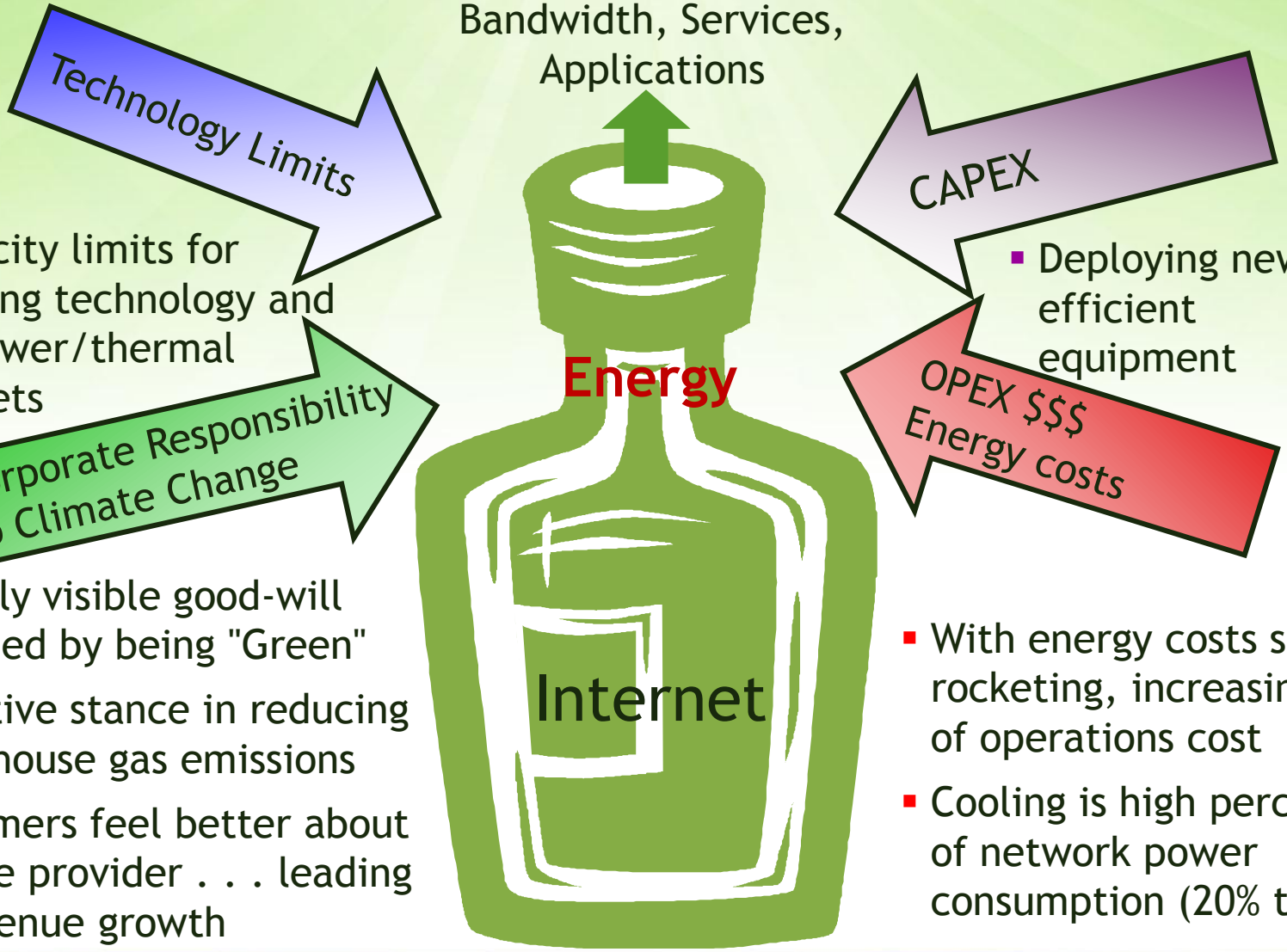
GreenTouch Consortium: Roadmap Review Nov. 2011

Dan Kilper
Chair, GreenTouch Technical Committee

Tightening Energy Bottleneck



- Capacity limits for existing technology and by power/thermal budgets
- Deploying new efficient equipment
- Publicly visible good-will provided by being "Green"
- Proactive stance in reducing greenhouse gas emissions
- Customers feel better about service provider . . . leading to revenue growth
- With energy costs sky-rocketing, increasing share of operations cost
- Cooling is high percentage of network power consumption (20% to 50%)

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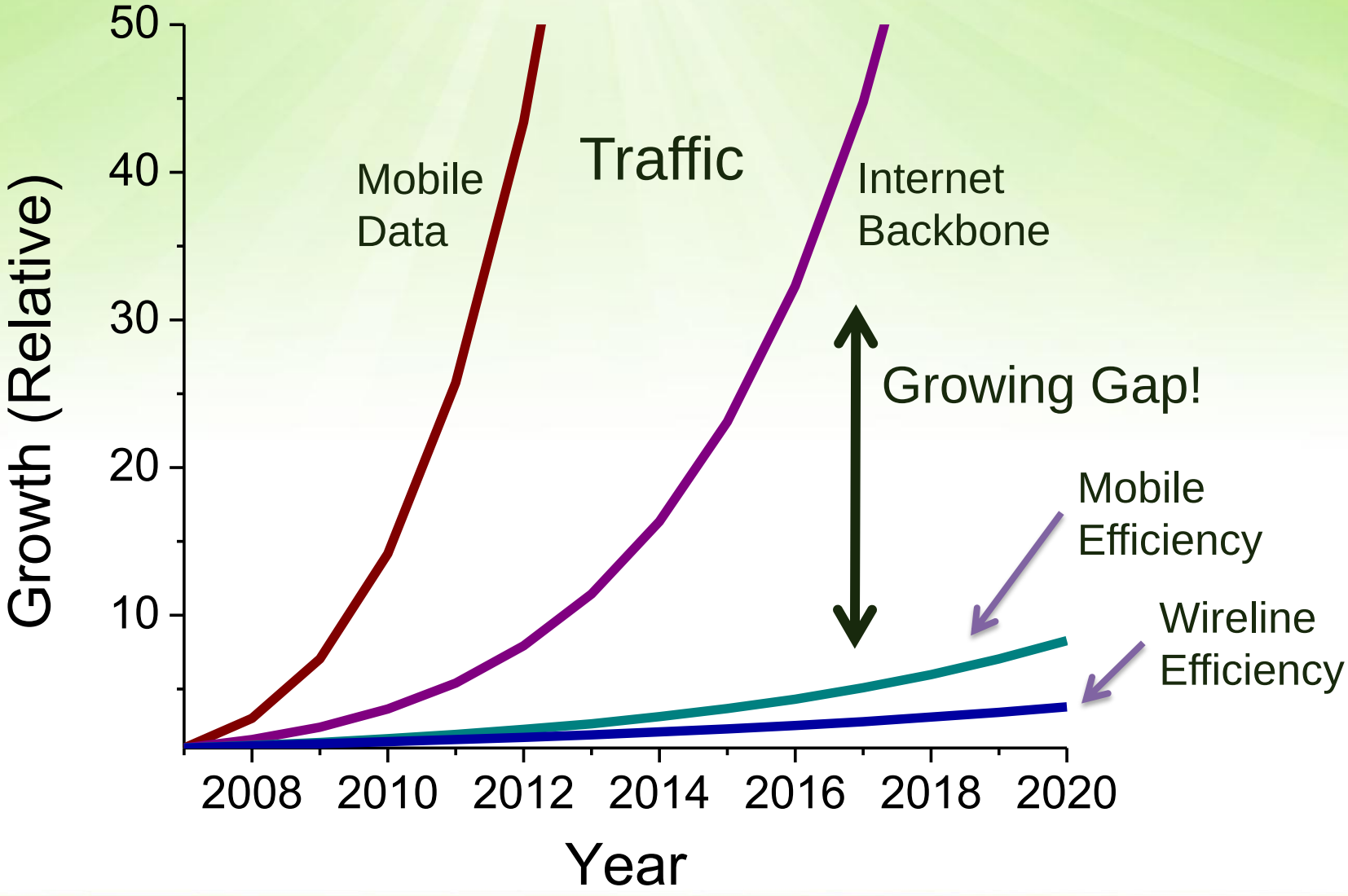
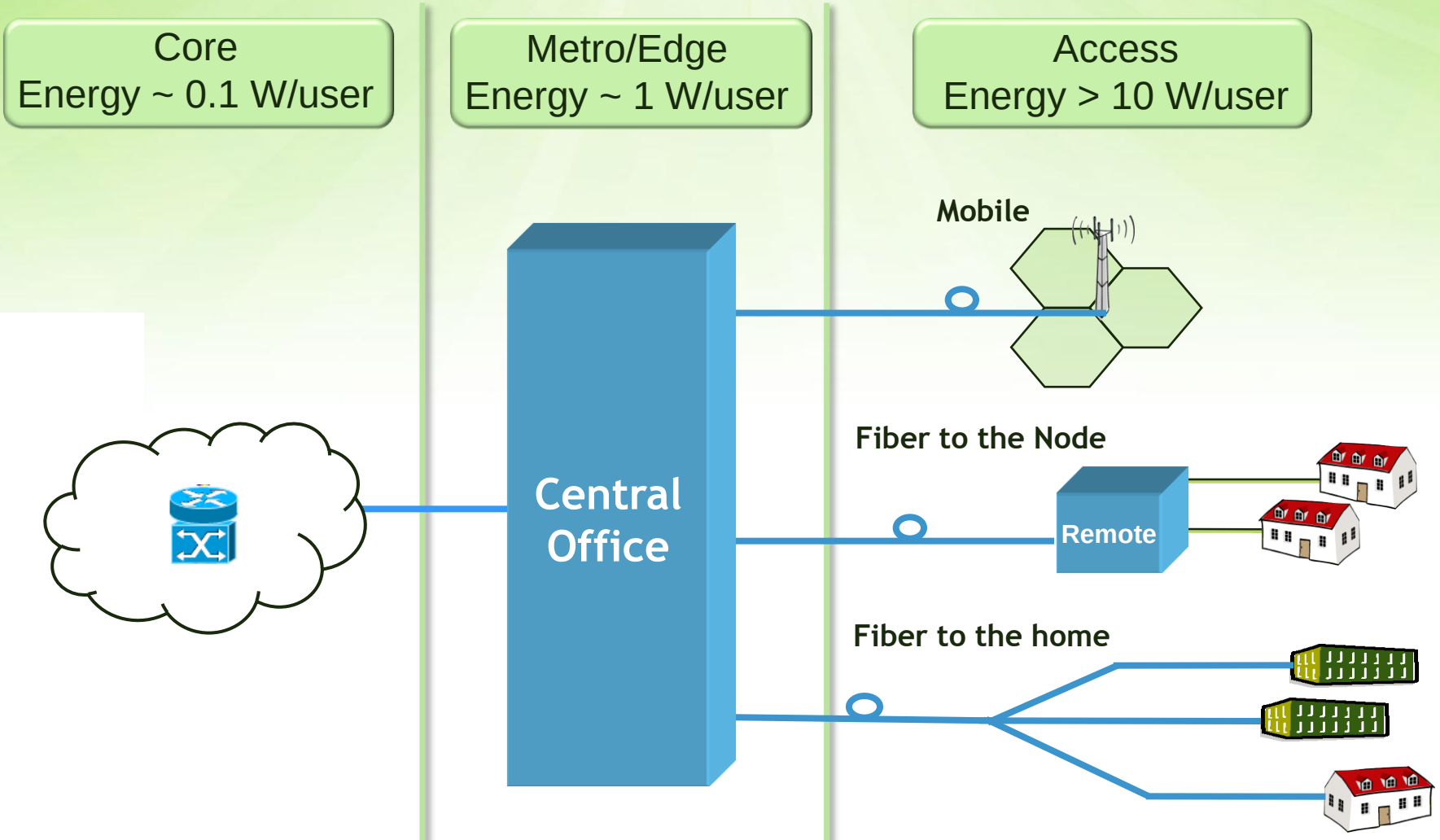
The Network Energy Gap



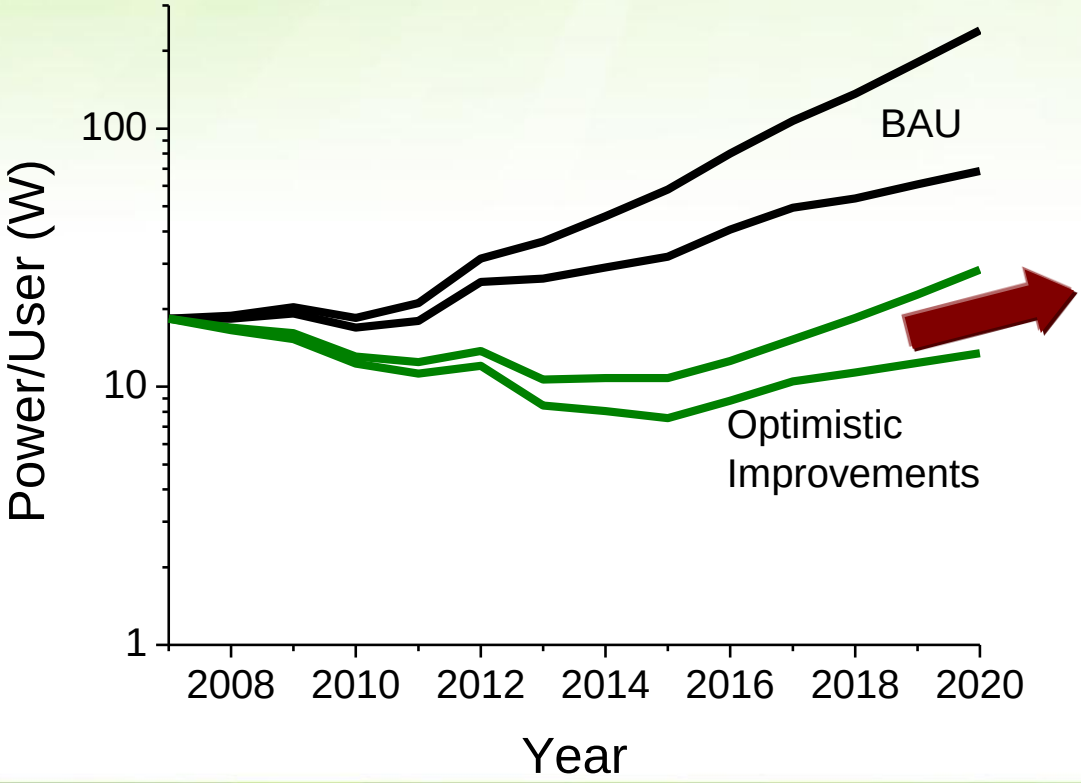
Energy Use is Largest at Endpoints: Access

Proliferation of Devices, Services, Platforms



Ideal Efficiency Improvements on BAU: Flat by 2020

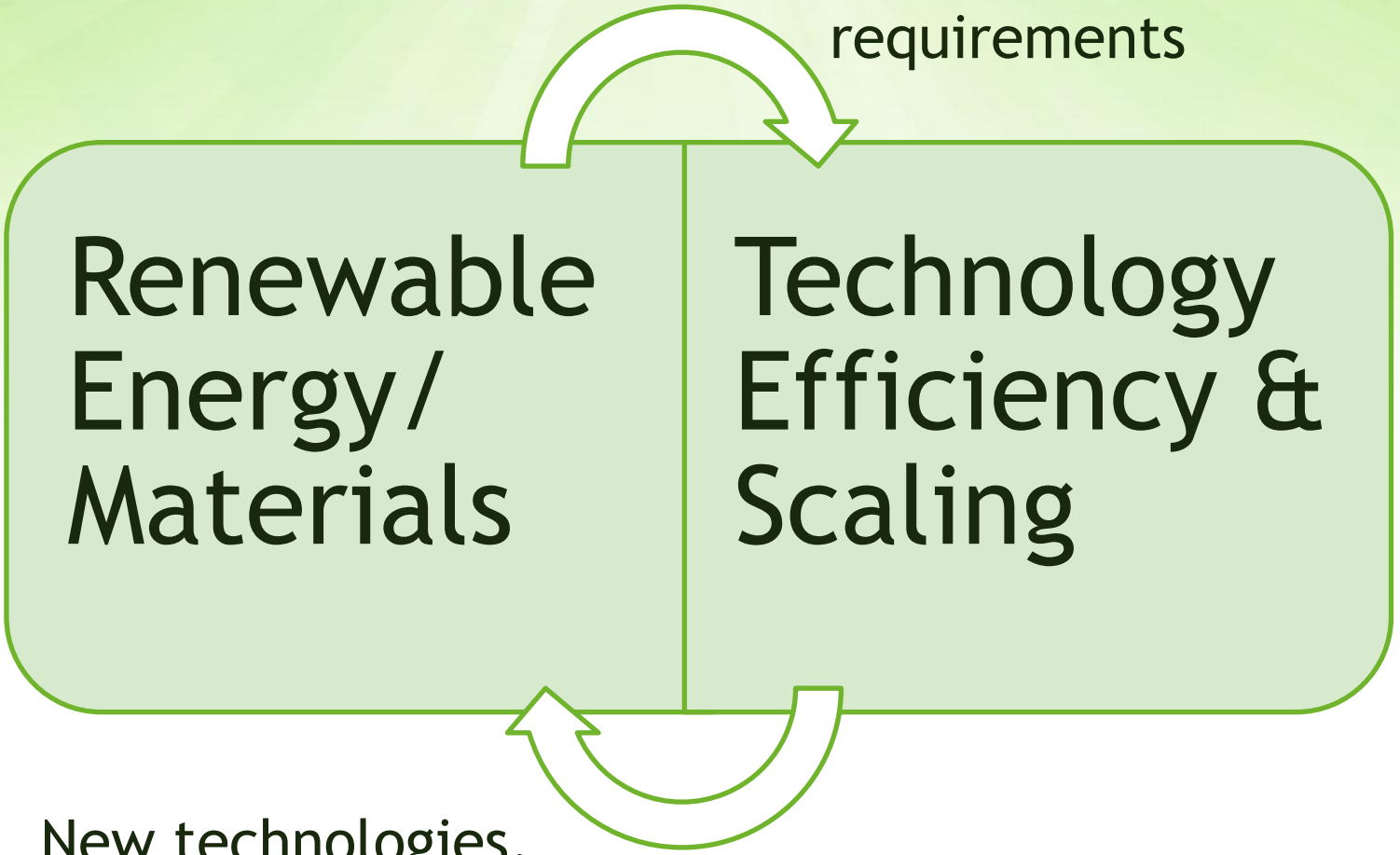
- Improving network efficiency at best keeps power consumption flat over next decade
  - What happens after 2020?
  - Can only use ‘sleep modes’ once



Current technology will only sustain us for another decade: how do we go beyond?

Kilper, et. al. JSTQE 2011

Finding a Balance



ICT Industry Responds

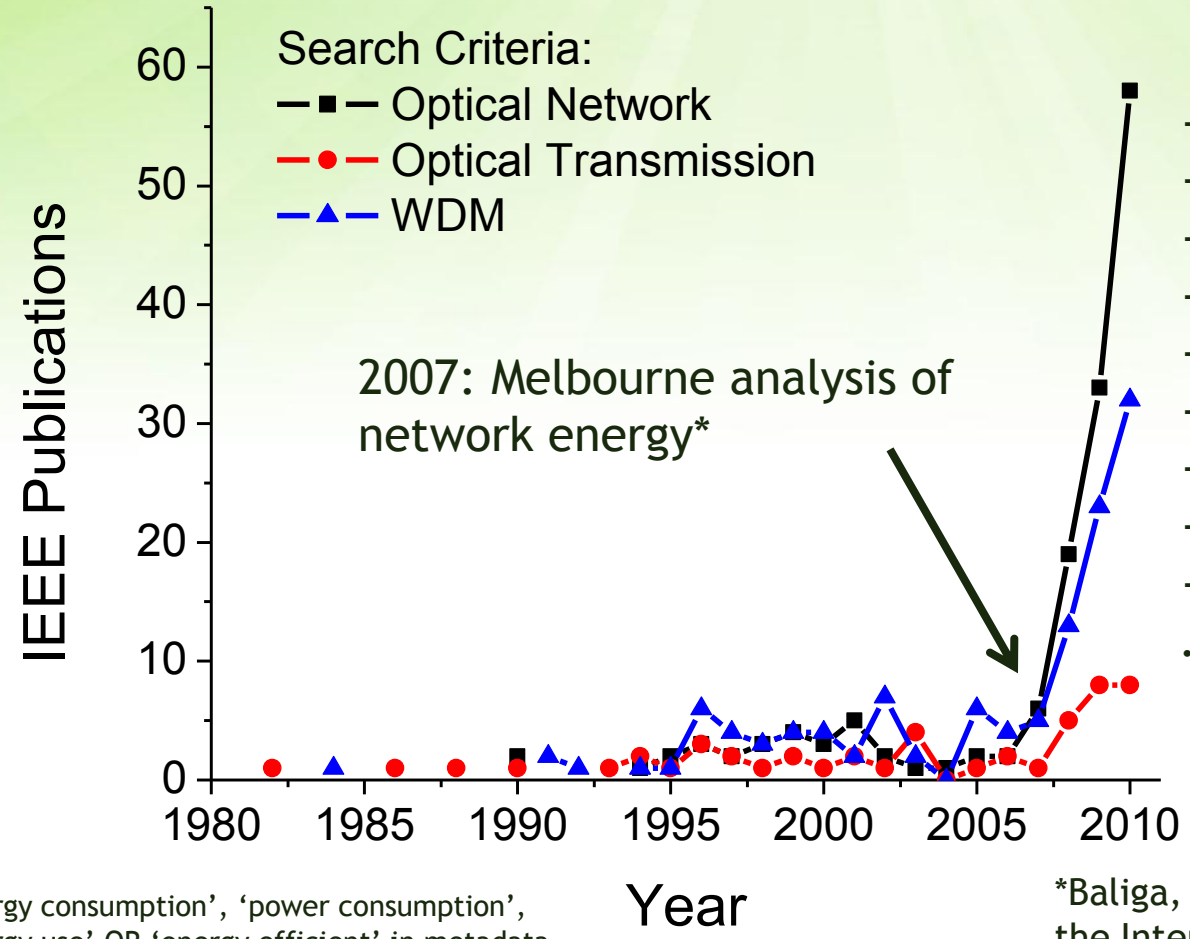
- First Step: metrics, awareness, standards, call to action
  - Global e-Sustainability Initiative (GeSI)
  - ITU-T
  - GreenGrid

Semiconductor Industry Already Organized for the Long View:

ITRS 15 years out

- Next Step: cooperation, action
  - EARTH: LTE 2x
  - Mobile VCE: Green Radio 100x
  - Institute for Energy Efficiency: Wireless and optical 100x
  - GreenTouch: ICT Networks 1000x

Growing Focus on Energy Efficiency



-Smart2020, WWF Reports
-EU Programs
-Wireless Energy Focus
-Router/CO Thermal Issues
-INTERNET
-CIAN
-GreenTouch
-CEET
-TOEC
…

'energy consumption', 'power consumption', 'energy use' OR 'energy efficient' in metadata

*Baliga, et. al., "Energy Consumption of the Internet" COIN-ACOFT 2007

Cooperating Organizations

ACCORDANCE — EU Consortium

- A converged copper-optical-radio OFDMA-based access network with high capacity and flexibility (Liaison partner: AIT)

CIAN — US Consortium

- Keren Bergman (Columbia Univ.) is a member of CIAN and facilitates cooperation with GreenTouch through the SEASON project.

GeSI — Global Consortium

- Established MoU to work together on e-sustainability initiatives

INTERNET — UK Consortium

- GreenTouch Core Switching & Routing Working Group members Jaafar Elmirghani (Univ. of Leeds) and Richard Penty (Cambridge Univ.) are members of the INTERNET consortium and facilitate cooperation with GreenTouch through the OPERA project.

ITRS — International Technology Roadmap for Semiconductors

- GreenTouch Technical Committee chair Dan Kilper (Bell Labs, ALU) is participating on the Assembly and Packaging technical working group as a liaison between the ITRS and GreenTouch.

Cooperating Organizations

ITU-T — JCA on ICT & Climate Change

- GreenTouch Executive Board member Claude Monney (Swisscom) is participating in this Joint Action Committee to share information between GreenTouch and ITU-T.

Microphotonics Center — US Research Center

- Established MoU to work cooperatively on common roadmap and lifecycle analysis problems

TUCAN — PIANO PLUS Consortium

- The project targets the development of a low cost tunable transceiver technology that will be capable of meeting access network cost targets whilst maintaining high performance and reducing power requirements (Liaison partner: University of Cambridge)

TREND — EU Network of Excellence

- GreenTouch Executive Board member Rodney Tucker (IBES, Univ. of Melbourne) is representing GreenTouch on the TREND Advisory Board; TREND members are active within GreenTouch technical committees.

What is GreenTouch?

GreenTouch Mission

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

- Broad, open and global consortium executing research projects to achieve aggressive goal
- Roadmap organization establishing reference architectures and research targets to overcome major challenges facing network scaling and energy
- Venue for cooperation and enabling demonstrations among research organizations
- Forum for the exchange of information on energy trends, challenges, & research on communication networks

GreenTouch Members

- AT&T Services
- Athens Information Technology (AIT) Center for Research & Education
- Bell Labs, Alcatel-Lucent
- Broadcom
- Carnegie Mellon University
- CEA-LETI Applied Research Institute for Microelectronics
- China Mobile
- Chunghwa Telecom
- Columbia University
- Commscope/Andrew
- Draka Communications
- Dublin City University
- ETRI
- ES Network/Lawrence Berkeley Labs
- Fondazione Politecnico di Milano
- Fraunhofer-Geselleschaft
- France Telecom
- Freescale Semiconductor
- Fujitsu
- Huawei
- IBBT
- IIT Dehli
- IMEC
- INRIA
- KAIST
- Karlsruhe Institute of Technology
- Katholieke Universiteit Leuven (K.U. Leuven)
- King Abdulaziz City for Science and Technology
- KT Corporation
- National ICTA Australia
- Nippon Telegraph and Telephone Corp
- Politecnico di Torino
- Portugal Telecom Inovação, S.A.
- Samsung (SAIT)
- Seoul National University
- 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 New South Wales
- University of Paderborn
- University of Rochester
- University of Toronto
- Waterford Institute of Technology
- ZTE

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GreenTouch Approach

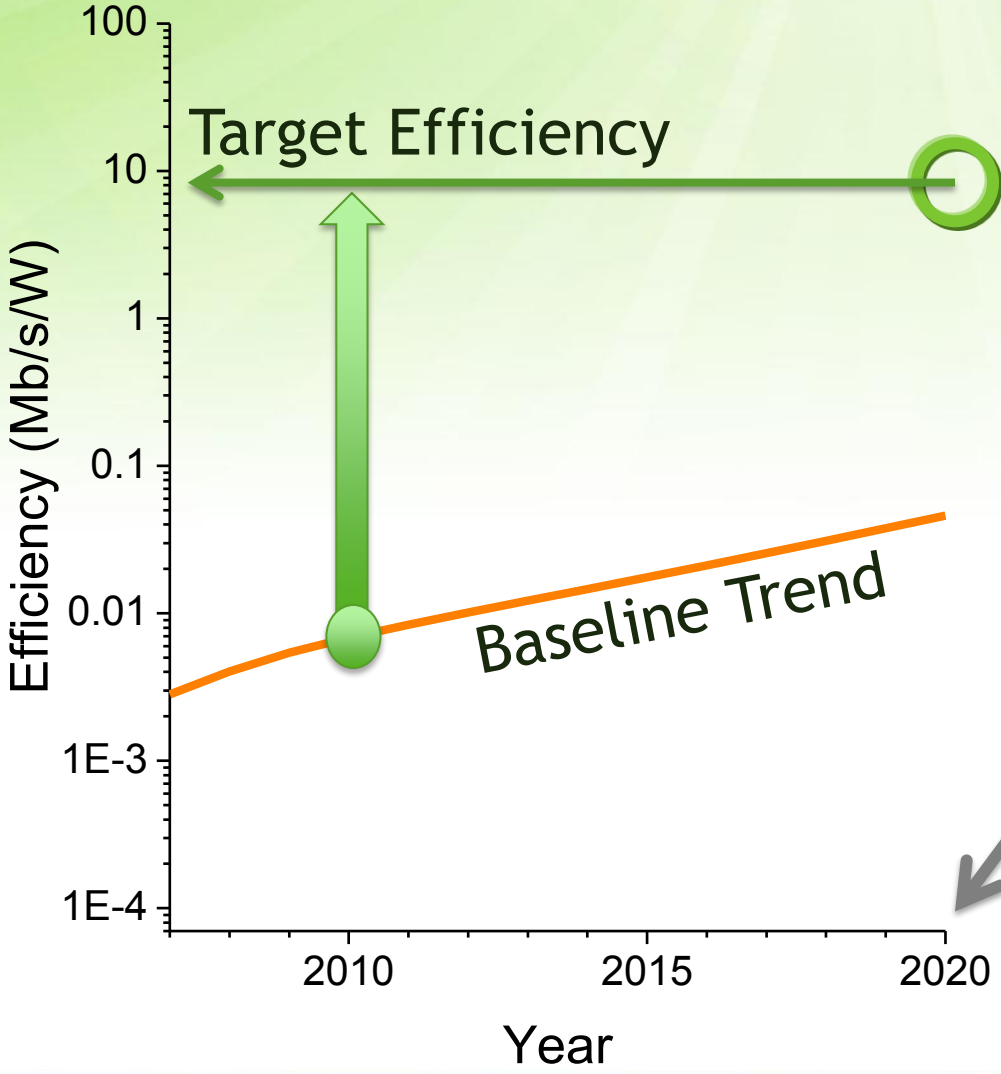
- Bottom Up Research Organization
- Use of models to structure and guide research and collaboration
- Funding through member contributions & external sources
- Gauge impact of innovations on:
  - Alternative metrics (carbon footprint, network power, embedded energy)
  - Adjacent technologies (data centers, handsets)
- Measure, model and predict energy consumption in ICT networks (equipment trends, traffic, deployment)

GreenTouch Roadmap

- Where we are and where we need to get to…
  - Accounting for the major research challenges & targets
- Architecture Document
  - Captures models/trends from Network & SAT Committees
  - Describes baseline architecture(s)
  - Describes key research challenges & targets to achieve GT goals
- Roadmap Spreadsheet
  - Tables from Architecture Document
  - Key research challenges & targets
  - Baseline models and data

Final documents coming soon…

Consortium 5 Year Goal



- Define architectures
- Demonstrate tech.

Use models for network in 2020 to set technology demonstration requirements

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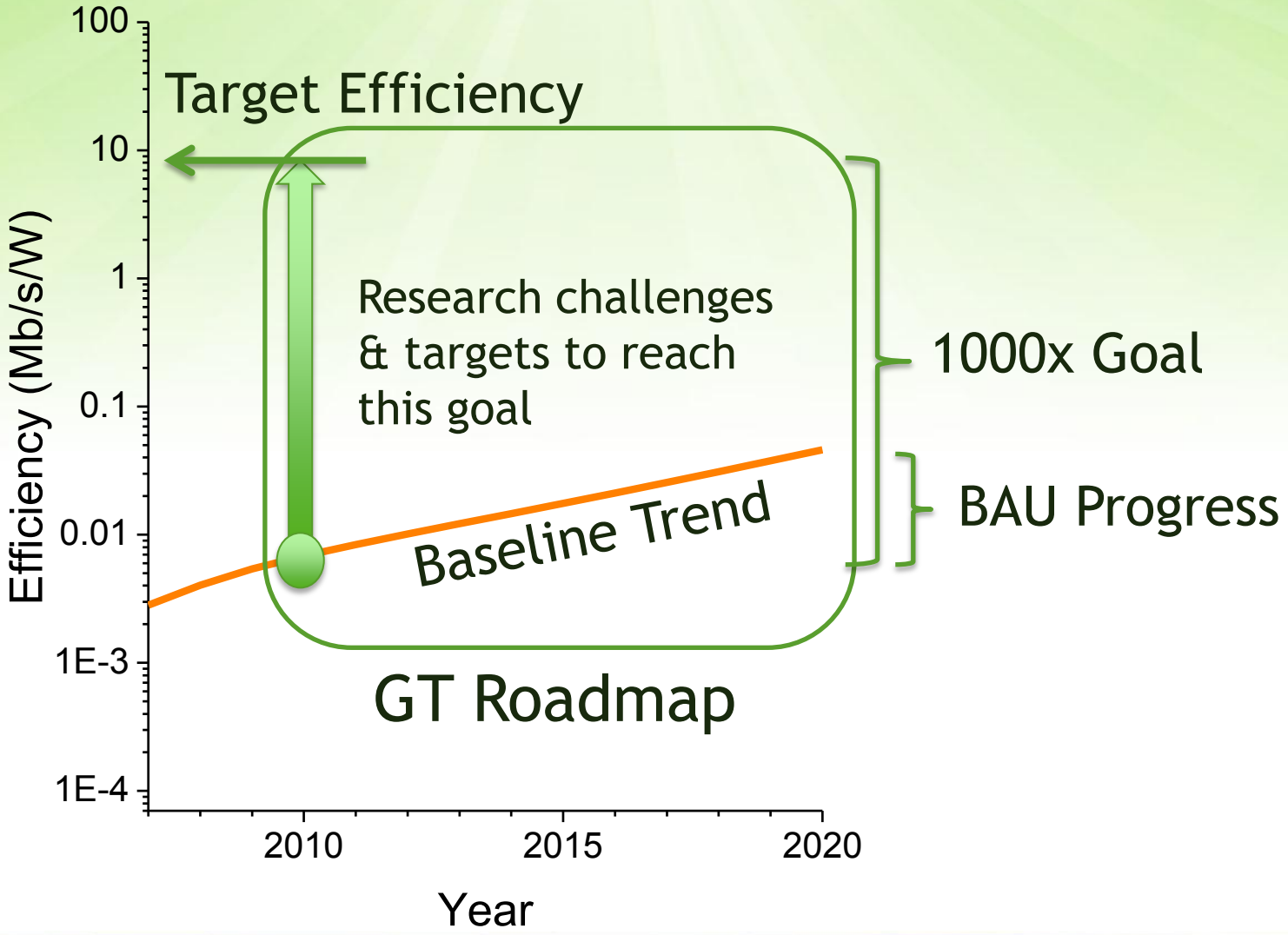
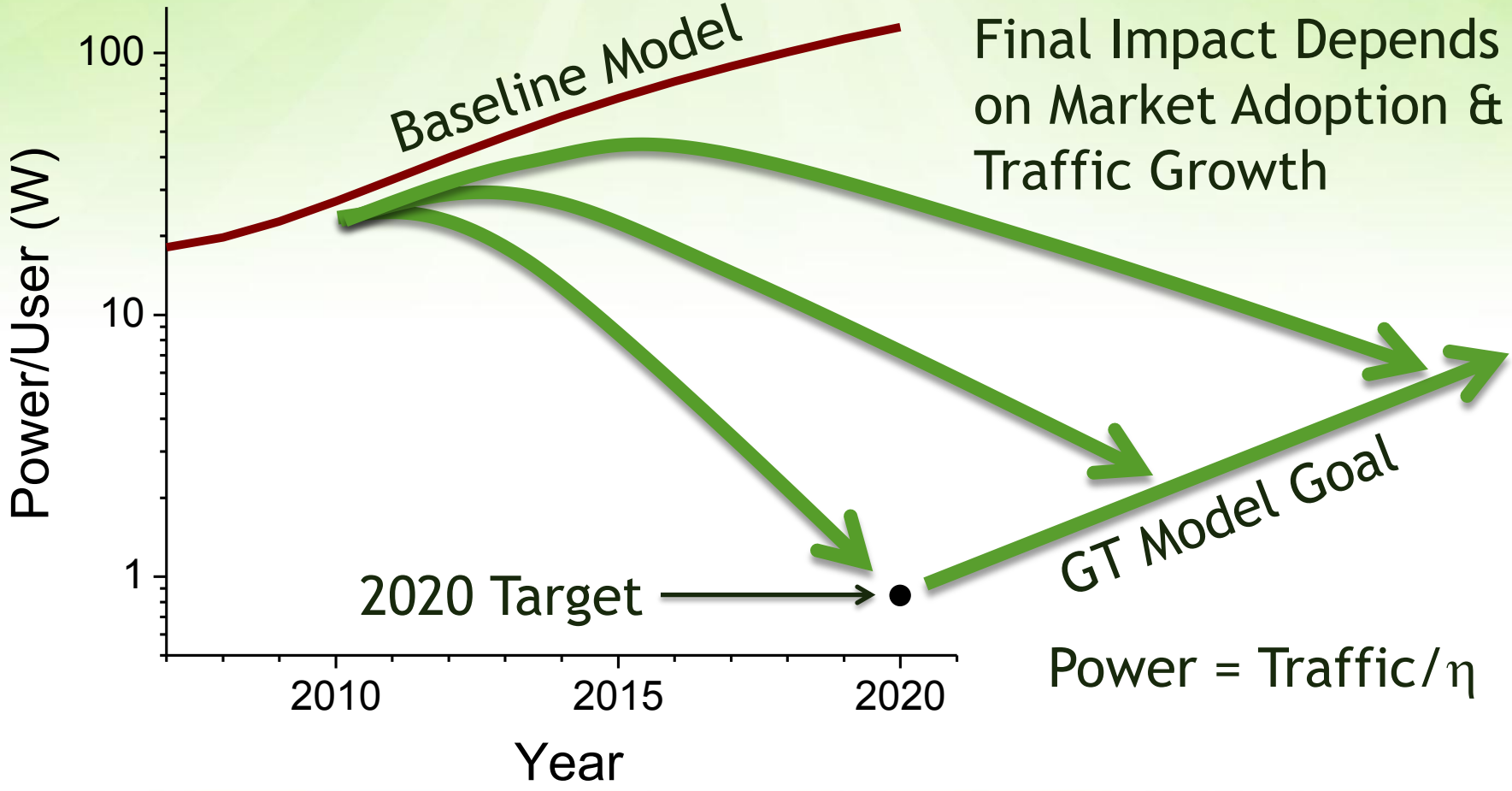
GreenTouch Roadmap



Overall Power/User Impact



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Cooperation

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New Approaches: Focus on Energy

- New devices
  - Analog vs digital, best use of optics and electronics
  - Old ideas finding new life: large scale MIMO
- New architectures
  - trade-off transmission/bandwidth and processing, distributed versus centralized
- New protocols
  - Longer packet sizes or no packets at all for certain applications
- Service optimized networks
  - Move away from one size fits all—use most energy efficiency hardware for the service
  - Coordinate service delivery/applications with network hardware operation
- Restructuring layers, architectures, feature options
  - How much do way pay in energy for convenience? duplicated functions (FEC)?
  - What technologies do we really need in order to support the essential capabilities?

Minimizing Processing

- Repetition
  - Unnecessary router hops
  - Inter-operator exchange
  - Multiple transmissions
- Remove processing from the data path
  - Separate control channel?
- Focus on Service
  - Content delivery vs. browsing vs messaging
- Push to the edges
  - FEC
  - Security, policy processing
- Simplified Addressing
  - Geographic addressing/binary switching

Separate what is needed from what is convenience

A Scalable Internet: Holistic Re-Design

- Processing
  - New addressing—transparent data flow
  - End-to-End—security, FEC
- Back to the Future
  - Optimized hardware for given task: service differentiation
    - Take the movies out of the routers
- How many layers do we need?
- How do protocols and algorithms impact hardware design?
- How do we unlock physical potential—small cells, efficient MIMO?
- What is the real energy cost for the features and functions supported in the network?

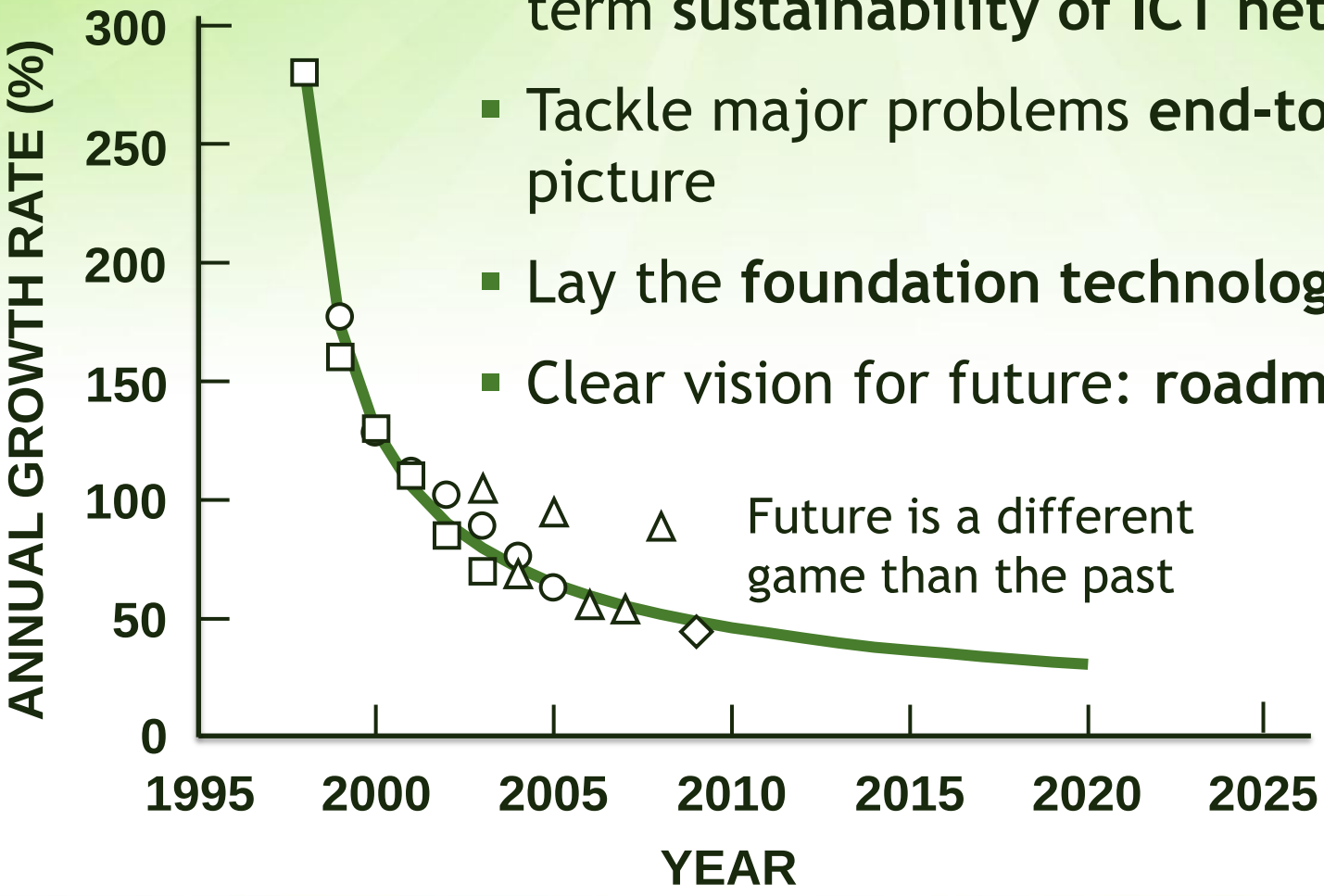
Current GreenTouch Projects

- Mobile Communication Networks (Ulrich Barth), MCN
  - BCG^2: Beyond Cellular Green Generation*
  - GTT: Green Transmission Technologies*
  - LSAS: Large Scale Antenna Systems*
- Wireline Access (Peter Vetter), WA
  - Minimum Energy Access Architectures
    - Minimum energy access architecture demonstration
  - VHG: Virtual Home Gateway
- Core Switching and Routing (Thierry Klein), CSR
  - OPERA: Optimal End to End Resource Allocation
  - STAR: Switching & Transmission
  - REPTILE: Router Power Measurements
  - SCORPION: Silicon Photonic Interconnects and Single Chip Linecard
  - ZeBRA: Zero Buffer Router Architectures
- Core Optical Networking and Transmission (Bill Shieh), CONT
  - SEASON: Service Energy Aware Sustainable Optical Networks*
  - HALF MOON: Highly Adaptive Layer for Mesh On-off Optical Networks
  - EFICOST: Energy Efficient High Capacity OFDM Signal Transmission
- Services Applications & Trends Committee (Steve Korotky), SAT
  - Telecommunication Audits and Data Aggregation

*Cluster project made up of several sub-projects/activities

Opportunities

- A global organization dedicated to the long term **sustainability of ICT networks**
- Tackle major problems **end-to-end**, full picture
- Lay the **foundation technologies**
- Clear vision for future: **roadmap**



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Thank You

www.greentouch.org