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Energy Saving in Optical Networks (and ICTs in General)

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Contents

- Why consider energy saving in optical networks?
- How can energy be saved in optical networks?
- Power requirement trends for fixed access technologies
- Impact of broadband access technologies
- A zero carbon strategy
- The challenge for the future

Discussion topics to consider during this presentation

- Energy needs
 - Do you think that ICTs (driven by their users) leads to insatiable demand for energy?
 - Where will this energy come from in the future?
 - Is solar energy on the right evolution path?
- Climate Impact
 - How does the technology you are working on have an impact on climate?

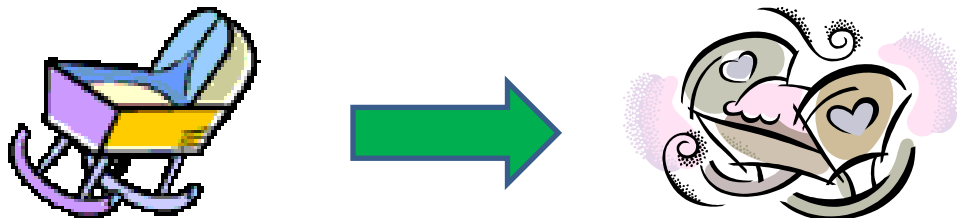
Why consider energy saving in optical networks?



- Electrical energy is a scarce resource
 - Mainly dependent on a mix of fossil fuels and nuclear
- Optical networks need electrical energy to function and are on a path of exponential growth and upgrade (like their end devices- server, pc, TV etc)
 - Worldwide coverage needed
 - Moore's law leads to obsolescence every 2-4 years
- Every 1W saved at the edge
 - is worth one power plant worldwide
 - reduces CO₂ emissions and other waste products

A Zero Carbon Strategy

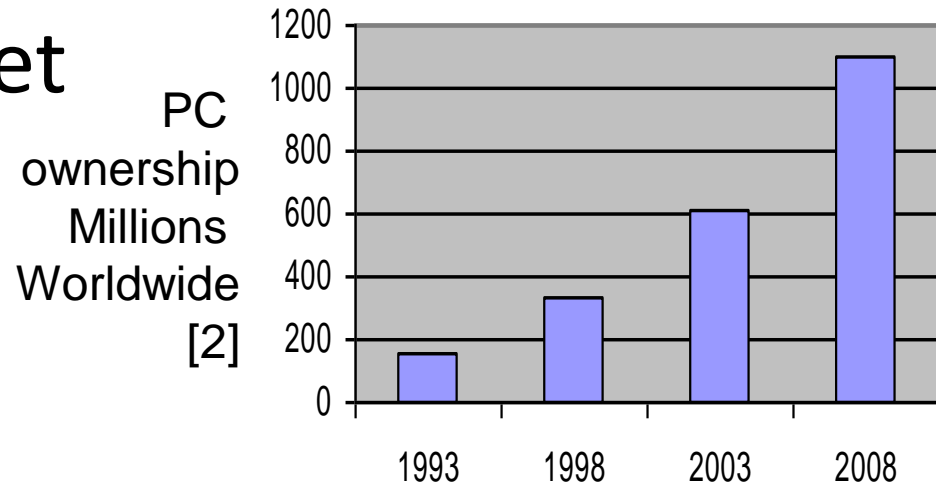
- Optoelectronic Devices do not emit GHGs in their use
 - But to minimise emissions their energy should be sourced from non-fossil fuels such as solar, tidal, wind etc.,
 - Energy used for extraction of raw materials must be included
 - A 'Cradle to Cradle' approach is advocated by Bill McDonnagh for manufacturing and recycling.
 - New products made from old so that the minerals stay in circulation
 - If this system could be perfected there would be no need for mining



Today's Global Market

In Nov 2009, broadband wireless link connection numbers exceeded wireline

PC ownership is a driver for wireline or wireless connectivity



- Wireline

- DSL 300M [1,5]
 - Cable 95M [1]
 - Fibre 53M [1]
 - Ethernet 600M [2]
 - Fixed line telephony 1270M [4]
- } 448M

- Wireless

- Cellular broadband 432M [3]
- Wifi 700M [2]
- Cellular voice 4090M [3]

Wireline supports backhaul bandwidth growth.....

[1] www.Ovum.com

[2] projection from

http://upload.wikimedia.org/wikipedia/commons/5/53/Personal_computers_%28million%29_ITU.png

[3] <http://www.gsacom.com/index.php4>

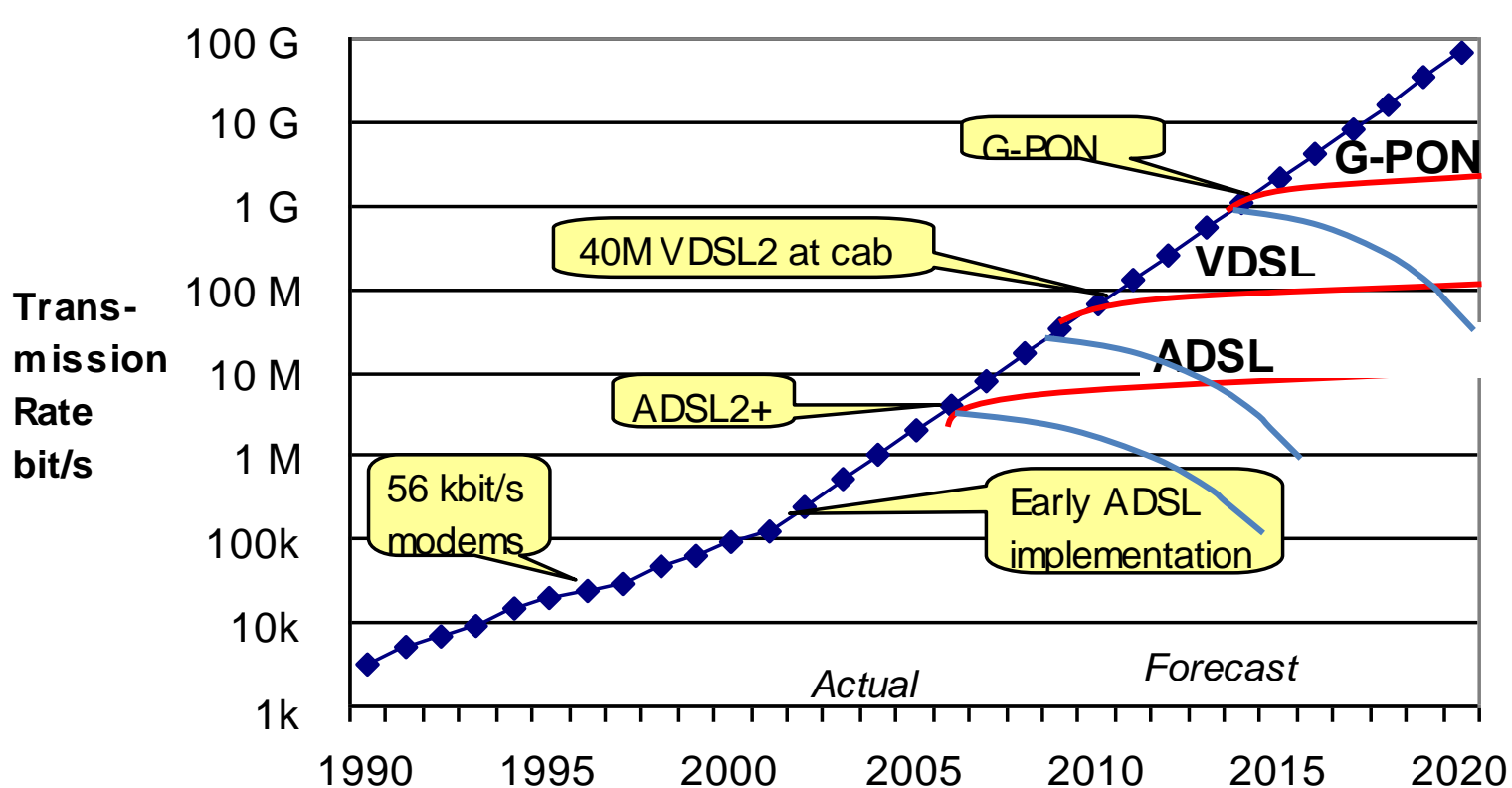
[4] <http://en.wikipedia.org/wiki/Telephone>

[5] <http://www.dslprime.com/dslprime/42-d/1329-dsl-prime-issue>

Device Example- Broadband Modems

Bit-rate and power consumption versus time

Can we increase speed while saving power?

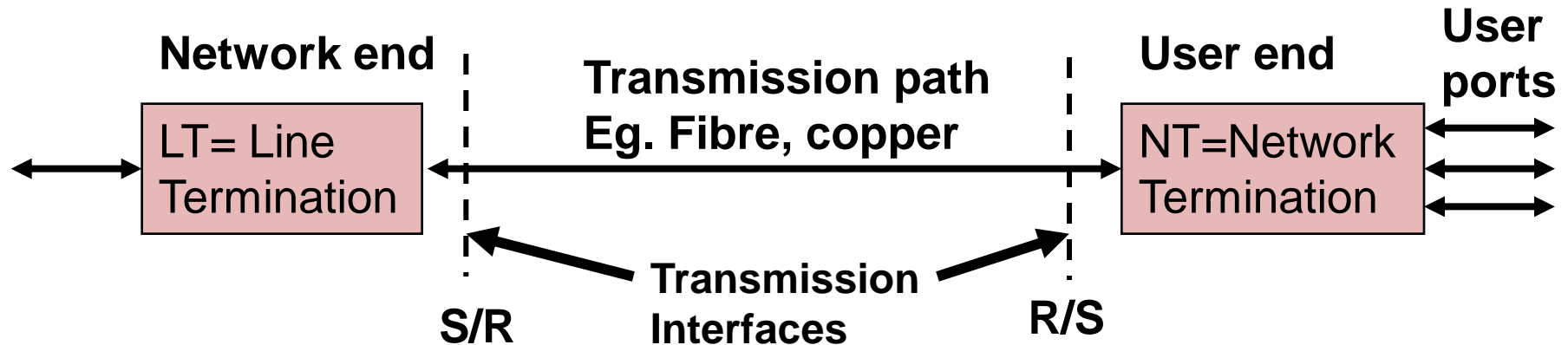


LT and NT Power consumption trend

Trend line based upon "Next Generation Broadband in Europe: The Need for Speed", Heavy Reading Report, Vol. 3, No. 5, March 2005.

Transmission Equipment Standards

- Specify power spectra in the transmission interfaces



- But do not specify power (energy) needed to operate the termination devices
- Is competition between vendors sufficient to drive energy reduction?

Why Consider Broadband Access?

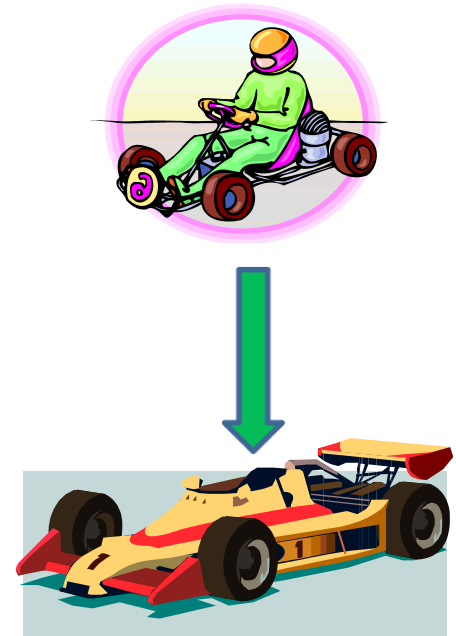
- Energy required per user leads to a huge multiplier worldwide (2B)
- No concentration in this part of the network to share energy of a device
- Require frequent upgrades to satisfy the 'need of speed'

Fixed

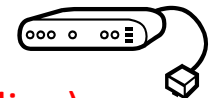
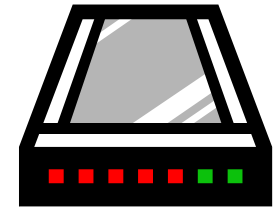
ADSL (G992 series)
VDSL (G.993 series)
G-PON (G.984 series)
DOCSIS(J.112, J.122 and J.122 series)
IEEE 802.3 series (Ethernet)

Wireless

IEEE 802.11 series (WiFi)
IEEE 802.16 series (WiMAX)
3G Wireless



What is the power consumption of Wireline Access Technologies?



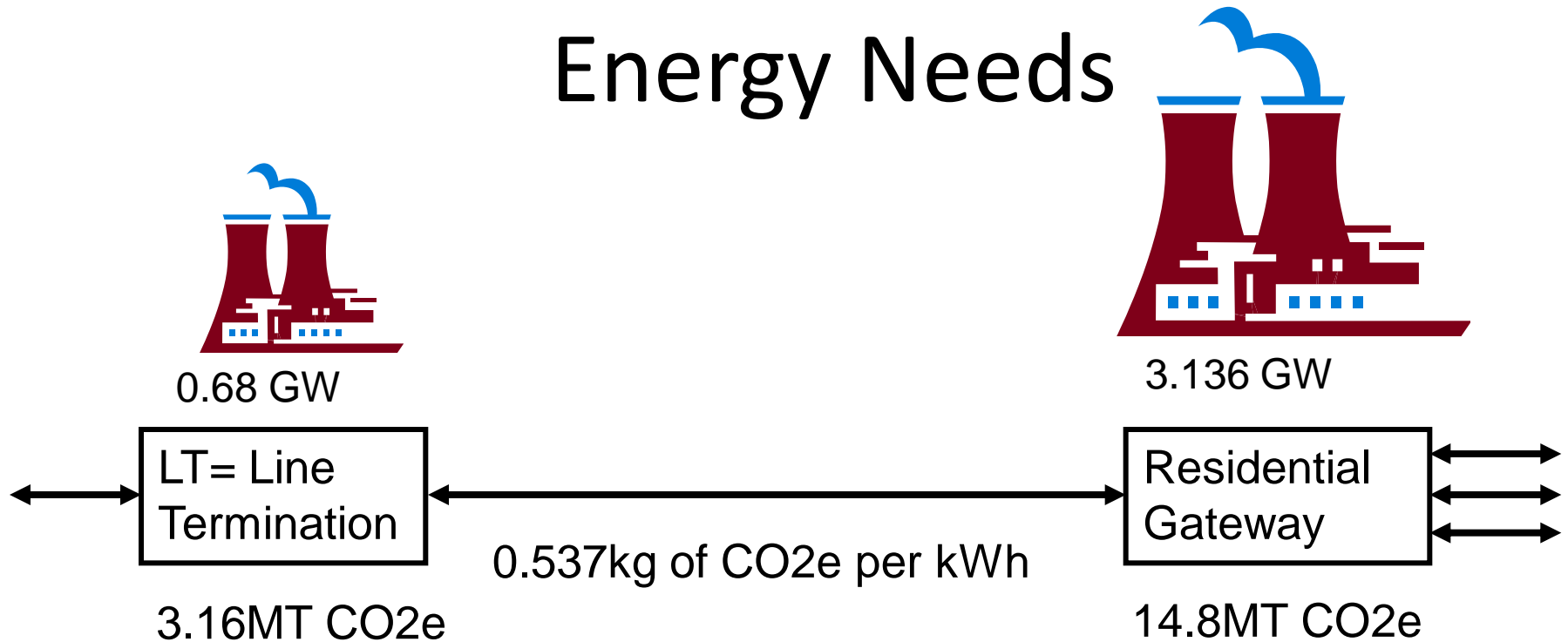
- Power consumption of a modem pair per line (approximate without user ports)
 - ADSL 3.0 W (1.5W NT plus 1.5W LT*)
 - VDSL 6.75 W (4W NT plus 2.75WLT*)
 - PON 2 W (1.5W ONT including a 1/32 share of OLT at 0.5W per line)
 - PSTN 1W (LT only)

- *At the customer end (NT) central functions and user ports can add up to a further 2.3-5 W and include*
 - Router/Firewall, 4 Ethernet, Wifi, and VOIP ports
 - As integrated 'home gateways' this power is reducing



*<http://re.jrc.ec.europa.eu/energyefficiency/pdf/CoC%20Broadband%20Equipment/Code%20of%20Conduct%20Broadband%20Equipment%20V3%20final.pdf>

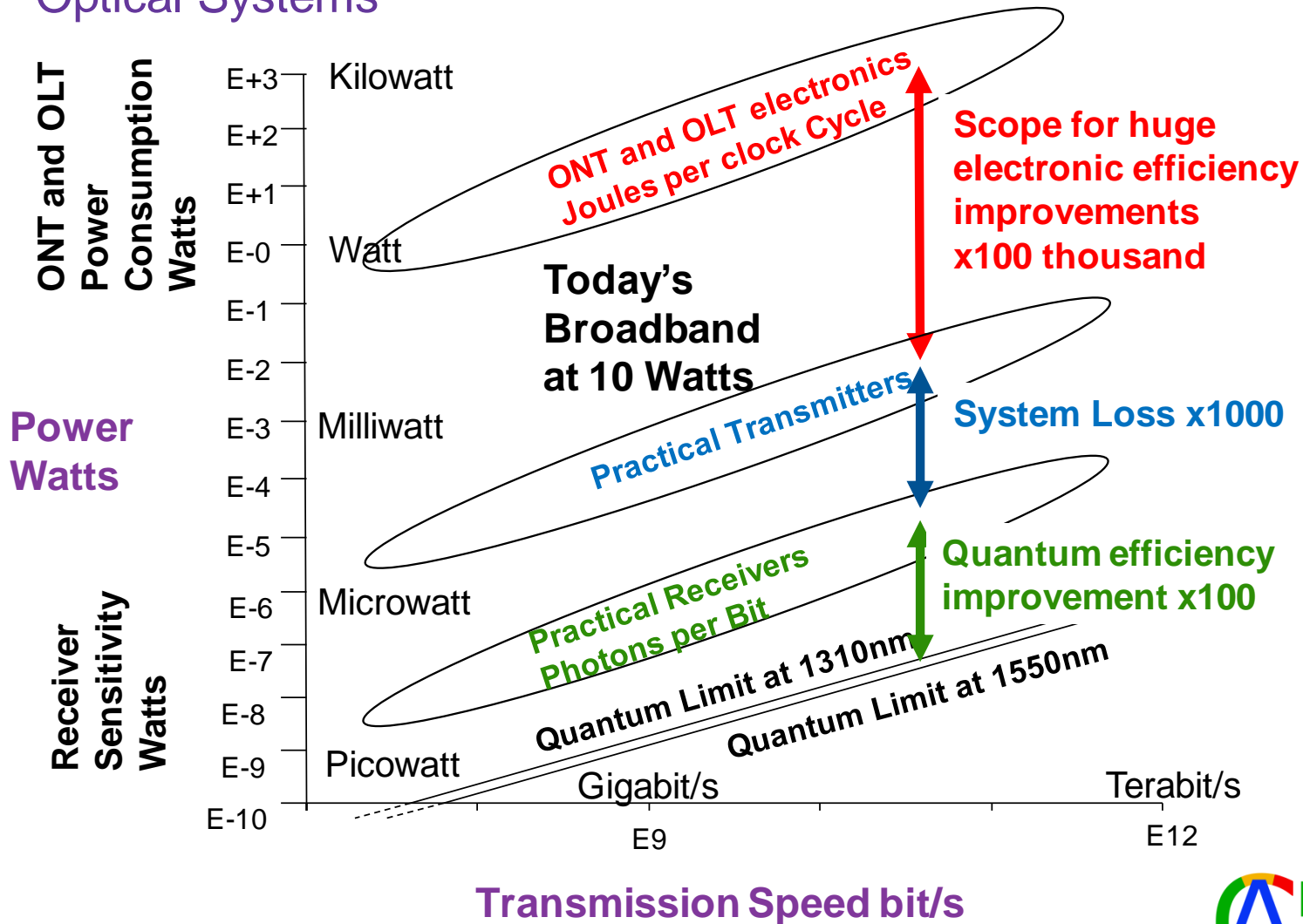
Worldwide Fixed Broadband Access Energy Needs



- Focus is on LT and home hub for wireline
 - Currently always on
 - CPE is a large extra at customer end e.g. an old style PC at 100 Watts for the device plus 100Watts for the monitor
 - Multiplexer is an extra at exchange end

How can power be reduced in optical networks?

Relationship between Power and Speed of Optical Systems



Energy saving in Networks - What more can be done?

- Telephony services
 - How to integrate VoIP, avoiding overlays, but without exceeding the power of a direct exchange line?
 - Universal Service Obligation. Should we keep it?
- VDSL2
 - Energy saving modes. What can be done in this area?
 - Always available rather than always on (like L2)
 - **Green Plugfests** could stimulate interest in this area
- G-PON
 - OLT's. Can the split rate be increased to save per line energy?
 - ONT's. Reducing energy also reduces backup battery size for telephony service



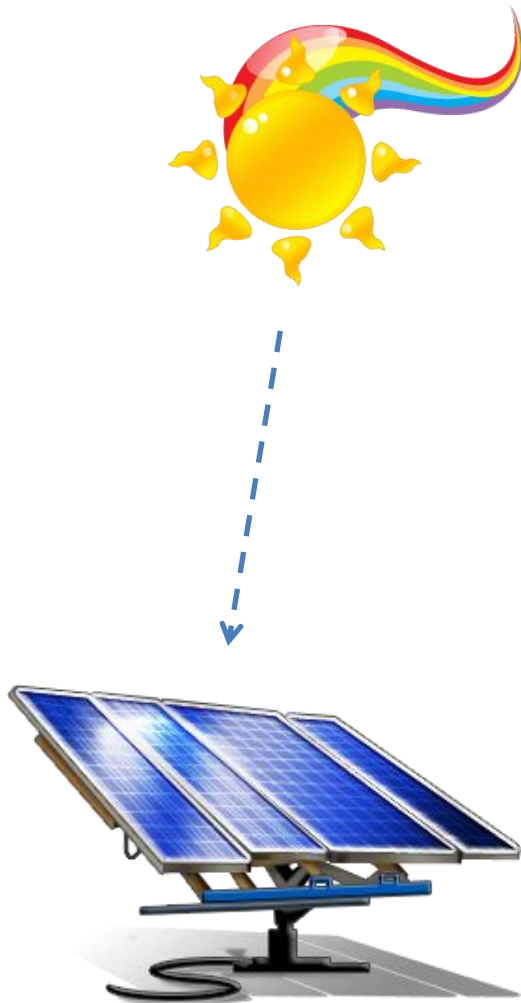
Energy Efficiency versus Absolute Energy Need

- Industries support increasing the energy efficiency of their products because they gain economic advantage
 - **but** the overall actual energy usage increases
 - Khazzoom–Brookes_postulate [1]
- Industries tend not to support environmental ideas with no payback
 - Auditing the carbon footprint of their raw materials
 - Pollution control and recycling
- Regulation is needed at the macro-economic level to ensure sustainability e.g.
 - carbon taxes [2]
 - incentives for non-fossil fuel and micro generators (wind, wave and solar...)

[1] http://en.wikipedia.org/wiki/Khazzoom%E2%80%93Brookes_postulate

[2] http://en.wikipedia.org/wiki/Carbon_tax

The challenge for the future



- Solar Power?
 - 1% unused land surface could be dedicated to solar farms with minimal adverse impact to generate 100 Terawatts*
 - But with the ICT sector's energy needs doubling every 5 years this (solar) resource would be exhausted by 2055 and the entire planet would be covered by solar cells by 2085 assuming that 10% of the 98 Petawatts could be captured**
 - So how can we meet our future energy needs?....

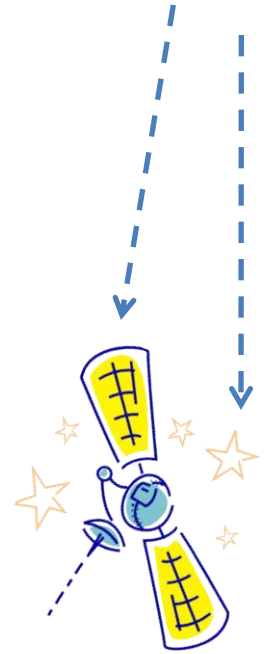
*http://www.cleanairnet.org/caiasia/1412/articles-73486_helios.pdf

**http://en.wikipedia.org/wiki/World_energy_resources_and_consumption

How can we meet our future energy needs(#1)?



- An example using optoelectronics and radio wave
- Space deployment of solar panels
 - Up to 8 times more solar energy (per unit area) is available than on the surface.
 - Radio spectrum allocation for power transmission is being considered by ITU-R (Question 210-2/1)
 - Radio rectennas (80%***) are more efficient than pv arrays (20%)*
 - However dispersion of microwave beams for the downlink is a problem to be overcome.
 - Could free space optics have a role here?



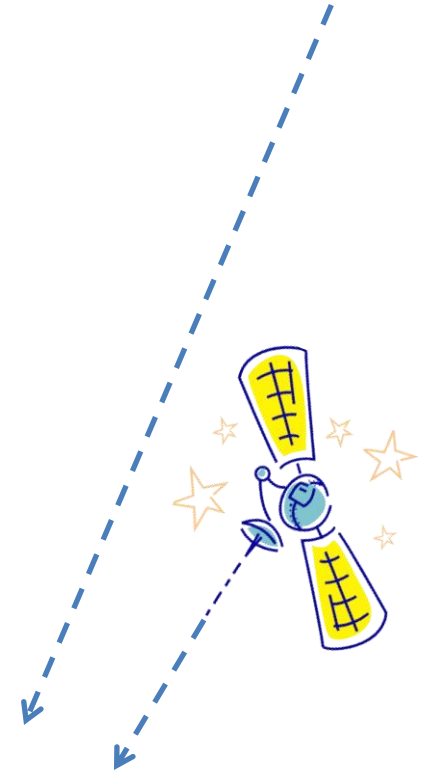
*http://www.lunarpedia.org/index.php?title=Solar_Power_Satellites

** <http://sciencelinks.jp/j-east/article/199918/000019991899A0304161.php>

How can we meet our future energy needs(#2)?



- An example using opto-electronics
- Space deployment of solar panels
 - Dispersion of microwave beams for the downlink is a problem to be overcome.
 - Could free space optics have a role here?
 - Additional light energy directed at existing solar farms
 - More efficient optical emitters and detectors needed



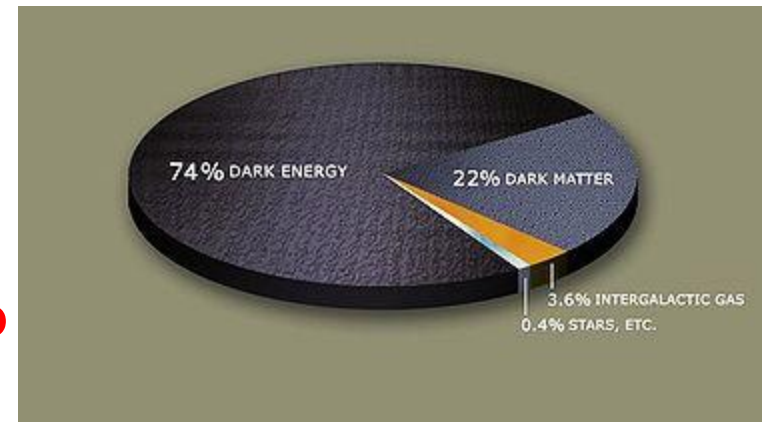
*http://www.lunarpedia.org/index.php?title=Solar_Power_Satellites

Conclusion

- There is scope for significant reduction in the power consumption of the network
 - Reduce the energy required by the electronics (e.g. during one clock cycle) to the much lower level of the optical signals
 - The issue for the future system designers is how to achieve it?
- Exponential growth of internet traffic is continuing
 - Unless Moore's Law reaches a physical limit, the energy required by the ICT industry will continue to grow exponentially
- Where will the energy for the future network come from?
 - Can your skills be turned towards maximizing the utilization of solar power without introducing a negative environmental impact
 - Will Nuclear meet all our needs?
- How will we ensure that the available resources are shared amongst industries and populations?
 - See "The Tragedy of The Commons" (Hardin, Science, 11 Dec 1968) (<http://www.sciencemag.org/cgi/reprint/162/3859/1243.pdf>)

And Finally:- Wild Speculation

Do ICTs collectively lead to an insatiable demand for energy?



Estimated distribution of dark matter and dark energy in the universe[3]

- At the quantum level Information and energy are interchangeable [1]
 - Landauer's principle: each bit of lost information (e.g. erasure of memory) will lead to the release of an amount $(kT \ln 2)$ of heat, where k is the Boltzmann constant and T is the absolute temperature of the circuit. [2]
- Mass and energy are interchangeable
 - Einstein's $e=mc^2$
- "It appears that about 70% of the energy driving the universe's expansion is "dark energy" having no known source....
 - the accumulation of bits of information in the universe might be considered a candidate source of this dark energy..." [1].
- If this is true, how are the bits manipulated and stored?
- Will **we** discover how to make more dark matter as the number of bits we store increases exponentially - or has **someone!** beaten us to it?

[1] <http://scottkurowski.com/massbit/index.htm>

[2] http://en.wikipedia.org/wiki/Landauer's_principle

[3] <http://en.wikipedia.org/wiki/File:DarkMatterPie.jpg>

Thank You for Your Attention

*Please come along to my short course
on the Basic Physics of Climate Change*

