Carbon and Computers in Australia

The Energy Consumption and Carbon Footprint of ICT Usage in Australia in 2010

A report for the Australian Computer Society by Connection Research

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About the Australian Computer Society
The ACS is the recognised association for ICT professionals in Australia, attracting a large and active membership from all levels of the ICT industry. It is the public voice of the ICT profession and the guardian of professional ethics and standards in the ICT industry, with a commitment to the wider community to ensure the beneficial use of ICT.
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About Connection Research
Connection Research is an Australian market research and analysis company with a focus on corporate and consumer usage of sustainable and digital technologies. Its primary methodology is demand-side research, surveying consumers of technology about usage patterns, attitudes and plans. It operates across four practice areas: Green ICT, Carbon and Compliance, Building Industry and Trades, and Community Sustainability.
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Introduction

What is the carbon footprint of ICT usage in Australia? What proportion does it comprise of Australia's total carbon footprint? Is it possible to even come up with a definitive answer?

For many years now many ICT people have been fond of saying things like "the computer industry consumes as much power as the airline industry" or "ICT is 2% of the world's carbon footprint" or "a Google search consumes as much electricity as boiling a kettle". All of these statements sound definitive, but they are largely unsubstantiated.

There is no doubt that computers use large amounts of energy, and through the usage of that energy they cause substantial emissions of greenhouse gases, but there has been little attempt to measure or to estimate the total energy consumption or carbon footprint caused by the usage of ICT equipment, in Australia or internationally. This report attempts to determine the numbers, through primary research, through the use of existing data, and through detailed modelling.

The Australian Computer Society is at the forefront of providing usable information about and to the ICT industry in Australia. Its excellent Australian ICT Statistical Compendium[1] is one of the source documents for this study. And in 2007 the ACS published a study of the carbon emissions of ICT usage in Australian Business[2]. This study builds on those documents and uses data from the Australian Bureau of Statistics and other public sources, from primary research conducted by Connection Research and other companies, and from a large body of literature internationally on ICT's energy consumption and carbon footprint, to paint as complete a picture as possible of the carbon footprint of ICT usage in Australia in 2010.

This report is, to our knowledge, the first time that anyone has attempted to definitively determine ICT's carbon footprint in Australia. It is a difficult task, but it is not impossible – a large amount of data already exists. All that has been necessary is to bring it together, to relate the various aspects, and to develop a robust, accurate and defensible model. We believe we have done so.

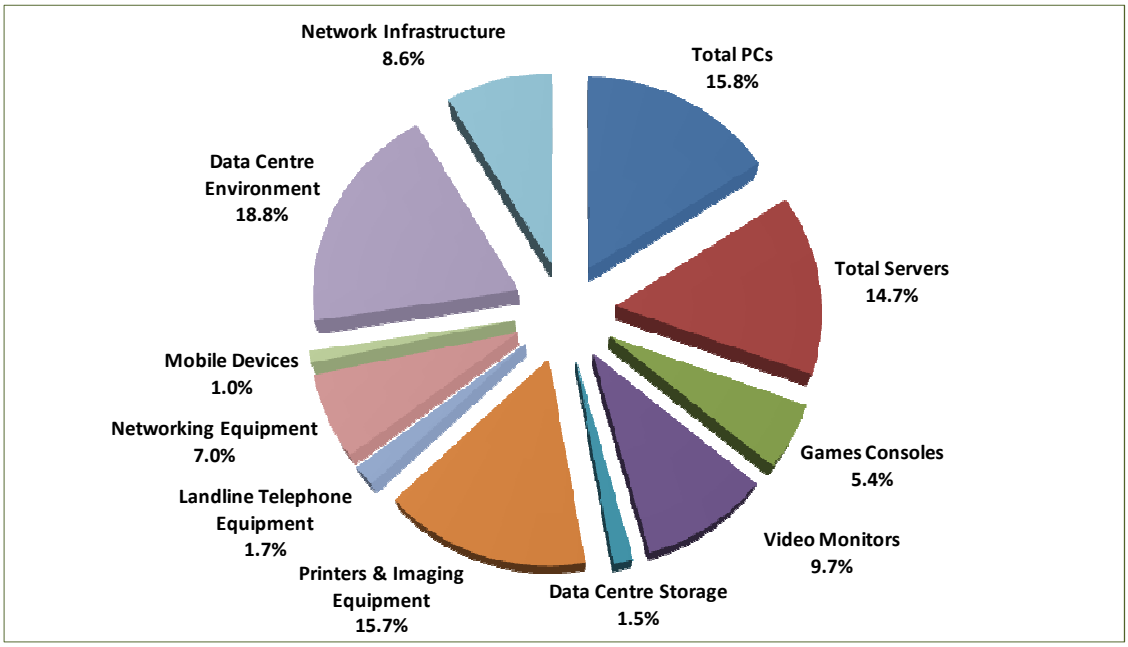
We could not have done it without help. Connection Research and the Australian Computer Society would like to thank many people for their input and assistance. Special thanks to Idris Sulaiman of the Australian National University, Turlough Guerin of Telstra, Bianca Wirth of Computers Off Australia, and Bob Hayward of CSC for their support and ideas. We also acknowledge the assistance of many patient individuals in the Australian Bureau of Statistics, and Shadi Haddad of the Ethan Group, whose pioneering work laid the ground for this study.

Executive Summary and Recommendations

ICT is responsible for nearly 2.7% of Australia's total carbon emissions. More significantly, it is directly responsible for more than 7% of all electricity generated in Australia. These are significant figures, particularly given that Australia is one of the largest carbon emitters per capita in the world.

In 2009 Australia's ICT users consumed 13.248 million kilowatt hours (kWh) of electricity, which caused 14.365 Megatonnes (Mt) of Scope 2 CO_2e (carbon dioxide equivalent) emissions. This compares to Australia's total emissions of 539 Mt, and total electricity generated of 203 Mt. By any estimation, ICT's energy consumption and carbon emissions are significant proportion of Australia's total.

ICT Carbon Footprint in Australia, 2009
by Device Category (%)



The biggest components of ICT carbon emissions are data centre environment (18.8%), PCs (15.8%), printers and imaging equipment (15.7%) and servers (14.7%). But if video monitors are added to PCs, their total energy consumption exceeds a quarter of the total. Add games consoles, and the figure is nearly one third of the total. Games consoles consume five times more energy than mainframe computers.

Mobile phones and other portable devices, though widely used, account for only 1% of ICT energy consumption, and fixed line telephones and related equipment less than 2%. But data networking equipment accounts for more than 7%, and the network infrastructure to support the voice and data another 8.6%.

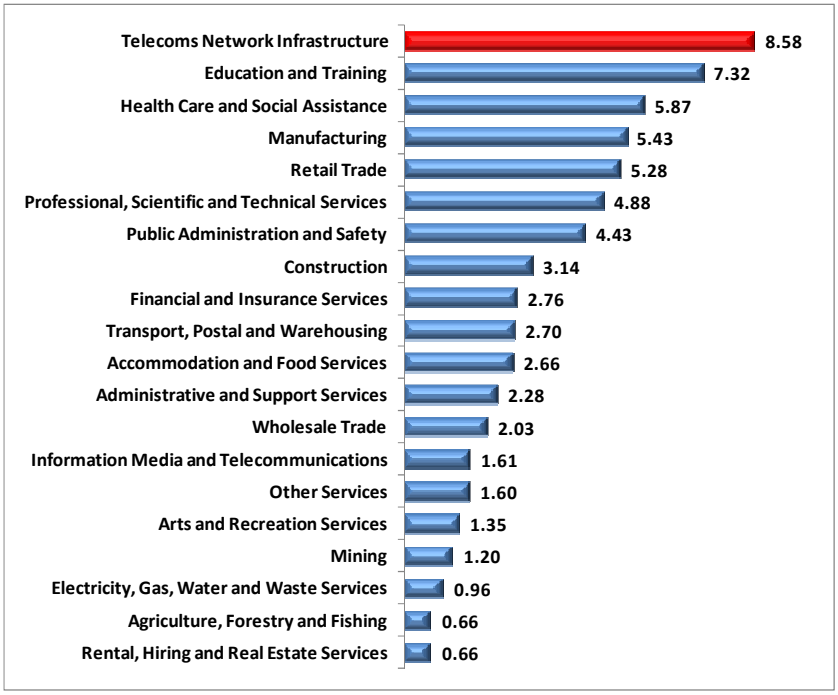
There is an almost even split between households (34.6%), data centres (34.4%) and a combination of other enterprise ICT usage (22.4%) and network infrastructure (8.6%). The majority of data centre power consumption is accounted for by environmentals – mostly air conditioning and other types of cooling. The household figure is so high because of the sheer number of PCs and video monitors (and games consoles) they contain – an average of close to two devices per household, for over eight million households.

Energy Consumption and ICT Carbon Footprint in Australia, 2009
by Data Centre, Other Enterprise, Household and Network Infrastructure

	KwH/year	CO_2e	% of CO_2e
Total Data Centre	4,572,118	4,936,650	34.4
Total Other Enterprise	2,989,078	3,223,620	22.4
Total Household	4,639,737	4,971,743	34.6
Network Infrastructure	1,047,109	1,232,819	8.6
TOTAL	**13,248,041**	**14,364,832**	**100.0**

The enterprise ICT carbon footprint is split over many industry sectors, with the largest being Education and Training (7.3%), Health Care and Social Assistance (5.9%), Manufacturing (5.4%) and Retail Trade (5.3%). Note that household ICT usage, at 34.6% of the total, is greater than that for the six largest industry sectors combined.

Enterprise ICT Carbon Footprint in Australia, 2009
by Industry Sector (% of total ICT emissions)

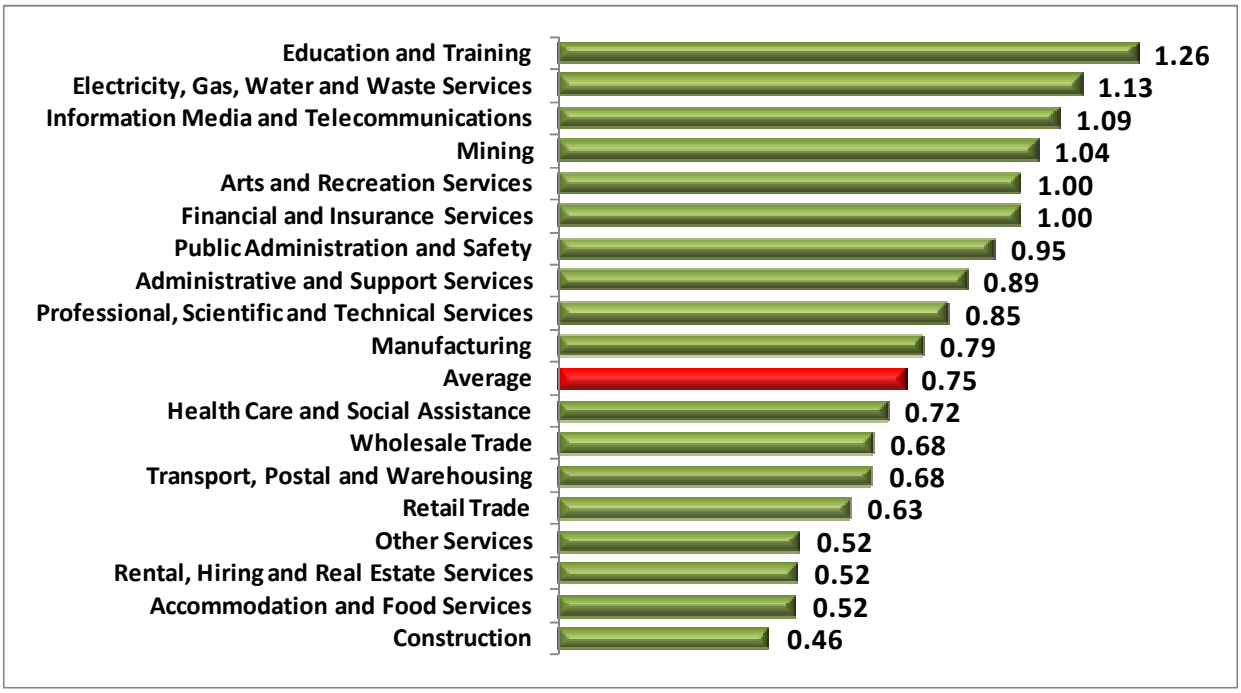


Some significant industry sectors, such as the primary industries of mining and agriculture, have a relatively small ICT carbon footprint. Note also that a combination of education and training, government (public administration and safety) and health (health care and social assistance) is 17.6 of the total.

Another useful metric is that of ICT carbon emissions per employee (FTE – full-time equivalent). This can be determined by industry sector, giving a picture of which industries are high end low emitters per capita.

On average, employees in Australian enterprises are each responsible for 0.75 tonnes A year of carbon emissions. The figure varies significantly by industry. The highest figure (1.26 tonnes) is in the education and training sector, because of the large number of computers being used by non-employees (students). The lowest is construction (0.46 tonnes).

ICT Carbon Emissions per Employee, Australia, 2009
by Industry (tonnes of CO_2e)

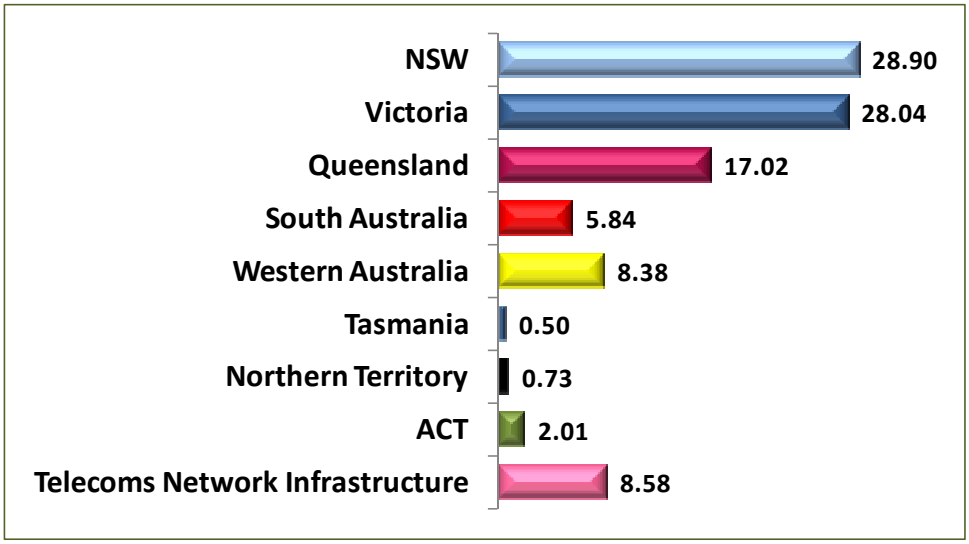


ICT's carbon footprint by state is approximately proportionate to state populations, with a few notable exceptions. Victoria's share of the total (28.0%) is almost as large as NSW's (28.9%) despite its lower population.

That is because most electricity in Victoria is generated by brown coal, which leaves a much larger carbon footprint than electricity generated in other states. And the ACT (2.0%) has a much higher ICT carbon footprint than its population would indicate, because of the large amount of ICT in

government. Tasmania's ICT carbon footprint is smaller than the Northern Territory's, despite its much larger population, because of the high proportion of its electricity generated by clean hydroelectric power.

ICT Carbon Footprint in Australia, 2009
by State (% of total ICT emissions)



We believe this report gives the most complete picture of ICT energy consumption ever undertaken in Australia. It shows the location and extent of ICT's carbon footprint, broken down by many factors. By highlighting the biggest areas of consumption it also shows where the biggest potential improvements can be made.

What the report does not show, at least directly, is the potential for ICT to reduce carbon emissions in other areas. This enablement factor is an increasingly important part of the emerging Green ICT debate – some studies show that ICT has the potential to decrease the planet's carbon emissions by five times more than those caused by its own activities.

That is where the real changes can be made, and where the real challenges are.

Recommendations

The findings of the report lead to a number of recommendations. Green ICT has been an issue in the industry for some time now, but the data from this report suggests a number of key areas of focus. Work on the big problems first. The ACS recommends:

1. Work Harder on Data Centre Efficiency

Data centres are responsible for more than one third of Australia's ICT footprint. The real culprit is data centre cooling – data centre environmentals consume more power than data centre ICT equipment. There are many techniques and technologies for increasing the energy efficiency of data centres – they all need to be implemented, and quickly.

2. Reduce the Usage and the Number of Printers and Imaging Devices

Printers, multi-function devices, fax machines, scanners – they are real energy hogs. The report shows the massive amount of energy they use. Most people print too much, though the techniques for saving on printing are well known – print management, centralised printing, duplex printing (though its advantages are greatly overrated). The easiest thing is to simply print less, and on fewer printers. We don't need all that paper, and we certainly don't need all those printers.

3. Turn Computers Off – Standby is Not Good Enough

Standby power is power wasted. The research for this study clearly shows that electronic devices left on when they are not being used constitute close to 20% of all ICT power consumption. With some devices, like games consoles and video monitors, the waste is excessive. Turn them off at the wall when not in use, or implement power management systems that have the same effect.

4. Think Green

There are many ways to reduce ICT power consumption. Most of them have to do with changing behaviour, not introducing new technology. Green ICT does not cost money, it saves money. All ICT users, from casual home users to power users in large corporations, should adopt a power saving attitude to everything they do in ICT.

5. Use ICT to Reduce Carbon Emissions in Other Areas

This is the big one. We can work hard on reducing ICT's carbon footprint, but much more significant savings can be made outside of ICT – improving business processes, making transport and electricity distribution and building systems and healthcare more efficient – working greener, not harder. Efficiency means green. They are the same thing. ICT has always been an enabling technology – now its biggest challenge lies before it.

1. Methodology

This report follows a six-part process, as described below. Any such analysis relies on three key aspects – definition, data, and modelling:

- **Definition**. All definitions must be as precise as possible, with minimal scope for confusion. For that reason it is useful, wherever possible, to use standard definitions. The methodology in this report relies on two key types of definition – that of industry sector and that of ICT equipment.

  Standard ABS (Australian Bureau of Statistics) definitions are used for industry codes, and in the absence of any standard a basic categorisation of ICT equipment is used (see below).

- **Data**. There are two types of data: that which already exists, and that which is created to serve the purposes of the research. This report uses existing ABS data for ICT user demographics, and a combination of existing ABS and industry data, with some recent primary research data, for ICT usage.

- **Modelling**. The best definitions and data are useless without a sound modelling process. This report keeps the modelling process very simple to minimise the chances of error and confusion. All modelling makes assumptions – this report attempts to support its assumptions with credible and accurate analysis. The modelling is done using Excel spreadsheets, with simple formulas, as described in this report.

Step One – Scope the Users

The first step is to clearly define which users of ICT are being measured. This report includes all ICT users in Australia, divided into two categories –Enterprise (business and government organisations) and Households.

Enterprise users are broken down by ABS ANZSIC industry codes, with ABS demographics used to determine the size and demographic makeup of each group. The number of household users is also based on ABS data.

Step Two – Determine Definitions, Inclusions and Exclusions

The second step is to determine what is to be measured (or computed), and what is to be excluded. The calculations for this report are of usage of a number of ICT device types. Many domestic devices are excluded: stand-alone digital cameras and camcorders, digital and analogue TVs and DVD players, digital set-top boxes and PVRs (personal video recorders), and amplifiers and home cinemas.

This exclusion of home video and entertainment equipment is because they are rarely, if ever, included as part of ICT market analyses. The boundaries are blurring as the world goes digital, but consumer electronics and ICT remain separate industries.

Note however that games consoles and portable music devices are included. These have ICT functionality, are usually manufactured and sold by ICT companies, and are connected to ICT networks.

Device types included are:

- **Computers**: Desktop and laptop PCs, (including netbooks and tablets), terminals and thin clients, games consoles, and servers (in three size categories).
- **Peripherals**: Video monitors, storage devices, printers and other digital imaging equipment (including fax machines and multi-function devices).
- **Dedicated data centre environmentals**: CRACs (computer room air conditioners), humidifiers, lighting systems, etc.
- **Digital communications devices**. Landline telephone handsets and PABXs, routers, switches, modems, networking equipment, etc.
- **Mobile devices**: Mobile phones, portable music players, PDAs (personal digital assistants) and hybrids of these (PDAs are now rarely stand-alone devices).

Also included is Australia's telecommunications network infrastructure: The exchanges, mobile phone towers, cabling, networking devices and other equipment used by Australia's telecommunications carriers to connect all of the above.

Only actual usage of these device types in Australia is included – what are known as Scope 2 emissions (emissions caused by the use of purchased electricity). Excluded are:

- ICT activity conducted offshore but initiated in Australia, e.g. Google searches, cloud computing or SaaS (software as a service) activities, where these are not hosted in Australia. Conversely, such activities initiated offshore but hosted in Australia are included.

- Purchases of carbon offsets.

- "Embedded" carbon – CO_2e emissions as a consequence of the manufacture, storage or transport of ICT equipment and consumables.

- e-Waste – CO_2e emissions as a consequence of the disposal of ICT equipment and consumables.

- Other ICT-related environmentals: Transport of ICT staff in the execution of their activities. Lighting, heating and cooling (outside of dedicated data centres), etc.

Step Three – Scope the Usage

The third step is to scope ICT usage. There are two aspects – ownership and usage patterns. Ownership of ICT equipment can be determined from many sources. Substantial information exists from the ABS and market analyst companies on ICT equipment ownership, which can be determined to a high degree of accuracy.

Much more difficult is the extent of usage of this equipment, where there is much less data. Some computers are left on all the time, some are powered up only when in use. Various different types of ICT equipment use different amounts of power depending on how they are used. Many assumptions have been made, but where possible these are based on existing literature, and are generally conservative.

Step Four – Compute the Energy Consumption

The fourth step is to bring the above data together. This involves determining

- The population of users
- The total number of devices
- The usage patterns of those devices
- The energy consumption of those devices over a defined period (this report uses calendar 2009).

Total energy consumption, and energy consumption by sector or user type, is a calculation involving the above variables.

Step Five – Compute the Carbon Footprint

The fifth step is to convert energy consumption into CO_2e emissions. This is a relatively simple process, based on standard formulas. The formulas in Australia differ by state, due to their different electricity generation technologies. Very roughly, one kilowatt hour of electricity converts into 1 gram of CO_2e emitted. To the computed figure is added the CO_2e generated by Australia's telecommunications infrastructure, which is not included in the above calculations.

Step Six – Make the Comparisons

The final step, once all calculations are made, is to determine the relativities of the carbon footprint. The methodology used in the report has the great advantage of allowing extensive comparisons of carbon footprint within the user base – by state, industry sector, etc. These are useful comparisons.

Other useful comparisons are external – comparing ICT's carbon footprint to that of other industries or usage types (e.g. transport). It also allows ICT's carbon footprint to be measured as a proportion of that of Australia as a whole.

2. The Demographics of Australia's ICT Users

Enterprise

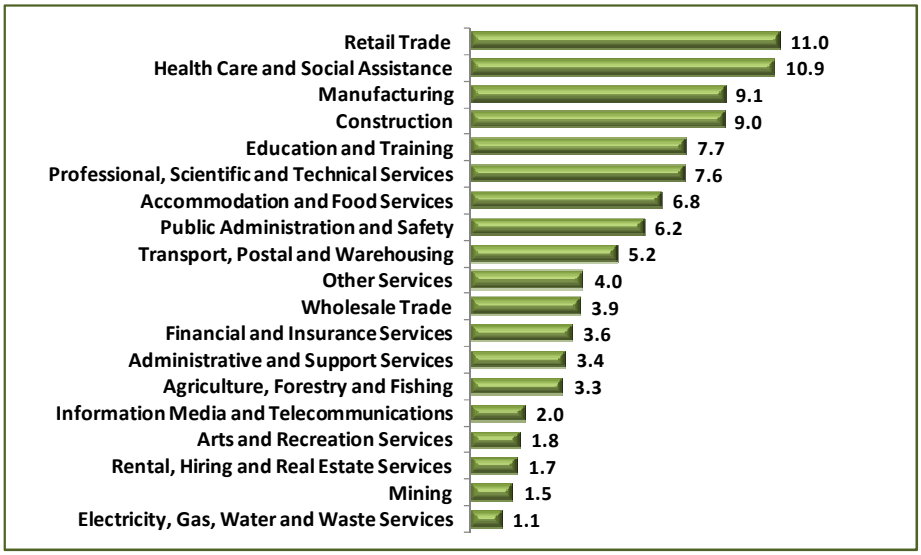
The ABS has a number of measures of the number of people employed in various industry sectors in Australia. Data in this report is taken from the quarterly figures for November 2009[3]. The ABS categorises industries using the ANZSIC (Australia and New Zealand Standard Industry Classification) system. There were 10,849,000 people employed in Australia in June 2009.

Employees by Industry Sector and State, Australia 2009 ('000 employees)

Industry	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Total
Agriculture, Forestry and Fishing	96	90	84	35	37	14	3	1	360
Mining	35	11	41	7	64	4	3	0	165
Manufacturing	302	295	183	83	96	18	5	3	985
Electricity, Gas, Water and Waste Services	34	29	28	10	12	5	2	1	121
Construction	283	217	240	65	125	22	13	14	980
Wholesale Trade	139	120	79	34	41	7	2	3	426
Retail Trade	364	315	247	91	127	26	13	14	1196
Accommodation and Food Services	250	176	162	48	72	16	7	9	741
Transport, Postal and Warehousing	183	137	131	37	58	10	8	6	569
Information Media and Telecommunications	80	62	30	10	18	4	2	6	213
Financial and Insurance Services	165	116	53	24	27	5	2	3	395
Rental, Hiring and Real Estate Services	56	34	52	13	19	2	3	4	183
Professional, Scientific and Technical Services	277	222	151	54	84	11	7	20	827
Administrative and Support Services	117	95	75	28	39	6	4	6	369
Public Administration and Safety	207	120	133	52	63	21	16	59	672
Education and Training	253	213	160	62	97	18	13	21	836
Health Care and Social Assistance	372	302	232	105	114	27	12	15	1178
Arts and Recreation Services	50	61	38	13	20	5	3	5	193
Other Services	134	107	100	28	48	8	6	6	438
Total	**3398**	**2724**	**2218**	**798**	**1163**	**230**	**123**	**195**	**10849**

Source: ABS

Employees by Industry Sector, Australia 2009 (sorted by percentage of all employees)



The ABS also publishes a report showing the number of organisations by industry sector, but the most recent analysis dates from 2007 and uses the old ANZSIC concordance (the system was revised in 2006, but not all ANZSIC data used the new system immediately). The breakdown of employees by industry sector allows us to calculate the amount of ICT usage per sector, using data on penetration of ICT equipment by sector (see Chapter 3).

This report assumes that small, medium and large organisations use ICT differently, and have a different mix of ICT equipment (as outlined in Chapter 3). It is possible, by using other ABS data[4], to divide the workforce into these three groups – but not by state, and not for the Financial and Insurance Services industry, which is excluded from this data. The ABS defines "small" organisations as those having fewer than 20 employees, "medium" as having from 20 to 99 employees, and "large" as those with 100 employees or more.

The proportions of employees in each size group are shown in the table below. In this table, Financial and Insurance Services numbers are apportioned the same as the average for Australia as a whole.

Proportion of Employees in Small, Medium and Large Organisations by Industry Sector, Australia 2009

Industry	Small (1-19)	Medium (20-99)	Large (100+)
Agriculture, Forestry and Fishing	84.3	13.5	2.2
Mining	17.2	18.8	64.1
Manufacturing	36.2	28.5	35.3
Electricity, Gas, Water and Waste Services	17.0	13.0	70.0
Construction	77.6	11.8	10.6
Wholesale Trade	42.9	28.4	28.8
Retail Trade	42.0	15.0	42.9
Accommodation and Food Services	55.3	23.5	21.2
Transport, Postal and Warehousing	49.6	14.4	36.0
Information Media and Telecommunications	22.7	15.7	61.0
Financial and Insurance Services	51.0	22.2	26.8
Rental, Hiring and Real Estate Services	80.2	10.7	9.1
Professional, Scientific and Technical Services	56.9	25.9	17.2
Administrative and Support Services	30.4	38.9	30.7
Public Administration and Safety	51.3	19.2	29.5
Education and Training	34.9	46.9	18.5
Health Care and Social Assistance	42.6	24.3	33.0
Arts and Recreation Services	49.7	22.8	27.5
Other Services	71.6	20.1	8.3
Total	**51.0**	**22.2**	**26.8**

Source: ABS

Note the major disparities by industry sector. Some sectors (e.g. Agriculture and Rental, Hiring and Real Estate Services) have by far the majority of employees in small organisations, and some (e.g. Electricity, Gas, Water and Waste Services) have by far the majority in larger organisations.

Household

This report uses both Australia's population and its number of households to determine the demographics for household ICT usage. The ABS last measured Australia's population in the 2006 census, but projects to 2101. These numbers are projections for July 2009[5]. The ABS also last measured household numbers in the 2006 census, but projects to 2026.

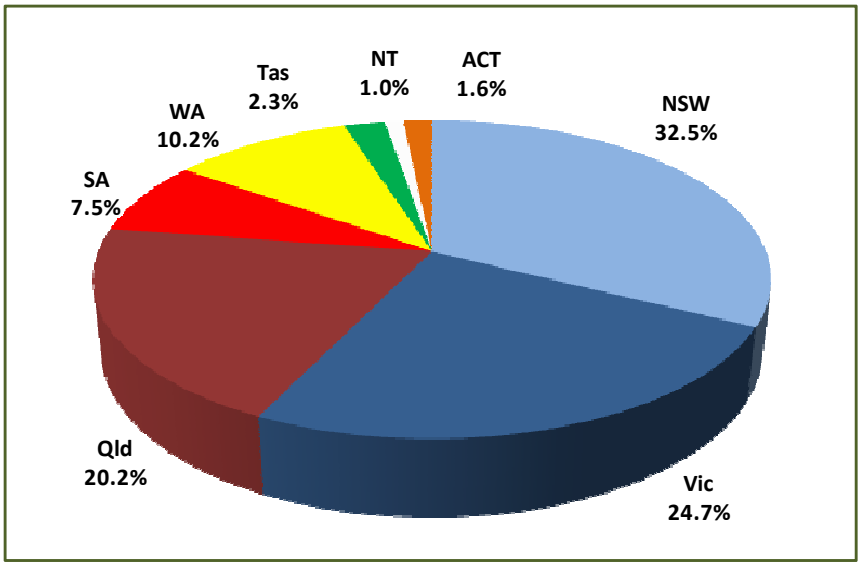
These numbers are projections for July 2009 (Series I)[6]. This breakdown of population and households allows a calculation of individual ICT usage, using data on penetration of ICT equipment by household (see Chapter 3). There were 21,702,351 Australians in July 2009, in 8,320,992 households.

Population and Households by State, Australia 2009

State	Population	Households	People per HH
New South Wales	7,045,540	2,723,535	2.59
Victoria	5,366,158	2,035,529	2.64
Queensland	4,385,282	1,661,881	2.64
South Australia	1,617,470	652,681	2.48
Western Australia	2,206,658	840,009	2.63
Tasmania	503,668	202,267	2.49
Northern Territory	225,527	70,278	3.21
Australian Capital Territory	349,612	133,842	2.61
Australia	**21,702,351**	**8,320,992**	**2.61**

Source: ABS

Population by State, Australia 2009
(percentage of total population)



Source: ABS

NSW contains nearly one third of Australia's population, and Victoria nearly one quarter. Tasmania and the two territories combined do not even equal the next smallest state, South Australia. Given the similarities in household sizes (with the exception of the Northern Territory, where it is inflated by the younger population and the higher proportion of indigenous inhabitants), the proportional breakdown by household by state is very close to that of the population by state.

South Australia and Tasmania have the fewest people per household because they have the highest average age, and therefore the highest proportion of one person households.

3. ICT Usage in Australia

This report separates ICT usage by enterprise (industry and government) and by individuals (expressed as households). But in reality there is no clear distinction – many devices, for example laptop PCs and mobile phones, are often used for both private and business purposes. Nevertheless, the distinction is made, though occasionally it must be a trifle arbitrary.

There are a number of sources available on the usage of ICT equipment in Australian private and public organisations. Unfortunately, much of this is not in the public domain, and is sold commercially and under strict confidentiality restrictions by market research companies, to whom such information is their livelihood. This report uses some of this data where possible – some of it is often included in public reports or academic research.

The methodology used in this chapter is to determine usage rates for each device for each industry sector (and households) by state, and from that data determine the total numbers of devices in each sector, and for Australia as a whole. In some cases device numbers are not computed, but energy consumption is calculated from the usage characteristics of dependant devices.

Computers

Desktop PCs, Laptop PCs, Terminals and Thin Clients, Games Consoles

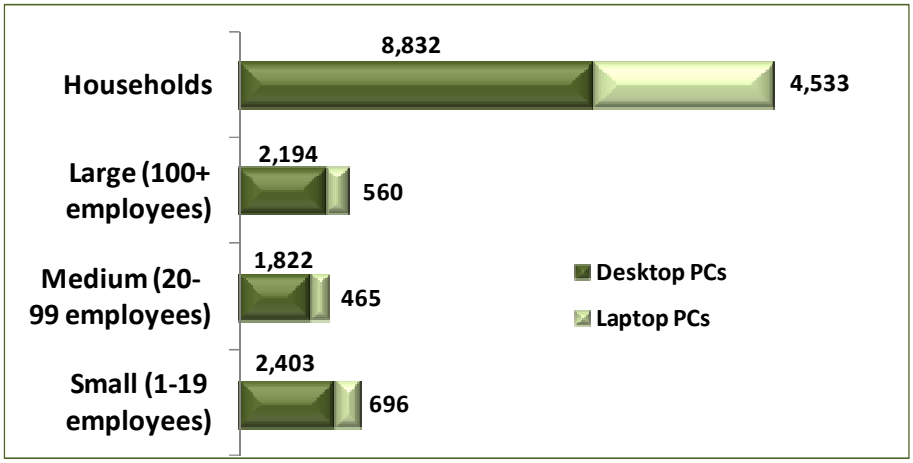
The data on household desktop PC, laptop PC and games console usage comes from ***The Digital Atlas of Australia***[7], which in turn partially draws on an ABS publication on the household usage of ICT[8]. ***The Digital Atlas of Australia*** is a report by Connection Research examining the household ownership of digital devices. Its data was computed from extensive primary research of over 10,000 households, conducted in two rounds in late 2007 and late 2008 for Connection Research's ***Connected Home*** reports.

This base data was weighted according to ABS data for each of Australia's 65 Statistical Regions (SRs). The usage rates for each SR were determined by applying the appropriate weighting and by a statistical technique known as multi-level modelling, which is particularly useful for examining the significance of a range of variables, such as those used in the Atlas. It also has the effect of smoothing any statistical anomalies, giving a high degree of certainty to the analysis.

The usage rates published in ***The Australian Digital Atlas*** for each technology type were therefore based on both the demographic characteristics of each SR and on the responses to the two ***Connected Home*** surveys. The numbers of devices for each SR was determined by applying the usage rates to ABS 2006 Census data, modified for population growth projections since then. That data was then aggregated by state, by metro and non-metro within state, and across all of Australia. This report uses only the state aggregations. Consumer devices vendor Canon Australia also commissions a twice yearly survey from market research company GfK, the ***Canon Digital Lifestyle Index***[9]. This has been published for some years now, and details shipment figures (dollar value and unit numbers) of various digital devices for six-monthly periods.

Much of the data on industry desktop PC, laptop PC and terminal/thin client usage comes from an analysis of the ***MIS Marketbase***[10]. This database, acquired by Fairfax in 1999 but originally designed in 1992 as a research tool, lists over 3500 Australian organisations with more than 50 staff, with reasonably accurate data for numbers of desktop PCs, laptop PCs, terminals and servers. It also contains number of employees and the organisation's industry sector. It does not use ANZSIC codes, but the industry sectors in the database can be mapped to ANZSIC with a high degree of accuracy. To maintain consistency, a snapshot of this database from mid-2009 was used.

Desktop and Laptop PCs in Australia
by Employee Numbers and Households, 2009 ('000)



Sources: Employee Numbers - ABS
Usage Rates – MIS Marketbase

For medium and large organisations, device numbers per employee are applied to the total number of employees in that sector. For small organisations, the device number per employee is assumed to be smaller, and it is further assumed that only desktop and laptop PCs are used. The device numbers per employee for smaller organisations are discounted by the proportion of organisations that use the internet, as outlined in the ABS overview of business usage of ICT[11]. As shown in the chart above, there are more than 21.5 million PCs in Australia, almost one for every person. This report assumes that all terminal and thin client usage is by organisations with 20 or more employees, and none by households or organisations with fewer than 20 employees. It also assumes all games console usage is in households.

Household Ownership of Desktop PCs, Laptop PCs and Games Consoles by State, 2009

Australia		Device Type	% of Households with Device	Average Devices per household	Total Devices
Population	21,702,351	Desktop PC	67.81	1.06	8,832,038
Number of Households	8,320,992	Laptop PC	40.66	0.54	4,533,149
Average People per Household	2.61	Games Console	45.33	0.73	6,111,192

New South Wales		Device Type	% of Households with Device	Average Devices per household	Total Devices
Population	7,045,540	Desktop PC	66.33	1.03	2,815,132
Number of Households	2,723,535	Laptop PC	41.87	0.59	1,614,694
Average People per Household	2.59	Games Console	45.64	0.74	2,018,969

Victoria		Device Type	% of Households with Device	Average Devices per household	Total Devices
Population	5,366,158	Desktop PC	68.04	1.06	2,162,058
Number of Households	2,035,529	Laptop PC	37.12	0.54	1,093,553
Average People per Household	2.64	Games Console	44.47	0.74	1,510,420

Queensland		Device Type	% of Households with Device	Average Devices per household	Total Devices
Population	4,385,282	Desktop PC	68.12	1.09	1,810,357
Number of Households	1,661,881	Laptop PC	40.56	0.52	864,230
Average People per Household	2.64	Games Console	46.39	0.72	1,195,167

South Australia		Device Type	% of Households with Device	Average Devices per household	Total Devices
Population	1,617,470	Desktop PC	67.16	1.07	701,227
Number of Households	652,681	Laptop PC	33.81	0.46	300,191
Average People per Household	2.48	Games Console	43.89	0.74	484,431

Western Australia		Device Type	% of Households with Device	Average Devices per household	Total Devices
Population	2,206,658	Desktop PC	71.15	1.10	920,488
Number of Households	840,009	Laptop PC	38.74	0.53	448,387
Average People per Household	2.63	Games Console	46.59	0.76	642,218

Tasmania		Device Type	% of Households with Device	Average Devices per household	Total Devices
Population	503,668	Desktop PC	69.22	1.31	265,321
Number of Households	202,267	Laptop PC	39.66	0.80	161,560
Average People per Household	2.49	Games Console	52.76	0.90	182,539

Northern Territory		Device Type	% of Households with Device	Average Devices per household	Total Devices
Population	225,527	Desktop PC	65.62	1.22	85,912
Number of Households	70,278	Laptop PC	46.24	1.07	74,886
Average People per Household	3.21	Games Console	66.64	1.07	75,314

Australian Capital Territory		Device Type	% of Households with Device	Average Devices per household	Total Devices
Population	349,612	Desktop PC	77.82	1.42	190,098
Number of Households	133,842	Laptop PC	54.61	1.09	146,328
Average People per Household	2.61	Games Console	57.38	0.99	132,968

Sources: Population - ABS
Households – ABS
Device Ownership –The Australian Digital Atlas

Australian Digital Atlas percentages and averages are from December 2008, applied against the increased household numbers in July 2009.

Desktop PCs, Laptop PCs and Terminals/Thin Clients (Non-Household) in Australia by Industry Sector, 2009

Industry Sector	Desktop PCs	Laptop & Notebook PCs	Terminals & Thin Clients	Total
Agriculture, Forestry and Fishing	69.4	19.4	0.6	**89.5**
Mining	97.0	25.3	2.8	**125.1**
Manufacturing	423.8	113.1	9.6	**546.5**
Electricity, Gas, Water and Waste Services	100.0	26.0	2.9	**129.0**
Construction	386.1	108.4	3.4	**497.9**
Wholesale Trade	113.3	30.5	2.3	**146.1**
Retail Trade	229.0	61.4	4.9	**295.2**
Accommodation and Food Services	123.9	33.6	2.3	**159.7**
Transport, Postal and Warehousing	218.6	59.0	4.3	**281.9**
Information Media and Telecommunications	169.2	44.5	4.5	**218.1**
Financial and Insurance Services	328.9	89.7	5.6	**424.2**
Rental, Hiring and Real Estate Services	93.6	26.4	0.7	**120.7**
Professional, Scientific and Technical Services	600.7	165.0	9.0	**774.7**
Administrative and Support Services	183.0	48.5	4.5	**236.0**
Public Administration and Safety	643.5	171.9	14.4	**829.8**
Education and Training	1535.4	403.0	41.5	**1979.9**
Health Care and Social Assistance	436.8	117.4	9.0	**563.2**
Arts and Recreation Services	195.9	53.2	3.5	**252.6**
Other Services	191.5	53.3	2.2	**246.9**
TOTAL	**6139.5**	**1649.6**	**128.0**	**7917.1**

Sources: Employee Numbers - ABS
Usage Rates – MIS Marketbase

Servers

For ease of analysis this report assumes that all server usage is by enterprises, and none by households. Some household PCs are used as servers, but they are counted as high end PCs in the calculations above.

There are many different types of server, and many different ways of defining them. This report uses a general distinction used by research company IDC, because that is the distinction used in the report's primary source for server power usage (Jonathan Koomey's much quoted 2007 Stanford University paper on server power consumption)[12].The distinction is simple:

- **Volume** – Typically, those with a PC-type architecture used as servers, and individual blade servers in racks. These servers cost less than $US25,000.

- **Midrange** – Specialist stand-alone servers costing between $US25,000 and $500,000, from vendors such a IBM, Sun and HP.

- **High end** – Large servers, often referred to as mainframes, costing more than $US500,000.

Server numbers in this report are based on a number of sources: Koomey's report, an analysis of the MIS Marketbase, ABS employment figures, and a private list of mainframe (roughly equivalent to high end server) sites maintained by Connection Research. MIS Marketbase usage rates are computed from organisations where these are reported, expanded for the entire workforce, then divided into server classes according to the Asia Pacific breakdown in Koomey's study. ABS data is used to break down employee numbers into those working in small, medium and large companies, then server numbers apportioned based on the following assumptions:

- Only large organisations (those with over 100 employees) use high end servers.
- Only large and medium organisations (those with more than 20 employees) use midrange servers.
- Small organisations (those with fewer than 20 employees) have an average of one volume server for every 50 employees (there are very many small organisations with no servers at all, and many using desktop PCs as servers).

The analysis shows 1,258 high end servers installed in Australia. These are disproportionately used by a comparatively small number of very large organisations. When apportioned by industry and state according to the above distribution, some anomalies occur which are corrected manually according to Connection Research's database of mainframe sites (unpublished). The overall number remains the same, but the distribution by state and industry changes (e.g., fewer in Retail, which is inflated because of high employee numbers, and more in Professional, Scientific and Technical Services, which covers outsourcing and facilities management operations. Also, many more in the ACT to represent government usage than the raw data would indicate).

Servers in Australia
By Type and Business Size, 2009 ('000)

Size of Business (employees) / Server Type	Small (1-19)	Medium (20-99)	Large (100+)	Total
Volume	123.9	555.1		**679.0**
Midrange	0	24.4		**24.4**
High end	0	0	1.258	**1.258**
Total	**123.9**	**579.4**	**1.258**	**704.6**

Sources: Enterprise Numbers - ABS
Usage Rates – MIS Marketbase
Size breakdown: J. Koomey

The table above shows the breakdown of the total number of servers in Australia (704,600), based on the above calculations. There are approximately 679,000 volume servers, of which 123,900 are in small enterprises and 555,100 are in medium and large enterprises. There are 24,400 midrange servers, all of them in medium and large enterprises, and there are 1,258 high end servers, all of them in large enterprises.

Peripherals

Video Monitors

This report assumes that all desktop PCs, thin clients and terminals, games consoles, and half of all volume servers, have one video monitor, and that laptops and larger servers have none. There are many assumptions here. Games consoles often use TVs as terminals, in which case those TVs are consuming power and are treated as video monitors for the purpose of the study. Many people use more than one monitor on a single PC, and many volume servers have none. The overall assumption is that these factors largely cancel out.

Storage Devices

This report does not separately measure storage devices for PCs, games consoles or volume servers – they are usually integral to the device and are included in those devices' energy consumption figures.

Storage devices for larger servers are also not counted separately, as their energy consumption is measured as a proportion of server energy consumption in data centres, based on accepted measurements (see Chapter 4).

Printers and Other Digital Imaging Equipment

This category includes computer printers, and also fax machines and multi-function devices (MFDs) – devices used for any combination of printing, scanning, copying and faxing. Stand-alone photocopiers are excluded, but stand-alone fax machines are included.

There is little existing data on the installed base of printers and other imaging devices in Australia. Shipment figures, from the ***Canon Digital Lifestyle Index*** and elsewhere, tell some of the story (over 1.3 million were sold in Australia last year), but these figures tell us little about the number in use. A report from Connection Research in 2007[13], which surveyed over 3,000 households, found almost as many printers in use in households as PCs. This report assumes printer numbers in households to be 75% of the number of desktop and laptop PCs.

The calculations for the number installed in organisations are more difficult. Networked printing is commonplace, and one printer may serve dozens of users. This report uses the proxy of total number of servers to equal total number of imaging devices in medium and large businesses – server numbers are representative of both networking penetration and size, as well as the number of end users. The number of imaging devices in small business is calculated as the 25% of the total number of desktop and laptop PCs (i.e. one imaging device is shared on average between every four ICT users).

Dedicated Data Centre Environmentals

This report does not measure the number of devices in this category, but measures their total energy consumption as a proportion of all data centre consumption (see Chapter 4). This is an important calculation, given the high energy consumption of this category.

Digital Communications Devices

Landline Telephone Handsets

The Australian Communications and Media Authority (ACMA) reported 10.67 million fixed line telephone services in Australia in 2008-2009[14], a number that declined by approximately 4% in the previous 12 months. Determining the number of handsets is not so easy. This report assumes two handsets for each household, and one for each employee who has a PC.

PABXs

PABXs (private automatic branch exchanges) are ubiquitous in business, and range in size from tiny boxes to large and complex devices that are increasingly indistinguishable from server computers. At the low end they are often called Key Telephone Systems (KTSs). This report assumes that there are no PABXs in households. Some households have small devices, but their energy consumption is comparatively insignificant and they are included in household handset usage. For enterprise usage, the number of PABXs is not measured, but their total energy consumption is expressed as a multiple of handsets – there is a direct relationship between the number of lines and the size (and power consumption) of the PABXs they serve (see Chapter 4).

Routers, Switches, Modems and Other Networking Equipment

Internet connection is now ubiquitous. All devices need to connect via a modem, and multiple devices can be connected to one modem or to a network using devices known as routers or switches. Some devices combine all three functions.

Every internet connected household (proportions from the ABS[15]) is assumed to have one modem, which may also function as an internet switch and allow multiple PCs in that household to connect. Routers, switches and modems are apportioned to enterprises in the same numbers and using the same formula as for printers (see above). There is a significant amount of other networking equipment, usually in data centres. This equipment is not separately counted, but its energy consumption is expressed as a percentage of all data centre consumption (see Chapter 4).

Mobile Devices

Mobile Phones

Mobile phone usage is now ubiquitous in Australia – there are more mobile phone connections than people. ACMA reported 24.22 million mobile phone services in Australia in 2008-09[16], for a population of around 22 million. This figure increased by approximately 10% in the previous twelve months, a time when the usage of mobile phone services for data communications was growing strongly.

There is a distinction between mobile phone *services* and mobile phone *devices*. There are more of the former than the latter (though if decommissioned mobile phones were counted, there would be many more devices than services). But for the purposes of this study, we assume one mobile phone (device) per Australian, distributed by state and territory in the same proportion as the Australian population. One phone is assigned to each employee by industry sector and state, the remainder applied to non-employed by state. The report does not separately measure the declining class of products known as PDAs (personal digital assistants), as the functionality of these devices are increasingly contained within mobile phones.

Portable Music Players

Data on portable music players comes from ***The Australian Digital Atlas 2007*** (not tracked in 2008), supplemented by subsequent shipment figures in the ***Canon Digital Lifestyle Index***. The installed base at the end of 2007 is supplemented by shipments in the following 18 months, discounted by 50% to allow for retirements. There were more than 10 million portable music players in use in Australia in mid 2009.

Portable Music Players in Australia
by State, 2009 ('000)

State	Portable Music Players
New South Wales	3330.8
Victoria	2529.5
Queensland	1991.3
South Australia	790.4
Western Australia	1021.9
Tasmania	240.9
Northern Territory	86.9
Australian Capital Territory	187.8
Australia	10179.5

Sources: The Australian Digital Atlas, Canon Digital Lifestyle Index

4. The Energy Consumption of ICT Equipment

Usage Considerations

All energy consumption figures in this report are expressed in kWh/year – the amount of kilowatts hours consumed by each device in one year.

Usage Patterns and Standby Power

One of the key variables to be considered in determining the energy consumption of ICT devices is the way in which they are used. How often are they switched on, and are they left on even when they are not being used? How much power do they consume when idle or in standby mode? How much power do they consume performing different functions?

These questions are of concern to all who attempt to calculate the energy consumption of ICT equipment. Fortunately, there exists a substantial body of work on the subject, and this report draws on much of this data for the assumptions it makes.

Green Power and Dirty Power

The calculations in this report attempt to measure overall differences in carbon emissions caused by different power generating technologies in each state (see Chapter 5), but do not take into account any "green power" purchased by any users. "Green power" is a broad term introduced by power utilities to indicate that some of their power is drawn from renewable sources (e.g. solar or wind), or which it offsets (see below). It does not take into account co-generation or tri-generation, emerging technologies and techniques that supplement data centre power with that drawn from energy sourced or generated by the user from somewhere other than the electricity grid (e.g. in-house gas turbines).

Carbon Offsets

In recent years carbon offsets have become a popular way of helping people believe they are reducing their carbon footprint. Basically, offsets work by allowing someone to replace, or "offset", their carbon emissions in one area by performing some activity that reduces carbon emissions in another area. Increasingly, this takes the form of buying offset credits from a broker

who claims to be achieving carbon reduction elsewhere. The concept of offsets was introduced in the 1997 Kyoto conference as a way for developed countries to move towards carbon emission reduction by helping developing countries reduce their emissions. Since then the idea has expanded into an industry that sells offsets to companies and individuals to help them justify their carbon emissions.

A growing body of opinion believes that the concept of carbon offsets is fatally flawed – it is an easy way out for carbon polluters that does nothing to help overall planetary carbon emissions. In June 2009 Friends of the Earth produced a report called ***A Dangerous Distraction***[17] which highlighted the problems of offsets. Some of its arguments:

- Offsets count action in developing countries as part of the cuts promised in developed countries, although the science is clear that action is needed in both developed and developing countries.
- Offsets cannot guarantee the same cuts as would have happened without offsetting.
- Offsets are causing major delays to urgently needed economic transformations in developed countries.
- Offsets do not ensure positive sustainable development in, or appropriate financial transfers to, developing countries.

The calculations in this report do not take any carbon offsets into account, for the above reasons and because they cannot be verified.

Power Lost in Transmission

There are a number of calculations that show that the amount of energy consumed is significantly less than the amount produced – that much energy is lost in inefficiencies in transmissions and storage. This is certainly the case, but it is very difficult to quantify. This report uses the Australian Government's National Greenhouse Accounts conversion factors for converting power usage to carbon emissions, which take into account power lost in transmission.

Cloud Computing and Offshore Energy Consumption

There is a growing movement in the ICT industry towards "cloud computing" and software as a service (SaaS). Both terms refer to the practice of "utility computing" – performing processing activities remotely through a service offered over the internet by a service provider, with the user having no knowledge as to where the processing is actually occurring. The calculations in this report do not take into account any energy consumed offshore through cloud computing or SaaS activities by ICT activities initiated in Australia, but includes such activities that take place in Australia whether initiated locally or offshore.

Energy Consumption of Computers

Desktop PCs, Laptop PCs, Terminals and Thin Clients

Energy consumption figures for PCs are based on the EU Energy Star ratings calculator[18], which can be found at www.eu-energystar.org. The calculator gives a range of scenarios based on different types of PC (e.g. "value PC", "multimedia PC", "large notebook", "small server "), different sizes of video monitor, and different usage patterns (hours per day in on-mode, standby-mode and off-mode). There are five usage patterns.

PC Usage Patterns

Mode (hours per day)	Light Office	Average Office	Busy Office	Never Off	Always On
On-mode	2	4	8	4	24
Stanby-mode	9	5	2	20	-
Off-mode	13	15	14	-	-

Source: EU Energy Star

With so many variables it is hard to determine an average figure. The following assumptions have been made:

- Half of all desktop PCs, in both office and home, are "value PCs" (41 watts in on-mode), and half are "multimedia PCs" (67 watts in on-mode)
- Half of all laptop PCs, in both office and home, are "value notebooks" (41 watts in on-mode), and half are "large notebooks" (67 watts in on-mode)
- Terminals are rated the same as thin clients, at 13.9 watts. All are in "average office" mode (see above), which equates to 24.8 kWh/year (and is very close to the "never off" figure of 26.6 kWh/year).
- PC usage, in both office and home, is split evenly (20% each) between each of the five modes in the Energy Star calculator (see above).

Using these assumptions, average kWh/year figures for desktop and laptop PCs can be computed. Desktop PCs are rated at 121 kWh/year, and laptop PCs at 44.4 kWh/year.

The calculations to arrive at these figures are contained in the table below, which shows the EU Energy Star kwH/year ratings for the nominated desktop and laptop ("notebook") PCs in each mode, the average across the five modes ("Average I"), and the average of those figures for desktop and laptop PCs ("Average II").

Average Energy Consumption for PCs (kWh/year)

Annual Consumption (kWh/year)	Light Office	Average Office	Busy Office	Never Off	Always On	Average I	Average II
Value PC	33.7	50.1	83.5	80.8	218.5	93.3	121.7
Multimedia PC	44.2	74.8	137.3	104.7	389.5	150.1	
Value Notebook 15-17"	12.8	17.7	28.1	19.8	71.2	29.9	44.4
Large Notebook	21.4	32.4	55.5	35.3	149.5	58.8	

Source: EU-Energy Star

Games Consoles

Games consoles are almost as popular in Australian homes as PCs. There are four major types: Microsoft Xbox 360, Sony Playstation 2, Sony Playstation 3, and Nintendo Wii. There are also a number of smaller devices, mostly from Nintendo. All use different amounts of power, in each of three modes – off, idle and active.

The US National Resources Defense Council (NRDC) published an excellent paper in 2008 on games console usage and power consumption[19]. Its findings on power consumption by device, in three different modes, are contained in the table below.

Many games consoles are left on when not in use, through forgetfulness or idleness, or because players want to save the game they are on. This report assumes all consoles are left on 25% of the time (42 hours a week). This report also assumes the installed base market share in Australia is similar to that in the USA, as reported by the NRDC.

These assumptions lead to an average energy consumption for games consoles (weighted by wattage and share of installed base) of 116.8 kWh/year – close to the figure for desktop PCs.

Average Power Measurement by Manufacturer, Games Consoles (Watts)

Console Type (year of release)	MODE (W) Off	Idle	Active	US Installed Base %
Micrsooft Xbox 360 (2007)	3.1	117.5	118.8	15
Micrsooft Xbox 360 (2005)	2.2	162.0	172.0	
Micrsooft Xbox (2001)	1.7	59.9	64.0	15
Sony Playstation 3 (2007)	1.1	152.9	150.1	5
Sony Playstation 3 (2006)	1.1	181.0	188.6	
Sony Playstation 2 (2000)	1.7	24.2	24.2	40
Sony Playstation (1994)	1.4	6.5	8.0	
Nintendo Wi (2006)	1.9	10.5	16.4	12
Nintendo GameCube (2000)	0.7	22.7	23.0	13
Nintendo 64 (1996)	1.1	7.8	7.3	
Super Nintendo (1991)	1.5	5.4	7.3	

Source: NRDC

Servers

The most authoritative source by far on average server power consumption remains Jonathan Koomey's 2007 analysis at Stanford University[20], and some of his subsequent work[21]. Drawing on that work, this report calculates average energy consumption for the three classes of server, with consumption figures increased from Koomey's 2005 figures by an annual growth rate based on power increases computed by Koomey from 2000 to 2005.

Servers are very large consumers of power, especially as they are almost always left on permanently, which Koomey's calculations assume. High end servers (mainframes) use vast amounts of power, to which must be added ancillary environmental equipment, mainly used to cool them (see below).

Average Power Consumption by Server Type

Server Type	Average Power Usage	Annual Power Consumption (kWh)
Volume	265.6	2,333.4
Midrange	790.3	6,942.2
High end	13,733.3	120,633.0

Source: J. Koomey, IDC

Energy Consumption of Peripherals

Video Monitors

This report uses the EU-Energy Star ratings for monitor types and usage (see above). The following assumptions have been made:

- There is an equal mix (20% each) of five video monitor types: CRT (90 watts), "value 17 inch" (20 watts), "system 17 inch" (22 watts), "system 19 inch" (26 watts) and "value 24 inch" (43 watts). Note that U-Energy Star does not rate CRT monitors – the rating used here is an indicative average based on previous research by the author[22].
- Usage patterns are all for EU-Energy Star "busy office" mode (8 hours a day in on-mode, 2 hours a day in stand-by mode, 14 hours a day in off-mode), as video monitors are often left on when PCs are off.

These assumptions lead to an average energy consumption figure for video monitors of 83.7 kWh/year.

Data Centre Storage Devices

As mentioned above, this report does not count storage devices separately – their energy consumption is included with the device (PCs and volume servers outside of data centres) or measured as a proportion of all data centre energy consumption. Much work has been done in this area – this report relies on the extensive data collected by the US Environmental Protection Agency (EPA) and reported to the US Congress in 2007[23]. That report has been very influential and is widely quoted.

The EPA report estimates data centre storage devices consume 5% of the total energy consumption in data centres, which equates to 12% of that consumed by servers. This report assumes all high end and midrange servers, and 90% of volume servers used by medium and large organisations, are in data centres. Data centre storage energy consumption is therefore calculated at 12% of all data centre server energy consumption. Other storage energy consumption is included with PC, games console and volume server energy consumption.

Printers and Other Digital Imaging Equipment

The energy consumption of digital imaging equipment is very difficult to calculate because of the large numbers of variables – hundreds of different models, many different usage patterns, whether they are left in standby mode, etc. Nevertheless, some assumptions must be made.

This report uses the average TEC (Typical Energy Consumption) figures for hundreds of 230 volt imaging devices published by Energy Star in the USA[24]. The TEC provides a weekly kWh rating, which is multiplied out to represent annual consumption, with the figures for printers and multi-function devices averaged out. Imaging equipment is a very high consumer of energy – the average annual consumption per device based on the above calculations is 433.2 kWh/year.

That figure is used for enterprise printers, and 25% of that figure (108.3 kWh/year) is used for devices used in households, where usage is much lower and the devices on average much smaller.

Energy Consumption of Dedicated Data Centre Environmentals

This category includes CRACs (computer room air conditioners), humidifiers, lighting systems, etc. The US EPA report on data centre energy consumption (see above) assumes that on average all energy used in data centres is apportioned 50% to ICT equipment and 50% to the data centre environment. This ratio is known as the PUE (Power Usage Effectiveness) or DCiE (Data Centre Infrastructure Effectiveness), two measures developed by The Green Grid[25] and commonly used throughout the data centre industry.

It is probable, however, that the Australian figure is significantly higher. This report uses a PUE of 2.43, based on recent calculations[26] of Australian government data centres. This PUE means that for every watt consumed by ICT equipment in the data centre, 1.43 watts is consumed by non-ICT equipment (mostly air conditioning and other cooling technologies). PUEs are dropping as data centre energy efficiency improves, but 2.43 is a reasonable assumptive average for Australia in 2009. Environmental energy consumption outside of data centres (e.g. extra air conditioning in an office with many PCs) is not included in the calculations used in this report.

Energy Consumption of Digital Communications Devices

Landline Telephone Handsets and PABXs

Conventional landline handsets use only a marginal amount of power, but devices such as cordless handsets and some of the more complex handsets attached to PABXs can use 5 watts or more, and are left on all the time. This report assumes a nominal constant overhead of 1 watt per handset, which translates to 8.8 kWh/year.

The power usage of PABXs varies enormously, but data published previously by the ACS[27] shows an average of a little under 1 watt of power per maximum number of connected handsets. Few PABXs have the maximum configuration – this report calculates PABX power consumption at .5 watts per business handset, always on, which equals 4.4 kWh/year per enterprise handset.

Routers, Switches, Modems

The Australian Greenhouse Office published a detailed report on modem power usage in 2005[28]. That report looks mostly at standby power, and is now a little out of date.

There is a large amount of published data on the power consumption of routers, switches and modems, showing a wide range of power consumption figures. A reasonable average is about 10 watts, which translates to 87.9 kWh a year if the devices are left on, as they usually are. That is the figure used in this report.

Other Networking Equipment

Modern ICT-using organisations employ significant amounts of networking equipment, mostly in data centres. As with storage equipment (see above), the energy consumption of this equipment is measured as a proportion of all data centre energy consumption, relying also on data from the US EPA report on data centre energy consumption[29].

That report estimates storage devices consume 5% of the total energy consumption in data centres, which equates to 12% of that consumed by servers. This report assumes all high end and midrange servers, and 90% of volume servers used by medium and large organisations, are in data centres. Storage energy consumption is therefore calculated at 12% of all data centre server energy consumption.

Other networking equipment energy consumption is included with PC, games console and volume server energy consumption.

Energy Consumption of Mobile Devices

Estimating the energy consumption of mobile devices is particularly difficult, because of the many variables involved: hours of usage, hours of charging, methods of charging, etc. There is significant literature about the amount of standby energy consumed by mobile phone chargers when they are left plugged in but not in use. This so-called "vampire" usage (it sucks power!) is significant, typically more energy consumption than that used to actually charge the device. But there is little information about the total power consumption of mobile phones.

One credible calculation[30] estimates the average annual power consumption of a mobile phone at 4.09 kWh, based on 300mW no-load dissipation and 64% efficiency when charging for an hour a day. This report rounds this figure to 4 kWh/year for all mobile devices including portable music players – efficiency is improving, but newer devices such as the iPhone use more power.

Energy Consumption of the Telecommunications Infrastructure

There is further significant consumer of energy within the ICT sector which cannot be accounted for with the above calculations – Australia's telecommunications network infrastructure. Voice and data networks consume vast amounts of energy in themselves, independently of all the end user devices measured in the body of this report.

It would be potentially very difficult to measure this figure, but fortunately Australia's largest carrier, Telstra, has already measured its own emissions. From that data the entire amount can be calculated, from Telstra's market share. Telstra publishes its environment data in terms of CO_2e emissions, so a conversion from kWh (see Chapter 5) is not necessary – all that is needed is to add it as an extra category at the end of the calculations.

Telstra reports[31] that the Scope 2 CO_2e emissions (what this report measures) for its network in 2008-2009 were 986,255 tonnes. This figure is for the financial year preceding the calendar year of 2009 covered in this report, but Telstra has also reported previous years and the number has levelled out, with improvements in efficiency roughly cancelling increases in capacity. What is more difficult is to measure what proportion of the total telecommunications infrastructure is accounted for by Telstra. A credible estimate of this figure comes from leading Australian telecommunications consultant Paul Budde[32], who believes Telstra accounts for roughly 80% of the total figure, given its ownership of the voice network and telephone exchanges.

This report therefore assumes total CO_2e emissions for Australia's telecommunications infrastructure at 125% of the Telstra figure (equivalent to Telstra comprising 80%), or 1,232,819 tonnes. This figure is published as a separate category alongside device types, and is kept separate from industry sectors and state totals (see Chapter 5).

Energy Consumption – Summary

The table below summarises the energy consumption of all ICT device types mentioned in this report, expressed in kWh/year. Telecommunications network infrastructure energy consumption is not included, as it is not a function of type or number of devices (see above). The kWh/year figures in the table are a function of average power consumption (in watts) and the usage patterns of the devices, multiplied out over a year. Total energy consumption in Australia of all devices (see Chapter 5) is that figure multiplied by the number of devices (see Chapter 3).

Energy Consumption by Device Type (kWh/year)

Device Type	kWh/Year (Household)	kWh/Year (Non-Household)	Notes
Desktop PCs	121.7	121.7	
Laptop & Notebook PCs	44.4	44.4	
Terminals & Thin Clients	n/a	24.8	
Games Consoles	116.8	n/a	
Volume Servers	n/a	2333	
Midrange Servers	n/a	6942	
High-end Servers	n/a	120633	
Video monitors	83.7	83.7	
Storage devices	n/a	derived	12% of data centre servers
Printers & Imaging equipment	108.3	433.2	
Landline telephone handsets	8.8	8.8	
PABXs	n/a	4.4	per connected handset
Routers, switches, modems	87.8	87.8	
Other networking equipment	n/a	derived	12% of data centre servers
Mobile Phones	4.0	4.0	
Portable Music Players	4.0	n/a	
Data Centre Environment	n/a	derived	PUE of 2.43 (multiple of 1.21 of data centre ICT equipment)

5. Total ICT Energy Usage and Carbon Footprint

Measuring Energy and Converting to CO_2e

Once the number of devices and their average power consumption has been determined, total energy usage is calculated by multiplying the two. This report does that for every device type, across every state and for every industry sector, allowing for comparison between all factors. Data is expressed in terms of kWh for 12 months of usage (calendar 2009).

The carbon footprint can then be determined. There is no simple formula for converting kWh to the standard measure of carbon footprint, which is CO_2e (carbon dioxide equivalent) emissions. The formula varies depending upon how the power that is being consumed is generated. Victoria, for example, generates most of its power from brown coal, which emits significantly more CO_2e than the black coal used in most other states.

Tasmania, which uses a lot of hydroelectric power, is much cleaner still. This report uses the figures published in the Australian Government's National Greenhouse Gas Accounts Factors[33], which contains a table outlining the average kWh to CO_2e conversion rates for each state:

Scope 2 and 3 emissions factors for consumption of purchased electricity by end users by Australian state, 2009

State	Emission Factor
New South Wales	1.07
Victoria	1.34
Queensland	1.01
South Australia	0.92
Western Australia	0.94
Tasmania	0.24
Northern Territory	0.79
Australian Capital Territory	1.07

Source: Australian Government Department of Climate Change

Thus, a company in NSW consuming 10,000 kWh of electricity annually from the grid is responsible for 1.07 tonnes of CO_2e. One in Victoria is responsible for 1.34 tonnes. These figures also take into account transmission losses, and are recommended by the Department of Climate Change as the most accurate for measuring end user contributions to CO_2e emissions.

To the total carbon footprint figures determined by those calculations must be added the total figure for the telecommunications network infrastructure carbon footprint (see Chapter 4). Because the source data for this amount is expressed in CO_2e emissions, the above conversion factor needs to reversed to express it in kWh/year. This report does that, at the average figures across all Australian ICT (1.08).

ICT's Total Carbon Footprint

ICT is responsible for nearly 2.7% of Australia's total carbon emissions. More significantly, it is directly responsible for more than 7% of all electricity generated in Australia. These are significant figures, particularly given that Australia is one of the largest carbon emitters per capita in the world.

In 2009 Australia's ICT users consumed 13.248 million kilowatt hours (kWh) of electricity, which caused 14.365 Megatonnes (Mt) of Scope 2 CO_2e (carbon dioxide equivalent) emissions. This compares to Australia's total emissions of 539 Mt, and total electricity generated of 203 Mt.

ICT Carbon Footprint in Australia Compared to Other Components, 2009
(Mt / year and as % of component)

Source	Mt / year	ICT as %
Electricity generated for ICT	14	
Total electricity generated	203	7.1
Other stationery energy	90	16.0
Transport	79	18.2
Fugitive emissions	40	35.9
Industrial processes	27	53.2
Waste	15	95.8
Agriculture	84	17.1
TOTAL EMISSIONS	**539**	**2.7**

The table above shows ICT emissions (14.365 Mt in 2009) as a percentage of other components of Australia's total CO_2e emissions. The emissions data is taken from the ***September 2009 Quarterly Update of Australia's National Greenhouse Inventory***[34]. ICT's emissions are 18.2% of those from all transport, 53.2% of those from industrial processes, and almost as high (95.8%) of those from waste.

By any estimation, ICT's energy consumption and carbon emissions are significant proportion of Australia's total.

Energy Consumption and Carbon Footprint by ICT Device Category

This report calculates the total energy consumption for all ICT equipment in Australia, by multiplying average energy usage per device type by the number of devices. It then converts those energy usage figures into CO_2e emissions, using the standard formulas used by the National Greenhouse Accounts. To that figure is added the telecommunications network infrastructure emissions (8.6% of the total). Energy consumption and carbon emissions are computed by device type, by state, and by industry sector (plus households). This enables the data to be presented in many ways.

Energy Consumption and ICT Carbon Footprint in Australia, 2009
by Device Category

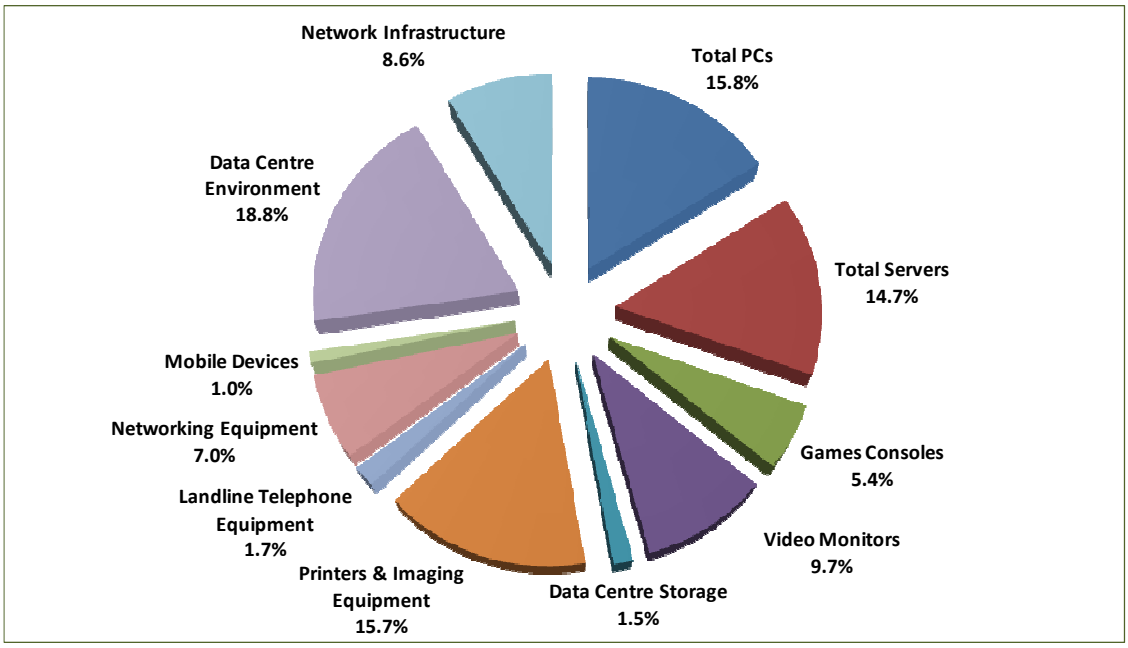
Device Category	KwH/year	CO_2e	% of CO_2e
Desktop PCs	1,836,533	1,971,850	13.7
Laptop & Notebook PCs	281,895	301,554	2.1
Terminals & Thin Clients	3,173	3,421	0.0
Total PCs	*2,121,601*	*2,276,825*	*15.8*
Volume Servers	1,622,501	1,752,750	12.2
Midrange Servers	174,038	188,093	1.3
High-end Servers	157,869	168,908	1.2
Total Servers	*1,954,408*	*2,109,751*	*14.7*
Games Consoles	729,267	781,175	5.4
Video Monitors	1,302,792	1,399,022	9.7
Data Centre Storage	199,822	215,754	1.5
Printers & Imaging Equipment	2,103,435	2,258,844	15.7
Landline Telephone Handsets	201,790	217,334	1.5
PABXs	27,863	30,038	0.2
Routers, Switches, Modems	725,325	782,827	5.4
Other Networking Equipment	199,822	215,754	1.5
Mobile Phones	86,800	93,576	0.7
Portable Music Players	40,718	43,919	0.3
Data Centre Environment	2,507,290	2,707,195	18.8
Network Infrastructure	1,047,109	1,232,819	8.6
TOTAL	**13,248,041**	**14,364,832**	**100.0**

The table above shows energy consumption (kWh/year) and $C0_2e$ (tonnes of emissions/year) for Australia for 2009, and the $C0_2e$ emissions as a percentage of all ICT emissions, for the device categories used in this report. Summary data is presented in a graph on the next page.

The biggest categories are data centre environment (18.8%), PCs (15.8%), printers and imaging equipment (15.7%) and servers (14.7%). But if video monitors are added to PCs, their total energy consumption exceeds a quarter of the total. Add games consoles, and the figure is nearly one third of the total. Games consoles consume five times more energy than mainframe computers (defined

as “high end servers” in this report). Mobile phones and other portable devices, though widely used, account for only 1% of ICT energy consumption. Fixed line telephones and related equipment account for less than 2%, but data networking equipment for more than 7% and the telecommunications network infrastructure for another 8.6%.

ICT Carbon Footprint in Australia, 2009
by Device Category (%)



Energy Consumption and ICT Carbon Footprint in Australia, 2009
by Data Centre, Other Enterprise, Household and Network Infrastructure

	KwH/year	CO_2e	% of CO_2e
Total Data Centre	4,572,118	4,936,650	34.4
Total Other Enterprise	2,989,078	3,223,620	22.4
Total Household	4,639,737	4,971,743	34.6
Network Infrastructure	1,047,109	1,232,819	8.6
TOTAL	**13,248,041**	**14,364,832**	**100.0**

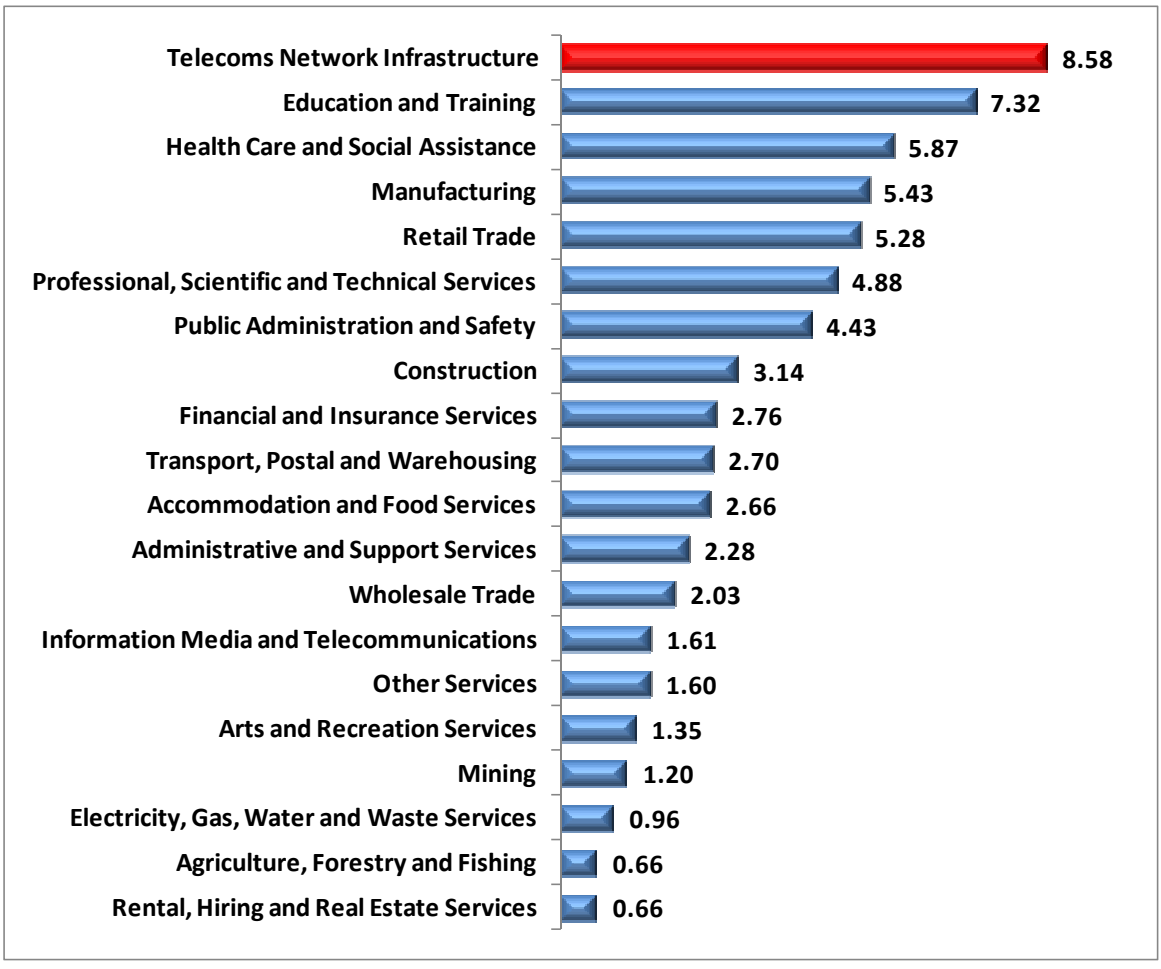
Another useful comparison is to look at where consumption takes place. There is an almost even split between households (34.6%), data centres (34.4%) and a combination of other enterprise ICT usage (22.4%) and network infrastructure (8.6%). The majority of data centre power consumption is accounted for by environmentals – mostly air conditioning and other types of cooling.

The household figure is so high because of the sheer number of PCs and video monitors (and games consoles) they contain – an average of close to two devices per household, for over eight million households.

ICT Carbon Footprint by Industry

The enterprise ICT carbon footprint is split over many industry sectors, with the largest being Education and Training (7.3%), Health Care and Social Assistance (5.9%), Manufacturing (5.4%) and Retail Trade (5.3%). Note that household ICT usage, at 34.6% of the total, is greater than that for the six largest industry sectors combined.

Enterprise ICT Carbon Footprint in Australia, 2009
by Industry Sector (% of total ICT emissions)



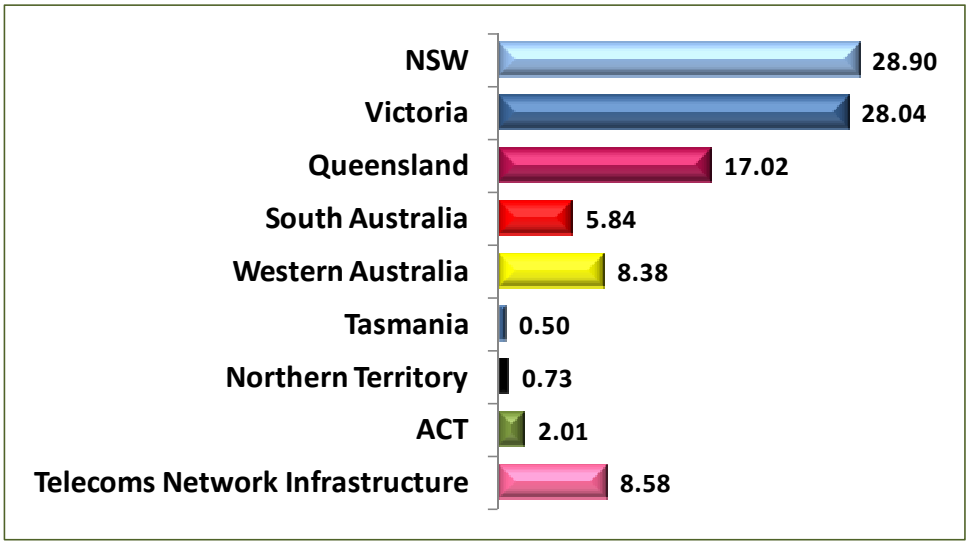
Some significant industry sectors, such as the primary industries of mining and agriculture, have a relatively small ICT carbon footprint. Note also that a combination of education and training, government (public administration and safety) and health (health care and social assistance) is 17.6 of the total.

It would be possible to apportion the telecommunications network infrastructure by industry sector. That would add a little to each percentage, but would not change the ranking.

ICT Carbon Footprint by State

ICT's carbon footprint by state is approximately proportionate to state populations, with a few notable exceptions. Victoria's share of the total (28.0%) is almost as large as NSW's (28.9%) despite its lower population. That is because most electricity in Victoria is generated by brown coal, which leaves a much larger carbon footprint than electricity generated in other states.

ICT Carbon Footprint in Australia, 2009
by State (% of total ICT emissions)

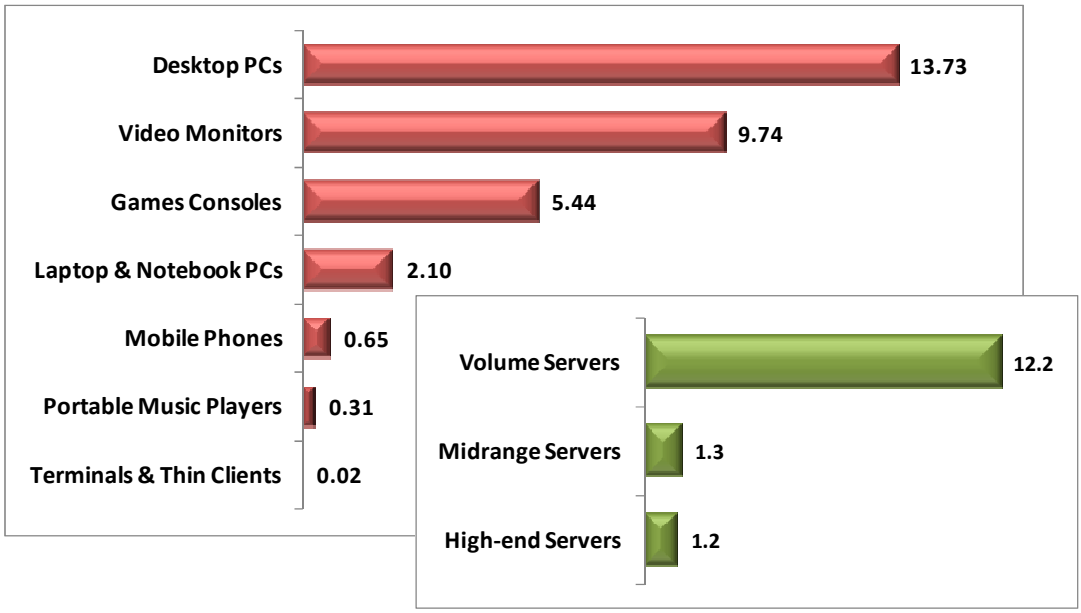


And the ACT (2.0%) has a much higher ICT carbon footprint than its population would indicate, because of the large amount of ICT in government. Tasmania's ICT carbon footprint is smaller than the Northern Territory's, despite its much larger population, because of the high proportion of its electricity generated by clean hydroelectric power. It would be possible to apportion the telecommunications network infrastructure by industry state. That would add a little to each percentage, but would not change the ranking.

End User Equipment, Servers and Data Centres

The methodology in this report allows for comparison by device type, by industry sector and household, and by state. Comparisons can also be made within sectors (e.g. industry by state, or device type by industry sector), and by both energy consumption and carbon footprint. Much of this information is contained in the detailed tables in the remainder of this chapter. The above charts show the major comparisons. This section looks at End User Equipment, Servers and Data Centres in more detail.

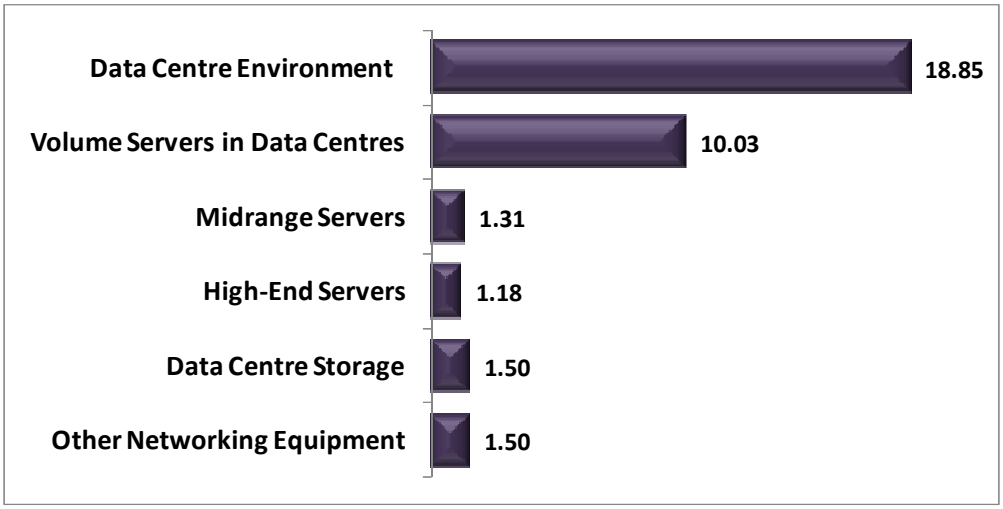
ICT Carbon Footprint in Australia, 2009
End User Devices and Servers (% of total ICT emissions)



The charts above show the mix of end user equipment and servers. By far the largest component of end user equipment is desktop PCs and the video monitors they use. And volume servers have a much larger carbon footprint than larger servers, despite the massive energy consumption of the larger devices, because of their sheer numbers.

The chart below shows the components of data centre ICT carbon footprint. By far the largest component is the environmental equipment, followed by volume servers (this figure differs from the figure above because not all volume servers are in data centres). Large servers, despite their high energy consumption, account for only a small proportion of the total because of their comparatively small numbers.

ICT Carbon Footprint in Australia, 2009
Data Centre Equipment (% of total ICT emissions)



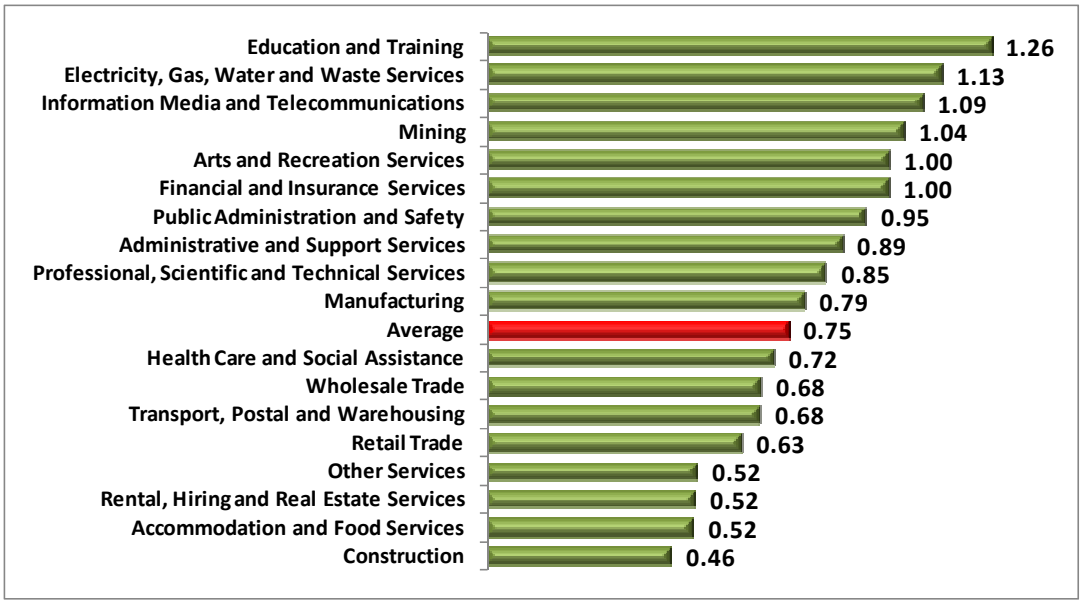
Carbon Footprint per Employee

Using the available data, another useful metric is possible – that of ICT carbon emissions per employee (FTE – full-time equivalent). This can be determined by industry sector, giving a picture of which industries are high end low emitters per capita.

ICT Carbon Emissions per Employee, Australia, 2009
by Industry

Industry	CO_2e (tonnes)	Employees (000)	CO_2e/Emp
Agriculture, Forestry and Fishing	**95,154**	360	0.26
Mining	**171,691**	165	1.04
Manufacturing	**780,459**	985	0.79
Electricity, Gas, Water and Waste Service	**137,286**	121	1.13
Construction	**451,020**	980	0.46
Wholesale Trade	**291,472**	426	0.68
Retail Trade	**759,181**	1196	0.63
Accommodation and Food Services	**381,894**	741	0.52
Transport, Postal and Warehousing	**388,189**	569	0.68
Information Media and Telecommunication	**231,717**	213	1.09
Financial and Insurance Services	**395,886**	395	1.00
Rental, Hiring and Real Estate Services	**95,125**	183	0.52
Professional, Scientific and Technical Serv	**700,526**	827	0.85
Administrative and Support Services	**327,204**	369	0.89
Public Administration and Safety	**635,834**	672	0.95
Education and Training	**1,050,922**	836	1.26
Health Care and Social Assistance	**843,297**	1178	0.72
Arts and Recreation Services	**193,718**	193	1.00
Other Services	**229,695**	438	0.52
Total Enterprise	**8,160,270**	**10849**	**0.75**

On average, employees in Australian enterprises are each responsible for 0.75 tonnes A year of carbon emissions. The figure varies significantly by industry. The highest figure (1.26 tonnes) is in the education and training sector, because of the large number of computers being used by non-employees (students). The lowest is construction (0.46 tonnes).



Data Tables

The data and calculations used in determining the final results presented in this report involved eleven large linked spreadsheets, which are far too large and detailed to reproduce here. The following tables show the key data behind the above charts. Figures are expressed as kWh/year, carbon footprint (tonnes of CO_2e emitted), and as a percentage of the total ICT carbon footprint.

ICT Energy Consumption in Australia, 2009 by State and Industry Sector (kWh/year)

Sector	NSW	Victoria	Qld	SA	WA	Tas	NT	ACT	Australia
Agriculture, Forestry and Fishing	26,041	22,155	19,543	7,761	9,109	2,843	824	775	**89,050**
Mining	37,020	16,090	38,265	14,384	58,002	3,839	3,385	486	**171,472**
Manufacturing	222,203	204,980	134,629	58,826	70,603	13,924	4,521	4,348	**714,035**
Electricity, Gas, Water and Waste Services	36,962	30,619	28,440	10,230	14,096	6,170	1,908	2,181	**130,605**
Construction	129,474	99,017	92,997	29,632	48,330	9,689	4,986	6,464	**420,589**
Wholesale Trade	86,908	73,408	50,862	20,882	26,243	4,763	1,542	2,338	**266,947**
Retail Trade	216,570	184,905	143,045	51,785	73,116	15,585	7,279	8,729	**701,015**
Accommodation and Food Services	119,304	84,211	77,042	23,183	34,904	7,791	3,422	4,553	**354,410**
Transport, Postal and Warehousing	115,709	87,282	79,475	23,690	37,135	6,755	4,778	4,724	**359,549**
Information Media and Telecommunications	77,045	58,670	33,508	11,582	18,981	4,253	2,057	5,305	**211,400**
Financial and Insurance Services	134,771	99,381	58,215	23,337	31,707	6,622	2,899	4,260	**361,193**
Rental, Hiring and Real Estate Services	28,155	19,869	20,644	6,490	9,084	1,648	1,121	1,619	**88,631**
Professional, Scientific and Technical Services	210,801	165,215	121,416	45,159	65,170	11,614	5,925	19,323	**644,624**
Administrative and Support Services	95,053	76,018	60,636	22,576	31,302	5,326	3,208	7,836	**301,955**
Public Administration and Safety	182,737	123,175	116,681	44,897	56,973	16,016	10,148	47,366	**597,993**
Education and Training	304,851	243,170	191,197	72,236	105,682	21,743	12,574	23,201	**974,654**
Health Care and Social Assistance	245,950	196,799	154,061	66,131	76,139	17,873	7,958	16,664	**781,576**
Arts and Recreation Services	51,664	49,421	35,356	12,635	18,283	4,374	2,310	4,503	**178,547**
Other Services	67,245	52,386	45,674	14,803	22,663	4,428	2,592	3,162	**212,952**
Total Enterprise	**2,388,463**	**1,886,772**	**1,501,687**	**560,218**	**807,522**	**165,257**	**83,437**	**167,839**	**7,561,196**
Household	1,491,248	1,118,747	919,500	351,044	473,569	134,480	49,387	101,762	**4,639,737**
Telecoms Network Infrastructure	(not apportioned by state or industry)								**1,047,109**
TOTAL	**3,879,711**	**3,005,519**	**2,421,187**	**911,262**	**1,281,090**	**299,737**	**132,824**	**269,601**	**13,248,041**

ICT Carbon Footprint in Australia, 2009 by State and Industry Sector (tonnes of CO_2e)

Sector	NSW	Victoria	Qld	SA	WA	Tas	NT	ACT	Australia
Agriculture, Forestry and Fishing	27,863	29,688	19,738	7,140	8,563	682	651	829	**95,154**
Mining	39,612	21,560	38,648	13,234	54,522	921	2,674	520	**171,691**
Manufacturing	237,757	274,673	135,975	54,120	66,367	3,342	3,572	4,653	**780,459**
Electricity, Gas, Water and Waste Services	39,550	41,029	28,724	9,411	13,250	1,481	1,507	2,334	**137,286**
Construction	138,537	132,682	93,927	27,261	45,430	2,325	3,939	6,917	**451,020**
Wholesale Trade	92,992	98,366	51,371	19,212	24,668	1,143	1,218	2,502	**291,472**
Retail Trade	231,730	247,772	144,476	47,642	68,729	3,740	5,751	9,340	**759,181**
Accommodation and Food Services	127,655	112,843	77,813	21,328	32,810	1,870	2,703	4,872	**381,894**
Transport, Postal and Warehousing	123,809	116,958	80,269	21,795	34,907	1,621	3,775	5,054	**388,189**
Information Media and Telecommunications	82,438	78,617	33,843	10,655	17,842	1,021	1,625	5,676	**231,717**
Financial and Insurance Services	144,205	133,171	58,797	21,470	29,805	1,589	2,291	4,558	**395,886**
Rental, Hiring and Real Estate Services	30,126	26,625	20,851	5,971	8,539	396	886	1,733	**95,125**
Professional, Scientific and Technical Services	225,557	221,388	122,631	41,547	61,260	2,787	4,681	20,675	**700,526**
Administrative and Support Services	101,706	101,864	61,242	20,770	29,424	1,278	2,534	8,385	**327,204**
Public Administration and Safety	195,528	165,055	117,848	41,305	53,555	3,844	8,017	50,682	**635,834**
Education and Training	326,190	325,848	193,109	66,457	99,341	5,218	9,933	24,825	**1,050,922**
Health Care and Social Assistance	263,167	263,710	155,602	60,841	71,571	4,290	6,287	17,831	**843,297**
Arts and Recreation Services	55,281	66,225	35,709	11,625	17,186	1,050	1,825	4,818	**193,718**
Other Services	71,952	70,197	46,130	13,619	21,303	1,063	2,047	3,384	**229,695**
Total Enterprise	**2,555,656**	**2,528,274**	**1,516,704**	**515,401**	**759,071**	**39,662**	**65,915**	**179,588**	**8,160,270**
Household	1,595,635	1,499,122	928,695	322,960	445,154	32,275	39,016	108,885	**4,971,743**
Telecoms Network Infrastructure	(not apportioned by state or industry)								**1,232,819**
TOTAL	**4,151,291**	**4,027,396**	**2,445,399**	**838,361**	**1,204,225**	**71,937**	**104,931**	**288,473**	**14,364,832**

ICT Carbon Footprint in Australia, 2009
by State and Industry Sector (% of Total ICT Carbon Footprint)

Sector	NSW	Victoria	Qld	SA	WA	Tas	NT	ACT	Australia
Agriculture, Forestry and Fishing	0.19	0.21	0.14	0.05	0.06	0.00	0.00	0.01	**0.66**
Mining	0.28	0.15	0.27	0.09	0.38	0.01	0.02	0.00	**1.20**
Manufacturing	1.66	1.91	0.95	0.38	0.46	0.02	0.02	0.03	**5.43**
Electricity, Gas, Water and Waste Services	0.28	0.29	0.20	0.07	0.09	0.01	0.01	0.02	**0.96**
Construction	0.96	0.92	0.65	0.19	0.32	0.02	0.03	0.05	**3.14**
Wholesale Trade	0.65	0.68	0.36	0.13	0.17	0.01	0.01	0.02	**2.03**
Retail Trade	1.61	1.72	1.01	0.33	0.48	0.03	0.04	0.07	**5.28**
Accommodation and Food Services	0.89	0.79	0.54	0.15	0.23	0.01	0.02	0.03	**2.66**
Transport, Postal and Warehousing	0.86	0.81	0.56	0.15	0.24	0.01	0.03	0.04	**2.70**
Information Media and Telecommunications	0.57	0.55	0.24	0.07	0.12	0.01	0.01	0.04	**1.61**
Financial and Insurance Services	1.00	0.93	0.41	0.15	0.21	0.01	0.02	0.03	**2.76**
Rental, Hiring and Real Estate Services	0.21	0.19	0.15	0.04	0.06	0.00	0.01	0.01	**0.66**
Professional, Scientific and Technical Services	1.57	1.54	0.85	0.29	0.43	0.02	0.03	0.14	**4.88**
Administrative and Support Services	0.71	0.71	0.43	0.14	0.20	0.01	0.02	0.06	**2.28**
Public Administration and Safety	1.36	1.15	0.82	0.29	0.37	0.03	0.06	0.35	**4.43**
Education and Training	2.27	2.27	1.34	0.46	0.69	0.04	0.07	0.17	**7.32**
Health Care and Social Assistance	1.83	1.84	1.08	0.42	0.50	0.03	0.04	0.12	**5.87**
Arts and Recreation Services	0.38	0.46	0.25	0.08	0.12	0.01	0.01	0.03	**1.35**
Other Services	0.50	0.49	0.32	0.09	0.15	0.01	0.01	0.02	**1.60**
Total Enterprise	**17.79**	**17.60**	**10.56**	**3.59**	**5.28**	**0.28**	**0.46**	**1.25**	**56.81**
Household	11.11	10.44	6.47	2.25	3.10	0.22	0.27	0.76	**34.61**
Telecoms Network Infrastructure			(not apportioned by state or industry)						**8.58**
TOTAL	**28.90**	**28.04**	**17.02**	**5.84**	**8.38**	**0.50**	**0.73**	**2.01**	**100.00**

ICT Energy Consumption in Australia, 2009
by Industry and Device Type (kWh/year)

Industry / Device Type	Desktop PCs	Laptop & Notebook PCs	Terminals & Thin Clients	Volume Servers	Midrange Servers	High-end Servers	Games Consoles	Video monitors	Storage devices
Agriculture, Forestry and Fishing	8,443	863	16	19,841	1,796	406		6,216	1,915
Mining	11,806	1,122	69	35,165	4,345	9,836		8,983	5,696
Manufacturing	51,574	5,016	239	170,253	19,986	7,923		39,327	21,722
Electricity, Gas, Water and Waste Services	12,171	1,156	72	26,277	3,193	5,817		9,085	4,017
Construction	46,986	4,809	84	87,989	6,975	4,218		34,174	7,755
Wholesale Trade	13,791	1,355	57	64,783	7,722	5,481		10,837	8,683
Retail Trade	27,863	2,723	122	179,029	22,029	9,737		22,784	24,063
Accommodation and Food Services	15,075	1,491	56	87,505	10,511	7,526		12,125	11,827
Transport, Postal and Warehousing	26,605	2,618	106	81,181	9,126	8,719		20,111	10,531
Information Media and Telecommunications	20,587	1,974	111	44,195	5,173	6,472		15,326	6,153
Financial and Insurance Services	40,031	3,978	138	67,150	6,155	16,287		29,200	8,352
Rental, Hiring and Real Estate Services	11,389	1,170	18	17,575	1,154	869		8,208	1,304
Professional, Scientific and Technical Services	73,108	7,319	222	127,493	11,315	17,499		53,313	13,860
Administrative and Support Services	22,273	2,153	111	69,056	8,188	6,897		16,930	9,338
Public Administration and Safety	78,307	7,625	358	106,332	10,394	25,437		56,967	13,855
Education and Training	186,852	17,881	1,029	172,304	17,408	9,082		135,062	19,182
Health Care and Social Assistance	53,153	5,210	224	185,632	21,507	11,526		40,637	23,736
Arts and Recreation Services	23,838	2,360	87	35,097	3,118	2,639		17,317	3,558
Other Services	23,303	2,364	54	45,644	3,942	1,501		17,025	4,277
Total Enterprise	**747,156**	**73,186**	**3,173**	**1,622,501**	**174,038**	**157,869**		**553,627**	**199,822**
Household	1,089,377	208,709					729,267	749,165	
TOTAL	**1,836,533**	**281,895**	**3,173**	**1,622,501**	**174,038**	**157,869**	**729,267**	**1,302,792**	**199,822**

Industry / Device Type	Printers & Imaging equipment	Landline telephone handsets	PABXs	Routers, switches, modems	Other networking equipment	Mobile Phones	Portable Music Players	Data Centre Environment	TOTAL
Agriculture, Forestry and Fishing	17,457	786	394	3,539	1,915	1,440		24,026	**89,050**
Mining	12,453	1,099	550	2,525	5,696	660		71,468	**171,472**
Manufacturing	76,968	4,800	2,404	15,605	21,722	3,940		272,557	**714,035**
Electricity, Gas, Water and Waste Services	10,155	1,133	567	2,059	4,017	484		50,402	**130,605**
Construction	93,171	4,373	2,190	18,891	7,755	3,916		97,305	**420,589**
Wholesale Trade	27,416	1,284	643	5,559	8,683	1,700		108,954	**266,947**
Retail Trade	64,841	2,593	1,299	13,147	24,063	4,788		301,933	**701,015**
Accommodation and Food Services	35,746	1,403	703	7,248	11,827	2,960		148,406	**354,410**
Transport, Postal and Warehousing	43,143	2,476	1,240	8,747	10,531	2,280		132,134	**359,549**
Information Media and Telecommunications	20,224	1,916	960	4,100	6,153	848		77,208	**211,400**
Financial and Insurance Services	57,852	3,726	1,866	11,730	8,352	1,580		104,795	**361,193**
Rental, Hiring and Real Estate Services	22,414	1,060	531	4,544	1,304	732		16,359	**88,631**
Professional, Scientific and Technical Services	115,747	6,804	3,408	23,468	13,860	3,304		173,905	**644,624**
Administrative and Support Services	29,863	2,073	1,038	6,055	9,338	1,480		117,163	**301,955**
Public Administration and Safety	80,972	7,288	3,651	16,417	13,855	2,684		173,850	**597,993**
Education and Training	122,560	3,478	1,742	24,849	19,182	3,348		240,693	**974,654**
Health Care and Social Assistance	88,336	4,947	2,478	17,910	23,736	4,716		297,828	**781,576**
Arts and Recreation Services	31,782	2,219	1,111	6,444	3,558	780		44,639	**178,547**
Other Services	43,151	2,169	1,086	8,749	4,277	1,748		53,665	**212,952**
Total Enterprise	**994,250**	**55,624**	**27,863**	**201,585**	**199,822**	**43,388**		**2,507,290**	**7,561,196**
Household	1,109,185	146,166		523,739		43,412	40,718		**4,639,737**
TOTAL	**2,103,435**	**201,790**	**27,863**	**725,325**	**199,822**	**86,800**	**40,718**	**2,507,290**	**12,200,932**
					Plus Telecommunications Network Infrastructure				**1,047,109**
								TOTAL	**13,248,041**

ICT Carbon Footprint in Australia, 2009
by Industry and Device Type (tonnes of CO_2e)

Industry / Device Type	Desktop PCs	Laptop & Notebook PCs	Terminals & Thin Clients	Volume Servers	Midrange Servers	High-end Servers	Games Consoles	Video monitors	Storage devices
Agriculture, Forestry and Fishing	9,102	930	17	21,154	1,905	430		6,697	2,032
Mining	12,728	1,210	75	35,015	4,306	9,429		9,632	5,607
Manufacturing	55,600	5,408	258	186,568	21,941	8,643		42,452	23,840
Electricity, Gas, Water and Waste Services	13,122	1,246	78	27,804	3,374	5,647		9,785	4,184
Construction	50,654	5,184	91	94,224	7,436	4,476		36,830	8,266
Wholesale Trade	14,868	1,460	61	70,875	8,460	5,954		11,702	9,507
Retail Trade	30,039	2,935	131	193,738	23,844	10,832		24,576	26,081
Accommodation and Food Services	16,252	1,608	60	94,340	11,332	8,042		13,072	12,743
Transport, Postal and Warehousing	28,683	2,823	114	87,629	9,853	9,469		21,683	11,376
Information Media and Telecommunications	22,194	2,128	120	48,676	5,712	7,077		16,541	6,785
Financial and Insurance Services	43,156	4,289	149	73,960	6,841	17,955		31,508	9,264
Rental, Hiring and Real Estate Services	12,278	1,262	19	18,834	1,230	926		8,847	1,389
Professional, Scientific and Technical Services	78,815	7,890	240	138,926	12,392	19,035		57,501	15,163
Administrative and Support Services	24,012	2,321	119	74,921	8,889	7,453		18,260	10,133
Public Administration and Safety	84,421	8,220	386	112,391	10,913	27,016		61,374	14,584
Education and Training	201,439	19,277	1,109	185,862	18,781	9,722		145,607	20,686
Health Care and Social Assistance	57,302	5,617	241	200,371	23,219	12,372		43,814	25,616
Arts and Recreation Services	25,699	2,544	94	38,214	3,411	2,821		18,676	3,884
Other Services	25,122	2,548	58	49,249	4,255	1,608		18,355	4,615
Total Enterprise	**805,485**	**78,900**	**3,421**	**1,752,750**	**188,093**	**168,908**		**596,912**	**215,754**
Household	1,166,365	222,654	0				781,175	802,110	
TOTAL	**1,971,850**	**301,554**	**3,421**	**1,752,750**	**188,093**	**168,908**	**781,175**	**1,399,022**	**215,754**

Industry / Device Type	Printers & Imaging equipment	Landline telephone handsets	PABXs	Routers, switches, modems	Other networking equipment	Mobile Phones	Portable Music Players	Data Centre Environment	TOTAL
Agriculture, Forestry and Fishing	18,762	847	424	3,804	2,032	1,528		25,491	**95,154**
Mining	12,721	1,185	593	2,579	5,607	654		70,351	**171,691**
Manufacturing	83,711	5,175	2,592	16,972	23,840	4,325		299,135	**780,459**
Electricity, Gas, Water and Waste Services	10,820	1,221	612	2,194	4,184	511		52,504	**137,286**
Construction	100,291	4,714	2,361	20,334	8,266	4,175		103,716	**451,020**
Wholesale Trade	29,808	1,384	693	6,044	9,507	1,862		119,289	**291,472**
Retail Trade	70,081	2,796	1,400	14,209	26,081	5,183		327,255	**759,181**
Accommodation and Food Services	38,538	1,513	758	7,814	12,743	3,191		159,890	**381,894**
Transport, Postal and Warehousing	46,538	2,669	1,337	9,436	11,376	2,462		142,742	**388,189**
Information Media and Telecommunications	22,053	2,066	1,035	4,471	6,785	936		85,139	**231,717**
Financial and Insurance Services	62,749	4,016	2,012	12,722	9,264	1,756		116,243	**395,886**
Rental, Hiring and Real Estate Services	24,136	1,143	572	4,894	1,389	780		17,428	**95,125**
Professional, Scientific and Technical Services	125,143	7,335	3,674	25,373	15,163	3,618		190,258	**700,526**
Administrative and Support Services	32,309	2,235	1,119	6,551	10,133	1,607		127,142	**327,204**
Public Administration and Safety	86,751	7,857	3,936	17,589	14,584	2,818		182,994	**635,834**
Education and Training	132,156	3,749	1,878	26,795	20,686	3,612		259,561	**1,050,922**
Health Care and Social Assistance	95,293	5,333	2,671	19,321	25,616	5,091		321,419	**843,297**
Arts and Recreation Services	34,355	2,392	1,198	6,965	3,884	853		48,729	**193,718**
Other Services	46,530	2,338	1,171	9,434	4,615	1,887		57,910	**229,695**
Total Enterprise	**1,072,744**	**59,967**	**30,038**	**217,500**	**215,754**	**46,850**		**2,707,195**	**8,160,270**
Household	1,186,100	157,368		565,327		46,726	43,919		**4,971,743**
TOTAL	**2,258,844**	**217,334**	**30,038**	**782,827**	**215,754**	**93,576**	**43,919**	**2,707,195**	**13,132,013**
					Plus Telecommunications Network Infrastructure				**1,232,819**
								TOTAL	**14,364,832**

ICT Carbon Footprint in Australia, 2009
by Industry and Device Type (% of Total ICT Carbon Footprint)

Industry / Device Type	Desktop PCs	Laptop & Notebook PCs	Terminals & Thin Clients	Volume Servers	Midrange Servers	High-end Servers	Games Consoles	Video monitors	Storage devices
Agriculture, Forestry and Fishing	0.06	0.01	0.00	0.15	0.01	0.00		0.05	0.01
Mining	0.09	0.01	0.00	0.24	0.03	0.07		0.07	0.04
Manufacturing	0.39	0.04	0.00	1.30	0.15	0.06		0.30	0.17
Electricity, Gas, Water and Waste Services	0.09	0.01	0.00	0.19	0.02	0.04		0.07	0.03
Construction	0.35	0.04	0.00	0.66	0.05	0.03		0.26	0.06
Wholesale Trade	0.10	0.01	0.00	0.49	0.06	0.04		0.08	0.07
Retail Trade	0.21	0.02	0.00	1.35	0.17	0.08		0.17	0.18
Accommodation and Food Services	0.11	0.01	0.00	0.66	0.08	0.06		0.09	0.09
Transport, Postal and Warehousing	0.20	0.02	0.00	0.61	0.07	0.07		0.15	0.08
Information Media and Telecommunications	0.15	0.01	0.00	0.34	0.04	0.05		0.12	0.05
Financial and Insurance Services	0.30	0.03	0.00	0.51	0.05	0.12		0.22	0.06
Rental, Hiring and Real Estate Services	0.09	0.01	0.00	0.13	0.01	0.01		0.06	0.01
Professional, Scientific and Technical Services	0.55	0.05	0.00	0.97	0.09	0.13		0.40	0.11
Administrative and Support Services	0.17	0.02	0.00	0.52	0.06	0.05		0.13	0.07
Public Administration and Safety	0.59	0.06	0.00	0.78	0.08	0.19		0.43	0.10
Education and Training	1.40	0.13	0.01	1.29	0.13	0.07		1.01	0.14
Health Care and Social Assistance	0.40	0.04	0.00	1.39	0.16	0.09		0.31	0.18
Arts and Recreation Services	0.18	0.02	0.00	0.27	0.02	0.02		0.13	0.03
Other Services	0.17	0.02	0.00	0.34	0.03	0.01		0.13	0.03
Total Enterprise	**5.61**	**0.55**	**0.02**	**12.20**	**1.31**	**1.18**		**4.16**	**1.50**
Household	8.12	1.55					5.44	5.58	
TOTAL	**13.73**	**2.10**	**0.02**	**12.20**	**1.31**	**1.18**	**5.44**	**9.74**	**1.50**

Industry / Device Type	Printers & Imaging equipment	Landline telephone handsets	PABXs	Routers, switches, modems	Other networking equipment	Mobile Phones	Portable Music Players	Data Centre Environment	TOTAL
Agriculture, Forestry and Fishing	0.13	0.01	0.00	0.03	0.01	0.01		0.18	**0.66**
Mining	0.09	0.01	0.00	0.02	0.04	0.00		0.49	**1.20**
Manufacturing	0.58	0.04	0.02	0.12	0.17	0.03		2.08	**5.43**
Electricity, Gas, Water and Waste Services	0.08	0.01	0.00	0.02	0.03	0.00		0.37	**0.96**
Construction	0.70	0.03	0.02	0.14	0.06	0.03		0.72	**3.14**
Wholesale Trade	0.21	0.01	0.00	0.04	0.07	0.01		0.83	**2.03**
Retail Trade	0.49	0.02	0.01	0.10	0.18	0.04		2.28	**5.28**
Accommodation and Food Services	0.27	0.01	0.01	0.05	0.09	0.02		1.11	**2.66**
Transport, Postal and Warehousing	0.32	0.02	0.01	0.07	0.08	0.02		0.99	**2.70**
Information Media and Telecommunications	0.15	0.01	0.01	0.03	0.05	0.01		0.59	**1.61**
Financial and Insurance Services	0.44	0.03	0.01	0.09	0.06	0.01		0.81	**2.76**
Rental, Hiring and Real Estate Services	0.17	0.01	0.00	0.03	0.01	0.01		0.12	**0.66**
Professional, Scientific and Technical Services	0.87	0.05	0.03	0.18	0.11	0.03		1.32	**4.88**
Administrative and Support Services	0.22	0.02	0.01	0.05	0.07	0.01		0.89	**2.28**
Public Administration and Safety	0.60	0.05	0.03	0.12	0.10	0.02		1.27	**4.43**
Education and Training	0.92	0.03	0.01	0.19	0.14	0.03		1.81	**7.32**
Health Care and Social Assistance	0.66	0.04	0.02	0.13	0.18	0.04		2.24	**5.87**
Arts and Recreation Services	0.24	0.02	0.01	0.05	0.03	0.01		0.34	**1.35**
Other Services	0.32	0.02	0.01	0.07	0.03	0.01		0.40	**1.60**
Total Enterprise	**7.47**	**0.42**	**0.21**	**1.51**	**1.50**	**0.33**		**18.85**	**56.81**
Household	8.26	1.10		3.94		0.33	0.31		**34.61**
TOTAL	**15.72**	**1.51**	**0.21**	**5.45**	**1.50**	**0.65**	**0.31**	**18.85**	**91.42**
					Plus Telecommunications Network Infrastructure				**8.58**
								TOTAL	**100.00**

6. ICT as a Low-Carbon Enabler

ICT's carbon emissions come mainly through the usage of electricity to run ICT hardware. Most of this electricity comes from carbon-emitting power stations.

This study finds that ICT is responsible for 2.7% of Australia's carbon emissions. The worldwide proportion is likely to be similar. That means that even if the carbon footprint of the entire world's ICT function was halved, overall emissions would fall by only 1.4%. The real potential benefits of Green ICT are in using ICT as an enabling technology to help the organisation, and the wider community, reduce its carbon emissions.

Market research company IDC has published an excellent report on the subject[35], which looks at the potential carbon emissions savings in a number of countries, including Australia, which can be enabled through ICT. IDC calculates that with the intelligent use of ICT-enabled systems Australia could reduce its carbon emissions by 116.6 million tonnes annually, nearly ten times more than ICT's own emissions, with the biggest area of savings being in more efficient power generation and transmission, and in improved transportation systems.

The Smart 2020 Report

An influential report called ***Smart 2020***[36] was published in Europe in 2008 by GeSI (Global e-Sustainability Initiative), a loose consortium of major vendors including Cisco, Dell, Deutsche Telekom, HP, Intel, Microsoft, Nokia and others. It is of course in these companies' interest that people should use ICT more, but the report still has great insights into how ICT can help organisations and individuals reduce their environmental degradation.

"Aside from emissions associated with deforestation, the largest contribution to man-made greenhouse gas emissions comes from power generation and fuel used for transportation," the report states. "It is therefore not surprising that the biggest role ICT could play is in helping to improve energy efficiency in power transmission and distribution, in buildings and factories that demand power and in the use of transportation to deliver goods."

The report estimates that ICT has the potential to reduce global emissions by 15% by 2020. "This represents a significant proportion of the reductions below 1990 levels that scientists and economists recommend to avoid dangerous climate change In economic terms, the ICT-enabled energy efficiency translates into approximately $US100 billion of cost savings. It is an opportunity that cannot be overlooked."

The report examines many ways that ICT can help us move towards a more sustainable world. These include smart buildings, reduced travel, a smaller ICT footprint, industrial automation, and many more. The report's title uses the contrived acronym SMART:

- "S" stands for standardisation – ICT's ability to bring disparate processes together.
- "M" stands for monitoring, particularly of energy consumption.
- "A" stands for accountability, which is not possible without information and by extension information systems.
- "R" stands for rethinking – the inevitable paradigm shift.
- "T" stands for transformation, which is self-evident.

The report identifies four key IT-enabled technologies that will have a substantial impact in reducing the overall carbon footprint:

- **Smart Motor System**s: Applied globally, optimised motors and industrial automation would reduce 0.97 $GtCO_2e$ in 2020, worth $US105 billion.
- **Smart Logistics**: The global emissions savings from smart logistics in 2020 would reach 1.52 $GtCO_2e$, with energy savings worth $US440 billion.
- **Smart Buildings**: Globally, smart buildings technologies would enable 1.68 $GtCO_2e$ of emissions savings, worth $US340 billion.
- **Smart Grids**: Smart grid technologies were the largest opportunity found in the study and could globally reduce2.03 $GtCO_2e$, worth $US125 billion.

Smart Grids

Smart Grid technology has special relevance to Australia, with an extensive transmission network and very high energy consumption. An organisation called Smart Grid Australia[37] has been formed

to formulate a strategy for transforming Australia's electric power grid with advanced communications, automated controls, and other forms of ICT.

An Australian Smart Grid would incorporate such things as:

- Intelligent communications networks
- Digital sensors and controls for remote monitoring and operation
- Tools for grid planning, design and operation to simulate, plan and automate complex transmission and distribution operations
- Better ways to connect next-generation equipment such as advanced storage, improved transformers, and superconducting wires
- Advanced meters to collect usage data electronically and automatically
- Load management/demand response technologies that help reduce peaks in electric demand and thereby reduce the need for standby power plants
- Smart devices ranging from motors to HVAC (heating, ventilating, and air conditioning) systems to home appliances with embedded intelligence which will empower end users to actively participate in this process.

Source: www.smartgridaustralia.com.au

Teleworking

The term "teleworking" covers a range of technologies and practices that have to do with working at a distance or working remotely. The carbon reduction benefits of teleworking are mostly related to removing the necessity of personal travel – if people don't have to drive a car or catch a train or plane to do their work, they are reducing their carbon footprint by the amount of fuel generated by that travel. Varieties of teleworking include telecommuting, teleconferencing and videoconferencing, and telepresence (a form of high-resolution videoconferencing).

Telecommuting

Telecommuting usually refers to working from home. If you work at home even part of the time, you don't have to waste time and energy travelling to an office. Nowadays telecommuting is part of the fabric of business life, and working at home is a normal part of many people's lives. As technology has improved, organisations and their employees have adapted to teleworking, with

many tasks formerly undertaken in an office now undertaken from people's homes. This is true of managerial jobs, but it is also true of entry level jobs like data entry and call centre work.

There are many staff management issues around telecommuting, and there are also environmental issues such as a possible lack of economies of scale in heating and cooling. Telecommuting is not necessarily green, but it is very often so.

Teleconferencing and Videoconferencing

Many organisations are now making increased use of teleconferencing (using phones or VoIP) and videoconferencing (also using cameras) to interact with remote staff and business partners. The technology is becoming more widespread as the technology improves and the costs of travel become more significant. An important technology contributing to the rise of teleconferencing and videoconferencing, has been the increasing sophistication of workplace collaboration software, which has made it easier to share and collaboratively update electronic documents.

Teleprescence

Telepresence is a new technology that is essentially vastly improved videoconferencing, using high resolution cameras and screens, life-size imaging and high fidelity sound to recreate the sensation of a conference room table. The technology is still new and expensive, but its price is dropping quickly.

Collaboration

Collaboration tools and techniques enhance the capability of a group of people to work together. There are a great many ways to do this, but all of them entail being able to share documents, processes and information, making their business processes more efficient (see below) and reducing the need for physical contact. In that sense, collaboration is a teleworking, with all the benefits of that process.

Business Process Management and Business Applications

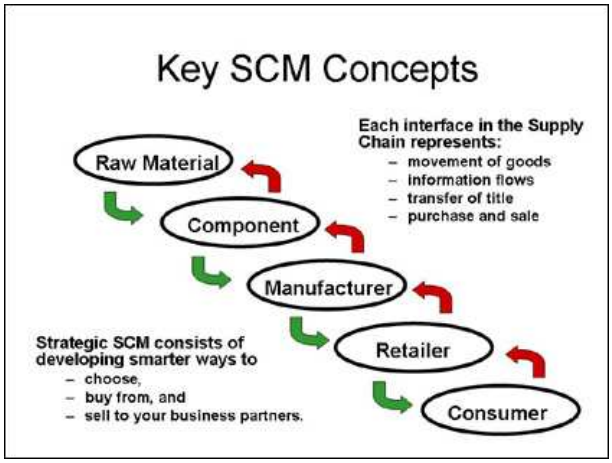
Business Process Management (BPM) is the process of improving the ways an organisation or an individual does things – making them more efficient, with fewer steps or greater effect. The term is used in both a specific and a general sense. The specific sense refers to a management discipline called BPM, which typically identifies five phases: Design, Modelling, Execution, Monitoring and Optimisation. In the general sense, BPM refers to the overall process of managing and improving business processes.

ICT has a major role to play in improving most business processes. It provides both the tools for modelling the processes and many of the enabling technologies for execution. This can be done both with business processes in the broadest sense, and through and with the use of specific business applications. Most organisations run a number of ICT-based business applications. The range varies greatly depending on the industry sector, but typical applications include Financial Management Information Systems (FMIS), Enterprise Resource Planning (ERP), Supply Chain Management (SCM – see below) and Customer Relationship Management (CRM). Many organisations also run more specialised or even custom applications specific to their industry, or to provide them with competitive advantage.

Each of these are essentially specialised business process management exercises. Managers seek greater efficiencies in every phase of every process. ICT has a very important role in improving the efficiency of many industrial and commercial processes specific to individual industries, such as the manufacturing process, electricity distribution, and engineering and construction. Every industry has unique processes which can be made more efficient through the application of ICT – and efficiency means less energy consumption and lower carbon emissions.

Supply Chain Management (SCM)

Supply chain management is essentially a business process management exercise. The fewer times and the shorter distance physical items have to be moved, the better. The fewer transactions that need to be made the better, and the longer the supply chain, the greater the savings to be made with any efficiencies. Very small improvements can have a significant effect, because of the scale of the operation and because of flow-on effects further up (or down) the supply chain.



Source: MIT

Effective SCM relies on tracking the movement of material and products throughout the chain. In the modern world, this can only happen efficiently with the use of ICT systems. In large supply chains, such as those employed by major manufacturers and retailers, this involves the use of sophisticated ICT-based SCM software.

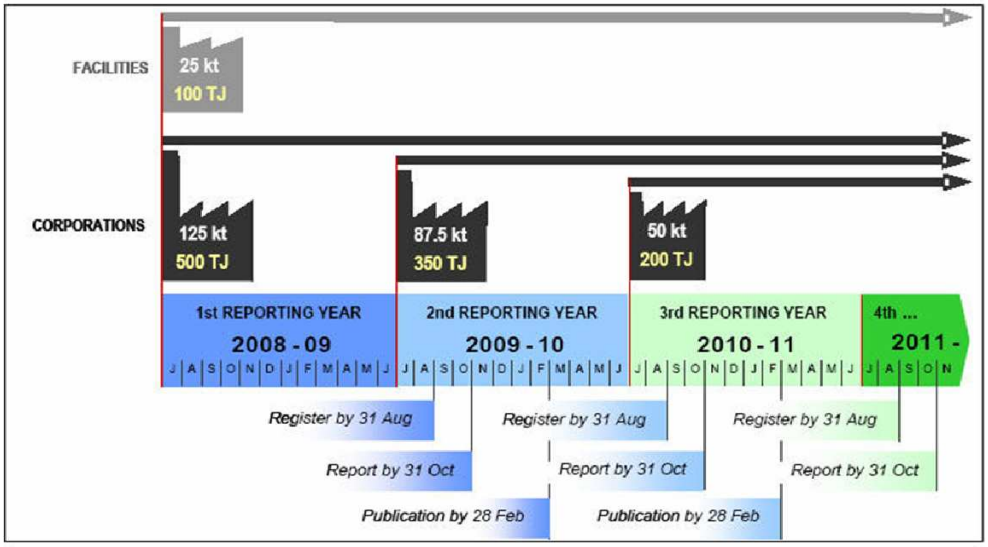
All organisations' supply chains are linked. One company's "upstream" is another's "downstream". And even organisations whose activities do not involve the movement of large quantities or physical material still have supply chains – of information.

Consultancy Ovum says that SCM is crucial to sustainability because of the need for accurate cradle-to-grave environmental information for products of all types. "But the challenge is complex because meaningful results require common standards and methodologies, as well as coordination across industry, geographic and regulatory boundaries"[38].

ICT and Carbon Emissions Management

Carbon emissions management is an emerging discipline which focuses on the management – and ultimately the mitigation – of an organisation's carbon emissions. This includes the use of ICT systems specifically designed to reduce the carbon footprint, rather than doing so as a byproduct of greater efficiency. A key ICT application is Carbon Emissions Management Software (CEMS), which provide a compliant and consistent format for presenting greenhouse gas emission data to executive management and regulators[39].

NGERS Reporting Schedule



Source: Australian Government

As the carbon emissions regulatory framework continues to evolve, CEMS is becoming an increasingly popular tool to manage the carbon emissions lifecycle. The market will continue to mature and will most likely consolidate around major technology vendors and a smaller group of vertical industry or niche players, and CEMS products will become a functional component within many organisations' application portfolio.

All major Australian organisations are now required by law to report on their carbon emissions. The National Greenhouse Emissions Reporting System (NGERS) became law in 2007, and all organisations with emissions exceeding the equivalent of 125 kilotonnes of carbon per year must have registered by 31 August 2009 and reported by 31 October 2009. Reporting requirements will become more stringent over time, with all organisations exceeding 50 kilotonnes annually needing to report by 31 October 2011.

NGERS reporting is applied to the entire organisations operations, not just IT. Emissions and energy reports will be required to be lodged on OSCAR (the Online System for Comprehensive Activity Reporting).

NGERS uses the definitions developed by the GHG (Greenhouse Gas) protocol. The key distinction under this protocol is between Scope 1, Scope 2, and Scope 3 emissions.

- **Scope 1** emissions are those caused by direct emissions of carbon dioxide and other greenhouse gases into the atmosphere, e.g. vehicle exhausts, manufacturing emissions, etc.

- **Scope 2** emissions are those caused indirectly through the usage of energy which causes GHG emissions in its generation. By far the most common Scope 2 emission is the usage of electricity from the power grid.

- **Scope 3** emissions are those caused by the organisation's supply chain, i.e. the embedded carbon used in the manufacture of products it buys or services it uses.

NGERS requires reporting only on scope 1 and 2 emissions. Virtually all emissions from ICT usage are scope 2 – and that is all that is measured by this report. NGERS reporting requires that information is presented in a consistent and universal format – hence the growth of CEMS.

Suggestions for Further Research

There is substantial scope for further research in this area. For a start, this study is confined only to Australia – much work could be done in developing equivalent studies for other countries, using a similar methodology. It is also possible to extend the study to a global scale, though this would take considerable resources.

More needs to be more done in computing the carbon footprint of the manufacture of ICT equipment. There has been some work in this area, which suggest that as much energy is consumed in the production of the typical piece of ICT equipment as it consumes in its entire lifecycle. The carbon emissions caused by the disposal of this equipment at the end of its lifecycle are also significant, but little has been done to analyse these lifecycle issues properly.

There is much work being done, in many countries, to develop better metrics for ICT energy consumption. The data centre is attracting considerable attention, because of the vast amounts of power it can consume. But there is no international agreement as to what those metrics should be – they all fall down on the vexing issue of measuring the efficiency of ICT processing, and how that relates to energy usage. This will be an increasingly important area in the next few years.

But the biggest area of potential research is in properly measuring the effect ICT can have as an enabling technology, as outlined in the previous chapter. The main game is ICT's ability to improve the efficiency of areas as diverse as electricity transmission, supply chain management, building information systems, and business processes generally. ICT may be a small contributor to the carbon emissions problem, but it is a major contributor to the solution.

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