



The TREND experiments in green networking

TREND Final Workshop
Brussels, 24 October 2013

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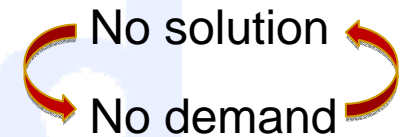


Outline

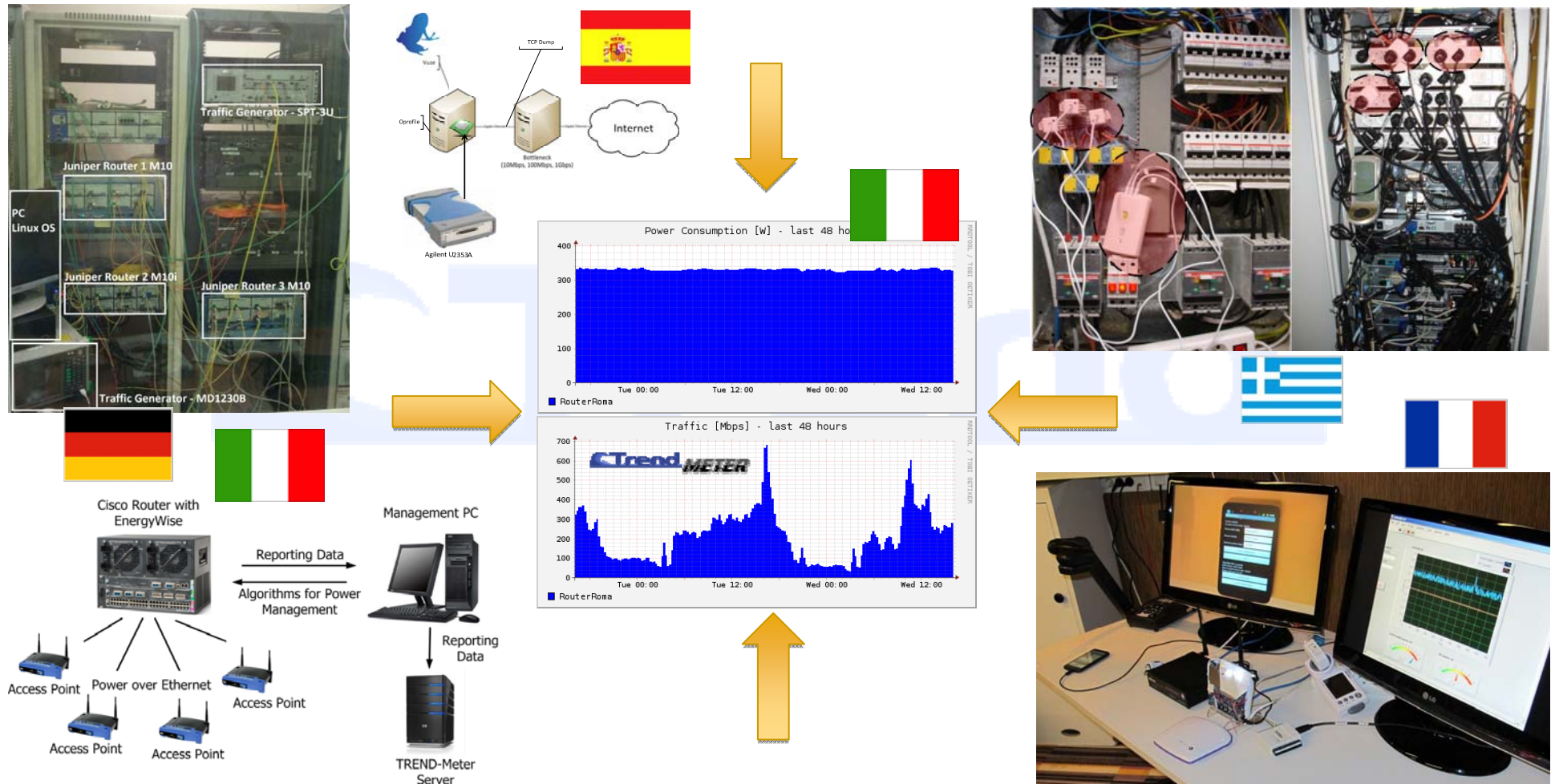
- The TREND “big picture” from experimental point of view
- Remote monitoring and control for energy-efficient femto
Ivaylo Haratcherev (A-LBLF)
- Energy saving mechanisms in metro/core and their validation on a testbed
Filip Idzikowski (TUB)
- Measuring the energy cost of networking intensive applications
Olga Jaramillo (CNIT-UNIGE)
- Estimating effectiveness of energy-efficient solutions for dense WLANs through measurements
Michela Meo (PoliTO)

The WP4 view: conclusions & big picture

- Verification by experimentation is ~~often~~ always a difficult, tedious and exhausting process
- ... but we absolutely need it, before algorithms and concepts can be deployed in practice:
 - validates the approaches
 - gives credibility – helps breaking the vicious circle
- Results show good coherence with theoretical anticipations
- ... but there were some unexpected findings, like:
 - long network configuration times in FUFL/DUFL implementation
 - femto LEDs contribute much more to its power consumption than PA
 - adjacent-channel interference in Wi-Fi hurts power-efficiency more than in-channel interference



The WP4 view: conclusions & big picture



Time for the WP4 tech talks ...



Remote monitoring and control for energy-efficient femto

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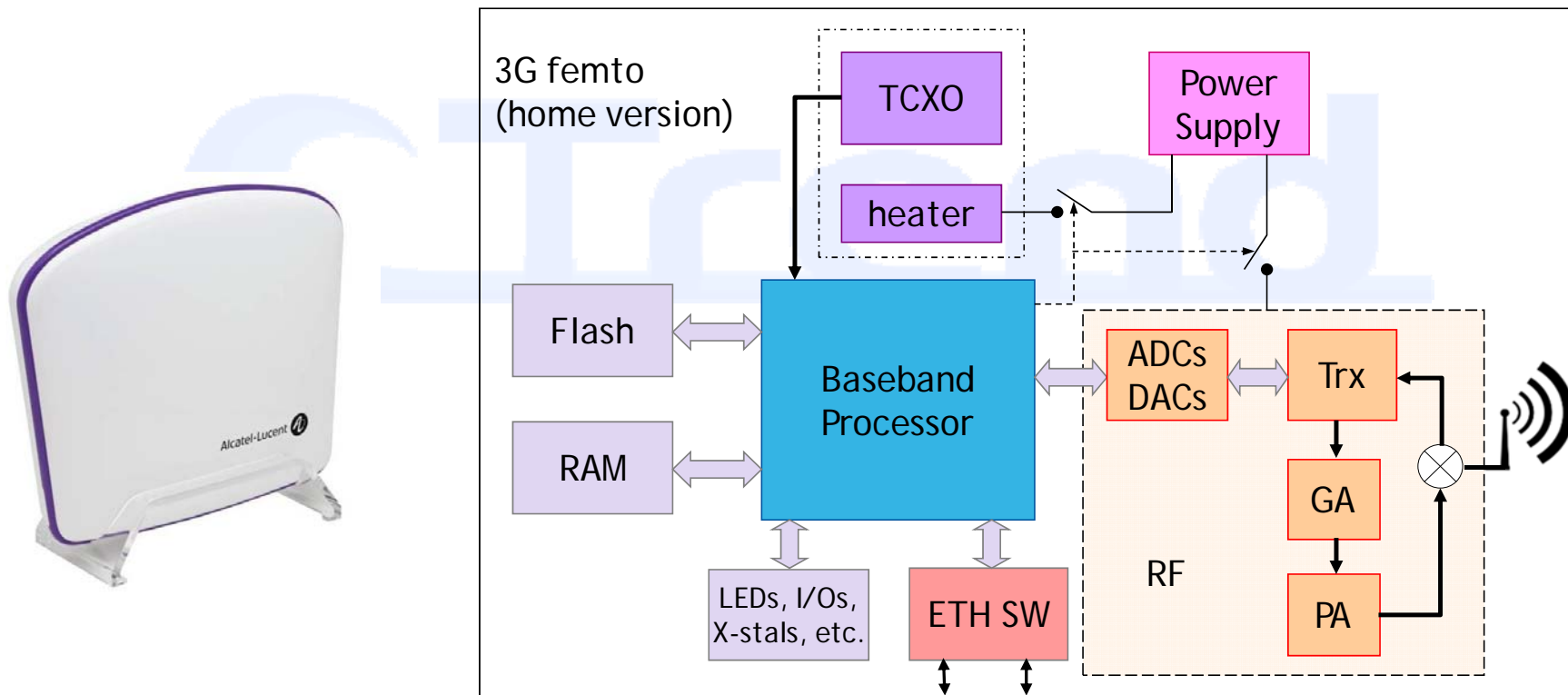
Introduction

“Green” wish list:

- Collect information about:
 - overall system power consumption
 - system utilization (bandwidth, N of users)
- Report this information remotely (both push and pull)
- Provide an API for direct and scheduled remote power-mode control
- Couple the above with TREND-Meter

Femto real-time power estimation

- Add ability to report power consumption w/o measurements (cost)
- What HW is in a femto:



Real-time power estimation model

- Based only on internal state reported by different SW modules
- Final refined femto electrical power estimation model:

$$P_{\text{TOT}} = P_0 + P_{\text{RF}} + DP_{\text{TCXO_H}} + nP_{\text{LED}}, \text{ where:}$$

P_0 – base power consumption (BB + ETH + MEM + TCXO + DC/DC)

P_{RF} – RF power consumption (ADC/DAC + TRx + PA)

$P_{\text{TCXO_H}}$ – TCXO heater power consumption

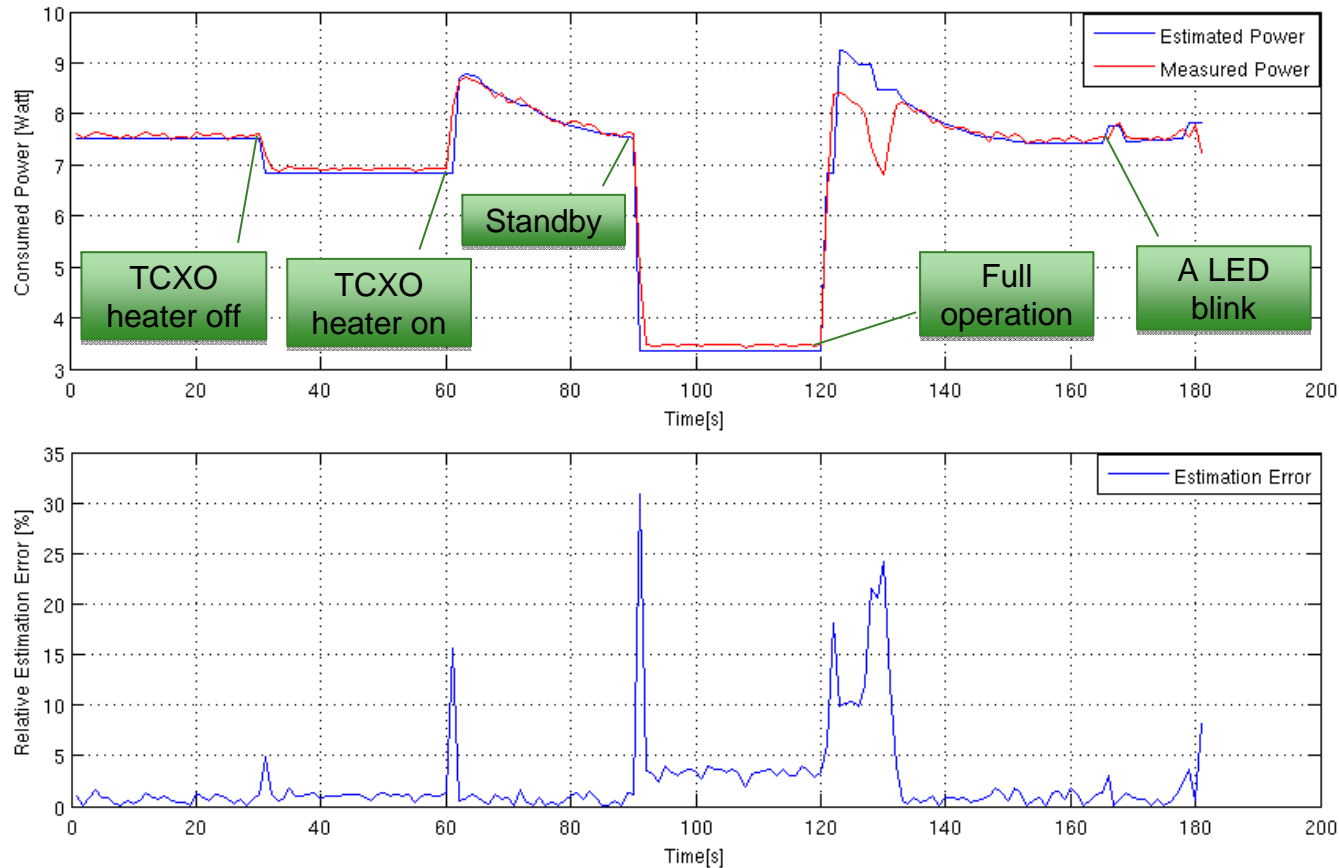
P_{LED} – LED power consumption

D – TCXO heater duty cycle

n – number of powered LEDs

- Refresh rate: 1s


Power estimation accuracy



- Average estimation error ~ 2%

Power-mode control interface

- On-system very light-weight web-server has been implemented

.....Alcatel-Lucent 

[Home Page](#) [Power Consumption](#)

ALWAYS ON

SCHEDULE 1 on off on off
18:22 12:22 hh:mn hh:mn

SCHEDULE 2 20:32 14:32 23:56 24:59

WEEKLY

MON Always ON Schedule 1 Schedule 2

TUE Always ON Schedule 1 Schedule 2

WED Always ON Schedule 1 Schedule 2

THU Always ON Schedule 1 Schedule 2

FRI Always ON Schedule 1 Schedule 2

SAT Always ON Schedule 1 Schedule 2

SUN Always ON Schedule 1 Schedule 2

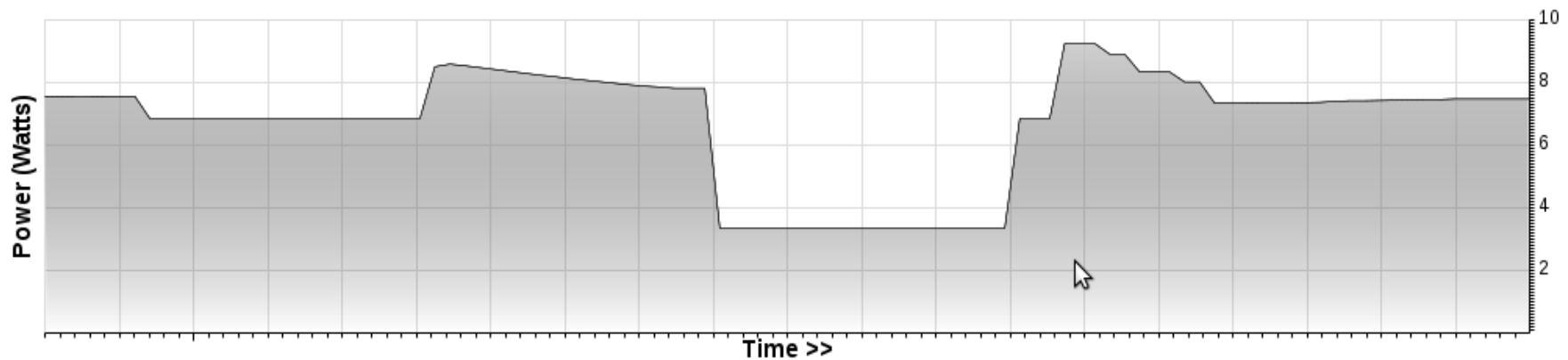
submit Reset

Local power-reporting interface

- ... served by the same web server and by power-estimation process



REAL-TIME FEMTOCELL POWER CONSUMPTION

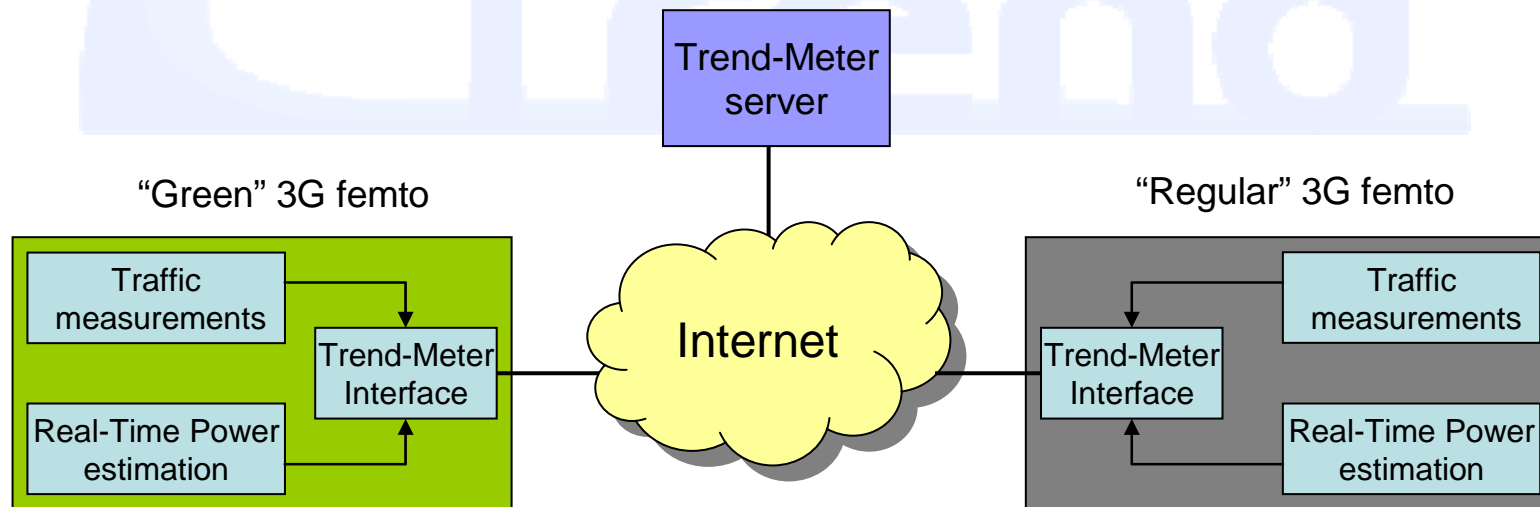


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Integration with TREND-Meter

- Successfully added to the list of other devices doing real-time reporting
- Perform experiments, compare power consumptions and evaluate gains brought by energy-saving algorithms in realistic conditions



... and some live results

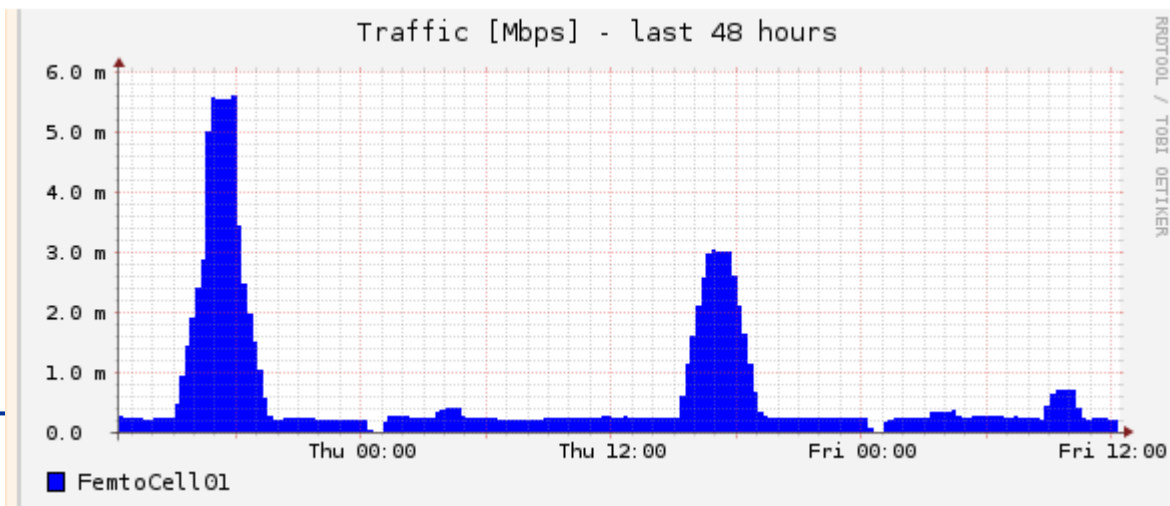
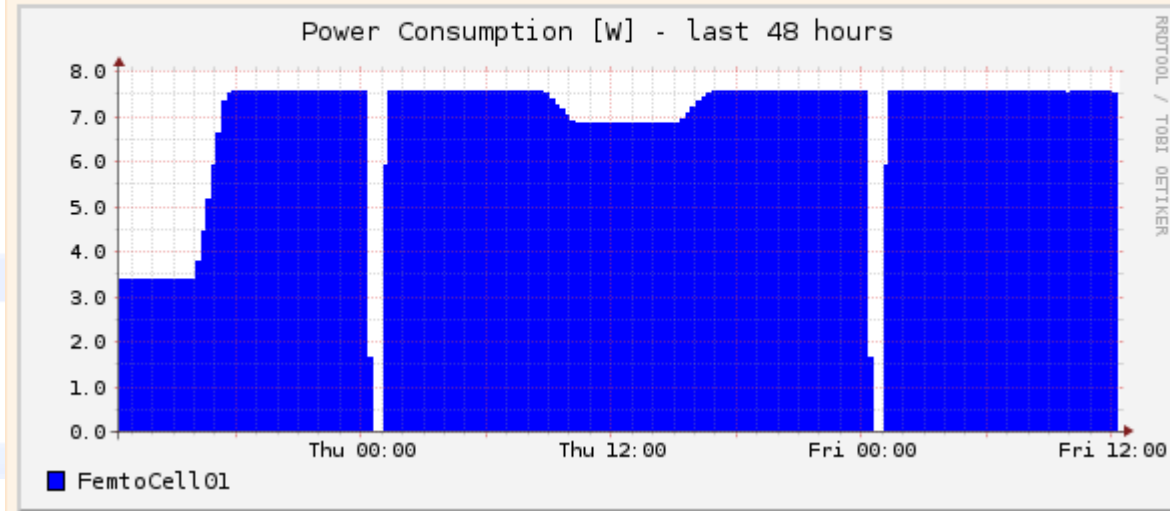
- Available online:

<http://trend.polito.it/>

FemtoCell ALBLF

[Link to Description](#)

Daily View



Conclusions

- Accurate power-estimation is possible:
 - with careful analysis of the system (power flow, components, etc.)
 - while retaining model simplicity
- Providing remote power control and monitoring completes (kind of) the cycle of creating a fully **green** femto prototype, and:
 - creates opportunities for large testbeds (hopefully)
 - brings us another step further on the path to a real product

Thank you!



Questions?