Life Cycle Assessment of the Mobile Communication System UMTS Towards Eco-Efficient Systems

Mireille Faist Emmenegger1*, Rolf Frischknecht1, Markus Stutz2, Michael Guggisberg3, Res Witschi4 and Tim Otto5

1 ESU-services, Kanzleistr. 4, 8610 Uster, Switzerland
2 Motorola GmbH, Motorola Advanced Technology Center – Europe, Wiesbaden, Germany
3 Swisscom AG, Swisscom Innovations, Bern, Switzerland
4 Swisscom Fixnet AG, Environmental Management, Bern, Switzerland
5 Deutsche Telekom AG, Central Environmental Affairs Office, Darmstadt, Germany

* Corresponding author (faist@esu-services.ch)

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Abstract

Goal, Scope and Background. Goal of this study is an evaluation of the environmental sustainability of the UMTS mobile communication system in Switzerland by means of a Life Cycle Assessment (LCA). A baseline environmental impact profile across the full life cycle of the UMTS (Universal Mobile Telecommunication System) and its predecessor, the GSM (Global System for Mobile Communication) is presented. The baseline assessment was a necessary first step to evaluate the environmental impacts of the mobile communication systems use and growth, thus permitting the evaluation of its environmental sustainability.

Main Features. Two functional units are defined: a data set of 1 Gbit (1,000,000 kbit), and the yearly mobile communication of an average customer. In the UMTS, both data packages and calls can be conveyed. In order to be able to standardize the results, an equivalence between these two kinds of transmission is formed. Two different options are defined, which represent different ways of transferring the data: mobile phone to mobile phone, and mobile phone to fixed network. All components of the UMTS network like the mobile phones, base stations, antennae, switching systems and the components of the landline like cable system and switching centers, are assessed. The environmental impacts are assessed taking into account all major life cycle phases like raw material extraction, manufacturing, use, disassembly and disposal of the product and the needed infrastructure. Electronic components like printed wiring boards and integrated circuits are assessed using a simple model based on the size (for IC) or number of layers (for PWB), respectively. Mining of precious metals (gold, silver) is included.

The study was carried out by ESU-services, Motorola, Swisscom and Deutsche Telekom. Thanks to the industrial partners it can rely on primary data for the production of mobile phone and base station, and for the operation of the networks. As the UMTS network is still being built, no actual data of network operation is assumed that large improvement potentials are still present for the UMTS network components concerning expenditures and emissions of pollutants and greenhouse gases regarding the entire production of the devices in the UMTS system are compensated by the faster data transmission rate. Per customer, the result is inverse, however, since the higher efficiency is compensated by the higher data communication per user in the UMTS system. The UMTS network in its state of 2004 according to the 2001 planning and with the accordingly calculated number of customers and data transfer causes 2.1 times more CO2 emissions and requires 2.4 times more (non-renewable) primary energy per customer than for the GSM system in its current state. It must be noted, however, that the UMTS technology supports other services than the GSM system. The development of the UMTS is accompanied with an increased consumption of resources and emissions of pollutants and greenhouse gases regarding the entire system for mobile telephone communication.

From an environmental point of view, the mobile telephone is the most important element of the mobile communication network (UMTS and GSM). The short service life of the mobile phone plays a substantial role. Increasing the utilization period of the mobile phone (e.g. by leasing, re-use, extension of the innovation cycles, etc.) could thus represent a large potential for its improvement. The second most important components are the base stations. In the assessment mainly the use phase proved to be important. The lower environmental impact (per Gbit data transfer) as compared to the mobile phone can be explained by the longer service life (around factor 8). Main impacts are caused by the electricity consumption, in particular the energy needed for cooling the base stations. By choosing an environmentally benign electricity mix and/or by increasing the portion of renewable sources of energy, the network operators have a substantial potential of lowering the environmental impacts (in particular the greenhouse gas emissions) of mobile telecommunication. Furthermore, the manufacturing of electronic components, the life time of the appliances and energy consumption are key parameters influencing the environmental profile of the networks most. Given its larger data transfer rate, the UMTS is ecologically more favorable in terms of data transfer rate than its predecessor, the GSM system. The higher energy consumption and the more complex production of the devices in the UMTS system are compensated by the faster data transmission rate. Per customer, the result is inverse, however, since the higher efficiency is compensated by the higher data communication per user in the UMTS system. The UMTS network in its state of 2004 according to the 2001 planning and with the accordingly calculated number of customers and data transfer causes 2.1 times more CO2 emissions and requires 2.4 times more (non-renewable) primary energy per customer than for the GSM system in its current state. It must be noted, however, that the UMTS technology supports other services than the GSM system. The development of the UMTS is accompanied with an increased consumption of resources and emissions of pollutants and greenhouse gases regarding the entire system for mobile telephone communication.

The GSM system is a mature technology, while the UMTS is still at the beginning of its learning curve. Thus, it can be safely assumed that large improvement potentials are still present for the UMTS network components concerning expenditures and emissions both at production and by the use of the devices. This study provides the necessary information where such improvements are most effective in environmental terms.

Keywords: Base station; eco-efficiency; GSM (Global System for Mobile Communication); mobile phone; UMTS (Universal Mobile Telecommunication System)
Introduction

The demand for mobile communication services is globally on the rise. Mobile phone networks are being built rapidly and are mainly steered by economical and legislative drivers. Environmental aspects are mainly incorporated only for singular aspects like non-ionizing radiation of antennae and mobile phones, or the energy use of switching centers. A complete picture of the different environmental impacts of the UMTS (Universal Mobile Telecommunication System) allows operators and manufacturers to intensify actions concentrating on the components of the whole system with the highest potential of improving their environmental properties.

Several studies have assessed environmental aspects of telecommunication systems (e.g. Oiva 2000) for a mobile phone, (Harada 2001) for the fixed network in Japan, (Blazek 1999) for the telecommunication systems of two cities). A study of the complete UMTS network is being done for Ericsson components; first results were presented in (Malmodin 2001). The study presented in this article is the first environmental assessment of UMTS in Switzerland.

1 Goal and Scope

Goal of the project is to assess the environmental sustainability of the Swiss UMTS network, which is currently being built by different telecommunication operators in Switzerland (Faist Emmenegger et al. 2003a). In order to do this, a life cycle assessment was carried out. The goal of the LCA is to assess the environmental impacts caused by a call via the UMTS mobile phone system. The results of the life cycle assessment (LCA) are used to quantify the environmental impact of the use and growth of the total UMTS mobile phone system and its components, thus making an assessment of its environmental impacts possible. All the components of the UMTS like the mobile phones, base stations, antennae and switching systems, and the components of the landline like cable system and switching centers, are assessed. The environmental impacts are assessed taking into account all major life cycle phases like raw material extraction, manufacturing, use, disassembly and disposal of the product and the needed infrastructure. A baseline environmental impact profile across the full life cycle of the GSM (Global System for Mobile Communication) was also done and allows the comparison between the two networks.

1.1 Mobile networks

GSM, which was first introduced in 1991, is one of the leading digital cellular systems. Eight simultaneous calls can occupy the same radio frequency. It provides integrated voice mail, high-speed data, fax, paging and short message services capabilities, as well as secure communications. Originally a European standard for digital mobile telephony, GSM has become the world’s most widely used mobile system in use in over 100 countries. GSM networks operate on the 900 MHz and 1800 MHz waveband in Europe, Asia and Australia, and on the 1900 MHz waveband in North America and in parts of Latin America and Africa.

UMTS is the name for the third generation mobile telephone standard in Europe. 3G is a generic term covering a range of future wireless network technologies, including UMTS, WCDMA (Wideband Code-Division Multiple-Access), CDMA (Code-Division Multiple-Access) 2000 and EDGE (Enhanced Data rates for GSM Evolution). 3G combines high-speed mobile access with Internet Protocol (IP) based services.

1.2 Functional unit

Functional Unit Data Transfer. As a functional unit, a data set of 1 Gbit (1,000,000 kbit) is defined. For most of the network components, the normalization of manufacturing, installation, operating and disposal expenditure per transferred data set is required. In the UMTS, both data packages and calls can be conveyed. In order to be able to standardize the results, an equivalence is formed between these two kinds of transmission. This is based on the assumption of an average transmission rate of data packages and calls as well as on assumptions for the average use of the UMTS equipment by the customer. Based on an average minute of use the time share of data transfer in 2004 was determined. The total kb per year were calculated on the basis of an average data throughput (kb/s), the anticipated number of users and utilization ratio of the data throughput. Data used are based on planning network data and anticipated number of users for 2004. It can be assumed that the calculated network has some over-capacity as the licence asks from the operators to secure a certain coverage independent of the actual demand.

As a basis for the GSM (Global System for Mobile Communications) mobile network, the ‘taxed minutes of calls’ are taken in the year 2000. The ‘taxed minutes of calls’ are assessed by the operator on the basis of selling figures.

Some components in the network are used symmetrically, e.g. the mobile phone is used twice regarding a call between two mobile users. Therefore, these components were accounted for twice.

Energy use of the equipment is not proportional to the data transfer; however, the number of elements in the network is proportional to it, as the amount of the data transfer defines the capacity of the network and therefore the devices needed.

Functional Unit Total System (Network). As another functional unit, the yearly mobile communication of an average customer of the total UMTS and GSM networks is considered. Since the UMTS technology supports other services than the GSM system, the comparability is only limited. However, this functional unit allows one to evaluate how the total impacts of telecommunication are likely to develop.

1.3 System definition

Two different options are defined, which represent different ways of transferring the data:

- Mobile phone to mobile phone
- Mobile phone to fixed network