MARKETING REPORT

MR-204

ENERGY EFFICIENCY, DEMATERIALIZATION AND THE ROLE OF THE BROADBAND FORUM

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1 Executive Summary

The Broadband Forum (BBF) is taking a leadership role in "green telecom." Broadband Forum Technical Reports, initially focused on Broadband Architecture and Transport such as TR-101, TR-156, and the emerging WT-145, have paved the way for equipment consolidation resulting in efficiencies in capital, operating, and energy expenses. TR-069-based documents regarding remote management of customer premises equipment (CPE) enable cascaded energy management via new proxy management capabilities ((currently covered in PD-174 extension)) and new works are being developed to transition the behavior of broadband from "always on" to "always available." Collectively these efforts will result in fundamental improvements in both consumer and operator energy efficiency but broadband infrastructure plays an even greater role in the context of a global energy footprint as the services enabled by broadband replace high impact activities such as printing, flying, and driving with low impact alternatives such as electronic documents and telepresence applications.

This white paper, MR-204, establishes the Broadband Forum's role in energy efficiency and dematerialization with a discussion of current works, future direction, and liaisons with other organizations.

2 Introduction

The cost of doing business the traditional way—without specific reference to energy and transportation costs—has steadily climbed year over year. Rising energy prices, greenhouse gas (GHG) caps and corresponding trade systems coming to many developed countries have prompted businesses to focus on energy and environmental sustainability aspects of their everyday operations. With Information and Communication Technology (ICT) forming a large part of the post-industrial world, green telecom is quickly taking shape as a new economic reality.

Telecommunications companies around the world are highly motivated to improve their business processes and best practices. Coupling the common business practice of continuous improvement with soaring energy prices and a broader scientific understanding of human impact on the environment creates an opening for product and business innovations based on energy efficiency and dematerialization.

In June of 2008, the Climate Group and Global e-Sustainability Initiative (GeSI), in alliance with GeSI's Secretariat, the United Nations Environment Programme (UNEP), and the International Telecommunication Union (ITU), published the SMART 2020 report [1] identifying opportunities for the ICT industry to reduce its own emissions and enable other sectors to reduce their emissions, resulting in global emissions reductions by as much as 15% by 2020.

The GeSI SMART 2020 report defines dematerialization as "the substitution of high carbon products and activities with low carbon alternatives." Broadband is the primary enabler of home offices, virtual businesses, and telecommuting that are now taking root in every region of the world, enabling fundamental changes in transportation and material usage.

Although broadband can be a solution to an increasing number of economic, social, and environmental challenges, broadband infrastructure can also be a problem, contributing to global energy depletion and greenhouse gas production as illustrated in Figure 1.

This white paper outlines opportunities and corresponding industry activities in the area of energy efficiency and dematerialization for vendors and service providers in the telecommunications sector.

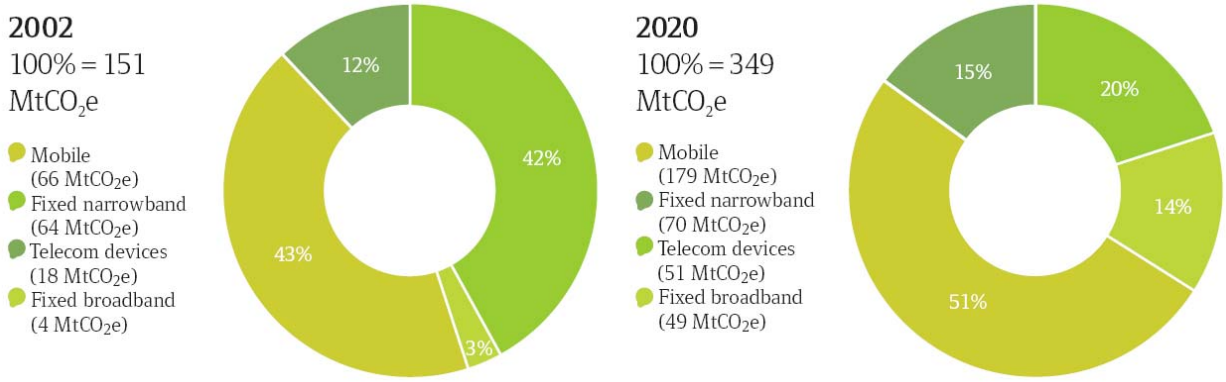


Figure 1 – Fixed broadband as a percent of global telecom ICT footprint (Source: SMART 2020)
MtCO2e = Metric tons carbon dioxide equivalent

3 Focus and Framework

SMART is an acronym in the SMART 2020 report:

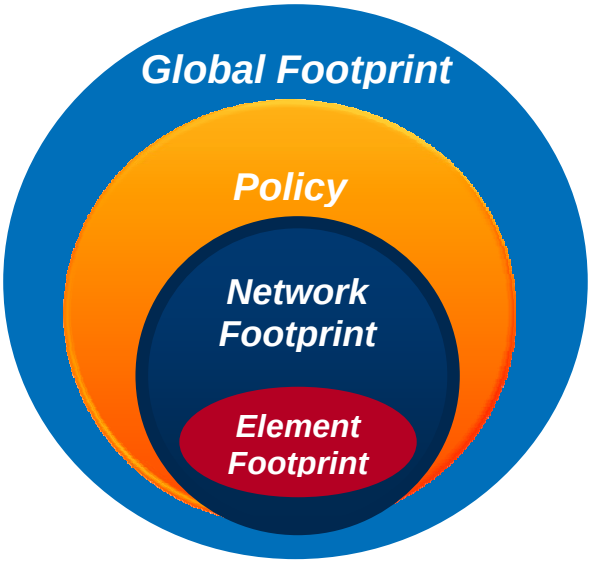
S (Standardise what and how to measure)
M (Measure or Monitor it)
A (Account for energy consumption or emissions)
R (Rethink your approach)
T (Transform)

This white paper focuses on the Broadband Forum's role in broadband standards and measurements enabling accounting, rethinking, and transformation both within the ICT sector and beyond, working to fulfill the promise of the SMART 2020 report. Energy efficiency is addressed by standardizing new technologies that transform communications infrastructure from "always on" to "always available." Dematerialization is enabled by the standardization of next-generation network architectures enabling services such as distance learning, video conferencing, and virtual medicine.

To better understand the connection between Broadband Forum activities and SMART 2020's 15% emissions reduction goal, we utilize a tiered environmental framework establishing the efforts and effects of work at the network element, network footprint, policy, and global levels.

3.1 Layered Environmental Context Framework

In order to map the focal areas to discreet implementations and solutions, we leverage the taxonomy illustrated in
Figure 2 as a framework. (Under the Element Footprint, STB, RG, AN, BRAS, and BNG are acronyms for set-top box, residential gateway, access node, and broadband network gateway, respectively.).



Global Footprint
Cumulative impact of the network on sustainable growth and operations on a global scale—factors in costs versus benefits

Policy Footprint
National and global policies influencing or mandating emissions quotas and dematerialization constructs

Network Footprint
The network architecture or design that maximizes infrastructure investments and utilization of energy

Element Footprint
Energy efficient network elements involving load levels and usage profiles for all network elements including STBs, RGs, ANs, BRAS/BNGs, etc.

Figure 2 - Layered environmental context framework

This framework can be viewed in a top-down approach where global, per country, and per industry energy targets are formulated and enforced through economic incentives and compliance directives influencing the "global footprint." A bottoms-up approach may be leveraged by equipment vendors seeking to increase their value proposition by enabling capital and operational cost reductions through product and solution efficiency, impacting the "element footprint." The "network footprint" is typically governed by operators, while "policy" is shared between industry consortiums such as the Broadband Forum, standards development organizations (SDOs), and government.

Note though that none of those layers are sufficient to ensure global sustainability alone. For example, using efficient network elements is not enough to build an energy-efficient solution, because the topology, protocols, technology or operational properties may be inefficient at the Network Footprint level.

3.2 Global Footprint

In 2000, the world's green house gas emissions accounted for a staggering 34 $GtCO_2(e)$ per year, as illustrated in Figure 3, Figure 4 and Figure 5 show the breakdown by region and country.

Strong scientific evidence exists to link climate change to increasing GHG production (source: MetOffice UK). Between 2000 and 2007, the world's GHG production rose to approximately 40 $GtCO_2(e)$ per year, and by 2020 it is estimated to reach 51.9 $GtCO_2(e)$ per year if behavioral changes do not happen [2]. It is therefore imperative that all sectors of the global economy take measured steps to reduce the production of GHGs and our dependency on fossil fuels.

In 2007, the Information Communication and Technology (ICT) sector accounted for approximately 2% of the global GHG footprint. While this may not seem significant in isolation, the danger stems from the fact that ICT is the fastest growing industry on earth and this percentage will likely rise. On the other hand, GESI research indicates that the ICT sector can potentially dematerialize other sectors of the global economy by an amount greater than its own footprint. The SMART 2020 report estimated that by 2020, the ICT sector's own GHG emissions will have grown to approximately 2.7% of the world's GHG production, yet will be able to offset up to 460 $MtCO_2(e)$. This is a key finding and one which indicates that,

for industries comprising the ICT sector, a combination strategy based on energy footprint reduction and dematerialization can positively influence the environment while sustaining economic and technology goals.

Being part of the ICT, the broadband ecosystem has the potential to play a powerful role in enabling the dematerialization of other sectors. In simple terms, this can be thought of as "shifting bits and not atoms." Ubiquitous broadband DSL and next-generation access such as FTTx, delivering advanced services such as high definition video conferencing, can reduce the need for energy intensive activities such as travel. and contribute to the abatement part of the global ICT footprint. A truly broadband infrastructure combined with innovative and advanced services can cause significant change in behaviors, which will enable migration to a low carbon economy.

Next-generation home, access and core architectures will evolve with the need for increasing energy efficiency in the network elements upon which they are built. The end-to-end aspects of service delivery will become increasingly important and these will be facilitated by advanced management and policy protocols such as TR-069. Innovation in these areas will reduce the ICT sector footprint, thereby helping to reduce the effects of GHG emissions white enabling operating costs (such as electricity bills) to fall. Driving the full use of the broadband ecosystem will bring economic and social benefits. Further adoption of this key technology will contribute to the protection of the planet from undesirable climatic changes while at the same time reducing costs and increasing margins for those industries that transform.

The Broadband Forum's role in promoting broadband and developing new standards and implementation guidelines is central to the ability of the broadband industry to catalyze the move to a low carbon economy. Energy efficient networks and protocols will deliver the ability to dematerialize other sectors, creating a highly significant mitigating effect on the global GHG footprint.

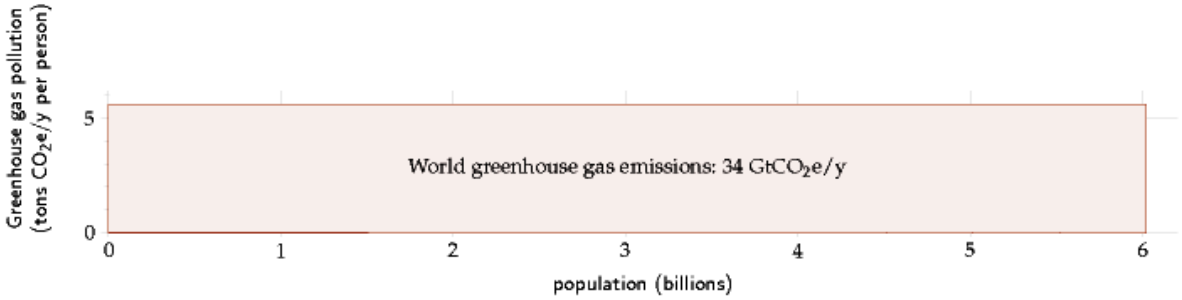


Figure 3 - World greenhouse gas emissions (year 2000) [1]

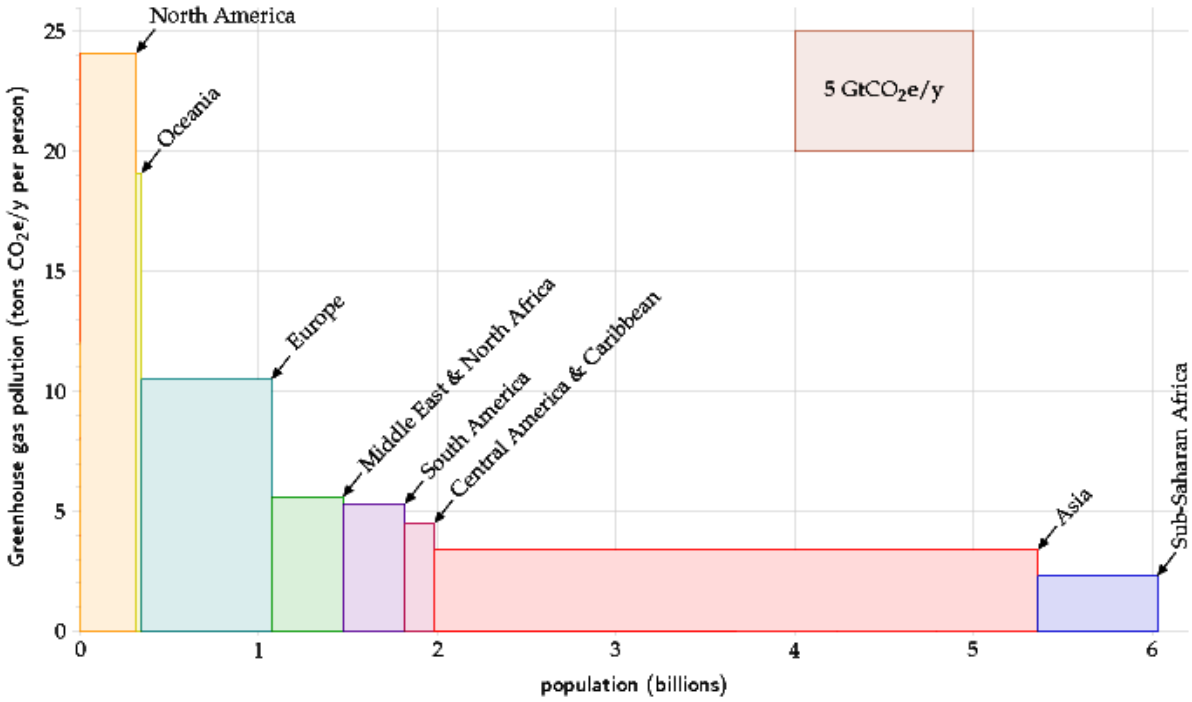


Figure 4 - World greenhouse gas emissions by region (year 2000) [1]

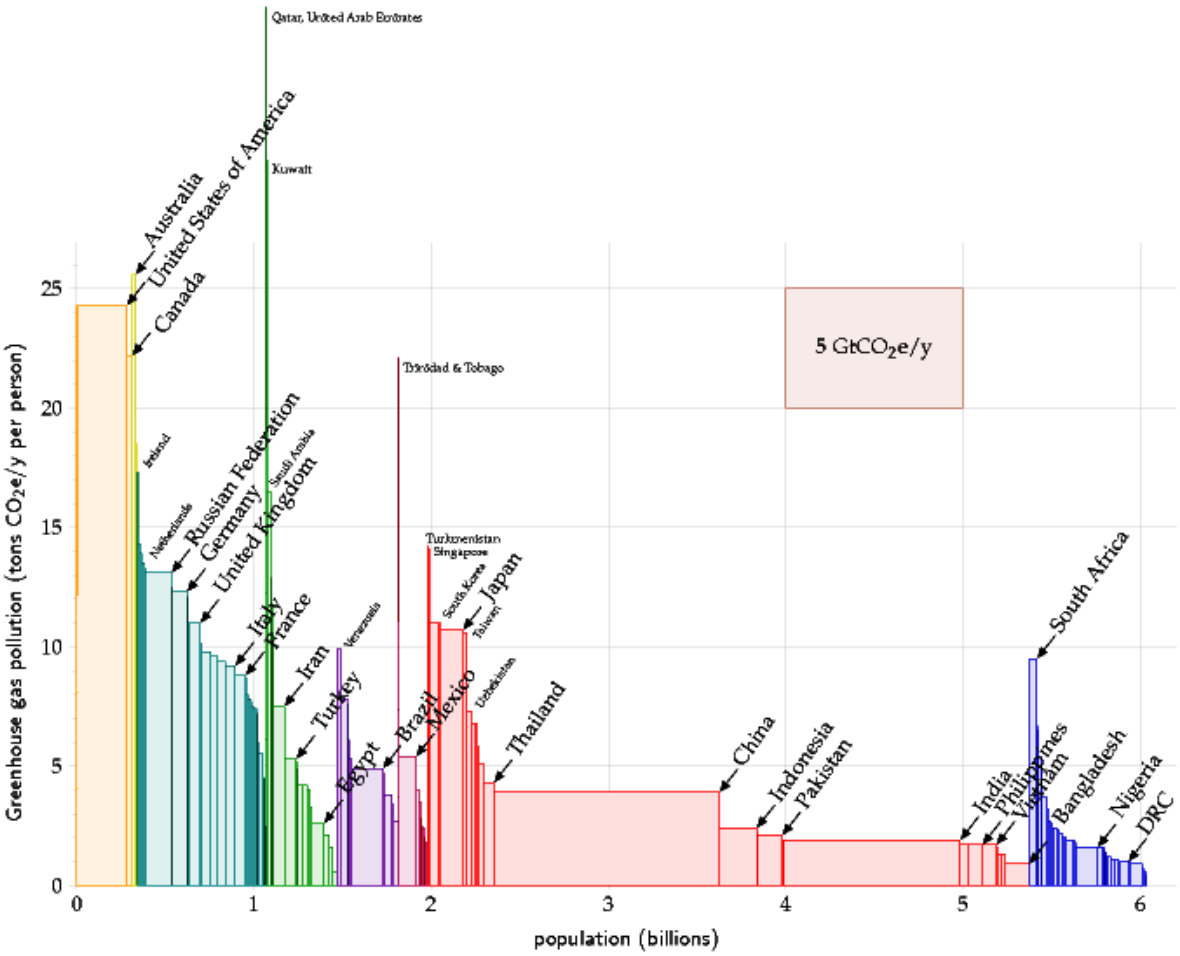


Figure 5 - World greenhouse gas emissions by country (year 2000) [1]

3.3 Energy Efficiency (definition)

Energy efficiency is the delivery of more work per unit of energy. In the context of broadband infrastructure, energy efficiency enables a reduction in the energy/broadband ratio such as watts/megabit and thus has an impact on the element, network, and global environmental layers previously referenced when considering the continued growth of broadband speeds offered worldwide. Specific to the network infrastructures and element Layers, energy efficiency has significant implications for operations and capital expenses because energy efficient devices reduce power and cooling requirements as illustrated in Figure 6. Large central offices may be reduced or even eliminated as legacy switches collapse to soft switches and copper infrastructure is replaced with fiber.

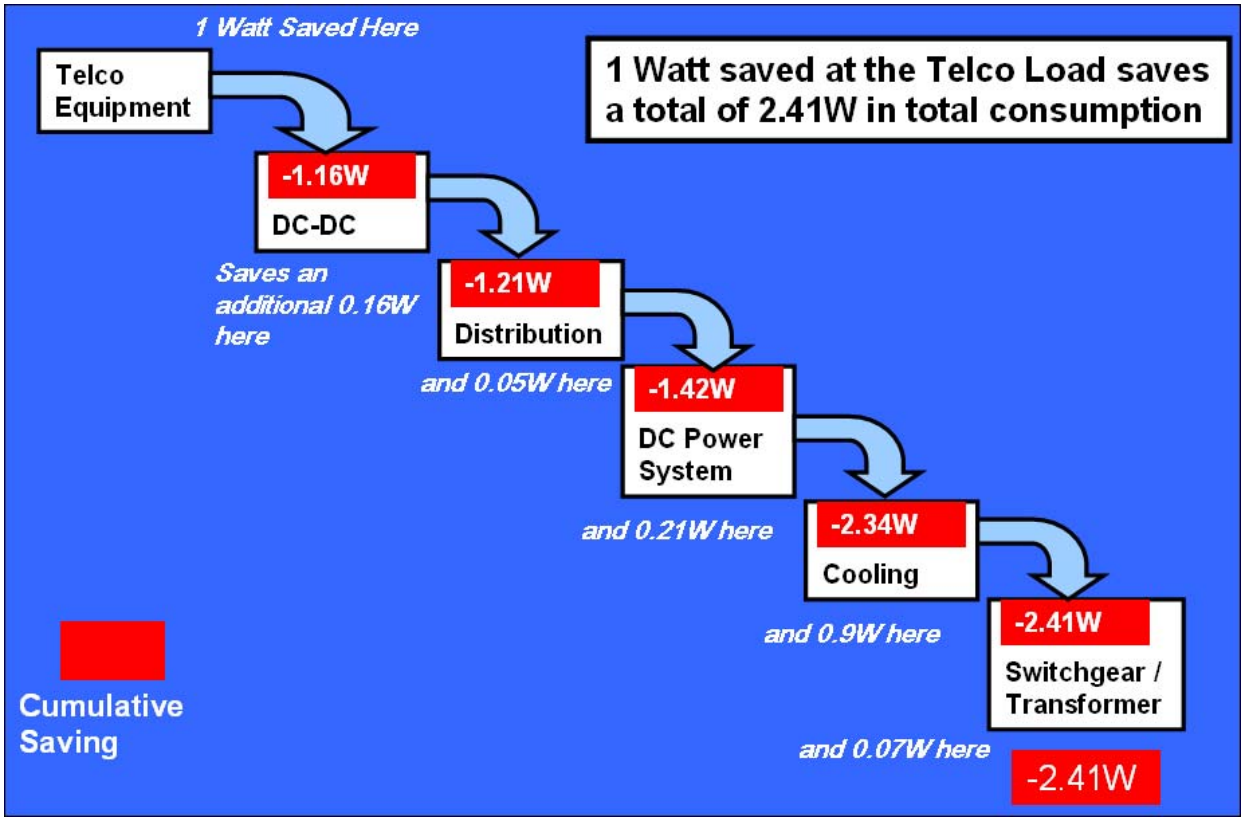


Figure 6 – Example of CapEx and OpEx benefits of energy efficiency [Verizon BBF Keynote, Q1-09]

3.3.1 Energy Efficiency - Element Footprint

Element footprint efficiency equates to greater output for a given level of energy consumption. Energy consumption of a network element can be defined in three time domains: peak, variable, and idle.

Peak energy efficiency links throughput (in aggregation and backbone network) or user ports served (in access network) to energy consumption on a fully loaded system. Peak efficiency is a good approximation of energy performance under high utilization. Peak efficiency metrics are often expressed in physical units. In the Energy Consumption Rating (ECR), the useful work for aggregation and backbone equipment is defined as the overall system throughput, leading to a physical metric as watts/Gbps.In the Normalized Power Consumption (NPC as defined in ETSI EE) (see appendix), the useful work for DSL access equipment is defined per user port as the Mbps carried over the loop length, leading to a physical metric as watts/(Mbps x km). The ECR and NPC are normalized metrics for comparison of energy efficiency over different technologies. However, for network equipment compliance, the ETSI EE standard and the European Code of Conduct (CoC) also define recommended energy footprint without normalization, with individual allowances defined in watts/port or watts/feature.

Variable energy efficiency gauges energy consumption against different system utilization levels. Similar to “energy-proportional computers,” future network devices are expected to lower their energy consumption according to load profile in real time, transparent to the end users. Any state transitions are expected to be “lossless” and “instant” from the network perspective. Variable efficiency metrics, such as

ATIS TEER, are built around weights assigned to utilization profile points and are often dimensionless numbers expressed as abstracts with no explicit physical meaning.

Idle load efficiency reflects the ability of network systems to conserve energy during periods of predictably low utilization. Network elements in the idle-power state are allowed to operate at a fraction of nominal capacity in exchange for extra energy savings.

Innovation in silicon and system design has time and again demonstrated the potential for equipment vendors to significantly improve the network element level efficiency. Significant savings in capital and operating expenses to service providers and consumers will naturally further drive the R&D investment of the equipment makers. Broadband Forum encourages service providers to include energy efficiency into device selection criteria and ROI calculations.

3.3.2 Cascaded Energy Management Using TR-069

Broadband Forum advocates for transparency in energy consumption of network devices. We recommend all carrier-grade equipment to be able to report power draw and load level in real time. This information would allow service providers to avoid energy-inefficient designs and usage profiles, where network segments are significantly underutilized.

At the end user side, homes and small offices connected via broadband represent a distinct and significant opportunity for energy savings via cascaded energy management as illustrated in Figure 7. With broadband equipment being a central connectivity point, it is also a natural fit for power control and two-way communication between energy provider and Advanced Metering Infrastructure (AMI).

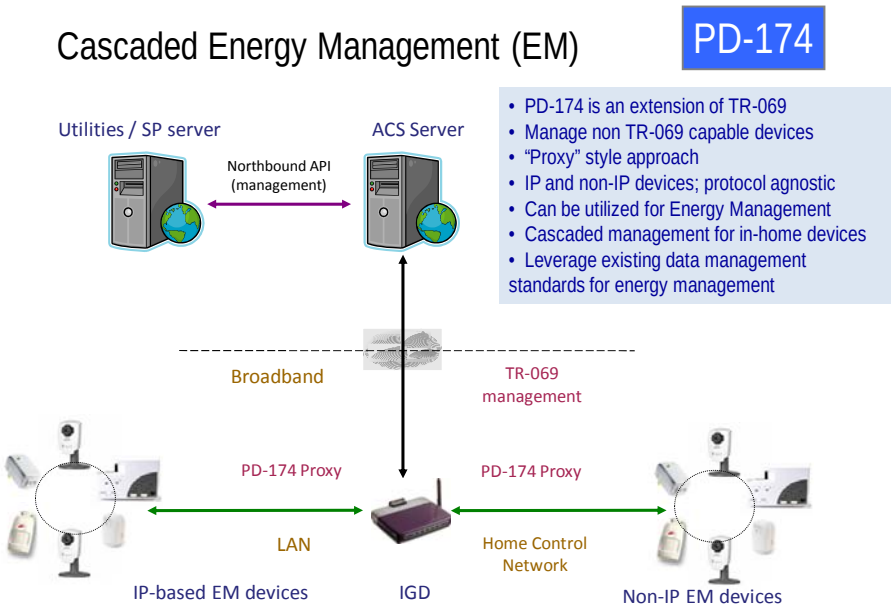


Figure 7 - *Cascaded energy management diagram*

For consumers, home/office energy management via broadband can have a positive effect on energy bills. It could first enable power savings for equipments related to communication (STB, network attached storage). In particular, broadband equipment can be involved in advanced thermal and cooling management, adapting the temperature to the degrees of building occupancy. Broadband-based AMI integration as illustrated in Figure 8 also makes it easy to take advantage of differential energy pricing schemes, where consumers are charged variable rates depending on time and date of energy consumption. Networked intelligence of this kind allows energy intensive operations (e.g., charging a hybrid plug-in car or running a full washer/dryer cycle) to be scheduled against off-peak periods, when energy prices are the lowest.

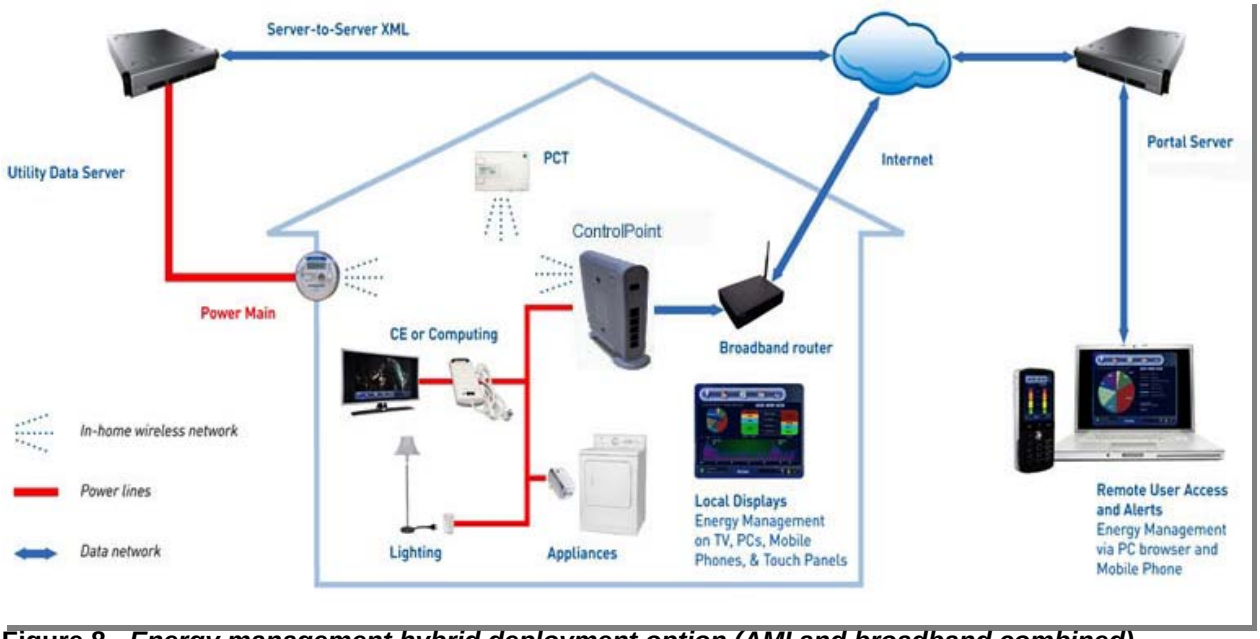


Figure 8 - *Energy management hybrid deployment option (AMI and broadband combined)*

The following levels of energy management intelligence should be noted as key to energy efficiency:

- **Energy Awareness**
  - Energy consumption to-date
  - Real-time tariff information
  - Energy consumption by devices
- **Energy Monitoring**
  - Energy consumption by device
  - Energy consumption by time and price
- **Energy Control**
  - Load shedding
  - Load shaping through tariff awareness
- **Energy Management**
  - Software and user interfaces to improve energy usage and consumption patterns
  - Smart profile management via existing WAN-based tools (TR-069/PD-174)

With the proper implementation of energy management, the percentage decrease in energy loads with home based equipment is expected to be within the following range (relative to the energy bill):

- With a smart meter: 13% savings (awareness)
- With a smart meter with a connected thermostat: 26% savings (awareness + DSM)
- With a smart meter, connected thermostat, and an energy management gateway system with service: 52% savings

Source: Ahmad Faruqui, The Brattle Group

Furthermore, future broad availability of energy management will give further enhanced savings as it will enable power generation plants to operate in optimal balance and thus with better efficiency. Broadband will also be key in guaranteeing the development of wide distributed generation through renewable sources such as wind, solar, and geothermal, as energy management will guarantee the needed balance between these (variable) sources and the electrical demand.

The Broadband Forum's long-term vision is to fully integrate end user broadband equipment into "smart home" and "smart grid" infrastructure, thus empowering broadband users to make smarter, economical decisions on their energy usage and costs. Work underway is illustrated in Figure 7 and paves the way for TR-069 enhancements in support of energy monitoring and management.

The BroadbandHome™ Working Group is working on an initiative that enables management of non-TR-069 devices connected to the TR-069 capable CPE via a "proxy" mechanism. This approach allows management capabilities of the CPE WAN Management Protocol (CWMP, a subset of TR-069) far beyond just CPE, STB, and network attached storage devices to the complete "connected home" ecosystem, allowing monitoring, diagnostics, and management of a variety of IP and non-IP devices.

Examples of such devices that are expected to be manageable via this initiative include, but are not limited to:

- Home monitoring and security devices
- Home control and automation devices
- Energy management devices
- Home health devices
- Media management devices

It provides support for both IP-based and non-IP devices and abstracts the transport and the data model from the actual underlying physical protocol. One of the most anticipated use cases is expected to be monitoring of energy consumption within the customer premise either from one consolidated source (such as a smart meter) or from individual devices enabled with specific home control technologies via Load Control Modules (LCMs)

The Broadband Forum is working closely with the Home Gateway Initiative (HGI), who have a project on "Smart Energy" (similar to Cascaded Energy Management), which builds on their initial work in energy efficiency for home gateways (HGs) (HGI-RWD009-R3).

HGI's Smart Energy work comprises:

- The investigation of service provider business and service models for provision of home automation and home energy management services
- The definition of a technical architecture for these services, including the required data flows among service providers, utilities, and in-home components

- The specification of technical requirements including HG-based features, protocols, and management functions

The BBF and HGI will continue collaborating regarding TR-069, PD-174, and "smart energy" management requirements as this work evolves.

The most recent trend in energy management services deployment is shifting from utilizing only traditional AMI-based infrastructure to broadband-based and hybrid (AMI + broadband as illustrated in Figure 8) deployment approaches. This innovation expands the range of manageable energy management devices from just smart meters and programmable communicating thermostats to the wider variety of devices within the digital home.

Broadening the landscape of remotely managed devices within the home network opens a remarkable opportunity for service providers to become more active players in smart grid/energy management initiatives, and take advantage of the existing mature communication management protocols such as CWMP and data models such as TR-106.

Further, there is clearly an argument to be made that service providers must act to deliver energy management type services as a defensive measure. A gateway combined with wireless energy management devices will be marketed to homeowners in the near term as market interest continues to grow. Energy management represents an obvious opportunity for service providers to deliver relevant compelling content over the broadband connection. There is also evidence that the utilities are showing interest in expanding their offers beyond energy management and could include home control/monitoring functionality as well.

The Broadband Forum looks forward to establishing clear leadership in enabling residential energy management and monitoring through connected broadband access points. Members are encouraged to participate in this ongoing and promising effort.

3.3.3 Energy Efficiency—Network Footprint

Orthogonal and complementary to the element footprint, network architecture and design also impacts energy efficiency in profound ways. With the union of the IP/MPLS Forum, the Broadband Forum now has an end-to-end scope at network level as shown in Figure 9. Power consumption occurs in multiple parts of the broadband ecosystem as is later depicted in Figure 10.

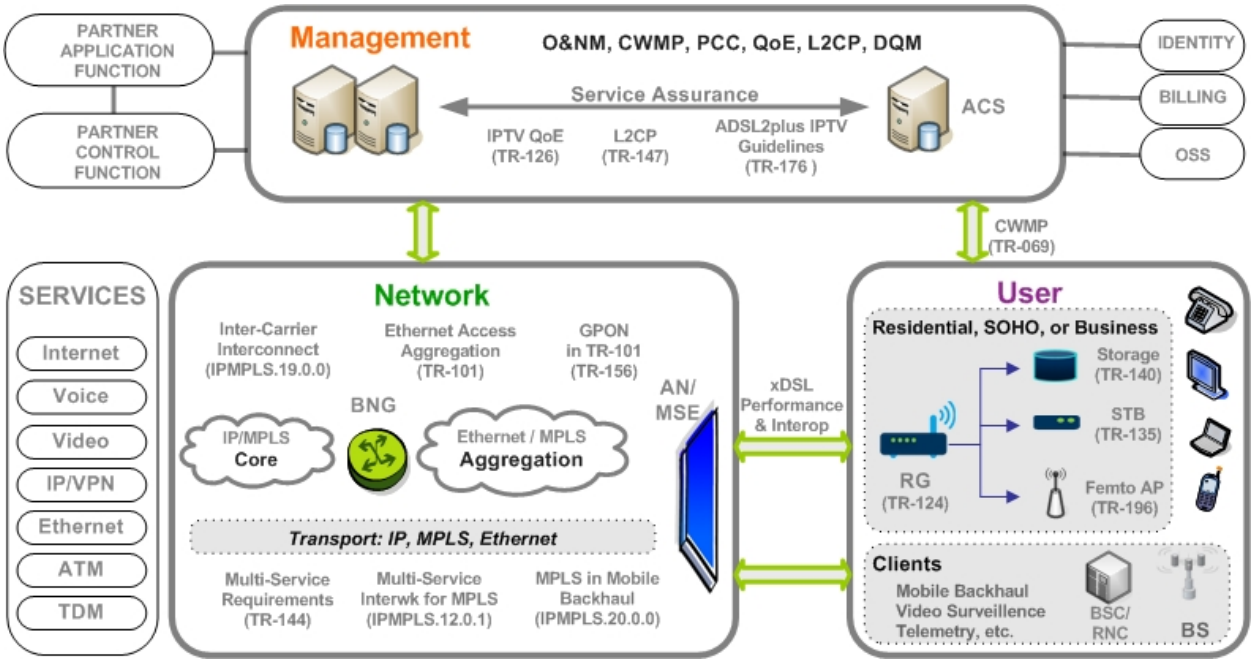


Figure 9 – Scope of work of the Broadband Forum

Following are key considerations at the network footprint level.

- **Time-domain consideration**: The concept of "always on" is being replaced by "always available" in the same time constraints as described at the element level (variable and idle load) as illustrated in Figure 11. End-to-end network visibility ensures that the periods of extended underutilization can be detected and utilized for additional energy savings. This creates opportunities ranging from energy-aware traffic engineering to load-dependent management of network segments.
- **Transmission media:** Fiber-based access technologies generally offer a better energy cost per bit, but are generally at the higher CapEx levels, and may be cost prohibitive for certain geographical deployments, compared to the readily available copper access infrastructure. In addition, the Khazoom-Brookes postulate assumes that increased bandwidth normally available on fiber access infrastructure can be stimulating bandwidth growth requirements and increasing the total network energy footprint. Wireless, copper and fiber transmission use different amounts of energy per bit and provide service with different levels of flexibility.
- **Network topology: I**n a broadband aggregation network, the consolidation of aggregation layers reduces non-revenue generating ports, and thus reduces energy and space consumption. This is further explored in the section titled, "Equipment Consolidation in Network Design."
- **Deep packet processing**: Processing higher layer protocols generally involves deeper packet processing and more energy usage. The placement of this function in the network can significantly affect the **overall network-**wide energy efficiency.

The added advantage of optimizing the network-level footprint described above often leads to reduced consumption of space as well as energy.

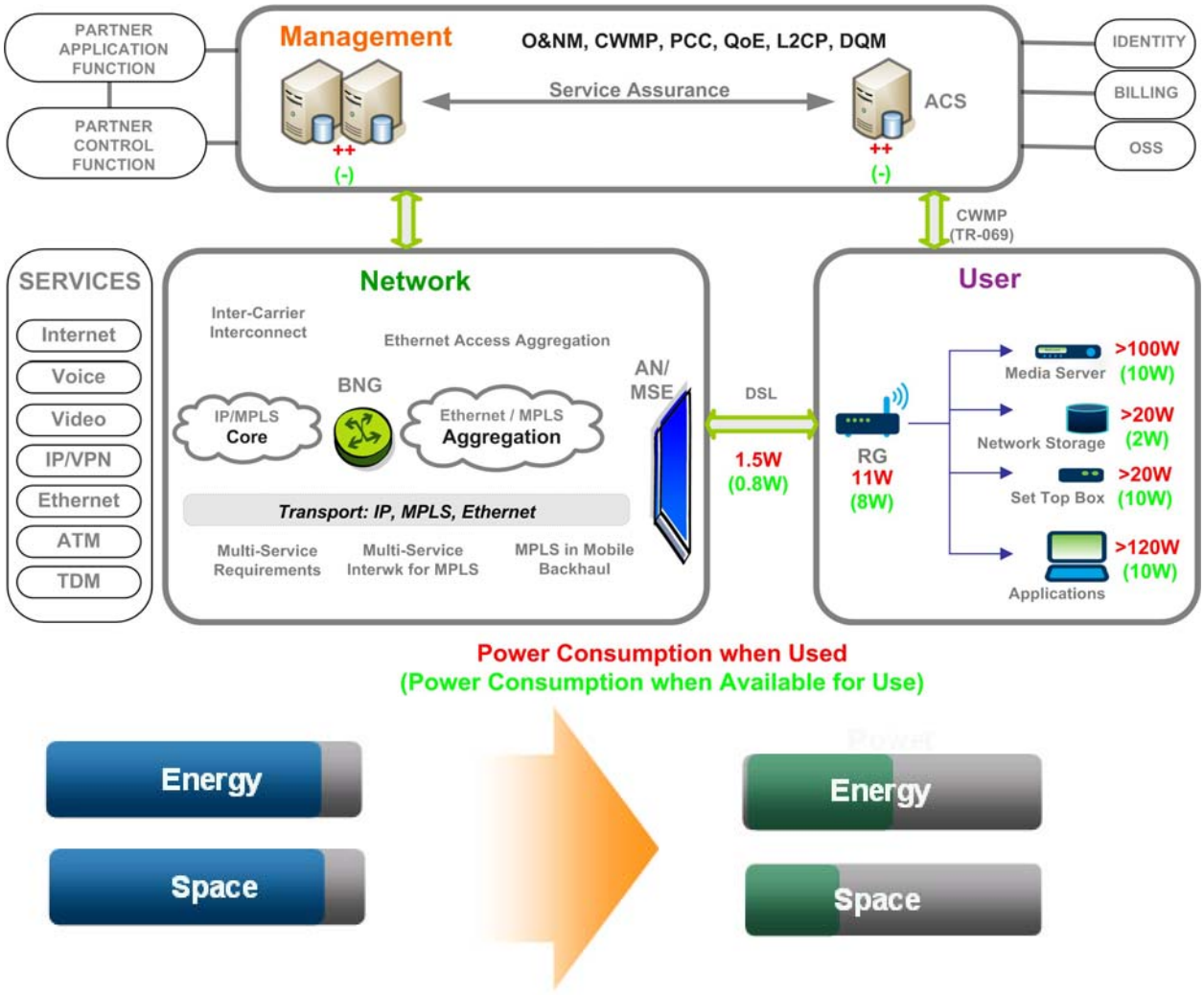


Figure 10 - Typical "side-effect" of energy efficient network design

3.4 Always On to Always Available

Consumer electronics and broadband infrastructure are typically designed to enable maximum performance in an “always on” mode of operation. Similar to laptops with a “sleep mode,” connected devices have an opportunity to reduce their power consumption when not in use. Enabling broadband infrastructure to reduce power when not in use allows a shift from “always on” to “always available.”

Figure 11 illustrates potential energy savings in “always available” broadband infrastructure within the scope of the Broadband Forum’s work.

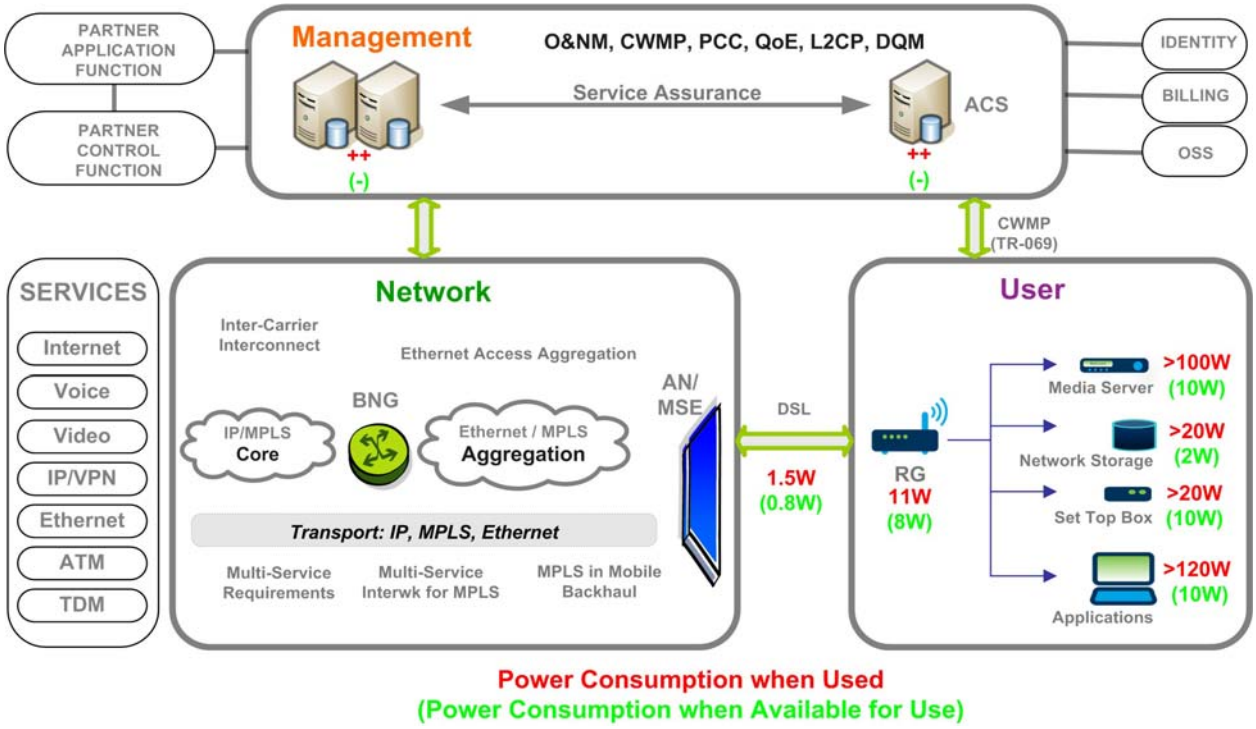


Figure 11 - Always on versus always available

Managing the user or network equipment in a transparent and nonintrusive way is a cornerstone of energy efficiency at the network level.

3.5 Equipment Consolidation in Network Design

Standardization of broadband architecture and transport enables consolidation in network design. TR-101 and TR-156 are great examples, defining the architecture for DSL and gigabit passive optical network (GPON)-based access with Ethernet aggregation that has created new classes of broadband network infrastructure such as broadband loop carriers and multiservice access platforms as illustrated in Figure 12 . These platforms integrate legacy digital loop carriers (DLCs), optical add-drop multiplexers (ADMs), digital subscriber line access multiplexers (DSLAMs), optical line terminals (OLTs), aggregation and transport elements into a single device to significantly reduce the energy used by the equipment itself and the surrounding HVAC requirements.

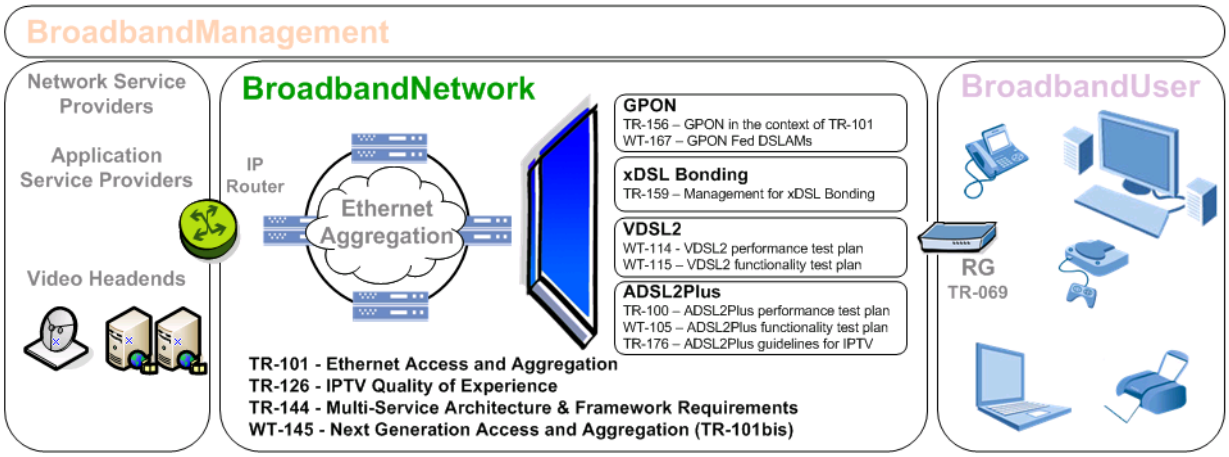


Figure 12 - Consolidation of access and aggregation enabled by broadband network TRs

Consider an aggregation network where a large number of access interfaces are aggregated into a small set of uplinks toward a core network. Figure 13 shows two network designs. The dark links are customer facing and are revenue generation links, while the gray links are internal links interconnecting network devices. Both network A and network B scale to the same number of access interfaces and achieve the same upstream and downstream capacity and oversubscription ratio. With design and innovation, network B is able to achieve higher energy and space efficiency with reduced internal, non-revenue generation links. This has generally been regarded as a cornerstone of network-level cost reduction as well as energy optimization.

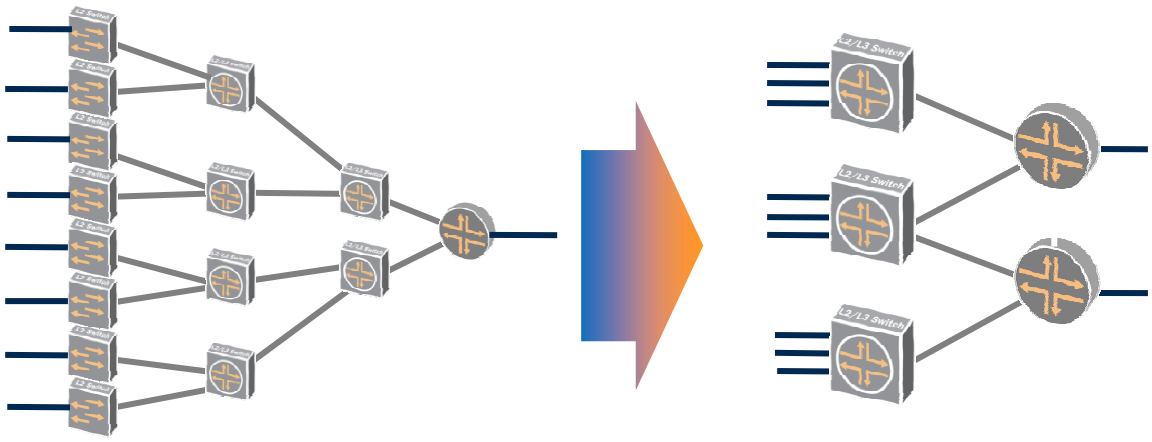


Figure 13 - Equipment consolidation in network design

3.5.1 Energy Efficient Mobile Backhaul Networks

The Broadband Forum's work on MPLS in Mobile Backhaul Initiative (MMBI) is another good example of deriving energy efficiency through the substantial reduction of network equipment. Work on MMBI was started at the IP/MPLS Forum (IP/MPLS 20.0.0) which has since continued within the Broadband Forum and is currently addressed by the IP/MPLS and Core Working Group.

Mobile backhaul networks have historically used time-division multiplexing (TDM) or ATM-based transport facilities to support revenue generating and mission critical services which are delay and loss sensitive and require a high level of network availability. Today's mobile backhaul networks must support these legacy services while also supporting the high growth in demand for data services and bandwidth by today's mobile subscribers.

In order to meet these evolutionary requirements of operators, the Broadband Forum's MMBI proposed a general framework for the use of IP/MPLS technology including pseudowires to transport TDM, ATM, Ethernet, and IP Radio Access Network (RAN) backhaul traffic over one converged access, aggregation, and core network.

This consolidation of multiple networks onto one network offers a substantial reduction in networking equipment. TDM/SDH aggregation devices, ATM access switches at base stations and radio network controller locations can be replaced by multiservice IP/MPLS-based products. This improves network efficiency with fewer devices and also reduces energy consumption, because such network deployment will increase network utilization by leveraging statistical multiplexing. In TDM backhaul networks, left over capacity on T1/E1 links cannot be dynamically used to support other types of traffic when needed. The MMBI enables energy efficiency by multiplexing second-generation (2G) (TDM or HDLC), third-generation (3G) (ATM), and fourth-generation (4G) (IP) traffic over a converged network as illustrated in Figure 14.

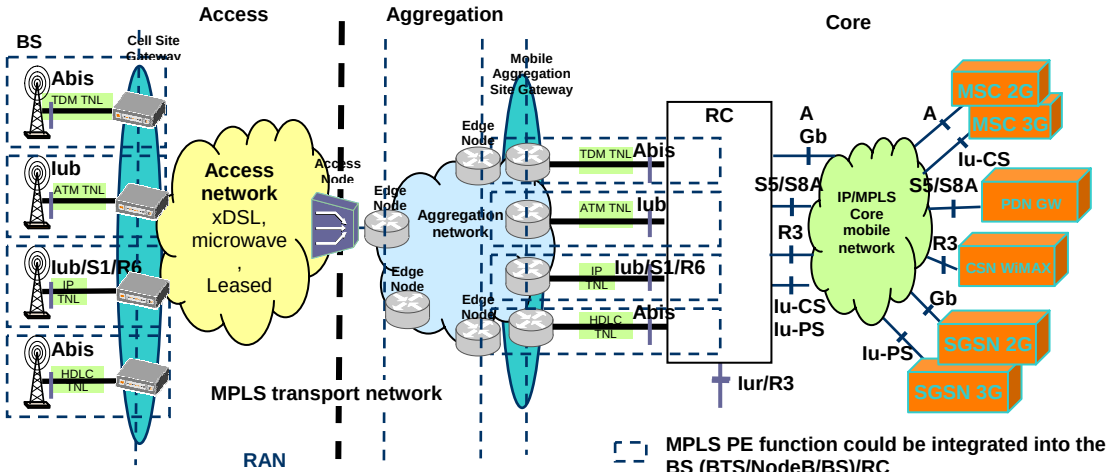


Figure 14 - Reference architecture for MPLS in Mobile Backhaul Initiative (IP/MPLS 20.0.0)

Further 4G Long Term Evolution (LTE) networks permit the point-to-multipoint connectivity where base stations can communicate to other base stations without passing through gateway nodes. In designing such flat all-IP networks, the Broadband Forum recommends leveraging IP/MPLS-based technologies such as L3 VPNs or virtual private LAN service (VPLS). This further improves energy efficiency because inter-base-station traffic can be routed locally using IP/MPLS.

3.6 Controlling the User Experience in Energy Aware Networks

Extensive use of energy control, especially idle state management at element and network levels, creates the potential risk of degrading performance in case of unexpected and unpredicted traffic surges. However, improvements in energy efficiency and dematerialization need not be at the expense of critical system performance or the ultimate end user experience. Quality-of-experience (QoE) requirements are discussed in depth in TR-126. Whether equipment is running "always on" or "always available," the following aspects must be considered while developing methods to improve broadband network energy efficiency:

- Quality of service (QoS) requirements for services and applications
- Quality of experience (QoE) including application response time
- Application or service start-up time
- Support of emergency services such as lifeline plain old telephone service (POTS).
- Subscriber line bit rate versus line length performance
- QoS, error rate, and bit rate impact of other subscriber lines in the same cable, including the effects of nonstationary crosstalk to other lines
- Efficiency of network operations, maintenance, and provisioning, including performance monitoring
- Complexity of network equipment and CPE
- Support of multiline bonding
- Support of DSL vectoring (MIMO)
- Resulting changes to industry standards

3.7 Policies and Opportunities for Dematerialization

Broadband networks create opportunities for productivity and lifestyle changes. Broadband-specific possibilities for dematerialization include services such as:

- Audio/video conferencing to replace travelling
- Telework to replace commuting
- E-commerce, business-TV, E-business, E-learning, E-teaching, E-government, etc.

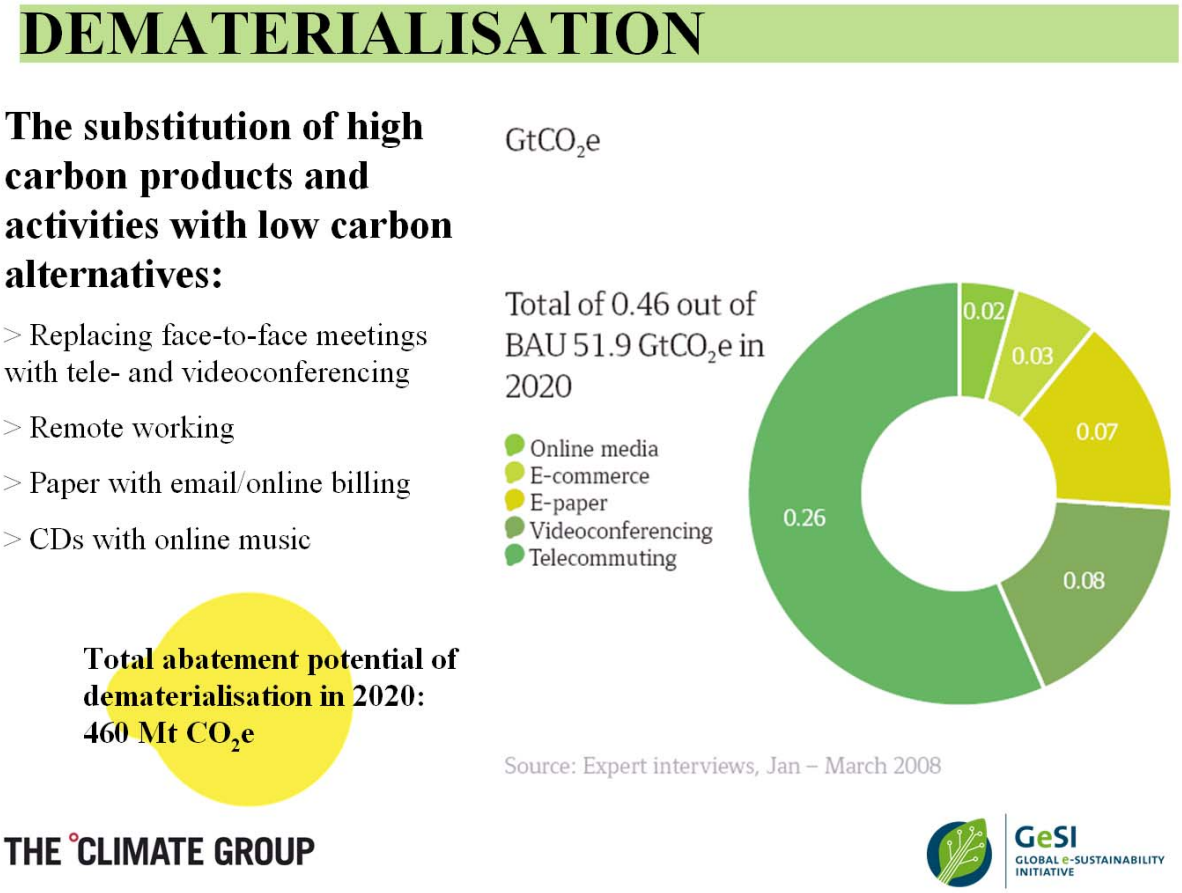


Figure 15 - Potential impact of dematerialization (Source: SMART 2020)

With 400 Million broadband subscribers worldwide (source: Point Topic), one could easily imagine a postindustrial economy where most offices are virtual and work sites are effectively insulated from the cost and commute restrictions of major urban hubs.

Moreover, with 80% of all developed countries being within 200 ms network delay of one another (source: CAIDA 2001, Juniper Networks 2008), our entire world can be seen as “net-centric” as opposed to “commute-centric.” For many categories of employees and entrepreneurs, this creates the opportunity to live and work in virtually any well-known location on earth, from snow covered mountain villages to sun drenched beaches.

37% of IT workers would agree to take a pay cut in exchange for telecommuting (source: poll by Dice Holding, 2008). However, the same poll reveals that the current percentage of teleworkers in U.S. corporations remains remarkably low, estimated to be at merely 7%.

A technical obstacle to broader adoption of telecommuting has been the fact that residential broadband access has not offered the quality of service and reliability of an Ethernet port on the desk of a corporate-bound employee. Telecommuters equipped with state-of-the-art telepresence systems have had no guarantee that a virtual meeting will run smoothly over a broadband connection because there may be no guarantee of the service that is provisioned end-to-end between the subscriber and corporate office. TR-144 addresses requirements for next-generation access and aggregation infrastructure enabling residential and business services that would address this technical obstacle.

If broadband can be the vehicle that enables 35-40% of eligible workers to maintain their presence and work duties remotely as represented in Figure 15, it can lead to the social and lifestyle changes comparable to those that followed the rise of the auto transport and highway systems.

The Broadband Forum sees dematerialization as a crucial evolution of human society. It is clear that the opportunities brought by ubiquitous network connectivity are still not realized to their full potential, which sets the roadmap for future work.

4 Broadband Forum Green Pledge

The Broadband Forum has a role in standardizing and promoting broadband as a key ICT technology. In 2008, the Forum began incorporating new energy efficiency considerations:

- Acting as an industry advocate in energy efficiency and encouraging global adoption of effective and responsible broadband deployment techniques.
- Assessing the environmental impact of all new Broadband Forum specifications, to catalog the expected society and technology effects of implementation, and to develop options wherever possible that reduce carbon footprint.
- Working with global and regional bodies that are committed to ICT energy advancement, to continue to educate and encourage service providers and equipment manufacturers to invest in the future of green broadband efficiencies.

Our unique strength is in our cumulative member expertise that combines industry insight with standardization experience and the ability to implement our standards in practical, commercial-grade solutions.

BBF plans to make a significant contribution to a broadband enabled, low carbon economy.

5 Current Broadband Forum Activities

Broadband Forum Technical and Marketing Reports will provide the basis for greater service provider and consumer energy savings. Work has been launched in multiple Broadband Forum working groups in support of energy efficiency, always on to aways available, and dematerialization initiatives.

- Energy management in the home or small business
  - Building on TR-069, CPE WAN Management Protocol
  - Proxy management
- Implementation guidelines for low-power asymmetric digital subscriber line (ADSL2/ADSL2plus) L2 mode
- Energy test methodology and plans for
  - Network equipment
  - Customer premises equipment (CPE)
- Informative broadband white paper
  - Energy efficiency
  - Dematerialisation
- Collaboration with other SDOs on EE
- Energy impact statement now required for new TRs and WTs
- Working with the EU JRC and HGI on BB CoC (especially V2 to V3)
- Work with HGI on the residential gateway energy efficiency requirements

Specifically, the latest work includes:

- WT-124 Issue 2 will include new EE requirements for residential gateways
- WT-189 is an energy efficiency test plan for network equipment
- WT-190 is an energy efficiency test plan for end user equipment
- WT-222 enables energy efficiency through network convergence
- PD-174 enables management of home devices which can be used for cascaded energy management (See Figure 7)
- PD-194 enables service activation which may be used in cascaded energy management
- PD-202 provides guidelines for low power mode using ADSL2plus

The Broadband Forum is working as a catalyst to align industry efforts to address energy efficiency requirements. See Annex A for a listing of other organizations active in this space.

6 Conclusion

Energy efficiency and dematerialization have the potential to enable global emissions by as much as 15% by 2020. Equipment consolidation, cascaded energy management, and the transformation of broadband from “always on” to “always available” not only serve to support this global emissions reduction, they dramatically lower the capital, operating, and energy expenses of broadband networks.

The Broadband Forum is taking a leadership position in the green telecom movement, leveraging work in architecture and transport to enable equipment consolidation, TR-069 extensions for cascaded energy management, and new ventures to enable “always available” broadband.

Beyond the footprint of the ICT sector, broadband dematerializes other sectors by enabling low carbon alternatives to traditional high carbon activities, such as driving or flying to meetings versus video-conferencing, shifting bits and not atoms.

As standards bodies and organizations around the world work towards a more planet friendly and energy efficient future, the Broadband Forum will help coordinate, participate in, and work to address relevant gaps in an effort to accelerate the availability and adoption of technologies enabling energy efficiency and dematerialization.

7 Annex A. Agencies, Standards Bodies and Industry Alliances

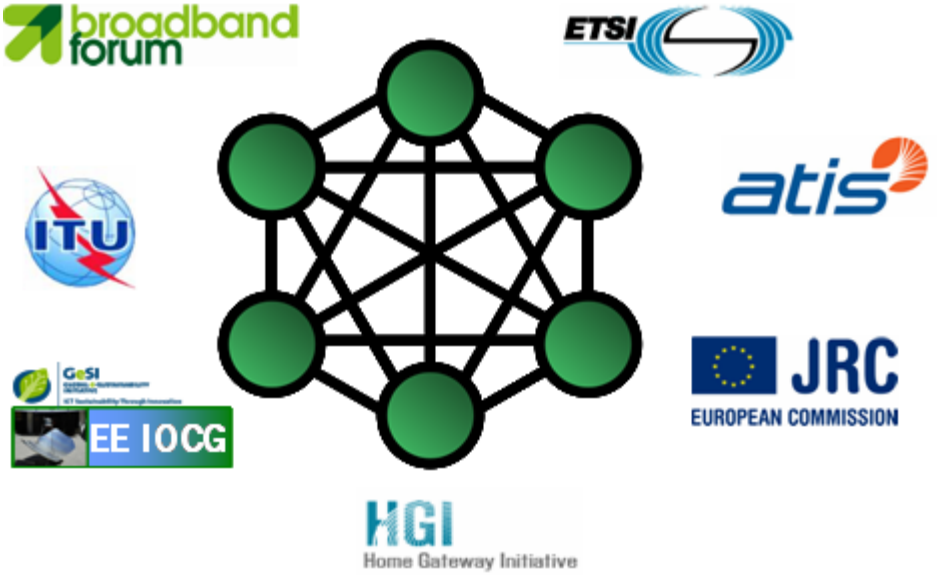


Figure 16 – Standards development organizations (SDO) landscape

In scoping and fulfilling the work on various standards within BBF, it is important to maintain the relations with peer organizations worldwide to avoid duplication of effort and multiplicity of standards.

Here is a live list of the main organizations, their briefs charters, active efforts, and BBF relation status.

- **ATIS**
  - **About**: ATIS is an alliance of communications companies of North America (250 members strong) committed to providing leadership for, and the rapid development and promotion of, worldwide technical and operations standards for information, entertainment, and communications technologies.
  - **Website**: http://www.atis.org/
  - **Related committee**: Network Interface Power and Protection – Telecom Energy Efficiency (NIPP-TEE) http://www.atis.org/0050/tee.asp
  - **Focus**: ATIS focuses on test methodology and efficiency metric design (ATIS TEER) for various types of packet processing and TDM equipment.
  - **Work status**: As of May 2009, ATIS has published standards 0600015.2009 - Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting - General Requirements and ATIS 0600015.02.2009 - Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting - Transport Requirements (TDM/MSPP/ROADM/mux equipment) .
    - A new standard for router and switch equipment is going through the ballots.
    - Roadmap announced for BRAS/BNG and firewall/deep packet inspection (DPI) equipment standards

- **ECR Initiative**

- **About**: Formed in 2008 as an alliance between Lawrence Berkeley National Laboratory, Juniper Networks, and IXIA Communications, ECR initiative acts as a pre-standard development group for metrics and methodologies of efficiency rating of network products.
- **Website**: http://www.ecrinitiative.org/
- **Related committee**: None
- **Focus**: ECR initiative focuses on experimental and commercial-grade development of test methodology, test profiles, and metrics for energy efficiency ratings of network devices.
- **Work status**: As of May 2009, ECR has published version 2.0 of their test methodology, covering core, edge, and metro Ethernet network devices. This work was partially reused in ATIS draft 0600015 "Routers and switches." Similar work is being scoped for BRAS/BNG and firewall/DPI network security devices.

- **EPA/DOE**
  - **About**: EPA is a U.S. government agency that leads the nation's environmental science, research, education, and assessment efforts. The mission of the Environmental Protection Agency is to protect human health.
  - **Website**: http://www.epa.gov/
  - **Related committee**: Energy Star http://www.energystar.gov
  - **Focus**: The Energy Star certification is a voluntary partnership program for consumer products and business products, and buildings. EPA establishes the "minimum" requirements to be met for products to achieve the "Energy Star" certification.
  - **Work status**: As of April 23 2009, The EPA has introduced a computer server specification and is scoping the energy performance of storage equipment for the Energy Star program. There are no plans announced for network equipment yet, but EPA stated interest in this.

- **ETSI**
  - **About**: The European Telecommunications Standards Institute (ETSI) produces globally applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast, and Internet technologies. ETSI is a not-for-profit organization with almost 700 ETSI member organizations drawn from 60 countries worldwide.
  - **Website**: http://www.etsi.org and http://portal.etsi.org
  - **Related committee**: The Technical Committee EE is responsible for defining the environmental and infrastructure aspects for all telecommunication equipment in different types of installations. The Technical Committee ATTM is responsible for Access, Terminals, Transmission, and Multiplexing including all aspects within the ETSI scope covering cabling, installations, signal transmission, multiplexing, and other forms of signal treatment up to digitalization in private and public domain. The Technical Committee ATTM addresses the specific technology, equipment, installations, and regulatory aspects of the physical layer, e.g., of specification of the transmission function's performance, and global key performance indicators of energy efficiency of the network and of its elements such as transmission paths, path elements, sections, systems, functional entities, antenna, cable, and optical fiber.
  - **Focus**: Among other areas of interest, the TC EE and ATTM are focusing on the reduction of energy consumption in telecommunications equipment and related infrastructure.
  - **Work status**: In July 2008, ETSI published the technical standard TS 102 533 on Environmental Engineering (EE) - Measurement Methods and Limits for Energy Consumption in Broadband Telecommunication Networks Equipment. This standard is currently in review for a second version to align with the EU CoC on a broader range of technologies and related measurement methods. For technology comparison, an

informative Normalized Power Consumption (NPC) is defined per user port as the Mbps carried over the loop length, expressed in watts/(Mbps x km). For network equipment compliance, energy efficiency requirements are defined separately for each individual DSL and fiber access technology, with individual requirements expressed in watts/port. In July 2009, ETSI published the first version of technical standard TS 105 174 Series on Broadband Deployment - Energy Efficiency and Key Performance Indicators. The multi-part set (TS 105 174 Series) which has been produced by TC ATTM in close collaboration with CENELEC via the Coordination Group on Installations and Cabling (CGIC). It offers a contribution to the required standardization process by establishing an initial basis for work on ICT networks and transmission engineering, with active collaboration from a number of other ETSI and CENELEC technical bodies.

- **European Union Joint Research Center (Code of Conduct)**
  - **About**: EU Code of Conduct is a voluntary commitment of individual companies, with the aim of reducing energy consumption of products and/or systems through the setting of agreed upon targets in a defined development timescale.
  - **Website**: http://re.jrc.ec.europa.eu/energyefficiency
  - **Related committee**: Broadband equipment
  - **Work status**: As of May 2009, there are five Codes of Conduct in operation for: data centers, digital TV service systems (set-top boxes), external power supplies, uninterruptible power systems (UPS), and broadband equipment. A new version of the digital TV services CoC is in development

- **GeSI**
  - **About**: In alliance with the United Nations Environment Programme (UNEP) and the International Telecommunication Union (ITU), GeSI supports companies and institutions across the ICT industry, including manufacturers, network operators, service providers, trade associations, and associate organizations connected to the industry. Since June 2009, GeSI has officially joined with Energy Efficiency Inter Operator Collaboration group (EE IOCG), creating the new GeSI – EE IOCG Standardization Branch
  - **Website**: http://www.gesi.org
  - **Related committee**: none
  - **Work status**: As of May 2009, several studies published on ICT sustainability through innovation, including “Smart 2020: Enabling the Low Carbon Economy”. This report identified the need for energy efficiency in the equipment but also the benefits of dematerialization that broadband can provide. The GeSI report is an important catalyst to the work of the BBF and other organizations working to bring about a green strategy. The GeSI – EE IOCG Standardization Branch, which currently accounts for 21 worldwide telecom operators, is aimed at defining high-level strategic actions towards standardization bodies in order to speed up the availability of globally recognized standards on energy efficient equipment, networks, and services, Its action spans across all ICT areas, both for network and user equipment.

- **Green Grid**
  - **About**: The Green Grid unites140+ member companies that have taken up the challenge of developing standards to measure data center efficiency, which includes both the facility and the IT equipment housed inside. Most of its members are from vendors. This is a point of strength as great technical knowledge is available, but it’s also a point of weakness as the efficiency needs of users is not completely represented.
  - **Website**: www.thegreengrid.org
  - **Related committee**: Energy Efficiency of Consumer Electronics Initiative

- **Focus**: CEA supports voluntary, market oriented programs and initiatives, including industry-led standards, which highlight and sustain energy efficiency in the consumer electronics industry.
- **Work Status**: The Green Grid started at a rather primitive level, first formulating energy efficiency in the data center through power conversion metrics PUE/DCiE. However, over time it slowly drifted towards understanding of energy efficiency in terms of the energy cost of the useful work unit (defined as transaction or computational unit). This led to development of proxy efficiency metrics, some of which are close in nature to generic network efficiency (watts/Gbps). At some point, the Green Grid is also expected to decompose data center efficiency in archetypes (such as computing elements, power conversion, cooling, and network infrastructure), at which time they will need to be directed towards existing network efficiency standards.

- **Home Gateway Initiative (HGI)**
  - **About**: The Home Gateway Initiative is an open forum launched by telcos in December 2004 with the aim to release specifications of the home gateway. HGI develops requirements related to home gateways.
  - **Website**: http://www.homegatewayinitiative.org/
  - **Related committee**: Energy Task Force, Business Group
  - **Work status**: The HGI has worked on the energy efficient gateway since 2008. The initial work was a contribution to the EU Broadband Code of Conduct document (CoC). The HGI is developing requirements on the gateway as part of a more global program on energy saving at home. BBF provided feedback on "Draft requirements for the Energy Efficient HG" including comments recorded during Broadband Home and Testing and Interoperability working groups in July 2009 via existing liaison.

- **ITU-T**
  - **About**: The Telecommunication Standardization Sector (ITU-T) coordinates standards for telecommunications on behalf of the International Telecommunication Union (ITU) and is based in Geneva, Switzerland.
  - **Website**: http://www.itu.int/ITU-T/
  - **Related committee**: SG5 http://www.itu.int/ITU-T/studygroups/com05/index.asp
  - **Work status**: ITU-T has been active in climate change and energy efficiency, leading symposia, producing study papers and tutorials, studying the impact of ICT on climate change, and promoting energy efficiency through ICT. As of April 2009, the Focus Group on Climate Change completed its study on ICTs impact on climate change and possible efficiencies, and transferred its work to ITU-T study groups, with SG5 tasked with taking the lead.

- **METI**
  - **About**: Japanese Ministry of Economy, Trade and Industry (METI) created the "Green IT" Initiative in 2007 to promote energy saving product and technologies and to introduce more efficient supply chains. This initiative also focuses on creating an energy efficient society by using IT.
  - **Website**: http://www.meti.go.jp/english/
  - **Related committee**: Top Runner Program
  - **Work status:** As of May 2009, the Top Runner program has been covering over 18 product categories, with a goal to select the top most efficient designs and discourage products from the bottom part of the pool. Product tests include methodology and metric design. Computer and network products are reported to be tested under this program.

- **NIST**
  - **About**: Founded in 1901, NIST is a nonregulatory federal agency within the U.S. Department of Commerce. NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.
  - **Related committee**: SmartGrid Interoperability Project http://www.nist.gov/smartgrid/
  - **Focus:** Interoperability and mediation of standard for SmartGrid
  - **Work Status:** As of May 2009, NIST completed the Release 1.0 of Recognized Standards for Green Grid (BBF work was not referenced). Going forward, NIST revealed the following work plan:
    - Further engage utilities, equipment suppliers, consumers, standards developers, and other stakeholders to achieve consensus on Smart Grid standards. By early fall 2009, the process should deliver:
      - The Smart Grid architecture
      - Priorities for interoperability and cyber security standards, and an initial set of standards to support implementation
      - Plans to meet remaining standards needs
    - Launch a formal partnership to facilitate development of additional standards to address remaining gaps and integrate new technologies.
    - Develop a plan for testing and certification to ensure that Smart Grid equipment and systems conform to standards for security and interoperability
  - **Special Note**: Coordination with NIST is crucial for success of the BBF PD-174 initiative.

- **IEEE**
  - **About**: A nonprofit organization, IEEE describes itself as "the world's leading professional association for the advancement of technology." Through its global membership, IEEE is a leading authority in areas ranging from aerospace systems, computers and telecommunications to biomedical engineering, electric power, and consumer electronics among others.
  - **Related committee**: 802 (http://grouper.ieee.org/groups/802/3/az/)
  - **Focus:** Energy Efficient Ethernet (802.3az)
  - **Work Status:** IEEE is developing an Adaptive Link Rate (ALR) mechanism in Ethernet data links as higher data rates require dramatically more power, while increasing energy is being used to transmit small amounts of data most of the time. For instance, a 100 Mbps Ethernet network interface card (NIC) consumes in the order of 1 W, while a 10 Gbps NIC consumes tens of watts. ALR has fundamentally been conceived in order to adjust NIC speed (and hence power) to effective traffic levels. Moreover, reducing the network link data rate for PCs in low power states would not affect user productivity.

- **ECMA**
  - **Related committee**: TC32-TG21 - Proxying Support for Sleep Modes (http://www.ecma-international.org/memento/TC32-TG21.htm)
  - **Focus:** Network proxying of ICT devices to reduce energy consumption
  - **Work Status:** Standard expected by end 2009

For completeness, there is also a list of second level interest organizations which may have similar interests to those of the Broadband Forum green initiatives:

- **Climate Savers Computing**
  - **About**: Started by Google and Intel in 2007, the Climate Savers Computing Initiative is a nonprofit group of eco-conscious consumers, businesses, and conservation organizations. The Initiative was started in the spirit of WWF's Climate Savers program

which has mobilized over a dozen companies since 1999 to cut carbon dioxide emissions, demonstrating that reducing emissions is good business.
  - **Website**: http://www.climatesaverscomputing.org
  - **Related committee**: None
  - **Focus**: Promotes usage of power saving modes in consumer electronics and high efficiency power supplies for computer manufacturers. Despite high profile supporters, this organization seems to currently be limiting its technical development focus to the relatively trivial subject of power supply efficiency.
  - **Work Status**: CSCI formulated labeling program (bronze/silver/gold) for power supplies of PCs and volume servers based on methodology published by Electric Power Research Institute (EPRI).

- **Consumer Electronics Association**
  - **About**: CEA is a 2,200 member consortium of consumer electronics companies. It is dedicated to standards development and to representing the electronics industry before U.S. federal policymakers.
  - **Website**: www.ce.org
  - **Related committee**: Energy Efficiency of Consumer Electronics Initiative
  - **Focus**: CEA supports voluntary, market oriented programs and initiatives, including industry-led standards which highlight and sustain energy efficiency in the consumer electronics industry.
  - **Work Status**: CEA formulated the following standards: CEA-2013-A (Digital STB Background Power Consumption), CEA-2022 (Digital STB Active Power Consumption Measurement). These standards date back to 2007.

- **EPEAT**
  - **About**: EPEAT is a voluntary product labeling program managed by an Oregon-based nonprofit organization, Green Electronics Council (GEC). EPEAT labeling criteria are based on 51 assorted criteria which focus on hazardous substance management and sustainability. Some criteria back-reference other programs, such as RoHS, Energy Star, or IS140001. EPEAT maintains close relations with the U.S. federal government, which in some cases mandates EPEAT registered product purchases in registered categories.
  - **Website**: www.epeat.net
  - **Related committee**: None
  - **Focus**: Current focus is on computers and monitors, although the focus of this program will undoubtedly be extended in the near future.
  - **Work Status**: EPEAT reuses existing compliance criteria as defined in IEEE 1680 and other standards and programs.

8 Annex C. References

[1] David J.C. MacKay. "Sustainable Energy – without the hot air." UIT Cambridge, 2008. ISBN 978-0-9544529-3-3. Available free online from www.withouthotair.com

[2] SMART 2020: Enabling the low carbon economy in the information age, The Climate Group on behalf of GeSI, 2008. Available from www.gesi.org