Can computer processor component choice enable greenhouse gas abatement?

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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. In context, this is equivalent to emissions generated by 1.4bn fossil fuel car miles and requires a 2.8m km^2 forest the size of Argentina to sequester the carbon from our atmosphere. Approximately one-third of the total carbon footprint of personal computers 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, research identifies that current end user computing 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 measures only low power modes such as off, sleep and idle. The results therefore 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 disparity is differing workloads plus the inclusion of seemingly similar components that when in the active state require varying amounts of power draw. To test the influence of computer processors upon device energy efficiency and associated emissions, this research measures three similar Lenovo ThinkPad X13 notebooks under identical workloads for electricity consumption. The results find that the notebook powered by the Snapdragon 8cx Gen 3 consumes 45% less electricity than the notebook powered by Intel Core i5-1240P and 24% less than the notebook powered by AMD Ryzen 5 PRO 6650U. This is achieved by Snapdragon reducing average active state power draw by as much as 66%. Consequently, scope 2 emissions and utility costs are reduced by a similar percentage showing that computer processor component choice can enable greenhouse gas abatement.

Keywords: Human-computer interaction; computer energy efficiency; computer product carbon footprint; scope 2 and scope 3 end user computing greenhouse gas emissions; sustainable information technology.

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Qualcomm Technologies, Inc. commissioned this research to scientifically test the hypothesis. All experiments are undertaken using previously peer reviewed scientific test set-up and conduct methodologies. Results are delivered pragmatically and without bias to ensure the findings withstand scientific and academic scrutiny.

1. Introduction

Since the Industrial Revolution, anthropogenic interference has 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 by reaching and sustaining net zero global anthropogenic CO_2 emissions by mid-century, global warming may halt 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 enabling strategies are applied without delay [3]. As an example, significant supply chain (scope 3) GHG emissions reductions can be achieved by selecting hardware with the lowest manufacturing carbon footprint [3, 4] and then retaining equipment for longer periods [3, 5, 6, 7, 8] to displace procurement refresh cycles. Electricity consumption (scope 2) emissions can also be reduced by adopting low energy products [3, 5, 8, 9,10] and low carbon computing services [3, 7, 11, 12]. Additionally, associated behavioural changes such as 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].

The concept of sustainable EUC procurement and use contributing to GHG abatement is already internationally recognised [3, 4]. Linked with the United Nations Sustainable Development Goal (UN SDG) number 12, 'responsible consumption and production' [15], 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, 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 detailing GHG emissions associated with production, transportation, the use-phase and end of life processes.

Considering that ICT now accounts for over 10% of all commercial electricity consumption [16] and 14% of all waste electrical and electronic equipment (WEEE) recycling [3], selecting computers using sustainability criteria is becoming more prevalent. This is encouraged by both a growing realisation and substantiation that sustainable IT can drive climate action plus national and regional legislation and strategies that require commercial and public sector organisations to include sustainability as a criterion when procuring ICT products and services [3, 4, 16].

To determine which EUC devices have the lowest carbon footprint, organisations rely on two key data sources [3, 4, 10, 16-18]. The first is typical energy consumption (TEC) data published by organisations such as Energy Star and as part of the Eco Declaration process. Using this data organisations can select devices that they believe will consume the least amount of electricity during the computer's useful lifespan. The TEC data is also used to calculate concomitant scope 2 (electricity) use-phase GHG emissions within the second data source of product carbon footprint reports generated by EUC manufacturers such as Acer, Apple, ASUS, Dell, HP, Lenovo and Microsoft.

However, research determines that such data sources, whilst accurate within the parameters of their function, lack contextual validity [3, 4, 10]. As an example, the TEC data only measures low power modes including off, sleep and idle. Consequently, the active-state power draw measurement, when the device will experience human interaction, is not included within the projected electricity consumption value. Arguably, if all computers are judged by energy efficiency when measured in low power modes, then it is logical that the resulting TEC data is created with parity and therefore devices can be compared and selected with confidence.

However, research also shows that unlike operations in low power modes, different operating systems and components require more or less power during the active-state [3, 10]. As such, computers that appear almost equivalent based upon the existing low power mode TEC data often produce very different electricity consumption outcomes when used in the workplace [10]. Specifically, by excluding the active state data, the typical energy consumption benchmark data is proven to become inaccurate in the context of real world electricity consumption by between -60% to +121% causing a disparity maxim of 181% [10].

As the TEC data is used to generate scope 2 use-phase GHG emissions data for product carbon footprint reports, the lack of contextual validity is passed onto this second source of data. Within carbon footprint reports, parity between manufacturers is further eroded as each utilises varying approaches to use-phase emissions calculation [4]. Some manufacturers will include just one year of electricity consumption within a carbon footprint report, whilst others will include as much as 6-years causing use-phase emissions contribution to become incomparable. Additionally, where one brand may use high carbon intensity electricity to GHG conversion factors, such as those published in the USA, to convert TEC values to scope 2 GHG emissions, other brands may use low carbon intensity factors, such as those published in Europe to reduce the apparent use-phase scope 2 impact.

Consequently, the substantiated success experienced by including sustainability as a criterion when procuring ICT products and services is effectively compromised [4]. This is because organisations inadvertently procure products that appear to have a lower carbon footprint but in reality are often increasing GHG emissions due to a lack of contextual sustainability data. Previously developed device use-phase analysis (DUPA) energy measurement and associated commercial typical electricity consumption (cTEC) methodologies overcome such issues by including the power draw results from low power modes and the active state [3, 5-10]. In each case, such the results enable identification of end user computing devices that are shown to reduce electricity consumption during the device's useful lifespan and therefore abate scope 2 electricity based GHG emissions.

Research determines that computer electricity consumption is directly influenced by two key factors [3,8,10]. These are the choice of operating system and component specification such as central processing units (CPU), memory and storage. The body of research identifies that component selection influences energy efficiency by an average of 23% [3,8]. The variation of efficiency achieved depends upon the inclusion of components such as reduced thermal design power CPUs, embedded multi-media card storage and low power double data rate memory [3,8]. In all cases, variations of each component exist and therefore the impact of each variation upon power draw and electricity consumption will differ.

Research also highlights that notebooks powered by Snapdragon deliver extreme energy efficiency when compared to average notebook electricity consumption values [19]. While the research measures the device in isolation, the purpose of this research is to expand upon the findings and to determine the impact of a device powered by Snapdragon compared to nearly identical devices powered by an alternative Intel and AMD processor. By doing so, it is therefore reasonable to conclude that any changes to power draw and electricity consumption are influenced by the processor present in whichever device delivers the lowest energy values. The results can then be converted to scope 2 GHG emissions to calculate the impact of feasible climate action generated by selecting highly energy efficient devices enabled by computer processor component choice.

2. Methodology

The objective of the research is to determine the percentage of electricity consumption reduction caused by differing compute chipsets. By doing so, use-phase scope 2 GHG emissions abatement values can be calculated to demonstrate how selecting such computers can support IT focused responsible consumption and climate action. To achieve this, valid energy use data must be generated for comparable devices. As such, three notebooks are subjected to power draw and electricity consumption measurement testing using the DUPA practice [3]. The results are then applied to the cTEC methodology [3] to generate a commercial typical energy consumption (cTEC) value for 1-year (kWh/y) for each device.

The equipment under test are three Lenovo ThinkPad X13 notebooks. All are specified with a 13.3" widescreen ultra extended graphics array (WUXGA) screen with a 1920x1200 resolution, 16GB low power double data rate (LPDDR) memory, 256GB solid state drive (SSD) storage and Windows 11 operating systems (Table 1).

Table 1. Notebook specification

Model	Screen Size	Resolution	Memory	Drive	Operating system	Processor
Lenovo ThinkPad X13	13.3"	1920 x 1200	16 GB LPDDR5	256 GB SSD M.2 2242 PCIe	Windows 11	Intel Core i5-1240P
Lenovo ThinkPad X13	13.3"	1920 x 1200	16 GB LPDDR5	256 GB SSD M.2 2242 PCIe	Windows 11	AMD Ryzen 5 PRO 6650U
Lenovo ThinkPad X13s	13.3"	1920 x 1200	16 GB LPDDR4X	256 GB SSD M.2 2242 PCIe	Windows 11	Snapdragon 8cx Gen 3

As highlighted by table 1, the key difference between each device is the processor. The first notebook includes an Intel Core i5-1240P; the second an AMD Ryzen 5 PRO 6650U and the third, a Snapdragon 8cx Gen 3.

Further to capturing the energy data the results are compared to determine differences or similarities between each device. Once complete, the next stage calculates concomitant scope 2 GHG emissions created by electricity consumption. This is achieved by converting the kWh/y cTEC results to kilogram carbon dioxide equivalent ($kgCO_2e$) units using current published and forecasted electricity to GHG emissions factors in line with GHG reporting and accounting protocol [20]. Unlike the kWh unit of electricity consumption measurement that is universal regardless of location, scope 2 emissions quantification will differ depending upon which country or region the device is used in. This is because the electricity supply for each country exhibits different carbon intensity caused by the percentage of adoption of low-carbon renewable energy specific to each grid. As such, the Dynamic Carbon Footprint™ application [4] is used to generate annual scope 2 GHG emissions values for four regions to enable comparison of environmental impact in these key IT markets. These include Europe, the UK, the USA and a holistic Global representation. Doing so avoids restricting findings to one country and enables relevance to a wider user audience for consideration.

Beyond the standard unit of measurement for electricity use and GHG emissions, a tangible analogous equivalent is also included to enhance comprehension of impact and feasible abatement. In this instance human steps represent energy consumption and car miles are used to represent the equivalent volume of pollution avoided [3].

The results are discussed in relation to single device comparison and expanded in the summary to offer an example of positive climate action when applied to a large organisation of 1,000 users. All tests are conducted under scientific conditions and results are delivered pragmatically and without bias.

3. Results

To generate a substantiated and valid baseline, the results section examines the findings of the electricity consumption measurement experiment ahead of determining associated GHG emissions values and feasible abatements delivered by energy efficiency.

Computer Energy Data

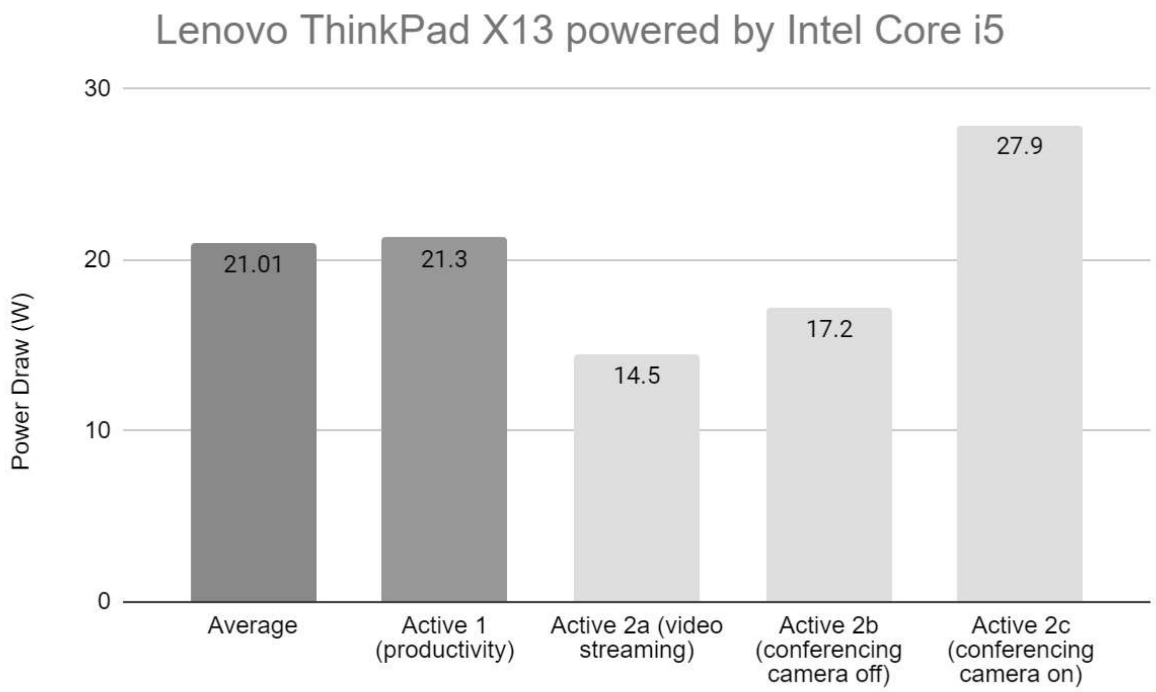
As noted, three Lenovo ThinkPad X13 device variations are tested to generate comparable power draw and electricity consumption results.

Lenovo ThinkPad X13 powered by Intel Core i5

The Lenovo ThinkPad X13 powered by the Intel Core i5-1240P processor exhibited an average active state power draw of 21.01W (Figure 1). The active state represents a 209% increase in power draw when compared to the short idle mode measurement of 6.8W; again proving congruent with associated research [3, 8, 10]. Examining specific activities, the average power draw for productivity tasks as described previously is 21.3W. For video content based tasks, the power draw ranges from 14.5W when streaming, 17.2W when conducting video conferencing with the camera switched off, to 27.9W with the camera switched on.

Applying the findings to the cTEC methodology, the Intel model device will consume 27.09 kWh of electricity per year when used in a business environment (Figure 4). For contextual purposes, daily electricity consumption is equivalent to the energy required to walk 2,008 human steps.

Figure 1. Active state power draw (W) results for Lenovo ThinkPad X13 powered by Intel Core i5

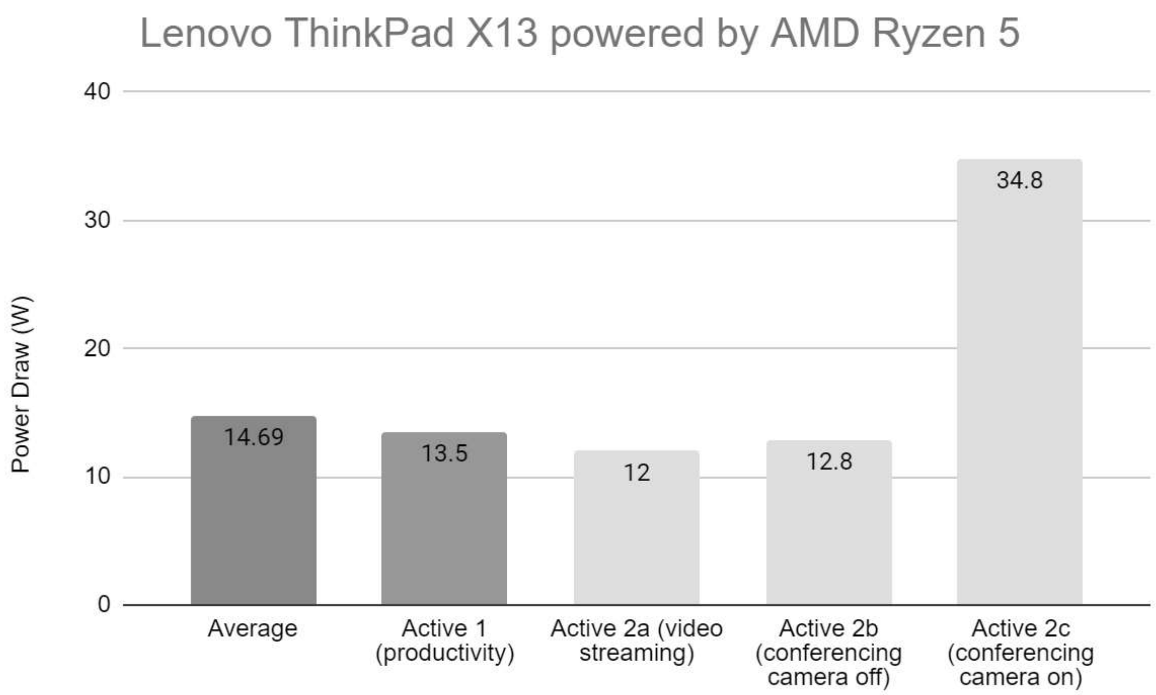


Lenovo ThinkPad X13 powered by AMD Ryzen 5

The Lenovo ThinkPad X13 powered by the AMD Ryzen 5 PRO 6650U exhibited an average active state power draw of 14.69W (Figure 2). The active state represents a 242% increase in power draw when compared to the short idle mode measurement of 4.3W. The increase from the short idle to active state is anticipated and congruent with associated research [3, 8, 10] determining that all devices will experience raised power draw during this mode due to additional processing not experienced during the low power modes such as off, sleep and idle. Examining specific activities, the average power draw for productivity tasks including messaging, document creation and review, local presentations and accessing software as a service (SaaS) applications is 13.5W. For video and content based tasks, the power draw ranges from 12W when streaming, 12.8 W when conducting video conferencing with the camera switched off, to 34.8W with the camera switched on.

Applying the findings to the cTEC methodology, the AMD model device will consume 19.46 kWh of electricity per year when used in a business environment (Figure 4). For contextual purposes, daily electricity consumption is equivalent to the energy required to walk 1,443 human steps.

Figure 2. Active state power draw (W) results for Lenovo ThinkPad X13 powered by AMD Ryzen 5

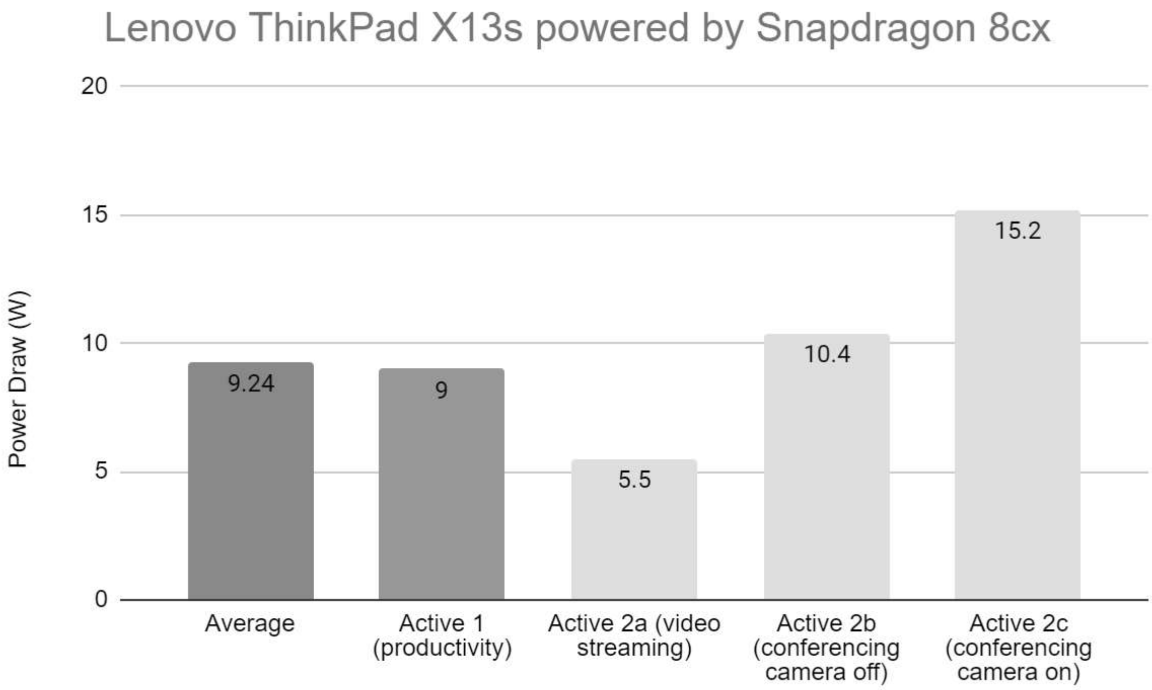


Lenovo ThinkPad X13s powered by Snapdragon 8cx

The Lenovo ThinkPad X13s powered by the Snapdragon 8cx Gen 3 processor exhibited an average active state power draw of 9.24W (Figure 3). The active state represents a 198% increase in power draw when compared to the short idle mode measurement of 3.1W; proving congruent with associated research as before [3, 8, 10]. Examining specific activities, the average power draw for productivity tasks as described previously is 9W. For video content based tasks, the power draw ranges from 5.5W for activities such as content streaming, 10.4W when conducting video conferencing with the camera switched off, to 15.2W with the camera switched on.

Applying the findings to the cTEC methodology, the Snapdragon model device will consume 14.91 kWh of electricity per year when used in a business environment (Figure 4). For contextual purposes, daily electricity consumption is equivalent to the energy required to walk 1,105 human steps.

Figure 3. Active state power draw (W) results for Lenovo ThinkPad X13s powered by Snapdragon 8cx



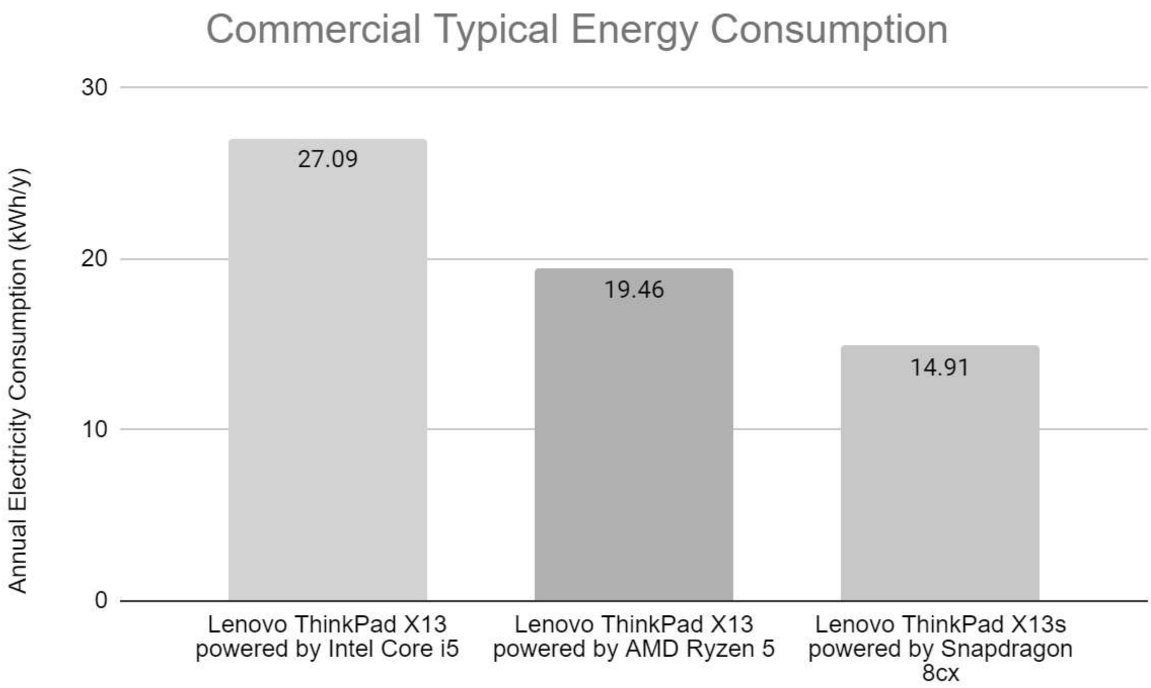
Energy Efficiency Comparison

The results highlight that the active state power draw exhibited when subjected to human-computer interaction differs significantly between all three Lenovo ThinkPad X13 notebooks. The influence of this is best demonstrated by the commercial typical energy consumption (cTEC) results (Figure 4).

The least energy efficient device is the Intel variant. In a workplace environment the device will consume an average of 27.09 kWh of electricity for each year of use. This is +39% higher than the AMD model that will consume 19.46 kWh/y and +82% higher than the Snapdragon model. Evidently of the three devices, the Lenovo ThinkPad X13s powered by Snapdragon is the most energy efficient consuming 45% less electricity annually than the Intel model and 24% less than the AMD model (Figure 4).

With the exclusion of the CPU, the components in each device are equivalent. As such it is reasonable to determine that the power draw required by Snapdragon is considerably lower during the active state than the Intel and AMD processors. This is substantiated by the active state power draw averages (Figure 5).

Figure 4. Commercial Typical Energy Consumption (kWh/y) results for Lenovo ThinkPad X13 devices

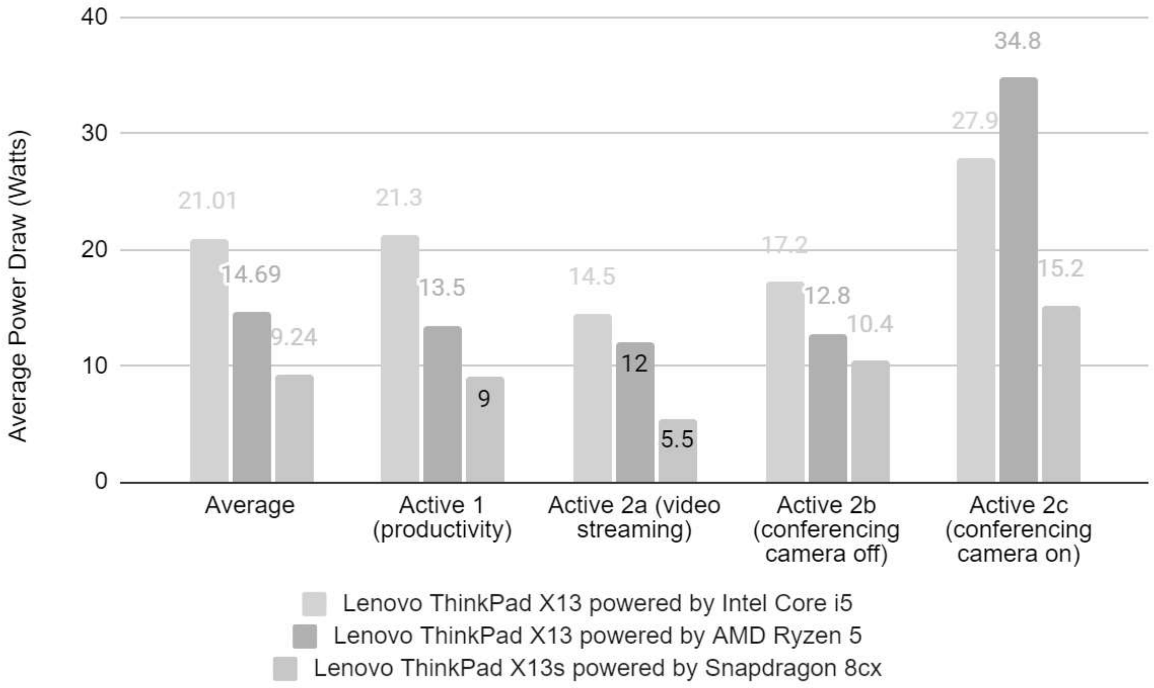


Specifically, the Intel active state average is again the highest at 21.01W. In context, this is +43% when compared to the AMD model at 14.69W and +127% higher than the Snapdragon model (Figure 5). Reflecting the trend of the cTEC results, the Lenovo ThinkPad X13 installed with Snapdragon requires 37% less average power than the AMD variant and 66% less than the Intel variant. The cTEC and average active state power draw percentage difference are not identical as the active state power draw will not remain constant due to task changes throughout a working day. Additionally, periods of time spent in low power modes such as off, sleep and idle will be experienced during a working day. The test set up and cTEC methodology caters for this, specifically measuring task based power draw and applying identical mode weightings to each annual electricity consumption value to ensure parity of data between all equipment under test. As highlighted by figure 5, the device with Snapdragon requires less power draw in all active state variations when compared to both the AMD and Intel processor models. While similar percentage reductions to the average power draw results are reflected in the productivity task results of 33% and 58% in favour of the notebook powered by Snapdragon, the most significant efficiency gains are exhibited by the video focused results.

Content streaming such as video from social media sites and online training determined the model with Snapdragon required 54% less power draw than the AMD model and 62% less than the Intel model.

For video conferencing, power draw for the AMD model increased from 12.8W by 172% to 34.8W comparing camera off and camera on results. In comparison, the Intel model increased by 62% from 17.2W to 27.9W. Notably, the Intel model consistently produces the highest power draw in the active state with the exception of the video conferencing 'camera on' task measurement. In this instance, while the Intel model requires 34% higher power draw than the AMD model when conducting video conferencing with the camera off, the AMD model proves to require 25% more power that the Intel model when the camera is switched on. As both camera components are identical, the result arguably points to a specific nuance within the processor itself and how it interacts with data capture and processing.

Figure 5. Power draw (W) results for Lenovo ThinkPad X13 devices



As noted, the Snapdragon variant produces the lowest results for both video conferencing activities. Specifically, when the camera is switched off the device power draw is 10.4 W and -9% when compared to the AMD model and -40% compared to the Intel model. With the camera active, the contrast increases to -57% and -45% respectively with the power draw being 15.2W.

Planet: GHG Emissions

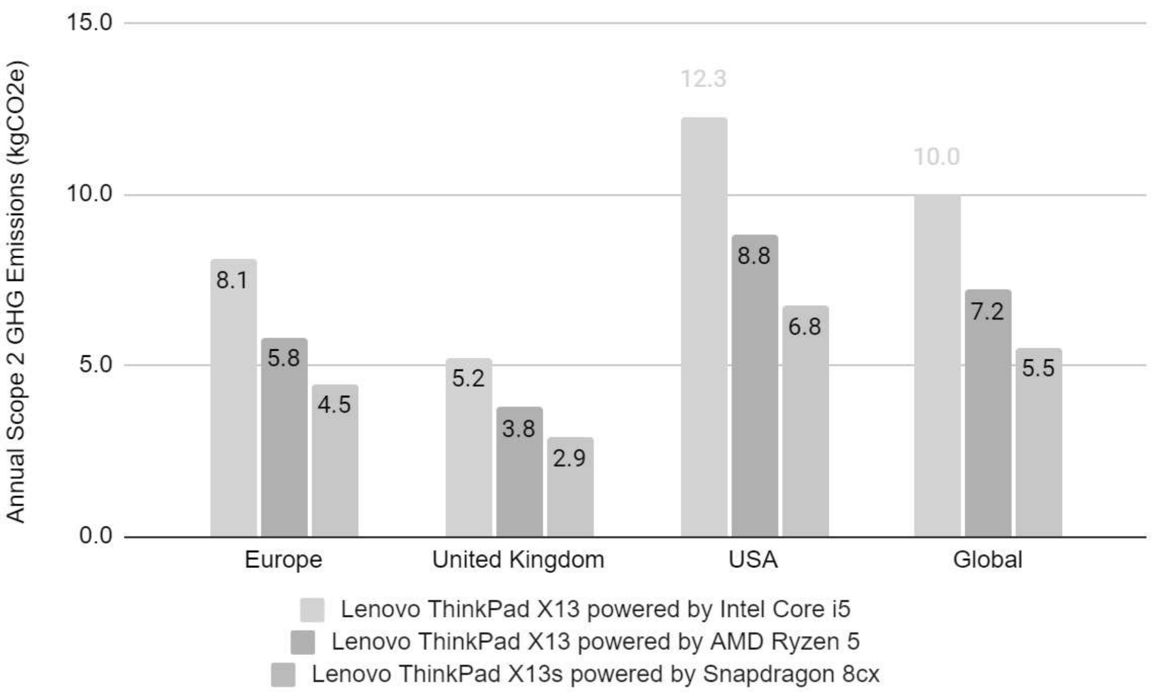
Logically, greater energy efficiency enables avoidance of scope 2 GHG emissions as less electricity is consumed by each computer during the useful lifespan. Energy based GHG emissions generated will differ depending upon the location of use [4]. This is because national electricity grids exhibit different levels of carbon intensity defined by the percentage adoption of low carbon energy sources such as hydro, solar or wind in favour of fossil fuel sources. The following results are, as previously noted, based upon average carbon intensities exhibited in Europe, the USA, the UK and globally to ensure relevance for organisations operating either locally or internationally.

Scope 2 GHG Emissions: Single Device Values

Due to the electricity consumption results, the Lenovo X13 including the Intel processor generates the highest scope 2 GHG use-phase emissions. For the initial year the use-phase emissions are 12.3 $kgCO_2e$ in the USA, 10 $kgCO_2e$ globally, 8.1 $kgCO_2e$ in Europe and 5.2 $kgCO_2e$ in the UK (Figure 6). Comparatively, the Lenovo X13 with the AMD processor generates 28% less scope 2 emissions annually creating 8.8 $kgCO_2e$, 7.2 $kgCO_2e$, 5.8 $kgCO_2e$ and 3.8 $kgCO_2e$ of emissions in each region respectively (Figure 6).

Based upon achieving the lowest electricity consumption results and therefore the highest energy efficiency, the notebook with a Snapdragon processor generates the least amount of concomitant use-phase GHG emissions. Specifically, the Lenovo ThinkPad X13s powered by Snapdragon generates 6.8 $kgCO_2e$ of scope 2 GHG emissions when used in the USA, 5.5 $kgCO_2e$ globally, 4.5 $kgCO_2e$ in Europe and 2.9 $kgCO_2e$ in the UK (Figure 6). Drawing comparison, the Lenovo notebook with a Snapdragon processor proves to be 45% less impactful to the environment than the device with the Intel processor and 24% less impactful than the AMD model notebook.

Figure 6. Annual scope 2 GHG emissions (kgCO_2e) results for 3 devices by location of use



Positive Impact at Scale

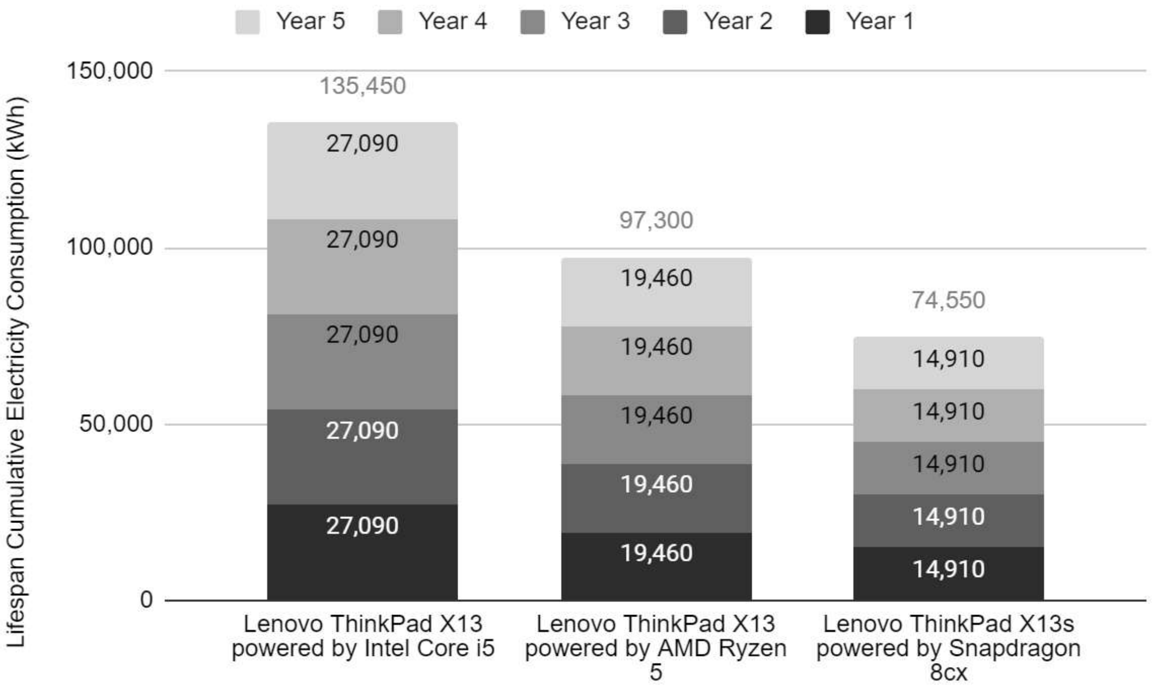
Research determines that key barriers to the adoption of sustainable IT include a limited perception of the environmental gains delivered through transformation and anticipated costs associated with making the change [16]. Further research determines that in reality, climate action is substantial in relation to IT and usually generates a reduction in capital and operational costs [5, 6, 9]. Both outcomes are delivered by strategies such as procurement displacement caused by devices lifespan extension and lowered utility consumption.

To contextualise the environmental and cost improvements delivered by energy efficient devices at scale, the following section applies the single device electricity consumption and concomitant scope 2 GHG emissions results to 1,000 users in a standard business environment. The value of doing so allows public and commercial sector organisations to simply increase or reduce the findings based upon their user numbers or computer install base. Values used for the cost of electricity and scope 2 emissions are based upon average global current and projected utility prices and emissions factors to account for expected change to both influencing factors. As an example, whilst electricity prices will rise, carbon intensity factors will decline as the world adopts more renewable energy capacity. The time horizon for the impact example is 5-years as research indicates this to be a standard retention period for devices [3, 4]. To ensure comprehension of the GHG unit values (kgCO_2e), a tangible equivalent is used to convert the emissions to common analogous examples such as emissions generated by driving a combustion engine car.

Workplace Impact Example

In a business environment, the total lifespan electricity consumption for 1,000 Lenovo X13 devices is 135,450 kWh for the Intel variant, 97,300 kWh for the AMD variant and 74,550 kWh for the Snapdragon variant. As previously identified, the device powered by Snapdragon therefore consumes 45% less energy than the Intel model and 24% less than the AMD model (Figure 7). Consequently, the Snapdragon model will consume 60,900 kWh less electricity than the Intel variant during a 5-year use-phase period and 22,750 kWh less than the AMD powered device (Figure 7).

Figure 7. Lifespan electricity consumption (kWh) results for 3 devices in a business environment



Responsible Consumption and Climate Action

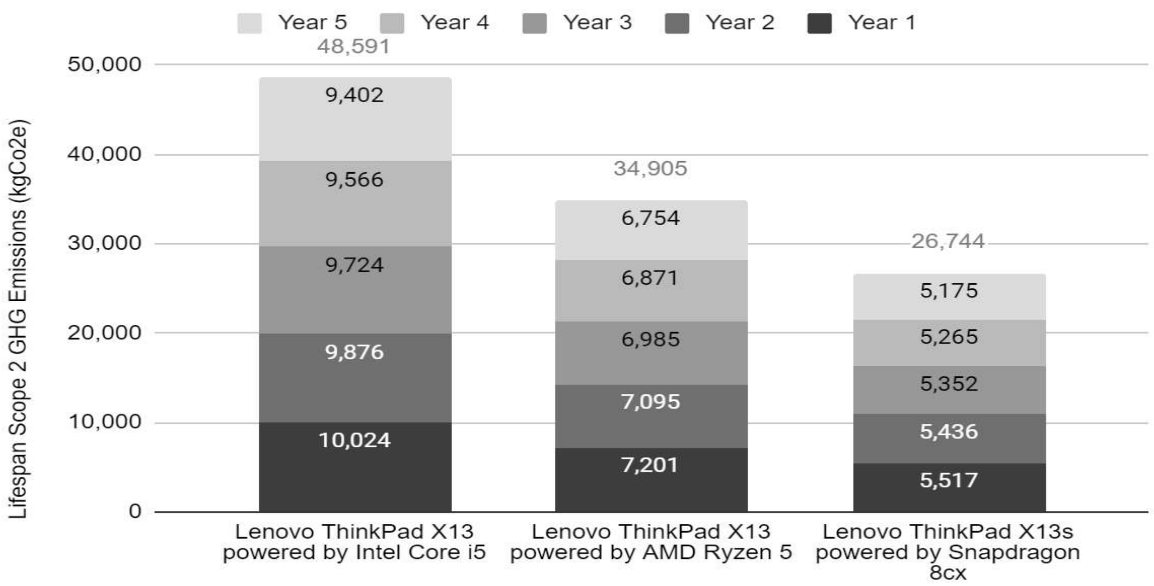
The reduction of electricity consumption translates into scope 2 GHG abatement. Unlike the kWh value, the GHG emissions value is not equal for all 5-years. The reason for this is that, as noted, the majority of national grids will slowly transition away from reliance on fossil fuel energy sources, therefore reducing carbon intensity during the time horizon.

As the notebook with a Snapdragon processor is the most energy efficient device, it therefore represents the benchmark for responsible consumption as concomitant emissions are the lowest produced by all three notebooks at 26,744 kgCO_2e for 1,000 users (Figure 8).

When used as a baseline for environmental impact, the AMD model is calculated to produce 31% more scope 2 GHG emissions at 34,905 kgCO_2e per 1,000 users. Comparatively, the Intel variant creates 82% higher emissions at 48,591 for the 5-years period (Figure 8).

In this example, it is feasible to reduce scope 2 GHG emissions by a maximum of 21,847 kgCO_2e by selecting the Lenovo ThinkPad X13s powered by Snapdragon 8cx Gen 3. In context, this is equivalent to avoiding pollution caused by 79,545 car miles.

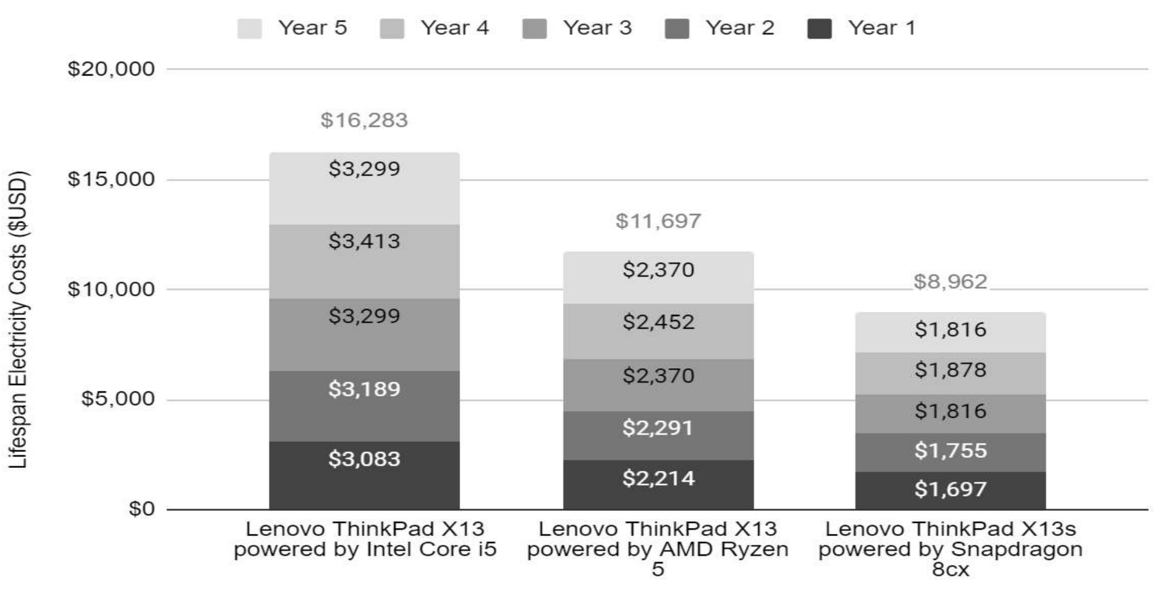
Figure 8. Lifespan scope 2 GHG emissions ($kgCO_2e$) results for 3 devices in a business environment



Utility Cost Reduction

Having determined that climate action is achievable by selecting low energy devices enabled by Snapdragon, it is worthwhile examining associated utility savings. Doing so improves awareness that adopting sustainable IT strategies also reduces cost. As highlighted in figure 9, the annual electricity costs for the 1,000 device environment varies as time progresses for each computer model due to rising electricity costs. As a consequence of the electricity consumption results, the device powered by Snapdragon logically produces the lowest utility cost value of $8,962 for the useful lifespan of the devices. Comparatively, the costs incurred by the Intel variant are 82% higher at $16,283 and 31% higher for the AMD variant at $11,697 (Figure 9). Consequently, selecting Lenovo X13s notebooks powered by Snapdragon offers a feasible utility cost saving of $7,321 for 1,000 users based on a global average electricity price during a 5-year period.

Figure 9. Lifespan electricity cost ($USD) results for 3 Devices in a business environment



4. Summary

The results show that energy efficiency is significantly influenced by the processing power of similarly specified notebook computers. The finding is congruent with existing research [8,10, 19] and enables both utility cost reductions and climate action via responsible consumption. Specifically, the Lenovo ThinkPad X13 notebook powered by Snapdragon 8cx Gen 3 consumed 24% less electricity annually than the similar device with an AMD Ryzen 5 PRO 6650U and 45% less than the Intel Core i5-1240P model. The reason for the decrease in consumption is that the Snapdragon processor is demanding less power draw when in the active state. This is highlighted by the average power draw being 9.24W compared to 14.69W for the AMD model and 21.01W for the Intel variant when experiencing the same active workloads driven by human-computer interaction.

Examining published energy benchmark data suggests the power draw disparity range between the device with a Snapdragon processor and the two further devices is 1.2W and 3.7W when in the short idle state. Consequently, as the active state is not considered in existing typical energy consumption benchmarks, the significant percentage increase in electricity consumption due to the use-phase power draw would not be obvious to IT or procurement teams when selecting suitable computers for business or similar environments.

As the research substantiates, the power draw difference is actually between 5.45W and 11.77W when comparing the active state for the notebook powered by Snapdragon with the AMD and Intel models respectively. As such, the average active state power draw increase experienced is in fact +286% when selecting either the AMD or Intel variants. The consequence being that when the active state is included within the calculation, the consumption difference between devices is as much as 7.63 kWh/y.

From a planet perspective, the 1,000 user impact example defines that cumulative energy savings at scale enable meaningful climate action. Specifically, 21,847 kgCO_2e of scope 2 GHG emissions are avoided during a 5-year use-phase.

From a profit perspective, energy consumption reduction delivered by sustainable IT strategies is proven to be achievable and challenges the misconception that adopting green IT adds to cost [16]. In the one thousand device example, utility consumption is reduced by as much as 60,900 kWh. The energy efficiency causes an electricity spend reduction of $7,321 by simply selecting the Lenovo ThinkPad X13s powered by Snapdragon.

5. Conclusions

As IT procurement and use legislation and policy [4] reaches beyond manufacturers and intensifies focus within consumer environments, commercial and public sector organisations must focus upon reducing the impact of high emissions sources such as end user computing [3]. As substantiated by the research, the results highlight that by supporting the UNSDGs of responsible production and consumption, the ultimate goal of climate action can be achieved by selecting devices with an energy efficient processor.

Arguably, by selecting notebook computers that include components such as Snapdragon at scale, it is feasible to 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.

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