Device Use Phase Analysis (DUPA): Active Mode and Use Phase Energy Consumption Measurement Technical White Paper

MARKETING NAME	HP T640 Thin Client
CATEGORY	Computer (Desktop, Thin Client)
MODEL NUMBER	T640
MANUFACTURED	2020
TESTING REGION	Europe (United Kingdom) 230 V ac
TEST DATE	July - August, 2021

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Overview

International end user computing (EUC) presale energy benchmarks measure no-user present power draw and electricity consumption for operational modes such as 'off', 'sleep' and 'idle'. This is undertaken to provide prospective purchasers with an indication of the device energy efficiency and allows for comparison between available brands and models.

However, such benchmarks do not include the impact of user interaction upon the computer's energy consumption performance as the device carries out useful work. During this 'active' mode, the EUC device will consume additional electricity as it processes requests, seeking data from storage, memory, or cache and populating the screen with images. Additionally, depending upon variables such as the type of operating system (OS), EUC device energy efficiency varies considerably during the active mode. As such, without a clear understanding of power demand during use, annual typical energy consumption (TEC) cannot be calculated to reflect real world scenarios.

Not having access to such information not only prevents associated energy costs to be accounted for, it also prevents accurate greenhouse gas (GHG) emissions generated by EUC device use from being assessed and reported. As an example, GHG accounting protocol for scope 2 (electricity purchased for consumption) requires quantities of carbon dioxide equivalents (CO_2e) to be calculated as 'neither over nor under actual emissions'. As such, excluding the energy used during the active mode causes associated carbon footprint reporting to be both inaccurate and therefore non-compliant. As an example, research highlights that not accounting for this active mode causes associated EUC GHG accounting to be underestimated by 30% and abatement opportunities of up to 55% to be overlooked [1].

Consequently, the Px^3 'device use phase analysis' (DUPA) fills the information void by generating data highlighting energy performance in the field. Specifically, the Px^3 DUPA field measurement process accurately captures power draw (watts) and energy consumption values (kilo-watt hours) for EUC devices during the active mode. Two data sets are produced during the comprehensive analysis. The first 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 includes real world user scenarios such as energy consumption during a working day that reflect accurately how a device performs when used in a commercial environment.

Equipped with this valuable data EUC device manufacturers, commercial and public sector organisations and users can accurately assess annual energy consumption.

Doing so enables:

- Informed EUC device procurement based upon accurate environmental impact criteria.
- Accurate EUC device GHG product carbon footprint reporting.
- Accurate EUC device GHG emissions accounting and reporting required to comply with associated national and international legislation.
- Accurate EUC device GHG emissions calculation to be included in Corporate and Social Responsibility (CSR) and Environmental Social and Governance strategies.

[1] Sutton-Parker, J. (2020). 'Determining end user computing device Scope 2 GHG emissions with accurate use phase energy consumption measurement.' 10th International Conference on Sustainable Energy Information Technology. Amsterdam: Elsevier Procedia Computer Science

Test Set Up and Conduct

In order to ensure accurate power draw and energy consumption measurement the DUPA test set up and conduct methodology is undertaken in accordance with international standards. Specifically, International Electrotechnical Commission (IEC) standards IEC 62301:2011 household electrical appliances measurement of standby power and IEC 62623:2012 desktop and notebook computers measurement of energy consumption.

Before testing begins, the equipment under test (EUT) is charged to 100% when a battery is present (e.g. a notebook or tablet). The device is then power drained (if relevant) to 0% twice before being fully charged ahead of measurement. This is undertaken to create parity across differing brands and models by ensuring equivalent battery calibration.

The input power source selected is determined by the country or region that the device will operate within. As an example, a DUPA test conducted for the United Kingdom (UK) will connect to an alternating current (AC) mains supply connected to a UK voltage source (230 V ac). In order to emulate a standard office or home working environment the measurement facility's 'ambient temperature' is controlled. The temperature ranges from 18^{o}C and 28^{o}C with differing temperatures applied as various stages of the process to examine for environmental influence.

In order to ensure measurement accuracy, instrumentation used to meter power draw (W) and energy consumption (kWh) meet the IEC standards. Specifically, the metering equipment is proven to be accurate to within 0.2%, enabling ten times higher precision than required by associated standards.

In accordance with international non-user present benchmarking and manufacturing design standards the sleep/alternative low power mode is set to activate after no more than 30 minutes of user inactivity. Additionally, the display sleep mode is set to activate after no more than 15 minutes of user inactivity. Where applicable, screen brightness is switched to 100% on all EUT to ensure parity between differing models and brands. Bluetooth capability is switched off as standard although additional measurement is undertaken with this function activated as detailed by the conduct phase.

Active Mode Test Conduct

The test conduct is carried out according to the requirements of the aforementioned IEC standards. The objective of the conduct is to produce highly accurate data for the energy performance of an EUC device whilst being used for commercial and leisure tasks.

The active mode is defined as the power state in which the computer is carrying out useful work in response to prior or concurrent user input and includes active processing, seeking data from storage, memory, or cache, including Idle State time while awaiting further user input and before entering low power modes.

To allow for accurate measurement of the EUT power draw and energy consumption during the active mode both, structured and unstructured tests are conducted.

Structured

To enable parity between brands and models of EUC devices, structured active mode tests are conducted. The rationale being that each test will be identical in format regardless of the EUT type or specification. As such, the results enable 'level playing field' comparison between brands, model and types of EUC devices to support both sustainable device procurement decisions and environmental reporting.

The structured tests include:

- The Structured Day: The EUC device is measured for energy consumption (kWh) and high-low power draw (W) whilst subject to a structured working day for 5 days between the hours of 9am and 5pm. Identical user operations are conducted each day to ensure consistency. As an example, defined periods of productivity tasks, video streaming, video conferencing and internet calling together with a 30-minute lunchtime construct the 8-hour time frame. To ensure parity with regards to software application impact on energy consumption and to reflect modern working practices, all applications are browser based.
- Productivity Tasks: The EUC device is measured for energy consumption (kWh) and high-low power draw (W) whilst subject to productivity tasks such as messaging, document creation and review, spreadsheet population and review, web based application interaction, web browsing, and presentation. Each task is undertaken for eight one hour periods.
- Video Conference: The EUC device is measured for energy consumption (kWh) and high-low power draw (W) whilst subject to video conferencing with both the camera on and off (when applicable). Each session is undertaken for eight one hour periods.
- Video Streaming: The EUC device is measured for energy consumption (kWh) and high-low power draw (W) whilst subject to video streaming. Each session is undertaken for eight one hour periods.

Unstructured

The unstructured test includes:

- The Unstructured Day: The EUC device is measured for energy consumption (kWh) and high-low power draw (W) whilst subject to an ad hoc working day for 60 days between the hours of 9am and 5pm. User operations including productivity and video based tasks are conducted each day as and when required to reflect a ‘natural working day’. In line with current research a 30-minute lunch break is included within the 8-hour time frame.

Battery Only Operation

The battery only operation test includes (applicable to mobile devices only):

- Battery Only: The EUC device is measured for the time taken between initial 100% charge and reaching 0% charge before switching to sleep mode. During this period the device remains disconnected from a power source and subject to an ad hoc working day for 5 days between the hours of 9am and 5pm. User operations including productivity and video based tasks are conducted each day as and when required to reflect a ‘natural working day’. In line with current research a 30-minute lunch break is included within the 8-hour time frame. The EUC device battery is also measured for the time taken to re-charge from 0% to 100% full charge and the energy required to do so.

All data and results are reported as measured and where appropriate are represented in 1 hour increments. This is undertaken in order to enable annual values and representations highlighted in associated Px^3 scope 2 GHG emissions reports.

End User Computing Device Specification

The asset profile specification of the equipment under test is as follows:

Table 1 – EUT specification

TYPE	Desktop Computer, Thin Client
MARKETING NAME	HP T640 Thin Client
MODEL NAME	T640
MODEL NUMBER	7TK40UT#ABA
OPERATING SYSTEM	IGEL OS
SCREEN	NA
PROCESSOR BRAND	AMD
PROCESSOR NAME	Ryzen R1505G
BASE PROCESSOR SPEED PER CORE (GHz)	2.4 GHz
PHYSICAL CPU CORES (COUNT)	2
SYSTEM MEMORY (GB)	3.9GB (3712 MiB)
HARD DRIVE	16GB
DEFAULT LOW POWER MODE	Sleep
SLEEP MODE DEFAULT TIME UPON SHIPMENT (MINUTES)	20
DISPLAY SLEEP MODE DEFAULT TIME UPON SHIPMENT (MINUTES)	NA

Results

The results section is organised to reflect the test conduct methodology and designed to support the population of associated and subsequent use phase greenhouse gas emissions reports. GHG values are not included within this report. The rationale being that whilst electricity consumption is constant within regions, electricity conversion factors used to generate GHG accounting values (CO_2e) differ between countries. As such, the power, energy and time values represented act as the scientific foundation for all future environmental and financial extrapolations.

Power draw values are represented in watts (W), energy consumption in kilo-watt hours (kWh) and time in hours (hr), minutes (min) and seconds (sec).

A 'Watt' is the international system of units (SI) unit of power, equivalent to one joule per second. In simple terms the watt is a method of measuring the rate of energy transfer of an electrical appliance such as an EUC device. As an example, more intensive computing tasks such as video streaming with ever changing and bright backgrounds plus sound production require increased 'power draw' than binary activities such as email. Think of it as the momentary effort required to enable a task and not the time taken and total energy required to complete a task.

The energy consumption value (kWh) is generated automatically by the measuring equipment and contextually reported by automated data loggers. The internationally recognised calculation is achieved by multiplying the power (watts) value supplied to the device by the length of time (hours) the device is used, divided by equivalent energy used by a 1,000W electrical device for one hour.

Consequently, measured energy in kWh is expressed as follows:

$$\text{kWh} = \frac{\text{Watts}}{1000} \times \text{Time (hr)}$$

As such when interpreting this report, readers should consider the kWh value as the electricity consumed whilst actively using the EUC device.

As noted on the methodology the results include:

- Energy Consumption: Unstructured Working Day 9am to 5pm
- Energy Consumption: Structured Working Day 9am to 5pm
- Energy Consumption: Battery Drain during the Unstructured Day 9am to 5pm
- Power Draw: By Task, Productivity
- Power Draw: By Task, Video
- Energy Consumption Rating

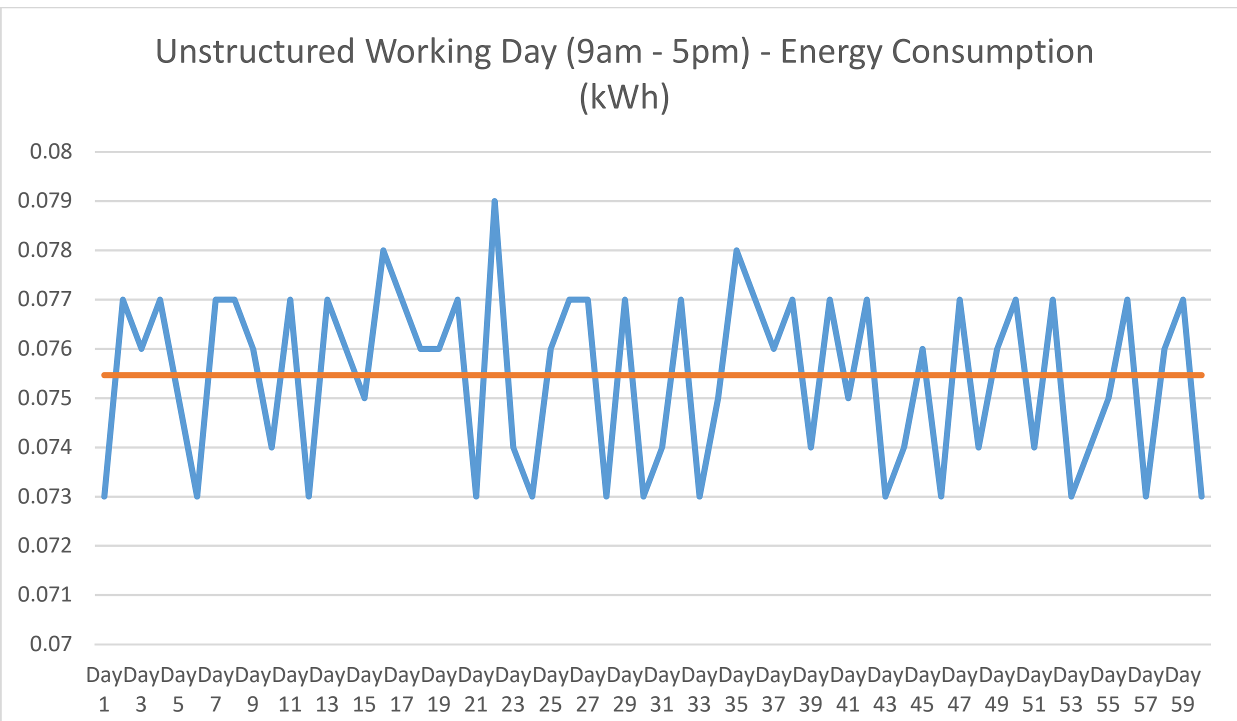
Energy Consumption: Unstructured Working Day 9am to 5pm

The EUC device under test consumed between 0.073 and 0.079 kWh of electricity per unstructured working day (9am and 5pm). This represents a range of 8% between the lowest to highest use phase electricity consumption when subjected to a full range of video and productivity tasks. The average daily consumption for the sixty-day measurement period is 0.0755 kWh. This generates an average hourly energy consumption value of 0.0094 kWh.

Table 2 – EUC device daily electricity consumption when operated 9am to 5pm in an unstructured manner

Daily Energy Consumption Range	0.073 kWh to 0.079 kWh
Daily Power Draw Range	Lowest 7.6W to Highest 23.4W
Average Daily Energy Consumption	0.0755 kWh
Average Hourly Energy Consumption	0.0094 kWh

Figure 1 – EUC device daily electricity consumption when operated 9am to 5pm in an unstructured manner



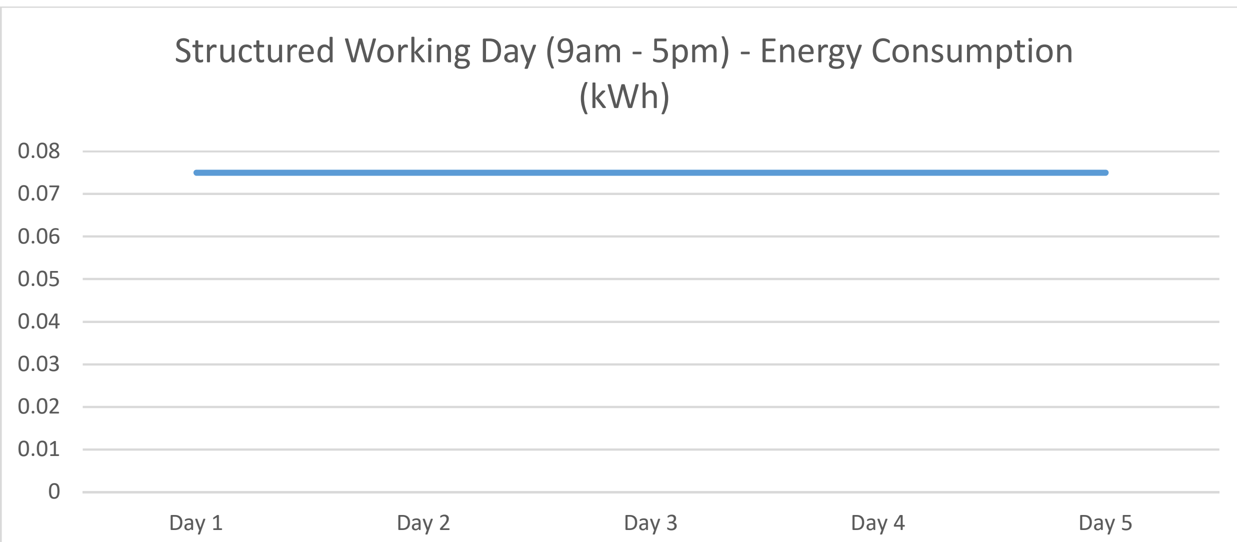
Energy Consumption: Structured Working Day 9am to 5pm

The EUC device under test consumed 0.075 kWh of electricity per structured working day (9am and 5pm). This generates an average hourly energy consumption value of 0.0094 kWh. This represents consistent energy consumption during the measurement period. Compared to the unstructured day the device's energy consumption values for the measurement periods are congruent. Specifically, the data sets produce an average daily energy consumption value within a 5% range.

Table 3 – EUC device daily electricity consumption when operated 9am to 5pm in a structured manner

Daily Energy Consumption Range	0.075 kWh (+/- 5%)
Daily Power Draw Range	Lowest 7.6W to Highest 23.4W
Average Daily Energy Consumption	0.075 kWh
Average Hourly Energy Consumption	0.0094 kWh

Figure 2 – EUC device daily electricity consumption when operated 9am to 5pm in a structured manner



Power Draw by Task

Measuring the EUT power draw whilst conducting a variety of tasks enables identification of energy consumption expectation associated with specific roles. This proves useful to organisations that undertake longer durations of certain activities when assessing an EUC device for environmental performance. As an example, an organisation supplying training or education services may experience longer periods of video conferencing during the working day compared to a company offering administrative services. As such the following section details the results of the EUT when measure for power draw recorded as watts. The data is represented as the highest and lowest power draw required during the activity together with a 1-hour energy consumption value. The intention of the latter value is to enable working days to be constructed to support associated GHG reporting not included within this technical report.

Productivity Tasks

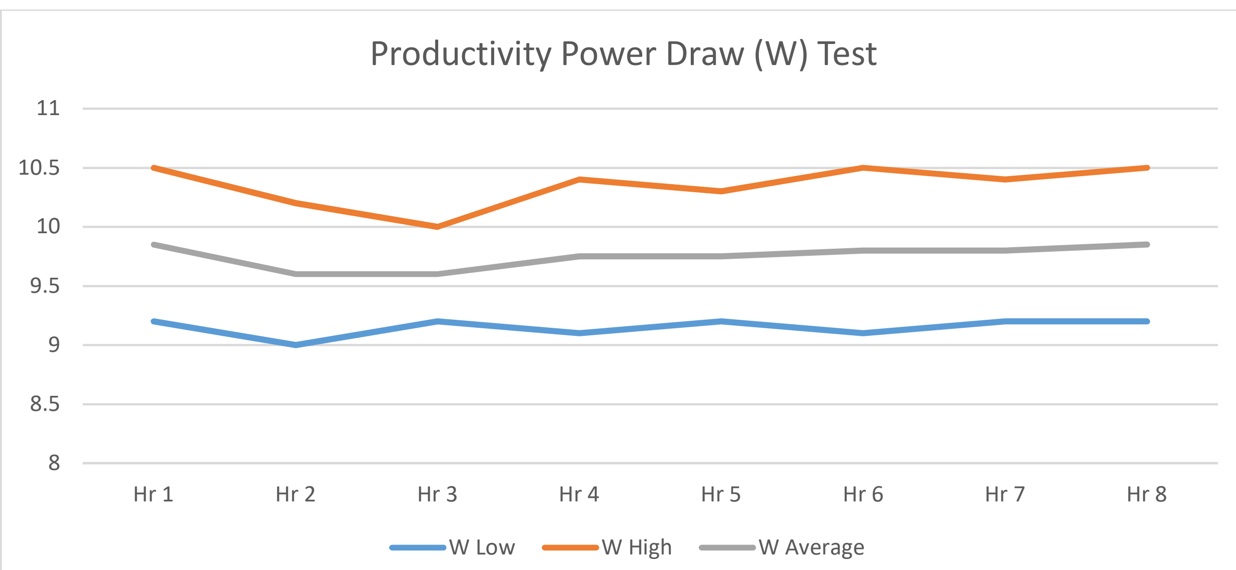
Productivity tasks include messaging such as email, document creation and review, spreadsheet population and review, web based application interaction, web browsing, and presentation.

The EUC device under test drew between 9W and 10.5W of power when conducting productivity tasks creating a high / low range of 16%. The power average was 9.75W and the energy consumed per hour was determined to be 0.0098 kWh.

Table 4 – EUC device power draw and energy consumption for productivity tasks

Productivity Task Power Draw Range	9W to 10.5W
Productivity Task Power Draw Average	9.75W
Average Hourly Energy Consumption	0.0098 kWh

Figure 3 – EUC device power draw for productivity tasks



Video Conferencing

Video conferencing includes inactive participation (watch and listen) and active participation (presenting and or communicating). Power draw is measured in two scenarios including 'camera off' and 'camera on' mode when measuring devices with an integrated camera and only in camera off mode for desktop computers. The rationale being that the monitor connected to the desktop computer powers the camera. Video conferencing is determined as utilising a business communications platform accessed via an internet browser.

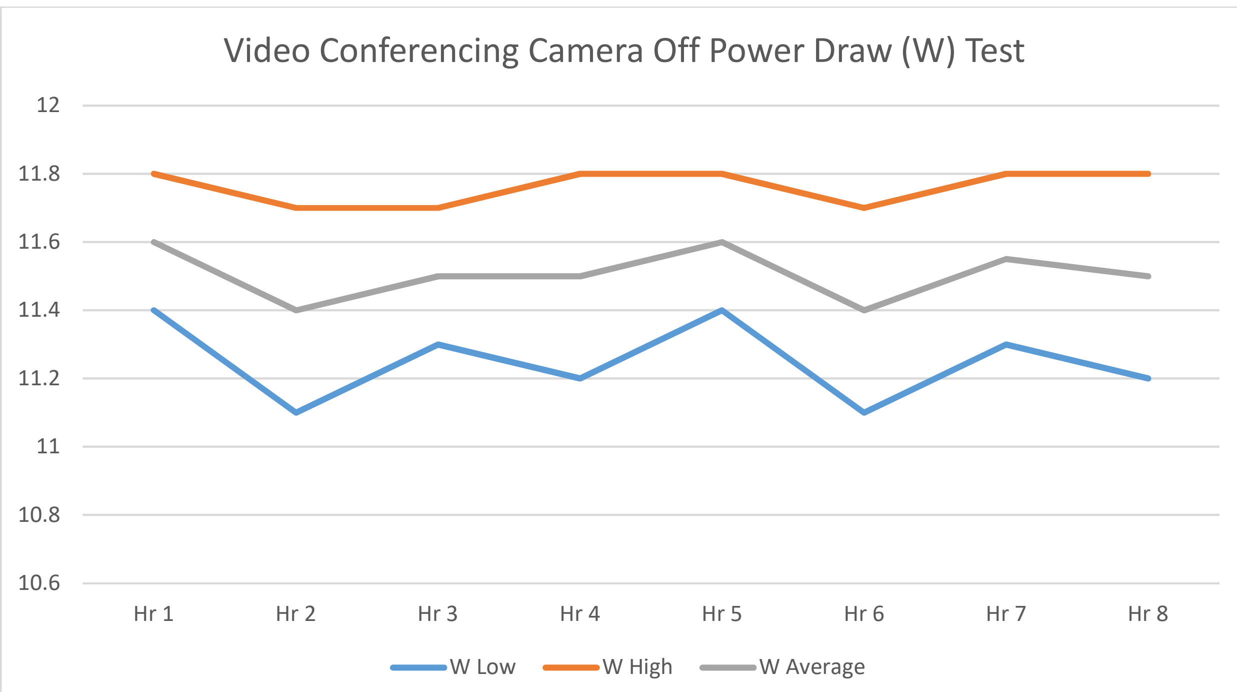
Camera off

The EUC device under test drew between 11.1W and 11.8W of power when conducting video conferencing with the device camera switched off creating a high / low range of 6%. The power average was 11.5W and the energy consumed per hour was determined to be 0.012 kWh.

Table 5 – EUC device power draw and energy consumption for video conferencing (camera off)

Video Conferencing Camera Off Power Draw Range	11.1W to 11.8W
Video Conferencing Camera Off Power Draw Average	11.5W
Average Hourly Energy Consumption	0.012 kWh

Figure 4 – EUC device power draw for video conferencing (camera off)



Video Streaming

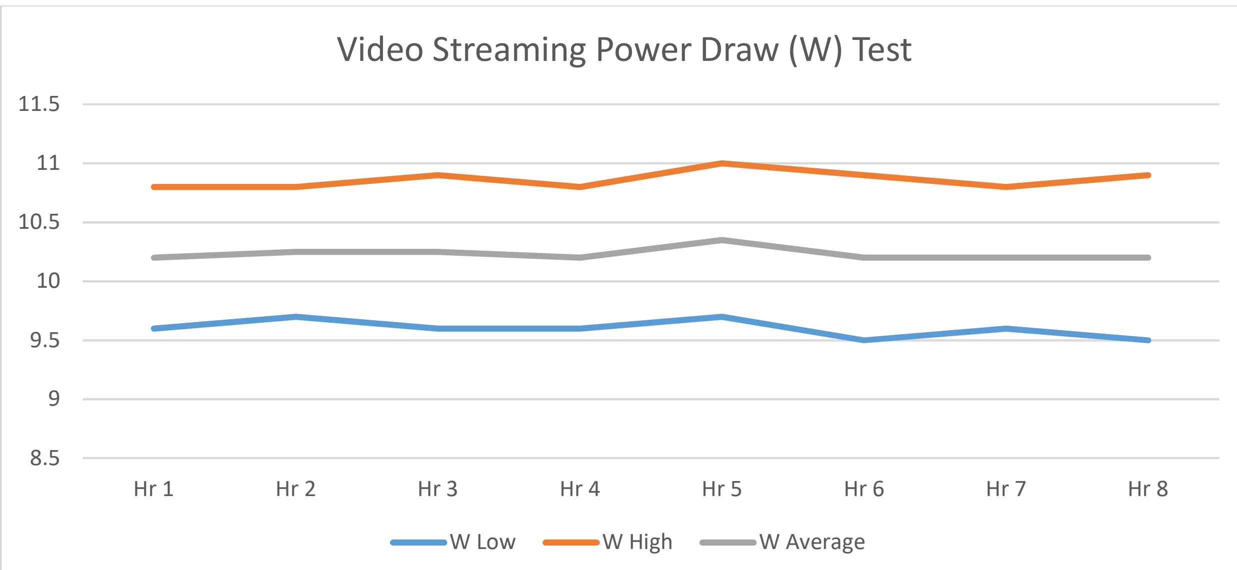
Video streaming is determined as streaming digital content via an internet browser from video sharing and content platforms. Although similar to video conferencing in camera off mode, the display and sound continuity variation coupled with a lack of capability to communicate and interact causes video streaming to be worthy of individual analysis.

The EUC device under test drew between 9.5W and 11W of power when conducting video streaming creating a high / low range of 16%. The power average was 10.2W and the energy consumed per hour was determined to be 0.0102 kWh.

Table 6 – EUC device power draw and energy consumption for video streaming

Video Streaming Power Draw Range	9.5W to 11W
Video Streaming Power Draw Average	10.2W
Average Hourly Energy Consumption	0.0102 kWh

Figure 5 – EUC device power draw for video streaming



Px^3 'Silent Sole' Energy Efficiency Certification Rating

All EUC devices measured using the DUPA methodology receive a Px^3 energy efficiency certification. This is called the 'Silent Sole' certificate. The numeric value shown within the digital footprint icon represents human steps. The number of steps indicated expend the equivalent amount of energy as consumed by the EUC device in one business day (9am to 5pm). The electricity consumption is converted to human steps for two reasons. The first is to achieve a universal constant offering the same value regardless of location. This is due to both steps and electricity being quantified in the same manner across the world. As an example, if GHG emissions were used as an alternative to equivalent steps, the results would differ from country to country. This is due to the differing percentages of green, renewable and fossil derived energy that supply each nation's electricity grid and therefore affect the carbon intensity of the electricity consumed. The second reason is to simply create a tangible analogy that can be instantly recognised and understood by all. As such, we believe that the concept of equivalent steps demystifies the often complex unit of 'kWh' applied to electricity consumption. Do so causes the results to be universally meaningful.

Colour too plays a key role in certification. A green 'Silent Sole' indicates that the device is among the most efficient tested within its classification, such as a notebook, tablet or desktop computer. Whereas amber or red indicate the device has not reached the 'green' classification threshold. The requirements to attain the various environmental thresholds are as highlighted in figure 8. In summary, devices achieving less than 1500 equivalent steps receive a green Silent Sole. Devices achieving between 1501 and 2000 equivalent steps receive an amber certification, whilst red is awarded for energy equivalent to in excess of 2000 steps.

Figure 6 – DUPA EUC Device Active Mode Energy Consumption Thresholds for Ratings

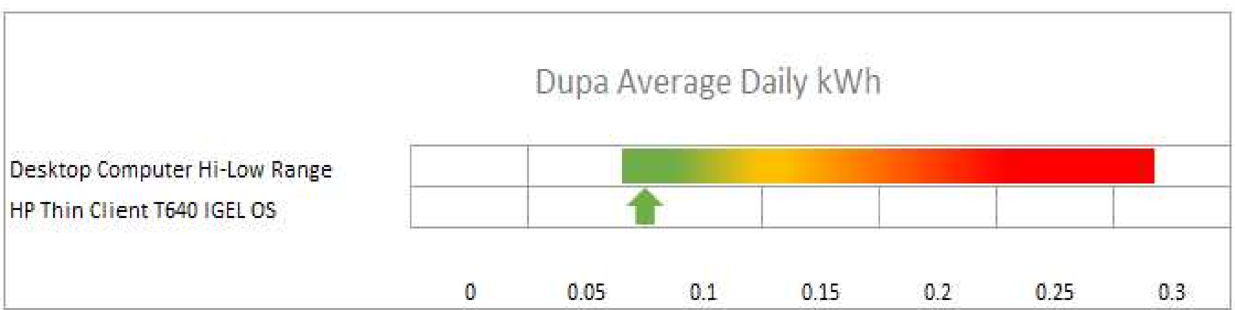
Px^3 'Silent Sole' Certification

The HP T640 IGEL OS thin client computer, as detailed in the specification section of this document, achieved the following Px^3 Silent Sole use phase energy efficiency certification:

Specifically, the EUC device consumed 0.0755 kWh electricity during a working day meaning that just 1,299 human steps are required to expend the equivalent energy.

In context with computers of the same classification, the device is position as a low energy device as highlighted in figure 7.

Figure 7 – DUPA average EUC device comparison for desktop computers



Px^3

Px^3 is a research focused IT consulting organisation specialising in sustainability and specifically the reduction of GHG emissions created by the way we work today. Our unique services enable IT manufacturers, 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 is copyright of Px^3 Ltd as is the Silent Sole certification icon and methodology. Both 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.

As described in the methodology, the electricity consumption values are accurate at time of measurement and subsequent publishing. Px^3 reserves the right to amend the DUPA efficiency RAG classifications as new and increasing energy efficient EUC device technology is developed and manufactured.

All measurements are conducted by qualified Px^3 research scientists and done so without bias in order to create science based data to support science based goals and behaviours. As such, energy efficiency classification is awarded solely upon data captured and results produced.

At Px^3 sustainability represents the principle of ensuring that our actions today do not limit the range of economic, social, and environmental options open to future generations. As such, it is Px^3's mission is to remove the CO_2e emissions equivalent of 100,000 cars from our atmosphere by 2050 via the diffusion of sustainable IT hardware and services.

Px^3 Ltd
Innovation Centre
University of Warwick Science Park
Warwick Technology Park
Gallows Hill
Warwick
CV34 6UW
United Kingdom
01926 20623510
analysis@px3.org.uk
www.px3.org.uk