Green future networks
some tough question for an engaged telco actor

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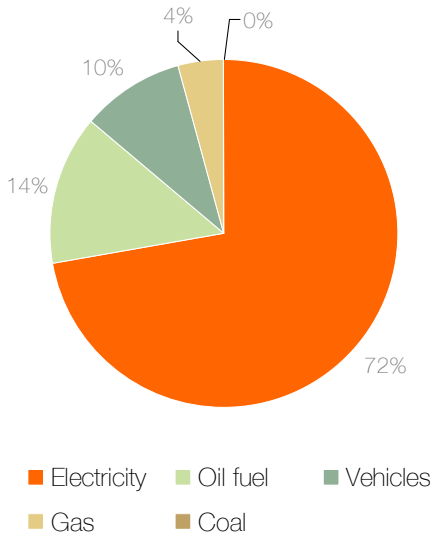
Orange Labs
19/10/2012 , EJC 2012 Lyon

Overview

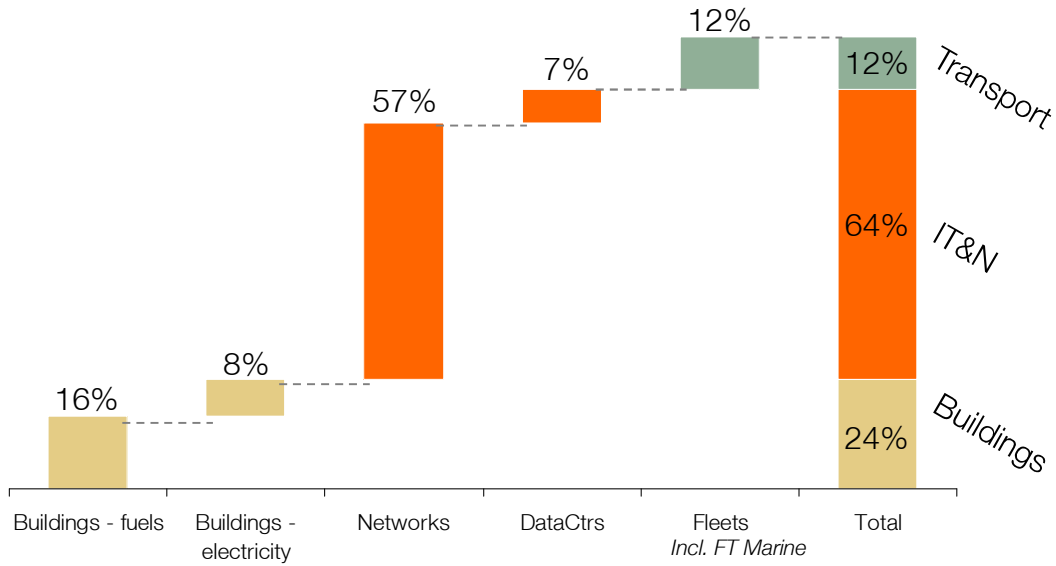
group internal energy consumption

ITN facility consumption is 2/3 of energy consumption

group – 2010 energy sources



group energy consumption – 2010



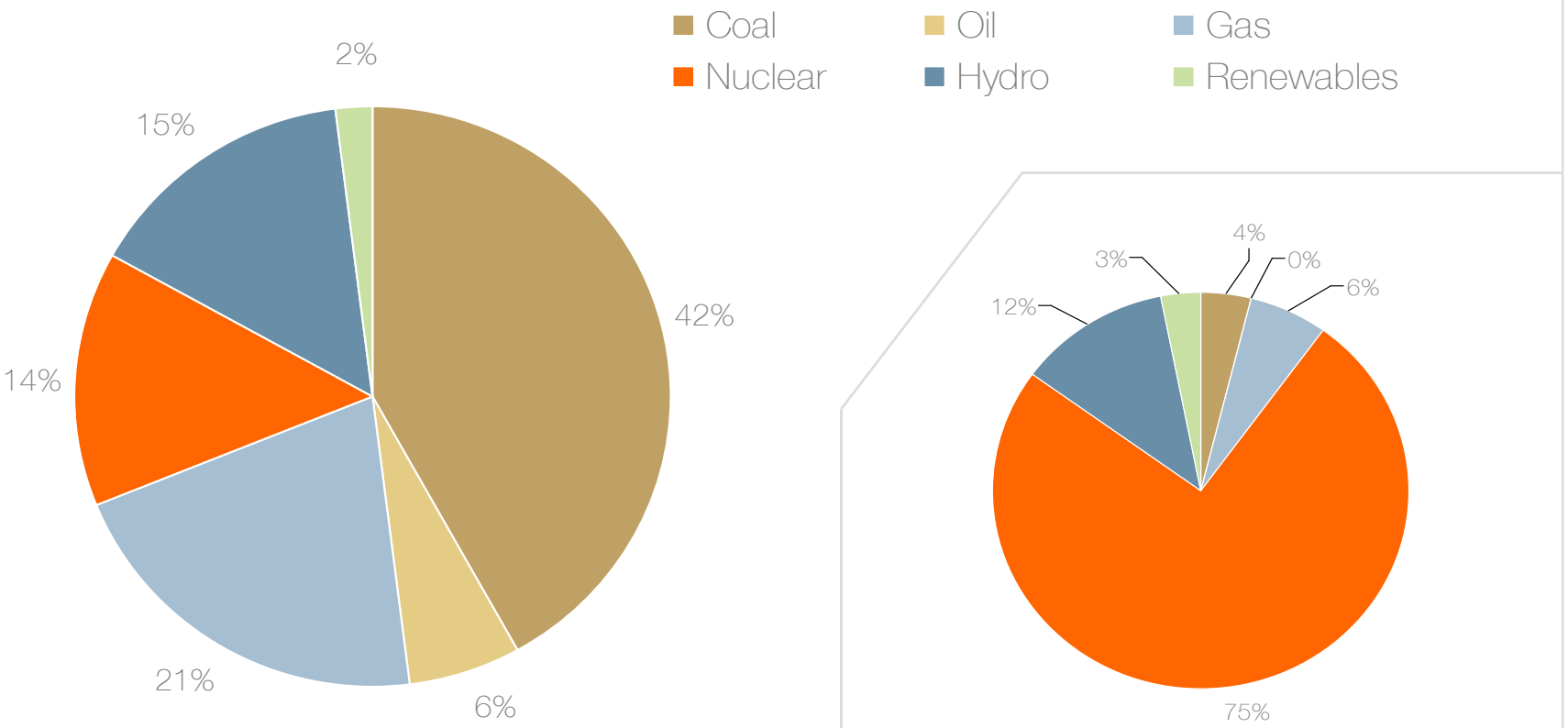
insight

- electricity is mainly consumed by the network, other energy sources by buildings and fleet.

electricity generation mixes

electricity price depends on the production means

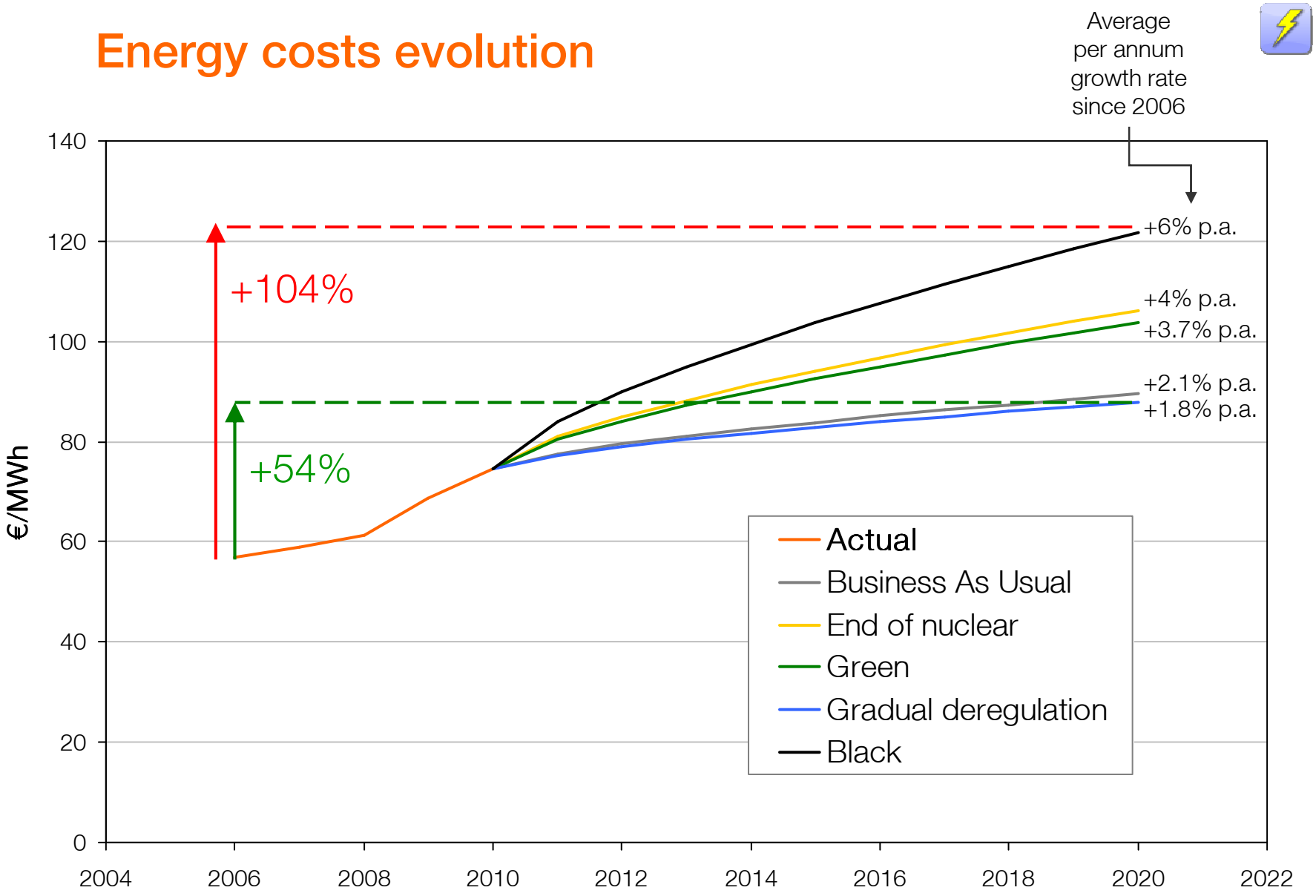
World electricity mix (2007)



Source: Carbone 4

French electricity mix (2010)

Energy costs evolution



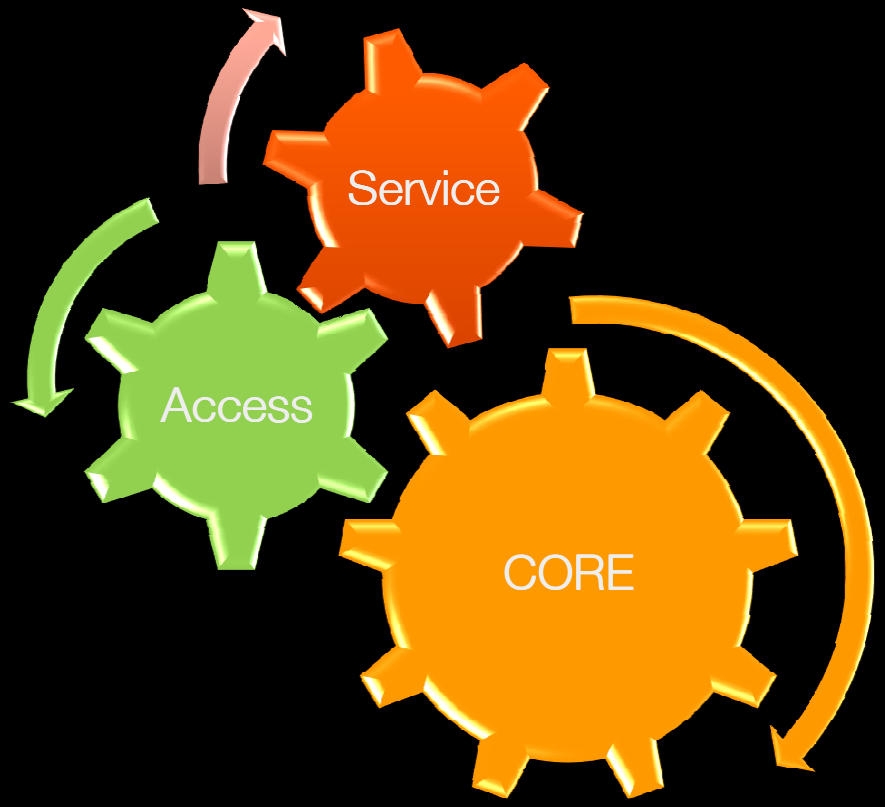
Carbone 4 projections: electricity unitary cost for FT – example of France

A

Our commitments

- reduce C02 emissions by 20% below 2006 levels by 2020.
- reduce energy consumption by 15% below 2006 levels by 2020
- 25% of FT group electricity in Africa to be sourced from solar by 2015
- involve all employees in environmental issue.

so what for Orange Group



over 224 million customers worldwide…

> residential operations in 33 countries

> business services in 220 countries and territories

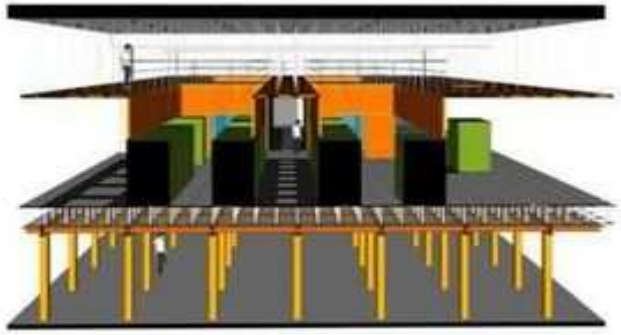
in 2011

> our total ITN energy consumption
~ 1 year consumption of the city of Lyon (500 000 inhabitants)

> our CO_2 emissions
~ 300,000 round trips Paris – New York by plane

green IT and Network transformation within our Group

solar powered
base stations
+ 2000 sites in AMEA

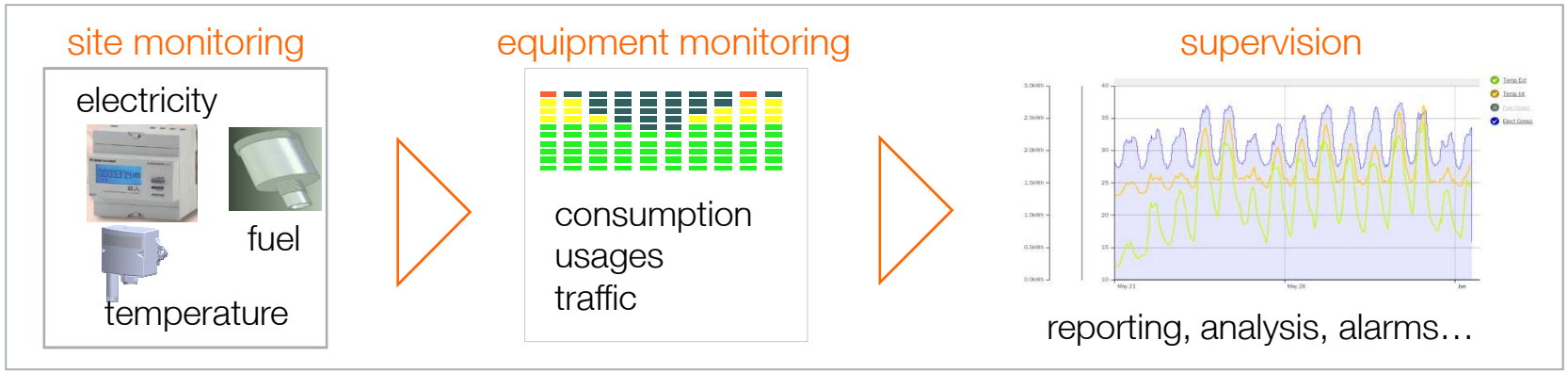


new eco-efficient datacenters
e.g. Val de Reuil, France
PUE 1.3

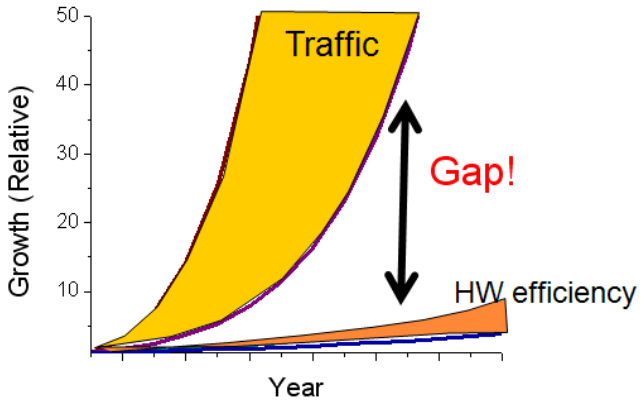
air free cooling
+13,000 sites
in Europe

new milestones ahead of us to reach our CSR objectives

- measure our consumptions through the energy metering programme launched in 2011



- work on innovative breakthrough solutions with our research and innovation teams and our suppliers

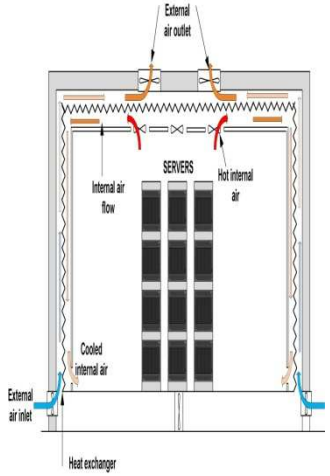


low consumption features needed for IT and Telecom equipment

innovation is key for the future

- innovations from our Orange Labs
  - solar based stations: in 2011, this programme was awarded as the « best mobile technology for emerging market » at the Global Mobile Awards and the « best new service » at the World Communication Awards
  - free cooling
  - the current Livebox is 30% more energy efficient than the previous generation

- many « green » patents in our portolio, related to:
  - chargers and power supply
  - energy savings
  - exothermal buildings
  - antennas



exothermal building

- commitment in international research programmes with our suppliers and peers

GreenTouch™ CTrend OPERA-Net Power efficient Wireless

innovation is key within the whole community of operators, vendors and standardization bodies

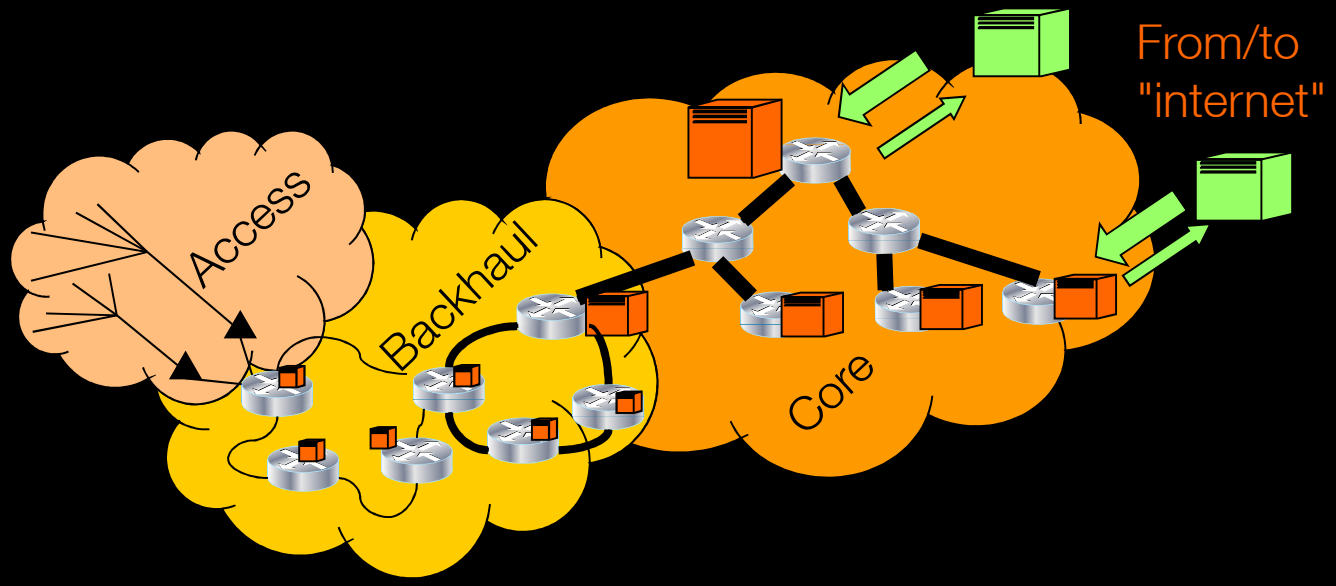
- through cooperation between all actors of our ecosystem but also with other industries using ICT
- through common rules and standards as supported by the European Commission

in a nutshell

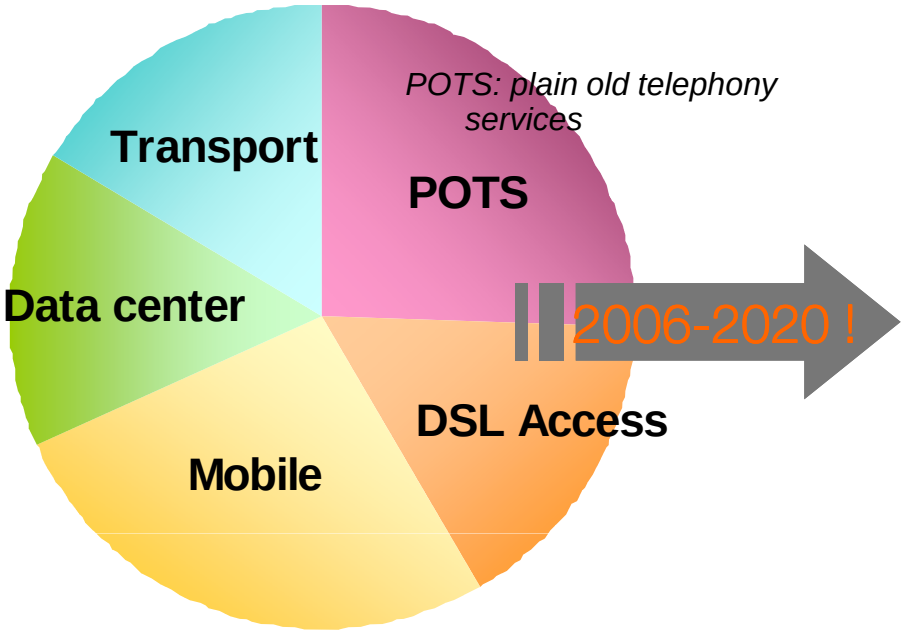
a paradigm shift:

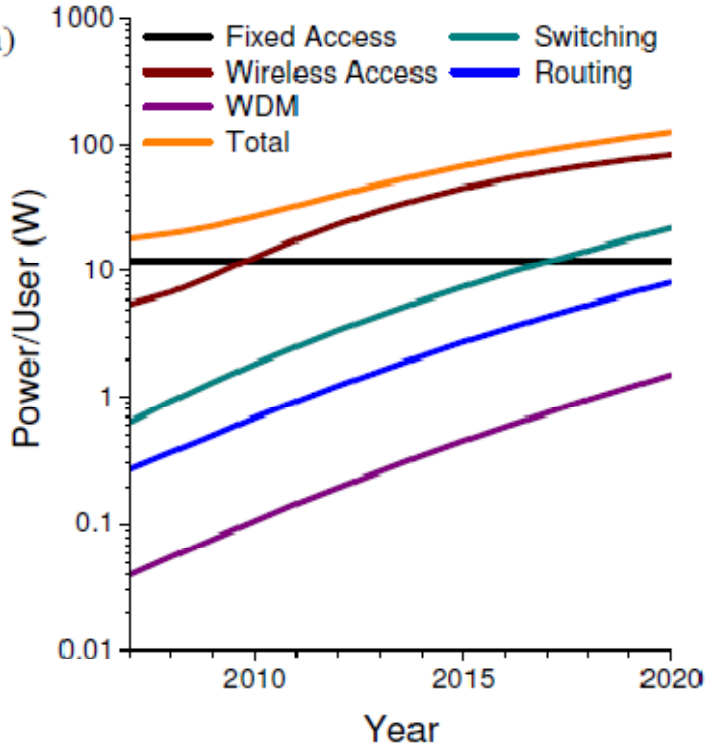
always-on > always-available-on-need

The challenge



Energy consumption of networks : trends





- Access (mobile+DSL) is the largest contributor to our networks consumption (PhD L. Souchon 2008)
- RAN is 80% of the total consumption of mobile networks,
- Other sectors should not neglected
- Energy/user growth is exponential

Data issued from a PhD study (L. Souchon) based on 2006 FT data collection

Short terms actions

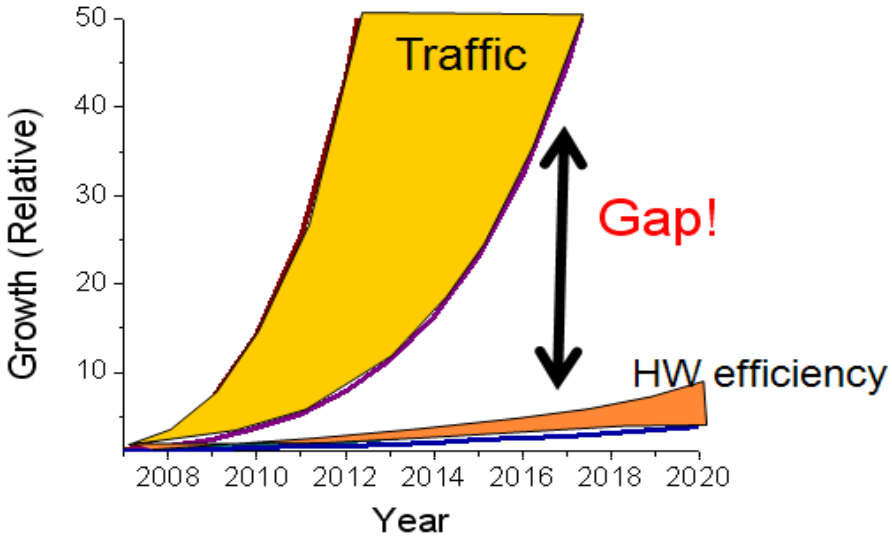
- **operational activities : Launch of greenITN2020 program (corporate program)**
  - Supervising our consumption - tele-metering (Spain, France, Poland, Moldavia)
  - Green renewal : -20% of energy consumption obtained in the RAN
  - Generalization of Free cooling for sites and buildings
  - Test and implement energy saving features in our networks (sleep mode, low power mode)
    - need for standardized solution (3GPP)
    - Trails are on-going in Poland (3G), Cairo (3G) and ImaginLabs(4G)
  - Build and renew green datacenters to increase efficiency with free cooling (example Val De RUEIL and Sophia green DC), improve cooling efficiency with new materials CPM, move to more efficient servers and power supply in direct current 400V and more dynamic power management
  - refurbishing devices (the 10 “green actions” in Orange Stores)

- **challenge providers : BuyIN**
  - Green is mandatory in all Orange Labs RFP
  - Efficient hardware : compliance with international standards (ETSI, ITU)

- **regulation and standardization**
  - Orange is an active partner in major SDOs (ETSI, ITU-T/SG5 and 3GPP, ADEME)
  - Coordination shall be established to avoid duplication and ensure proper flow

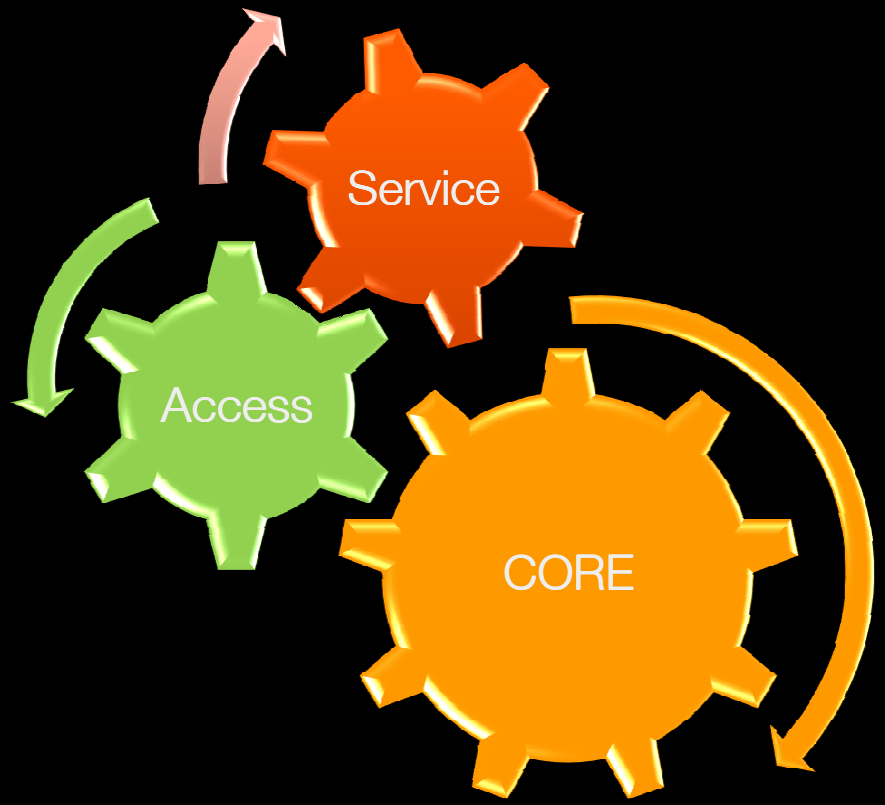
New paradigm is needed: long term actions

- reduce the consumption of IT is facing fundamental questions:
  - hardware energy efficiency improvement does not compensate the rise of traffic and software ("Wirth law") → need new architecture, new development method
  - what will be the usage in 2020 ?
  - easy access to always-on ICT services can lead to an over-usage of the resources : e.g. rebound effects
  - emerging countries wants the same technology
- manage and reduce the consumption of the equipments is not enough; consequently, a new paradigm must be analysed

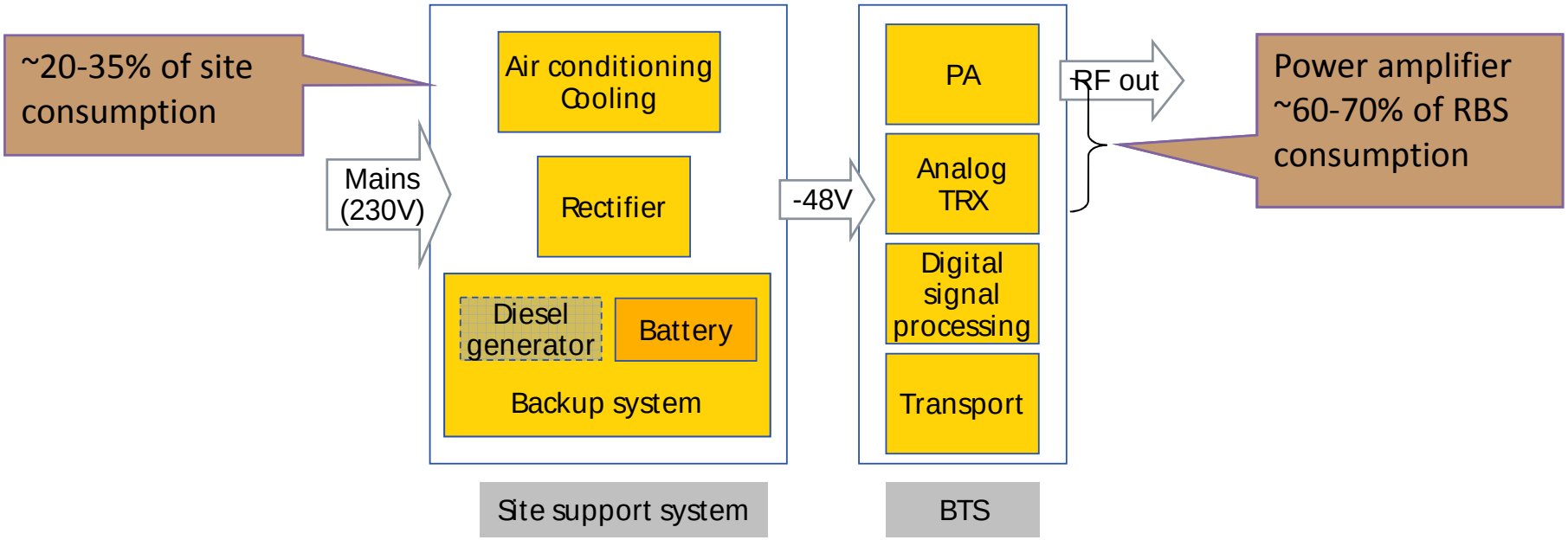


Source: D. Kilper IEEE 2011

Legacy



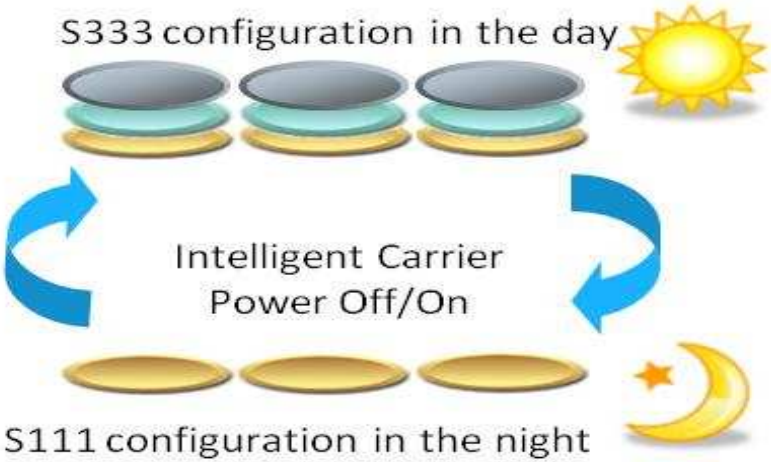
Energy consumption of Macro-base station



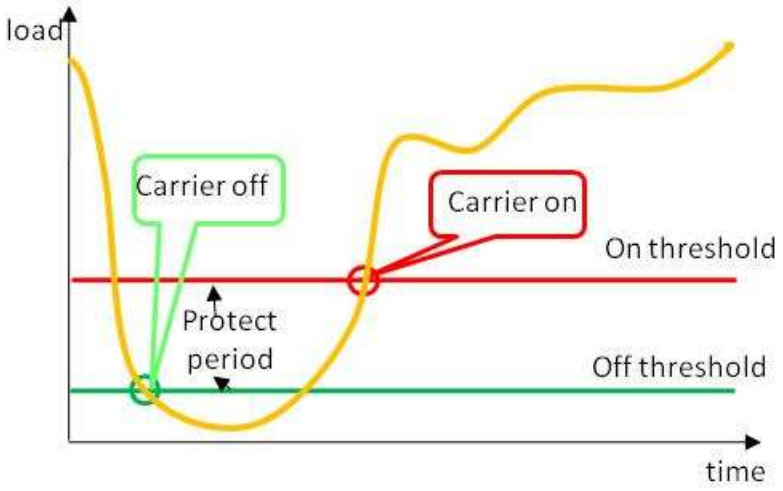
Traffic variation has low influence on RBS power consumption !

Sleep mode mechanisms

- software feature
  - 2G shut down TRX
  - 3G shut down carriers
  - night activation / All the day
  - shut down capacity resources
  - 3GPP functionality



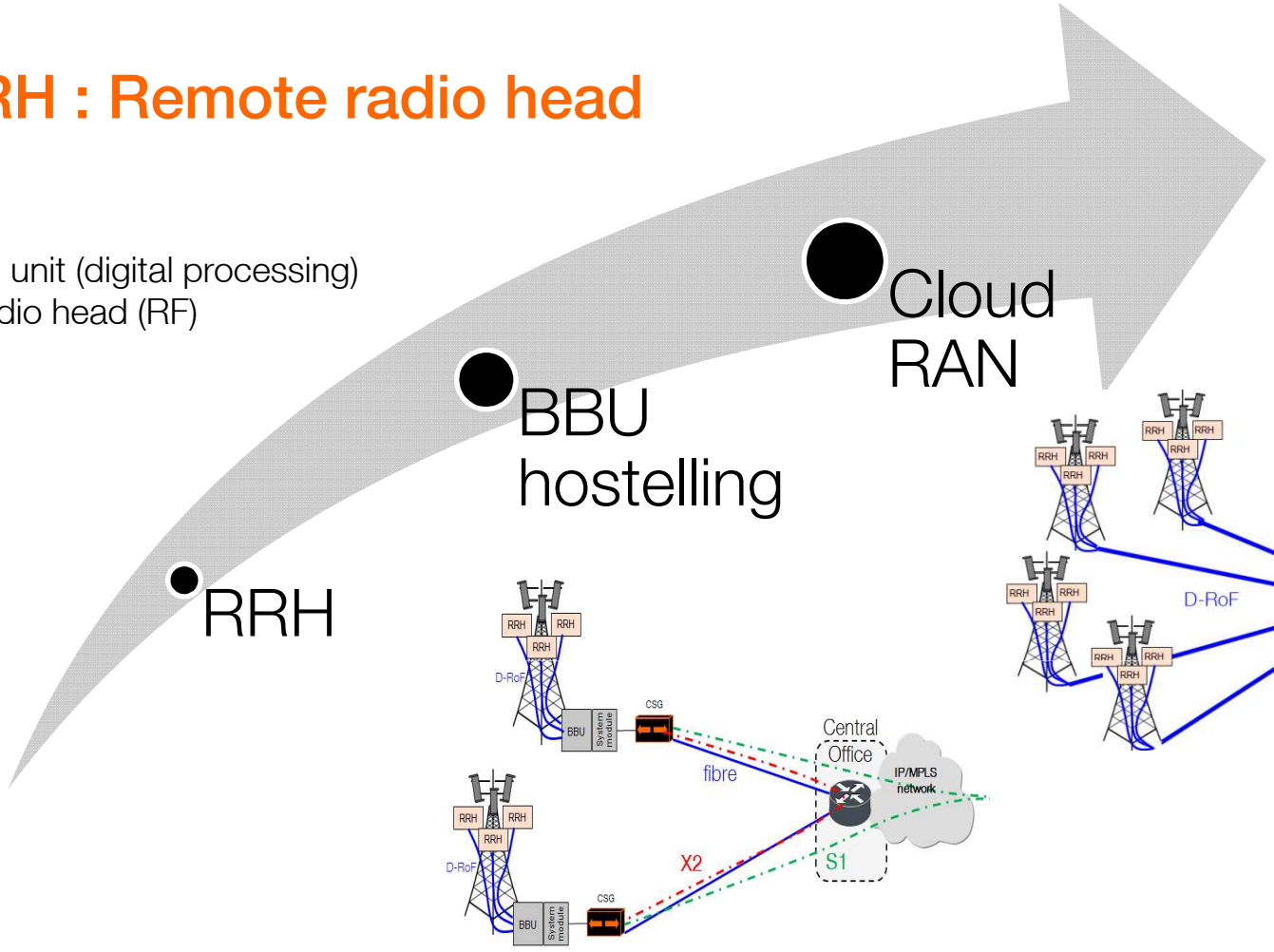
- optimize to avoid “ping pong” rebound effect



- Sleep-mode is more efficient in 2G

RRH : Remote radio head

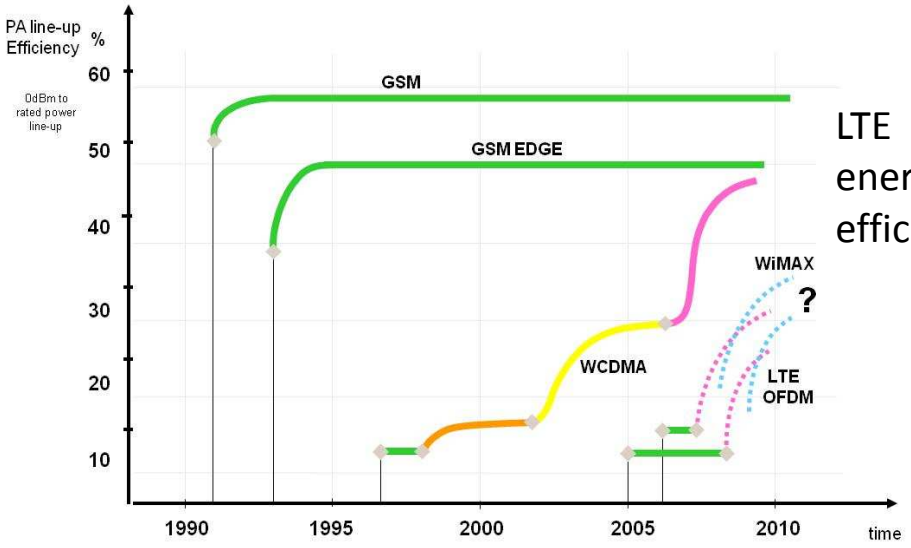
BBU: Base band unit (digital processing)
RRH: Remote radio head (RF)



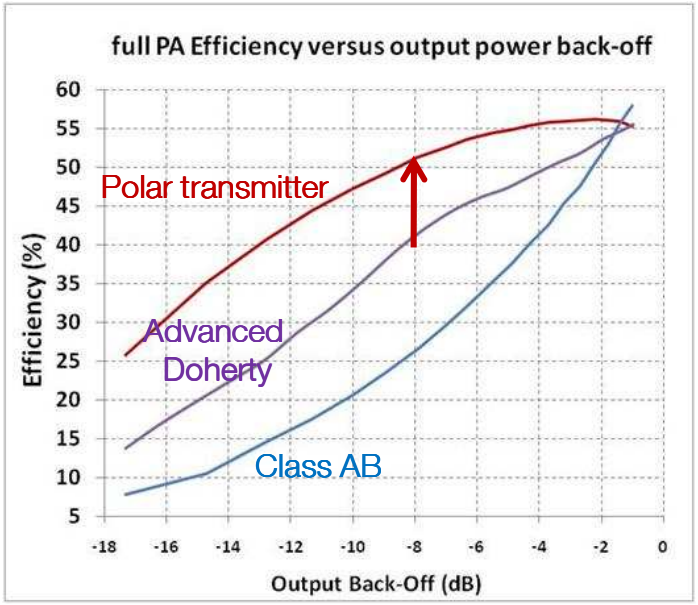
Outdoor RRH reduce power consumption due to passive cooling
BBU host + RRH induce a gain of 22% (estimation) of total site consumption

Hardware supplier

Power amplifiers



LTE 20% energy efficiency

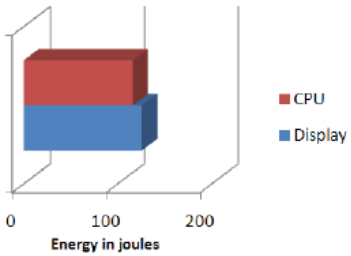


Large bandwidth systems need drastic hardware improvement

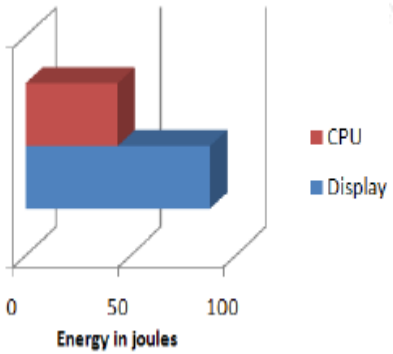
Efficiency should be given for low, medium and high load (in accordance with ETSI)

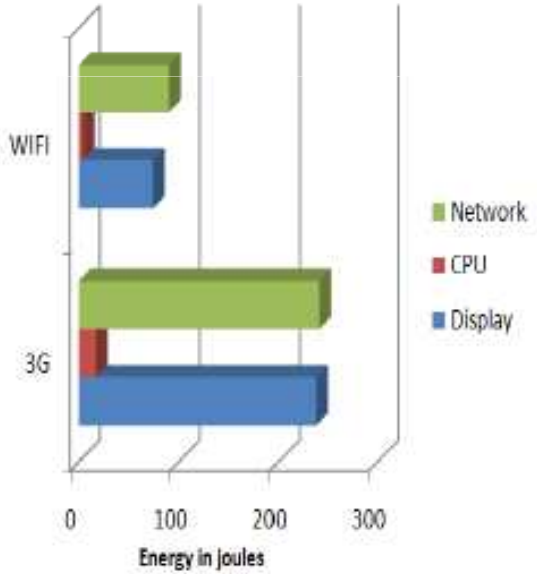
Devices

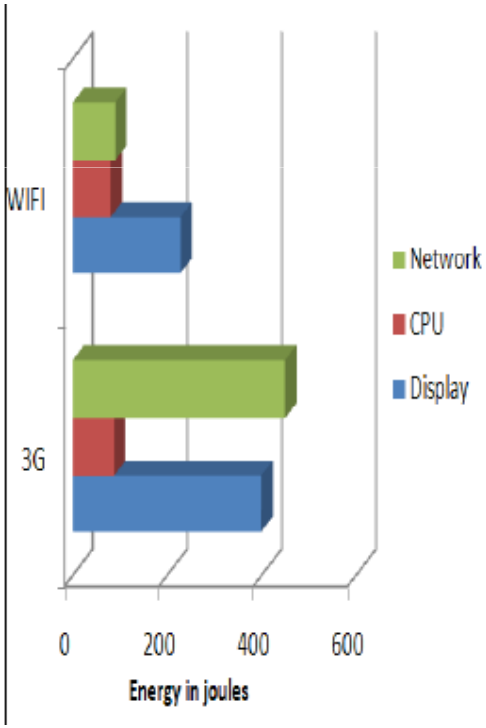
examples of services consumption



Talk to me

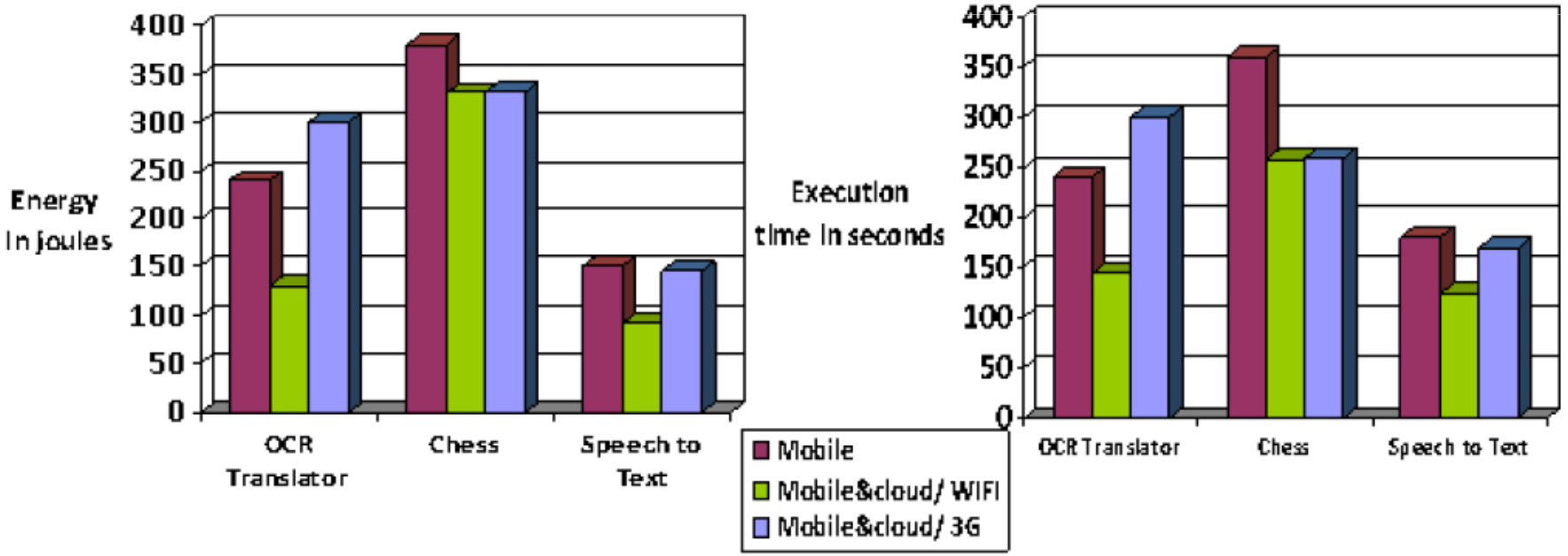






internal vs. cloud

- cloud can reduce by 30% the device consumption



Orange

What is background traffic?

- "Background" traffic : traffic generated by background activity of user's equipment (UE) → Connections with distant servers for information updates without any direct user action

- Push : the server send new data to the UE as soon as it's available
  - UE needs to maintain an always-on TCP connection => ***keep-alive*** packets
  - ex: email, IM (MSN messenger, Gtalk, …)

- Pull : the UE accesses Internet periodically to check for new events
  - needs a new TCP connection at every access
  - ex: weather updates, time zone update, email, stock exchange
  - Each application uses its own server

- The choice of Pull vs. Push depends on OS or application developers or the users themselves (ex: email)

Wireless networks

Heterogeneous networks

Example of results: green impact of small cells

- Comparison of energy efficiency macro homogeneous network vs heterogeneous network, for different loads

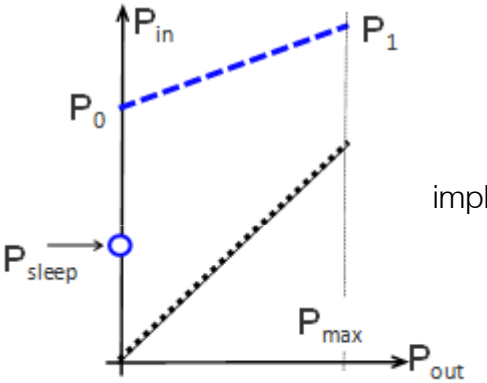
- Comparison of PA sleep mode unabled or not unabled

➔ 4 simulations (system level), repeated for low load and for medium-high load:

  - ❖ Macro homogeneous, no PA sleep
  - ❖ HetNet, no PA sleep
  - ❖ Macro homogeneous, PA sleep
  - ❖ HetNet, PA sleep

Power model used

- **Contribution to 3GPP RAN1 #66bis (october 2011)**: R1-113495 'Base Station Power Model'
- **Authors**: Docomo + Alcatel Lucent + Ericsson +Telecom Italia, from the **EARTH** project



implemented

BS type	Nsec	P_{max} [W]	P_{max} [dBm]	P0 [W]	delta_p	P_{sleep} [W]
Macro (with 3dB feeder loss)	3	40.0	46	260.0	4.7	150.0
RRH	3	40.0	46	168.0	2.8	112.0
	1	5.0	37	103.0	6.5	69.0
	1	1.0	30	96.2	1.5	62.0
	1	0.25	24	13.6	4.0	8.6
Pico	1	5.0	37	103.0	6.5	69.0
	1	1.0	30	96.2	1.5	62.0
	1	0.25	24	13.6	4.0	8.6
Femto	1	0.1	20	9.6	8.0	5.8

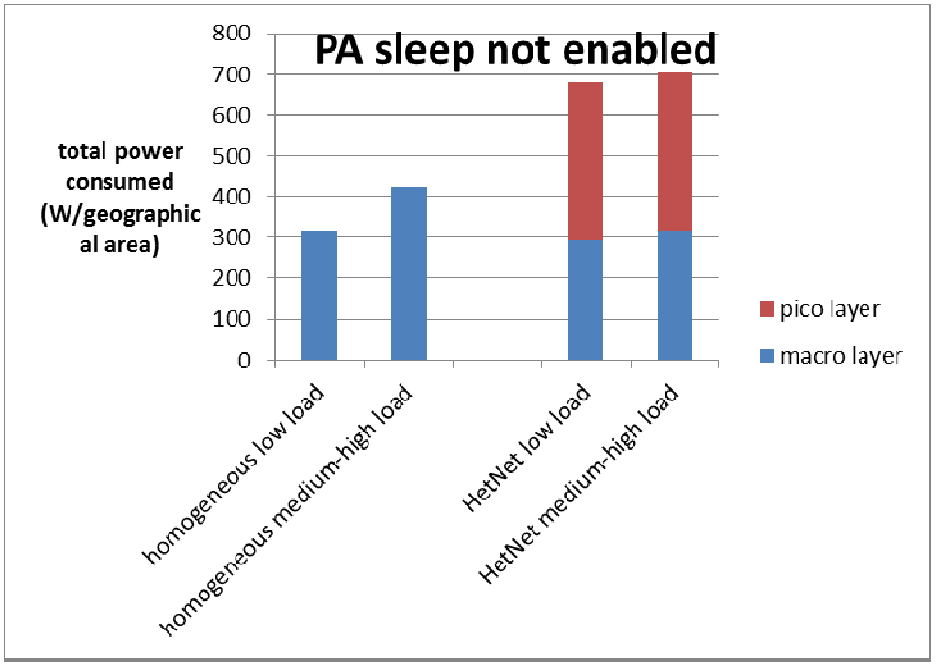
$$P_{\text{in}} = \begin{cases} N_{\text{sec}} \cdot (P_0 + \Delta_{\text{p}} P_{\max} \chi), & 0 < \chi \leq 1 \\ N_{\text{sec}} \cdot P_{\text{sleep}}, & \chi = 0 \end{cases}$$

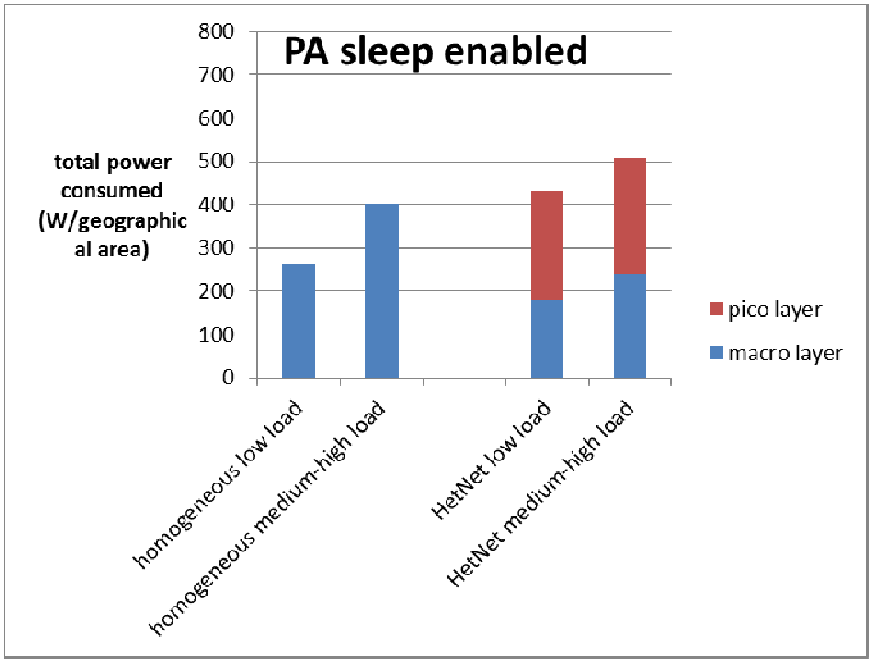
$$\chi = \frac{\sum_{k=0}^{12 N_{\text{RB}}^{\text{DL}}} n(k)_{\text{RE}}^{\text{DL}} \cdot p_k}{12 N_{\text{RB}}^{\text{DL}}}$$

Resource utilization

Psleep: when the power amplifier of RRU is deactivated (not the whole BS), which can be done very quickly (time necessary to enter in / exit from sleep mode around 35 us); different from dormant mode of 3GPP TR36.927 (RAN3)

Power consumption

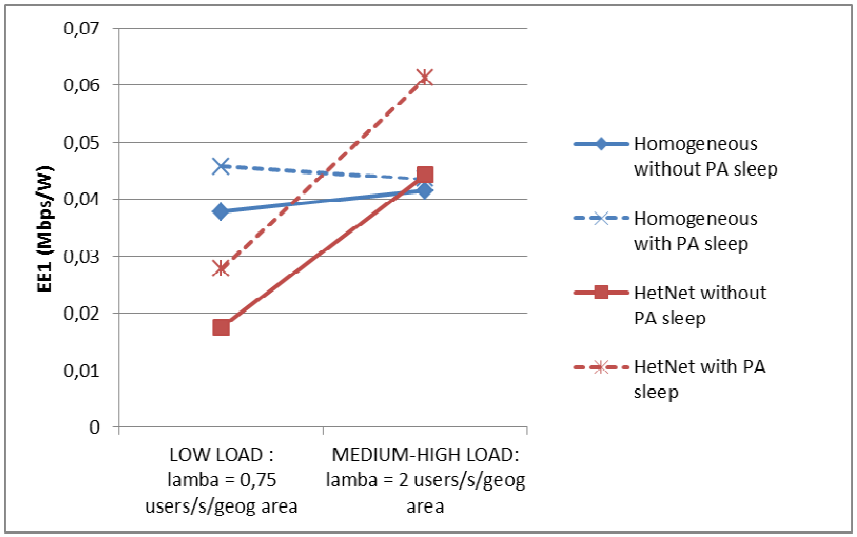




- The addition of small cells (HetNets) imply a considerable amount of energy consumption increase, particularly if PA sleep is not enabled
- PA sleep allows to reduce power consumption by saving power
  - in low load (consumption follows now the load level)
  - particularly in HetNets (since resource utilization is less than in homogeneous networks)

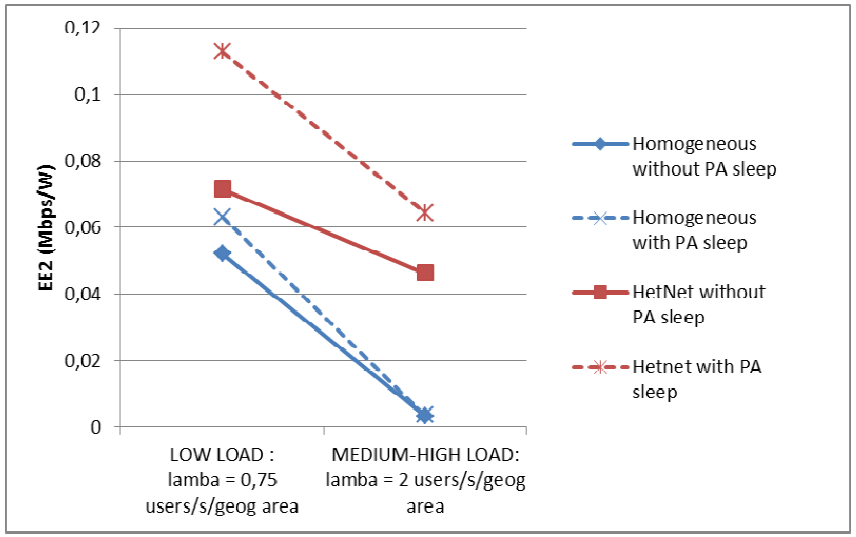
Energy efficiency results

$$EE1 = \frac{\sum_{cells} cell\_throughput}{\sum_{cells} Power\_consumed_{cell}}$$



- HetNets improve EE1 only at medium-high load. At low load, the increase in energy consumption is not counteracted by the increase of system throughput, then the EE decreases

$$EE2 = \frac{\sum_{cells} average\_UE\_throughput}{\sum_{cells} Power\_consumed_{cell}}$$

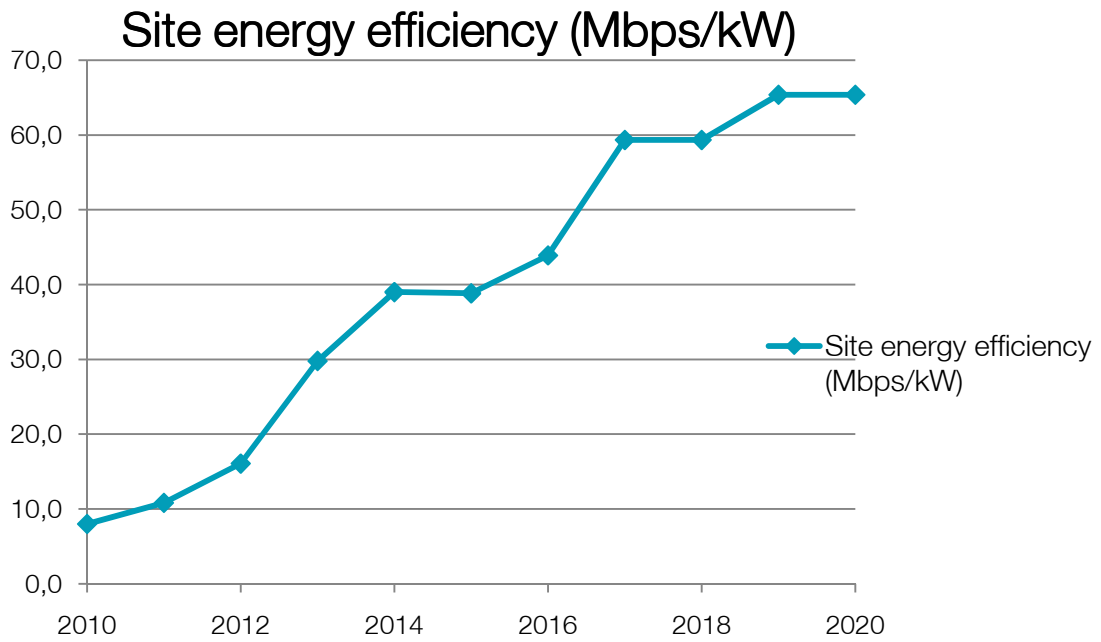


- HetNets always outperform macro-cell homogeneous network in terms of EE2

- Obviously, PA sleep (dashed lines) enables power consumption reduction, particularly in low load conditions
- If EE1 is the chosen metric, it needs to be used along with QoS contraints, to be defined!

Preparing the next generation

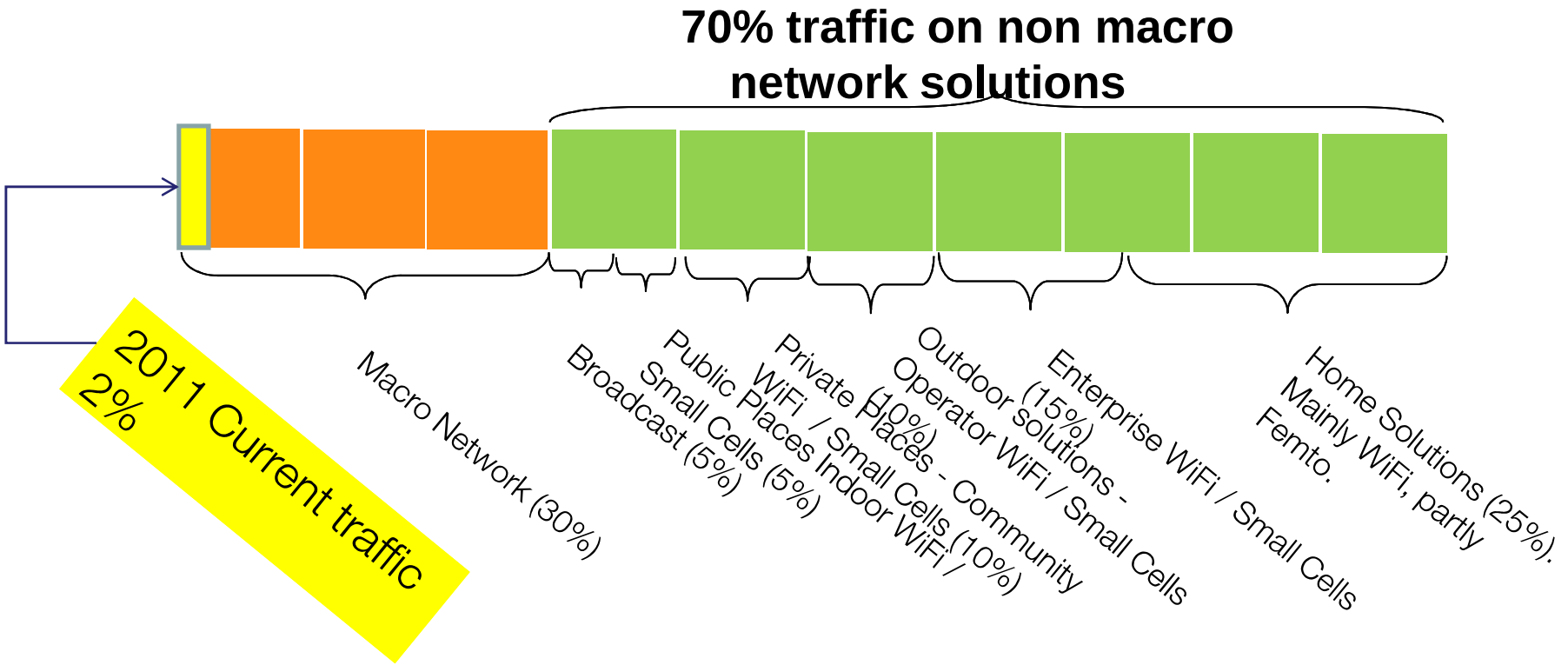
Power consumption of mobile networks show nevertheless a very effective evolution of throughput efficiency for 2G, 3G & LTE Site (Mbps/kW) with a factor of 8 improvement.



- Throughput efficiency of macro site increases by factor of 8 from 2010 to 2020
- Due to use of more efficient 3G and LTE technologies
- However, in order to meet FT energy reduction targets for 80x data traffic growth, throughput efficiency needs to increase by a factor of 75.
- Even the most efficient LTE macrocells will not enable FT to meet our energy reduction targets`

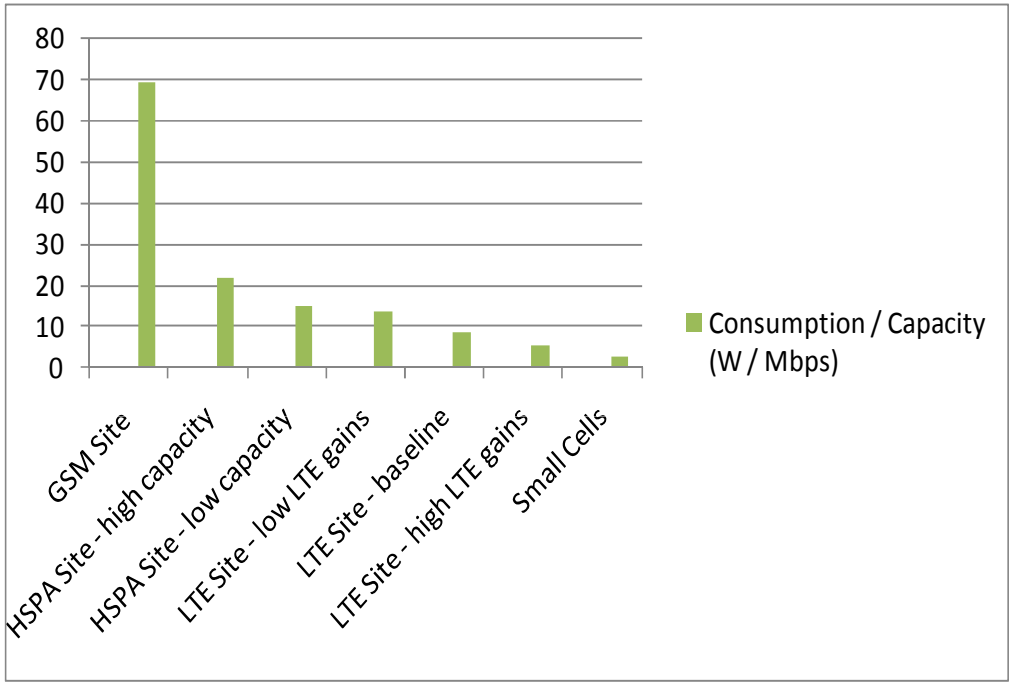
Potential Offload Scenario with traffic growth of x50 by 2020

- Case of Smartphone / Tablet driven market
- Based on usage location: 40% at home, 20% at work and 40% on the move



-> Any solution would require tech-eco studies to fully compare macro networks, WiFi and 3GPP Small Cells solutions

Consumption vs capacity for 2G, 3G, LTE and Small Cells (Watts / Mbps). Small cells can be a real alternative to decrease global power consumption.



–GSM is the least energy efficient technology

–LTE is more efficient than HSPA

–But even the most efficient LTE macrocell cannot compete with a well placed Small Cell

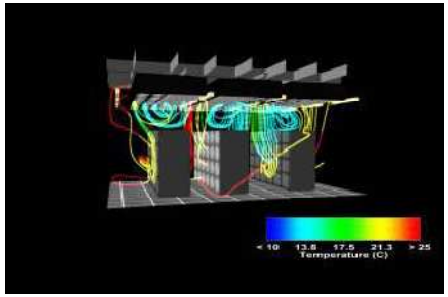
–Small cells introduction in network seems to be a real green alternative to classic mobile network hardware upgrade

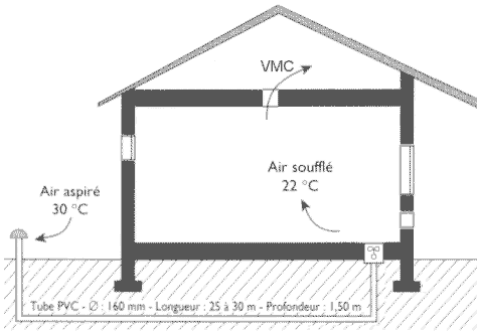
- Small cells inputs based on information from Ericsson and simulations from ALU and Qualcomm
  - Assumes a loaded Small Cell
  - To be checked through field measurements, especially vs. interferences from other cells

Data centers

Optimizations in data centers

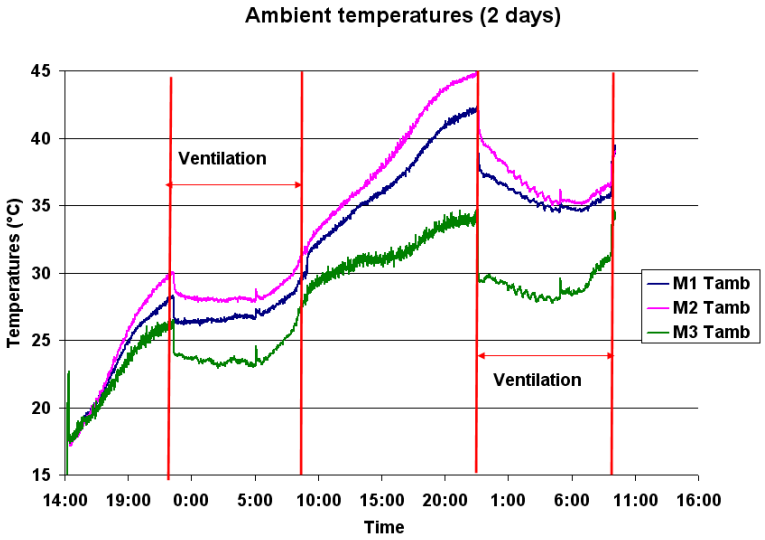
- cooling
- température range
- building architecture
- DC powering (400 HVD)



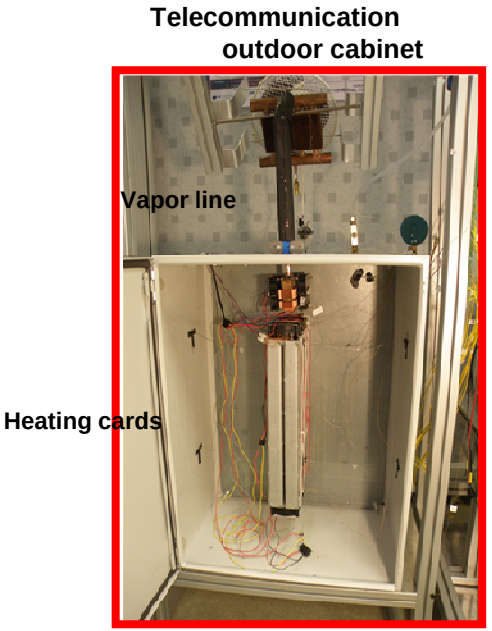


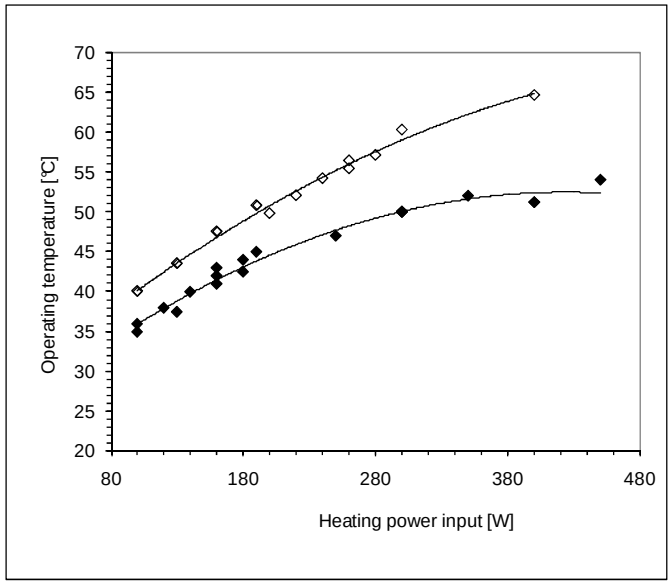
cooling

- Datacenter
  - Free cooling studies, new building architectures and simulations
  - Use of Phase Change Materials (PCM)
  - PUE targets => 1.2 => (<1.07 for cooling only)
  - Liquid cooling ?



- Outdoor cabinet
  - Cooling optimization
    - Numerical
    - Experimental
  - Passive cooling ?
    - PCM
    - Thermosyphon loop





Stephane Le-masson – Orange Labs

paradoxes

- Parasites consumption
  - **for example** spam estimated to 33 TWh = 10 x Orange (2009 study of Mac Affee)
  - **Equipment Always ON** : Energy = P x t → «gains are killed by allways on

- Rebound Effets
  - **no 1 to 1 substitution :** avearge 3 conferences for 1 physical meeting
  - do we receive 100 letters par day !
  - **Addition et superposition of services :** web-conference and emails
  - **Mosaique de services** (encore plus de serveurs que pour le zapping)
  - **substitution ≠dématérialization**

Tough questions to prepare the future

- change the paradigm : move from “always-on” to “always available”
  - e.g. switch off non-used resources
- adapt telecom/ICT to smart grid (social responsibility)
  - e.g. reduce consumption of network + devices in peak period (infrastructure + service),
  - support grid during peak period, … etc…(already discussed in ITU-T)

GreenTouch™ **International initiative**

- balance between energy efficiency and spectral efficiency
  - optimize the hardware efficiency by adapting the capacity to the usage

ICTrend **EU Network of Excellence**

- tackle the dilemma of the traffic exponential (+50% /y) vs. the hardware efficiency linear (+10%/y) evolution
  - moving from uniform to heterogeneous networks
- adopt a sustainable way of thinking future networks architecture : “concentrated” versus “distributed” architectures
  - optimize the delivery (CDN) services and the points of presence (NGPoP) regarding the customers services
- optimize coexistence of multiple access technologies (2G, 3G, H+, LTE, Wifi, fixed)
  - need for seamless and multi-Radio-access optimization to avoid redundancy
  - accelerate fixe-mobile convergence

OPERA-Net **EU - CELTIC** Power efficient Wireless

- reinforce multi-sectors collaboration towards smart and sustainable cities :
  - e.g. between BTP and ICT sectors for immersive technologies
- build an end-to-end evaluation (usage<-service<-network)
  - the top-down (service driven) and a bottom-up (hardware driven) visions shall be conducted simultaneously

We build too many roads and not enough bridges

I. Newton