Optical Networks & Green IT

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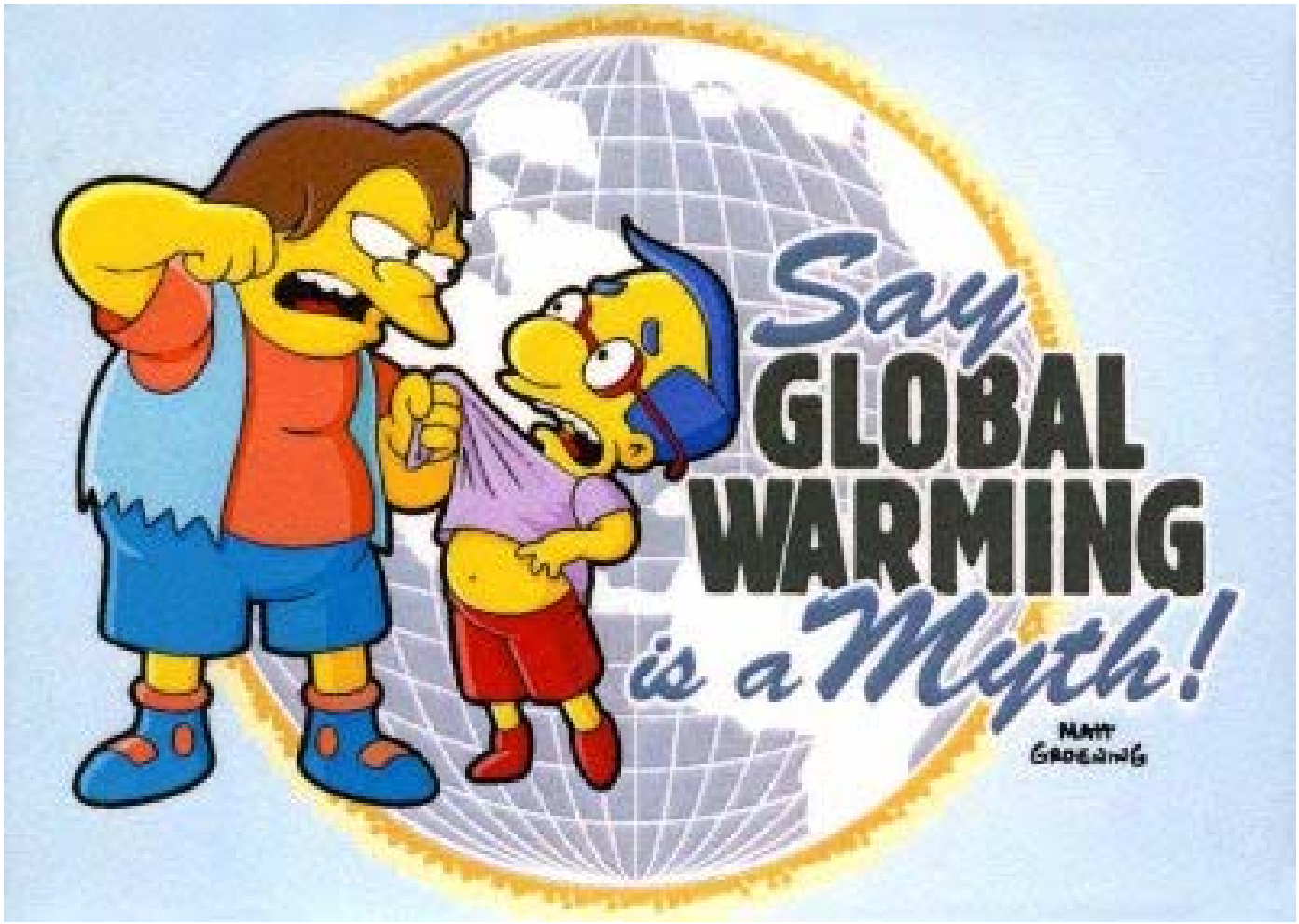
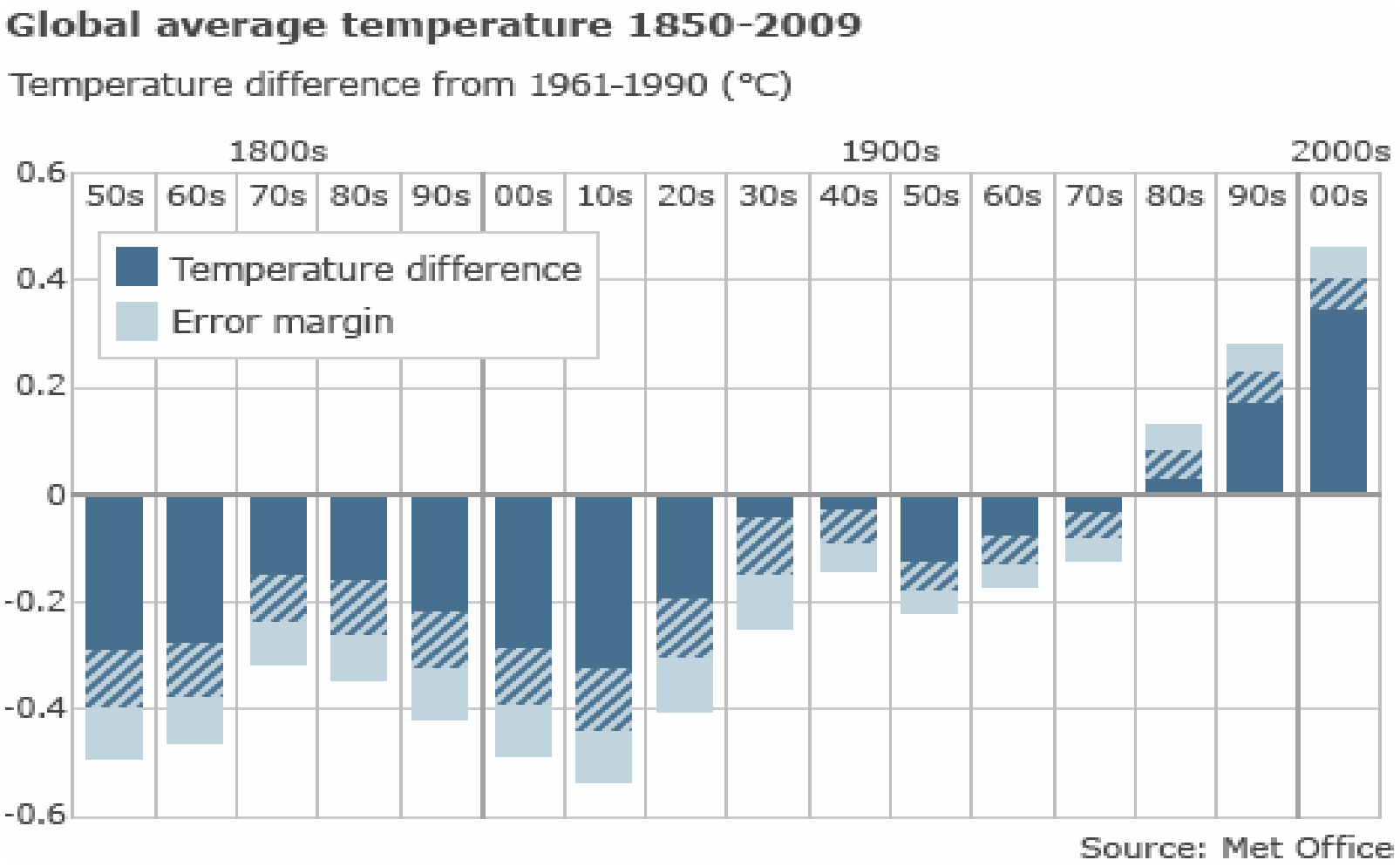

Say
GLOBAL
WARMING
is a Myth!
MATT GROENING

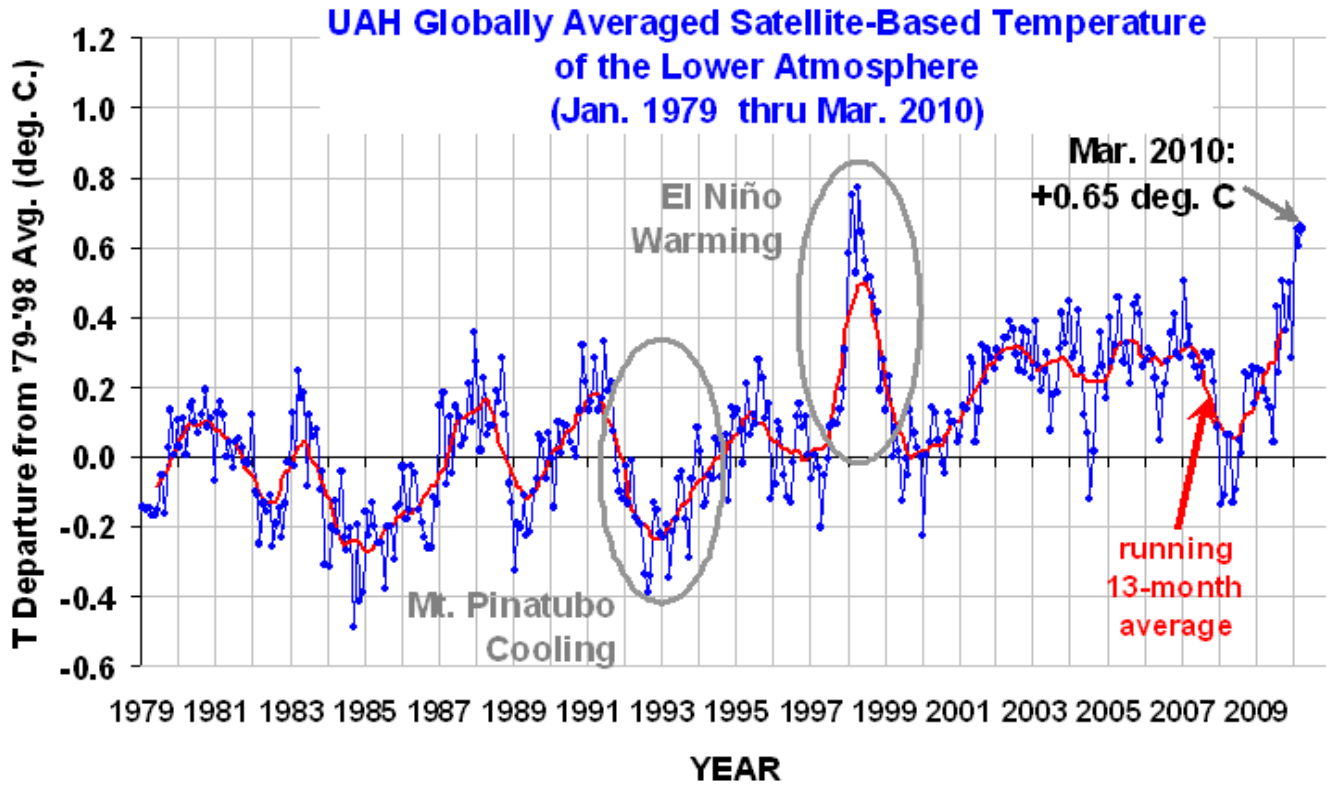
Global Average Temperature



2009 second warmest year ever

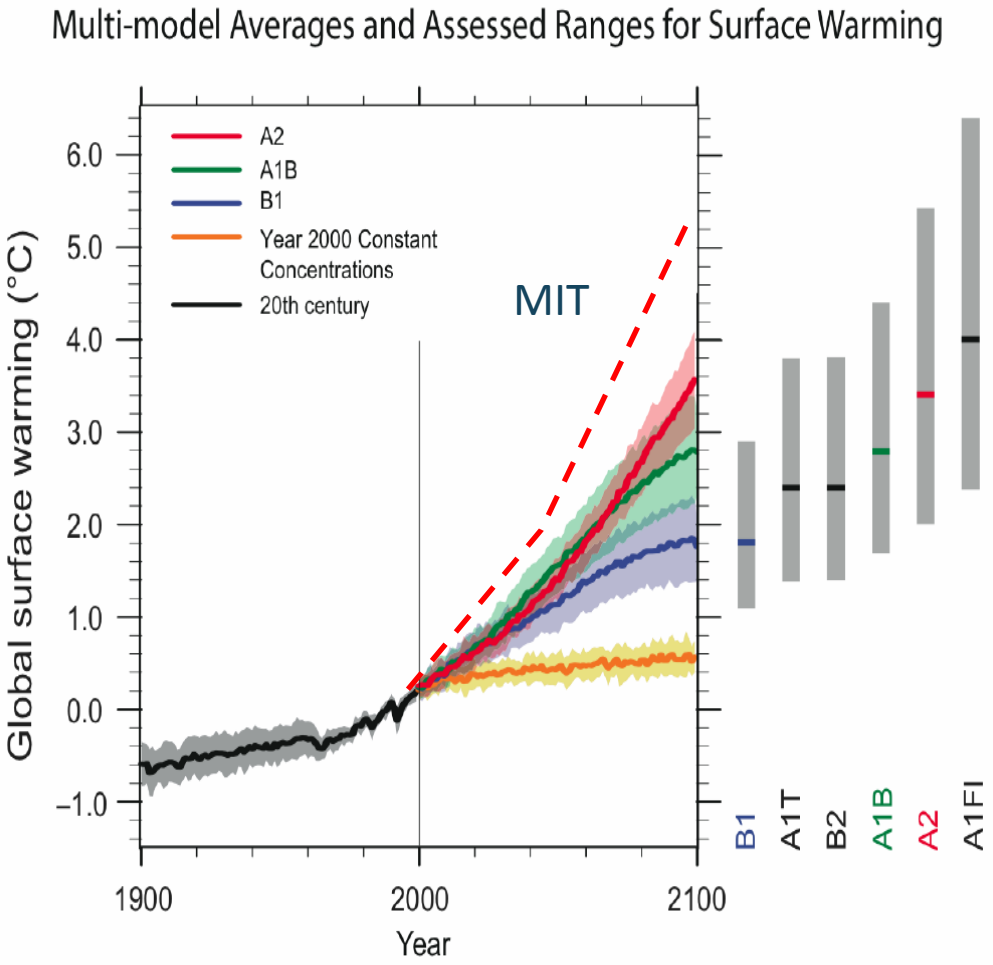
Jan, Feb Mar 2010 warmest ever

This is despite a solar sun spot minimum



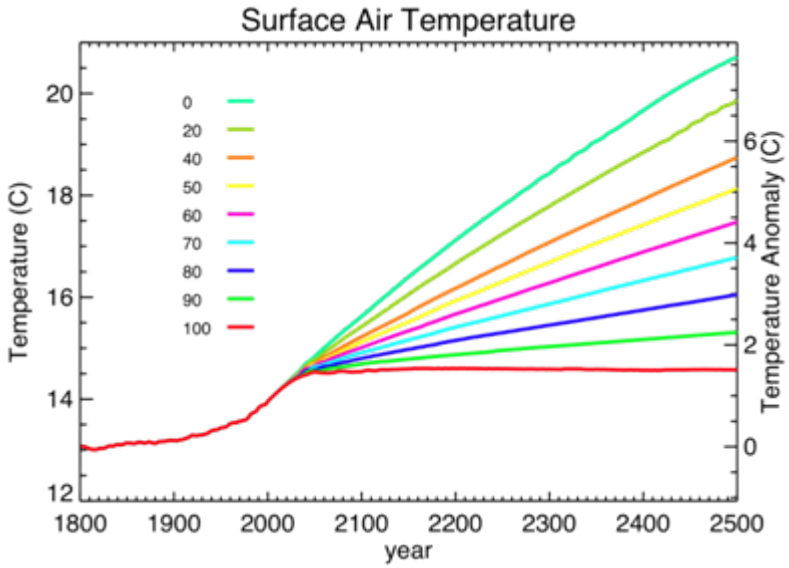
Climate Forecasts

- MIT report predicts median temperature forecast of 5.2°C
  - 11°C increase in Northern Canada & Europe
  - http://globalchange.mit.edu/pubs/abstract.php?publication_id=990
- Last Ice age average global temperature was 5-6°C cooler than today
  - Most of Canada & Europe was under 2-3 km ice
  - With BAU we are talking about 5-6°C change in temperature in the opposite direction in less than 80 Years



Climate Change is not reversible

- Climate Change is not like acid rain, water management or ozone destruction where environment will quickly return to normal once source of pollution is removed
- GHG emissions will stay in the atmosphere for thousands of years and continue to accumulate
- Planet will continue to warm up even if we drastically reduce emissions



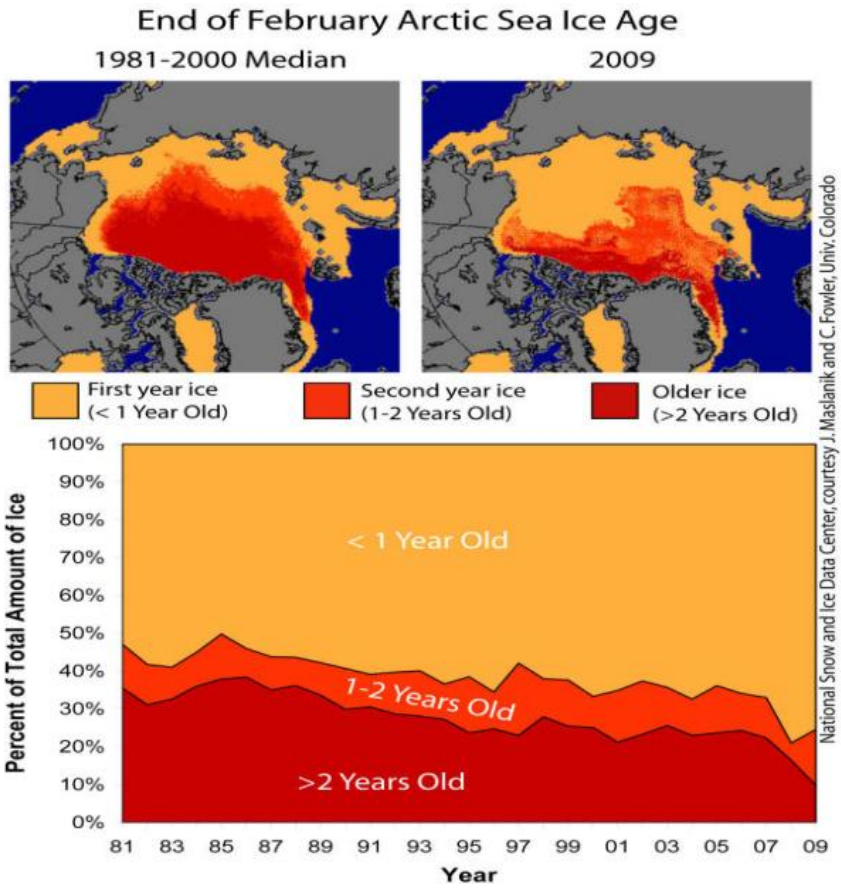
Weaver et al., GRL (2007)

All we hope to achieve is to slow down the rapid rate of climate change

Climate tipping points

- USGS report finds that future climate shifts have been underestimated and warns of debilitating abrupt shift in climate that would be devastating.

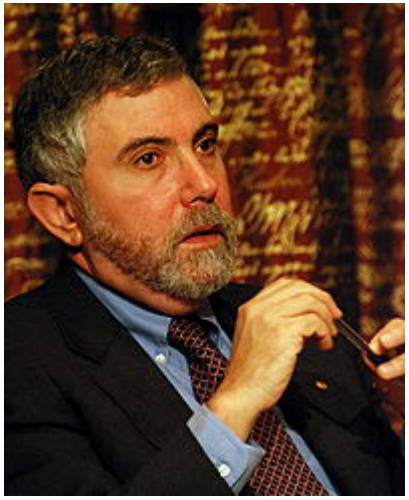
- Tipping elements in the Earth's climate - National Academies of Science
  - "Society may be lulled into a false sense of security by smooth projections of global change. Our synthesis of present knowledge suggests that a variety of tipping elements could reach their critical point within this century under anthropogenic climate change. "



WAIS

- Western Antarctic Ice Sheet (WAIS)
- Sits on land below sea level
- Can easily break up once sea water gets under ice
- Originally thought that breakup would take hundreds of years
- New evidence indicates that breakup will happen within 40 years when planet warms up 1C (we are already up .8C)
- Sea levels would be 3.3m – 4.8m

Urgency of Action



Nobel Laureate Paul Krugman

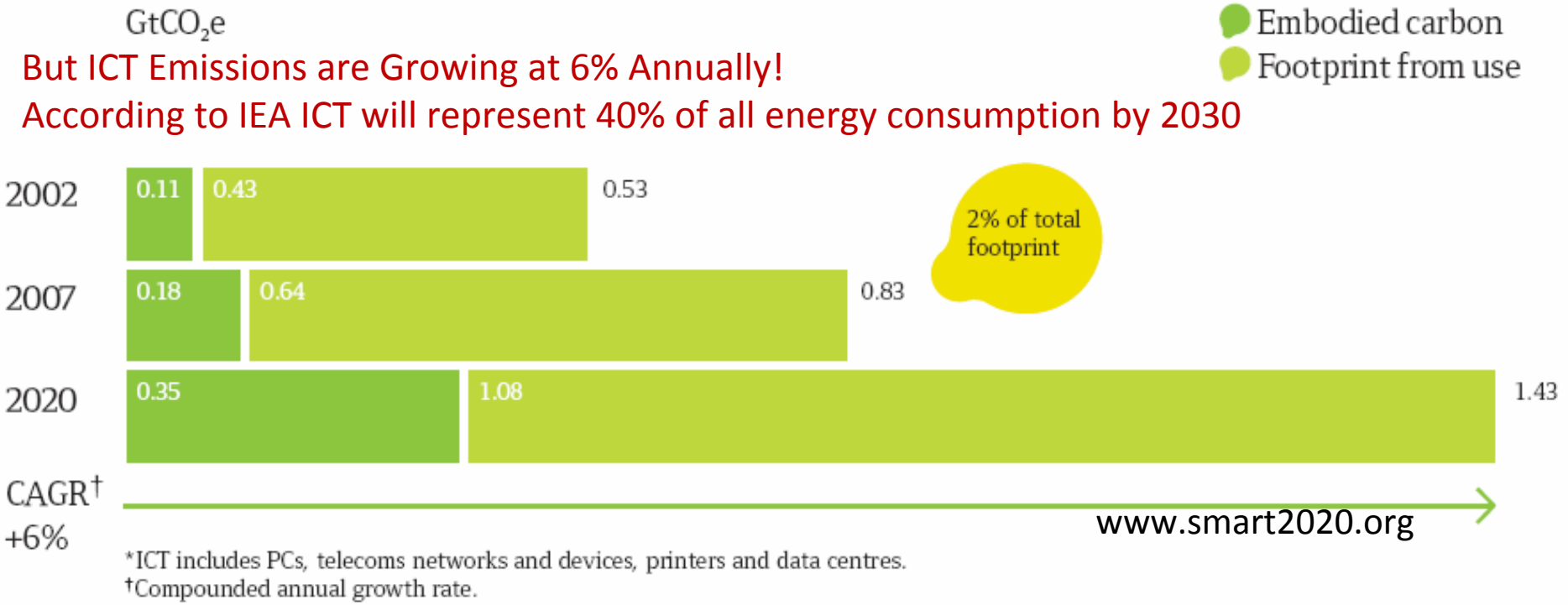
http://www.nytimes.com/2010/04/11/magazine/11Economy-t.html?pagewanted=1

- "We're uncertain about the magnitude of climate change, which is inevitable, because we're talking about reaching levels of carbon dioxide in the atmosphere not seen in millions of years.
- You might think that this uncertainty weakens the case for action, but it actually strengthens it.
- This risk of catastrophe, rather than the details of cost-benefit calculations, makes the most powerful case for strong climate policy.
- Current projections of global warming in the absence of action are just too close to the kinds of numbers associated with doomsday scenarios. It would be irresponsible — it's tempting to say criminally irresponsible — not to step back from what could all too easily turn out to be the edge of a cliff."

The Global ICT Carbon Footprint is Roughly the Same as the Aviation Industry Today

But ICT Emissions are Growing at 6% Annually!

According to IEA ICT will represent 40% of all energy consumption by 2030



ICT represent 8% of global electricity consumption

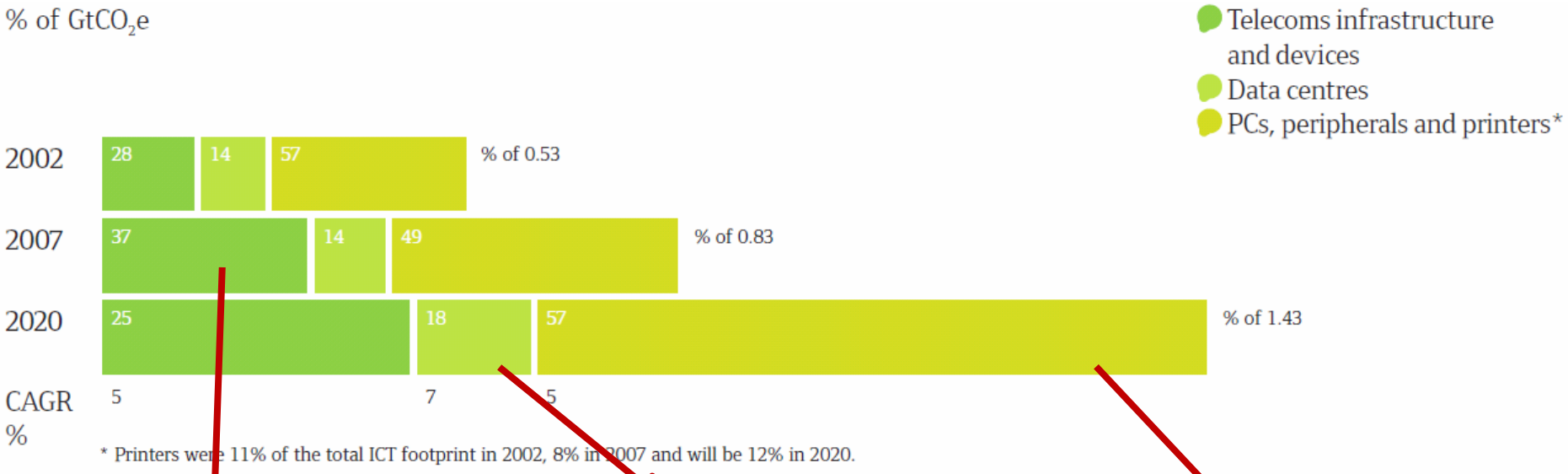
Projected to grow to as much as 20% of all electrical consumption in the US (http://uclue.com/index.php?xq=724)

Future Broadband- Internet alone is expected to consume 5% of all electricity
http://www.ee.unimelb.edu.au/people/rst/talks/files/Tucker_Green_Plenary.pdf

The Global ICT Carbon Footprint by Subsector

The Number of PCs (Desktops and Laptops) Globally is Expected to Increase from 592 Million in 2002 to More Than Four Billion in 2020

www.smart2020.org



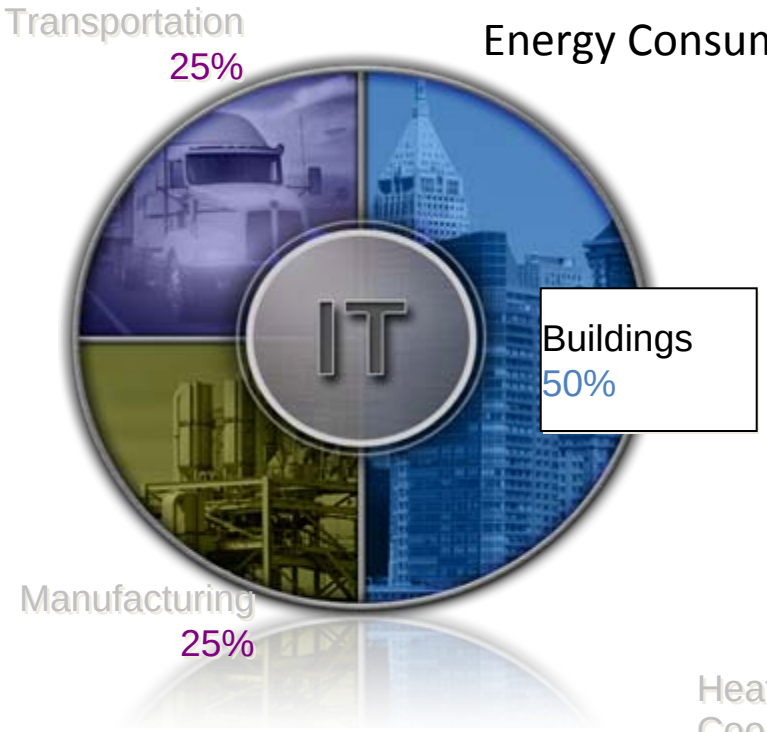
Telecom & Internet fastest growing

Data Centers & Clouds Are Low Hanging Fruit

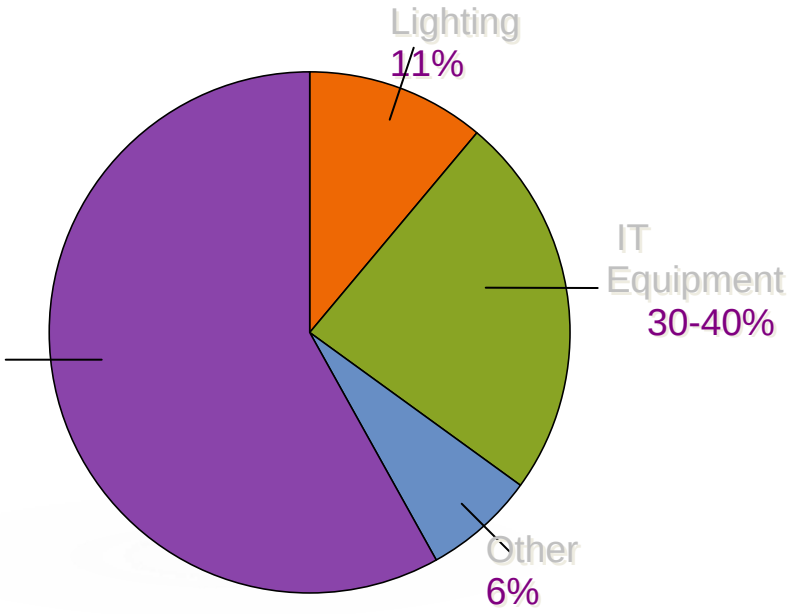
PCs Are Biggest Problem

IT biggest power draw

Energy Consumption World Wide



Energy Consumption Typical Building



Sources: BOMA 2006, EIA 2006, AIA 2006

Digital vs Traditional appliances

Growth Projections Data Centers

- Half of ICT consumption is data centers
- In ten years 50% of today's Data Centers and major science facilities in the US will have insufficient power and cooling;*
- By 2012, half of all Data Centers will have to relocate or outsource applications to another facility.*
- CO2 emissions from US datacenters greater than all CO2 emissions from Netherlands or Argentina http://bit.ly/cW6jEY
- Coal fuels much of Internet 'cloud,' Greenpeace says http://bit.ly/bkeSec
- Data centers will consume 12% of electricity in the US by 2020 (TV Telecom)

Source: Gartner; Meeting the DC power and cooling challenge

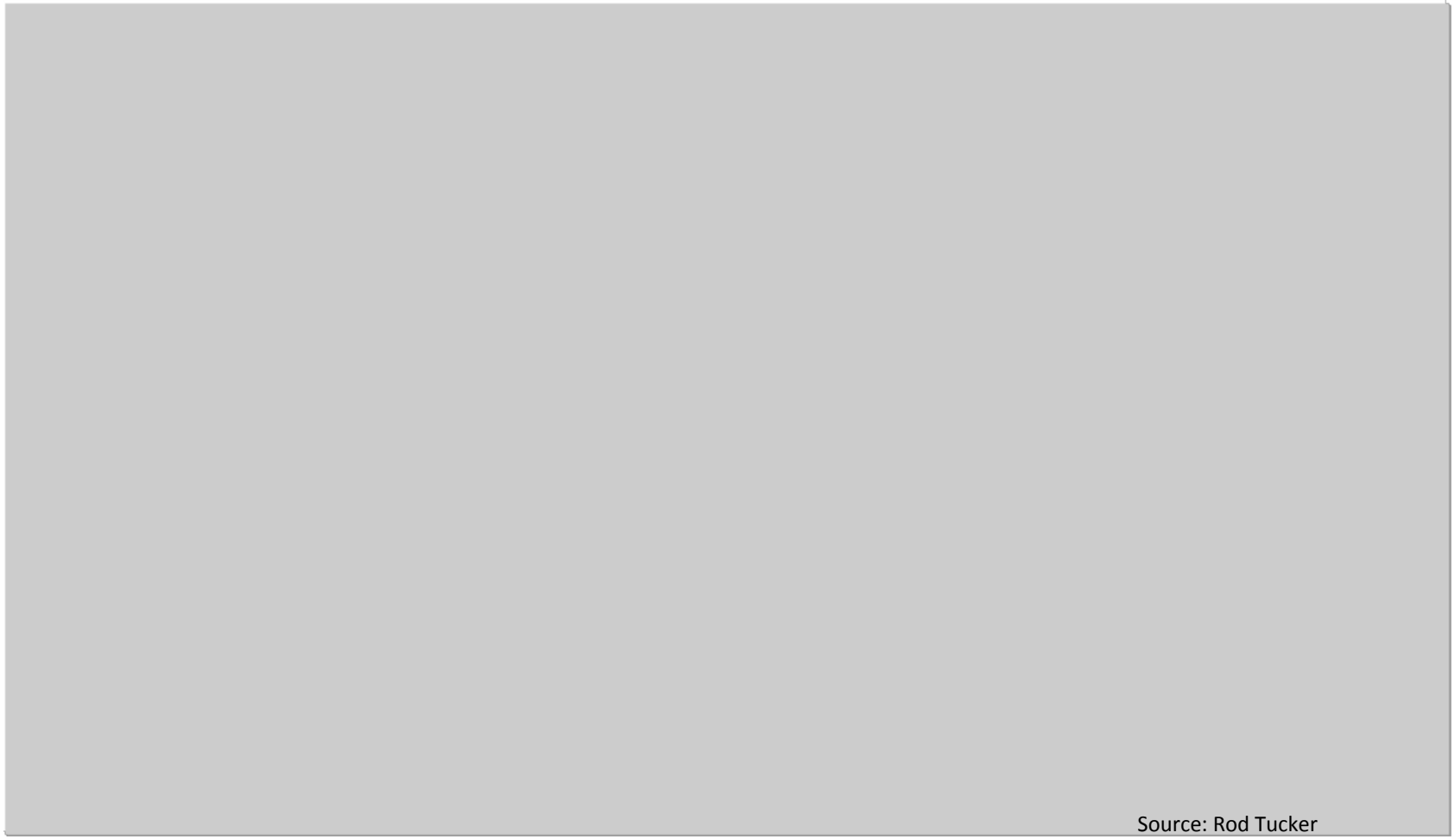
The Challenge of Energy Efficiency

- Most current approaches to reduce carbon footprint are focused on increased energy efficiency of equipment and processes
  - No question it save money, but does little for the environment

- But greater efficiency can paradoxically increase energy consumption by reducing overall cost service and therefore stimulates demand
  - Khazzoom-Brookes postulate (aka Jevons paradox - not to be confused with rebound effect)
  - In last Energy crisis in 1973 Congress passed first energy efficiency laws (CAFÉ) which mandate minimum mileage for cars, home insulation and appliances
  - Net effect was to reduce cost of driving car, heating or cooling home, and electricity required for appliances
  - Consumer response was to drive further, buy bigger homes and appliances

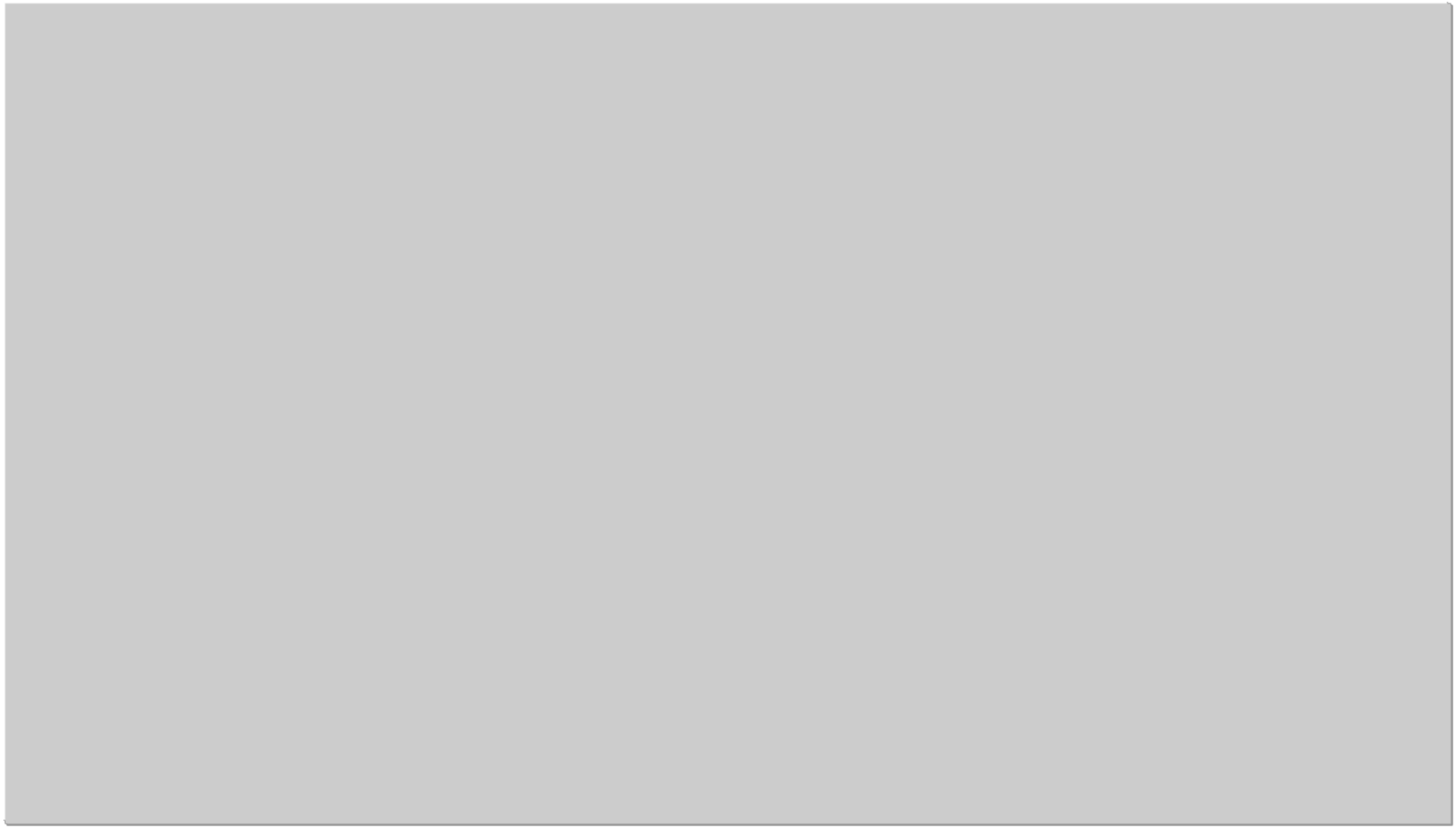
- **The issue is not the amount of energy that we use, but the type of energy**

Power Consumption of IP network



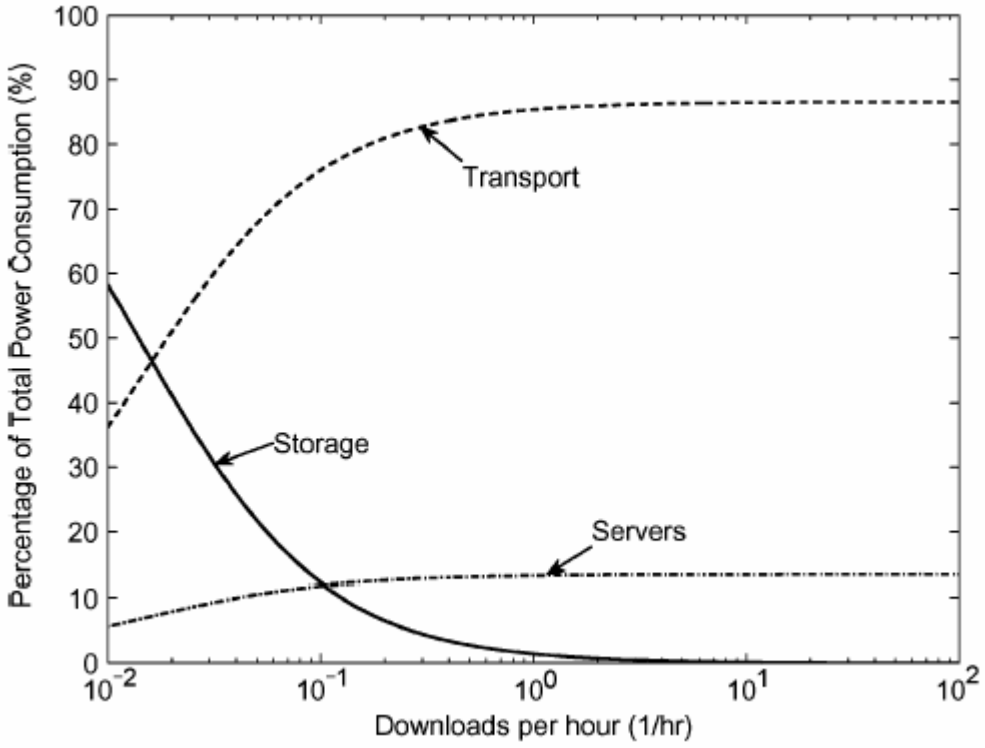
Source: Rod Tucker

Challenge of efficiency



Source: Rod Tucker

Total Energy Cost of Public Cloud and IP Transport



http://people.eng.unimelb.edu.au/rtucker/publications/files/Baliga_Ayre_Hinton_Tucker_JRLStrTrans.pdf

Zero Carbon strategy essential

- Zero carbon strategy using renewable energy critically important if governments mandate carbon neutrality, or if there is a climate catastrophe

- With a zero carbon strategy growth in demand for services will not effect GHG emissions
  - Anything times zero is always zero

- Wind and solar power are most likely candidates because of opportunity cost/benefit analysis especially time to deploy
  - Nuclear has high opportunity cost because of time to deploy
  - http://climateprogress.org/2008/12/14/stanford-study-part-1-wind-solar-baseload-easily-beat-nuclear-and-they-all-best-clean-coal/

- But renewable energy sites are usually located far from cities and electrical distribution systems are not designed to carry load
  - http://www.americanprogress.org/issues/2008/12/pdf/renewable_transmission.pdf
  - Local wind/solar will be an important component

Uncongested optical networks essential

- Optical networks have much smaller footprint than routed networks
  - Energy consumption and CO2 not linear with bandwidth
- Computing and storage will be delivered by a relatively small number of international mega-scale data centers
- Datacenters, large science instrument and clouds will increasingly be at remote locations e.g. Norway, Iceland, Canada
- Transfer of virtual machines from site to site requires large instantaneous bandwidth
- Impossible to know what will be source destination sites for VM beforehand
  - So mirroring not practical

Grand Challenge – Building solutions using renewable energy only

- Most government GHG plans plan to 30-40% of electrical power will come from renewable sources
- How do you provide mission critical services when energy source is unreliable?
  - Ebbing wind or setting sun
- Back up diesel and batteries are not an option because they are not zero carbon and power outages can last for days or weeks
- Need new energy delivery architectures and business models to ensure reliable service delivery
  - R&E networks and clouds can play a critical role
  - Not so much in energy efficiency, but building smart solutions that adapt to availability of renewable power

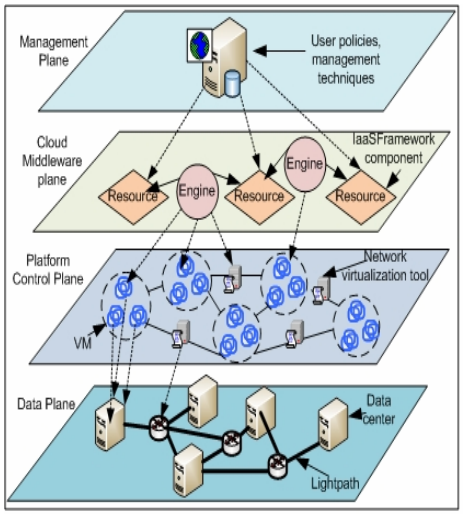
MIT to build zero carbon data center in Holyoke MA

- The data center will be managed and funded by the four main partners in the facility: the Massachusetts Institute of Technology, Cisco Systems, the University of Massachusetts and EMC.

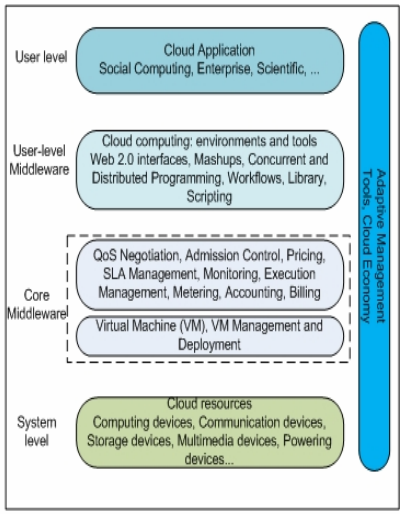
- It will be a high-performance computing environment that will help expand the research and development capabilities of the companies and schools in Holyoke
  - http://www.greenercomputing.com/news/2009/06/11/cisco-emc-team-mit-launch-100m-green-data-center
  -

GreenStar Network

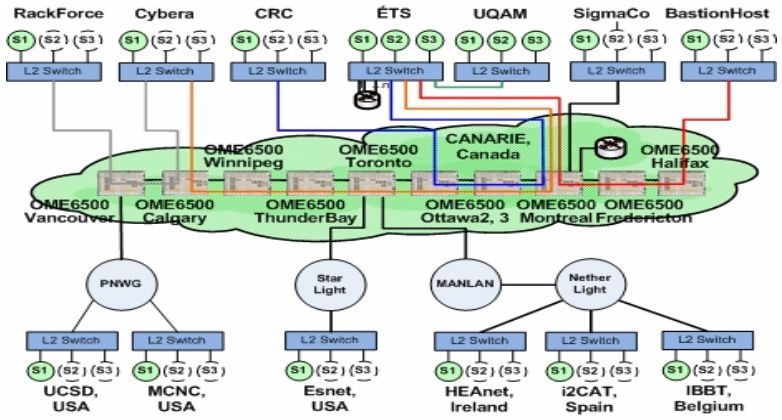
- World's first zero carbon network
- Nodes in Ireland, USA Spain and Belgium to be added shortly
- http://www.greenstarnetwork.com/



Layers of the GreenStar Network



Reference layered model of a Cloud Architecture



A) Physical connection

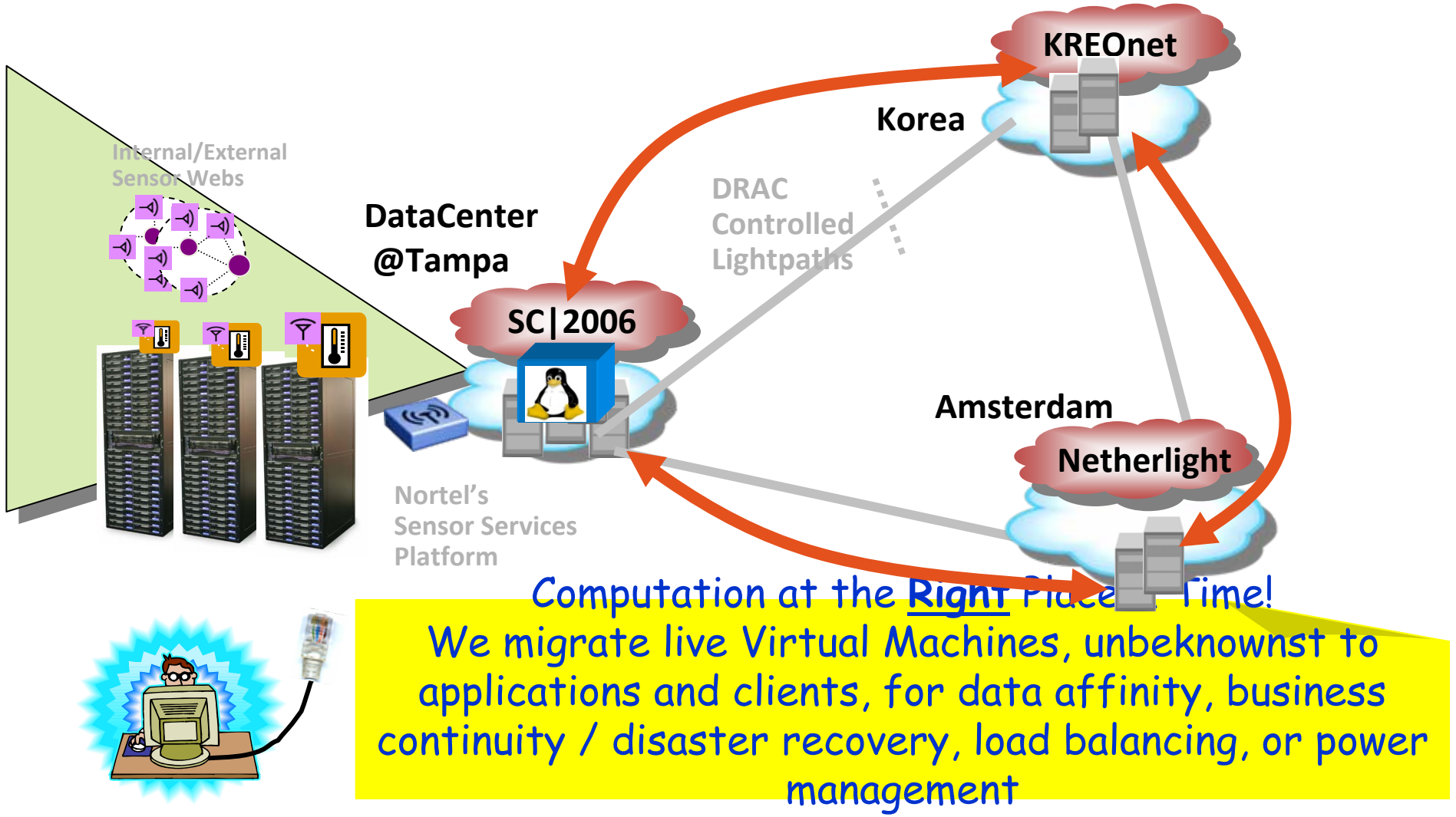
B) Geographical distribution

Carbon neutral infrastructures

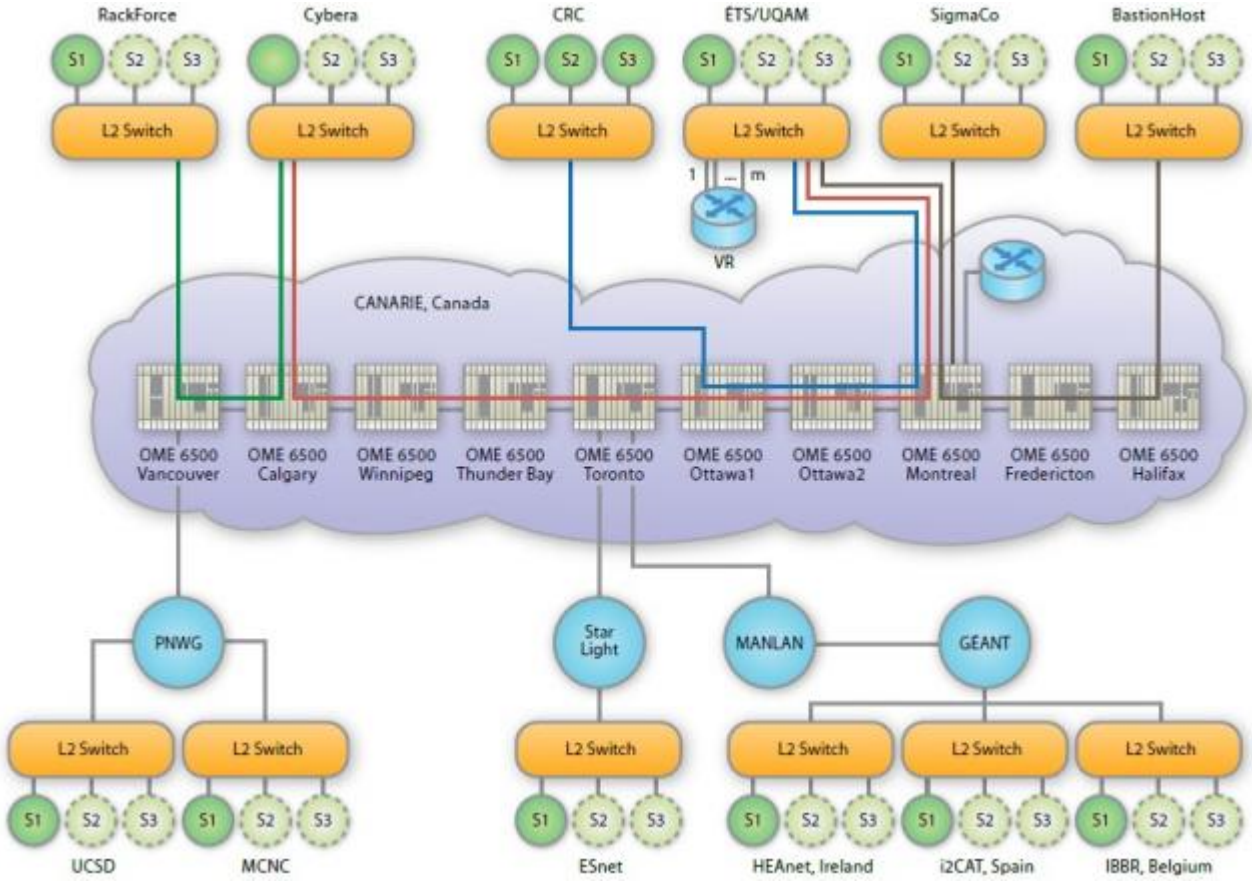
Use (IaaS) services to contribute to the research performed in the GreenStar Network (GSN) project to enable carbon-neutral infrastructures.

- How it will be achieved:
  - GreenStar uses virtualization technologies to allow the nodes in a network (both hosts and network devices) to change its location based on renewable energy availability (hydro, solar, wind).
  - MANTICORE (Europe) and GSN will collaborate in a joint experimentation to identify and try to address the issues of having the nodes in the network powered by unreliable power sources.
  - MANTICORE and GSN will use a joint infrastructure, with some nodes powered by renewable energy sources, to experiment with and validate the scenarios identified by both projects.

The SC06 VMT Demonstrator

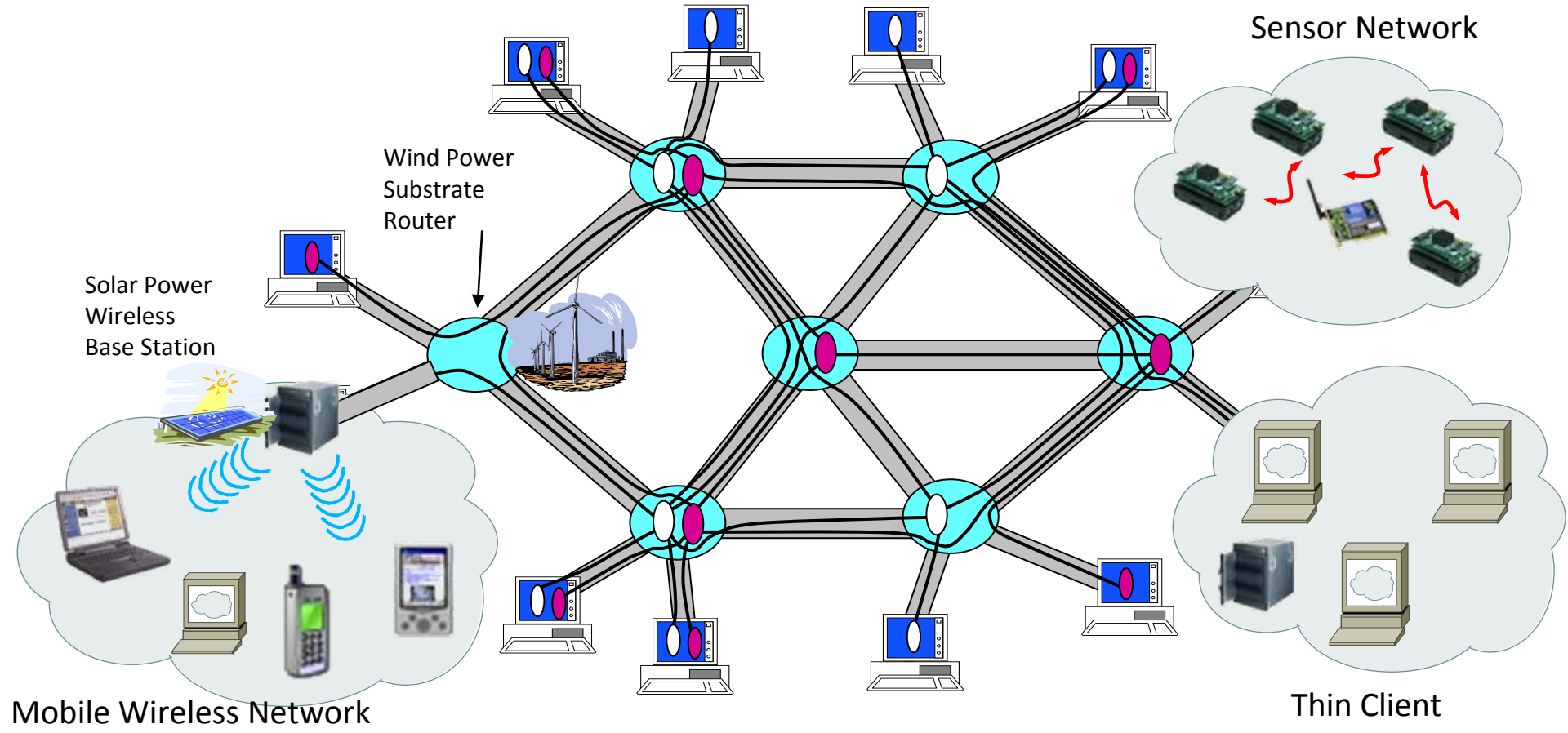


International Greenstar



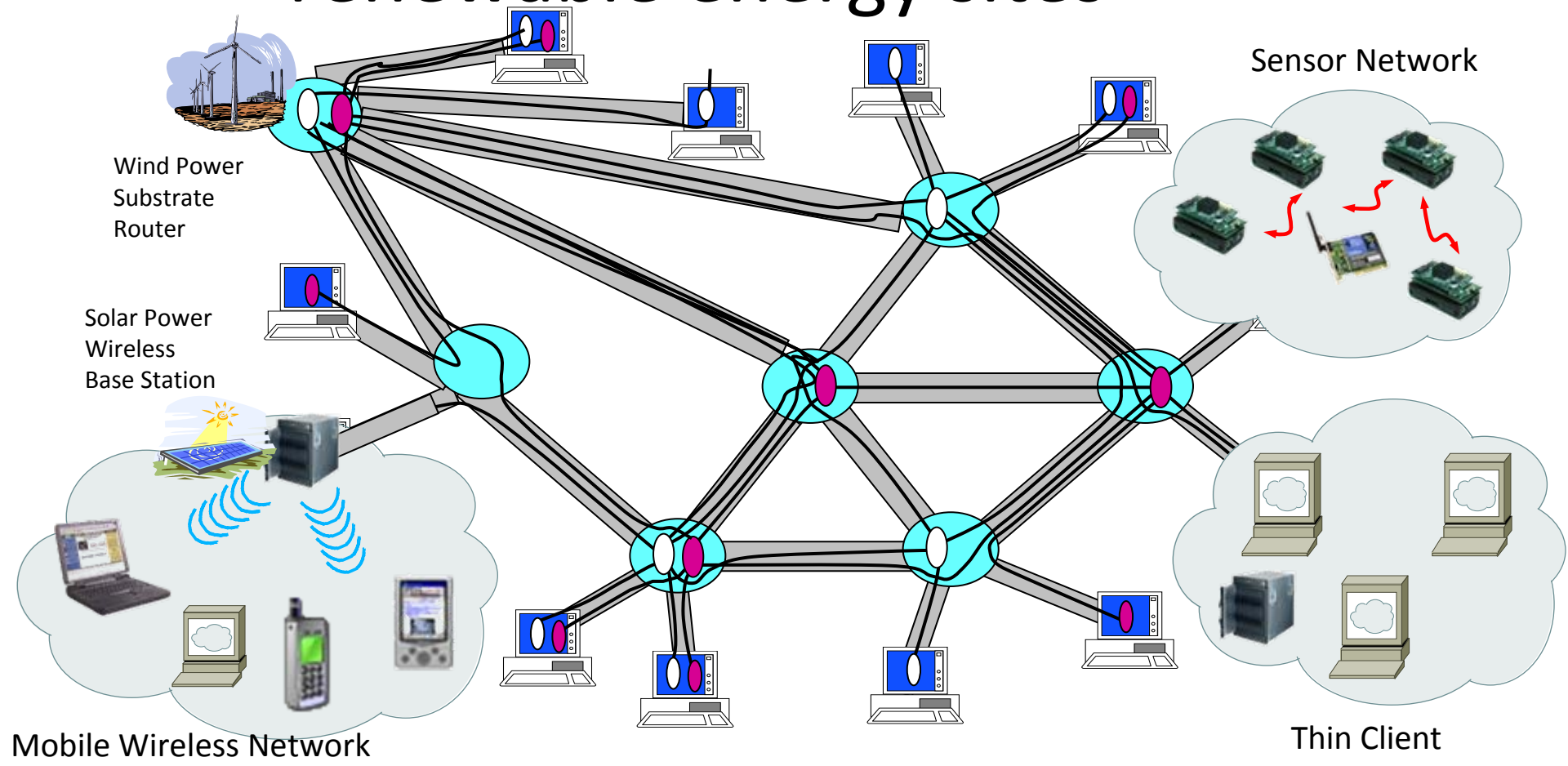
GENI

Topology optimized by source destination



Source: Peter Freeman NSF

GENI with router nodes at renewable energy sites



Topology optimized by availability of energy

Source: Peter Freeman NSF

GreenStar Global Collaboration

Université du Québec
École
de technologie
supérieure

UQÀM

Université du Québec à Montréal

UNIVERSITY OF CALGARY

wico 上海无线通信研究中心
Shanghai Research Center for Wireless Communications

prompt

CYBERA

hina
(MCU)

RACKFORCE

ackForce Networks

BASTIONHOST

Communications Research Centre Canada
An Agency of Industry Canada

Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

Canadian Standards Association (CSA), Climate Change Division

CSA STANDARDS

Deal inc.

California Institute for Telecommunications and Information Technology

USA

HEAnet
IRELAND'S NATIONAL EDUCATION & RESEARCH NETWORK

ESnet
Energy Sciences Network

rel
an
d

i2cat

SIGMACO

IBBT

International Institute for Broadband Technology

Belgium

pa
in

SA

Building a “5G” wireless network

- Over 100,000 cell phone towers to be powered by renewable energy by 2012
- Vertical axis turbines and solar
- Existing 3G and 4G networks cannot handle data load
- Need to offload data at nearest node or tower
- New Wifi standards 802.11u allow for data handoff from 3G networks
- WiFi nodes can be powered by renewable sources such as roof top solar panel over 400Hz power systems or ethernet power
- Cell phones also become sensors
- SURFnet – Dutch R&E network to deploy

Impact of 5G networks

- **The PC is out of the loop**
- **The phone is a sensor platform**
  - **Hardware add-on innovation**
  - **Location based sensing**
  - **Touch screen UI**
- **Processing is done in real time in the cloud**
  - **Allowing processing that can't be done on the device**
  - **Big data analysis**
- **Building new networks on the back of existing ones**
- **Reinventing a major industry**

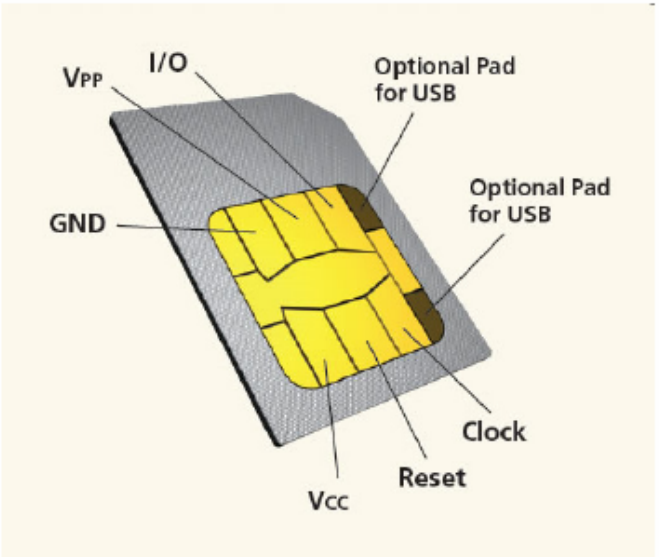
Source: Tim OReilly

Sensors + Cloud

Source: Tim OReilly

SIM cards & PST

- SIM cards likely to be main vehicle for consumer identity and authentication with proliferation of smart phones
- Next gen SIM Cards integrate with new functionality…
  - Address book, calendar back-up, messaging, teleconferencing and file transfers, banking and access control, Web!
- Smart Card Web Server - Web apps right on SIM Cards! And TCP stacks
- Cell phone companies will be soon competing with Visa and MasterCard for Point of Sales
- Security, identity and authentication
  - will be under control of cell phone company
- Need open standards and controls for SIM cards



Card 3: Classic Functionality Gets a Connectivity Boost

New Green IT research funding

- OECD ICCP recommendations that Green IT should be funded actual carbon savings
- Several governments looking at fundng IT research (green and otherwise) out of carbon taxes
- Quebec to launch Green IT program funded from carbon tax on gasoline
- Conference Board of Canada finds that funding green research provides more bang per buck in terms of outcome than carbon trading
- Linking the base revenues for technology funds to emissions provides a direct and useful link between the sources of emissions and potential solutions.
- The economic impacts are expected to be significant. Identified spending over the five-year period will total $11.8 billion, the bulk of which will be in Alberta ($6.1billion) and Ontario($1.97billion), the two provinces with the largest GHG emissions
- FCC, NSF, EPA to launch a formal Notice of Inquiry on Green IT

Final remarks

- The problem we face is NOT energy consumption, but carbon emissions
- Think carbon, not energy
- We must start addressing climate change now – not in 2050 or 2020
- 80% reduction in CO2 emissions will fundamentally change everything we do including universities and networks
- Huge potential for innovation and new business opportunities for green communications enabled applications because 30% of energy must come from renewable sources

Let’s Keep The Conversation Going

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