Energy Efficiency and Green Data Centers

Overview of Recommendations ITU-T L.1300 and ITU-T L.1310

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Agenda

- Introduction
- ITU-T L.1300 “Best practices for green data centers”
- ITU-T L.1310 “Energy efficiency metrics and measurement for TLC equipment”
- Future activities of ITU-T SG5 Q17
ITU-T Study Group 5

- Working Party 1: Damage prevention and safety
- Working Party 3: ICT and climate change

Environment and Climate change

Electromagnetic compatibility and electromagnetic effects
Question 17/5
Energy Efficiency for the ICT sector and harmonization of environmental standards

Brief Description

- Definition of measurement methods, metrics/KPI and reference values for different technologies
- Sharing of best practices for ICT’s energy efficiency enhancements
- Analysis of the most energy efficient architectures and solutions in support of smart grids
- Complement and harmonize ICT and environmental standards developed by other SGs and Std Bodies

Main Tasks

- Develop Recommendations in the in the field of energy efficiency (see next slide)
- Develop best practices and best reference cases
- Provide and maintain an overview of key mitigation technologies
- Coordinate with other SGs and other bodies on a regular basis to ensure closest alignment
ITU-T L.1300 and L.1310

- **ITU-T L.1300** “Best practices for green data centers”
  - Definition of best practices for: Data Center utilization, management and planning; ICT equipment and services; power and cooling equipment
  - Detailed real case studies reported in a specific Supplement

- **ITU-T L.1310** “Energy efficiency metrics and measurement for TLC equipment”
  - Metrics and measurement methods defined for broadband wireline/wireless equipment and small networking devices
  - These metrics allow for comparisons of equipments within the same class (e.g. equipments using the same technologies)
Green Data Centers

A Data Center is a repository for the storage, management and disseminations of data.

A Green Data Center has mechanical, lighting, electrical and computer systems designed for maximum energy efficiency and minimum environmental impact.

Looks for benefits in:

- Reduction in power and cooling
- Increase server/storage utilization
- Improvement in Data Center space

“Data centers forecasted to surpass airlines in terms of CO2 emissions by 2020 due to energy consumed”
McKinsey & Co. 2008
# Key Issues Facing Data Centers Managers

<table>
<thead>
<tr>
<th>Issue</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Density/Cooling</td>
<td>22%</td>
</tr>
<tr>
<td>Space Constraints/Growth</td>
<td>19%</td>
</tr>
<tr>
<td>Power Density</td>
<td>18%</td>
</tr>
<tr>
<td>Monitoring Capabilities</td>
<td>8%</td>
</tr>
<tr>
<td>Availability (Uptime)</td>
<td>7%</td>
</tr>
<tr>
<td>Technology Changes</td>
<td>7%</td>
</tr>
<tr>
<td>Energy Cost/Efficiency</td>
<td>5%</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
</tr>
</tbody>
</table>

The Efficient Data Center: Improving Operational Economy & Availability  
2007 Data Center Users Group Conference

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Data Centers consumption breakdown

Typical Data Center Energy Consumption

- Facility: 64%
- Power Conversion: 11%
- Network Hardware: 10%
- Servers & Storage: 25%
- Cooling: 50%
- Lighting: 3%

Equipment: 36%

Source: Google search on “Data Centers consumption breakdown”
Recommendation ITU-T L.1300 describes best practices aimed at reducing the negative impact of data centers on the climate. The application of the best practices defined in this document can help owners and managers to build future data centers, or improve existing ones, to operate in an environmentally responsible manner.

Best Practices organized in 8 building blocks providing the tools to operational saving and business growth:
1. Data center utilization, management and planning

It is important to develop a holistic strategy and management approach to the data center to support economic efficiency and environmental benefits.

- **Organizational groups & General Policies**
  - Involve organizational groups: creation of Board approval, representatives from different departments. E.g. software, ICT, power cooling and other facilities)
  - Ensure that the existing equipment has optimal use before making any new investment

- **Resilience level and provisioning:**
  - Energy efficiency **design**:
    - Ensure Business Requirement and Disaster Recovery (BC/DR) in accordance with the architecture
    - Avoid unnecessary fixed losses of provision of excess power and cooling capacity
    - Maximize architecture design efficiency using variable ICT electrical load
2. ICT equipment and services

Best practices

Selection of new ICT and telecom equipment:

- Tender process considering: energy performance, humidity and temperature
- Measurement of energy efficiency performance (eco-rating, service level, energy star)
- Max. temperature & humidity supported
- Compliance with green regulations
- Energy & temperature reporting hardware (IPMI, DCMI and SMASH)
- Selection of equipment suitable for the datacenter: power density and airflow direction

Results

Reduce power and cooling for the ICT equipment
- Maximize efficiency in refrigeration and free cooling
- Reduction of the use of hazardous materials
- Suitable use and control of the electrical network

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Best practices

Deployment of new ICT services
- Virtualization and consolidation of servers
- Select/develop efficient software
- Reduce hot/cold standby equipment

Management of existing ICT equipment and services
- Audit existing physical equipment and services (consider ITIL practices CMDB & SC)
- Decommission unused and low value services
- Management systems to control energy: ICT workloads

Data management
- Define polices to efficient storage of information
- Select lower power storage devices
- Use technologies such as de-duplication, compression, snapshots and thin provisioning

Results

- Reduce physical infrastructure
- Accurate information about ICT assets
- Improve storage efficiency
- Reduce large volume of data not required
- Meet the business service level requirement defined in data management policy
Select equipment with good environmental performance

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2. ICT equipment and services

The cloud and server load improving

Apps Live Migration

APP1
APP2
APP3

APP4
APP5

APP6

0.26 tonnes CO2

Shut down

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3. Cooling

**Best practices**

**Airflow design and management**
- Equipment should share the same airflow direction
- Design raised floor or suspended ceiling height
- Separate from external environment

**Cooling Management**
- CRAC settings with appropriate temperature and relative humidity
- Regular maintenance of cooling plant

**Results**
- Airflow protection of equipment
- Uniform equipment inlet temperatures
- Allow set points to be increased
- Control over CRAC
3. Cooling system

**Best practices**
- Temperature and Humidity Settings: expanded ICT environmental conditions
- Free and economized cooling: Air and water direct/indirect free cooling
- High efficiency cooling plant: Select the adequate CRAC units, cooling towers, refrigerants, compressor,..
- Computer room air conditioners CRAC: Calculate the adequate cooling capacity, disposition and quantity of CRAC units
- Reuse of data center waste heat: Recycling the heat rejected from data center (can use heat pumps to raise temperature)

**Results**
- Optimizes cooling plants efficient operation, without compromising reliability
- Improvement of CRAC system: reduce overcooling, decrease server temperatures
- Increase server reliability and density
- Re-used energy from the environment (air, waste heat, water..)
3. Cooling system

Best practices examples

➢ Segregation of ICT equipment to create precise cooling solutions

- Temperature and Humidity Settings: expanded ICT environmental conditions
- Free and economized cooling: Air and water direct/indirect free cooling
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3. Cooling system

Best practices examples

- The selection of equipment in the racks the importance of a good integrations
3. Cooling system

Best practices

- Temperature and Humidity Settings: expanded ICT environmental conditions
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The importance of simulation before realize ....
4. Data center power equipment  1/3

Power equipment normally includes uninterruptible power supplies, power distribution units, and cabling, but may also include backup generators and other equipment.

Best practices
Selection and deployment of power equipment
✓ Power systems, UPS and cabinet panels
✓ Energy efficiency batteries
✓ Direct Current DC power technology
✓ Use new and renewable energy: solar, wind, hydraulic and geothermal

Management of power equipment
✓ Optimal power density
✓ Wired power cables under raised floor
✓ Load balance management

Results
Reduction of capital cost and fixed overhead losses
Reduce the amount of carbon emissions
Distributed equal power energy to equipment
Prevent damage and malfunction in datacenter equipment
4. Data center power equipment

Best practices in practical view

UPS with High Energy efficiency

The selection of the right sizing

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400Vdc solutions. A solutions to power ICT equipment.

An alternative to realize two separate power distributions:
- DC for classical telekom
- AC for servers
5. Monitoring

The development and implementation of an energy monitoring and reporting management strategy is core to operating an efficient data center.

**Best practices**

*Energy use and environmental measurement*
- Meters for measuring: incoming energy, ICT equipment, air temperature and humidity

*Energy use and environmental collection and logging*
- Periodic manual reading
- Automatic daily and hour reading

*Energy use and environmental reporting*
- Periodic written reports on energy consumption
- Energy and environmental reporting console to monitor energy

*ICT reporting*
- Server, network and storage utilization

**Results**

*Improve visibility of data center infrastructure*
*Managing the energy efficiency*
*Proper use of ICT equipment and network*
5. Monitoring

- Meters for measuring: incoming energy, ICT equipment, air temperature and humidity
- Periodic manual reading
- Automatic daily and hourly reading
- Periodic written reports on energy consumption
- Energy and environmental reporting console to monitor energy

The environmental checking

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6. Design of network

This chapter contains requirement on network design to connect equipment present in the data center with other data centers

Best practices

✓ Selection of network equipment (switches, routers, etc) with the best EE performance

✓ Network design: minimize the number of internal networks elements “grey ports”

✓ Plan for run-time energy consumption profiling of the network

✓ Establish extended energy conservation policies for network devices

✓ Use network as medium to propagate energy conservation policies throughout DC

Results

Maximize egress bandwidth
Reduce network management complexity

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Annexes

1- 2- Possible methodology for **cooling data centers with high density ICT devices**
   - Outline of air conditioning methods
   - Selection of cooling systems suited to data center specifications
3- Practical solutions for **correcting airflow direction for equipment**
4- **Minimum data set** for controlling data center equipment for energy saving management in data centers
Supplement L.1300rev

Recommendation ITU-T L.1300rev will have a Supplement containing case studies of Best Practice implemented by different Companies
ITU-T L.1310 “Energy Efficiency metrics and measurement for TLC equipment”

- Metrics and measurement methods defined for broadband wireline/wireless equipment and small networking devices
- These metrics allow for comparisons of equipments within the same class (e.g. equipments using the same technologies)
Energy efficiency will be defined as the relationship between the specific functional unit for a piece of equipment and the energy consumption of that equipment. For example, when transmission time and frequency bandwidth are fixed, a **TLC system that can transport more data (in bits) with less energy (in Joules)** is considered to be more energy efficient.

**DSLAM, MSAN, GPON OLT**

\[ P_{\text{port}} = \frac{P_{\text{EQ}}}{N_{\text{ports}}} \text{ [W/port]} \]

**Wireless Equipment**


**Routers and Ethernet Switches**

**Small Networking devices**

\[ EER = \frac{0.35 \cdot T_{\text{idle}} + 0.5 \cdot T_{\text{lowpower}} + 0.15 \cdot T_{\text{maximum}}}{0.35 \cdot F_{\text{idle}} + 0.5 \cdot F_{\text{lowpower}} + 0.15 \cdot F_{\text{maximum}}} \text{ (Mbit/s/W)} \]
ITU-T L.1310 benefits

- Understand the evolution of network in term of efficiency
- Compare different solution of the same technologies
The work on methodology to develop ITU-T L.1310

- ITU-T wants to cooperate with other Standard Organizations (SDOs);
- ITU-T takes into consideration the proposals of other standards developed by other SDOs;
- ITU-T will consider whether to:
  - make a direct reference to an entire existing standard,
  - use it partially,
  - write new requirements.
The requirements of L.1310

- Measurement condition
  - General
    - Environmental conditions
    - Equipment powering Voltage
      - DC Voltage $-55.5$ to $-52.5$ V ($54 \pm 1.5$ V).
      - AC nominal specified voltage $\pm 5\%$ and the specified frequency $\pm 1\%$.
  - Instrumentation characteristics
  - Reporting
Metrics

- Why a metrics?
- A metrics is a number to evaluate the energy efficiency of an equipment based on the ratio: **useful work/energy consumption**
Broadband fixed access equipment

- Metrics \( P_{\text{port}} = \frac{\text{PEQ}}{N_{\text{ports}}} \) \([\text{W/port}]\);
- Measurement condition contained in ETSI ES 203 215:
  - measurement made with different traffic conditions;
- This metrics allows operators:
  - to estimate the energy consumption of the equipment;
  - to compare equipment of the same technologies and type.
To this regard, ITU makes reference to ETSI TS 102 706 for the metrics definition and the measurement methodology:

- Different type of metrics based on coverage and traffic load;
- Measurement with different load conditions and in static and dynamic mode.
Router and switches

- Metrics defined in the recommendation
- $\text{EER} = \frac{T_i}{P_w} \quad [\text{Mbit/seconds/W}]$
- Measurement methodologies contained in ATIS-0600015.03.2009
- Traffic load defined in L.1310
Small networking equipment

- Metrics defined

\[ EER = \frac{0.35T_{idle} + 0.5T_{lowpower} + 0.15T_{Maximum}}{0.35P_{idle} + 0.5P_{lowpower} + 0.15P_{Maximum}} \]

- Measurement methodologies contained in ATIS-0600015.03.2009
- Traffic load defined in L.1310
WDM/TDM/OTN transport MUXes/switches

- The metrics and relevant measurement methods for transport equipment (excluding microwave radio equipment) are defined in [ATIS-0600015.02.2009].
Future activities

- **Rec. ITU-T L.M&M_Network**
  - The aim is to define **energy efficiency metrics** for BB fixed and wireless **networks**
  - The activity is **jointly performed with ETSI EE**

- **Rec. ITU-T L.M&M_infra**
  - The aim is to define **metrics** and measurement to assess the **energy efficiency of power and cooling equipment** for TLC and Data Centres

- **Rec. L.Ref**
  - The aim is to define **energy efficiency informative values** for different type of TLC network equipment. These informative values should represent a valid support in the process of choice of the most energy efficient technologies for network upgrade/deployment, reducing therefore the carbon footprint of the ICT sector

- **Rec. ITU-T L.DC_minimum set**
  - The aim is to define the **minimum set of parameters** to be communicated depending on **power/cooling system and ICT equipment** to manage in an environmental conscious manner Data Centers and TLC Centers
  - L.130 revision. Addition on cloud services and general update
Moving from Equipment to network level energy efficiency

- **equipment specification**
- **Router**
  - ES 203 136
  - ATIS-0600015.03.2013
  - L.1300
- **Transport**
  - ATIS-0600015.01.2009
  - ES 203 184
  - L.1300
- **Broadband access**
  - ES 203 215
  - ATIS-0600015.07.2013
  - L.1300
- **BTS**
  - TS 102 706
  - ATIS-0600015.06.2011
  - L.1300
- **Core**
  - ES 201 554
- **Server**
  - ATIS-0600015.01.2009
- **Small networking devices**
  - L.1300

**Why?**
- Carbon Tax.
- Operators to demonstrate the efficient evolutions of their networks. Move the discussion from energy consumption towards energy efficiency.
THANK FOR YOUR ATTENTION

www.itu.int/ITU-T/climatechange/