The environmental sustainability of the Internet for all and everything
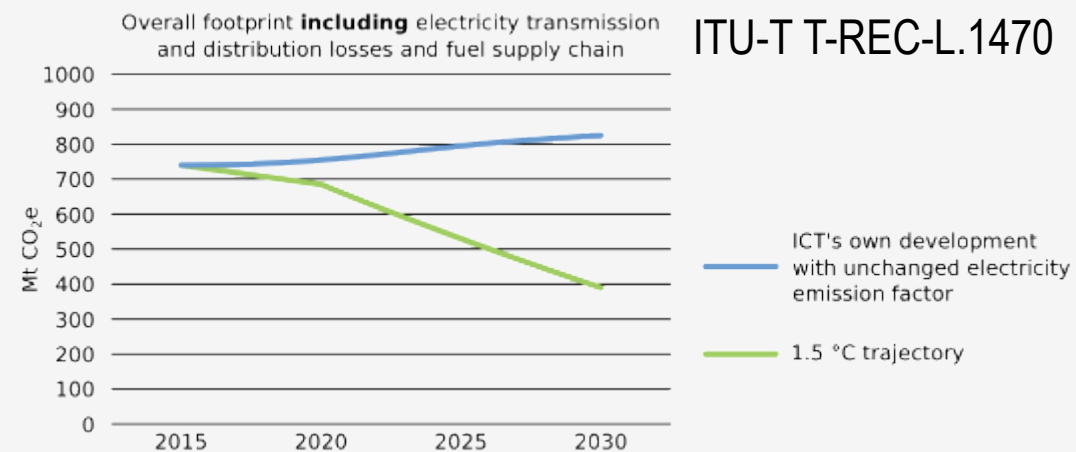
- **Leandro Navarro**

  UPC.EDU

  leandro.navarro@upc.edu

Situation

- More than 6 billion new ICT goods are sold annually worldwide, and beyond 28 billion are expected in 2025

- Can we afford the growth of ICT devices for more people (*everyone*), more devices per person (*mobiles, laptops, desktops, servers, cloud providers, the internet, mobile networks*), more IoT (*everything*)

- … and the energy spent in all we do on the Internet?

- Climate change and environmental degradation are an existential threat to the world

- Decarbonisation: reduction of green-house gas (GHG) emissions

Goals?

Overall footprint **including** electricity transmission and distribution losses and fuel supply chain

Mt CO₂e / 2015 2020 2025 2030

ICT's own development with unchanged electricity emission factor

1.5 °C trajectory

- Reduction of environmental impact of about 50% by 2030 to align with the 1.5°C trajectory, or the 2ºC severe effects, or …

- Contribution of ICT in electricity usage is a major green-house gases factor:

  - By 2030 it could use up to 51% of global electricity, and contribute up to 23% of globally released GHG emissions

A. Andrae, T. Edler. *On Global Electricity Usage of Communication Technology: Trends to 2030*. Challenges 2015

GHG emissions across the life cycle of a smartphone

J. Suckling, J. Lee. *Redefining Scope: The True Environmental Impact of Smart-phones?* International Journal of Life Cycle Assessment, 2015
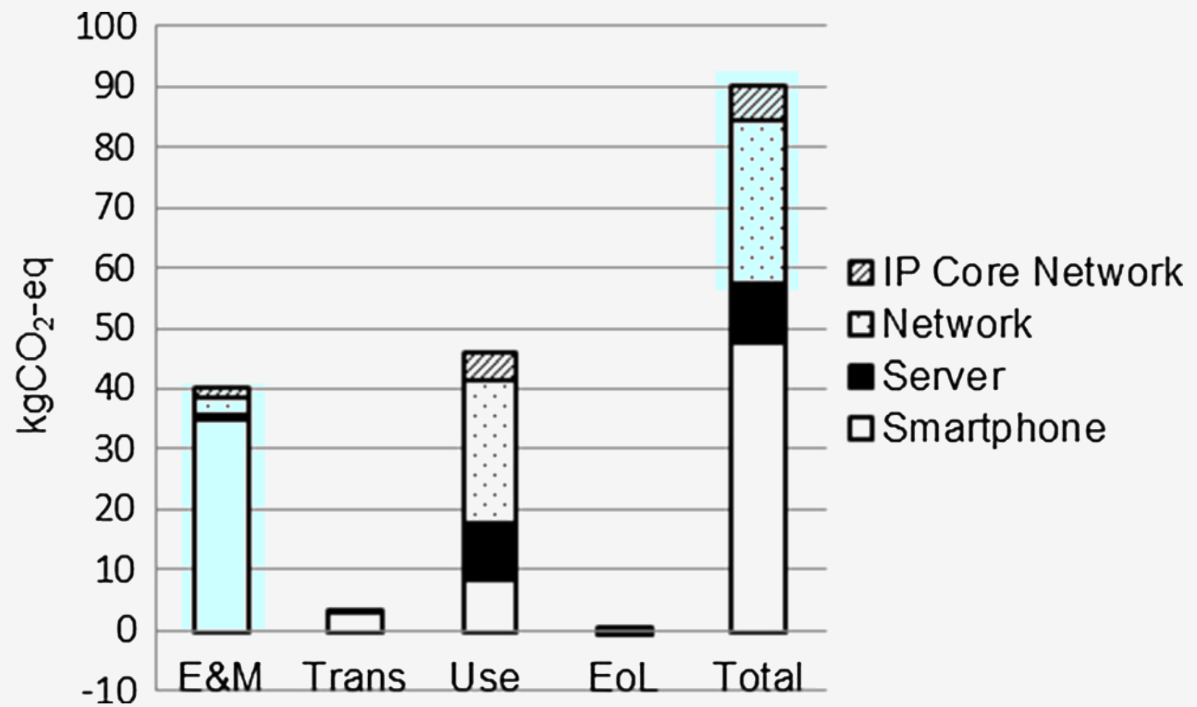
The global warming potential for a mobile phone with two year usage life-cycle

A. Andrae, *Life-Cycle Assessment of Consumer Electronics: A review of methodological approaches*, IEEE Consumer Electronics Magazine, 2016
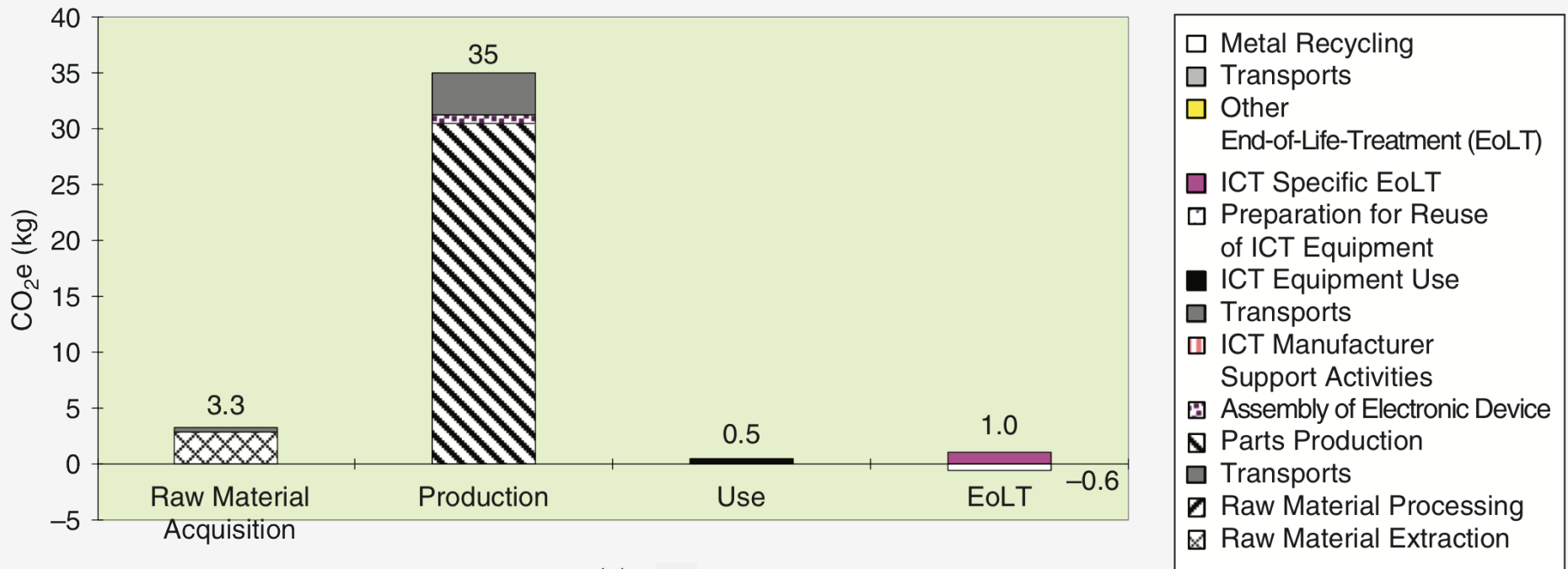
Questions

- Fast-forward 10 or 20 years,
  can we imagine a scenario by 2030 or 2040?

- How to achieve a desirable scenario?

- Need for changes on how the Internet works?

  - Architecture: caching, replication, locality, asynchrony, slower

  - Protocols: format, overhead reduction, slowdown

  - Formats: less verbose, compression

  - Parameters: timers, negotiation

Environmental protocol considerations: energy

RFC 6464	ASCII, PDF, HTML	**A Real-time Transport Protocol (RTP) Header Extension for Client-to-Mixer Audio Level Indication**	J. Lennox, Ed., E. Ivov, E. Marocco	December 2011		Proposed Standard
RFC 6465	ASCII, PDF, HTML	**A Real-time Transport Protocol (RTP) Header Extension for Mixer-to-Client Audio Level Indication**	E. Ivov, Ed., E. Marocco, Ed., J. Lennox	December 2011		Proposed Standard
RFC 6988	ASCII, PDF, HTML	**Requirements for Energy Management**	J. Quittek, Ed., M. Chandramouli, R. Winter, T. Dietz, B. Claise	September 2013		Informational
RFC 7228	ASCII, PDF, HTML	**Terminology for Constrained-Node Networks**	C. Bormann, M. Ersue, A. Keranen	May 2014		Informational
RFC 7326	ASCII, PDF, HTML	**Energy Management Framework**	J. Parello, B. Claise, B. Schoening, J. Quittek	September 2014		Informational
RFC 7460	ASCII, PDF, HTML	**Monitoring and Control MIB for Power and Energy**	M. Chandramouli, B. Claise, B. Schoening, J. Quittek, T. Dietz	March 2015		Proposed Standard
RFC 7461	ASCII, PDF, HTML	**Energy Object Context MIB**	J. Parello, B. Claise, M. Chandramouli	March 2015		Proposed Standard
RFC 7577	ASCII, PDF, HTML	**Definition of Managed Objects for Battery Monitoring**	J. Quittek, R. Winter, T. Dietz	July 2015		Proposed Standard
RFC 7603	ASCII, PDF, HTML	**Energy Management (EMAN) Applicability Statement**	B. Schoening, M. Chandramouli, B. Nordman	August 2015		Proposed Standard
RFC 7668	ASCII, PDF, HTML	**IPv6 over BLUETOOTH(R) Low Energy**	J. Nieminen, T. Savolainen, M. Isomaki, B. Patil, Z. Shelby, C. Gomez	October 2015		Proposed Standard
RFC 7772 a.k.a. BCP 202	ASCII, PDF, HTML	**Reducing Energy Consumption of Router Advertisements**	A. Yourtchenko, L. Colitti	February 2016		Best Current Practice
RFC 8036	ASCII, PDF, HTML	**Applicability Statement for the Routing Protocol for Low-Power and Lossy Networks (RPL) in Advanced Metering Infrastructure (AMI) Networks**	N. Cam-Winget, Ed., J. Hui, D. Popa	January 2017		Proposed Standard
RFC 8105	ASCII, PDF, HTML	**Transmission of IPv6 Packets over Digital Enhanced Cordless Telecommunications (DECT) Ultra Low Energy (ULE)**	P. Mariager, J. Petersen, Ed., Z. Shelby, M. Van de Logt, D. Barthel	May 2017		Proposed Standard
RFC 8352	ASCII, PDF, HTML	**Energy-Efficient Features of Internet of Things Protocols**	C. Gomez, M. Kovatsch, H. Tian, Z. Cao, Ed.	April 2018		Informational

Even more ...

- Locality of edge/fog computing?

- Servitised user-devices: light clients (xterminal like)

- Env accountability:

  - GHG metering, reporting: per device, per org

  - Circular economy: reuse of devices (2nd hand): traceability from manufacturing until final recycling

  - Environmental limits, env budget? Environmental congestion control, caching, rate/update limits?

Lessons, actions
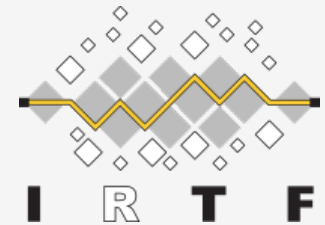
- GAIA! Network + end-hosts + people
  + things + environmental limits

- Sustainability: the Internet adds or subtracts on GHG
  Better materials, better energy, more durable, less usage ...

- Lightness: materials, energy, processing, data, ...

- Locality of data and computation, caching, replication,
  slower by design or choice (asynchrony), limits ...

- Any lesson from COVID?

- How to turn into IRTF research, discussion, documents