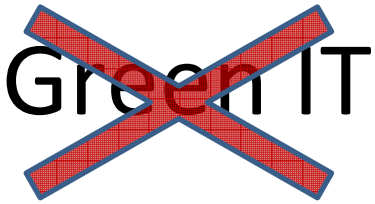


Survival IT
Future of CIOs and NRENs

Bill St. Arnaud

Bill.st.arnaud@gmail.com

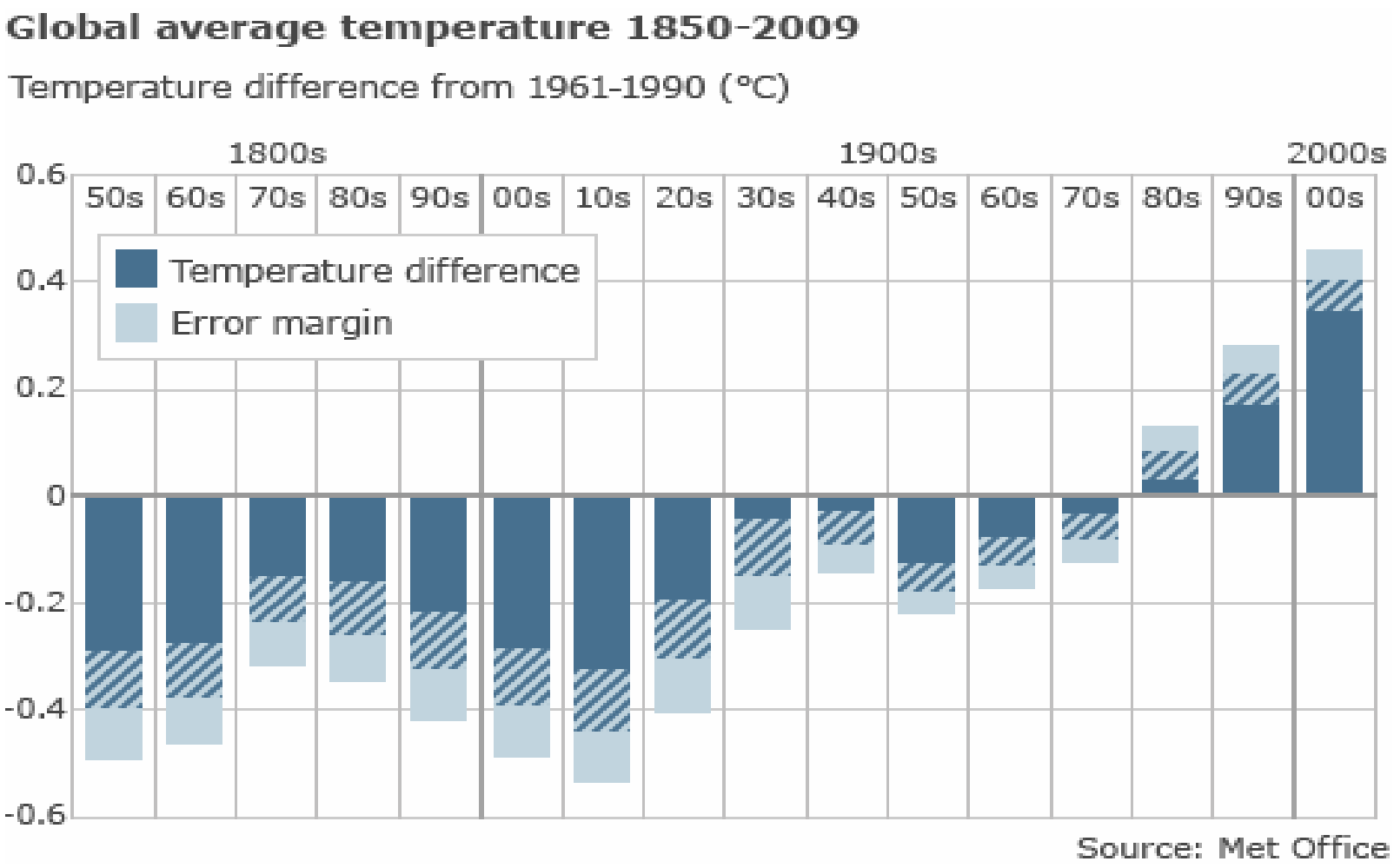
Theme of this talk

- Explosion of data and energy consumption by computers and networks
- We have already lost the battle to save the planet from extreme climate change. Rather than focusing on reducing energy consumption, (Mitigation) we now need to focus on surviving climate change (Adaptation)
- How can Internet and IT help us build NRENs and support science that can survive global warming?
- The future of computing will be like what has happened to other big science projects
- New revenue opportunities for Rrd Clara and NRENs

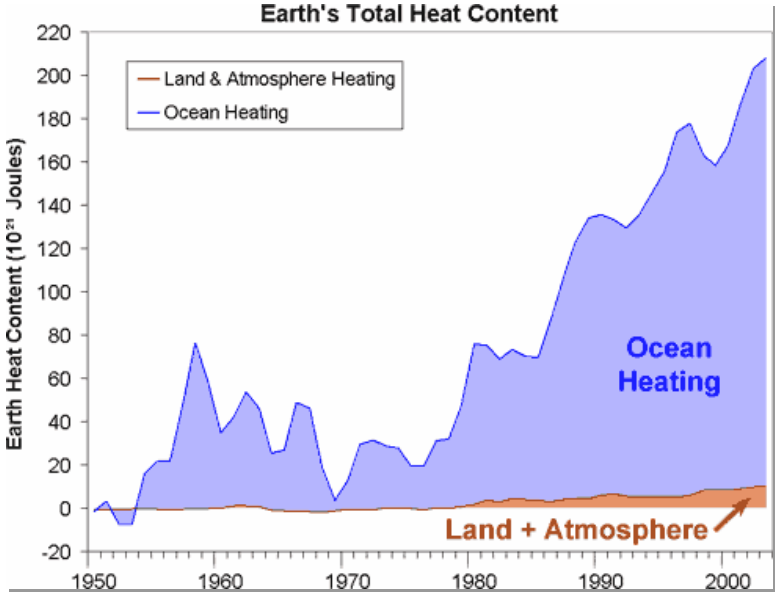
Changing networking environment

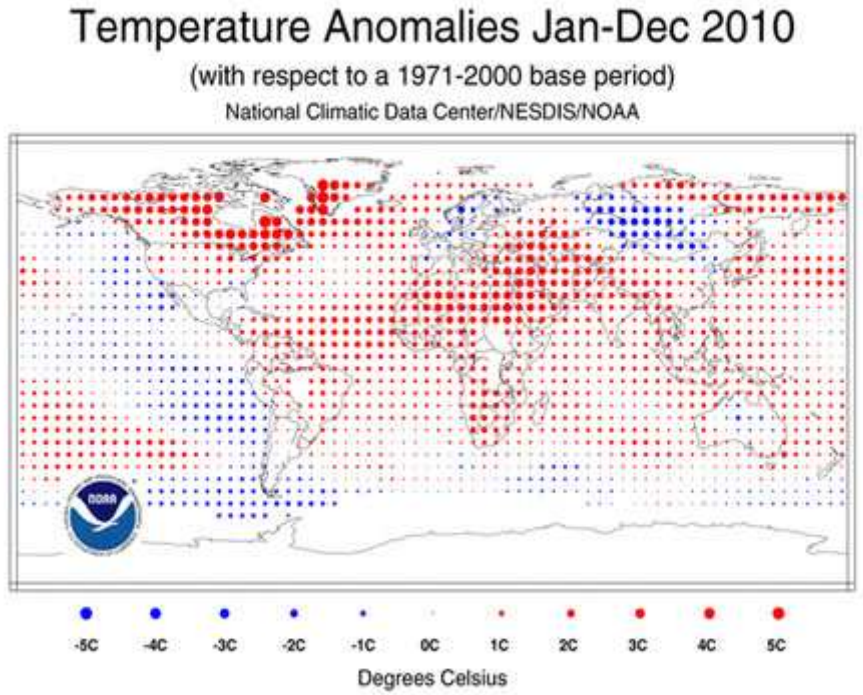
- Global Virtual Research Communities
- Increasing co-operation between public and private researchers
- Rapidly changing users demands
- Increasing potential of commercial ICT-service providers
- Emerging data deluge
- Education: any time, any place, any device
- Diminishing expertise in ICT centres of connected institutions

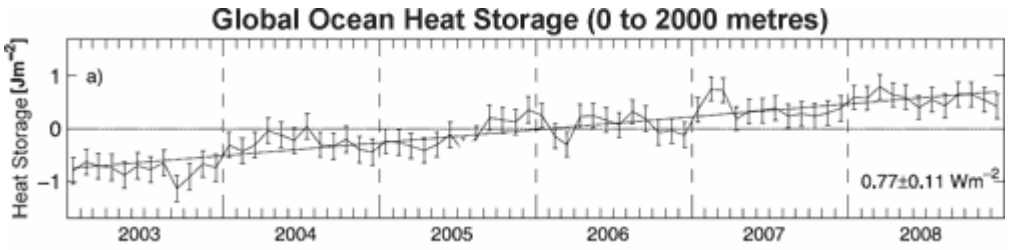
Global Average Temperature



2010 warmest year ever

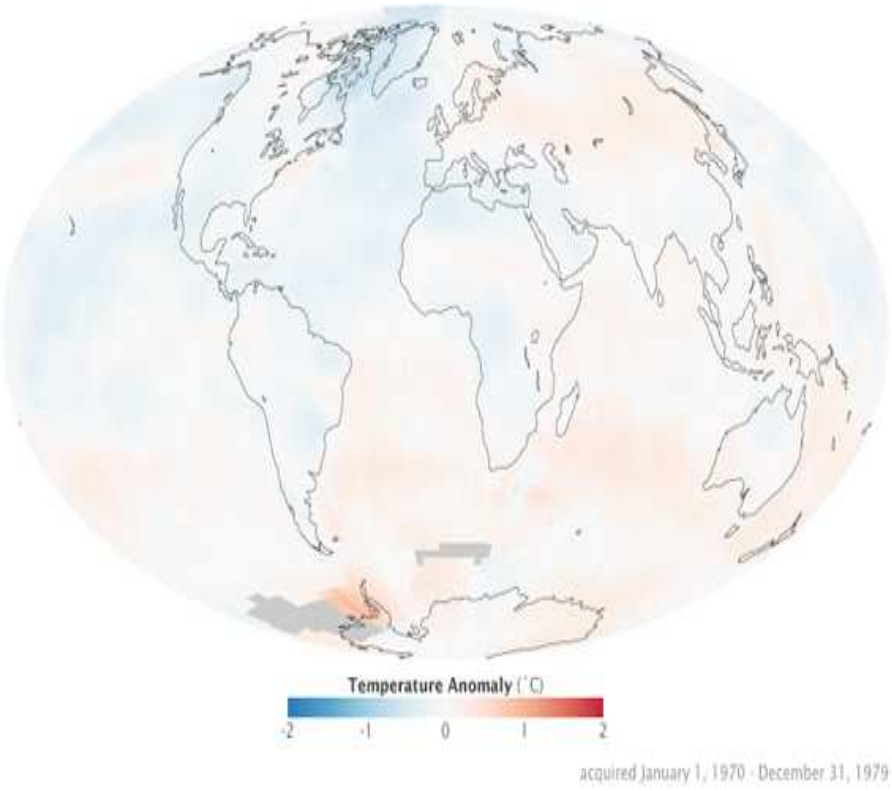




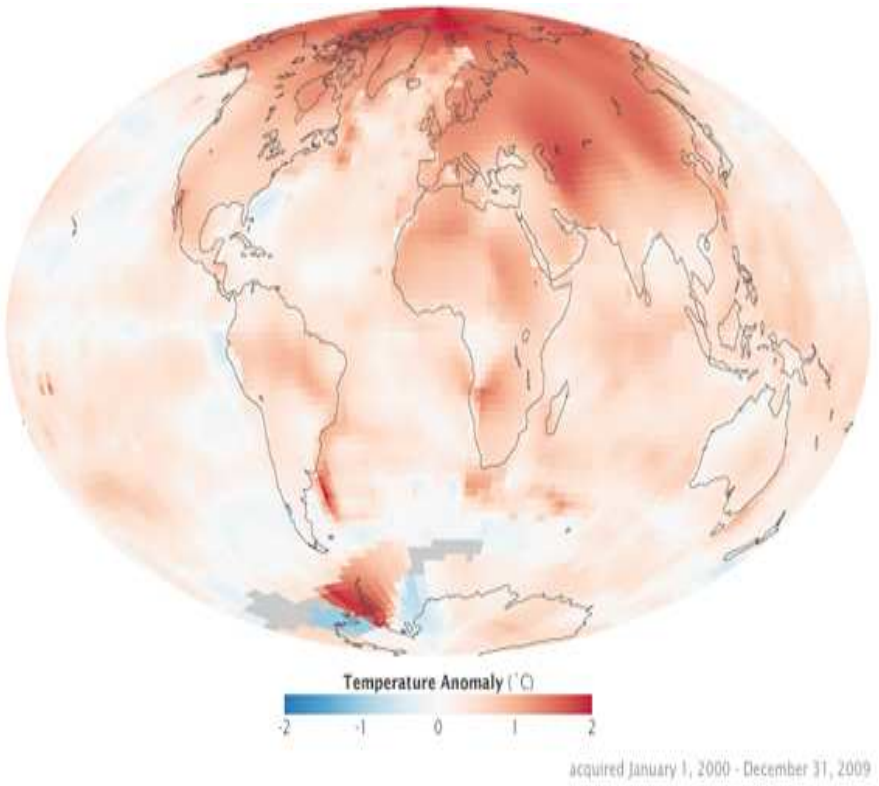


Global warming since 1970

See the world heating up 1884-2010 in this new NASA animation. http://bit.ly/NasAni

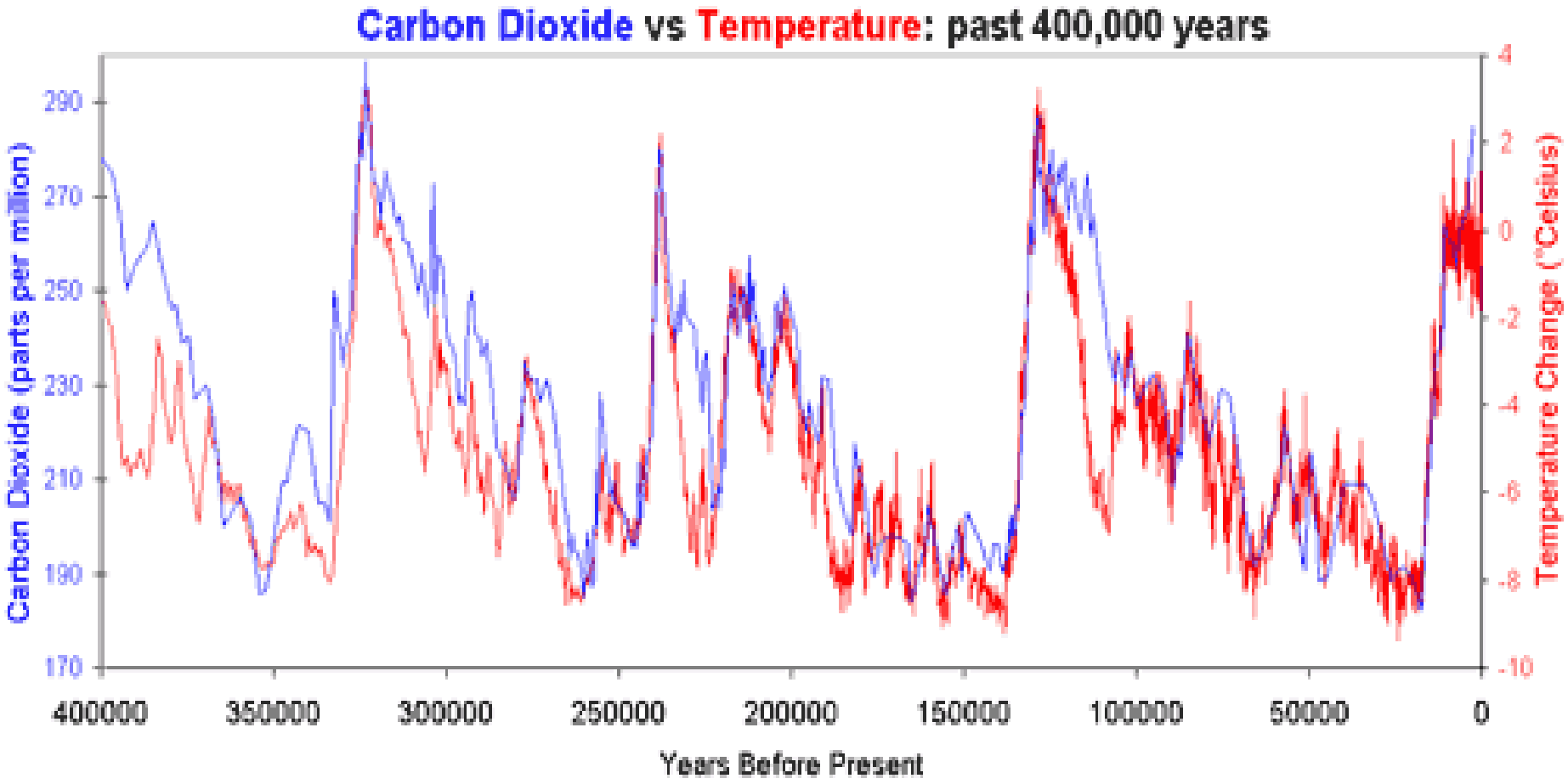


1970-1979



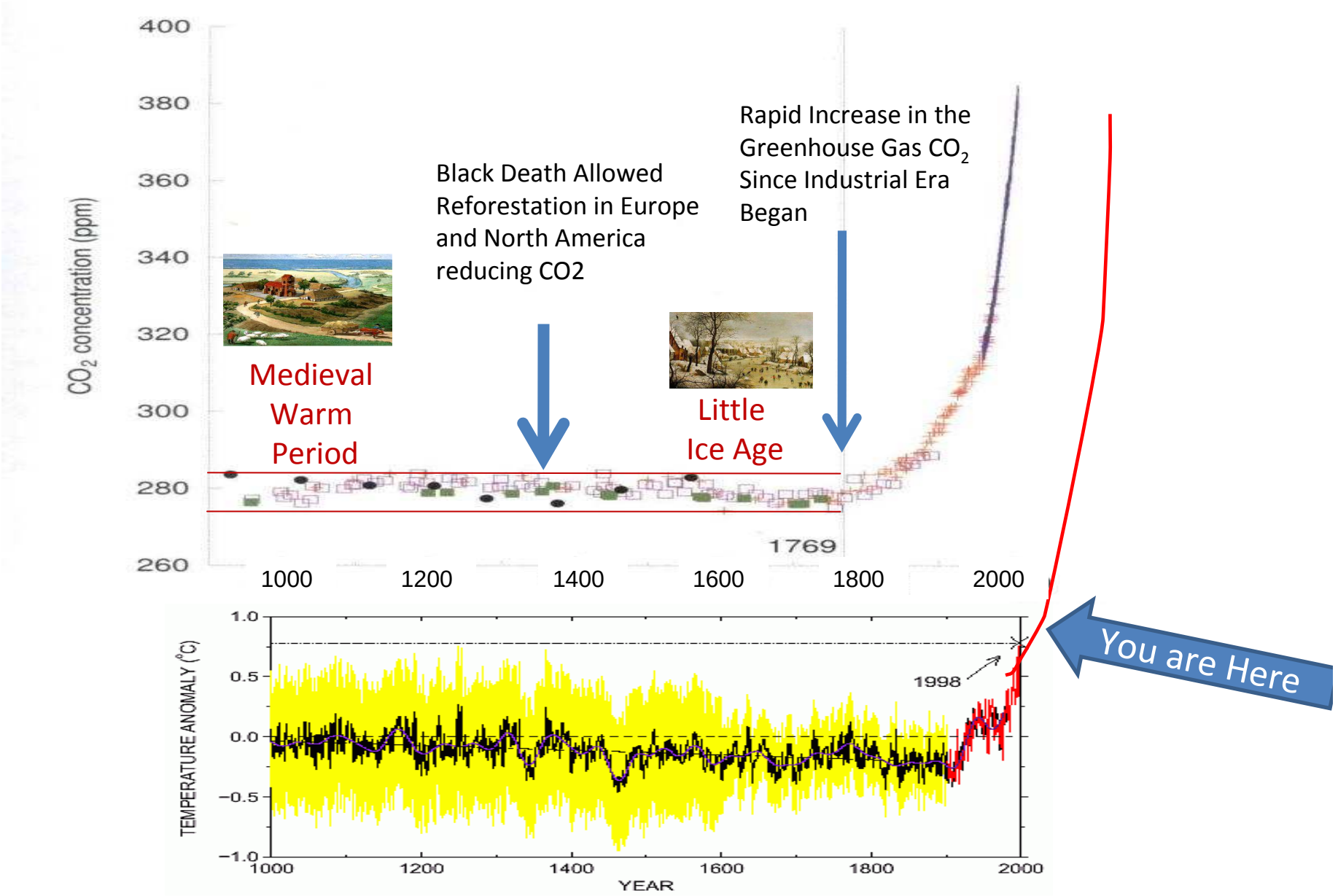
2000-2009

CO2 vs Temperature



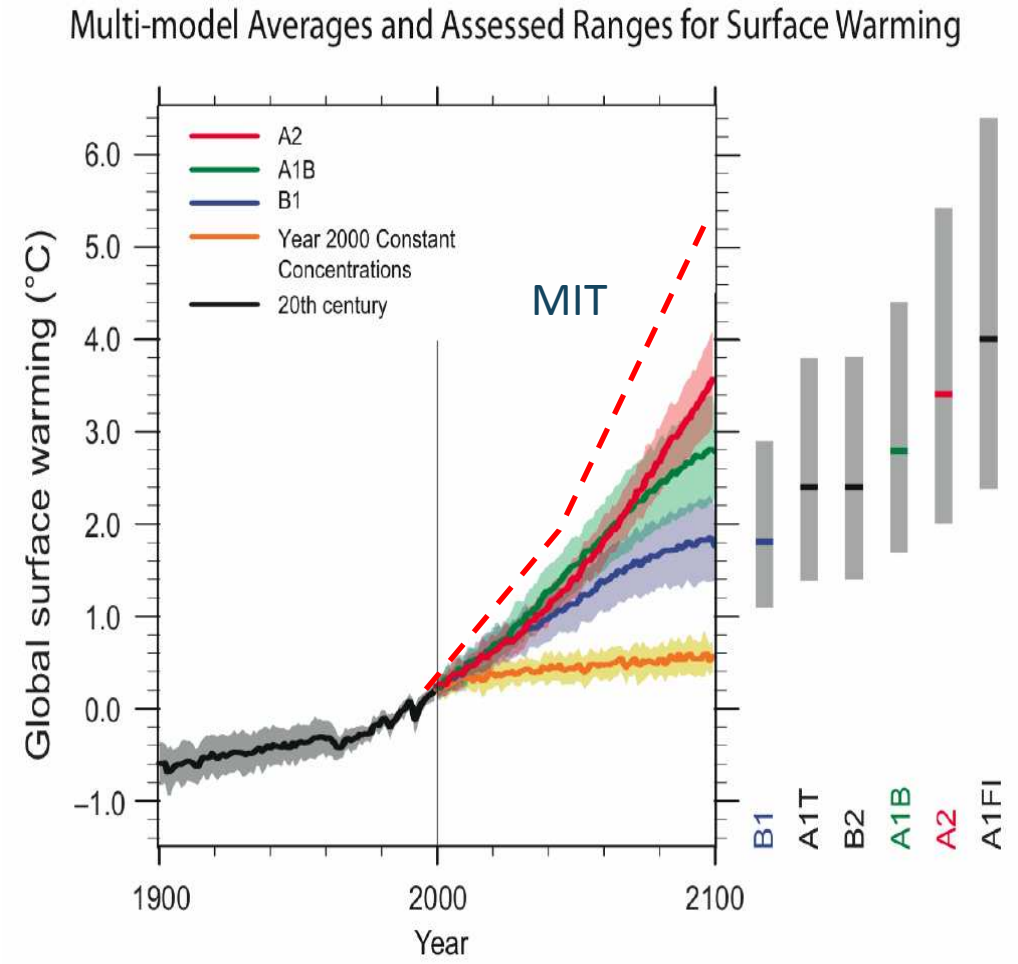
Rule of Thumb: 1°C for 10 ppm CO2

Climate Sensitivity
The Worst is yet to come



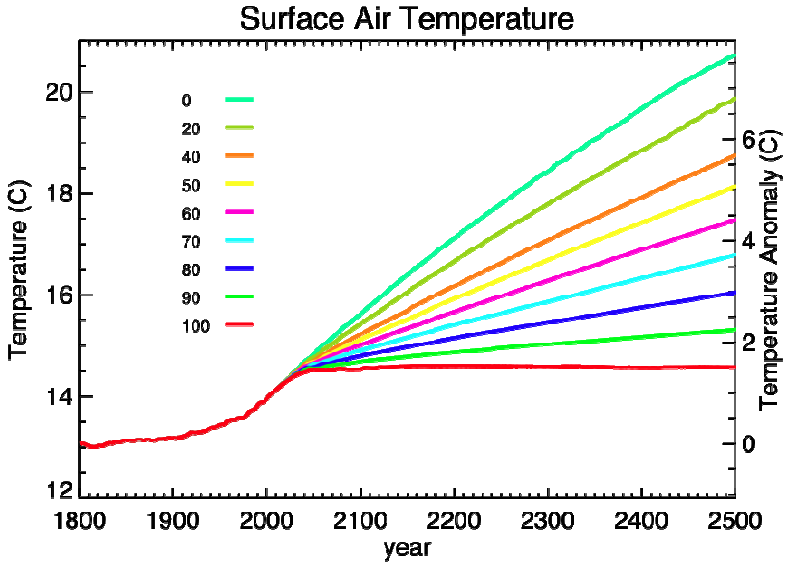
Climate Forecasts

- 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
- Nearly 90 per cent of new scientific findings reveal global climate disruption to be worse, and progressing more rapidly, than expected.
  - http://www.skepticalscience.com/pics/Freudenburg_2010_ASC.pdf



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



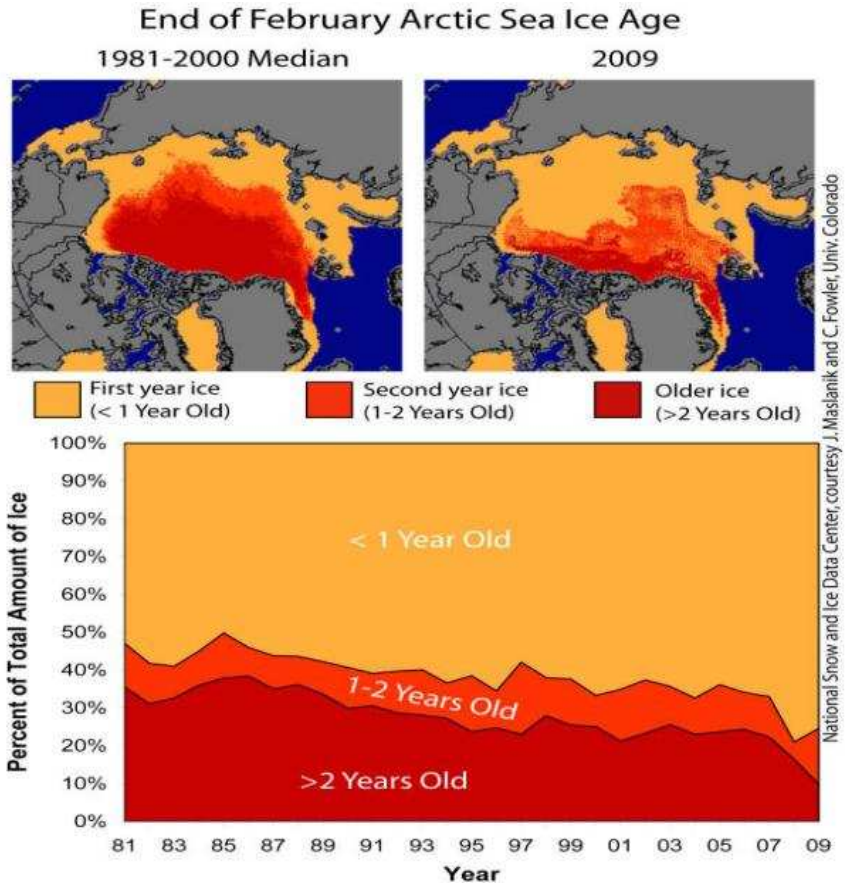
Weaver et al., GRL (2007)

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. "



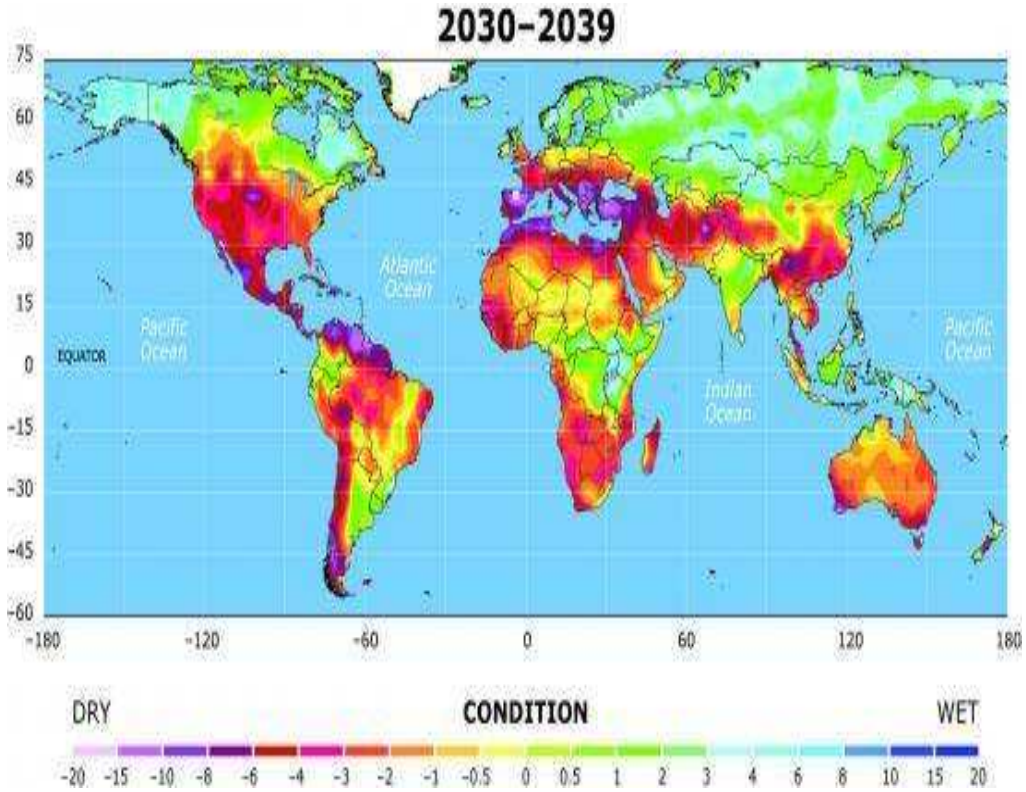
Future Droughts

• Palmer Drought Severity Index, or PDSI.

• The most severe drought in recent history, in the Sahel region of western Africa in the 1970s, had a PDSI of -3 or -4.

• By 2030 Western USA could see -4 to -6

• By 2100 some parts of the U.S. and Latin America could see -8 to -10 PDSI, while Mediterranean areas could see drought in the -15 or -20 range.

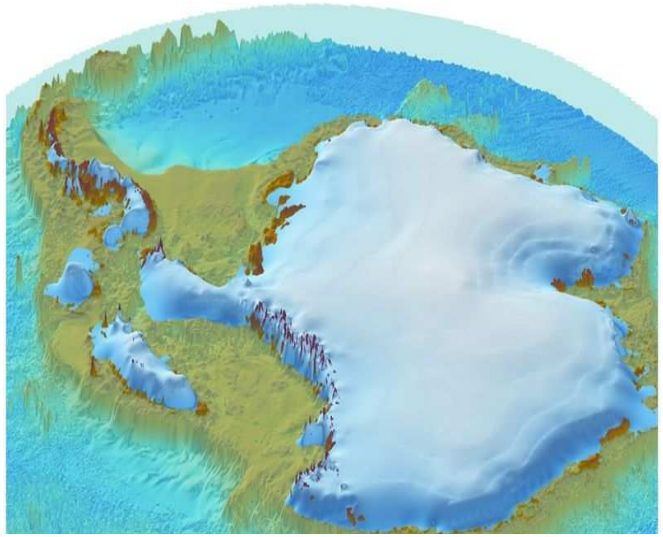


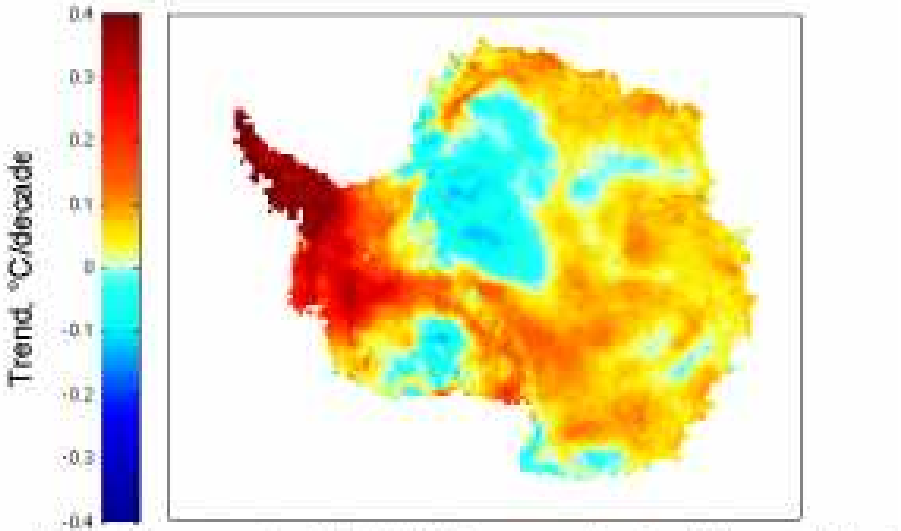
http://www.msnbc.msn.com/id/39741525/ns/us_news-environment/

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)
- S ea levels would be 3.3m – 4.8m
- Ice collapsed as recent as 125,000 years ago
- IPCC says ice is one of the poorest understood areas

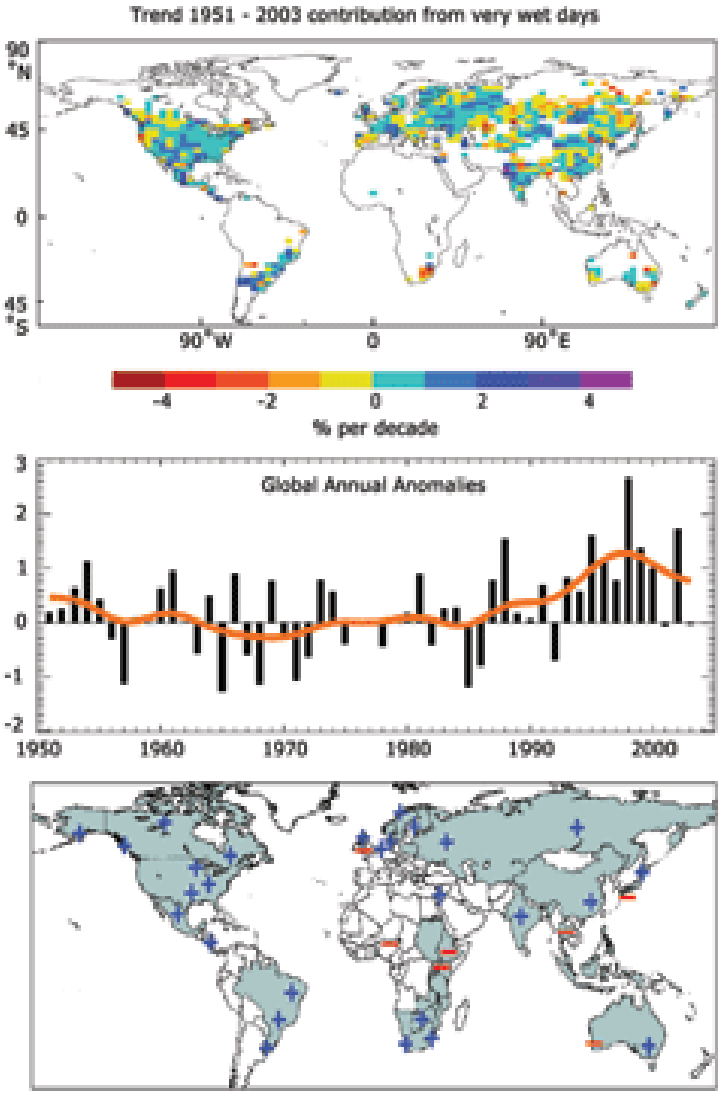
http://news.discovery.com/earth/how-stable-is-the-west-antarctic-ice-sheet.html
Sea levels may rise 3x faster than predicted by IPCC
http://climateprogress.org/2009/12/09/sea-level-rise-six-feet-three-times-faster-than-the-ipcc-estimat/

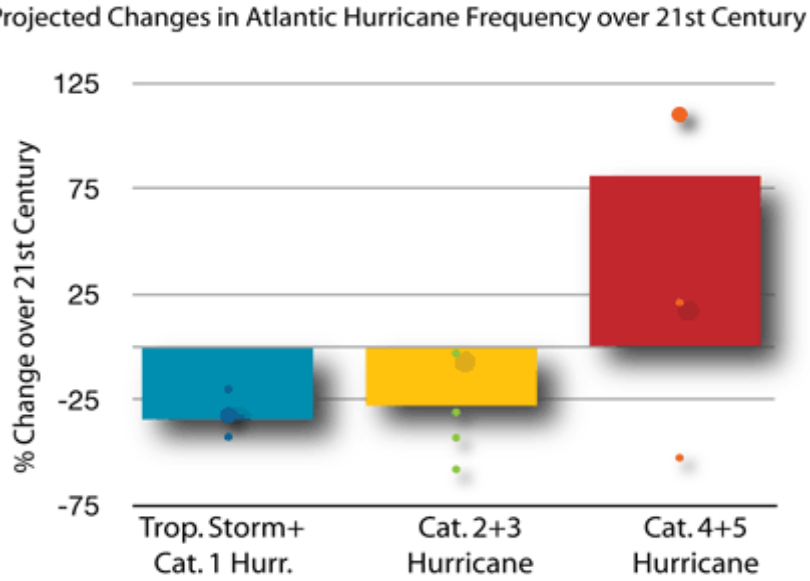




Antarctic warming 1957-2006, according to O'Donnell et al.

Dramatic changes in precipitation





- Every continent has suffered record rainfalls
- Rains submerged one-fifth of Pakistan, a thousand-year deluge swamped Nashville and storms just north of Rio caused the deadliest landslides Brazil has ever seen.
- Observed increase in precipitation in the last few decades has been due in large part to a disproportionate increase in heavy and extreme precipitation rates which are exceeding predictions made in models

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."

Climate Change Impact on Internet and NRENs

- UK Government study Climate Change could ruin the Internet
  - http://www.grist.org/list/2011-05-09-climate-change-could-ruin-the-internet
- Severe Flooding and Droughts will affect energy distribution system
- The impacts of Sea Rise on California Coast
  - http://www.pacinst.org/reports/sea_level_rise/index.htm
- Last year Nuclear power plants in France were forced to shut down because cooling water was too warm
- Germany is committed to shutting down all of its nuclear plants
- Droughts will restrict production of hydro-electric power

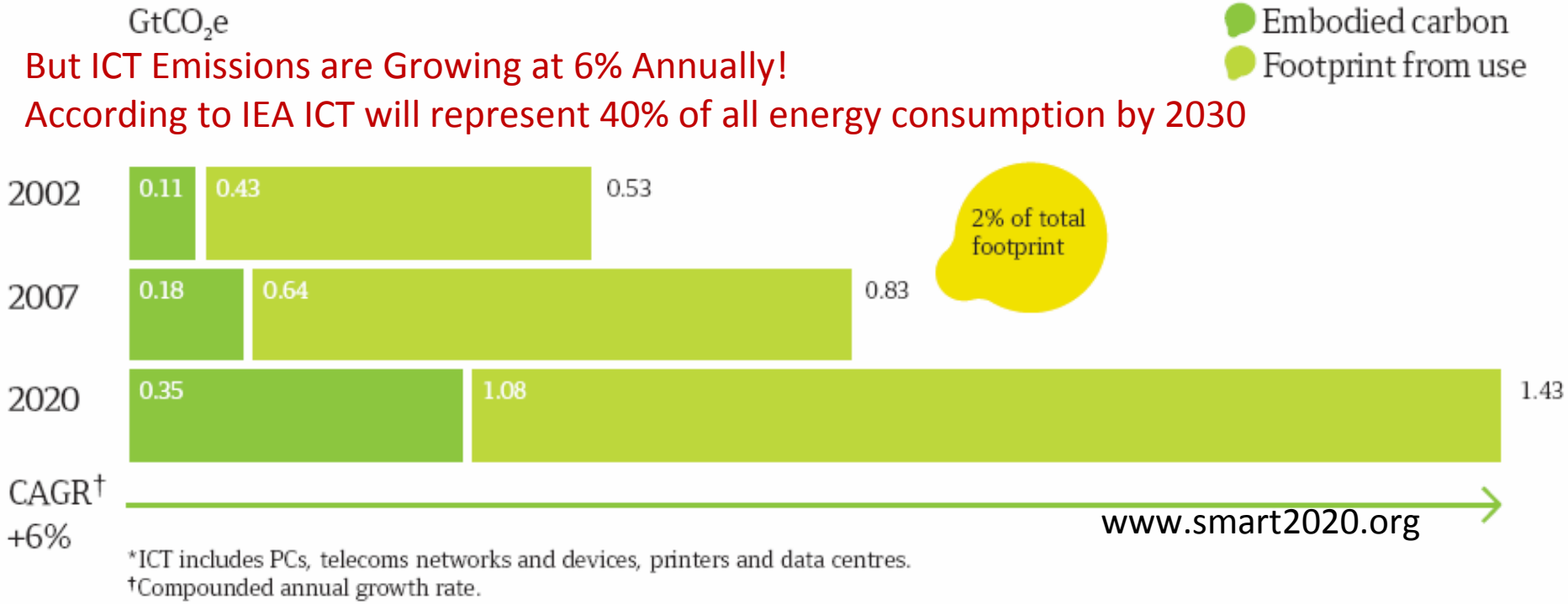
Survival IT

- Obama's National Science Advisor John Holdren "Mitigation alone won't work, because the climate is already changing, we're already experiencing impacts….A mitigation only strategy would be insanity,"

- Equal emphasis given to adaptation – avoiding the unmanageable, and adaptation – managing the unavoidable."

- Obama's Climate Adaptation Executive Order
  - http://www.stumbleupon.com/su/1tU8go/www.good.is/post/obama-s-secret-climate-adaptation-plan/

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



But ICT Emissions are Growing at 6% Annually!

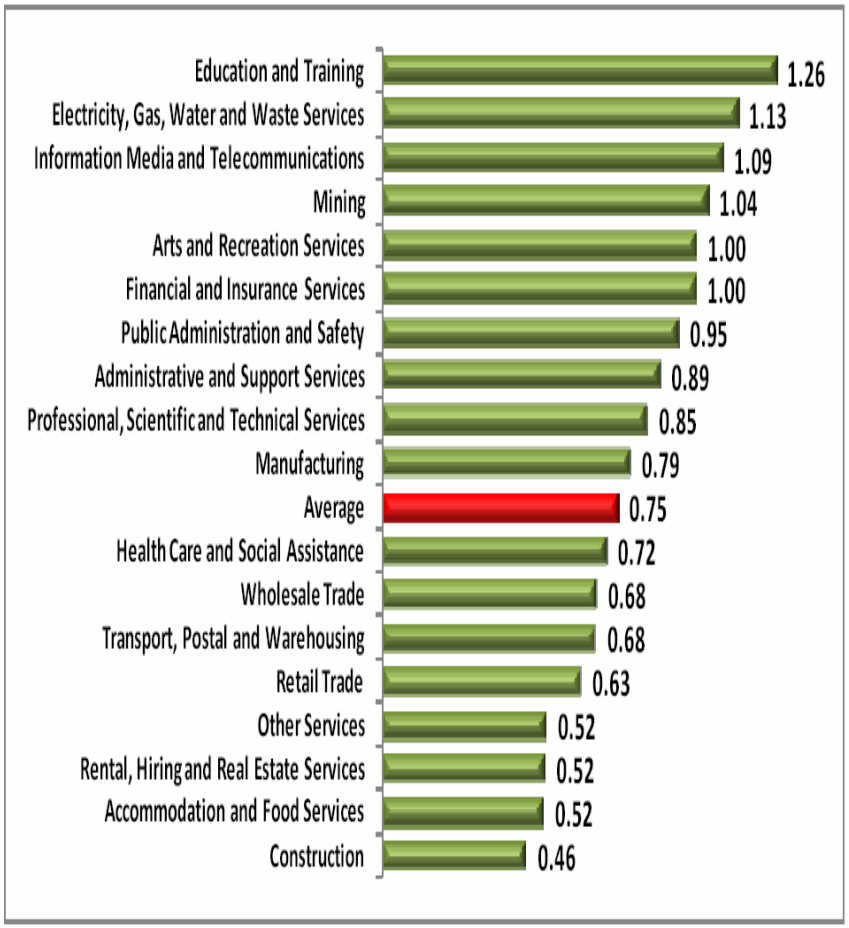
According to IEA ICT will represent 40% of all energy consumption by 2030

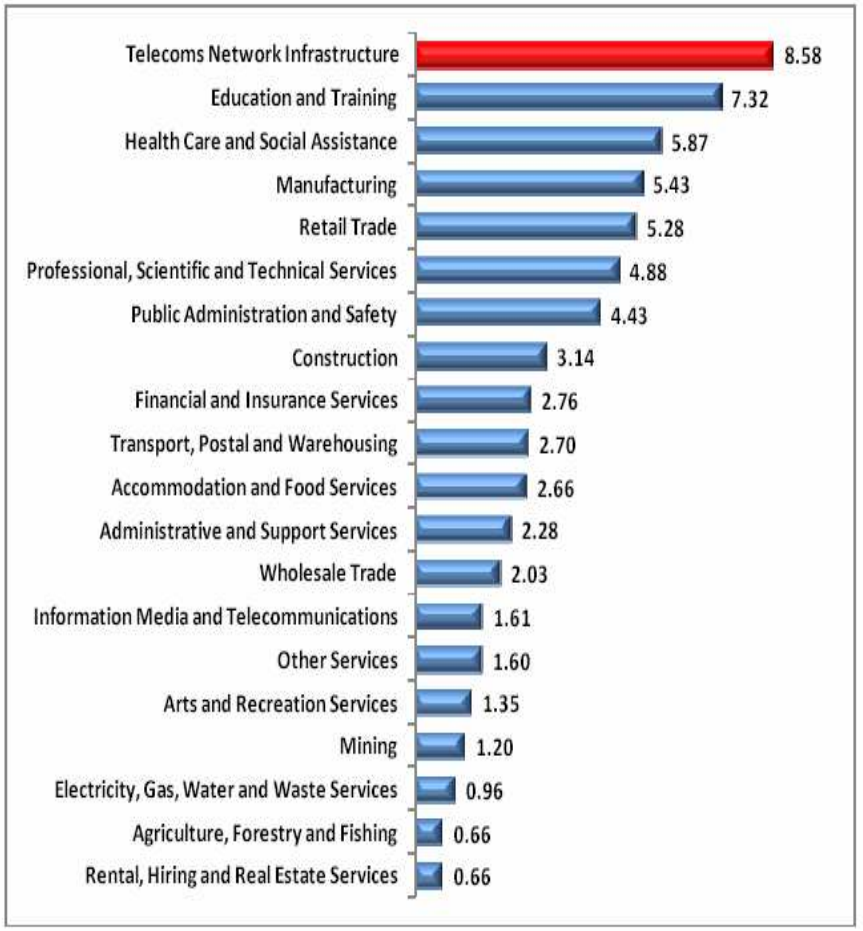
ICT represent 8% of global electricity consumption

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

Education biggest contributor





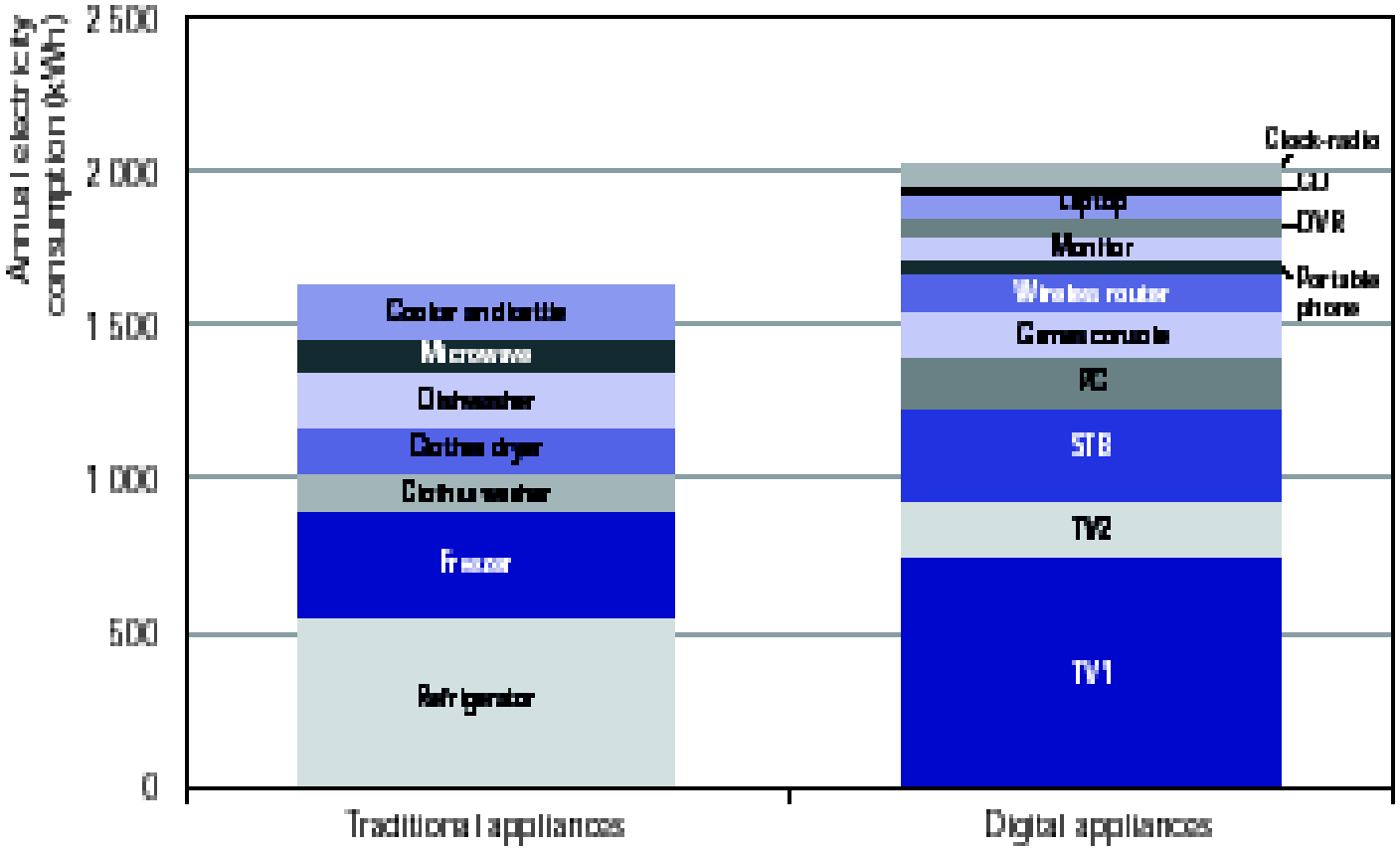
Per employee

Per sector

Australian Computer Society Study
http://www.acs.org.au/attachments/ICFACSV4100412.pdf

Digital vs Traditional appliances

Figure 83 • Typical OECD household electricity consumption of major traditional and digital appliances



Building Networks to Survive Climate Change

- 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
- Design Principles for Building Networks to Survive Global Warming
  - http://green-broadband.blogspot.com/2011/02/design-principles-for-building-networks.html

The Falsehood 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

- Greenpeace Report "Electricity demand of IT remains on the rise, efficiency can only slow emission growth. In order to achieve the reductions necessary to keep the sector's emissions in check and maintainsafe levels of global greenhouse gases, clean energy needs to become the primary source of power for IT infrastructure.
  - Greenpeace "How dirty is your data" http://www.greenpeace.org/international/Global/international/publications/climate/2011/Cool%20IT/dirty-data-report-greenpeace.pdf

- 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)

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

The need to move to clouds powered by wind and sun

- Campus computing 20-40% electrical energy consumption on most campuses
  - Studies in UK and The Netherlands
- Closet clusters represent up to 15% of electrical consumption – UBC study
- Campus data center represents 8-20% of electrical consumption
  - IISD study of Dalhousie, UoAlberta and Ottawa U
- IISD study demonstrated that moving Canadian research to cloud would pay for itself in energy savings and CO2 reduction
- Clouds could save universities millions of dollars in energy and support costs
  - http://green-broadband.blogspot.com/2010/12/how-r-networks-can-help-universities.html
  - Millions of dollars being wasted on old clusters and HPC facilities that could be spent on critical research

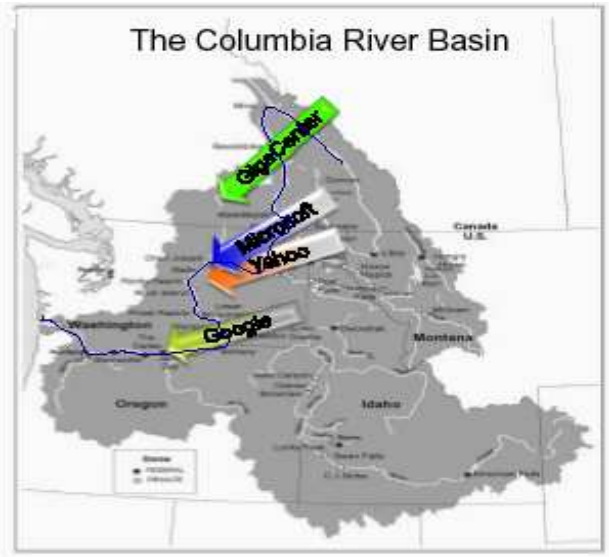
Get off the Grid!

- Purchasing green power locally is expensive with significant transmission line losses
  - –Demand for green power within cities expected to grow dramatically
- ICT facilities DON'T NEED TO BE LOCATED IN CITIES
  - —-Cooling also a major problem in cities
- But most renewable energy sites are very remote and impractical to connect to electrical grid.
  - – Can be easily reached by an optical network
  - – Provide independence from electrical utility and high costs in wheeling power
  - – Savings in transmission line losses (up to 15%) alone, plus carbon offsets can pay for moving ICT facilities to renewable energy site
- ICT is only industry ideally suited to relocate to renewable energy sites
  - – Also ideal for business continuity in event of climate catastrophe

Many examples

Wind powered data centers

Ecotricity in UK builds windmills at data center locations with no capital cost to user



Hydro-electric powered data centers

Data Islandia
Digital Data Archive

ASIO solar powered data centers

17

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
  -

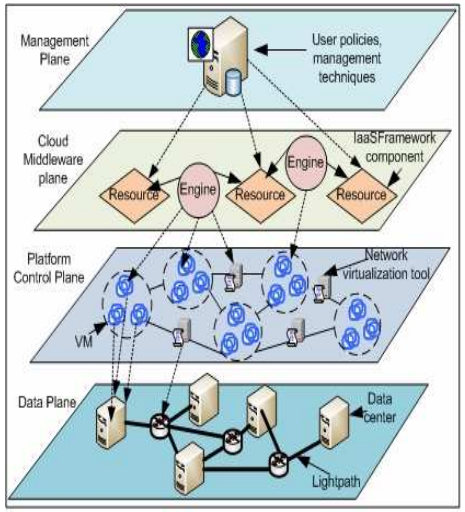
SDSC-McGill Computing Project

- Join study undertaken by San Diego Super Computing Center and McGill University looking at energy and cost savings of relocating SDSC to Canada
  - http://green-broadband.blogspot.com/2011/03/relocating-data-centers-to-colder.html
- Potential overall cost savings of 75% and energy savings of 47%
  - Approximately $8 million per year in savings
- Zero carbon powered by hydro electric turbine spin up power and ice cooling

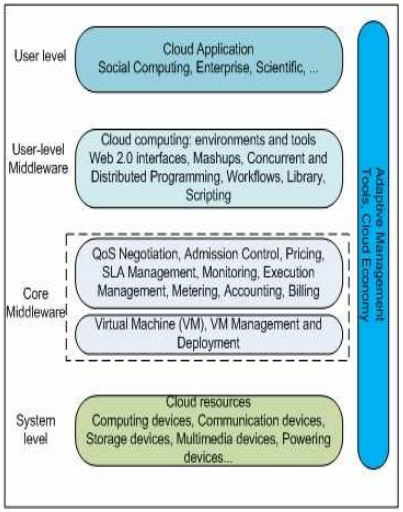
GreenStar Network

World's First Zero Carbon Cloud/Internet

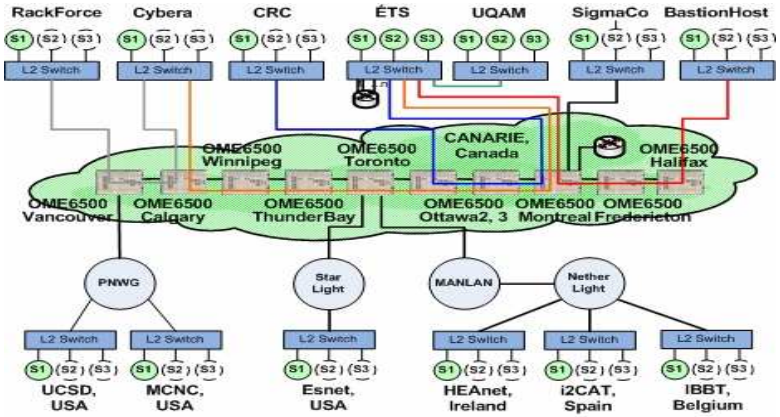
- World's first zero carbon network
- Nodes in Ireland, USA, China, Spain and Belgium to be added shortly
- http://www.greenstarnetwork.com/



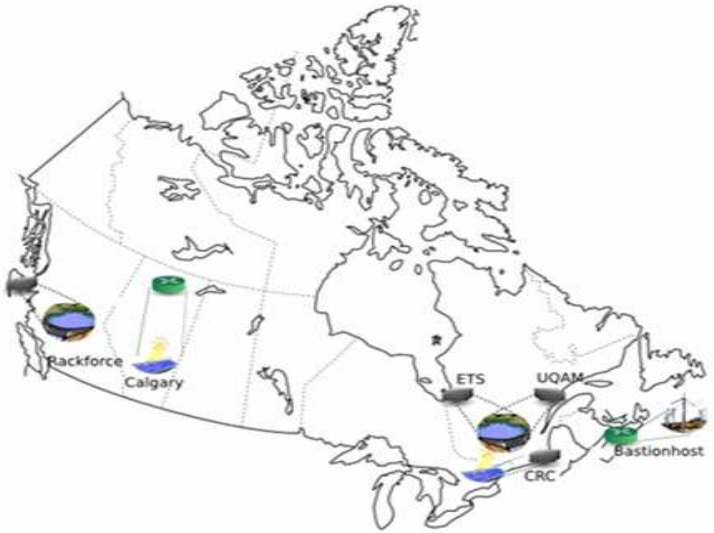
Layers of the GreenStar Network



Reference layered model of a Cloud Architecture



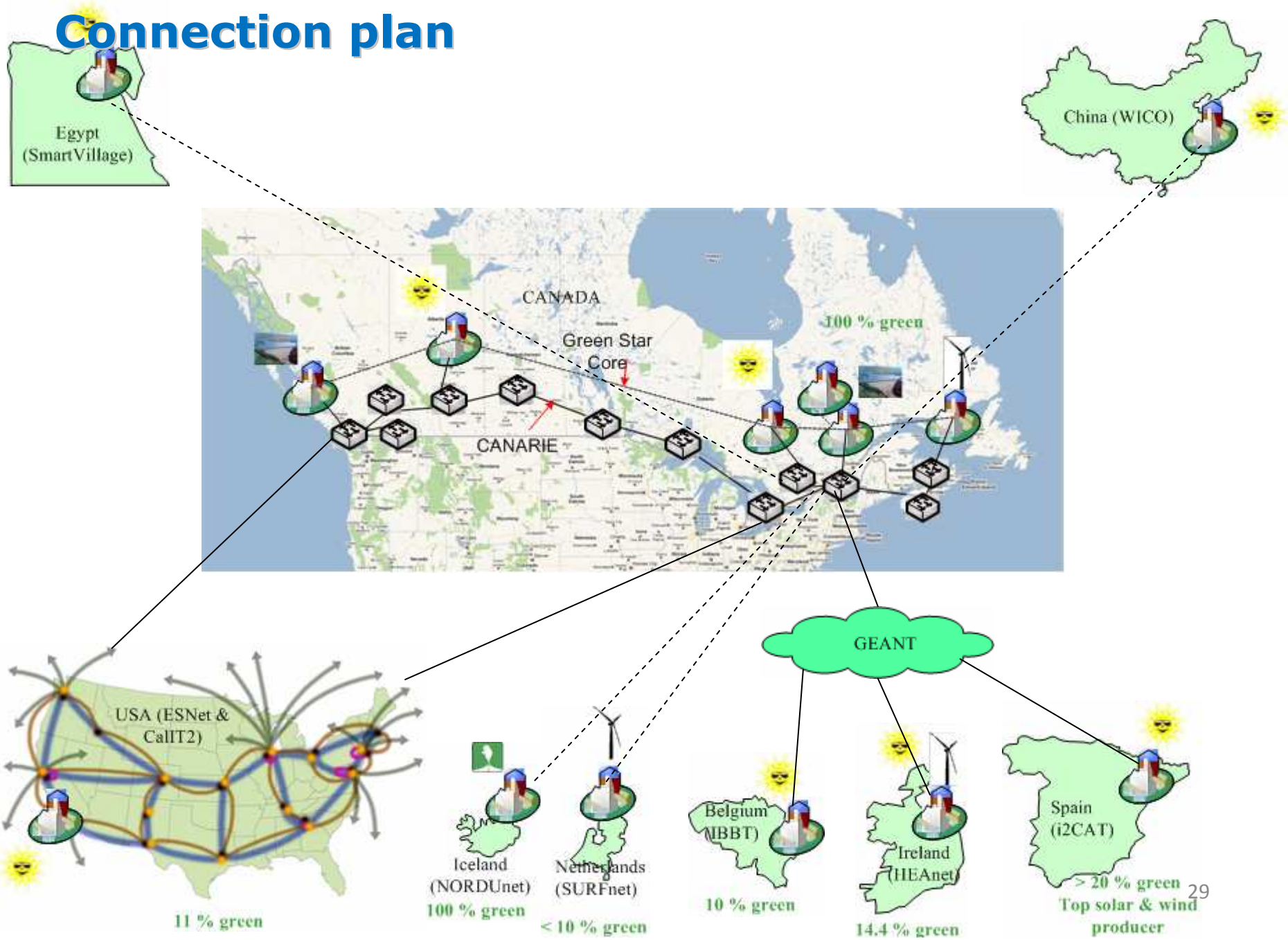
A) Physical connection



B) Geographical distribution

The GreenStar Network

Connection plan



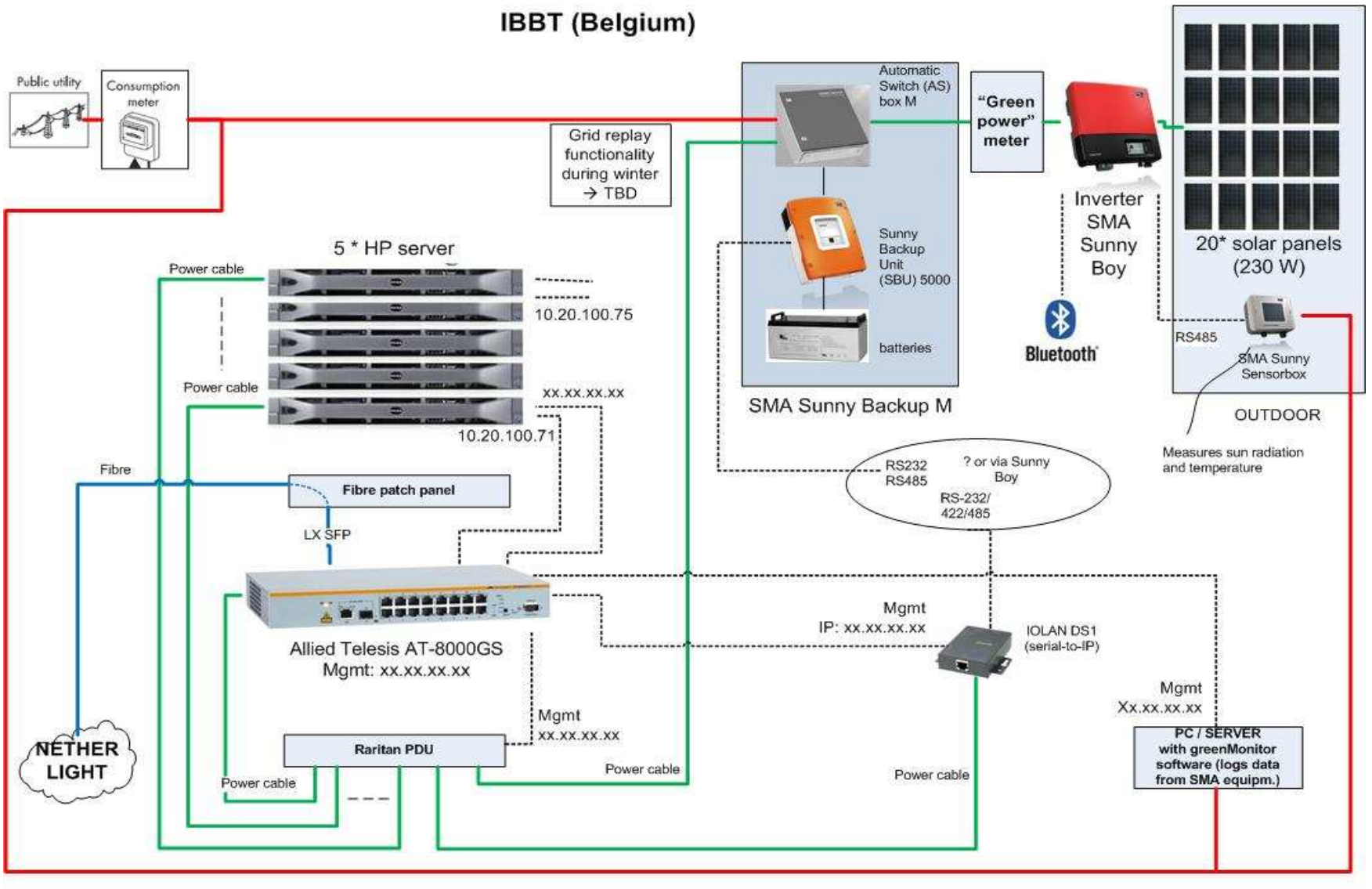
European Mantychore

- MANTYCHORE-GSN
  - Design necessary experiments and tests
    - Check the viability of the movement of services : VMs and applications.
    - using innovative networking paradigms such as IaaS and BoD solutions.
  - Perform the integration between GSN and MANTYCHORE
    - Physical integration between the GSN and the NRENs infrastructure
    - Services integration
    - Distributed virtual routing – slit FIBs

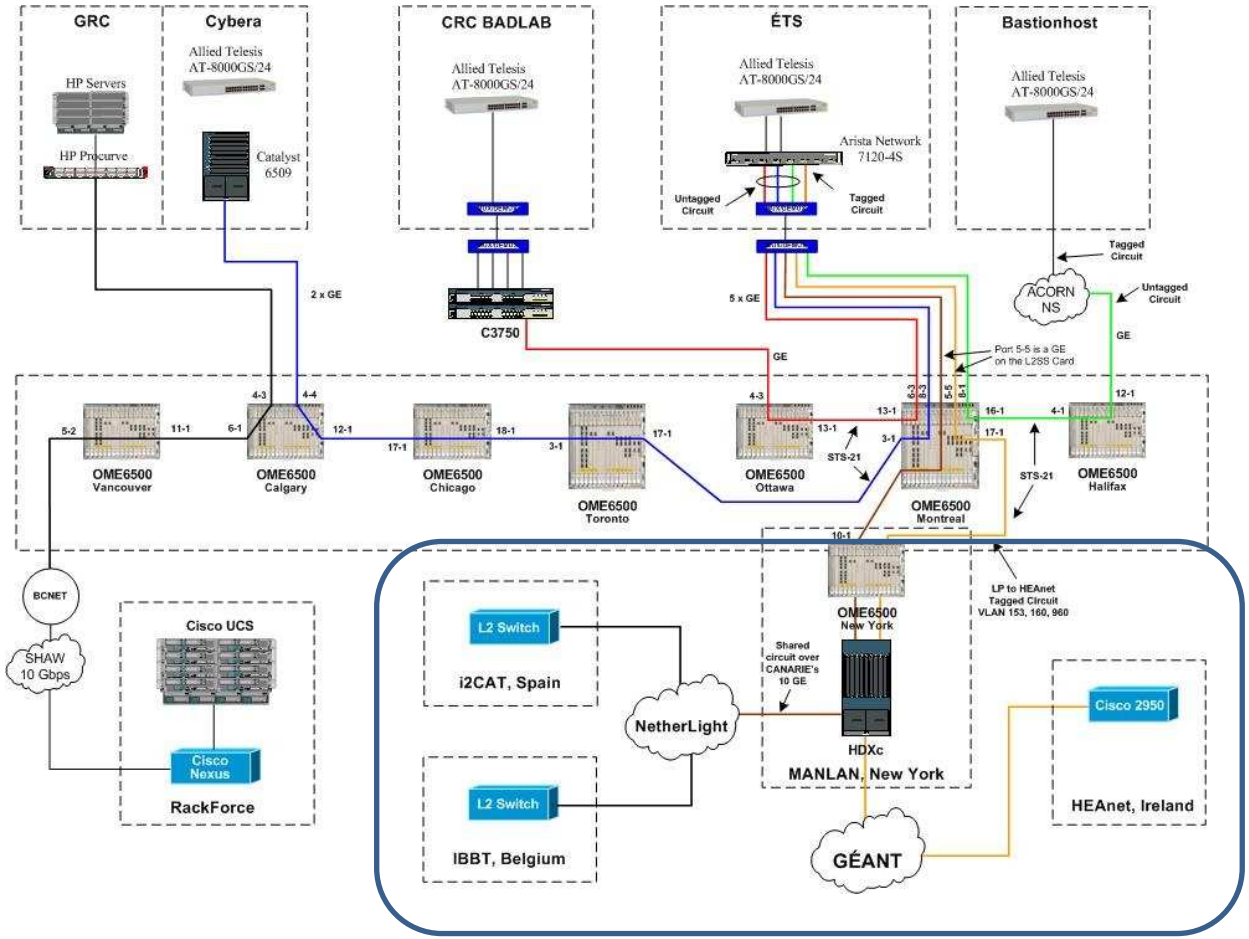
EPA rooftop, Ireland

Dundalk, Ireland

IBBT GSN Node



GSN Node & Network

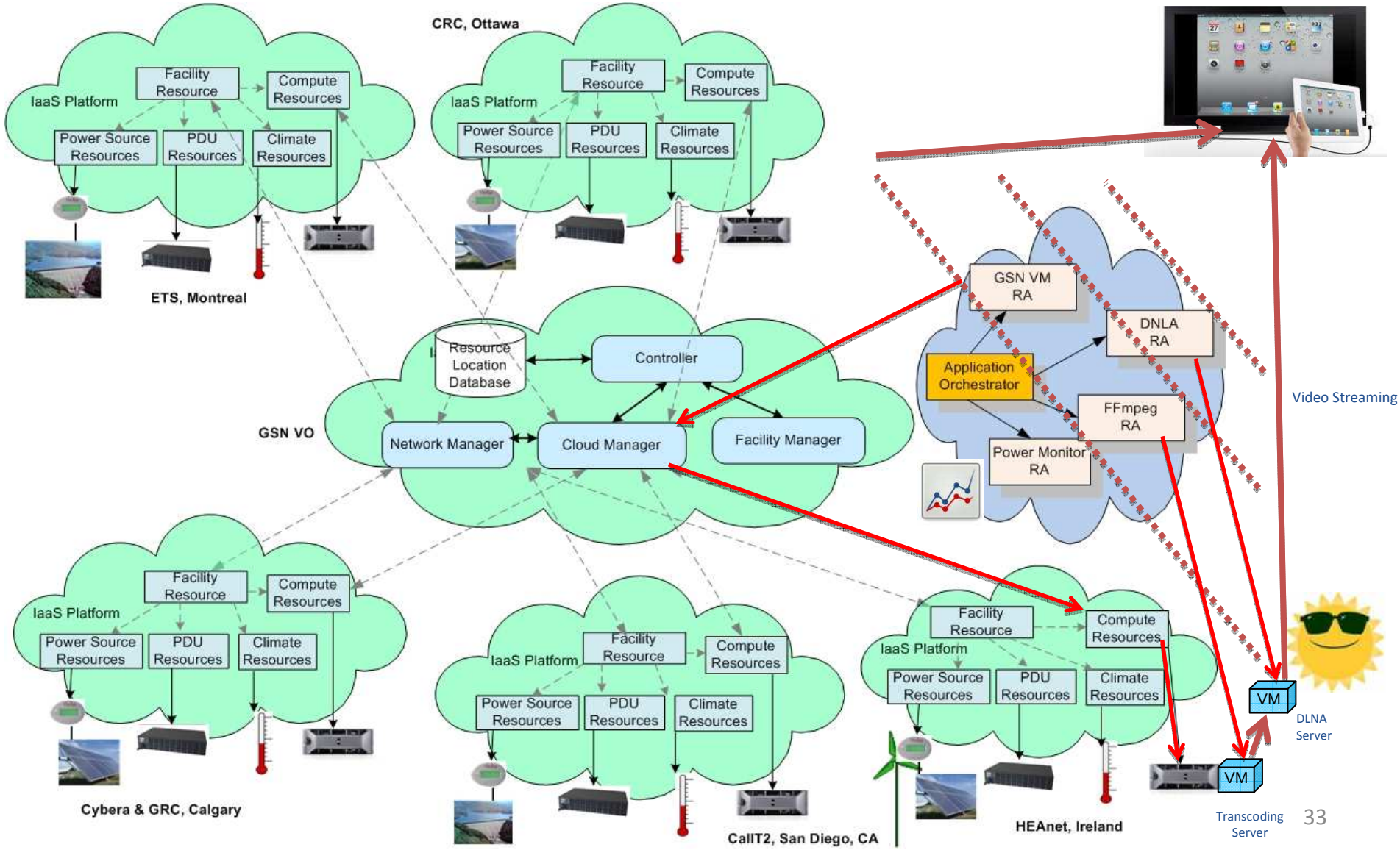


GSN associates and MANTYCHORE

- Follow the wind, follow the sun.
- Collect network energy consumption metrics.
- Estimate remaining green energy.
- Migrate VMs to another location.
- The network must be reconfigured.

GSN – Panlab

Transcoding and Video Streaming service provision based on Follow the Sun and the Wind



Economic benefits of follow the wind/sun architectures

- Cost- and Energy-Aware Load Distribution Across Data Centers
  - http://www.cs.rutgers.edu/~ricardob/papers/hotpower09.pdf
  - Green data centers can decrease brown energy consumption by 35% by leveraging the green data centers at only a 3% cost increase

- Cutting the Electric Bill for Internet-Scale Systems
  - Companies can shift computing power to a data center in a location where it's an off-peak time of the day and energy prices are low
  - Cassatt a product that dynamically shifts loads to find the cheapest energy prices
  - 45% maximum savings in energy costs
  - http://ccr.sigcomm.org/online/files/p123.pdf
  - http://earth2tech.com/2009/08/19/how-data-centers-can-follow-energy-prices-to-save-millions/

- Computing for the future of the planet
  - http://www.cl.cam.ac.uk/research/dtg/~ah12/
  - http://earth2tech.com/2008/07/25/data-centers-will-follow-the-sun-and-chase-the-wind

Building a “5G” wireless network

- Vision: to allow students, researchers and employees to collaborate, research, learn anytime and anywhere they seem fit!
- Existing 3G and 4G networks cannot handle data load
- New mobile networks seamlessly integrate with WiFi on campus
  - New Wifi standards 802.11u allow for data handoff from 3G networks
  - Eduroam can be the global authorization tool
- Mobile operators need access to WiFi on Campus
- WiFi nodes can be powered by renewable sources such as roof top solar panel over 400Hz power systems or ethernet power

Wireless Challenges on Campus

- Gap between management and IT staff
  - Maintenance of wireless networks is substantial
  - Wireless access is essential for end-users
  - Wireless infrastructure is regarded as secondary
- Network planning
  - constantly changing building infrastructure raises
  - coverage challenges and is unpredictable
- WLAN — scalability, interference, availability
  - Limited or too much coverage (eduroam conflicts)
  - Session continuity and access to campus services whilst moving

- Wireless Campus Desires
  - Coupling of wireless campus with (private)3G/4G infrastructures
  - “Open SIM” /operator agnostic
- Guest access to eduroam
  - Traceability and privacy-proof indoor positioning of individuals
- Easier network planning — coverage outside buildings
  - Outsourcing of network maintenance
  - Less bureaucracy, match finances with plans and stop reinventing the wheel

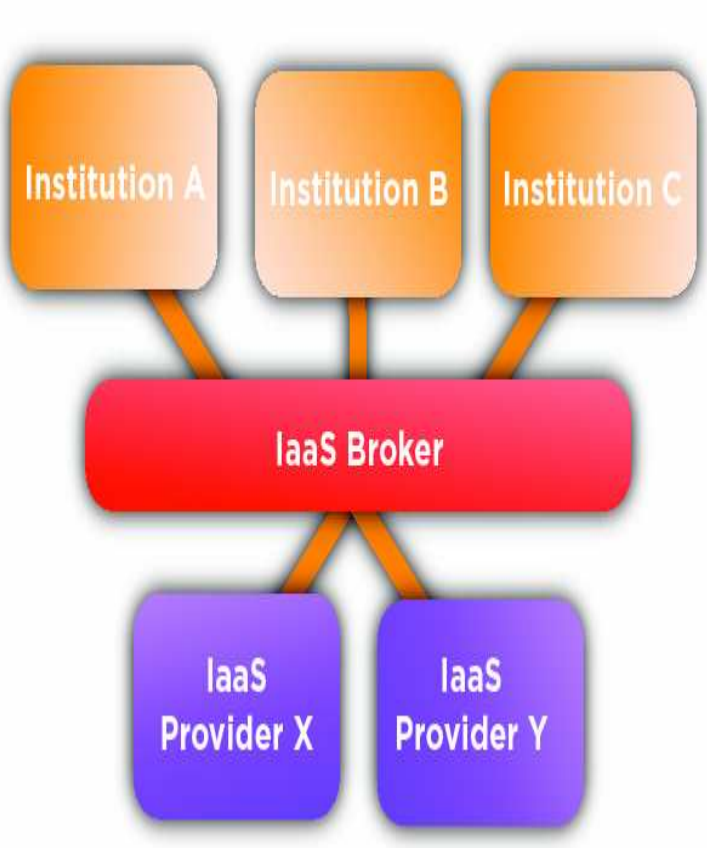
Impact of 5G networks

- 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

NREN as Cloud Broker

- NREN takes care of trust establishment and contract settlement
- Broker can handle disputes in the cloud
- More transparent in terms of
  - Operation and Accountability
  - Awareness raising
  - Guidance on expectations regarding the use of the
- Community Cloud
  - Levels of security
  - Meeting legal obligations (compliance)
- No need to tender



Cyber-infrastructure in a Carbon Constrained World

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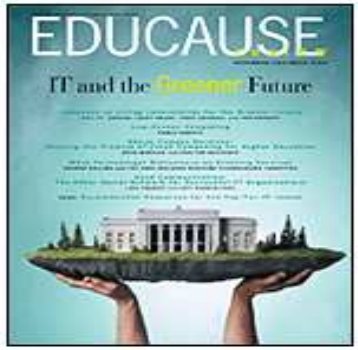
IT and the Greener Future



features

Campuses as Living Laboratories for the Greener Future

BILL ST. ARNAUD, LARRY SMARR, JERRY SHEEHAN, AND TOM DEFANTI

Institutional leaders need to reduce the campus carbon footprint by decreasing the emissions of their existing cyberinfrastructure while they simultaneously increase their use of cyberinfrastructure in areas such as intelligent infrastructure and dematerialization.

Web Bonus

For more on the science behind the current energy and climate change imperative and on the impact for colleges and universities from potential regulation, see:

Climate Change and Higher Education

BILL ST. ARNAUD, LARRY SMARR, JERRY SHEEHAN, AND TOM DEFANTI

Read online: http://www.educause.edu/library/erm0961

http://net.educause.edu/ir/library/pdf/ERM0960.pdf

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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