Proposal for Standards

Unified Energy Efficiency Standard for Computing Appliances

Appliance Efficiency Standards and Measures

for California Energy Commission's Invitation to Submit Proposals

by Vojin Zivojnovic, 07/29/2013, AGGIOS, Inc., Irvine, CA

July 29th 2013

Table of Contents

1 Executive summary

We are proposing a unified mandatory minimum energy efficiency standard (aka horizontal standard) for a wide class of plug load computing devices, like computers, routers, gaming consoles or set-top boxes. These devices are converging in their functionality, connectivity and hardware/software construction. As an example, both the Apple iTV HD streaming device and the Sony PS3 gaming console are computing devices capable of delivering the identical HD movie streaming experience. Both devices have the main processor, the Ethernet and HDMI ports and run the same HD streaming software. The difference in power consumption is 64 fold.[1] Other similar examples are web browsing on a tablet vs. a TV or audio playback on a smartphone vs. a laptop.

The proposed standard defines a unified set of modes of operation across all computing devices (computers, routers, gaming consoles, set-top boxes) we call Scenes. For each Scene we define the generic components used (e.g. processor, decoder, Ethernet, HDMI, DVD reader) and the generic software task executed (e.g. 1080p video playback, 720 video streaming). Each component and software task of the Scene is given a power allowance which sums up to the total power allowance per Scene. The testing procedure involves setting the device under test to the selected Scene and measuring the resulting power consumption. Under the standard the equipment shall be classified based on the measured power vs. the allowance.

The motivation behind the proposed standard is to guide the equipment manufacturers and service providers to faster adopt newest energy efficient methods used in the mobile devices and develop improved hardware, software and protocols for their equipment. The rapid development and extreme efficiency of the mobile equipment was the result of the mobility/battery limitations, equipment's direct exposure to the needs of the end user and the fierce competition among mobile device manufacturers and among service providers.

The key benefits of the proposed standard are:

1. Establishes tighter minimum energy efficiency requirements for higher energy savings
2. Enables faster adoption of energy standards for future equipment classes
3. Fosters energy savings competition among manufacturers of various equipment classes
4. Lowers the cost of energy management technology as companies across equipment classes can share same power management technology
5. Enables the introduction of formal energy descriptions of equipment and automated generation of the power management software and hardware
6. Allows for run-time reporting of equipment's energy consumption

[1] http://www.energy.ca.gov/appliances/2013rulemaking/documents/2013-05-28-31_workshop/presentations/Game_Consoles_workshop_presentation.pdf

7. Allows unified testing, measurement and standardization procedures
8. Brings together a larger pool of power management experts to focus on the same problem and improves technical education for younger engineers

2 Product Description and Proposal Scope

For the basic information required in the Sections 2.1 to 2.10 we are referring to the following documents:

1. "Natural Resources Defense Council's (NRDC) Responses to CEC's Invitation to Participate in the Development of Appliance Energy Efficiency Measures 2013 Appliance Efficiency Pre-Rulemaking on Appliance Efficiency Regulations: Docket Number 12-AAER-2A on Consumer Electronics."[2]
2. "IOUs Response to California Energy Commission 2013 Pre-Rulemaking Appliance Efficiency Invitation to Participate" – Computers[3], Game Consoles[4], Set-Top Boxes and Small Network Equipment [5]
3. "2013 Appliance Efficiency Rulemaking California Energy Commission: Results of Invitation to Participate" - Computers[6] , Game Consoles[7], Set-Top Boxes[8], Network Equipment[9]

In the next sections we are emphasizing only those aspects which are relevant for our standardization proposal and the targeted product class.

---

[2] http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Consumer_Electronics_12-AAER-2A/NRDC_Response_to_CEC_Invitation_to_Participate_with_Excel_Spreadsheets_2013-05-09_TN-70852.pdf

[3] http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Consumer_Electronics_12-AAER-2A/California_IOUs_Response_to_the_Invitation_to_Participate_for_Computers.pdf

[4] http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Consumer_Electronics_12-AAER-2A/California_IOUs_Response_to_the_Invitation_to_Participate_for_Game_Consoles.pdf

[5] http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Consumer_Electronics_12-AAER-2A/California_IOUs_Response_to_the_Invitation_to_Participate_for_Set-Top_Boxes.pdf

[6] http://www.energy.ca.gov/appliances/2013rulemaking/documents/2013-05-28-31_workshop/presentations/Computers_workshop_presentation.pdf

[7] http://www.energy.ca.gov/appliances/2013rulemaking/documents/2013-05-28-31_workshop/presentations/Game_Consoles_workshop_presentation.pdf

[8] http://www.energy.ca.gov/appliances/2013rulemaking/documents/2013-05-28-31_workshop/presentations/Set_Top_Boxes_workshop_presentation.pdf

[9] http://www.energy.ca.gov/appliances/2013rulemaking/documents/2013-05-28-31_workshop/presentations/Network_Equipment_workshop_presentation.pdf

2.1 Technical Description

This proposal applies to a wide variety of computing devices with the single requirement that the device operation can be represented by a sequence of overlapping Scenes and that for these Scenes and combinations thereof reliable energy and power measurements can be conducted. Initially the product class involves computers, game consoles, set-top boxes and network equipment. It can be easily extended to other existing (e.g. electric cars, medical equipment, sound systems, pool equipment) or future (e.g. internet of things (IoT)) plug load devices.

2.2 Technologies and Best Practices for Energy/Water Efficiency

2.3 Design Life

2.4 Manufacturing Cycle

2.5 Product Classes

Unified computing equipment product class: computers, game consoles, set-top boxes, network equipment.

3 Unit Energy/Water Usage

We are referring to the references provided in Section 2.

3.1 Duty Cycle

3.2 Efficiency Levels

3.3 Energy and/or Water Consumption

4 Market Saturation and Sales

We are referring to the references provided in Section 2.

4.1 California Stock and Sales

4.2 Efficiency Options: Current Market and Future Market Adoption

5 Statewide Energy Usage

We are referring to the references provided in Section 2.

6 Proposal

6.1 Summary of proposal

The goal of the proposal is to promote "energy proportional computing" across a wider class of equipment. Energy proportional computing optimally matches the "work" or performance delivered by the equipment with equipment's energy consumption.[10] As an example, Figure 1 shows measurements from network router equipment with very low energy proportionality. The performance variation of 380% resulted in only 0.4% in power consumption variation.

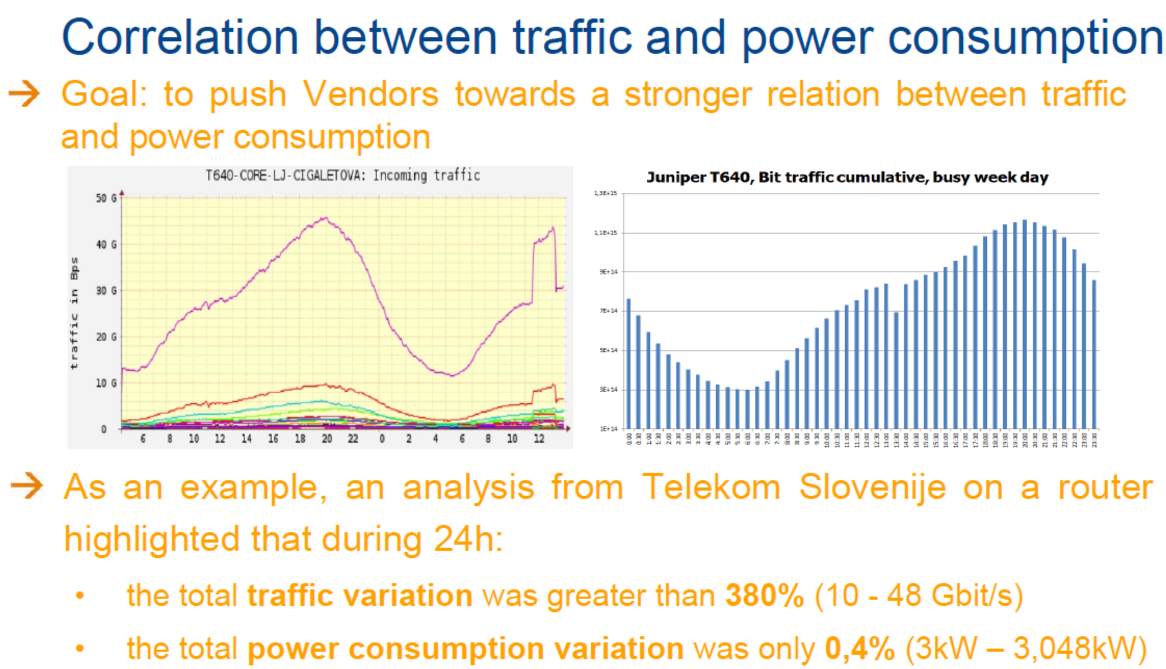

Figure 1: Computing systems with low energy proportionality

Most of the current computing systems are not nearly energy proportional. The goal of the proposed standard is to motive and impose stricter energy proportional computing.

Figure 2 shows the structure of typical standards based on operating states. For each type of equipment the standard defines the corresponding operating states and the associated minimum efficiency requirements for power consumption per state. The key issue with these types of standards is the ambiguity in the definition of the operating states and as the result the lax minimum efficiency requirements.

[10] "Case for Energy-Proportional Computing", 2007, retrieved from http://impact.asu.edu/cse591sp11/Barroso07_EnergyProp-clean.pdf

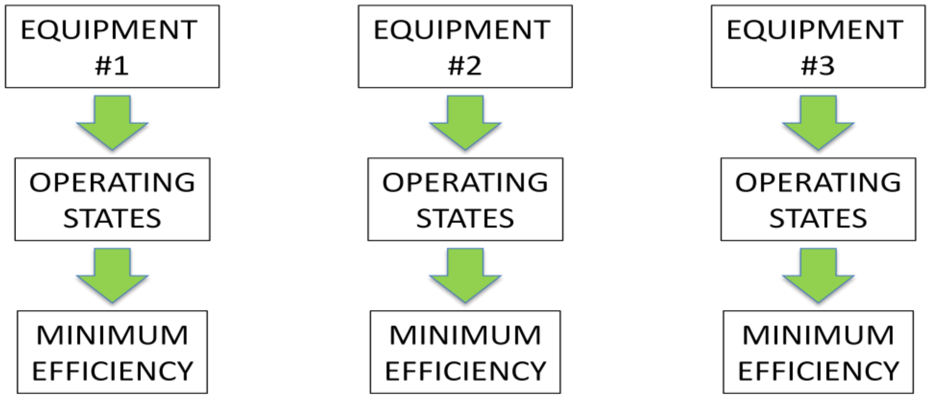

Figure 2: Standards based on operating states

Figure 3 shows a component based standard which adds the power allowance for key components of the design, e.g. for the central processing unit or the WAN port. These types of standards basically further refine the operating state by adding the power allowances per individual components.

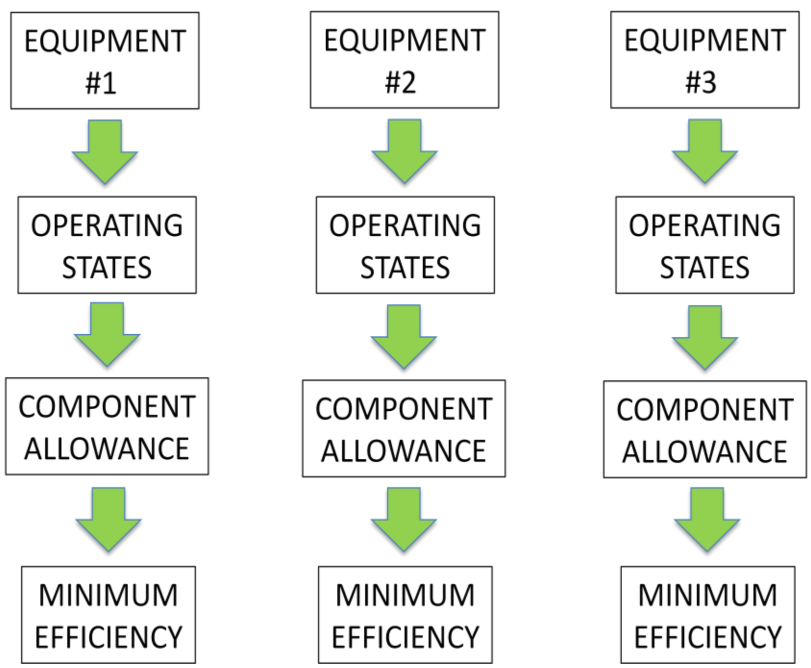

Figure 3: Component based standards

Figure 4 shows an example of a component based standard - the EU Code of Conduct for Broadband equipment standard. For each operating state the minimum efficiency is calculated based on the sum of per component power allowances. The key limitation of such standards is that the allowances are not activity based, but fixed for a type of equipment and its operating state. Although more accurate in terms of energy proportionality than pure operation states based standards, the component allowances just reflect the existence of a physical component in the equipment not the delivery of any "work".

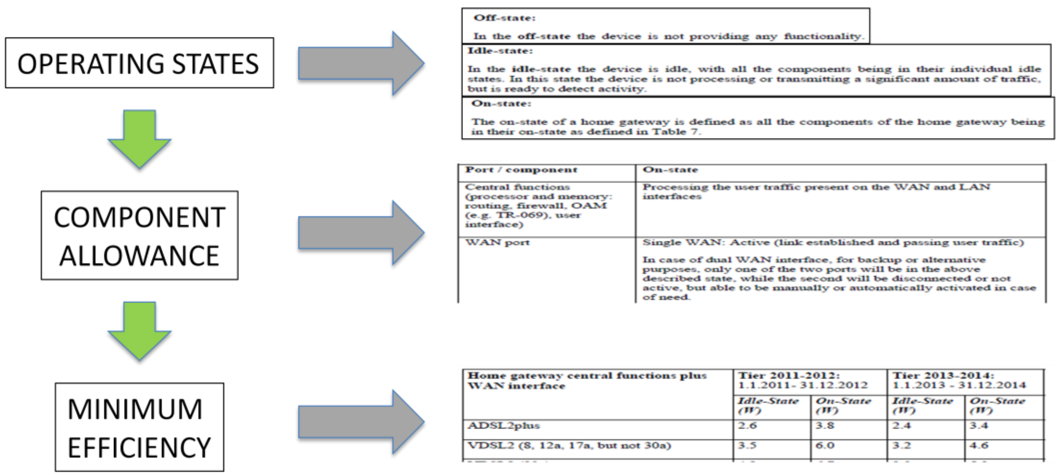

Figure 4: Example of component based standard – EU Code of Conduct

The new standard proposed here unifies the class of computing equipment and establishes a standard based on the activity of the equipment. First a class of equipment is defined, in this

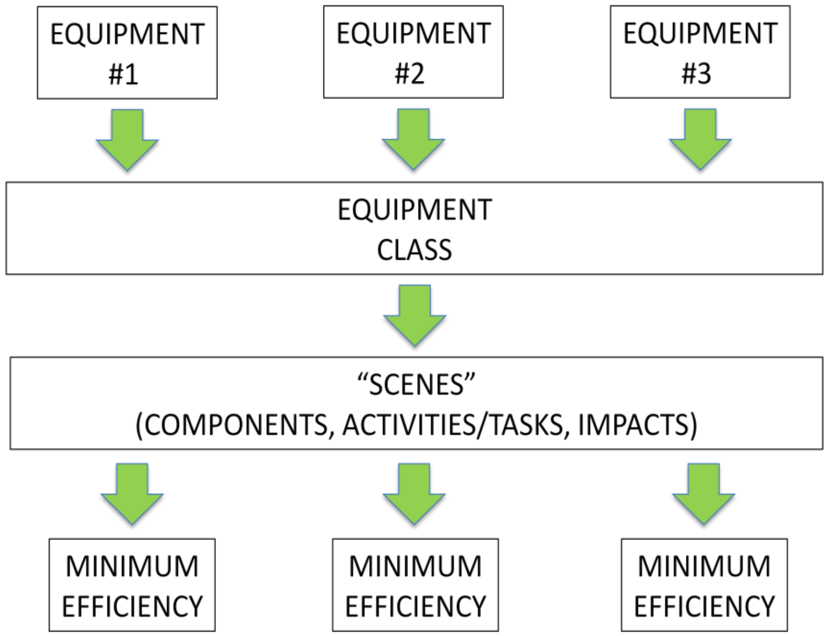

Figure 5

case the class consisting of computers, game consoles, set-top boxes and network equipment. For the given class the standard defines a set of Scenes, which depict the services delivered and the components used to deliver the service. For each Scene the minimum efficiency is computed.

Each Scene is further described by the Tasks/Activities, Impacts and Components. Tasks are the activities done by the equipment. Impacts represent the external influence on the equipment. Components are the hardware components of the equipment consuming energy. For example, a Scene "Video streaming" contains the Tasks "Netflix HD video" and "Dolby stereo sound" and the Impact "100MB internet connection".

Figure 6 presents the case when multiple Scenes are defined for a single hardware platform. These Scenes can be as simple as off, on and idle or more complex as the Scene HD video streaming over WiFi or the Scene providing maintenance wakeup of an idle device. More detailed Screen descriptions lead to tighter minimum efficiency.

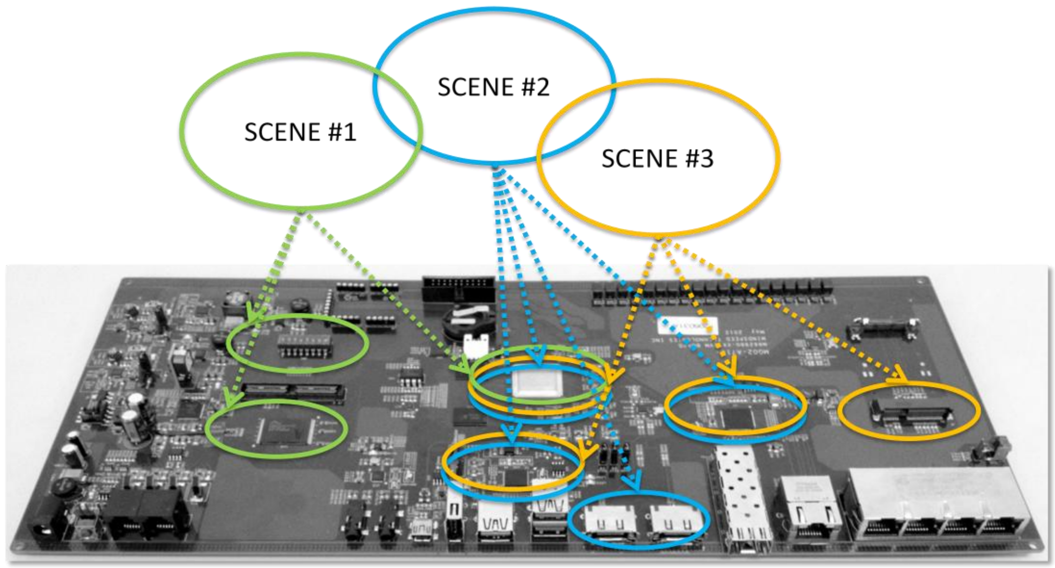

Figure 6

The key benefits of the proposed standard are:

1. Establishes tighter minimum energy efficiency requirements for higher energy savings
2. Enables faster adoption of energy standards for future equipment classes
3. Fosters energy savings competition among manufacturers of various equipment classes
4. Lowers the cost of energy management technology as companies across equipment classes can share same power management technology
5. Enables the introduction of formal energy descriptions of equipment and automated generation of the power management software and hardware
6. Allows for run-time reporting of equipment's energy consumption
7. Allows unified testing, measurement and standardization procedures
8. Brings together a larger pool of power management experts to focus on the same problem and improves technical education for younger engineers

6.2 Implementation Plan

The implementation involves formalizing the Scene description mechanism using a Unified Hardware Abstraction (UHA) as the abstract model for the equipment under test. The UHA descriptions can be used to automatically calculate the minimum efficiency allowances and also as a formalism to automate the design of power management software and hardware.

6.3 Proposed Test Procedure(s)

The testing procedure involves setting the device under test to the selected Scene and measuring the resulting power consumption.

6.4 Proposed Regulatory Language

TBD

7 Technological Feasibility

8 Economic Analysis

TBD

8.1 Incremental First Costs

TBD

8.2 Incremental Operating Costs and Savings

TBD

8.3 Infrastructure Costs and Savings

TBD

8.4 State or Local Government Costs and Savings

TBD

8.5 Business Impacts

TBD

8.6 Lifecycle Cost and Net Benefit

TBD

9 Savings Potential

TBD

10 Acceptance Issues

TBD

11 Environmental and Societal Impacts

TBD

12 Federal Preemption or Other Regulatory or Legislative Considerations

TBD

13 Methodology for Calculating Cost and Savings

TBD

14 Bibliography and Other Research

Included in the above text.

APPENDIX: Cost Analysis Assumptions

[The Energy Commission used the following rates to evaluate initial proposals received in response to the August 31, 2011 scoping workshop.

The cost of electricity: $0.15 per kWh

The cost of natural gas: $1 per therm

The cost of water: $0.0052 per gallon

Discount rate: 3%

The Energy Commission is investigating whether to update these figures over the course of the rulemaking. Stakeholders are welcome to suggest appliance-specific rates, or alternates to these flat rates to support cost-effectiveness of their proposals. If stakeholders choose a different rate, they should describe the analysis and rationale for the different rate.]