EcoBalance2010
The 9th International Conference on EcoBalance
November 9-12, 2010, Tokyo, Japan

B2-1040

Life Cycle Assessment of Virtual Meeting Solutions

Fredrik Guldbrandsson[1,*] and Jens Malmodin[1]
[1]Ericsson Research, SE-164 80 Stockholm, Sweden
[*]fredrik.guldbrandsson@ericsson.com

Abstract

Virtual meeting solutions, such as audio and video conferencing, are seen as efficient collaboration tools that have the potential to replace face-to-face meetings thereby saving time and reducing costs and carbon dioxide (CO_2) emissions. In this paper, the environmental impact in the form of CO_2 and carbon dioxide equivalent (CO_2e) emissions from three virtual meeting solutions are estimated using a life cycle perspective. The results show that none of the three services exceed emissions of 3 kg CO_2e per hour of usage. The impact from the usage of video conferencing is compared with the impact from personal air travel during one year. If one long-haul flight per week is replaced, approximately 90 tonnes of CO_2 emissions or about 215 tonnes CO_2e (including also indirect emissions), could potentially be avoided, while the emissions from the yearly average use of the video conference system adds only about 1.3 tonnes CO_2e.

Keywords: Life cycle assessment (LCA), virtual meetings, information and communication technology (ICT), video conferencing.

1. Introduction

We live in a global economy where companies do business all over the world and people travel long distances by air for both business and pleasure with ease. The increasing travel will mean increased emissions of carbon dioxide (CO_2) from the use of fossil fuel. The transport sector contributes significantly to rising emissions of greenhouse gases (GHGs) and in a business-as-usual scenario the sector is expected to double in activity by 2050 along with a predicted doubling of related GHG emissions [1]. Consequently, there is an immediate need to be able to meet and communicate in a more sustainable way. Virtual meeting solutions are today seen as efficient collaboration tools that have the potential to replace face-to-face meetings, reducing business travel and thus CO_2 emissions. Previous conservative estimates have suggested that teleconferencing and videoconferencing solutions could replace between 5 and 20% of global business travel [2] and thereby not only avoid unaccesary CO_2 emissions from travelling, but also increase productivity and save costs.

1.1 Goal and scope

In this paper, the environmental impact in the form of CO_2 and carbon dioxide equivalent (CO_2e) emissions from manufacturing and use of three virtual meeting solutions have been studied. All three systems, developed as prototypes and currently deployed and used within Ericsson Research, are high quality audio and video systems. The systems studied are: 1) a video conference system with remote connection to laptops and mobile phones; 2) a video-meeting solution between two homes and; 3) a solution for using the mobile phone for audio conversation with several people and the ability to share real-time video with other users.

Besides including the impacts from manufacturing and utilization of virtual meeting devices, such as TV monitors, PCs, laptops and mobile phones, the system boundary was expanded to also include the network infrastructure needed to run the systems. Again, this was completed in a life cycle perspective and included components such as the core network, the mobile and fixed access networks, data transport and the submarine cable system.

The disposal of electronic products is not handled in this study. The handling of e-waste is an issue of great importance, however, in terms of CO_2e emissions the disposal phase is a smaller part of the total life cycle [3-4]. For example, the LCA of a mobile phone shows that recycling and reuse of metals from a mobile phone is almost insignificant for most environmental impact categories, including climate change [3].

1.2 Use cases

All three studied virtual meeting solutions are IMS (IP Multimedia Subsystem) based which means that they use the same IMS core for fixed or mobile voice over IP (VoIP). IMS is a recognized international standard, first specified by the 3GPP/3GPP2 bodies and functions across different networks, devices and access technologies.

1.2.1 Video conference system

The video conference system is a high quality multi-party connection between two meeting rooms, with the possibility to connect remotely with mobile phones or PCs/laptops. A conference room consists of two large High Definition (HD) TV monitors, one HD video camera, loudspeakers and a desktop PC used for operating the meeting. The lifetime of the system and all devices in the conference room is assumed to be six years. The lifetimes of a mobile phone and a laptop are three years and four years respectively [4]. The environmental impact depends on the use rate (i.e. number of hours used per day), the number of remote connections used per meeting and the amount of data transferred (i.e network traffic generated by Internet Protocol (IP), mobile and IMS). The conference rooms are assumed to be used, on average, 4 hours per day for 240 days per year.

1.2.2 Home video communication

The home video communication system is a home-to-home (point-to-point) connection, using high quality audio and video. Besides a TV monitor, an HD video camera is needed, also loudspeakers, a set-top box and the home network connection (modem and router). The system is assumed to be used on average two hours per week. It is estimated that the lifetime of the TV monitor is eight years and the lifetime of the system is six years. An estimated impact from the broadband modem and router for this specific service was also included in the calculations.

The TV and set-top box in the home are assumed to be used for other purposes as well and not only for this specific service. The HD video camera, microphones and loudspeakers are assumed to be used only for this specific service.

1.2.3 Real-time audio and video with mobil phone

By using a mobile phone, the real-time audio and video system makes it possible to have an audio conference with stereo sound and a visual indication of the active speaker. It is also possible to share real-time video with other users. In this case, four smartphones are connected for audio conversation and sharing of real-time video. The lifetime of a mobile phone is three years [4] and it is assumed to be used for other purposes as well. The impact from the manufacturing and use phases for this specific service was then allocated based on the total impact from the use and data traffic, which is network dependant (IP, mobile and IMS).

1.3 Method

An LCA (life cycle assessment) based methodology [5-6] developed by Ericsson Research has been used to estimate the environmental impact in the form of CO_2e emissions from the three virtual meeting solutions studied. The method is generic and was developed to be used for ICT services and to estimate the potential carbon emission reductions due to the substitution of travel and transport through the use of ICT. The method builds on results from LCA studies of ICT based systems, e.g. mobile phones, laptops/PCs and network access and studies on the environmental impact from transports and travel. To be able to use the methodology for a specific service, the environmental impact from the total system needs to be allocated to all different services provided. This is achieved by considering equipment type, life time, use time and data traffic.

1.3.1 Manufacturing of ICT devices

For assessing the environmental impact from the manufacturing process of ICT devices used in the three solutions, results from different LCA studies on ICT products and networks are used. Where LCA results are missing, different LCA indicators are used. These indicators can be used to estimate the environmental impact from a product by looking at a similar product that consists of similar materials and is assumed to have a similar manufacturing process. For example, by examining all laptops produced in 2007, the market value and the estimated CO_2e emissions from manufacturing, LCA indicators based on the weight and price can be measured. This method was used in [4] and again here as a basis for these kind of estimations.

1.3.2 Impact from usage

The CO_2e emissions from usage depend on how the electricity is produced - which varies for different countries and regions. The world average electricity emission factor used in this study was 0.6 kg CO_2e/kWh. This factor has been derived from existing LCA studies and it also includes the indirect emissions, i.e. fuel chain (extraction, production and distribution), building of power plants, the grid itself and finally waste treatment.

1.3.3 Sending data between two video conference rooms

The network and data traffic includes the core network, the mobile and fixed access networks, data transport and the submarine cable system. The energy consumption of the core network data hops has been studied, together with repeaters multiplied with cooling factors. For manufacturing of all network cables (including deployment), servers, disk storage, routers, other network equipment, required infrastructure such as power and back-up systems, cooling and the building itself, an addition of approximately 25% relating to operation (using world average electricity), was made based on Ericsson LCA studies of telecom networks.

Further results were used from an LCA study of a generic submarine cable system utilizing a fiber optic cable, submarine repeaters and land terminal stations [7]. The results from the study show that 7 grams of CO_2e are potentially released for every ten thousand gigabit kilometers (10 000 Gbkm). This result includes the whole lifecycle of the fiber optic submarine cable system (i.e. raw material extraction, design & manufacturing, installation, use & maintenance and end-of-life decommissioning).

1.3.4 Mobile access

For mobile access the allocation method used is CO_2e per GB data sent. The impact per average user was based on an average 3G network in Sweden, however with world average power production factors. Traffic data is from the Swedish Post and Telecom Agency (PTS). By combining the traffic per user with the energy consumption of the 3G network, it is possible to estimate the CO_2e emissions per GB.

1.3.5 Fixed access

For the video conference case it is possible to connect to a meeting using a desktop PC and an office LAN connection. The allocation method used for fixed access is time-of-use, i.e. CO_2e/h. Due to the “always on” nature of these nodes, time-of-use is better than data traffic for allocation purposes. Calculations were made based on LCA data for manufacturing and average usage of a broadband modem, home network, fixed broadband access node and LAN access [4].

1.3.6 Data transport

The impact from the operation of data transport networks has been estimated to be 12 Mton CO_2e in 2008 [4,8]. The impact from manufacturing and deployment of cables has been estimated to be 17 Mton CO_2e in 2008 [4]. Cisco estimates the total data traffic to 150 million TBytes in 2008 [9]. Dividing 29 Mton CO_2e with 150 million TB results in about 0.2 kg CO_2e/GB. This figure includes the whole life cycle impact from data transport equipment, including elements such as the optical and radio links. About 40% of the impact comes from operation and 60% from manufacturing and deployment.

2. Results

2.1 Video conference system

The total LCA result for the video conference service per hour is shown in Table 1. The conference room is assumed to be an average room anywhere in the world, thus the global emission factor of 0.6 kg CO_2e/kWh for electricity production has been used. The total CO_2e emission figure for one average conference room is calculated at 0.7 kg/hour. For the remote connection the result is about 0.3 kg/hour, about 0.7 kg/hour for a laptop with High Speed Packet Access (HSPA) connection and about 0.2 kg/hour for a laptop with office LAN connection. All estimates includes manufacturing and data traffic.

Table 1: Total estimated CO_2e emissions for a video conferencing scenario including remote connections.

	Total CO_2e emissions (kg/hour)
One video conference room	~ 0.7
Smartphone (voice)	~ 0.3
Laptop with HSPA connection	~ 0.7
Laptop in office LAN	~ 0.2
Total	**~ 2.0**

2.2 Home video communication

The emissions for the home video communication service is estimated to be about 0.8 kg CO_2e per hour and home, including the manufacturing, use and data traffic. For the whole video communication solution, involving two homes, the result is 1.6 kg CO_2e per hour. The biggest impact comes from the manufacturing process, see Fig. 1. The HD camera used for this service is the significant contributor to the total result for one home, about 50%. This is due to the relatively high emissions for manufacturing, about 40 kg CO_2e per year and the assumption that the use of the camera will be allocated for this service only, i.e. 104 hours per year. However, if the camera is also used for other purposes, the impact would be much lower. For the TV and set-top box, where the impact from the service is shared with the average TV use in the home, the manufacturing process is only approximately 10-15%.

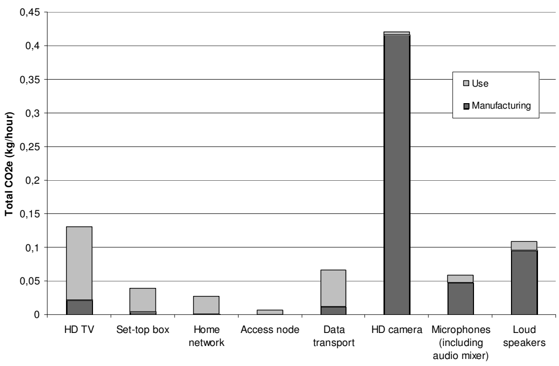

Fig.1: Total estimated CO_2e emissions for one home video communication system using world average electricity production.

2.3 Real-time audio and video

The estimated CO_2e emissions per hour for one smartphone, including manufacturing and use, mobile access, data transport and operator activities is shown for both voice and video in Fig. 2. Operator activities include impact from offices, stores and vehicle fleet and the results are based on an operator survey carried out by Ericsson. The result for voice traffic is the same as the video conference service. The largest impact comes from the mobile access, about (80%) , the reason being, that the user of this specific service will be seen as a relatively heavy data user compared to an average user.

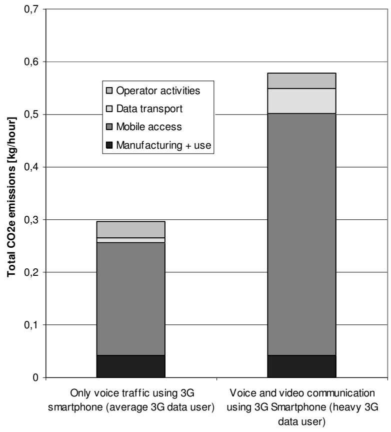

Fig.2: Total CO_2e emissions per hour for one smartphone user both with and without video communication.

If four smartphones are connected in a voice conversation, the result will be about 1.2 kg CO_2e/hour and if one user is sharing video with the other three participants the result will be about 2.4 kg CO_2e/hour.

3. Comparing video conference meeting with air travel

The impact from the manufacturing and usage of two video conference rooms was compared with the impact from personal air travel during one year. The case scenario is that one room is installed in Stockholm, Sweden and one in Dallas, USA. Remote connections with mobile phone or laptop are not included, only the room-to-room connection. It is assumed that the video meeting solution is used on average 4 hours per day for 240 days per year and will replace on average one business trip per week or in total 48 business trips between Sweden and the US during one year.

The total emissions from the two video meeting systems during one year is about 1.3 tonnes CO_2e, see Fig. 3.

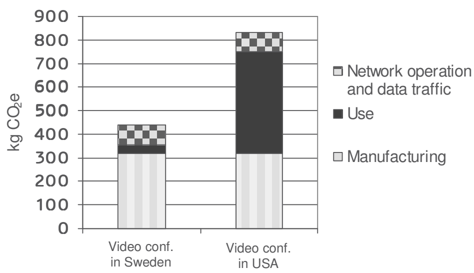

Fig.3: CO_2e emissions for the use of a video conference room in Sweden and USA respectively for one year.

The impact from video conferencing includes the emissions from the manufacturing, power use and the required infrastructure needed for the data traffic. The network operation and data traffic includes the core network and submarine cable hop between Europe and USA.

To calculate the impact from air travel, an emission factor for long-haul flights (0.115 kg CO_2/pkm) is used and multiplied with the total roundtrip distance (16260 km) [10-11]. The distance is for a direct flight. The total emissions for one person roundtrip between Stockholm and Dallas is estimated to be about 1.8 ton CO_2. Saving 48 person roundtrips for one year amounts to an annual reduction of approximately 90 tonnes of CO_2 emissions.

An important part of an LCA on a service is to also include indirect emissions over time that can be related to both ICT systems and all conventional activities, such as travel and transport [11]. For the video conference, this includes the indirect emissions from electricity production. There is an ongoing debate regarding the CO_2e emissions related to air travel. Aircraft CO_2 emissions are sometimes multiplied by a factor of 2-4 to also include effects from nitrous oxides, water vapor, cloud formation, etc. An emission factor of 2.4 has been calculated in [5] that includes not only the effects from nitrous oxides, water vapour, cloud formation etc, but also indirect emissions from supporting infrastructure including fuel supply, airport operation and ground transport, aircraft and airport construction, as well as travel to and from the airport. Using this multiplying factor means that the emissions from one personal airtrip between Stockholm and Dallas potentially results in emissions of about 4.5 ton CO_2e or about 215 tonnes CO_2e for one year (48 roundtrips).

The reduction factor, defined as the relation between air travel and the use of two video conference systems, is approximately 70:1. If the indirect emissions from air travel are accounted for, then approximately 215 ton CO_2e will potentially be avoided and the resulting reduction factor is approximately 170:1.

4. Discussion

The limitations of the study are that the estimation of the impact from the manufacturing of the products has been made using LCA data from average or similar products and not the specific ones. Assumptions on the use of the services has, in some cases, been made without statistical data on the actual use. Also, the disposal of the products is not handled.

The impact from the data traffic, as included in this study using LCA methodology, has to our knowledge never been undertaken for virtual meetings. There is no, or very little, proportionality between energy consumption and data traffic. The data traffic may be increased several times without a significant increase in energy consumption, which is also the most likely scenario for the future. The figures used in this study can be seen as a snapshot of the situation today and the figures should be seen as conservative figures for the future.

5. Summary and conlusions

In this study life-cycle based assessments of the virtual meeting case scenarios have been undertaken. These include the impact from both manufacturing and use of all equipment, e.g. TV monitors, video cameras, microphones, laptop computers, and mobile phones. Also, the impact from the network infrastructure (data traffic), allocated for the specific services, has been considered.

The results of the case study show that none of the three systems exceeds emissions of 3 kg CO_2e per hour of usage, which includes the impact from manufacturing, power use, network infrastructure and data traffic.

It is also shown that if 48 person roundtrips by air are saved between Stockholm and Dallas by using video conference instead, then approximately emissions of 90 tonnes of CO_2 or about 215 tonnes of CO_2e when also including indirect emissions, could potentially be avoided. The emissions from the yearly average use of the video conference systems adds about only 1.3 tonnes CO_2e. The reduction factor equates to approximately 70:1 and 170:1 respectively.

7. References

[1] The World Business Council for Sustainable Development (WBSCD). Mobility 2030: Meeting the Challenges to Sustainability Full Report. 2004

[2] The Climate Group on behalf of the Global eSustainability Initiative (GeSI). SMART 2020: Enabling the low carbon economy in the information age. 2008

[3] Bergelin, Frida. Life cycle assessment of a mobile phone - a model on manufacturing, using and recycling. MSc thesis, Ericsson Research and Uppsala University. ISSN: 14-5773, UPTEC Q08014. 2008

[4] Choi, B-C., H-S. Shin, S-Y. Lee and T. Life Cycle Assessment of a Personal Computer and its Effective Recycling Rate. *International Journal of LCA*. Vol. 11. No. 2, 2006, pp. 122-128

[4] Malmodin et al. Greenhouse gas emissions and operational electricity use in the ICT and entertainment & media sectors. Journal of Industrial Ecology. Paper accepted for publication in 2010.

[5] Jens Malmodin, Nina Lövehagen and Dag Lundén. Methodology for Life Cycle Based Assessments of the CO2 Reduction Potential of ICT Services. IEEE, International Symposium on Sustainable Systems and Technologies, Arlington, 2010, May 17-19.

[6] Ericsson White Paper. Measuring Emissions Right. <http://www.ericsson.com/res/docs/whitepapers/methodology_high3.pdf>.

[7] Donovan, Craig. Twenty thousand leagues under the sea: A life cycle assessment of fibre optic submarine cable systems. MSc thesis, Ericsson Research and Royal Institute of Technology (KTH). 2009

[8] Roth, K.W., F. Goldstein and J. Kleinman. Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings - Volume I: Energy Consumption Baseline. Arthur D. Little, Inc. 2002

[9] Cisco white paper. Approaching the Zettabyte Era. 2008. <http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481374_ns827_Networking_Solutions_White_Paper.html>. (Accessed 12.12.2009).

[10] DEFRA, Department of Environment, Food and Rural Affairs UK, Guidelines to DEFRA's GHG conversion factors for company reporting, Annexes updated June 2007.

[11]<http://www.webflyer.com>,(Accessed 12.12.2009).

[12] Chester, Mikhail V. Horvath, Arvath. Environmental assessment of passenger transportation should include infrastructure and supply chains. *Environmental Research Letters*, Vol 4, No. 2, 2009, pp.