Power consumption of base stations

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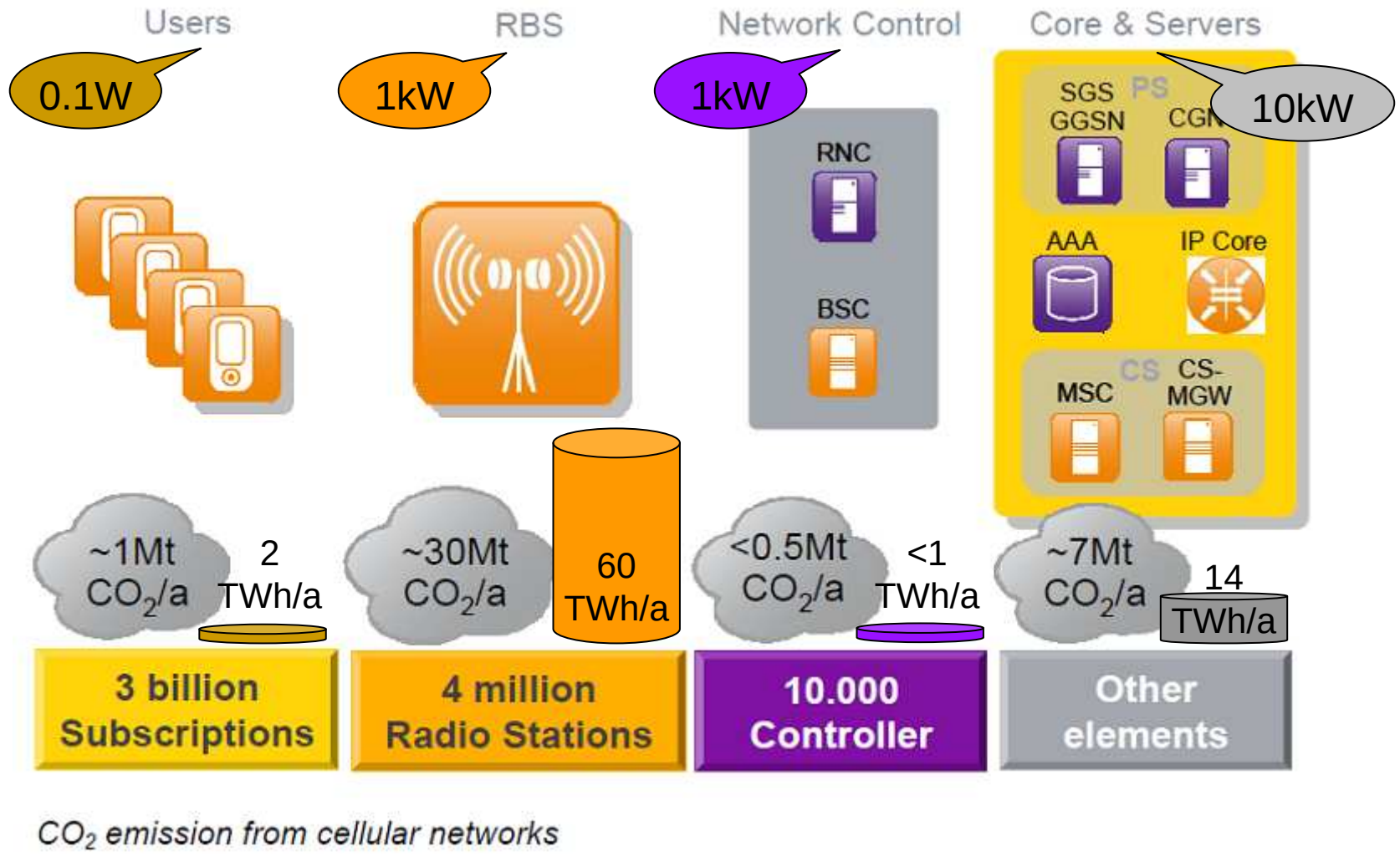
SEVENTH FRAMEWORK PROGRAMME

Outline

- BS consumption... why we care?
- Functions, grouping and integration
- Power consumption figures
- Consumption vs. Cell Load
- Possible BS power models

Mobile Communications: where is the power going ?



CO_2 emission from cellular networks

Based on: ETSI_RRS05_024, NSN

More than 90% is used to power the radio sites !!

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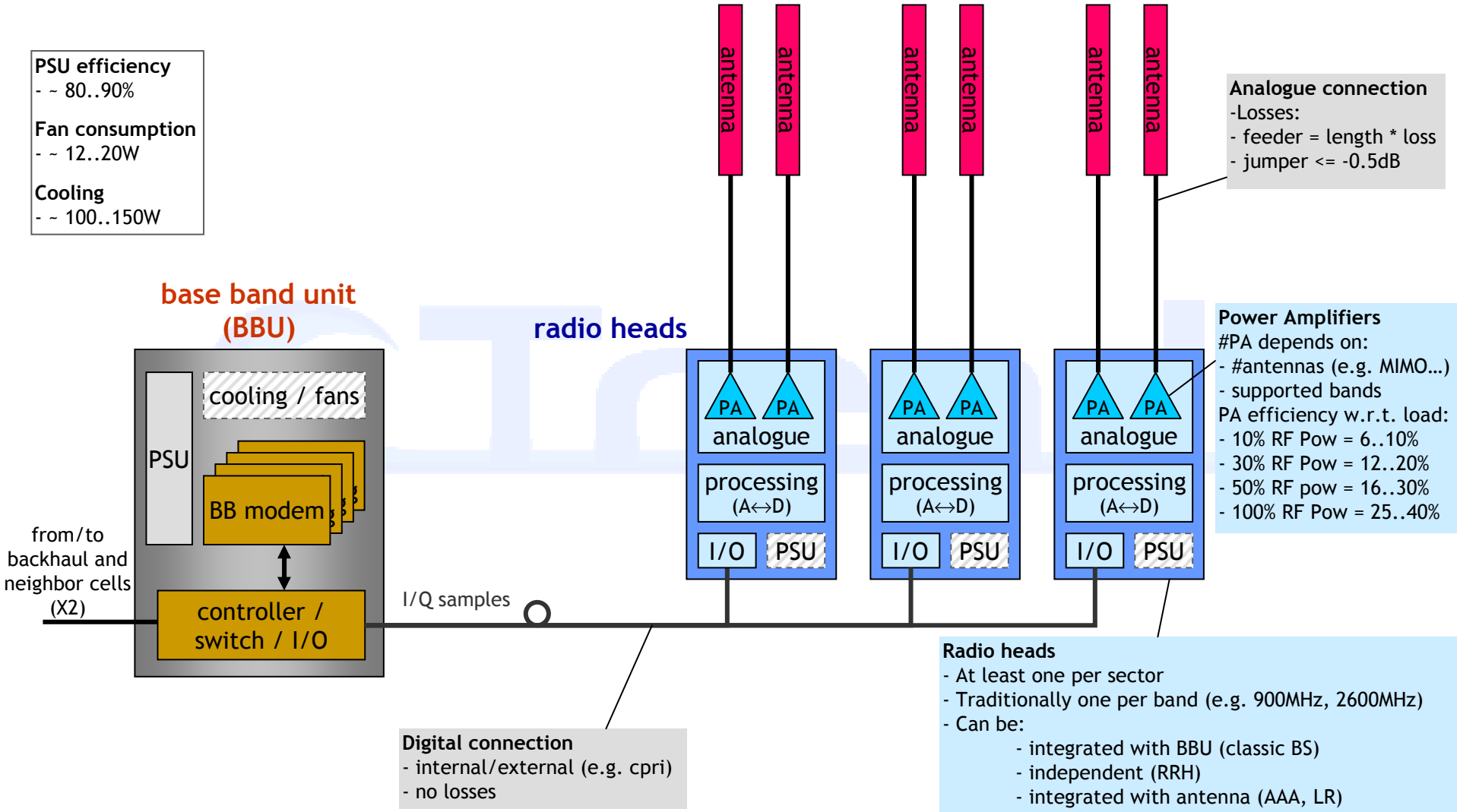
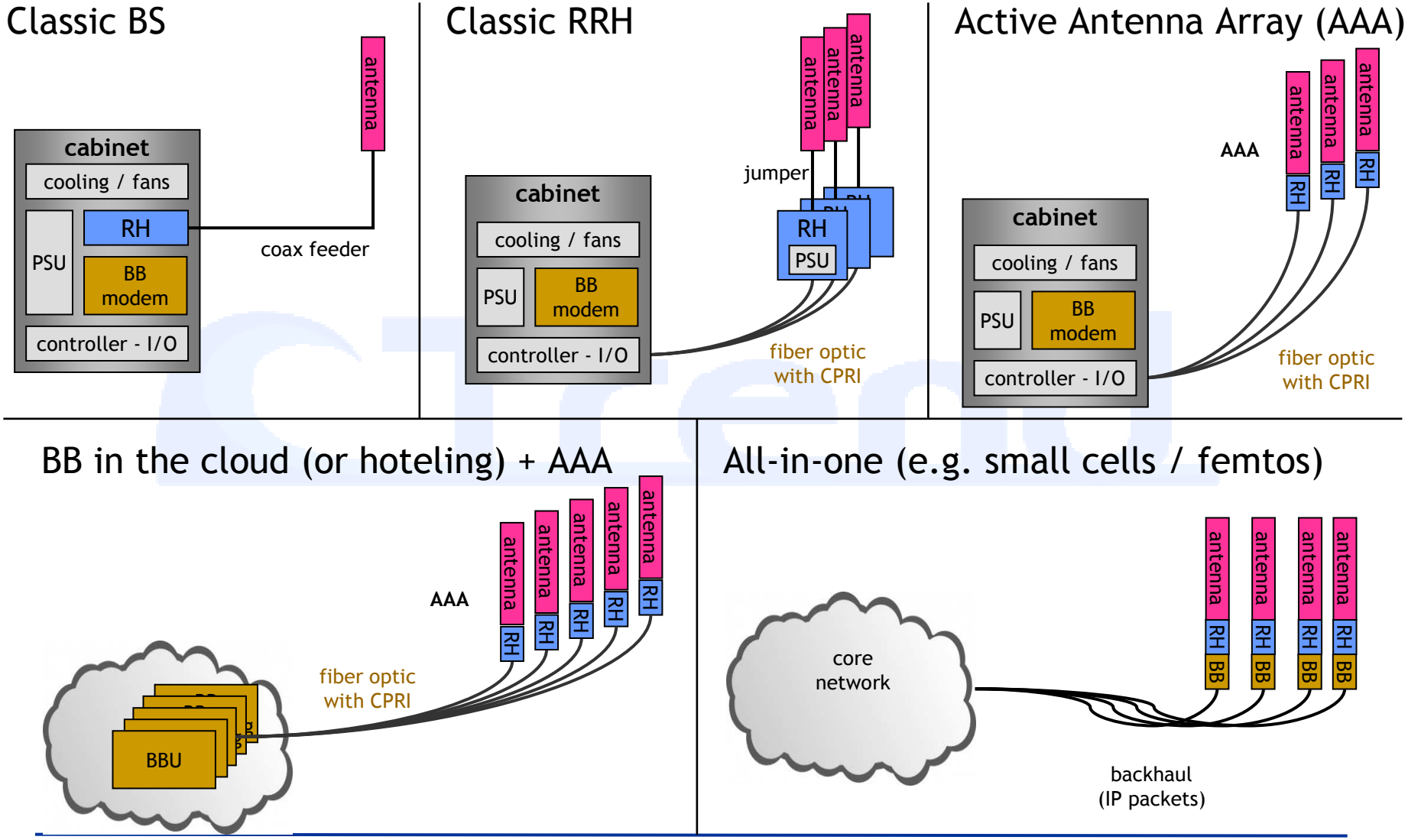
Base station functional components



PSU = Power Supply Unit

Possible options for grouping functions



PSU = Power Supply Unit

Rules of thumb on BB grouping

- BBU in the cloud (or in large cabinets = hoteling)
  - Well adapted for multi-cell processing (like network-MIMO)
  - High CPRI BW required + fiber distance limited due to latency limits
  - BB pooling => energy savings by matching load with # of active BBUs
- All-in-one
  - BB processing can be small, cheap and integrated (e.g. on SoC)
  - Best choice for small cells (price constrained)
  - Lack of BB pooling. Duplication of “common” functions (e.g. synchronization)

Rough estimation of BB<-->RRH link (LTE)

- A rough estimation of the needs (in bps) on the link between BB and RRH can be easily obtained by basic sampling rules
  - **$R_{link}[bps] \approx N_{sectors} \times N_{antennas/sector} \times N_{samples/s/carrier} \times N_{bits/sample} \times 2(I/Q)$**
    - $N_{sectors}$ = # sectors
    - $N_{antennas/sector}$ = # antennas in each sector
    - $N_{samples/s/carrier} \approx 2 \times BW$ (e.g. 20M samples/s for 10MHz radio channel width)
    - $N_{bits/sample} = 15$ (typical sample representation width in CPRI)
    - 2(I/Q) = Multiplication factor of two to account for in-phase and quadrature-phase data
- Example: LTE, 20 MHz, MIMO 4x2, downlink (BB --> RRH)
  - $N_{sectors} = 1$
  - $N_{antennas/sector} = 4$ (from MIMO 4x2)
  - $N_{samples/s/carrier} \approx 2 \times 20 = 40$
  - $N_{bits/sample} = 15$
  - $R_{link} = 1 \times 4 \times 40 \times 15 \times 2 \approx 4800$ Mbps

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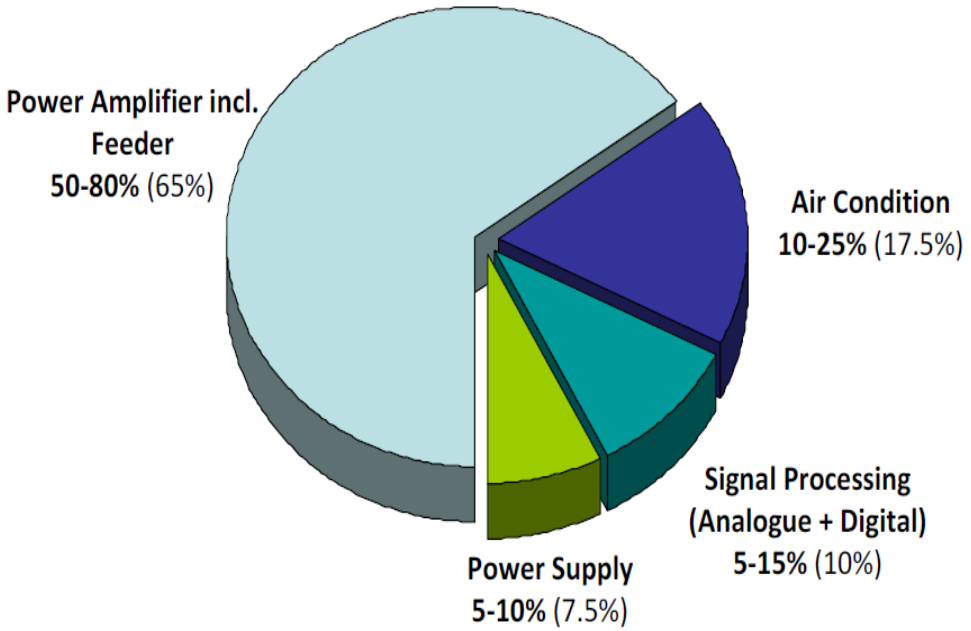
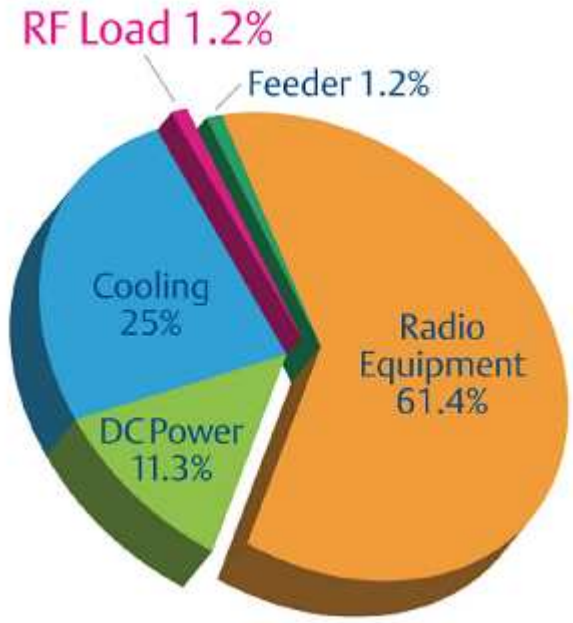
Power Consumption of Radio Access Equipment

Who is consuming what ?



Study on Energy Efficient Radio Access Network Technologies, 2009
Alcatel-Lucent / TU Dresden Vodafone Chair Mobile Communications Systems

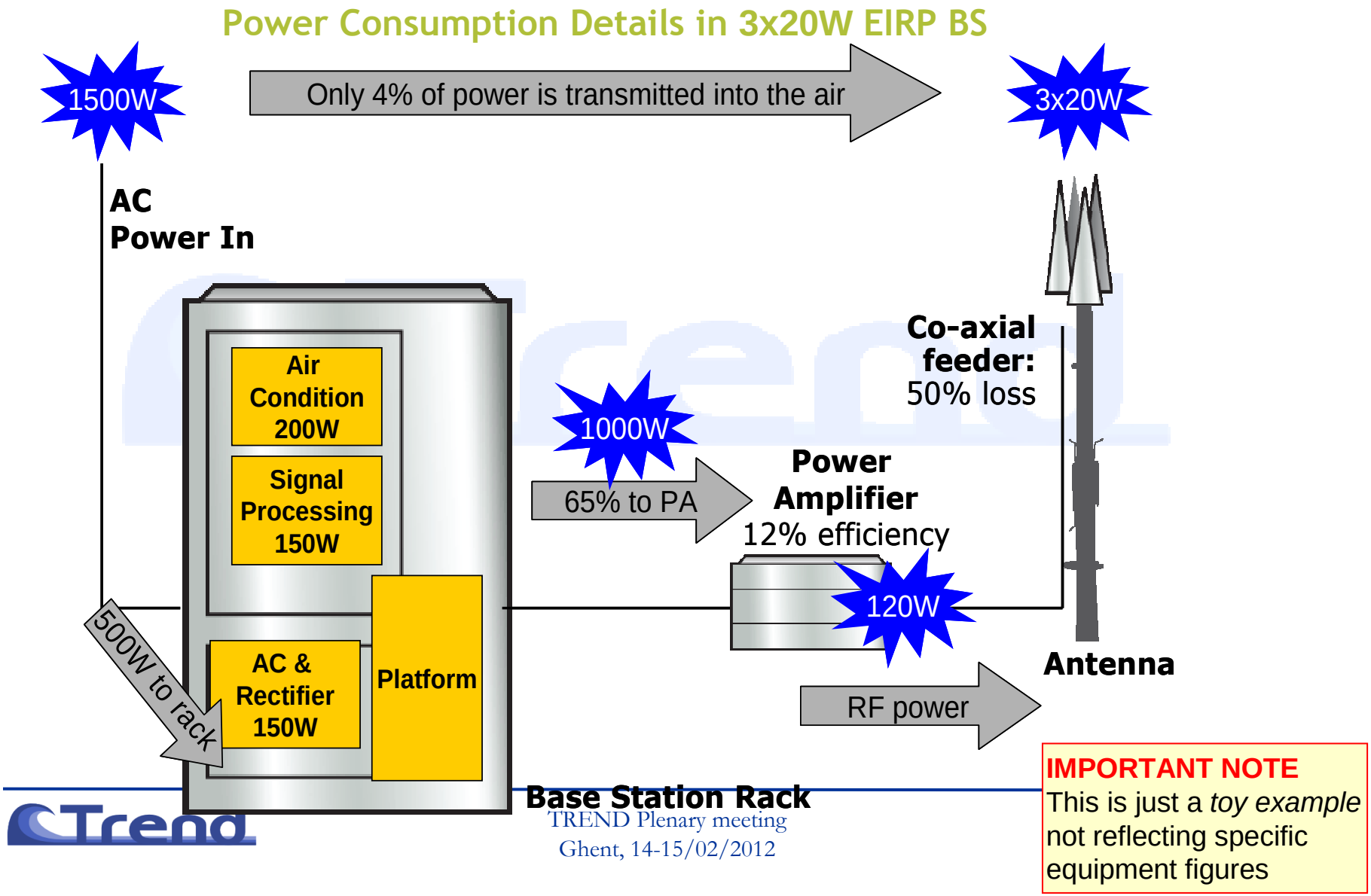


ATIS Report on Wireless Network Energy Efficiency, January 2011

Energy saving at RF amplifier is most efficient : Additional savings in power supply and cooling !

Macro BS energy consumption breakdown

- *Toy example*



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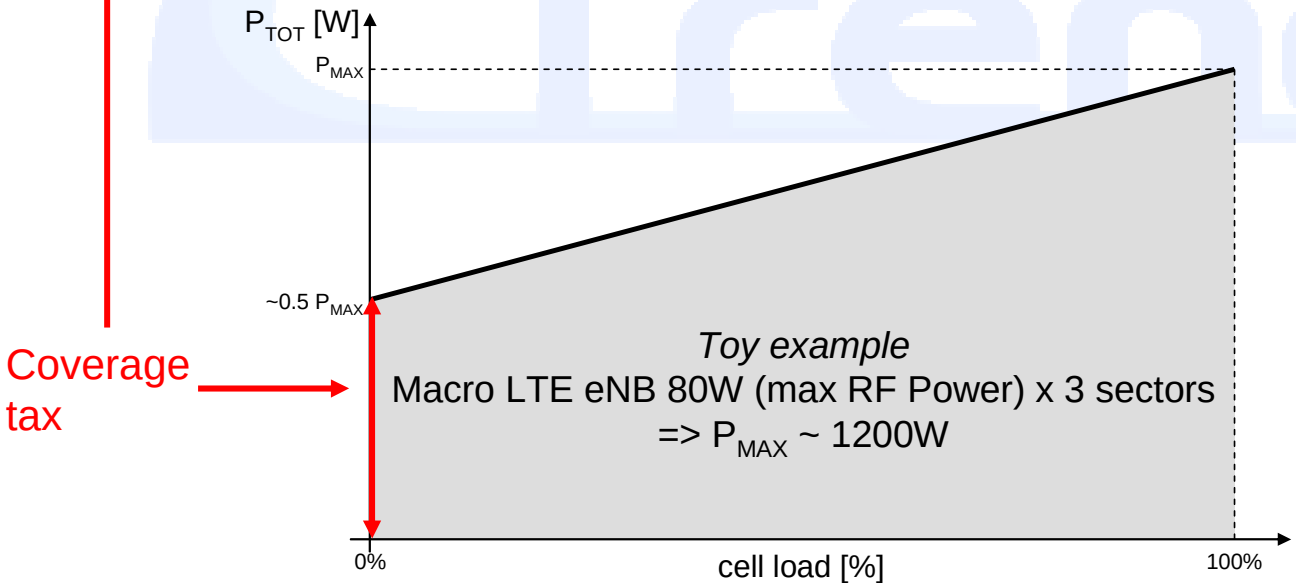
Base Station power consumption figures
- LTE case (eNB)

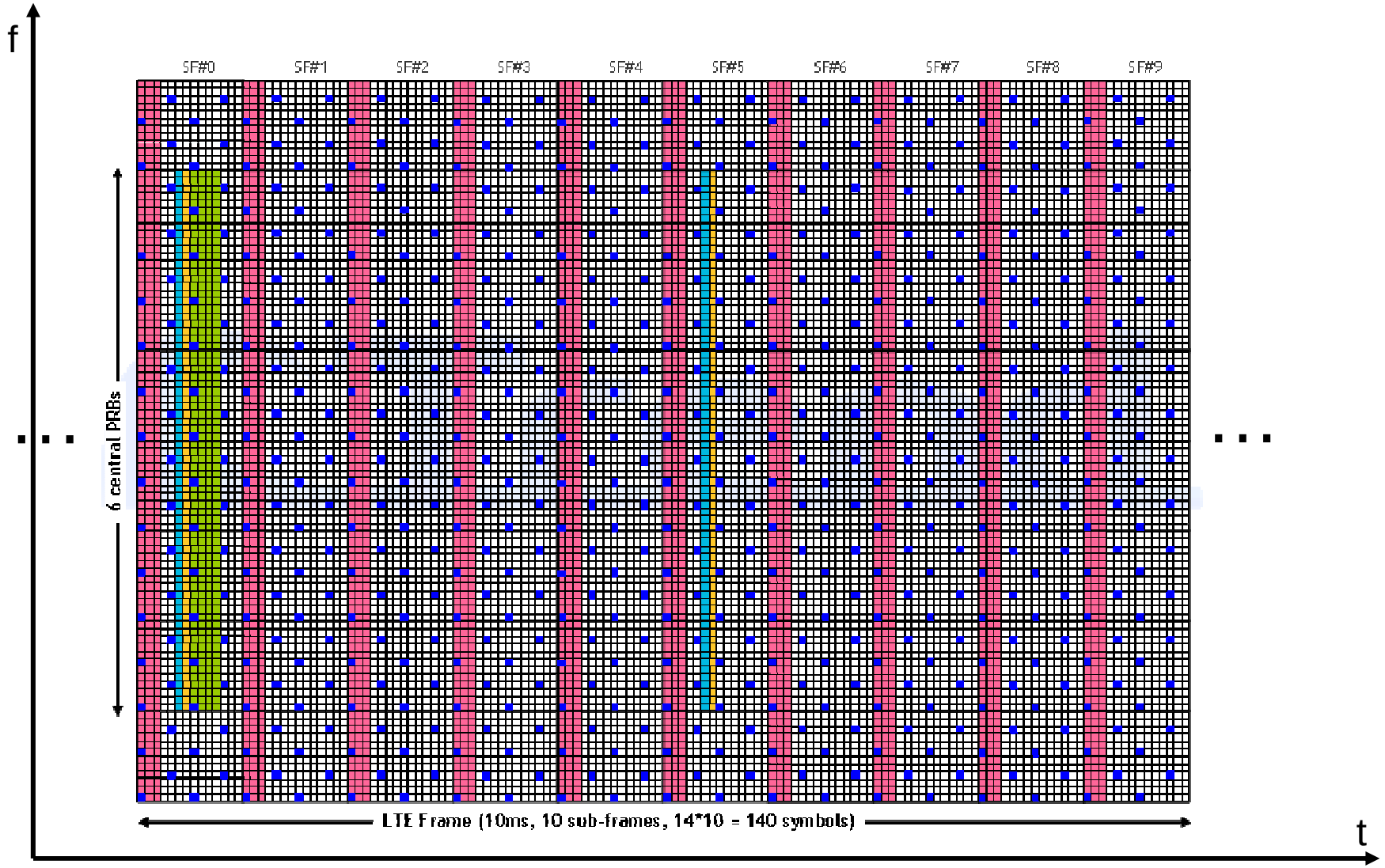
- BS consumption analysis
  - BBU, PSU, cooling/fans consumption is poorly dependent on cell load
  - RH: ~60% of its consumption scales with data traffic load
    - The remaining ~40% is not dependent on data traffic load
      - HW consumption
      - Broadcast channels: continuously emitted (10-15% of RF power) even at 0 load



ETSI definitions
-- "**low load**" = 10% RF power (no data – only common ch)
-- "**medium load**" = 30% RF power (data + common ch)
-- "**busy hour**" = 50% RF power (data + common ch)
-- "**average**" = 6/24 low + 10/24 medium + 8/24 busy = 31.7%

IMPORTANT NOTE
This is just a *toy example* not reflecting specific equipment figures

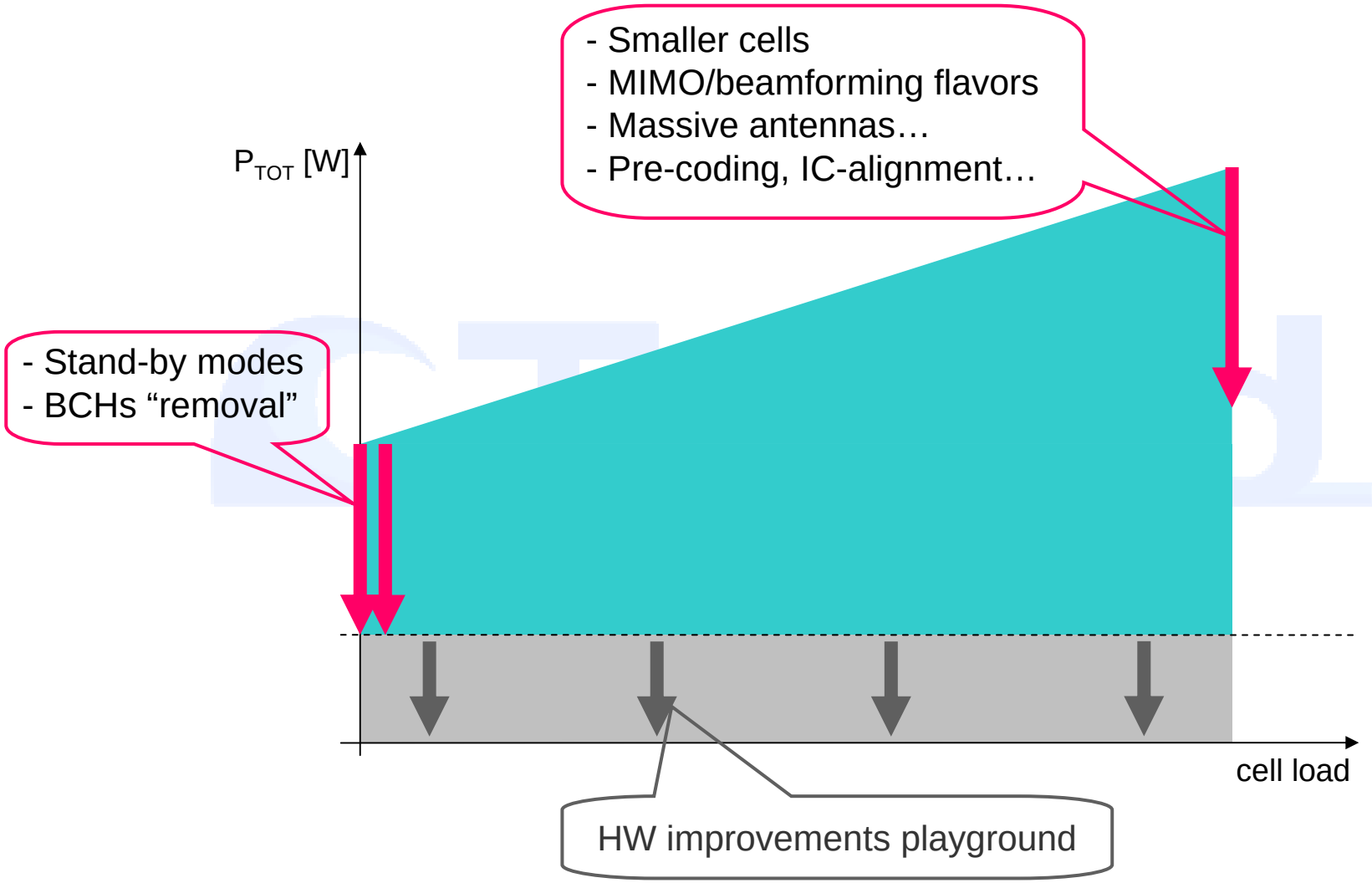
LTE frame structure



Ideas on BS efficient operational behavior

- A part from hw-efficiency improvements, savings can be obtained through energy efficient operational behavior
  - Reduce coverage tax
    - Rethink broadcast/common channels for minimal emission…
    - ... without impact on current quality of service
  - Reduction of RF power consumed by RH
    - Different levels of “stand-by” mode, particularly on PAs
  - Reduction of BBU consumption
    - BBU pooling: match load with right amount of BB processing
    - Turn off some BB process when load is low
- … and by densification (small cells)

Ideas to improve BS efficiency



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BS power models

- Basic model

$$P_{TOT} = P_0 + \alpha \cdot P_{data}$$

$$0 \le \alpha \le 1 \quad (\alpha \text{ is the cell load})$$

- A bit more advanced…

$$P_{TOT} = P_{BB} + N_{Sectors} \cdot P_{RF\_Sector}$$

$$P_{RF\_Sector} = \underbrace{A \cdot P_{TOT\_RF\_Sector}}_{\text{coverage tax}} + \underbrace{\alpha \cdot B \cdot P_{TOT\_RF\_Sector}}_{\text{data transmission}}$$

$$A + B = 1 \quad \text{(e.g. A = B = 50\%)}$$

Thanks!

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