

# MEASURING EMISSIONS RIGHT

ASSESSING THE  
CLIMATE-POSITIVE  
EFFECTS OF ICT

A holistic methodology for effectively  
measuring CO<sub>2</sub> emissions



# OVERVIEW

Climate change is perhaps the topmost challenge of our time. To prevent climate change from severely impacting almost every facet of life on the planet, scientific consensus points to a need to reduce the emissions of greenhouse gases (GHG), measured in terms of CO<sub>2</sub> equivalents (CO<sub>2</sub>e), by as much as 80 percent by 2050.

So far the focus has centered on incremental reductions of CO<sub>2</sub>e emissions in areas in which they are the highest, without negatively impacting the economy. But there is also a large untapped opportunity to drive economic growth by applying transformative solutions. Without taking a holistic view, however, we run the risk of ending up with incorrect solutions.



Figure 1: Overview of the process to implement climate-positive solutions

The first step in measuring emissions is to determine where emissions occur and at what levels. Once emission levels and inefficiencies have been identified and assessed, it is possible to change operating models, supporting systems, and behavior – it is here that the information and communications technology (ICT) sector plays an important role. Figure 1 symbolizes a scale in balance. The message of this illustration is that the same function can be delivered in either a new transformative way (represented by the smaller, green weight on the left) or in incremental ways (heavy weight on the right).

Life cycle assessments (LCA) constitute a well-established methodology and tool for measuring CO<sub>2</sub>e emissions, and are used for comparing the emissions of different systems. This holistic methodology is needed in order to successfully understand the complexity between large industrial systems and user behavior, and ultimately to measure the reductions of CO<sub>2</sub>e emissions on a large scale.

This paper takes the traditional LCA approach one step further, by presenting:

- a method for assessing the potential reduction of future CO<sub>2</sub>e emissions by avoiding or substituting those emissions with environmentally smarter solutions; and
- the results of two case studies.

The method, which is an enhancement of LCA based on the ISO 14040 series of LCA standards, is used to show how the introduction of an ICT system can reduce CO<sub>2</sub>e emissions. Indeed, this method is especially useful for evaluating the potential of ICT-based solutions to reduce CO<sub>2</sub>e emissions in other sectors not traditionally associated with ICT.

## POTENTIAL OF ICT TO REDUCE OVERALL CO<sub>2</sub>E

One industry study, SMART 2020, estimates that ICT has the potential to reduce overall CO<sub>2</sub>e emissions by around 15 percent by 2020. A complete life cycle approach was not used, however. In economic terms, ICT-enabled energy efficiency translates into savings of approximately EUR 600 billion. ICT-enabled energy efficiency can be introduced through a variety of solutions, such as:

- virtual meetings
- smart buildings
- e-health (healthcare informatics over the internet) and m-health (mobile e-health)
- smart grids
- smart logistics and intelligent transport systems
- e-learning (technology-enhanced learning) and m-learning (mobile e-learning)
- dematerialization – the substitution of high-carbon products and activities with low-carbon alternatives; for example, replacing face-to-face meetings with video conferencing or telepresence, replacing paper bills with e-billing, or replacing recorded tapes with e-files.

By replacing physical products with services, and by helping people to use resources more efficiently, ICT-based solutions can improve basic services while reducing CO<sub>2</sub>e emissions. Within the realm of ICT, broadband provides the most effective foundation for a resource-efficient infrastructure that can deliver many different services in a low-carbon way – for instance, via machine-to-machine, machine-to-human or human-to-human communication.

## THE FACTOR EFFECT

Ericsson estimates that smart use of broadband-enabled services can reduce CO<sub>2</sub> emissions by a factor of 10kg to 100kg; that is, the use of a telecom service that emits 1kg of CO<sub>2</sub> may enable a 10kg to 100kg reduction in CO<sub>2</sub> emissions.

# FINDING A WAY THROUGH THE MIST

Scientific consensus points to a need to reduce CO<sub>2</sub>e emissions. To succeed, several different courses of action are needed. The primary focus to date has centered on incremental reductions of CO<sub>2</sub>e emissions, in particular in areas where they are the highest and without negatively impacting the economy. But by itself, this approach will not adequately achieve the necessary scale of reductions.

To achieve the scale of reductions needed to slow climate change, we must replace traditional methods, processes and systems with “smarter,” more efficient ones. In many instances, these solutions are enabled by the ICT sector. ICT-based solutions can reduce CO<sub>2</sub>e emissions and improve basic services – for example, by replacing physical products with services, supporting home energy management, and by helping people to use resources more efficiently.

Broadband constitutes the foundation of a resource-efficient infrastructure that can deliver many different services in a low-carbon way.

## CURRENT MEASUREMENT METHODS

At present, several methods are used to analyze the effect of introducing ICT-based solutions to replace traditional solutions and thereby reduce CO<sub>2</sub>e emissions. However, few of these methods have been designed to include all possible aspects of potential reductions. As a consequence, it is possible to overlook changes that are critical for identifying long-term reductions in CO<sub>2</sub>e emissions. These methods are seldom based on life cycle assessments and typically only include end-user equipment.

Most standards and assessment methods tend to focus on particular aspects of the life cycle – there are, for example, a number of “energy labeling” standards for products that use electricity. One such is the EU energy label, Energy Star.

Unfortunately, none of these methods include “infrastructure” as part of their assessment of direct and indirect impacts. Consequently, these methods have only limited value. Recent scenario-building studies have demonstrated that comprehensive LCAs are, in fact, necessary to provide a holistic image of environmental impacts.

LCA methodologies, such as “Process-Sum” and “Economic Input-Output,” have two different approaches for evaluating environmental impact. There are also hybrid models that use adaptations of these methods in an effort to take advantage of key benefits while overcoming certain inadequacies. This is especially so in the case of ICT products, in which the variety of materials and components involved, as well as the rapid evolution of high-tech manufacturing processes and product innovations, makes an LCA seem a daunting task.

Several standardization organizations are currently developing standards that should provide guidelines for performing an LCA relating to ICT-based products, services and solutions. These organizations include the European Telecommunications Standards Institute (ETSI) and the International Telecommunication Union (ITU). This process will provide requirements for assessing the “direct” environmental impact of a product (that is, those activities associated with the actual manufacture and use of a product) as well as the “indirect” environmental impact of a product or service (that is, those activities associated with the applications of the product and how they tangibly affect or benefit the end user or society as a whole).

In summary, there is not currently an agreed methodology for measuring the potential reductions in CO<sub>2</sub>e emissions that ICT-based solutions can provide.

Nevertheless, the industry should adopt the use of comprehensive LCAs to calculate the potential of ICT-based solutions to reduce CO<sub>2</sub>e emissions. The adoption of a holistic LCA methodology would:

- enable companies to prioritize solutions based on their impact on sustainability;
- enable and guide policy makers to support balanced decisions regarding sustainability;
- provide means of making comparisons between ICT services and other services; and
- help put focus on the total level of energy usage and highlight the potential for CO<sub>2</sub>e reductions in business cases, thereby motivating investments in ICT.

As the name implies, LCA-based methods assess the environmental impacts of products and services through their entire life cycle, from resource extraction (for example, forestry) through manufacture, distribution, usage, and end-of-life (disposal or recycling). In other words, in order to answer a question about the overall impact of a particular product or service, we must first determine the cumulative impact of said product or service across its entire life cycle.

# REDUCING THE EMISSIONS

## METHODOLOGY FOR ASSESSING THE USE OF ICT TO REDUCE CO<sub>2</sub>E EMISSIONS

To quantify the potential that ICT-based applications and services have to reduce CO<sub>2</sub>e emissions, it must be possible to assess, from a life cycle perspective, the environmental impact of both the ICT-based system and the conventional system it replaces – for example, physical transport. Figure 2 shows a schematic illustration of a holistic LCA method for comparing a new ICT-based service with a conventional service. The method builds on results from LCA studies of ICT-based systems, for example, PCs and network access, and LCA studies of the conventional systems from traditional sectors, for example, buildings and transport. The conventional system and the ICT-based system are each assessed in the same way and then compared.

The climate-positive approach to LCA provides a systematic method for measuring the cumulative environmental impacts of a product or service. The scope of this method, which is based on the ISO 14040 series (14040 and 14044), encompasses a wider perspective than other methods by incorporating needed infrastructure. In simple terms, this method consists of the three main LCA steps: system definition, data collection, and an assessment of the impacts of CO<sub>2</sub>e.

### SYSTEM DEFINITION

The first step – system definition – entails defining the processes and boundaries of the system. A system is made up of the processes and boundaries of the service to be analyzed. Setting the scope of the analysis entails deciding what changes result from implementing the system and what CO<sub>2</sub>e impact the system has.

Access to ICT has direct and measurable impacts on society, the environment, and economic development. In some cases – depending on the service – it might be necessary to consider both fixed and mobile broadband in order to analyze the environmental impacts of the introduction of ICT.

### DATA COLLECTION

During the second step – data collection – data is collected from a variety of sources, such as LCA databases, field studies, and statistics published via outlets such as government agency websites. This baseline data enables the comparison against which reductions or increases can be measured or estimated. The crucial part, in order to compare different systems, is to collect real-world data about the use of the service in the conventional system as well as in the new ICT-based system. In some instances, scenarios can be used to bridge the gap when real-world data about the new ICT-based systems is not available.

The availability of published LCA data about the infrastructure of conventional services and activities (such as the production of cars and roads) and higher-order infrastructure (such as the construction of the factories in which cars are manufactured) is limited.

Statistics about travel (distance, in kilometers), transportation (weight, in 1000kg x kilometer), building area (in square meters), and so forth, must be collected during the life cycle inventory (LCI) phase. There is only limited published data about road infrastructure and other infrastructure (such as street lighting, gas and service stations, car dealers, and parking facilities) that can be linked to road transport.

Some LCA data about mobile and fixed broadband networks (for instance, data about PCs) has already

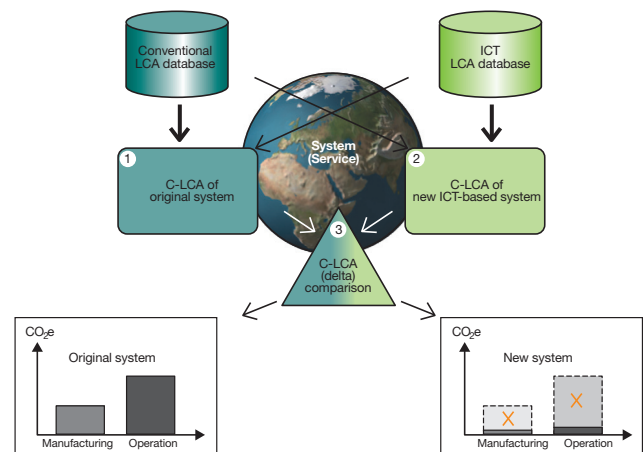


Figure 2: Overview of a holistic LCA method for comparing ICT-based systems with conventional systems that deliver equivalent services (C-LCA = CO<sub>2</sub>e-based LCA)

been published. Ericsson, for example, has for some time performed LCAs relative to communication networks (including mobile phones).

### CO<sub>2</sub>e ASSESSMENT BASED ON THE LCA METHOD

In the third step – assessment of CO<sub>2</sub>e impacts – the CO<sub>2</sub>e emissions of the defined ICT-based system and the conventional system, including the infrastructure needed, are assessed. This assessment is based on the LCA methodology, the scope of which includes the manufacturing as well as the operation phases of the new ICT-based system. The LCA must also include fuel extraction, production and distribution, vehicle manufacturing and construction, and the operation of infrastructure for all travel and transportation associated with the service.

Figure 3 shows the average CO<sub>2</sub>e emissions of travel related to car travel and air travel, as well as emissions from buildings related to building operation.

The emission profile given for car travel is valid for most road travel and transport, with the exception of manufacturing due to different lifetimes of, for instance, trucks. The fuel-chain and CO<sub>2</sub>e effects (others) of air freight are similar to that given for air travel. However, compared with air travel, less of the impact of airport operation and construction can be allocated.

The fuel chain includes the extraction, production and distribution phases of fuel: primarily gas and oil. The utilities infrastructure can share the electricity model used for ICT systems and should include the electricity infrastructure.

The others bar for buildings includes renovation. To go from a general view to a more specific view of a building, one needs to know the type and amount of energy that is consumed per unit of area. The others bar for air travel indicates the uncertainty that exists for various other GHG emissions and the uncertain effects attributed to aircraft, including high-altitude emissions and their effects.

For the ICT-based system, the use of mobile broadband services must, based on data traffic, also consider:

- user profiles and behavior, including type of mobile device;
- the characteristics of mobile network access; and
- the core or transmission network and specified data centers.

Operator business overheads should also be specified for the analysis.

Fixed broadband has many different user profiles with individual types of PCs, modems, or home network setups. Access sites and data traffic may be aggregated to form a total or average ICT system user profile for all users or for an entire company, organization or region.

Finally, it is necessary to determine the total use of the specific service and all related services. Preferably, the data traffic of the service should be compared with the total data traffic of the user profile. The data traffic ratio (service data traffic/total data traffic) is called the allocation key.

For PCs and advanced PC-like mobile phones, the allocation attributed to the manufacturing and operation phases should be based on use time (duration) instead of data traffic, because lifetime and operation are proportional to use time, not data traffic.

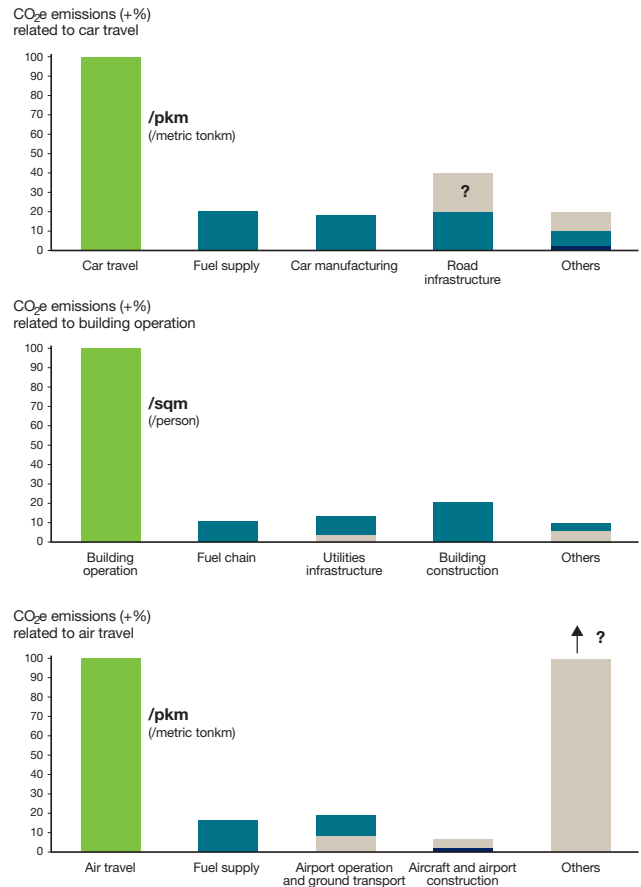


Figure 3: Average CO<sub>2</sub>e emissions from infrastructure for car travel, buildings and air travel related to the direct emissions

MANDATORY ELEMENTS TO CONSIDER	COMMENTS
Type of end-user equipment (PC, mobile phone)	This information provides manufacturing impact and operation characteristics
Use time and baseline operation (standby)	This is dependent on electrical power consumption and the type of end-user equipment. The specification needs to be based on user behavior.
Energy consumption for network access	The type of access and use time is used to quantify network access. Data traffic cannot be used because most energy consumption relates to network access standby.
Average data traffic of the service	This is used to quantify data transport, cable infrastructure and data centers, in order to calculate the services share of the total network infrastructure.
Electricity mix in the region studied	All electrical power consumption in the operation phase can be adjusted to the specific region.

Table 1: Mandatory elements to consider when assessing the CO<sub>2</sub>e emissions of an ICT service

## COMPARISON OF SYSTEMS

After the CO<sub>2</sub>e assessment is complete, it is possible to compare the two systems and evaluate the potential of the ICT-based service to reduce CO<sub>2</sub>e emissions. The total results of the analysis are twofold: **potential reduction factor** and **relative reduction factor**.

The potential reduction factor is the total reduction in CO<sub>2</sub>e divided by the total CO<sub>2</sub>e of the new ICT-based system. For fixed services using a PC, this factor is typically a figure (or a goal to be reached) above 10; for mobile services using a mobile phone, the factor is typically a figure above 100.

The relative reduction factor is the total potential reduction in CO<sub>2</sub>e divided by the total CO<sub>2</sub>e emissions of the replaced conventional system.

These results can be complemented by an uncertainty figure that summarizes the known or estimated uncertainties introduced by the adjustments, allocations and scope limitations.

# CONCLUSIONS

One of the most significant ways of achieving substantial reductions in CO<sub>2</sub>e is by shifting from a high-carbon physical infrastructure to a low-carbon virtual infrastructure based on the evolving information society and smart technology – what we call information and communications technology (ICT).

Much of the focus to date has been on sectors with high-carbon emissions, such as energy and transport. However, it is just as important to understand how improving low-carbon infrastructure and strengthening other services will affect CO<sub>2</sub>e emissions. Investments in broadband, for example, are paving the way for ICT-based services, such as the increased use of virtual meetings to enhance teleworking; the rollout of telemedicine services; and smart homes, where energy management plays a central role in replacing traditional high-carbon solutions.

To support the transition to low-carbon ICT-based solutions, society needs to know to what extent the new solutions will reduce CO<sub>2</sub>e emissions. And given that discussions about climate change take a long-term view, this perspective must be reflected in the LCA studies that are used as input for the discussions.

This paper presents a holistic methodology for measuring CO<sub>2</sub>e emissions. Armed with data from these measurements, society can finally begin:

- to assess a large number of solutions;
- to understand the magnitude of reductions (including infrastructure changes over time); and
- to understand where these reductions will take place.

Detailed LCAs are important and should be considered together with a less detailed approach. The detailed LCAs provide more exact estimations. They also identify (new) areas that must be included in assessments in order for an approximate estimation to yield results of the right magnitude.

Ericsson has studied several services, calculating the potential of ICT-based solutions to reduce CO<sub>2</sub>e emissions compared with traditional solutions. One example indicates that the potential of broadband to reduce CO<sub>2</sub>e emissions increases by 50 to 150 percent when the life cycle emissions and underlying infrastructure are included in the calculations – as opposed to when only direct emissions are included.

# CASE STUDIES

## CASE STUDY NO. 1: INTRODUCTION OF E-HEALTH IN CROATIA

### BACKGROUND

The term e-health refers to the application and use of ICT in all aspects of healthcare:

- to provide better and more efficient services; and
- to facilitate access to healthcare.

The Healthcare Networking Information System, developed by Ericsson Nikola Tesla in Croatia, is a comprehensive ICT solution for integrating healthcare processes, information management and business workflows for healthcare organizations, enterprises and delivery systems. In this study, the system was used to transfer prescriptions and referrals electronically. Among other things, this reduced the need for:

- printing prescriptions for patients
- patients to travel.

### DATA AND ASSUMPTIONS

#### Conventional healthcare system

Croatia has about 4.5 million inhabitants, 55 percent of whom live in cities. There are about 260 cars per 1000 people. In addition, there are 6600 primary healthcare teams/units in Croatia and approximately one doctor for every 450 people.

The main assumptions were as follows:

- The e-referral service can reduce patient visits (approximately 12 million per year) by 50 percent.
- On average, patients travel 10km + 10km per visit. Twenty-five percent of patients travel by car; the other 75 percent by public transport.
- The e-prescription service can reduce paper consumption by 50 percent.

#### The new e-health system

The data center consumes 400MWh of electrical power a year. There are approximately 10,000 PCs in the network. The PCs and the data center are used for many purposes, not just the two services studied. Therefore, in all likelihood, the allocation of the total system to the two services studied will decline over time, especially as new services are introduced.

The main assumptions were as follows:

- About 10 percent of the system's PCs were installed in parallel to the system. Therefore, 10 percent of the total system will be allocated to the e-referral service.
- One percent of the total system is allocated to the e-prescription service. Without the e-prescription service, prescriptions would require input and printing. The service can be quantified by its added datacom overhead for which the assumption of 1 percent of the total system is probably high.

#### Comparing the two systems

In total, the two services in the e-health system account for about 330 metric tons of CO<sub>2</sub>e emissions per year. Of this amount, PCs and networks account for over 90 percent and the data center accounts for the rest. Given that patients reduce their travel, on average by almost three visits per year, the potential reduction in travel is about 7kg CO<sub>2</sub>e per patient and year. This results in a reduction of up to 15,000 metric tons of CO<sub>2</sub>e, provided 50 percent of all travel can be avoided.

A 50 percent reduction of paper consumption due to the e-prescription service would result in approximately 230 metric tons of CO<sub>2</sub>e per year.

Figure 4 shows added CO<sub>2</sub>e emissions due to the introduction of the service and the potential reductions that can be derived from the two e-health services.

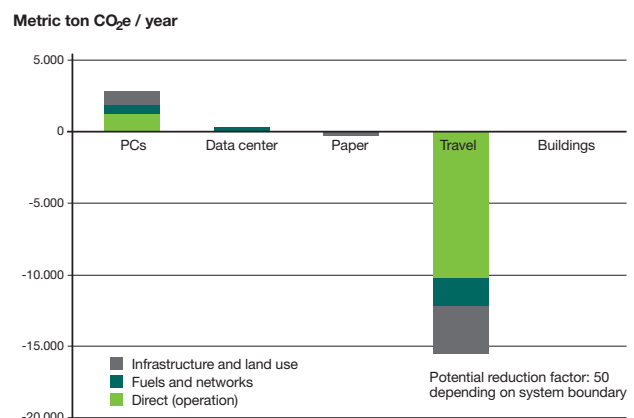


Figure 4: Graphical presentation of the e-health case study results

## Conclusions

The e-health system installed to support primary healthcare in Croatia can significantly reduce CO<sub>2</sub>e emissions, thanks to reductions in patient travel as well as to reductions in paper consumption.

Taken together, the e-referral and e-prescription services have the potential to reduce CO<sub>2</sub>e emissions by up to 15,000 metric tons per year while the two services only add 330 metric tons of CO<sub>2</sub>e/year from operation and manufacturing activities.

The potential reduction factor over a 20-year period is up to 50, depending on whether infrastructure is included and, if so, to what extent.

## CASE STUDY NO. 2: SPOTS4MEDIA SOLUTION IN SPAIN

### BACKGROUND

Spots4media is an Ericsson digital distribution solution used for media campaigns. Media agencies and TV broadcasters use the Spots4media platform to manage advertising materials. With the solution, Ericsson receives a videotape of the media from the advertiser's production company, digitizes it, and sends a digital copy to an FTP server to which all TV channels are connected. The platform serves as an interface that media agencies use to access and complete a distribution form that identifies the TV channels to be used for distributing spots. The TV channels, in turn, use the platform to download the materials.

This case focused on a specific media campaign in Spain, which provided digital delivery to 10 television-broadcasting networks of seven separate advertisements in two languages (Spanish and Catalan).

### DATA AND ASSUMPTIONS

#### Conventional media distribution

Traditionally this media campaign would have required the delivery of a total of 38 physical media tapes to the television stations. Traditional transportation methods would have used a total of 1520km worth of motorcycle and car deliveries.

A main assumption in this study is:

- The infrastructure for transportation (roadways) exists independently of method and is therefore not included in the calculations.
- The system boundary is limited to the distribution phase of the delivery.

#### New ICT-based digital delivery solution

The Spots4media digital solution only required the delivery of seven tapes to Ericsson for digitizing. This resulted in a travel distance of six kilometers per motorcycle delivery.

The main assumptions are as follows:

- The infrastructure for the ICT delivery method (fiber) exists independently of method and is therefore not included in the calculations.
- The system boundary is limited to the distribution of the delivery.
- A dedicated quad-core server is used for digitizing and transfer; therefore, the manufacture and operation of this computer have been included.
- A quad-core server is equivalent to two standard PCs.
- A PC has a lifetime of four years.

#### Comparing the two systems

A single media campaign using traditional methods of delivering taped media produces approximately 410kg of CO<sub>2</sub>e emissions. These emissions can be divided evenly between tape production and transportation. The Spots4media digital delivery solution produces approximately 40kg of CO<sub>2</sub>e emissions, including tapes and physical distribution. The actual addition due to the ICT service is less than 2kg of CO<sub>2</sub>e per media campaign. This translates into a 370kg (91 percent) reduction in CO<sub>2</sub>e emissions per media campaign. The potential reduction factor is up to 230. The manufacture and disposal of the tapes used to transfer media from the media agency accounts for 95 percent of the impact.

Spots4media digitizes approximately 1500 media campaigns per year. By multiplying this figure by the results of a single media campaign we obtain the total annual reduction of 558 metric tons of CO<sub>2</sub>e emissions.

Moreover, the digital delivery solution reduces delivery times by more than 90 percent.

## Conclusions

Compared to traditional media campaigns, the Spots4media digital delivery solution can reduce the CO<sub>2</sub>e emissions by more than 90 percent thanks to less transportation and fewer physical tapes.

The service has the potential to reduce CO<sub>2</sub>e emissions by about 500 metric tons per year when used for 1500 campaigns, while the service adds less than 3 metric tons of CO<sub>2</sub>e per year.

The potential reduction factor in this case for 1500 media campaigns per year is up to 230.

# GLOSSARY

C-LCA	CO <sub>2</sub> e-based LCA
CO <sub>2</sub>	carbon dioxide
CO <sub>2</sub> e	carbon dioxide equivalent
ETSI	European Telecommunications Standards Institute
EU	European Union
FTP	file transfer protocol
GHG	greenhouse gas
ICT	information and communications technology
ISO	International Organization for Standardization
ITU	International Telecommunication Union
LCA	life cycle assessment
LCI	life cycle inventory
MWh	megawatt hour
metric ton	1000kg

# REFERENCES

Borealis Centre for Environment and Trade Research, 2009. *Findings from the US book industry – Environmental trends and climate impacts*. Book Industry Study Group. Green Press Initiative.

Chester M. V. and Horvath A., 2009. *Environmental assessment of passenger transportation should include infrastructure and supply chains*. Environmental Research Letters, 4 024008 (8pp).

GeSi, *SMART 2020: Enabling the low carbon economy in the information age*, Global e-Sustainability Initiative, 2008.

International Organization for Standardization 2006. *ISO 14040, Environmental management – Life cycle assessment – Principles and framework*.

International Organization for Standardization 2006. *ISO 14044, Environmental management – Life cycle assessment – Requirements and guidelines*.

Loerincik, Y., 2006. *Environmental impacts and benefits of information and communication technology infrastructure and services, using process and input-output life cycle assessment*. École Polytechnique Fédérale de Lausanne (EPFL), These no 3540.

Malmodin J., Moberg Å., Lundén D., Finnveden G. and Lövehagen N., 2009. *Greenhouse gas emissions and operational electricity use in the ICT and entertainment and media sectors*. Submitted to Journal of Industrial Ecology. To be published.