Product Life Cycle Assessment 2018
FUJITSU Desktop ESPRIMO P957

Climate change is one of the most important global challenges that society of the 21st century faces. According to the Intergovernmental Panel on Climate Change (IPCC), it is necessary to limit the average temperature to two degrees towards the pre-industrial level in order to minimize the risks of global warming. This means that Greenhouse gas emissions, which are the main reason for climate change, have to be reduced by at least 80% by 2050 as compared to 1990. The rapidly developing ICT industry, whose products now dominate almost all aspects of daily life, can help to reach this target.

Content

Fujitsu's Environmental Philosophy and Mission

Environmental sustainability has always formed a core part of Fujitsu's business. From the adoption of park-style design for our factory in Kawasaki in 1935 to today's ambitious Fujitsu Group Environmental Action Plan, sustainability is a key to every stage of our end-to-end ICT services.
Significant climate change and declining biodiversity are just two of many serious environmental issues that continue to escalate on a global scale. Furthermore, with the world's population now more than 7 billion, there are rising concerns about a shortage of food, water, energy and other resources.
As a global ICT company, Fujitsu can create new value to transform business and society. The Fujitsu Group is committed to helping resolve global environmental issues through the power of ICT. By doing so, we will continue working together with our stakeholders in the global value chain with our customers, partners and suppliers to shape a sustainable and prosperous society.

Fujitsu is a member of The Green Grid, a consortium of IT companies and professionals seeking to lower the overall consumption of power in data centers around the globe. Fujitsu is also a member of the Climate Savers Computing Initiative. This initiative brings together industries, consumers and conservation organizations to significantly increase the energy efficiency of computers and servers. As a member, Fujitsu is committed to develop and offer products that meet or exceed energy efficient standards.

With a product life cycle assessment, (LCA) Fujitsu intends to acquire scientifically proven information and insights about the environmental performance and impacts of a system. In an LCA, different impact categories are analysed and not only on the well-known product carbon footprint (CO_2, climate change, greenhouse effect). Based on the results measures will be implemented to actively influence the impact.
In 2010, Fujitsu already did an LCA for the DESKTOP ESPRIMO E9900 together with the 'bifa' environmental institute (www.bifa.de) based on the international standards ISO 14040 and ISO 14044. The LCA underwent a critical review by the Fraunhofer Institute for Reliability and Micro integration (www.izm.fraunhofer.de). Partners are assigned for a new LCA and critical review in 2018.

Impact categories of LCA

The following impact categories have been selected in order to assess the environmental performance.

Impact Category	Impact assessment model	Unit
Climate change (GWP 100)	IPPC [IPPC 2013]	kg CO_2 equivalents
Acidification (AP)	CML 20016 [Guinée 2002], [CML 2016]	kg SO_2 equivalents
Particular Matter	RiskPoll Model [Rabl 2004]	kg PM 2,5 equivalents
Eutrophication (EP)	CML 2016	kg PO_4 equivalents
Photochemical oxidation (POCP)	CML 2016	kg C_2H_4 equivalents
Ozone layer depletion (OPD)	CML 2016	kg R11 equivalents
Primary Energy Demand	Primary energy demand from renewable and non-renewable resources (net cal. Value)	kJ
Resource Depletion – mineral, fossil (ADP)	CML 2016	kg Sb equivalents
Resource Depletion – Water	Swiss Ecoscarcity [Frischknecht 2008]	m^3 H_2O equivalents

Table 1: selected impact categories for LCA

Selected System for LCA

The selected system Fujitsu ESPRIMO P957 is a reliable, power saving microtower that is available in different power supply versions and is certified for EPEAT, TCO and Energy Star.

Product specification of ESPRIMO P957/E94+ version

- Microtower housing with E94+ Power Supply Unit (PSU)
- Motherboard with Intel® Core™ processor incl. heat sink
- 2 x 4 GB DDR4 Memory modules
- 1 TB Hard Disk Drive (HDD)
- 512 GB Solid State Drive (SSD) M.2 Module
- Supermulti Optical Disk Drive (ODD)
- Graphic card incl. heat sink
- Microsoft® Windows® 10 Professional operating system

Figure 1: Microtower ESPRIMO P957

Sections of LCA

The life cycle of the examined ESPRIMO P957, including mouse, keyboard, manuals and packing, covers the following sections:

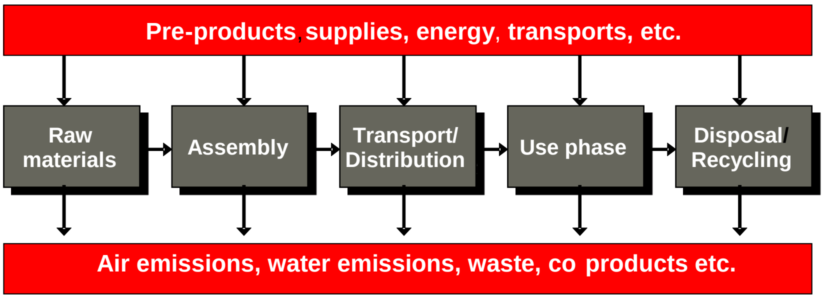


Figure 2: Section of the LCA

Raw Materials

Include extractions, treatment, supply of raw materials, manufacturing of subassemblies and the energy consumption of all these processes. The following components have been taken into account:

- Chassis, power supply
- Mainboard components and printed circuit board including assembly in Augsburg
- Processor (CPU), processor cooler, memory, graphic card incl. heat sink
- Hard disk drive (HDD), optical disk drive (ODD), Solid State disk (SSD, M.2 module)
- Cable, mouse, keyboard
- Manuals, packaging

Desktop assembly

Desktop assembly in the Augsburg plant includes:

- Energy supply
- Scrap and waste management
- Installation software
- System test

Transport/Distribution

Almost all routes have been considered including the transport of:

- Subassemblies from manufacturing in China to assembly in Augsburg by ship and airplane respectively
- Desktops from the Augsburg plant to the distribution center by large trucks and after that to the customer by van and car respectively or from the Augsburg plant to the customer directly by large trucks
- Desktops from the customer to the place of collection by car and following to nearest dismantling facility by mid-sized trucks

Use phase

The following definition of the use phase is determined by:

- An average lifetime of 5 years
- Typical annual energy consumption:

- 159.2 kWh/year for maximum configuration calculated for Energy Star 6.1 certification (based on worst case power supply E85+)
- 37.5 kWh/year for standard configuration based on Energy Star 6.1 calculation in terms of sensitive analyses

- Use phase of the desktop in Germany and for comparison in France, Poland and Norway in terms of sensitivity analyses (country specific energy mix)
- Spare parts: processor, memory, mainboard, optical disk drive, hard disk drive, power supply, keyboard (in relation to total failure rates)

Recycling

The following conditions are assumed:

- Recycling rate including thermal recovery: >98% by weight
- The desktop is recycled after the anticipated lifetime of 5 years
- No components are reused or resold (assumption only!)
- Dismantling process in recycling center almost exclusively by hand
- Main material and components: iron, aluminum, copper, plastics, power supply, printed circuit boards, cable
- Additional recycling of keyboard, mouse, packaging and manuals is considered

Results of LCA

1. Climate change (greenhouse effect) - Product Carbon Footprint of the ESPRIMO P957

The greenhouse gas (GHG) emissions have been identified as the most relevant indicator for environmental performance. The results of the calculation were used to assign the product carbon footprint over its entire life cycle. The product carbon footprint includes the contribution of GHG emissions to global warming in kg of CO_2 equivalents (CO_2eq).
In a sensitivity analysis of the use phase, the footprint of the system was also assessed for several countries (France, Poland and Norway) because of the different energy mixes, which have a big impact on the carbon footprint of the product. The total amount of carbon emissions comprises mainly the use phase and the raw materials. The greenhouse gas emissions resulting from the use phase are caused exclusively by energy consumption during the use of the product. The replacement of spare parts has almost no influence on the results.
Figure 3 shows the net result in the amount of total 961 kg CO_2 equivalents and is determined by the use phase and the raw materials. Emissions of transport/distribution play a minor role and emissions of assembly contribute less than 1 % to the net result. The effect of disposal/recycling credits is small with a reduction of less than 2 %.

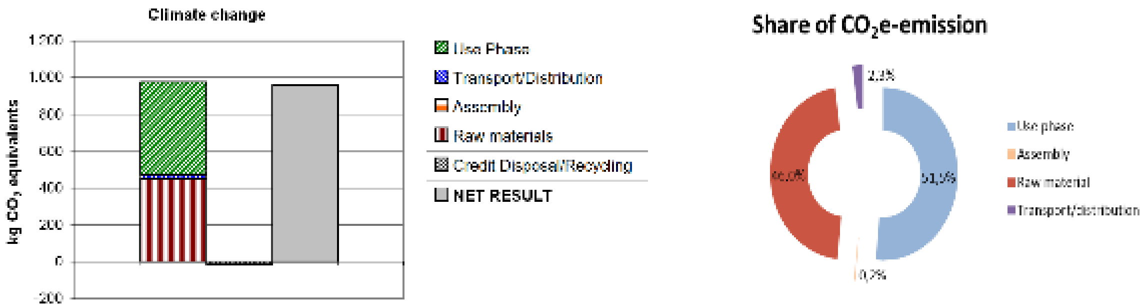


Figure 3a and b: Global warming potential for one unit of ESPRIMO P957/E94+ and share of sections (share without offsetting the "avoided" emission of recycling)

The amounts are:

- Use phase: 503 kg CO_2 equivalents
- Raw materials: 449 kg CO_2 equivalents
- Transport/Distribution: 22 kg CO_2 equivalents
- Assembly: 2 kg CO_2 equivalents
- Credit Disposal/Recycling: -15 kg CO_2 equivalents

The figure 4 shows the share of raw material with the main impact of 512GB SSD M.2 module.

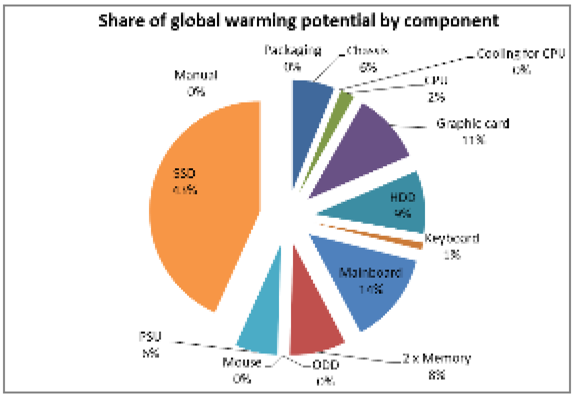


Figure 4: Share of global warming potential by component (raw material); elements displayed 0% are less than 1%

The emissions resulting from the use phase are caused by the energy supply. Replacement of spare parts has almost no influence on the use phase result.
The emissions, mainly carbon dioxide, resulting from raw materials primarily originate from the production of SSD and graphic card as well as from the production of mainboard components. The largest quantities occur from the production of wafer for integrated circuits, the production processes for electronic components and wiring board material as well as from power generation for all production processes.
The mainboard and desktop assembly in Augsburg (Germany) contributes a very low share to the total footprint. This share mainly consists of the energy consumption for the manufacturing plant. Almost all pre-products (excluding mainboards) are produced in Asia, particularly in China. The transport to our assembly in Germany takes place either by ship or by plane.

Only high-value components, such as processors or hard disk drives, are delivered by plane. High volume components like chassis or power supply units are transported by ship. Transport to the customer (by truck) and to the recycling center (by car and truck) with an assumed average value has a lower impact on the result.

Through the reuse of resources in our recycling center in Paderborn, we can reduce the environmental impact of our products. This includes electricity and heat from incineration and secondary raw materials from recycling. These "avoided" impacts are balanced out and credited to the environmental impacts of the respective product.

Results of sensitivity analysis: Use phase with different energy mix

Fuel	German electricity mix (time period 2014)	French electricity mix (time period 2014)	Polish electricity mix (time period 2014)	Norwegian electricity mix (time period 2014)
Lignite	25 %	-	34 %	-
Hard coal	19 %	2 %	48 %	< 0.5 %
Nuclear power	16 %	78 %	3 %	-
Natural gas	10 %	2 %	-	2 %
Wind power	9 %	3 %	5 %	2 %
Photovoltaic	6 %	1 %	-	-
Biogas	5 %	< 0.5 %	1 %	< 0.5 %
Hydropower	4 %	12 %	2 %	96 %
Waste	2 %	1 %	< 0.5 %	< 0.5 %
Biomass	2 %	< 0.5 %	6 %	< 0.5 %
Coal gas	2 %	< 0.5 %	1 %	< 0.5 %
Heavy fuel oil	1 %	< 0.5 %	1 %	< 0.5 %
Peat	< 0.5 %	-	-	-
Geothermal power	< 0.5 %	-	-	-
Solar thermal power	< 0.5 %	-	-	-

Table 2: used energy mix for sensitive analyses (Thinkstep 2017)

The use of the desktop in Germany is applied for the base scenario. For the sensitivity analysis the results were derived from using the desktop in France, Poland and Norway. This means that the German energy mix for energy supply in the use phase has been replaced by the corresponding energy mixes from the other countries. All differences between the electricity mixes are shown in Table 2.
If the ESPRIMO P957 is used in Germany with its big share of coal and lignite for power generation, it causes approximately a total amount of 961 kg CO_2eq over its lifetime of 5 years. The energy mix of Poland with a higher share of lignite and coal results in approximately 1300 kg CO_2eq. On the other hand, the use of the same Microtower in France, which has a large share of nuclear power, causes a carbon footprint of approximately 500 kg CO_2eq. With approximately 480 kg CO_2eq, the usage of the desktop in Norway also has a lower footprint because of its considerable proportion of renewable energy.

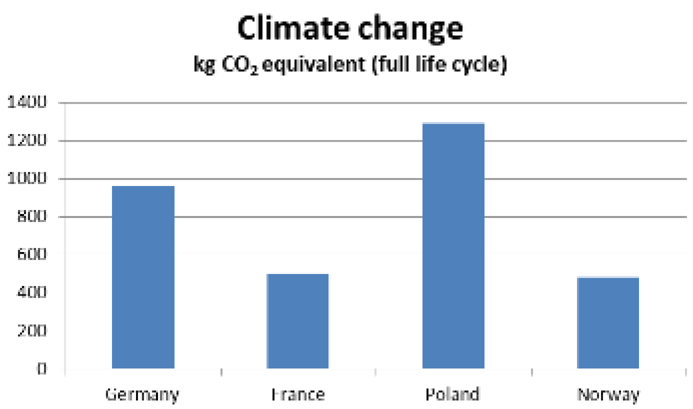


Figure 5: Total Global warming potential for one ESPRIMO P957 for usage in different countries with specific energy mix (sensitive analyses)

These results indicate that the use phase and, therefore, the total amount of the carbon footprint depend highly on the energy supply/energy mix of the power generation in the respective country.

Results of sensitivity analysis: Standard configuration without graphic card

Fujitsu offers the ESPRIMO P957 with a selection of different components. The power consumption measurement for Energy Star certification has to be measured with maximum possible configuration with maximum power consumption. These values are used for the LCA analyses to show the maximum impact.
These Energy Star configurations result in highest power consumptions which are normally not used on the customer side. Therefore, Fujitsu offers more realistic power consumption in addition to its "White paper power consumption". Link:
http://www.fujitsu.com/fts/products/computing/pc/desktops/datasheet-finder/
For the ESPRIMO P957 with a standard configuration (Intel Core i7, 2x4GB, 3.5"HDD, ODD, Windows 10) the power consumption is 37.5kWh/year only.
The reduced power consumption during the use phase results in a reduced environmental burden. The climate change impact decreases from 961 to 529 kg CO_2-eq which is a reduction of 45%. All changes are mainly a result of use phase and partly of raw materials. The reductions of transport/ distribution and end of life are marginal.

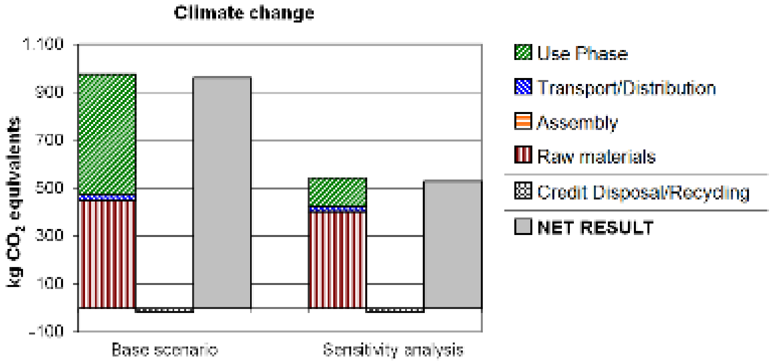


Figure 6: Global warming potential for one ESPRIMO P957 of base scenario and sensitivity analysis (desktop PC without separate graphic card and adapted power consumption in use phase)

2. Other impact categories of LCA

The Greenhouse effect is the most intensely discussed environmental impact category. Nevertheless, Fujitsu is also aware of other environmental effects. The contributions of life cycle phases to emissions of all investigated impact categories are summarized in figure 7

Impact Category (net result in equivalents)	Raw Materials	Assembly	Transport/ Distribution	Use Phase
Climate change (961 kg CO_2 equivalents)	**46 %**	< 1 %	2 %	**52 %**
Acidification (3.8 kg SO_2 equivalents)	**78 %**	< 1 %	3 %	**19 %**
Particulate matter (744 g PM2.5 equivalents)	**94 %**	< 1 %	1 %	5 %
Eutrophication (2.6 kg PO_4 equivalents)	**96 %**	< 1 %	< 1 %	4 %
Photochemical oxidants formation (294 g ethene equivalents)	**81 %**	< 1 %	3 %	**16 %**
Ozone layer depletion (96 mg R11 equivalents)	**96 %**	< 1 %	4 %	< 1 %
Cumulative energy demand (15.7 GJ CED)	**39 %**	1 %	2 %	**58 %**
Depletion of abiotic resources (34.8 g Sb equivalents)	**99 %**	< 1 %	< 1 %	< 1 %
Water consumption (54.5 m^3 H_2O equivalents)	**10 %**	< 1 %	< 1 %	**89 %**

Figure 7: Contributions of life cycle phases to investigated impact categories (environmental burden without credit disposal/recycling)

The overview shows that the net results are determined by the use phase and the raw materials. Furthermore, for eutrophication and for depletion of abiotic resources the environmental burdens are significantly reduced by about 33 % and 56 % as a result of credits from recycling processes. The effect of disposal/recycling credits of the other impact categories is up to 5 %.

2.1 Cumulative primary energy demand in detail

Primary energy demand is often difficult to determine due to the various types of energy sources. Primary energy demand is the quantity of energy directly withdrawn from the hydrosphere, atmosphere or geosphere or energy source without any anthropogenic change. For fossil fuels and uranium, this would be the amount of resource withdrawn expressed in its energy equivalent (i.e. the energy content of the raw material). It is important that the end energy (e.g. 1 kWh of electricity) and the primary energy used are not miscalculated with each other; otherwise the efficiency for production or supply of the end energy will not be accounted for.
The total Primary energy consumption renewable and non-renewable resources are given in GJ.

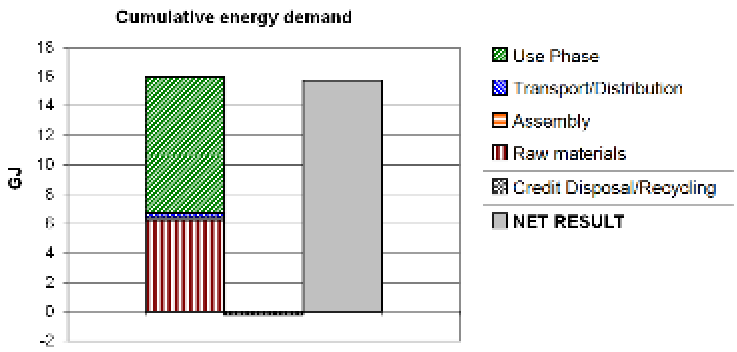


Figure 8: Cumulative energy demand for one desktop

The net result in the amount of total 15.7 GJ CED is mainly determined by the use phase and the raw materials. Emissions of transport/distribution play a minor role and emissions of assembly contribute approximately 1 % to the net result. The effect of disposal/recycling credits is small with a reduction of less than 2 %.

The amounts are:

- Use phase: 9.2 GJ
- Raw materials: 6.3 GJ
- Transport/Distribution: 0.3 GJ
- Assembly: 0.2 GJ
- Credit Disposal/Recycling: - 0.2 GJ

The energy demand resulting from the use phase is caused by the energy supply. Replacement of spare parts has almost no influence on the use phase result. The energy demand resulting from raw materials primarily originates from the production of SSD and graphic cards as well as from the production of mainboard components. Responsible are mainly the use of non-renewable energy resources for electricity consumption and during the production of wafer for integrated circuits.

2.2 Water consumption in detail

In comparison to resource depletion of abiotic resources, water is treated as a separate issue, as it has many unique properties that make the problem of water availability very different (e.g. quality, regional factors). Water resource use weighting is based on the water pressure index published by OECD.

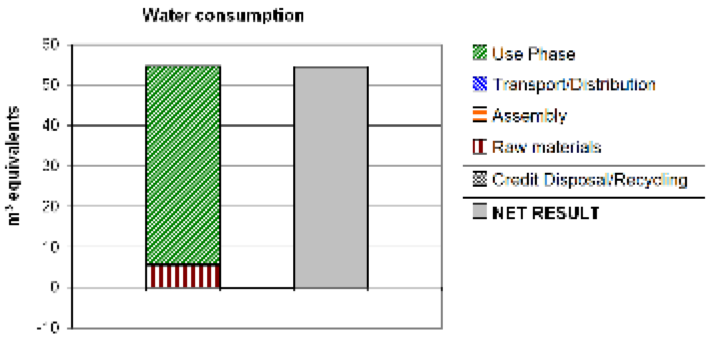


Figure 9: Water consumption for one ESPRIMO P957

The net result in the amount of total **54.5 m³ equivalents** is mainly determined by the use phase and the raw materials.

The amounts are:

- Use phase: 48.9 m³ equivalents
- Raw materials: 5.5 m³ equivalents
- Assembly: 0.2 m³ equivalents
- Transport/Distribution: 0.03 m³ equivalents
- Credit Disposal/Recycling: - 0.1 m³ equivalents

The water consumption resulting from the use phase is caused by the energy supply. Replacement of spare parts has almost no influence on the use phase result.
The water consumption resulting from raw materials primarily originates from the production of SSD and graphic cards as well as from the production of mainboard components. Unspecified water used for energy consumption and the production of wafer are mainly responsible.

3. Measures of Fujitsu

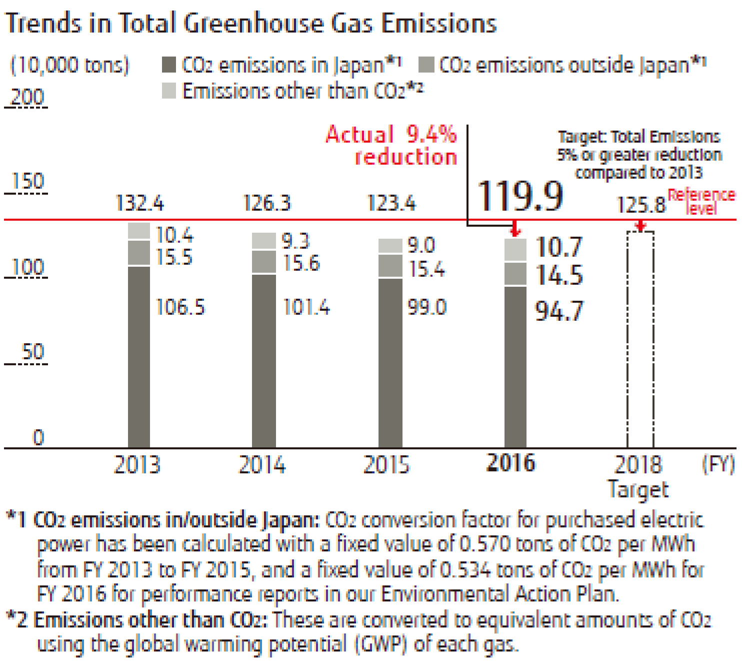
Raw material

Emissions resulting from raw materials primarily originate from the production of SSD (wafer), mainboards (components and printed circuit board), graphic cards, memory, and power supply units. Responsible is mainly the energy supply in upstream processes of these components. Although the influence of Fujitsu is limited, the high environmental impact especially of wafer production will continuously be addressed to the suppliers by quarterly supplier meetings and improvements checked by supplier questionnaires.

Assembly/manufacturing

In fiscal 2016, we were introducing and upgrading BAT* at each business site, streamlining manufacturing, making energy consumption "visible" and utilizing measurement data, etc. GHG emissions in fiscal 2016 totalled approximately 1,199,000 tons (specific consumption/sale: 26.6 tons/100 million yen), down 9.4% since fiscal 2013. Despite increased production in Japan, we implemented measures to reduce approximately 20,000 tons. However, energy intensity worsened by 1.0% year on year. We will optimize specific consumption indicators in addition to conduction energy-saving activities.

*BAT (Best Available Technologies): Usable stat-of-the-art technologies to reduce GHG.



In our Augsburg plant, where the ESPRIMO P957 is produced, we are certified for ISO50001 and constantly track our GHG emission. For 2018, we set a goal to reduce our GHG emission by 81% compared to 2013.

Transport/distribution

In order to reduce the environmental impact associated with transport, Fujitsu is working to reduce its CO_2eq emissions through modal shifts, promoting the effective utilization of railroad and sea transportation and reducing the proportion of air transport.

Additionally, we are promoting reduce, reuse and recycle efforts for packing products and parts in order to reduce the environmental burden of the distribution process.

Use phase

The main area to reduce the Product Carbon Footprint is the use phase; in this section the biggest savings of emissions are possible. In order to reduce the energy consumption of the products, we focus on developing and producing energy efficient products like small desktops, Mini PCs and thin clients. Offering systems with high efficient power supplies more than required by Energy Star certification will help to reduce the power consumption in general. Also, we give our customers recommendations on how to reduce the footprint of their product and thereby take an active part in climate protection.

Recycling

In accordance with the concept of Extended Producer Responsibility (EPR), the Fujitsu Group carries out recycling programs that comply with the waste disposal and recycling laws and regulations of the various countries in which it operates. We also try to carry out as much collection, reuse and recycling as we can in countries where recycling is not obligatory keeping in line with the concept of Individual Producer Responsibility (IPR).
http://ts.fujitsu.com/recycling

4. Lessons learned

The calculation of absolute and comparable values for all the impact categories of a life cycle analysis and especially for product carbon footprint during the entire life cycle of a product is not possible especially for the intention of a product-to-product comparison.
Following items beside fast changes of portfolio in ICT have influence:

- high effort for data collection and analyses of complete supply chain
- different geographies, configurations, services and customers
- multiple databases with different content and consistency

Nevertheless, Fujitsu has attained a good transparency concerning CO2eq -emissions along the entire value chain of the product in order to identify potential for additional reduction of emissions.

Further insights

- Continue activities for further improvement of the energy efficiency of the desktop PC.
- Intensify information for users regarding their possibilities to reduce the energy consumption in use phase.
- Avoid sole focus on energy efficiency of desktop PC (although use phase is a key factor in the greenhouse effect as raw materials are a key factor for several other impact categories).
- Continue communication with suppliers about their possibilities to reduce environmental loads. New technologies with high-integrated components like memory and SDD have big influence on climatic impact.
- Continue and spread intensive recycling activities as recycling provides important positive effects in aquatic eutrophication and toxic and eco-toxic parameters.
- Due to the significant influence of a high proportion of transport by airplane, we keep in mind that it is advantageous for the environment to perform assembly close to the end user.
- In future, with an increasing share of renewable energy, the influence of the use phase on the CO2eq emissions will decrease. From a mid to long-term perspective, the importance of rising non-use life cycle phases means a higher impact especially from raw materials

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