutions and building capacity amongst policy makers, business executives, and employees, as well as within society
- Identify and remove regulatory barriers that hinder the deployment of teleworking and virtual meetings, e.g., national regulations or collective bargains that demand physical presence in a workplace, as well as requirements to interact with public officials or customer representatives in person and on paper, even when such interaction could easily take place remotely with IT

- Use public procurement and public services in general to spur the adoption of teleworking and virtual meetings, with a focus on GHG emission reductions
- Articulate methodologies to collect relevant data and assess the impact of teleworking and virtual meetings at the level of individual implementations – this may require (IT) systems to communicate relevant information between different companies, or between companies and employees, and may also include approaches to track indirect impact throughout the economy
- Systematically evaluate the impact of teleworking and virtual-meeting deployments to assess direct effects and if/what virtuous cycles were activated, if/what negative outcomes occurred, and what net impact on GHG emissions was achieved
- Set up appropriate data-collection systems that are able to regularly gather the statistical data needed to assess and monitor progress in this field, at an aggregated level
- Collect and disseminate information about best practices on teleworking and virtual meetings, using examples of organizations that are successful at minimizing direct GHG emission while activating positive emission reductions cycles
- Introduce broad policies that, when resources (time or money) are liberated by teleworking or virtual meetings, automatically provide incentives for the use such resources in ways that lead to additional reductions in GHG emission – for example, a white-certificate or offset system that provides rewards if the economic savings generated by teleworking or virtual meetings are deployed in initiatives that further reduce GHG emissions (such as a renewable energy investment)
- Fund technology development initiatives to improve teleworking and virtual-meeting solutions and to tailor them to the needs of countries or sectors that can adopt such solutions in an early phase of development, thus achieving a low-GHG-emission path. Many opportunities are likely to be present in developing countries with high growth
- Implement capacity-building and technology-transfer policies designed to benefit developing countries or sectors that are lacking in critical knowledge and expertise, but that have the potential to adopt teleworking and virtual meetings to reduce GHG emissions and activate low-carbon cycles

Most of these activities are most effectively undertaken with the active participation of both the public and private sector, as highlighted by the table below:

	Public sector	**IT industry**	**Leading users (trendsetters)**
Ensure broadband infrastructure	√ (regulatory framework and incentives)	√√√ (direct investment)	
Build knowledge and capacity on IT use to reduce GHG emissions	√√√ ("core business" of the public sector)	√√√ (most knowledgeable on technology and its uses)	√√√ (direct experience and practical insight)
Remove regulatory barriers	√√√ (assess and revise regulation)	√√ (identify barriers and propose solutions)	√√ (identify barriers and propose solutions)
Leverage procurement to support GHG reductions with low-carbon feedback	√√√		√√
Articulate methodologies for data collection and	√ (for dissemination and	√√√ (work with customers	√√√ (direct application and

analysis	standardization)	and facilitate)	standard development)
Systematically assess the GHG impact of IT solutions (including rebound effects)	√√√ (for macro-level analyses)	√√√ (systematically assess the impact of products and services)	√√√ (gain direct experience and practical insight)
Set up data-collection systems	√√√ (macro level and to create standards)	√√√ (embed data collection and communication capabilities in IT)	√√√ (implement company- and supply-chain-wide systems)
Disseminate best practices	√√√ (country level)	√√√ (with customers and policy makers)	√√√ (with peers, suppliers, and policy makers)
Introduce policies that channel resources towards creating low-carbon feedback	√√√ (assess and develop appropriate policies)	√√ (provide advice and explore solutions)	√√ (provide advice and explore solutions)
Technology development and tailoring to developing countries	√√√ (provide support and knowledge)	√√√ (develop technologies)	√√√ (help articulate requirements)
Capacity building and dissemination in developing countries	√√√ (support with tools and funding instruments)	√√√ (work with local suppliers and customers)	√√√ (work with local suppliers and customers)

Table 17: Policies and strategies to reduce GHG emissions with IT and generate low-carbon feedback in relation to different stakeholders.
Key: √√√ = important role; √√ = medium important role; √ = limited role. The notes in brackets provide a short explanation of the role of different stakeholders.

By jointly working at the implementation of these strategies, policy makers and private-sector companies may enable IT applications, such as the ones supporting teleworking and virtual meetings, to gain a broader acceptance in society. They would deliver greater GHG emission reductions while liberating resources and providing models that can help reduce GHG emissions more broadly, thus fostering low-carbon feedback loops. If this potential is fully achieved, the results in terms of GHG emission reductions can be dramatic, as highlighted in section 5.

6 Appendix 1 – Assumption tables

Some of the assumptions utilized in building the projections for the different worlds are illustrated below.

6.1 Teleworking

- **LDV car ownership rate (per 1,000 population) pre- and post-teleworking**
  - Carbon world: For historical data for 2000 and 2005 as well as future projections on car ownership rates for the regions considered in the study, figures from the International Energy Agency (IEA) and the World Business Council on Sustainable Development (WBCSD) were used. Car ownership figures post-telecommuting are corrected by the teleworkers that give up their cars. The proportion of teleworkers that give up their vehicles is assumed to be small in the carbon and tech worlds, and higher in the policy and smart worlds.

LDV Car ownership rate (per 1000 population) pre telecommuting

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	618	626	636	644	651	659	667	674	682	690	698
EU 27	463	463	501	520	537	553	569	585	601	618	635
Japan	395	395	396	397	398	399	400	401	402	403	404
SK AU NZ CA	360	380	399	418	437	456	476	495	514	533	552
FSU	100	108	133	168	212	258	310	340	373	408	447
Other Europe	201	218	235	304	345	391	440	466	493	522	551
China	13	17	26	37	50	66	86	111	142	181	231
Other Asia	21	25	29	33	37	46	56	68	82	98	117
India	10	14	17	21	26	30	40	51	66	83	105
Middle East	42	45	47	51	57	63	68	74	79	85	91
Latin America	78	87	101	118	136	157	181	209	240	276	317
Africa	20	23	27	31	34	38	42	46	50	54	58

Car ownership rate post telecommuting (per 1000 inhabitants)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	618	626	636	643	650	657	664	671	678	685	692
EU 27	463	463	501	520	536	552	567	583	599	615	631
Japan	395	395	396	397	397	398	399	399	400	400	401
SK AU NZ CA	360	380	399	418	437	456	474	493	511	530	548
FSU	100	108	133	168	211	258	309	339	372	407	445
Other Europe	201	218	235	304	345	391	440	465	492	519	549
China	13	17	26	37	50	66	86	110	142	181	230
Other Asia	21	25	29	33	37	46	56	68	82	98	116
India	10	14	17	21	26	30	39	51	65	83	104
Middle East	42	45	47	51	57	63	68	73	79	85	91
Latin America	78	87	101	118	136	157	181	208	240	275	315
Africa	20	23	27	31	34	38	42	46	50	54	58

  - Policy world: In this world, it was assumed that, due mainly to the adoption and implementation of ambitious and effective GHG-emission-reduction policies and targets in the transportation sector as well as in other sectors, the growth in car ownership rates will decrease over time, as compared to the carbon world, in both developed countries and developing countries. In developing countries, such decline would mainly take place in the second half of the total time period considered, while in the first half, car ownership rates are expected to increase due to growing average incomes.

LDV Car ownership rate (per 1000 population) pre telecommuting

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	618	626	636	641	645	649	653	657	662	666	670
EU 27	463	463	499	515	529	542	555	567	580	593	607
Japan	395	395	394	393	392	391	390	389	388	387	386
SK AU NZ CA	360	380	397	414	431	447	464	480	496	512	527
FSU	100	108	133	168	211	255	305	333	364	396	432
Other Europe	201	218	235	304	344	387	434	457	481	506	532
China	13	17	26	37	50	65	84	108	138	176	223
Other Asia	21	25	29	33	37	46	55	67	80	95	113
India	10	14	17	21	25	30	39	50	64	81	101
Middle East	42	45	47	51	57	62	67	72	77	83	88
Latin America	78	87	101	118	135	155	179	205	234	268	306
Africa	20	23	27	31	34	38	41	45	49	52	56

Car ownership rate post telecommuting (per 1000 inhabitants)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	618	626	635	639	643	646	649	651	654	656	658
EU 27	463	463	499	514	527	540	551	562	574	585	596
Japan	395	395	394	392	391	389	387	385	383	381	379
SK AU NZ CA	360	380	397	413	430	445	461	476	490	504	518
FSU	100	108	133	168	210	255	304	331	361	392	426
Other Europe	201	218	235	304	343	386	432	454	477	501	526
China	13	17	26	37	50	65	84	108	137	174	220
Other Asia	21	25	29	33	37	45	55	67	80	94	112
India	10	14	17	21	25	30	39	50	64	80	100
Middle East	42	45	47	51	56	62	67	72	77	82	87
Latin America	78	87	101	117	135	155	178	204	233	265	302
Africa	20	23	27	31	34	38	41	45	48	52	56

- Tech world: In this world, the same figures included in the carbon world were used, as it was assumed that the IT industry will not have a direct impact on car ownership rates around the world. Lower ownership rates are, however, obtained when the vehicles that will be given up by telecommuters are also considered.

LDV Car ownership rate (per 1000 population) pre telecommuting

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	618	626	636	644	651	659	667	674	682	690	698
EU 27	463	463	501	520	537	553	569	585	601	618	635
Japan	395	395	396	397	398	399	400	401	402	403	404
SK AU NZ CA	360	380	399	418	437	456	476	495	514	533	552
FSU	100	108	133	168	212	258	310	340	373	408	447
Other Europe	201	218	235	304	345	391	440	466	493	522	551
China	13	17	26	37	50	66	86	111	142	181	231
Other Asia	21	25	29	33	37	46	56	68	82	98	117
India	10	14	17	21	26	30	40	51	66	83	105
Middle East	42	45	47	51	57	63	68	74	79	85	91
Latin America	78	87	101	118	136	157	181	209	240	276	317
Africa	20	23	27	31	34	38	42	46	50	54	58

Car ownership rate post telecommuting (per 1000 inhabitants)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	618	626	635	643	650	657	664	670	677	683	689
EU 27	463	463	501	519	536	551	567	582	597	612	627
Japan	395	395	396	397	397	398	398	399	399	399	399
SK AU NZ CA	360	380	399	418	437	455	474	492	510	528	545
FSU	100	108	133	168	211	258	309	339	371	406	444
Other Europe	201	218	235	304	345	390	439	464	491	518	547
China	13	17	26	37	50	66	85	110	141	180	229
Other Asia	21	25	29	33	37	46	56	68	82	98	116
India	10	14	17	21	26	30	39	51	65	83	104
Middle East	42	45	47	51	57	63	68	73	79	85	91
Latin America	78	87	101	117	136	157	181	208	239	274	314
Africa	20	23	27	31	34	38	42	46	50	54	58

- Smart world: The figures included in this world were based on those included in the policy world, for the reasons discussed above. In a smart world the impact of teleworking on curbing car ownership is the greatest.

LDV Car ownership rate (per 1000 population) pre telecommuting

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	618	626	636	641	645	649	653	657	662	666	670
EU 27	463	463	499	515	529	542	555	567	580	593	607
Japan	395	395	394	393	392	391	390	389	388	387	386
SK AU NZ CA	360	380	397	414	431	447	464	480	496	512	527
FSU	100	108	133	168	211	255	305	333	364	396	432
Other Europe	201	218	235	304	344	387	434	457	481	506	532
China	13	17	26	37	50	65	84	108	138	176	223
Other Asia	21	25	29	33	37	46	55	67	80	95	113
India	10	14	17	21	25	30	39	50	64	81	101
Middle East	42	45	47	51	57	62	67	72	77	83	88
Latin America	78	87	101	118	135	155	179	205	234	268	306
Africa	20	23	27	31	34	38	41	45	49	52	56

Car ownership rate post telecommuting (per 1000 inhabitants)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	618	626	634	631	625	609	583	546	499	459	435
EU 27	463	463	498	509	515	513	500	477	442	412	394
Japan	395	395	393	388	381	369	350	325	294	268	251
SK AU NZ CA	360	380	397	410	420	424	419	404	379	356	343
FSU	100	108	133	167	207	245	282	292	296	302	313
Other Europe	201	218	235	302	337	372	401	401	392	385	386
China	13	17	26	37	48	61	74	87	102	120	143
Other Asia	21	25	29	33	36	43	48	54	59	65	73
India	10	14	17	21	25	28	34	40	47	55	65
Middle East	42	45	47	51	55	58	59	58	57	56	57
Latin America	78	87	101	116	131	145	156	165	173	183	196
Africa	20	23	27	30	33	35	36	36	36	36	36

- **LDV average travel per vehicle (vehicle kilometers per year)**
  - Carbon world: As for LDV car ownership rates, figures for average travel per vehicle were taken from the International Energy Agency and the World Business Council on Sustainable Development.
  - Tech world: In this world, the same figures included in the "gray world" were used, as it was assumed that the IT industry will not have an impact on average travel per vehicle other than that associated with the reduction in travel due to telecommuting and teleconferencing.

LDV average travel per vehicle (vehicle km per year) - IEA/WBCSD numbers

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	17,600	17,600	17,600	17,600	17,600	17,600	17,600	17,600	17,600	17,600	17,600
EU	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500
Japan	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
SK AU NZ CA	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500
FSU	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Other Europe	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000
China	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Other Asia	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
India	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
Middle East	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Latin America	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Africa	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000

- Policy world: In this world it is assumed that, due to the same reasons discussed above for car ownership rates, the average travel per vehicle will tend to decrease over time, both in developed and in developing countries (in a later phase for the latter).

- Smart world: The figures included in this world were based on those included in the policy world, for the reasons discussed above.

LDV average travel per vehicle (vehicle km per year) - Pretelecommuting

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	17,600	17,600	17,600	17,424	17,072	16,544	16,016	15,488	14,960	14,432	14,080
EU 27	12,500	12,500	12,500	12,375	12,125	11,750	11,375	11,000	10,625	10,250	10,000
Japan	10,000	10,000	10,000	9,900	9,700	9,400	9,100	8,800	8,500	8,200	8,000
SK AU NZ CA	12,500	12,500	12,500	12,375	12,125	11,750	11,375	11,000	10,625	10,250	10,000
FSU	13,000	13,000	13,000	12,870	12,610	12,220	11,830	11,440	11,050	10,660	10,400
Other Europe	11,000	11,000	11,000	10,890	10,670	10,340	10,010	9,680	9,350	9,020	8,800
China	10,000	10,000	10,000	9,900	9,700	9,400	9,100	8,800	8,500	8,200	8,000
Other Asia	10,000	10,000	10,000	9,900	9,700	9,400	9,100	8,800	8,500	8,200	8,000
India	8,000	8,000	8,000	7,920	7,760	7,520	7,280	7,040	6,800	6,560	6,400
Middle East	13,000	13,000	13,000	12,870	12,610	12,220	11,830	11,440	11,050	10,660	10,400
Latin America	12,000	12,000	12,000	11,880	11,640	11,280	10,920	10,560	10,200	9,840	9,600
Africa	10,000	10,000	10,000	9,900	9,700	9,400	9,100	8,800	8,500	8,200	8,000

- **Teleworking implementation as a percentage of total commuters**
  - Carbon world: Historical data on the penetration of teleworking in the different regions considered in the study were taken from the following sources: WorldatWork (2007), Gartner (2005), UK Office for National Statistics (2005), and Gareis (2002). Regarding future projections, growth rates consistent with those registered in the recent past were used.

Telecommuting take up - as % of number of commuters

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	11.0%	17.0%	19.6%	22.2%	24.8%	27.4%	*30.0%*	32.5%	35.0%	37.5%	*40.0%*
EU	5.5%	8.0%	11.4%	14.8%	18.2%	21.6%	*25.0%*	27.5%	30.0%	32.5%	*35.0%*
Japan	6.5%	12.0%	14.6%	17.2%	19.8%	22.4%	*25.0%*	28.8%	32.5%	36.3%	*40.0%*
SK AU NZ CA	6.5%	6.5%	10.2%	13.9%	17.6%	21.3%	*25.0%*	27.5%	30.0%	32.5%	*35.0%*
FSU	2.7%	4.0%	6.2%	8.4%	10.6%	12.8%	*15.0%*	17.5%	20.0%	22.5%	*25.0%*
Other Europe	2.7%	4.0%	6.2%	8.4%	10.6%	12.8%	*15.0%*	17.5%	20.0%	22.5%	*25.0%*
China	2.7%	4.0%	6.2%	8.4%	10.6%	12.8%	*15.0%*	17.5%	20.0%	22.5%	*25.0%*
Other Asia	2.7%	4.0%	6.2%	8.4%	10.6%	12.8%	*15.0%*	17.5%	20.0%	22.5%	*25.0%*
India	2.7%	4.0%	6.2%	8.4%	10.6%	12.8%	*15.0%*	17.5%	20.0%	22.5%	*25.0%*
Middle East	2.7%	4.0%	6.2%	8.4%	10.6%	12.8%	*15.0%*	17.5%	20.0%	22.5%	*25.0%*
Latin America	2.7%	4.0%	6.2%	8.4%	10.6%	12.8%	*15.0%*	17.5%	20.0%	22.5%	*25.0%*
Africa	2.7%	4.0%	6.2%	8.4%	10.6%	12.8%	*15.0%*	17.5%	20.0%	22.5%	*25.0%*

  - Policy world: In this world, it is assumed that the implementation of ambitious and effective GHG-emission-reduction policies and targets, particularly in the transportation sector, will indirectly lead to a rate of implementation of teleworking that is marginally faster than in a carbon world.

Telecommuting take up - as % of number of commuters

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	11%	17%	20%	23%	26%	29%	33%	36%	39%	42%	45%
EU	5%	8%	12%	16%	20%	24%	29%	33%	37%	41%	45%
Japan	7%	12%	16%	19%	23%	27%	30%	34%	38%	41%	45%
SK AU NZ CA	7%	7%	11%	15%	19%	24%	28%	32%	36%	41%	45%
FSU	3%	4%	7%	10%	13%	16%	18%	21%	24%	27%	30%
Other Europe	3%	4%	7%	10%	13%	16%	18%	21%	24%	27%	30%
China	3%	4%	7%	10%	13%	16%	18%	21%	24%	27%	30%
Other Asia	3%	4%	7%	10%	13%	16%	18%	21%	24%	27%	30%
India	3%	4%	7%	10%	13%	16%	18%	21%	24%	27%	30%
Middle East	3%	4%	7%	10%	13%	16%	18%	21%	24%	27%	30%
Latin America	3%	4%	7%	10%	13%	16%	18%	21%	24%	27%	30%
Africa	3%	4%	7%	10%	13%	16%	18%	21%	24%	27%	30%

  - Tech world: In this world, it was assumed that aggressive and effective R&D and marketing strategies by the IT industry targeted to teleworking-related technologies and services will lead to a greater and faster adoption of teleworking by enabling better and deeper virtual interactions among employees (as well as between the latter and employers), thus broadening the type of sectors and professions in which telework can be conducted.

Telecommuting take up - as % of number of commuters

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	11%	17%	22%	27%	31%	36%	41%	46%	50%	55%	60%
EU	5%	8%	14%	20%	25%	31%	37%	43%	48%	54%	60%
Japan	7%	12%	17%	23%	28%	33%	39%	44%	49%	55%	60%
SK AU NZ CA	7%	7%	12%	18%	24%	30%	36%	42%	48%	54%	60%
FSU	3%	4%	8%	12%	16%	20%	24%	28%	32%	36%	40%
Other Europe	3%	4%	8%	12%	16%	20%	24%	28%	32%	36%	40%
China	3%	4%	8%	12%	16%	20%	24%	28%	32%	36%	40%
Other Asia	3%	4%	8%	12%	16%	20%	24%	28%	32%	36%	40%
India	3%	4%	8%	12%	16%	20%	24%	28%	32%	36%	40%
Middle East	3%	4%	8%	12%	16%	20%	24%	28%	32%	36%	40%
Latin America	3%	4%	8%	12%	16%	20%	24%	28%	32%	36%	40%
Africa	3%	4%	8%	12%	16%	20%	24%	28%	32%	36%	40%

- Smart world: In this world, it is assumed that in addition to the aggressive R&D and marketing strategies by the IT industry, policy makers would also articulate ambitious GHG-emission-reduction policies that leverage IT. This leads to the highest adoption of teleworking, which will be preferred to physical travel (for commuting purposes) by a considerable and growing number of people worldwide.

Telecommuting take up - as % of number of commuters

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	11%	17%	23%	29%	35%	41%	46%	52%	58%	64%	70%
EU	5%	8%	15%	22%	29%	36%	42%	49%	56%	63%	70%
Japan	7%	12%	18%	25%	31%	38%	44%	51%	57%	64%	70%
SK AU NZ CA	7%	7%	14%	21%	28%	35%	42%	49%	56%	63%	70%
FSU	3%	4%	10%	15%	21%	27%	32%	38%	44%	49%	55%
Other Europe	3%	4%	10%	15%	21%	27%	32%	38%	44%	49%	55%
China	3%	4%	10%	15%	21%	27%	32%	38%	44%	49%	55%
Other Asia	3%	4%	10%	15%	21%	27%	32%	38%	44%	49%	55%
India	3%	4%	10%	15%	21%	27%	32%	38%	44%	49%	55%
Middle East	3%	4%	10%	15%	21%	27%	32%	38%	44%	49%	55%
Latin America	3%	4%	10%	15%	21%	27%	32%	38%	44%	49%	55%
Africa	3%	4%	10%	15%	21%	27%	32%	38%	44%	49%	55%

- **Average teleworking days per week**
    - Carbon world: Figures on the average teleworking days per week in the various regions and countries included in this study were taken from (or calculated based on) the following sources: WorldatWork (2007), Gartner (2005), UK Office for National Statistics (2005), and Gareis (2002). Regarding future projections, a growth rate similar to that measured in the past few years for the number of days teleworked per week (by teleworkers) was applied.

Average telecommuting days per week

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	2.50	2.70	2.73	2.76	2.78	2.81	2.84	2.87	2.89	2.92	*2.95*
EU	0.90	1.00	1.14	1.29	1.43	1.58	1.72	1.87	2.01	2.16	*2.30*
Japan	1.80	2.20	2.24	2.29	2.33	2.38	2.42	2.47	2.51	2.56	*2.60*
SK AU NZ CA	0.90	1.00	1.17	1.33	1.50	1.67	1.83	2.00	2.17	2.33	*2.50*
FSU	0.90	1.00	1.14	1.29	1.43	1.58	1.72	1.87	2.01	2.16	*2.30*
Other Europe	0.90	1.00	1.14	1.29	1.43	1.58	1.72	1.87	2.01	2.16	*2.30*
China	0.90	1.00	1.14	1.29	1.43	1.58	1.72	1.87	2.01	2.16	*2.30*
Other Asia	0.90	1.00	1.14	1.29	1.43	1.58	1.72	1.87	2.01	2.16	*2.30*
India	0.90	1.00	1.14	1.29	1.43	1.58	1.72	1.87	2.01	2.16	*2.30*
Middle East	0.90	1.00	1.14	1.29	1.43	1.58	1.72	1.87	2.01	2.16	*2.30*
Latin America	0.90	1.00	1.14	1.29	1.43	1.58	1.72	1.87	2.01	2.16	*2.30*
Africa	0.90	1.00	1.14	1.29	1.43	1.58	1.72	1.87	2.01	2.16	*2.30*

- Policy world: In this world, it is assumed that the implementation of ambitious and effective GHG-emission-reduction policies and targets, particularly in the transportation sector, will indirectly lead to a more frequent use of teleworking (by current teleworkers).

Average telecommuting days per week

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	2.50	2.70	2.74	2.79	2.83	2.88	2.92	2.97	3.01	3.06	3.10
EU	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80
Japan	1.80	2.20	2.27	2.33	2.40	2.47	2.53	2.60	2.67	2.73	2.80
SK AU NZ CA	1.00	1.00	1.19	1.38	1.57	1.76	1.94	2.13	2.32	2.51	2.70
FSU	0.90	1.00	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.20	2.35
Other Europe	0.90	1.00	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.20	2.35
China	0.90	1.00	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.20	2.35
Other Asia	0.90	1.00	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.20	2.35
India	0.90	1.00	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.20	2.35
Middle East	0.90	1.00	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.20	2.35
Latin America	0.90	1.00	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.20	2.35
Africa	0.90	1.00	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.20	2.35

- Tech world: In this world, it is assumed that aggressive and effective R&D and marketing strategies by the IT industry targeted to teleworking-related technologies and services will increase the frequency of teleworking by enabling better and deeper virtual interactions among employees (as well as between the latter and employers), thus broadening the type of activities that may be carried out from remote locations via teleworking.

Average telecommuting days per week

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	2.50	2.70	2.74	2.84	2.98	3.11	3.24	3.38	3.49	3.61	3.72
EU	0.90	1.00	1.20	1.43	1.68	1.94	2.22	2.51	2.78	3.07	3.36
Japan	1.80	2.20	2.27	2.38	2.52	2.66	2.81	2.96	3.09	3.23	3.36
SK AU NZ CA	1.00	1.00	1.19	1.41	1.65	1.90	2.16	2.43	2.69	2.96	3.24
FSU	0.90	1.00	1.15	1.33	1.52	1.73	1.94	2.17	2.38	2.60	2.82
Other Europe	0.90	1.00	1.15	1.33	1.52	1.73	1.94	2.17	2.38	2.60	2.82
China	0.90	1.00	1.15	1.33	1.52	1.73	1.94	2.17	2.38	2.60	2.82
Other Asia	0.90	1.00	1.15	1.33	1.52	1.73	1.94	2.17	2.38	2.60	2.82
India	0.90	1.00	1.15	1.33	1.52	1.73	1.94	2.17	2.38	2.60	2.82
Middle East	0.90	1.00	1.15	1.33	1.52	1.73	1.94	2.17	2.38	2.60	2.82
Latin America	0.90	1.00	1.15	1.33	1.52	1.73	1.94	2.17	2.38	2.60	2.82
Africa	0.90	1.00	1.15	1.33	1.52	1.73	1.94	2.17	2.38	2.60	2.82

- Smart world: In this world, it is assumed that the combined effect of ambitious GHG-emission-reduction policies and aggressive R&D and marketing strategies by the IT industry will lead to the highest use/frequency of teleworking, which will replace physical travel by commuters in a considerable and growing number of days.

Average telecommuting days per week

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	2.50	2.70	2.86	3.02	3.18	3.34	3.50	3.68	3.85	4.03	4.20
EU	0.90	1.00	1.39	1.78	2.17	2.56	2.95	3.26	3.58	3.89	4.20
Japan	1.80	2.20	2.42	2.64	2.86	3.08	3.30	3.53	3.75	3.98	4.20
SK AU NZ CA	1.00	1.00	1.38	1.77	2.15	2.54	2.92	3.07	3.21	3.36	3.50
FSU	0.90	1.00	1.30	1.60	1.90	2.20	2.50	2.75	3.00	3.25	3.50
Other Europe	0.90	1.00	1.30	1.60	1.90	2.20	2.50	2.75	3.00	3.25	3.50
China	0.90	1.00	1.30	1.60	1.90	2.20	2.50	2.75	3.00	3.25	3.50
Other Asia	0.90	1.00	1.30	1.60	1.90	2.20	2.50	2.75	3.00	3.25	3.50
India	0.90	1.00	1.30	1.60	1.90	2.20	2.50	2.75	3.00	3.25	3.50
Middle East	0.90	1.00	1.30	1.60	1.90	2.20	2.50	2.75	3.00	3.25	3.50
Latin America	0.90	1.00	1.30	1.60	1.90	2.20	2.50	2.75	3.00	3.25	3.50
Africa	0.90	1.00	1.30	1.60	1.90	2.20	2.50	2.75	3.00	3.25	3.50

- **Direct rebound effect (driven by additional time availability), increased kilometers traveled by telecommuters for chores or leisure**

- Carbon world: Assumptions on this rebound effect are based on the review of over 30 studies undertaken by Steven Sorrell UKERC (2007). In a carbon world this rebound effect is assumed to remain constant over time.

Direct rebound effect - increased km travelled by telecommuters working from home as % of km saved by telecommuting

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
EU	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Japan	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
SK AU NZ CA	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
FSU	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Other Europe	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
China	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Other Asia	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
India	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Middle East	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Latin America	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Africa	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%

- Policy world: In this world, it is assumed that the implementation of ambitious and effective GHG-emission-reduction policies and targets, particularly in the transportation sector, will indirectly lead to fewer kilometers traveled by telecommuters for leisure and chores.

Direct rebound effect - increased km travelled by telecommuters working from home as % of km saved by telecommuting

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
EU	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
Japan	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
SK AU NZ CA	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
FSU	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
Other Europe	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
China	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
Other Asia	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
India	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
Middle East	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
Latin America	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%
Africa	25%	25%	25%	20%	15%	15%	15%	15%	15%	15%	15%

- Tech world: Same as in carbon world.

- Smart world: In this world, it is assumed that the implementation of IT solutions in a framework that pursues GHG emission reductions, combined with ambitious GHG-emission-reduction policies, will lead to the neutralization of this rebound effect.

Direct rebound effect - increased km travelled by telecommuters working from home as % of km saved by telecommuting

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
EU	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
Japan	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
SK AU NZ CA	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
FSU	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
Other Europe	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
China	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
Other Asia	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
India	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
Middle East	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
Latin America	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%
Africa	25%	25%	25%	20%	15%	10%	5%	0%	0%	0%	0%

- **Indirect rebound effect (driven by income availability), impact on GHG of money saved by telecommuting**

The GHG emissions associated with the expenditures of the economic savings made available by teleworking was used as a proxy for several indirect effects that may result from teleworking (and discussed in section 1.4).

- Carbon world: Savings from telecommuting (e.g., deriving from fewer fuel purchases) are assumed to be spent in goods or services that generate emissions proportionate to the GHG intensity (GHG emissions/GDP) of individual regions. Emissions per GDP are assumed to decline steadily over time.

Indirect rebound effect - kg CO2 emissions associated to each US $ saved by telecommuters (and spent in other goods and services causing CO2 emissions)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	0.64	0.64	0.64	0.62	0.60	0.58	0.56	0.54	0.52	0.50	0.48
EU	0.39	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30
Japan	0.39	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30
SK AU NZ CA	0.39	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30
FSU	0.39	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30
Other Europe	0.39	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30
China	0.90	0.90	0.90	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55
Other Asia	0.90	0.90	0.90	0.90	0.90	0.90	0.88	0.86	0.84	0.82	0.80
India	0.90	0.90	0.90	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55
Middle East	0.90	0.90	0.90	0.90	0.90	0.90	0.88	0.86	0.84	0.82	0.80
Latin America	0.60	0.60	0.60	0.60	0.60	0.60	0.58	0.56	0.54	0.52	0.50
Africa	0.60	0.60	0.60	0.60	0.60	0.60	0.58	0.56	0.54	0.52	0.50
simple average	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59

- Policy world: As in a carbon world, it is assumed that savings from telecommuting are spent on goods or services that generate emissions in proportion to the GHG intensity (GHG emissions/GDP) of individual regions. In a policy world, however, it is assumed that effective climate change policies will lead to an overall decrease in the carbon intensity of regional economies.

Indirect rebound effect - kg CO2 emissions associated to each US $ saved by telecommuters (and spent in other goods and services causing CO2 emissions)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	0.64	0.64	0.62	0.57	0.49	0.41	0.34	0.27	0.21	0.15	0.10
EU	0.39	0.39	0.37	0.34	0.30	0.25	0.20	0.17	0.13	0.09	0.06
Japan	0.39	0.39	0.37	0.34	0.30	0.25	0.20	0.17	0.13	0.09	0.06
SK AU NZ CA	0.39	0.39	0.38	0.35	0.31	0.27	0.24	0.20	0.17	0.14	0.11
FSU	0.39	0.39	0.38	0.35	0.31	0.27	0.24	0.20	0.17	0.14	0.11
Other Europe	0.39	0.39	0.38	0.35	0.31	0.27	0.24	0.20	0.17	0.14	0.11
China	0.90	0.90	0.89	0.85	0.73	0.62	0.53	0.43	0.35	0.28	0.21
Other Asia	0.90	0.90	0.89	0.85	0.77	0.70	0.62	0.53	0.45	0.38	0.30
India	0.90	0.90	0.89	0.85	0.73	0.62	0.53	0.43	0.35	0.28	0.21
Middle East	0.90	0.90	0.89	0.85	0.77	0.70	0.62	0.53	0.45	0.38	0.30
Latin America	0.60	0.60	0.59	0.56	0.52	0.47	0.41	0.35	0.29	0.24	0.19
Africa	0.60	0.60	0.59	0.56	0.52	0.47	0.41	0.35	0.29	0.24	0.19
simple average	0.59	0.59	0.58	0.55	0.50	0.46	0.41	0.36	0.32	0.27	0.22

- Tech world: Same as in carbon world.

- Smart world: In this world, it is assumed that the IT industry and policy makers articulate policies and strategies that enable the creation of virtuous cycles in which the additional resources generated by initial emission reductions are deployed in ways that achieve further reductions in emissions.

Indirect rebound effect - kg CO2 emissions associated to each US $ saved by telecommuters (and spent in other goods and services causing CO2 emissions)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	0.64	0.64	0.62	0.30	0.20	0.10	-	(0.10)	(0.10)	(0.10)	(0.10)
EU	0.39	0.39	0.37	0.20	0.10	-	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Japan	0.39	0.39	0.37	0.30	0.20	0.10	-	(0.10)	(0.10)	(0.10)	(0.10)
SK AU NZ CA	0.39	0.39	0.38	0.30	0.20	0.10	-	(0.10)	(0.10)	(0.10)	(0.10)
FSU	0.39	0.39	0.38	0.35	0.31	0.20	0.10	-	(0.10)	(0.10)	(0.10)
Other Europe	0.39	0.39	0.38	0.35	0.31	0.20	0.10	-	(0.10)	(0.10)	(0.10)
China	0.90	0.90	0.89	0.85	0.60	0.40	0.20	-	(0.10)	(0.10)	(0.10)
Other Asia	0.90	0.90	0.89	0.85	0.60	0.40	0.20	-	(0.10)	(0.10)	(0.10)
India	0.90	0.90	0.89	0.85	0.60	0.40	0.20	-	(0.10)	(0.10)	(0.10)
Middle East	0.90	0.90	0.89	0.85	0.60	0.30	0.10	-	(0.10)	(0.10)	(0.10)
Latin America	0.60	0.60	0.59	0.56	0.30	0.20	0.10	-	(0.10)	(0.10)	(0.10)
Africa	0.60	0.60	0.59	0.56	0.30	0.20	0.10	-	(0.10)	(0.10)	(0.10)
simple average	0.59	0.59	0.58	0.55	0.30	0.20	0.10	-	(0.10)	(0.10)	(0.10)

6.2 Virtual meetings

- **Total business travel, passenger-kilometers**

No statistical data were found on business travel passenger-kilometers. This data was therefore estimated using total passenger-kilometer data and an Ecofys assumption on the percentage of business air travel relative to total air travel. Historical data and projections on total passenger-kilometers of travel were taken from (or calculated based on) figures from the International Civil Aviation Organization (ICAO) and, for European countries, from the European Environment Agency (EEA). These data and projections were used for all worlds.

Total passenger-km of travel (bil)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	885	1,040	1,219	1,376	1,545	1,724	1,949	2,149	2,357	2,576	2,803
EU	980	1,188	1,400	1,610	1,771	1,985	2,125	2,259	2,390	2,569	2,695
Japan	253	280	356	403	433	483	520	557	594	644	681
SK AU NZ CA	240	284	346	398	443	499	553	605	659	723	782
FSU	63	78	94	118	147	177	210	253	304	366	441
Other Europe	52	70	95	127	170	205	248	292	339	388	438
China	141	197	266	422	721	1,027	1,481	1,922	2,363	2,801	3,239
Other Asia	197	248	316	398	493	604	734	895	1,087	1,316	1,591
India	50	66	89	118	152	193	244	304	378	469	583
Middle East	102	121	144	172	209	251	295	340	390	444	502
Latin America	281	337	430	546	690	869	1,095	1,368	1,706	2,125	2,643
Africa	77	98	126	161	204	256	319	392	478	580	698

business travel as % of total passenger-km travel

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	18%	17%	17%	17%	16%	16%	16%	16%	15%	15%	15%
EU	32%	32%	30%	28%	27%	25%	23%	22%	20%	18%	17%
Japan	26%	26%	25%	24%	23%	22%	20%	19%	18%	17%	16%
SK AU NZ CA	26%	26%	25%	24%	23%	22%	20%	19%	18%	17%	16%
FSU	40%	40%	38%	37%	35%	33%	32%	30%	28%	27%	25%
Other Europe	40%	40%	38%	37%	35%	33%	32%	30%	28%	27%	25%
China	57%	50%	47%	45%	43%	41%	39%	37%	34%	32%	30%
Other Asia	57%	50%	47%	45%	43%	41%	39%	37%	34%	32%	30%
India	57%	50%	47%	45%	43%	41%	39%	37%	34%	32%	30%
Middle East	57%	50%	47%	45%	43%	41%	39%	37%	34%	32%	30%
Latin America	57%	50%	47%	45%	43%	41%	39%	37%	34%	32%	30%
Africa	57%	50%	47%	45%	43%	41%	39%	37%	34%	32%	30%

- **Business travel avoided with virtual meetings as a percentage of total**
  - Carbon world: Figures on the adoption of teleconferencing were based on anecdotal evidence and occasional surveys included in a number of studies, including Barclay card Business and Future Foundation (2007), Arnfalk (2002), and Roy and Filistrault (1998).

business travel avoided with virtual meetings % of

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	4%	8%	9%	12%	16%	21%	27%	30%	33%	34%	35%
EU	3%	5%	6%	9%	13%	17%	22%	25%	28%	29%	30%
Japan	3%	6%	7%	10%	13%	18%	22%	25%	28%	29%	30%
SK AU NZ CA	3%	6%	7%	10%	13%	18%	22%	25%	28%	29%	30%
FSU	1%	1%	3%	6%	9%	13%	17%	20%	22%	24%	25%
Other Europe	1%	1%	3%	5%	8%	12%	17%	20%	23%	24%	25%
China	1%	1%	3%	5%	8%	12%	17%	20%	23%	24%	25%
Other Asia	1%	1%	3%	5%	8%	12%	17%	20%	23%	24%	25%
India	1%	1%	3%	5%	8%	12%	17%	20%	23%	24%	25%
Middle East	1%	1%	3%	5%	8%	12%	17%	20%	23%	24%	25%
Latin America	1%	1%	3%	5%	8%	12%	17%	20%	23%	24%	25%
Africa	1%	1%	3%	5%	8%	12%	17%	20%	23%	24%	25%

  - Policy world: In this world, it is assumed that the adoption and implementation of ambitious and effective GHG-emission-reduction policies – especially in the transportation sector (such as the proposed cap on GHG emissions from aviation in the EU) will indirectly lead to a higher adoption of teleconferencing than in a carbon world.

business travel avoided with virtual meetings % of total

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	4%	8%	9%	13%	18%	24%	30%	34%	37%	39%	40%
EU	3%	5%	7%	11%	16%	22%	29%	33%	37%	38%	40%
Japan	3%	6%	8%	12%	17%	23%	29%	33%	37%	39%	40%
SK AU NZ CA	3%	6%	7%	11%	15%	20%	26%	29%	32%	34%	35%
FSU	1%	1%	2%	4%	7%	12%	19%	23%	26%	28%	30%
Other Europe	1%	1%	2%	4%	7%	12%	19%	23%	26%	28%	30%
China	1%	1%	2%	4%	7%	12%	19%	23%	26%	28%	30%
Other Asia	1%	1%	2%	4%	7%	12%	19%	23%	26%	28%	30%
India	1%	1%	2%	4%	7%	12%	19%	23%	26%	28%	30%
Middle East	1%	1%	2%	4%	7%	12%	19%	23%	26%	28%	30%
Latin America	1%	1%	2%	4%	7%	12%	19%	23%	26%	28%	30%
Africa	1%	1%	2%	4%	7%	12%	19%	23%	26%	28%	30%

  - Tech world: In this world, it is assumed that aggressive and effective R&D and marketing strategies by the IT industry targeted to teleconferencing-related technologies and services (particularly videoconferencing) will lead to a significant and growing use of teleconferencing by enabling more reliable, interactive, and meaningful communications between people via virtual meetings. This would lead to an increase in the number and the type of meetings that could be held via teleconferencing.

business travel avoided with virtual meetings % of total

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	4%	8%	11%	20%	31%	44%	50%	55%	57%	60%	60%
EU	3%	5%	8%	17%	27%	39%	44%	49%	52%	54%	55%
Japan	3%	6%	10%	19%	30%	43%	49%	54%	57%	60%	60%
SK AU NZ CA	3%	6%	9%	18%	28%	40%	45%	49%	52%	55%	55%
FSU	1%	1%	3%	5%	9%	16%	24%	29%	34%	38%	40%
Other Europe	1%	1%	3%	5%	9%	16%	24%	29%	34%	38%	40%
China	1%	1%	3%	5%	9%	16%	24%	29%	34%	38%	40%
Other Asia	1%	1%	3%	5%	9%	16%	24%	29%	34%	38%	40%
India	1%	1%	3%	5%	9%	16%	24%	29%	34%	38%	40%
Middle East	1%	1%	3%	5%	9%	16%	24%	29%	34%	38%	40%
Latin America	1%	1%	3%	5%	9%	16%	24%	29%	34%	38%	40%
Africa	1%	1%	3%	5%	9%	16%	24%	29%	34%	38%	40%

- Smart world: In this world, it is assumed that the combined effects of the supportive policy environment discussed in the policy world and of the proactive and effective IT industry in the tech world will lead to a widespread and growing use of teleconferencing as an alternative to physical travel.

business travel avoided with virtual meetings % of total

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	4%	8%	14%	25%	39%	53%	66%	78%	83%	88%	90%
EU	3%	5%	12%	23%	37%	52%	64%	77%	82%	87%	90%
Japan	3%	6%	12%	24%	38%	52%	65%	78%	83%	87%	90%
SK AU NZ CA	3%	6%	12%	24%	38%	52%	65%	78%	83%	87%	90%
FSU	1%	1%	4%	8%	15%	26%	37%	46%	53%	60%	65%
Other Europe	1%	1%	4%	8%	15%	26%	37%	46%	53%	60%	65%
China	1%	1%	4%	8%	15%	26%	37%	46%	53%	60%	65%
Other Asia	1%	1%	4%	8%	15%	26%	37%	46%	53%	60%	65%
India	1%	1%	4%	8%	15%	26%	37%	46%	53%	60%	65%
Middle East	1%	1%	4%	8%	15%	26%	37%	46%	53%	60%	65%
Latin America	1%	1%	4%	8%	15%	26%	37%	46%	53%	60%	65%
Africa	1%	1%	4%	8%	15%	26%	37%	46%	53%	60%	65%

- **Additional electricity used per hour of virtual meeting (kWh)**
  - Carbon world: In this world it is assumed that average electricity use would be equivalent to the electricity used by a high-end solution, so the HP Halo telepresence solution was taken as benchmark (see HP, 2008).

Additional electricity used per hour of virtual meeting (kWh)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
EU	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
Japan	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
SK AU NZ CA	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
FSU	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
Other Europe	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
China	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
Other Asia	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
India	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
Middle East	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
Latin America	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
Africa	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43

  - Policy world: Effective climate change policy is assumed to drive a reduction in the average electricity used by virtual-meeting solutions.

Additional electricity used per hour of virtual meeting (kWh)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
EU	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
Japan	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
SK AU NZ CA	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
FSU	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
Other Europe	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
China	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
Other Asia	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
India	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
Middle East	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
Latin America	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46
Africa	2.43	2.43	2.43	2.31	2.19	2.07	1.94	1.82	1.70	1.58	1.46

- Tech world: In this world it is assumed that the IT industry achieves significant improvements in terms of electricity needed to deliver virtual-meeting solutions.

Additional electricity used per hour of virtual meeting (kWh)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
EU	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
Japan	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
SK AU NZ CA	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
FSU	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
Other Europe	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
China	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
Other Asia	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
India	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
Middle East	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
Latin America	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49
Africa	2.43	2.43	2.43	1.94	1.46	1.09	0.85	0.68	0.58	0.51	0.49

- Smart world: In this world an even faster increase in energy efficiency is achieved for virtual-meeting technologies thanks to the combined effort of the IT industry, policy makers, and end users.

Additional electricity used per hour of virtual meeting (kWh)

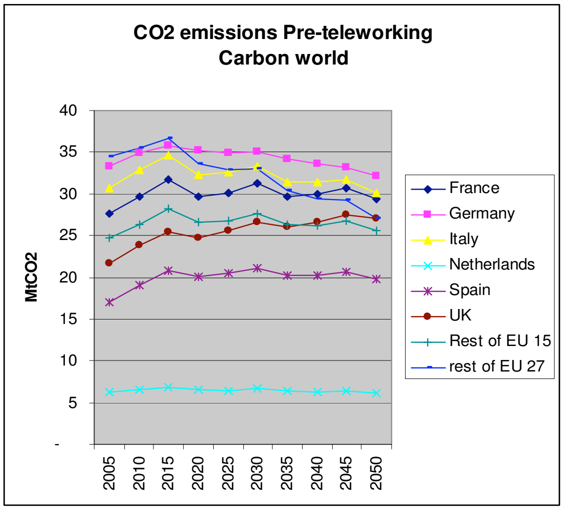
	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
USA	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
EU	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
Japan	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
SK AU NZ CA	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
FSU	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
Other Europe	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
China	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
Other Asia	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
India	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
Middle East	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
Latin America	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12
Africa	2.43	2.43	2.43	1.94	1.22	0.73	0.49	0.34	0.24	0.17	0.12

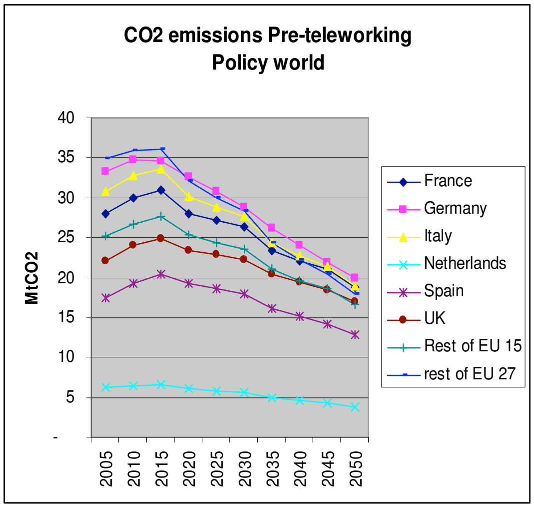
- **Direct and indirect rebound effects**

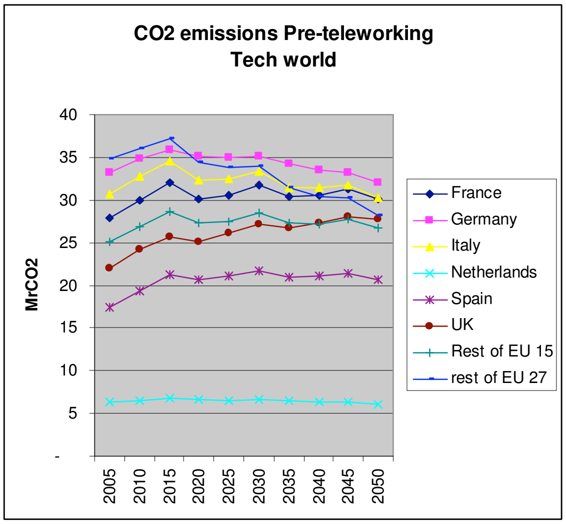
For virtual meetings, the assumptions made for direct and indirect rebound effects were in line with the assumptions made for teleworking.

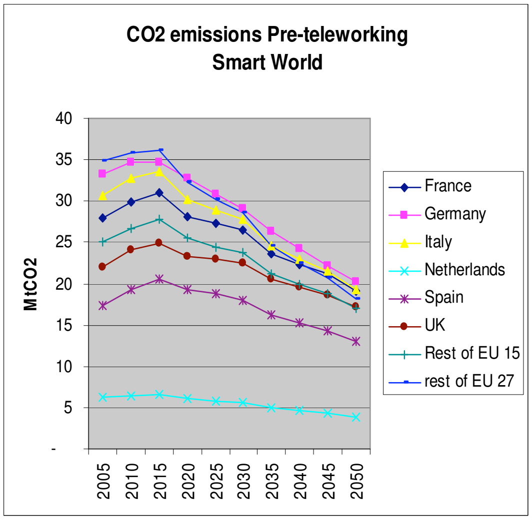
7 Appendix 2: Summary data for EU countries

Teleworking – CO_2 emissions for commuting pre-teleworking

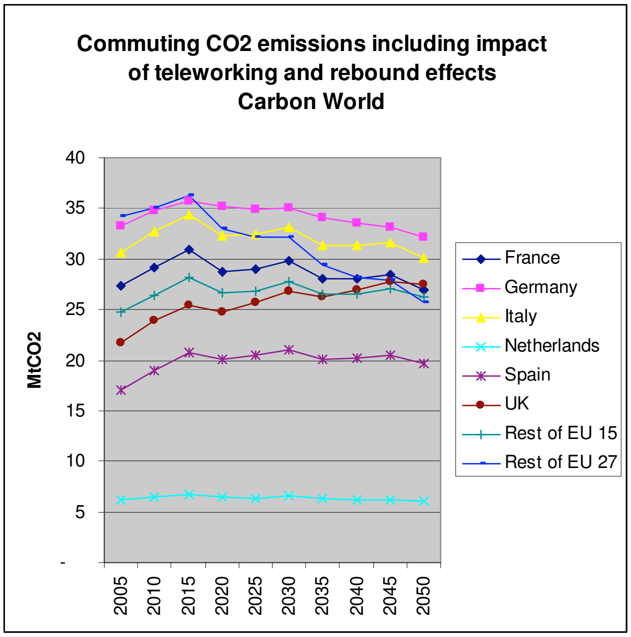


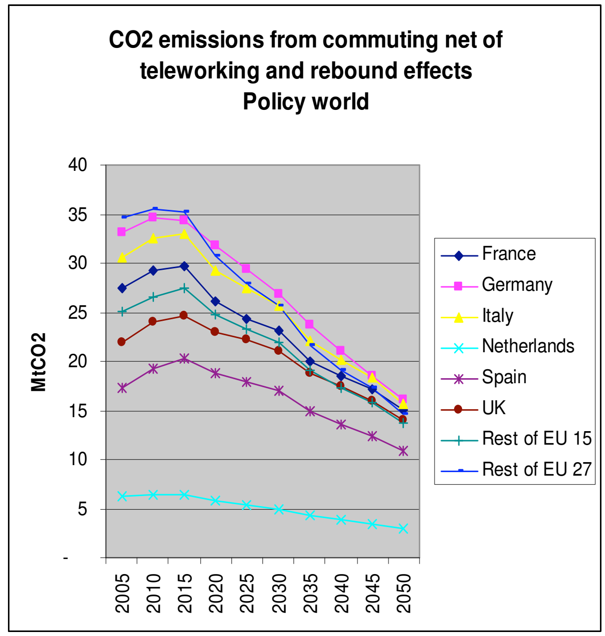


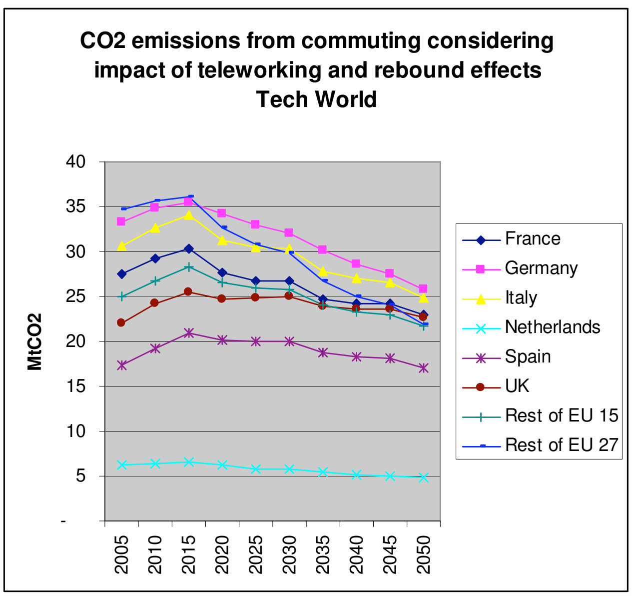


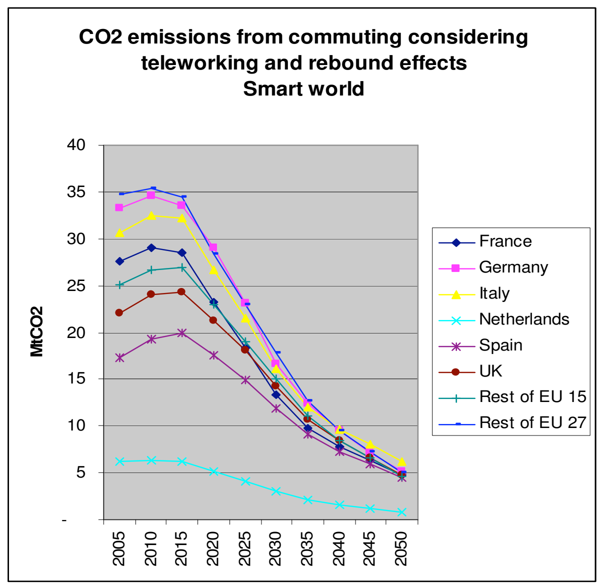


Teleworking – CO_2 emissions for commuting with teleworking, including rebound effects

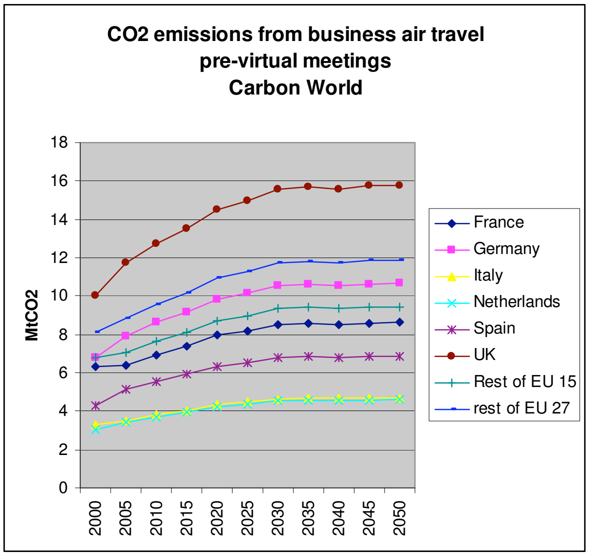


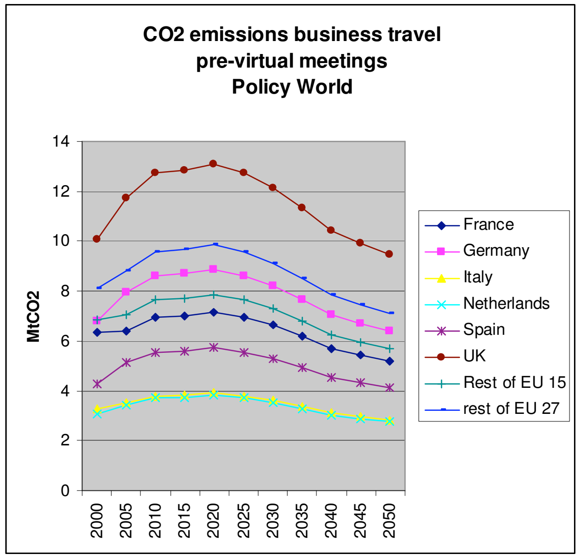


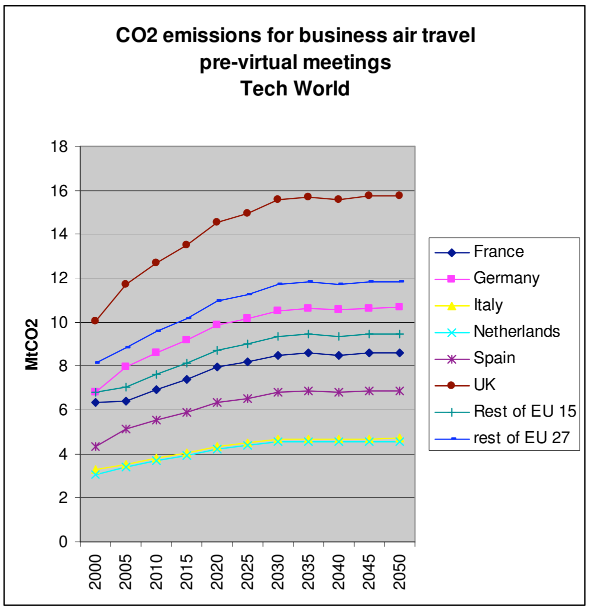


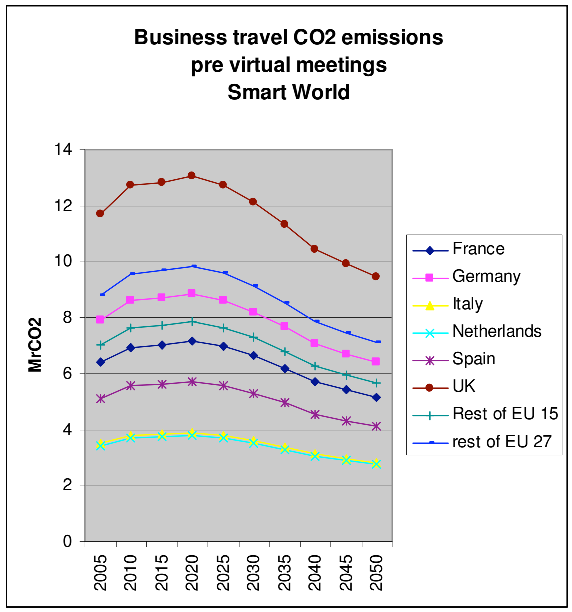


Virtual meetings – business air-travel emissions, pre–virtual meetings

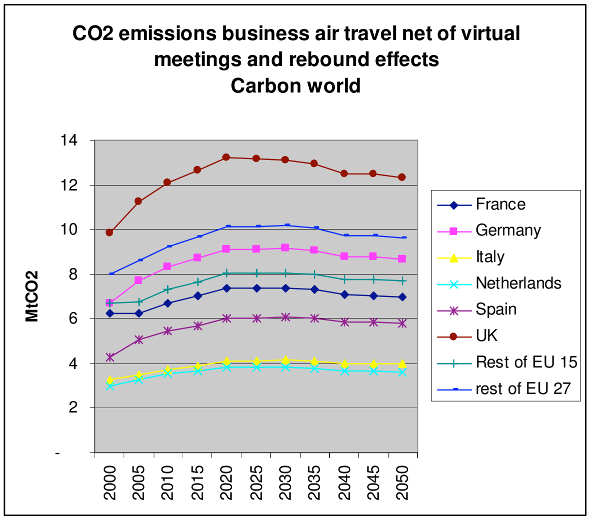


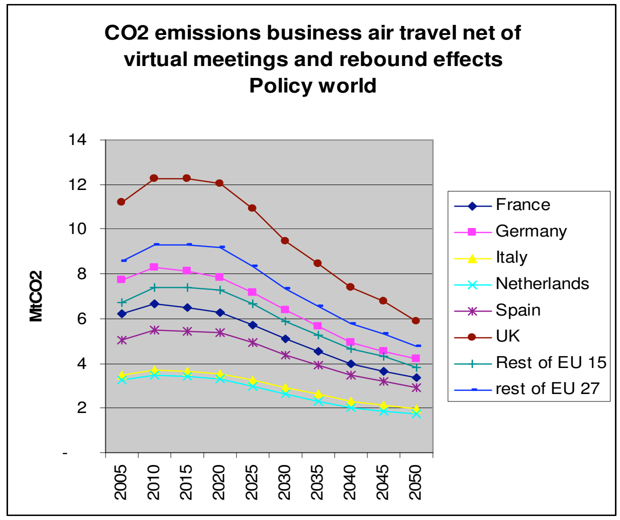


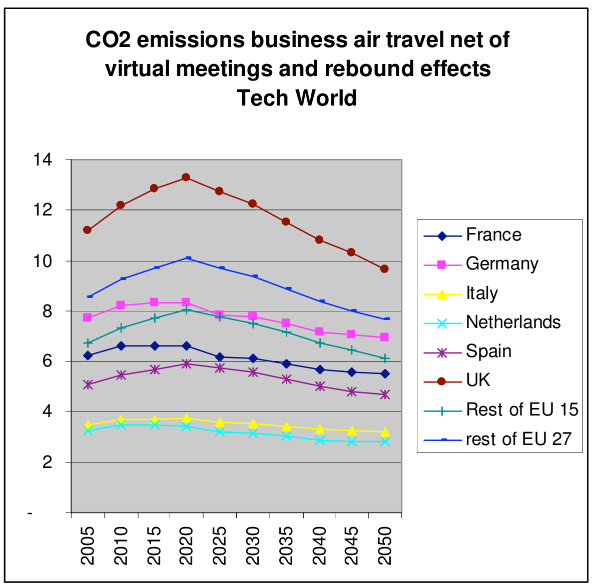


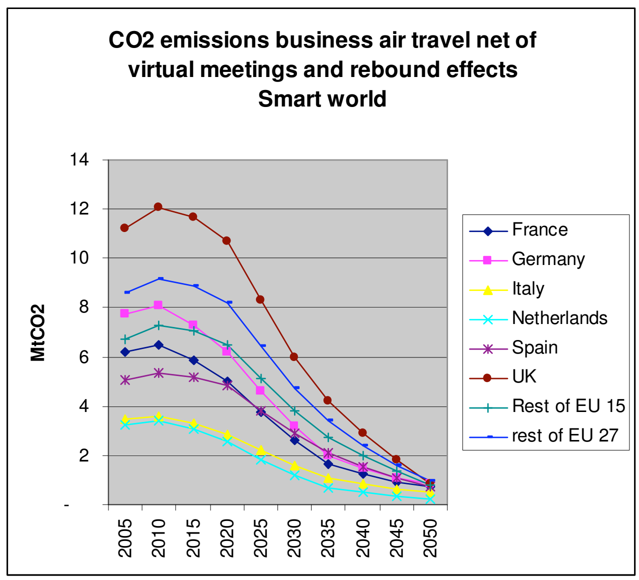


Virtual meetings – business air-travel emissions with virtual meetings, considering emissions deriving from electricity use and rebound effects









8 Appendix 3: Unemployed people interested in teleworking

	Interested in permanent home-based telework	Interested in alternating home-based telework	Interested in centre-based telework	Interested in any of these types of telework
AUSTRIA	47.1	63.5	58.6	70.6
BELGIUM	37.8	50.8	72.9	75.1
DENMARK	45.8	44.9	61.8	68.9
FINLAND	58.3	64.7	67.2	78.0
FRANCE	49.7	59.3	64.5	73.4
GERMANY	51.5	60.8	68.4	73.5
GREECE	52.0	52.1	55.7	61.1
IRELAND	72.2	77.9	75.4	86.4
ITALY	63.8	68.5	74.2	83.4
LUXEMBOURG	63.4	54.4	75.8	84.3
NETHERLANDS	(62.0)	(72.0)	(67.9)	(76.2)
PORTUGAL	37.6	43.8	46.1	52.3
SPAIN	57.6	62.8	70.1	78.5
SWEDEN	(59.6)	(68.9)	(54.8)	(82.5)
U.K.	61.3	69.3	71.6	77.0
EU	55.3	62.9	68.1	75.6
CH	42.0	49.8	55.2	68.4
USA	61.3	65.2	65.3	77.7

Table 1: Unemployed people interested in teleworking, source: Gareis (2002).

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