# The Transition from Desktop Computers to Tablets: A Model for Increasing Resource Efficiency?

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**Abstract.** Sales statistics of computing devices show that users are not replacing units one by one, but rather adding additional devices to their hardware portfolios. This chapter describes the outcomes of a first attempt to quantify the ecological implications of changes in the use of ICT hardware for computing services by using LCA and applying three different perspectives ranging from individual devices to global sales of desktop, laptop, and tablet computers. In particular, it addresses the question of which effect actually predominates: the increase in efficiency induced by the emergence of new technologies or the growing energy consumption due to an increased number of devices combined with a higher utilization rate by individual users.

The comparison shows a clear reduction of the environmental impact per hour of active use; and the smaller the device, the smaller the impact due to the active use of the device. However, when the evolution in the use of these kinds of devices is taken into account as well, the picture changes. The calculations show that the higher efficiency of individual devices is fully compensated by the production efforts for all additional devices in use, without any increased use time. If increased use intensity is assumed as well, a clear increase of the overall impact per day can be observed.

**Keywords:** Life Cycle Assessment, LCA, Resource Efficiency, Desktop Computer, Tablet

## 1. Introduction

Sales statistics of computing devices show that users are not replacing units one by one (i.e., they are not replacing one desktop computer with one tablet), but are rather adding additional devices to their hardware portfolios. In the United States of America, for instance, ownership of laptop computers increased from 30% in 2005 to 64% in 2013, while only a slight decrease from 65 to 57% could be observed for desktop computers [1]. But what are the ecological implications of this growing use of ICT devices in our society? Since the 1970s, a very useful framework for examining this type of question has been established – Life Cycle Assessment (LCA). However, in the early stages of ICT development, data for the ICT sector were very scarce, and such studies were not possible. For example, the first version of the database ecoinvent, published in 2004 and one of the most widely used public LCA background databases worldwide [2], included only a single dataset for the electronics sector (i.e., a general dataset for control electronics in industrial processes). Reasonable coverage of the ICT sector was achieved with version 2 of the ecoinvent database in 2007 [3], which contained more than 150 specific datasets for the electronics sector. Using these data, it is now possible to measure the ecological implications of, e.g., the growing use of ICT devices in our society.

The objective of this chapter is to give an initial overview of the ecological consequences of changes in the ICT technology used, i.e., the shift from desktop computers to tablet computers. Hence, taking a global view of sustainability, the question is which effect actually predominates: the increase in efficiency induced by the emergence of new technologies or the growing energy consumption due to the increased number of devices combined with a higher utilization rate of the devices by individual users.

## 2. Methodology

The Life Cycle Assessment (LCA) method was applied to examine the ecological implications of shifts in the hardware used for private computer work. The aim of this LCA study was to evaluate whether ecological savings due to technical developments (a shift from desktop computers to mobile devices such as laptop or tablet computers) are compensated or overcompensated by consumer behavior (e.g., more devices per person and/or longer daily use of such devices), i.e., if the usage patterns of modern ICT equipment result in a rebound effect (more about term rebound e.g. in [4]).

This comparison was made from different perspectives in order to capture the broad diversity in using such devices. The first perspective focused on the devices addressed in this study, using “1 hour of active use” as the functional unit for comparison. In a second perspective, a family household with its evolution in terms of its ICT equipment was examined in more detail, looking at the development of the hourly and daily impacts from this usage. Last but not least, in a third perspective, these data were extrapolated to the total impact (per type of device) in our global society by means of sales statistics, including a projection into the near future (i.e., the year 2016).

The assessment covered a time period ranging from 2004 to 2016 and addressed ICT devices for private computer work that were typically used in the years 2004, 2008, and 2012. For 2004, this is a desktop computer with a 17-inch CRT Screen; for 2008, a desktop computer with a 17-inch LCD screen and a first-generation laptop computer (Laptop I, Table 1); and for 2012, the same desktop computer system together with a newer generation of laptop computer (i.e., Laptop II) as well as a tablet computer. Table 1 summarizes key information for all of these devices – taken from [5-7]. Inventory data of the database ecoinvent – version 3.01 [8] – have been used for modeling these devices. For the use phase, the global average electricity mix (as reported in the market dataset “Electricity, low voltage, RoW (Rest of the World)” of ecoinvent v3.01) – representing average global use of the devices – was applied throughout this study.

On the level of Impact Assessment, one of the most up-to-date methods in this area was applied: the ReCiPe method [9]. ReCiPe is a very convenient way of calculating and presenting the results both on a midpoint and an endpoint level. Its large choice of impact categories allows fulfilling the requirements of the ISO 14,040/44 standards ([10,11]), which demand a "selection of impact categories that reflects a comprehensive set of environmental issues related to the product system being studied, taking into account goal and scope." In the following section, the results for four ReCiPe midpoint indicators (global warming potential (GWP), freshwater eutrophication potential (FEP), freshwater ecotoxicity potential (FETP), and metal resource depletion (MDP)), three endpoint indicators (one for each of the ReCiPe damage categories Ecosystem Diversity (EQ), Human Health (HH), and Resource Availability (Res)), as well as the overall total (based on the default weighting factor between these three damage categories according to [9])) are reported. No individual indicator for grey energy is shown here, as GWP is directly correlated with the consumption of (fossil) energy resources – and thus leads to similar results as a factor for grey energy (see also the analysis of various ICT devices in the chapter on grey energy [12]).

**Table 1**. Key data of examined ICT devices. Life cycle inventory models of each of these devices were established using the database ecoinvent [8].

| | **Desktop plus CRT** | **Desktop plus LCD** | **Laptop I** | **Laptop II** | **Tablet** |
|---|---|---|---|---|---|
| **Screen size** | 17" | 17" | 12" | 14-15.6" | 10" |
| **Total weight [kg]** | 32.3 | 17.5 | 3.5 | 2.8 | 0.66 |
| **Composition** | | | | | |
| **- Housing [kg]** | 15.2 | 8.7 | 1.71 | 0.68 | 0.27 |
| **- Screen [kg]** | 10.9 | 4.0 | 0.33 | 0.56 | 0.15 |
| **- Electronics [kg]** | 3.42 | 2.77 | 0.78 | 0.47 | 0.04 |
| **- Power supply [kg]** | 1.47 | 1.47 | 0.36* | 0.36* | 0.050* |
| **- Battery [kg]** | 0.003 | 0.003 | 0.28 | 0.36 | 0.14 |
| **- Others [kg]** | 1.34 | 0.58 | 0.02 | 0.45 | 0.03 |
| **Energy Consumption** | | | | | |
| **- Active [W]** | 150 | 85 | 19 | 17.9 | 3.16 |
| **- Stand-by [W]** | 45 | 30 | 4.0 | 1.33 | 0.45 |
| **- "Off" [W]** | 5 | 3.5 | 1.5 | 0.32 | 0 |
| **Lifetime [a]** | 6 | 6 | 4 | 4 | 2 |
| **Data source(s)** | [6] | [6];[7] | [6] | [7] | [5] |

* Number represents the weight of the external power adapter/charger

The whole system was modeled with the LCA software SimaPro 8.0.2 and the integrated database ecoinvent v3.01 [8], and the implementation of the impact assessment method ReCiPe into SimaPro by PRé Consultants (version 1.09) was used.

# 3. Results and Discussion

## 3.1 The Single Device Perspective

In a first step, the various devices described in Table 1 were compared to each other, based on the assumption that each device was used for 2 hours/day. The results of this comparison are shown in Figure 1.

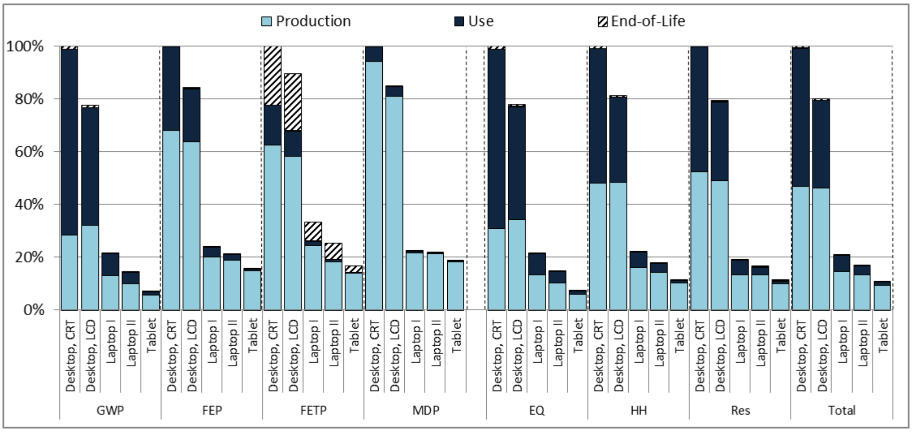


**Fig. 1**. Environmental impacts of 1 hour of use of the computer systems described in Table 1 (relative to the impact of the desktop computer with a CRT Screen, which is set at 100%). The ReCiPe midpoint impact categories global warming potential (GWP), freshwater eutrophication potential (FEP), freshwater ecotoxicity potential (FETP), and metal resource depletion (MDP), and the ReCiPe endpoint damage categories ecosystem diversity (EQ), human health (HH), and resource availability (Res) are shown as well as their weighted total.

At first glance, the resulting pattern for the examined environmental impacts of one hour of use of these devices are rather similar for all ReCiPe mid- and endpoint impact categories examined here. Based on Figure 1, it could be concluded that exchanging the screen used with a desktop computer results in a reduction of about 15 to 20% of the environmental impact; the first laptop computer is on the order of 20 to 30% of the impact compared to the desktop computer with a CRT screen, the second laptop results in an impact on the order of 15 to 20%, and the tablet has an impact that is 5 to 10 times smaller than the one from a desktop equipped with a CRT screen.

A closer look reveals considerable differences, especially on the level of the midpoint indicators. When considering GWP, the use phase is the dominant element for both desktop computers (representing 70 and 60% of the impact), while mobile devices – due to their much lower energy consumption – are dominated by the impact related to production: only 20% of the GWP of a tablet computer arises during the use phase, but 80% during production. The relevance of the use phase decreases more and more for the other midpoint indicators examined and is lowest for MDP, with less than 10% of the impact resulting from the use phase. The only factor for which end-of-life (EoL) treatment is of relevance is the toxicity factor FETP, with a share of 20% of the total impact (for all devices). The three damage categories on the level of the endpoint as well as the overall total show a quite uniform picture, which is rather similar to the GWP midpoint indicator.

### 3.2 The Family Perspective

A second perspective focused on a "model family" with two adults and two children and the evolution of their behavior in terms of ICT equipment consumption. The development of such a family's ICT equipment and the environmental impacts of its active use were modeled for the period from 2004 to 2012 according to the three ICT use scenarios characterized in Table 2.

**Table 2**. Scenarios for ICT use by a family during the period 2004 to 2012

| **2004** | **2008** | **2012** |
|---|---|---|
| 1 Desktop & CRT x 2h | 1 Desktop & LCD x 1h | 1 Desktop & LCD x 0.5h |
| | 2 Laptops (Type I) x 2h | 2 Laptops (Type II) x 2h |
| | | 2 Tablets x 2h |
| *Total use time: 2h/day* | *Total use time: 5h/day* | *Total use time: 8.5h/day* |

Figure 2 shows the resulting environmental impacts per hour of use of the family's ICT mix for each of the indicators in 2004, 2008, and 2012, respectively, while Figure 3 shows the corresponding total daily impacts (taking into account the evolution in the total daily use time of such devices).

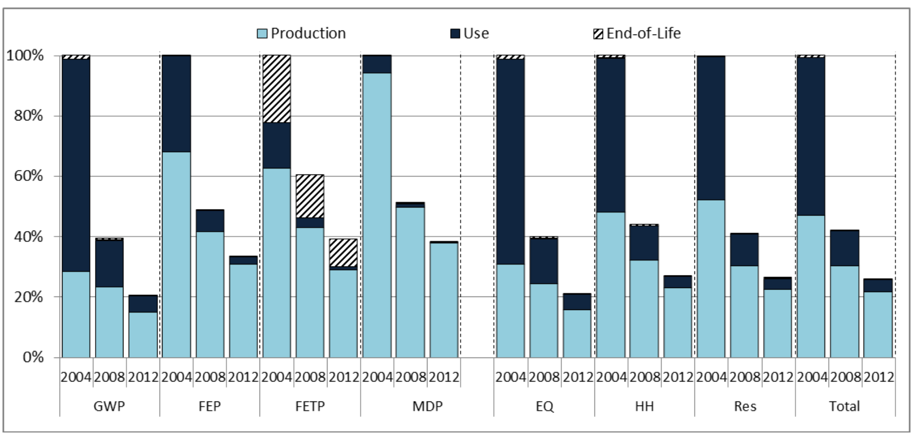


**Fig. 2**. Environmental impacts of 1 hour use of ICT devices (desktop, laptop, and tablet computer, respectively) in a "model family" in 2004, 2008, and 2012 (relative to the impact for 2004, which is set at 100%). The same ReCiPe mid-/endpoint impact categories are shown as in Fig. 1.

With the change from using a desktop computer only (2004) to a combination of a laptop and a desktop computer (2008) and to a tablet, a laptop, and a desktop computer (2012), a clear reduction in the impact per hour of use can be observed. The impact of an hour of ICT use in 2012 is up to 5 times lower than the impact in 2004, and 2 times lower than the impact in 2008 (when considering the GWP and the ReCiPe endpoint indicators). The three midpoint indicators in the figure which are not dominated by the use phase also show a steady reduction of the impact over time; however, the amount of the reduction is less important (with only about 60% reduction for 2012, compared to the year 2004).

Because more devices were assumed to be used by a family in 2012 (five compared to only a single computer in 2004), which is expected to lead to a much longer use time (8.5h/day compared to 2h/day), Figure 3 shows the results for all three scenarios based on use per day.

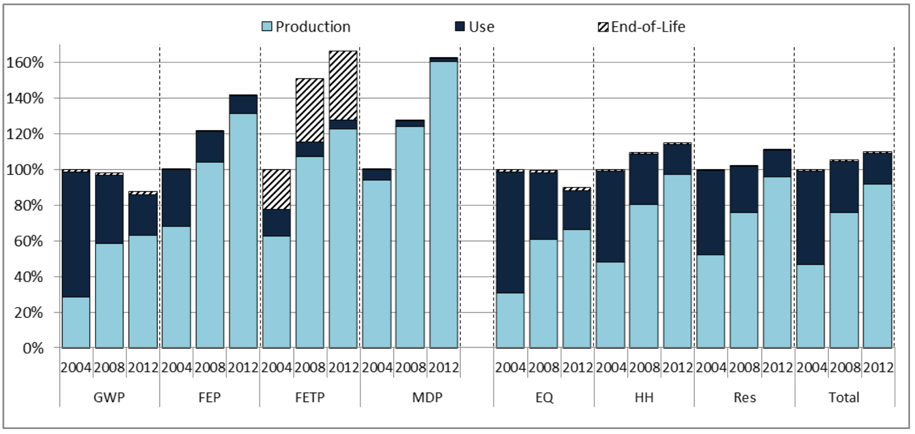


**Fig. 3**. Environmental impacts of one day of use of ICT devices (desktop, laptop, and tablet computer, respectively) in a "model family" in 2004, 2008, and 2012 (again relative to impact for 2004, which is set at 100%). The same ReCiPe mid- and endpoint impact categories are shown as in Fig. 1.

Figure 3 shows a completely different picture than Figure 2. In the case of the impact categories dominated by the use phase in 2004 (GWP, EQ, HH, Res, and Total), the reduction of environmental impacts for the use phase observed in Figure 2 is more or less compensated by an increase in environmental impacts from production due to the use of numerous additional (mobile) devices. For GWP, for example, this leads to a reduction of about 15% for 2012 (compared with the situation in 2004), while the overall total increases by about 10%. When taking into account the midpoint categories already dominated by the production phase in 2004, a clear increase of the impact per day can be observed – ranging from 40% (FEP) to more than 60% (FETP, MDP). When comparing the results for the 2008 and the 2012 scenarios only, a similar development can be found for all examined impact categories: while the GWP shows a reduction, all further midpoint indicators show a net increase.

As the three scenarios for the "family" ICT mix in Table 2 are not based on any kind of statistical information, but are simply assumptions by the authors, we examined the influence of variations of the key figures reported in Table 2 on the overall results in more detail. As a first element, the possible number of mobile devices in use in the model family is varied for the years 2008 and 2012: for 2008, two more scenarios with 1 and 3 laptops are examined, while for the year 2012 all combinations between "1 tablet & 1 laptop" up to "3 tablets & 3 laptops" are included. For each of these devices, a constant daily use time of 2 hours is assumed in order to take into account in a simplified way the fact that more devices usually result in a higher amount of daily use. Figure 4 shows the influence of these variations on the hourly impact for 2008 and 2012. The original values from Figure 2 are indicated by the term "Default" in this figure.

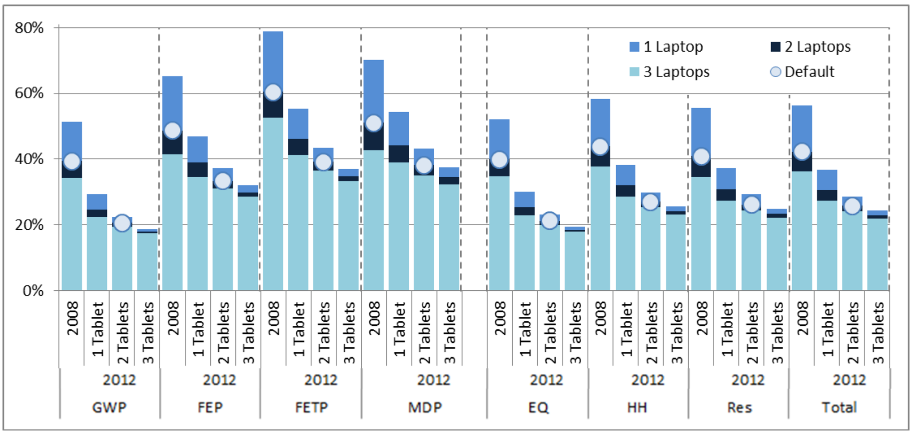


**Fig. 4**. Influence of the number of mobile devices on the environmental impacts of 1 hour of use of ICT devices (desktop, laptop, and tablet computer, respectively) in the "model family" in 2008 and in 2012 (relative to the impact for 2004, which is set at 100%). The original values from Fig. 2 are indicated by the term "Default." The same ReCiPe mid-/endpoint impact categories are shown as in Fig. 1.

As in each of the years examined, the family is also using a desktop computer. The hourly impact of using the family mix in each of the two years (i.e., 2008 or 2012) is lower the more mobile devices are in use (and the more time is spent with such mobile ICT devices). Compared to the default values (i.e., 2 laptops in 2008, 2 laptops and 2 tablets in 2012), the hourly impact would be about 30% (2008) to 40% (2012) higher for all shown impact factors when using a minimum of mobile devices (i.e., only 1 laptop in 2008, and 1 laptop and 1 tablet in 2012), while 3 of these devices would further lower the impact by 12 to 15%.

However, as owning more of these devices also means longer active use of ICT devices during the day (e.g., 12.5 h/d in the case of using 3 laptops and 3 tablets for the 2012 scenario), Figure 5 shows these results on a daily basis as well. For purposes of clarity, this figure contains only the scenario 1 laptop (2008) and 1 laptop and 1 tablet (2012), respectively (designated "low" in the figure), and the scenario 3 laptops

(2008) and 3 laptops and 3 tablets (2012), respectively (called “high” in the figure) in addition to the default values shown in Figure 3 above. Again, the relative changes of the impacts are about the same for all examined impact factors – i.e. +/-20% for the 2008 situation and about +/-25% for the situation in 2012, which in the case of the “low” scenario results in a reduction of the overall impact compared to the situation in 2004.

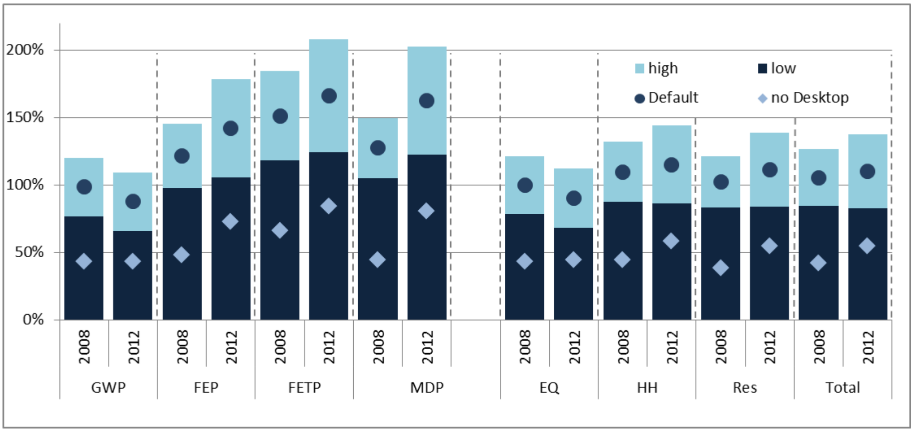


**Fig. 5**. Influence of the number of mobile devices on the environmental impacts of the use of ICT devices (desktop, laptop, and tablet computer, respectively) in a “model family” per day in 2008 and in 2012 (relative to impact for 2004, which is set at 100%). The original values from Fig. 3 are indicated by the term “Default.” The same ReCiPe mid-/ endpoint impact categories are shown as in Fig. 1.

At the same time, Figure 5 shows that an even higher reduction would be possible by eliminating the desktop computer and its half hour of daily use. Such a scenario would result (compared to the default scenario, reported in Table 2) in a reduction of the impact by 60% (in 2008) and 50% (in 2012).

It is interesting to examine this point (i.e. no desktop computer anymore) and its consequences from the opposite perspective as well – i.e. how long mobile devices could be used in order to get a similar impact as with the “family” desktop computer in 2004, assuming an equal split (of time) between all mobile devices. Figure 6 shows the results for the three scenarios from above – i.e., the scenarios default (indicated as 1), low (2), and high (3). For the third scenario, three of the factors examined do not show any result, as the impact due to the production and the end-of-life phase of all mobile devices alone is already higher than the total for the system in 2004. In all other cases, the resulting values (in hours of use per day – per device, as well as for all devices) show results quite similar to the preceding figures for all those factors that are dominated in 2004 by the use phase (i.e., GWP and all endpoint indicators). For all these indicators, the daily time amount can be increased quite considerably by the elimination of a desktop system (only used for a short time) for the scenarios 2008 and 2012, with scenario low (i.e., scenario 2 in the figure) showing the highest daily use time (as the impact due to the infrastructure is the lowest in this scenario) – going up to about 30 to 35 hours/day for the 2012 scenario. For the remaining midpoint indicators, this time amount is even bigger (up to more than 250 hours in 2012 in case of MDP) due to the fact that those indicators are mainly dominated by the infrastructure (i.e., production and/or end-of-life treatment).

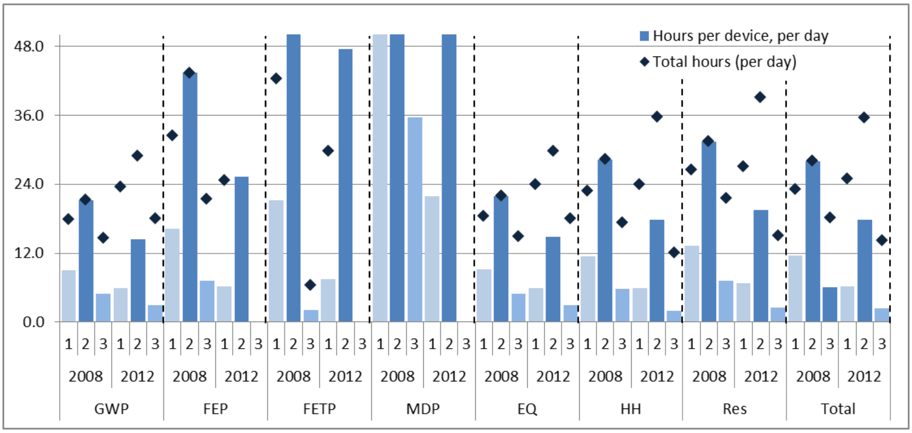


**Fig. 6**. Use time for mobile devices (in hours/day) per device and for all devices (laptop and tablet – assuming equal use of this kind of ICT devices) for three different scenarios (1, 2, and 3) in order to get an overall impact equal to the daily impact in 2004. The same ReCiPe mid-/ endpoint impact categories are shown as in Fig. 1.

### 3.3 The Sales Perspective

Last but not least, the evolution of the amount of ICT equipment sold globally was examined, using the assumption of a daily default use time of 2 hours for each of the devices. Table 4 summarizes the figures for the four years (2004, 2008, 2012, and 2016) studied here, using data from different sources.

**Table 4.** Scenarios for the global sales figures of the computer systems examined here

| | **2004** | **2008** | **2012** | **2016** |
|---|---|---|---|---|
| Desktop computer | 144.6 | 145.6 | 145.6 | 117.9 |
| Laptop computer | 48.2 | 138.1 | 198.0 | 194.7 |
| Tablet computer | - | - | 134.2 | 320.5 |
| *Total* | *192.9* | *283.7* | *477.8* | *633.0* |

Data sources: statistical data from etforecasts, Gartner, IDC & statista [13-16]

In analogy to the second perspective, the first figure (i.e., Figure 7) shows the resulting development of the environmental impact per hour of use of the globally sold hardware mix according to the four scenarios described above.

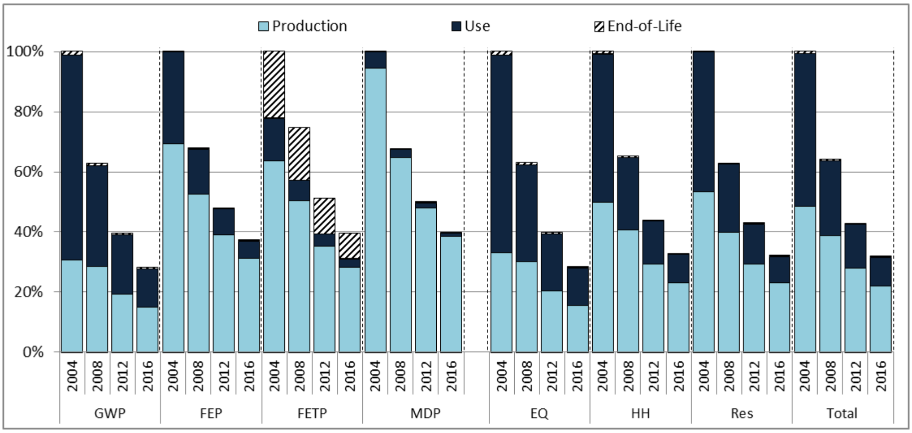


**Fig. 7**. Environmental impacts of 1 hour of use of ICT devices (desktop, laptop, and tablet computer, respectively) for the mix sold in 2004, 2008, and 2012, and the projected mix in 2016 (relative to the impact for 2004, which is set at 100%). The same ReCiPe mid-/endpoint impact categories are shown as in Fig. 1.

As in the second perspective, the mix of ICT devices (i.e., desktop, laptop, and tablet computers) sold shows a constant reduction of its environmental impacts per hour of use from 2004 to 2016. Again, the picture for the various examined impact categories is rather similar at first sight, i.e., all show a reduction from 2004 to 2008 on the order of 30 to 40%, a reduction from 2004 to 2012 on the order of 50 to 60%, and a reduction from 2004 to 2016 on the order of 70%.

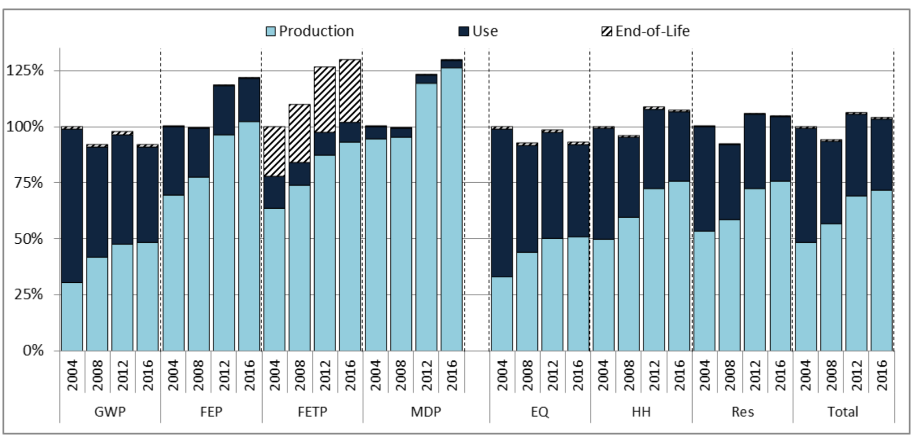


**Fig. 8**. Environmental impacts per day of use of ICT devices (desktop, laptop, and tablet computer, respectively) for the mix sold in 2004, 2008, 2012, and the projected mix in 2016, assuming a constant daily use time (again relative to the impact for 2004, which is set at 100%). The same ReCiPe mid-/endpoint impact categories are shown as in Fig. 1.

Examining the daily instead of the hourly impact by using a daily default use time of 2 hours for each of the devices throughout the entire time period results in the impacts shown in Figure 8. The pattern here is rather similar to the daily impact of the family perspective in Figure 3, i.e., the impact categories dominated by the use phase (GWP, EQ, HH, Res, and Total) show only very small changes throughout the examined time period – changes in the use phase are almost entirely compensated by changes in the production of the various (mobile) devices. When taking into account the remaining midpoint categories dominated by the production phase, the picture leads to a clear increase of the daily impact on the order of 20 to 25% for 2012 and 2016.

Statistical data also show that the use of these devices is growing over time. An average British citizen, for example, spent about 3.6 hours/week on the Internet in 2004, which increased to around 14.1 hours/week in 2010 [17]. These data for the UK show that the average time spent on the Internet has doubled more or less every three years. As a consequence, we recalculated the daily environmental impact of the use of the ICT device mix sold based on the evolution of the use of mobile devices as summarized in Table 5.

**Table 5.** Assumed development of the daily use times along the four scenarios for 2004, 2008, 2012, and 2016,

| Hours/day | 2004 | 2008 | 2012 | 2016 |
|---|---|---|---|---|
| Desktop computer | 0.5 | 0.5 | 0.5 | 0.5 |
| Laptop computer | 0.5 | 1.0 | 2.0 | 4.0 |
| Tablet computer | - | - | 2.0 | 4.0 |

Data sources: authors' estimate based on the reported 3.6 hours/week (= 0.5 hours/day) in [17], assuming that there is an increase of 100% every 4 years for mobile devices only (while the desktop computer stays constant at half an hour per day).

According to Figure 9, which shows the results of this recalculation, there is no more reduction over time; the use of smaller (and thus less energy-consuming) devices is more than overcompensated by the combination of a growing number of devices and increasing usage time. The development of the use time assumed here results in impacts in 2016 that are about 50% higher compared to 2004 for the impact categories dominated by the use phase (GWP, EQ, HH, Res, and Total). The impact of the use phase itself is thereby constantly growing from 2008 to 2016, despite the rising amount of (energy-efficient) mobile devices.

Taking into account the other midpoint categories, which are all dominated by the production phase, the picture is less uniform. While the factor FEP shows a quite similar pattern to the ones listed above, the two remaining factors (FETP and MDP) result in smaller increases through 2016 due to the small influence of the use phase in these two situations. For FETP, the increase through 2016 is still on the order of 40%, caused however by the production and especially also the EoL treatment of all the devices. MDP, largely dominated by the production phase, rises by only about 30% in the period examined here.

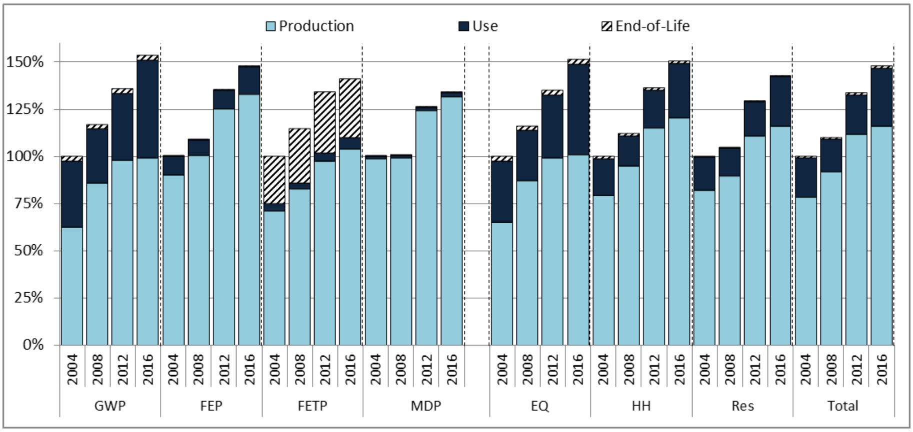


**Fig. 9**. Daily environmental impact of use of ICT devices (desktop, laptop, and tablet computer) for the mix sold in 2004, 2008, and 2012, and the projected mix in 2016, assuming a growing daily use time as summarized in Table 5 (again relative to the impact for 2004, which is set at 100%). The same ReCiPe mid- and endpoint impact categories are shown as in Fig. 1.

However, when considering this figure, one must keep in mind that the development of use time is a rather rough estimate based on a single data source (i.e. [17]). Furthermore, it should be noted that all the figures shown here represent only the impacts due to the use of ICT end-user devices; possible impacts from the infrastructure required, e.g., to download a scientific publication from a server at a university is not taken into account. The latter could have a relevant impact, as shown in the chapter on 'grey energy' of ICT devices (i.e. [12]).

## 4. Conclusion

The comparison of different "generations" of ICT hardware for private computing activities shows a clear reduction of the environmental impact *per hour of active use* over time. In particular, it can be observed that the smaller the device, the smaller the contribution of the impact due to the active use of the device (in comparison to the total impact of the device). Consequently, on the use side a very high increase of efficiency can be observed. When the comparison is based of 1 hour of active use, these general conclusions are also valid for the development of the mix of ICT hardware in the family perspective as well as for the development of the mix of global sales of these kinds of devices.

However, as soon as the evolution in the use of such devices is taken into account as well, which has been accomplished by shifting the functional unit from "1 hour of active use of a single device" to "1 day of use of a mix of ICT devices," the picture changes. In a 4-person-family perspective (that used one computer in 2004 but 5 in 2012), the results show a daily impact that remains more or less constant under the assumed boundary conditions for all those impact indicators dominated by the use phase in 2004 (i.e., GWP, EQ, HH, Res, and Total); the other midpoint categories examined here lead to a clear increase of the daily impact. However, it has to be taken into account that the results and hence the conclusions might be affected considerably by choosing other scenarios.

For example, a change in the daily use intensity of the mobile devices could significantly affect results. In the global sales perspective, when assuming a constant daily use time of 2 hours, the results show that the daily impact of the ICT devices sold stays constant during the time period 2008 to 2016 (again for those impact indicators dominated by the use phase in 2004), i.e., the higher efficiency of individual devices is fully compensated by the production efforts for all additional devices in use. If, in addition, increased use intensity for this time period 2008 to 2016 is assumed, a clear increase of the overall impact per day can be observed. This is a typical example of the rebound effect.

Of particular concern in view of reducing or ideally eliminating this rebound effect are desktop computers (with LCD screens) that are still in use, but used only for very short times. As shown in the sensitivity analysis, their contribution to the impact of the use of the ICT mix is relatively high. One conclusion from these investigations is that the number of ICT devices in use should be kept as small as possible. Specifically concerning the future use of mobile devices, two further aspects need to be considered: (i) longer use of these devices and (ii) their more selective use, allowing for reductions in the daily use time overall.

However, it is rather difficult to provide clear limits that should not be exceeded (in the sense of daily use of such devices, but also in the sense of the overall lifetime of a single device). One of the reasons for this is that this study quantified only the impacts of the user's ICT hardware. Neither were the impacts of the Internet and data centers taken into account (a rough estimation of their impact, compared to various types of ICT devices, is to be found, e.g., in [12]), nor was the sector of smartphones included, with growth rates that are even higher than the ones for the mobile devices covered here. Another reason is the fact that modern (especially modern mobile) devices are used increasingly not only to replace traditional personal computers, but also as an alternative to further devices, e.g., radio or television – leading then to even more complex comparisons and scenarios.

All in all, from the sustainability perspective, the results presented in this chapter clearly indicate that the increasing number of devices combined with their higher utilization rate overcompensates the ecological gains from size reduction in ICT hardware components for the moment.

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