ESU-services

fair consulting in sustainability

Life Cycle Assessment of Virtual Mobility

Implemented in ecoinvent data v2.2 (2010)

Authors

Marianne Leuenberger

Rolf Frischknecht

ESU-services Ltd.

Uster, June 2010 Report

ESU-services Ltd.
Rolf Frischknecht
Niels Jungbluth
Sybille Büsser
Marianne Leuenberger
Matthias Stucki
www.esu-services.ch

Kanzleistrasse 4
T +41 44 940 61 91
T +41 44 940 61 32
T +41 44 940 61 35
T +41 44 940 61 38
T +41 44 940 67 94
F +41 44 940 61 94

CH - 8610 Uster
frischknecht@esu-services.ch
jungbluth@esu-services.ch
buesser@esu-services.ch
leuenberger@esu-services.ch
stucki@esu-services.ch

Imprint

Title	Life Cycle Assessment of Virtual Mobility
Authors	Marianne Leuenberger, Rolf Frischknecht
	ESU-services Ltd., fair consulting in sustainability Kanzleistr. 4, CH-8610 Uster www.esu-services.ch Phone +41 44 940 61 91, Fax +41 44 940 61 94 email: frischknecht@esu-services.ch
Copyright	ESU-services Ltd. owns the life cycle inventory data shown in this study.
Liability Statement	Information contained herein have been compiled or arrived from sources believed to be reliable. Nevertheless, the authors or their organizations do not accept liability for any loss or damage arising from the use thereof. Using the given information is strictly your own responsibility.
Version	VM_ecoinvent_report_v1.0.doc, 30 June 2010 09:59

.

Summary

Videoconferencing and work at home are seen as measures to reduce environmental impact from travel activities. The IT-technology substitutes real mobility by transferring the required data and information through the IP network. Identical to the life cycle inventory of real mobility processes, the infrastructure and the operation thereof are considered to assess the environmental impact of virtual mobility.

Acknowledgement

We thank Res Witschi and Rolf Schenker (Swisscom) for the information provided on equipment and energy use of network devices

Abbreviations and Glossary

ADSL	Asymmetric Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
IP	Internet Protocol
PWB	Printed Wiring Board

Contents

1 Virtual Mobility

Author: Marianne Leuenberger, Rolf Frischknecht, ESU-services, Uster
Review: Christian Bauer, PSI
Last changes: 2009

1.1 Introduction

Internet communication technology can substitute travel activity for business purposes. Two types of internet communication are assessed in the following sections: videoconferences and work at home.

1.1.1 Videoconferences

Business meetings often require long distance travelling of one or more participating parties. Similar to traditional telephone conferences current internet technologies allow for videoconferences, which transmit audio and visual data by internet to the members of the meeting. This technology facilitates a more natural interaction between the participants as well as debates on visual matters without the need for actual physical presence in the meeting. Videoconferences therefore can avoid travelling and help reducing the environmental impact of business meetings. However, the infrastructure required for a videoconference and the need for the transmission of large amounts of data may have a considerable environmental impact.

1.1.2 Work at home

Many employees travel a considerable distance to work. In order to reduce the environmental impact of daily commuter traffic, the employees might work some days a week at home. This requires an adequate office environment at the employee's home office. Some companies provide corporate access infrastructure, which makes internal data bases and information accessible from home office workplaces. Corporate access infrastructure bases on special channels that provide a secure data transmission. This additional request for internet infrastructure is taken into account in the life cycle inventory of work at home.

1.1.3 Data sets

The data sets described in this report focus on the use of the devices shown in Fig. 1.1. The use of these devices is calculated for one hour of videoconference or work at home in Switzerland. For instance, the IP network establishes the communication with the server based in the World Wide Web and send queries and answers from and to the user.

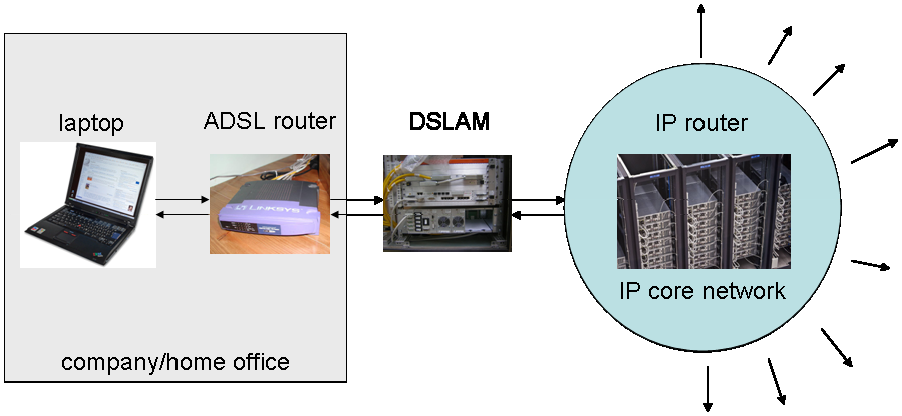

Fig. 1.1: Devices required for internet communication

In order to describe the life cycle inventory of a videoconference, the data sets presented in Tab. 1.1 are established.

Tab. 1.1: Overview data sets for virutal mobility (work at home, videoconference)

Information	Data set name
Use of laptop computer in home office environment, charged with certified electricity	use, computer, laptop, work at home, certified electricity/CH/hr
Use of laptop computer in home office environment, charged with supply mix	use, computer, laptop, work at home /CH/hr
Use of laptop computer in a videoconference, charged with certified electricity	use, computer, laptop, videoconference, certified electricity/CH/hr
Use of laptop computer in a videoconference, charged with supply mix	use, computer, laptop, videoconference, /CH/hr
Use of IP core network for data routing during work at home	use, IP network, work at home/CH/hr
Use of IP core network for data routing in a videoconference	use, IP network, videoconference/CH/hr
Use of network access devices for work at home, using certified electricity	use, network access devices, certified electricity/CH/hr
Use of network access devices for work at home, using supply mix	use, network access devices /CH/hr
Use of network access devices for videoconference, using certrified electricity	use, network access devices, certified electricity/CH/hr
Use of network access devices for videoconference, using supply mix	use, network access devices/CH/hr
Router used in the IP network	Router, IP network, at server/CH/unit
Network access devices (ADSL router, modem, DSLAM)	network access devices, internet, at user/CH/unit

1.2 System description

1.2.1 Videoconference

The system comprises the end-user devices and the network infrastructure required for data transmission. The included devices consist of the following elements:

- Laptop with integrated video camera and microphone

- Network access devices: ADSL modem with router and DSLAM
- Server and router for data communication in the IP network

Further devices such as beamers and additional cameras or microphones are not included in the data set.

The infrastructure for data transmission is a complex structure of routers, servers and cables. An exact mapping is beyond scope, due to the complexity of these transmission systems. We estimate that the environmental impact is mainly influenced by the electricity and material demand of the routers in the system. The number of routers run through by a data package depends on the geographical setting of the videoconference. An average number of 18 routers are assumed[1], which is suitable for data transfer within Switzerland.

Functional unit

The functional unit is set to one person attending one hour of a business meeting. This allows for comparing videoconferences with traditional business meetings with varying numbers of participants.

Scenarios

The videoconference is powered by both Swiss supply mix and certified electricity.

1.2.2 Work at home

The system includes the technology required to provide a working environment at the home office equivalent to the one at the company office. Tab. 1.2 describes the infrastructure needed for both working environments. The data set "work at home" does not consider that a part of the office infrastructure at the company is not used during the time the employee works at home. Furthermore, travel distances saved by working at home are not accounted for.

Tab. 1.2: Infrastructure required in company and home office

Infrastructure	Company office	Home office
Laptop	Standard	Standard
ADSL-Modem	Company capacity	Home capacity
Router	Only for internet access use	For company data exchange and internet use
DSLAM	For internet access use	For internet and company intranet access
IP-Network	Only for internet access use	For internet and company intranet access

Functional unit

The functional unit of the data set of work at home is defined as an average working hour in a home office environment with connection to company internal databases and servers. It is therefore necessary to establish a scenario for an average working hour including database requests, internet research and work based on local data resources. Electricity saved at the company office is not considered.

Scenarios

The electricity consumption is on one hand covered by the Swiss supply mix and on the other hand by certified electricity.

[1] Personal communication, Mr. Res Witschi, 2009-11-03, Swisscom, Bern

1.3 LCI of laptop use

The power requirement of a laptop computer depends on its activity. Values during maximum performance can reach up to 40 W. We presume that the power consumption during the transmission of video data is above average and therefore is set to 30 W[2].

The average use modes for a working day are derived from the EPIC study (EPIC_ICT 2003), which was applied for the average laptop use in offices. As the functional unit of work at home is set to one working hour, the work at home data set only considers the mode mix during 8 working hours (see Tab. 1.3).

In the ecoinvent report on the use of electronic devices (Hischier et al. 2007) the following values are provided:

Tab. 1.3: Power requirement of a laptop computer (Hischier et al. 2007)

Modes	Range (Literature study)	ecoinvent values	% whole day (EPIC_ICT)	% working hours (own calculation)
Active mode	15-36 W	19 W	20.83% (5.5h)	68.75% (5.5h)
Standby/sleep mode	1.4 –6 W	4 W	8.33% (2h)	25% (2h)
Off mode	0.5-2.5 W	2 W	70.83% (16.5h)	6.25% (0.5h)

For the laptop used for work at home we assume the same hours for the active or standby mode as given in the EPIC_ICT model above. Half an hour per working day are accounted for as off mode, which represents non-computer based work (literature study, meetings or telephone calls).

Further equipment is not accounted for, as it is assumed that current laptop models contain a video camera and microphone to set up a videoconference. The laptop is being used during four years and 1850 hours.

Transport is included for rail and lorry transport from the plant to the customer (see Tab. 1.3). The applied values correspond to the ecoinvent data (Frischknecht et al. 2007).

Tab. 1.4: Unit process raw data of laptop use for work at home and videoconference

	Name	Location	InfrastructureP	Unit	use, computer, laptop, work at home	use, computer, laptop, work at home, certified electricity mix	use, computer, laptop, videoconference	use, computer, laptop, videoconference, certified electricity mix	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH	CH	CH			
	InfrastructureProcess				0	0	0	0			
	Unit				h	h	h	h			
product	use, computer, laptop, work at home	CH	0	h	1	0	0	0			
	use, computer, laptop, work at home, certified electricity	CH	0	h	0	1	0	0			
	use, computer, laptop, videoconference	CH	0	h	0	0	1	0			
	use, computer, laptop, videoconference, certified electricity mix	CH	0	h	0	0	0	1			
technosphere	laptop computer, at plant	GLO	0	unit	1.35E-4	1.35E-4	1.35E-4	1.35E-4	1	1.14	(2,3,2,2,1,4); lifttime: 4 years and 1850 hours
	electricity, low voltage, consumer mix, at grid	CH	0	kWh	1.42E-2		3.00E-2		1	1.13	(2,2,1,1,1,4); according to ecoinvent report no. 18: 12.75% ff: 2W, 25%standby: 4W, 68.75% active:19W, 100%video: 30W
	electricity, low voltage, certified, at grid	CH	0	kWh		1.42E-2		3.00E-2	1	1.13	(2,2,1,1,1,4); according to ecoinvent report no. 18: 12.75% ff: 2W, 25%standby: 4W, 68.75% active:19W, 100%video: 30W
	transport, freight, rail	RER	0	tkm	1.80E-5	1.80E-5	1.80E-5	1.80E-5	1	2.10	(2,3,1,3,3,5); according to ecoinvent report no.18, section 5.1.1
	transport, lorry >16t, fleet average	RER	0	tkm	8.59E-6	8.59E-6	8.59E-6	8.59E-6	1	2.10	(2,3,1,3,3,5); according to ecoinvent report no.18, section 5.1.1

[2] Personal communication R. Witschi, Swisscom, 2009-10-07

1.4 LCI of internet devices

1.4.1 Network access devices

The internet connection of computers requires several devices for communication and guidance of the information through the network. Most commonly, a modem and a router are connected to the local network or computer.

The current technology involves a Digital Subscriber Line (DSL) connection to broadband internet. It can be installed on analogue (POTS) or digital (ISDN) telephone connections. Because the DSL technology uses the telephone line for data transmission, a splitter is introduced to split telephone information from internet data transmission. The majority of the modems include a router, which sorts the incoming and outgoing data and sends them to the correct destination.

The following network access devices are taken into account:

- ADSL modem with router
- DSLAM

Splitters are excluded from the LCI because they are passive modules without electricity demand and often are part of the routing devices.

The LCI data representing the DSLAM is taken from the factsheet of the Zyxel IES-6000 Series DSLAM, which contains ports for 768 users (ZyXel 2009). The material use for the devices manufacture is roughly estimated based on weight and dimensions of the devices. The chassis dataset accounts for plastics and metals input, whereas the printed wiring board represents the electronic equipment of the devices. Further specifications are presented in Tab. 1.6.

1.4.2 IP core network devices

The Internet Protocol (IP) network provides the infrastructure for data transmission in the internet. The information is introduced to the IP-network by a digital subscriber line access multiplexer DSLAM. The DSLAM is the link between the local and the global IP network, which sends or receives data to or from a regional broadband remote access server.

In order to reach the point of destination, the data is routed from the entry of the IP network to further servers according to its IP address. Usually, the data package passes several routers on the way to its destination. The number of routers run through by a data package depends on several factors one of which is the geographical distance between the two points of communication. Other factors are difficult to quantify and are partly subject to random.

The data set “router, IP core network,”describes the composition of a commonly used router. The data for the material use of IP core network devices is estimated using product information on weight and printed wiring board area of a Cisco Service Routers 1800 Series (Cisco Systems 2009). The specifications are listed in Tab. 1.6.

1.4.3 Chassis, network main devices

Data on the production and composition of a chassis in network devices are scarce. The broad variety of network devices leads to many different shares of material inputs. The values used for the data set “chassis, network main devices” represent an estimation of the average input materials derived from factsheets (Cisco Systems 2009; ZyXel 2009) and the estimation of other electronic network devices (GSM base station, inverse rectifier). Main components are steel (62%) and copper (15%). The processing of these materials is taken into account by sheet rolling, powder coating and wire drawing (see Tab. 1.5).

Tab. 1.5: Unit process raw data of chassis, network main devices

	Name	Location	InfrastructureProcess	Unit	chassis, network main devices	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
product	chassis, network main devices	RER	0	kg	1			
technosphere	electricity, low voltage, production UCTE, at grid	UCTE	0	kWh	1.00E+00	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	aluminium, production mix, cast alloy, at plant	RER	0	kg	2.50E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	aluminium, production mix, at plant	RER	0	kg	2.50E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	cast iron, at plant	RER	0	kg	5.00E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	copper, at regional storage	RER	0	kg	1.50E-01	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	steel, low-alloyed, at plant	RER	0	kg	6.22E-01	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	tin, at regional storage	RER	0	kg	2.00E-03	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	brass, at plant	CH	0	kg	1.00E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	zinc, primary, at regional storage	RER	0	kg	1.00E-03	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	epoxy resin, liquid, at plant	RER	0	kg	2.00E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	polyethylene, HDPE, granulate, at plant	RER	0	kg	1.00E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	polyvinylchloride, bulk polymerised, at plant	RER	0	kg	1.00E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	polypropylene, granulate, at plant	RER	0	kg	5.00E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	flat glass, coated, at plant	RER	0	kg	2.00E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	silicone product, at plant	RER	0	kg	1.00E-03	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	corrugated board, mixed fibre, single wall, at plant	RER	0	kg	4.00E-03	1	1.57	(5,na,2,3,3,na); packaging
	transport, lorry >16t, fleet average	RER	0	tkm	1.00E-01	1	2.28	(5,na,2,3,3,na); standard distance 100km
	transport, freight, rail	RER	0	tkm	2.00E-01	1	2.28	(5,na,2,3,3,na); standard distance 200km
	transport, lorry 3.5-16t, fleet average	RER	0	tkm	5.00E-01	1	2.28	(5,na,2,3,3,na); delivery to storage 500km
	transport, van <3.5t	RER	0	tkm	3.00E-01	1	2.28	(5,na,2,3,3,na); installation, service, deinstallation 300km
	sheet rolling, steel	RER	0	kg	6.22E-01	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	powder coating, steel	RER	0	m2	5.00E-02	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	wire drawing, copper	RER	0	kg	1.50E-01	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	disposal, building, bulk iron (excluding reinforcement), to sorting plant	CH	0	kg	6.72E-01	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	disposal, packaging cardboard, 19.6% water, to municipal incineration	CH	0	kg	4.00E-03	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
	disposal, plastic, industr. electronics, 15.3% water, to municipal incineration	CH	0	kg	1.10E-1	1	1.57	(5,na,2,3,3,na); assumption according to factsheets of network devices
emission air, high population	Heat, waste	-	-	MJ	3.60E+0	1	1.11	(3,na,1,1,1,na); calculation

Tab. 1.6: Specifications of network access and IP core network devices

Weights of devices without PWB	Unit	Core network router	Access devices	Source
ADSL modem with router	kg		2.40E-01	Estimation, total weight from factssheet Zyxel
DSLAM per port	kg		3.91E-02	Factssheet Zyxel IES-6000 Series: 15 kg / 768 ports, 50% utilisation
Core network router	kg	1.82E+00		Cisco router factssheet: 3.63 kg, assumption PWB=50% of weight
Area of PWB	Unit	Core network router	Access devices	
ADSL modem with router	m2		1.40E-02	Estimation
DSLAM	m2		3.96E-03	Factssheet Zyxel IES-6000 Series: 39.6x24cm per 48 ports, 50% utilisation
Core network router	m2	7.49E-02		Cisco router factssheet: area 26.67cmx28.07cm
Parts	Unit	Core network router	Access devices	Source
total weight of device withouth PWB	kg	1.82E+00	2.79E-01	Sum of ADSL modem/router and DSLAM
area of wiring board	m2	7.49E-02	1.80E-02	Sum of ADSL modem/router and DSLAM

Tab. 1.7: Unit process raw data of network access devices

	Name	Location	InfrastructureP	Unit	router, IP network, at server	network access devices, internet, at user	UncertaintyTyp e	StandardDevia tion95%	GeneralComment
	Location				CH	CH			
	InfrastructureProcess				1	1			
	Unit				unit	unit			
product	router, IP network, at server	CH	1	unit	1	0			
	network access devices, internet, at user	CH	1	unit	0	1			
technosphere	chassis, network main devices	RER	0	kg	1.82E+0	2.79E-1	1	1.59	(4,3,2,1,4,4); Estimation, total weight from factssheet Zyxel; Factssheet Zyxel IES-6000 Series: 15 kg / 768 ports, 50% utilisation; Cisco router factssheet: 3.63 kg, assumption PWB=50% of weight
technosphere	printed wiring board, surface mount, at plant	GLO	0	m2	7.49E-2	1.80E-2	1	1.59	(4,3,2,1,4,4); Estimation; Factssheet Zyxel IES-6000 Series: 39.6x24cm per 48 ports, 50% utilisation; Cisco router factssheet: area 26.67cmx28.07cm
	transport, transoceanic freight ship	OCE	0	tkm	4.36E+1	6.70E+0	1	2.07	(2,3,1,3,3,4); Over all weight of device = 2* chassis weight, transport from Asia: 12000km
	transport, lorry 3.5-16t, fleet average	RER	0	tkm	2.90E+0	4.47E-1	1	2.07	(2,3,1,3,3,4); Over all weight of device = 2* chassis weight, transport from Rotterdam: 800km

1.5 LCI of device use in videoconference, per participant

For one hour of videoconference the material share and the electricity consumption of the involved devices are taken into account. The material includes one laptop equipped for videoconferencing, one set of network access devices and an average core network device per participant. As the data transmission is mutual, the IP network use is equal for all participants. The videoconference usally includes 3 to 5 participants. This can be modelled by multiplying the LCA results for one participant by the number of participants.

The electricity used in the network access devices is either Swiss supply mix or certified electricity. The electricity used in the core network is Swiss supply mix, because the majority of the core network devices run on non-certified electricity.

1.5.1 Use of network access devices for a videoconference

The life expectancies of the ADSL modem/router and the DSLAM are set to 6 years (1850 working hours each). The ADSL router demands 0.0042 kWh per hour, when constantly working at full load. The difference of electricity consumption between full load and standby mode is marginal and therefore neglected. Similarly, for the DSLAM only average values of electricity consumption are available, which is 0.0013 kWh per port. The data sets use either the Swiss supply mix, or certified electricity, which consists of electricity from renewable energy sources. The electricity conversion to 48V has an estimated efficiency of 90%.

Tab. 1.8: Electricity consumption of network access devices

Electricity demand of access devices	Unit	Videoconference	Work at home	Source
DSLAM, power consumption per port	kW	0.0013	0.0013	Personal communication Witschi (2009)
DSLAM capacity utilization	%	0.5	0.5	Personal communication Witschi (2009)
ADSL router+modem power consumption full load	kW	0.0042	0.0042	Assumptions based on unpublished report
Conversion efficieny	%	0.9	0.9	Calculation

1.5.2 Use of IP core network for a videoconference

The material share is calculated for all network devices using the lifetime of the device (6 years) and the annual hours in use (8760 hours). We assume that the core network devices are used 24 hours per day. Additionally, the material share is divided in proportion to the actually used bandwidth for the videoconference. The router data set represents a router with an average used bandwidth of 25 MBit/s. The share is calculated using the data exchange of the specific activity. The data packages run through

18 routers on their way between the participants of the conference and require a bandwidth of 0.7 MBit/s.

Tab. 1.9: Values used for the calculation of the share of the IP core network router infrastructure for a videoconference

Information	Values
Life time of IP core network device	6 years
Annual hours	8760 hours
Total hours in operation	52560 hours
Number of routers run through by data package	18
Average bandwidth in use in an IP router	25 MBit/s
Bandwidth demanded for videoconferencing	0.7 MBit/s
Amount of data exchange	315 Mbytes/hour

Experts estimate an electricity demand of 0.0042 kWh per hour at a bandwidth of 1 MBit/s (Witschi 2009). Depending on the utilised capacity of the router the electricity demand per data amount can vary widely. Small servers with a low efficiency achieve values of 8.5 kWh at 1MBit/s. On the other hand, a larger server with full capacity load consumes only 0.0005 kWh at 1MBit/s. The electricity consumption used for this data set is 0.0042 kWh per hour at a data flow rate of 1MBit/s.

The electricity consumption is calculated extrapolating the average electricity demand of 0.0042 kWh per IP router at 1 MBit/s for the actually required bandwidth of 0.7 MBit/s for the videoconference. This corresponds to 315 Mbytes data transferred per hour. We estimate that the electricity demand is correlated linearly to the used bandwidth or amount of data in transfer. Furthermore, the routers have a high energy demand for cooling, which additionally increases the electricity demand of data routing by factor 1.5[3]. 10% of the electricity is lost by electricity conversion.

Tab. 1.10: Electricity demand of IP core network devices for videoconference use

Electricity demand of IP core network devices	Unit	Videoconference	Source
Power demand of core network router at 1Mbit/s	kW	0.0042	Personal communication Witschi (2009)
Electricity consumption at 0.7 Mbit/s bandwidth	kWh	0.00294	Calculation
Indirect electricity use of IP core network devices			
Indirect electricity use for cooling per kWh	kWh	0.5	Personal communication Witschi (2009)

1.6 LCI of device use for work at home

Work at home requires a laptop computer connected to the company's server by internet. The internet access is provided by a set of network access devices.

Depending on the working activities, the data transfer between the company server and the laptop varies considerably. For an average work at home scenario, the following assumptions are taken:

- data transfer during 30 minutes in one working hour
- the amount of data exchanged is comparable to the data load of an average internet search (24kB/s)
- modest email activity (256 kB/hr)

[3] Personal communication R. Witschi, Swisscom, Bern, 2009-10-07

The electricity used in the network access devices is either Swiss supply mix or certified electricity. The electricity used in the core network is Swiss supply mix, because the majority of the core network devices run on non-certified electricity.

1.6.1 Use of network access devices for work at home

The data set for the network access device is independent of the bandwidth used for the communication service. The network access device use for work at home is therefore identical to the use in videoconferences (see Section 1.5.1)

1.6.2 Use IP core network for work at home

The material share is calculated using the lifetime of the devices (6 years) and the hours in use (8760). It is assumed that all devices are used 24 hours a day. For the IP core network router, the material share depends on the amount of data exchange. The router data set represents a router with an average real load of 25 MBit/s. The share is calculated using the data exchange of the specific activity. The data packages run through 18 routers on their way between the company and the home office at a bandwidth of 0.2 MBit/s for average internet use and email communication.

Tab. 1.11: Values used for the calculation of the share of the IP core network router infrastructure for work at home

Information	Values
Life time of IP core network device	6 years
Annual hours	8760 hours
Total hours in operation	52560 hours
Number of routers run through by data package	18
Average bandwidth in use inan IP router	25 MBit/s
Bandwidth demanded for videoconferencing	0.2 MBit/s
Amount of data exchanged	90 Mbytes/hour
Internet use	50% of working hour

The electricity consumption is calculated extrapolating the average electricity consumption of 0.0042 kWh per IP router at 1 MBit/s for the bandwidth of 0.2 MBit/s, which corresponds to 90 Mbytes data transfer per hour. The routers have a high energy demand for cooling, which additionally increases the electricity demand of data routing by factor 1.5 (see Tab. 1.12).

Tab. 1.12: Electricity demand of the IP core network devices for work at home

Electricity demand of IP core network devices	Unit	Work at home	Source
Power demand of core network router at 1Mbit/s	kW	0.0042	Personal communication Witschi (2009)
Electricity consumption at 24 kBytes/s	kWh	8.06E-04	Calculation
Indirect electricity use of IP core network devices			
Indirect electricity use for cooling per kWh	kWh	0.5	Personal communication Witschi (2009)

Tab. 1.13: Unit process raw data of IP core network and access devices for one hour of videoconference and work at home

	Name	Unit	use, IP network, videoconference	use, IP network, work at home	use, network access devices	use, network access devices, certified electricity mix	UncertaintyType	StandardDeviation95%	GeneralComment
	Location		CH	CH	CH	CH			
	InfrastructureProcess		0	0	0	0			
	Unit		h	h	h	h			
	use, IP network, videoconference	h	1	0	0	0			
	use, IP network, work at home	h	0	1	0	0			
	use, network access devices	h	0	0	1	0			
	use, network access devices, certified electricity mix	h	0	0	0	1			
technosphere	network access devices, internet, at user	unit			9.01E-5	9.01E-5	1	3.11	(4,3,1,1,3,4); 1 ADSL modem/router, DSLAM per port
	router, IP network, at server	unit	9.59E-6	2.74E-6			1	3.11	(4,3,1,1,3,4); 18 routers bandwidth 25MBits
	electricity, low voltage, consumer mix, at grid	kWh	8.82E-2	1.26E-2	7.56E-3		1	1.33	(4,3,1,1,3,4); Electricity demand: 4.2Wh ADSL, 1.3Wh DSLAM per port, 4.2Wh/Router at 1MBit/s
	electricity, low voltage, certified, at grid	kWh				7.56E-3	1	1.33	(4,3,1,1,3,4); Electricity demand: 4.2Wh ADSL, 1.3Wh DSLAM per port, 4.2Wh/Router at 1MBit/s

1.7 LCI of videoconference and work at home

The life cycle inventories of videoconference and work at home combine the use of the different devices used for communication services. Both data sets include the use of one laptop, one set of network access device and one set of IP core network routers. However, they differ in the electricity consumption due to the different use of bandwidth. For both communication services the Swiss supply mix on one hand and certified electricity on the other cover the electricity demand of the laptop and the network access devices.

In order to assess the environmental impact of a videoconference with two or more participants, the LCA results of the videoconference data set can be multiplied by the number of participants.

Tab. 1.14: Unit process raw data of work at home

	Name	Location	InfrastructureProcess	Unit	work at home, corporate access	work at home, corporate access, certified electricity mix	videoconference, laptop, participant	videoconference, laptop, participant, certified electricity mix	UncertaintyType	StandardDeviation95 %	GeneralComment
	Location				CH	CH	CH	CH			
	InfrastructureProcess				0	0	0	0			
	Unit				h	h	h	h			
	work at home, corporate access	CH	0	h	1	0	0	0			
	work at home, corporate access, certified electricity mix	CH	0	h	0	1	0	0			
	videoconference, laptop, participant	CH	0	h	0	0	1	0			
	videoconference, laptop, participant, certified electricity mix	CH	0	h	0	0	0	1			
technosphere	use, computer, laptop, videoconference	CH	0	h			1.00E+0		1	2.06	(4,3,1,1,1,4); 1 hour laptop use according to user profile
	use, computer, laptop, videoconference, certified electricity mix	CH	0	h				1.00E+0	1	2.06	(4,3,1,1,1,4); 1 hour laptop use according to user profile
	use, computer, laptop, work at home	CH	0	h	1.00E+0				1	2.06	(4,3,1,1,1,4); 1 hour laptop use according to user profile
	use, computer, laptop, work at home, certified electricity mix	CH	0	h		1.00E+0			1	2.06	(4,3,1,1,1,4); 1 hour laptop use according to user profile
	use, IP network, videoconference	CH	0	h			1.00E+0	1.00E+0	1	2.06	(4,3,1,1,1,4); 1 hour IP router use according to user profile
	use, IP network, work at home	CH	0	h	1.00E+00	1.00E+00			1	2.06	(4,3,1,1,1,4); 1 hour IP router use according to user profile
	use, network access devices	CH	0	h	1.00E+0		1.00E+0		1	2.06	(4,3,1,1,1,4); 1 hour network access device use according to user profile
	use, network access devices, certified electricity mix	CH	0	h		1.00E+0		1.00E+0	1	2.06	(4,3,1,1,1,4); 1 hour network access device use according to user profile

1.8 Cumulative results and interpretation

1.8.1 Introduction

Selected LCI results and values for the cumulative energy demand are presented and discussed in this chapter. Please note that only a small part of the about 1'000 elementary flows is presented here. The selection of the elementary flows shown in the tables is not based on their environmental relevance. It rather allows to show by examples the contributions of the different life cycle phases, or specific inputs from the technosphere to the selected elementary flows. Please refer to the ecoinvent database for the complete LCIs.

The shown selection is not suited for a life cycle assessment of the analysed processes and products. Please use the data downloaded from the database for your own calculations, also because of possible minor deviations between the presented results and the database due to corrections and changes in background data used as inputs in the dataset of interest.

The ecoinvent database also contains life cycle impact assessment results. Assumptions and interpretations were necessary to match current LCIA methods with the ecoinvent inventory results. They are described in Frischknecht et al. (2007). It is strongly advised to read the respective chapters of the implementation report before applying LCIA results.

1.8.2 Results

Tab. 1.15 shows selected LCI results and the cumulative energy demand for the videoconferences and work at home. The use of non-renewable energy sources is higher for the processes, in which the devices run on supply mix. Reciprocally, the consumption of renewable energy is higher in processes using certified electricity. However, the difference between the processes is rather small, as the main energy demand arises from the production of the devices and the IP core network, which runs on supply mix in both cases. Air emissions, such as CO_2 or NMVOC, arise from the electricity production and therefore their variation among the processes is similar to the variation of the energy demand.

The emissions of BOD and Cadmium vary only slightly, which shows that the manufacture of the equipment contributes significantly to these emissions.

Tab. 1.15 Selected LCI results and the cumulative energy demand of videoconference and work at home

	Name		videoconference, laptop, participant, certified electricity	videoconference, laptop, participant, consumer mix	work at home, corporate access, certified electricity	work at home, corporate access, consumer mix
	Location		CH	CH	CH	CH
	InfrastructureProcess		0	0	0	0
	Unit	Unit	hr	hr	hr	hr
CED	Non renewable, fossil	MJ eq	4.34E-1	4.92E-1	3.02E-1	3.36E-1
CED	Non-renewable, nuclear	MJ eq	7.23E-1	9.85E-1	1.91E-1	3.43E-1
CED	Non-renewable, biomass	MJ eq	1.28E-6	1.31E-6	1.20E-6	1.21E-6
CED	Renewable, biomass	MJ eq	2.17E-2	2.05E-2	1.42E-2	1.35E-2
CED	Renewable, wind, solar, geothe	MJ eq	5.86E-3	4.64E-3	3.26E-3	2.55E-3
CED	Renewable, water	MJ eq	3.21E-1	2.26E-1	1.31E-1	7.57E-2
NMVOC	air	kg	2.00E-5	2.11E-5	1.69E-5	1.75E-5
Carbon dioxide, fossil	air	kg	3.47E-2	3.91E-2	2.48E-2	2.73E-2
Sulphur dioxide	air	kg	1.49E-4	1.63E-4	1.11E-4	1.20E-4
Nitrogen oxides	air	kg	8.51E-5	9.26E-5	6.53E-5	6.96E-5
Particulates, <2.5 um	air	kg	1.30E-5	1.37E-5	9.39E-6	9.81E-6
Land occupation	resource	m2a	2.81E-3	2.76E-3	2.20E-3	2.17E-3
BOD	water	kg	1.86E-4	1.89E-4	1.80E-4	1.81E-4
Cadmium	soil	kg	7.58E-10	7.56E-10	7.47E-10	7.45E-10

1.8.3 Data uncertainty

The data uncertainty mainly arises from production und the energy consumption of network devices. Many different types of servers and routers with various capacities lead to a high variation of energy consumption and material input for these devices. Additionally, the number of routers used in the IP core network varies. The material composition of network devices is based on rough assumptions and does not accurately represent the chassis of the devices.

1.9 Conclusions

Virtual mobility substitutes travel by using IT-technology for the transfer of information. This office environment and the home office environment basically only differ in the use of an additional laptop and internet connection. Similarly, the videoconference can be held with a laptop per participant and a broadband internet connection. For both processes, the technical effort can be augmented to special connection to the company server or telepresence meetings with highly developed audiovisual equippement. Considering the substituted travel activity, which is not specifically accounted for in the data set, the environmental impact of work at home could be considerably lower than the one assessed with this data set.

The selected LCI results show, that the energy demand of the IT-infrastructure operation and the manufacture of the equipment have a considerable influence on the environmental impact of virtual mobility. The selection of the equipment and the data amount are therefore considered to be the key factors.

1.10 References

Cisco Systems 2009 — Cisco Systems (2009) Cisco 1861 Integrated Services Router. Retrieved 2009-10-20 retrieved from: http://www.cisco.com/en/US/products/ps5853/index.html.

EPIC_ICT 2003 — EPIC_ICT (2003) Development of Environmental Performance Indicators for ICT Products on the example of Personal Computers. EU/FP6. European Commission, Brussels.

Frischknecht et al. 2007 — Frischknecht R., Jungbluth N., Althaus H.-J., Bauer C., Doka G., Dones R., Hellweg S., Hischier R., Humbert S., Margni M. and Nemecek T. (2007) Implementation of Life Cycle Impact Assessment Methods. ecoinvent report No. 3, v2.0. Swiss Centre for Life Cycle Inventories, Dübendorf, CH, retrieved from: www.ecoinvent.org.

Hischier et al. 2007 — Hischier R., Classen M., Lehmann M. and Scharnhorst W. (2007) Life Cycle Inventories of Electric and Electronic Equipment - Production, Use & Disposal. ecoinvent report No. 18, v2.0. EMPA St. Gallen, Swiss Centre for Life Cycle Inventories, Dübendorf, CH, retrieved from: www.ecoinvent.org.

Witschi 2009 — Witschi R. (2009) Abschätzungen Router und Stromverbrauch bei Videokonferenz und work@home. (ed. Leuenberger M.). Swisscom, Bern.

ZyXel 2009 — ZyXel (2009) IP DSLAM IES-6000 Series 12.5U High Capacity Multi-Service Access Node. Retrieved 2009-12-15 retrieved from: http://www.zyxel.com/web/product_category.php?PC1indexflag=20040812100619.

Appendices: EcoSpold Meta Information

Tab. A. 1 EcoSpold Meta Information of laptop use in videoconferences and for work at home

ReferenceFunction	Name	use, computer, laptop, work at home	use, computer, laptop, work at home, certified electricity mix	use, computer, laptop, videoconference	use, computer, laptop, videoconference, certified electricity mix
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	h	h	h	h
	IncludedProcesses	This data set includes the use of a laptop and the energy consumption for working at home. It includes the laptop production, transport from plant to customer and electricity consumption (from consumer mix) for average office work.	This data set includes the use of a laptop and the energy consumption for working at home. It includes the laptop production, transport from plant to customer and electricity consumption (from certified electricity) for average office work.	This data set includes the use of a laptop and the energy consumption for a videoconference. It further includes the laptop production and transport from plant to customer).	This data set includes the use of a laptop and the energy consumption for a videoconference. It further includes the laptop production and transport from plant to customer).
	LocalName	Nutzung, Computer, Laptop, Heimarbeit	Nutzung, Computer, Laptop, Heimarbeit, zertifizierter Strom	Nutzung, Computer, Laptop, Videokonferenz	Nutzung, Computer, Laptop, Videokonferenz, zertifizierter Strom
	Synonyms	Heimarbeit	Heimarbeit		
	GeneralComment	The data set represents the use of a laptop computer during work at home.	The data set represents the use of a laptop computer during work at home.	The data set represents the use of a laptop computer during a videoconference. An average electricity consumption of 30W is set (Swiss consumer mix).	The data set represents the use of a laptop computer during a videoconference. An average electricity consumption of 30W is set (certified electricity mix).
	InfrastructureIncluded	1	1	1	1
	Category	electronics	electronics	electronics	electronics
	SubCategory	services	services	services	services
	LocalCategory	Elektronik	Elektronik	Elektronik	Elektronik
	LocalSubCategory	Dienstleistung	Dienstleistung	Dienstleistung	Dienstleistung
	Formula				
	StatisticalClassification				
	CASNumber				
TimePeriod	StartDate	2005	2005	2005	2005
	EndDate	2009	2009	2009	2009
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText				
Geography	Text	Data for Swiss conditions	Data for Swiss conditions	Data for Swiss conditions	Data for Swiss conditions
Technology	Text	Work at home using an average laptop computer with 68% active mode, 25%standby mode and 6% off mode	Work at home using an average laptop computer with 68% active mode, 25%standby mode and 6% off mode	Laptop use in videoconferences, 100% video mode (30W)	Laptop use in videoconferences, 100% video mode (30W)
Representativeness	Percent				
	ProductionVolume	unknown	unknown	unknown	unknown
	SamplingProcedure	unknown	unknown	unknown	unknown
	Extrapolations	Average technology	Average technology	Average technology	Average technology
	UncertaintyAdjustments	none	none	none	none

Tab. A. 2 EcoSpold Meta Information of router and network access devices, at user

ReferenceFunction	Name	router, IP network, at server	network access devices, internet, at user
Geography	Location	CH	CH
ReferenceFunction	InfrastructureProcess	1	1
ReferenceFunction	Unit	unit	unit
	IncludedProcesses	This data sets represents an IP core network router. Manufacture and transport included.	This data set includes all network access devices usually required for internet communication. It namely includes: ADSL modem with router, DSLAM and connecting cables. Manufacture and transport included.
	LocalName	Router, IP Netz, in Server	Netzwerkzugangsgeräte, Internetverbindung, bei Benutzer
	Synonyms		
	GeneralComment	The data set represents an average IP core network device, based on assumption for the chassis and PWB.	The data set represents the material in internet access devices, based on assumptions for the chassis and PWB.
	InfrastructureIncluded	1	1
	Category	electronics	electronics
	SubCategory	devices	devices
	LocalCategory	Elektronik	Elektronik
	LocalSubCategory	Geräte	Geräte
	Formula		
	StatisticalClassification		
	CASNumber		
TimePeriod	StartDate	2005	2005
	EndDate	2009	2009
	DataValidForEntirePeriod	1	1
	OtherPeriodText		
Geography	Text	Data for Swiss conditions	Data for Swiss conditions
Technology	Text	IP core network device (IP router) derived from Cisco Service Router 1800 Series, maximal data rate: 100 Mbit/s, realistic: 25 Mbit/s. Power demand: 0.0042 kW at 1 Mbit/s.	Included devices: ADSL modem with router and DSLAM, DSLAM with 17 line cards with 48 ports. 50% capacity utilisation.
Representativeness	Percent		
	ProductionVolume	unknown	unknown
	SamplingProcedure	unknown	unknown
	Extrapolations	Average technology	Average technology
	UncertaintyAdjustments	none	none

Tab. A. 3 EcoSpold Meta Information of chassis, main network device

ReferenceFunction	Name	chassis, network main devices
Geography	Location	RER
ReferenceFunction	InfrastructureProcess	0
ReferenceFunction	Unit	kg
	IncludedProcesses	materials, standard transport distances, electricity use for manufacturing, disposal
	Amount	1
	LocalName	Gehäuse, Netzwerk Gerät
	Synonyms	
	GeneralComment	Rough assumption based on previous study for telecom equipment and personal communication with experts.
	InfrastructureIncluded	1
	Category	electronics
	SubCategory	component
	LocalCategory	Elektronik
	LocalSubCategory	Bauteile
	Formula	
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2000
	EndDate	2009
	DataValidForEntirePeriod	1
	OtherPeriodText	
Geography	Text	Switzerland
Technology	Text	average material composition of chassis for network devices. Life expectancy: 6 years, annual working hour depending on use.
Representativeness	Percent	
	ProductionVolume	unknown
	SamplingProcedure	expert guess, factsheets
	Extrapolations	none
	UncertaintyAdjustments	none

Tab. A. 4 EcoSpold Meta Information of IP network and network access devices use

ReferenceFunction	Name	use, IP network, videoconference	use, IP network, work at home	use, network access devices	use, network access devices, certified electricity mix
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	h	h	h	h
	IncludedProcesses	This data set includes the use of the IP core network for videoconference (0.7 Mbit/s) data exchange for one hour, taking into account IP router use and electricity consumption.	This data set includes the use of the IP core network for work at home data exchange (0.2 Mbit/s) for one hour taking into account IP router use and electricity consumption.	This data set includes the use of internet access devices for one end user during one hour, taking into account device use and electricity consumption (consumer mix)	This data set includes the use of internet access devices for one end user during one hour, taking into account device use and electricity consumption (certified electricity mix)
	LocalName	Nutzung, IP Netz, Videokonferenz	Nutzung, IP Netz, Heimarbeit	Nutzung, Netzwerkzugangsgeräte	Nutzung, Netzwerkzugangsgeräte, zertifizierter Strom
	Synonyms				
	GeneralComment	The data set represents average values for one hour of IP network use during a videoconference per participant	The data set represents average values for one hour of IP network use for work at home per person	The data set represents average values for one hour use of network access devices per work station.	The data set represents average values for one hour use of network access devices per work station.
	InfrastructureIncluded	1	1	1	1
	Category	electronics	electronics	electronics	electronics
	SubCategory	services	services	services	services
	LocalCategory	Elektronik	Elektronik	Elektronik	Elektronik
	LocalSubCategory	Dienstleistung	Dienstleistung	Dienstleistung	Dienstleistung
	Formula				
	StatisticalClassification				
	CASNumber				
TimePeriod	StartDate	2005	2005	2005	2005
	EndDate	2009	2009	2009	2009
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText				
Geography	Text	Data for Swiss conditions	Data for Swiss conditions	Data for Swiss conditions	Data for Swiss conditions
Technology	Text	IP core network device (IP router) derived from Cisco Service Router 1800 Series, maximal data rate: 100 Mbit/s, realistic: 25 Mbit/s. Power demand: 0.0042 kW at 1 Mbit/s. Band width for videoconference: 0.7Mbit/s	IP core network device (IP router) derived from Cisco Service Router 1800 Series, maximal data rate: 100 Mbit/s, realistic: 25 Mbit/s. Power demand: 0.0042 kW at 1 Mbit/s. Band width for work at home: 0.2Mbit/s	Included devices: ADSL modem with router (0.0042kW) and DSLAM (0.0013 kW) per end user	Included devices: ADSL modem with router (0.0042kW) and DSLAM (0.0013 kW) per end user
Representativeness	Percent				
	ProductionVolume	unknown	unknown	unknown	unknown
	SamplingProcedure	unknown	unknown	unknown	unknown
	Extrapolations	Average technology	Average technology	Average technology	Average technology
	UncertaintyAdjustments	none	none	none	none

Tab. A. 5 EcoSpold Meta Information of videoconference and work at home

ReferenceFunction	Name	work at home, corporate access	work at home, corporate access, certified electricity mix	videoconference, laptop, participant	videoconference, laptop, participant, certified electricity mix
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	h	h	h	h
	IncludedProcesses	This data set includes the use of hardware (laptop, internet devices) and energy consumption for on hour work at home using broadband access to company server. Consumer mix electricity consumption.	This data set includes the use of hardware (laptop, internet devices) and energy consumption for on hour work at home using broadband access to company server. certified electricity consumption.	This data set includes the use of hardware (laptop, internet devices) and energy consumption for on hour videoconference using broadband access per participant. Consumer mix electricity consumption.	This data set includes the use of hardware (laptop, internet devices) and energy consumption for on hour videoconference using broadband access per participant. Certified mix electricity consumption.
	LocalName	Heimarbeit, Corporate Access	Heimarbeit, Corporate Access, zertifizierter Strom	Videokonferenz, Laptop, Teilnehmer	Videokonferenz, Laptop, Teilnehmer, zertifizierter Strom
	Synonyms				
	GeneralComment	The data set represents average values for one hour of work at home using a laptop computer. The data set does not account for energy saved at the company work place and avoided travelling.	The data set represents average values for one hour of work at home using a laptop computer. The data set does not account for energy saved at the company work place and avoided travelling.	The data set represents average values for one videoconference using a laptop computer.	The data set represents average values for one videoconference using a laptop computer.
	InfrastructureIncluded	1	1	1	1
	Category	electronics	electronics	electronics	electronics
	SubCategory	services	services	services	services
	LocalCategory	Elektronik	Elektronik	Elektronik	Elektronik
	LocalSubCategory	Dienstleistung	Dienstleistung	Dienstleistung	Dienstleistung
	Formula				
	StatisticalClassification				
	CASNumber				
TimePeriod	StartDate	2005	2005	2005	2005
	EndDate	2009	2009	2009	2009
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText				
Geography	Text	Data for Swiss conditions	Data for Swiss conditions	Data for Swiss conditions	Data for Swiss conditions
Technology	Text	Work at home using a laptop computer and broadband transmission for data exchange. Consumer mix electricity. Calculated for 1850 annual working hours, 50% internet use, band width: 0.2 Mbit/s	Work at home using a laptop computer and broadband transmission for data exchange. Certified mix electricity. Calculated for 1850 annual working hours, 50% internet use, band width: 0.2 Mbit/s	videoconference using laptops and cameras for image and sound transmission. Band width: 0.7MBit/s. Consumer mix electricity consumption.	videoconference using laptops and cameras for image and sound transmission. Band width: 0.7MBit/s. Consumer mix electricity consumption.
Representativeness	Percent				
	ProductionVolume	unknown	unknown	unknown	unknown
	SamplingProcedure	unknown	unknown	unknown	unknown
	Extrapolations	Average technology	Average technology	Average technology	Average technology
	UncertaintyAdjustments	none	none	none	none