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BRIEF 3

Reducing the energy use of video gaming: energy efficiency and gamification

KEY MESSAGES

- Video gaming is an increasingly popular leisure activity worldwide, but it has environmental impacts due to the energy used driving climate change and resource issues over the entire life cycle of the gaming devices.
- Among electric equipment in households, gaming devices are gradually becoming more relevant in terms of their overall energy use.
- Playing video games on newer generation game consoles uses significantly less energy than playing on computers, when the unit energy consumption of the equipment is considered.
- Playing video games in the cloud, known as cloud gaming, can draw as much as a three-fold increase in energy use compared to local gaming.
- The energy used in gaming should be integrated into end-use energy demand forecasts and routinely updated with demographic data and technology preferences, which can change quickly.
- Improved consumer information and the gamification of energy information are recommended strategies that can have a direct effect on behaviour change.

THE POPULARITY OF VIDEO GAMING

Video gaming is a popular leisure activity worldwide; it engages millions of people of all ages and is especially widespread among the young. Video gaming is enjoyed on gaming consoles, desktop and laptop computers, and media streaming devices. Trends in internet usage predict that video gaming will continue growing, especially as more people own smartphones and can afford a broadband subscription. Indeed, streaming of games is expected to take off in 2020, as gamers are increasingly detaching from consoles and computers, and using mobile devices instead[i]. Moreover, some of the most populous countries in the world – like China, India and Bangladesh – now feature among the top 20 countries with lowest prices of information and communication technology[ii]; therefore the number of gamers in these countries is expected to continue growing.

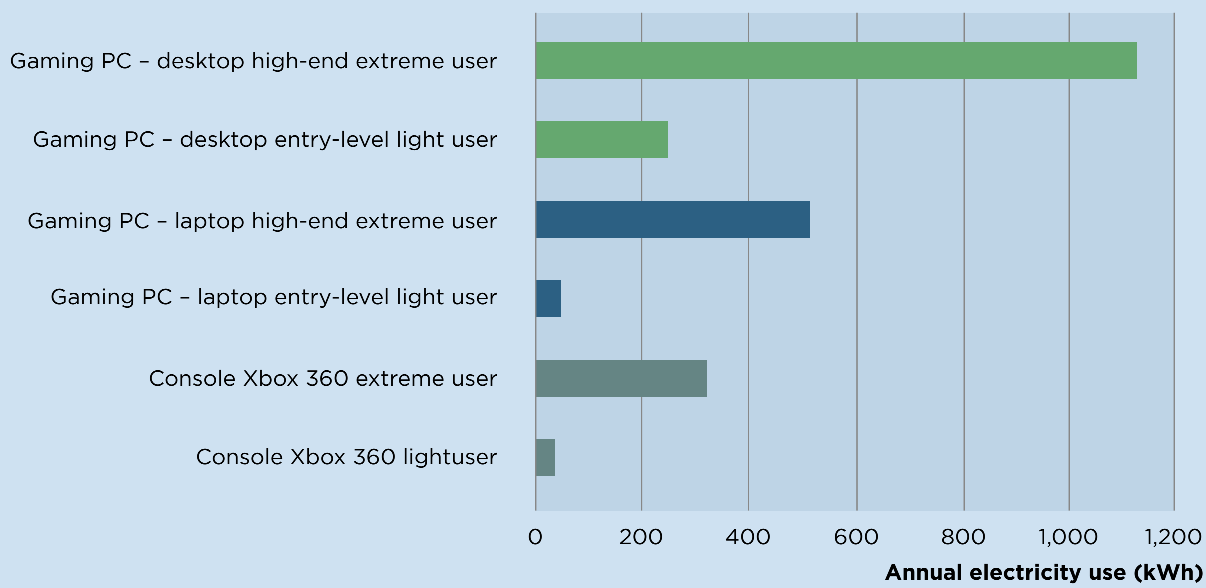
Although data on video gaming is not regularly collected by national governments, some statistics can be found in surveys conducted by market insight businesses or industry associations. According to these sources, it is estimated that one third of humanity plays video games, or around 2.7 billion people in 2020[iii]. Asia Pacific contains 55 per cent of gamers worldwide, with around 1.5 billion people regularly engaged in gaming[iii]. In the United States, video games engage about two thirds of the population[iv]. As of 2016, the most recent year for which data on consumer preferences is available, mobile gaming was the preferred gaming platform worldwide, followed by gaming on computers. Gaming on consoles came last[v]. On average, gamers spend more than six hours per week playing[vi].

Video games have environmental impacts due to their energy consumption, which drives climate change, and life cycle issues related to the equipment used for gaming and for the distribution of games – for example extraction of raw materials, manufacturing, and disposal at the end of life. However, video games also have a powerful influence on people's lifestyles, and through gamification people can be influenced to adopt pro-environment behaviour. Therefore, this brief looks at energy use in video gaming and the potential of gamification for promoting energy conservation behaviour.

THE ENERGY USE OF VIDEO GAMES

Playing video games is so widespread that concerns about energy use and the resulting greenhouse gas emissions are warranted. However, quantifying the energy use

Figure 1: Estimated annual electricity consumption of gaming computers in perspective (only client-side energy, excludes connected devices, network and data centre energy). Elaborated with data from Mills et al. (2019)[vii].



of this activity is a tremendous challenge because it involves a large number of different platforms and is heavily dependent on user behaviour, and the technologies used in video gaming are in constant evolution[vii].

The energy used in playing video games is much higher than when the first games appeared in the 1970s because of the much higher quality of the graphics, higher resolution of the connected displays, and the streaming of game content. Whereas in 1970s playing a video game would draw 10W of energy, nowadays that number is 70 times higher[viii]. Yet, the energy consumption of this activity is largely overlooked because the gaming devices in households are typically classified as non-appliances and their power draw is hence assumed to have little significance.

PLAYING ON COMPUTERS

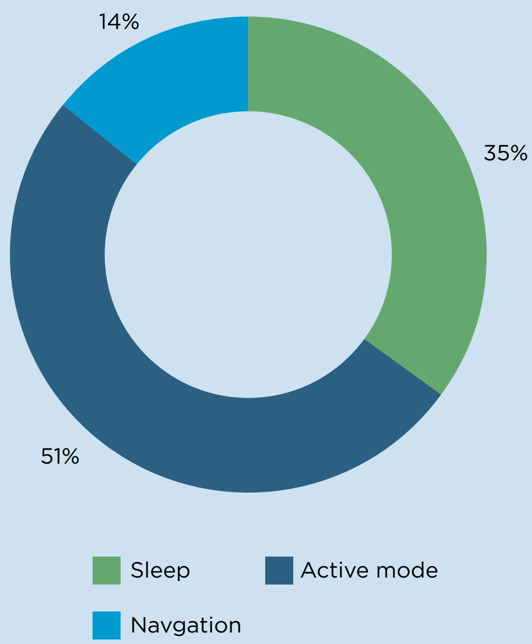
Of all the possible uses of personal computers, gaming is the most energy intensive. Globally, it is estimated that 54 million people played games on personal computers (laptop and desktop), which consumed about 75 TWh of electricity in 2012; this represented about 20 per cent of total energy used by gaming (excluding streaming devices) in that year[vii]. The annual electricity use of gaming computers varies substantially, depending on the technological components of the computer and the behaviour of the user. As shown in Figure 1, the lowest range of electricity used by gaming computers is estimated at 45 kWh per year, for a laptop entry-level computer used by a light user; whereas an extreme user on a high-end desktop computer can use as much as 1124 kWh, that is, nearly 25 times more electricity.

Gaming consoles also draw a significant amount of electricity. However, for the entire range of user behaviours, from light to extreme gaming, the last generation gaming consoles typically use less electricity than both gaming laptops and desktop computers.

PLAYING ON GAME CONSOLES

Video gaming also happens through game consoles. Game consoles are high performance electronic devices that have become increasingly sophisticated, with advanced graphics, internet connectivity, wireless controllers, voice control and gesture recognition. Estimating the energy use of game consoles is challenging, mainly because user behaviours are uncertain concerning powering off consoles after use[ix]. In 2015, a study with field-metered usage data found that 20 per cent of game consoles was never turned on, whereas about 10 per cent were left on the entire day[x]. Characterizing the energy use of game consoles is key for energy efficiency policy design, yet it requires empirical data on console usage patterns and on the mix of consoles across countries – data that in most cases is not collected or is collected on an ad-hoc basis.

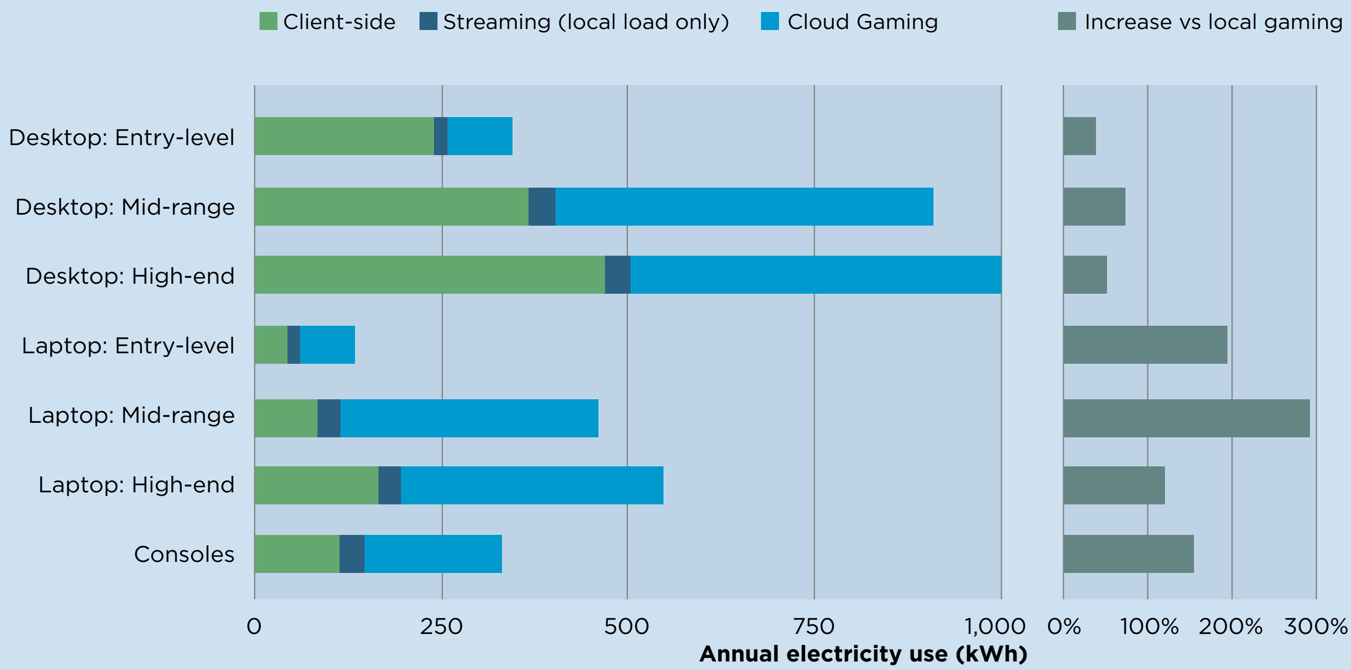
Figure 2: Estimated unit energy consumption of game consoles in United States. Elaborated with data from Urban et al. (2017)[xi].



Recent studies on energy use by game consoles report estimates done for the United States. The overall energy consumption ranged from 16 TWh in 2010[x] to 7 TWh in 2012[ix]. A study with data for the United States in 2017 reckons that game consoles consumed 8.3 TWh in that year[xi]. The average unit energy use for the newer generation consoles[xii] is estimated at 123 kWh/year[xi], putting it on par with the energy use of efficient washing machines sold in the European market.

Nevertheless, Figure 2 shows that game consoles still use a lot of energy in sleep (stand-by) mode, with nearly half of energy use attributed to inactive (navigation or sleep) modes. Therefore, there are energy saving opportunities for when consoles are not receiving user input, which could be addressed by a default short-time power down feature, coupled with auto saving the game state, when the console is in non-active mode.

Figure 3: Energy consumption in cloud gaming across different devices. Data and figure generously contributed by Evan Mills.



CLOUD GAMING

Local gaming is the conventional way of playing video games, in which the computing resources used are nearly entirely from the player's hardware. Conversely, in cloud gaming the processing tasks are off-loaded to high-end servers in a remote data centre and the video stream is delivered to computers or consoles via the internet. A study based on conditions prevailing in 2016 showed that the energy use in cloud gaming is significantly higher than in local gaming[vii]. Note that with cloud gaming the majority of computational activity happens at the data centre, and therefore the client-side equipment draws less power than with local gaming. The energy consumption varies across types of equipment, but the increase in energy consumption of cloud gaming is significant, as illustrated in Figure 3.

Mobile cloud gaming – situated at the intersection of cloud-based services, mobile devices and digital entertainment – is a growing trend. From a gamer perspective, the key benefits are the possibility of accessing games at any place and time and the reduced cost of hardware. Possible drawbacks are the degradation in user experience due to the latency of content delivery, the costs of data plans and the potential energy challenges resulting from battery drain. A few studies measured the energy consumption of cloud gaming and local gaming in smartphones. They found that cloud-based gaming saves energy in the mobile device when Wi-Fi is used as the network connection[xiii, xiv]. These studies did not consider the energy use happening on the cloud service side, and therefore have limitations that need to be addressed to understand what type of mobile gaming is overall more efficient.

CHALLENGES OF ENERGY MEASUREMENT OF GAMING DEVICES

Measuring the energy efficiency of gaming devices and identifying opportunities for energy savings is challenging. The lack of standardized testing procedures and protocols for energy measurement and energy performance metrics hinders an adequate tracking of energy use for gaming purposes, and creates confusion in the consumer information environment[iv].

Studies that relied on nameplate power data for the energy use of components and gaming devices are rife with uncertainty because nameplate power estimates tend to exceed measured power use in practice[viii]. Future testing, with the view to improving consumer information, should be done under as-used conditions and following standardized test procedures and methodologies[viii].

POLICY STRATEGIES FOR VIDEO GAMING'S ENERGY USE

Video gaming is relatively untouched by regulation with respect to energy use. For example, existing energy-labelling programmes for computers and computer energy standards do not properly consider energy use in active gameplay nor the use of high-performance computers for gaming[iv]. Where standards exist, they are not adequate because of inadequate metrics for benchmarking. For example, units of energy use in relation to performance or service delivered are very difficult to quantify because performance or service are subjective, depending on the user experience. A possible solution could be to focus on energy standards for specific components of gaming devices, for example standards for graphics processing units (GPUs), motherboards, or central processing units (CPUs)[viii].

Consumer information also needs to improve with respect to distribution of games. For example, there are ratings for games' content to help consumers make their purchasing decisions, yet games lack any information about their induced energy consumption and the resulting GHG emissions. Whereas a variety of in-game statistics are provided to gamers, energy use and GHG emissions associated are not included among them. This information could not only be offered to gamers but even could be gamified to stimulate the pursuing of goals with environment and climate goals[iv].

A key challenge with regards to policy design for the gaming industry is that technology (hardware and software) is evolving at a much faster pace than the regulatory process can respond to. This requires energy regulators to work closely with technology developers in order to continuously learn about the evolving challenges and encourage energy efficiency aspects to be regularly considered.

GAMIFICATION OF ENERGY INFORMATION IN VIDEO GAMES

The potential of gamification and serious games to engage consumers in pro-environment behaviours is a recent topic of investigation. Much of the research on applied gaming has focused on the negative impacts of playing computer games, such as health and psychological effects. Nonetheless, gamification and serious games has already been used in different fields (e.g. education, health, military) to motivate and persuade people to change behaviour.

Serious games are game-like contests that use entertainment for the purposes of training, education and strategic communication[xv]. Gamification, on the other hand, applies game mechanics and game design elements to non-gaming activities in an effort to create game-playing in these contexts.

There are reports of utility companies applying gamification to promote energy efficiency. An energy conservation game named Behavioural Customer Engagement has been provided to customers of utility companies. Customers receive detailed energy usage reports and can compare their energy usage against other consumers. They can join challenges and compete to reduce their energy use and win prizes and rewards. The game has reportedly saved over 1 billion kWh of electricity during a period of five years[xvi].

Serious games are widely recognized as tools with potential for active learning. They can contribute to the development of collaboration, competition, and decision-making skills[xvii]. These kind of games could be used to increase consumers' knowledge about, for example, how to use energy efficiently at home. With the incorporation of persuasive technology, serious games simulate environments that users can explore and where they can safely experience cause and effects relations. An example is the game PowerHouse, which was designed to increase the players' knowledge on energy-consuming activities at home[xviii].

Despite promising results, research in key aspects related to gamification is still lacking. Important aspects to investigate are the maintenance of behaviour change over time, and the transferability of learned behaviour from the game to real life. It is crucial to identify in which conditions gamification is effective for socially significant behaviour change[xix].

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AUTHOR

Ana Cardoso
Researcher, UNEP DTU Partnership

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