Sustainable ICT Research

CITRIX

Hybrid Working

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Executive Summary

Transport generates 16% of global greenhouse gas emissions with 17% being produced by employees commuting to a fixed workplace. The resulting emissions require a forest the size of Australia to remove the carbon from Earth's atmosphere. As such, Citrix hybrid working solutions are well placed to support sustainable ICT strategies designed to reduce employee commuting.

While low carbon commuting modes will become widely diffused in the future, the transition to electric vehicles is slow meaning the world will not decarbonise road transport until beyond 2050. Considering between 64-74% of employee commuting journeys involve cars, a short term and meaningful solution to reduce commuting emissions is required during the coming 25 years.

This need for such solutions is amplified by global warming. Current data projects surface temperatures will rise to 2°C by 2060 unless immediate climate action is taken.

To examine how increasing potential workforce 'mobility' can abate emissions, this paper examines the differing impact of device type choices and employee hybrid working participation enabled by a Citrix secure hybrid working solution.

The two studies find that within a 5,000 user group, transitioning to mobile type devices can reduce product carbon footprint by 45%, e waste by 65% and cost by 24%. Additionally, by increasing employee participation in 2 days per week hybrid working schemes avoids a maximum of 2,935,233 kgCO_2e of commuting GHG emissions every year.

In context, this is equivalent to emissions created by a combustion engine car travelling 17,282,342 km. A distance equal to driving around Earth's circumference 431 times.

In conclusion, having generated compelling reasons for the reader to consider adoption of a secure hybrid working solution, it is reasonable to suggest that the question, 'How does Citrix support sustainable ICT strategies via secure hybrid working?' is answered.

Introduction

Transport generates as much as 21% of global carbon emissions [1, 2]. Examining the contribution on a regional basis shows that in Europe this value rises to 25% [3] of all greenhouse gas (GHG) emissions and 28% in the United States of America (USA) [4]. Overall, an estimated 17% of all transport is attributed to employees commuting to a fixed workplace such as an office building [5].

Consequently, based upon projected GHG emissions for 2024 [6], commuting generates in the region of 1.6 billion tons of emissions per year. At such a scale, this requires 7.8 million kilometre square (km^2) of mature forest every year to remove the resulting carbon from the atmosphere via photosynthesis [7]. In context, the same forest would cover the entire land mass of Australia.

In the future, low carbon commuting modes will become widely diffused. As an example, many countries have agreed to cease the production of combustion engine vehicles between 2030 and 2040 [8, 9], meaning that electric vehicles will eventually become the norm. Additionally, the electricity powering cars, lorries and multiple passenger commuting modes such as buses, taxis and trains, will reduce in carbon intensity per kilowatt hour (kWh) consumed. This is because national energy supplies are transitioning to renewable low carbon energy sources such as hydro, nuclear, solar and wind [10]. Consequently, land commuting in particular has the potential to decrease its carbon footprint in the long term.

However, the transition to electric vehicles is slow. As an example, electric car sales rose by 14% in 2023 [11], to represent 18% of all new car sales [11] although combustion engine cars still represent 96.5% of existing cars in Europe [11] and 99% in the USA [11]. Sources project that even though car sales will reach 100% electric by 2040 [11] due to the new production laws [8, 9], at least 50% of existing vehicles will remain powered by diesel or petroleum [11]. With the typical lifespan of a combustion engine car being 12 years, it's reasonable to suggest the world will not decarbonise road transport until beyond 2050.

Considering between 64-74% of employee commuting journeys involve cars [5], a short term and meaningful solution to reduce commuting emissions is required during the coming 25 years.

This need is amplified by the fact that in 2017, 1.0°C sustained global warming became a reality. More recently, 2023 represented the first 12 month period to experience a consistent 1.5°C rise in temperature [12].

While the annual percentage increase of GHG emissions has slowed, levels continue to rise overall [12]. Consequently, a long term 1.5°C increase is predicted with high confidence to become permanent by 2030 [12]. Based upon current data, temperatures will rise to 2°C

by 2060 unless immediate climate action is taken to avoid passing the 1.5°C point permanently [12].

Because of this it is logical to look beyond international climate action and towards organisation or personal level strategies if we are to realise immediate and meaningful GHG abatement.

Doing so is called 'sustainability' and since the mid 1990s the practice has become a key contributor to corporate social responsibility (CSR) and more recently environmental, social, and governance (ESG) strategies.

The United Nations (UN) notes that sustainability is the principle of ensuring that our actions today do not limit the range of economic, social, and environmental options open to future generations. In simple terms, it is the practice of examining whether our current actions can be conducted in a way that has a more positive influence and impact moving forward.

While remote working was increasing in popularity due to improvements in internet technologies and SaaS applications from 2000 onwards [5], the 2019 pandemic accelerated adoption through necessity [5]. Today, research shows organisations have shifted away from the 5 days per week remote working enforced by the pandemic to a hybrid equivalent [13]. This simply means that companies enable some employees to work from both the office and an alternative location, such as 'home'.

Figures show the number of employees participating in hybrid working varies by region. As an example, in Europe the figure is close to 30% [14], while in the USA it is as high as 53% [15]. Globally, the average is 28% [16] with the optimum time spent working from home determined to be 2 days per week [13].

Research suggests that companies are moving towards this preferred model involving employees working for three days per week in a company office [13]. As such, to reduce commuting emissions ahead of low carbon global infrastructure change, the key to success lies within increasing employee participation in hybrid working programmes rather than trying to extend the number of days spent working from home. As an example, if 60% of the European workforce participated in hybrid working rather than current uptake [14], then current commuting emissions in the region would decline by almost one quarter.

To enable users to adopt hybrid working concerns such as information and device security and device mobility must be overcome. Citrix addresses both of these issues from a solutions standpoint. As an example, using a Citrix hybrid working solution means that the device effectively becomes a thin client with the user's desktop, applications and storage all occurring securely in a company or cloud data centre. As such, endpoint access can be undertaken on any device using a secure login and therefore offering security and user mobility.

However, one key aspect of sustainable EUC strategies is the reduction of device duplication. In this sense, EUC devices supplied by companies ought to be capable of operating in all situations to ensure only one computer maximum is required per user.

Research shows that EUC estates within commercial, public and third sector organisations include approximately one third 'static' computers [17, 18]. This includes desktop computers, all in one (AIO) devices, desktop thin clients and workstations. While these devices may be located either at home or in the office, by nature of their immobility they cannot regularly reside in both places on an individual user basis.

As such, too high a saturation of static devices will restrict employee participation in hybrid working strategies. As an example, if designated a static style device, office based employees are potentially denied the ability of hybrid working. This is because they cannot reduce their travel patterns as they must commute to access IT (CAIT). Obviously, employees faced with such a restriction could become responsible for a second device whether owned by the company or themselves. However, by doing so they increase their device carbon footprint two fold.

Comparatively, increasing the percentage of mobile EUC devices, such as notebooks, tablets, mobile thin clients and notebook workstations within an EUC estate can be considered suitable to support hybrid working uptake. This is because the devices can move with the employee as they change working location without the need for a second device. Additionally, as static devices have on average far greater carbon footprints and electricity consumption than mobile equivalents, increasing percentages of mobile devices will support sustainability strategies.

Considering this, the following sections examine the differing impact of device type choices and employee hybrid working participation when enabled by a Citrix solution. The examples include:

- EUC device Planet and Profit benefits achieved by increasing percentages of mobile computers
- Commuting GHG emissions abatement achieved by increasing employee participation in hybrid working

By doing so, two outcomes are achieved. Firstly the question, 'How does Citrix support sustainable ICT strategies via hybrid working?' is answered. Secondly, information is generated to enable the reader to consider hybrid working as a strategy for immediate climate action via the medium of sustainable ICT.

Methodology

To achieve the research objective, the first study calculates the Planet and Profit influence of differing percentages of static (e.g. desktops) versus mobile (e.g. notebooks) devices present in a 5,000 user EUC estate. Planet metrics relate to product carbon footprint and e waste and Profit metrics relate to procurement and utility costs.

This study is enabled by first generating an average percentage proportional representation of computer types commonly found within business EUC estates. This includes static devices (desktop, All-in-One, thin client, workstation) and mobile devices (notebook, mobile workstation and thin client, tablet). To achieve this, asset data from 3.2 million devices captured during Px^3 EUC carbon footprint reporting exercises is used [19]. Average Planet and Profit device metrics are generated using the Px^3 sustainable ICT application platform database [19]. Resulting GHG emissions results are presented in kilograms of carbon dioxide equivalent ($kgCO_2e$) in accordance with protocol. E waste is calculated in kilograms (kg) and electricity consumption in kilowatt hours per year (kWh/y). Concomitant scope 2 use-phase GHG emissions are calculated using relevant carbon intensity conversion factors. Procurement and utility costs are based upon averages experienced in the United Kingdom (UK) [19]. These metrics are multiplied by the relevant proportional representation for a 5,000 device EUC estate. The results are projected across an 8 year retention and proportionately adjusted to represent increments of change including a 100% static or mobile environment, a 75% variation, plus the standard environment. This enables comparison of the influence of static versus mobile computers in an EUC estate.

The second study examines the influence upon employee commuting GHG emissions caused by increased participation in hybrid working in a 5,000 user environment.

Commuting emissions data is drawn from a prior international research study on the subject [5]. This enables specific abatement values for Europe, USA and Globally to be determined. To enable this, annual commuting emissions for an individual employee for between 0 and 5 days is determined. This is then applied to the 5,000 user EUC estate showing 20% increments of employee remote working uptake (20% to 100%) together with increasing numbers of remote working days per week (0 to 5).

The findings enable demonstration of how increased participation in hybrid work aligned with a 2 days per week company policy and supported by sufficient mobile devices delivers significant commuting GHG emissions reduction.

Results

Mobile vs. Static EUC Devices to support Hybrid Working Strategies

The EUC device proportional representation calculations reveal that the average EUC estate consists of just over 68% mobile computers and 32% static computers [17, 18]. Therefore within a 5,000 user estate, 3,400 computers will be variations of notebooks, mobile thin clients, mobile workstations and tablets.

Comparably, 1,600 computers will be variations of desktops, All-in-One (AIO), desktop thin clients and workstations. As each static computer will require a monitor (1,600 in total) to function, the total EUC device count for a 5,000 user estate rises to 6,600.

In terms of the total product and use-phase carbon footprint, static computers are however dominant despite being less in number. This is because desktop and monitor combinations are on average +266% higher in GHG emissions when kept for the proposed ideal lifespan of 8 years (Figure 1). While 66% of the static devices' total carbon footprint is generated by the supply chain, the disparity is also highly influenced by use-phase emissions.

Specifically, the combination of a static computer and monitor consumes +635% more electricity each year than a mobile device (Figure 1).

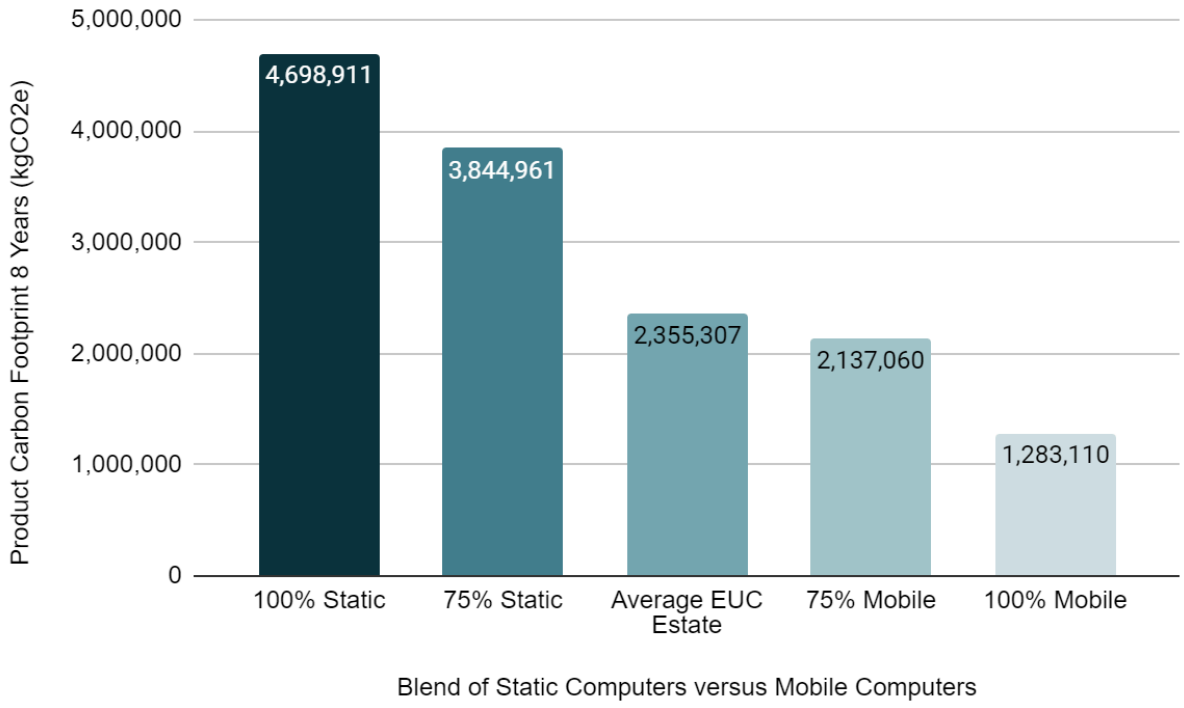
Based upon this finding, it is reasonable to suggest that increasing mobile computer numbers within the 5,000 user group will both reduce Planet and Profit impacts, while removing the immobility barrier to employee hybrid working participation.

To demonstrate the product influence, figure 1 shows that an average EUC estate will generate 2,355,307 $kgCO_2e$ of combined supply chain and use-phase emissions during an 8 year period.

Changing the blend to include 100% static devices causes the carbon footprint to rise by +99% to 4,698,911 $kgCO_2e$ (Figure 1). Similarly, should the same estate transition to 100% mobile, then the carbon footprint declines by 45% to 1,283,110 $kgCO_2e$ (Figure 1) when compared to the standard estate.

In context, the difference of 3,415,801 $kgCO_2e$ of emissions between the two 100% scenarios (Figure 1) requires a 2 km^2 mature forest every year for 8 years to remove the carbon from Earth's atmosphere.

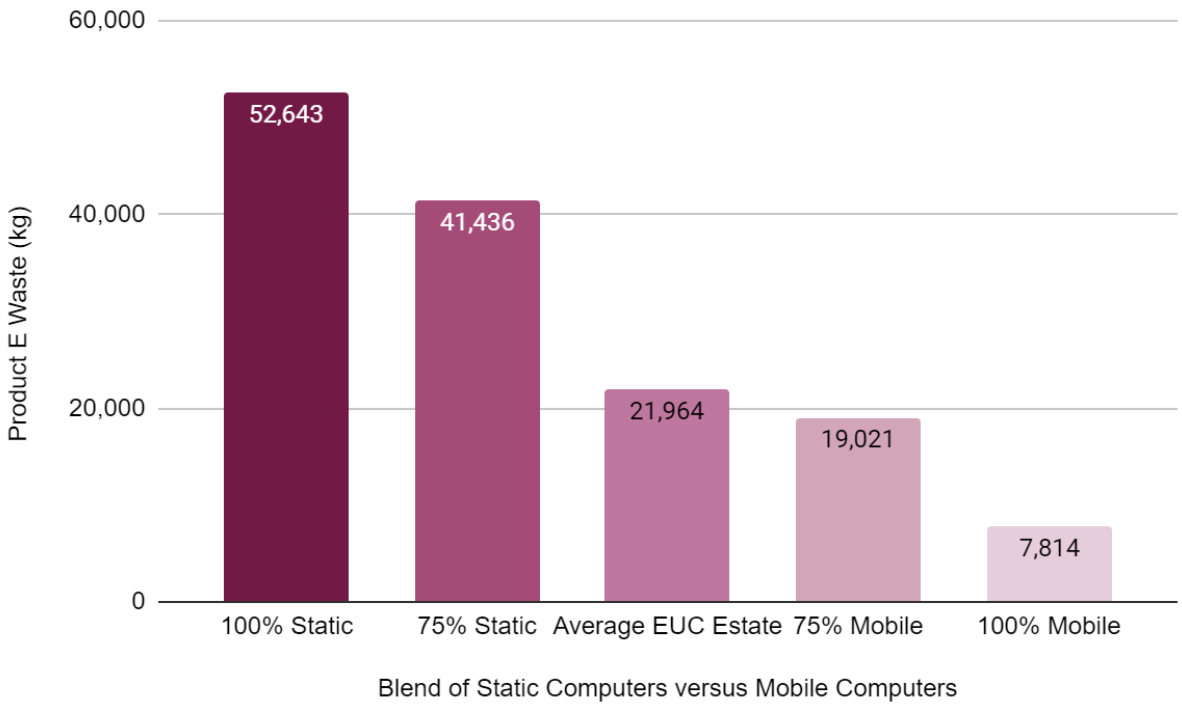
Figure 1. Comparing the lifespan (8 years) carbon footprint for a 5,000 device EUC estate when introducing differing percentages of static versus mobile devices



Because mobile devices are lighter than their static counterparts, e waste is also influenced when proportional representation changes. Figure 2 shows that the same average 5,000 user estate generates 21,964 kg of potential e waste based upon a third desktops and two thirds mobile devices. Comparatively, if the EUC environment is populated with 100% desktop style computer and monitor combinations, then the e waste value rises by +140% (Figure 2). This is simply because on average static devices are +553% heavier than mobile devices (Figure 2).

Therefore, because of the weight disparity an entirely mobile EUC strategy reduces potential e-waste values by 65% to 7,814 kg (Figure 2). This is 85% lower than an entirely static strategy and in comparison, avoids 44,829 kg of EUC hardware that will eventually require recycling and disposal services. Reducing e waste supports sustainability strategies by introducing elements of a circular economy. In this example, less e waste reduces resource depletion as less material is required during production. Equally, as the devices are lighter on average, then fewer associated transportation and distribution GHG emissions are created during the supply chain phase of the product's life cycle.

Figure 2. Comparing e waste (kg) for a 5,000 device EUC estate when introducing differing percentages of static versus mobile devices



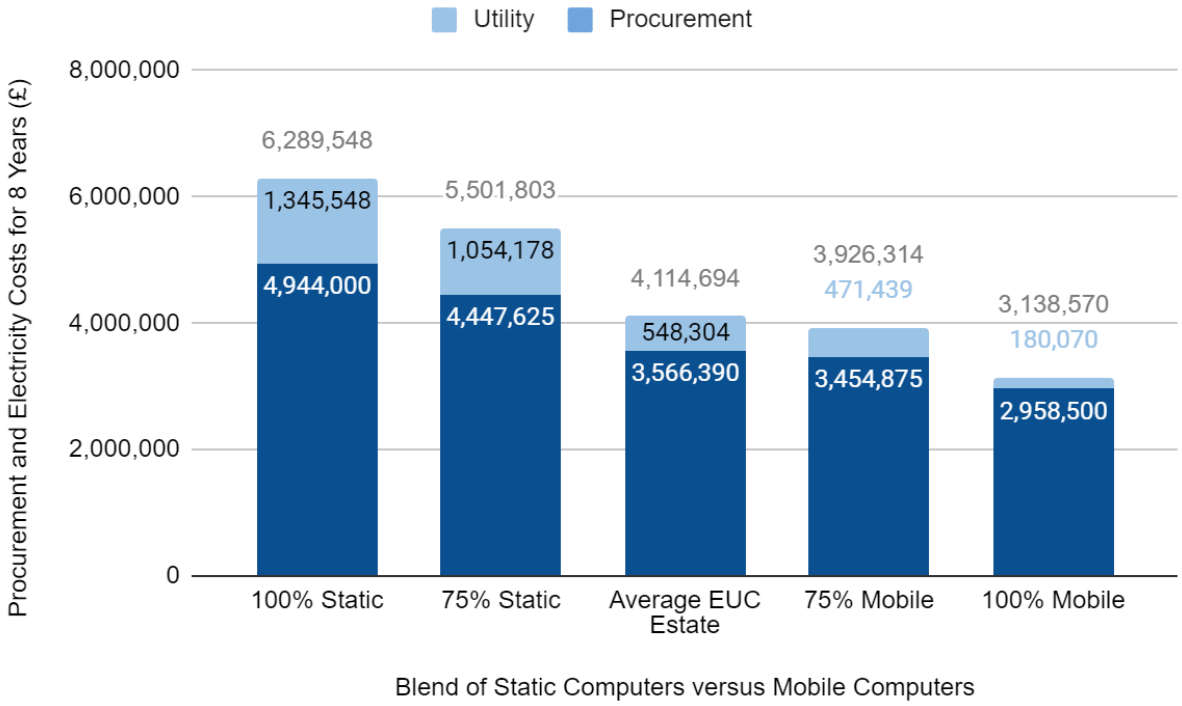
As demonstrated, it is clear that increasing device mobility percentages within EUC estates improves Planet metrics. From a Profit perspective procurement and utility costs can also be reduced. This is achieved by two key influencing factors. Firstly, the combined cost of a monitor and desktop is on average +66% higher than the cost of a single notebook computer (Figure 3). Secondly, as previously noted desktop and monitor combinations consume +635% more electricity each year than a mobile device (Figure 3).

Figure 3 shows that within an average 5,000 user EUC estate the cost of combined electricity and procurement during an 8 year retention period is £4.1 million.

Should an organisation have a 100% static device strategy, then this rises by +53% to £6.3 million (Figure 3). Comparatively, should an organisation transition to a 100% mobile strategy, then when compared to the standard environment, costs reduce by 24% to £3.1 million (Figure 3).

Comparing the two extremes, the difference in cost is £3.2 million between the highest cost associated with an all static approach and the lowest cost of an all mobile approach (Figure 3). This means that the available -51% cost reduction equates to saving of £393,872 annual saving for each of the 8 years.

Figure 3. Comparing hardware procurement and electricity costs (£) for a 5,000 device EUC estate during 8 years when introducing differing percentages of static versus mobile devices



Examining Planet and Profit improvements it is evident that when compared to standard EUC environments, an all mobile strategy offers an average 45% reduction in GHG emissions, 65% less potential e-waste and reduces product lifespan costs by 24%.

Faced with such disparity between mobile and static device strategies, it is reasonable to question why EUC estates do not transition to 100% mobile strategies. While desktop devices retain a position within company EUC estate provision, global production figures indicate that despite this behaviour, a trend towards mobility is in fact already underway.

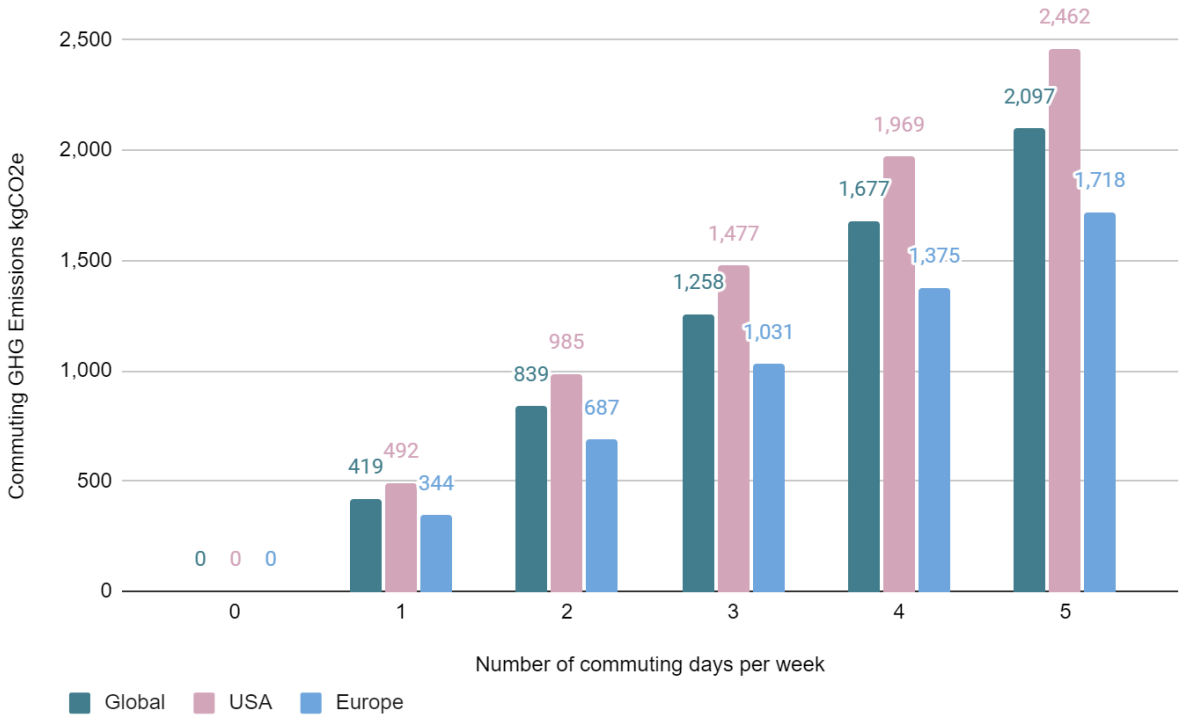
Specifically, static device sales have declined by 25% in the last 5 years [20]. Comparatively, notebook sales are experiencing 3% compound annual growth and tablets rising by 18% year on year [21].

Citrix hybrid working solutions: Commuting GHG emissions abatement

Exploring the positive Planet and Profit benefits of increasing device mobility, effectively helps to remove the barrier of adopting 100% mobile environments at an equipment level. In simple terms, if doing so supports climate action, helps circularity and reduces costs then resistance to the concept becomes all the more difficult. With this in mind the following study assumes that supplying every employee with a mobile device is feasible. Because of this, 100% employee participation in hybrid working becomes a theoretical possibility.

To determine the impact of increasing employee participation upon Planet metrics, an individual value for annual commuting emissions is determined. Research shows that should an employee commute to work for all 5 days of each working week, the annual average commuting emissions are 2,097 $kgCO_2e$ [5]. In context, this requires 95 mature trees every year to remove the resulting carbon from Earth's atmosphere [19]. The value represents a global average and as figure 4 shows, emissions are influenced by location and travel habits. As an example, research shows that commuting in Europe involves shorter distances when compared to the USA overall [5]. Additionally, travel modes differ between the two regions, with car travel being more popular in the USA [5]. Coupled with larger engine capacities in the USA, car emissions per km travelled increase too [5].

Figure 4. Determining commuting GHG emissions (kgCO2e) generated by a single employee annually based upon the number of commuting days per week

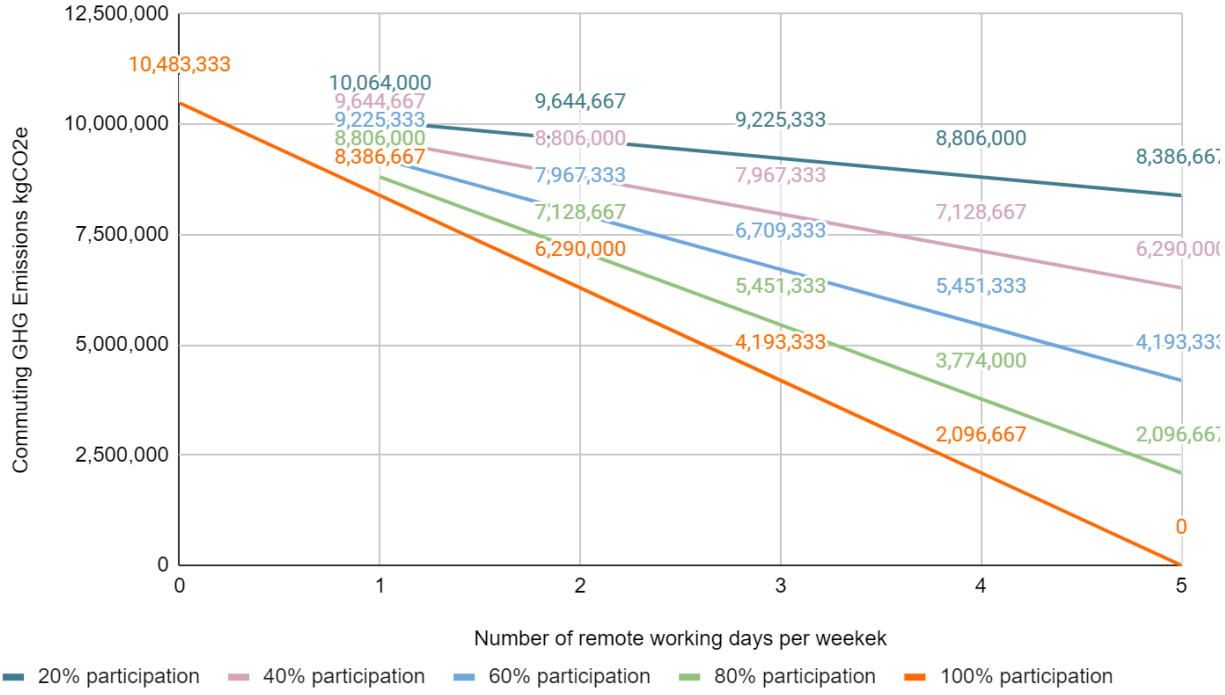


Consequently, a commuter in the USA will generate 2,462 $kgCO_2e$ of GHG emissions on average each year (Figure 4), whereas in Europe this decreases by 30% to 1,718 $kgCO_2e$ (Figure 4). Circling back to the average hybrid working employee participation noted in the introduction, this means that increased participation in areas with higher per capita commuting emissions is vital to successful travel related abatement strategies.

Logically, for each day spent not commuting the annual impact will reduce in all cases by 20% (Figure 4). Therefore using an average of 2 days spent remote working per week [13] and the global emissions value, an employee will generate 1,258 $kgCO_2e$ of commuting emissions annually (Figure 4) .

Having determined an individual's commuting carbon footprint, the influence of the percentage uptake of employees is examined. As such, in figure 5, 20% incremental percentage increases of hybrid working participation are plotted against numbers of days spent remote working per week. In this example it is assumed that those employees not participating in hybrid working are commuting 5 days per week. Unsurprisingly, the greatest volume of commuting GHG emissions are generated when 100% of employees partake in zero remote working days. Figure 5 highlights that for the 5,000 user group, this strategy generates 10.5 million $kgCO_2e$ of emissions annually.

Figure 5. Comparing commuting GHG emissions ($kgCO_2e$) generated by 5,000 employees when influenced by increasing participation and number of remote working days per week



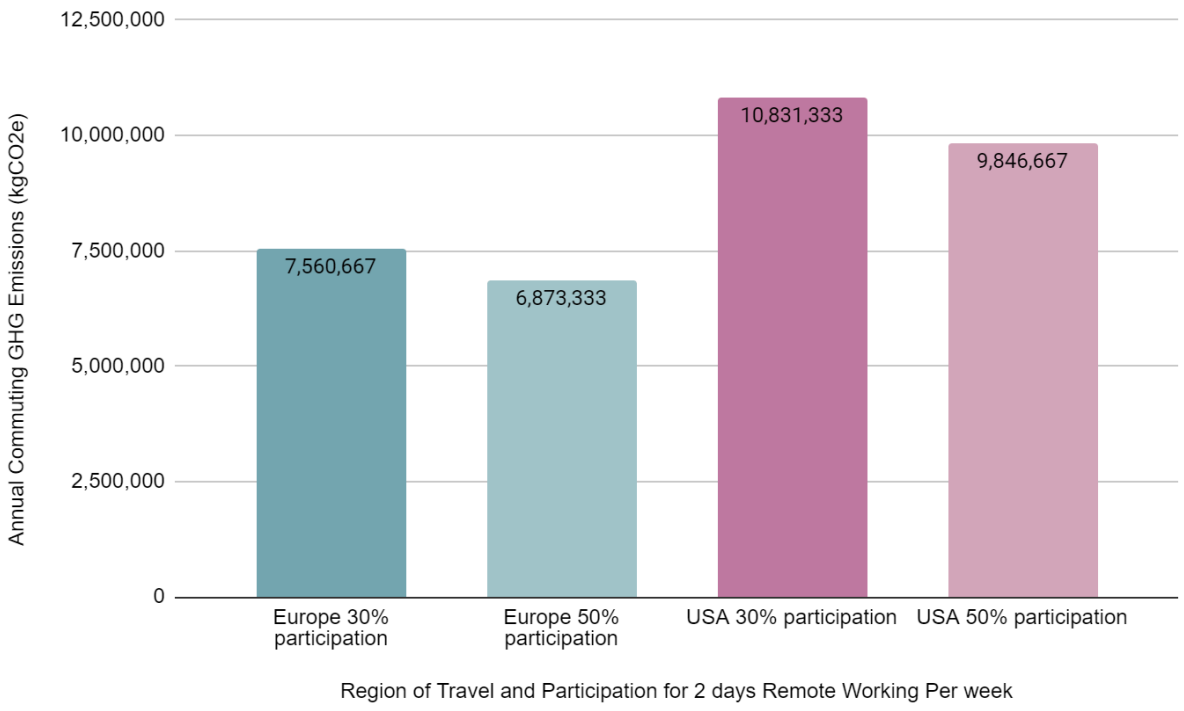
Examining the current average trend of 2 days remote working per week [13], emissions range from 9.7 million $kgCO_2e/y$ with 20% participation (Figure 5), to as low as 6.3 million $kgCO_2e/y$ with 100% uptake (Figure 5).

In context, the difference of 3,354,667 $kgCO_2e/y$ between the two results is equivalent to avoiding 19,751,925 km being driven by a combustion engine car [19]. This is equal to driving 493 times around Earth's circumference.

In the same instance, if a standard EUC environment currently restricts employee participation in hybrid working to a maximum of just under two thirds [17, 18] due to one third of devices being static, the resulting commuting emissions will be 27% higher at 8 million $kgCO_2e/y$ when compared to 100% uptake. The emissions difference between the two strategies requires 76,242 mature trees every year to remove the carbon from Earth's atmosphere [19].

The influence of regional emissions versus participation within a 5,000 user EUC environment is equally important. Figure 6 shows the European average commuting GHG emissions per year for 2 days remote working per week to be 7.6 million $kgCO_2e$. The same level of participation in the USA generates 43% more emissions caused by differences in travel distances, modes and vehicle carbon intensity [5] (Figure 6).

Figure 6. Comparing commuting GHG emissions ($kgCO_2e$) generated by 5,000 employees when influenced by region



Consequently, even at 50% participation in the USA, commuting emissions per capita exceeds the Europe value at 30% participation (Figure 6). Specifically, current estimated commuting emissions for a 5,000 user estate are 9.9 million $kgCO_2e$ with half of all employees partaking in hybrid working. While in Europe, even with only one third participating, emissions remain 23% lower (Figure 6).

Summary

The two studies clearly indicate that sustainability strategies are supported by a combination of mobile style devices, such as notebooks, in preference to desktops and increased employee participation in hybrid working schemes.

In the first example, for a 5,000 user group transitioning to mobile devices can reduce product carbon footprint by 45%, avoiding 1,027,197 $kgCO_2e$ of GHG emissions (Figure 1). Additionally, e waste is reduced by 65% (Figure 2) and cost by 24% (Figure 3). Specifically, an estimated £976,124 is saved by moving from static desktops to notebooks and tablets (Figure 3). As device Planet and Profit metrics are improved with mobility and Citrix solutions address security concerns, then the barrier to achieving 100% participation in hybrid working is effectively removed.

Compared to today's average uptake of approximately just under 30% [16] of people participating in hybrid working for 2 days per week, the difference in achieving total participation is significant. For a 5,000 user environment the annual commuting GHG for 30% participation is 9,225,333 $kgCO_2e$. With all employees participating in hybrid working, an additional 2,935,233 $kgCO_2e$ of commuting GHG emissions can be avoided every year. This is equivalent to emissions created by a combustion engine car travelling 17,282,342 km. A distance equal to driving around Earth's circumference 431 times.

In specific circumstances, the resulting abatement can actually be higher when examining the long term benefits. Research shows that a UK Greater London Council with 4,069 employees was enabled from 2020 onwards, to reduce annual employee car commuting mileage by 40% [22]. The Citrix solution enabled employees to work from home for two days per week. As such, previous annual commuting emissions were reduced from 3,224,146 $kgCO_2e$ to 1,931,708 $kgCO_2e$ [22]. Having now been in place for 4 years, the scheme has avoided a total of 5,169,752 $kgCO_2e$ [22]. In context, this has avoided 3.4 million car kilometres being travelled on local roads; a distance equivalent to driving 760 times around Earth's circumference.

In conclusion, having generated compelling reasons for the reader to consider adoption of a secure hybrid working solution, it is reasonable to suggest that the question, 'How does Citrix support sustainable ICT strategies via secure hybrid working?' is answered.

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About Px³

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

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Founded in 2013, Px³ is a world leading sustainable ICT research and consulting organisation. Working globally for leading ICT manufacturers, eco certification labels, governments, commercial, public and third sector organisations, our aim is to drive climate action via the adoption of sustainable ICT.

This is achieved by combining our research and consulting skills with our unique sustainable ICT applications platform. The Px³ sustainable ICT cloud-based applications platform is the only solution of its kind in the world to be validated by science.

Already being used by organisations responsible for millions of computer users, the platform was researched, developed and peer reviewed during PhD research conducted at the world leading University of Warwick Computer Science Faculty. Consequently, the data produced is compliant with GHG accounting protocols, international Life Cycle Analysis (LCA) and electronic equipment energy testing standards and sustainable procurement legislation.

The Px³ applications platform enables organisations to create baseline ICT carbon footprint and energy consumption baseline reports. Then to model strategic policy changes such as selecting low carbon footprint devices and extending device lifespans to significantly reduce ICT GHG use phase and supply chain emissions, e-waste, electricity consumption, utility and procurement costs.

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.

Dr Sutton-Parker is widely published in scientific journals, a national government policy contributor, regular public speaker, digital green educator and 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.

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