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Energy efficiency of satellite broadband network

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

Modal verbs terminology

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Introduction

Up until now, broadband services have mainly been provided using fixed (VDSL or optical) or mobile (3G or LTE) networks. However, satellite networks are now becoming able to provide broadband services of similar bandwidth and response times to those from terrestrial networks, especially with the introduction of new hybrid satellite networks where alternative paths can be selected depending on the bandwidth and response times required. It is therefore useful to be able to assess the energy efficiency of satellite networks and compare this on an equivalent basis to the energy efficiency of terrestrial networks.

Energy efficiency is also a growing concern in the design of satellite networks and there are increasing efforts to minimize the energy consumption of SatCom systems, especially in the ground segment where most terminals have been designed to operate on an always-on basis. By carrying out an assessment of the energy efficiency of a satellite network, the subsystems and components that have the most impact can be identified and attention paid to reducing their energy consumption. In particular, given the relatively large numbers of satellite terminals in operation, their impact can be identified compared with that of the other subsystems and appropriate measures taken to improve their energy efficiency.

1 Scope

The present document reviews the assessment of energy consumption during the operational phase of satellite networks, and identifies whether additions are required to the general assessment methodology developed in ETSI TS 103 199 [i.10]. It also reviews the energy efficiency related metrics developed for terrestrial wireless and mobile networks in ETSI TR 103 117 [i.7] and identifies any necessary adaptations to enable the methodologies to be applied to satellite networks.

Satellite Networks allow broadband services to be delivered to approaching 100 % of the population, even in remote areas, and can therefore be used to fill gaps in the coverage of other access technologies. Broadband services can be offered to residential or business customers via satellite in a cost effective manner compared to other methods of services provisioning. However, their energy consumption needs to be assessed and compared with other ways of delivering broadband services.

2 References

2.1 Normative references

As informative publications shall not contain normative references this clause shall remain empty.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Code of Conduct on Energy Consumption of Broadband Equipment, EC Joint Research Centre, Version 4, 10 February 2011.

[i.2] Code of Conduct on Energy Efficiency of Digital TV Service Systems, EC Joint Research Centre, Version 8, 15 July 2009.

[i.3] Code of Conduct on Energy Efficiency of External Power Supplies, EC Joint Research Centre, Version 4, 8 April 2009.

[i.4] The Green Grid Consortium.

NOTE: Available at http://www.thegreengrid.org/.

[i.5] Data centre Metrics Task Force: "Recommendations for Measuring and Reporting Overall Data centre Efficiency", May 2011.

[i.6] The GreenTouch Consortium.

NOTE: Available at http://www.greentouch.org/.

[i.7] ETSI TR 103 117: "Environmental Engineering (EE); Principles for Mobile Network level energy efficiency".

[i.8] ETSI ES 203 228: "Environmental Engineering (EE); Assessment of mobile network energy efficiency".

[i.9] EC FP7 ICT EARTH research project deliverable D2.3: "Energy efficiency analysis of the reference systems, areas of improvements and target breakdown".

[i.10] ETSI TS 103 199: "Environmental Engineering [EE]; Life Cycle Assessment (LCA) of ICT equipment, networks and services; General methodology and common requirements".

[i.11] ISO 14044:2006: "Environmental management-life cycle assessment - requirements and guidelines".

[i.12] ETSI ES 202 336: "Environmental Engineering (EE); Monitoring and Control Interface for Infrastructure Equipment (Power, Cooling and Building Environment Systems used in Telecommunication Networks)".

[i.13] IEC 60038 Edition 6.2 2002-07: "IEC standard voltages".

[i.14] ANSI C84.1-2011: "American National Standard for Electric Power Systems and Equipment - Voltage Ratings (60 Hertz)".

[i.15] ETSI ES 201 554: "Environmental Engineering (EE); Measurement method for Energy efficiency of Mobile Core network and Radio Access Control equipment".

[i.16] EC FP7 Project BATS (Broadband Access via Integrated Terrestrial and Satellite Systems) Deliverable D5.2: "Cost Benefit Analysis".

NOTE: Available at http://www.batsproject.eu.

[i.17] EC FP7 Project BATS (Broadband Access via Integrated Terrestrial and Satellite Systems) Deliverable D5.3: "Energy Efficiency".

NOTE: Available at http://www.batsproject.eu/.

[i.18] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council.

[i.19] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products.

[i.20] Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products.

[i.21] European Parliament COM(2009) 7604 2009/2228(INI): "Mobilising Information and Communication Technologies to facilitate the transition to an energy-efficient, low-carbon economy".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

cut-off: threshold below which part of a product, service or system can be considered insignificant and need not be considered by a LCA

energy consumption: amount of consumed energy

energy efficiency: relation between the useful output and energy consumption

3.2 Symbols

For the purposes of the present document, the following symbols apply:

A_{SN}	Coverage Area of a Satellite Network
ECI	Energy Consumption Index
$ECI_{P/A}$	Energy Consumption Index (Power per Unit Area)
$ECI_{E/B}$	Energy Consumption Index (Energy per Bit)
N_{SG}	Number of Satellite Gateways
N_{ST}	Number of Satellite Terminals supported (by a satellite network)
P_{SG}	Power consumption of a Satellite Gateway
P_{SN}	Power consumption of a Satellite Network
P_{ST}	Power consumption of a Satellite Terminal
T_{SN}	Throughput of a Satellite Network

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3G	Third generation telecom networks
AC	Alternating Current
CoC	Code of Conduct
DC	Direct Current
EC	European Commission
EU	European Union
FP7	EC 7th R&D Framework Programme
GHG	Green House Gas
ICT	Information and Communication Technology
ING	Intelligent Network Gateway
ISO	International Organisation for Standardization
IUG	Intelligent User Gateway
kbps	Kilobit (1 000 bits) per second
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LTE	Long Term Evolution
Mbps	Megabit (1 000 kilobits) per second
MW	Mega Watts
PUE	Power Usage Effectiveness
QoE	Quality of Experience
RF	Radio Frequency
SN	Satellite Network
STB	Set Top Box
Tbps	Terabit (1 000 Gigabit) per second
TV	TeleVision
US	United States
VDSL	Very-high-bit-rate Digital Subscriber Line

4 Requirements arising from relevant policies/legislation

European Member States have committed themselves to reducing GHG emissions by 20 %, increasing the share of renewables in the EU's energy mix to 20 %, and achieving a 20 % energy efficiency target by 2020. The European Roadmap for Moving to a Competitive Low Carbon Economy in 2050 notes that the EU is currently on track to meet two of those targets, but will not meet its energy efficiency target unless further efforts are made.

In COM(2009) 7604 [i.21], the EC notes that "*the use of ICT equipment in the delivery of services represents about 1,75 % of carbon emissions in Europe; a further 0,25 % of carbon emissions come from the production of ICT and consumer electronic equipment. As the range and penetration of ICTs increase, their overall energy use is growing*". The Communication went on to recommend the ICT sector set itself an energy reduction target.

In line with this policy landscape, the European Union has issued a number of directives to foster energy efficient design of products:

- Directive 2005/32/EC on 6th July 2005 [i.18] establishing a framework for the setting of eco-design requirements for energy-using products.

- Directive 2009/125/EC on 21st October 2009 [i.19] establishing a framework for the setting of eco-design requirements for energy-related products.

- Directive 2010/30/EU on 19th May 2010 [i.20] on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products.

In parallel with this, the EU have defined a series of voluntary Codes of Conduct (CoC) which specify annual targets for reductions in electricity consumption of different types of equipment. The CoCs relevant to satellite broadband networks are:

- CoC on Energy Consumption of Broadband Equipment [i.1]:

  This sets targets for reducing the energy consumption of equipment such as broadband modems and home gateways. Equipment on both the consumer side (end-use equipment) and the network side (network equipment) is covered for any service providing a two-way data rate of 144 kb/s or above. Several operational states are defined for each type of equipment (e.g. full load, low load and standby) with typical targets of 0,3 W for a fast ethernet port in the idle state, reducing to 0,2 W in 2013-2014.

- CoC for Digital TV Systems (Set-Top Boxes) [i.2]:

  This covers complex set top boxes (STBs) and similar equipment for the reception, decoding, recording and interactive processing of digital TV and related services accessible through a Conditional Access system. This gives targets for annual energy allowance of 60 kWh/year for a Satellite STB, falling to 53 kWh/year on 1 January 2013. There is pressure from regulators to reduce the target for power consumption of STBs to < 1 W in standby.

- CoC on Energy Efficiency of External Power Supplies [i.3]:

  This is referenced by the above CoCs in the case where the equipment has an external power supply, and targets for the energy consumption for these are set here. It covers single voltage external ac-dc and ac-ac power supplies, including AC adapters, battery chargers for mobile phones and IT equipment, in the output power range 0,3 W to 250 W.

Some parts of the ICT industry have already developed standardized energy related performance metrics.

- The data centre industry (for example through Green Grid [i.4] has defined Power Usage Effectiveness (PUE), an energy efficiency metric that measure the total energy of the data centre divided by the IT energy consumption. A typical legacy data centre would have a PUE of about 2. In this case for each Watt-hour consumed by the IT system, an additional Watt-hour is consumed to cool or distribute the electricity to the IT system. When all the energy is used for the IT system, then the PUE is close to 1 (see Green Grid consortium). There is now an agreement [i.5] between major data centre industry bodies and the US, EU and Japanese governments on the composition and measurement of PUE.

- The telecom industry has established a number of consortia such as GreenTouch [i.6] to reduce the carbon footprint of telecom devices, platforms and networks. ETSI have produced ETSI TR 103 117 [i.7] to define metrics for the energy efficiency of mobile broadband networks at both equipment and network level. Further work at ETSI has been recently published in ETSI ES 203 228 [i.8] based on the FP7 ICT Earth project results [i.9].

5 Energy Efficiency in context of Satellite Network

5.1 Scope and Boundaries

Only the power consumed during the operational lifetime of a satellite network is considered here.

Figure 1 shows the main components of a 2 way service satellite network architecture (e.g. broadband) with:

- The satellite composed of the payload and the platform.
- The satellite terminals composed of the antenna system (dish), the RF part (Power Amplifier, Low Noise Amplifier and filters) and the modem implementing the base band processing of the satellite radio interface.
- The satellite gateway that includes both a Network Control Centre to manage the in orbit radio resources and a Gateway with its antenna system, the RF part, a set of modems.

The Network Control Centre is not shown here and the power consumption is ignored under cut-off rules.

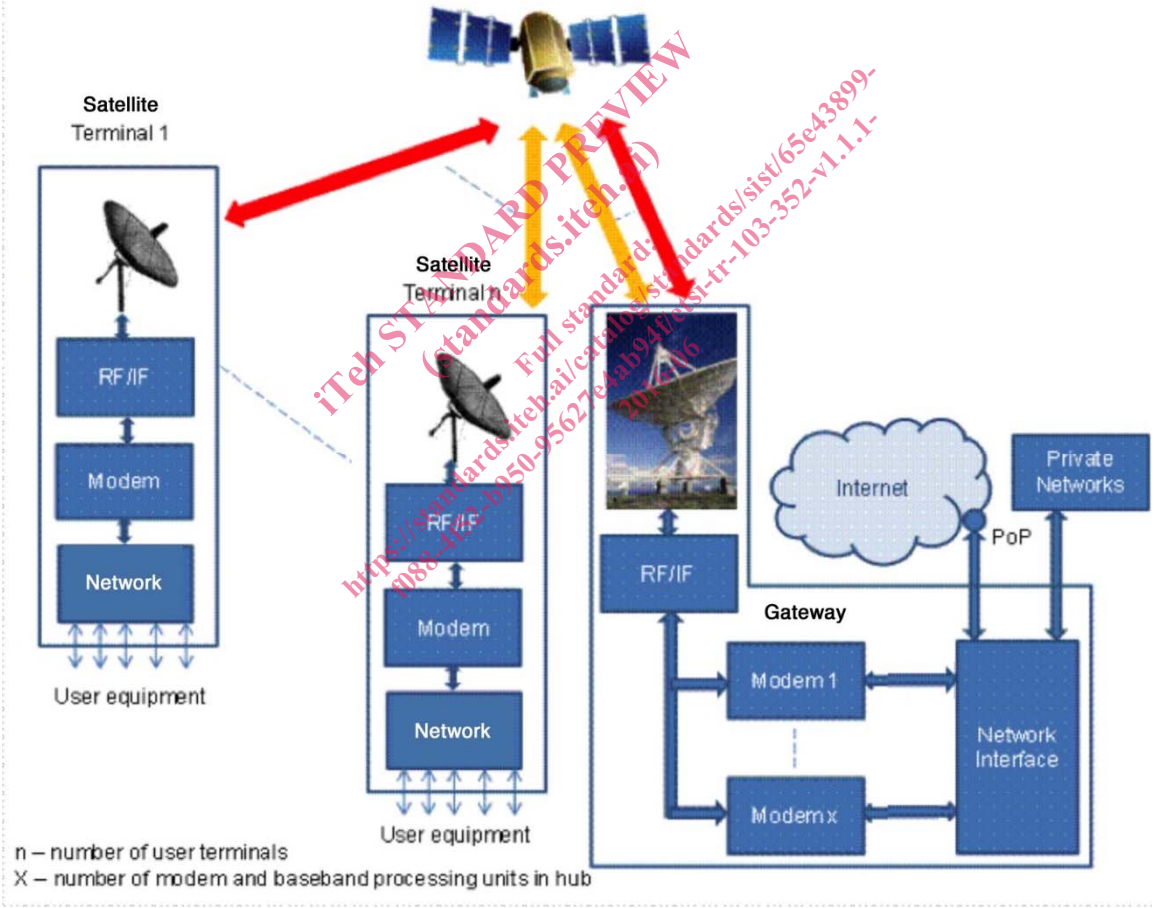

Figure 1: 2 way service satellite network architecture (e.g. Broadband)

The power consumption of a satellite network during its use is the sum of the power consumption of all subsystems and equipment included within the boundary of the system under investigation (figure 1). The network power consumption per operator is the sum of the power consumption of the satellites, satellite control centres, gateways and terminals under the control of the operator that are used to provide the service.

There are many ways to reduce the electricity consumption including energy saving mechanisms, energy efficiency technologies and energy efficient installation/set-up.

In order to foster the SatCom industry to research and develop energy saving features and technologies for satellite terminals, it is proposed to develop a standardized set of terminal modes and a Standardized measurement method to characterize the energy efficiency of satellite network, in priority geostationary satellite broadband network. The following modes are standardized for the satellite terminal so that comparable measurements of power consumption can be made in each:

- Full activity mode: Terminal transmission and reception at maximum service rate.
- Receive only mode: Terminal reception possible at maximum service rate but not transmission.
- Standby mode: Terminal is in low power state waiting to wake up.

5.2 Assumptions and approximations

The design operational lifetime of a satellite network is considered to be 15 years.

The approximations made during the environmental assessment will depend on the purpose of the assessment. Often a provisional assessment will provide sufficient results to allow optimization of a subsystem to provide significant energy savings without the need for a detailed analysis. Generally a more accurate model need only be developed if there is doubt about the validity of the application of a cut off rule.

During the operational lifetime of a satellite network, approximations should be made of:

- The number of terminals deployed.

  If the number of terminals deployed is lower than originally estimated, then the total power consumed by the terminals may be a less significant proportion of the total power consumed by the full hybrid satellite broadband system. This could mean that other energy use becomes significant according to the cut off rules.

- The average power used by an equipment or subsystem over the assessment period. For systems such as satellite earth stations or network control centres which are permanently powered up, the electricity consumed can be measured over a specific period and a rate of consumption determined. However, it is more difficult to estimate for user equipment such as satellite modems as the proportion of time the equipment will be switched on and used cannot be known in advance.

5.3 Cut-off rules

Cut-off is the process for the exclusion of insignificant items and activities from the analysis [i.10]. Invoking cut-off can simplify the assessment and reduce the cost by excluding items and activities that will not significantly change the overall conclusions of the study. This is valid as long as the intended purpose of the assessment is still met. Cut-offs should be avoided if possible, and are only acceptable if allowed according to guidance given in ISO 14044 [i.11] and an alternative to cut-off can be to model unavailable data based on known data.

6 Energy efficiency related metrics

Energy consumption should be measured in Wh or J over the period of the assessment including all subsystems.

Similarly to the cellular industry, a standard should be developed to calculate the energy efficiency of a satellite network and possibly its different component.

In ETSI TR 103 117 [i.7], there are general considerations about the design of mobile network which can be adapted to the satellite network context:

- The objective in the design of a mobile network is to maximize the number of bits that can be delivered over a certain time and in a given bandwidth; in this sense the throughput delivered in a given area and in such a bandwidth is deemed as an appropriate way to estimate the performance of the network.