Document Identification	
Identifier	E1451-20.00.TP-IEP.00
Issue	1.0
Date	2023-03-08

Computer Efficiency and Performance

Software Guide and Measurement Procedure – PCEET

GTD GmbH
Ravensburger Straße 32a
88677 Markdorf

☎ +49 (0) 7544 96440-0
+49 (0) 7544 96440-29

gtd@gtd-gmbh.de
http://www.gtd-gmbh.de

Revisions

Revision	Description	Date
0.1	Webinar draft	2020-07-07
0.2	Webinar draft 2 Updated version containing the following changes: • Add newly supported power meter models • Describe local time synchronization • Fix various typos	2020-10-26
0.3	Updated version containing the following changes: • Replace UUT with EUT (Equipment under Test) • Add instructions for ChromeOS EUT setup • Update list of included worklets	2021-11-29
0.4	Updated version containing the following changes: • Update supported operating systems • Update instructions for ChromeOS EUT • Update list of included worklets	2022-09-19
1.0	Updated version containing the following changes: • Update supported operating systems • Update list of included worklets • Remove need for external monitor for EUT with integrated monitor • Update instructions for ChromeOS EUT	2023-03-08

Contents

List of Figures

List of Tables

1 Background, Context and Contacts

In 2019, the European Commission indicated that it would welcome support developing an on-mode test method for computers. CLASP contacted the Commission and offered to assist on this topic, by developing a first version of a software tool that would quantify both energy consumption and performance of different computer configurations across several operating systems. The Commission then invited CLASP and its Team (GTD and Intertek UK) to present their concept to key stakeholders to determine whether this idea should be taken forward.

On Monday, 13 January 2020, a three-hour meeting/webinar was held at Directorate General Energy, Rue Jean-André de Mot 24, Brussels with more than 50 participants including DigitalEurope's members and other experts. The conclusion of that meeting was an agreement for CLASP and its team to work on developing this software tool in consultation with DigitalEurope and other key stakeholders.

This document is part of the package of draft deliverables being shared with participants of the 7th July webinar for review. It encompasses the following: (1) downloading and installing the test suite; (2) test set-up and connecting the test equipment; (3) conducting the test on a computer; (4) exporting and interpreting the test results. Reviewers of the software tool are invited to provide comments using the online comment tool:

`https://redmine.gtd-gmbh.de/projects/computer-energy-efficiency-test/issues/new`

User accounts for the comment tool must be requested via Email to Andoni.Arregui@gtd-gmbh.de.

Following that review and comments received, CLASP/GTD/Intertek will work with this input to prepare a first draft of the software tool and deliver that to the Commission. This delivery will consist of all of the (uncompiled) software code, this test procedure document and anonymous test results being given to the Commission. The Commission has announced that it then intends to hold a Consultation Forum meeting on Computers and may present the tool for stakeholder review.

If you have any questions about the project or technical questions / issues that arise while conducting the test, please contact one of the following individuals:

	Technical / Software Issues	**Project-related Questions**
Name	Andoni Arregui	Michael Scholand
Organisation	GTD GmbH	CLASP
Email	andoni.arregui@gtd-gmbh.de	mscholand.consultant@clasp.ngo
Telephone	+49 7544 964 4022	+44 7931 701 568

2 Acknowledgements

CLASP, GTD and Intertek would like to warmly thank two companies who have kindly loaned equipment to us on very short notice to facilitate the development of this software test suite. We would like to thank Apple Computer, and especially Frank Lenderink and Thomas Barillot, for lending us a MacBook Pro. We would also like to thank the Yokogawa Test & Measurement Corporation, and especially Michael Rietvelt and Lee Thomas for lending us a WT310. We greatly appreciate their support because having this equipment available at GTD in Germany, enabled us to conduct parallel testing sequences with Intertek (UK) and thereby verify and confirm test results.

3 Disclaimer

While every precaution has been followed in the preparation of this document, including careful internal review by competent and experienced technical experts, this work does involve measurements of mains voltage and current in a test laboratory. The procedure set out in this document should only be attempted by competent, experienced technical experts who have worked with power measurements of computers or similar equipment in the past and are familiar with the best laboratory safety procedures and practices.

CLASP, GTD GmbH and Intertek do not accept any liability for any direct, indirect, punitive, incidental, special, or consequential damages arising out of, or in connection with, the use or misuse of any information provided in this report, the accompanying software and any other instructions or deliverables provided in association with this project. This information is provided as a free resource for measuring the energy efficiency and performance of computers and users of this test method acknowledge and agree that any use of this information is done at their own risk.

4 Introduction

4.1 Purpose

This document sets out the procedure to follow to test the energy efficiency and performance of a computer. The equipment necessary for conducting the testing is specified as well as all the steps related to hardware setup and software execution which need to be followed by the technician.

4.2 References

Table 4.1: Reference documents

Ref	Code	Date	Version	Title
RD01	Web Site	2014-08-20	-	Understanding And Performing Standby Power Measurements
RD02	IM WT310-02EN	-	3	WT310/WT310HC/WT332/WT333 Digital Power Meter Getting Started Guide
RD03	IM WT310-17EN	-	3	WT310/WT310HC/WT332/WT333 Digital Power Meter Communication Interface User Manual
RD04	IM WT310E-01EN	-	2	WT310E/WT310EH/WT332E/WT333E Digital Power Meter User Manual
RD05	IM WT310E-17EN	-	2	WT310E/WT310EH/WT332E/WT333E Digital Power Meter Communication Interface User Manual

4.3 Acronyms and Abbreviations

Table 4.2: Acronyms and abbreviations

Term	Definition
A	Ampere
BIOS	Basic Input Output System
GUI	Graphical User Interface
HD	Hard Disk
Hz	Hertz
OS	Operating System

PC	Personal Computer
TBD	To Be Defined
USB	Universal Serial Bus
EUT	Equipment Under Test
V	Voltage

5 Hardware Setup

5.1 Required Equipment

The following list identifies the required equipment for testing:

- Regulated Power Supply (laboratory quality, as per EN 62623)
- Power meter (laboratory quality, as per EN 62623); at this time the software is compatible with the following power meters:
  - Yokogawa WT310 and WT310E Power Meter (USB connection)
  - Yokogawa WT333 (USB connection)
  - Yokogawa WT500 (USB connection)
  - Hioki PW3335 (only serial connection, 38400 bps 8n1)
  - Hioki 3332 (only serial connection, 38400 bps 8n1)
  - Yokogawa WT3000 (only GPIB connection on Windows)
  - Yokogawa WT210 (only GPIB connection on Windows)
- Measurement Adapter to connect the computer being tested, also called the equipment under test (EUT) power socket to the power meter
- EUT including an external monitor with 1080p resolution, mouse and keyboard for desktop computers. In case of an EUT with integrated monitor and peripherals (e.g. Laptop), the integrated monitor and peripherals can be used
- Controller Computer (Windows, Mac or Linux OS; see above for power meters only supported on Windows) to read power values from the power meter
- For power meters connected via serial or GPIB: A serial to USB or GPIB to USB adapter is recommended. Make sure that the appropriate driver for your adapter is installed before running any parts of the test software. The following adapters have been confirmed working:
  - Keyspan USA-19HS serial to USB adapter
  - National Instruments GPIB-USB-HS GPIB to USB adapter with NI-VISA 20.0
- For power meters connected via USB: USB cable to connect the power meter to the Controller Computer. No previous driver installation is necessary.
- USB key containing the test software

Figure Test Hardware Setup presents a scheme of the equipment and the connections.

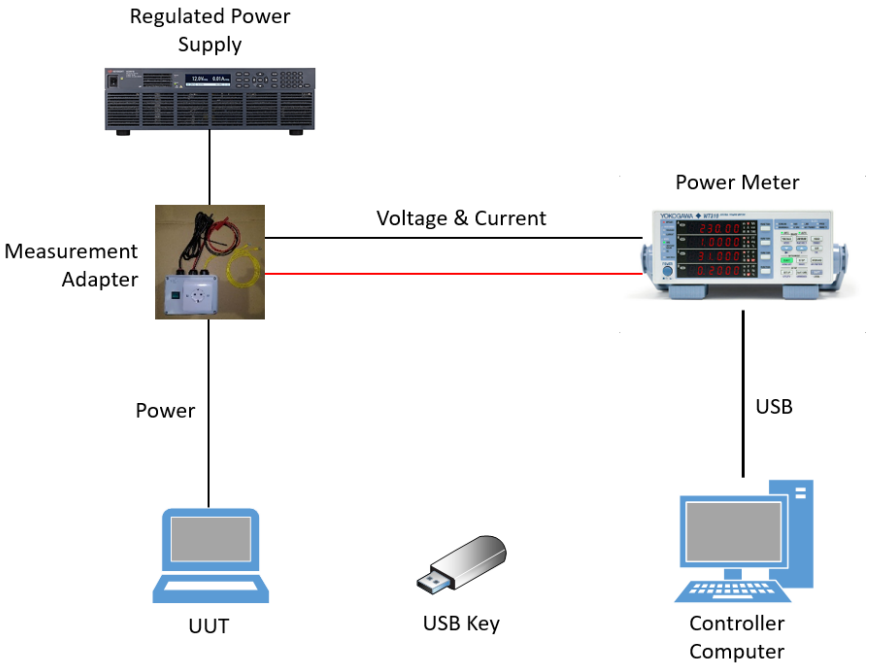
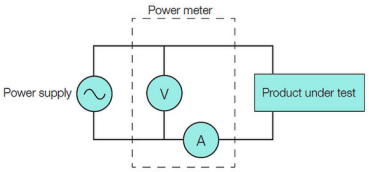


Figure 5.1: Test Hardware Setup

Table 5.1: Test equipment and requirements

Name and Description of Equipment	Requirements Defined	Notes
Power Meter	EN 62623	Power consumption measurement
Regulated Power Supply	EN 62623	Clean power for testing
Controller Computer	Two USB ports (2.0 or higher) for interface with power meter and USB key	Can be running Microsoft Windows 10 and 11 64-bit, MacOSX 12 or Ubuntu 22.04 Linux 64-bit or newer.
USB key	16 GB or larger	USB 3.0 or higher recommended
Measurement Adapter	A socket with separate measurement leads for voltage and current. See article in Power Electronics for circuit diagram.	

5.2 Hardware Connection Procedure

When connecting all the elements, standard laboratory safety procedures must be followed to avoid risk to the technician as well as risk of damage to the test equipment and EUT from static electricity. The work surface must be connected to ground and the operator should use an anti-static wrist strap.

Connect the Controller Computer and the EUT to the Yokogawa Power Meter using the Measurement Adapter by carrying out the following steps:

- Make sure the Measurement Adapter is not connected to the Regulated Power Supply.
- Make sure the Power Meter is not plugged into a wall socket.
- Connect the Measurement Adapter to the Power Meter:
  - Connect the voltage sensing cables of the Measurement Adapter to the voltage input terminals located at the back of the Power Meter.
  - Connect the current cables to the current input terminals at the back of the Power Meter.
  - Consult the user's manual of your measurement adapter and power meter to verify the connections.
- Plug the EUT into the Measurement Adapter socket.
- Plug the Power Meter into a wall socket, connected directly to the mains.
- Plug the Measurement Adapter into the Regulated Power Supply.
- Use the USB cable to connect the output USB channel of the Power Meter to a USB socket of the Controller Computer
- Turn-on the Power Meter.
- Navigate to the settings menu on the Power Meter and set the measurement ranges to cover the whole range of power draw expected during the benchmark. (Note: For a normal desktop computer, the 300 V and 0.5 A range should be fine, a high end desktop computer might need the 1 A or even 2 A settings). Also adjust the crest factor accordingly.
- No further manual configuration of the Power Meter is required as other settings will be set automatically by the test-suite software.
- At this point we are ready to start both computers (Controller Computer and EUT).

6 Creating USB Key

The whole Test Suite is delivered as an image file (.img). This file has to be flashed on a USB key with a capacity of at least 16 GB. This can be done on any operating system you have available:

- Microsoft Windows - see §Microsoft Windows
- Apple MacOSX - see §Apple MacOSX
- Linux - see §Linux

It is recommended to use a reasonably fast USB 3 key, to speed up flashing the image and installation on the EUT.

WARNING: Following the flashing procedure will erase all data on the target device. Make sure to select your USB key and not an external hard drive containing any important files!

A single 16GB partition is created on the USB key independently of its size. If the capacity of the stick is higher, a tool such as GParted (https://gparted.org/livecd.php) can be used to expand the size of the partition.

6.1 Microsoft Windows

A third party tool to configure USB keys is needed. In this case we explain how to use a free multi-platform application called Rufus that can be downloaded from https://rufus.ie/. This test procedure has been verified with Rufus version 3.10.

Perform the following steps (you can take Figure USB key configuration with Rufus as a reference):

- Download and launch Rufus (there is a portable version that do not require installation)
- Insert the USB key in one of the PC's USB connectors
- Select the USB device from the Device field's drop-down menu
- Select "Disk or ISO Image" from the Boot selection menu
- Click the SELECT button to select the delivered IMG in the window that pops-up and then click open.
- Write the image to the USB stick by clicking on START
- If when clicking START you get the mode selection dialog, select "DD Image mode".
- It could happen that Rufus requires some additional files, if this is the case, a new dialog box will appear, select Yes to continue.
- If additional warning messages appear, keep the default values and select Yes to continue
- The image is now being written and a progress bar is displayed at the bottom of the main Rufus window, under Status.
- When the image writing process is finished, the word READY appears in the centre of the progress bar (now shaded green). Select CLOSE. Your USB stick now contains the Test Suite.

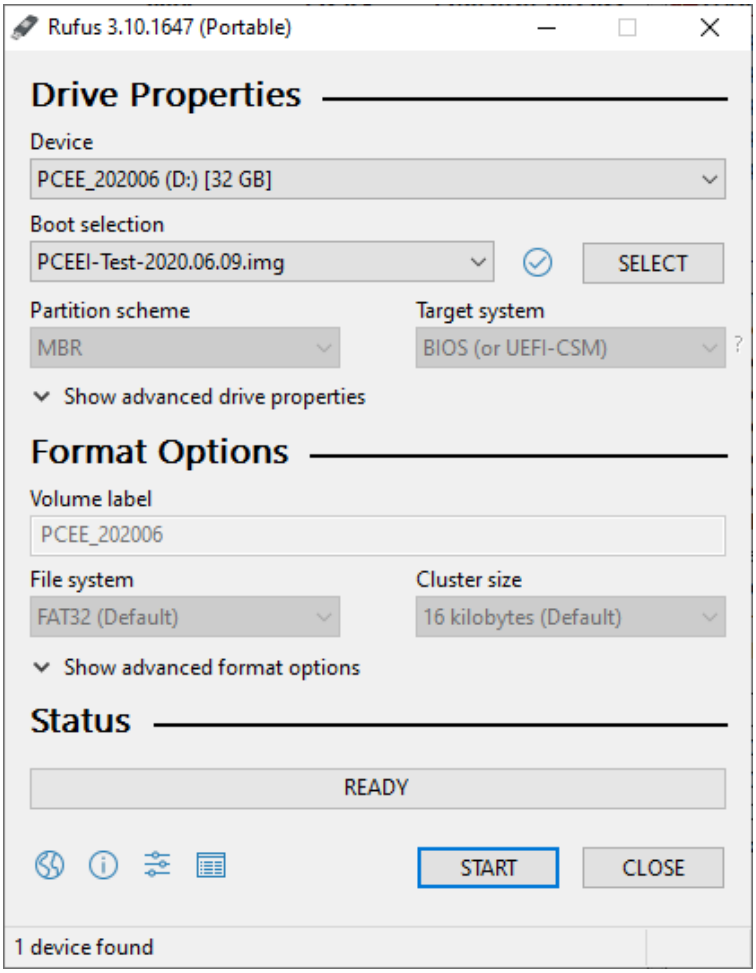


Figure 6.1: USB key configuration with Rufus

6.2 Apple MacOSX

Perform the following steps:

- Insert the USB key in one of the Computer's USB sockets
- Open a terminal
- Find the device identifier of the USB key by typing:
  - `diskutil list`
  - The device identifier of the USB key will be something like e.g. "disk2"
  - Check that you have selected the correct device by comparing the size and name in the diskutil output to the expected values depending on you USB key.
- Unmount this device by typing (replace `<device-id>` with the device identifier of the USB key from the previous step):
  - `diskutil unmount <device-id>`

- Type the following command to actually write the image (replace `<device-id>` with the device identifier of the USB key from the previous step):
  - `sudo dd if="name of the IMG file" of=/dev/<device-id>`

6.3 Linux

For Linux it is assumed that you have `sudo` set up to elevate privileges. If this is not the case, use `su` to open a root shell first, then enter the commands without prefixing `sudo`.

Perform the following steps:

- Insert the USB key in one of the PC's USB connectors
- Open a Linux terminal
- Find the device identifier of the USB key by typing:
  - `sudo fdisk -l`
  - The device identifier of the USB device will be something like e.g. `/dev/sdc`.
  - Check that you have selected the correct device by comparing the size and name in the fdisk output to the expected values depending on your USB key.
- Unmount this device by typing (replace `<device-id>` with the device identifier from the previous step and with the partition number) for each auto-mounted partition on the USB key.
  - `sudo umount <device-id><X>`
  - Example: `sudo umount /dev/sdc1`
- Type the following command to write the image (replace `<device-id>` with the value from the previous step). Make sure to select the device itself (e.g. `/dev/sdc`) and not the first partition (`/dev/sdc1`) in this step.
  - `sudo dd if="name of the image file" of=<device-id>`
  - Example: `sudo dd if="PCEEI-Test-2021.01.19.img" of=/dev/sdc`

6.4 Updating an existing USB key

Once a USB key has been created it can be easily updated once a new version of the test suite software is released, without having to download the new full image and going through the flashing procedure.

To update the USB key connect it to an internet connected computer, then run `update.bat` for a Windows Computer or `update.command` for MacOSX and Linux computers. The update mechanism will only download changed files, so an update usually only takes a few minutes.

IMPORTANT: The update procedure will not remove your `test-results` folder from the USB stick, but will remove all other files and folders which are not part of the test suite software in its initial state.

IMPORTANT: To use the newly updated software you have to install it as described in §Software Installation

7 Software Installation

In this section we detail how to install the controller software on the Controller Computer and the Test Suite on the EUT. All the required software is in the USB stick you have flashed on the previous step.

7.1 General Remarks

Before installing the Controller Computer software and the EUT Test Suite you have to take into account the following remarks:

- An internet connection is required. Most files will be served from the USB media, though, so data transfer volume is limited.
- The installation procedure has to be run only once for each particular Controller Computer and EUT. If the installation produces an error, it can be safely repeated; only the missing packages and applications will be installed.
- The user account on the Controller Computer and the EUT which is used to carry out the test procedure should have administrative permissions. On Windows and MacOSX this means to use an administrator account, on Linux this means to use an account which can use `pkexec` to elevate privileges.

7.2 Controller Computer

The controller software is multi-platform; it runs on:

- Microsoft Windows 10 or Windows 11 64-bit.
- MacOSX 12
- Ubuntu 22.04 LTS 64-bit Linux

This software allows the user to:

- Synchronize the Controller Computer and the EUT clock
- Check the connection between the Power Meter and the Controller Computer
- Start/Stop the acquisition of power measurements
- Examine the results via a web browser application

The figure Controller Computer GUI below serves as a reference as this GUI is the same for the 3 version for each supported OS.

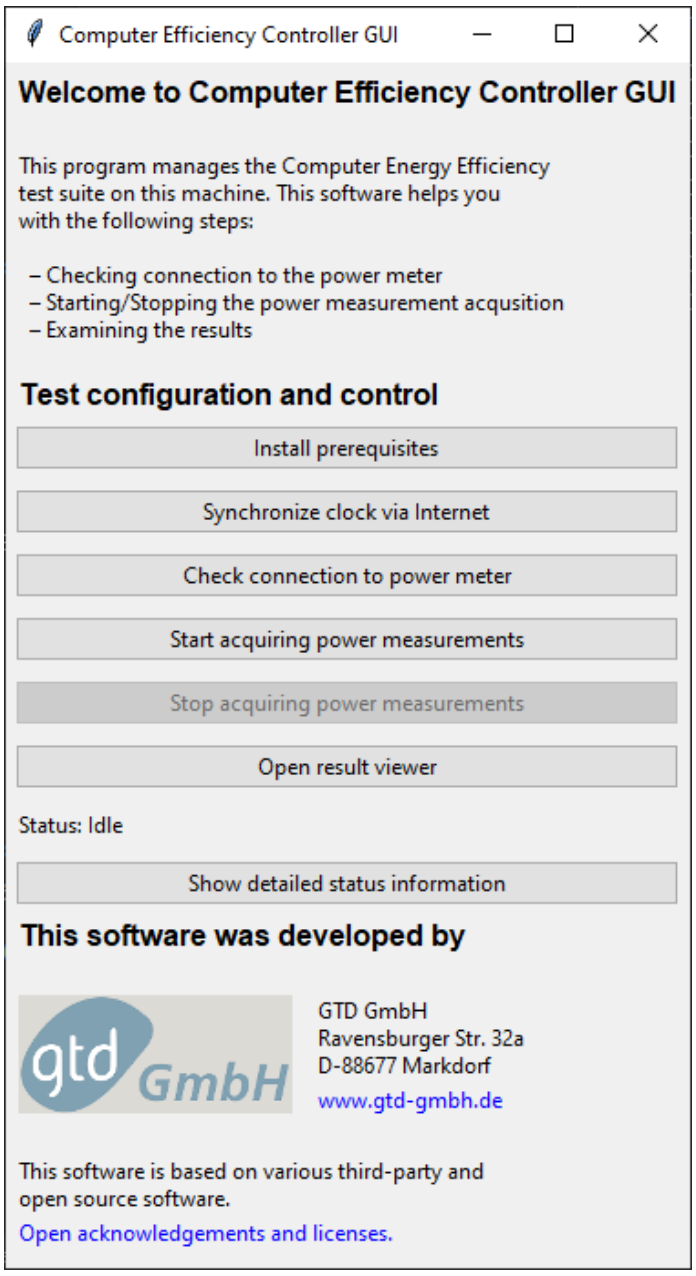


Figure 7.1: Controller Computer GUI

The Computer Controller software can be installed on any operating system you have available:

- Microsoft Windows - see §Microsoft Windows
- Apple MacOSX - see §Apple MacOSX
- Linux - see §Linux

NOTE: The installation procedures below only install the required software dependencies and drivers. The Controller Computer application has to be executed from the USB key, a procedure explained in a subsequent section.

7.2.1 Microsoft Windows

- Insert the USB key in one of the PC's USB connectors
- Open a file explorer and navigate to the root directory of the USB key
- Double click on the `windows_controller.exe` file.
- Click "yes" when asked if you want to allow this app to make changes on your computer. The Controller Computer GUI is now displayed (see Figure Controller Computer GUI)
- Click "Install prerequisites". You can check the current status of the installation on the "Status" field on the bottom left side of the GUI. If you want more detailed information, click on "Show detailed status information". A text box containing more log messages is then presented.
- When a driver-installation utility called Zadig pops up do the following, if you have a USB connected Yokogawa power meter (otherwise just close the Zadig utility):
  - Select the Yokogawa meter on the top deployable bar. Usually it is listed as "WT series" and already selected. If it doesn't show up, click "List all devices" from the "Options" menu and select it.
  - Select the "WinUSB" driver in the text field on the right side of the green arrow. Usually the correct driver is already selected
  - Click "Install driver"
  - Once the installation is complete, close the Zadig utility
- During the rest of the installation no more user interaction is required
- When the installation is completed a success window pops up and the Status is reported as "Idle"

7.2.2 Apple MacOSX

- Insert the USB key in one of the Computer's USB connectors
- Open a Finder window and navigate to the root directory of the USB key
- Double click the `macosx_controller` file. The Controller Computer GUI pops up (see Figure Controller Computer GUI)
- Click "Install prerequisites". You can check the current status of the installation on the "Status" field on the bottom left side of the GUI. If you want more detailed information, click "Show detailed status information". A text box containing more log messages is then presented
- When the installation is completed a success window pops up and the Status is reported as "Idle"

7.2.3 Linux

The installation procedure is the same independently of the Linux distribution as the software will be installed with the distribution's native package manager:

- Insert the USB key in one of the PC's USB connectors
- Open a file explorer

- Double click the `linux_controller` file. The Controller Computer GUI pops-up (see Figure Controller Computer GUI). If you get an error message, the reason might be that the USB stick was automounted without execute permissions. In this case do the following steps:
  - Get the device id of the USB key (e.g. `sdb1`) in a Terminal with the `lsblk` command
  - Unmount the USB key with the following command: `sudo umount /dev/<device-id>`
  - Mount the USB key again with default mounting options: `sudo mount -o uid=$(id -u) /dev/<device-id> /mnt`
  - Navigate to the `/mnt` folder in your file browser and double click the `linux_controller` file
- Click "Install prerequisites". You can check the current status of the installation on the "Status" field on the bottom left side of the GUI. If you want more detailed information, click "Show detailed status information". A text box containing more log messages is then presented
- When the installation is completed a success window pops up and the Status is reported as "Idle"

7.2.4 Check the Connection to the Power Meter

Once the Controller Computer software has been installed, we want to make sure that the Power Meter can be accessed by the test framework. To do so, select your power meter and, in case of serial or GPIB connection, the port to use via the dropdown menus on the Controller Computer GUI, then click the button on labeled "Check connection to power meter". A message should be shown stating that the meter was found and detailing the model, serial number and channels of your device, as you can see in Figure Power Meter found.

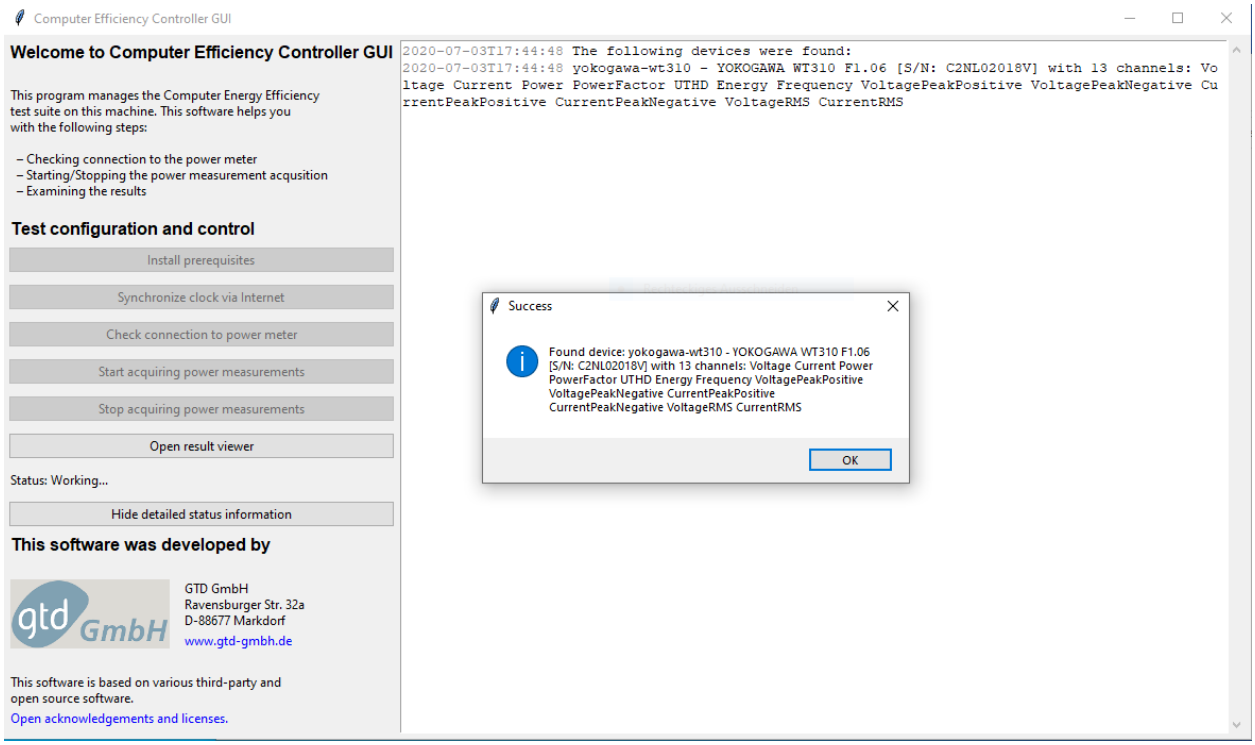


Figure 7.2: Power Meter found

If the meter is not detected correctly, make sure that it is properly connected via USB to the EUT, is switched on and that drivers have been set correctly.

7.3 EUT Software Preparation

The Computer Efficiency Test Suite is multi-platform; it runs on:

- Microsoft Windows 10 or Windows 11 64-bit.
- MacOSX 12
- Ubuntu 22.04 64-bit Linux

The figure Test Suite installation GUI below serves as a reference as this GUI is the same for the 3 proposed OS versions of the software.

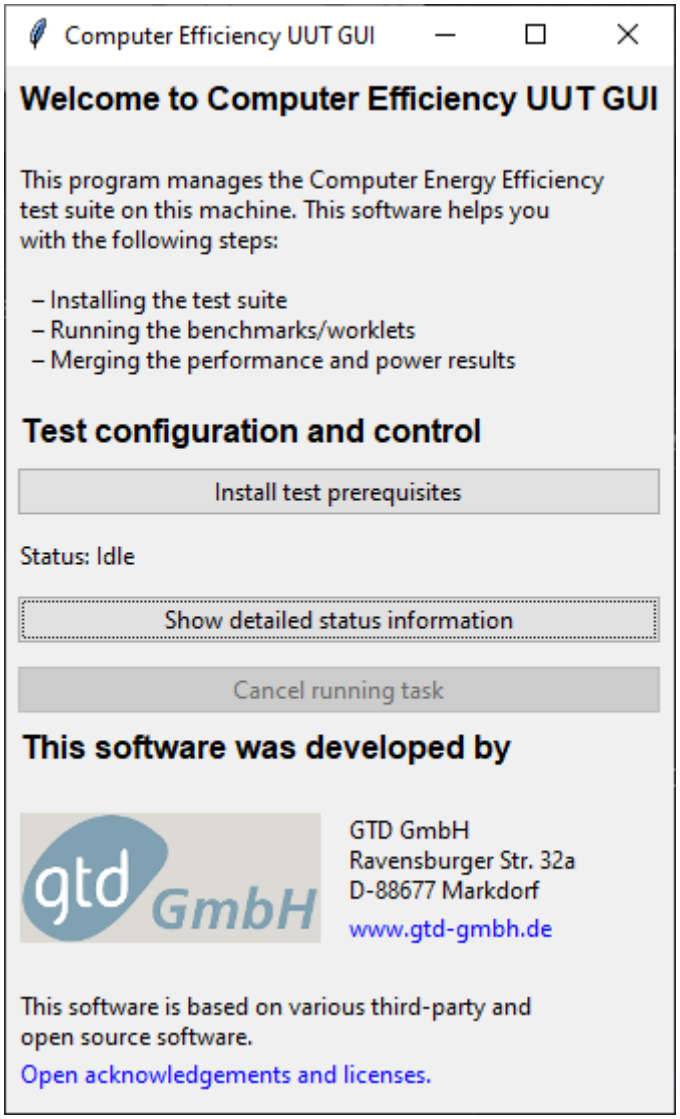


Figure 7.3: Test Suite installation GUI

The Computer Efficiency Test Suite can be used to test a new computer running one of the following operating systems:[1]

- Microsoft Windows - see §Microsoft Windows
- Apple MacOSX - see §Apple MacOSX
- Linux - see §Linux

NOTE: please be aware that the installation can take a long time as some software packages are downloaded from the Internet and some required package managers like homebrew for MacOS might give up with the download. This will issue an error on the console identifying the software

[1]Note: We have registered the request to make this software suite able to examine Computers running Google ChromeOS. This work will be undertaken if there is sufficient budget remaining after developing the test suite for these three initial OS.

packages that could not be downloaded in a reasonable time. The installer was designed to take this into account, and may be run as many times as is necessary with only the missing packages being installed on subsequent runs.

7.3.1 Microsoft Windows

- Insert the USB key in one of the EUT's USB connectors
- Open a file explorer and navigate to the root directory of the USB key
- Double click the `windows_uut_install.exe` file.
- Click "yes" when asked if you want to allow this app to make changes on your computer. The EUT installation GUI is now displayed (see Figure Test Suite installation GUI)
- Click on "Install test prerequisites". You can check the current status of the installation on the "Status" field on the bottom left side of the GUI. If you want more detailed information, click "Show detailed status information". A text box containing more log messages is then presented (see Figure Test Suite installation GUI with text box deployed)
- When the installation is completed a success window pops up and the Status is reported as "Idle"
- Close the GUI and remove the USB key

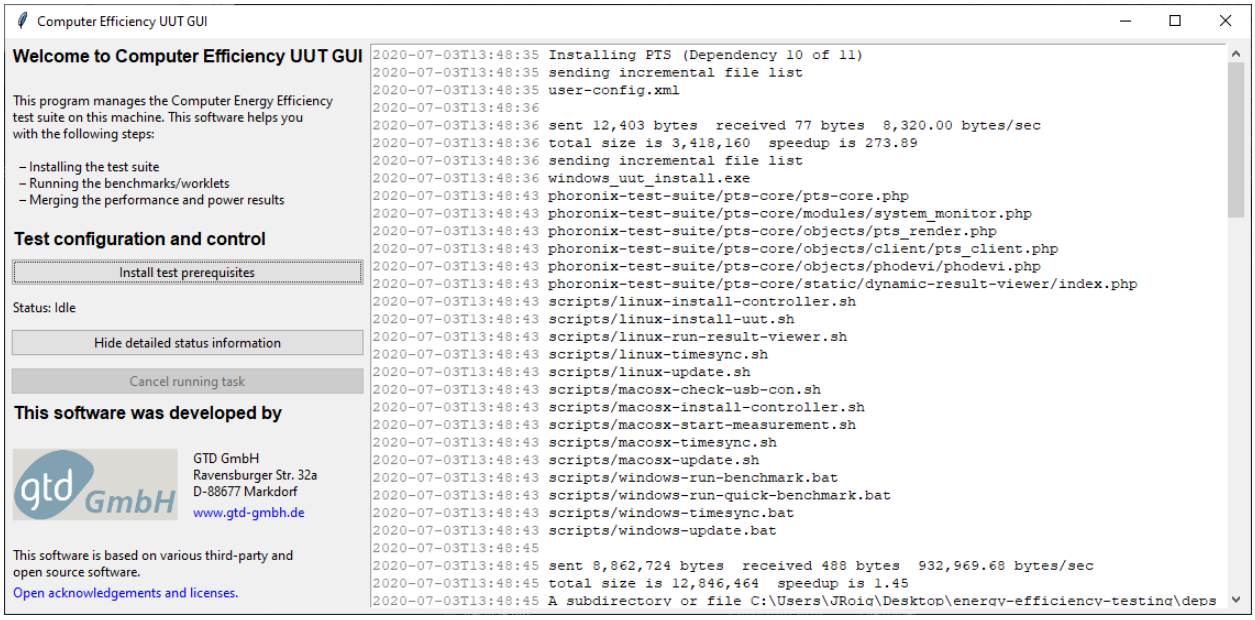


Figure 7.4: Test Suite installation GUI with terminal deployed

7.3.2 Apple MacOSX

- Insert the USB key in one of the EUT's USB connectors
- Open a Finder window and navigate to the root directory of the USB key
- Double click the `macosx_uut_install` file. The EUT installation GUI pops-up (see Figure Test Suite installation GUI)

- Click “Install test prerequisites”. You can check the current status of the installation on the “Status” field on the bottom left side of the GUI. If you want more detailed information, click “Show detailed status information”. A text box containing more log messages is then presented (see Figure Test Suite installation GUI with text box deployed)
- When the installation is completed a success window pops up and the Status is reported as “Idle”
- Close the GUI and remove the USB key

A new security feature introduced in MacOSX Big Sur requires that all applications installed are signed with a key notarized by Apple. This new feature might prevent the execution of software that worked with previous MacOSX versions. This means that applications that have not yet been notarized have to be removed from quarantine to run them. The following applications are automatically removed from quarantine during installation so no user action is necessary:

- FreeCAD
- GIMP
- LibreOffice
- Blender

NOTE: to check that those applications are correctly removed from quarantine and to ensure that they will not generate a failure during a Test Suite execution, please manually start them one at a time right after the test suite software installation.

As we cannot control the changes that Apple might introduce in their OS in the future, it could happen that additional applications also stop working. If the error “application cannot be opened because the developer cannot be verified” appears when executing the software, you have to remove it from quarantine by typing the following command in a text console (the example is given for FreeCAD):

```
sudo xattr -d com.apple.quarantine /Applications/FreeCAD.app
```

7.3.3 Linux

The installation procedure is the same independently of the Linux distribution as the software will be installed with the distribution’s native package manager:

- Insert the USB key in one of the PC’s USB connectors
- Open a file explorer
- Double click the `linux_uut_install` file. The Test-Suite GUI pops-up (see Figure Test Suite installation GUI). If you get an error message, the reason might be that the USB stick was automounted without execute permissions. In this case do the following steps:
  - Get the device id of the USB key (e.g. `sdb1`) in a Terminal with the `lsblk` command
  - Unmount the USB key with the following command: `sudo umount /dev/<device-id>`
  - Mount the USB key again with default mounting options: `sudo mount -o uid=$(id -u) /dev/<device-id> /mnt`

  - Navigate to the `/mnt` folder in your file browser and double click the `linux_uut_install` file

- Click on “Install test prerequisites”. You can check the current status of the installation on the “Status” field on the bottom left side of the GUI. If you want more detailed information, click “Show detailed status information”. A text box containing more log messages is then presented (see Figure Test Suite installation GUI with text box deployed)
- When the installation is completed a success window pops up and the Status is reported as “Idle”
- Close the GUI and remove the USB key

7.3.4 ChromeOS

On ChromeOS the test software runs in a change-root environment on the ChromeOS Linux kernel. This approach prevents the overhead of virtualization. To be able to run the software, ChromeOS needs to be switched to developer mode.

- Enable developer mode on the EUT according to the manufacturer’s documentation, e.g. follow the steps in Section “Enable Developer Mode” on https://chromium.google-source.com/chromiumos/docs/+/master/developer_mode.md.
- Once booted in developer mode, open Chrome, press Ctrl + Alt + T to open a Crosh Tab, type `shell` to get to a user shell, and then `sudo su -` to get to a root shell.
- Insert the USB key in one of the USB connectors
- Change directory by typing `cd /media/removable/PCEET`
- Allow to execute files from the mounted USB key by typing `mount -o remount,exec .`
- Install the change root environment based on Ubuntu 20.04 by typing `./deps_chromeos/crouton -f deps_chromeos/focal.chroot`
- Start the chroot with the following command: `enter-chroot startxfce4`. An XFCE Linux environment should start up.
- On the XFCE desktop, start the test application by clicking the “PCEET USB Key” shortcut on the desktop or navigating to `/var/host/media/removable/PCEET` in a file browser, then double-click the `linux_uut_install` file.
- Click on “Install test prerequisites”. You can check the current status of the installation on the “Status” field on the bottom left side of the GUI. If you want more detailed information, click “Show detailed status information”. A text box containing more log messages is then presented (see Figure Test Suite installation GUI with text box deployed)
- When the installation is completed a success window pops up and the Status is reported as “Idle”
- Close the GUI and remove the USB key

8 Test Suite Execution

As seen in Figure Test Hardware Setup you need two computers to run the Test Suite:

- The Equipment Under Test (EUT)
- A Controller Computer

Each of these computers runs its own application: the Controller Computer application on one side and the EUT Test Suite on the other. In this chapter we explain how to prepare the computers for testing and how to run the required applications.

IMPORTANT: The Controller Computer application **must** be started **before** running the EUT Test Suite.

8.1 General Remarks

Before running the Controller Computer Software and EUT Test Suite benchmarks, please take into account the following remarks:

- Screen saver, screen blanking and automatic standby mode must be switched off
- A desktop wallpaper according to EN 62623 shall be set on the EUT
- All currently available OS updates must be installed and after that automatic OS updates must be disabled
- Disable any firewall software installed on the EUT (e.g. on Windows disable the Windows Defender Firewall).
- If the EUT has a rechargeable battery, i.e. it is a laptop, remove the battery for the test. If the battery cannot be removed, make sure that the battery is charged to 100% before starting a test run.
- The EUT shall not be connected to the internet when running the benchmarks, but should be connected to a wireless access point or network switch supporting the highest speed available by the EUT. In order to restrict influence of external factors, the EUT shall be confined within a local test network without external network connections.
- The USB key used during the Test Suite software installation shall **not** remain connected to the EUT during the test run.
- The internal Controller Computer and EUT clocks have to be synchronized by starting a NTP server on the controller computer and synchronizing the EUT clock to this NTP server. For this the controller computer and EUT need to be connected to the same local area network.

8.2 Preparing the Controller Computer

Before running the EUT Test Suite, we first have to synchronize both computers' clocks and start the acquisition of the power measurements from the Power Meter by doing the following:

- Follow the steps explained in the corresponding installation section to open the Controller Computer Software GUI from the USB stick (i.e., Microsoft Windows – see §Microsoft Windows; Apple MacOSX – see §Apple MacOSX; Linux – see §Linux)
- Click "Start time server" on the Controller GUI and note the IP address of the controller computer.
- Click the GUI button "Start acquiring power measurements". A message stating that the power data acquisition has started is presented in the detailed status window and the status in the GUI changes from "Idle" to "Working". A file named "sys_power.csv" is also created in the root directory of the USB key
- Note: once the power measurement acquisition has started, no more user interaction is required on the Controller Computer until the end of the EUT Test Suite execution

After completing a run of the EUT Test Suite (i.e., after following the procedure in section 5.3), the message "Insert USB key with power measurements from controller computer" will pop up on the EUT. When this message appears on the EUT, do the following steps on the Controller:

- Click "Stop acquiring power measurements" on the Controller Computer GUI
- Safely remove the USB key from the Controller Computer
- Note: this same USB key is inserted into the EUT to collect the power measurements from the EUT.

8.3 Preparing and Running the EUT

The complete Test Suite is installed in a folder called "energy-efficiency-testing" located on the Desktop of the EUT. The Test Suite must be run from this folder.

Open a file viewing tool, navigate to the "energy-efficiency-testing" folder and double-click the executable file that corresponds to the OS of the EUT:

- Microsoft Windows: `windows_uut_run.exe`
- MacOSX: `macosx_uut_run`
- Linux: `linux_uut_run`

Note: the current duration of the Test Suite execution is about 1 hour depending on the performance of the tested computer.

The benchmark tests are started from within the EUT Testing Suite GUI (see Figure Test Suite execution GUI) by following these steps:

- Enter the IP address of the controller computer in the provided text box and click "Synchronize clock". When the process is finished a success message pops up. After this step no network connectivity to the controller computer is necessary.
- Enter a test configuration name in the corresponding text field (text box next to "Name of test configuration"). This name must not contain any spaces. This name is used as an identifier for your EUT in the test results, e.g. "EUT-EC-Test-Results-2020-001".

- Write a test description (optional) in the corresponding text field. This can describe your EUT with a sentence, e.g. “Testing the Energy Efficiency of my computer, model number xxx-xxx” and it can contain spaces
- Configure which worklets shall be executed by clicking “Configure worklets”. The default setting is to run all worklets and determine the number of repetitions automatically.
- Click “Run full test” to execute the selected worklets, lasting up to 5 to 7 hours in case the default selection of worklets is used. Alternatively, a short test lasting approximately 30 minutes may be run in order to review the process but these incomplete results will not be valid.
- You can follow the test progress in the text window which is opened by clicking “Show detailed status information”
- After the complete suite of tests has been run, the message “Insert USB key with power measurements from controller computer” appears. Once this appears, insert the USB key that was used to get the power measurements on the Controller Computer into the EUT USB socket and press “Yes”. The USB key will have a file named “sys_power.csv” in its root directory. If this file is not present, you will be prompted again to insert the correct USB key.
- When the result combining process is finished you can see the message “Finished system sensor monitoring process” in the text window
- To archive and analyze the results on another computer (for example the Controller Computer), copy the “test-results” folder that has been created in “energy-efficiency-testing” directory on the EUT computer to the USB key

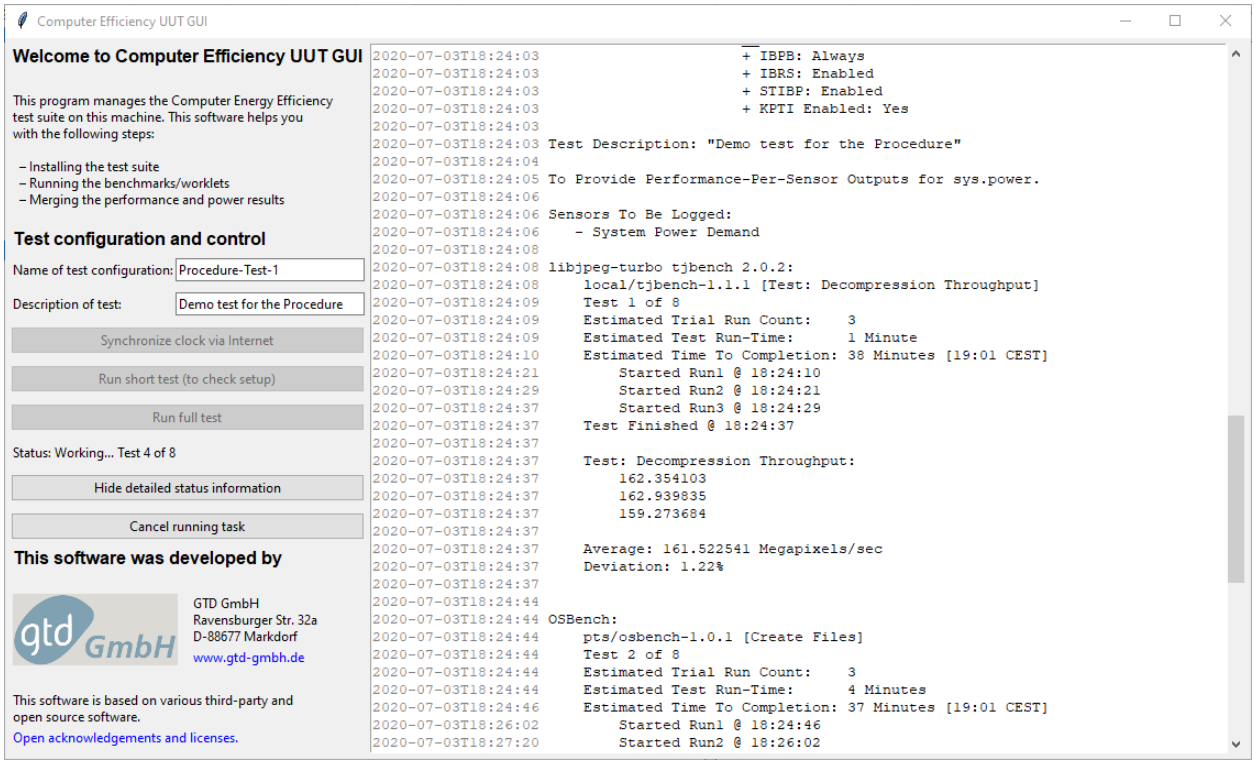


Figure 8.1: Test Suite execution GUI

8.3.1 Check the Tests Progress

When you run the tests and you select to display the detailed status information, the presented text box provides information on the progress of the tests together with some additional data (see Figure Test Suite execution GUI).

In particular, the main shown data are:

- Worklet name
- Worklet ID (Name of the test if the Worklet can run in different configurations)
- Test number and total number of tests
- Estimated Trial Run Count: number of times the Worklet will be initially repeated (more if necessary to decrease deviation)
- Estimated test run time: estimated duration of the Worklet
- Estimated time to test-suite completion: estimated duration of the rest of the Worklets
- Timestamp of each Worklet repetition
- Timestamp of Worklet execution end
- Performance result for each of the Worklet repetitions
- Calculated average of performance results
- Deviation in performance result

9 Complete List of Worklets

In the table below, we include a complete list of the Worklets which are included with this version of the software tool. The table lists them grouped by the performance or hardware configuration they are intended to test.

Table 9.1: Test Suite software Worklets and description

#	Worklet Name	Category	Description / Test Purpose
1	Compress 7zip	CPU	Compress a file with the 7zip algorithm
2	Compress ZSTD	CPU	Compress a file with the ZSTD algorithm
3	Stockfish	CPU	Chess AI simulation
4	Encode MP3	CPU	Encode WAV Audio to MP3
5	Blender	System	Render a scene in Blender using available GPUs
6	FreeCAD	System	Create several 3D models in FreeCAD
7	Libreoffice Calc	System	Create a spreadsheet with formulas and diagrams
8	Libreoffice Writer	System	Create a text document with images and tables
9	Libreoffice Impress	System	Create a presentation with several slides
10	Libreoffice Convert	System	Convert Documents to PDF
11	PyBench	System	Test performance of python programs
12	Selenium Kraken Chrome	System	Run the Kraken Javascript Benchmark in Chrome
13	TJBench	System	JPG image decompression
14	SQLite 1 thread	Disk	Create and query a database
15	Decompress ZSTD	Disk	Compress a file with the ZSTD algorithm
16	3Dmark Wildlife Extreme	GPU	Graphics Benchmark provided by UL
17	Unity Spaceship	GPU	Graphics Benchmark provided by Unity
18	Handbrake	GPU	Hardware-accelerated video transcoding

10 Results Analysis

The final combined test results are contained in the “test-results” folder that was created in the “energy-efficiency-testing” directory on the Desktop of the EUT. Please copy the “test-results” folder to the USB key and then insert it again in the Controller PC and open the Computer Controller GUI.

In the Controller Computer GUI, click on “Open result viewer” and a web browser with a list of all the executed tests will be opened.

By default test results are sorted by date, the newest listed first. The name of the test result includes the test configuration name given through the EUT GUI and the date and time of when the test was started (see List of example test results).

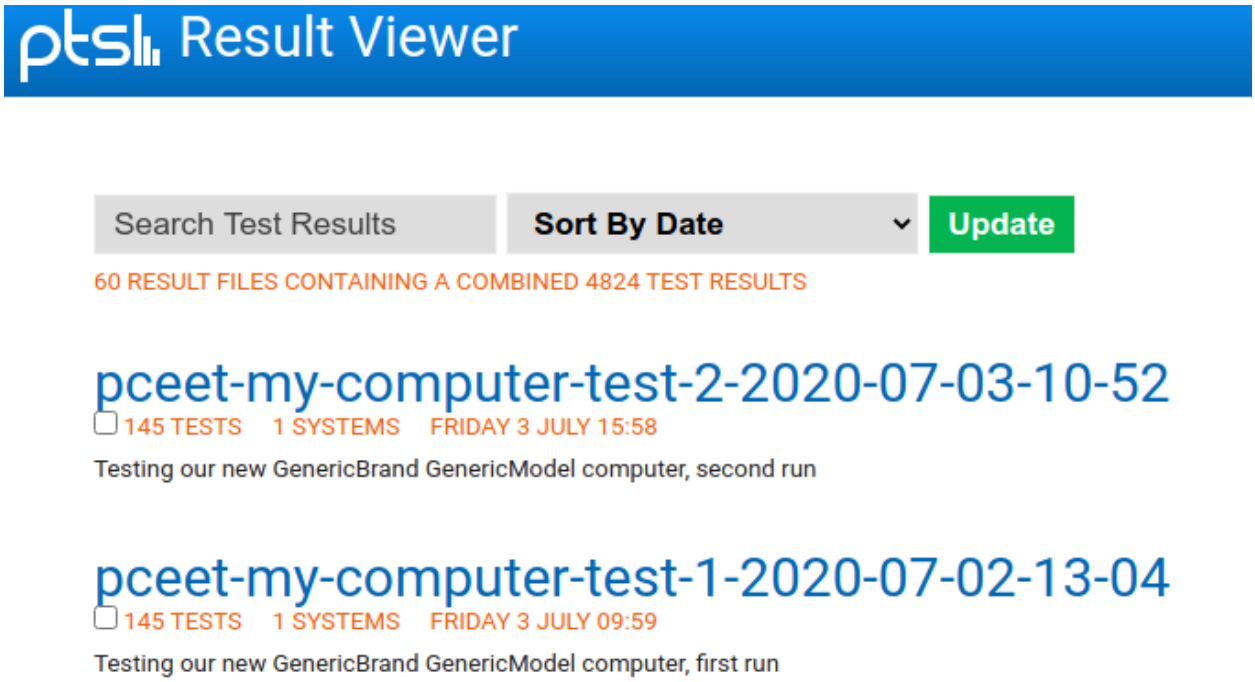


Figure 10.1: List of example test results

To open a single result, click the test result entry to display all available metrics produced during the corresponding test run.

To compare several test results, click the checkbox below each result entry’s title, then click the appearing button to compare the results.

The opened result page consists of several sections, which will be briefly explained in the following sections.

10.1 Technical Details about the EUT(s)

Technical details, such as CPU model, motherboard model, amount of memory, graphics card model, operating system versions and much more is listed in a table. This helps to clearly identify the EUT and gives an overview of the tested hardware.

10.2 Performance and Efficiency Comparison

This section is only shown when several systems are selected for comparison. When comparing two EUTs, a bar graph will be shown, when comparing three or more systems a circular plot (also called a "spider plot") will be shown. An example of such a plot is shown below (see Circular Efficiency Plot).

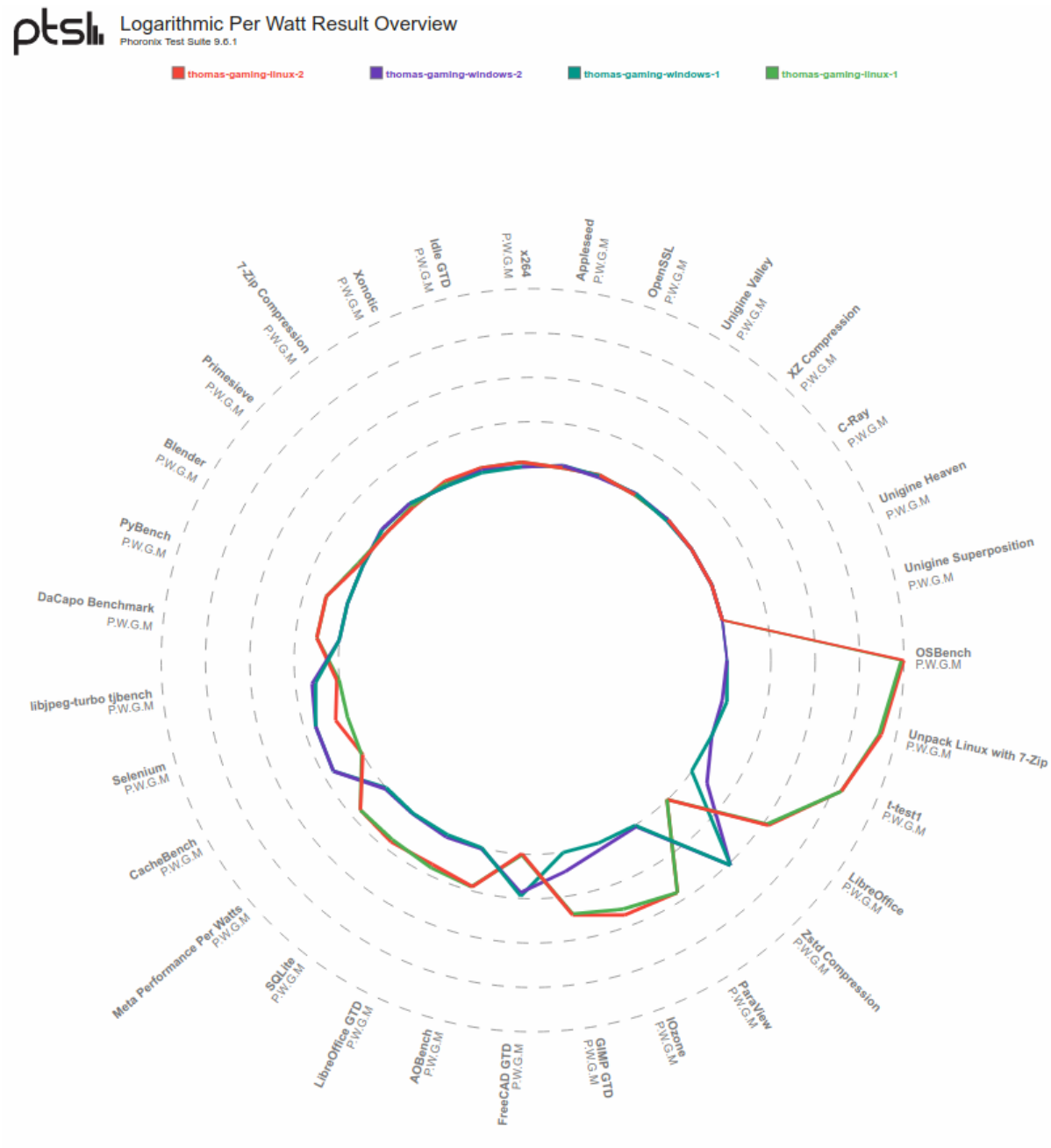


Figure 10.2: Circular Efficiency Plot

In this plot better (i.e. more efficient) results are located further to the outside of the concentric circles. The scale of the graph is logarithmic.

10.3 Table of Performance Results

For each Worklet the performance results are listed in a table. This table does not provide a measure of power consumption, but gives an assessment of the performance of the computer conducting these tests.

10.4 Detailed Test Results for each Worklet

For each Worklet at least three graphs are shown, detailing the performance, efficiency and power demand measurements. Additional graphs may be generated depending on what the benchmark provides in terms of additional results.

Choose between one of the three graphs by clicking the orange buttons above the performance graph which is shown by default. See screenshots below for an example for each of these graphs when four test runs are selected for comparison.

Each graph defines the unit of the measured values, such as MB/s and whether higher values are better or lower values are better. This depends on the type of benchmark and is important to consider.

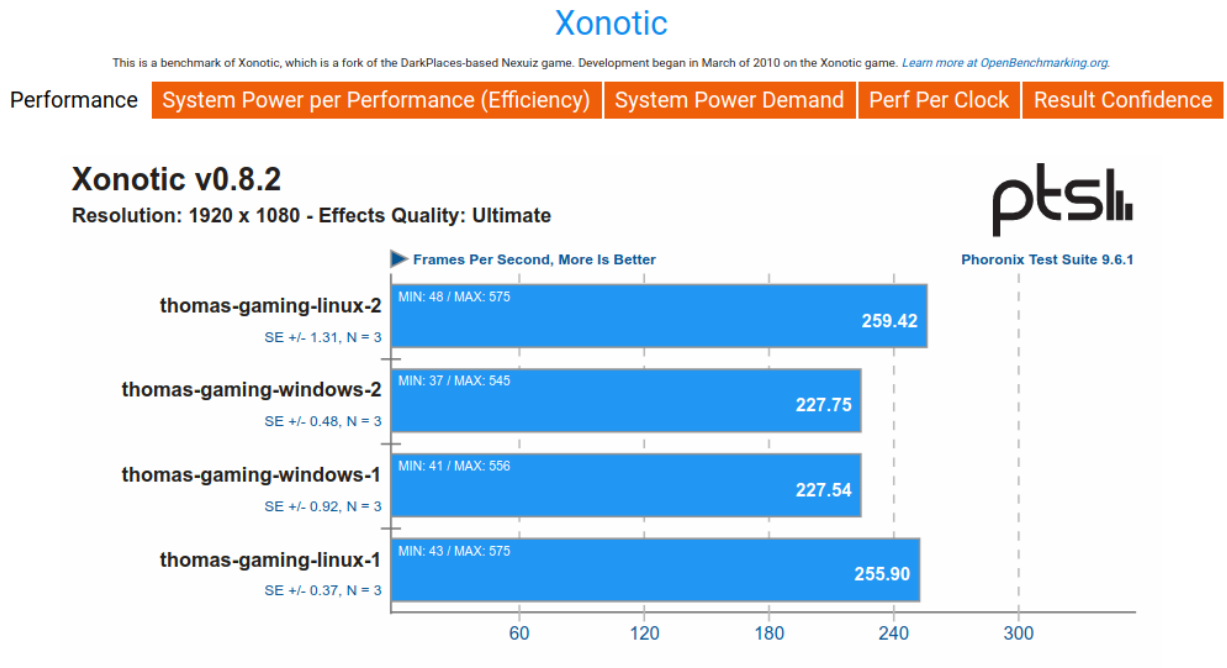


Figure 10.3: Example Worklet performance

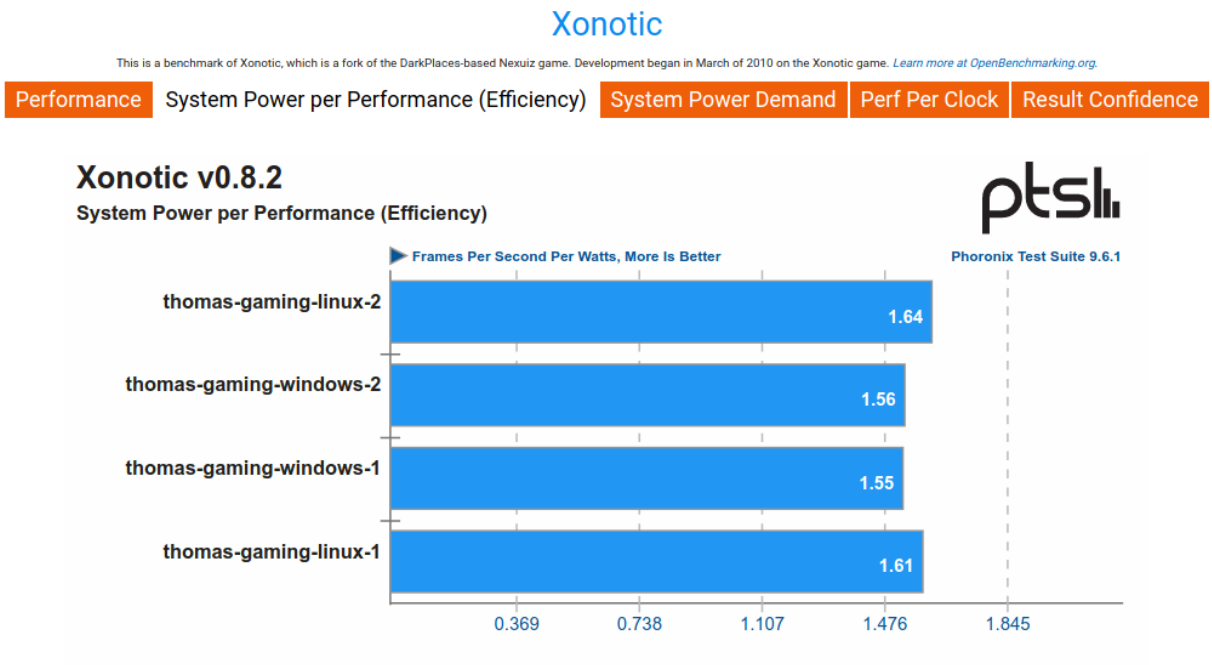


Figure 10.4: Example Worklet efficiency

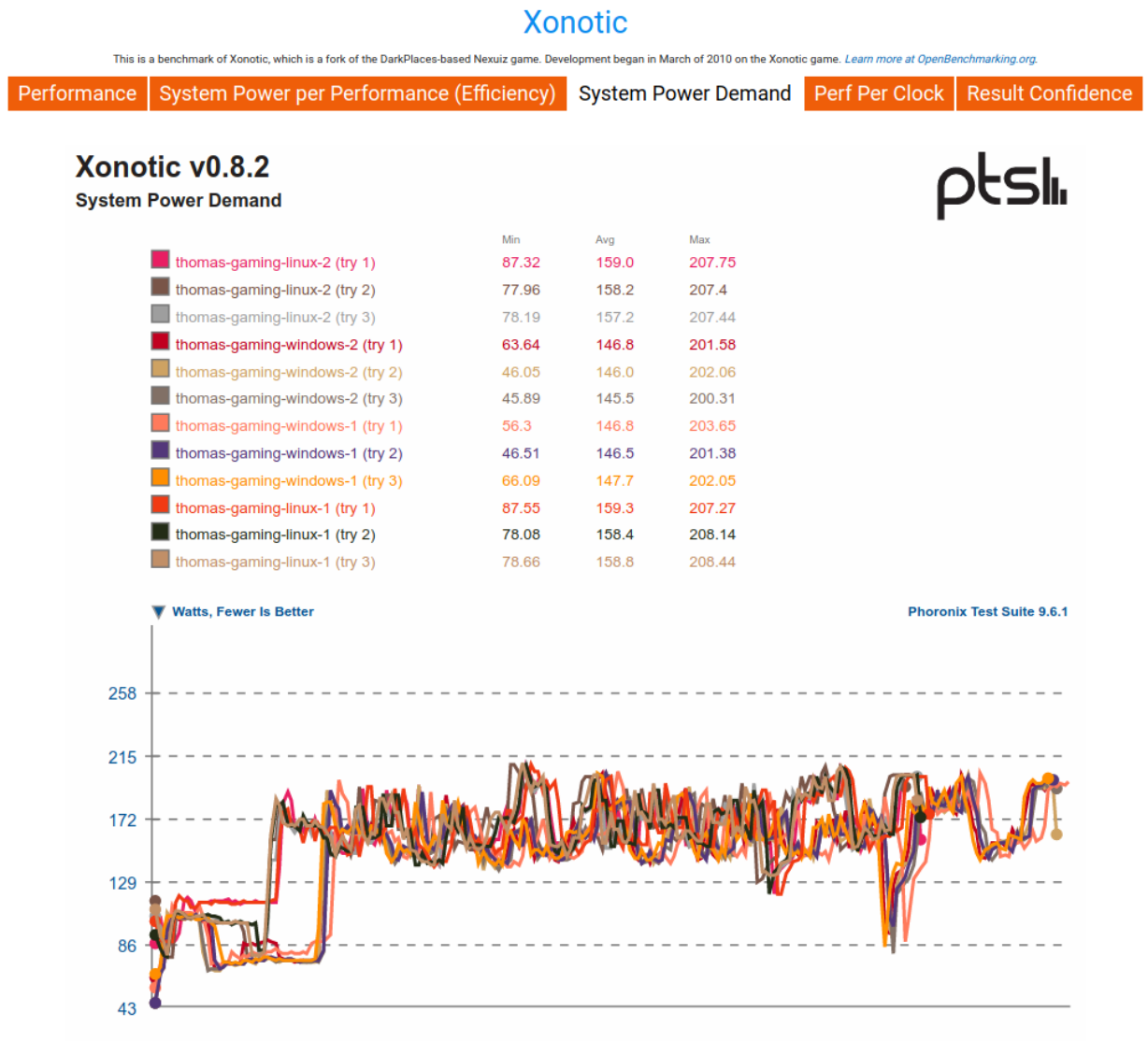


Figure 10.5: Example Worklet power

For the power measurements each automatic repetition of the Worklet during a test run is shown as a separate line in the result graph. Comparing several systems with many repetitions can lead a very complex graph.

10.5 Meta Values and System Power Monitor

All the way to the end of the report, two graphs are showing the meta efficiency calculated over all Worklets and the full series of power measurements logged during the test run.

The meta efficiency is created by calculating the geometric mean of the individual efficiency results of each Worklet and represents the efficiency result of the EUT fused into a single number. These numbers are only comparable between test runs if exactly the same selection of Worklets has been run. See Example Meta Efficiency below.

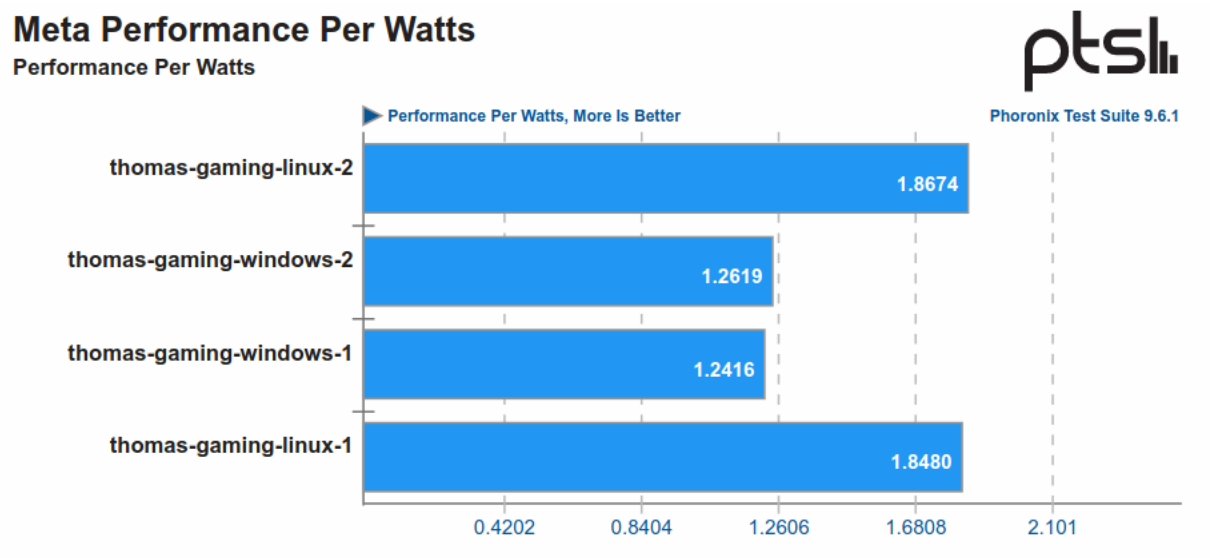


Figure 10.6: Example Meta Efficiency

The system power monitor includes the full series of power measurements acquired during the test runs. These line graphs are not directly comparable to each other in terms of average or length as Worklets are dynamically repeated during the test run as needed to improve statistical accuracy.

10.6 Exporting Results

At the top of the result page, all benchmark results can be exported to various formats, e.g. CSV. This can then be loaded into a spreadsheet to continue analysis and calculate custom averages or geometric means for example based on a specific subset of the full suite of Worklets.