Device Use Phase Analysis

End User Computing Scope 2 GHG Emissions

Acer Chromebook 311

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Abstract

End user computing generates over 1% of global greenhouse gas annual emissions caused by the production of over 460m new devices annually and the use-phase activity of 4.2bn users. Approximately one-third of the total carbon footprint of personal computers, such as desktops and notebooks, is generated during the use-phase due to electricity consumption. Consequently, legislation, policies and third-party certifications exist to ensure devices are produced and consumed responsibly in line with the United Nations Sustainable Development Goals. The rationale being that organisations are able to select energy efficient devices using available typical energy consumption data and therefore reduce concomitant scope 2 (electricity) greenhouse gas emissions in the workplace.

However, empirical research identifies that current end user computing use-phase energy consumption methodology does not accurately reflect device electricity use when subjected to human-interaction. This is because the typical energy consumption benchmark data used to determine efficiency focuses on measuring only the low power modes such as off, sleep and idle. As such, the results exclude the active state when power draw is at its highest causing inaccuracies between -60% to +121% and creating a disparity maxim of 181%. The reason for this is that varying operating systems and components require different levels of power draw during active use. The difference is so great, that despite comparable low power mode results, devices using alternative operating systems can exhibit energy consumption reductions of 46% on average.

Consequently, organisations believing they are purchasing computers that will consume the least electricity and produce the fewest emissions can often be unintentionally misled. To overcome such issues, Px^3 conducts Device Use Phase Analysis (DUPA™) testing to generate energy consumption data that includes the active state. The resulting commercial typical energy consumption (CTEC™) value measured in kilowatt hours (kWh) per year enables organisations to achieve three key outcomes. Firstly, to accurately compare prospective devices by real-life energy based sustainability criterion. Secondly, to predict ongoing lifespan utility costs. Thirdly, to quantify anticipated annual scope 2 end user computing greenhouse gas emissions.

In this research, the Acer Chromebook 311 is tested for real-world energy efficiency. The results substantiate that the notebook computer consumes 65% less electricity than than average notebook computers. The results also highlight that the device is capable of reducing mixed end user computing estate emissions by 85%. Additionally, the equivalent utility savings generated by the improved energy efficiency validate that selecting devices based upon valid sustainability criteria supports gains for both planet and profit.

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Introduction

Since the Industrial Revolution, human polluting activity known as anthropogenic interference has already caused 1.0°C of global warming [1]. A further increase to 1.5°C will be reached by 2033 if greenhouse gas (GHG) emissions continue to rise at the current annual growth rate [1]. However, scientists calculate that reaching and sustaining net zero global anthropogenic CO_2 emissions by mid-century, will halt global warming on a multi-decadal scale and temperature gains will begin to peak [1].

To achieve this goal, it is suggested that the world cannot rely solely on emerging key GHG abatement strategies, such as vehicle electrification and renewable energy transition. This is because evidence indicates current adoption rates and subsequent GHG abatement will not be sufficient to bridge the anticipated annual emissions gap forecast for 2030 [2].

To compensate, the United Nations Environmental Programme (UNEP) suggests that existing technology should be examined as an enabler of societal emissions reduction [2].

Generating in excess of 2.5% of all global greenhouse gases, it is reasonable to suggest that information technology (IT) represents a viable source of abatement if sustainability strategies are applied with urgency [3].

As an example, significant supply chain (scope 3) reductions can be achieved by selecting hardware with the lowest manufacturing carbon footprint [3, 4] and retaining equipment for longer periods [3, 5, 6, 7, 8]. Electricity consumption (scope 2) emissions can be avoided by adopting low energy products [3, 5, 8, 9,10] and low carbon computing services [3, 7, 11, 12]. Plus, remote working enabled by IT solutions can reduce scope 3 commuting emissions [3, 6, 7, 9, 13] .

Consequently, end user computing (EUC) as a subset of IT, is a prime candidate to contribute to this sustainability strategy. Setting aside data centre and networking emissions, personal computing generates over 1% of global GHG annual emissions [14]. This is caused by the yearly manufacturing of 460 million devices and the associated energy consumed by 4.2bn active users [3, 4].

Based upon current world emissions, this annual carbon footprint is 556,000,000 tCO_2e. This is equivalent to 1.4bn fossil fuel car miles and requires a 2.8m km^2 forest the size of Argentina to sequester the pollution [3].

Compliance as a Sustainability Driver

The concept of EUC procurement and use contributing to GHG abatement is internationally recognised [3, 4].

Linked with the United Nations Sustainable Development Goal (UN SDG) number 12, 'responsible consumption and production', legislation [4], standards [4], certifications [4], protocols and policies [4] exist to ensure environmental impact is reduced and monitored at each stage of the device lifespan.

As an example, EUC manufacturers are subject to eco-product design directives[4] and certification [4] to ensure raw materials are sourced responsibly, products are manufactured in safe environments and to strict standards and include energy efficiency as a key criterion. Before products are ready for sale, standards and protocols act as a framework for life cycle assessment (LCA) activities [4] that result in customer facing carbon footprint reports. At the point of assessment and selection, organisations utilise this data and third-party certification labelling to ensure the prior expectations have been achieved.

This latter activity is becoming more prevalent in order to respond to national and regional requirements relating to IT procurement and use [3, 4, 16]. From a UK national perspective, the public sector is subject to a combination of government strategies, associated laws and policies that, beyond a desire to tackle climate change, drive the necessity to adopt sustainable IT from a compliance and cost perspective.

At the highest level, the Climate Change Act [17] includes an amendment to the Companies Act [18], ensuring that organisations operating in the UK are subject to mandatory GHG emissions reporting. Specifically, from April 2019, all organisations listed on the London stock exchange, all large unquoted companies and large limited liability partnerships (LLPs), government departments, non-ministerial departments, agencies and non-departmental public bodies must adhere to the legislation. This includes reporting electricity purchased for consumption and concomitant scope 2 GHG emissions.

These organisations, known as the ‘service sector’, represent over 50% of the total national workforce with 10.74m working in large companies and 5.4m in public organisations [3, 19]. The sector is so significant that it consumes 32% of all UK electricity [19].

To ensure organisations not only report emissions but also focus on efficiency, the Climate Change Levy (CCL) exists [20]. In simple terms, this is an environmental tax charged on energy consumed by organisations. As such, reducing utility consumption avoids emissions and improves profitability due to lower operational costs and associated taxation.

11% of commercial electricity consumption is attributed to the use of IT solutions [19]. Consequently, information technology (IT) is the UK service sector's third largest consumer of electricity behind lighting (14.5%) and cooling (13.4%) [3].

Beyond cost as a driver, to directly address this growing GHG emissions source, the UK government's 'Greening ICT' policy [21] also exists. As contributing research [22] and resulting strategy documents highlight [23], public sector organisations must quantify and report EUC scope 2 emissions plus adopt environmentally conscious procurement practices.

To achieve the former, public sector organisations calculate annual device electricity consumption (kWh) and multiply this by GHG conversion factors that reflect the carbon intensity of the national grid. To achieve the latter, IT and procurement teams adhere to what are described as 'hard targets' [21]. These include all future IT purchases to be accompanied by a scientific target capable of supporting the Government plan for net zero by 2050 [21]. In response, this could be as simple as selecting EUC devices proven to be energy efficient when operated in the workplace. The rationale being that the concomitant scope 2 GHG emissions would therefore be reduced during the useful lifespan of the product.

Science Based Targets

However, despite public sector stakeholders expressing a want to realise climate action via responsible IT consumption, organisations face barriers to adopting meaningful sustainable IT strategies [16]. As an example, the Department for Education has a vision to become 'the world-leading education sector in sustainability and climate change by 2030'. However, almost one half of surveyed universities and multi-academy trusts do not yet have strategies that include emissions reduction targets [24].

The problem is caused by data used to form potential strategies being complex to compile and limited in relevance. Of those that do attempt to create science based targets, currently, 39% convert the publicly available energy efficiency benchmark data to GHG emissions [16, 25] and a further 35% rely upon the manufacturer published GHG use phase emissions values [16, 25]. In both cases, research identifies that the resulting GHG emissions values are underestimated by 30% and cause substantiated abatement opportunities in excess of 55% to be overlooked [10].

The existing benchmark data error is caused by the exclusion of the active-state power draw measurement. As this same value is used to populate manufacturer carbon footprint reports, it is proven that the error is passed forward [4, 10]. Additionally, the reports vary in the number of years of use included in calculations and utilise electricity to GHG conversion factors applicable to single sales regions.

Consequently, a UK public sector organisation that retains devices for 5-years, will be relying on comparing product carbon footprint reports that exclude the impact of actual human-computer interaction (use) [10], include anywhere between 1 and 6-years of electricity use (depending on brand) [4] and will reflect scope 2 carbon intensity based upon values for Europe, the USA or a worldwide average [4].

This lack of specific validity causes organisations to incorrectly perceive sustainable IT strategies in two ways. Firstly, as costly to implement due to time spent on complexity [16]. Secondly, as limited in impact due to a lack of substantiated and relevant data proving otherwise [16]. Such barriers cause inertia within an organisation as stakeholders struggle to form science based targets that realise and justify that sustainable IT reduces both utility and procurement costs whilst driving climate action [16].

When overcome, the rewards from both a planet and profit perspective are substantial and the perception of complexity and impotence proven to be unfounded [3, 5, 6, 9]. Recent scientific case studies identify that implementing practices, such as selecting devices based upon sustainability criteria, displacing procurement cycles with extended device lifespan and remote working enabled by IT, support all aspects of corporate and social responsibility (CSR) and environmental, social and governance (ESG) strategies [3, 5, 6, 9].

As an example, by adopting such practices, a greater London council has reduced IT related GHG emissions by 4.5m kgCO_2e and now saves over £200,000 per year in operational and capital expenditure [9].

To achieve this, organisations are increasingly ensuring the data they use to form science based IT abatement targets are relevant to their specific IT retention and use policies. To overcome the lack of parity between computer carbon footprint reports, organisations are using unique online tools such as the Px^3 Dynamic Carbon Footprint tool [4]. The application is used by IT and procurement teams for selecting EUC devices based upon comparable carbon footprint data. This is achieved by the application recalculating the scope 2 contribution of each device based upon inputs from the user. These include the number of years the device will be used for and the location of use, whether that be at a national, regional or international level.

Additionally, organisations are ensuring that products assessed for purchase have energy data available that represents an accurate quantification of anticipated electricity consumption in the workplace or institute [3, 5, 6, 9, 26-28] . Doing so enables public sector and commercial businesses to select devices that will reduce utility costs and lower scope 2 emissions. While the necessity to safeguard profit through electricity efficiency is increasing due to supply cost escalation, the environmentally focused assessment supports both climate action and compliance.

In relation to the latter, GHG accounting protocol for scope 2 (electricity purchased for consumption) emissions requires quantities of carbon dioxide equivalents (CO_2e) to be calculated as 'neither over nor under actual emissions' [29]. As such, without contextual data that defines actual use-phase emissions, accuracy and therefore compliance cannot be assured when forming annual reports [3].

At scale, the impact of including relevant sustainability data as a foundation for IT sustainability strategies is significant. As an example, in relation to scope to emissions, research indicates that energy consumption can be reduced by an average of 46% if suitable low energy computers are selected [10]. Consequently, almost half of all scope 2 (electricity consumed) GHG emissions could be avoided if such practices were diffused within large markets and sectors.

While the public sector is sizable as noted, specific areas with high numbers of computers in active and constant use are key to success if the UN technology bridging strategy is to be realised.

The education sector represents such an opportunity being twice the size of the entire UK public sector. Specifically, statistics indicate that in the UK there are over 10.9m pupils, teachers and associated staff [30]. Data also suggests that there are in the region of over 4m computers in operation within educational institutes [30]. As such, it is reasonable to suggest that unlike business environments where devices are supplied on a ratio closer to one unit per employee [3], the education system has almost three people for every available computer.

Consequently, it is logical that computers in educational institutes will be subject to intensive active-state periods due to significant device sharing causing increased use. As such, to select devices based on energy performance criteria that excludes actual human-computer interaction can be considered counterintuitive.

To explore this oversight, the Acer Chromebook 311 notebook is measured for electricity consumption during the active-state with the results applied to several academic based scenarios.

The objective being to generate data that highlights the GHG abatement and utility cost savings available by identifying EUC devices that are proven to deliver extreme energy efficiency during the use-phase.

The Acer Chromebook 311 is specifically selected for two reasons. Firstly, it is speculated that the device will require a low power draw during the active-state due to the inclusion of an operating system and components previously identified to cause electricity consumption reduction [8, 10]. Secondly, because the Acer Chromebook 311's certified-durable design [31] makes it a suitable choice for learners of all ages and therefore appropriate for the education sector.

As such, the following sections discuss the methodology used to conduct the research plus the results, discussion and summary findings.

Methodology

The research is conducted in four key stages. Firstly, the device is subjected to electricity consumption measurement using the Px[3] DUPA™ test practice [3, 32]. Secondly, using the Px[3] CTEC™ methodology [3, 32] a commercial typical energy consumption value for 1-year (kWh/y) is calculated. Thirdly, scope 2 emissions are calculated and compared to a standard education EUC environment [3, 7, 24] to highlight abatement achieved by adopting the device. Finally, utility cost savings compared to average device consumption costs to highlight operational expenditure reductions delivered by the notebook.

The device measured for energy metrics is an Acer Chromebook 311, exhibiting an 11.6" screen, MediaTek MT8183 CPU, 4GB LPDDR4 memory, 32GB eMMC storage and installed with the Google Chrome OS operating system. Test set-up and conduct procedures adhere to the DUPA™ methodology with active power draw measurements defined in watts (W). Specifically, the measurement process accurately captures power draw (watts) for EUC devices during active use. Two sets of data are produced during the comprehensive analysis, proven to be accurate within +/- 0.1%. The first data set being power demand when conducting common user interactions such as productivity tasks (e.g. email and application access), content streaming and video conferencing. The second data set includes real world user scenarios such as energy consumption during a working day that reflect accurately how a device performs when used in a business environment.

The power draw results are applied to the CTEC™ equation that accounts for off, sleep, short and long idle and active state power and mode weightings as defined by the methodology. The calculation produces the electricity consumption value that is to be expected during commercial use and expressed in kWh/y.

The electricity to GHG emissions factor used in calculations is defined as the factor published by the UK government for 2022 [33]. All values are represented in kgCO2e units as per international GHG accounting protocol. The average electricity consumption values for comparison devices are defined by prior primary research using the DUPA™ and CTEC™ approach to enable parity. The average install base EUC profile is derived from associated computer asset profile research within the education sector [3, 24]. The cost of electricity is based upon published current costs per kWh and extrapolated where relevant to 5-years of use. Tangible equivalents are included to ensure comprehension of the GHG unit values is achieved through analogous values. These include step counts [34], forest acres required to sequester resulting carbon emissions and car miles representative of volume of pollution [3].

All tests are conducted under scientific conditions and results delivered pragmatically and without bias.

Results

The results section examines the findings of the electricity consumption measurement experiment before determining possible influences upon the environment (planet) and financial (profit) benefits delivered by adoption of the device.

Acer Chromebook 311 energy performance

As noted in the methodology, the device measured for energy metrics is an Acer Chromebook 311, exhibiting an 11.6" screen, MediaTek MT8183 CPU, 4GB LPDDR4 memory, 32GB eMMC storage and installed with the Google Chrome OS operating system.

Measured for energy metrics using the DUPA™ methodology, the Acer notebook computer active state average power draw is 4.1W and 0.0041 kW when subjected to human-computer interaction. This represents a 58% increase in power draw when compared to the short idle mode measurement of 2.6W.

The increase from the short idle mode to active state is anticipated and congruent with associated research [8, 10] determining that all computers will experience raised power draw during human-computer interaction due to additional processing not experienced during the low power modes such as off, sleep and idle.

Extrapolated to one year using the CTEC™ methodology, it is determined that the device consumes 7.61 kWh/y in a working environment. For contextual purposes the device consumes the equivalent energy required to take 564 steps during each working day.

As such, when compared to the average notebook computer energy consumption values of 22.35 kWh/y, the device is determined to be highly energy efficient.

Specifically, electricity use is 65% lower than the average for measured devices in the notebook category.

As defined by prior associated research [8, 10], the extreme energy efficiency exhibited by the device is attributed to the Chrome OS operating system being combined with low energy components.

PLANET: Scope 2 GHG Emissions Impact

The following section examines scope 2 (electricity consumed) GHG emissions generated by an average academic environment consisting of 1,680 devices in two scenarios. The first being based upon an average existing install base formed of 60% mobile computers and 40% desktop based computers. The second being the same environment having transitioned to the Acer Chromebook 311 for the entire EUC estate.

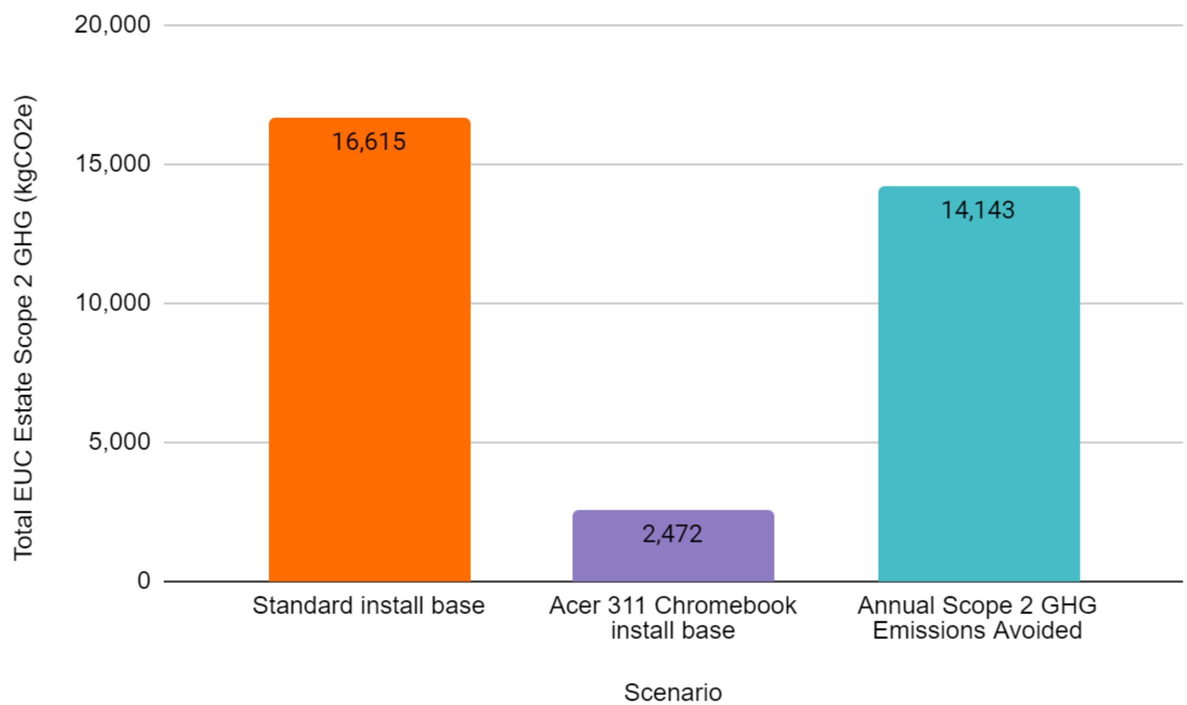
As indicated in figure 1, the standard install base generates 16,615 $kgCO_2e$ scope 2 GHG emissions per year. The total is dominated by the desktop use-phase emissions created by the necessity of both the computer and a peripheral monitor. Specifically, although desktop computers represent 40% of the EUC estate, the contribution to the annual carbon footprint is 74%. In this example, the average per device annual emissions value is 9.9 $kgCO_2e$.

Transitioning to the highly energy efficient Acer Chromebook 311 generates 2,472 $kgCO_2e$ per year causing the per device value to be 1.5 $kgCO_2e$.

As such, it is reasonable to indicate that transitioning from the average sized mixed desktop computer and mobile computing environment to the Acer 311 Chromebook reduces annual scope 2 emissions by 85%.

The total abated GHG emissions are 14,143 $kgCO_2e$. This is equivalent to avoiding pollution generated by 51,500 car miles. Such emissions would otherwise require the sequestration capacity of 17 forest acres to remove the resulting carbon from the atmosphere via photosynthesis.

Figure 1. Annual Scope 2 (electricity consumed) GHG emissions comparison

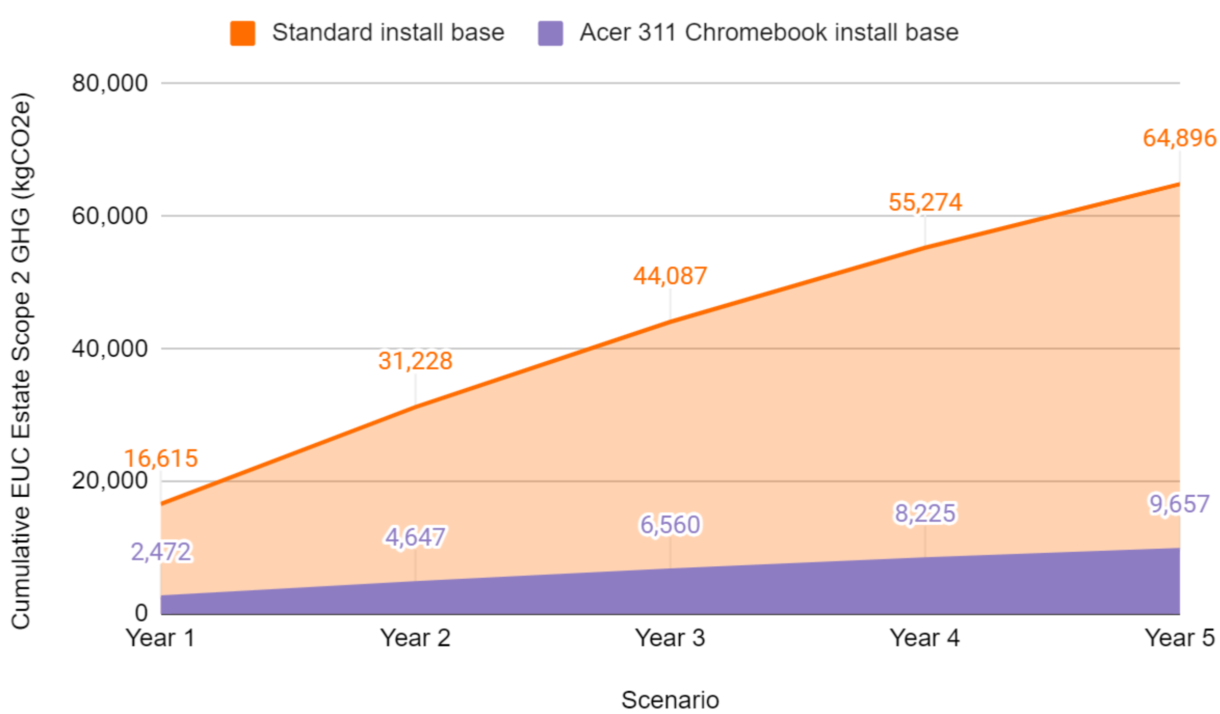


Applying an average useful device lifespan of 5 years [4], the impact of cumulative GHG abatement becomes increasingly significant. Figure 2 includes an annually reducing electricity to GHG emissions factor incorporated to consider government predictions for growing renewable energy diffusion and therefore reducing carbon intensity in the national grid. During the device total use period, scope 2 emissions for the standard install base amount to 64,896 $kgCO_2e$.

Comparatively, the Acer Chromebook 311 EUC estate cumulatively generates just 15% of this value at 9,657 $kgCO_2e$.

This is equivalent to abating 55,239 $kgCO_2e$ of scope 2 emissions during a 5-year period. This is equivalent to avoiding pollution generated by 201,125 car miles.

Figure 2. 5-year Scope 2 (electricity consumed) GHG emissions comparison



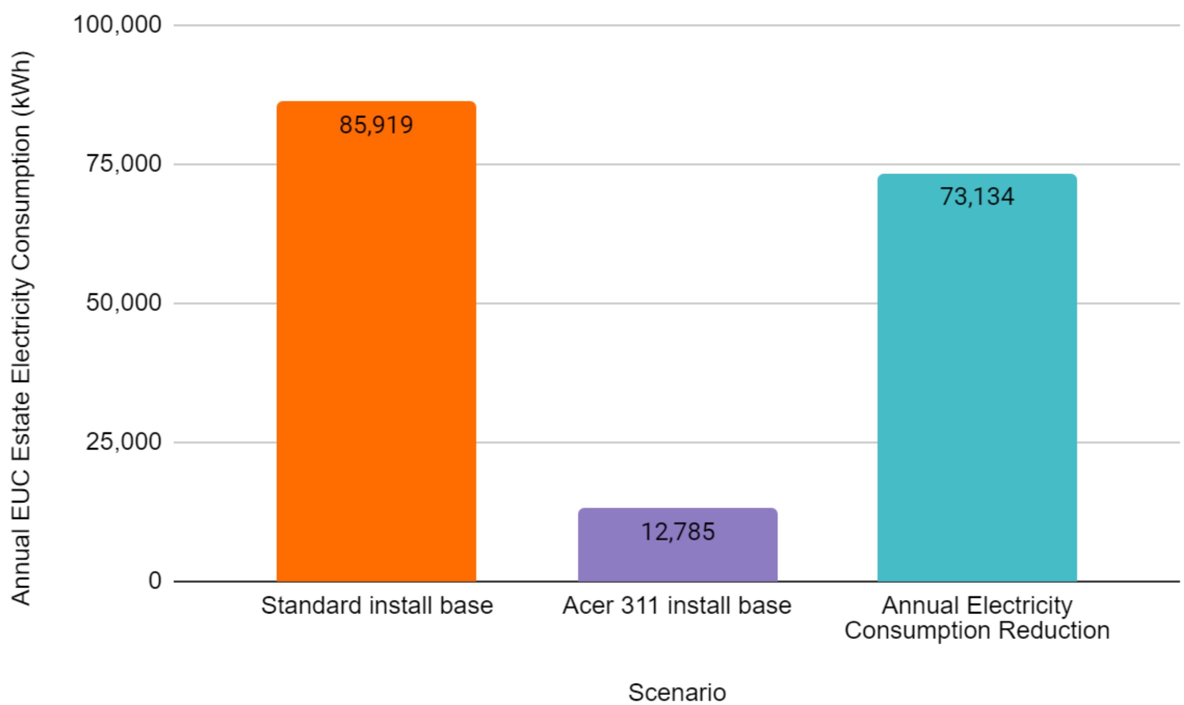
Consequently, it is reasonable to conclude that for every EUC device, 33 $kgCO_2e$ or the equivalent pollution created by 120 fossil fuel car miles can be avoided by transitioning to highly energy efficient notebooks such as the Acer Chromebook 311.

PROFIT: Utility Costs Impact

Logically, improved device energy efficiency reduces electricity consumption and therefore utility costs. As indicated in figure 3, the standard install base consumes 85,919 kWh per year. As before, the desktop and monitor combination is responsible for 74% of the total consumption. This is due to both desktop computers and monitors being less energy efficient than notebook and other types of mobile computing devices. As such, the per device consumption value is 51 kWh/y.

Comparatively, the electricity consumption for the Acer 311 Chromebook estate reflects the 85% reduction experienced previously. Specifically, the total reduces by 73,134 kWh per year to 12,785 kWh/y. Consequently, the per device consumption value declines to 7.6 kWh/y.

Figure 3. Annual electricity consumption (kWh/y) comparison



Extrapolated to represent a standard 5-year retention period the standard install base cumulatively consumes 429,595 kWh/y and the Acer 311 Chromebook estate consumes 63,925. This causes the total electricity consumption value to decline to 15% of the original total having avoided 365,670 kWh/y of utility consumption.

From a cost perspective, figure 4 highlights that annual electricity costs associated with the standard install base EUC estate are £29,212. This equates to £17.40 per year budgeted for single device utility expenses. In comparison, the 85% reduction in consumption experienced by the Acer 31 Chromebook estate causes the annual utility cost to decline to £4,347 or £2.60 per device.

Figure 4. Annual electricity cost (£GBP) comparison

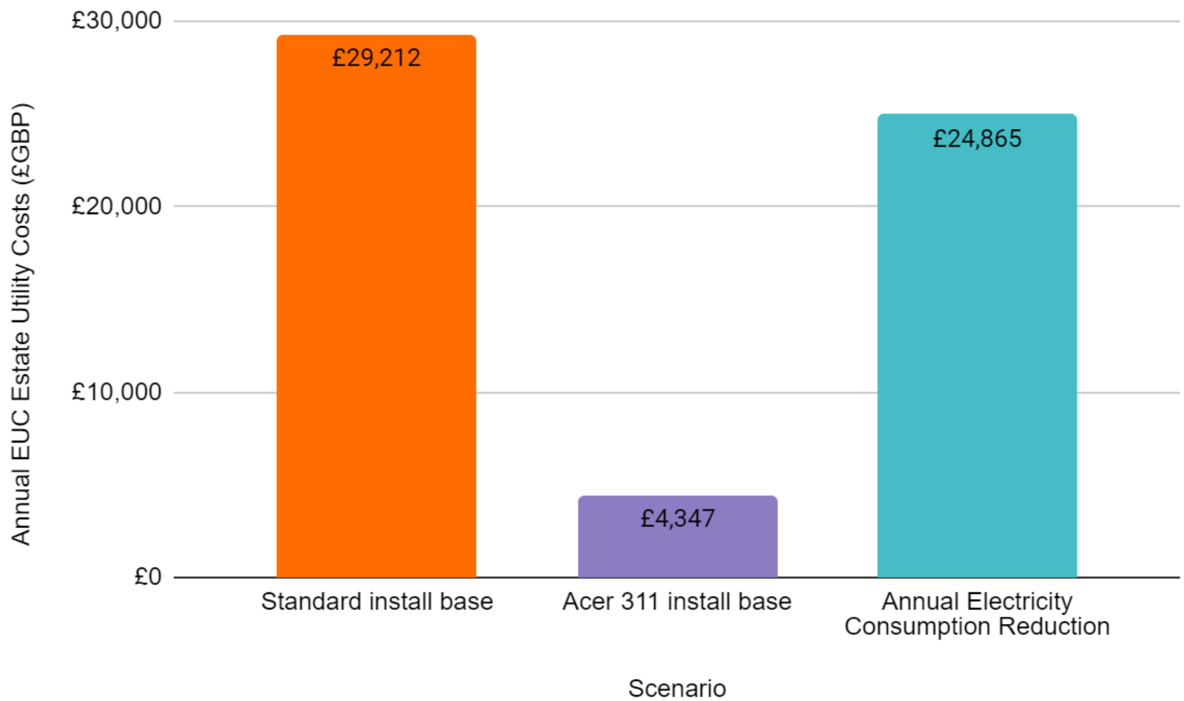
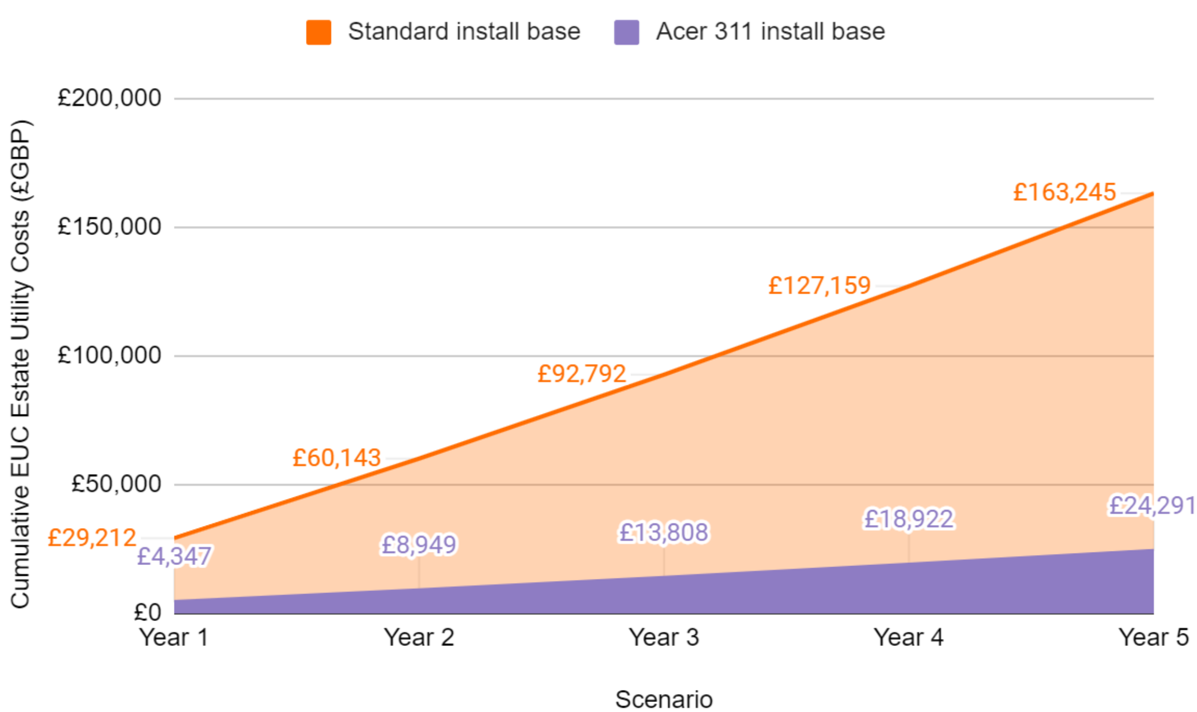


Figure 5. 5-year electricity cost (£GBP) comparison



As before, extrapolated to account for the entire 5-year device retention period, the cumulative impact upon profitability becomes emphasised. Figure 5 includes a median annual price increase anticipated for electricity costs in the UK. As such, the standard install base total utility expenditure will be £163,245 and £97 per device during device use-phase while comparatively the Chromebook electricity costs reduces to £24,291 in total and £14.45 per device.

Consequently, it is reasonable to state that by transitioning to the highly energy efficient Acer 311 Chromebook, utility costs can be reduced by 85%.

For an average sized EUC install base in the education sector this represents a saving of £138,954 during the device's useful lifespan and reduces device operational expenditure by £82.55 per computer.

Summary

The results substantiate that transitioning from standard EUC environments that include desktops and monitor combinations, to a 100% mobile estate based on highly energy efficient devices, such as the Acer Chromebook 311, supports the UN sustainable development goal of responsible consumption.

This is achieved by an 85% reduction in electricity consumption that causes equivalent abatement of concomitant scope 2 GHG emissions. Consequently, the average use-phase emissions exhibited by a single device in a standard install base will decline from 38.6 kgCO_2e to 5.7kg CO_2e during the product lifespan. As such, it is possible to avoid 33kgCO_2e per device and realise tangible climate action.

While the abatement examples based upon average EUC install base sizes prove significant, the feasibility of meaningfully contributing to the UNEP aspiration of reducing societal emission via existing technology is emphasised when examined at scale.

As an example, as noted statistical data indicates there are over 4m computers operating in UK education establishments today [30]. Based upon the average values, the scope 2 emissions for the next 5-years created by such devices will be in the region of 154.5m kgCO_2e. In context, this is equivalent to pollution created by 562.6m car miles; a distance equal to four journeys to Mars.

When buying incremental computers or replacing obsolete devices, selecting highly energy efficient devices at scale will reduce this footprint to just 15% of the current environmental impact.

Positively, if 100% diffusion of devices such as the Acer Chromebook 311 was experienced in the UK education system, 131.5m kgCO_2e of scope 2 GHG emissions would be avoided every 5-years.

This is equivalent to preventing pollution from 478.9m car miles. This quantity of emissions would otherwise require almost 115,000 forest acres to sequester the carbon from our atmosphere every year. To visualise this, it is worth considering that such a forest would cover the entire land mass of inner London and Manchester combined.

While there are obvious environmental benefits from responsible consumption, the results validate that profitability is improved too as utility costs decline. Specifically, the calculations determine that an average standard device utility expenditure is calculated to be £97 per unit during the use-phase.

Selecting low energy consumption devices such as the Acer Chromebook 311 reduces this to £14.45 per device. As such, it is feasible that an estimated £82.55 of electricity costs can be saved per device during a 5-year period. Once again, at scale and considering rising utility costs, this value becomes increasingly significant in terms of financial efficiencies.

Applying the savings generated by the Acer Chromebook 311 to the 4m computers used within UK education determines an available utility cost reduction of £330.2m achieved by simply selecting notebooks based upon scientifically validated energy data.

Consequently, the findings support prior research that sustainable IT is not complex to adopt if accurate environmental information is made freely available. Additionally, adopting sustainability as part of assessment and procurement criteria significantly supports both planet and profit.

As such, it is reasonable to suggest that examining beyond standard benchmark energy data that does not consider the active-state power draw is beneficial. By determining electricity consumption during the use-phase when students, teachers, administrative and support staff are productive, enables science based decisions and targets to be formed. From this foundation, abatement goals can be assessed and climate action documented to ensure that a more sustainable future is realised as organisations strive to attain net zero operations.

Conclusions

As IT procurement and use legislation and policy [4] reaches beyond manufacturers and intensifies focus within consumer environments, institutes such as schools, academies, colleges and universities must focus upon reducing the impact of high emissions sources such as end user computing.

Energy consumption reduction via the adoption of low energy devices such as the Acer Chromebook 311 enables feasibility to become reality. Reducing scope 2 emissions by 85%, the carbon footprint of EUC estates is proactively reduced in both the short and long-term contributing directly to the UN aspiration to lower societal emissions via existing technology.

Arguably, taking such action at scale will make the difference between imminent incremental global warming or enabling a cessation of temperature gain in the short term. Such concerted climate action driven by responsible consumption will bridge the gap, facilitating long term strategies such as renewable energy diffusion to mature ahead of attaining national net zero aspirations in 2050.

References

[1] Intergovernmental Panel on Climate Change (IPCC). (2022), ‘Climate Change 2022: ARG WGIII SPM’. Switzerland: IPCC

[2] United Nations Environment Programme. (2019), ‘Emissions Gap Report’. Table ES1 Page 8.

[3] Sutton-Parker, J. (2022), 'The impact of end user computing carbon footprint information on human behavioural change and greenhouse gas emission abatement.' Warwick, UK: University of Warwick, Computer Science Dept.

[4] Sutton-Parker, J. (2022), ‘Is sufficient carbon footprint information available to make sustainability focused computer procurement strategies meaningful?’. 1877-0509. Procedia Computer Science, Volume 203, 2022, Pages 280-289. Amsterdam, the Netherlands: Science Direct, Elsevier B.V.

[5] Sutton-Parker, J. (2022), ‘Modernising and extending device lifecycles to support climate action: Nordic Choice Hotels impact case study.’ California, USA: Google.

[6] Sutton-Parker, J. and Procter, R. (2022), ‘Determining greenhouse gas abatement achieved by repurposing end user computing devices’. Warwick, UK: University of Warwick, Computer Science Dept.

[7] Sutton-Parker (2022), 'Can modern work applications and endpoints abate end user computing greenhouse gas emissions and drive climate action?'. Redmond, USA: Microsoft.

[8] Sutton-Parker, J. (2022), ‘Quantifying greenhouse gas abatement delivered by alternative computer operating system displacement strategies’. 1877-0509. Procedia Computer Science, Volume 203, 2022, Pages 254-263. Amsterdam, the Netherlands: Science Direct, Elsevier B.V.

[9] Sutton-Parker, J. (2022), 'Determining the impact of information technology greenhouse gas abatement at the Royal Borough of Kingston and Sutton Council’. 1877-0509. Procedia Computer Science, Volume 203, 2022, Pages 300-309. Amsterdam, the Netherlands: Science Direct, Elsevier B.V.

[10] Sutton-Parker, J. (2020), ‘Determining end user computing device Scope 2 GHG emissions with accurate use phase energy consumption measurement’. Volume 175, 2020, Pages 484-491. doi.org/10.1016/j.procs.2020.07.069. 1877-0509. Procedia Computer Science. Amsterdam, the Netherlands: Science Direct, Elsevier B.V.

[11] Sutton-Parker, J., Procter, R., Kass, S. and Rowe, D. (2020), ‘Hydro66 Green Cloud Infrastructure – Cloud Computing Gives a Damn’. Boden, Sweden: Hydro 66, a Northern Data company.

[12] Sutton-Parker, J. (2015), 'Corporate and Social Responsibility (CSR) as a driver for the adoption of cloud computing'. Ambleside, Cumbria: IFLAS, University of Cumbria.

[13] Sutton-Parker, J. (2021), 'Determining commuting greenhouse gas emissions abatement achieved by information technology enabled remote working'. Volume 191, 2021, Pages 296-303. doi.org/10.1016/j.procs.2021.07.037. 1877-0509. Procedia Computer Science. Amsterdam, the Netherlands: Science Direct, Elsevier B.V.

[14] Sutton-Parker, J. (2022), 'Can analytics software measure end user computing electricity consumption?' Clean Technologies and Environmental Policy. 1618-9558. New York, USA: Springer.

[15] United Nations (2015), 'Sustainable Development Goals'. New York: United Nations

[16] Sutton-Parker, J. (2020), 'Quantifying resistance to the diffusion of information technology sustainability practices in the United Kingdom service sector'. Volume 175, 2020, Pages 517-524. doi.org/10.1016/j.procs.2020.07.073. 1877-0509. Procedia Computer Science. Amsterdam, the Netherlands: Science Direct, Elsevier B.V.

[17] HM Government. (2006), 'Climate Change and sustainable energy Act'. London: The Stationery Office Limited.

[18] HM Government. (2013) 'The Companies Act 2006 (Strategic Report and Directors' Report) Regulations).' Section 416 London: The Stationery Office Limited.

[19] Dahlmann, F., and Sutton-Parker, J. (2020), 'The Cost of Running IT is the Next Sustainability Challenge'. Page 105. Paris, France: The Council on Business and Society.

[20] HM Government. (2021), 'Environmental taxes, reliefs and schemes for businesses'. London: The Stationery Office Limited.

[21] Department for Food Environment and Rural Affairs. (2020). 'Greening government: ICT and digital services strategy 2020-2025'. London: Crown copyright.

[22] Sutton-Parker, J. (2022), 'Determining United Kingdom government information and communications technology scope 3 greenhouse gas emissions' for Department for Environment, Food and Rural Affairs (DEFRA). Warwick, UK: University of Warwick, Computer and Urban Science Dept.

[23] HM Government, DEFRA and Sutton-Parker, J. (2022), 'Greening government ICT: annual report 2021 to 2022'. London: United Kingdom. Crown Copyright.

[24] Px^3 Ltd. (2022), 'Sustainable IT in education – issues, trends & attitudes among decision makers.' Warwick: UK

[25] Sutton-Parker, J. (2021), '2021 JSP UK Service Sector Sustainable Device Selection Survey Data'. Mendeley Data, V2, doi: 10.17632/6d7r874jtz.2

[26] Sutton-Parker, J. (2022), 'Net Zero Computing for Planet Earth'. New Taipei City, Taiwan: Acer Inc.

[27] Sutton-Parker, J. (2021), 'EUC Device Use Phase GHG Emissions Research Paper for the Acer Chromebook Spin 513 Computer'. New Taipei City, Taiwan: Acer Inc.

[28] Sutton-Parker, J. (2021), 'EUC Device Use Phase GHG Emissions Research Paper for the Acer Chromebook Spin 713 Computer'. New Taipei City, Taiwan: Acer Inc.

[29] World Business Council for Sustainable Development and World Resources Institute. (2004), 'The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard'. Geneva, Switzerland and New York, USA.

[30] British Educational Suppliers Association. (2022), 'Key UK education statistics.' London: UK

[31] Acer Inc. (2022). 'Acer Chromebook 311'. New Taipei City, Taiwan: Acer Inc.

[32] Px^3 Ltd. (2022), 'Service R1: Computer Life Cycle Assessment (LCA)'. Warwick: UK

About Px3

Px3 is an award winning research focused IT consulting organisation specialising in sustainability and specifically the reduction of GHG emissions created by the way people work today. Our unique services enable global IT manufacturers, software vendors, cloud computing service providers, technology distributors, value added resellers plus commercial and public sector organisations to plan for and adopt sustainable IT that is good for the planet, people and productivity – hence our name. The DUPA process, Px3 framework, cTEC methodology, Dynamic Carbon Footprint and Silent Sole certification name and icon are copyright of Px3 Ltd. All practices were developed during PhD research conducted under the supervision of the University of Warwick Computer and Urban Science faculty and the Warwick Business Schools Sustainability and Business faculty.

The United Nations notes, 'The Global Goals can only be met if we work together. International investments & support is needed to ensure innovative technological development. To build a better world, we need to be supportive, empathetic, inventive, passionate, and above all, cooperative.' For information technology to drive SDG 13 Climate Action then SDG 17 Partnership for the goals is essential. Without cooperation we cannot achieve SDG12 Responsible Consumption and Production. At Px3 our ethos reflects this. When asking IT stakeholders to rank the importance of climate change from 1-10, the average response is '9'. Whilst this identifies a passion for action, many organisations don't feel equipped to make the bridge between IT & climate action.

We empathise with this complex problem and use innovation to reveal that 'Great IT can also be Green IT'

To support responsible production, we conduct scientific research measuring the environmental impact of products & services produced by global technology companies. The rationale being that these organisations enable 4.2bn computer users to be productive or enjoy digital content. From a responsible consumption perspective, we help these companies to produce material explaining why their offerings meet SDG12 criteria. We also work in partnership and directly with their customers globally to drive behavioural changes that reduce IT supply chain, use-phase & end of life treatment emissions. As an example, our applications and consultants assist companies to select computers with the lowest carbon footprint, to measure their current IT carbon footprint and to realise potential sustainable IT strategies that enable positive change & ultimately GHG emissions abatement. This may be as simple as keeping devices for longer periods to reduce demand for the 460m new end user computing devices produced annually.

Such change is what ultimately drives SDG 13 Climate action. We've measured and advised people using almost 5m computers to date. As a result, as each year passes companies reduce their environmental footprint caused by IT.

We are achieving our goal to cumulatively abate 10,000,000 kgCO_2e of GHG emissions every year via the diffusion of sustainable IT. In fact, as a result of empathy, support, innovation and cooperation, by 2035, carbon requiring the photosynthesis of 250,000 acres of forest will no longer enter our atmosphere. In context, that's a forest equivalent to 3.9m tennis courts.

We cannot do this without embracing SDG 17 partnership for the goals. If our passion isn't shared by manufacturers, vendors and customers then our research and consulting will not be adopted and diffused. And that's why Px3 considers SDG 17 to be the binding element that enables us all to realise our ultimate goal of Climate Action. As such, we collectively thank our current and prospective ecosystem of companies that utilise Px3 services to create a more sustainable future.

About the Author

Justin Sutton-Parker is a sustainable information technology professional. As a MBA in Sustainability & PhD Doctorate researcher for Computer and Urban Science with the University of Warwick and Warwick Business School, Justin regularly publishes empirical research in the world's leading scientific computing and environmental journals. Specialising in the field of information technology greenhouse gas abatement, Justin conducts commercial research for national government and over one dozen of the world's leading computer manufacturers, software vendors, cloud computing service providers, services organisations and internationally renowned third-party environmental certification organisations.

Responsible for empirical research within the field of sustainable IT, such as meaningful commercial computing typical energy consumption (cTEC) calculation, alternative operating system energy and concomitant greenhouse gas emissions reduction and the invention of the dynamic carbon footprint, Justin's research represents the foundation for research and consulting services, applications and frameworks delivered and used by Px^3.

A regular public speaker, Justin is also editor, columnist and contributor for sustainability focused consumer and national press publications such as My Green Pod, having published the world's first mainstream magazine entirely dedicated to sustainable IT.

Whether via academic, commercial or social media channels, Justin specifically promotes the adoption of 4 simple steps to achieving a lower IT carbon footprint. These include low carbon footprint devices, green data centres, remote working to reduce commuting and the reduction of e-waste via displacement and circular economy strategies.

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