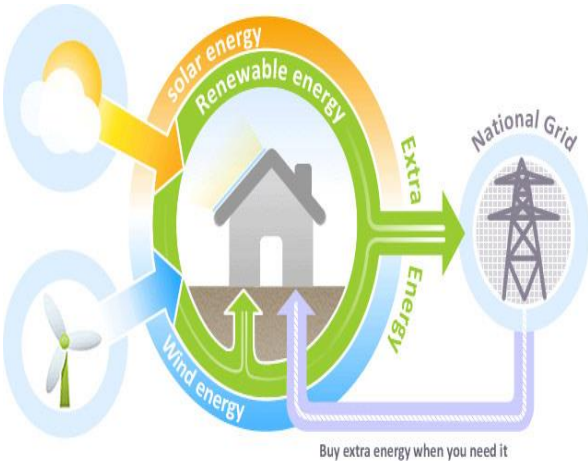
Doubling Energy & Resource Productivity by 2030 -

Improving Business Competiveness and Profitability + Transitioning to a Low Carbon Future

Report 3 of 3



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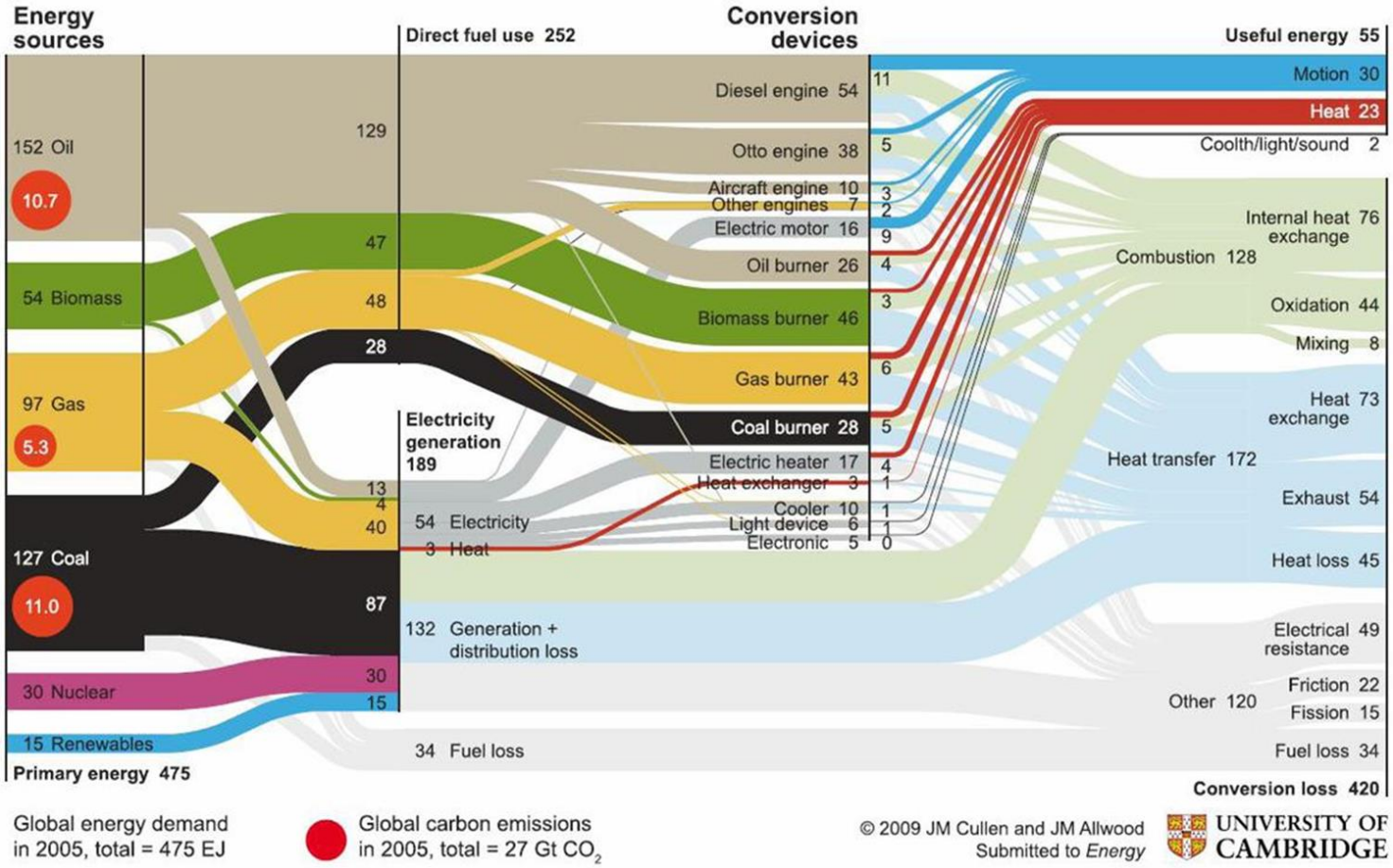

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Doubling Energy and Resource Productivity by 2030

Improving Business Competiveness and Profitability + Transitioning to a Low Carbon Future

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Executive Summary with 10 Policy Recommendations

Business and union leaders, government leaders and citizens all agree that it is important to focus on improving productivity because increases in productivity boost business profits and competitiveness whilst enabling wage increases. Increased productivity means that output levels are increased with the same or less inputs or the same output is produced with fewer inputs. The existence of higher profits can enable businesses to further improve productivity by:

- Investing more in strategies to improve market share;
- Investing some of the profits to further improve internal labour, capital, energy and resource productivity;
- Provide higher compensation to their employees in the form of higher wages and/or fringe benefits in return for further labour productivity improvements. This helps to attract the best and brightest and retain the best staff.
- Attracting greater investment capital to expand and improve capital productivity.

It creates a virtuous cycle whereby companies can improve their competitive advantage compared to their competitors

On the other hand, a decline in productivity risks causing a vicious cycle of loss of market share, cost cutting, job losses, lack of access to capital and inability to recruit the best and brightest. Historically, strategies to improve firm level productivity have focused on innovations that improve both labour and capital productivity to improve overall business productivity. This is because, over the 20th century, the cost of energy and resource inputs fell whilst labour costs grew significantly. So, historically, the need to improve energy and resource productivity was given much less attention compared to the need to improve labour productivity.

1. Energy and Resource Productivity Improves Profitability and Competitiveness

A focus on energy and resource productivity can improve business profitability and competitiveness in the following ways;

- **Reducing operational costs** - Energy, water and resource efficiency and waste reduction, which reduces input costs and exposure to rising energy and resource input prices.[1] Studies show that improving energy and resource efficiency reduces intermediate input costs (ie energy, water and resource input costs) to business, which go straight to the bottom line, increasing profits higher than business as usual.[2]
- **Strategically positioning for rapidly emerging markets and improving product differentiation** - Energy and resource efficient-product design can boost revenue by strategically positioning companies for growing clean tech markets now worth in excess of US$7 Trillion globally.
- **Improving firm level productivity - Investing in energy, water and resource efficiency improvement can also achieve additional financial co-benefits from improved capital, labour productivity and reduced maintenance costs**. For instance, the value of non-energy co-benefits of energy efficiency investment are in the range of 40-50% to as much as 2.5 times the direct value of energy savings.[3] For instance,
    - Improving the energy-efficiency of new resource developments can improve capital productivity. For large scale resource developments, if profit margins on a long-term asset are 5% and energy is 20% of operational costs, a 25% improvement in energy efficiency will double the profit of the life of that capital asset and project.

- Investing in energy and resource efficient "green buildings" has been shown to increase labour productivity and reduce absenteeism of staff.[4] It is now imperative in Australia to have buildings that are 4.5 star or higher to attract and keep premium tenants like government departments.
- Newer, more energy and water efficient equipment can simultaneously boost labour productivity**.** This is because more eco-efficient equipment often either enables the same task to be done faster or to be done with fewer people to operate and maintain the equipment.

- **Improving management and contributing to a more innovative culture** - Also, it is important to note that implementing company-wide energy and resource efficiency programs and management systems can also improve management and staff communication and team work which help foster an innovative culture to identify and achieve further productivity gains.
- **Helping to attract and retain the best staff**. Numerous studies show that high performing innovative companies which can attract and retain the best staff and best graduates, tend, on average, to outperform market averages.

2. Energy and Resource Productivity – Profits Up, Carbon Down

International Energy Agency and Global McKinsey Institute studies also show a focus on energy and resource efficiency can contribute over half of the required greenhouse-gas-emission mitigation by 2030 with excellent short term returns on investment contributing to increased business profits. Studies show that business's which pro-actively invest in profitable climate change mitigation and adaptation strategies have improved valuation by investors and improve their bottom lines. For instance, studies show that

- Companies taking smart action on climate deliver double the financial returns of their rivals.[5]
- 79% of companies responding to the Carbon Disclosure report reported higher return on investment for emissions reduction investments than on the average business investment.[6]
- 53 Fortune 100 companies reporting on climate and energy targets have collectively saved US$1.1 billion. Studies show that the US corporate sector could reduce emissions by 3% each year to 2020 and deliver and additional $780 billion in savings by 2020.[7]

3. Rising Energy Costs - Make Improving Energy Productivity Critical

Consider the example of Australia. In Australia, domestic factors have also contributed to significant rises in electricity and gas prices, which have more than doubled over the last decade and are forecast to keep rising. Australian business spends over $100 Billion per annum on energy, water and resource input costs (energy - ~AUD$110 Billion per annum, resource inputs - ~AUD$24 billion, water input costs - AUD$2.7 billion). **So, to improve productivity it is essential now that businesses also improve energy efficiency to reduce exposure to these input price rises.**

4. Energy and Resource Productivity – Key to Boosting Global Economic Growth

Also, as Report #1 showed, a focus on energy and resource productivity is critical to helping the global economy to economically grow out of the global financial crisis in a lasting way to create greater investor and business confidence. For instance, the IEA's 2012 World Energy Outlook found that investment in energy efficiency could boost global output by around US$18 trillion to 2035, whilst avoiding the need for $7 Trillion in energy supply infrastructure, and also saving ~$17 trillion in avoided fuel costs.[8] But, as the Australian Commonwealth Government has acknowledged, *"Unfortunately, many businesses simply do not have the time or resources to adequately respond to green growth opportunities. Green growth potential often remains unrecognised or unexplored, due to a lack of information, inadequate skills, or a perception that it is peripheral to the bottom line."*

There is a lot of evidence that businesses are not realising these opportunities as shown by the following facts;

- Most small to medium businesses have not improved energy efficiency performance significantly.
- Research by ANU shows that best performing manufacturing companies are at least 50% more water efficient than the laggards.
- Research shows that many businesses are still not systematically and pro-actively managing their resource inputs and waste streams to improve resource productivity
- Many businesses do not understand what climate change adaptation means or involves for them despite extreme weather events harming business productivity, in countries around the world over the last decade.[9] This is why the 2013 World Economic Forum "*Global Risk Report*" identified failure to adapt to climate change as one of the top risks most likely to materialize within a decade for business.[10]

Clearly this needs to be addressed by elevating these issues by adopting the following recommendations.

5. Ten Policy Recommendations

Overarching Recommendation #1. Business adopt internally targets of doubling energy and resource productivity by 2030. Support national coalitions of peak business groups and governments to work together to achieve a doubling of energy and resource productivity nationally by 2030. Many countries are starting to do this. For instance, President Obama has formally adopted a commitment to double US energy productivity by 2030. The "US Energy Productivity Roadmap" study shows that a doubling of energy productivity by 2030 would boost US GDP growth by 2% above business as usual, achieving per annum savings of US$327 billion per year. Other G20 nations, are also committing to improving energy productivity due to these significant economic benefits. (Table 1) Also over 80 developing nations have signed up to the UN's "*Sustainable Energy for All*" Initiative which includes as one of its goals, "*Doubling the global rate of improvement in energy efficiency*"[11].

Table 1: Sample of National Energy Productivity-Related Targets

Nation	Target	Baseline	Target Year
China	15% energy intensity reduction	2010	2015
Germany	2.1% average annual energy productivity improvement	2008	2020
Indonesia	1% energy intensity reduction per year	2005	2025
Japan	30% energy efficiency improvement	2003	2030
South Korea	46% energy intensity reduction	2007	2030
EU	energy efficiency to save 20% of EU energy consumption	2012	2020

Recommendation #2. Increase adoption of climate change mitigation in business strategy and practice through encouraging investment in profitable climate change mitigation strategies. Improve information and access to finance for business sectors on profitable climate change mitigation opportunities.

Recommendation #3. Assist business cut energy costs by expanding minimum energy performance standards beyond the usual focus on domestic appliances to cover a wider range of industrial, mining, farming, and cooking and hospitality equipment. For instance, if we take Australia as an example, according to the Australian Commonwealth Government figures, if industrial equipment was included, it would save at least $1.5 Billion per annum in industry energy costs and result in annual greenhouse abatement of up to 2.8 mt co2-e.[12]

Recommendation #4. Reform of the national electricity market to enable business to contribute to, and earn revenue from, helping meet peak electricity demand. For instance, in Australia, the Australian Energy Market Commission has identified substantial demand management opportunities in the Australian electricity system; opportunities that could lead to savings of $4-$12billion over the next ten years.[13] Business could contribute to this and earn new sources of revenue as part of national electricity market reform by being rewarded for

- turning down industrial equipment/processes during peak periods, which some companies already do to avoid paying high electricity tariffs
- increasing onsite generation capacity through co-generation, renewables and energy efficiency so industry and manufacturing can sell back electricity to the grid during peak demand periods when electricity spot prices are the highest. Self-generated electricity and other off-grid electricity has increased in the business sector in Australia by 58% between 2008-09 and 2011-12.

Recommendation #5. Assist business cut energy and water costs through improving access to relevant information and improving staff skills in identifying and implementing energy and water efficiency opportunities. Also improve information on energy/water efficiency nexus efficiency opportunities for each business sector to help business identify and implement such opportunities.

Recommendation #6. Work with business to help reduce resource input and “waste to landfill” costs through improving knowledge, skills and economic incentives for materially efficient “material” or “product” design by increasing the use of recycled materials. Studies show a strong correlation between resource productivity and competitiveness.

Recommendation #7. Partner with business to improve OH&S and reduce toxic chemical emissions through investing in capacity building to support businesses (i) stocktake all toxic chemicals in use, and (ii) develop and implement “safer alternative chemical” plans for their business. In Massachusetts, where business is required to do this, they have seen reduced usage of toxic chemicals by 40%, reduced production of toxic chemical by-products by 70% and reduced toxic emissions by over 90% over the last two decades whilst boosting profits.

Recommendation #8. Reduce productivity losses from extreme weather events by mainstreaming climate change adaptation into business and investor considerations. This can be done through improving:

- GIS information of risks from sea level rises, flooding, and bushfires, to business from climate change across nations.
- Economic incentives and improved access to financing for investment in cost effective climate change adaptation strategies and,
- Information for business sectors on return of investment for climate change adaptation investments.

Recommendation #9. Improve sustainability assessment and reporting by requiring the largest 200-500 companies in a particular nation to annually review and publically report on one of the following, (i) energy efficiency or (ii) water efficiency or (iii) materials efficiency or (iv)safer chemical opportunities as is done in Massachusetts, USA.

Recommendation #10. Improve “National System of Innovations” to better enable, foster and encourage innovation to improve firm level and national productivity long term.

Doubling Energy and Resource Productivity by 2030 – Improving Business Productivity and Competitiveness

Business and union leaders, government leaders and citizens all agree that there is a need for a greater focus on improving productivity because increases in productivity boost profits, thus enabling wage increases. Historically, the focus has been on innovations that improve both labour productivity to improve overall business productivity. This is because, over much of the 20th century, the cost of energy and resource inputs fell whilst labour and capital costs grew significantly. (See Figure 1) So, historically, the need to improve energy and resource productivity was given much less attention compared to the need to improve labour and capital productivity.

1. The Holy Grail – Firm Level Energy and Resource Productivity Strategies That Can Simultaneously Enhance Business Labour, Capital and Multi-Factor Productivity

As argued in Report #1 and above in the Executive Summary here, there is a range of enabling technologies and strategies which enable business to simultaneously achieve improved levels of

- energy and resource productivity (which cuts operational energy and resource input costs)
- labour productivity, capital productivity and multi-factor productivity (which improves efficiency of production, value of capital assets, and levels of technical innovation)

This may sound too good to be true, so let's consider this in the context of a range of important business sectors.

1.1 Property, Commercial Buildings and Services Sectors

Investing in energy and resource efficient "green buildings" has been shown to increase labour productivity, capital productivity, and multi-factor productivity.[14]

Labour productivity: In the operation of green buildings, there can be up to 11 per cent gains in labour productivity from improved ventilation[15], and up to 23 per cent gains[16] in labour productivity from improved lighting design. Even small staff health and labour productivity gains can dramatically improve organisational profitability (Figure 3). This is because, in the services sectors, labour costs (staff salaries and expenditures) make up over 85% of total workplace costs, compared to less than 10% on rent and less than 1% on energy.

So, most of the cost benefit for business, from investing in energy and resource efficient green buildings, arises from the resulting improved labour productivity benefits from their staff.[17] For instance, at the City of Melbourne's CH2, Australia's first 6 Star Green Star - Office Design rated building, productivity has risen by an impressive 10.9% since staff moved in, with an estimated productivity benefit of $2 million per annum.[18]

This matters when trying to quantify the potential of energy productivity to help boost national productivity growth because commercial building based services sectors constitute over 60-80% of OECD country GDP. So, even just small improvements in labour productivity in these sectors, can significantly boost OECD economies' overall productivity like that of Australia and the USA.

Capital productivity: In a number of studies that compared certified green buildings to non-certified buildings in the same sub-market, price premiums were found to be up to 30% better. These studies find that green buildings improve capital productivity by enhancing asset value,[19] achieving higher asset values through securing premium tenants (i.e. government departments), higher rents[20], lower tenant turnover[21], lower lease-up costs, higher occupancy levels, and lower operating costs.[22]

Multi-factor productivity: Studies report that green buildings on average use 25-50% less energy and 30-70% less water, thus reducing operational intermediate energy and water input costs.

Other productivity benefits: Other studies have found that well designed energy efficient green buildings assist productivity by reducing

- Indoor air quality through energy efficiency measures, in a high energy efficiency scenario, could save the European Union's economy as much as USD 259 billion (EUR 190 billion) annually[23].
- Hospital stays by 8.5% as well as enabling faster recovery rates in rooms with windows views of nature[24].
- Patients'/ need for pain medication by 22% in rooms with natural daylighting and bright sunlight.[25]

and increasing

- sales per square foot in Walmart[26] a 15 - 20% increase in sales at Target[27] and a 73-store retail chain in California with a 40% increase in sales due to daylighting[28] and
- attendance by three days per year, a 5 - 14% improvement in test scores[29] and 20 - 26% faster learning rates in schools with optimal daylight.[30] (See Figure 1)

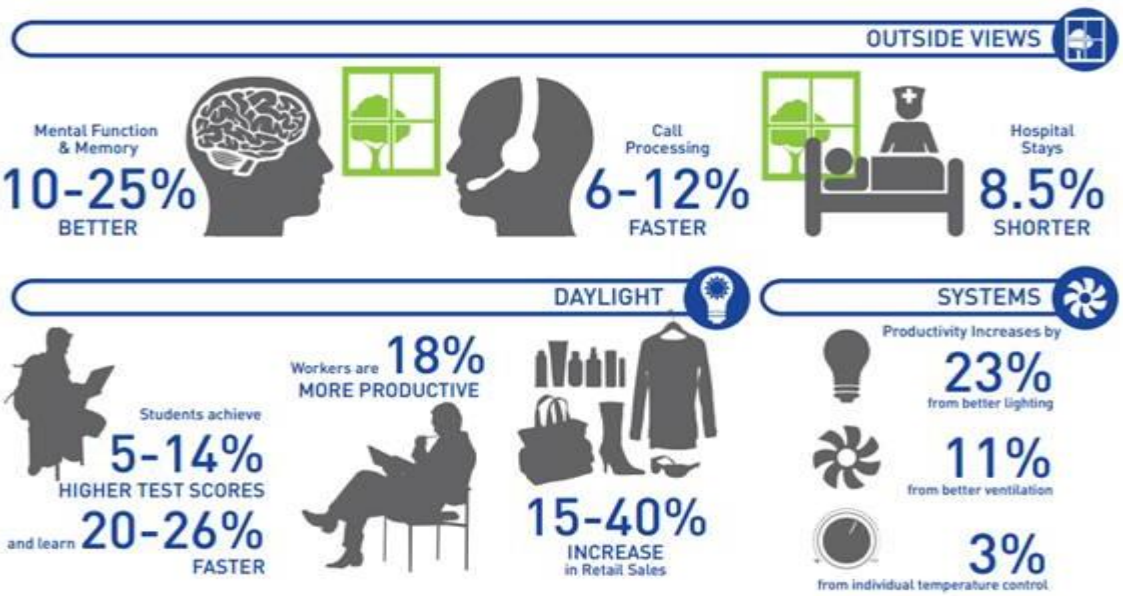


Figure 1 Net present value analysis of the operational cost, productivity and health benefits of energy and resource efficient "green" LEED certified buildings (Source: World Green Building Council, 2013[31])

BOX 1: The labour "productivity" benefits of investing in the energy and resource efficient green buildings has been demonstrated since the mid-1990s.

Greening the Building and the Bottom Line: Increasing Productivity Through Energy-Efficient Design by William Browning and Joseph Romm[32] demonstrated very attractive economic returns, not only through savings in electricity and other energy sources, but also far more significantly through sustained savings in employee-related costs, such as improved productivity, improved work quality and reduced absenteeism. The large savings in employee-related costs are due to these costs being about 6 times higher than gross office rent and about 70 times higher than energy costs (see Figure 8.3), so it only took a very small improvement in labour productivity or small reduction absenteeism or reductions

in product defects to accumulate a large financial saving.

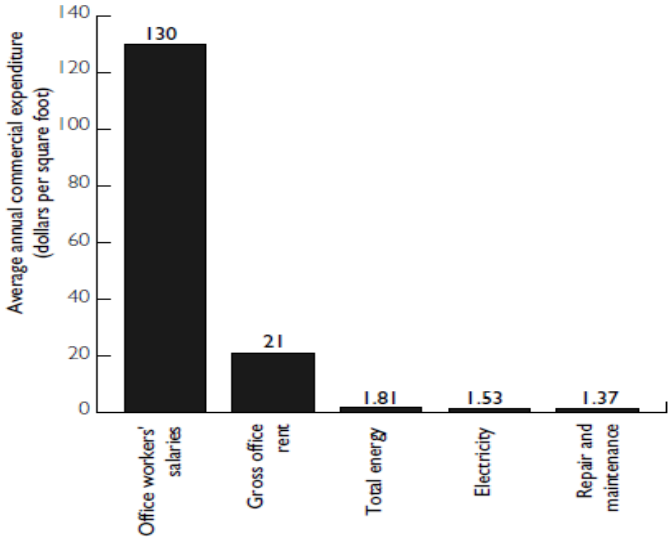


Figure 2 Comparison of average annual expenditure of various costs for commercial buildings.

Source: Building Owners and Managers Association (1991) and *Statistical Abstract of the United States* (1991) cited in Romm and Browning (1998)[1]

As far back as the mid- 1990s the paper concluded that these savings arise in buildings where the quality of employee workspaces are improved through improved visual acuity and thermal comfort, and that such improvements can be achieved concurrently with large energy savings. This paper featured numerous case studies showing this for retrofit and new buildings such as :

- Reno Post Office (retrofit): a lighting retrofit and new ceiling at a cost of $300,000 resulted in annual savings of $22,400 in energy costs and up to $500,000 through a 6 percent increase in processing rate.
- Boeing (retrofit): a lighting retrofit resulted in a 2 year payback through 90 percent savings in lighting electricity and even greater financial savings through a reduction in defects.
- Hyde Tools (retrofit): a lighting retrofit at a cost of $98,000 resulted in annual savings of $48,000 in energy costs and $25,000 through an increase in product quality.
- Pennsylvania Power & Light's (retrofit): a lighting retrofit at a cost of $8,362 resulted in annual savings of $2,035 in energy costs through 69 percent savings in lighting electricity, $42,240 through a 13 percent increase in product quality, at least $50,000 through a reduced error rate and a 25 percent reduction in absenteeism.
- Lockheed Building 157 (new): daylighting and energy efficiency measures at a cost of $2 million resulted in annual savings of $500,000 in energy costs, a one year payback of all addition costs through a 15 percent reduction in absenteeism and a 25 percent improvement in productivity.
- West Bend Mutual Insurance (new): energy efficient lighting, HVAC, controls and other measures resulted in annual savings of $126,000 in energy costs through a 40 percent reduction in total energy consumption, $364,000 through a 2.8 percent increase in productivity and a 16 percent increase in claims processed.
- Wal-Mart (new): daylighting and energy efficient HVAC resulted in an increase in sales compared to the non-daylit area.
- ING Bank (new): daylighting and energy efficient HVAC and building design at a cost of $700,000 resulted in annual savings of $2.6 million in energy costs through a 90 percent reduction in total energy consumption, a 15 percent

[1] Romm, J.J. and Browning, W.D. (1998).

reduction in absenteeism and a 16 and a positive new image.

In the services sectors there are also sub-sector specific opportunities to boost energy and labour productivity such as

- ***Service Sectors - Food retail – Restaurants/Bakeries*:** Better insulated and more energy efficient ovens, catering/cooking equipment in general, and induction stoves cook food faster improving labour productivity and improving service to customers. Reducing heat losses from ovens in bakeries also helps productivity by ensuring work areas are not extremely hot in summer.
- ***Service Sectors – Supermarkets and online delivery*.** Online orders and delivery of food to customers has been shown to cut life cycle analysis energy costs significantly with labour productivity and congestion reduction co-benefits. This is achieved through

  a) one van delivering food to multiple customers rather than multiple customers driving to and from supermarkets

  b) the food being able to be stored and refrigerated in a warehouse. Actual supermarkets are very energy intensive buildings because, to keep customers warm, supermarkets use energy to heat the isles next to refrigerated cabinets. This results in the heating of the store and refrigeration of food competing with each other resulting in significant inefficiencies. Ordering food online enables food to be delivered from warehouses instead, where the food is efficiently refrigerated in cool rooms, saving energy overall.
- ***Service Sectors - Dry Cleaning (Hotels, Aged Care, and Laundromats)*** - Even in dry cleaning, newer more energy efficient technologies boost labour productivity. For instance, advanced ozone technology washing machines boost labour productivity in dry cleaning because they wash clothes more effectively and faster than traditional systems. For instance, Oak Towers Aged Care Facility in Melbourne have invested in ozone washing machines and reduced energy usage by 490 GJ of gas per year, whilst lifting labour productivity by 12%. This investment paid itself back in 18 months. This technology allows hotels, aged care facilities, as well as dry cleaners to improve labour productivity.

1.2 Industry Sectors

Newer, more energy and resource efficient technologies and equipment can simultaneously boost labour, capital and multi-factor productivity. This is because more eco-efficient equipment or technologies often either enables the same task to be done faster or to be done with fewer people. This can boost labour productivity across many industries and service sectors. For instance, innovations to improve industrial/manufacturing processes to utilise recycled materials as source materials can reduce the size of the manufacturing plant and the number of steps required in a manufacturing process yielding labour, capital, energy and resource productivity co-benefits.

- ***Steel Manufacturing*:** For instance, electric arc steel making furnaces (EAF) have been replacing blast furnaces for steel making plants, after world war two because of

- **Improved Labour Productivity** – EAF plants that utilise recycled materials cut out a number of steps (raw material mining and extraction and processing) and have quicker processes because of the lower melt temperatures required to reprocess scrap steel into new products. EAF mini-mills have adopted *"New innovations in iron and steelmaking technology e.g. new productive and energy efficient technologies in scrap melting (DC-furnace, utilization of post combustion, off-gas and fossil energy), thin slab casting, direct reduction of iron ore as well as new smelting reduction techniques for ironmaking without sintering and cokemaking."*[33]
- **Improved Capital Productivity** - The low capital cost for an electric arc furnace mini-mill—around US$140–200 per ton of annual installed capacity, compared with US$1,000 per ton of annual installed capacity for an integrated steel mill.
- **Improved Multi-Factor Productivity:** EAF mini mills have far lower energy, water and resource input costs compared to blast furnace operations.
- **Improved Energy and Resource Productivity** – Electric arc furnaces use 30-50% less energy per tonne of steel partly because can use 100% recycled steel as inputs. Energy savings are also possible through the fact that
  - EAF mills have greater flexibility and can be shut down depending on supply and demand. By contrast, blast furnaces cannot vary their production by much.
  - EAF mills, being smaller, can be built closer to local markets reducing transport energy consumption to deliver product to market.

As a result, recent literature shows that EAF plants using scrap, from an economic and environmental perspective, are always cheaper and better than mining virgin ore and moving it through the process of making new steel[34].

- ***Metal Manufacturing*** - A similar trend can be seen in other industries which produce metal products. Many researchers in the past have shown that a similar trend applies to the shift to plants that focus on metals recycling and metal scrap utilisation[35-36]. As lower grades of ore increase energy input costs, this trend is likely to increase labour, capital, energy and resource productivity improvements relative to producing metals from extracting raw mineral ores.
- ***Material Manufacturing*:** A similar trend can be seen in other materials manufacturing sectors using recycled materials such as the trend of smaller paper recycling mills increasingly replacing large Kraft paper manufacturing plants. The smaller paper recycling mills have improved capital, energy and resource productivity for similar reasons to EAF steel plants[37]. Using recycled paper over the life cycle saves 30–50%[38] compared with virgin fiber production. A range of reports show that better insulated and more energy efficient furnaces[39], kilns[40], and ovens[41] tend to melt metals, glass and ceramics more quickly improving labour productivity and energy productivity.

- ***Paper Manufacturing: Office printers now allow you to recycle and reuse your own paper in your office up to 5 times*:** This has effectively moved paper recycling and manufacturing from the paper mill into the office achieving significant energy, resource, labour and capital productivity gains and efficiencies. (Pictured right). Over the lifecycle the energy savings are >60%.
- ***Cement Manufacturing*:** Cement manufacturing has not changed much in over 200 years since the invention of Portland cement. Australian cement company Zeobond Pty Ltd is the first company to commercialise a low carbon, low embodied energy cement material based on industrial waste streams through innovations in geopolymer cement technology. This new cement technology has 80% less embodied energy and greenhouse gas emissions. Produced at scale it is also cost competitive with Portland cement. It can be made in existing Portland cement plants, meaning there is no significant capital costs to change over to making low carbon cements. The Green Building industry globally is increasingly demanding low embodied energy building materials such as this.

1.3 Product Manufacturing

Designing manufacturing products to be energy and resource efficient in their operation is now widely recognised as being critical to remain competitive in the 21st century. This is because most of the energy and water use of manufactured products arises from their use by customers over the course of their operational life. (Table 2) Manufactured energy-efficient technology markets are growing from $200 billion (2010) to $312 billion(2015)[42] Focussing on improving the energy efficiency of manufactured products is, therefore, vital for remaining competitive and building customer loyalty. For instance:

- Siemens predicts a record $55 billion revenue projection from green technologies by 2014, after seeing a record $38 billion net return result from their global Environmental Portfolio in 2010. Siemens original target of $34 billion revenue for 2011 was reached significantly earlier than planned due to strong growth in demand for energy efficient technologies and products for manufacturing and mining.
- Philips are committed to generating 30% of total revenues from green products over the next five years (up from 15% in 2006), It doubled investment in energy efficient green innovations to €1 billion in 2012. It also hopes to further increase the energy efficiency of operations by 25% by 2012.

Table 2: Energy Use of Manufactured Products over the Life Cycle is dominated by the "Use Phase".

Type of Product – A Sample - Transportation Vehicle, Manufactured Products, Industrial Equipment or Buildings	% age of Total Life Cycle Energy Consumed During the "Use" Phase of the Life Cycle
Cars, SUVs, pickups, buses	65-74%[43]
US Family Sedan	85%[44]

Passenger transportation (private and public): 63-70%	63-70%[45]
Aircraft	69-79%[46]
Appliance – Clothes Dryer	97%
Lighting – All Forms	98%

1.4 Mining and Resources Sector

In the capital intensive mining and resources sector improving energy-efficiency of new resource developments can reduce their operational costs (Opex) enabling companies to pay off their capital investment costs (Capex) quicker thus boosting profits and thus the capital productivity of such investments. For instance, recent analysis of large scale resource developments in Australia have found that, if profit margins on a long-term asset are 5% and energy is 20% of operational costs, a 25% improvement in energy efficiency will double the profit of the life of that asset and project. Some of these more energy productive mining technologies also offer significant labour productivity savings such as

- **In underground mining,** significant energy efficiency savings, labour productivity and safety improvements can be achieved by investing in automated electric powered underground drilling, scooping and materials movement machines.[47] These electric powered underground equipment can now replace diesel powered underground mining machines and thereby eliminate diesel fumes reducing the amount of ventilation energy demand in underground mining by up to 90%.[48]
- **In open cut mining** – most mines have haul trucks to move ore out of the mine to be processed. In-pit crushers and conveyors (IPCC) can now often be used instead yielding significant energy, water and labour productivity gains. BHP Billiton informed UK investors of their decision to move towards truckless mines through investing in IPCC systems in 2012. BHP executive Marcus Randolph stated, *"'When you run a truck, it takes 10 to 11 employees for every truck. It takes 4½ to five to run it, all the crews that do the maintenance on it, all the camp people that do the camp cleaning and cooking and everything else. If you go truckless (and use input crushers and conveyors) you do not need any of these staff. You do this at a time when you see increasing diesel prices, carbon taxes, a number of reasons why getting rid of trucks or using fewer trucks is desirable." Mr Randolph said "the technology was already viable in mines with soft ground that did not require blasting but he said it could be adapted to also work in mines that did require blasting."*[49]

US mining giant Vale is also replacing trucks at some of its mines with in-pit crushers and conveyors. In its largest Brazilian iron ore mines, Vale SA (VALE5) is replacing trucks with 23 miles of conveyor belts and a new railway line to cut materials movement related energy costs by 77%.[50] As Vale states, "*This measure will cut fuel consumption by 77%. Compared with conventional methods, the truckless system and ore processing using natural moisture will together cut S11D's annual greenhouse gas emissions by 50%, or 130,000 metric tons of CO2 equivalent. In addition, the main equipment used at the project will be powered by*

electricity. Only crawler dozers, motor graders and other auxiliary equipment will run on diesel."[51]

Figure 3 Mobile crushing plant, mobile transfer conveyor & bench conveyor.

1.5 Farming and Agricultural Sectors

FAO (2011)[52] along with numerous recent reviews[53] have highlighted that it is both possible and highly advantageous to address future food needs by transitioning to systems of food production that are based on "ecological intensification"—using land, water, biodiversity and nutrients efficiently and in ways that are regenerative, minimizing negative environmental impacts."[54] This can boost productivity and profits by (i) increasing yields compared to BAU, ii) gaining premium organic prices, (iii) reducing input costs (ie artificial fertilisers and pesticides), (iv) reducing overall energy consumption (ie reducing high embodied energy fertiliser inputs) v) increasing resilience of landscapes, soils, grasslands to drought (vi) and improving capital productivity by increasing the asset value of the property. For instance, in Australia, holistic grazing practices which restore natural capital to grazing farms have been shown to increase carrying capacity and stock rates, reduce farming input costs, improve the health and value of farm assets and thereby increase farm productivity in grazing systems in the majority of the literature since 1996. Earl and Jones, 1996[55], McCosker, T. 2000[56]; McArthur 1998[57]; Gatenby 1999[58]; Joyce 2000[59]; Sparke 2000[60], Ampt & Doombos, 2011[61] Walsh, D. 2009[62], Teague et al, 2011[63], Sanjari et al, 2008.[64]

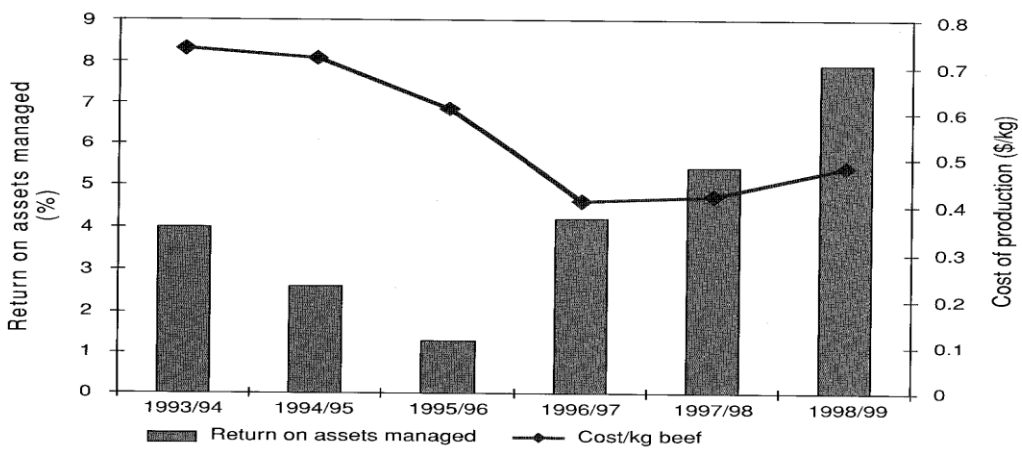
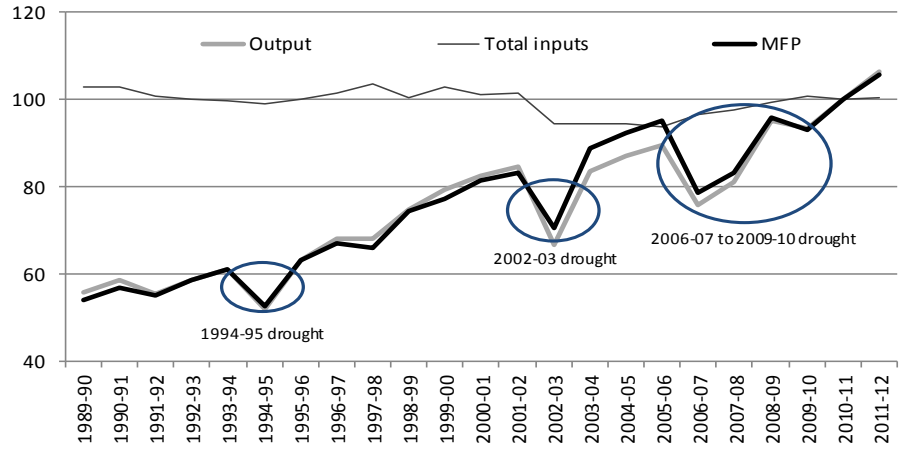


Figure 4: Trends in return on assets managed and cost of production from a case study group of grazing farms in central Queensland who have implemented time controlled holistic grazing. (McCosker, T. 2000[65].)

As the figure above shows, implementation of time controlled grazing in central Queensland, Australia led to almost a halving of farm input costs of production and a significant increase in return on assets managed[66]. The *Soils for Life* initiative in Australia also features actual grazing farms (http://www.soilsforlife.org.au/case-studies.html) evidencing that holistic grazing practices have also improved labour productivity too. The restoration of the natural capital of the farm also increases the value of the asset increasing capital productivity. It is also important to note the farming sector can also improve productivity by diversifying to gain additional revenue for land sector businesses (ie farms, forest projects), through for instance, carbon farming and selling energy to the grid from wind farms, in ways that do not compromise agricultural production, and help to insulate farmers from loss of revenue due to extreme drought. Drought significantly harms the productivity of Australian agriculture sector (Figure 5 below) hence these strategies to help insulated farmers from loss of revenue are important.

Figure 5 Inputs, output and Multifactor Productivity in Agriculture, Fisheries and Forestry Indexes (2009-10=100)



1.6 Forestry and Forest Products Sectors

There is great potential to re-invent the forestry and forest products sector by moving away from low value products (ie woodchips) to higher value products and new revenue streams through, for instance, expanding production and markets of high strength engineered timber, such as cross laminated timber,[67] products that can replace high embodied energy steel and cement in building construction. Using engineered timbers instead of steel has been shown to enable low carbon embodied buildings to be constructed faster increasing labour productivity and reducing construction costs. Engineered timbers can be made from plantation forestry stocks that are only 10-15 years old, thus increasing also the return on capital investment (ie improving capital productivity) with which the forestry sector can produce high value products. Lendlease Australia has built the first high rise apartment building in Melbourne in 2012 using engineered timbers reducing embodied energy and CO2 equivalent emissions by more than 1,400 tonnes when compared to concrete and steel[68].

Clearly then improving the energy and resource efficiency of operations and product design whilst also improving labour and capital productivity is critical now, in the 21st century, for companies to maintain and improve business competitiveness.[69] But, as the Commonwealth Government has acknowledged, *"Unfortunately, many businesses simply do not have the time or resources to*

adequately respond to green growth opportunities. Green growth potential often remains unrecognised or unexplored, due to a lack of information, inadequate skills, or a perception that it is peripheral to the bottom line."[70] Clearly this needs to be addressed by elevating these issues by adopting the following recommendations.

Overarching Recommendation #1. Include a focus on doubling energy and resource productivity by 2030 as part of nation's national productivity agenda. And encourage more companies to voluntarily adopt energy and resource productivity stretch goals by:

- **Recommendation #1.1.** Enabling more businesses to get access to financing to invest in cost effective energy and resource efficiency opportunities.
- **Recommendation #1.2.** Improve economic incentives for investment in energy and resource efficient measures.
- **Recommendation #1.3.** Fund research and development of technological roadmaps for major business sectors to map options to achieve a step change in energy and resource efficiency.

Support recommendations #1.1-#1.3 by addressing information and skills gaps through:

- **Recommendation #1.4.** Creating a high profile, easy to use, one stop shop national "Sustainable Business" web portal building on the successful Energy Efficiency web portals such as the Australian Exchange web portal example (www.eex.gov.au). This web portal would address eco-efficiency, product stewardship, chemicals management as well as climate change adaptation and mitigation opportunities for each major business sub-sector in the one place.
- **Recommendation #1.5.** Requiring greater levels of technical and environmental sustainability training for all current and future business leaders, accountants, and engineers in partnership with the formal education system, industry skills councils, the Institute of Company Directors as well as professional engineering and the peak accountancy bodies, and
- **Recommendation #1.6.** Funding peak industry groups to develop energy, water and resource efficiency guides and programs with their members based on best practice.

2. Improve Energy Productivity through Investing in Profitable Climate Change Mitigation Solutions.

The debate in some countries around climate change mitigation has revolved around how much it will "cost" industry". However, the International Energy Agency has shown that over 60% of greenhouse gas emission opportunities by 2020 and 2030 lie in profitable measures that reduce business energy costs through energy efficiency (Figure 6).

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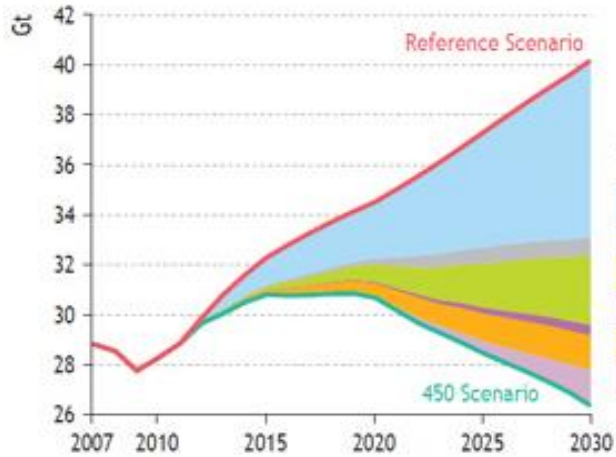

	Abatement (Mt CO_2)		Investment ($2008 billion)	
	2020	2030	2010-2020	2021-2030
Efficiency	2 517	7 880	1 999	5 586
End-use	2 284	7 145	1 933	5 551
Power plants	233	735	66	35
Renewables	680	2 741	527	2 260
Biofuels	57	429	27	378
Nuclear	493	1 380	125	491
CCS	102	1 410	56	646

Figure 6: International Energy Agency – World energy related CO2 emissions abatement options. (Source: IEA, 2009)

The IEA has concluded that that has significant potential to achieve a step change in energy efficiency in the 21st century due to the following,

- "*The energy intensity of most industrial processes is at least 50% higher than the theoretical minimum determined by the laws of thermodynamics. Many processes have very low energy efficiency and average energy use is much higher than the best available technology would permit.*"
- *"Investing in the most energy efficient motors, variable speed drives and optimising the efficiency of the entire motor driven system could reduce global electricity demand by 10%."*

According to the International Panel on Climate Change 2007 Assessment, new buildings can be designed, through an integrated systems approach, to achieve significant energy efficiency improvements including - 50-90% improvements in the energy efficiency of lighting, HVAC, appliances, office equipment and hot water systems.

Energy costs to businesses can be as much as 30% of total business costs. Given Australian business spends close to $88 billion in annual energy costs in Australia, it is technically possible for over $8 billion in annual business energy costs savings to be achieved through profitable mitigation strategies such as energy efficiency and heat and power recovery (e.g. cogeneration) as shown in Figure 7 below.

Recent studies, by ClimateWorks Australia, show that for many of the largest 587 energy using companies there are $3.3 Billion in energy cost savings due to there being potential to improve

energy efficiency across most industries by 11% in Australia.[71] Investing in energy efficiency can help insulate business from rising energy costs in Australia and around the world.

ClimateWorks Australia's studies show that, whilst 40% of these energy efficiency opportunities are likely to be realised, a further 60% is likely not to be invested in, even with ongoing energy cost rises. The main reasons they have found are as follows:

- competition within companies for internal capital,
- tough internal ROI requirements of less than 1 year,
- a failure to include energy efficiency considerations adequately in the design phase of new projects, and
- lack of reliable information or skills to identify and implement such profitable mitigation projects.[72]

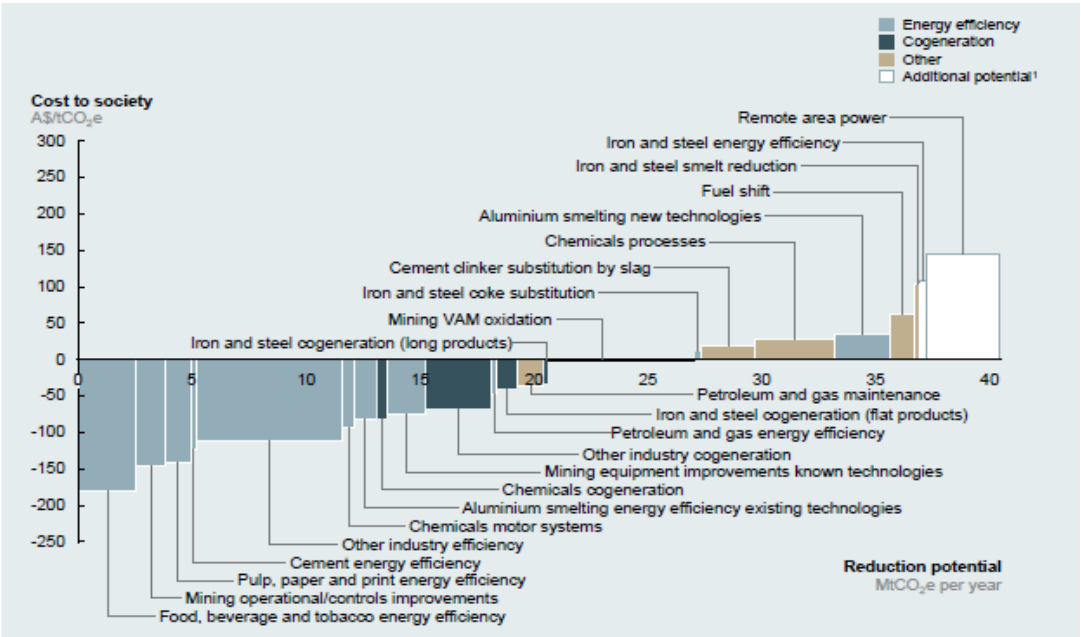

Figure 7: Australian Business Sectors - Greenhouse Gas Mitigation Cost Curve. (Source: ClimateWorks Australia, 2010[73])

Recommendation #2 Mainstream climate change mitigation into investor and business decision making through a focus on energy efficiency opportunities. This can be achieved by;

- creating better economic incentives and improving access to financing for business for energy efficiency investment,
- greater engagement and education of the institutional investment sector of the long term financial benefits companies investing in energy efficiency, even if the ROI is longer than one year, and
- greater promotion of energy efficiency information resources, such as the Australian Government's Energy Efficiency Exchange web portal and the Industrial Energy Efficiency Data Analysis[74] to assist business.

3. Improve Business Energy Productivity by Using Energy Efficient Equipment

Studies show that the energy efficiency performance of commonly used industrial, mining, agriculture and hospitality equipment contributes significantly to the energy usage of business. To date, the COAG Equipment Energy Efficiency (E3) program has focused on domestic appliances and largely ignored industrial and business equipment. According to Commonwealth Government figures, if industrial equipment was included, it would save at least $1.5 Billion per annum in industry energy costs and result in annual greenhouse abatement of up to 2.8 mt co2-e.[75] Government should expand minimum energy performance standards significantly into business sectors to cover a wider range of industrial, mining, agriculture, cooking and hospitality equipment. In a recent speech, Commonwealth Minister for the Environment, Greg Hunt stated that

> *"In the industrial sector, motors are absolutely integral to virtually every process. Motors control everything from pumps to compressors, drives to fans. Over half of Australia's electricity passes through an electric motor. The International Energy Agency believes that it's possible to cost-effectively improve the energy efficiency of motor systems by roughly 20 per cent to 30 per cent using technology that already exists. Such an outcome would reduce total global electricity demand by about 10 per cent. In other words, there are massive opportunities to reduce energy use and emissions from targeting the upgrade of just one type of industrial system."*[76]

Recommendation #3 Assist business cut energy costs by expanding minimum energy performance standards beyond the current focus on domestic appliances to cover a wider range of industrial, mining, farming, cooking and hospitality equipment.

4. Improve Energy Productivity and Business Profits through Demand Management and National Electricity Market Reform

In Australia, recent rapid increases in electricity prices have been largely the result of historically high levels of investment in Australia's electricity network due to a supply side focus, stronger reliability standards and the replacement of aging network infrastructure[77]. Part of the justification for this has been the need to invest to meet rising peak electricity demand. For example, in New South Wales, capacity that caters for less than 40 hours a year of electricity consumption (or less than 1 per cent of time) accounts for around 25 per cent of retail electricity bills. The Australian Energy Market Commission has identified substantial demand management opportunities in the Australian electricity system; opportunities that could lead to savings of $4-$12 billion over the next ten years[78] One way to do this is for industry and manufacturing to assist meeting Australia's peak electricity demand through

- turning down industrial equipment/processes during peak periods
- increasing onsite generation capacity through co-generation, renewables and energy efficiency so industry and manufacturing can sell back electricity to the grid during peak demand periods when electricity spot prices are the highest. Self-generated electricity and other off-grid electricity has increased in this sector by 58% between 2008-09 and 2011-12.

Recommendation #4. Reform of the national electricity market to enable business to contribute to, and earn revenue from, helping meet peak electricity demand through

- turning down industrial equipment/processes during peak periods and

- increasing onsite generation capacity through co-generation, renewables and energy efficiency so industry and manufacturing can sell back electricity to the grid during peak demand periods.

5. Improve Business Energy and Water Productivity through Improving Energy and Water Efficiency Skills

A 2012 survey of business by the Australia Industry Group[79] showed that the majority of businesses have not begun to manage their energy costs and invest in energy efficiency. Of those surveyed, who had not started to manage their energy usage, many admitted that it simply had not occurred to them to do so. A significant percentage stated that lack of skills and relevant and reliable information were barriers to investment in energy efficiency opportunities. The Australian Commonwealth and State governments and large companies can do much to improve the energy efficiency skills and knowledge of the workforce. (See the 4th report in this series). Improving skills in this area is critical to enabling business to achieve a step change in energy efficiency to reduce energy costs to business as much as possible. It is especially critical to improve skills in two areas

- Energy efficiency metering, monitoring and data analysis to underpin effective and comprehensive energy efficiency opportunity assessment and
- Whole of system optimisation of technical systems to optimise overall energy efficiency savings.

5.1 A step change in energy efficiency can be achieved by properly analysing energy usage.

Craig Roussac, former general manager sustainability, safety and environment with Investa Property Group in Australia, argues that "*most commercial properties can reduce by half energy use, once (metering is installed and) data is made available in a clear and usable format, easily understood by property portfolio managers and others who make spending decisions about sustainable building upgrades.*"[80] Investa Property Group is now making its energy performance data publically available and reporting on it quarterly.[81] Investa started by investing in an effective building energy management system so they could begin to understand and determine where the most cost effective energy efficiency retrofits could be implemented. They have shown that a step change in energy efficiency can be achieved through *"careful planning (and investing in existing energy efficient technologies, based on good data from energy metering and monitoring as part of a comprehensive energy management system."*

5.2 A step change in energy efficiency can be achieved through a "whole of system" approach.

This is the finding of the 5 year Australian Federal Government's Energy Efficiency Best Practice (EEBP) program run by the Department of Industry, Tourism and Resources (DITR).[82] The team involved found that through a 'whole-of-system' approach they could achieve 30-60% energy efficiency gains across a wide range of industries from bakeries, to supermarkets, mining, breweries, wineries, and dairies to name a few. This is because decisions made in the design phase of engineering projects largely determine the level of energy efficiency of engineered systems. *"By the time the design for most engineering systems is completed but before they have actually been built, about 80-90 percent of their life-cycle economic, (energy) and ecological costs have already been made inevitable*." Decisions made in the decision phase can make a significant difference to the energy efficiency of engineered systems – namely how much work is done per unit of energy input. Undertaking a "whole of system" engineering design process, which seek explicitly to optimise the energy efficiency of systems in the design phase, has been shown by a

number of empirically based books to be able to achieve large 20-50% energy efficiency improvements compared to design approaches which do not focus on improving the energy efficiency of a system.

5.3 A step change in water efficiency

Research by ANU shows that best of sector companies, have reduced their freshwater intensity by over 70% often in just 5 years or less. That is, these companies, at one or more major sites, were using at least 70% less freshwater to produce the same volume of product or service than they were pre 2005 at that site. (Table 3)

Table 3 Australian and USA Water Efficiency Business Case Studies

Sectors	Best of Sector Case Studies
Petroleum Refining	Refineries have shown that up to 80% of water used in refineries can be recycled water. • British Petroleum's Brisbane based refinery at Bulwer Island, which has reduced potable water use by 80% from 2005-2009. • The Shell petroleum refinery, in Geelong, is in the process of shifting by 2012 to close to 100% use of recycled water for its industrial processes. • The British Petroleum's Kwinana Petroleum Refinery, south of Perth, has implemented best practice water management practices since 1997 leading, by 2004, to 70% less drinking water being used and wastewater flows being reduced by 40%, saving over US$1 million a year. [83]
Paper Manufacture	Since 1900 best practice in the amount of water used per kg of paper produced has improved from 500-1000 litres per kg to 1.5 litres per kg of paper produced.[84] The Visy Tumut paper mill has shown to what extent paper mills can both reduce energy and water consumption simultaneously. The Visy Tumut mill is virtually climate neutral. Total water usage is 80 per cent lower than the average water used by standard industry pulp and paper mills elsewhere in the world.
Cardboard Manufacture	At their Cartonboard Mill in Petrie, Amcor Australia has achieved annual savings of more than 1000 Ml, via a 90% reduction in the use of drinking water in the manufacturing process, by using treated and recycled water.[85]
Glass Manufacture	MHG Glass, at their Geelong automotive glass manufacturing plant won the Business Regional and Rural category of the 2004 Savewater Award, for reducing its per piece water consumption by 60% in five years. It is using 70 ML less water each year than in the baseline year, 1999.
Food Processing	Oberti Olives olive processing plant in Madera, California processes in the order of 128 tons of olives per day, involving washing, curing, storing and packaging. Through installing a best practice membrane filtration system to enable water reuse, the company has reduced its freshwater use by 91%, equating to more than 3.5 million litres per day.[86]
Beverage Manufacturing	Fosters Brewery at Yalata, Queensland has achieved a 75% improvement in water efficiency since 1993. Breweries, on average, use about 6-8 litres of water per litre of product, but Fosters Brewery at Yalata only uses around 2 litres of water per litre of beer. [87]
Beverage - The Wine Industry	Leading wineries have invested in water recycling plants to recycle 100% of the waste water generated by the winery and bottling hall. This water is then stored in dams on site for reuse on the vineyards. This plus the investment in computer controlled "need-only' dripper lines to each vine[88] has reduced demand for freshwater by over 50%.[89]
Product Manufacturers	Grundfos Pumps Manufacturers of Fresno, California has cut freshwater consumption by 80%.[90]
ICT - Manufacture	Intel's 1000 acre (405 hectare) operation in Arizona includes processing equipment that uses 75% less water than the industry average (down from 25 to 8 million litres per day).

	Additionally, Intel constructed a system that treats wastewater and then injects it into the local aquifer, treating and injecting more than 3.5 billion gallons (13.2 billion litres) of drinking-quality water into the aquifer since the plant's inception in 2000.[91]
Commercial/Office Buildings	Melbourne University's new Faculty of Economics and Commerce building shows it is possible to achieve 90% reductions in mains freshwater.[92] The building achieves this through reducing cooling demand by utilising natural ventilation, using chilled beam cooling technology, and by the installation of dry/hybrid cooling, combined with rainwater harvesting and grey-water reuse.
Commercial Buildings _ Airports	Brisbane Airport Corporation has shown that it is possible for an airport to reduce freshwater use by 82% in just five years since 2004.
Golf Club	The Rossdale Golf Club, in Melbourne, has achieved an annual reduction of mains water usage of 35 Ml, a reduction of 56%, through water treatment and reuse from a combination of stormwater harvesting, aquifer storage, recovery and reuse facility.[93]

(Source; Smith, M, 2014)

These significant reductions in freshwater intensity have been achieved because, over the last forty years there have been significant innovations in water efficient technologies and water treatment and recycling technologies. Utilising the technologies outlined in Table 4 below in an integrated fashion has enabled decoupling of GDP from freshwater abstraction in the successful case studies above.

Table 4 Enabling Technologies to Reduce Freshwater Demand – Agricultural, Building and Industrial Sectors

Sector	Enabling Technologies
Agriculture	– Drip or sprinkler irrigation, sensors and irrigation scheduling, mulching, drought and salt tolerate crops, no-tillage farming practices, rainwater harvesting and managed aquifer recharge and recovery.
Residential Buildings	– Various low flow showerhead designs exist to reduce water consumption by between 50-75%,[94] resulting in sizable reductions in water consumption along with the requirement for water heating. – Low-flow aerators reduce faucet water flow by 30-50% and can also reduce the energy costs of heating water by up to 50%. – Water efficient appliances such as front loading domestic washing machines are 40-75% more efficient than top loading options. – Toilets that use 6/3 litre dual flush systems are capable of reducing water usage by 67% compared with conventional models.[95] – Rainwater tanks for rainwater harvesting and reuse.[96] – Drip irrigation, drought tolerant plants, mulch to reduce water loss from evaporation.
Commercial Buildings	– Waterless urinals use liquid-repellent coatings and a lighter-than-urine biodegradable trap liquid to prevent odours. They cost less to install and save between 150,000-230,000 litres per conventional unit per year.97 Hundreds of thousands of non-water urinals have been installed around the world savings millions of gallons/litres of water each year.98 – Ultra-Efficient water urinals are being developed by manufacturers that flush at 1.9-liters and below, some with as little as 0.5-liters. – Hybrid dry air/water cooling systems for large buildings have been optimised to reduce

	typical consumption of water by as much as 75%.[99] – Rainwater tanks[100]
Commercial Buidings - Commercial Laundromats	– Highly efficient washers can reduce water consumption by 35-50% and achieve energy savings of up to 50%, with highly efficient washers requiring 50% less detergent.
Commercial Buildings - Restaurants	– Food Steamers: There are two types of food steamers used by the food industry to heat food in large quantities. The traditional design uses steam trays connected to a central boiler. In recent years, the food service manufacturers have developed much more efficient boiler-less compartment steamers, often called connectionless steamers (though some are connected to water supplies) that use 90 per cent less water. – Water-efficient commercial dishwashers can save 25% of water usage. Payback periods for installing small efficient commercial dishwashers range between 1-4 years. – Waterless wok stoves that use air instead of water for cooling can save nearly 90% of water consumption.[101] – Pre-rinse spray valves account for 14% of water consumption in commercial kitchens. Replacing a traditional pre-rinse spray valve can save between 25-80% of this water.
Industry/Manufacturing	– Water efficient technologies: - Waterless conveyor belt lubricants, water efficient spray nozzles[102] and spray guns[103] nozzles/guns, clean in place technologies (ie sensors), steam traps and condensate return systems, water efficient cooling tower technologies.[104] – Onsite water harvesting technologies: Rainwater tanks[105], stormwater harvesting systems[106], constructed wetlands[107]. – Onsite water treatment technologies[108] (to enable onsite water recycling): Settling ponds, dissolved air flotation (DAF),[109] membrane filtration (micro/nano/ultra filtration), membrane bioreactors[110], sequential batch reactors (SBR), ion exchange[111], disinfectants (ultraviolet light, chemicals, ozone)[112]. – Utilise recycled water supplied by water utility: dual reticulation piping to ensure freshwater and recycled water can both be used.
Power Stations	– Water Efficient Cooling Systems - Hybrid Cooling Towers, Saline Water Cooling Towers (which use sea water directly).

Source: Compiled by Smith, M (2012) based on referenced sources

5.4 Some of the Best Ways to Save Energy are Through Saving Water

In the field of energy/water nexus many researchers are now finding that action to reduce water consumption can yield multiple benefits such as reducing energy demand and greenhouse gas emissions by reducing the need for distribution, heating and cooling of potable water. The potential to save energy this way is significant as shown by the fact that the Californian Energy Commission, in their 2005 report California's Water–Energy Relationship, showed that water-related energy use makes up 19 per cent of all electricity and 30 per cent of all natural gas used in California.[113]For businesses, water efficiency not only saves money from reduced water costs, but also saves money by simultaneously reducing wastewater, trade waste, energy, and chemical costs. These hidden costs of water usage have rarely been properly evaluated by business and thus the potential cost savings from water efficiency improvements tend to be underestimated. Again, new enabling technologies are now making it easier for business to simultaneously achieve energy and water savings (Table 5)

Table 5: Technologies Enabling Simultaneous Water and Energy Savings

	Table 1: Enabling Technologies in Energy/Water Nexus Efficiency	
Sector	**Enabling Technologies**	**Water Saving (%)**
All Buildings	Low Flow Showerheads: Various shower-head designs exist to reduce water consumption by up to 75 per cent, they use a combination of high pressure and innovative orifice design.[114] Roughly 30 per cent of energy use in the home is for heating water therefore such an investment in showerheads pays itself back within months since they cost only around US$12 each.	50
	Low-flow Faucet Aerators: cost only around US$5 and reduce faucet water flow by 30 to 50% (range is based on aerator type and faucet use). Low-flow aerators also reduce the energy costs of heating faucet water by up to 50%.[115]	50
	Water Efficient Appliances: Front loading domestic washing machines are 40-75 per cent more efficient than top loading.[116] Front loading machines also work better because the chemicals are more concentrated and clothes last longer because they are not agitated.	30-50
Commercial Laundromats	Highly Efficient Washers: Can reduce water consumption by 35 to 50% and achieve energy savings of up to 50%. More efficient washers can reduce energy bills by up to 50% and water and sewer costs by 35 to 50. Highly efficient washers require 50% less detergent.	35-50
Commercial Restaurants	Food Steamers: There are two types of food steamers used by the food industry to heat food in large quantities. The traditional design uses steam trays connected to a central boiler. In recent years, the food service manufacturers have developed much more efficient boiler-less compartment steamers, often called connectionless steamers (though some are connected to water supplies) that use 90 per cent less water.	90
	Commercial Dishwashers: Commercial dishwashers, considered to be one of the largest water and energy consumers in the commercial kitchen, often using more than two-thirds of the overall water use. Water-efficient commercial dishwasher's can save 25 per cent of water usage. Payback period for installing small efficient commercial dishwasher ranges between one and four years.[117]	25
	Commercial Kitchen Pre-rinse Spray Valves: Pre-rinse spray valves account for 14% of water consumption in commercial kitchens. Replacing a traditional pre-rinse spray valve can save between 25-80 per cent less water and energy. If pre rinse spray valves are used roughly three hours per day, a water-efficient pre-rinse spray valve can save up to $1050 in water and energy costs per year.	25-80

(source: Smith, M)

Recommendation #5 Assist business cut energy and water costs through improving access to relevant information and improving staff skills in identifying and implementing energy efficiency opportunities. Also improve information on energy/water efficiency nexus opportunities for each business sector to help business identify and implement such opportunities

6. Improve Business Resource Productivity to Cut Resource Input Costs

As discussed in the opening, over the last ten years the costs of inputs for manufacturers and industry have risen dramatically to such an extent that input commodity price rises in the last decade wiped out the previous 100 years of commodity price reductions.

Improving resource productivity through material efficiency, onsite recycling and diversifying supply chains to purchase more recycled materials, and product stewardship, can help reduce both resource input costs as well as waste disposal costs. In addition, increasingly nations are requiring manufacturer's to design products to maximise the potential for remanufacturing and recycling. Not surprisingly then, research has found a correlation between improved resource productivity and increased competitiveness.To date Australia's progress on product stewardship has been patchy and recycling levels for industrial waste sits at 56%. This can be addressed through the National Waste Policy Reform agendas and in particular:

- Building markets for recycled materials and recycled and remanufactured products.
- Accelerating the development of extended producer responsibility standards for key products and .
- Setting clear timelines for banning categories of waste to landfill; this has been shown to rapidly increase recycling rates and be highly economically efficient. (Figure 9 below) For instance, a cost-benefit analysis for the United Kingdom suggested that restricting metals, glass, plastics, organics, paper from both landfill and other residual waste treatment (such as incineration) would provide a net benefit to society over the period 2009 to 2024 of £8.246 billion.

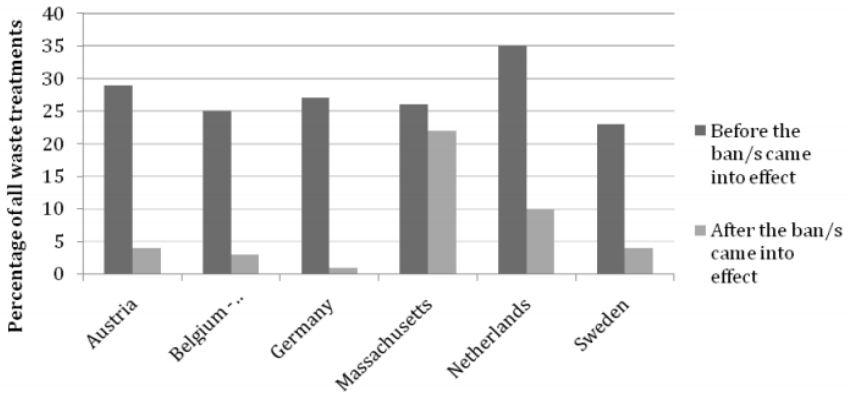

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Figure 9: Percentage of Waste Going to Landfill Before and After Bans.

Governments should also consider levies that incentivise the use of recycled materials over that of raw resources to boost the use of recycled materials. For instance, a simple small levy on non-recycled paper products to offset the costs of deinking paper for recycling would make recycled paper cost competitive with non-recycled paper overnight.

Recommendation 6 Governments should work with business to help reduce resource input and "waste to landfill" costs through building markets for recycled materials, improving knowledge, skills and economic incentives for materially efficient product design and the use of recycled materials. Studies show a strong correlation between resource productivity and competitiveness. For detailed policy options regarding resource productivity see Report #2 in this series of reports.

7. Raise Productivity by Improving OH&S and Cutting Toxic Emissions

In Massachusetts, industry which is required to annually undertake "Safer alternative chemical" analysis has reduced usage of toxic chemicals by 40%, production of toxic chemical by-products by 70% and toxic emissions by over 90% over the last two decades whilst boosting business profits.

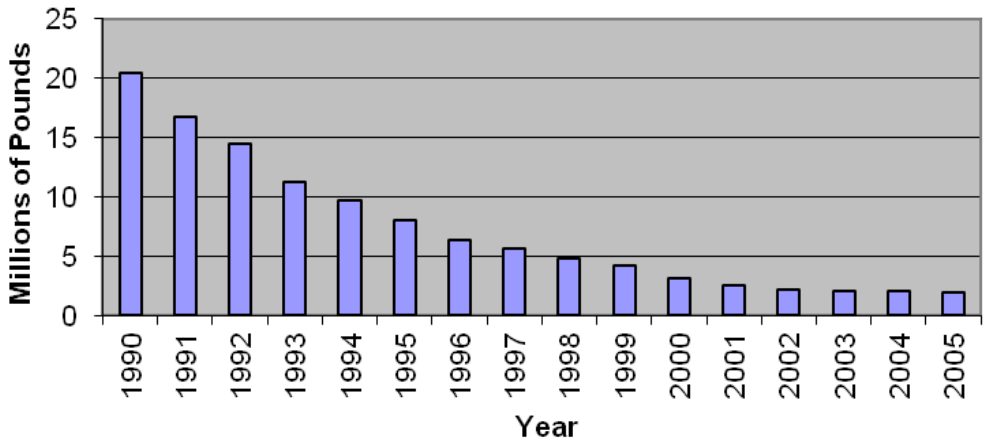

Figure 10: Toxic chemical emissions/releases in the state of Massachusetts. (TURI, 2013)

The results in Massachusetts are widely regarded as the most outstanding internationally. They have been achieved through simply requiring industry and manufacturing in Massachusetts to stocktake all chemicals use and review the potential for "safer alternative" chemicals to be used. Business is supported in this endeavour by education and training and access to databases of safer alternative chemicals produced by the Toxic Use Reduction Institute (TURI). TURI then audits and reviews randomly a sample of such plans and provides constructive feedback. Given the success of Massachusetts, governments should reach out to and partner with the Massachusetts government to implement the same scheme requiring all industry and manufacturers above a certain size to:

- Stocktake all toxic and hazardous chemicals currently in use, and develop "safer alternative chemical" plans,
- Fund an equivalent version of the Toxic Use Reduction Institute in your country to assist business with training, reliable databases and advice, and.
- Initiate a national "Safer Alternative Chemical" research program in partnership with similar research programs operating in many nations internationally.

Recommendation #7 Partner with business to improve OH&S and reduce toxic chemical emissions through investing in education and training, to support businesses (i) stock take all toxic chemicals in use, and (ii) develop and implement "safer alternative chemical" plans for their business. In Massachusetts, where business is required to do this, as mentioned above, they have seen reduced usage of toxic chemicals by 40%, reduced production of toxic chemical by-products by 70% and reduced toxic emissions by over 90% over the last two decades whilst boosting profits.

8. Reducing Business Productivity Losses from Extreme Weather Events

In some countries, such as Australia, the USA and Canada, the climate change discourse has focused largely on the "costs" to industry from action on climate change. There has been virtually no discussion on the "costs of inaction" on climate change for this sector. Yet, the 2013 World

Economic Forum "*Global Risk Report*" identified rising greenhouse gas emissions and failure to adapt to climate change as the two top risks most likely to materialize within a decade for business.[118] The main potential costs of inaction for business from climate change arise from extreme weather events. Natural catastrophes caused $US160 billion worth of global economic costs in 2012.. This is especially relevant for business subsectors which are capital intensive with many long life fixed assets, long supply chains, and significant energy, water and resource input requirements to be able to operate. Recent extreme weather events around the world have shown that business cash flow is more at risk than previously thought [119] and that business' cash flow, profitability and productivity is more at risk from extreme weather events than previously thought. This is illustrated by the many examples of cases where many companies have had their bottom line and productivity negatively impacted in the last few years across all sectors.

- Oil and Gas Industry: The Gorgon LNG project has experienced construction cost blow outs of US$15 billion or 40% to $US52bn partly due to starting construction at the start of the cyclone season.
- Mining: The 2011, Queensland Floods had a bigger negative impact on the Australian mining industry than the Global Financial Crisis.

The probability of these and other risks occurring and negatively impacting on the cash flows of companies will increase with climate change over the coming decades. Yet many cost effective adaption measures exist to reduce net business costs through improving water efficiency whilst reducing risks of asset damage, operational loses and exposure to price spikes. (Table 6)

Table 6: Climate Risk, Forecast Change, Potential Impact, Adaptation Strategies (Example Australia)

Risk	Forecast change	Potential Impact	Sample of Business Adaptation Strategies
More Intense Cyclones + Floods	+ 60% by 2030 (in cyclone intensity) + 140% by 2070 (in cyclone intensity)	Flood damage to manufacturing, equipment, automated production lines and assets. Operations disrupted Supply chains disrupted Increased insurance costs	For Cyclones and Hailstorms – Securing facilities roofs to withstand cyclonic winds. Using appropriate roof materials to withstand hailstorms Placing effective metal wire screens or shutter protection on windows. Weatherise facilities to ensure no gaps. For Flooding – Employ storm-water management strategies. Pumping equipment and backup generators Insurance Engage with government and other stakeholders
More Frequent Hailstorms + Flooding	Modelling predicts about a further +20% increase in frequency by 2050[120]		
More Intense Rainfall Events	Despite overall decreases in rainfall (see below), rainfall events will become more intense creating a greater risk of flooding.		
Sea Level Rises and Storm Surges	+18-79cm by 2100[121] sea level rise combined with a storm surge poses, by 2100, a risk of serious flooding to approximately 3700-6200 industrial facilities		
Reduced Freshwater Availability	2030 % / 2050 % / 2070: % North: -10 to +5 / -20 to +10 / -30 to +20 South: -10 to 0 / -20 to 0 / -30 to +5 No. of months of drought by 2070 South WA +80% Eastern Australia +40%	Increase in water prices and costs Higher electricity costs	Improve efficiency of water usage Rainwater and stormwater harvesting and reuse Purchase recycled water from water utilities Invest in energy efficiency and co-generation technologies
Average Higher Temperatures	0.1-1.5°C by 2020 0.3-4.0°C by 2050 0.4-8.0°C by 2080[122]	Higher energy and water costs (ie. higher air-conditioning and refrigeration loads)	Improved building "thermal" envelope Cool roofs Reduce waste heat losses Recovery waste heat

No. of Days Over 35 Celsius (North Australia)	7-11 days per annum in 2000 69 days per annum by 2030 308 days per annum by 2070		Energy efficient air-conditioning Solar powered air-conditioning
Higher Risk of Bushfire	Days with very high and extreme Forest Fire Danger Index (FFDI) ratings[123] +4-25% by 2020 +15-70% by 2050	Electricity transmission line shut downs to reduce bushfire risk Electricity brownouts from demand exceeding supply	Implement a bushfire prevention and management plan Work with local fire authorities Improve onsite energy efficiency Reduce waste heat losses Invest in onsite co-generation Invest in onsite backup generators

(Source: Smith, M, 2013[124])

Also business has a critical role to play in developing and producing technologies and products to help adapt to climate change. Many product manufacturers are already strategically positioning themselves for growth by producing climate change adaptation technologies and products to help business and households adapt to risks from climate change. To address these issues, the following is recommended;

Recommendation #8 Reduce productivity losses from extreme weather events by mainstreaming climate change adaptation into the Australian business sector. This can be done through improving

- (i)understanding of risks and opportunities from climate change in each business sector
- (ii) economic incentives for investment in cost effective climate change adaptation strategies, and.
- (iii) information for business sectors on climate change risks and adaptation opportunities. To do this, the following steps are recommended:
    - Fund an in depth study into climate change risks and adaptation opportunities for this sector. As part of this study, map industry and manufacturing's climate change adaptation enabling products which can help other nations adapt to climate change.
    - Update relevant parts of the education system to improve knowledge and skills in business for climate change risk and adaptation assessment. (Smith, 2013[125])
    - Create a "one stop shop" climate change adaptation web portal for business.
    - Improve economic incentives for investment in climate change adaptation measures.
    - Engage with the investment and insurance community to provide better signals into the market to drive climate change adaptation investment.

9. Improve Sustainability Assessment and Reporting.

The Commonwealth Government of Australia between 2007-2012 required the largest 250 energy using companies to review and publically report on energy efficiency opportunities under the successful Energy Efficiency Opportunities Act and program managed by Department of Industry. This program provides business with significant guidance and assistance to undertake such a review. It has been very successful in helping to address information and organisational barriers to change in firms. A review of this program suggested that within another 5 years this program will have largely achieved its goals. A logical next phase is to copy what Massachusetts has done, which is to expand on this idea, and for national governments to

- Require the largest 100-300 companies in their nations to annually review and report on one of either water efficiency opportunities, product stewardship/recycling opportunities, and safer chemical opportunities, and natural capital opportunities.
- Streamline all sustainability assessment, and finally, using the Global Reporting Initiative, move beyond simply financing reporting of industry and manufacturing performance to sustainability reporting, initially for large sized manufacturers by 2020 and businesses and then medium sized manufacturers by 2030. Many nations already require, by law, aspects of environmental sustainability reporting for large companies in their jurisdictions in line with the Global Reporting Initiative.

Recommendation #9 Improve sustainability assessment and reporting by requiring the largest 200-300 companies to annually review and publically report on one of either (i) energy efficiency or (ii) water efficiency or (iii) materials efficiency or (iv) safer chemical opportunities as is done in Massachusetts, USA.

10. Improve National Innovation Systems and Grow Markets for "Energy and Resource Efficient" Materials and Products as well as the Circular Economy

Nations and businesses do not achieve large productivity gains by simply tweaking existing systems. Holistic innovation is needed in production and consumption systems to really achieve large productivity improvements. That requires innovation.

Recommendations #10

To enable this, national governments should undertake the following:

(a) Immediate action

- Review and phase out overtime all perverse subsidies that harm the environment,
- Modernise the tax system by, for instance, instituting a congestion tax and other reforms to enable the phase out of payroll taxes to reduce labour costs for business and instead tax environmental bads,
- Improve R&D in environmental technologies by investing in public research programs and encouraging private R&D through increased targeted tax incentives,
- Increase support and facilitate greater collaboration for innovation and commercialisation of key green products and services by implementing the recommendations of national reviews . For instance, in Australia, this means implementing the recommendations of the 2008 Venturous Australia report – a review of Australia's National Innovation System[126] and the 2012 Prime Minister's Taskforce on Manufacturing[127]. In particular, invest in a series of eco-innovation and advanced manufacturing cluster hubs. Identify and facilitate opportunities for eco-innovation where Australia clearly has a competitive advantage through cutting edge world leading research advances such as eco-efficient comminution technologies and equipment in mining.

(b) Develop an environmental policy and vision for green industries and 'greening' of all industries based on

- Sound analysis of the future climate change and economic projections,
- Opportunities for creating and meeting demand for the manufacturing of "green" materials products and services, and
- Fund a study to map how industry and manufacturing already are contributing through the products made to help enable this in your nation ,

(c) Assist in building markets for green products and services through

- Establishing rigorous environmental performance standards for all government operations, including unambiguous procurement mandates that offer preferential consideration and price premiums for green products and services..
- Strengthening engagement between investors and green business for industry and researchers to showcase new technologies, services and ideas to investors and other stakeholders.

References

[1] Dobbs, R. , Oppenheim.J., & Thompson, F *et al* (2011) *Resource Revolution: Meeting the World's Energy, Materials, Food and Water Needs*. McKinsey Global Institute

[2] [2] McKinsey Global Institute (2012) The Resource Revolution. McKinsey Global Institute and Vivid Economics (2013) Economic Growth and Energy Efficiency. Vivid Economics and The Climate Institute at http://www.climateinstitute.org.au/verve/_resources/Vivid_Economics_-_Energy_efficiency_and_economic_growth_June_2013.pdf

[3] Lilly, P. and D. Pearson (1999), Determining the Full Value of Industrial Efficiency Programs. Energy Efficiency in Industry Conference, Saratoga Springs. Retrieved from http://www.seattle.gov/light/Conserve/Reports/paper_7.pdf
Pearson, D. and L.A. Skumatz (2002), Non-energy Benefits Including Productivity, Liability, Tenant Satisfaction, and Others – What Participant Surveys Tell Us About Designing and Marketing Commercial Programs. Proceedings of the 2002 Summer Study on Energy Efficiency in Buildings. American Council for an Energy Efficient Economy, Washington DC

[4] Loftness, V., Hartkopf, V., Gurtekin, B., Hansen, D. & Hitchcock, R. (2003) Linking Energy to Health and Productivity in the Built Environment. Evaluating the Cost-Benefits of High Performance Building and Community Design for Sustainability, Health and Productivity. Greenbuild Conference cited in http://www.worldgbc.org/files/1513/6608/0674/Business_Case_For_Green_Building_Report_WEB_2013-04-11.pdf

[5] Damian Carrington (2011) Why Low Carbon Means High Profit – The Guardian at http://www.theguardian.com/environment/damian-carrington-blog/2011/sep/14/carbon-green-economy-emissions?guni=Article:in%20body%20link

[6] The Carbon Disclosure SP500 report at https://www.cdp.net/CDPResults/CDP-SP500-climate-report-2013.pdf

[7] The Carbon Disclosure SP500 report at https://www.cdp.net/CDPResults/CDP-SP500-climate-report-2013.pdf

[8] (pages 25 and 297) of IEA – World Energy Outlook (2012) at http://www.iea.org/publications/freepublications/publication/WEO2012_free.pdf

[9] National Climate Change Adaptation Research Facility (2013) *Ensuring Business and Industry are Ready for Climate Change. Policy Guidance Brief 11*. NCCARF

[10] World Economic Forum (2013) Global Risks Report. WEF at http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2013.pdf

[11] UN Sustainable Energy For All initiative at http://www.se4all.org/our-vision/our-objectives/

[12] COAG (2010) *Improving the Energy Efficiency of Industrial Equipment*. COAG Equipment Energy Efficiency Committee under the auspices of the Australian and New Zealand Ministerial Council on Energy

[13] Australian Energy Market Commission (2012) *Power of Choice Review - Giving Consumers Options in the Way They Use Electricity (Final Report).*AEMC

[14] Loftness, V., Hartkopf, V., Gurtekin, B., Hansen, D. & Hitchcock, R. (2003) Linking Energy to Health and Productivity in the Built Environment. Evaluating the Cost-Benefits of High Performance Building and Community Design for Sustainability, Health and Productivity. Greenbuild Conference cited in http://www.worldgbc.org/files/1513/6608/0674/Business_Case_For_Green_Building_Report_WEB_2013-04-11.pdf

[15] Loftness, V., Hartkopf, V., Gurtekin, B., Hansen, D. & Hitchcock, R. (2003) Linking Energy to Health and Productivity in the Built Environment. Evaluating the Cost-Benefits of High Performance Building and Community Design for Sustainability, Health and Productivity. Greenbuild Conference cited inhttp://www.usgbc.org/Docs/Archive/MediaArchive/207_Loftness_PA876.pdf

[16] Loftness, V., Hartkopf, V., Gurtekin, B., Hansen, D. & Hitchcock, R. (2003) Linking Energy to Health and Productivity in the Built Environment. Evaluating the Cost-Benefits of High Performance Building and Community Design for Sustainability, Health and Productivity. Greenbuild Conference cited inhttp://www.usgbc.org/Docs/Archive/MediaArchive/207_Loftness_PA876.pdf

[17] Loftness, V., Hartkopf, V., Gurtekin, B., Hansen, D. & Hitchcock, R. (2003) Linking Energy to Health and Productivity in the Built Environment. Evaluating the Cost-Benefits of High Performance Building and Community Design for Sustainability, Health and Productivity. Greenbuild Conference cited in World Green Building Council (2013) The Business Case for Green Buildings at http://www.worldgbc.org/files/1513/6608/0674/Business_Case_For_Green_Building_Report_WEB_2013-04-11.pdf

[18] Australian Green Building Council (2008) Dollars and Sense of Green Buildings. Building the business case for green buildings in Australia. AGBC at http://www.gbcsa.org.za/system/data/uploads/resource/62_res.pdf

[19] World Green Building Council (2013) – The Business Case for Green Building. World Green Building Council. March 2013 http://www.worldgbc.org/activities/business-case/

[20] The Royal Institution of Chartered Surveyors (2010) "Green Value: Green Buildings, Growing Assets". Details at http://www.bluewildernessgroup.com/index.php?action=display&cat=43&doc=greenvaluesreport_1.pdf

[21] The BCI Australia Green Building Market Report (2008) found that tenant "green building" owners are rewarded with decreased vacancy periods and a subsequent increase in occupancy ratios of 3.5%

[22] Owners are usually responsible for the costs related to central services energy. Studies show that central services energy accounts for almost half the entire energy used in a typical commercial building.

[23] International Energy Agency (2014) Multiple Benefits of Energy Efficiency: IEA. Paris at http://www.iea.org/Textbase/npsum/MultipleBenefits2014SUM.pdf

[24] Ulrich, R.S. (1984) View through a window may influence recovery from surgery. Science. Vol 224 No 4647, pp. 420-421.

[25] Walch, J.M., Rabin, B.S., Day, R., Williams, J.N., Choi, K. & Kang, J.D. (2005) The Effect of Sunlight on Postoperative Analgesic Medication Use. Psychosomatic Medicine. Vol 67, pp. 156-163.

[26] Romm, J.J. & Browning, W.D. (1994) "Greening the Building and the Bottom line." Rocky Mountain Institute. Snowmass, Colorado.

[27] Edwards, l. & Torcelli, P. (2002) "A literature Review on the Effects of Natural light on Building Occupants." National Renewable Energy laboratory. NREl/

TP- 550-30769. Golden, Colorado.
[28] Heschong Mahone Group (2003) Daylight and Retail Sales. Technical Report. California Energy Commission. 52. Heschong Mahone Group (2003) Windows and Offices: A Study of Office Worker Performance and the Indoor Environment.
California Energy Commission
[29] Nicklas, M.H. & Bailey, G.B. (1996) "Student Performance in Daylit Schools." Innovative Design. Raleigh, North Carolina
[30] Heschong Mahone Group (1999) "Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance." California Energy Commission: Pacific Gas and Electric Company. Fair Oaks, California.
[31] World Green Building Council (2013) The Business Case for Green Buidings. WGBC
[32] Romm, J.J. and Browning, W.D. (1998) 'Greening the Building and the Bottom Line', Rocky Mountain Institute, www.rmi.org/images/PDFs/BuildingsLand/D94-27_GBBL.pdf, accessed 30 July 2007.
[33] Allan Johansson a,b,∗, Lauri Holappa (2004) From megaplants to mini-mills—a trend in steelmaking—a prospect for papermaking. Resources, Conservation and Recycling 40 (2004) 173–183
[34] Muller, D.B., Wang, T., Duval, B., Graedel, T.E., 2006. Exploring the engine of anthropogenic iron cycles. PANS 103 (944), 16111–16116.
[35] Gesing, A., Wolanski, R., 2001. Recycling light metals from endof-life vehicles. JOM (November), 21–23
[36] Tilton, J.E., 1999. The future of recycling. Resour. Policy 25, 197– 204.
[37] Allan Johansson a,b,∗, Lauri Holappa (2004) From megaplants to mini-mills—a trend in steelmaking—a prospect for papermaking. Resources, Conservation and Recycling 40 (2004) 173–183
[38] Ibid
[39] US Department of Energy, Waste Heat, Reduction,and Recovery for Improving Furnace Efficiency, Productivity and Emissions Performance, http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/35876.pdf .
[40] Future of Rotary Kiln - Electric Furnace (RKEF) Processing of Nickel Laterites Authors: C. Walker, S. Kashani-Nejad, A.D. Dalvi, N. Voermann, I.M. Candy and B. Wasmund European Metallurgical Conference, EMC 2009, Innsbruck, Austria, June 2009
[41] Clean Energy Finance Corporation, New Generation Ovens Halve Energy Use for Plastic Products Manufacturer, http://www.cleanenergyfinancecorp.com.au/our-investments/case-studies/new-ovens-halve-energy-use-for-plastic-products-manufacturer.aspx
[42] Aggarwal, S. and Gu, J. (2012) Two kinds of demand-response.Siemens.at http://www.siemens.com/innovation/apps/pof_microsite/_pof-spring-2012/_html_en/facts-and-forecasts-growing-market-for-energy-efficiency-technologies.html
[43] Chester, M.V. and Horvath, A. (2009) Environmental assessment of passenger transportation should include infrastructure and supply chains. Environmental Research Letters, vol. 4, no. 2, pp. 1-8
[44] Sullivan, J. L., et al., 1998, Life cycle inventory of a generic U.S. family sedan – Overview of results USCAR AMP Project, proceedings of Total Life Cycle Conference Land, Sea and Air Mobility, SAE International P-339, pp.114
[45] Chester, M.V., Horvath, A. and Madanat, S. (2010) Comparison of life-cycle energy and emissions footprints of passenger transportation in metropolitan regions. Atmospheric Environment, vol. 44, no. 8, pp. 1071-1079.
[46] Chester, M.V. and Horvath, A. (2009) Environmental assessment of passenger transportation should include infrastructure and supply chains. Environmental Research Letters, vol. 4, no. 2, pp. 1-8
[47] Mineweb (2013) "Greener underground mining - Electric vehicles leading the way" *Mineweb* 26 April 2013. accessed 1/11/2013 from http://www.mineweb.com/mineweb/content/en//page68?oid=187840&sn=Detail
Vella H. (2013) "Maximising underground efficiency with energy conscious mining machines." 19 August 2013 *Mining-Technology.com* accessed 1/11/2013 from http://www.mining-technology.com/features/feature-underground-efficiency-energy-conscious-mining-machines/
[48] Ibid
[49] Ker, P. (2012) "BHP aims to dump trucks." Business Day, *The Sydney Morning Herald*. 1 November 2012. accessed 1/11/2013 from http://www.smh.com.au/business/bhp-aims-to-dump-trucks-20121031-28k9h.html#ixzz2k8EjoxUf
[50] Vale (2013) Carajás S11D Iron Project A new impetus to Brazil´s sustainable development. Vale http://saladeimprensa.vale.com/_arquivos/Book%20S11D%202013_INGLES_FINAL.pdf
[51] Ibid.
[52] FAO - Ecological Intensification Literature Review -
http://www.fao.org/fileadmin/templates/agphome/documents/scpi/Deliverable_7_2_LiberationBibliography.pdf
[53] Royal Society. (2009). Reaping the benefits: science and the sustainable intensification of global agriculture. RS Policy document 11/09. London**:** 86.
[54] Food and Agriculture Organization of the United Nations, AGP Ecological Intensification, http://www.fao.org/agriculture/crops/thematic-sitemap/theme/biodiversity/ecological-intensification/en/
[55] Earl, J. M., and Jones, C. E. (1996). The need for a new approach to grazing management – is cell grazing the answer? The Rangeland Journal 18, 327–350. doi:10.1071/RJ9960327
[56] McCosker, T. (2002) Cell Grazing the First 10 Years. Tropical Grasslands. Volume 34, 207-218 http://tropicalgrasslands.asn.au/Tropical%20Grasslands%20Journal%20archive/PDFs/Vol_34_2000/Vol_34_03-04_00_pp207_218.pdf
[57] McArthur, S. (1998). Practical evidence supports cell grazing benefits.
Australian Farm Journal – Beef, September, 8–9
[58] Gatenby, A. (1999). Rangeland management: sustainable agriculture requires sustainable profit. In: 'Outlook 99. Proceedings of the National Agriculture and Resource Outlook Conference. Vol. 2, Agriculture'. Canberra, ACT. pp. 165–172. (Australian Bureau of Agricultural and Resource Economics: Canberra.)
[59] Joyce, S. (2000). Change the management and what happens – a producer's
perspective. Tropical Grasslands 34, 223–229
[60] Sparke, R. (2000). Cell grazing – a producer's perspective. *Tropical Grasslands* **34**, 219–222
[61] Communities in Landscapes project .Benchmark Study of Innovators. Final Report November 2011. By Peter Ampt & Sarah Doornbos
[62] D. Walsh. 2009. A maximum sustainable stocking rate system in central Australia: Woodgreen Station, NT. DKCRC Working Paper 54, The Central Australian Grazing Strategies project Working Paper Series. Desert Knowledge CRC, Alice Springs.
[63] Teague, W. R., Dowhower, S. L., Baker, S. A., Haile, N., DeLaune, P. B., and Conover, D. M. (2011). Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie. Agriculture, Ecosystems & Environment 141, 310–322.
doi:10.1016/j.agee.2011.03.009
[64] Sanjari, G., Ghadiri, H., Ciesiolka,C. and Yu, B. (2008) 'Comparing the effects of continuous and time-controlled grazing systems on soil characteristics in Southeast Queensland', Australian Journal of Soil Research, vol 46, pp348-358

[65] McCosker, T. (2002) Cell Grazing the First 10 Years. Tropical Grasslands. Volume 34, 207-218 http://tropicalgrasslands.asn.au/Tropical%20Grasslands%20Journal%20archive/PDFs/Vol_34_2000/Vol_34_03-04_00_pp207_218.pdf
[66] McCosker, T. (2002) Cell Grazing the First 10 Years. Tropical Grasslands. Volume 34, 207-218 http://tropicalgrasslands.asn.au/Tropical%20Grasslands%20Journal%20archive/PDFs/Vol_34_2000/Vol_34_03-04_00_pp207_218.pdf
[67] Daniel Felton, Robert Fuller & Robert H. Crawford (2014) The potential for renewable materials to reduce the embodied energy and associated greenhouse gas emissions of medium-rise buildings, Architectural Science Review, 57:1, 31-38, DOI: 10.1080/00038628.2013.829022
[68] Stadler, A., Jutsen, J., Pears, A., & Smith, M., 2014, 2XEP: Australia's energy productivity opportunity. Sydney: Aus¬tralian Alliance to Save Energy http://www.a2se.org.au/files/2XEP_Foundation%20Concepts.PDF
[69] Dobbs, R. Oppenheim, J & Thompson, F et al (2011) Mobilizing for a resource revolution. McKinsey Global Institute
[70]http://www.startupsmart.com.au/planning/government-report-warns-start-ups-of-skills-shortages/201108013422.html
[71] ClimateWorks Australia and DRET (2013) Industrial Energy Efficiency Data Analysis - Detailed project results - Other manufacturing, construction and services. at http://www.climateworksaustralia.com/publications.html
[72] ClimateWorks Australia and DRET (2013) Industrial Energy Efficiency Data Analysis - Detailed project results - Other manufacturing, construction and services. at http://www.climateworksaustralia.com/publications.html
[73] ClimateWorks Australia (2010) Low Growth Carbon Plan 2010. ClimateWorks Australia http://www.climateworksaustralia.org/Low%20Carbon%20Growth%20Plan.pdf
[74] ClimateWorks Australia and DRET (2013) Industrial Energy Efficiency Data Analysis - Detailed project results - Other manufacturing, construction and services. at http://www.climateworksaustralia.com/publications.html
[75] COAG (2010) *Improving the Energy Efficiency of Industrial Equipment*. COAG Equipment Energy Efficiency Committee under the auspices of the Australian and New Zealand Ministerial Council on Energy
[76] http://www.environment.gov.au/minister/hunt/2013/sp20131203a.html
[77] Downes, J., Dunstan, C. & Sharpe, S. (2013) *Restoring Power: Cutting bills & carbon emissions with Demand Management. Institute for Sustainable Futures,* University of Technology Sydney. Prepared for the Total Environment Centre.
[78] Australian Energy Market Commission (2012) *Power of Choice Review - Giving Consumers Options in the Way They Use Electricity (Final Report).*AEMC
[79] AIG (2012) Energy Shock Pressure Mounts for Efficiency Action. AIG (http://www.aigroup.com.au/portal/binary/com.epicentric.contentmanagement.servlet.ContentDeliveryServlet/LIVE_CONTENT/Publications/Reports/2012/11426_energy_shock_pressure_mounts_efficiency_action_web.pdf)
[80] The Fifth Estate (2012) Craig Roussac on building data, trigen and the Darwinian principle. The Fifth Estate at http://www.thefifthestate.com.au/archives/39710
[81] The Fifth Estate (2012) Craig Roussac on building data, trigen and the Darwinian principle. The Fifth Estate at http://www.thefifthestate.com.au/archives/39710
[82] This program has now become the Department of Resources, Energy and Tourism's Energy Efficiency Opportunities Program.
[83] Smith, M (2011) Water Efficiency Opportunities – Best Practice Guide – Petroleum Refining. ANU Fenner School of Environment and Society and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities.
[84] von Weizsäcker, E., Lovins, A. and Lovins, H. (1997) Factor Four: Doubling Wealth, Halving Resource Use, Earthscan, London
[85] Amcor (undated) *Environmental Sustainability – Water Use*. Amcor at .http://www.amcor.com/about_us/sustainability_amcor/environmental_sustainability/64347357.html
[86] The Pacific Institute (1999) *Sustainable Use of Water California Success Stories*, The Pacific Institute.
[87] DEWHA (2010) *Prime Minister's Water Award Finalists*. DEWHA Water Efficiency Opportunities Program at http://www.environment.gov.au/water/publications/urban/pubs/pm-waterwise-award-finalists.pdf.
[88] Taylors Clare Valley (undated) Environmental Achievements. Taylors Clare Valley. http://www.taylorswines.com.au/environment
[89] Smith, M (2011) *Water Efficiency Opportunities – Best Practice Guide – Wineries*. ANU Fenner School of Environment and Society and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities.
[90] http://thebusinessjournal.com/news/energy-and-environment/9593-grundfos-slashes-water-demand-by-80-percent
[91] Cohen, R., Ortez, C. and Pinkstaff, C. (2009) *Making Every Drop Work: Increasing Water Efficiency in California's Commercial, Industrial, and Institutional (CII) Sector*, NRDC.
[92] Muller Industries (2009) '5 Stars for Melbourne University', Muller Industries Press Release, www.mullerindustries.com.au/home/newsApr2009_2.shtML,
[93] Ibid.
[94] von Weizacker, E., Lovins, A.B. and Lovins, L. H. (1997) *Factor 4: Doubling Wealth, Halving Resource Use*, Earthscan, London.
[95] Caroma (undated) 'Caroma Dual Flush System', www.caromauk.com/innovate/idea_1.htm, accessed 12 July 2009.
[96] Smith, M. and Stasinopoulos, P. (2010) Water Transformed: Sustainable Water Solutions for Climate Change Adaptation, Australian National University, Griffith University, The Natural Edge Project. http://www.naturaledgeproject.net/WaterTransformed/TNEP-WaterTransformed-Lecture7.2.pdf
[97] Hawken, P., Lovins,A.B. and Lovins, L.H. (1999) *Natural Capitalism,* Earthscan, London, Chapter 11: Aqueous Solutions, Available at http://www.natcap.org/images/other/NCchapter11.pdf.
[98] Cohen, R., Ortez, C., Pinkstaff, C., (2009) Making Every Drop Work; Increasing Water Efficiency in California's Commercial, Industrial, and Institutional (CII) Sector. NRDC. http://www.nrdc.org/water/cacii/files/cii.pdf
[99] von Weizsäcker, E., Hargroves, K., Smith, M., Desha, C. and Stasinopoulos, P. (2009*) Factor 5: Transforming the Global Economy through 80% Increase in Resource Productivity*, Earthscan, London.
[100] Smith, M. and Stasinopoulos, P. (2010) Water Transformed: Sustainable Water Solutions for Climate Change Adaptation, Australian National University, Griffith University, The Natural Edge Project. http://www.naturaledgeproject.net/WaterTransformed/TNEP-WaterTransformed-Lecture7.2.pdf
[101] Sydney Water (2009) Waterless Woks: Factsheet, Sydney Water
[102] Sydney Water (undated) 'Factsheet: Spray Nozzles', Sydney Water
[103] Sydney Water (undated) 'Factsheet: Spray Guns', Sydney Water
[104] Sustainability Victoria (2006) 'Fact Sheets and Calculation Fact Sheets: Boiler Optimisation', Victorian State Government, Australia; Sydney Water (2004), 'Solutions: Steam Systems – Recycle and Save', *The Conserver*, no 6, pp15-16.
[105] Smith, M. and Stasinopoulos, P. (2010) Water Transformed: Sustainable Water Solutions for Climate Change Adaptation, Australian National University, Griffith University, The Natural Edge Project. http://www.naturaledgeproject.net/WaterTransformed/TNEP-WaterTransformed-Lecture7.2.pdf
[106] http://www.naturaledgeproject.net/WaterTransformed/TNEP-WaterTransformed-Lecture6.3.pdf

[107] 'Smith, M. (2010) Water Transformed - Australia: Sustainable Water Solutions for Climate Change Adaptation – Constructed Wetlands, ANU, Griffith University, The Natural Edge Project (TNEP), Australia.' http://www.naturaledgeproject.net/WaterTransformed/TNEP-WaterTransformed-Lecture7.2.pdf
[108] Smith, M (2010) Industrial Water Treatment and ReuseTechnologies. Factsheet. Commonwealth Government of Australia at http://www.environment.gov.au/water/publications/urban/fs-water-treatment.html
[109] Ibid.
[110] Stephenson, T. Judd, S. Jefferson, B. Brindle, K (2006) *Membrane Bioreactors for WasteWater Treatment.* IWA Publishing. London
[111] Zagorodni, A. (2006) Ion Exchange Materials: Properties and Applications, Elsevier, Amsterdam
[112] Smith, M., (2010) Water Transformed - Australia: Sustainable Water Solutions for Climate Change Adaptation – Constructed Wetlands, ANU, Griffith University, The Natural Edge Project (TNEP), Australia.' http://www.naturaledgeproject.net/WaterTransformed/TNEP-WaterTransformed-Lecture6.3.pdf
[113]Californian Energy Commission (2005) *California's Water–Energy Relationship*, Californian Energy Commission, www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF
[114] von Weizacker, E., Lovins, A.B. and Lovins, L. H. (1997) *Factor 4: Doubling Wealth, Halving Resource Use*, Earthscan, London, pp 85.
[115] Cohen, R., Ortez, C., Pinkstaff, C., (2009) Making Every Drop Work; Increasing Water Efficiency in California's Commercial, Industrial, and Institutional (CII) Sector. NRDC. http://www.nrdc.org/water/cacii/files/cii.pdf
[116] ibid.
[117] ibid
[118] World Economic Forum (2013) Global Risks Report. WEF at http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2013.pdf
[119] Prior, E et al (2007) Global mining physical impacts of climate change on 12 major mining companies. Thematic Investing, Citigroup.
[120] Leslie, L.M., Leplastrier, M. & Buckley, B.W. (2008) 'Estimating future trends in severe hailstorms over the Sydney Basin: a climate modelling study', *Atmospheric Research*, no. 87, vol. 1, pp. 37-51
[121] IPCC (2007a) cited in McInnes, K & O'Farrell, S. (2007) *Sea Level Rise*. In 'Climate Change in Australia: Technical Report 2007', CSIRO,
[122] The lower temperature estimates align with the low-emission scenario (similar to a 450-500 parts per million CO2-equivalent path). The higher temperature estimates align with a high emission scenario (similar to the world's current emissions path).
[123] Hennessy, K., Lucas, C., Nicholls, N., Bathols, J., Suppiah, R. and Ricketts, J. (2006) *Climate Change Impacts on Fire-Weather in South-East Australia, Consultancy Report for the New South Wales Greenhouse Office, Victorian Department of Sustainability and Environment, Tasmanian Department of Primary Industries, Water and Environment, and the Australian Greenhouse Office*. CSIRO Atmospheric Research and Australian Government Bureau of Meteorology.
[124] Smith, M (2013a) *Assessing Climate Change Risks and Opportunities for Investor Guides - Oil and Gas Sector/Mining and Mineral Processing/Manufacturing/Construction and Property Sectors* at Investor Group on Climate Change, Sydney at http://www.igcc.org.au/assessing_risks
[125] Smith, M (2013a) *Assessing Climate Change Risks and Opportunities for Investor Guides - Oil and Gas Sector/Mining and Mineral Processing/Manufacturing/Construction and Property Sectors* at Investor Group on Climate Change, Sydney at http://www.igcc.org.au/assessing_risks
[126] Cutler, T. (2008) *Venturous Australia – Building Strength in Innovation*. Cutler & Company and DIISR
[127] Department of Industry, Innovation, Climate Change, Research, Science, and Tertiary Education (DIICCSTRE) (2012) *Prime Minister's Taskforce on Manufacturing Report – Smarter Manufacturing for a Smarter Australia*. DIICCSTRE