Power System Efficiency in Wireless Communication

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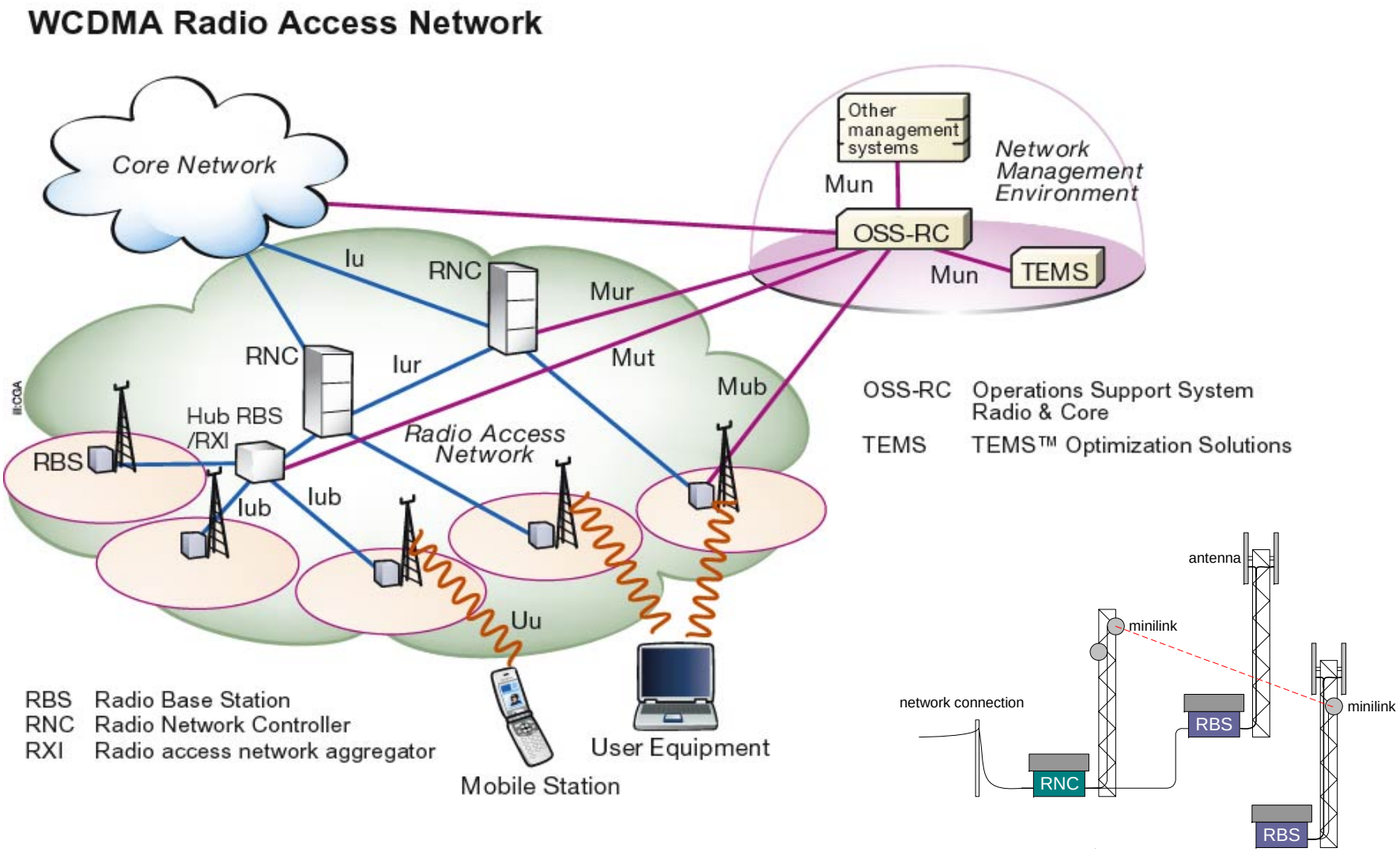
Agenda

- 3G RAN System Description
- RBS Product Types
- Background on RBS Efficiency
- RBS Efficiency Improvements
- Conclusions

3G RAN System Description



Main RBS Product Types

- Macro
  - Highly Flexible and Scalable Configuration optimized for incremental capacity growth and high capacity configurations as well as extended coverage.

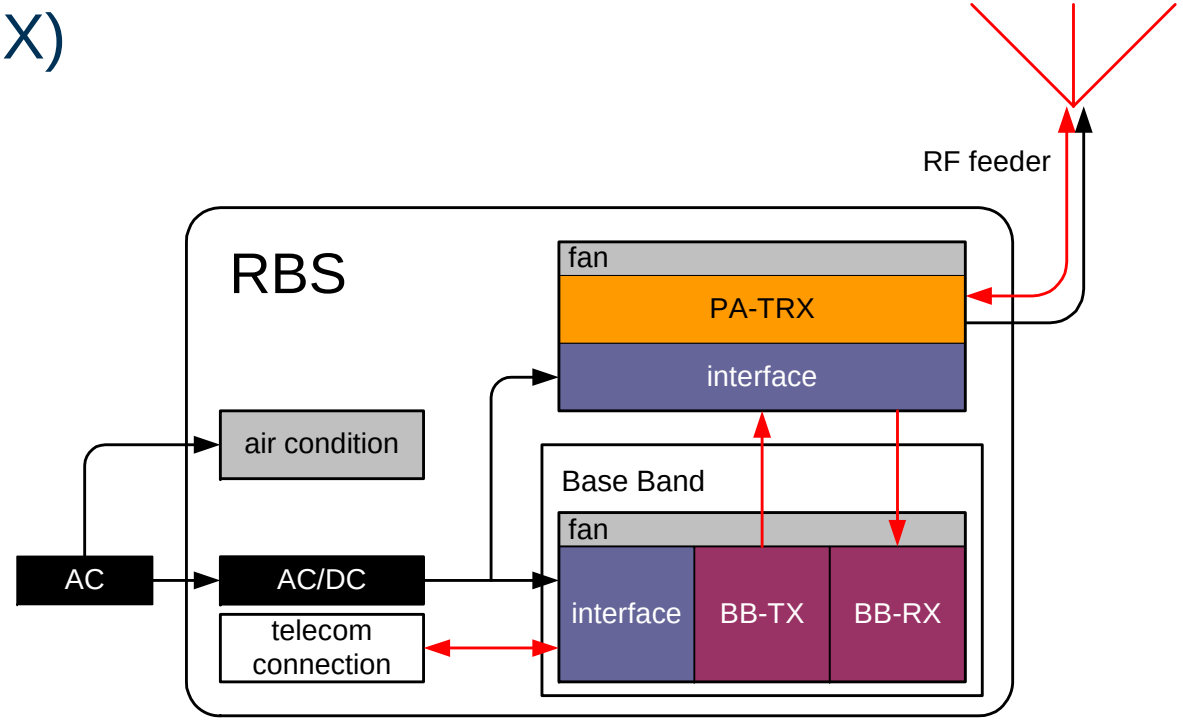
- Compact Macro
  - Compact Size, optimized for lower capacity configurations, initial roll-out and rural sites.

- Micro
  - Small size, low weight, micro cell coverage optimized, omni configurations

- Main-Remote
  - Distributed architecture for challenging site requirements and for cost and power efficient rural coverage

Radio Base Station

- Climate Equipment (Air Condition)
- Power Supply (AC/DC)
- Base Band (Signal Processing, RX/TX)
- Radio Unit (PA-TRX)
- Antenna



Why higher efficiency?

Life Cycle Cost

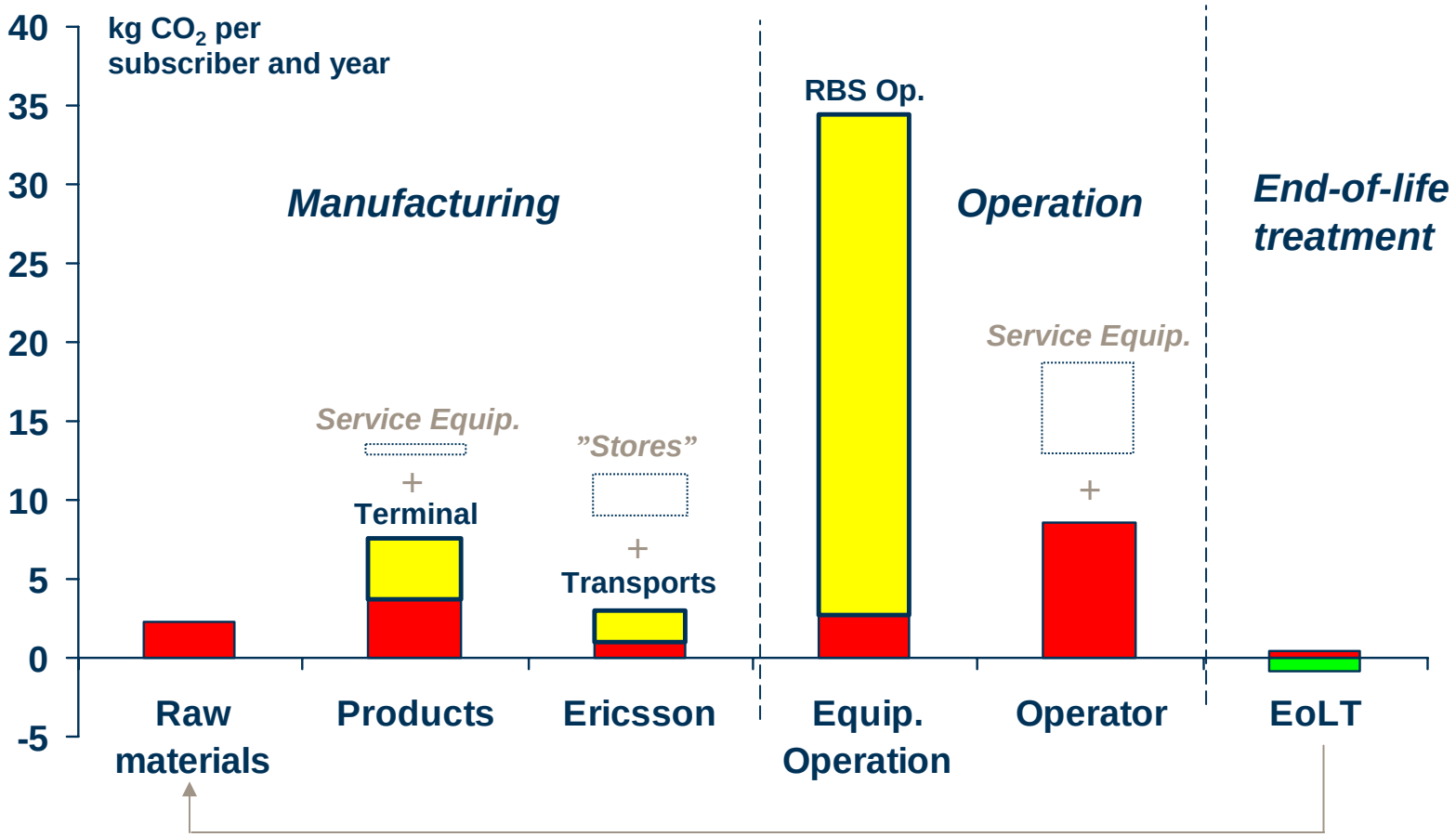
- RBS less expensive
- Requires less space → lower site cost (or increased capacity)
- Decreased production and installation cost
- Decreased energy cost
- Decreased service cost

Other aspects

- Life Cycle Assessment Studies shows that power consumption during operation is the most significant environmental burden
- Compatibility to “green” laws and directives: ISO 14001 demand continuous improvements
- Customer interest, positive image value

Power consumption - lifecycle phases

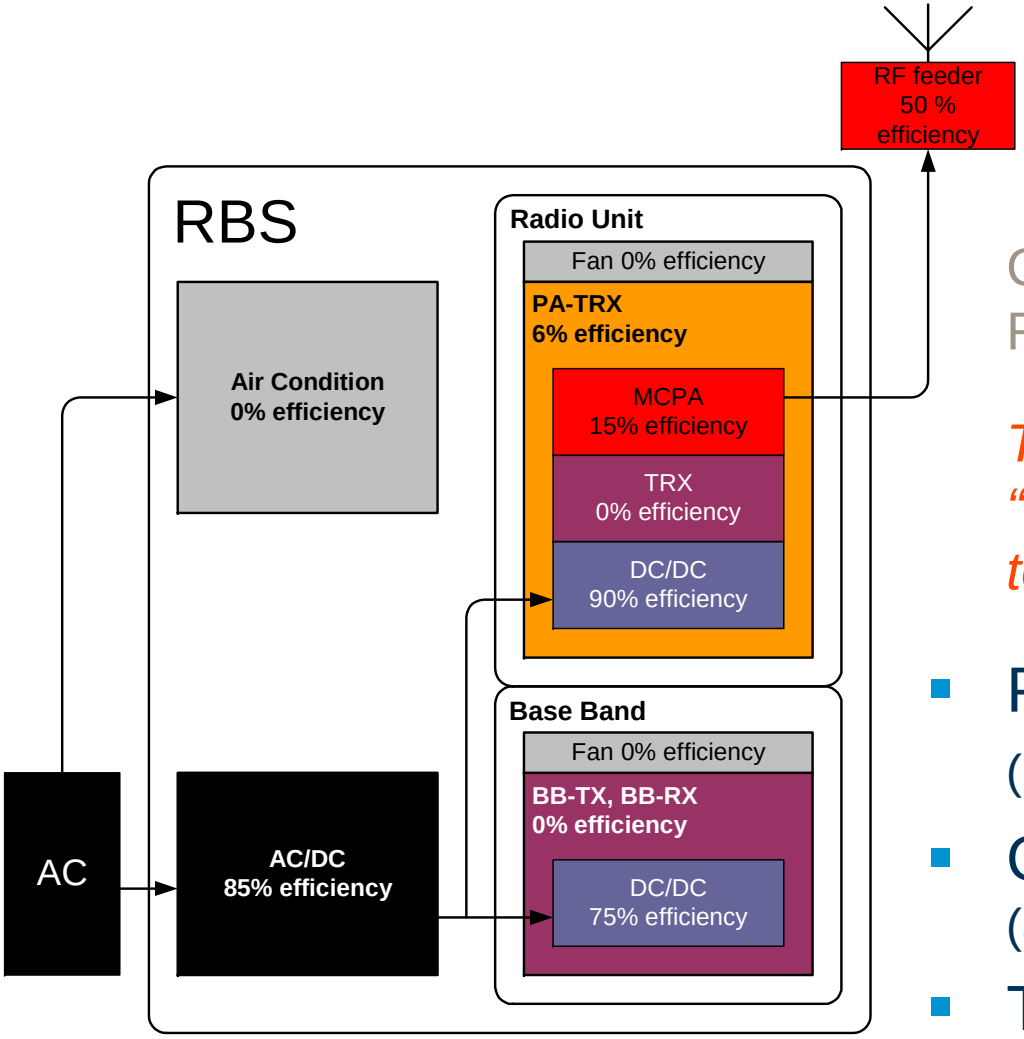
Climate change (CO_2) – proportional to power consumption



Why focus on RBS?

The 3G Life Cycle Assessment Study shows that RBS sites are responsible for more than 90 % of the power consumption during operation for a representative model network (including mobiles)

RBS efficiency



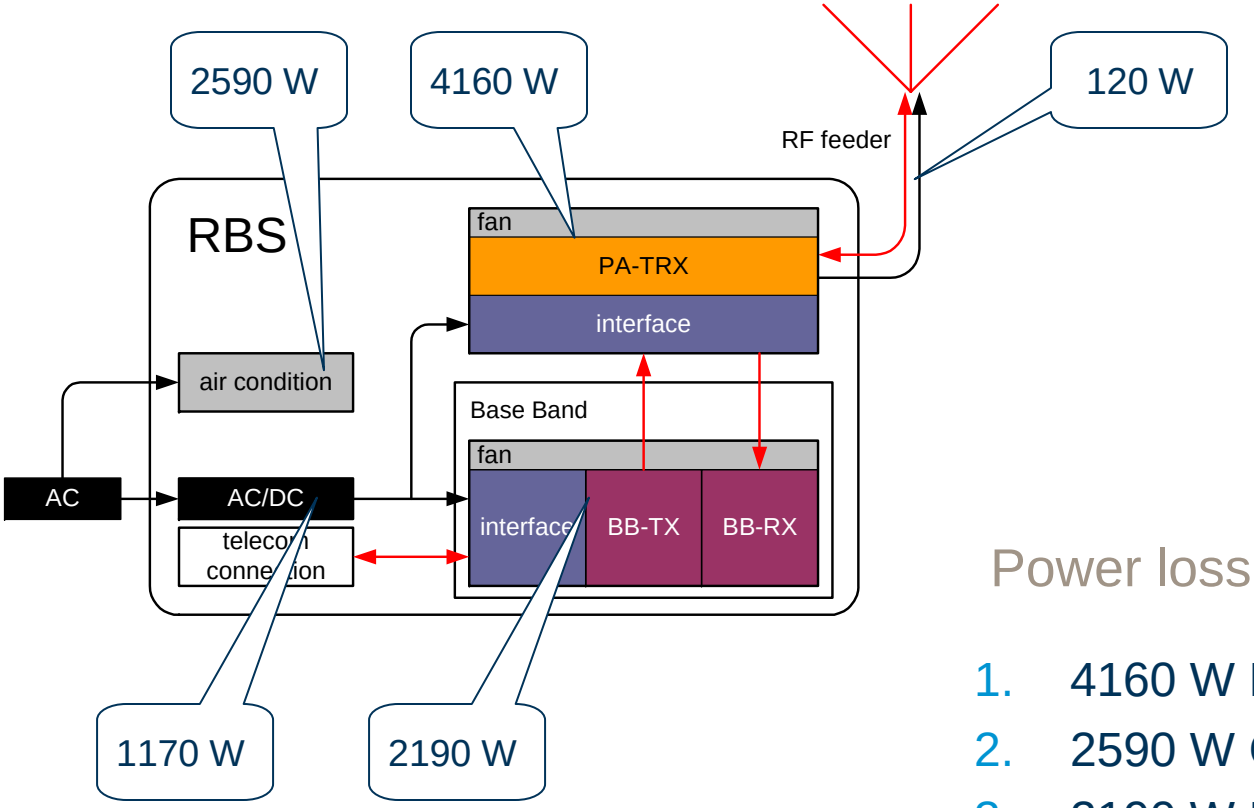
Efficiency of each included component

Calculations from first gen. 3G-RBS with Multi Carrier PA

Total efficiency defined as "useful" RF power compared to total input power

- Power consumption: 10 kW
  (includes Air Conditioner of 3,5 kW)
- Output Power: 120 W
  (3 sectors, dual carriers, 20W/carrier)
- Total RBS efficiency: 1,2%

Where goes the power?



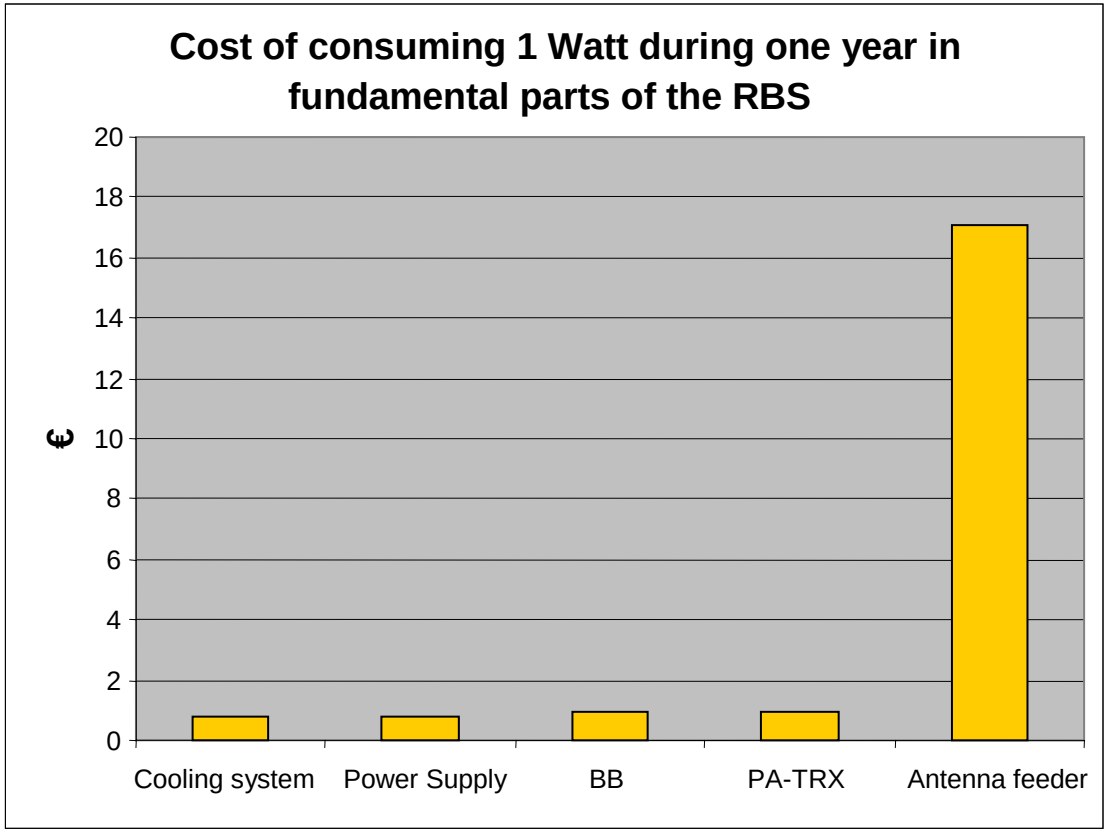
Power loss

1. 4160 W Radio Unit
2. 2590 W Climate equipment
3. 2190 W Base Band
4. 1170 W Power Supply
5. 120 W Antenna feeder

Where do we need improvements?

Improvements close to the antenna provides the most momentum since it affects the entire distribution chain

The closer you get to the antenna, the more expensive get the losses!



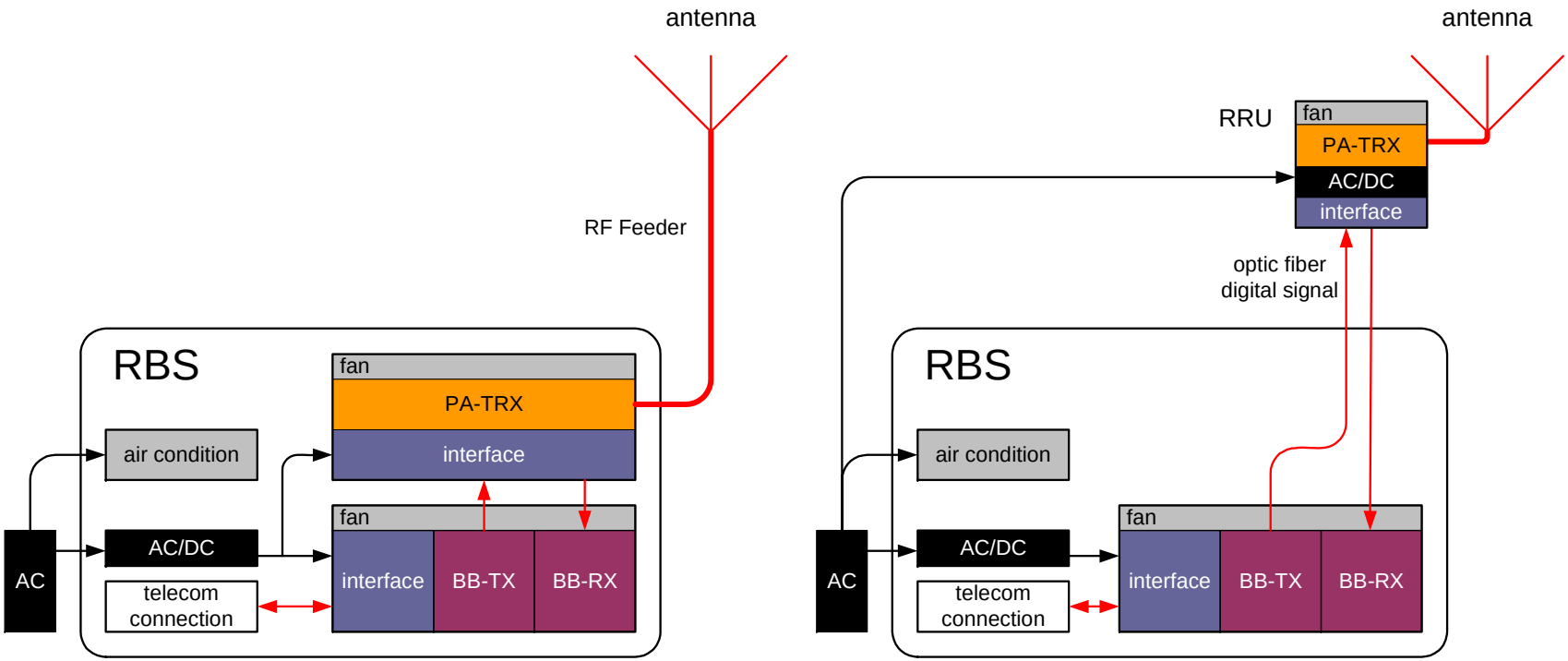
Three methods to improve efficiency

1. Remote Radio Unit (RRU) configuration
2. Sleep mode
3. High Efficiency PA

More efficient AC/DC and DC/DC conversion would also contribute, but not as effective

1. RRU or micro base station

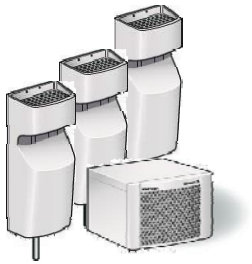
- PA-TRX placed on ground level results in 3 dB feeder loss (6 dB/100 m)
- Twice the output power needed from PA compared to 0 dB feeder loss (PA mounted close to the antenna)



1. RRU or micro base station cont'd

RRU-configuration

+ Minimum antenna feeder loss
  Cooling needs reduced
– -48V distributed to antenna tower
  Relatively heavy unit placed in tower
  Requires extended temp. range
  Less flexibility
  Serviceability



µ-RBS configuration

+ Minimum antenna feeder loss
  Cooling needs reduced
– AC or DC distributed to antenna tower
  Transmission distributed to ant. tower
  Heavy unit placed in tower
  Requires extended temp. range
  Low flexibility - increased no of RBS
  Serviceability

Assumption: RRU config., no Air Cond. needed, 120W output power

Result: RBS efficiency improved by 62%

2. Traffic adaptation/Sleep mode

- Reduced capacity during nights or periods of low traffic
- If one of two carriers are shut down (traffic < 50% max) and base band capacity are reduced by 50% at the same time, calculations prove that 1 kW (average) can be saved over 24 h
- Knowledge of traffic situations required
- Demands for power conversion parts:
  - Intelligence, on/off control
  - Fast response time for “wake-up”

Result: RBS efficiency improved by 17%

3. High efficiency PA

Examples of possible techniques for higher PA efficiency

- Improved semiconductor materials (LD-MOS, GaAs, SiC, GaN)
- Improved linearization methods (feed forward, digital pre-distortion)
- Doherty PA
- “Envelope Elimination and Restoration” (EER) or envelope tracking
- Switched PA-technique

Assumption: PA efficiency improved by 10%

Result: RBS efficiency improved by 6%

3. High efficiency PA cont'd

Problem

- Average amplitude of WCDMA signal much less than peak amplitude → conventional RF PA has low efficiency for WCDMA

Improved PA power supply

slow control

- Control functionality in DC/DC to PA can be used for traffic adaptation: lowered voltage level to PA-transistor reduces power loss during low traffic
- Fast modulated drain voltage (EER) or envelope tracking can be used for improved PA-efficiency.
  True EER implies very high bandwidth requirements for voltage supply.

fast control

Conclusions

…from a power distribution perspective

- Although high efficient AC/DC or DC/DC converters provide a valuable contribution to the overall efficiency, further improvements do not have a substantial effect to the overall system efficiency
- The entire system perspective has to be taken into account, most momentum reached in traffic adaptations, actions taken in PA-effectiveness or removing feeder loss
- Tower mounted power conversion (RRU-config) is effective, but requires e.g. customized power, resistant to mechanical stress and extended temperature range
- Other methods of increased efficiency requires some kind of intelligence in the power distribution parts, as well as high integration with system design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