



GreenTouch

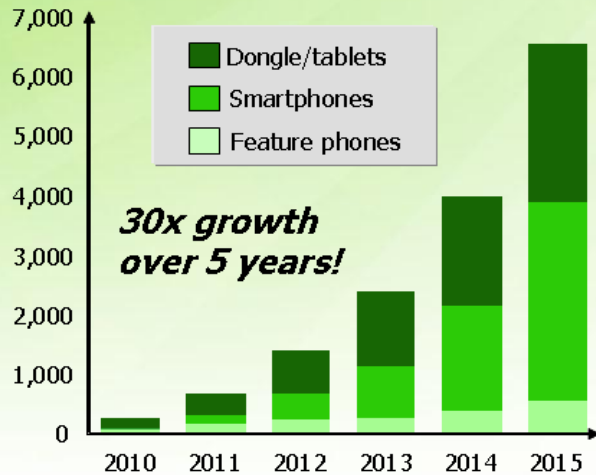
Reducing the carbon footprint of ICT devices, platforms and networks

GeSI Global Assembly

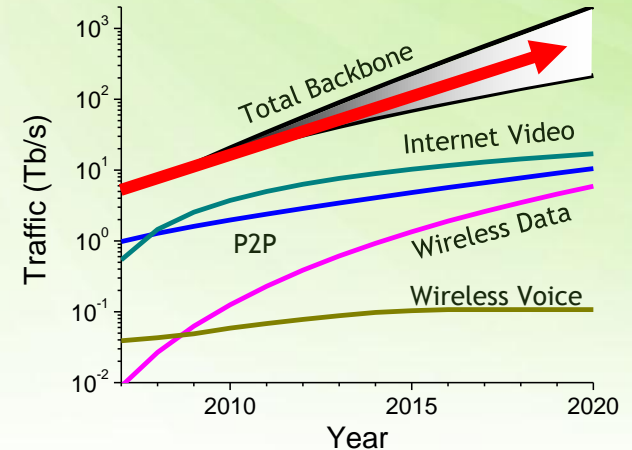
Thierry Van Landegem
Chair, GreenTouch Operations Committee

MASSIVE DATA TRAFFIC GROWTH

Pbytes/Month



North America



Data from: RHK, McKinsey-JPMorgan, AT&T, MINTS, Arbor, ALU, and

Bell Labs Analysis: Linear regression on log(traffic growth rate) versus log(time) with Bayesian learning to compute uncertainty

Today



=



- 17.5 GigaWatts
- ~ 9 Hoover Dams
- ~ 15 nuclear power plants

- ~ 15M car emissions a year
- ~ 150,000 Paris to New York round-trip flights

Future



2020 ICT CARBON FOOTPRINT

820m tons CO₂

- 2007 Worldwide ICT carbon footprint:
2% = 830 m tons CO₂
- Comparable to the global aviation industry
- Expected to grow to 4% by 2020



360m tons CO₂

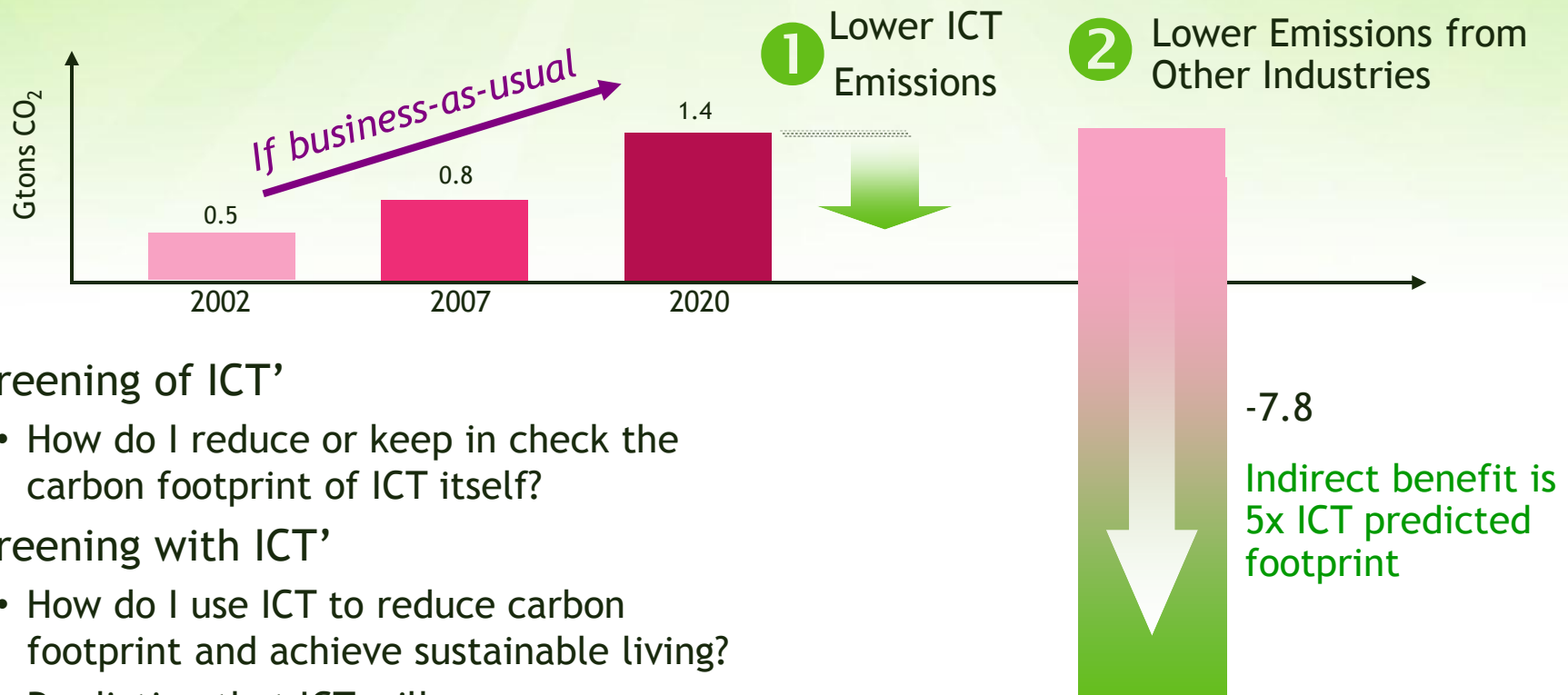
260m tons CO₂

Total emissions: 1.43bn tonnes CO₂ equivalent

The Climate Group, GeSI report
“Smart 2020”, 2008

ICT: A PROBLEM AND THE SOLUTION

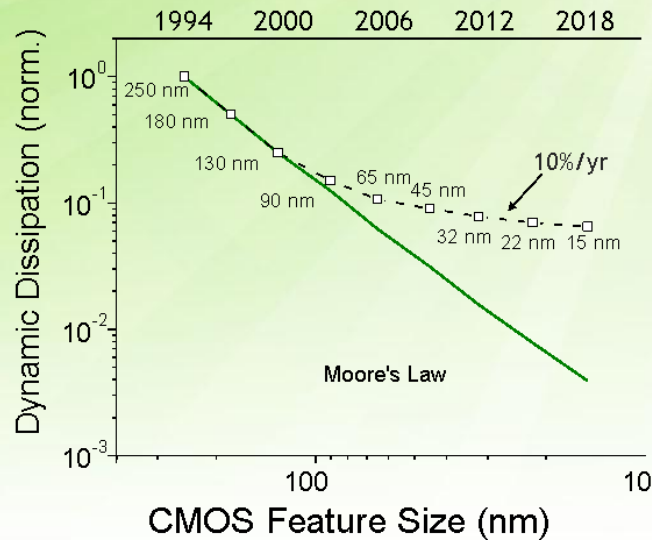
ICT today: 2% of global emissions...
with an opportunity to make tremendous impact on the remaining 98%



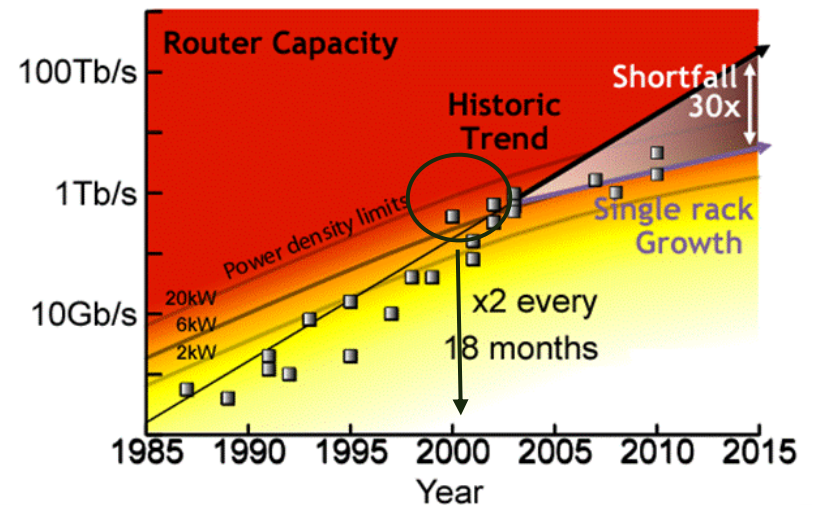
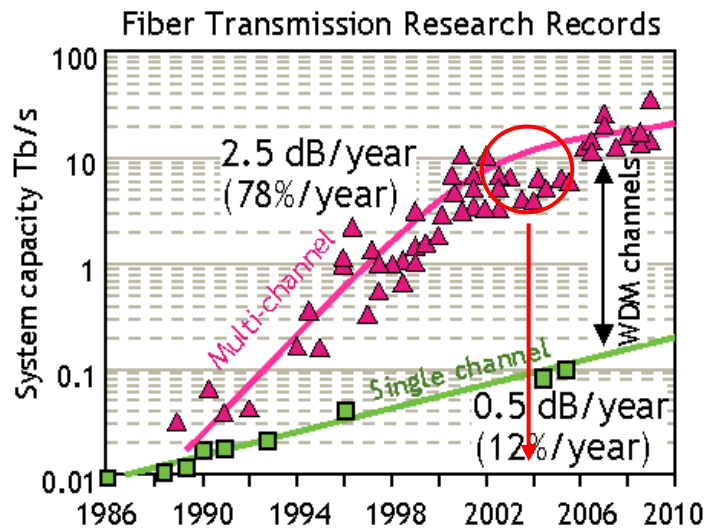
- 'Greening of ICT'
 - How do I reduce or keep in check the carbon footprint of ICT itself?
- 'Greening with ICT'
 - How do I use ICT to reduce carbon footprint and achieve sustainable living?
 - Prediction that ICT will save more energy than it will consume

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

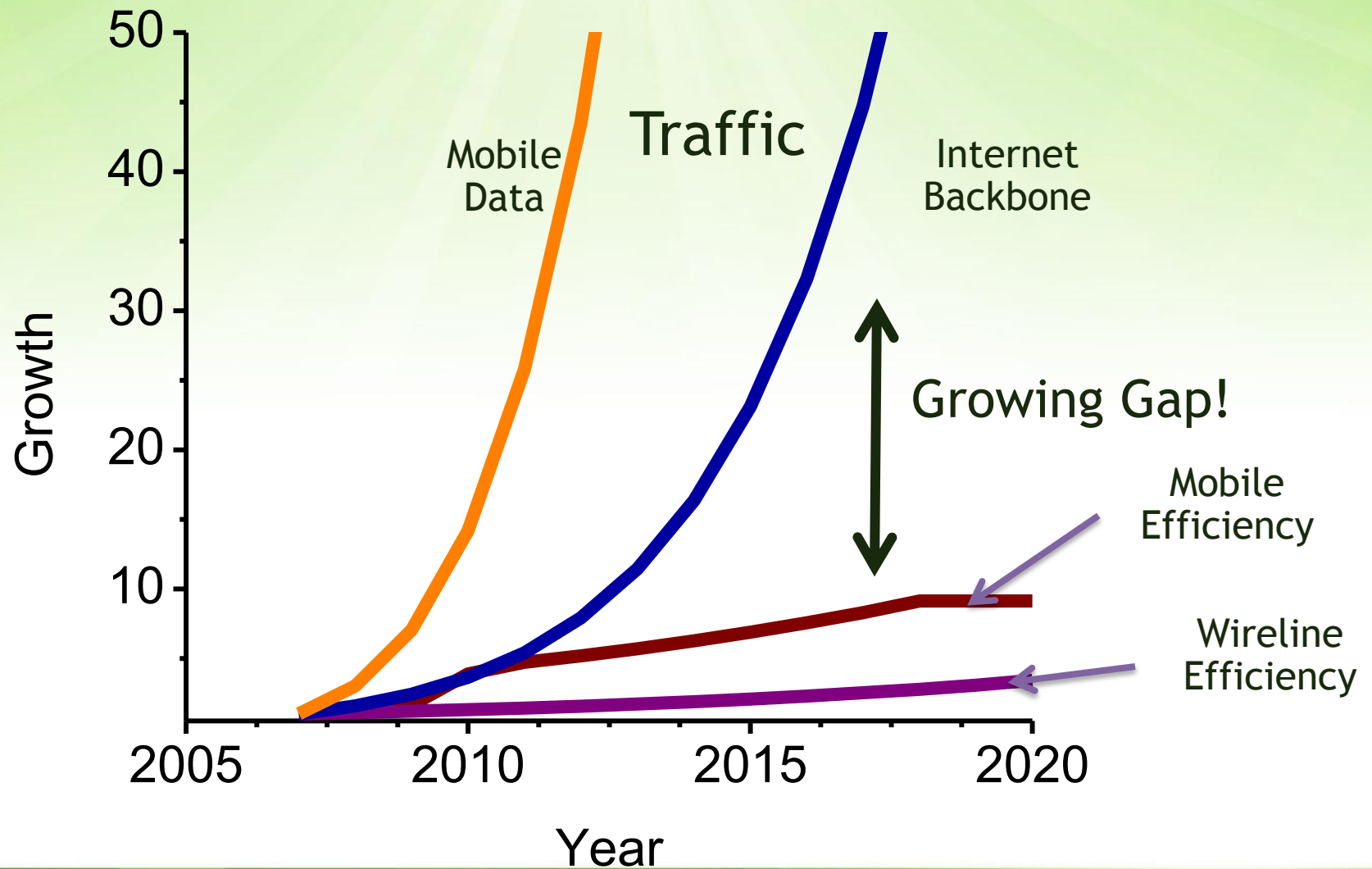
SLOW-DOWN IN TECHNOLOGY



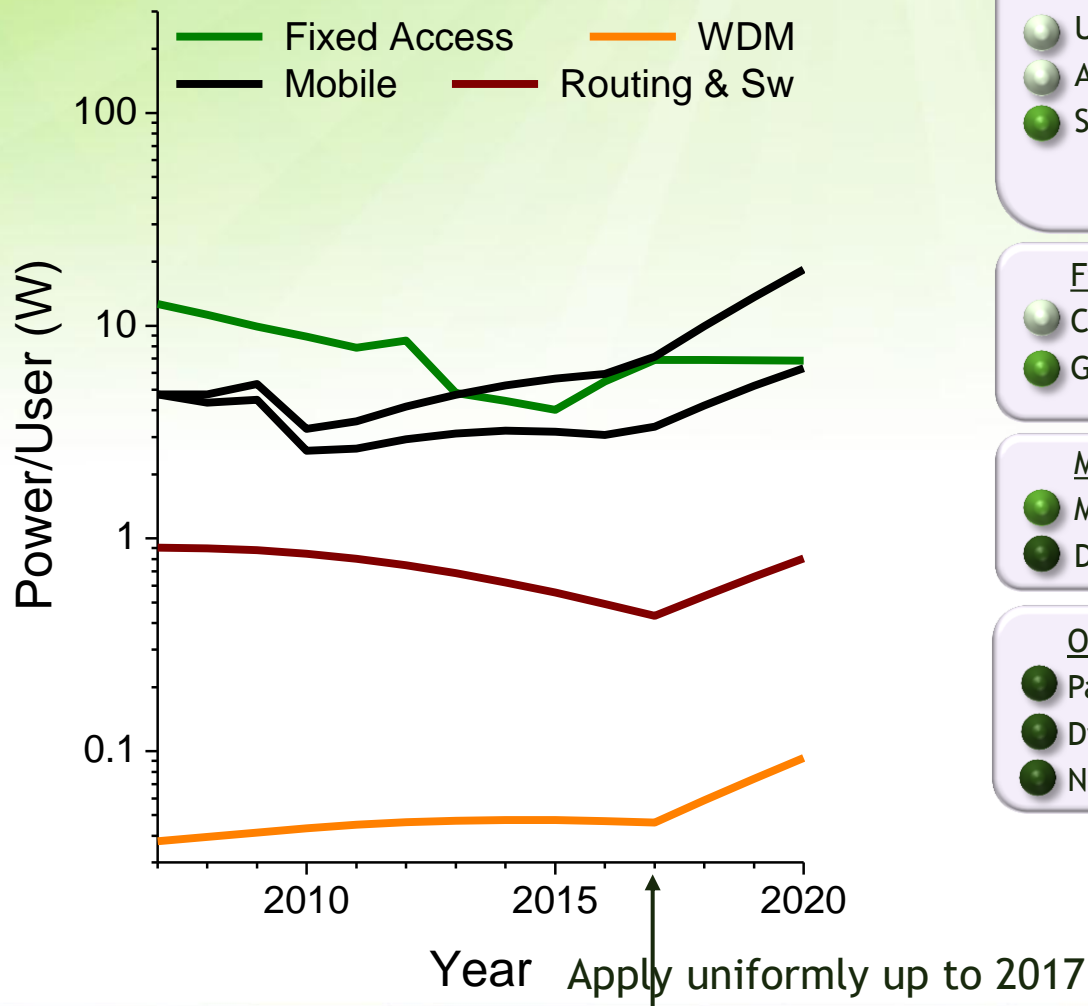
Network energy efficiency only increasing at 10-15% per year



THE NETWORK ENERGY GAP



BEST CASE EFFICIENCY IMPROVEMENTS



Mobile Access:

- Ultra-efficient power amplifiers (70%)
- Active antennas
- Self organizing networks

Fixed Access:

- Cost-reduced FTTH/N
- Green PON (from ~16W/user to ~5W/user)

Metro/Core:

- Mesh protection / fast restoration
- Dynamic Optical Bypass

Other:

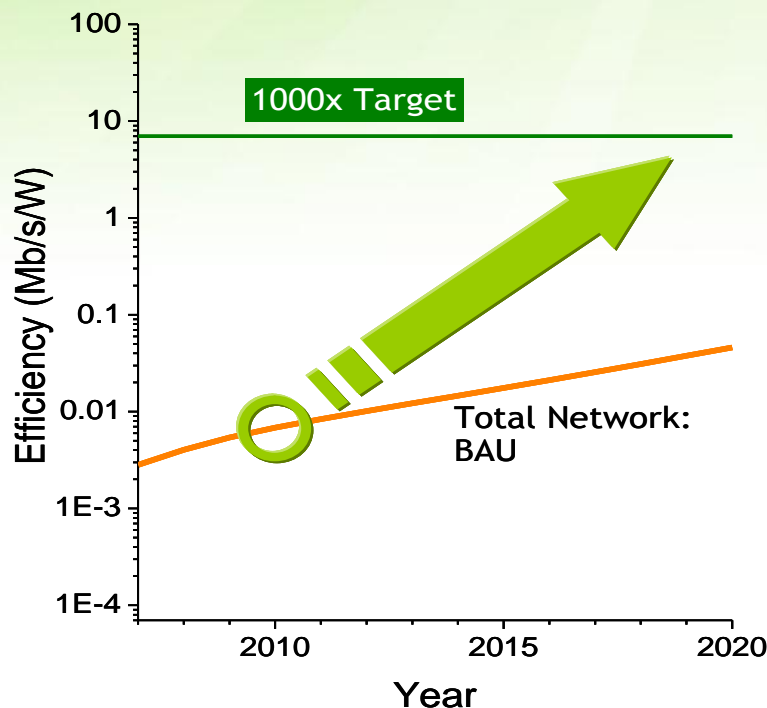
- Passive cooling everywhere
- Dynamic energy usage (proportional to load)
- Network Virtualization

Degree of
Difficulty:

● Lower
↑↓
● Higher

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.

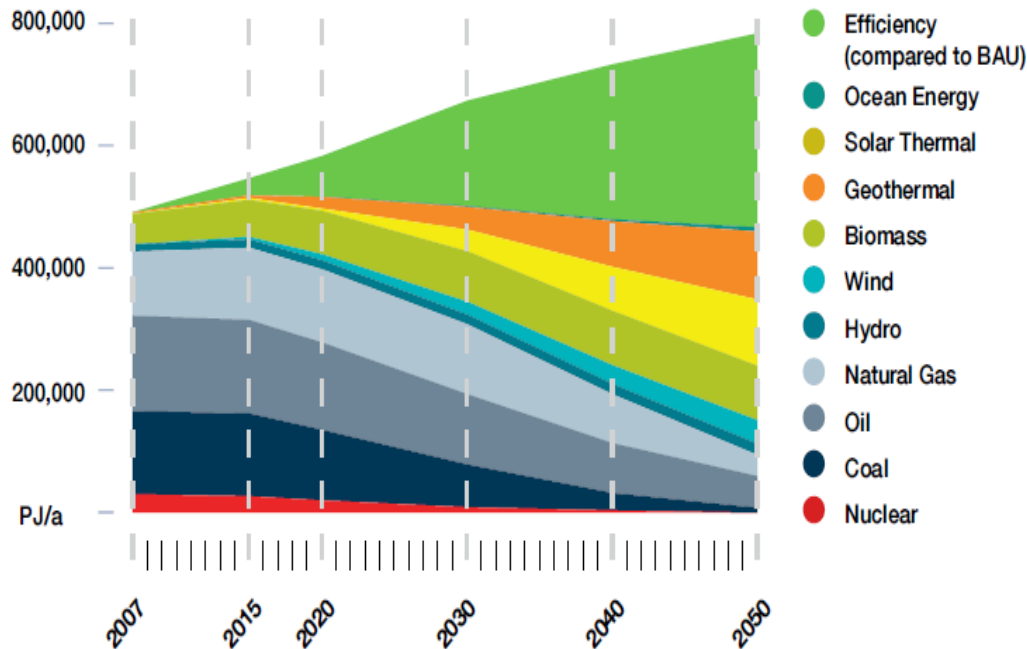


- Global research consortium representing industry, government and academic organizations
- Launched in May 2010
- 53 member organizations
- 300 individual participants from 19 countries
- 25+ projects across wireless, wireline, routing, networking and optical transmission

EFFICIENCY AND RENEWABLE ENERGY SOURCES

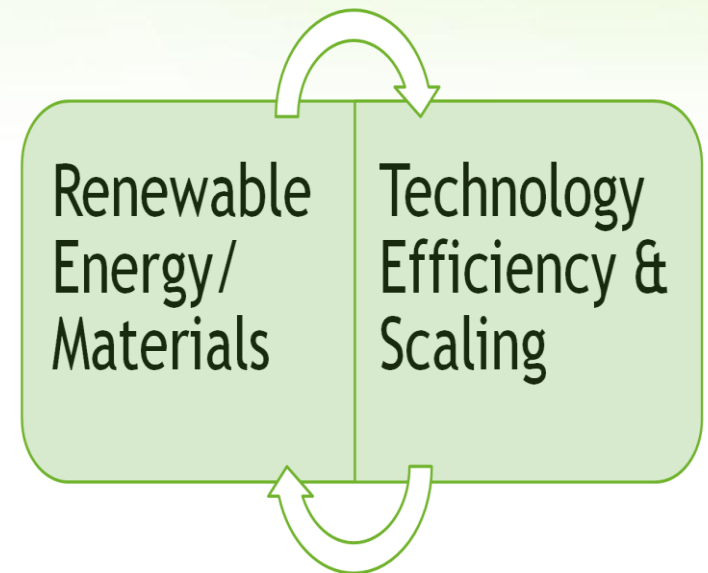
Development of primary energy consumption under the three scenarios

('Efficiency' = Reduction compared to the reference scenario)



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

Directions and
requirements



New technologies and
capabilities

GREENTOUCH STATUS: WHERE ARE WE?

- Over 25 research projects underway
- Two major public demonstrations
- Establish and define common reference architecture and roadmap with strategic research directions
- Initiated a policy and standards group within GreenTouch
- Collaboration and cooperation agreements with other leading organizations (including GeSI)
- Next face to face meeting

SOME RESEARCH PROJECTS...

Beyond Cellular - Green Mobile Networks



Virtual Home Gateway



Optimal End-to-End Resource Allocation



Service Energy Aware Optical Networks



Green Transmission Technologies



Minimum Energy Access Architectures



Single-Chip Linecards

Bell Labs

Large-Scale Antenna Systems



Highly-Adaptive Layer Mesh Networks

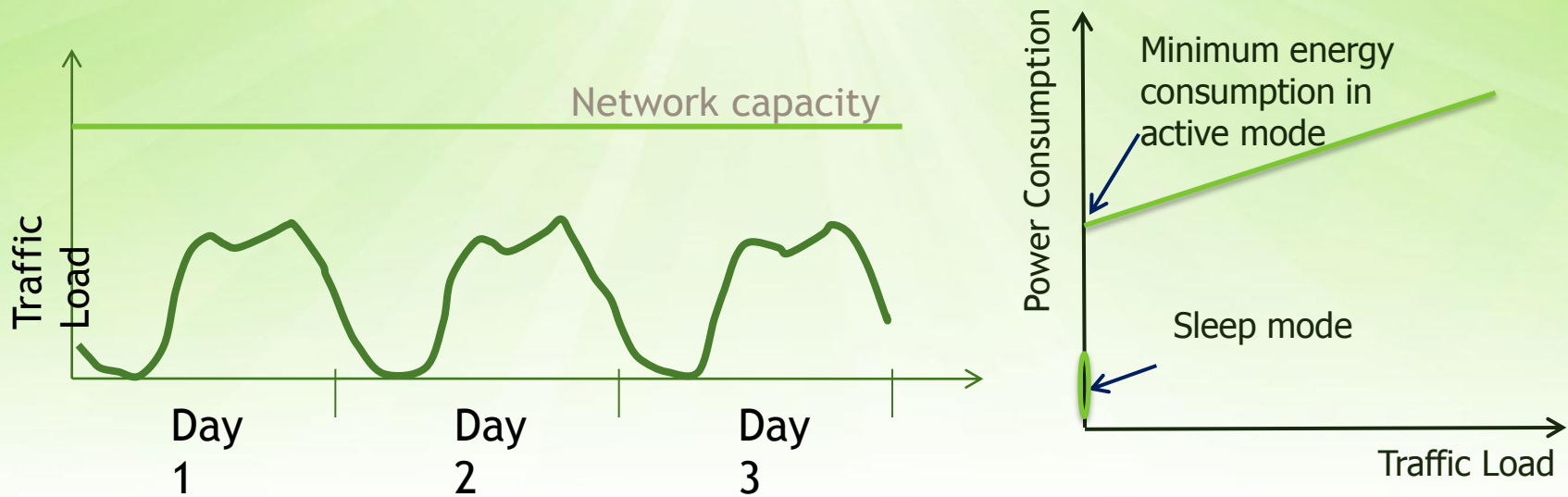
Bell Labs

Massive MIMO



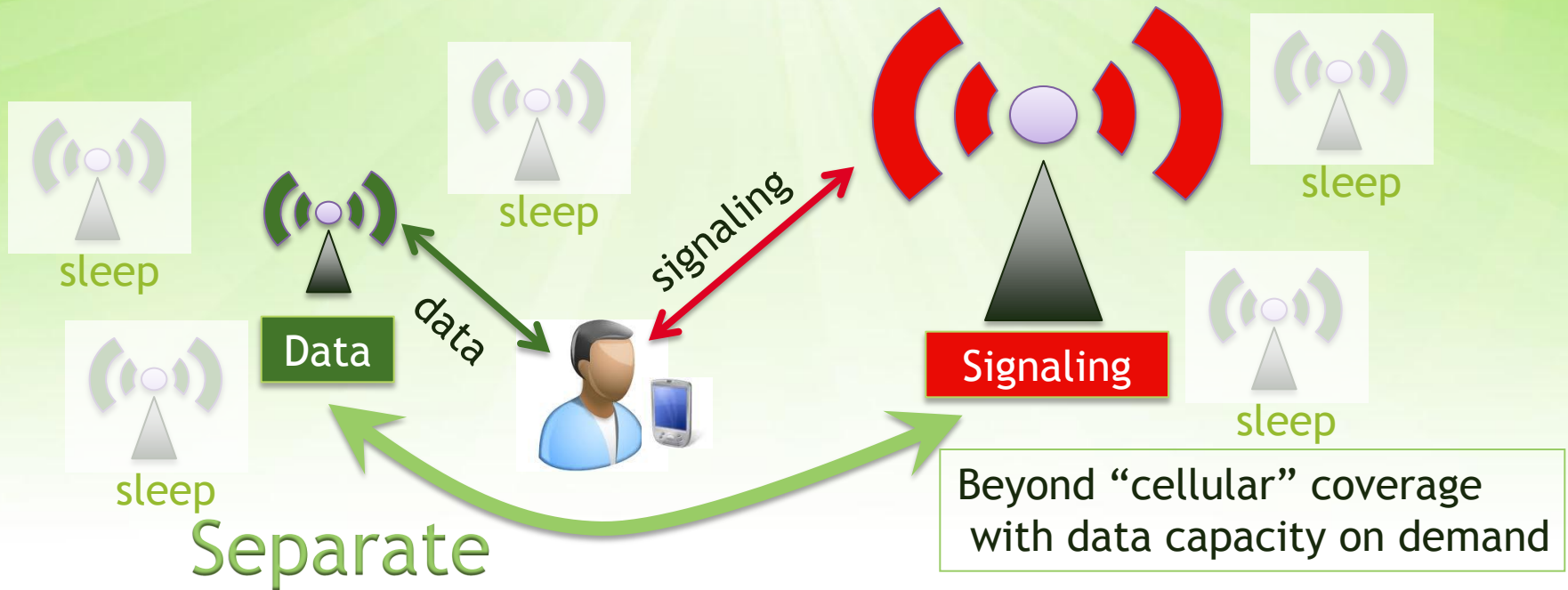
25+
Projects

1. BEYOND CELLULAR GREEN GENERATION (BCG²)



- Wireless access networks are dimensioned for estimated peak demand using dense layers of cell coverage
- Traffic varies during the day
- Energy consumption is almost constant - Due to the power consumed by signaling

BCG² ARCHITECTURE



Opportunities for sustainability:

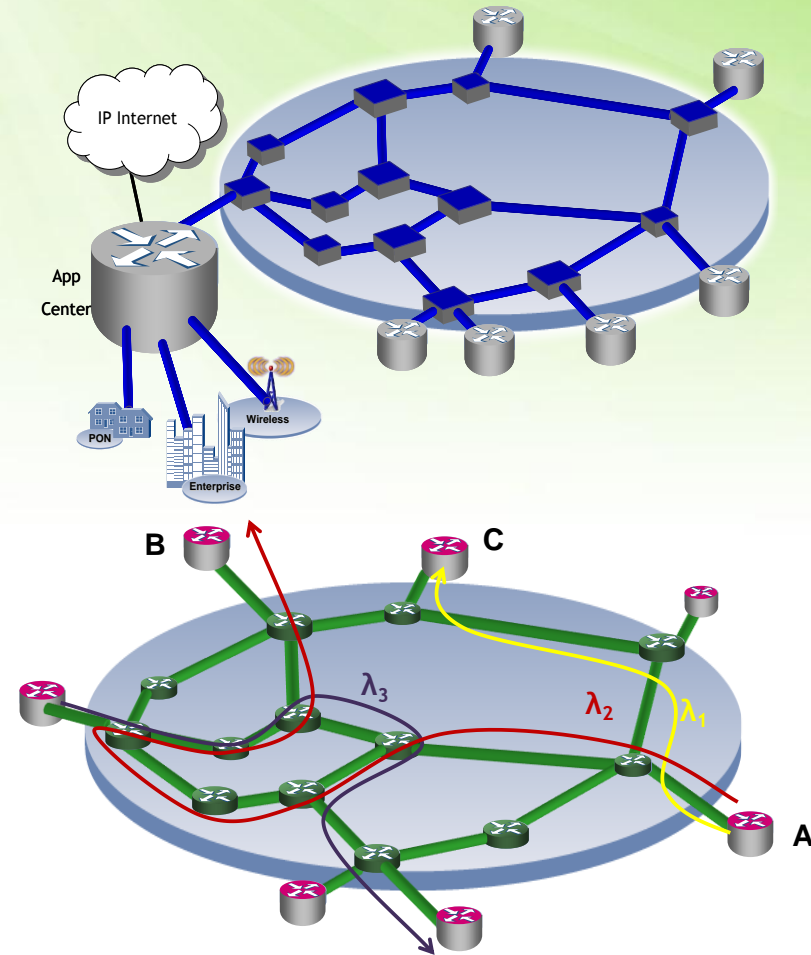
- System designed for energy efficiency
 - Separate capacity from coverage
 - Optimise signalling transmission
 - Lean access to system
- Cope with massive amount of low data rate services

Challenges:

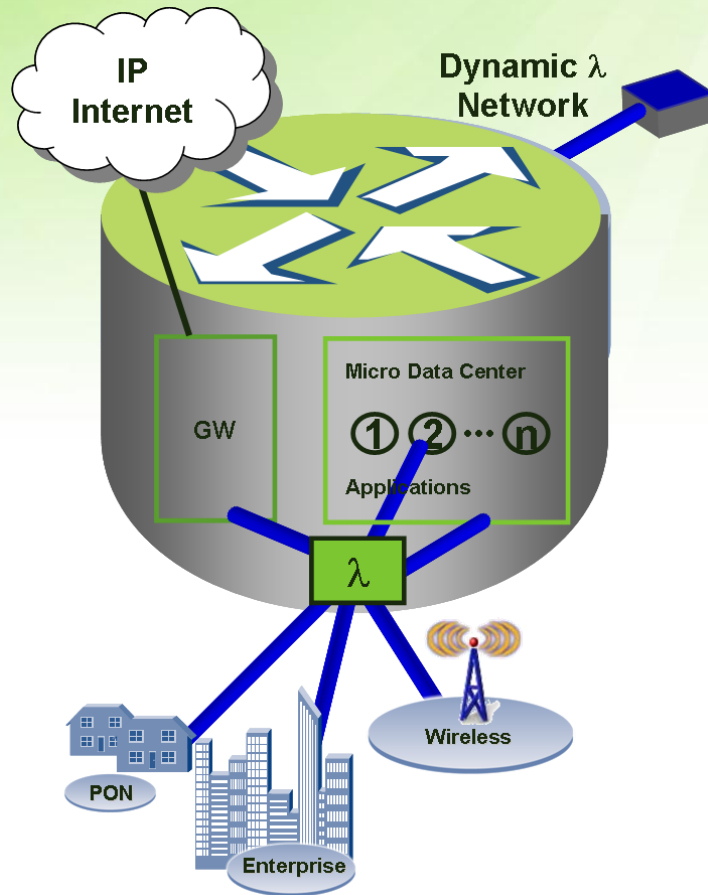
- New system architecture
- Re-invent mobility management
- Agile management, context aware, network with memory
- Hardware for fast reconfiguration

2. SEASON: SERVICE ENERGY AWARE SUSTAINABLE OPTICAL NETWORKS

- SEASON is a clean-slate network design project focusing on maximum energy efficiency through awareness of service requirements
 - Focus on services with high bandwidth
 - Understand how service requirements (bandwidth, duration, latency, multi-cast, security, protection,...) impact energy
 - Focus on core network dynamic functionality



IMPACT OF ENERGY EFFICIENT SERVICE-CENTRIC NETWORKS



- New platform for networked micro data centers with dynamically configured network
- Provides scalable and sustainable future networks, services and content delivery in the long-term
- Enables network operators, content providers, large enterprise and government institutions to transfer large amounts of data, synchronize databases and content caches and provide real-time, high-bandwidth services in the most energy efficient way
 - Supports big data / elephant flows (90% of traffic due to 10% of flows) (e.g. between data centers)
 - Supports new high-bandwidth real-time applications (e.g. high definition, multi-view video)
- Enables on-demand use of resources, reduce power consumption and over-provisioning of the network through dynamic network functionalities

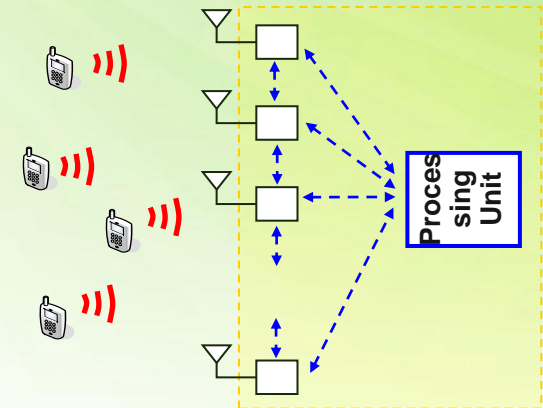
SEASON RESEARCH CHALLENGES

- Current network reconfigurations are slow and with complications from physical layer and control plane
- Traditional IP-over-WDM network not designed with energy efficiency in mind
- Project takes an end-to-end approach involving hardware, software, architecture, algorithms and protocols, each one being crucial for end-to-end energy efficiency, and requiring broad skills and expertise
- Demonstrate end-to-end solution in small scale lab and then in field-deployed prototype

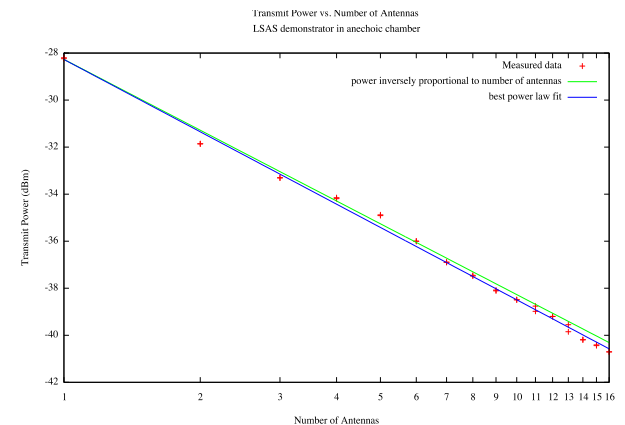
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1. LARGE SCALE ANTENNA SYSTEM



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



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

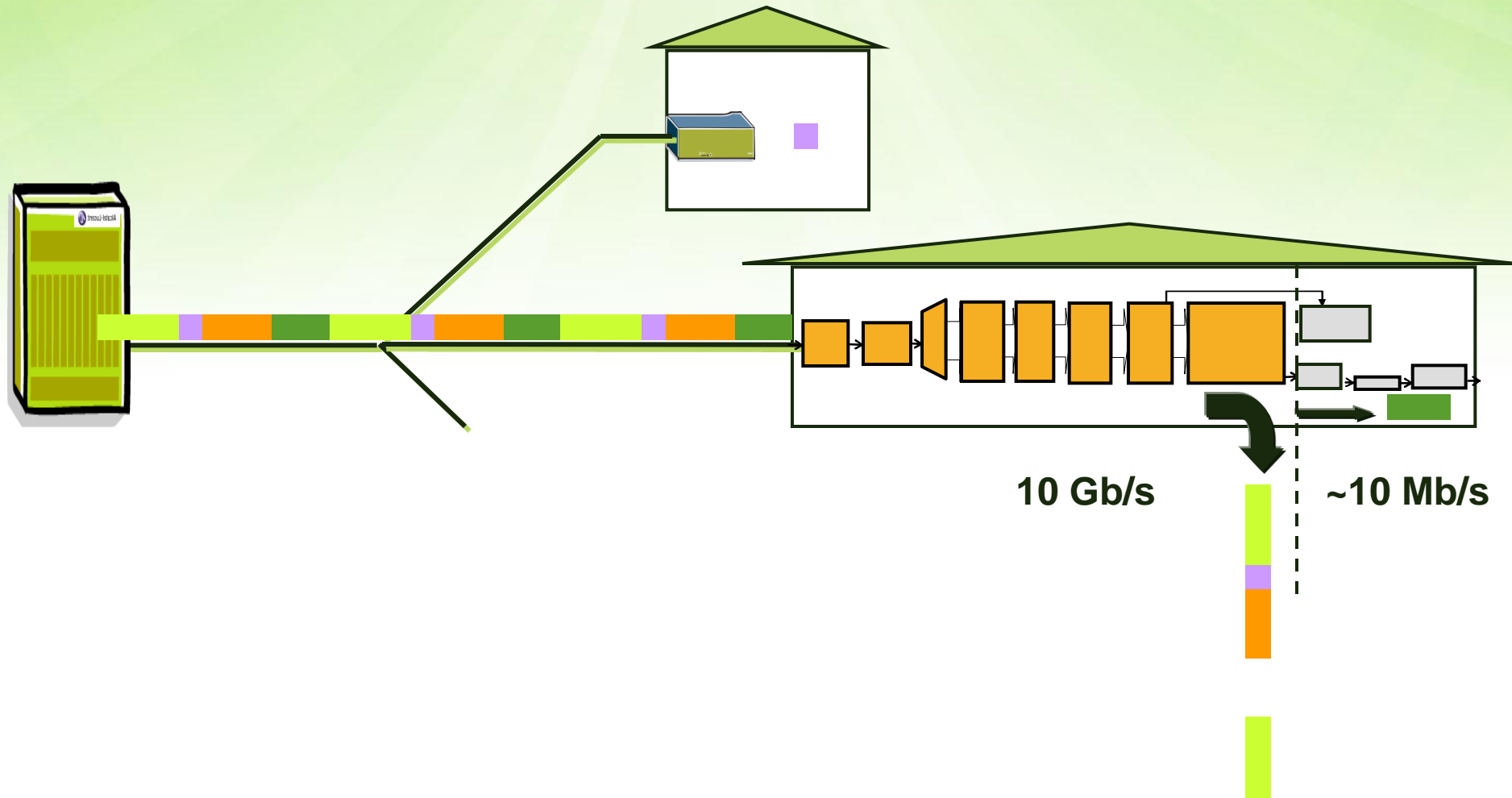
2. BIT-INTERLEAVING PASSIVE OPTICAL NETWORK (Bi-PON)

- The Problem: In current FTTH architectures, all data is processed but 97% is unused
 - With FTTH expected to nearly double over the next five years—to 142 million subscribers worldwide—energy consumption is a major concern.
- GreenTouch Solution: New Bit-Interleaving Passive Optical Network (BI-PON) technology
 - New FTTH protocol that consumes 10x less power than currently available technologies
 - Next major leap in optical technologies, expected to be a necessity as electronic processing will increase with the next-generation 40GPON systems expected by 2015
 - Enable power reduction equal to taking 3 million cars off the road
- Second major milestone toward achieving the GreenTouch goal

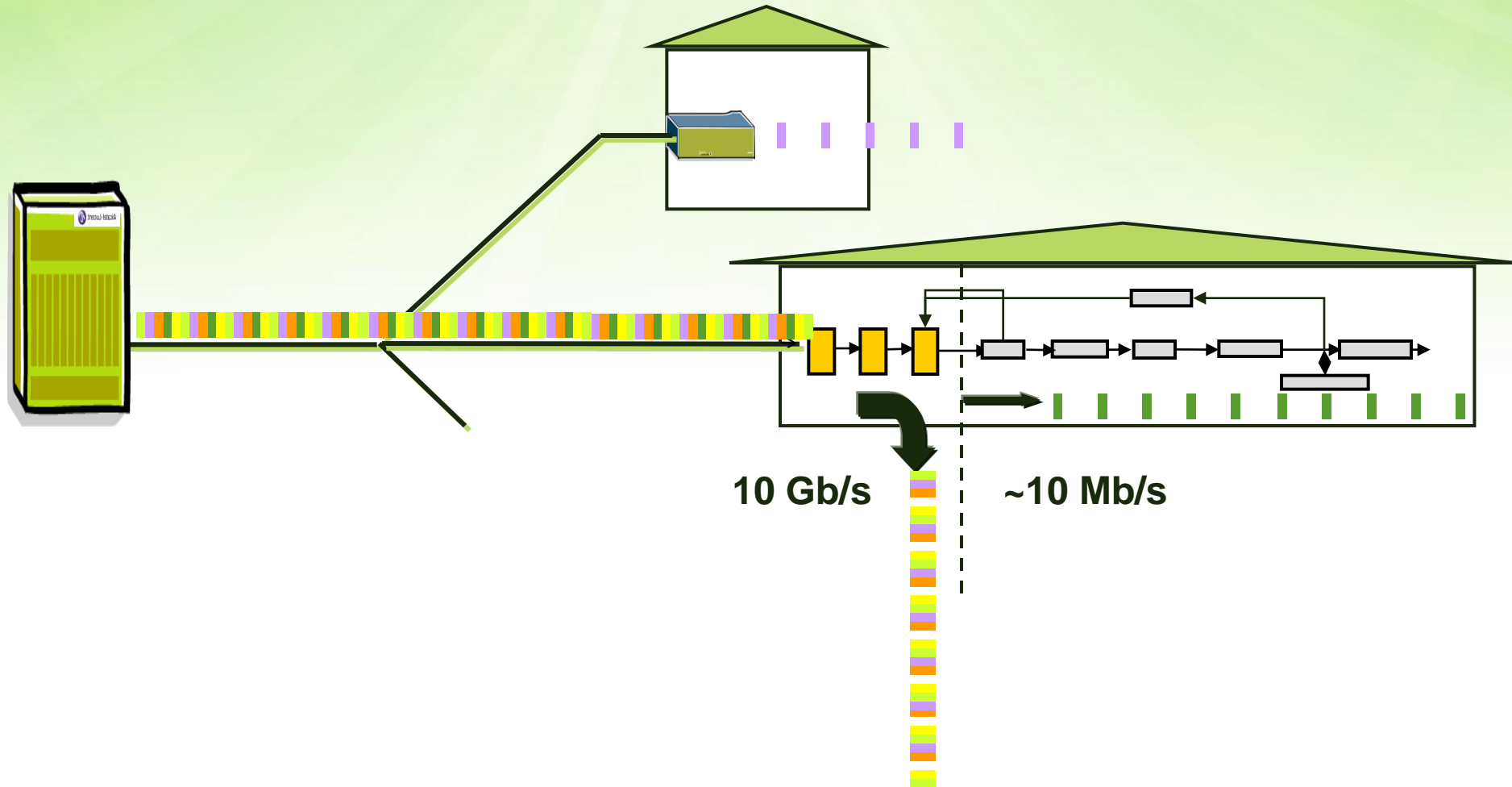
Alcatel-Lucent



STANDARD XG-PON



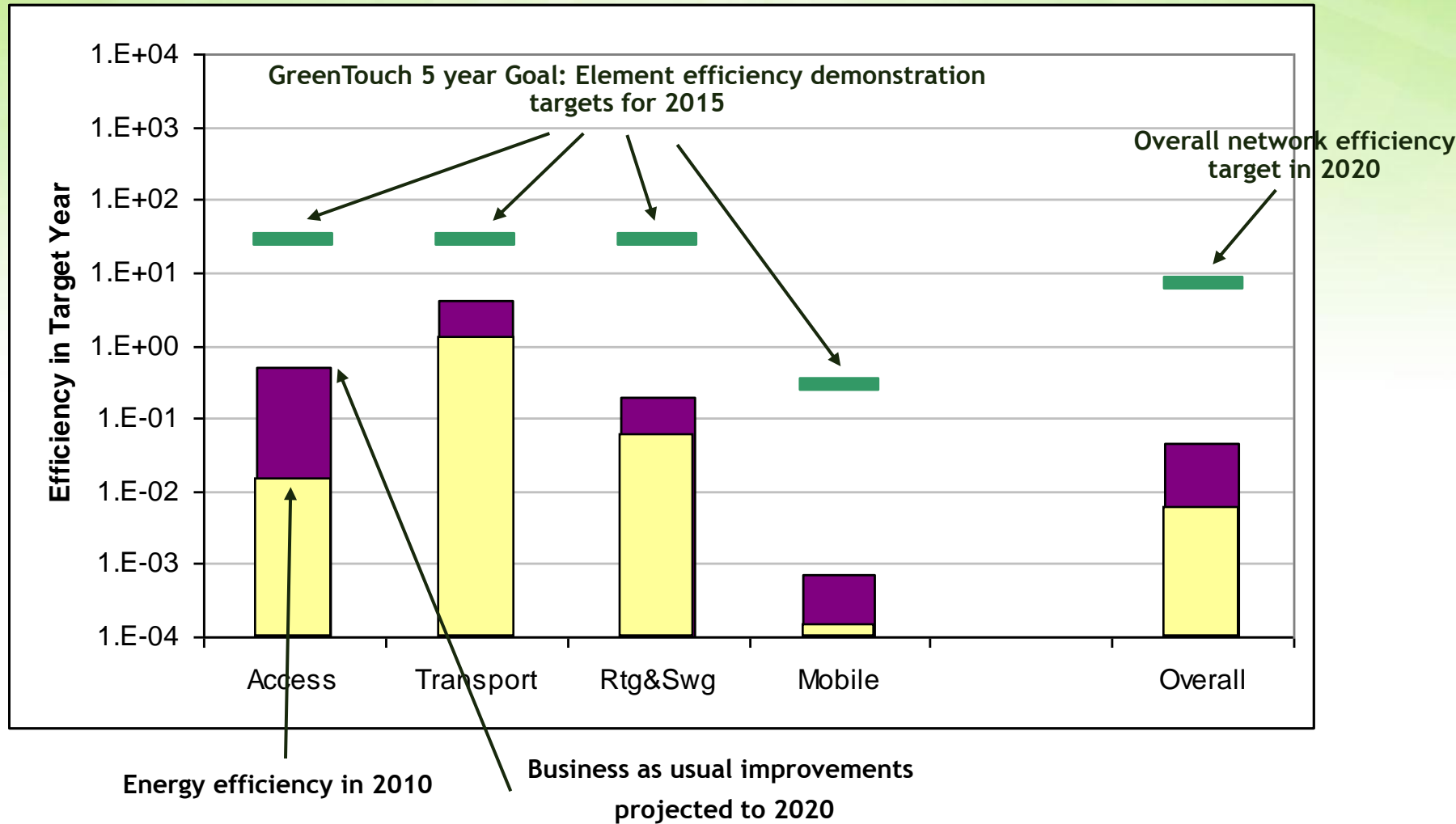
BIT-INTERLEAVING PON



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GETTING TO A FACTOR 1000



SIMPLE MODELS FOR EACH NETWORK ARCHITECTURE

This sheet contains key architecture- and scenario-defining parameter inputs for Model and final results computations.

Select Architecture: **Baseline**
Select Traffic Scenario: **Nominal**

Reference Mode: **Absolute**
Target (1000): **1000** Tgt Yr: **2020**

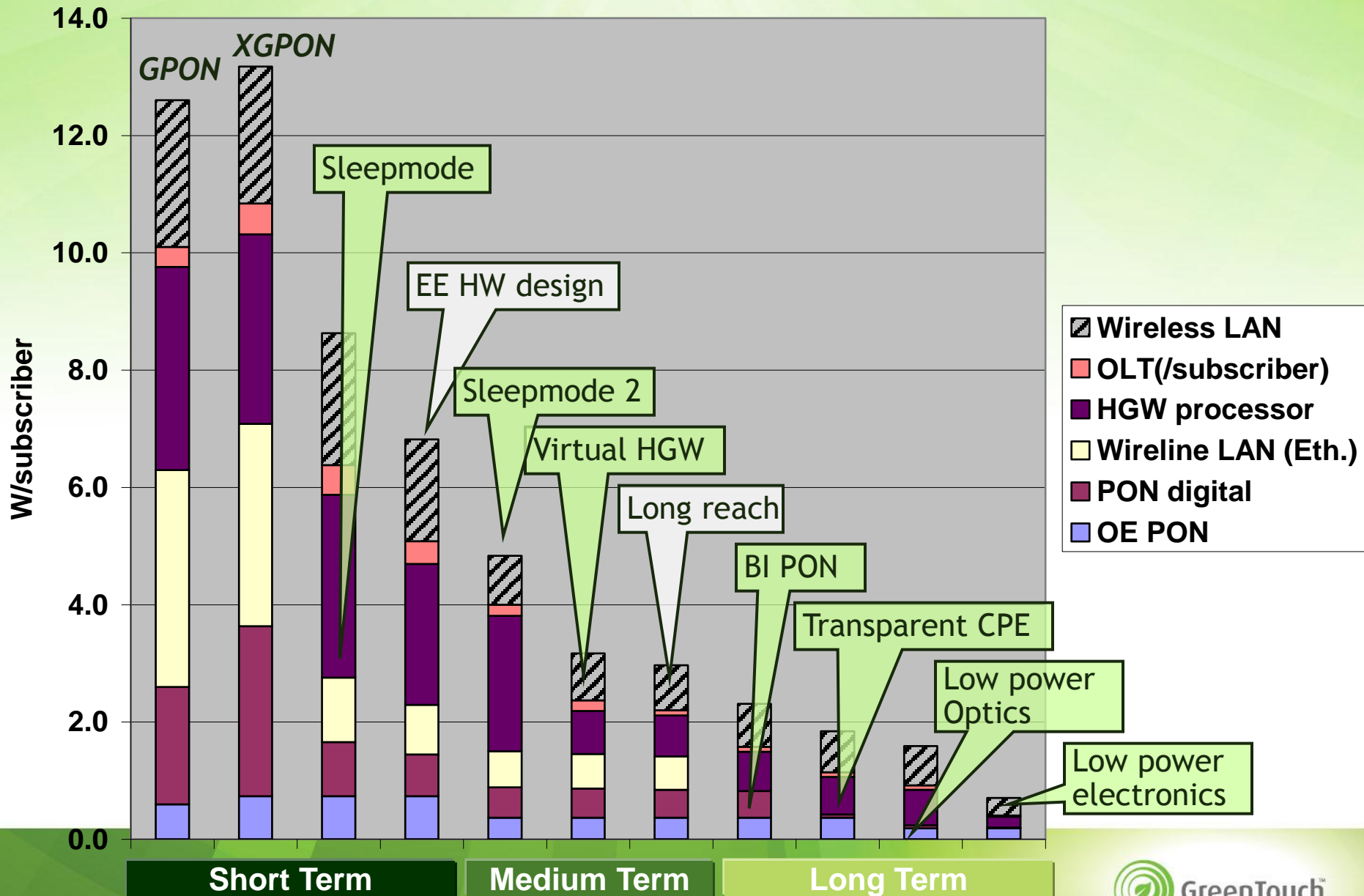


TRACKING PROGRESS TOWARDS OVERALL GOAL



- Define architectures and track research results
 - Identify targets for each architecture and update network efficiency in model as targets are achieved
 - Working groups define targets and evaluate completion
 - Targets can be achieved within GreenTouch projects or from broader community
 - Identify gaps in effort and solicit new activities

EXAMPLE OF MORE DETAILED ROADMAP



GREENTOUCH and GeSI

1. Smart Cities
2. 2020 Trends
3. Energy Surveys & Audits
4. Policy & Standards
5. Roadmap Equipment Trends
6. Micro-Traffic Models & Associated Technology Metrics

Next GreenTouch Meeting

June 5-7 in Dallas, TX



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

www.greentouch.org

GREENTOUCH MEMBERS

- Athens Information Technology (AIT) Center
- Bell Labs, Alcatel-Lucent
- Broadcom
- Carnegie Mellon University
- CEA-LETI Applied Research Institute for Microelectronics
- China Mobile
- Chunghwa Telecom
- Columbia University
- Commscope/Andrew
- Dublin City University
- ETRI
- ES Network/Lawrence Berkeley Labs
- Fondazione Politecnico di Milano
- Fraunhofer-Gesellschaft
- France Telecom
- Fujitsu
- Huawei
- IBBT
- IMEC
- Indian Institute of Science
- IIT Delhi
- INRIA
- KAIST
- Karlsruhe Institute of Tech.
- Katholieke Universiteit Leuven (K.U. Leuven)
- King Abdulaziz City for Science and Technology
- KT Corporation
- National Chiao Tung University
- National ICTA Australia
- Nippon Telegraph and Telephone Corp
- Politecnico di Torino
- Portugal Telecom Inovação, S.A.
- Samsung (SAIT)
- Shanghai Institute of Microsystems & Information Technology
- Swisscom
- TNO
- Tsinghua University
- TTI
- TU Dresden
- University College London
- University of Cambridge
- University of Delaware
- University of L'Aquila
- University of Leeds
- University of Manchester
- University of Maryland
- University of Melbourne's Institute for a Broadband-Enabled Society (IBES)
- University of Missouri-Kansas City
- University of New South Wales
- University of Paderborn
- University of Rochester
- University of Toronto
- Utah State University
- Vodafone Group
- Waterford Institute of Technology
- ZTE