# How Optical Networks can Help Reduce Global Warming

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# The Climate Change Imperative

- **One of , if not, the greatest threat to our future society and economy is global warming.**
- **15-30% cut in greenhouse gas emissions by 2020 will be needed to keep the temperature increase under 2 °C, and a deeper reduction by 60-80% may be needed by 2050.***
- **Past IPCC assessments have underestimated the pace of change**
  - Latest data indicates we are at the high end of projectiosn
- **It will be necessary to go beyond incremental improvements in energy efficiency, current life-styles and business practices. Significantly more drastic measures will need to be undertaken**

*International Panel on Climate Change

# An inefficient truth- ICT impact on CO2 emissions*

- It is estimated that the ICT industry alone produces CO2 emissions that is equivalent to the carbon output of the entire aviation industry.
- ICT is now 5th largest industry in terms of consumption of power
- ICT emissions growth fastest of any sector in society, doubling every 4 years
- One small computer server generates as much carbon dioxide as a SUV with a fuel efficiency of 15 miles per gallon
- Nearly 40% of servers at universities and businesses are under utilized by more than 50%.

*An Inefficient Tuth: http://www.globalactionplan.org.uk/event_detail.aspx?eid=2696e0e0-28fe-4121-bd36-3670c02eda49

# Cyber-infrastructure: the scary facts

- By 2008, 50% of today's Data Centers and major science facilities in the US will have insufficient power and cooling;*
- By 2010, half of all Data Centers will have to relocate or outsource applications to another facility.*
- During the next 5 years, 90% of all companies will experience some kind of power disruption. In that same period one in four companies will experience a significant business disruption*
- Cyber-infrastructure is often the 2nd largest consumer of electricity after basic heat and power on university campuses

*Sourcce: http://www.nanog.org/mtg-0802/levy.html

# The Problem

- Compute energy/rack : 2 kW (2000) to 30kW in 2010
- Cooling and power issues now a major factor in CI design
- But academic CI is often too small: departmental closets
- Energy use of departmental facilities is exponentiating creating crises of space, power, and cooling
- Unfortunately, almost nothing is known about how to make these shared virtual clusters energy efficient, since there has been no financial motivation to do so

*Sourrce: Tom Deafnti GreenLight

# Solutions to reduce global warming

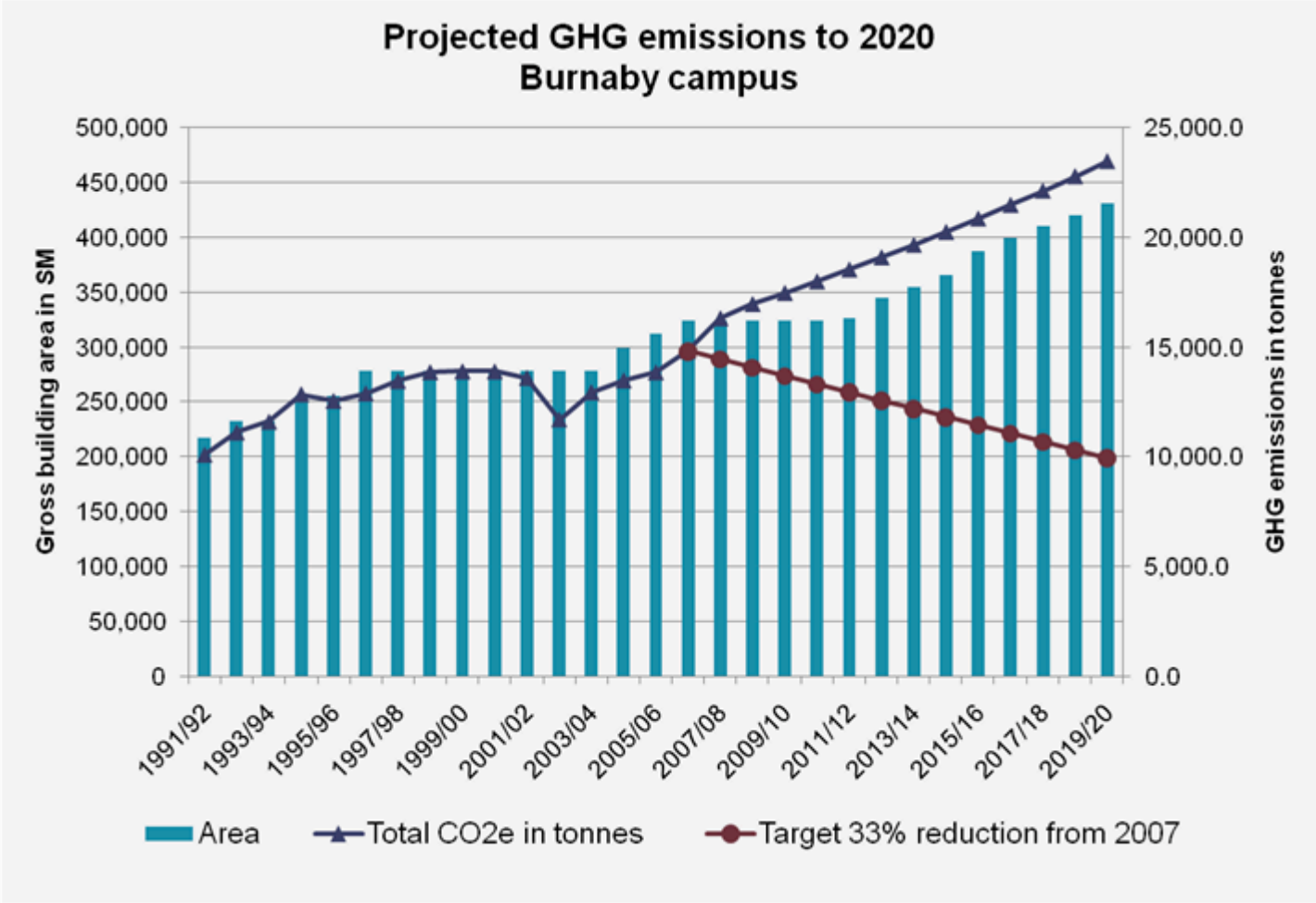
- **Carbon taxes**
  - Politically difficult to sell
- **Cap and trade**
  - Useful for big emitters like power companies
  - Addresses only supply side of CO2
- **Carbon offsets**
  - Immature market with no standards
  - But addresses demand side of CO2 by businesses and consumers
- **Carbon Neutrality imposed by law**
  - Growing in popularity especially as protests over gas tax escalates

# Public Sector to be carbon neutral by 2010 in BC

- **British Columbia was first government to introduce carbon tax in Western Hemisphere**
- **Provincial Government in province of British Columbia has mandated all public sector institutions to be carbon neutral by 2010**
  - Other provinces exploring to implement the same policy
  - New Zealand has also made the same requirements
- **Many universities and businesses are adopting voluntary carbon neutrality objectives**
  - Dell, Cisco, Google etc
- **This will have big impact on university research and optical networks**

# University GHG emissions

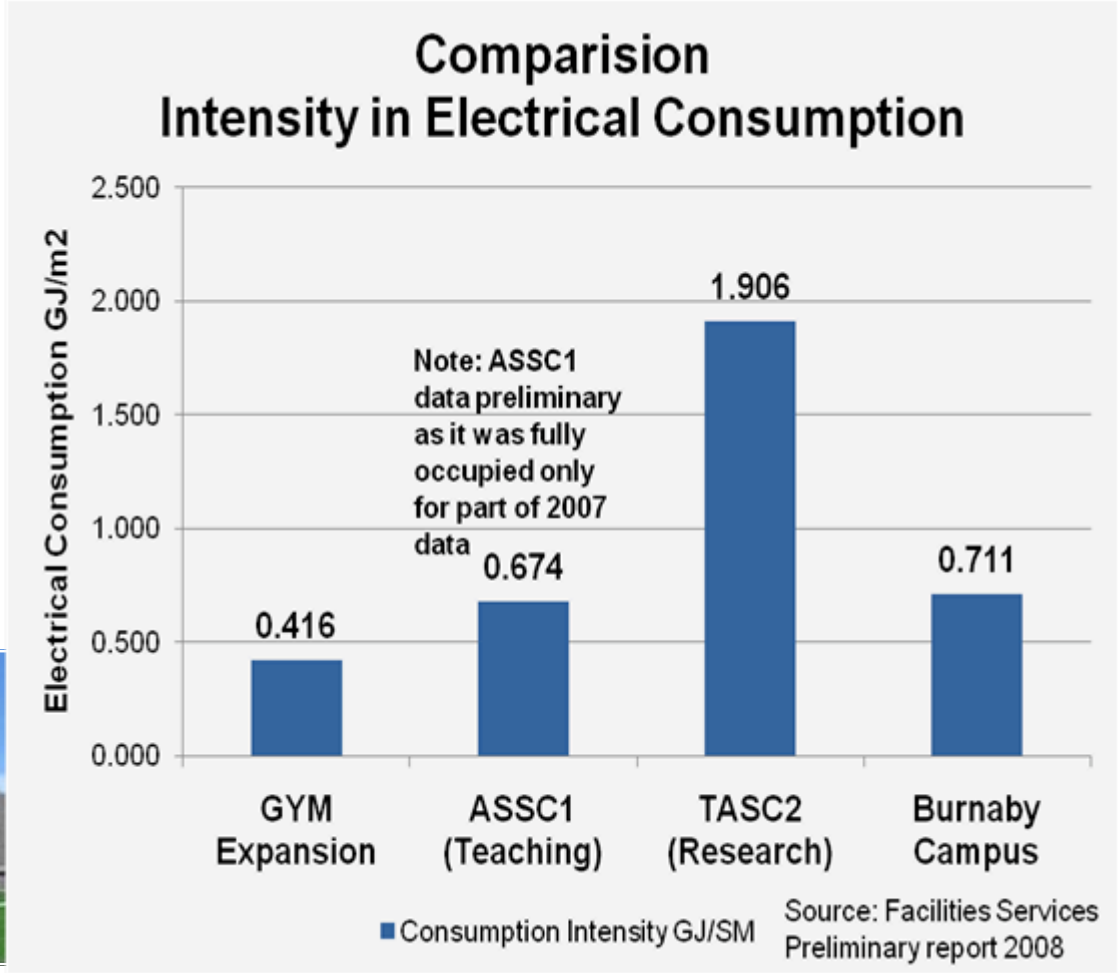
- Projected GHGs are based on Planned Growth in Ten Year Capital Plan




Source: SFU Facilities Services

# CI major cause of GHG emissions

## TASC2 Research Building



# Why advanced networks are critical to reducing CO2

- Direct emissions of Internet and ICT are important at 2-3% of world emissions but, in order of impact, the most significant contribution we can make is through leveraged, or indirect, emissions reductions.

- According to SMART 2020 these represent as much as a 15% reduction opportunity in global emissions.

- (And SMART 2020 is one of the most conservative reports on the topic. Others identify even higher potential for savings).

# SMART 2020

- Internet and ICT could reduce emissions by 15 per cent and save global industry $US 800 billion in annual energy costs by 2020.
- Could cut CO2 greater than the current annual emissions of either the US or China.
- One of the biggest contribution to reducing CO2 emissions by Internet and ICT is through “virtualization” or “de-materialization” of existing physical products and services.
- http://www.theclimategroup.org/news_and_events/news_and_comment/smart2020pressrelease

# The Falsehood of Energy Efficiency

- **Most current approaches to reduce carbon footprint are focused on increased energy efficiency of equipment and processes**
- **This approach is doomed to failure because of Khazzoom-Brookes postulate (aka Jevons paradox)**
  - Greater energy efficiency reduces overall cost and therefore promotes increased usage
- **We need a "zero carbon" strategy because increased usage will not change emission equation**
  - Anything times zero is zero
- **Internet networks and broadband architecture are the answer**

# Energy efficiency is bull---

- **Lots of confusion between energy efficiency and consumption versus CO2 emissions**
- **Energy efficiency is meaningless. In fact you can have increased energy consumption, but reduced CO2 emissions**
  - E.g. zero carbon data centers
  - Life cycle CO2 emissions can exceed any savings from energy emissions
- **The only thing that counts is CO2 emissions**

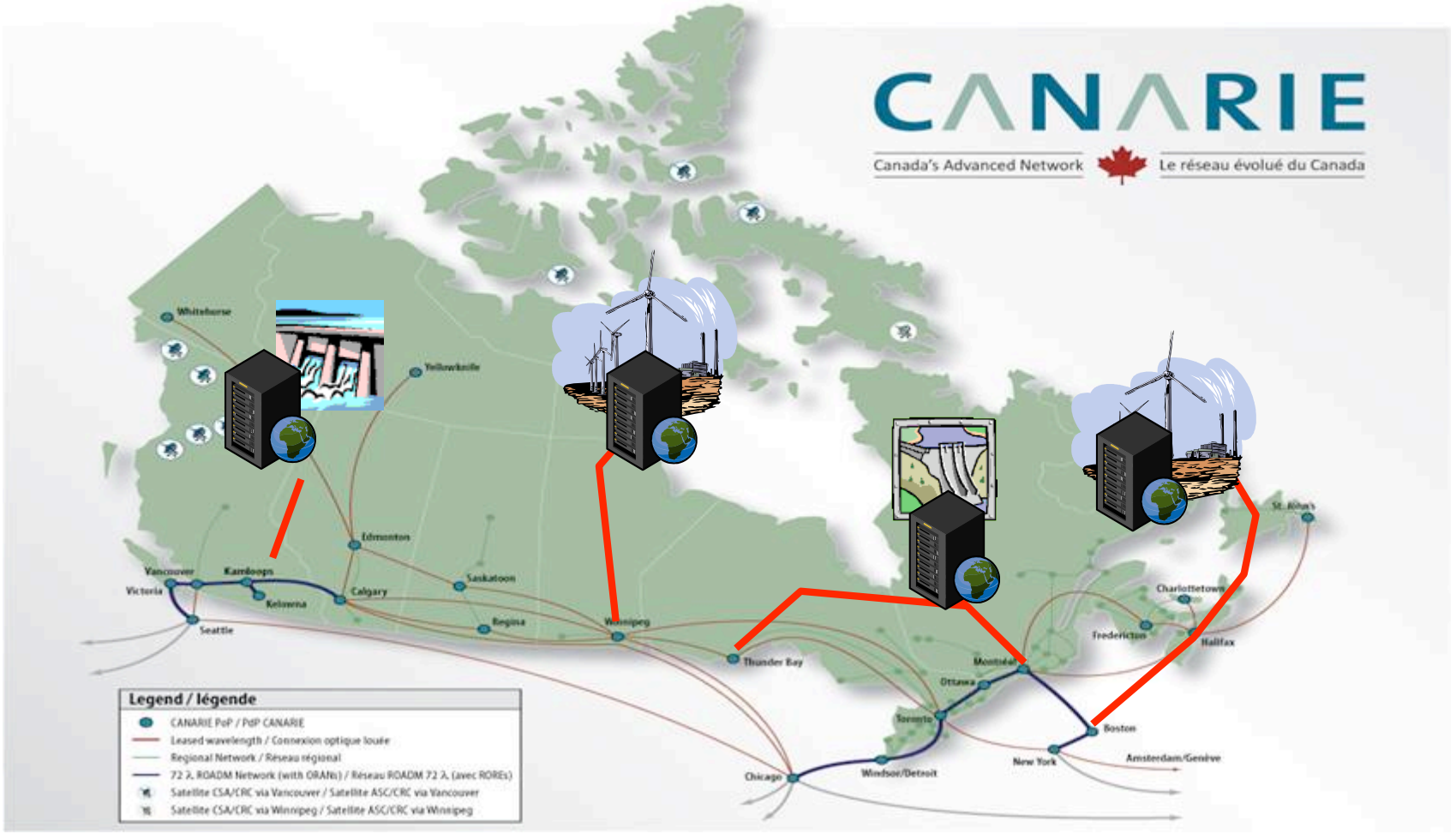
# Optical networks and cyber-infrastructure are the solution

- Optical networks have much smaller carbon footprint and allow relocating cyber-infrastructure equipment to zero carbon data centers
- Significant reduced CO2 impacts are possible through use of cyber-infrastructure tools like virtualization, clouds, SOA, grids, Web 2.0, etc.
- New “zero carbon” computer and network architectures needed to connect remote computers, databases and instruments will be essential

# “Zero Carbon” CI Facilities

- **Purchasing green power locally is expensive with significant transmission line losses**
  - Demand for green power within cities expected to grow dramatically
- **CI facilities DON’T NEED TO BE LOCATED IN CITIES**
  - -Cooling also a major problem in cities
- **Most renewable energy sites are very remote and impractical to connect to electrical grid.**
  - But can be easily reached by an optical network
  - May also meet some of government’s objectives of extending broadband to rural/remote areas
- **Many examples already**
  - Green House Data, Cheyenne WO
  - AISO wind powered data farm
  - Iceland and Lithuania National strategies

# “Zero Carbon” CI facilities connected by optical networks



# “The best place in North America for Data Center”- CIO Magazine

- Partnership between IBM and Rackforce
- $100m investment – 85,000 sq ft
- Cheap renewable power, well educated community, geological stability
- Hydro electric power as low as 2 cents per kilowatt, versus 20 cents in other jurisdiction

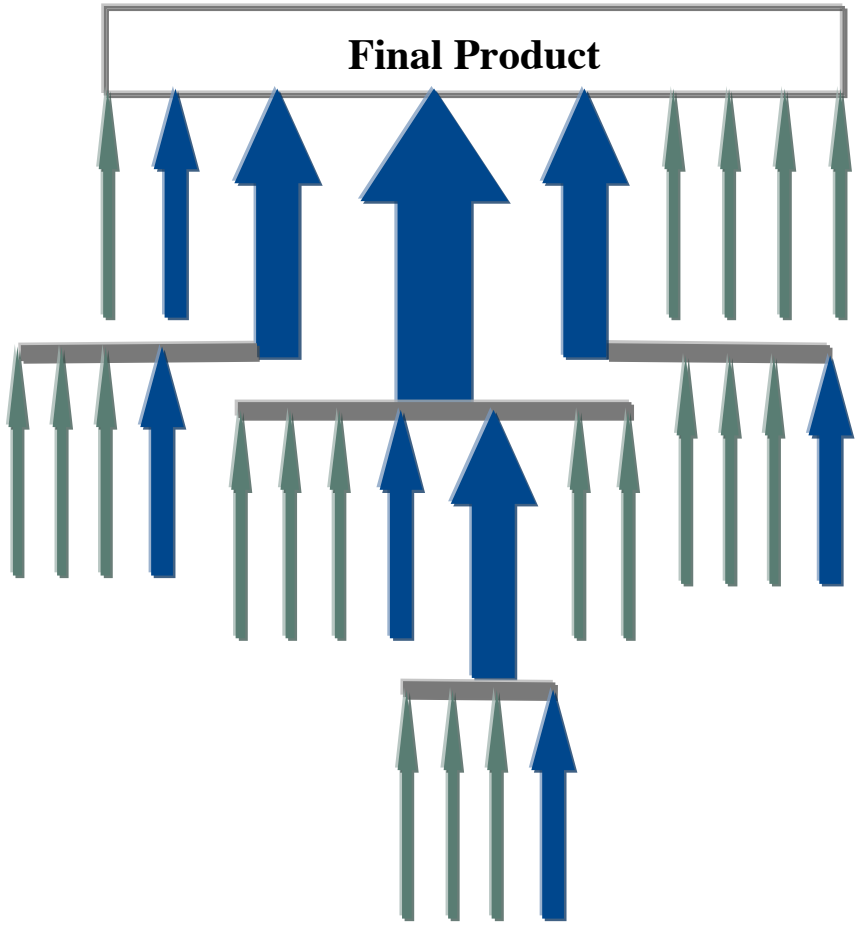
**Kelowna BC**

http://www.cio.com/article/183256/The_Best_Place_to_Build_a_Data_Center_in_North_America

# ISO 14064/2/3

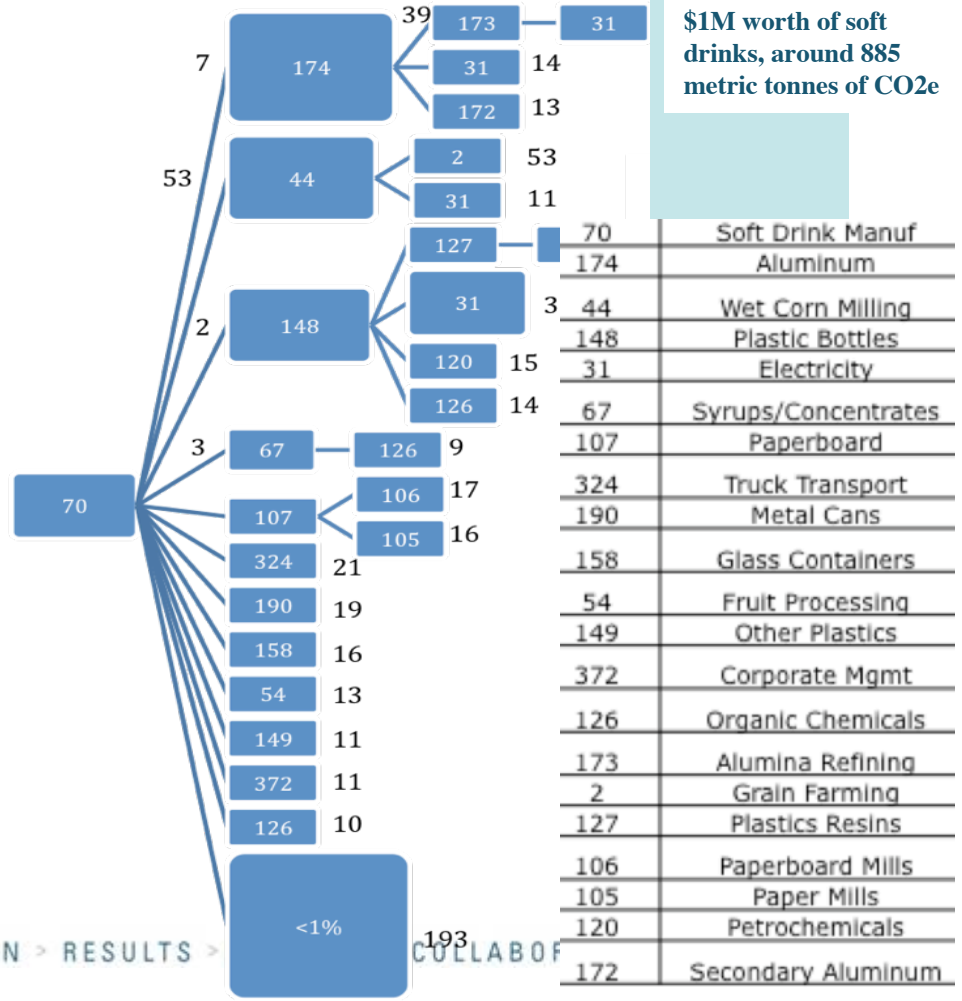
- **ISO 14064 is the accounting process required to validate whether a project actually reduces CO2**
- **ISO 14062/3 sets the measurement process for "life cycle" CO2 emissions for a product or service**
- **You need to implement ISO 14064 process to demonstrate actual CO2 reductions**
  - Vendors need to provide 14062/3 data for products and services

# Deep dive: CO2 Accounting




**Example:**
**Soft drink manufacturer**

**$1M worth of soft drinks, around 885 metric tonnes of CO2e**



# Calculating 14064 for your research network

| | 14062 life cycle | operation 5 years coal |
|---|---|---|
| > Optical Switch | 4 tons | 20 tons |
| > Router | 16 tons | 500 tons |
| > Optical Amplifiers | 2 tons | 40 tons |
| > Computer server | 12 tons | 300 tons |
| > Ethernet switch | 8 tons | 200 tons |
| > PC | 20 tons | 5 tons |
| > Travel to install and repair | - | 100 tons |
| > Total 14064 | 68 tons | 1165 tons |

> Virtualized network can save 50% of your carbon emissions

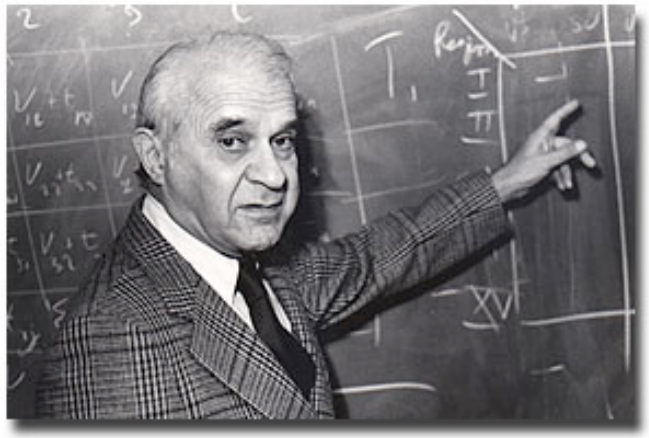
# Do your 14064 NOW!!

- You can not earn credits after you implement network equipment or architectures to reduce CO2
- Next year carbon is $100 per ton in Europe
- Int

# Economic Input-Output Life Cycle Assessment

## Definition and Usage

- Categorized the U.S. Economy into 491 sectors
- Measures the entire life-cycle of a product, from raw materials to recycling/disposal
- Traces the transactions along this path
- Traditionally used to measure economic value added at each step
- Adapted to measure environmental impact of each step



Wassily Leontief
Nobel Prize 1973

**Provide the environmental footprint of the "average" product per category, e.g. the average American car**

## Historic Background

- Invented by Wassily Leontief
- Data obtained from U.S. Department of Commerce
- In 1949 – One of the first economic models developed using a computer
- Continues to be used for economic planning

# EIO LCA example

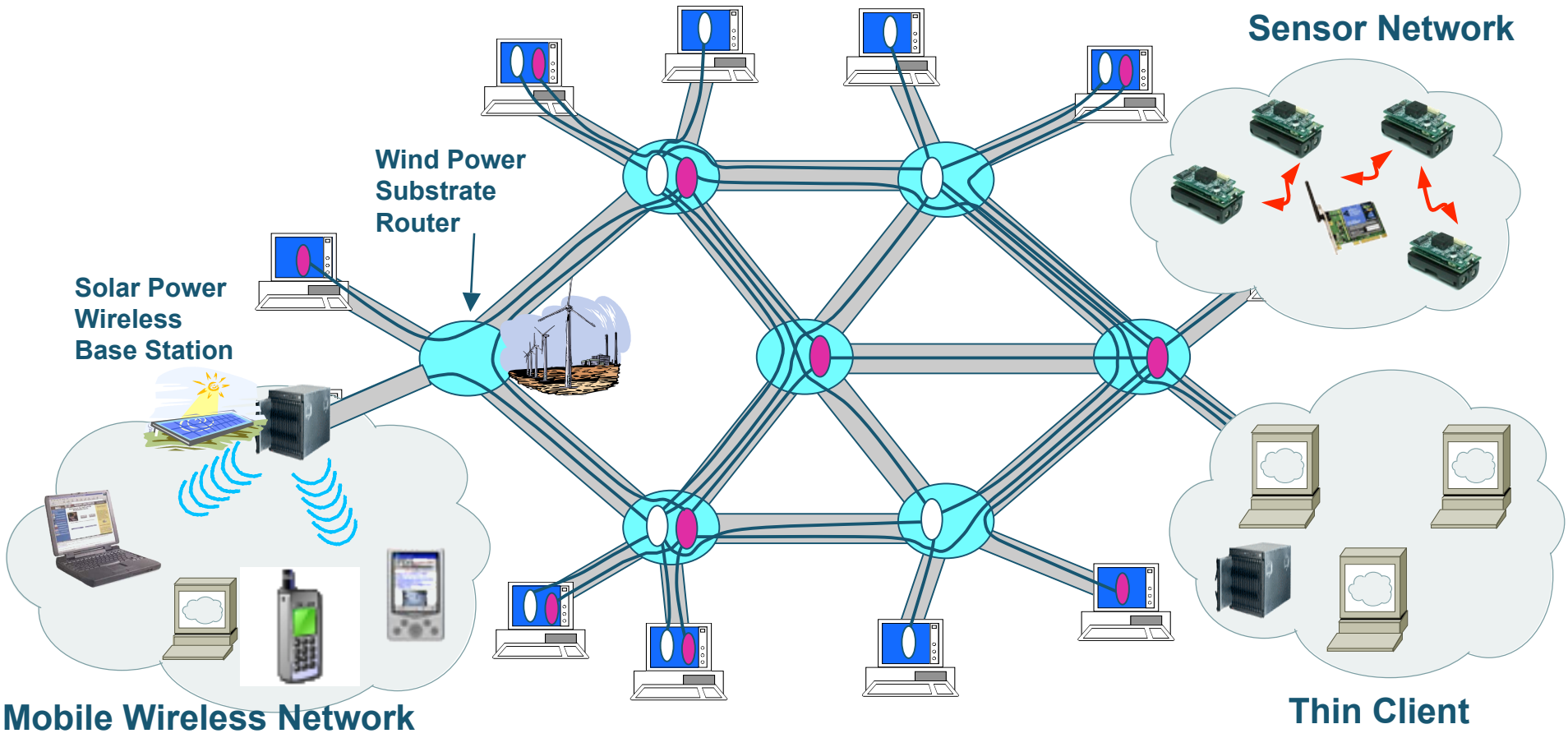
## GHG footprint of the average American car

| | Sector | GWP MTCO2E | CO2 MTCO2E | CH4 MTCO2E | N2O MTCO2E | CFCs MTCO2E |
|---|---|---|---|---|---|---|
| | **Total for all sectors** | 1260 | 1060 | 114. | 24.9 | 53.2 |
| 221100 | Power generation and supply | 375. | 371. | 0 | 0 | 4.51 |
| 331111 | Iron and steel mills | 137. | 137. | 0 | 0 | 0 |
| 484000 | Truck transportation | 117. | 115. | 0.179 | 1.61 | 0 |
| 562000 | Waste management and remediation services | 54.8 | 8.67 | 46.1 | 0.067 | 0 |
| 336300 | Motor vehicle parts manufacturing | 44.8 | 44.8 | 0 | 0 | 0 |
| 481000 | Air transportation | 35.0 | 34.5 | 0.044 | 0.372 | 0 |
| 331312 | Primary aluminum production | 27.4 | 9.24 | 0 | 0 | 18.2 |
| 211000 | Oil and gas extraction | 25.6 | 4.30 | 21.3 | 0 | 0 |
| 212100 | Coal mining | 23.5 | 1.56 | 21.9 | 0 | 0 |
| 336110 | Automobile and light truck manufacturing | 21.5 | 21.5 | 0 | 0 | 0 |

# Next Generation Internet to reduce Global Warming

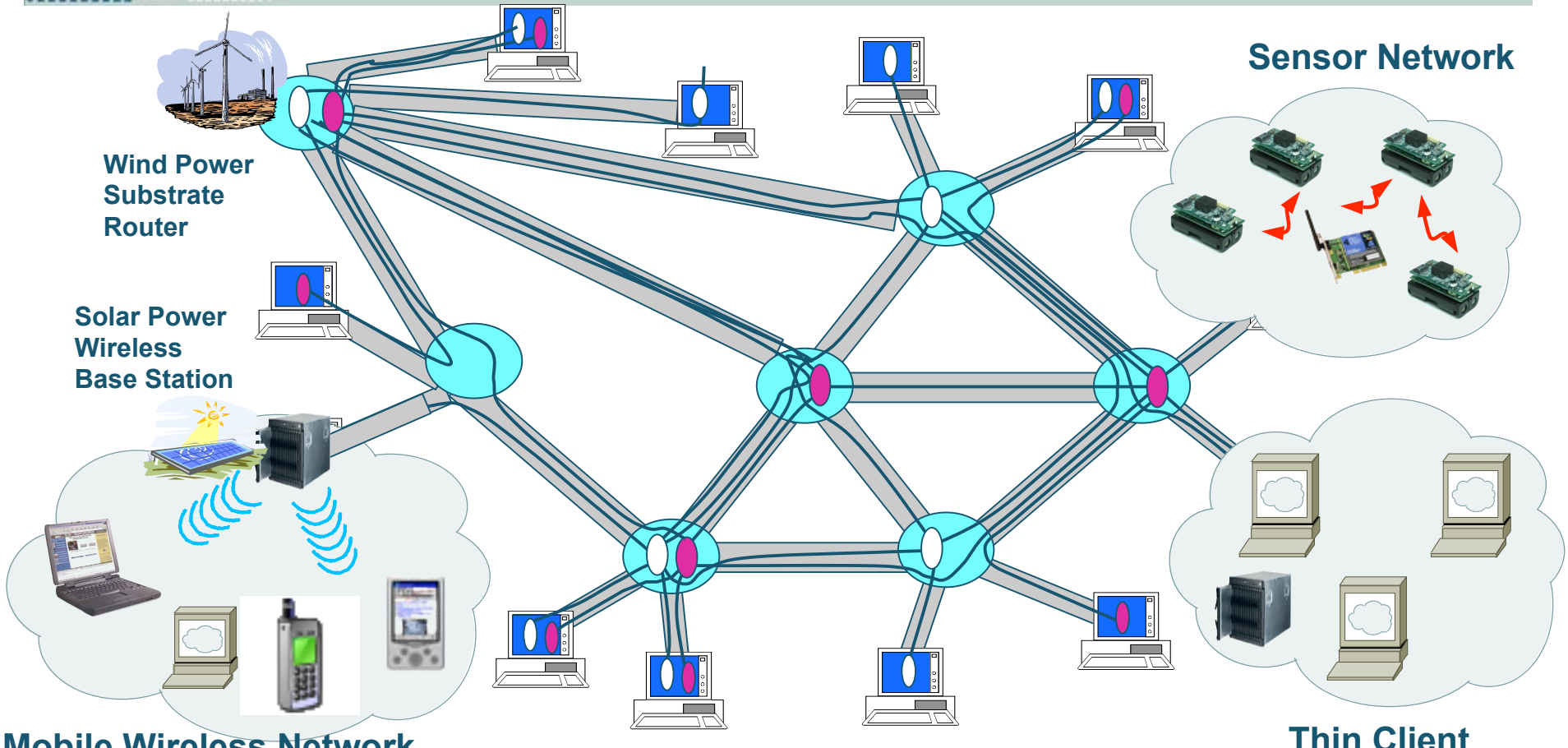
- **PROMPT: New $50m research consortium made up of Bell Canada, Nortel, Ericsson, McGill, UoT**
  - International participation including GENI, CAL-IT2, Scripps, etc
- **Any future internet network, project, program or application must have as its primary objective of a zero carbon footprint**
- **Zero carbon condition applies to**
  - Remote instrumentation and laboratories
  - all optical, wireless and last mile networks
  - all routers, switches, and web servers
  - all applications, computers instrumentation
  - and all customer  devices such as PCs, mobile phones, PDAs etc

# GENI with Zero Carbon Footprint




Source: Peter Freeman NSF

# GENI with remote nodes at renewable energy sites




Source: Peter Freeman NSF

# Re-purposing current research for G-NGI?

- **Network virtualization (with addition of zero carbon substrate routers and switches) – 4Ward, Federica and GENI**
- **Virtualization of networks and applications with SOA**
- **New routing and resiliency architectures for wired and wireless networks for massively disruptive topology changes due to setting sun or waning winds that power routers and servers**
- **New grid and data storage architectures with distributed replication and virtual machines for "follow the sun" and "follow the wind" grids**
  - Optiputer and CineGrid as precursor example
- **New virtualization and de-materialization applications**
  - CineGrid
  - Virtual Medicine HSVO – Stanford and Northern Medical school

# Novel licensing approach

- **Instead of complicated licensing agreements and royalties payment for IP will be made through carbon offsets**
- **PROMPT plans to set up a number of testbeds to develop CO2 reduction protocols, verification and audit systems to measure networks and ICT ability to reduce CO2**
  - Specific target will be remote instrumentation and laboratories
- **PROMPT will work with various carbon offset brokerage firms to aggregate and sell carbon offsets**
- **Many companies like Cisco, Google, IBM, etc will purchase carbon offsets if you use their technology top reduce Co2**

# The GreenLight Project

- UCSD now deploying first component of green cyber-infrastructure to consolidate vitrualized computer clusters and servers in energy-efficient mobile facilities.
- Every dollar spent on IT equipment will cost $2 more in power (and overhead!)
- GreenLight uses 10 Gbps over dedicated optical fiber links so end users move their clusters out of their faculty “closets” and into much “greener” configurations like data containers
- http://nsf.gov/awardsearch/showAward.do?AwardNumber=0821155

# Carbon Rewards rather than Carbon Taxes

- **Rather than penalize consumers and businesses for carbon emissions, can we reward them for reducing their carbon emissions?**

- **Using Internet and ICT to provide "virtual" products and services directly as a replacement for real equivalents, but also as incentive to "reward" consumers to reduce their own carbon footprint in other activities**
  - Virtual networks and computers for business
  - Cloud computing, Web 2.0 applications
  - Next generation solar powered PDAs and cell phones for access to the Internet
  - eMusic, eFilm, eBooks for consumer

- **Bits and bandwidth are virtually carbon free**
  - especially if we use zero carbon data centers and optical networks

# Problem: No business case for FTTh

- **Broadband networks, whether wireless or FTTx, overbuilders, municipal, requires huge capital outlay. In addition:**
  - Low takeup – “Tyranny of the takeup”
  - Revenues declining as more and more applications are free
  - Over the top providers are capturing most of the value
- **Many companies starting to offer free broadband, both wired and wireless**
  - Inuk, Sky, TalkTalk, Google, Microsoft, Cable and Wireless etc
  - Cable TV services are moving to the Internet
- **Business case for closed networks like Verizon FiOS are uncertain**

# Carbon Reward Strategy for last mile infrastructure

- **Provide free high speed Internet and fiber to the home with resale of electrical and gas power**
- **Customer pays a premium on their gas and electric bill**
- **Customers encouraged to save money through reduced energy consumption and reduced carbon output**
- **Customer NOT penalized if they reduce energy consumption**
  - May end up paying substantially less then they do now for gas + electricity + broadband + telephone + cable
- **Network operator gets guaranteed revenue based on energy consumption rather than fickle triple play**

# Thank you

- More information
- http://green-broadband.blogspot.com
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