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CHANGES IN ENVIRONMENTAL IMPACTS OVER TIME IN THE FAST DEVELOPING ICT INDUSTRY

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ABSTRACT

The information and communication technology (ICT) sector is changing: Data volumes and ICT usage is growing exponentially, ICT infrastructure is shared by many services instead of used only by voice, the volume of end user (customer) devices is increasing but at the same time the telecom operator's internal electricity consumption remains almost constant. This paper elaborate on identified trends during the period 1990 to 2010 using data from several LCA studies over time to conclude what implications can be drawn on the estimated environmental impact.

INTRODUCTION

The ICT sector has since Alexander Bell invented the telephone in 1876 (Whether Mr. Bell invented the telephone or not is another story) been under constant development. However the resent years rapid data volume increase in combination with increased mobility, new technical solutions and services have changed business models, energy consumption patterns as well as ICT's environmental impact. In this paper environmental impact is based on LCA and exemplified by energy consumption and CO2e emissions. In the early age of voice communication electricity was centrally distributed via the copper wire, i.e. the phone was passive and powered from a centralized exchange. Without the wire the phone was dead. When TeliaSonera (Telia up to 2003) performed the first LCA of a fixed telephony subscription service (Lindroth 1999) the result showed that the main environmental impact originated from powering the local exchange sites. The end user equipment had a minor part from an LCA perspective even when manufacturing was included.

But the situation has changed dramatically and the largest change has occurred during the last 10 years despite the sectors 130 year of history. An increased mobility in the society (Always connected!), streamed video services and growing numbers of personal ICT devices is increasing transported data volumes. In 1990th the mobile phone was limited to a few, in 2011 the situation was the opposite and there's almost one "smart phone" per person plus personal Tablet's, Laptops etc. in addition to the increased use of other connected devices (M2M). The usage of ICT based services has increased and the total data volumes is at least doubled every third year. Simultaneously information storage and processing have been moved in to "the cloud". Or to be more precise, in to one or more of the growing large data centers that have emerged during the last couple of years. Google and Facebook are probably the most known but there are other actors as well, not the least traditional telecom operators.

MATERIALS AND METHODS

TeliaSonera operates a large part of Sweden's core and access networks and has about 40% of all ICT subscriptions (PTS 2011). Figure 1 shows a summary of 10 years of operational data.

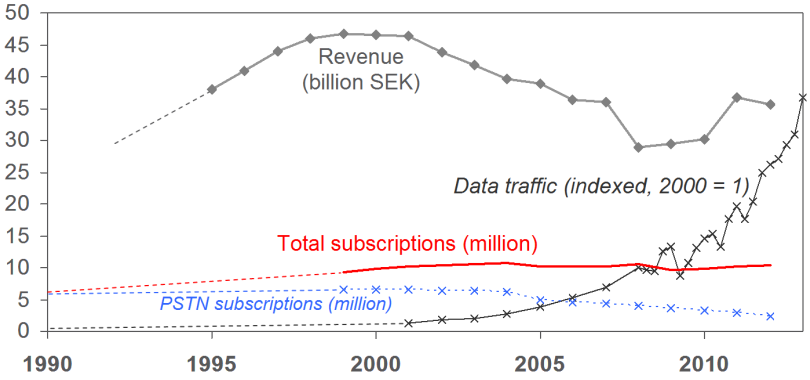

Figure 1. Revenue, total number of subscriptions, fixed telephony (PSTN) subscriptions and data traffic (indexed) for TeliaSonera operations in Sweden 1990-2011. Units shown in graph.

The total volume of subscriptions has grown from about 6 million fixed telephony subscriptions to about 10 million ICT subscriptions (fixed, mobile and IP telephony, mobile and fixed broadband and IPTV) in addition to TeliaSonera's core network traffic that today carries a large part of Sweden's enterprise data. Total data traffic including voice expressed as data has increased about 100 times and is still growing with approximately 30% per year. Revenue was higher in 2000 but is now on par with the revenue in 1995. The number of employees has decreased from more than 40000 to less than 10000. From energy consumption perspective a holistic approach has been applied and in this study all ICT connected user and network equipment have been included. The connected devices electricity consumption has increased substantially and is now about 4 times larger than the energy used by TeliaSonera's network, which used to be the main consumer in the past, see Figure 2. The Networks electricity consumption has been almost flat despite the growth in subscriptions, data rates and data traffic due to overall better network performance.

There are some data gaps due to the fact that the first thoroughly energy assessment was performed as late as in 1996 however existing data have been extrapolated to close these.The total ICT energy includes historical estimates of IT equipment based on energy investigations of buildings in 1990 (a) and in 2005 (b) (Swedish Energy Agency 2009) together with estimates of offline/modem connected PCs. The year 2010 (c) is based on the most recent study of ICT in Sweden (Malmodin et al 2013). Note that network energy (d) represents the primary energy content in fuel consumed while all other parts represent electricity consumption (secondary energy).

Figure 2 shows the convergence of IT and telecom into ICT. Connected IT equipment (data centers, LANs, PCs) has not been modeled in detail besides for recent years. The historical connectivity towards the Swedish ICT network has been modeled from 0% in 1995 to 100% in 2010. The increase in electricity consumption is mainly related to user equipment and data centers. The impact from fixed telephony equipment (office and cordless phones, answering machines etc.) that used to have high stand-by consumption is decreasing due to lower usage.

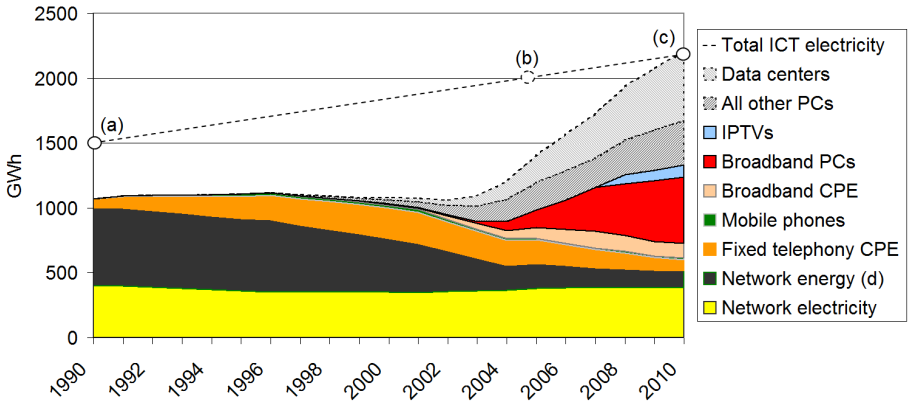

Figure 2.Electricity consumption of connected user and network equipment to TeliaSonera networks 1990-2010.

The performance of connected business related IT equipment is in control of business customers. The energy performance of private user equipment is mainly controlled by private customers but TeliaSonera as service provider is partly able to influence the actual performance on these in relation to energy and environmental impact.

RESULTS

The total carbon footprint for TeliaSonera operations in Sweden including all connected user and network equipment as described in *Materials and Methods* are shown in Figure 3.

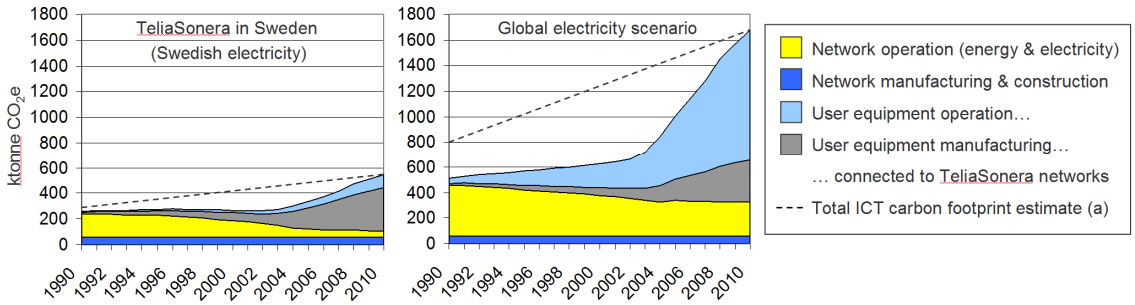

Figure 3. Total GWP (Global Warming Potential) results expressed as CO_2e (carbon dioxide equivalents) for TeliaSonera operations in Sweden 1990-2010. Including all (a) connected user and network equipment (data centers, LANs, PCs) as described in *Materials and Methods* also including all related manufacturing (embodied emissions).

If Swedish electricity mix is used manufacturing of user equipment (mainly PCs) abroad becomes the largest source of CO_2e emissions. Import of ICT products is also the reason why the absolute footprint has doubled since 1990. But if Swedish electricity mix is replaced by a global average the operation of user equipment becomes the main source for the growth and the main source of absolute carbon footprint (4 times larger than the actual footprint in Sweden in 2010). The global electricity scenario is similar to an average ICT scenario in developed countries. The average footprint in Sweden is 70 kg CO_2e per subscription, 160 kg CO_2e per person. On a global perspective this would be about 2-3 times higher per subscription or person with equal ICT use as in Sweden (Malmodin 2011).

DISCUSSION

The presented data shows that the ICT industry is expanding, the volume of connected devices is increasing and ICT is reaching more people, not the least via wireless communication. The number of fixed connections is increasing steadily but with a lower phase. In addition "cupper line" access in the past only used for PSTN is now shared by new fixed services. From a user perspective traditional voice communication is replaced by instant messaging services (IMS) such as SMS and chat.

TeliaSonera's core network energy consumption has been constant despite the huge data volume increase. However since end user devices requires local powering as well as " cloud data" and since the total number of devices is exploding the total ICT electricity consumption and the total environmental impact is increasing. But since the total impact is shared by more subscriptions the impact per subscription remains the same or decreases, the later one related to mobile services. The impact per data bit has been reduced by more than a factor of 10 since 2000 despite the growth in the ICT sector.

From a LCA perspective the large impact from end user equipment's embodied footprint is uncertain and especially in Sweden with low carbon electricity the embodied carbon footprint will have a larger relative impact. However in a global perspective with fossil based electricity the usage will have a larger share and by this the uncertainty is reduced.

CONCLUSIONS

Based on the change in ICT usage, the data volume increase in combination with changed usage behaviors it's obvious that it makes little sense comparing ICT studies from 1990ths with studies from 2012. The few conclusions that can be drawn are:

- The environmental impact per connected device and data volume are lower than in the past due to increased shared infrastructure.
- End user equipment's total share of ICT's environmental impact including the impact from shared data centers is increasing.
- To decrease ICT's total environmental footprint efforts should be focused on reducing electricity consumption in core sites, data centers as well as in end user devices.

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