



## Just measure IT

Electricity consumption for all electronic devices in one household was estimated to about 1230 kWh for one year. The desktop gaming PC, the large primary TV, and the home network each consumed more electricity than all other devices together. In addition, the household's share of data center and network services was estimated to about 560 kWh/year.

### Electricity consumption of ICT devices in a household

Nearly all electronics devices related to Information and Communication (ICT) or Entertainment and Media (E&M) were measured in a Swedish four-person household for two months, and the total extrapolated electricity consumption was about 1230 kWh for a year. In total about 45 devices were measured. The desktop gaming PC (350 kWh), the large primary TV (300 kWh), and the home network (300 kWh) each consumed more electricity than all other devices together (280 kWh). In addition, the household's use or share of network and data center services was estimated to 295 and 266 kWh respectively.

Electronic device	Annual electricity consumption (kWh)	...of which is stand-by (kWh)
Desktop gaming PC, two 24" displays, peripherals	353	8
Primary TV with peripherals	304	15
Fiber modem and home Wi-Fi router	111	(always on)
Two extension Wi-Fi routers (one outdoor)	190	(always on)
Home workplace laptop, 32" display, peripherals	72	12.5
Four smartphones with headphones	14	2 (chargers)
Three smart speakers	66	58
Two additional laptop PCs with peripherals	48	9
Two additional TVs with peripherals	47	20
Two Wi-Fi modules (two smart meters)	3	(always on)
6 smart Wi-Fi plugs (measurements in this study)	24	(always on)
<b>Total:</b>	<b>1232</b>	<b>124.5</b>

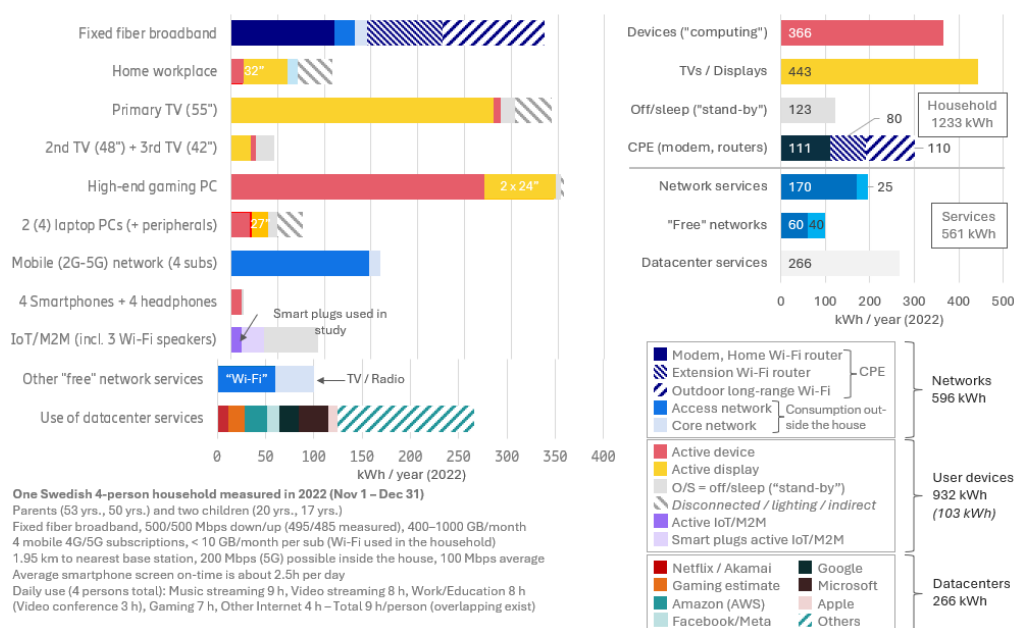


## Electricity consumption by electronic device and service

The annual electricity consumption per electronic device in the household is presented in the table together with the stand-by electricity use. The total stand-by mode electricity consumption was 123 kWh. For PCs and TVs including peripherals, the stand-by mode electricity consumption was 63 kWh, which is about 75% less than what was measured in an old study on Swedish households' electricity consumption from 2009. The total use of PCs/TVs (21 h/day) and electricity consumption (820 kWh) was almost the same as in 2009, but the number of PCs/TVs has increased, and the use has shifted from TVs to PCs.

## Streaming and videoconferencing only changes energy consumption slightly

Despite claims of the opposite, this study shows that video streaming, downloading, and videoconferencing only have a small impact on the electricity use. For example, the home workplace laptop power increases by about 5 W during videoconferencing. The fiber modem and home Wi-Fi router (CPE site) has a near constant average power consumption of 12.7 W. Day time average use and evening peak hour use including video streaming added in the order of +0.1 to +0.2 W. Short bursts of higher power around +1 W can be seen related to use over Wi-Fi. Downloading at high data rate (>400 Mbps) raises power by only 0.3 W if using a LAN cable and 2.5–5.5 W over Wi-Fi, depending on the signal quality. The additional electricity use from these activities over time is marginal.



The measurements show large variations in the electricity consumption of the TVs in the household. The variation is mainly related to the brightness of the material shown on the TVs, and on the TV's brightness settings. The 55" primary TV varied from under 100 W to slightly over 200 W with an average of 140 W. The average power of the newer 48" TV was considerably lower, on average 65 W (range 45 to 85 W). The following table presents the estimated annual electricity consumption for the household's different network services.



Network and data center services (estimates for this four-person household)	Annual electricity consumption (kWh)
<b>Network services</b>	
Fixed fiber broadband	35
Mobile network services (4 subscriptions)	160
Free network services (TV/radio, enterprise Wi-Fi)	~100
<b>Data center services total</b>	266
The data center services can be split on:	
Microsoft	31
Amazon	23
Google	20
Meta (FB)	13
Apple	9
Netflix	6
Akamai download & gaming estimate	~24
All other	~120

The household's fiber broadband was estimated based on the actual access equipment and estimates of the core network in Sweden. Swedish broadcast TV/radio and use of office/school and other public Wi-Fi was estimated to about 100 kWh. Data center services were estimated based on total electricity consumption and total users, e.g. 9.4 TWh split on 3 billion users for Meta (Facebook, Instagram, WhatsApp, Messenger), resulting in 3.2 kWh per user giving 13 kWh for the 4-person household.

### Possibilities for reducing electricity consumption

- **Gaming PC:** Apart from simply spending less time playing games, the gaming PC should be put in stand-by mode or turned off when not in use. Based on technology development it is possible to buy a new gaming PC with the same performance that only need roughly two-thirds of the power. One new larger display can reduce the power by about one-third compared to the current two old 24" displays. By combining these actions, the gaming PC electricity consumption can be reduced by at least 150 kWh per year.
- **TVs:** Use the newer smaller more efficient 48" TV instead of the older larger 55", would save about 125 kWh.
- **Wi-Fi:** The extra indoor and outdoor Wi-Fi router could be unplugged and that would save about 200 kWh per year, but using only one Wi-Fi router would likely result in poorer signal quality and reduced performance, and the two outdoor smart meters would stop working.
- **Smart speakers:** With better stand-by modes, the Wi-Fi smart speakers could consume about 50 kWh less per year, but this likely requires redesign and new speakers, or possibly only new software.
- **Unplug unused equipment:** One gaming console, the old TV aerial amplifier, and a few workplace peripherals including a webcam were unplugged due to the measurements as they were never used but consumed quite a bit of stand-by power. This resulted in annual savings of about 50 kWh.
- **Streaming and video conferencing:** The additional streaming services electricity consumption can be estimated to 6 kWh based on Netflix data and about 6 h/day. That is about the same as the Blu-ray player used only



about 0.3 h/day. A 6 h/day Blu-ray use would consume 27 kWh, which is about 3 times more than streaming, not including the embodied footprint of the Blu-ray discs. Video conferencing for about 1000 h/year only adds about 5 kWh or 0.4% to the household's ICT devices' electricity consumption. Claims that reducing streaming and video conferencing can reduce electricity consumption are exaggerated based on erroneous assumptions.

### **Greenhouse gas (GHG) emissions during the life cycle**

The corresponding annual GHG emissions from the electricity use for all ICT devices in the household and related network and data center services are less than 50 kg CO<sub>2</sub>e, using the Swedish electricity mix which is based mainly on renewable energy sources. With a global average electricity mix, the annual GHG emissions would instead be slightly over 1 metric ton of CO<sub>2</sub>e.

Investigating also the GHG emissions from the rest of the life cycle, the so called embodied emissions, for all ICT devices can be estimated to about 555 – 675 kg CO<sub>2</sub>e per year based on estimated lifetimes (or replacement rates) for smartphones (4 years), laptops (5 years), and desktop PCs, PC displays, and TVs (8 years). To use devices longer is the common recommendation to reduce the embodied emissions. The embodied GHG emissions of the fiber installation including all new routers is about 500 kg CO<sub>2</sub>e but due to the long lifetime of the fiber cable itself, the annual figure decreases to about 35 kg CO<sub>2</sub>e per year which is less than 10% of the total embodied GHG emissions.

### **Uniqueness and data quality**

This study has one obvious limitation - only one household is measured. However, it is the same type of devices based on similar components that behave in similar ways used in households around the world. Fifteen years ago, the Swedish Energy Agency published a study where nearly all appliances and electronic devices were measured for a whole year in forty Swedish households. This study is the first in-depth study in 15 years with real, device-level power measurements in a modern household. The measurements were made with a professional-grade multimeter and six smart plugs.

#### **Reference to full paper:**

Malmodin J, (2023). Just measure IT! - Electricity consumption measurements of electronic devices and estimates of datacenter and network services for one household, In: 2023 International Conference on ICT for Sustainability (ICT4S) June 2023. doi: [10.1109/ICT4S58814.2023.00013](https://doi.org/10.1109/ICT4S58814.2023.00013)