Standard ICT Carbon Footprint Report
GHG emissions created by end user computing devices

Customer Example

Px³

End User Computing Device Carbon Footprint Report

Information and communications technology (ICT) generates 3% of global greenhouse gas (GHG) emissions. Research [1-9] shows that this carbon footprint can be reduced by an average of 30% by adopting responsible consumption strategies within organisations responsible for purchasing ICT equipment at scale.

This study uses scientifically validated world leading calculation tools[10] to determine the current carbon footprint, electricity consumption, utility costs and potential e-waste caused by end user computing (EUC) operations at Customer Example.

It is calculated that Customer Example generates 619,388 $kgCO_2e$ of information and communications technology (ICT) related greenhouse gas (GHG) emissions during the total lifespan of the current end user computing (EUC) environment (Figure 1 and Table 2).

The total ICT carbon footprint of 619.4 thousand $kgCO_2e$ is equivalent to emissions caused by an average car driving of 3.6 million kilometres (km) or 91 times around Earth's equatorial circumference.

The annual GHG emissions of 123,878 $kgCO_2e$ requires 5,631 mature trees to remove the resulting ICT carbon footprint from the Earth's atmosphere via photosynthesis during every year of operation.

81% of the total carbon footprint is generated by computer supply chain GHG emissions (scope 3) including device production, distribution and eventual end of life services such as recycling e-waste. This equates to 502,246 $kgCO_2e$.

The remaining 117,142 $kgCO_2e$ or 19% of the total carbon footprint is caused by computer electricity consumption which generates use-phase GHG emissions (scope 2). Annually, 53,246 kWh of electricity is consumed generating 23,428 $kgCO_2e$ emissions per year. At USD$0.13 per kWh, this costs USD$6,922 annually.

Potential e-waste based upon the current computer asset inventory is 5,099kg. With 3,031 identified EUC devices in operation, the average e-waste value per device is 1.7kg.

Figure 1. Customer Example total EUC carbon footprint, electricity consumption and cost plus e-waste results

| CO2e Lifetime Carbon Footprint (kgCO2e) 619,388 | CO2e Scope 3 Emissions (kgCO2e) 502,246 | CO2e Annual Scope 2 Emissions (kgCO2e) 23,428 | Annual kWh (kWh) 53,246 | Annual Electricity Cost (USD$) USD$6,922 | E-Waste (kg) 5,099 |

A scientific ICT carbon footprint report by sustainable ICT experts Px³.

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Research Lead
Dr Justin Sutton-Parker holds a PhD in computer science in the field of sustainable ICT and a MBA in sustainability. As Chief Scientist for Px³ and a Research Fellow for the University of Warwick, Dr Sutton-Parker's findings advance and influence global ICT manufacturing, procurement and user behaviours designed to reduce the carbon footprint of ICT.

This activity supports the United Nations (UN) SDG 12 'responsible consumption and production' and ultimately SDG 13, 'climate action' via the diffusion of sustainable ICT. Many of the world's largest ICT manufacturers, eco-certification brands and governments use Dr Sutton-Parker's research to scientifically substantiate international sustainable ICT strategies. These include Acer, ASUS, Citrix, Google, IGEL, Microsoft, Qualcomm, TCO Development and the United Kingdom Government among others. Researching and developing the world's first ICT carbon footprint applications platform called Px³ , Dr Sutton-Parker is widely published in scientific journals and nominated for The Earth Shot Prize. A regular public speaker, Dr Sutton-Parker is also sustainable ICT editor for the world's leading ethics and sustainability magazine My Green Pod. Editions include the first dedicated sustainable ICT magazine series for the UN COP sessions.

Methods
All current and potential ICT carbon footprint, electricity consumption, e-waste plus utility costs are generated using the unique Px³ carbon footprint applications platform. Already used by organisations responsible for over 20 million computer users, the platform was researched, developed, tested and peer reviewed during PhD research conducted at the world leading University of Warwick Computer Science Faculty. Consequently, the platform is the only solution of its kind in the world to be validated by science and ensures the data produced is compliant with GHG accounting protocols and sustainable procurement legislation.

In this report, the existing end user computing estate is measured for carbon footprint, e-waste, electricity consumption and utility cost. This is achieved by adding user obfuscated computer asset data (e.g. device type, make, model and quantity into the Px³ Calculate' application. Accessing the Px³ database holding environmental and efficiency records for several thousands of computers dating back to 2009, scope 3 supply chain (production, distribution and end of life services) and scope 2 electricity consumed GHG emissions data is generated together with device annual electricity consumption values. The GHG emissions are reported in kilograms of carbon dioxide equivalent (kgCO$_2$e) as required by international GHG accounting protocol. Electricity is reported in kilowatt hours per year (kWh/y) as per international computer efficiency measurement standards. Scope 2 use-phase emissions are calculated using carbon conversion factors determined by the location in which the device is most regularly used. Commercial electricity costs are based upon the cost per kWh for the selected location. E-waste represents the weight of each and all devices owned by the organisation. This is reported in kg as per international policy and frameworks.

Key takeaway ideas suggesting sustainable ICT strategies are included throughout the report. This may include device lifespan extension or replacement with lowest carbon footprint devices when computers reach the end of their useful lives. These calculations in-depth can be conducted using the Px³ Calculate' applications plus the Px³ Compare, ChromeOS and Circular' web applications. Visit www.px3.org.uk to discover more.

Acknowledgements
Dr Sutton-Parker is a University of Warwick Research Fellow conducting sustainable ICT abatement research projects focusing on advancing global computer life cycle assessment (LCA) eco-certification, calculation accuracy that improve national and international sustainable ICT policies. For more details see www.drjustin.co.uk

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Results

EUC Device Profile

The EUC device profile shows the device categories, types and Px^3 Silent Sole sizing by quantity and the percentage representation within the computing estate. Device types are categorised by international standards. These include static devices such as desktop computers, integrated desktop computers (also known as 'all-in-one' computers), desktop workstations, desktop thin clients, displays and monitors plus mobile devices such as notebooks (also known as laptops), mobile workstations, mobile thin clients and tablets. The Px^3 Silent Sole sizing is based upon a range applied to metrics for each device that influence the total carbon footprint. This simplifies the ability to quickly identify if future action can be taken when selecting replacement devices. As an example, if the majority of devices are classed as XS or S then they are in the lower range of carbon footprint for their device type. While L and XL means they are in the upper range and lower carbon footprint options are available. This is important as over 80% of EUC device carbon footprint is created during production and distribution and therefore selecting low carbon footprint devices will deliver meaningful abatement. Also, whether devices are mobile or static is key. On average a mobile device such as a notebook will generate less than half of the carbon footprint associated with a desktop computer and monitor combination.

Table 1. Customer Example EUC devices owned by type, category and format/size

	Units Owned	% of Total By Type	% of Type by Format / Size				
			XS	S	M	L	XL
Total EUC Devices	**3,031**	**100%**					
Computers	**2,936**	**97%**					
Static Computers	*181*	*6%*					
Desktop Computers	95	3.1%	8.4%	43.2%	38.9%	9.5%	0%
Integrated Desktop AiO	86	2.8%	0%	50%	45.3%	1.2%	3.5%
Desktop Workstations	0	0%	0%	0%	0%	0%	0%
Desktop Thin Clients	0	0%	0%	0%	0%	0%	0%
Mobile Computers	*2,755*	*91%*					
Notebooks	1,936	63.9%	8.8%	55.5%	29.9%	5.7%	0.1%
Mobile Workstations	1	0%	0%	0%	0%	100%	0%
Mobile Thin Clients	0	0%	0%	0%	0%	0%	0%
Tablets	818	27%	29.5%	34.5%	14.5%	21.5%	0%
Other EUC Devices	*95*	*3%*					
Monitors	95	3.1%	0%	98.9%	1.1%	0%	0%
Displays	0	0%	0%	0%	0%	0%	0%
Smartphones	0	0%	0%	0%	0%	0%	0%
EUC Peripherals	0	0%	0%	0%	0%	0%	0%

Note: A comprehensive list of all devices showing quantity, type, brand, model, electricity consumption, associated costs, carbon footprint and e-waste data can be found in the Appendix.

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EUC Device Carbon Footprint

The total carbon footprint represents the total GHG emissions generated by all of the EUC devices during their useful lifespan. The results include scope 2 use-phase emissions generated by device electricity consumption and scope 3 supply chain emissions that account for device production, distribution and end of life services (EOL). As electricity GHG emissions are influenced by how many years a device is kept for, annualised GHG emissions values are included. This is to enable comparison between device types at both a total contribution level and at an annual single unit level. The percentage of devices by type within the estate is included together with the device types percentage contribution to the annual carbon footprint. This highlights that certain device types proportionally contribute higher or lower quantities of GHG emissions.

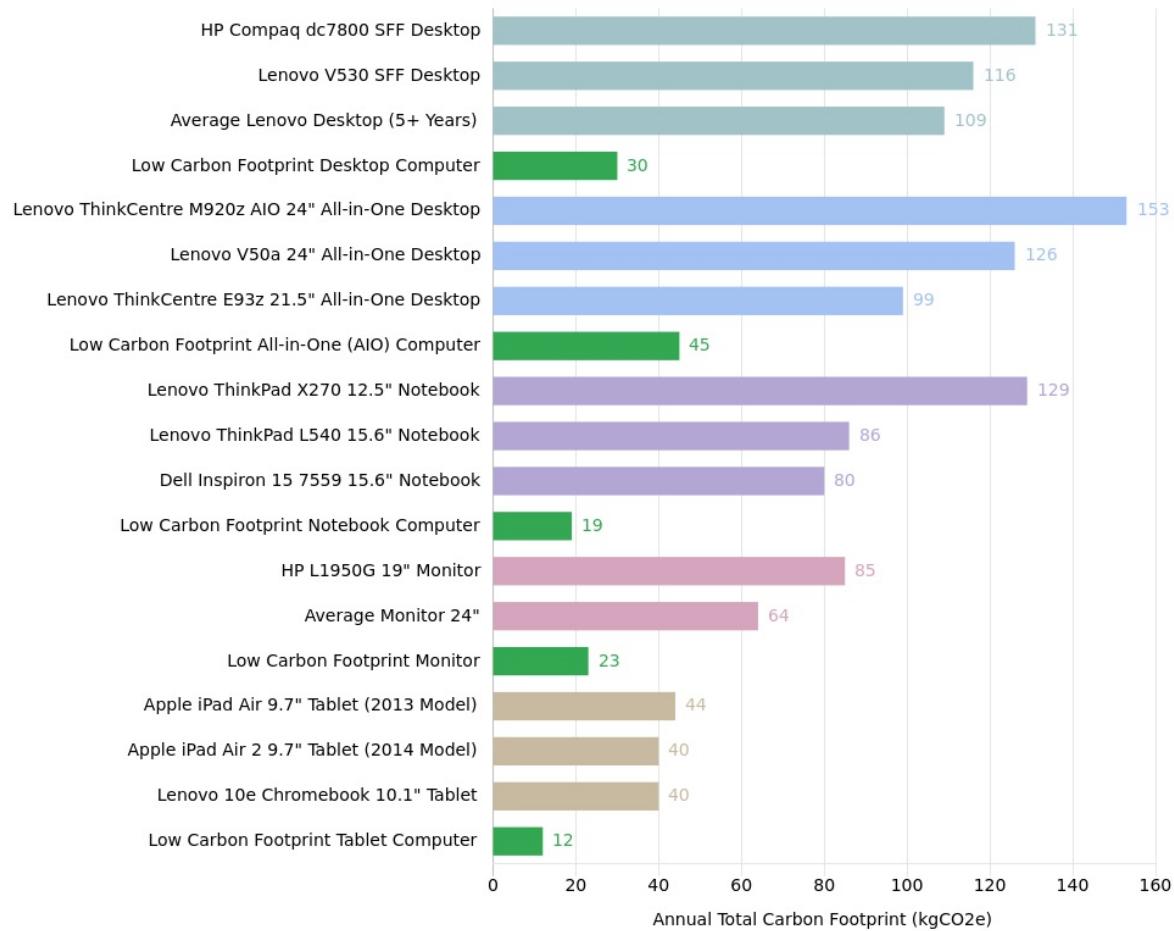Table 2. Customer Example EUC device carbon footprint (kgCO$_2$e) by device type and category

	Units Owned	% of Total By Type	% of Annual Carbon Footprint	Single Unit Annualised Carbon Footprint (kgCO$_2$e)	Annual Scope 2 Emissions (kgCO$_2$e)	Scope 3 Emissions (kgCO$_2$e)	Annualised Carbon Footprint (kgCO$_2$e)	Lifetime Carbon Footprint (kgCO$_2$e)
Total EUC Devices	**3,031**	**100%**	**100%**	**41**	**23,428**	**502,246**	**123,878**	**619,388**
Computers	**2,936**	**97%**	**95.1%**	**40**	**22,597**	**476,045**	**117,807**	**589,029**
Static Computers	***181***	***6%***	***12.0%***	***78***	***3,885***	***51,534***	***14,192***	***70,958***
Desktop Computers	95	3.1%	5.9%	76	1,865	26,978	7,260	36,300
Integrated Desktop AiO	86	2.8%	5.6%	81	2,020	24,556	6,932	34,658
Desktop Workstations	0	0%	0.0%	0	0	0	0	0
Desktop Thin Clients	0	0%	0.0%	0	0	0	0	0
Mobile Computers	***2,755***	***91%***	***88.0%***	***38***	***18,712***	***424,511***	***103,615***	***518,071***
Notebooks	1,936	63.9%	66.8%	43	13,241	347,593	82,760	413,799
Mobile Workstations	1	0%	0.1%	108	100	39	108	538
Mobile Thin Clients	0	0%	0.0%	0	0	0	0	0
Tablets	818	27%	16.7%	25	5,371	76,879	20,747	103,734
Other EUC Devices	***95***	***3%***	***4.9%***	***64***	***832***	***26,202***	***6,072***	***30,359***
Monitors	95	3.1%	4.9%	64	832	26,202	6,072	30,359
Displays	0	0%	0.0%	0	0	0	0	0
Smartphones	0	0%	0.0%	0	0	0	0	0
EUC Peripherals	0	0%	0.0%	0	0	0	0	0

Key takeaway: Using the Px^3 Compare web application, computing devices from all major brands can be compared by carbon footprint and energy efficiency. Doing this before creating a tender or procuring EUC devices ensures that the total EUC device carbon footprint is reduced on average by 30%[1-8] Additionally, doing so complies with sustainable purchasing and use policies and legislation[1-8]. Discover more at www.px3.org.uk

Highest and Lowest Carbon Footprint Devices

Introducing carbon footprint as a selection criterion drives long term IT GHG emissions reduction. The data below shows which top 3 devices in your end user computing environment are producing the highest annual carbon footprint. Conveniently grouped by device type, including desktops, AIO, workstations, notebooks, monitors and displays, means that you can quickly identify which devices may need your attention.

To add context to the results, the graph also shows an example of devices available from manufacturers that have the lowest carbon footprint. Coupled with the Px^3 Compare application, this enables you to realise the impact of procuring low carbon footprint products when selecting new devices.

| Device	Annual Total Carbon Footprint (kgCO2e)
HP Compaq dc7800 SFF Desktop	131
Lenovo V530 SFF Desktop	116
Average Lenovo Desktop (5+ Years)	109
Low Carbon Footprint Desktop Computer	30
Lenovo ThinkCentre M920z AIO 24" All-in-One Desktop	153
Lenovo V50a 24" All-in-One Desktop	126
Lenovo ThinkCentre E93z 21.5" All-in-One Desktop	99
Low Carbon Footprint All-in-One (AIO) Computer	45
Lenovo ThinkPad X270 12.5" Notebook	129
Lenovo ThinkPad L540 15.6" Notebook	86
Dell Inspiron 15 7559 15.6" Notebook	80
Low Carbon Footprint Notebook Computer	19
HP L1950G 19" Monitor	85
Average Monitor 24"	64
Low Carbon Footprint Monitor	23
Apple iPad Air 9.7" Tablet (2013 Model)	44
Apple iPad Air 2 9.7" Tablet (2014 Model)	40
Lenovo 10e Chromebook 10.1" Tablet	40
Low Carbon Footprint Tablet Computer	12

Key takeaway: Use the Px^3 Compare web application to identify low carbon footprint devices by type, model and manufacturer. Including thousands of devices you stack rank and can compare them side by side before downloading a bespoke carbon footprint report. Discover more at www.px3.org.uk

Annual Supply Chain & Electricity EUC Device Carbon Footprint

Scope 2 GHG Emissions: Electricity consumed by computer users generates what are known as use-phase GHG emissions. From a GHG accounting perspective, the values are categorised as 'Scope 2 Electricity Purchased for Consumption GHG emissions' and measured in $kgCO_2e$. The amount of carbon caused by electricity generation and distribution is determined by the percentage of low carbon energy sources adopted in a region, country or state. As an example, electricity carbon intensity in Norway is close to zero, whereas in the United Kingdom (UK) it is moderate and high in the United States (US). This is because Norway has already transitioned to 98% renewable energy, the UK in excess of 40% and just over 20% in the US.

Scope 3 GHG Emissions: Supply chain GHG emissions account for device production, distribution and end of life services (EOL) such as disposal and recycling as part of e-waste recovery. For GHG accounting purposes, the computer supply chain is categorised as 'indirect Scope 3 GHG emissions from capital goods' and often simply referred to as 'scope 3'. From an environmental perspective, keeping devices for longer periods is proven to reduce the total lifespan carbon footprint [1-7, 9]. This is because the simple act delays the production and supply of new devices by slowing demand. The practice is called displacement.

Figure 2. Customer Example annual electricity (scope 2) and supply chain (scope 3) EUC device GHG emission (carbon footprint) measured in $kgCO_2e$ by device type
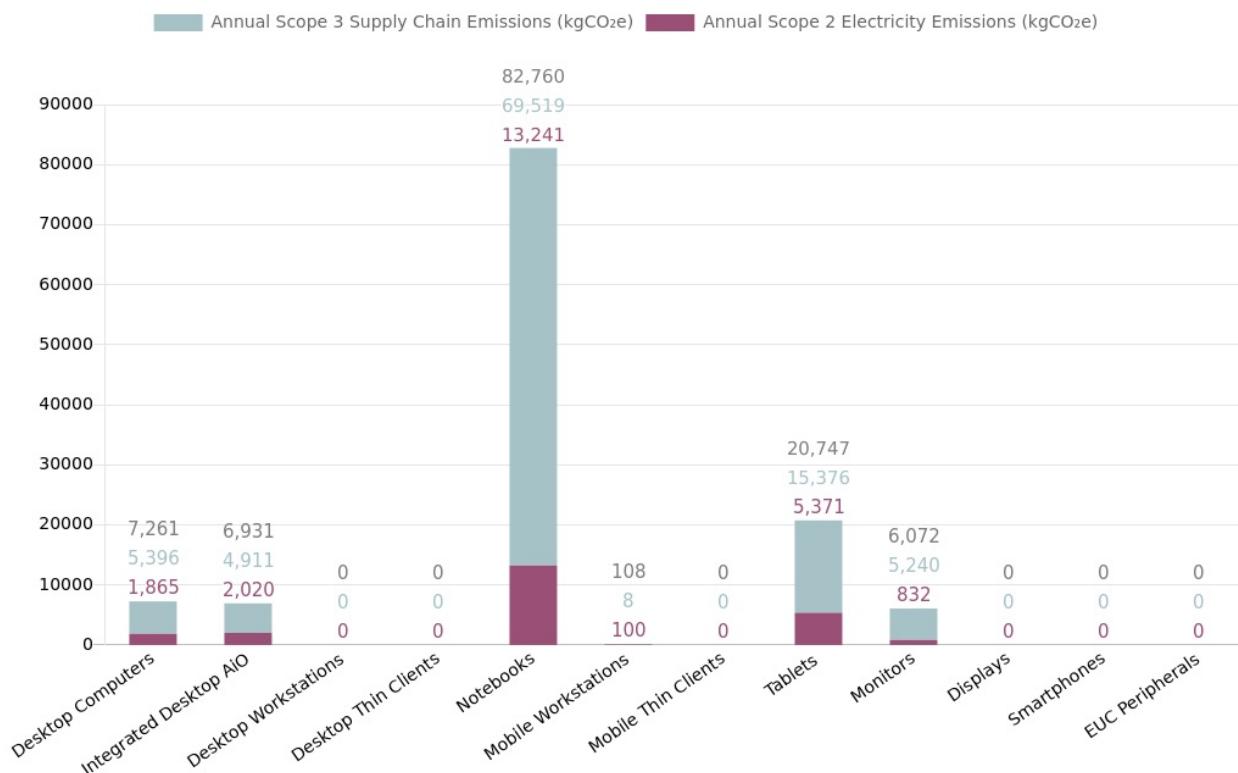
Key takeaway: Devices of the same type (such as notebooks) vary considerably in carbon footprint between models and manufacturers. This is due to materials used, manufacturing practices, distribution networks and energy efficiency. Use the Px³ Compare web application to identify the lowest carbon footprint device within any type. As an example, a simple rule will be to look for small or micro form factor desktop computers rather than tower devices. Also, notebooks with smaller screen sizes tend to have lower carbon footprints. Discover more at www.px3.org.uk
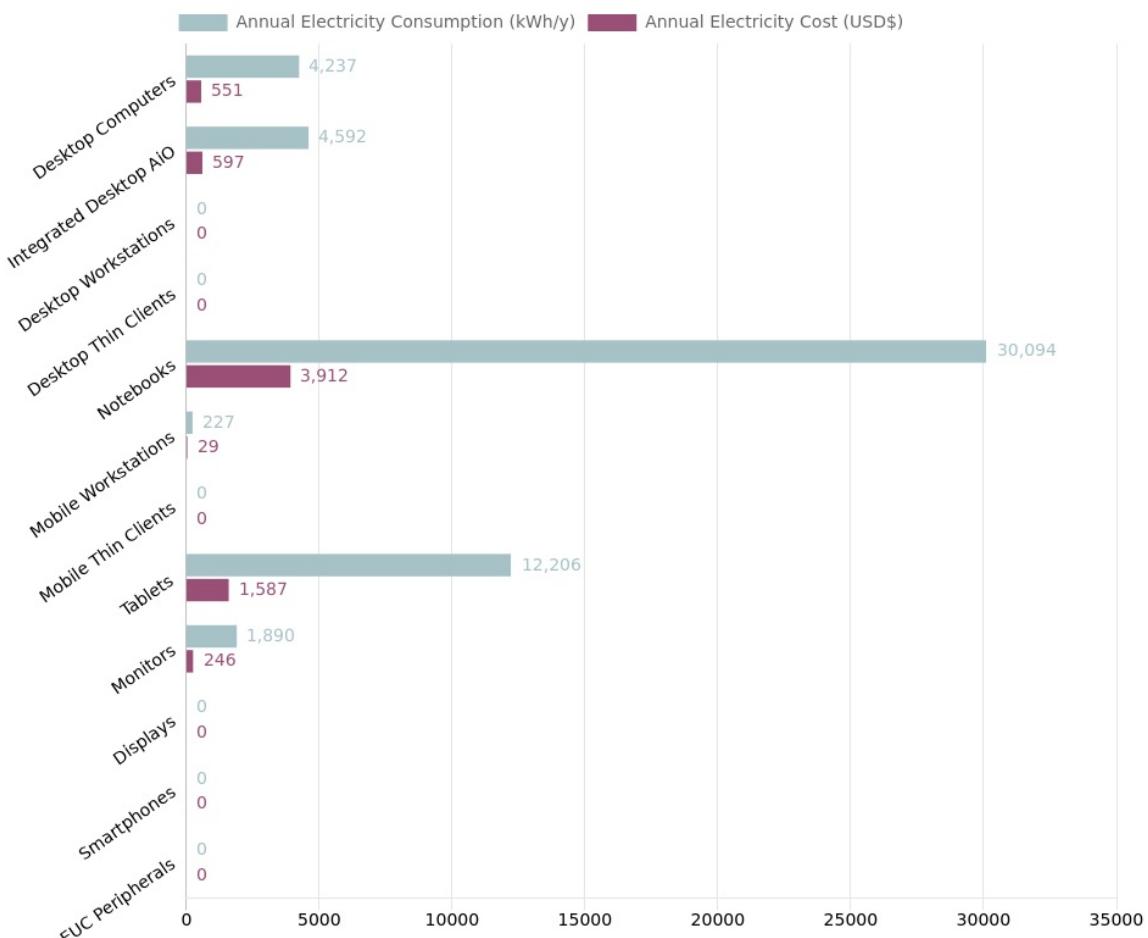
Electricity Consumption and Cost

ICT electricity consumption is the second highest consumer in the workplace behind lighting and heat. In fact, 12% of all commercial electricity is consumed by ICT equipment.

EUC devices vary considerably in energy efficiency between types, models and manufacturers. This is due to components used during production, plus the type of operating system and how it interacts with the hardware and applications.

A simple rule is that mobile devices consume less energy than desktop and monitor combinations. Computer energy efficiency influences electricity consumption and therefore utility costs.

Figure 3. Customer Example annual EUC device electricity consumption (kWh/y) and utility cost by device type

Key takeaway: Use the Px^3 Compare web application to identify energy efficient devices by type, model and manufacturer. Including thousands of new and refurbished EUC devices you can discover low electricity consumption models and compare them side by side. Discover more at www.px3.org.uk
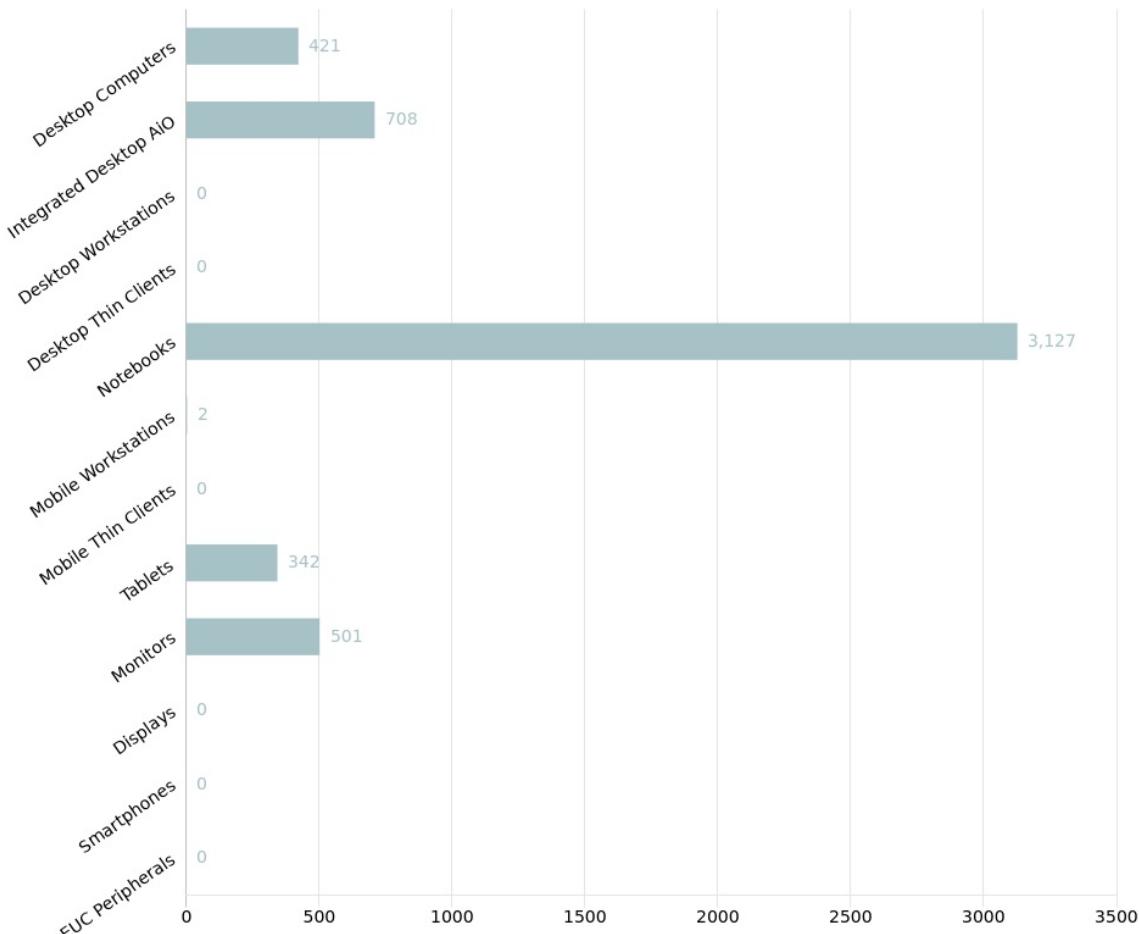
E-Waste Potential

E-waste potential is measured by the weight of computers. This creates context to show the amount of e-waste that is potentially created if existing end user computing devices are not recycled or re-used in a responsible and circular manner.

Reducing e-waste is simple. Selecting smaller and lighter devices and keeping them for longer periods lowers the annual e-waste value for all organisations

Figure 4. Customer Example E-waste (kg) potential by device type

Key takeaway: Devices vary considerably in weight due to size and function. A simple rule is that mobile devices weigh far less than desktop and monitor combinations, therefore creating less potential e-waste per user. Use the Px³ Compare web application to identify lightweight devices. Discover more at www.px3.org.uk

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