The role of the standard in the energy efficiency for radio access networks: the ETSI EEPS activities on Network level Energy Efficiency and radio base stations

Mauro BOLDI (Telecom Italia), Daniel DIANAT (Ericsson)
Presentation outline

- Scope of the presentation
- ETSI specification activities
  - Radio Base Station measurements
  - Mobile Network measurements
Energy Efficiency for mobile radio access

Single Node lab Measures

ETSI TS 102 706

Network lab Measures

Evolution towards

EE measurement of partial RAN

GLOBAL Networks

Extrapolation
Scope of the presentation

ETSI specification activities

- Radio Base Station measurements
- Mobile Network measurements
Why need of standard?
Static test setup

Static method is a basic method for efficiency measurement

RBS loaded in lab
- Low load: 10%
- Medium load: 30%
- Busy hour: 50%
- Measuring $P_{in}$
Why a Dynamic Methods?

- **Static methods are simple but don’t reflect real network conditions**
- **Duty cycle with simulated *dynamic radio conditions* more realistic than static methods**
  - Compare with e.g. gas consumption for a car. Necessary to use mixed traffic to achieve a realistic value

**Dynamic conditions**

EE standards should drive the industry towards improved products and solutions
Major dynamic radio factors:
1. Signal quality – in static method
2. Traffic variations due to:
   - Time of day*
   - Applications
   - Cell handovers
3. Distributed and mobile users
4. Multi-path and dispersion
5. Fast fading
6. Noise and interference
7. Uplink traffic

* Load figures for data and voice not comparable with each other – data >> voice
Major dynamic radio factors:

1. Signal quality – in static method
2. Traffic variations due to:
   • Time of day – in static method
   • Applications
   • Cell handovers
3. Distributed and mobile users
4. Multi-path and dispersion
5. Fast fading
   • 20 - 30 dB marginal needed
6. Noise and interference
   • Capacity \( \sim \log (1 + S/N) \)
7. Uplink traffic
   • Significant base-band processing load in RBS
Dynamic test setup

Factors:
- UE dynamics
- Applications
- Mobility
- Distributed UEs
- Dynamic environment
  - Multi-path and dispersion
  - Fast fading
  - Noise and interference

Diagram:
- Control
- Data server
- RBS Control
- Measured received UE data
- Sector 1
- 2
- n
ETSI EE TS 102 706 Status

Static measurement method published August 2009
ETSI TS 102 706 V1.1.1

Dynamic measurement method published October 2011
ETSI TS 102 706 V1.2.1

Dynamic measurement method Published July 2013
ETSI TS 102 706 V1.3.1

Enhanced Dynamic measurement method
ETSI TS 102 706 V1.4.1

- Just started
- Publication January 2015
Presentation outline

- Scope of the presentation
- ETSI specification activities
  - Radio Base Station measurements
  - Mobile Network measurements
Selected test areas

Metrics Methods

Extrapolation to complete country wide or operator specific network

Measurements of real, operational networks
Radio Access Networks

- TR 103 117 “Principles for Mobile Network level energy efficiency” V1.1.1, published 11/2012
- DES/EE-EEPS005, ongoing New Work Item on “Assessment of mobile network energy efficiency”

The TR 103 117 is an overview of energy efficiency for mobile access networks taking into account its complexity:
- complexities of network measurement in live network
- complexities of network measurement in lab

Models and simulations for network level energy efficiency is also studied

The covered technology is GSM, UMTS, LTE

A report of some European projects on the related matters is given, including EARTH and OperaNET projects

A new Work Item opened towards a specification
Environmental Engineering (EE) Assessment of mobile network energy efficiency

**Scope**

- Assess the energy efficiency of mobile networks
  - radio access part of the mobile networks
    - radio base stations, backhauling systems, radio controllers and other infrastructure radio site equipment
  - covered technology are GSM, UMTS, LTE (and LTE-A)
- Size and scale could be defined by topologic, geographic or demographic boundaries
  - topologic boundaries: the smallest network consists of a control node, its supported access nodes as well as the related network elements
  - geographic boundaries: such as city-wide, national or continental networks
  - demographic boundaries: such as urban or rural networks

**Early draft 0.0.1 released in June, stable draft in Sept’14**
### Metrics for energy efficiency assessment

**EE_{MN, D}**

<table>
<thead>
<tr>
<th>Consumption</th>
<th>Energy EC_{MN}</th>
<th>Wh or J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>Data volume DV_{MN}</td>
<td>kbit</td>
</tr>
<tr>
<td>3GPP ref.</td>
<td>TS36.314 §4.1.8.1&amp;2 TS 32.425 §4.4/4.5/4.10</td>
<td></td>
</tr>
<tr>
<td>Time period</td>
<td>week/month/year (week granularity)</td>
<td></td>
</tr>
</tbody>
</table>
| Comment     | • EC Based on metering information  
• DV Based on O&M counters at node level  
• MDT availability issue and MDT user consensus required  
• Availability/reliability as quality indicator |

**EE_{MN, C}**

<table>
<thead>
<tr>
<th>Consumption</th>
<th>Energy EC_{MN}</th>
<th>Wh or J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>Coverage Area</td>
<td>m2</td>
</tr>
<tr>
<td>3GPP ref.</td>
<td>TS36.314 §4.1.8.1&amp;2 TS 32.425 §4.4/4.5/4.10</td>
<td></td>
</tr>
<tr>
<td>Time period</td>
<td>week/month/year (week granularity)</td>
<td></td>
</tr>
</tbody>
</table>
| Comment     | • EC Based on metering information  
• Coverage based on geographic data or propagation models, for each RAT  
• Metric to be used in rural or deep rural areas |

\[
EE_{MN,D} = \frac{DV_{MN}}{EC_{MN}}
\]

\[
EE_{MN,C} = \frac{\text{coverage area}}{EC_{MN}}
\]

- Rather stable
- Still under discussion
Example of extrapolation (from TR 103117)

<table>
<thead>
<tr>
<th>Metric [Mbps/kW]</th>
<th>Load level</th>
<th>Low load</th>
<th>Medium load</th>
<th>High load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dense urban</td>
<td></td>
<td>0.2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Urban</td>
<td></td>
<td>0.25</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Suburban</td>
<td></td>
<td>0.3</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td>0.6</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Sparsely populated / wilderness</td>
<td></td>
<td>1.2</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

Hypothesis of $E_{MN,D}$ in the different environments

1. Weighting the metrics with an hypothesis of areas distribution (from EARTH project)

2. In a day
   - low load 6 hours
   - medium for 10 hours
   - high for 8 hours
   (from TS 102706)

3. Network efficiency [Mbps/kW]

<table>
<thead>
<tr>
<th>Low load</th>
<th>Medium load</th>
<th>High load</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.92</td>
<td>15.27</td>
<td>30.54</td>
</tr>
</tbody>
</table>

Daily average

<table>
<thead>
<tr>
<th>Network efficiency [Mbps/kW]</th>
<th>Daily average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16.77</td>
</tr>
</tbody>
</table>
Thank you!