Evaluating the carbon-reducing impacts of ICT

October 2010

Objectives

Recap objectives of study

Provide an overview of the approach

Share path forward

Addendum :

Recommended assessment methodology

GeSI

The Global e-Sustainability Initiative (GeSI) is uniquely dedicated to information and communication technologies (ICT) sustainability through innovation.

In 2000, 189 countries signed up to the Millennium Development Goals. These goals outlined action on matters as diverse as climate change and poverty elevation. The rapidly converging Information and Communications Technology Sector (ICT) recognized that addressing these issues would need an effective, industry-wide response.

As part of this response, GeSI, the Global e-Sustainability Initiative, was born in 2001 to further sustainable development in the ICT sector. GeSI fosters global and open cooperation, informs the public of its members' voluntary actions to improve their sustainability performance, and promotes technologies that foster sustainable development.

The World Summit on the Information Society described information and communication technologies as "a powerful instrument, increasing productivity, generating economic growth, and improving the quality of life of all". GeSI considers this a crucial principle to extend the influence of ICT into all aspects of socio-economic development, applying these technologies to both rich and poor countries to achieve sustainable development across the globe.

GeSI brings together leading ICT companies – including telecommunications service providers and manufacturers as well as industry associations – and non-governmental organisations committed to achieving sustainability objectives through innovative technology.

GeSI Membership

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Study context and objectives

GeSI commitments

1. Develop an agreed ICT industry-wide methodology for the carbon footprinting of ICT products and services

2. Put more emphasis on climate change issues in our supply chain work so we influence the end-to-end manufacturing process for electronic equipment

3. Ensure that energy and climate change matters are fully considered by the organisations that set the technical standards for our industry

4. Work with organisations in the key opportunity areas – travel/transport, buildings, grids and industry systems – to help turn potential CO2 reductions into reality. This will include a strong emphasis on the significant opportunities offered by dematerialisation

5. Work with public policy makers to ensure that the right regulatory and fiscal frameworks are in place to move us all in the right direction.

GeSI's commitment

"… Evidence shows that the Information and Communication Technology (ICT) industry has tremendous potential to increase energy efficiency and curb carbon emissions. However, in order to realize this promise, merely implementing ICT solutions will not be sufficient—being able to assess their impact more precisely is also critical

Now, with the launch of this report— Evaluating the carbon-reducing impacts of ICT: An assessment methodology—GeSI has produced a powerful tool with which to mitigate the risks that lie ahead.

In addition to the direct carbon emissions associated with the development and use of ICT solutions, this methodology assesses what are known as the "enabling effects" of ICT—the extent to which ICT technologies and systems can reduce or avoid the carbon emissions associated with traditional manual, mechanical, or physical activities. The report supplements the evidence documented in the SMART 2020 report of the important role that ICT, through its enabling effect, can play in reducing global carbon emissions.

The report recognizes the response of GeSI's members to calls for action. Now is the time to build on this support and generate further momentum. GeSI members have understood the magnitude of both the challenges and the opportunities and, together, they will help speed up the process of moving to a low-carbon economy.

…..

It is therefore our responsibility to promote the methodology, to engage others, and to ensure that the ICT industry as a whole adopts it and implements it fully. At the same time, we must cooperate with appropriate stakeholders worldwide to guarantee that the methodology is recognized and widely embraced so that the industry can move toward alignment in its assessment and communication of the positive benefits of ICT …."

Luis Neves, GeSI Chairman

Excerpt from forward

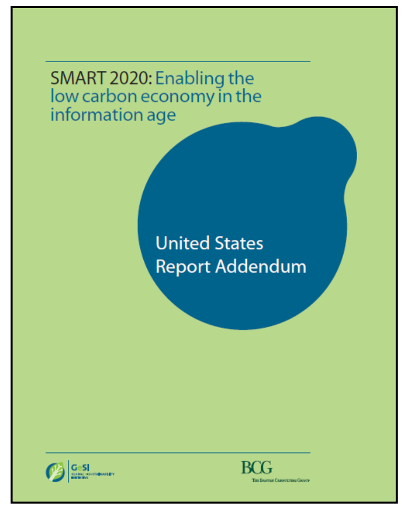
GeSI's SMART 2020 report series identified ICT as a major low carbon enablement opportunity

2008 SMART 2020 Report

- Globally, ICT solutions have the potential to reduce by 15% (7.8 Gt CO_2e) of the remaining 98% CO_2e emitted

2008 U.S. Addendum

- ICT enabled solutions could cut annual CO_2e emissions in the U.S. by 13–22% from business as-usual projections in 2020
- This translates to a gross energy and fuel savings of $140-240 billion dollars. These savings are equivalent to a reduction in total oil consumption by 11-21% and a reduction of oil imports into the U.S. by 20-36%



Reducing ICT Sector emissions

REDUCING ICT SECTOR EMISSIONS

PCs:

> Efficiency gains and longer product life.

> Shift from desktops to laptops

> Shift from CRT to LCD screens

> Potential breakthroughs – solid state hard drives, new LCD screens, new battery technology, quantum and optical computing

Data Centres:

> Higher rates of virtualisation; more efficient virtualisation architectures

> Low energy or free cooling

> Renewable power sources (follow the wind – follow the sun)

> "Utility"/"cloud" computing, Software as a service

Telecoms Devices :

> "Smart" chargers

> "no load" standby

> Power and network efficiency

Telecoms Infrastructure:

> New network management tools

> Network optimisation packages

> Solar-powered base stations

> Potential breakthroughs – night battery operation, natural ventilation, "network sharing"

> Spectrum optimization

ICT and "Green"

Green of ICT 2%	Green by ICT 98%
CO_2 reduction of infrastructure and products in ICT industry	CO_2 reduction through convergence with ICT in other industries

The reports identified government support needed to accelerate adoption

Create policies that build overarching framework for encouraging CO2 reduction and ICT solution adoption

Over-arching policies

Use targeted policies to accelerate adoption and address specific technical, economic and behavioral challenges

Targeted policies

Smart Grid

Road Transport

Smart Buildings

Travel Substitution

Principles for effective government policies

Create an enabling regulatory framework
- Aim for consistent legislation that supports market-based solutions

Enable development of solutions
- Conduct fundamental research benefiting all stakeholders
- Encourage innovation, not specific technologies
- Encourage investment in required infrastructure

Support the business case when necessary
- Create the right incentives
- Ensure that markets create desired environmental and social outcome

Encourage positive behavior change
- Lead by example and support pilot projects
- Facilitate and coordinate the sharing of information

Source: GeSI policy expert interviews; BCG analysis; SMART 2020 United States Addendum Report

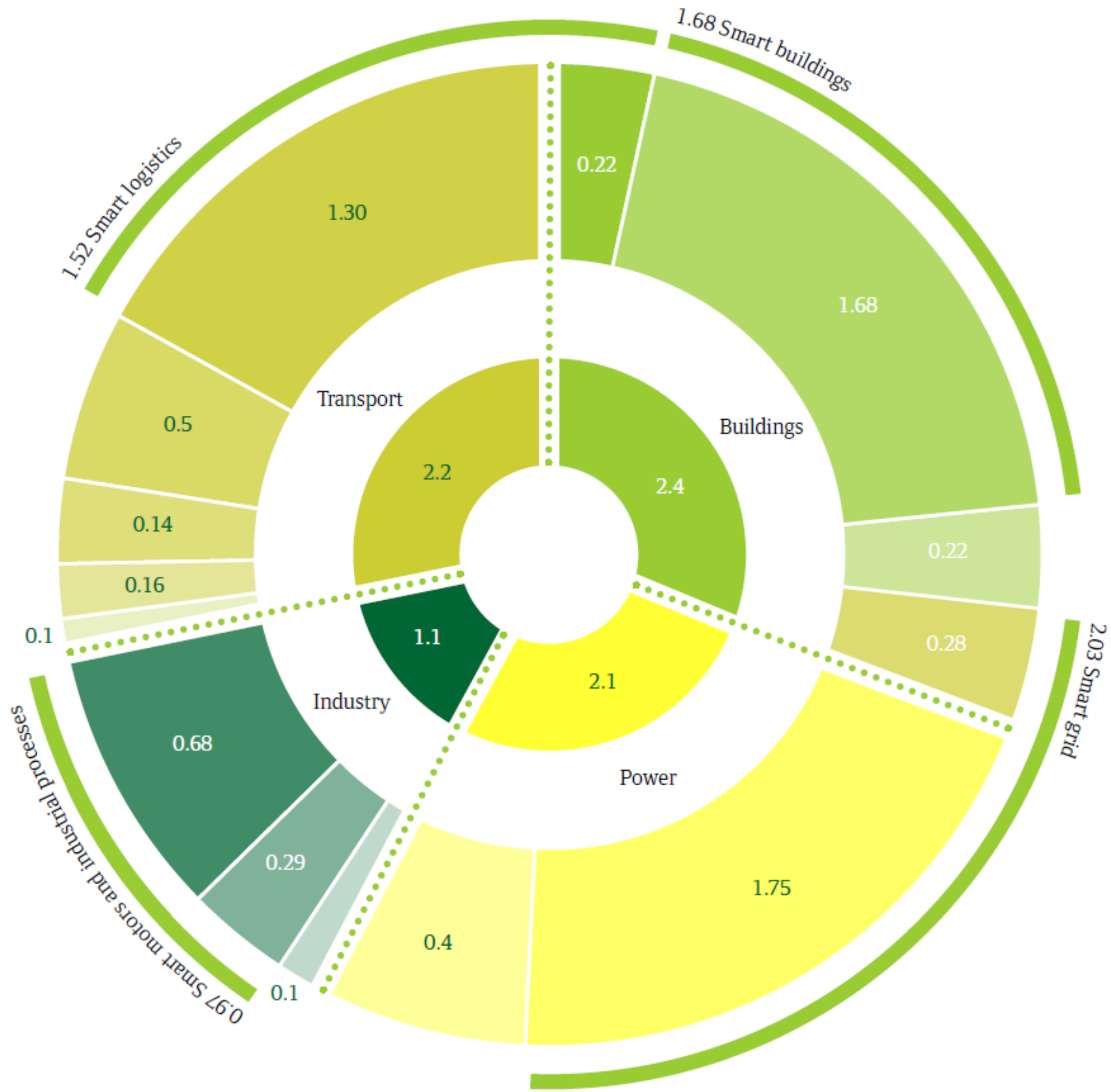
The enabling effect covers four primary areas

Industry
- Smart motors
- Industrial process automation
- Dematerialisation* (reduce production of DVDs, paper)

Transport
- Smart logistics
- Private transport optimisation
- Dematerialisation (e-commerce, videoconferencing, teleworking)
- Efficient vehicles (plug-ins and smart cars)
- Traffic flow monitoring, planning and simulation

Buildings
- Smart logistics†
- Smart buildings
- Dematerialisation (teleworking)
- Smart grid‡

Power
- Smart grid
- Efficient generation of power, combined heat and power (CHP)



ICT Enablement Methodology Study context and objectives

Context

Despite the positive reception of these reports, the lack of policy- and commercially-relevant assessments is preventing the full realization of benefits from smart use of ICT

- ICT industry unable to clearly define the specific benefits of different types of ICT investments
- Policy-makers unable to create appropriate incentives for the government, commercial and residential sectors

Project objectives

- Survey and evaluate existing methodologies relevant for assessing enabling impacts of ICT
- Highlight key characteristics of existing methodologies
- Develop an optimal "next step" methodology
- Apply methodology to selected case studies
- Identify issues for application and path forward for the ICT industry

Representatives from 18 international companies sponsored and provided input to the study

In addition to working team members, many industry and academic experts have provided input

1	Ted Reichelt	Principal Environmental Engineer, Intel
2	Kirsty MacDonald	Senior Manager, Global Public Policy, Intel
3	Marissa Yao	Analyst, Intel
4	Charlie Sheridan	Senior IT Consultant, Intel
5	John Malian	Manager, Global Supply Chain Management, Cisco
6	Jens Malmodin	Senior Research Engineer, Ericsson
7	Craig Donovan	Research Engineer, Ericsson
8	Pernilla Bergmark	Researcher, Ericsson
9	Fredrik Jonsson	Researcher, Ericsson
10	Hans Scheck-Otto	Researcher, Nokia Siemens Network
11	Emma Fryer	Head of Climate Change Programs, Intellect UK
12	Anders Andrae	Senior Expert, Huawei Technologies Sweden
13	Sarah Boyd	Researcher, Sustainability Consortium
14	Mattias Höijer	Head of Centre of Sustainable Communications, Royal Institute of Technology, Stockholm
15	Cristina Bueti	Programme Coordinator, ITU
16	Keith Dickerson	Climate Associates
17	Ian Mackenzie, Alex Velkov, Peter Thomond	Think, Play, Do, Imperial College London
18	Skip Laitner	Director of Economic and Social Analysis, American Council for an Energy-Efficient Economy
19	Simon Redding	Sustainable ICT Lead & Technology Innovation Consultant, Environment Agency of England & Wales
20	Fu Zhao	Assistant Professor of Mechanical Engineering, Purdue University

Developed methodology meets specific needs

Comprehensive	**Captures all major impacts, both positive and negative** (i.e., direct ICT emissions, enabling effects, and rebound effects)
Burden-limiting	**Limits burden of assessment**: Minimizes time and resources required by facilitating exclusion of negligible components of net effect
Communication-friendly	**Supports clear, transparent communication** of methodological approach and findings to broad stakeholder audience
Applicable for varying scope	**Widely applicable for assessing impact of ICT products and services and ICT category levels**
Applicable across geographies	**Effective when applied in both developed and developing world settings**
Flexible	**General and flexible enough for large-scale adoption** – will meet current and future stakeholder needs as sector innovation occurs
Adaptable	**Can adapt as more detailed guidance, industry-wide standards and software assessment tools are developed**
ISO compliant	**Based extensively on ISO 14040-series standard**, but introduces additional guidance specific to assessing enabling effects of ICT

Case studies intended to demonstrate use and applicability of assessment methodology

Case studies utilized to test the relevance and effectiveness of methodology in real-world setting

Diverse set of case studies developed to illustrate applicability across:

- ICT solution areas (dematerialization, SMART logistics, SMART grids, SMART transportation)
- Unique audiences: end-consumers, business customers, policymakers
- Diverse geographies: developed and developing world

Existing case studies and research data used as starting point

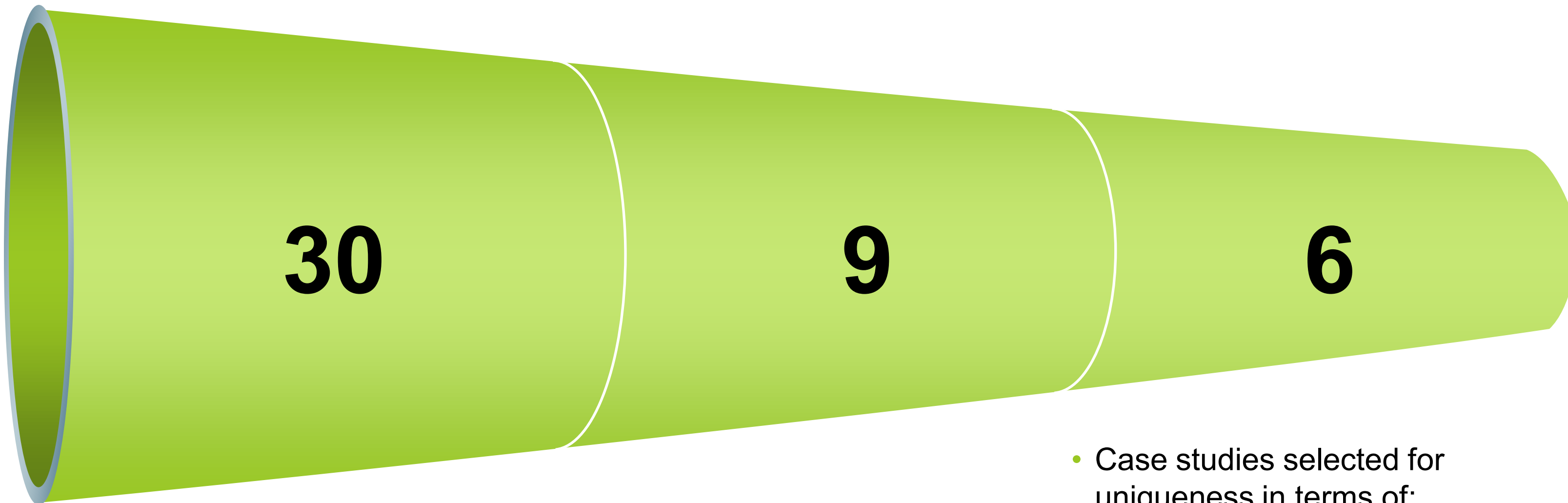
- Studies identified and aggregated from GeSI team members as well as external resources
- Key criteria for inclusion: existing robust quantification of key impacts

6 case studies selected from 30 identified and evaluated

Existing case study?

Sufficient data available?

Illustrates unique application?



- Existing studies identified via:
  - GeSI team members
  - Review of existing literature
  - Discussion with external experts

- Majority of studies eliminated due to lack of sufficient existing data on ICT impacts
  - E.g., emission reductions for key forms of impact

- Case studies selected for uniqueness in terms of:
  - SMART ICT category
  - Geographic scope
  - Scope of measurement

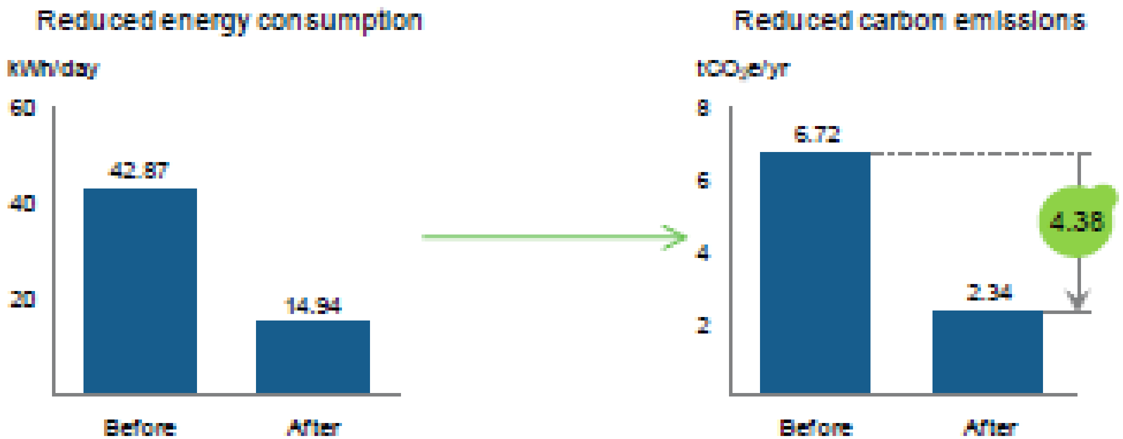
Six case studies included in report

	SMART area	Location	Assessor	Description
1 **Home energy monitoring kit**	SMART grids	United Kingdom	AlertMe	Energy savings in household before and after installation of AlertMe home energy monitoring system
2 **HVAC automation system**	SMART buildings	United States	Cypress	Energy savings in building complex after installation of HVAC automation system
3 **Eco driving software solution**	SMART logistics	United Kingdom	Microlise	Fuel efficiency gains across 350+ vehicle fleet after software implementation
4 **Telecommuting**	Dematerialization	United Kingdom	BT	Assessment of whether telecommuting has positive net enabling effect despite rebound effect of increased home energy use
5 **E-health delivery system**	Dematerialization	Croatia	Ericsson	Emission-reducing impact of e-referral and e-prescription services in Croatia
6 **Telepresence system**	Dematerialization	Multinational company	Cisco	Assessment of net enabling effect from company-wide adoption of telepresence

Source: BCG analysis

Case Study Summary Results

AlertMe provides residential clients with home energy monitoring kits to increase user information about energy consumption. By observing their consumption patterns, homeowners are able to modify their behaviors to optimize energy use. The solution includes a meter reader that clips to the home's electric meter, a wireless hub that compiles usage data to be viewed online and smart plugs that allow remote control of individual appliances.



Path forward

Path forward

Development of additional case studies

- Additional real-world case studies to demonstrate successful application of methodology

Expansion of shared data

- Increased volume of, access to primary data to more accurately capture real-world impacts (especially those driven by adoption rates and behavioral changes)

Development of assessment tools and databases

- Continued development of tools to support application of methodology
- Integration of tools and aggregation of underlying data

Standardization of impacts and life cycle processes included in assessment

- Establishment of agreed-upon approaches for assessing effects of specific ICT product or service categories

The launch website at GeSI.org is the starting point

There, you can:

- Download the Report
- Download methodology worksheets you can use to guide your own assessment and track your data
- Review the latest case studies
- Watch a video explaining the study
- Register your interest in future workshops and published case studies

GeSI GLOBAL e-SUSTAINABILITY INITIATIVE

Addendum - Recommended assessment methodology

ICT enablement methodology

1 Define goal and scope	2 Limit assessment	3 Assess and interpret
1a Define goal of study	2a Estimate BAU reference value	3a Rigorously assess significant life cycle processes
1b Define scope of study	2b Limit life cycle processes require rigorous	3b Interpret net results

Methodology uses a Life Cycle Assessment (LCA) approach to guide the assessment of changes to an existing system resulting from the adoption of an ICT solution

Source: BCG analysis

1a: Define goal of study

Assessment worksheet

Step 1: Define goal and scope

1a Define goal of study

Define the purpose of the study and the intended audience for the study. These attributes will guide decision-making on the set of effects to include in further assessment.

Q: What is the purpose of the study and the intended audience?

Purpose of study ____________________

Intended audience ____________________

Scale of adoption ____________________

Implications for assessment

Illustrative output

1a Define goal of study

Illustrative example used throughout worksheets

Purpose of study: *Quantify carbon abatements from use of logistics optimization software*

Intended audience: *Business customers*

Scale of adoption: *Use to manage operations of a single organization's 500-truck fleet*

Implications for assessment

Relevant effects to include in calculation of net impact are limited to near-term effects such as primary enabling and rebound effects, or secondary effects that occur over a shorter period of time

For further reference–additional examples

Purpose of study: *Assessment of emission reductions from home energy monitoring system*

Intended audience: *Business-to-business customers (marketing communication)*

Scale of adoption: *Single-business in United Kingdom*

Implications for assessment

Relevant effects from adopting home energy monitoring system likely to be limited to activities and operations of individual businesses; broader secondary effects such as reduced energy plant construction and operation not relevant

Purpose of study: *Communication of macro-scale benefits of telepresence*

Intended audience: *National policy makers*

Scale of adoption: *Adoption and use by all businesses in United States*

Implications for assessment

Relevant effects for ICT solution with broad adoption and targeted at policymakers would be more inclusive of enabling and rebound effects which often will only occur with sufficient time or adoption, such as the ability to reduce the need for travel infrastructure

Illustrative scale considerations by audience

Customers
"Low" scale of adoption

- Impact from adopting ICT solution likely to be limited to one's own activities, operations

Business/Industry
Variable scale of adoption

- Impact from adoption will depend on the size and characteristics of organizations

Policy makers
"High" scale of adoption

- Impact from adoption will include cumulative effects of use by many individuals or businesses

1b: Define scope of study

Assessment worksheet

Define | Limit | Assess & interpret

1a Define goal | 2a Estimate ref. value | 3a Rigorously assess

1b Define scope | 2b Limit stages | 3b Interpret net results

1b Define scope of study

Identify (1) ICT system and its components, (2) business-as-usual (BAU) system, and (3) all potential enabling and rebound effects. Irrelevant effects are excluded from assessment given goal of study.

Q: What are the ICT system, BAU system, and their components?

System	Description	Components of system	
ICT		1 2 3	4 5 6
BAU		1 2	4 5

Q: What are potential CO_2e-saving effects to the BAU system and CO_2e-adding effects from the ICT system?

Category	Identified effects	Exclude?	Rationale if excluded	System components assessed
+ Direct ICT emissions	1			
	2			
– Primary enabling	1			
	2			
– Secondary enabling	1			
	2			
	3			
+ Primary rebound	1			
	2			
+ Secondary rebound	1			
	2			
	3			

Effects not excluded are those considered relevant (and thus will be included in further assessment)

Illustrative output

Define | Limit | Assess & interpret

1a Define goal | 2a Estimate ref. value | 3a Rigorously assess

1b Define scope | 2b Limit stages | 3b Interpret net results

1b Define scope of study

ICT system, BAU system, and their components

System	Description	Components of system	
ICT	*Delivery optimization software, to optimize the distribution of goods*	1 *Software* 2 *PCs* 3 *Servers*	4 *Data centers*
BAU	*Trucking operations prior to introduction of optimization software*	1 *Trucks*	

Potential effects

Category	Identified effects	Exclude?	Rationale if excluded	System components assessed
+ Direct ICT emissions	1 *ICT emissions*			*Software, PCs, servers, data centers*
– Primary enabling	1 *Reduced travel*			*Trucks*
– Secondary enabling	1 *Reduced vehicle production*	*Yes*	*Relevant for large scale of adoption only*	*Not applicable*
	2 *Reduced road construction*	*Yes*	*Relevant for large scale of adoption only*	*Not applicable*
+ Primary rebound	*None identified*			*Not applicable*
+ Secondary rebound	1 *Purchase and use of new trucks with saved costs*			*Trucks*

Types of potential effects of ICT introduction

	Primary	Secondary
– Enabling *Decrease emissions*	**Primary enabling** Immediate reduction of BAU system emissions occurring as result of ICT system implementation	**Secondary enabling** Non-immediate reduction of BAU system emissions occurring as result of ICT system implementation; occur over time as either duration or scale of implementation increases
+ Direct ICT emissions *Increase emissions*	**Primary, direct ICT emissions** Emissions generated over life cycle of the implemented ICT system	*No secondary direct ICT emissions*
+ Rebound *Increase emissions*	**Primary rebound** Immediate increase in BAU or ICT system emissions occurring as result of ICT system implementation, often driven by behavioral changes in demand for carbon-intensive goods or activities	**Secondary rebound** Non-immediate increase in BAU or ICT system emissions occurring as result of ICT system implementation, often driven by behavioral changes in demand for carbon-intensive goods or activities

Source: BCG analysis

Expected primary enabling effects of ICT opportunity levers

SMART opportunity	*Sub-opportunity*	1 Reduced energy consumption		2 Reduced or eliminated travel/shipment	3 Reduced or eliminated materials
SMART Motors	Smart Motor	• Optimization of variable speed motor systems	• ICT driven automation in key industrial processes		
SMART logistics	Air transportation	• Reduction in ground fuel consumption	• In-flight fuel efficiency	• Reduction in unnecessary flight time	
	Road transportation	• Eco-driving		• Optimization of logistics network • Intermodal shift (to other transports) • Optimization of truck itinerary planning • Optimization of truck route planning • Flexible home delivery methods • Intelligent traffic management	• Minimization of packaging
	Ship / Rail / Other	• Optimization of ship operations		• Optimization of train operations • Maximization of ship load factor	
	Warehouse	• Centralized distribution centres • Reduction in inventory			• Reduction of damaged goods • Recycling and remanufacturing
SMART buildings	Building design	• Improved building design for energy efficiency	• Reduced building space through design		
	Building technology	• Building management systems • HVAC automation • Lighting automation • Ventilation on demand	• Intelligent commissioning • Benchmarking and building recommissioning • Voltage optimization		
SMART grids	Consumption efficiency	• Reduce consumption through user information	• Demand management • Intelligent load dispatch		
	Renewable Energy	• Integration of renewables			
	T&D Loss	• Reduce transmission and distribution losses			
Dematerial-ization	Physical material				• Online media • E-commerce • E-paper
	Travel substitution			• Video-conferencing • Telecommuting	

Illustrative secondary enabling effects

		Primary enabling effects		
		Reduced energy consumption	Reduced travel/shipment	Reduced materials
Associated secondary enabling effects	Reduced use of goods/vehicles	• Monitoring of home energy use leads individual to avoid consumption more generally (e.g., via vehicle/office)	• Individuals telecommuting may use public transportation in lieu of cars on more regular basis	
	Eliminated production of goods/vehicles		• Fewer cars manufactured	• Individuals using online media may not purchase new CD or DVD player in future
	Reduced use of infrastructure		• Fewer individuals using office space leads to reduced use of buildings	• Less storage of materials lead to reduced use of buildings
	Eliminated development of infrastructure	• Lower energy need results in construction of fewer power plants	• Lower energy need results in construction of fewer power plants • Over long-term, smaller or fewer buildings and roads may be built	

Source: BCG analysis

Illustrative rebound effects

		Primary enabling effects		
		Reduced energy consumption	Reduced travel/shipment	Reduced materials
Associated rebound effects	**Primary rebound**	• **Home energy monitoring**: Increased energy use during non-peak periods in-lieu of use during peak periods	• **Telecommuting**: Increased home energy use *(e.g., heating and lighting on at home)*	• **Online media**: Increased computer use to browse and sample music
	Secondary rebound	• **Home energy monitoring**: Increased consumption of goods using savings from lower energy bill	• **Telecommuting**: Increased urban sprawl (and associated inefficiencies) from employees' ability to live further from office	• **Online media:** Increased computer and server manufacturing

Source: BCG analysis

2a: Estimate BAU reference value

Assessment worksheet

1 Define | 2 Limit | 3 Assess & interpret
1a Define goal | 2a Estimate ref. value | 3a Rigorously assess
1b Define scope | 2b Limit stages | 3b Interpret net results

Step 2: Limit assessment

2a Estimate BAU reference value

Estimate the life cycle process presumed to be the major driver of reduced emissions, using secondary data where possible (to reduce burden of assessment).

Q: Which BAU system life cycle process is presumed to be the major driver in reduced emissions?

Assumed reference value

Primary enabling effect	System component	Life cycle process	Estimate (unit CO_2e)

Optional – another possibility

Primary enabling effect	System component	Life cycle process	Estimate (unit CO_2e)

BAU reference value intended to serve as a tool for determining significance of all BAU and ICT system life cycle processes by use as a point of comparison

Establish reference value estimate via use of reliable secondary data if possible; if not, primary data collection or assumption-based modeling may be necessary

Illustrative output

1 Define | 2 Limit | 3 Assess & interpret
1a Define goal | 2a Estimate ref. value | 3a Rigorously assess
1b Define scope | 2b Limit stages | 3b Interpret net results

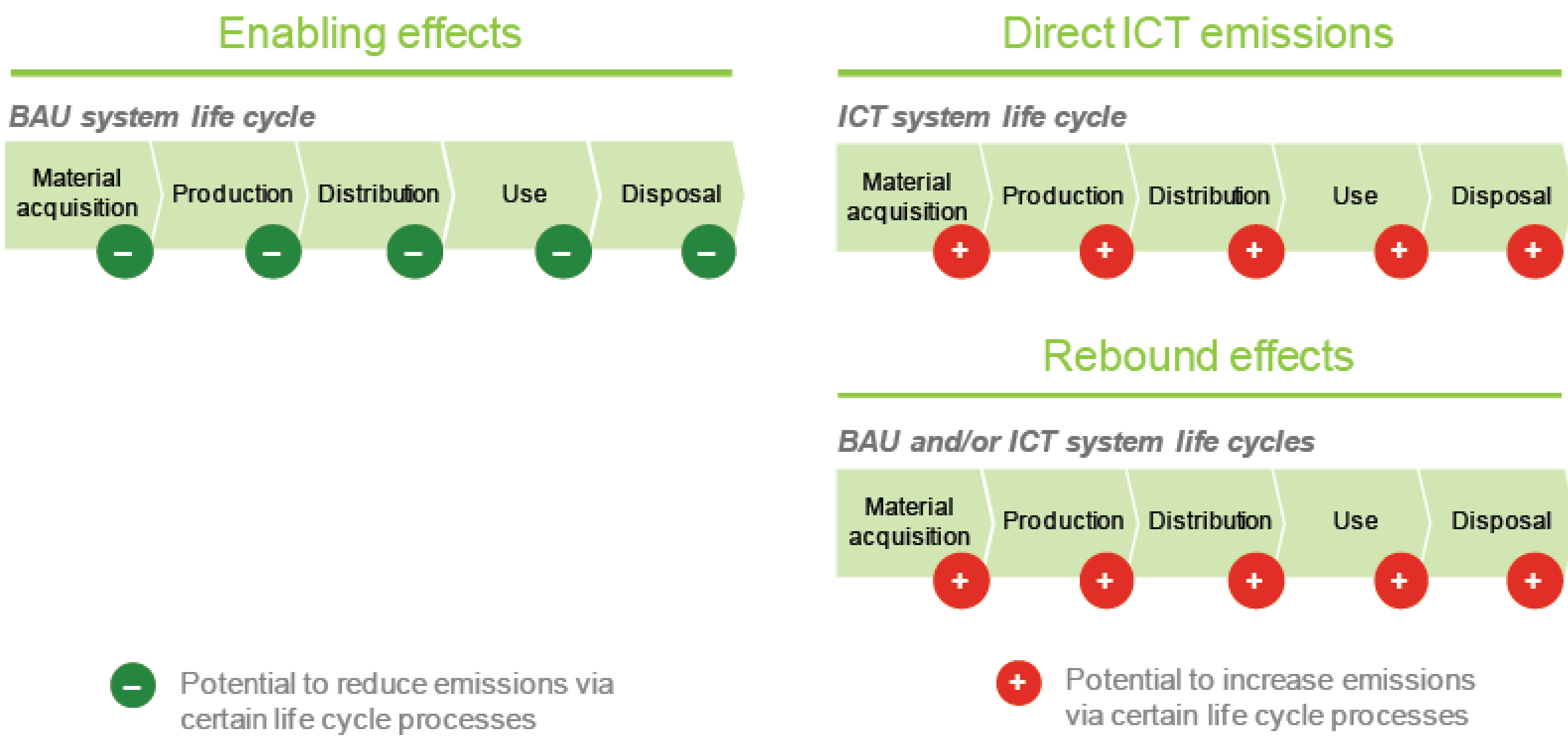
2a Estimate BAU reference value

BAU reference value

Assumed reference value

Primary enabling effect	System component	Life cycle process	Estimate (unit CO_2e)
Reduced travel / shipment	Trucks	Truck operation	500 tCO_2e per annum

BAU and ICT life cycle processes evaluated via screening assessment



Source: BCG analysis

2b: Limit life cycle processes requiring rigorous assessment

Assessment worksheet

1 Define | 2 Limit | 3 Assess & interpret
1a Define goal | 2a Estimate ref. value | 3a Rigorously assess
1b Define scope | 2b Limit stages | 3b Interpret net results

2b Limit life cycle processes requiring rigorous assessment

Estimate the change in emissions for the life cycle processes of each relevant effect. The BAU reference value can then provide guidance for cut-off criteria and which processes are insignificant.

Q: What are roughly estimated emissions volumes for the life cycle processes of the BAU and ICT system components?

Identified in Step 1b — *Screening assessment only – use secondary data where possible*

Category	*Relevant* identified effects	System components assessed	Material acquisition	Production	Distribution	Use	Disposal
+ Direct ICT emissions	1		☐	☐	☐	☐	☐
	2		☐	☐	☐	☐	☐
– Primary enabling	1		☐	☐	☐	☐	☐
	2		☐	☐	☐	☐	☐
– Secondary enabling	1		☐	☐	☐	☐	☐
	2		☐	☐	☐	☐	☐
	3		☐	☐	☐	☐	☐
+ Primary rebound	1		☐	☐	☐	☐	☐
	2		☐	☐	☐	☐	☐
+ Secondary rebound	1		☐	☐	☐	☐	☐
	2		☐	☐	☐	☐	☐
	3		☐	☐	☐	☐	☐

Estimate for processes of each life cycle stage (unit CO_2e)

Q: Which life cycle values are insignificant and can be excluded from more rigorous assessment?

Compare each estimate to BAU reference value established in step 2a: ☐

Identify life cycle processes that are insignificant in comparison, denote with an

- *Note: Cut-off criteria used to define "significance" will vary on case-by-case basis given goal and scope of study*

Illustrative output

1 Define | 2 Limit | 3 Assess & interpret
1a Define goal | 2a Estimate ref. value | 3a Rigorously assess
1b Define scope | 2b Limit stages | 3b Interpret net results

2b Limit life cycle processes requiring rigorous assessment

Roughly estimated emissions volume for each life cycle process

Figures illustrative only

Estimate (tCO_2e per annum)

Category	*Relevant* identified effects	System components assessed	Material acquisition	Production	Distribution	Use	Disposal
+ Direct ICT emissions	1 *ICT emissions*	*Software (physical media)*	0.1 ✗	0.1 ✗	0.1 ✗	N/A ✗	>0.1 ✗
		PC	0.4 ✗	0.4 ✗	0.2 ✗	1.0 ✓	0.1 ✗
		Servers	>0.1 ✗	>0.1 ✗	N/A	0.3 ✗	>0.1 ✗
		Data centers	>0.1 ✗	0.1 ✗	N/A	0.3 ✗	>0.1 ✗
– Primary enabling	1 *Reduced travel*	*Trucks*	N/A	N/A	N/A	500 ✓	N//A
+ Secondary rebound	1 *Purchase and use of new trucks*	*Trucks*	5.5 ✓	11.0 ✓	2.2 ✓	50 ✓	4.4 ✓

BAU reference value: 500 tCO_2e per annum

E.g., cut-off criteria of 0.2% of BAU reference value used in illustrative example above

- *Note that additional life cycle processes of PC might also be included in Step 3 (where more rigorous assessment applied) given that non-use processes exceed cut-off when aggregated*

3a: Rigorously assess significant life cycle processes

Assessment worksheet

1 Define – 2 Limit – 3 Assess & interpret

1a Define goal · 1b Define scope · 2a Estimate ref. value · 2b Limit stages · 3a Rigorously assess · 3b Interpret net results

Step 3: Assess and interpret

3a Rigorously assess significant life cycle processes

More rigorously assess the effects and life cycle processes identified as relevant in Steps 1 and 2. Where possible, primary data should be utilized.

Q: After more rigorous assessment, what are the emissions volumes for each life cycle process?

Identified in Step 1b — *Rigorous assessment – use primary data where possible*

Category	*Relevant* identified effects	System components assessed	Estimate for processes of each life cycle stage (unit CO_2e): Material acquisition	Production	Distribution	Use	Disposal
+ Direct ICT emissions	1						
	2						
– Primary enabling	1						
	2						
– Secondary enabling	1						
	2						
	3						
+ Primary rebound	1						
	2						
+ Secondary rebound	1						
	2						
	3						

Calculated net enabling effect:

Note: More rigorous assessment not applied to life cycle processes identified as "insignificant" in step 2b. However, screening estimates established for these "insignificant" life cycle processes may still be included in calculation of net enabling effect

- *E.g., decision to include screening estimates may depend on comfort with including figures that were not rigorously, irrespective of significance on net enabling effect calculation*
- *Choice to include or exclude screening estimate values should be documented*

Illustrative output

1 Define – 2 Limit – 3 Assess & interpret

1a Define goal · 1b Define scope · 2a Estimate ref. value · 2b Limit stages · 3a Rigorously assess · 3b Interpret net results

3a Rigorously assess significant life cycle processes

Rigorously assessed emissions volume for significant life cycle processes

Figures illustrative only

Category	*Relevant* identified effects	System components assessed	Estimate (tCO_2e per annum): Material acquisition	Production	Distribution	Use	Disposal
+ Direct ICT emissions	1 *ICT emissions*	*Software (physical media)*					
		PC				*1.22*	
		Servers					
		Data centers					
– Primary enabling	1 *Reduced travel*	*Trucks*				*542.64*	
+ Secondary rebound	1 *Purchase and use of new trucks*	*Trucks*	*4.92*	*13.72*	*1.83*	*56.21*	*4.43*

Calculated net enabling effect: ***460 tCO_2e per annum*** *+/- 20 tCO_2e based on scenario analysis*

Calculation of net enabling effect

Emissions eliminate/avoided by BAU system

− **BAU emissions**
- Primary enabling effects
- Secondary enabling effects

Emissions produced by ICT system or rebound effects

\+ **ICT and rebound emissions**
- Direct ICT emissions
- Primary rebound effects
- Secondary rebound effects

= **Net enabling effect**

Source: BCG analysis

3b: Interpret net Results

Assessment worksheet

1 Define	2 Limit	3 Assess & interpret
1a Define goal	2a Estimate ref. value	3a Rigorously assess
1b Define scope	2b Limit stages	3b Interpret net results

3b Interpret net results

Document how methodology applied, including discussion of assumptions, limitations, uncertainty/data quality, and conclusions

Q: What assumptions were made? Where is there uncertainty?

Is primary data collected from a representative sample set? Is secondary data outdated? What assumptions were used in modeling (e.g., behavior change, scale of adoption, etc.)?

Data source	Type of data	Potential assumptions / uncertainty

Q: Which effects and which life cycle processes were excluded from rigorous assessment?

		Identified effect	Excluded life cycle processes	Rationale
From Step 1	Entire effect excluded		• *All*	
			• *All*	
			• *All*	
From Step 2	Life cycle processes excluded			

Q: What conclusions can be drawn from this report?

Conclusions

Illustrative output

1 Define	2 Limit	3 Assess & interpret
1a Define goal	2a Estimate ref. value	3a Rigorously assess
1b Define scope	2b Limit stages	3b Interpret net results

3b Interpret net results

Assumptions and uncertainty

Data source	Type of data	Potential assumptions / uncertainty
• *Published academic study on PC LCA from 2003*	• *Secondary data*	• *LCA from 2003 may be dated if manufacturing processes have changed*
• *Company financial reports*	• *Modeled data*	• *Used to estimate secondary rebound effect. Wide range of potential outcomes presented to emphasize uncertainty*
• *Pilot study on customer implementing ICT solution*	• *Primary data*	• *Pilot study on one company may not be applicable to others (vehicle make and model may be different)*

Excluded effects and life cycle processes

	Identified effect	Excluded life cycle processes	Rationale
Entire effect excluded	*Reduced vehicle production*	• *All for trucks*	*Exclude, large scale of adoption*
	Reduced road construction	• *All for trucks*	*Exclude, large scale of adoption*
Life cycle processes excluded	*ICT emissions*	• *All for software, servers, data centers* • *All non-use for PC*	*Screening assessment used to determine insigificance*
	Reduced travel	• *None*	

Conclusions

The results of the study show that adoption of the delivery optimization software will create a significant net enabling effect. While variation across different makes and models of vehicles may exist, the company has utilized primary data to the extent possible to add legitimacy to its reported results. Remaining uncertainty related to secondary rebound effects suggest this would be an important area for future research.