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Green Telecoms

Sustainable Solutions for the Data Deluge

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Contents

1 Introduction

In 2010/11, BT consumed approximately 0.7% of all the electricity used in the UK, making BT one of the top ten energy users in the country. Clearly, the telecoms industry is a substantial user of energy.

Trends such as social networking are creating new demand for cloud, entertainment and mobile broadband services, and this is driving up the demand for energy. Emerging 4G services are likely to exacerbate the problem as smartphones are used to generate and access higher-bandwidth content that is stored on networks and repeatedly downloaded.

Although telecoms traffic is growing rapidly, the rate of growth is actually falling. Forecasts by GreenTouch[1] suggest that the Compound Annual Growth Rate (CAGR) of global wireline Internet traffic will decrease from approximately 45% in 2010 to 25% in 2020, while the CAGR for global mobile Internet traffic will decrease from approximately 170% in 2010 to 30% in 2020[2]. However, the key point here is that a CAGR of 25%-30% is still a dramatic rate of growth, so traffic in 2020 will still be doubling every 3 years.

Telecoms desperately needs to become "greener"

If no action is taken, the level of power required by telecoms networks is likely to grow very rapidly, and the expansion of many network nodes and data centres is already constrained by the availability of power rather than by the availability of space[3]. Telecoms desperately needs to become "greener". This white paper considers whether it would be possible to halt – or even reverse – the demand for power from the telecoms industry, whilst simultaneously reducing its carbon footprint.

[1] GreenTouch Green Meter Research Study: Reducing the Net Energy Consumption in Communications Networks by up to 90% by 2020, GreenTouch White Paper, Version 1.0, 26th June 2013, p10.

[2] Cisco forecasts for mobile data growth can be found at http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

[3] Energy Efficiency for Telecom Growth, Eltek White Paper, February 2012.

2 Identifying network hotspots

BT has initiated an energy efficiency programme that achieved a 59% CO2 intensity reduction globally by March 2011, with a target of 80% reduction by 2016. These reductions have been achieved by

- improving building efficiency
- increasing the use of low-carbon energy sources
- decommissioning legacy equipment
- reducing the power dissipated in the network.

The first three bullets are well-established ways of achieving carbon reductions, and this white paper will consider how these techniques can be applied to the telecoms industry. However, before we can address the fourth bullet – reducing the power dissipated in the network – we need to identify those parts of the network where significant amounts of power are being used.

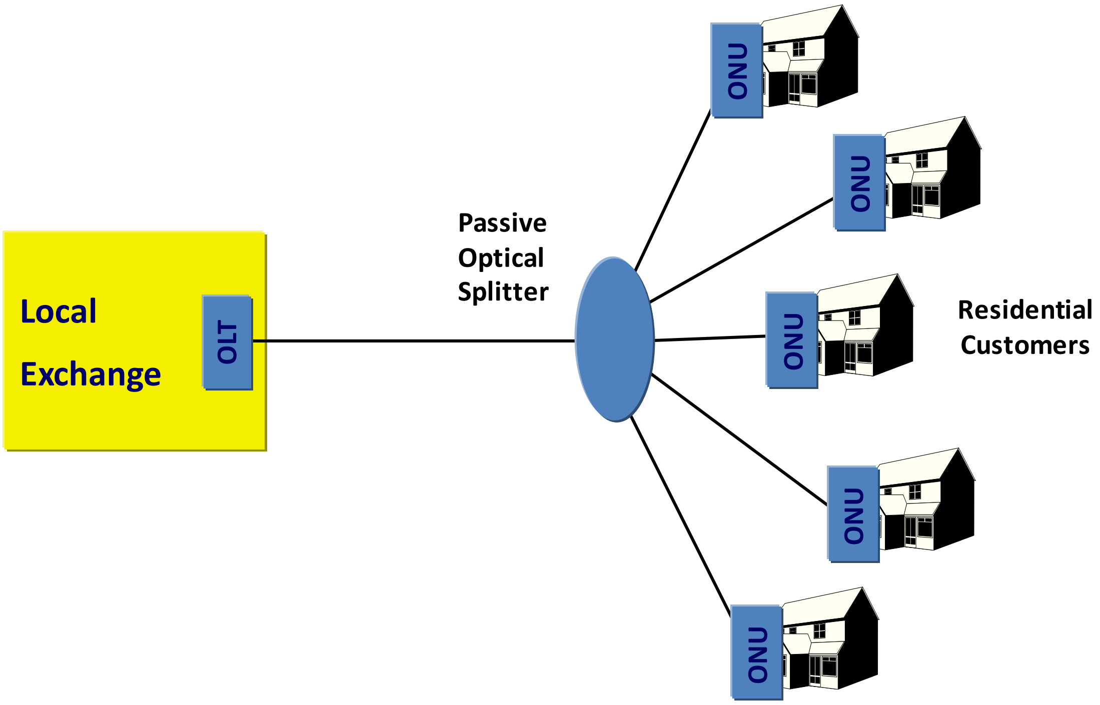
2.1 Fixed access networks

The fixed access network provides physical links between customer sites and the core network, and it includes equipment that is owned and operated by the network but is located on the customer site. The access network normally accounts for more than half the total energy consumed by a fixed network, with a high proportion of this energy being used on the customer site.

For conventional telephone networks, the energy dissipated in the access network is only about 1.2W per customer, and is only dissipated when a telephone is off-hook. Today, a service such as VDSL2 dissipates about 3.6W per customer, and it's an always-on service[4]. When multiplied-up by millions of customers, this represents a dramatic increase in power consumption.

[4] The customer can switch off the VDSL2 modem when the service is not in use, but this probably doesn't happen very often.

Figure 1: Gigabit Passive Optical Network (GPON)



Source: Mott MacDonald

It has been claimed that the migration from Fibre to the Curb (FTTC) technologies like VDSL2 to Fibre to the Home (FTTH) technologies such as GPON will result in a dramatic reduction in power per subscriber. This claim is misleading, because it ignores the power dissipated by the GPON ONU device on the customer's premises[5]. Ignoring the ONU is rather convenient, because that's where most of the power is dissipated in a GPON[6].

The 2010 reference ONU used by GreenTouch in their power reduction research dissipates 6W after the Wireless LAN functionality has been stripped out[7]. Although GreenTouch have identified opportunities for massive power savings in PON architectures, and the European Commission has called for significant power savings in both FTTC and FTTH access networks by the end of 2014[8], it seems inevitable that the power dissipated in fixed access networks will continue to rise for the foreseeable future as network operators strive to roll-out more/faster broadband.

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[5] It is certainly true that power to the ONU is supplied by the customer rather than the network because the power cannot be transmitted down a fibre connection. However, the fact that the network does not supply this power does not make this a "greener" solution.

[6] Since the power dissipated by the OLT at the headend is shared by up to 32 customers on the GPON (assuming a 32-way split), the power per subscriber typically works out at less than 1W. However, the power dissipated by an ONU is dedicated to a single customer, and can exceed 10W.

[7] GreenTouch Green Meter Research Study: Reducing the Net Energy Consumption in Communications Networks by up to 90% by 2020, GreenTouch White Paper, Version 1.0, 26th June 2013, p15.

[8] Code of Conduct on Energy Consumption of Broadband Equipment, Version 4.1, EU Commission, 25th January 2013.

2.2 Mobile access networks

Mobile handsets typically use less than 10% of the power in a mobile network, with most of the power being required by the network infrastructure (access and core) [9,10]. The majority of network power (potentially more than 80%) is consumed in the base stations.

The majority of power consumed in "traditional" base stations occurs in the power amplifier and feeder cables (50%-80%) and in associated cooling / air conditioning (10%-25%). Only a few percent of the consumed power is actually transmitted in the form of radio signals. Modern base stations use a number of methods to reduce overall power consumption whilst still maintaining appropriate radio signal transmission levels, thereby increasing the overall power efficiency:

- Power amplification (PA) efficiency has increased significantly over the 20+ years that mobile communications have been widely used. Efficiencies have increased from 15% (or less) and are currently heading towards 50%. To illustrate the implications of this, if coverage requirements dictate a PA output of 100W then a power input of 1kW is required at 10% efficiency, but only 200W at 50% efficiency.
- Historically, signal processing and power amplification were both implemented in the same ground-level base station cabinet, but modern base stations often split these two elements. Locating the PAs closer to the antennas by mounting them on the mast enables the long runs of copper feeder cable traditionally used to link base stations to antennas to be replaced with optical fibre. Feeder cables are very lossy – typically of the order of a few decibels per connection - and just 1dB of loss implies a 25% loss of power along the cable. Reducing the length of the feeder cables reduces overall base station power consumption.
- The increasing use of software in base stations has enabled the deployment of single base station solutions that can support 2G, 3G and 4G simultaneously, whereas historically these would have been deployed in separate cabinets. The swapping out of legacy base station cabinets when upgrading a site to a new technology can reduce overall power consumption by up to 50%[11].
- In 4G, there is a logical interface that allows base stations to communicate directly with each other. This new interface enables power savings, because a 4G base station that has no mobiles attached to it can shut down carriers / transmitters. If the base station becomes a target for cellular handover, then adjacent base stations can request re-powering. This feature can have a significant effect on power consumption - particularly in areas such as dense office districts that experience high traffic variations during the day.
- The power consumed by a base station that is not radiated as radio signals is converted to heat, and cooling or air conditioning is needed to maintain the correct working temperature for base station electronics. As base stations have become more efficient (using techniques such as those described above) the need for cooling has reduced. Many base stations no longer require any additional cooling – allowing the removal of (typically) 100-200W of cooling equipment.
- New topologies based on smaller cell sizes can drastically reduce the power necessary to run mobile data networks. This is because a smaller cell radius requires less power to maintain a connection with a mobile user.

Further base station power reductions are expected in the future. This is critically important, because the ever-increasing take-up and use of mobile communications is leading to a

[9] Power Consumption and Energy Efficiency of Fixed and Mobile Telecom Networks, Hans-Otto Scheck, Nokia Siemens Networks, ITU-T, Kyoto, April 2008.

[10] Power Consumption of Base Stations, Alberto Conte, Alcatel Lucent, Ghent, February 2012

[11] Green Base Station Solutions and Technology, Zhiping Chen and Licun Wang, ZTE, 2011

proliferation of base stations being installed globally, and this could have serious implications for network power consumption.

2.3 Core networks

Equipment in the core of a network tends to be larger and more power-hungry than equipment located at the edges of the network, so it might be reasonable to expect a high level of power dissipation in the core network. However, core network equipment is normally shared by a large number of services, while equipment at the edges of the network can be dedicated to a single customer. When the energy required to deliver an end-to-end service is considered, the majority of the energy is consumed in the access network, whilst the core network contributes relatively little to the total. Of the power that is consumed in the core network, 90% is concentrated in the network nodes with the remaining 10% being dissipated by the optical amplifiers used on long fibre routes[12].

2.4 Data centres

Core network nodes are typically hosted in data centre environments, and software executing on standard IT platforms hosted in data centres is becoming an increasingly critical part of most telecoms networks. Furthermore, user applications are often hosted in data centres belonging to network operators. As a result, data centres form an important part of most telecoms networks.

Data centres represented approximately 1.3% of worldwide electricity consumption in 2010[13]. Between 2011 and 2012, it is estimated that global data centre power requirements grew by 63%[14]. Although data centres have become considerably more energy-efficient in recent years, the power consumed by data centres is still a major cause for concern.

At the Powering the Cloud 2012 conference in Frankfurt, Dr Ian Bitterlin warned that ambitious government plans to increase broadband availability could have the unintended effect of forcing public and private sector ICT to consume unsustainable amounts of energy as a result of data growth that is now “outstripping both Moore’s Law and the rate of improvement in energy efficiency”. Without a substantial improvement in energy efficiency, the proportion of world electricity generating capacity consumed by data centres and the internet will continue to increase. His conclusion was stark: “Could we see 10% of grid capacity consumed by ICT in four to six years? 100% in under ten years? The result is unsustainable with any start value.”

[12] Power Consumption in Telecommunication Networks: Overview and Reduction Strategies, W. Vereecken et al, IEEE Communications Magazine, Vol 49 Issue 6.

[13] Growth in Data Center Electricity Use 2005 to 2010, Jonathan Koomey, Analytics Press, 1st August 2011.

[14] http://www.computerweekly.com/news/2240164589/Datacentre-power-demand-grew-63-in-2012-Global-datacentre-census

3 Reducing the network's carbon footprint

Although equipment vendors are constantly improving the power efficiency of their products, relentless increases in the demand for bandwidth have driven up energy consumption – and hence carbon emissions. There are a number of different ways in which telecoms network operators can address this problem, including:

1. Replace high-carbon electricity from coal-fired power stations with low-carbon electricity from renewables and nuclear.
2. Replace legacy equipment with more efficient designs that waste less energy.
3. Turn off parts of the network that are not being used so that power consumed is more closely related to services delivered by the network.
4. Implement design changes to optimise power efficiency.
5. Degrade the services offered to customers (lower speeds, reduced resilience etc.)

It is assumed that the final option is unacceptable – the market will continue to demand faster speeds and higher service availability. We therefore need to investigate how the remaining options could reduce the carbon footprint of telecoms networks without degrading service to customers.

Source: Wikimedia Commons

3.1 Switch to low-carbon electricity

Although cloud-based data centres can be located almost anywhere so long as the latency of the telecoms links is not too high, network nodes have less geographical flexibility; the access network serving a particular town has to be located in that town, and if that town receives its power from a coal-fired power station, then the access network is likely to have a significant carbon footprint. Whilst backbone nodes are a little less constrained than access nodes, they still need to be located relatively close to the area that they are serving.

However, the ubiquity of electricity grids in developed countries, coupled with the availability of energy suppliers offering electricity from low-carbon sources, means that it is often possible for network operators to buy low-carbon electricity irrespective of where their networks are located. Even if this is not possible, network operators still have the option to make carbon-offsetting payments. Furthermore, the European Union has set carbon reduction targets for power generation, so network operators that take no action at all may still be able to claim reduced carbon emissions as a result of their electricity becoming cleaner.

A different approach would be for network operators to generate their own power. This is starting to happen – particularly in remote areas where there is no convenient way of connecting to an electricity grid. Solar powered mobile base stations are becoming increasingly common in some parts of the world, and solar powered handsets have started to appear. Mott MacDonald has designed a solar-powered fixed network to deliver broadband and wireless services in a remote part of Africa. However, in areas where grid connection is readily available, the capital cost of such solutions can be hard to justify in purely economic terms.

Source: Wikimedia Commons

BT has set itself the target of generating 25% of its energy from renewable sources by 2016. For the remainder of its energy needs, BT will seek to purchase low-carbon energy generated from renewable sources[15].

"Energy prices have been going through the roof, but by investing to generate our own energy from fossil-fuel-free sources such as solar and wind we can guarantee security of supply and fix a proportion of our costs. This creates a very solid commercial case alongside the substantial sustainability benefits." Robert Williams, Head of Renewables, BT Operate.

3.2 Replace legacy equipment

Telecoms equipment, like IT equipment, has a notoriously short shelf life. Whilst the passive components of a network (ducts, cables, racks etc) might have a working life in excess of 20 years, the active equipment (routers, switches, management systems etc) often has a working life of less than 5 years before a "technology refresh" is required. A stylish new mobile phone can become embarrassingly out-of date in less than 18 months.

The problem here is not that the technology wears out after a few years, but that the pace of technology evolution is so rapid that existing equipment is soon left far behind. Legacy equipment is probably still doing the job that it was designed to do, but its capabilities have fallen so far behind the state of the art that it is no longer cost-effective to retain it. Since new equipment often operates more efficiently than the equipment that it replaces, it is likely that a technology refresh will have a beneficial effect on carbon emissions.

However, the very short life expectancy of some telecoms equipment raises the question of whether we are worrying about the wrong sort of carbon. There are two different types of carbon that need to be considered:

- Operational Carbon. The energy required to operate active telecoms equipment (such as a router or a switch) is referred to as Operational Energy. Operational Energy includes any energy associated with use-related activities such as maintenance, but the majority of this energy normally arrives in the form of electricity to power the equipment. The carbon emissions associated with generating and delivering this electricity can be calculated, and this "Operational Carbon" can be summed over the working life of the equipment to indicate the environmental impact of operating that equipment.
- Embodied Carbon. Energy is required to manufacture a piece of telecoms equipment. This energy can include the energy required to extract and refine the raw materials, the energy required to drive manufacturing processes and the energy required to transport the finished product to site and then dispose of it at the end of its working life. All of this energy is directly associated with the telecoms equipment, and so it is referred to as "Embodied Energy". Since this energy is likely to be derived from burning fossil fuels, the associated carbon emissions can be represented as "Embodied Carbon".

[15] BT Energy Efficiency Case Study, August 2011.

Source: Wikimedia Commons

Embodied carbon tends to predominate over operational carbon for portable devices such as mobile phones and tablets because these devices tend to have short working lives and have been designed to minimise power consumption.

However, equipment installed in telecoms networks tends to have higher power consumption and a longer working life, so operational carbon predominates. Furthermore, network equipment sometimes needs cooling, and this adds to the operational carbon. An analysis of the greenhouse gas emissions associated with delivering an ADSL2+ broadband service showed that operational carbon represented 94% of emissions while embodied carbon represented only 6%[16].

For this reason, the focus of this white paper is on reducing operational carbon rather than on reducing embodied carbon. If steps have already been taken to minimise the carbon content of the electricity consumed by telecoms networks (see previous section), then we need to look for ways of reducing the amount of electricity consumed.

3.3 Turn off unused parts of the network

Telecoms networks were traditionally designed to handle traffic peaks, with little thought being given to situations in which the network was lightly loaded. However, if traffic statistics are reliable enough, it should be possible to turn off some network equipment at times of low network usage without having any impact on the quality of service delivered to customers. Core networks are typically designed to be resilient, so it should be possible to reduce the capacity of some core nodes (or even turn them off completely) so long as the network traffic can still find an acceptable route to its destination. Turning off nodes will result in changes to the overall network topology, so modelling is required to determine which topology changes deliver the greatest benefits. Since core networks carry large amounts of traffic, the statistics governing traffic patterns should be relatively reliable.

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[16] Carbon Footprinting of Network Services, The Journal of the Institute of Telecommunications Professionals, Volume 6 Part 3, 2012, p14-24.

Telecoms networks were traditionally designed to handle traffic peaks, with little thought being given to situations in which the network was lightly loaded.

Although the majority of power is dissipated at the edge of a telecoms network, turning off equipment at the network edge is much more difficult than turning off equipment in the core because it can result in users being disconnected. However, there are areas within access networks where equipment is shared between a number of users, suggesting that some of this equipment could be turned off at times of day when fewer users are likely to be active.

One potential problem here is that if equipment is only shared by a relatively small number of users, then statistical predictions about user behaviour may not be valid. The line cards at the very edges of a network contain a small amount of hardware that is dedicated to each individual network connection, and switching this hardware on or off in response to traffic statistics is unlikely to be successful. However, when measured across a large number of network connections, this dedicated hardware can dissipate a significant amount of power, and this power is generally constant even though the traffic carried by the access network is very variable. If dedicated hardware could switch into low power mode when it is not carrying much traffic, and switch out of low power mode quickly enough to handle a sudden surge of traffic, then statistical traffic predictions might not be necessary.

In 2011, BT began trialling a new “sleep mode” for high-speed broadband connections that promised to reduce broadband energy use by 30%[17]. The “Cool Broadband” feature on the latest generation of ADSL line cards reduced the speed from (say) 20Mbit/s to 200kBit/s on a line-by-line basis if traffic on a line fell below 128kBit/s for a period of time[18]. The reduced speed was sufficient to support a voice call, but it was claimed that the line would return to full speed immediately when traffic levels rose. It was also claimed that switching in and out of low power mode would not result in any loss of data.

However, the Cool Broadband trial was quietly discontinued in mid-2012 after a number of complaints, and there have been suggestions that some modems may have experienced problems recovering from sleep mode. It is not clear whether this problem was caused by factors that will eventually be resolved (such as incompatibility with legacy equipment) or something more fundamental (such as power fluctuations or network noise). Despite this setback, BT’s efforts to make their networks “always available rather than always on” do represent a step in the right direction.

[17] It was claimed that Cool Broadband had the potential to save 2.9GWh/year for every million ADSL2+ lines in operation.

[18] Broadband Forum Technical Report TR-202 that explains how this works.


Source: Wikimedia Commons

3.4 Improve data centre design

Whilst access network equipment can be housed in street cabinets or on customer sites, core network nodes are typically hosted in data centre environments. Furthermore, software executing on standard IT platforms hosted in data centres is becoming an increasingly critical part of most telecoms networks, and user applications are often hosted in data centres belonging to network operators. As a result, data centres form an important part of most telecoms networks.

In recent years, the IT industry has made substantial efforts to improve the energy efficiency of data centres. Some of the techniques used are listed below:

- Consolidation. A large number of small, inefficient data centres can be consolidated into a smaller number of larger, more efficient data centres.
- Atmospheric cooling. Data centres can be seen as buildings that consume MegaWatts of electrical power and dissipate nearly all of it as heat. In older data centre designs, it is possible for half the energy consumed by a data centre to be driving chilling plants that are needed to get rid of the heat generated by the other half. One response to this issue has been to site new data centres in areas with cold climates or other sources of natural cooling to minimise the need for electrical chillers. Unfortunately, this idea does not always carry

across from data centres to network nodes, because telecoms equipment typically has to be located close to where the services are required.

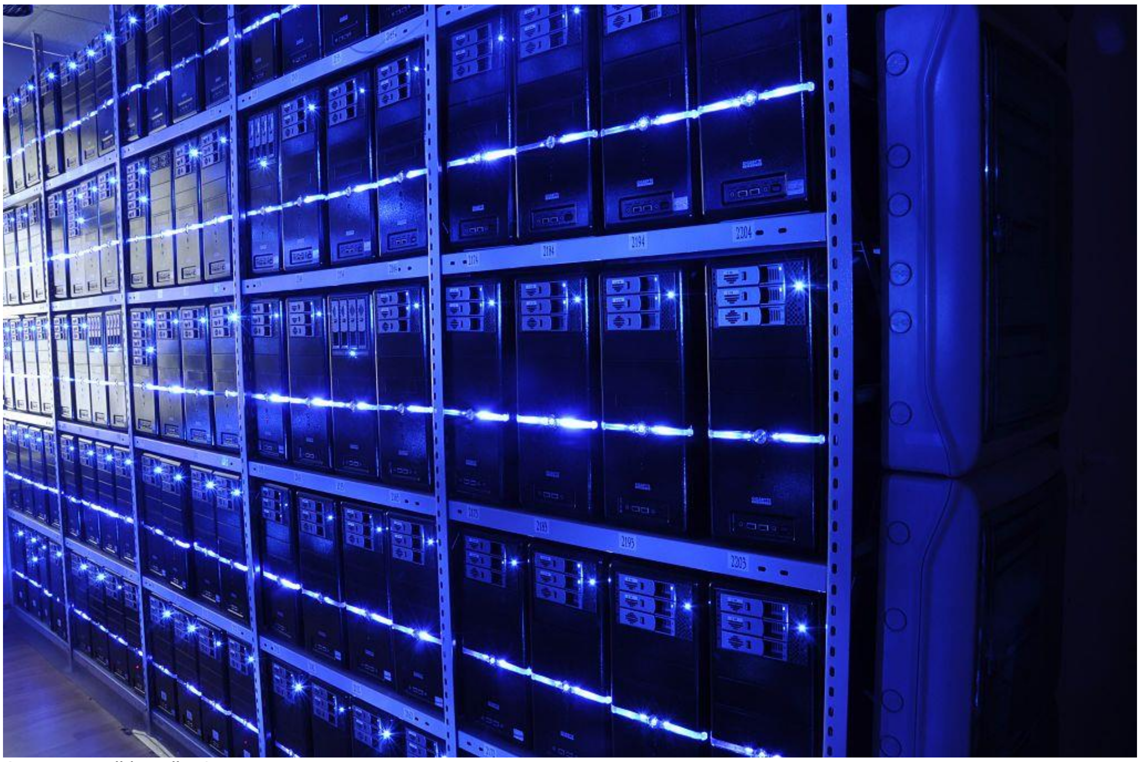
- Renewable energy sources. Electricity derived from the grid is likely to have been generated by burning fossil fuels, and so may come with a substantial carbon footprint. One solution to this problem is to locate data centres in areas with plentiful supplies of non-intermittent renewable energy (eg hydroelectric, geothermal or biomass).
- Hot /cold aisles. Rather than flooding the data centre with chilled air and hoping for the best, the air flow is carefully managed to ensure that chilled air entering a server is not able to mix with warm air being expelled from the server. Thermostatically-controlled fans are used to ensure that each server takes only as much chilled air as it actually needs, thereby reducing the amount of chilling required. Furthermore, since the fans are not operating continuously at full speed, additional power savings are achieved.
- Server virtualisation. If an application is assigned to a specific server, then the server must have enough spare capacity (processor cycles, memory etc) to handle peak demand, and it has been claimed that the average processor utilisation level is only 5%-15%[19]. However, if the application is executing in a virtual server that can be moved easily between physical servers, then it is possible to consolidate applications on to a smaller number of physical servers at times when demand is low; rather than having all the physical servers powered-up all the time, it becomes possible to dynamically match the number of operational servers to the level of demand.
- DC power supplies. The need to convert power from AC to DC (or vice versa) results in energy losses that show up in the form of heat. Not only is this lost energy no longer able to do useful work, but additional power is required to operate the chillers that will expel the heat from the data centre. Since grid power normally arrives at the data centre in AC form, while the power required by electronic components within servers and routers needs to be in DC form, at least one AC/DC conversion is required.

  The batteries used to maintain data centre power during grid outages also operate at DC but, for historical reasons, AC-powered equipment is sometimes hosted in a data centre. This means that the DC power from the batteries has to be converted back to AC to power the equipment – which then converts it back to DC to power the components! This problem can be eliminated by standardising on suitable DC-powered equipment, and the efficiency improvements from doing this can be as much as 25%[20].

Many of these data centre techniques are also applicable to core network nodes, and some are applicable to other parts of the telecoms network.

[19] Dynamic Energy Consumption Management of Routing Telecom and Data Centers through Real-Time Optimal Control, U.S. Department of Energy, DOE/EE-0496, May 2011.

[20] Energy Logic for Telecommunications, Steve Roy, Emerson white paper, September 2008.


Source: Wikimedia Commons

3.5 Improve telecoms design

Arguably, adding energy-saving features such as passive cooling and sleep mode could be considered to be design improvements. However, telecoms networks contain a number of energy inefficiencies, and it is sometimes possible to save energy by moving functionality to a new location – or by eliminating it altogether. In some cases, design changes to reduce power consumption may require trade-offs in areas such as cost or complexity. A few examples are given below:

- Bit Interleaving Passive Optical Network (Bi-PON). Bi-PON is a new time division multiplexing transfer protocol that can reduce the power consumption of a Fibre to the Home customer premises device (ONU) by more than an order of magnitude. In a conventional GPON system, each ONU has to process all the downstream data so that it can capture those packets that are addressed to it. This processing has to take place at the downstream rate of the GPON (2.488 Gbit/s), and so is relatively power-hungry. However, if the GPON has a 32-way split, then it is likely that an individual ONU will be retaining less than 5% of the packets received because the remaining packets are addressed to other ONUs. Bit interleaving makes it much simpler for an ONU to identify which packets it needs to capture. Subsequent processing can then be done at the user rate rather than the aggregate line rate, resulting in significant power savings[21]
- Migrate distributed functions to a central server. It was explained above that fixed networks dissipate a high proportion of their power at customer premises, and that this is particularly significant for FTTH broadband networks. GreenTouch have reported significant power reductions by migrating FTTH broadband functions such as routing, OAM (Operations,

[21] GreenTouch Green Meter Research Study: Reducing the Net Energy Consumption in Communications Networks by up to 90% by 2020, GreenTouch White Paper, Version 1.0, 26th June 2013, p16-17.

Administration & Maintenance) and security from a device on the customer's premises to a central server on the network.

- Reducing feeder cable losses by moving radio equipment closer to the antenna (as discussed above).
- Infrastructure sharing. The trend within mobile networks to share base station sites is driven primarily by cost savings. However, where active equipment is being shared, there is also the potential to achieve power savings.

4 Conclusions

In the past, the power consumed by data centres was not an issue that received much attention within the IT sector. However, this situation started to change as energy prices rose and companies came under increasing pressure to reduce their corporate carbon footprint. It also became clear that data centres were consuming a measurable proportion of total generated power, and capacity constraints within the power grid meant that it was becoming increasingly difficult to find viable sites for new data centres.

Identified improvements that have not yet been implemented are so significant that it should be possible to deliver very substantial power and carbon reductions in spite of the "data deluge".

The telecoms industry is a significant user of data centres, and has been aware of these pressures for many years. However, the massive traffic growth on both fixed and mobile networks has forced network operators to look far more carefully at all aspects of their operations, and a number of worthwhile improvements have already been implemented. Green issues are now firmly on the telecoms agenda, and organisations such as GreenTouch are helping to prevent any complacency by demonstrating just how much further there is to go. Identified improvements that have not yet been implemented are so significant that it should be possible to deliver very substantial power and carbon reductions in spite of the "data deluge".

Source: Wikimedia Commons

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A. Appendix: Energy Reduction Initiatives

There have been a number of initiatives to reduce the energy consumed by telecoms networks.

A.1 GreenTouch Consortium

The GreenTouch consortium launched in 2010 with the stated goal of making fixed and wireless networks 1,000 times more energy efficient than they are today. Theoretical studies carried out by Bell Labs had indicated that networks could consume 10,000 times less energy than they do today, so it was suggested that the technology to achieve a 1,000-fold reduction should be developed by 2015.

The consortium has now grown to include 53 vendors, carriers and research institutions, and it released its first set of recommendations in May 2013. The recommendations are a long list of technologies and network topologies, some of which would require minor software changes to current equipment while others would require new telecommunications standards and a new generation of network equipment. GreenTouch have claimed that, if fully implemented, the recommendations would meet its 1,000-fold improvement goal for wireless networks, and would get about halfway to meeting this objective for fixed networks[22].

A.2 U.S. Department of Energy

The Energy Efficiency & Renewable Energy department of the US Department of Energy has an Industrial Technologies Program (ITP) that has initiated projects to investigate ways of reducing network energy consumption[23]. In partnership with industry, ITP helps research, develop, and deploy innovative technologies that companies can use to improve their energy productivity, reduce carbon emissions and gain a competitive edge.

A.3 EU Commission

The EU Commission has produced a Code of Conduct on Energy Consumption of Broadband Equipment. Version 4.1 was published in January 2013[24].

A.4 Alliance for Telecommunications Industry Solutions (ATIS)

The Alliance for Telecommunications Industry Solutions (ATIS) has released a number of standards that provide a methodology for measuring and reporting on the energy consumption of various types of network equipment. ATIS introduced a new way to describe equipment efficiency (the Telecommunications Energy Efficiency Ratio) to make it simpler for telecommunications network operators to compare the energy efficiency of equipment offered by different vendors.

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[22] Reducing the Net Energy Consumption in Communications Networks by up to 90% by 2020, GreenTouch White Paper, Version 1.0, 26th June 2013.

[23] Information and Communication Technology Portfolio: Improving Energy Efficiency and Productivity in America's Telecommunications Systems and Data Centers, U.S. Department of Energy, March 2011.

[24] Code of Conduct on Energy Consumption of Broadband Equipment, Version 4.1, EU Commission, 25th January 2013.