Networked Devices Workshop

G20 Energy Efficiency Action Plan

17-18 June, Paris

Summary of progress with working groups

This document summarizes the current state of play within each of the G20 Network Devices working groups, that was discussed at the meeting on 17-18 June in Paris.

Please note that this document is NOT FOR WIDER DISTRIBUTION.

Contents

1 Networked Devices Definitions

For the G20 Networked Devices initiative, the following definitions are used:

Edge device	An end-user device that is connected to a network. Edge devices range from electronic devices such as smart TVs to appliances, heating, cooking and lighting equipment.
Latency	The time it takes for a device or part thereof to change state or mode so that it can respond to a request or to provide a requested function.
Network or Network System	A digital communication infrastructure with a topology of links, an architecture, including the physical components (devices), organisational principles, communication procedures and formats (protocols). Networks can interconnect with other networks and contain sub-networks.
Network(ed) infrastructure device	A device connected to a network that is shared by more than one edge device (client). A server would be an example of such a device.
Network(ed) devices	A general term meant to cover all devices that are connected to networks and make up the network. Edge devices, network(ed) infrastructure devices, and networking devices are all subsets of network (ed) devices.
Network idle	A power mode in which a device does not receive and process any "pay load" but maintains the necessary network connections.
Network(ed) standby	A low power mode in which a device has the capability to maintain a persistent network presence after its operation has been suspended.
Networking device	A device connected to a network whose main functions are to pass along data traffic, routing data between networked devices, and optimising available bandwidth and transmission delays according to a wide variety of requirements. A WiFi access point would be an example of such a device.
Networking functionality	The functionality to pass along data traffic and routing data between networked devices. For networking devices, the networking functionality is the main function. For edge devices, the networking functionality may be one of the (secondary) functions, e.g. a LED lamp that functions as a mesh in a (home) network.
Power management	The capability of a device or network to adapt its power to the required functionality. Examples of device power management are power scaling, and switching into a low(er) power mode. Examples of network power management include consolidation of resources, managing the state of network links, and proxying."
Power scaling	The capacity of a device to dynamically change its powerlevel in relation to its variable workload; it may involve voltage and/or frequency scaling.

Attachment A provides further explanation of these terms.

2 Vision & goals

The G20 mandate for the Networked Devices workstream is as follows:

> *"Participating countries will work together to accelerate the development of new ways to improve the energy efficiency of networked devices. In 2015, this work will include consideration of options for goals for reducing the global standby mode energy consumption of networked devices."*

After consideration, the following **vision** is appears likely to be shared by all participants:

> *A world where devices and networking are optimized for energy management while delivering increased value, productivity and services, with the goal of reducing the global energy consumption of edge devices, networking devices and networks.*

Governments involved in the G20 process have identified that any goal should be challenging, easily understood, grasped by politicians, and able to be tracked. A goal of "***1 W plus***" by 2025 for network standby and idle meets many of these criteria. It is noted that plus indicates a differentiation in targets for edge devices depending on the type of network connection; and would indicate a separate metric for power consumption in network idle, i.e. as percentage of the power consumption at maximum throughput (e.g. 10%).

However, industry participants have voiced a preference for measures based on energy consumption rather than power. One consideration is that a goal based on power is easier to monitor and is under the control of device designers/manufacturers, whereas it is considerably more difficult to track energy consumption, in part because this will involve assumptions about usage patterns and the stock of equipment.

An alternative goal based on the aspiration to prevent the growth in network standby energy consumption might also reflect the policy objectives of governments. Such a goal might be expressed as:

> *"Stop the growth in network standby energy consumption while maximizing the benefits of greater connectivity."*

If it is not possible to gain agreement, member governments would be willing to adopt a goal as a challenge for industry.

It should be noted that:

- Further work will be needed to determine a practical method for measuring progress towards an adopted goal.
- In addition to the policies currently implemented (noted in MDLE) and the range of new initiatives identified through the working groups in 2015, member governments and industry are encouraged to take further actions to work towards such a goal.

3 Guiding principles for the design and operation of energy efficient edge, networking and network infrastructure devices, and supporting policy principles

This section contains a working draft of guiding principles to promote efficient energy management in networks and networked devices, such that they actively support power management to maximize net system[1] energy efficiency without compromising performance. It combines two sets of principles (see below).

Good progress has been made in drafting a blended set of principles. Issues for discussion at the Paris workshop include the treatment of devices with edge and networking functionality; and the treatment of protocols in the design principles. Areas where discussion is still ongoing are flagged up in the text below.

3.1 Background to the two sets of principles

In 2007, the International Energy Agency (IEA) developed a set of principles to promote efficient energy management in networks and network-enabled devices. The principles underscore that no single power management solution ensures energy efficiency and that efficiency must be addressed in an integrated manner over the entire network-enabled value chain[2].

In 2015, the Consumer Electronics Association (CEA), Digital Europe (DE) and ITI (Information Technology Industry Council) developed a set of principles for government and industry regarding energy efficient networked devices. These built on the earlier work of CEA in this area.

3.2 Blended set of principles

In furtherance of the three pillars of the 2015 G20 agenda (Strengthening the Global Recovery and Lifting the Potential; Enhancing Resilience; and Buttressing Sustainability), governments and industry should advance the following design and operation principles and pursue policies guided by the following policy principles to help attain a world where networked devices and networked systems are optimized for power management while delivering increased value, productivity and services to society.

3.2.1 Design and operation principles

1. Networked device design should follow standards-based communication and power management protocols to ensure compatibility and interoperability, and should take advantage of protocols that actively support energy efficiency *[final clause here is under discussion]*.
2. Networked devices should not impede the efficient operation of a network (for example by injecting bottlenecks or faults, or impeding power management activities in other devices).
3. Connection to a network should not impede a device from implementing its internal power management activities.
4. Networks should be designed such that legacy or incompatible devices do not prevent other networked devices on the network from effective power management activities.
5. Networks and networked devices should have the ability to scale power levels in response to the amount of the service (level of functionality) required by the system.
6. Edge devices without networking functionality should enter network standby after a reasonable period of time when not being used. Edge devices with networking functionality should enter

[1] It is possible that some device(s) may need to consume more in order for other devices to consume less.

[2] In 2010, these principles were updated with some minor revisions. Since then the APP (Asia Pacific Partnership) Standby Project, the IEA 4E (Efficient Energy End-Use Equipment Implementing Agreement) Standby Annex and the Applied Power Electronics Conference all accepted these principles as the basis for future work in this field.

network idle after a reasonable period of time when the main function(s) are not being used *[treatment of devices with more than one type of function in under discussion]*.

7 Networking and networked infrastructure devices should not autonomously go to network standby mode. These devices should support power scaling.

8 Consumers should be informed about and have control over device power management, when applicable, including networked device low power modes that may affect the user experience.

9 The design and operation of networked devices should be compatible with, and promote the positive effects of, using consumer electronics and information and communication technology (ICT) to enable energy to be used more efficiently, often referred to as "Intelligent Efficiency."

10 The development of network and communications standards and protocols should allow for the optimization of net system energy efficiency, using network power management.

3.2.2 Policy principles

1 Policy, including terminology and test procedures, should be internationally aligned where possible and should benefit the global marketplace for efficient consumer and commercial products and services, and the enhanced productivity and efficiencies achieved through networks *[this principle is undergoing drafting revisions]*.

2 Policy, including government procurement and best-practice sharing, should support continued device, network and intelligent efficiency innovation.

3 Energy efficiency requirements should be performance-based and technology neutral.

4 Policy should account for the different capabilities of networked devices. Policy should neither impede the functionality of networked devices or efficiency of the network nor impair the implementation of standards for enabling device or network security.

4 Standards and Protocols

4.1 Background

The objective of this working group is to stimulate the development of standards and protocols that help to reduce the "energy cost" of connectivity for mains-powered networked devices. The standards and protocols of interest are those which govern how networked devices communicate and manage energy consumption. Product minimum energy performance standards (MEPS) and measurement protocols are of less interest.

Most recognized international standards bodies, such as the IEEE, IEC, ISO and IETF focus their standards activities on some subset of the seven layers of the Open Systems Interconnection (OSI) model[3]. Often these standards provide a wide range of features and options, from which designers and programmers can choose.

> *An example of this is IEEE 802.15.4g, which supports a wide range of wireless frequencies and modulation schemes (physical) and defines a large number of features at the "data link layer" but does not provide much, if anything, above the data link layer.*

In the case of the Internet of Things[4], the networks are governed not only by standards produced by the recognized international standards bodies, but also by more prescriptive standards developed by alliances, consortia and other standards bodies.

> *To follow our IEEE 802.15.4 example, the ZigBee Alliance define networking and application standards based on the IEEE standard, and Thread group defines networking standards based on IETF standards and working with IEEE 802.15.4. There are a number of standards that use IEEE 802.15.4 as their base, and some that even choose the same physical options for frequency and modulation, but differ significantly in the other layers, with very different results in terms of energy profile.*

4.2 Outcomes

Generally speaking, the building blocks for energy efficiency largely exist in the lower layer standards and protocols and these are currently optimized for energy efficiency. However, the efficiency elements of these are often optional - the efficiency options need to be specified by device designers in their designs in order to take advantage of them. In other words, protocol <u>adoption</u> is important.

However, there may be some "technical gaps" in standards and protocols, where further technical effort could be focused. One potential example is the issue of "latency", e.g. where device A attempts to communicate with device B, but device A cannot tolerate any delay in device B "waking up" from a low power state. If technical gap(s) are identified, they might represent a starting point for improving some standards and protocols.

Motivating the <u>authors</u> of standards and protocols to further improve device energy efficiency could be achieved by adoption of a set of design principles (refer working group 2) and by providing them with awards and recognition (refer working group 6).

[3] http://en.wikipedia.org/wiki/OSI_model
[4] http://en.wikipedia.org/wiki/Internet_of_Things

5 Energy Aware Devices

5.1 Background

The objective of reducing device energy use in network standby mode lead to "Energy Aware Devices" in the following way - networked devices are evolving rapidly, making it difficult to influence their energy efficiency (in the short term). However, the fact that networked devices can communicate presents an opportunity - what if these devices were to communicate their standby energy use to users?

This may encourage better device design. For example, IEA-4E recently tested networked LED lamps[5] which measured close to 3 Watts in network standby mode (when the lamps were "off"). Disclosure of such high energy consumption to consumers (and in product reviews and blogs, etc.) might encourage better product design in the first place.

This concept then grew in the following way:

- Devices could communicate power/energy in any operating mode - this may compel better efficiency across all modes.
- Actual electrical power can be measured by dedicated hardware built into devices or - as an alternative to power measurement - many devices can estimate their own power internally (e.g. by altering existing firmware to include a power estimation algorithm). This concept has been tested for a networked LED lamp[6]. Developing the estimation algorithm would also foster intimate manufacturer understanding of the relationship between device operation and energy consumption (e.g. may assist 3W lamp example above).
- Power estimation can also be performed outside the device, e.g. by pattern recognition algorithms based on advanced and high resolution power meters.
- Real time device power would be valuable for applications such as home energy management, smart buildings, smart grid, intelligent efficiency, user feedback to stimulate behaviour change, etc.
- The disclosure of power/energy consumption could also take place using a device's onboard display (if it has one) and this may also suit non-networked devices. Networked devices could disclose energy using apps/browsers on smart phones, tablets, computers, etc.
- More advanced information feedback mechanisms could promote further savings. These mechanisms include actual and live consumption displays, notification of major increases in consumption, comparison of the devices' efficiency level with other devices on the market.

One analogy for the concept of "energy aware devices" is vehicle fuel economy display, which is now ubiquitous in modern passenger vehicles. This is also typically an estimate produced by the vehicle management system (e.g. based on control signals sent to the fuel injection system). As vehicles are now "fuel consumption aware", electrical equipment could become "energy aware".

5.2 Related Initiatives

There are a number of industry initiatives and products which involve disclosing real time device energy use information, particularly in the ICT sector. Some ICT examples are linked in the footnote below[7]. The IETF has a developed a protocol[8] for use in energy management of devices connected to

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[5] http://edna.iea-4e.org/files/otherfiles/0000/0100/Smart_Lights_Paper_for_EDNA_Website_v3.pdf

[6] https://www.youtube.com/watch?v=CosIGT0MYk8

[7] Examples of ICT energy disclosure industry initiatives and products:
http://www.cisco.com/c/en/us/products/switches/energy-management-technology/index.html
http://www.cnet.com/how-to/calculate-your-pcs-energy-use/
https://support.apple.com/en-au/HT201464
https://software.intel.com/en-us/articles/intel-power-gadget-20

[8] https://datatracker.ietf.org/doc/rfc7460/?include_text=1

a communications network - it includes monitoring for power state and energy consumption of networked elements. The US standard ANSI/CEA-2047[9] also covers this for consumer electronics.

Technologies and algorithms are being developed to disaggregate high resolution electricity meter data such that the energy consumption of individual appliances can be identified. Some examples are linked in the footnote below[10]. Numerous smart grid and smart appliance initiatives are underway, where appliance energy use data is used in load control (particularly for larger appliances).

There are a number of current government initiatives which are related to this subject. These include the IEA-4E report Beyond Network Standby[11] which investigates "Energy Reporting". The Energy Star specification for computer servers[12] requires servers to:

> *provide* [real time] *data on input power consumption (W); Data must be made available in a published or user- accessible format that is readable by third-party, non-proprietary management software over a standard network; When an open and universally available data collection and reporting standard becomes available, manufacturers should incorporate the universal standard into their systems.*

The European Commission has also recently launched a preparatory study on smart appliances.

[9] http://www.ce.org/Standards/Standard-Listings/R7-8-Modular-Communication-Interface-for-Energy-Ma/ANSI-CEA-2047.aspx

[10] Examples of high resolution electricity meter data disaggregation and products: www.yetu.com, www.smappee.com, www.youknowwatt.eu

[11] http://standby.iea-4e.org/files/otherfiles/0000/0104/Network_Standby_Report_Final.pdf

[12] http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer_servers/Program_Requirements_V2.0.pdf?ea31-43fd

6 Centre of Excellence

6.1 Description

Energy Efficiency By Design is a centre of excellence that seeks to increase the understanding of energy saving opportunities and best practices that can be attained by networked devices and the networks within which they operate. It is established to provide open, independent and authoritative information to inform energy efficiency policy development. Its primary audience is governments, industry, academics and NGOs. The site is hosted by the IEA 4E Energy Technology Initiative and supported by member governments and industry. All materials posted have been subject to a brief review process and judged to be useful and appropriate.

Energy Efficiency By Design welcomes the submission of relevant papers for posting on this site. Papers that meet the following criteria will be accepted:

- Increase the level of understanding of an issue or issues that directly concern the energy consumed by networked devices or their networks;
- Provide information or guidance relevant to the development of energy efficiency policy;
- Avoid direct product related sales pitches, and criticism of competing products or approaches;
- Focus on data and argument in support of the energy claims of particular approaches, configurations, techniques;
- Are clear and understandable by non-technical readers, and where required include glossaries and footnotes to provide explanations;
- Are clearly identified by author and affiliation and include references, preferably to independent studies or analysis.

6.2 Pilot website

A pilot website will be established on the 4E site, in order to demonstrate the concept to the G20.

6.3 Review Panel

The role of the review panel is to assess whether materials submitted meet the criteria identified above (rather than providing a check on the veracity of the contents). The panel will comprise 3-5 people drawn from industry, governments and relevant organisations, such as ACEEE, ECEEE, LBL. It is proposed that the current working group should form the nucleus of the review panel under the overall management of 4E, adding others as it sees fit. This will allow the early consideration of materials already put forward and to populate a pilot website.

6.4 Potential materials

Working Group 7 (Intelligent Efficiency) have listed a number of reports which may be suitable for use on **Energy Efficiency By Design**.

7 Awards

7.1 High-level Award Program Objectives

- Maximize energy savings of networked devices.
- Raise awareness of energy consumption in networked devices.
- Increase market share of highly-efficient networked devices.
- Spur innovation among networked device manufacturers.
- Spur innovation among networked device manufacturer associations.
- Incentivize policy makers and standards/protocols organizations to address networked devices in [standby] mode.
- Support harmonization of networked standby terms and definitions.

7.2 Award Program Considerations

Perhaps the most important initial competition (or related award) program design consideration is to identify who the audience will be, and who will receive the award. To that end, we have identified some general award types below and listed important characteristics of each. We might consider implementing one or many of these programs depending on the timeframe.

7.2.1 Product Award

Generally, awarding a specific product for a networked standby energy efficiency criterion could be very difficult and take a considerable amount of time. There are many important concerns when considering a product awards:

- Product category – The wide scope of networked products with standby functionality necessitates a very careful and specific definition of the product to be considered. This limiting scope would limit the impact of an awards program intended to transform the networked device market.
- Standby modes – Different products have different levels of networked standby modes. Making comparisons between products that identify different levels of networked standby levels could be very difficult. This underscores the need to better harmonize some of the terminology that an awards program could support.
- Efficiency gains – Many networked products are already very efficient while in standby mode, so identifying an appropriate product that has much to gain with increased efficiency performance is important.
- Timeline – A specific product award/competition could take a significant amount of time to complete. Agreement on the product scope and competition characteristics through technical consultations, competition outreach, and winner verification would reasonably take 12 months. An effort to engage networked device manufacturers to design improved standby efficiency criteria in upcoming product lines would add to that timeline.

7.2.1.1 Product Award – Most Improved

An interesting twist on a product specific award could be identifying devices along the same product-line that have large improvements of networked standby energy efficiency in updated models. This has several potential advantages over the broader product award considered above:

Product category

- Comparing the same models will help focus the award on a very specific product and eliminate some of the concerns of comparing models of a similar product category that may have different functionality.

- This could also be a somewhat broad way to scope the competition. We could identify a winner in each of a few different product categories (i.e. most improved laser printer, most improved video game console, most improved set-top box, etc.).

Timeline – This type of award could be completed relatively quickly by evaluating existing data.

7.2.2 Incorporation of Network Standby into Existing Product Awards

Another option is not to create another category for networked products, but to add a network standby criteria to existing awards. This would involve factoring in network standby energy power measurements, for awards categories and for products which have a network standby mode (not all nominated products will have a networked standby mode, so for some entries this will just be N/A). Even if very few nominations have this feature, it may still be useful in terms of raising awareness.

7.2.3 Product Award - Small Network Equipment

One challenge with adding network standby to existing awards is that network standby may represent only a small proportion of the product's overall energy use. However the primary role of small network equipment to *provide* the network, thus network energy is a significant part of their energy use. An award for these products could leverage the Energy Star program for Small Network Equipment[13].

7.2.4 Standards/Protocols Award

In an effort to avoid some of the difficult issues presented by a product award and still work toward the goals of the awards program, an option might be a networked device standards/protocols award. An awards program for standards protocols could take a few different shapes:

- Award a single protocol based on networked standby power consumption (a winner-takes-all competition).
- Create a ranking system of protocols based on networked standby power consumption.
- Highlight initiatives being taken by the protocol makers to help educate manufacturers making products using the protocols (a recognition award that could highlight multiple "winners").

The timeline for a protocol award could also be relatively short if we consider protocols the way they are currently designed. A longer-timeline option that may spur innovation amongst protocol creators could be a challenge program. Here the awards program would set a target low-power consumption goal and challenge the protocol industry to reach that goal.

7.2.5 Program Award (standards development, technology components, etc.)

A program or project award might offer another opportunity to avoid some of the problems associated with a product award. A program award would be most impactful as a recognition award with the potential for multiple winners. This type of award has quite a few different design possibilities:

- Standards body award (looking at IEC TCs for example)
- Innovative hardware technology design award (an award for low power transistor design for example)
- Innovative software technology design award (an award for a UI or control that decreases power consumption through a user-behavior concept for example)

[13] http://www.energystar.gov/products/certified-products/detail/small-network-equipment

8 Intelligent Efficiency

8.1 Objective and Scope

The objective of this working group is to investigate how the G20 project could stimulate Intelligent Efficiency (IE). Intelligent Efficiency is loosely defined as the deployment of ICT technologies to facilitate efficient control of energy-using equipment/networks, leading to system-wide and cross-sectoral energy savings. The ACEEE explain Intelligent Efficiency as the deployment of affordable next-generation sensor, control, and communication technologies that help us gather, manage, interpret, communicate, and act upon disparate and often large volumes of data to improve device, process, facility, or organization performance and achieve new levels of energy efficiency. The key opportunities for Intelligent Efficiency energy savings include: real-time feedback (to humans), automation (bypass humans) and substitution / dematerialization (displace energy intensive activities).

8.2 Background

There are several organisations currently pursuing ways in which to further the benefits of Intelligent Efficiency. A number of studies of Intelligent Efficiency and its potential have been completed and there are numerous practical examples of the deployment of Intelligent Efficiency.

Recently, the Digital Energy and Sustainability Solutions Campaign (DESSC) drafted a report entitled ICT-Enabled Intelligent Efficiency: Shifting from Device-Specific Approaches to System Optima.

This Working Group did not wish to duplicate any of the ongoing work of other organisations in the area of Intelligent Efficiency. It was however felt that if the G20 project were to undertake any actions in this area, they should be specific and concrete.

9 Attachment A: Technical background to the G20 Network Devices workstream[14]

9.1 Scope

MDLE (2014, p. 44) distinguishes between:

- Data centres, networks, and other network infrastructure, and
- Edge devices and user premise network equipment (small network equipment: SNE)

Data centres, networks and other infrastructure constitute the ICT infrastructure. ICT infrastructure is an essential part when looking at "intelligent efficiency" (see "Energy efficiency" below).

Edge devices and small networking devices account for 42 % or 570 TWh of total ICT energy consumption in 2012 (MDLE 2014, p. 44). Note that the boundary between edge devices and small networking devices is blurred because several edge devices have network functions, e.g. a set-top box can have a network access point or a lamp can function as a mesh in a (home) network. Therefore, edge devices are differentiated into edge devices without and with networking functionality.

Many devices which connect to a network are battery powered, e.g. mobile phones, some smoke alarms, etc. These battery powered products have an intrinsic motivation to use as little energy as possible so that they function as long as possible without recharging or replacing the battery. Therefore, the scope of the G20 Action is restricted to grid connected devices, including DC powered devices e.g. by PoE or USB.

9.2 Power versus energy

The G20 Action aims in the short term to reduce the standby mode energy of networked devices, or in other words, reduce network standby energy consumption. Energy consumption is the result of the multiplication of power consumption and time:

E = P x T.

Therefore, a higher power over a shorter time can result in the same energy consumption as a lower power over a longer time. Similarly, a somewhat higher power when the product is in network standby (e.g. to enable proxying), can reduce overall energy consumption because the product spends less time in high power modes (MDLE 2014, p. 92-93). Thus, a total energy consumption (TEC) target provides more flexibility to achieve higher efficiency levels. However this requires the assumption or the measurement of a usage pattern; see also MDLE (2014, p. 93) for the problems.

For "cycling" within a mode, e.g. a product that "checks" the network every 20 seconds or has in general different power levels while being in a certain mode, the power versus energy discussion is solved by the measurement standard (IEC 62301. Ed. 2). According to this measurement method, the power consumption is taken as the average power consumption over a certain period that should include at least two cycles and lasts not less than 10 minutes.

9.3 Power management, power scaling, network standby/idle and latency

9.3.1 Power management, power scaling

In general the following strategies can be followed to reduce energy consumption of products (see also MDLE 2014, p. 64)

- Use efficient components (to reduce power consumption).
- Power scaling: the capability of the product to vary its power consumption to the performance (in active mode); two variants can be distinguished:

[14] Provided by Hans-Paul Siderius

- Stepped power scaling: turning off unneeded or redundant parts, e.g. the number of fans, additional power supplies, extra RAM;
- Continuous power scaling: the power varies continuously with the performance, e.g. the decrease of traffic through a router results in a decreasing power consumption or the increase of brightness of a television results in an increasing power consumption.

- Energy management: reduce the time spent in high-power modes and increase the time spent in low-power modes.

Note that these strategies are related and at some points overlap. This document uses the term power management to indicate the capability of a product to adapt its power consumption (automatically) to the required functionality. This includes, power scaling (in active mode) and switching into a low power mode when primary function(s) not being used. Note that the principle of power management can be applied at the component level, e.g. switching on and off the cores of a processor, at the product level or at the system level, e.g. switching servers off in a data centre when the utilization of the data centre is low.

9.3.2 Network standby/idle

Network standby (for a product) means that a product is connected to a network and is not delivering its (primary or secondary) functions, but is waiting from a signal through the network to resume or start a (primary or secondary) function (MDLE 2014, p. 16). It is noted that the term "standby" has connotations with "sleep" or "inactive" which are seen to be inappropriate for network equipment. Network equipment never sleeps because it always has to maintain the network connection(s) even if no "pay load" is processed. For the case that only the network connection is maintained, the term "network idle" is suggested. Network equipment is in "network idle" when the product does not receive and process any "pay load" but the necessary network connections are maintained.

9.3.3 Latency

To reduce the *energy* consumption of a product that has network standby or idle, the time in which the product is in network standby or idle need to be as long as possible and the power consumption in network standby or idle needs to be as low as possible (in any case lower than the power consumption in on-mode).

The first condition (time) means that the product needs to be switched to network standby or idle as soon as possible when the primary or secondary functions are no longer needed. In general, the important issue is the resume time or ***latency*** for an application getting back to work. The low power mode with network standby or idle needs to be designed in such way that it meets the resume time requirements of the user or of the network protocol[15]. The latency is for the largest part determined by the (physics of the) process when the reactivation signal has been received. For a laser printer where the drum needs to be heated before printing can start, the resume time can be several minutes, whereas for networking products the resume time can be milliseconds.

Note that the issue of latency also relates to power scaling (both stepped and continuous). Also here the main issue is not decreasing the performance (and the power consumption) when the load decreases, but increasing the performance fast enough to match increasing load.

9.4 Energy efficiency of network standby

Two perspectives to value network standby exist: the product and the system perspective. In the ***product perspective*** the energy consumption of a product with network standby for a certain product cycle (TEC) or the power consumption in standby can be used as measure: the "better" product is the product with the lower TEC or the lower power consumption in standby[16].

[15] Or, the other way around, to enable the protocol to deal with larger latencies.
[16] This assumes that both products perform their (main) function(s) equally well.

However, this does not take into account the usefulness of the product connected to a network regarding decreasing energy consumption or increasing energy efficiency of other products or its own. Through the network connection, a product may be able to control other products or can receive information from elsewhere to control its performance. In the ***system perspective*** these wider implications of both energy consumption and savings are taken into account. On the consumption side stand the energy consumption of the network(ed) products and the relevant ICT infrastructure, whereas on the saving side the energy savings count. In a simplified formula:

$$Energy\ efficiency = \frac{\sum energy\ savings}{\sum(energy\ consumption\ network(ed)products, ICT\ infrastructure)} \times 100\%$$

In this case the "better" product is the product with the higher energy efficiency. However, the energy savings should at least compensate the energy used to generate the savings, meaning that the energy efficiency should be higher than 100 %.

For a networked thermostat that uses cloud computing and data to determine an optimal heating curve, the energy savings would be the savings of the heating device using the optimal heating curve. The numerator would be the energy consumption of the relevant network infrastructure including the part of the data centre where the calculations are performed and the data is stored, and the network consumption of the heating device.

At the moment no methodology is available to assess energy efficiency of network standby at a system level.