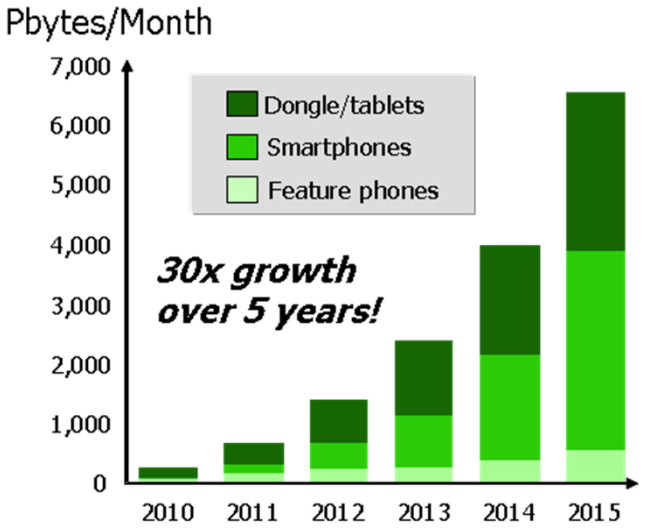
Green Wireless Networks

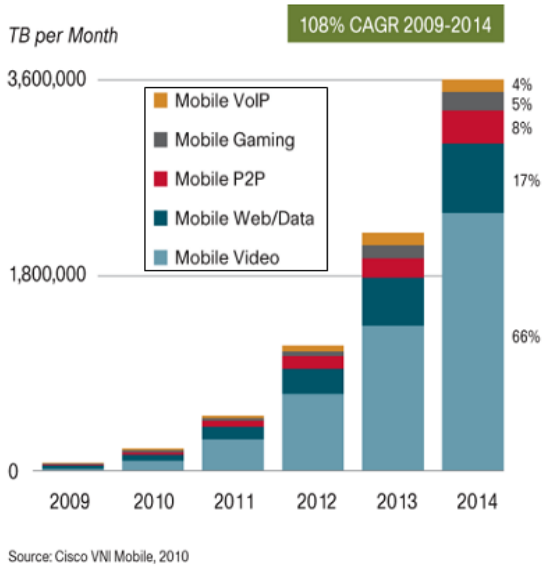
Dr. Gee Rittenhouse

Chairman of the Board, GreenTouch

Chief Operating Officer, Software/Services/Solutions Group, ALU

MASSIVE DATA TRAFFIC GROWTH





Source: Cisco VNI Mobile, 2010

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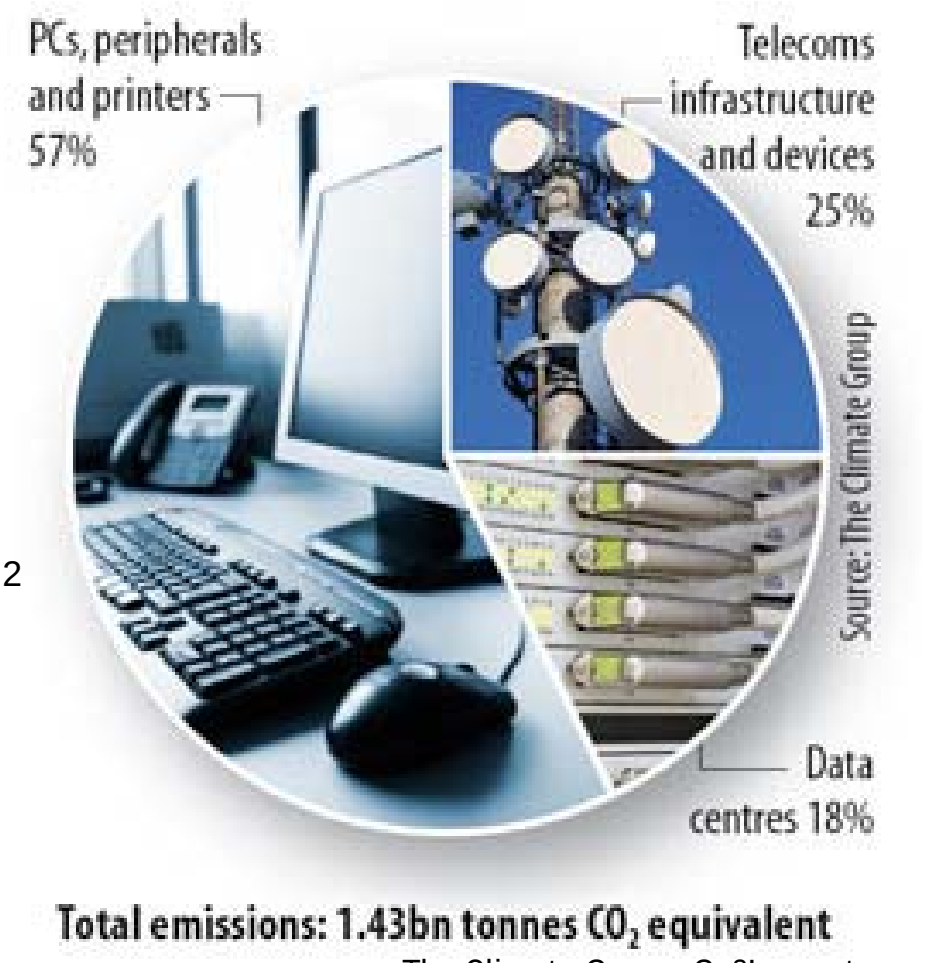
2020 ICT CARBON FOOTPRINT

820m tons CO_2



360m tons CO_2

260m tons CO_2

- 2007 Worldwide ICT carbon footprint: 2% = 830 m tons CO_2
- Comparable to the global aviation industry
- Expected to grow to 4% by 2020

The Climate Group, GeSI report "Smart 2020", 2008

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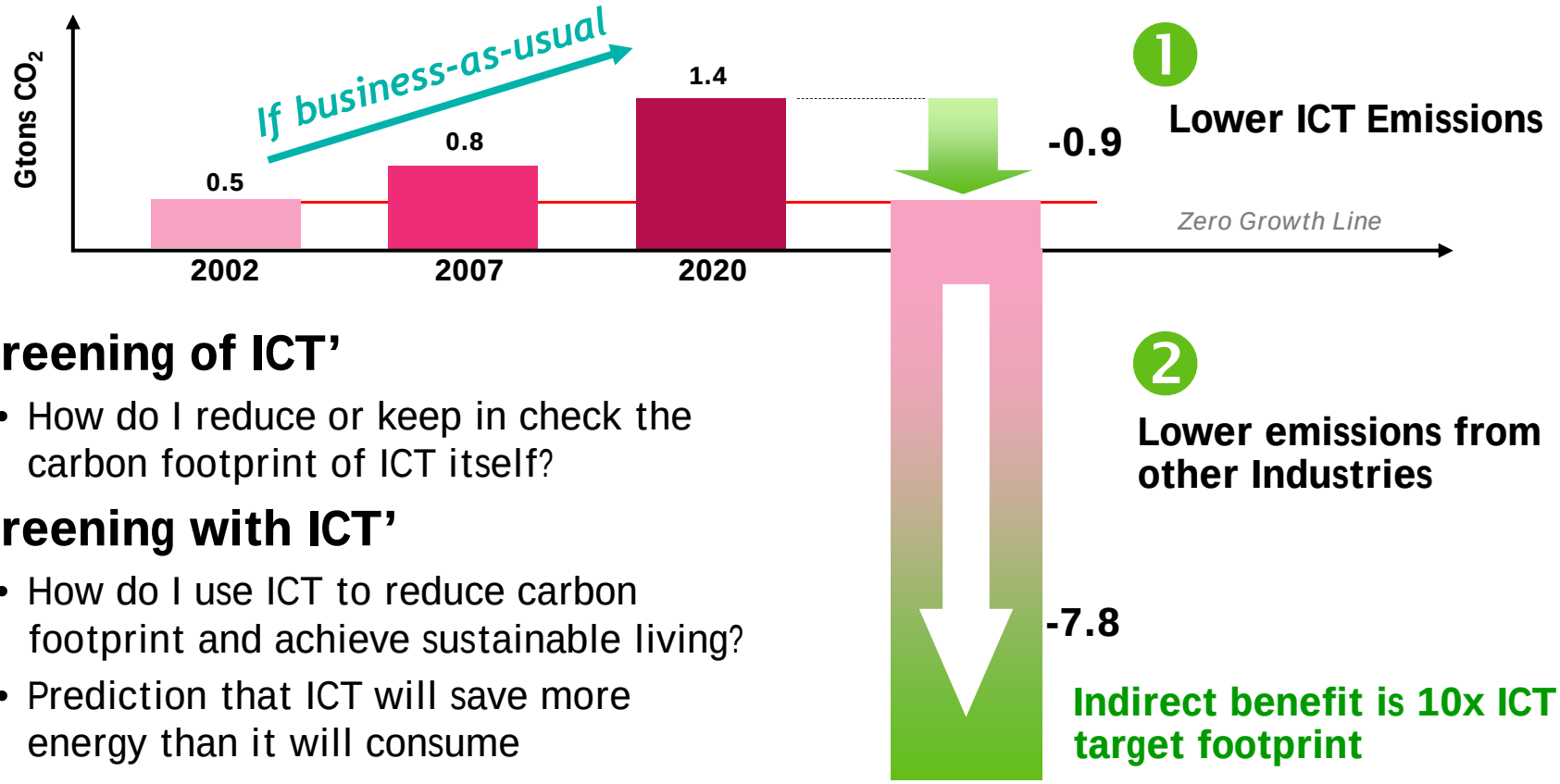
ICT: A PROBLEM AND THE SOLUTION

ICT today: 2% of global emissions…
with an opportunity to make tremendous impact on the remaining 98%



- **'Greening of ICT'**
  - How do I reduce or keep in check the carbon footprint of ICT itself?
- **'Greening with ICT'**
  - How do I use ICT to reduce carbon footprint and achieve sustainable living?
  - Prediction that ICT will save more energy than it will consume

Source: GeSI – SMART 2020: Enabling the Low Carbon Economy in the Information Age

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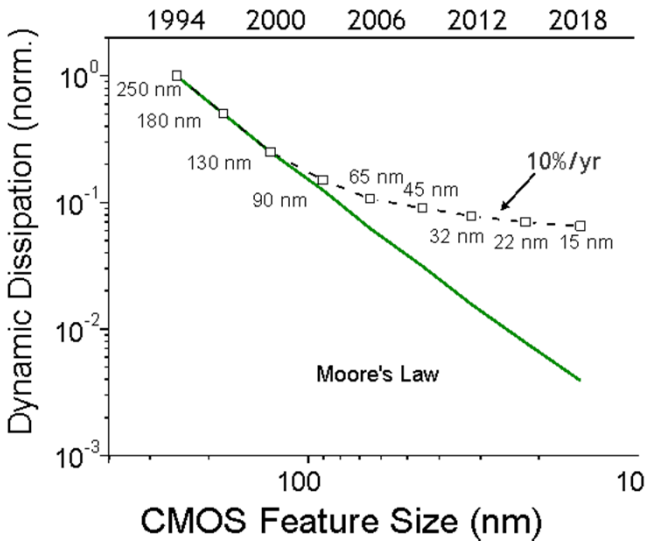
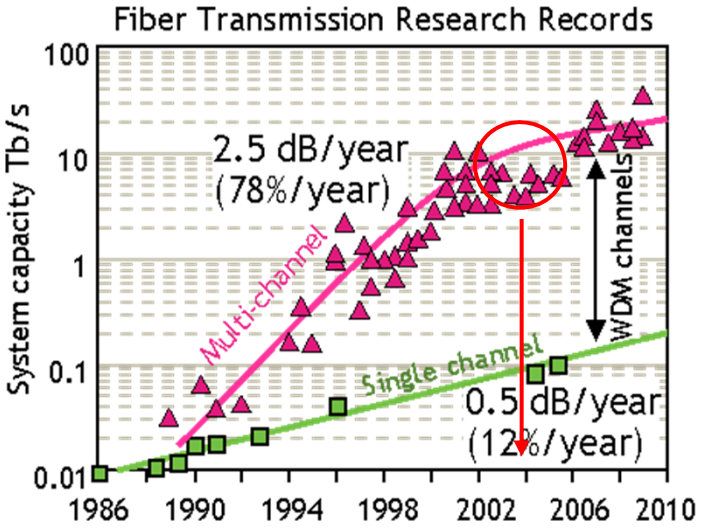
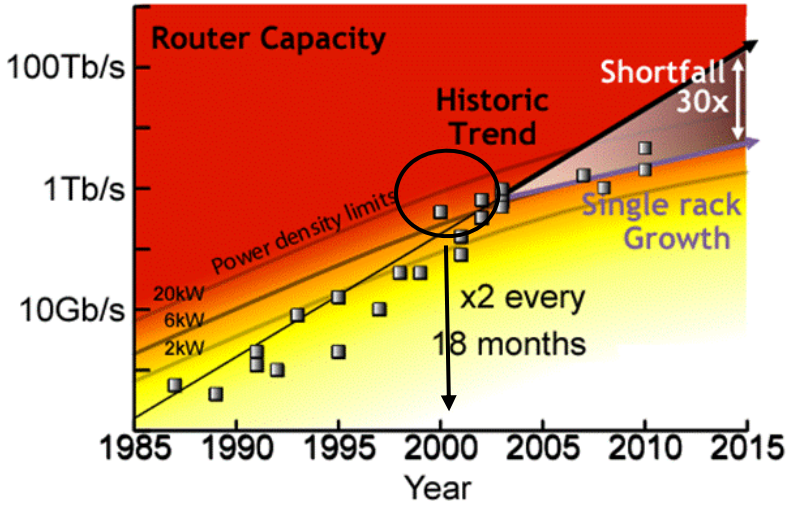
SLOW-DOWN IN TECHNOLOGY



Network energy efficiency only increasing at 10-15% per year





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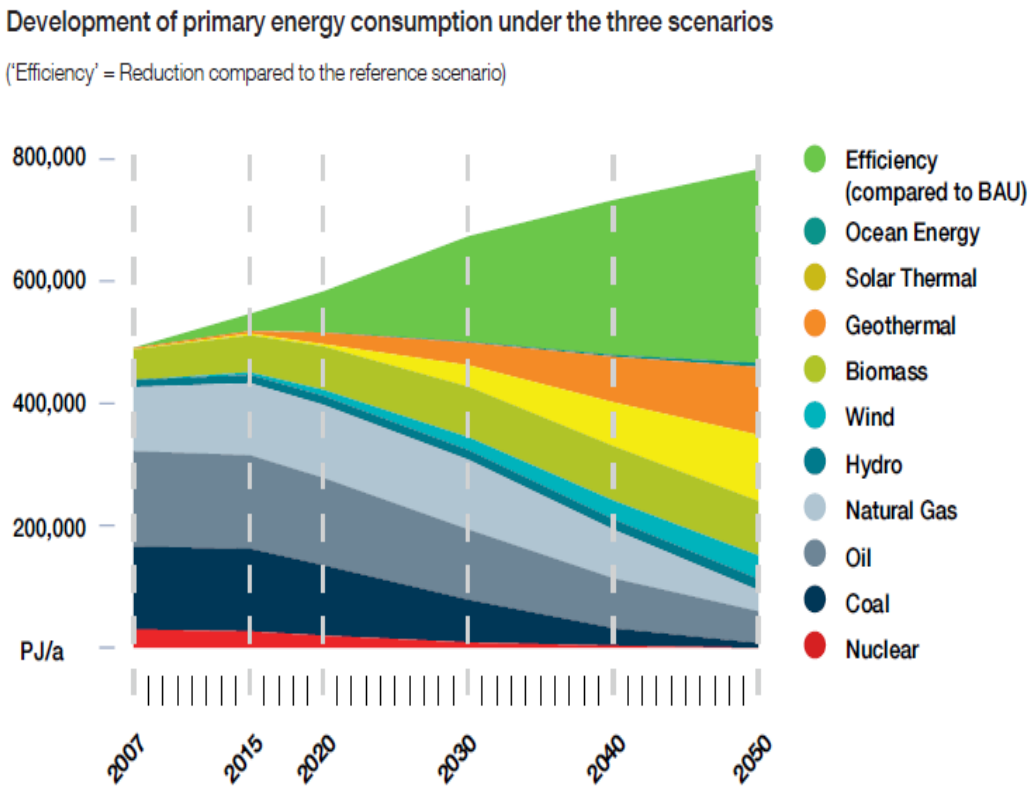
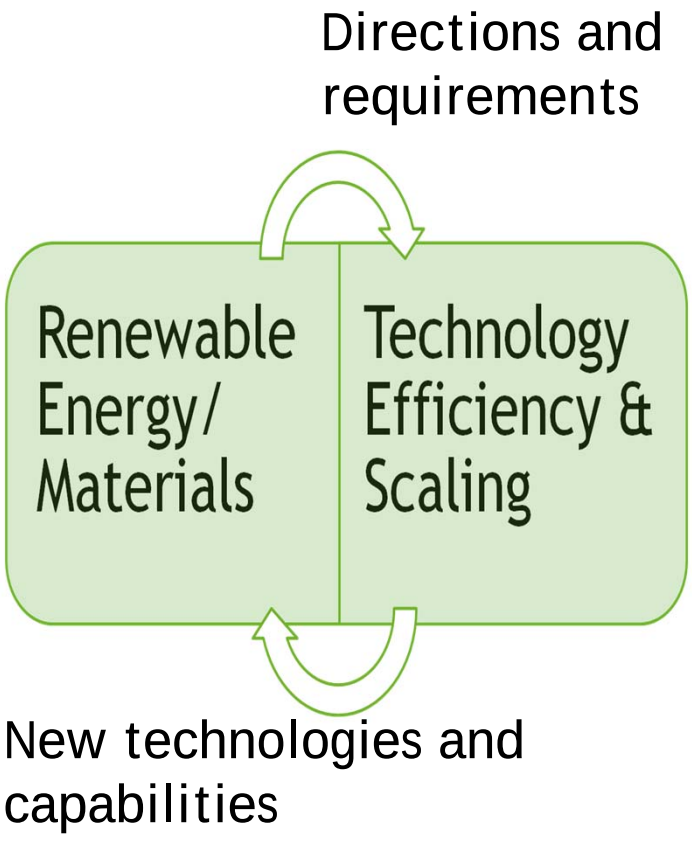
EFFICIENCY AND RENEWABLE ENERGY SOURCES





Greenpeace, G. Cook, J.V. Horn, 'How dirty is your data'
2011 Greenpeace, EREC 'Energy (R)evolution' 2010

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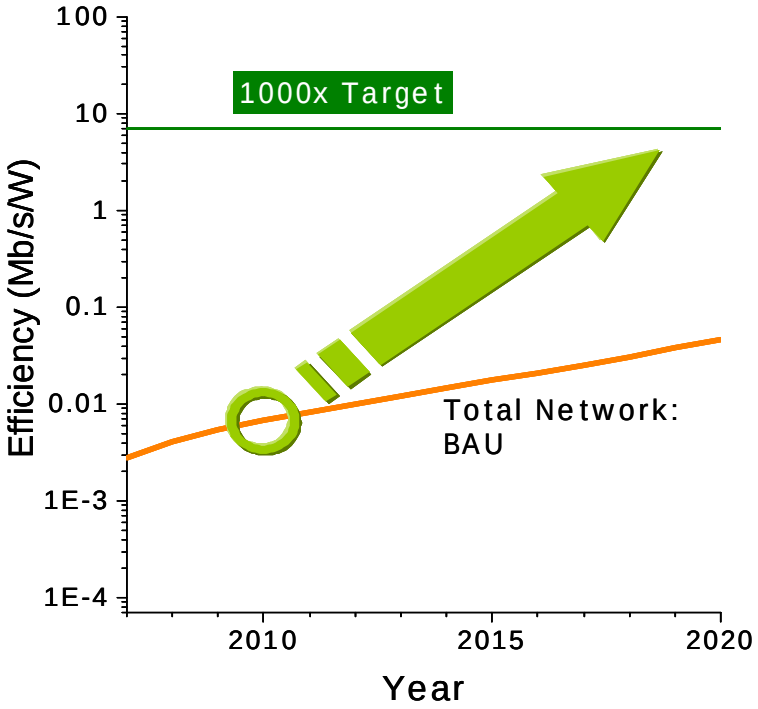
GREENTOUCH MISSION (www.greentouch.org)

By 2015, our goal is to deliver the architecture, specifications and roadmap — and demonstrate key components and technologies —needed to increase network energy efficiency by a factor of 1000 from current levels.



- Global research consortium representing industry, government and academic organizations
- Launched in May 2010
- 52 member organizations
- 300 individual participants from 19 countries
- 25+ projects across wireless, wireline, routing, networking and optical transmission

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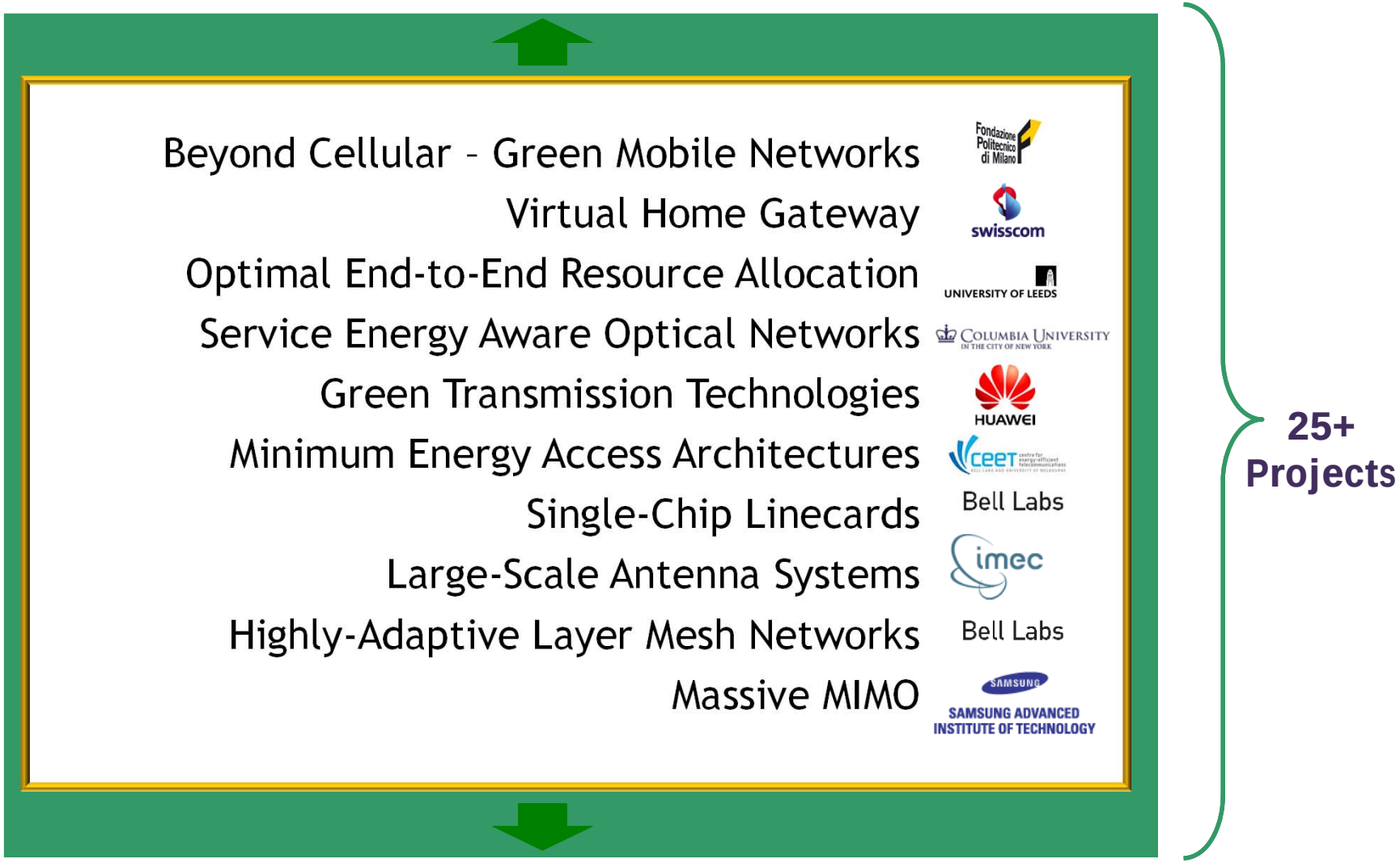
SOME RESEARCH PROJECTS…



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POWER CONSUMPTION OF MOBILE COMMUNICATIONS

Total Energy =

2 TWh/yr

0.1W per user for 3 billion Subscriptions

Users

Total Energy =

60 TWh/yr

1kW per user for 4 million Base Stations

Base Station

Total Energy =

<1 TWh/yr

1kW per user for 10,000 Controllers

Network Control

Total Energy =

14 TWh/yr

10kW per user for other elements

Core & Servers

Based on: ETSI RRS05_024, NSN

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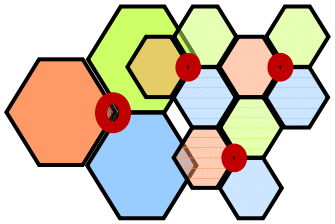
GREEN NETWORK OPPORTUNITIES (I)

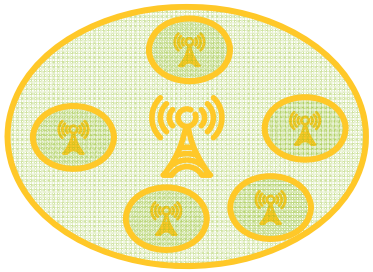
Deployment:

Relays Nodes

Multi RAT

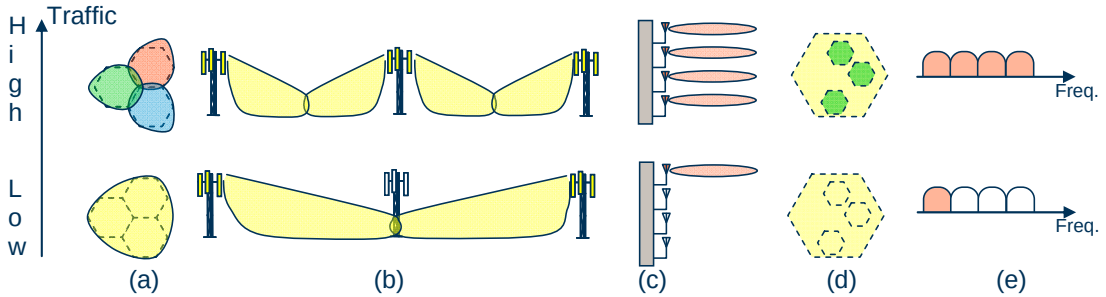


Heterogeneous Networks



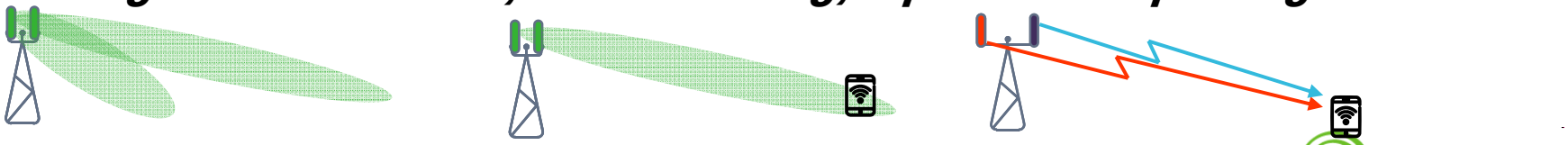
Network Management:

BS cooperation, Adaptive NW configuration



Multi-Antenna Techniques:

Reconfigurable antennas, Beam forming, Spatial multiplexing



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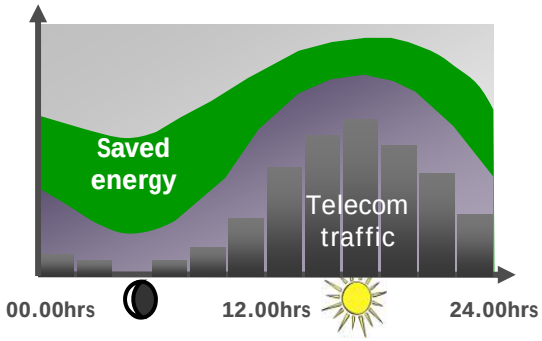
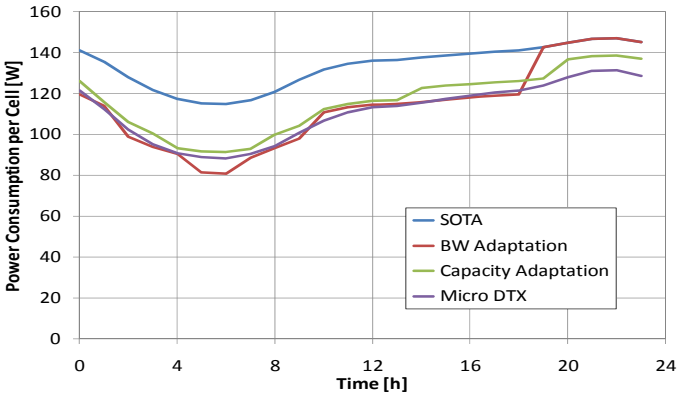
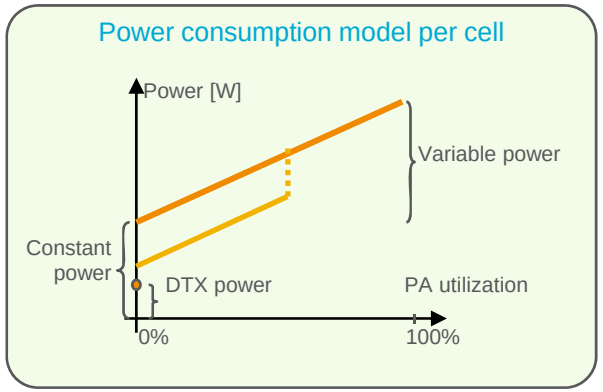
GREEN NETWORK OPPORTUNITIES (II)

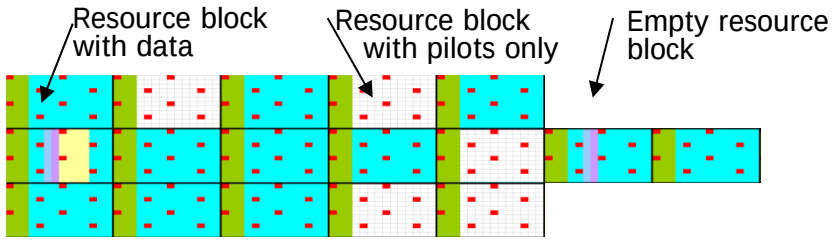
Radio Resource Management:

Energy efficient scheduling, Sleep modes, Bandwidth Adaptation









High load:
Most resources used

Low load:
Capacity adaptation

BW adaptation:
Pilots suppressed

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SOME SPECIFIC RESEARCH ACTIVITIES

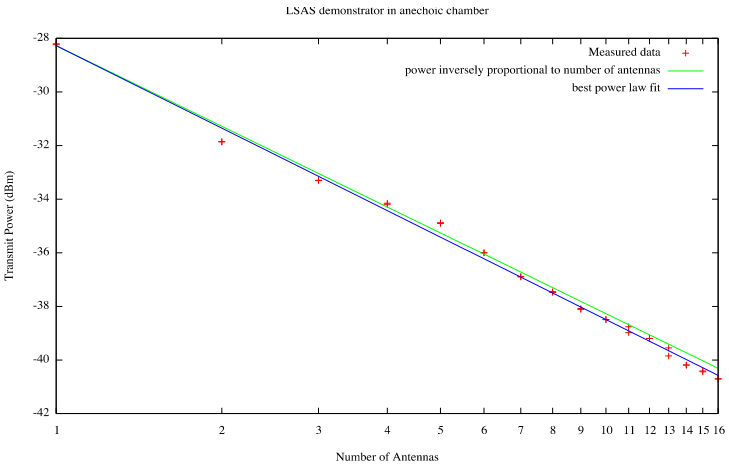
1. Large Scale Antenna Systems
   - Massive MIMO
   - Distributed Antenna Systems

2. EARTH (Energy Aware Radio and neTwork tecHnologies)
   - Small cells and heterogeneous network deployment
   - Network management

3. BCG^2 (Beyond Cellular Green Generation)
   - Green network management / intelligent power management
   - Independent network configuration for data and signaling

LARGE SCALE ANTENNA SYSTEM

Measured transmit power is inversely proportional to the number of antennas:



- ***Beam-forming for energy efficiency, not capacity***
- ***First GreenTouch technology demonstration***

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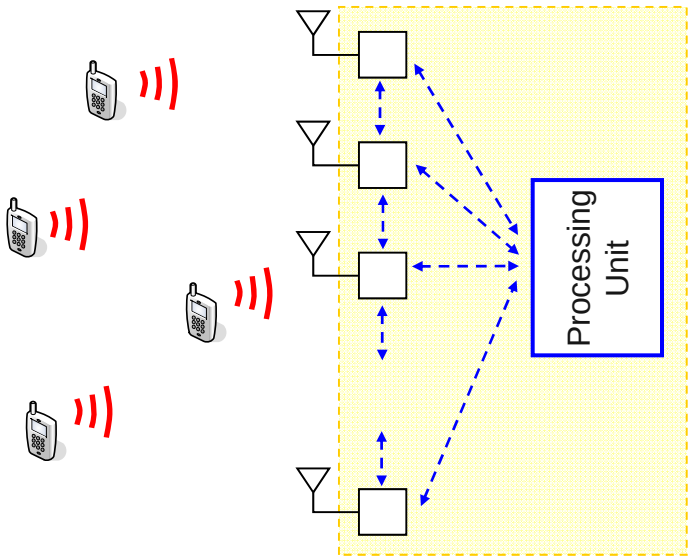
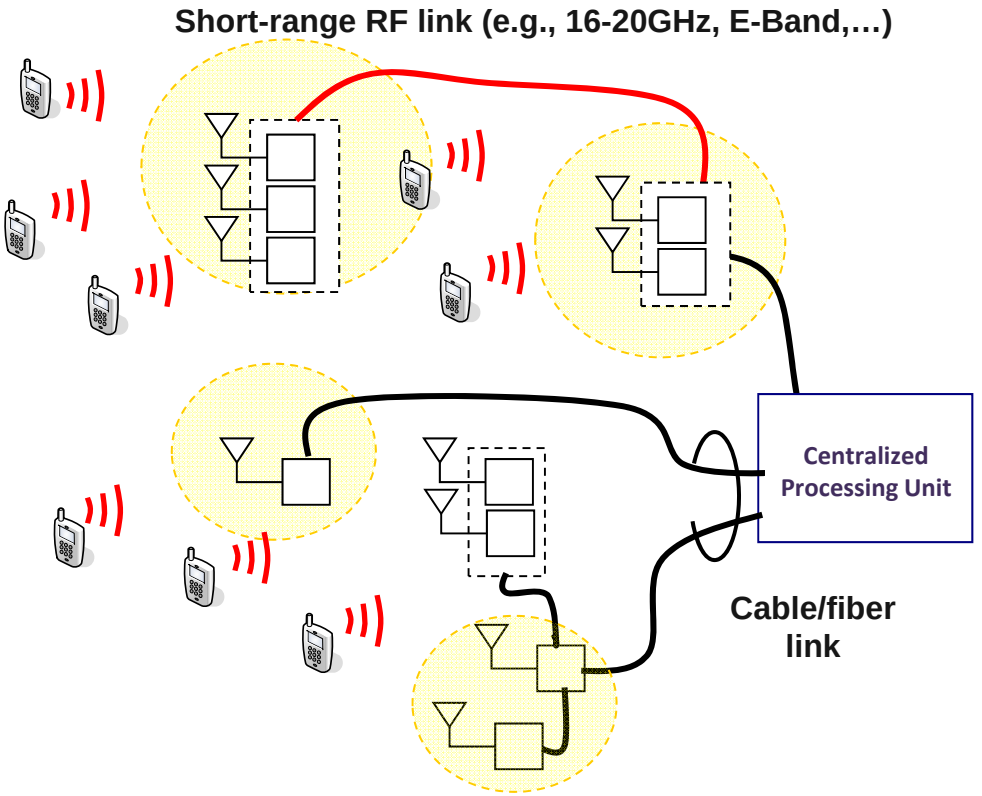
APPLICATION SCENARIOS

Massive Co-located Antennas



Marzetta, T. L., IEEE Trans Wireless Communications, Nov 2010

Spatially Distributed Antennas



- ***100's or 1000's of antenna elements***
- ***'Power amplifiers' operating at micro-Watt levels***

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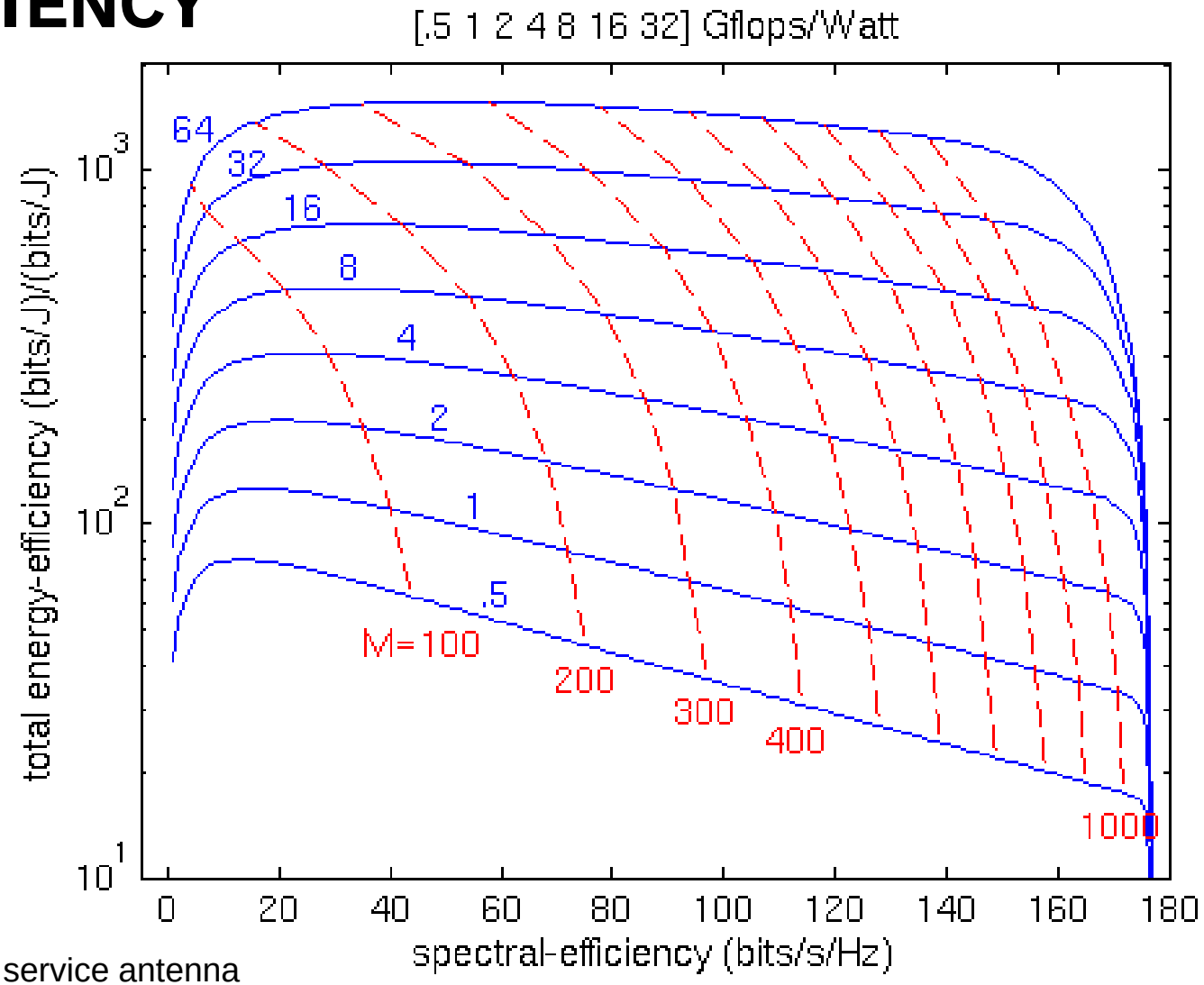
TOTAL ENERGY VS. COMPUTATIONAL ENERGY EFFICIENCY & SPECTRAL EFFICIENCY



M: number of service antenna

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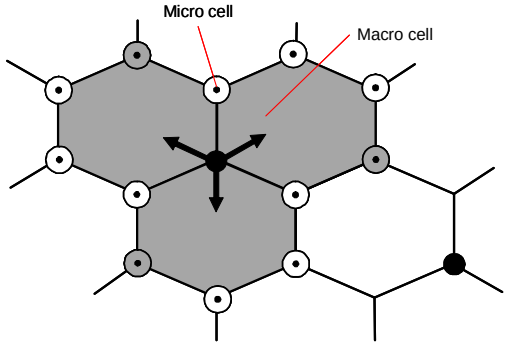
EU FP 7 PROJECT EARTH
(Energy Aware Radio and neTwork tecHnologies)

earth
Energy Aware Radio and neTwork tecHnologies

Alcatel·Lucent
ERICSSON
NXP
NTT docomo
DOCOMO Euro-Labs
TELECOM ITALIA
cea
UNIVERSITY OF SURREY
TECHNISCHE UNIVERSITÄT DRESDEN
MŰEGYETEM 1782
imec
TTI Tecnologías de Telecomunicaciones e Información
ETSI World Class Standards
UNIVERSITY of OULU OULUN YLIOPISTO
INSTITUTO SUPERIOR TÉCNICO

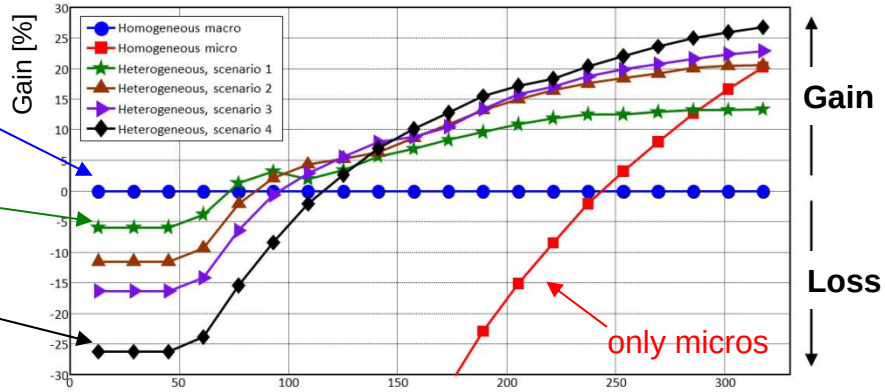


Relative gain in Area Power consumption [%]

Reference:
only macro cells

Scenario 1:
1 micro per sector

Scenario 4:
5 micros per sector



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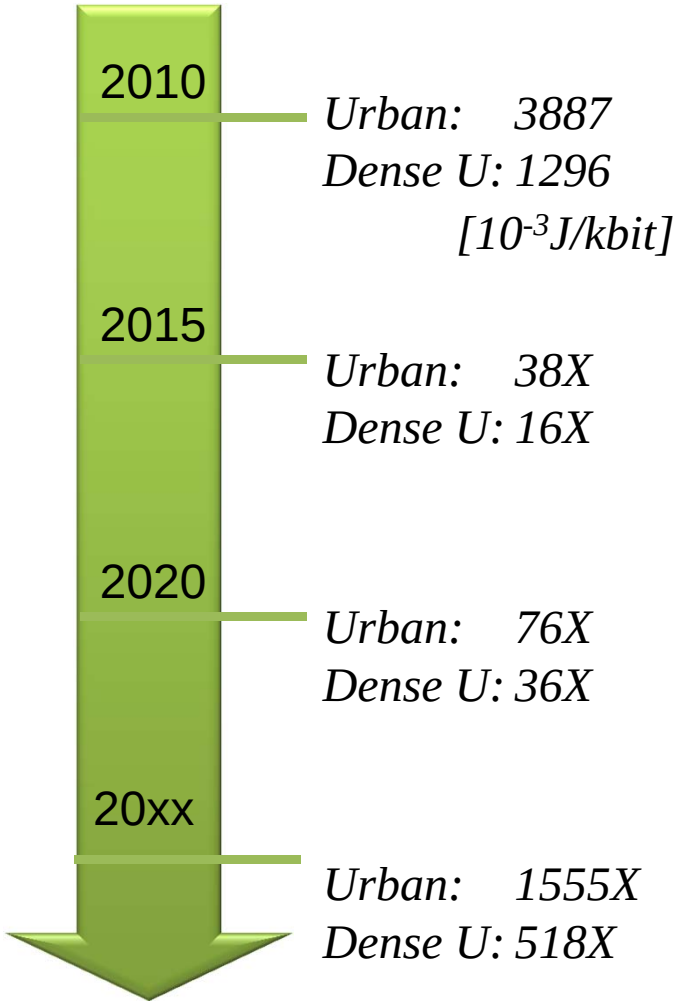
THEORETICAL UPPER BOUNDS ON POTENTIAL GAINS

2010
Reference scenario:
Macro BSs only (SCENARIO 1)
Always-on

2015
Mixed scenario with BCG
60% micro, 40 macro BSs (SCENARIO 2)
BCG energy management

2020
Micro/pico cellular scenario
10% macro, 60% micro, 30% pico BSs (SCENARIO 3)
BCG energy management

Long term scenario
Atto cellular scenario
100% atto BSs
BCG energy management



Alcatel·Lucent HUAWEI SAMSUNG orange TNO TECHNISCHE UNIVERSITÄT DRESDEN INRIA POLITECNICO DI MILANO

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CONCLUSIONS

- ICT networks are growing rapidly
  - Scaling networks is becoming more difficult
  - Bringing focus to energy efficiency
- ICT and research communities are organizing to address challenges
  - Dramatic, holistic change, but over long term evolution
  - Cooperative organizations such as GreenTouch guiding evolution
- Several promising research directions and initial results have been obtained
- More work remains!

Thank you!

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