Doubling Energy & Resource Productivity by 2030 –

A "How to Guide" for Policy Makers

Report 2 of 3

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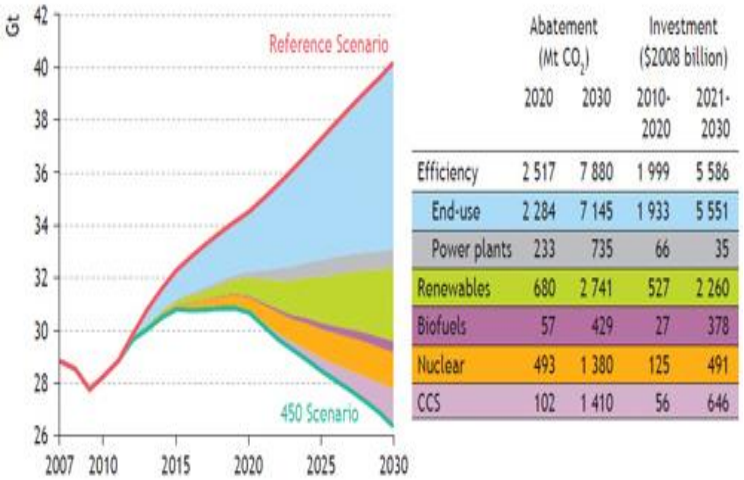
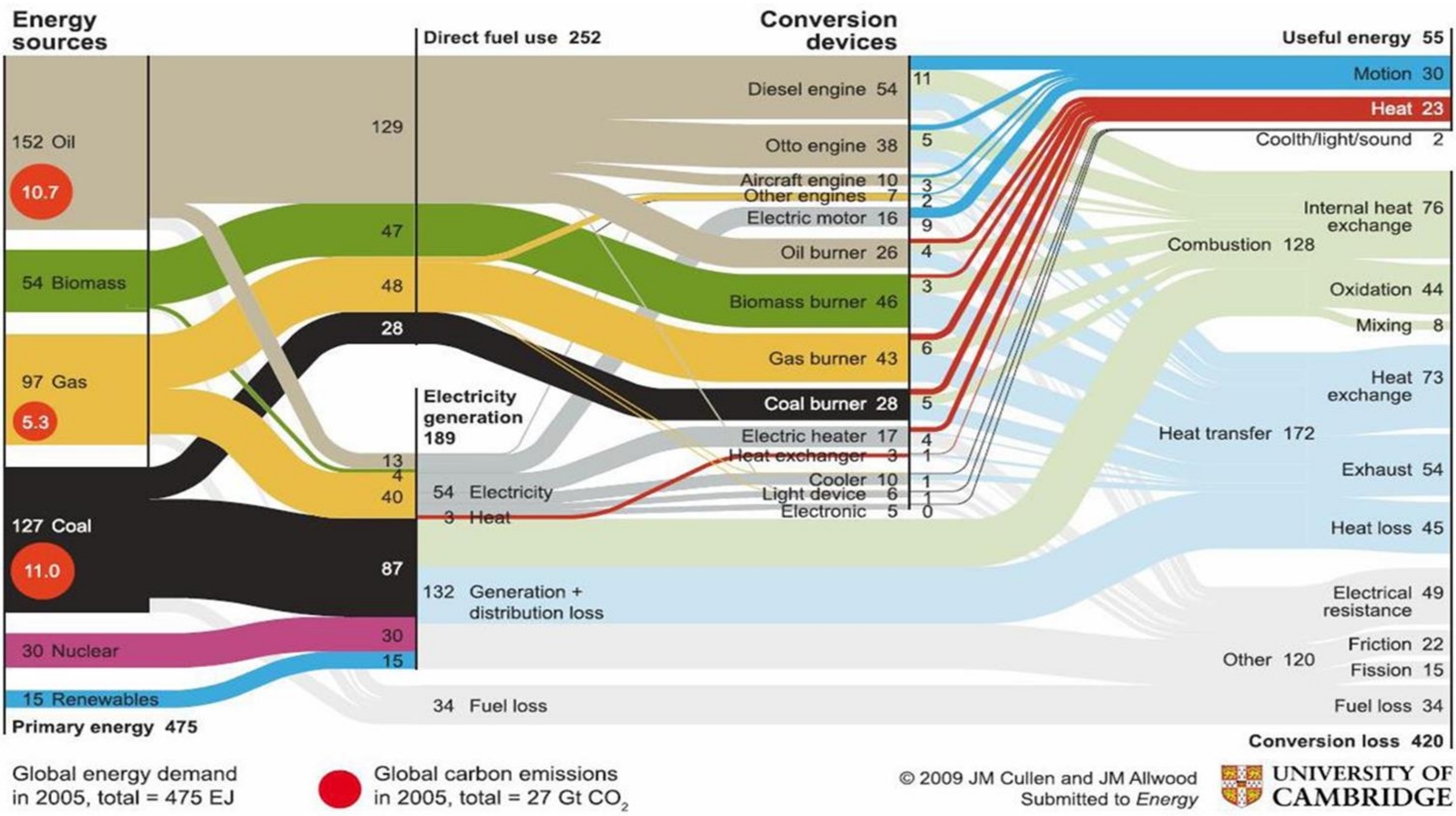


	Abatement (Mt CO_2) 2020	Abatement (Mt CO_2) 2030	Investment ($2008 billion) 2010-2020	Investment ($2008 billion) 2021-2030
Efficiency	2 517	7 880	1 999	5 586
End-use	2 284	7 145	1 933	5 551
Power plants	233	735	66	35
Renewables	680	2 741	527	2 260
Biofuels	57	429	27	378
Nuclear	493	1 380	125	491
CCS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



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Executive Summary

There is great interest amongst policy makers in how to unlock new sources of economic and jobs growth. This Report #2 compliments Report #1 by providing a "How to Guide" for policy decision makers to add a focus on improving energy and resource productivity their national productivity agenda's. As Report 1 showed, a focus on energy and resource productivity could boost cumulative global GDP economic growth by >US$25-30 Trillion by 2035 compared to BAU. This may seem unrealistic to some, but consider the following;

- **Energy Productivity** - The International Energy Agency (IEA)'s modelling in the 2012 World Energy Outlook suggests that investment of $US 11 trillion (in year 2011 dollars) in all economically viable energy efficiency opportunities will boost cumulative global GDP growth as much as US$18 Trillion by 2035 above BAU and reduce fuel costs by US$7 trillion by 2035[1].
- **Water Productivity** – Investments in water productivity also boosts economic growth and, like with energy productivity, they reduce the amount of expensive supply infrastructure needed. *"The annual cost of ensuring all globally have access to clean water through investing in more large-scale centralized dams and treatment plants would cost around US$180 billion per annum to at least 2025. However, this figure can be reduced to an annual cost of US$10–25 billion, if the emphasis is on investing in (water productivity) – namely water efficiency, demand management, rain & stormwater harvesting and water recycling at appropriate scale*."[2]
- **Non-Renewable Resource Productivity – A Transition to a Circular Economy:** Improving resource productivity through a transition to a circular economy could add US$1 Trillion per annum to global GDP by 2025[3]. Cumulatively, from 2015- 2035, this could increase global GDP US$5-10 Trillion.
- **Increase Natural Resource Productivity:** Studies also show that the economic costs of food waste, land degradation, and unsustainable management of wild fisheries are respectively around US$1 Trillion, EU$1.4-3.4 Trillion and US$50 Billion per annum. Therefore addressing these issues could conservatively add US$500 billion to US$1 trillion dollars per annum to global GDP (or cumulatively at least US$10 trillion extra to global GDP) by 2035 compared to BAU whilst helping to improve food security.
- **Investing in energy and resource productivity can also simultaneously unlock additional sources of labour and capital productivity growth** through improved rates of production, quicker returns on capital expenditure, reduced maintenance costs and other co-benefits including avoided capital misallocation.[4] **Improving energy and resource productivity can also lead to jobs growth** because focusing on labour intensive efficiency opportunities creates significantly more jobs than capital intensive "supply side" investment in new power stations, dams or desalination plants.

Based on the findings in Report #1 – this report recommends the following;

- **Recommendation #1 – Nations adopt targets to Double Energy and Resource Productivity by 2030.** This report recommends nations adopt both an energy and a resource productivity target because of the well documented energy-water-resource nexus meaning that many resource productivity improvements also enhance energy productivity and vice versa. It shows, in each of the sub-sections below, that some nations are already now adopting both energy and resource productivity targets. This report references many studies [See BOX 1 in Report #1] showing the technical potential of nations to achieve a doubling of energy and resource productivity by 2030-2035. The report also shows that leading nations have more than doubled their energy and resource productivity in the last 15 years.
- **Recommendation #2 - Prioritise "Economic Growth" and "Jobs" enhancing Climate Change Mitigation Strategies** To i) achieve rapid reductions in emissions and ii) build political will for strong action on climate change– International Energy Agency and Global McKinsey Institute reports also suggest that a focus on energy and resource productivity can achieve the majority of the required global climate change mitigation by 2020 and 2030 whilst enhancing economic growth, business competitiveness and jobs.
- **Recommendation #3 - Review and Implement Smart Policy Reform to simultaneously Enhance Economic, Environmental and Security goals. This report provides options for policy makers of how to do this** complimenting the OECD publications which show that smart environmental policies enhance firm level and national productivity growth, whilst also helping reduce environmentally and resource related security risks in the 21st century[5]. This report evidences the value of developing and implementing smart policy reforms to underpin the achievement of doubling energy and resource productivity by 2030.

Doubling Energy and Resource Productivity by 2030 – A "How to Guide" for Policy Makers

Step #1 Doubling Energy Productivity by 2030

Energy productivity is defined as the output and quality of goods and services per unit of energy input. It means we can produce more of the same things (or have a bigger profit) using the same amount of energy. This differs from energy efficiency, which means using less energy to deliver the same service. However, energy efficiency can actually improve energy productivity for companies and countries. On an economic level, energy productivity is the GDP countries produce for every unit of energy they consume. Globally, the current rate of energy productivity improvement is around 1.3%. This is not sufficient to keep up with rising global energy demand.

1.1 Nations Committing to Energy Productivity Targets

Internationally there is growing recognition of the value of prioritising energy productivity as a strategy to improve national productivity (Table 1).

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
Singapore	Aims to achieve a 35% improvement	2005	2030
Japan	30% energy efficiency improvement	2003	2030
South Korea	46% energy intensity reduction	2007	2030
EU	Energy efficiency to save 27% of EU energy consumption	2012	2030
USA	Double energy productivity by 2030	2010	2030

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.*"[6] Hence it is in the interests of all countries to adopt and implement such targets. The Australian Government, in the latest Energy White Paper has committed to developing a national energy productivity plan and deciding on an energy productivity target.

1.2 Technical Potential and Economic Benefits of Doubling Energy Productivity by 2030

Numerous studies show how regions of the world, such as the USA, Australia[7] and the EU, through a focus on energy productivity could double energy productivity by 2030, and could significantly boost GDP. For instance,

- President Obama has already convened a national taskforce on this topic and adopted a commitment to double US energy productivity by 2030[8]. study shows that a doubling of energy productivity by 2030 is technically possible and would boost US GDP growth by 2% per annum above business as usual, achieving per annum savings of US$327 billion per year, reducing oil imports as well as significant greenhouse gas reductions.
- ClimateWorks Australia's detailed bottom up 2015 modelling study on the *Energy Productivity Potential for Australia*[9] shows that *"the (technical) potential exists to nearly double the energy productivity of the Australian economy by 2030 by investing in the modernisation of our energy system and taking advantage of recent technological developments. This would mean almost double the economic output (in terms of GDP) for every unit of energy consumed in 2030."*[10] A2SE and partners UTS and ANU have similar shown in the *Doubling Energy Productivity by 2030 Technical Foundations* report that Australia could double its energy productivity by 2030.[11]

- The IEA estimates that, if the EU doubled energy productivity by 2030 it would create at least 1.1% per annum of additional GDP in the EU.[12] EcoFys has led a new 2015 study[13] evidencing how the EU could technically double energy productivity by 2030. Under their high Energy-Productivity Growth Scenario, the average European consumer would pay around €82.45 per month in energy costs, down from the average €123.27 today making such a scenario highly politically attractive.

There are a myriad of ways to improve energy productivity of national economies because, as shown in Report #1, currently, globally only 11% of primary energy is converted actual useful physical work that contributes to economic growth. The correct engineering way to describe this is that the global economy's exergetic efficiency is around 11%. 89% of primary energy is currently lost as energy conversion losses. Further evidence for the potential to improve energy productivity is shown in Figure 1 and Table 1, where there is a significant difference in energy productivity performance amongst OECD nations.

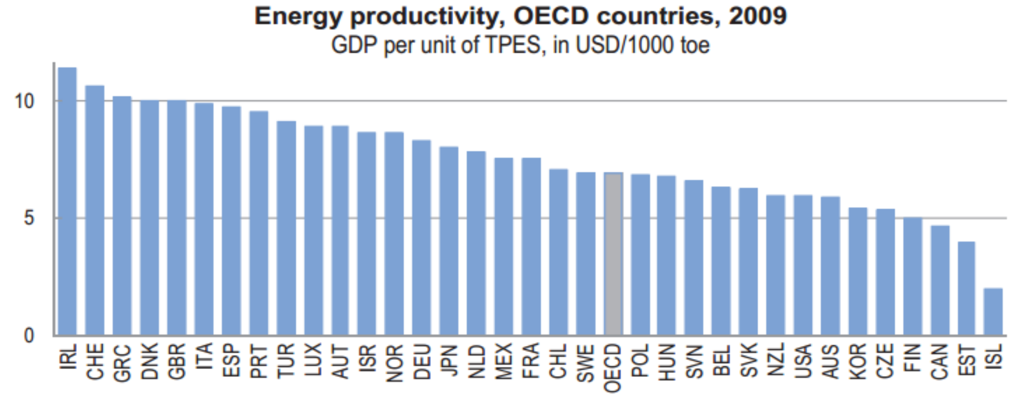

Figure 1: Energy Productivity, OECD Countries, 2009.GDP per unit of TPES, in USD/1000 toe (Source: OECD, 2011[14])

If a broader cross section of nations is considered the difference in performance is even greater. (Table 2) A 2011 World Bank comparison of country by country energy productivity (GDP per unit of energy use (PPP $ per kg of oil equivalent)) performance found that Hong Kong had the highest energy productivity at $23.8 per kg of oil equivalent, with Trinidad and Tobago one of the lowest at $1.8 per kg of oil equivalent. Australia and USA were ranked well down at #77 and #90 respectively in terms of with energy productivity compared to all other nations suggesting room for improvement. (See Table 2 below which provides a selection of countries and their energy productivity).

Table 2: Country by country energy productivity (GDP per unit of energy use (PPP $ per kg of oil equivalent) performance

Rank-ing	Country	Energy Productivity	Rank-ing	Country	Energy Productivity	Rank-ing	Country	Energy Productivity
1	Hong Kong SAR, China	23.8	**27**	Turkey	11.7	**50**	Netherlands	10
4	Switzerland	16.9	**28**	Ecuador	11.6	**51**	Jordan	9.9
6	Ireland	15.6	**29**	Singapore	11.6	**52**	Indonesia	9.8
15	Denmark	13.2	**33**	Austria	11.3	**55**	France	9.6
17	Costa Rica	12.9	**35**	Greece	11.2	**56**	Japan	9.5
18	Italy	12.7	**36**	Luxembourg	11.2	**63**	Sweden	8.5
19	Bangladesh	12.6	**37**	Germany	11.1	**71**	India	8

20	Botswana	12.6	**40**	Norway	10.9	**72**	Malaysia	8
21	Morocco	12.6	**44**	Brazil	10.4	**75**	Belgium	7.7
22	United Kingdom	12.3	**45**	Chile	10.4	**76**	New Zealand	7.7
23	Portugal	12.2	**47**	Mexico	10.2	**77**	Australia	7.6
						88	Cambodia	7.2
25	Spain	12.1	**49**	Isreal	10.1	**90**	United States	7.1

(Source: World Bank, 2011[15])

Many studies suggest that all countries, even Hong Kong[16], still have significant potential technically to significantly improve their energy productivity performance in many ways including the following;

(1) **Energy productivity, firstly, can be improved by improving end use energy/exergetic efficiency**. For instance, according to the International Energy Agency, McKinsey Global Institute, the International Panel on Climate Change and other reputable sources:

- New buildings can be designed to achieve 50-90% energy efficiency whilst existing buildings can be retrofitted to be at least 20% more efficient.[17]
- Potential exists with LED lighting, which uses up to 80% less electricity than incandescent lighting to cut electricity demand globally by close to 10% whilst providing the same or better service.
- According to the IEA, "The energy intensity of most industrial processes is at least 50% higher than the theoretical minimum determined by the laws of thermodynamics."[18]
- According to the IEA, potential exists to improve the energy efficiency of motor driven systems by 30-50% enabling over time a reduction in global electricity demand of 10%."[19] (See BOX 1 for more detail)

BOX 1 – Potential Global Energy Efficiency Improvement of ~70% by 2050

Studies have shown since 1997 that the theoretical technical potential to improve the energy efficiency by 2050 of newly designed and optimised end use energy using technical systems is in the order of 50-80% (Factor 2-5).[20] This was again shown in 2011 by a team from the University of Cambridge[21]. They analysed the buildings, vehicles and industry around us and applied "best practice" energy efficiency changes to them. They found that 73 per cent of global energy use could be saved by introducing such changes. By 2050, most energy using technologies (lighting, appliances, office equipment, transport vehicles etc), buildings and plants are replaced, rebuilt or significantly retrofitted. Hence their study shows significant energy demand reduction potential by 2050. Julian Allwood, one of the lead authors of the study stated that "*Many people are unaware of the scale of opportunities for reducing energy demand. By showing how global energy demand can fall to a quarter of its current level without any decline in services by 2050, the team hope to redress the balance. We think it's pretty unlikely that we'll find a good response to the threat of global warming on the supply side alone. But if we can make a serious reduction in our demand for energy, then all the options for changing the energy supply system look more realistic, as renewable energy systems only need to produce a quarter of the energy being currently produced.*"

(2) Energy productivity can also be improved by improving energy conversion/exergetic efficiency of energy supply systems by:

- Improving electricity power plant energy efficiency from typically around a 30-35% energy conversion efficiencies to higher rates through technologies such as co-generation.

- Investment in combined heat and power could meet 10% of future global electricity demand at significantly higher energy conversation efficiencies than current power stations. (IEA, 2011)
- Utilising hydropower which has energy conversion rates of around 70-80%.
- Investing in wind power which has conversion efficiencies of up to 59%.
- Investing in onsite renewable systems (solar thermal, solar PV powered heat pumps, renewably powered co-generation) to meet onsite electricity and heating and cooling demand. This has significantly higher energy conversion efficiencies compared to using electricity from fossil fuel based power stations for onsite heating and cooling.

(3) Energy productivity of the transport system can be improved by the following.

- **Transport vehicle efficiency:** improved engines/drivetrains, dynamic breaking, advanced lightweight materials, and improved aerodynamics means that new cars, light weight vehicles, trucks, buses, motorbikes, ferries, are available now with double the fuel efficiency of vehicles available a decade ago.
- **Air-Travel efficiency:** Airlines have improved energy efficiency by 70% on average over the last 50 years, but further efficiency improvement is technically possible by 2050. Through design and technical innovations it is possible to improve the average aircraft energy efficiency by 50% by 2050.
- **Modal shifts to more efficient forms of passenger transport:** In most OECD cities, the majority of trips/commutes are 5 kilometres or less by car and thus could be done by walking, cycling or public transport or a combinations of these. Cities, like Barcelona, which encourage walking and public transport usage, also have significantly lower greenhouse gas emissions per capita than most OECD cities.
- **Modal shifts to more efficient forms of freight transport**. Shifting freight transport from trucks to rail or shipping results in large energy efficiency savings of 75 and 85 per cent.
- **Intelligent transport systems** – which utilise real time logistics information to optimise driver routes/speeds and matching of freight vehicle supply to demand and optimise transport systems to help public transport systems better match supply and demand with customers to provide a more effective service.

Energy productivity can also be improved by reducing the need for

- **Traditional transport of goods and service in the first place** through email/dropbox/video-conferencing/electronic billing/online education and health services.
- **The daily commute to and from work** through, utilising IT and video conferencing enabling staff to work a day or two days a week from home.

These measures can enable mobility services/needs to be met using significantly less energy (and energy costs) so achieving an improvement of energy productivity. It is important to note that these measures, outlined above, can also help improve economic growth/productivity through reducing air-pollution, urban congestion and health costs from diseases of physical inactivity, which respectively cost the global economy US$3.5[22] Trillion, US$2-4.3 Trillion[23], and >$4 Trillion[24] per annum. A number of cities (Barcelona (Spain), Copenhagen (Denmark), Amsterdam (Netherlands), Freidberg (Germany), Curitiba, Brazil) are demonstrating what is possible through making the effort to reform urban and transport planning to enable cities to be walkable, cyclable and lift the percentage of trips being made by public transport. A number of nations, such as China and Germany, are investing in the rail freight networks to enable a model shift in freight transport. And finally, a number of countries are investing in very fast internet infrastructure and very fast train infrastructure to enable model shifts away from air transport through video-conferencing and very fast trains. For instance, the very fast train between London and Paris has reduced air-travel between those two cities significantly.

In addition to these strategies energy productivity can also be improved through new business models and strategies such as vertical integration to enable greater value adding resulting in higher value goods and services per unit of energy used. The Alliance to Save Energy (A2SE) and partners, like UTS and ANU's *Doubling Energy Productivity by 2030 – Technical Foundations* report[25] explores these and other additional ways to improve energy productivity.

1.3 Policy Options to Underpin Doubling Energy Productivity by 2030

A range of studies show that Australia and other nations can achieve this target using existing technologies (Saddler et al, 2014[26], CWA, 2015,and EcoFys et al 2015[27], USA Energy Productivity Roadmap[28]) in ways that significantly boost national economies and jobs. Australia and other countries can learn from nations and regions which have significantly improved their energy productivity such as California where their regulatory environment has helped Californian business become leaders in the clean tech industry. To realise a doubling of energy productivity**,** there are significant market and non-market barriers to improving energy efficiency and electricity demand management which need to be addressed, to compliment other measures. These include the following.

- **Imperfect and asymmetric information -** A large percentage businesses have reported that a lack of skills and lack of relevant and reliable information are significant barriers to identifying and implementing energy efficiency opportunities.[29]
- **Split Incentives –** This market failure is significant especially in the building and manufacturing sectors.
- **Lack of access to capital.** This is particularly relevant for SME businesses and low income households.
- **Perverse subsidies.** For instance, "off peak" overnight pricing for electricity appears to be a factor overnight electricity usage being remarkably high in many nations. This suggests significant energy efficiency opportunity.
- **Current regulatory practices for National Electricity Markets.** For example, the Australian National Electricity Market's flat-tariff pricing insulates high "peak demand time" electricity users resulting in underinvestment in energy efficiency to reduce peak demand. The Productivity Commission[30], The Garnaut Review[31] and others have shown that Australia could greatly benefit from policy reform in the national electricity market to better incentivise investment in energy efficiency and demand management to meet peak electricity demand more cost effectively. As the Garnaut Review has explained *"A lot of the demand for electricity network infrastructure, for increased investment in transmission, is driven by growing peak demand. The current (national electricity market) regulatory system creates incentives for the sellers of power to increase peak demand, because that will justify more investment on which they get a higher return. Other countries do it the other way; they introduce an incentive to reduce peak demand which means you don't have to invest so much in the system. So, Australia just has to substitute incentives for over investment by the sorts of incentives for economising on investment that other countries have got."*[32] These market failures have been widely documented.[33]

Hence a range of policy reform to is needed to underpin efforts to double energy productivity. If such policy reforms are not implemented, the IEA warns that, under existing policies, two-thirds of the economically viable energy efficiency potential available between now and 2035 will remain unrealised. There is a wide range of policy reforms available to improve energy efficiency and energy productivity some of which are summarised in Table 3 below. A range of policy reform is needed to underpin efforts to double energy productivity. If such policy reforms are not implemented the IEA warns that under existing policies, two-thirds of the economically viable energy efficiency potential available between now and 2035 will remain unrealised.

Table 3 Energy Efficiency, Conversion Efficiency and Demand Management Policy Options to Boost Energy Productivity – A Sample

Energy efficiency and demand management policy options	Economic benefits and international precedents
General	
Reduce fossil fuel subsidies	Currently globally, there is over US$650 Billion per annum in fossil fuel subsidies. This perversely encourages the use of fossil fuels and discourages investments in energy efficiency. A recent report by the IMF found that subsidies to fossil fuel companies total over $4 Trillion per annum subsidy if the costs of unpriced greenhouse gas emissions are included.
Buildings	
Consider tax incentives for energy efficiency retrofits.	Commercial building retrofits have the potential to save OECD economies billions.[34]
Improve government building energy efficiency	Investing in government building energy efficiency could save significant sums in government budgets.[35]
Higher energy efficiency standards in the building code of Australia.	Whilst progress has been made in this area to increase minimum new residential building standards to 5 star in 2006, countries like the Netherlands or German Passivhaus standards require new buildings to be built to the equivalent of ten star energy efficiency.
Develop a pathway towards a step change for energy efficiency for new buildings by 2020.	Studies show that the relative economic cost difference is negligible if nations pursue pathways to achieve a step change in building energy efficiency.[36] In California, for instance, by 2020, all new residential buildings need to be net zero emissions, and by 2030, all new commercial buildings have to be net zero emissions. Many OECD nations have similar targets.[37]
Improve minimum energy performance standards (MePS)	In Australia, MePS will already cut residential building sector energy costs by $5.2 billion (net present value) per annum by the year 2020 compared to BAU from 2000. This program will save the commercial building and industrial building sector over $10 billion per annum by 2020, compared to BAU from 2000.[38] More could be achieved if Australia introduced a high energy performance standard such as Japan's "Top Runner" scheme.
Strengthen Australia's capacity to assess building energy use.	Develop a pathway to enable a significant percentage of commercial buildings to have building information management systems to enable better management of energy usage in this sector. Consider instituting the well advanced UK model for improving building energy usage information and data.[39]
Industry and Manufacturing	
Run a top 100-1000 industrial big energy user energy efficiency program	Most OECD countries as well as China run a top 100-1000 big energy user industrial energy efficiency program which can be very effective at helping to improve energy productivity if designed well.

Expand the "Minimum Energy Performance Standards (MePS) and Equipment Energy Efficiency (E3) programs to all common industrial equipment	To date, most minimum energy efficiency appliance programs have focused on domestic appliances and largely ignored industrial equipment. If industrial equipment was included, it would save billions per annum globally.
Electricity Power Generation and Distribution	
Demand Management policy reforms to reduce peak demand.	Reducing peak electricity demand helps to reduce unnecessary energy supply investment costs thereby helping to improve productivity of the electricity sector and business. In Australia, economic cost savings of peak demand reduction in the National Electricity Market (NEM) are likely to be between $4.3 -11.8 billion over the next ten years.[40] Policy reform in this area involves "*A coordinated suite of reforms, including reform of retail price regulation; the capacity for distributors to include the installation of smart meters as part of standard regulatory arrangements; common meter standards; a capacity for all parties to install meter add-ons or upgrades; and time-based pricing for critical peak periods. Direct load control options would also play a role."*[41]
Review and re-align economic incentives and subsidies to boost energy productivity.	The implementation of cost-based, time of use pricing, would let the price of electricity vary to better reflect the cost of supply under different network demand loads. In particular it gives the consumer a price signal to reduce their consumption of peak electricity
Investigate off river pumped hydro for storage with renewables reduce summer peak	Investment in a relatively small number of off-river pumped hydro schemes, with elevation of at least 800m from top to bottom could take excess solar power midday to pump water uphill. This could then be run downhill for 5 hrs in the evening to meet evening summer peak electricity demand. This could even out the peakiness of demand and improve energy productivity of national electricity grids. Hydro systems have an 80% conversion efficiency.
Encourage electricity supply options with high conversion efficiency	Conversion energy efficiency in power stations has significant room for improvement and currently is only about 30%. By comparison, co-generation has close to 70-80% conversion energy efficiency and can be used for in large, medium and small scale energy applications. Australia is the lowest user of cogeneration of any developed non-nuclear country in the world.

(Sources: Commonwealth Government of Australia, 2010[42] plus referenced sources)

There is also a wide range of policy reforms available to improve energy efficiency and energy productivity in the transport sector (See Table 4)

Table 4 Sample of policy reforms to achieve a step change in transport sector energy productivity

Energy efficiency and demand management policy options	**Economic benefits and international precedents**
Implement economic incentives to encourage more energy efficient vehicle transport	Economic incentives can be implemented in different ways. For instance - One option would be a "fee-bate" scheme that puts a fee on inefficient vehicles and uses that to subsidize the cost of fuel efficient vehicles for customers. Feebates have been implemented in France. - Another option is to make the stamp duty and registration of fuel efficient vehicles cheaper than fuel inefficient vehicles.[43]
Adopt mandatory fuel efficient vehicle standards.	This could benefit some countries which are behind the rest of the world. For instance, in Australia, "*The average carbon dioxide emissions of new Australian cars were 198 g/km, compared to 136.1 g/km in Europe, or a 45 per cent difference.*" [44]
Adopt fuel efficiency standards for the government vehicle fleets.	Using fuel inefficient vehicles adds to government costs yet, in recent years, government fleet buyers still bought vehicles that were relatively inefficient. Many OECD governments have environmental targets of various kinds for their government fleets.[45]
Address information failures	Better promote the "Fuel Efficient Vehicle Guides" and expand it to other forms of transport (ie: light commercial vehicle, trucking, motorbike).[46]
Use economic incentives to encourage a model shift to more energy efficiency freight options.	For instance, significant energy efficiency and greenhouse gas emissions are achievable through encouraging companies to use rail instead of road freight options.
Encourage greater usage of video-conferencing	Governments and larger companies are increasingly using video-conferencing to save time, money and reduce emissions. Video-conferencing results in close to 100 times less greenhouse gas emissions than air travel.
Link transport infrastructure funding to energy efficiency outcomes	Require government infrastructure institutions to assess all proposals for funding of transport projects in terms of how they boost energy productivity.[47]

Step #2 Doubling Water Productivity by 2030

In the twentieth century, the focus of water policies was to simply make more "new" water available for human use through more investment in large scale water supply infrastructure and treatment systems. In this traditional paradigm, the best measure of success was total water delivered or used. But, as Dr Gleick explains,

> "*Society's goal should be not the use of water, but improved social and individual well-being per unit water used. This broader perspective is gaining traction in the water world, as shown by the growing effort to assess basin "productivity" rather than "efficiency."*[48]

Leading water productivity performers are evidencing the economic benefits from focusing on improving water productivity. Other nations can learn from these leaders to help them also improve water productivity.

2.1 Singapore Exceeds Targets - Boosts Water Productivity 10 Fold

Singapore has shown that it is possible to increase water productivity 10 fold (between 1977-2013) and is ranked #1 globally for water productivity performance as a result. Achieving such ambitious water productivity improvements has created the environment within which Singapore businesses have become world leading exporters of "water technologies and services." Seeking to achieve such rapid improvements in water productivity has not harmed economic growth. Singapore has achieved economic growth rates of in excess of 10% over this period. Its population has also grown by a factor of 2.5 in that period from 1.7 million to 4.4 million today. Yet by comparison water use has increased only 5 fold, which is only a 2 fold per capita increase in that 40 year period.

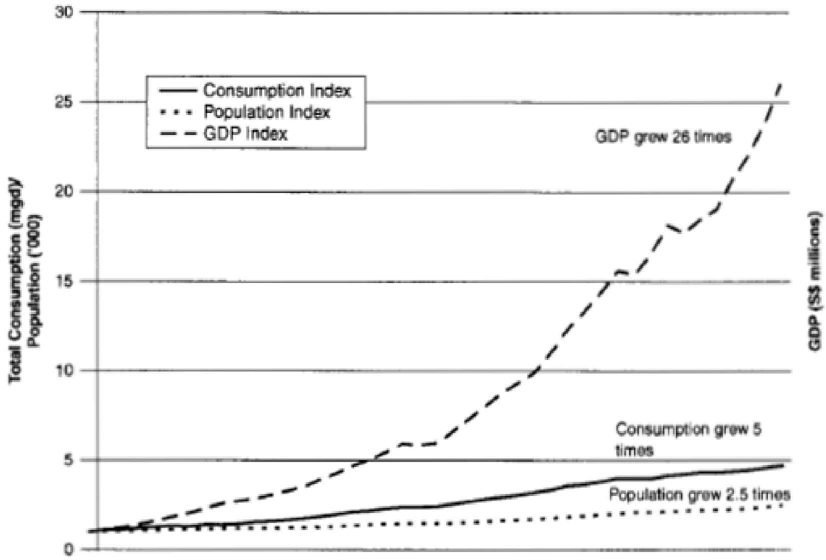

Figure 2 Singapore GDP, population and total water consumption growth (1965-2007) [1965 =1] (Source: Khoo, T, C., 2008[49]).

BOX 2 How did Singapore Increase Freshwater Productivity 10 Fold in 40 years?

The Singapore government, and public water utility, working with the private sector and the community, has achieved this result through a combination of demand side initiatives as well as diversifying water supply options.

Demand Management, Water Efficiency and Reducing Water Leakage

The Singapore government and Public Utilities Board (PUB) have managed to ensure water consumption has not risen with economic and population growth through running effective, purposeful and long-term demand management, water efficiency and water leakage prevention programs. For instance, in Singapore, per capita residential water use fell consistently for 15 years from an already low level of 172 litres per capita/day in 1995. To put this in perspective, the average home and USA citizen, on a comparable per capita income, uses four times more water per day than households and citizens in Singapore. The Singapore government has a publically stated target for residential sector per capita daily water use of 140 litres per capita per day by 2030.[50] Singapore and its Public Utilities Board have also reduced growth in water consumption by minimising water leakage throughout the city's water infrastructure which is tracked by measuring the level of "unaccounted for water (UFW)".[51] Unaccounted for water (UFW) has been reduced by the Public Utilities Board from 9.5% of the total water production in 1990[52] to 5 per cent by 2002. This is a level that no other country can match at present. The fact that unaccounted for water in most Asian urban centres now ranges between 40 and 60% shows the significance of Singapore's achievement.[53]

Substitution of Freshwater Supply with Alternative Water Sources

In addition, over the last 40 years Singapore has reduced absolute freshwater consumption by 60% through developing alternative sources such as extensive stormwater harvesting, treatment and reuse, treated and recycled municipal water, and desalination, to complement their demand management programs. Today, 35% of Singapore's water comes from rainfall captured on its own limited territory, about 15% is high-quality recycled water produced from wastewater by its "NEWater" treatment plants, 10% comes from desalinated water, and around 40% is water imported from Malaysia.[54] In 2010, the Singapore government and its water utility Public Utilities Board announced that it has now committed to replacing the final 40% of freshwater usage with further water efficiency improvements as well as the development of greater levels of water recycling and desalination by 2060.[55]

Other leading top 20 countries for water productivity, such as Israel, have also created an environment where Israeli companies have led the world in innovations for water efficient agriculture such as drip irrigation. Israel has been able to expand agriculture production 9 fold, over the last 40 years, without increasing water usage for several decades. Israel has achieved 70-80% levels of water efficiency in irrigated agriculture through drip irrigation, the highest water efficiency rate in the world, resulting in the highest crop yield per water unit. Whilst ensuring water consumption in agriculture has barely risen since 1960 through investments in water efficiency, Israel has invested heavily in water treatment and recycling so that today 83% of all water used in agriculture is recycled water. Country by country comparisons evidence the potential of many countries to significantly improve their water productivity rates. The below table shows that there is a 34 fold difference between Singapore's water productivity performance and that of the USA. The fact that Australia and the USA are ranked #55th and USA #64th in global water productivity rate rankings also suggests room for improvement.

Table 5: Country by Country Water Productivity ((2011 $GDP/ per cubic meter of total freshwater withdrawal) Performance (Source, World Bank Data)

Rank-ing	Country	Water Productivity	Rank-ing	Country	Water Productivity	Ranking	Country	Water Productivity
1	Singapore	1048	**19**	Israel	100	**38**	Cabo Verde	62
2	Luxembourg	717	**20**	Germany	97	**39**	St. Lucia	62
3	Equatorial Guinea	534	**21**	Seychelles	96	**40**	St. Vincent and the Grenadines	60
4	Denmark	401	**22**	Cyprus	96	**41**	United Arab Emirates	58
5	Qatar	292	**23**	Austria	95	**42**	Djibouti	54
6	Maldives	288	**24**	Czech Republic	90	**43**	Japan	53
7	Ireland	275	**25**	Gabon	83	**44**	Uganda	49
8	United Kingdom	197	**26**	Angola	83	**45**	Korea, Rep.	47
9	Congo, Rep.	189	**27**	Trinidad and Tobago	83	**46**	Benin	46
10	Switzerland	182	**28**	France	74	**47**	Lesotho	46
11	Sweden	167	**29**	Botswana	73	**48**	Comoros	45
12	Malta	131	**30**	Puerto Rico	71	**49**	Latvia	42
13	Finland	130	**31**	Croatia	71	**50**	Pacific island small states	41
14	Antigua and Barbuda	122	**32**	Netherlands	67	**51**	Fiji	41
15	Slovak Republic	120	**33**	Grenada	67	**52**	Slovenia	40
16	Iceland	115	**34**	Belgium	67	**53**	Bosnia and Herzegovina	39
17	Norway	112	35	Bahrain	65	**54**	Italy	38
18	Brunei Darussalam	109	36	European Union	63	**55**	**Australia**	38
			37			**63**	Canada	31
						64	**USA**	30

2.2 Technical Potential and Economic Benefits of Doubling Water Productivity

Investing in water productivity boosts growth by reducing water leakage, improving water efficiency and avoiding unnecessary investment in water supply infrastructure. Some developing country cities have urban water leakage rates of over 50%. Reducing urban water leakage globally could add US$165 Billion to GDP by 2030[56]. Improving water efficiency globally could add at least an additional $120 Billion per annum to global GDP by 2030[57]. For instance, modelling shows that if USA invested US$10 billion in water efficiency programs it could boost GDP by US$13-$15 billion above BAU creating 150-200,000 jobs[58] saving 35 trillion litres of water[59]. There is similarly significant potential to improve water productivity in most OECD countries including Australia, where there is a four-fold difference in national water productivity performance between best and worst performers. In developing countries significant water productivity gains can be improved by cleaning currently polluted water and ensuring universal access to clean and safe water. This can boost developing country national GDP by 5-15%[60]. Such investments have economic multipliers of 4:1 to 14:1[61]. *"The annual (investment) cost of ensuring all globally has access to clean water through investing in more large-scale centralized dams and treatment plants would cost around US$180 billion per annum to at least 2025. This figure can be reduced to US$10–25 billion, if the emphasis is on investing in (water productivity)*

– *namely water efficiency, demand management, rain and stormwater harvesting and water recycling at appropriate scale*."[62] Hence the draft UN Sustainable Development Goals has as one of its goals "*by 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity.*" [63]

2.3 Water Productivity - Energy Productivity Co-Benefits

A renewed focus on improving water productivity needs to be done in ways that enhance energy productivity. There are numerous ways to improve water productivity whilst also improving energy productivity. Hence, national water productivity initiatives, wisely designed, are critical to helping to realise all potential improvements in energy productivity.

Table 6: Technologies Enabling Simultaneous Water and Energy Savings and Greenhouse Gas Emission Reductions

Sector	Enabling Technologies	Water Saving (%)	Energy Saving (%)
Agriculture	Water and Energy Productivity can be enhanced by *"appropriate selection of crop species, using leaf and straw mulch irrigation scheduling at the farm level, advanced irrigation management: such as regulated deficit irrigation, reducing water leakage, rainwater harvesting and managed aquifer recharge and recovery*."	10-40%	10-40%
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.[64] 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	Up to 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%.[65]	50	Up to 50%
	Water Efficient Appliances: Front loading domestic washing machines are 40-75 per cent more efficient than top loading.[66] Front loading machines also work better because the chemicals are more concentrated and clothes last longer because they are not agitated.	30-50	~50%[67]
	Drought tolerant plants in household gardens and commercial building landscapes: Landscape and garden irrigation accounts for around half of Los Angeles's and Australia's residential water use. The Los Angeles Mayor's new water plan calls for increasing rebates for residential turf removal, giving property owners an incentive to switch from thirsty lawns to drought-tolerant vegetation	50%	
	Hot Water Systems: Domestic hot water systems are designed to meet the water needs of households of 4-6 people in most OECD countries. Yet most OECD homes/appartments now consist of 1-2 people. So designing and installing hot water systems to meet the needs of the actual number of people in households would cut water usage in half. Regarding energy, as the IPCC AR4 explained "*Energy requirements for domestic water heating can be reduced by at least 90 per cent, through a range of cost effective options, including: reducing consumption of hot water; improving thermal properties of hot water systems; recovering lost heat; and selecting low energy consumption hot water systems, such as solar thermal or heat pumps.*"	~50%	Up to 90%

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.[68]	35-50	Up to 50%
Commercial Restaurants	Steam Cookers: Steam cookers provide an effective way to batch-cook food but generating steam is an energy-intensive process. Energy and water efficient US EPA Energy Star qualified steamers have a sealed cooking cavity that consumes a fraction of the energy and water required by traditional open systems. This results in cost savings of roughly $1000 per annum of energy and $1000 per annum for water savings.[69]	90	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/energy-efficient commercial dishwasher's can save 25[70]-40[71] per cent of water and energy usage. Payback period for installing small efficient commercial dishwasher ranges between one and four years.[72]	40	40
	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[73]. 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	25-80
Industrial/ Processing/ Manufacturing	Boilers: There are many strategies to improve the efficiency by which steam is generated from boilers such as; - Optimise improved water treatment and total dissolved solids control to minimise "blowdown" to save energy and save water. - Utilise steam traps[74] and condensate return systems[75] to reduce the loss of water (and associated heat) by collecting water condensed as heat is removed from steam, and returning this condensate to the boiler. - Invest in blowdown heat recovery as the blowdown water contains significant energy that can be recovered - Solar thermal systems can also be used to pre-heat water before it enters the boiler system to further save energy, if sufficient solar resources are available.	Up to 80%[76]	30-50%
	Optimise Flow Pressure: Often equipment is operating at a water pressure or flow rate that is higher than is necessary. By trialling performance it is often possible to determine the optimal profile for water pressure and reduce flow rates saving water and energy.		
	Reducing Rinse Cycles: Rinse cycles employed by industrial and food processing facilities can be adjusted to save water. Reducing the rinse time, number of rinse cycles, and water flow rate, and reusing rinse water on-site, are common techniques for optimizing the efficiency of rinse processes.		
	Replacing liquid ring vacuum pumps with dry vacuum pumps: Vacuum systems are used extensively for gas extraction in the food and beverage sector. Replacing liquid ring with dry vacuum pumps can save a lot of water and energy.		
Water Supply Sector	Reducing water leakage in urban water infrastructure, generating electricity by using turbines in urban pipes with flowing water in urban supply systems or from methane emissions from water treatment plants are just some of the win-win opportunities to improve water and energy productivity.	n.d.a[77]	n.d.a

Energy Supply Sector	Business as usual will see a doubling of water intensity in the energy supply sector by 2030. Conversely a shift to certain renewable energy systems (solar PV, wind, co-generation) would reduce the water intensity of electricity supply.	n.d.a	n.d.a

(Source, NRDC, 2009 + other references cited)

2.4 Policy Options to Underpin Doubling Water Productivity by 2030

In the past couple of decades, California, South Africa, Australia, the European Union, and Russia have all passed innovative water policies, out of recognition of the need for more comprehensive, integrated water management to improve water productivity. As Gleick et al have found "*All water policy reform processes included several similar components, including:*

- *Recognition of persistent water-quality and scarcity problems or risks;*
- *Clarification of institutional roles and responsibilities, such as through formal legislation and changes in water rights; and*
- *Application of more modern economic approaches, including principles of "user pays" and "polluter pays" and "full-cost pricing."*
- *Better water data collection;*
- *Decentralized water decision making;*
- *Increased stakeholder participation";*

Hence, it is reasonable to suggest that the following policy options have been found to be useful to help improve water productivity to date by a number of countries. Hence the following are likely to assist most countries improve their water productivity performance.

Table 7: An Overview Of Policy Options To Improve Water Productivity

1. Phase our water subsidies and move to "full cost" pricing	Low water productivity is often the result of low water prices. In many countries, subsidies lead to irrationally low water prices, creating the impression that water is abundant when in fact it is scarce. Eliminating water and energy subsidies that encourage wasteful water use allows water prices to rise to market levels. Higher water prices encourage all water users to use water more efficiently.
2. Creating a market for water trading	Creating a market for water trading (based on tradable property rights and in combination with a review of existing caps on water extractions).
3. Incentivise water efficiency and water demand management	Transition from a focus on increasing water supply to reducing water demand. Historically, the traditional method of ensuring that rising demand for water was met was through building more centralized infrastructure: dams and reservoirs, pipelines and water treatment plants. This approach has brought tremendous benefits to billions of people, but it has also had serious social, economic, and ecological costs.[78] There is now a rapidly growing body of literature which recommends a more sophisticated approach to meeting water needs focused on an integrated approach of water efficiency, demand management[79] and supply augmentation through decentralised approaches to water reuse and recycling such as rainwater and stormwater harvesting.
4. Provide incentives for more water efficient irrigation	A few small countries— Cyprus, Israel, and Jordan—rely heavily on drip irrigation. Among the big three agricultural producers, this more-efficient technology is used on 1–3 percent of irrigated land in India and China and on roughly 4 percent in the United States.

5. Provide incentives and implement water efficiency labelling to encourage uptake of efficient water using appliances	As shown in Table 6 above, many water efficient appliances can save significant amounts of water and energy improving business and house-holds bottom line, whilst boosting productivity and economic growth.
6. Explore options and apply cost-benefit to decisions on alternative water supply options	There are many options to create a more resilient mix of water supply options from – water treatment and recycling, stormwater and rainwater harvesting, managed aquifer recharge and recovery to name a few. This should be explored with a thorough cost benefit analysis.
7. Map and encourage investment in "win-win" energy/water efficiency nexus opportunities.	Often energy efficiency investments can also save water and vica versa. The most cost effective resource efficiency investments for business are those that save both energy and water. It is widely recognized now that there are many of these "win-win" energy/water efficiency opportunities in each major business sector of the Australian economy. Yet, for Australia, the extent of these business sector nexus opportunities has never been comprehensively mapped or quantified. This "information failure" is holding back better allocation of investment and resources to target these opportunities. This information failure needs to be addressed.
8. Identify and create economic incentives to drive investment in low carbon water productivity initiatives.	Implement a study on how to double national water productivity by 2030 whilst enhancing energy productivity and greenhouse gas emission reductions. Based on this study, identify and implement economic incentives and policy reforms, to double water productivity by 2030 without increasing greenhouse gas emissions
9. Collect More Comprehensive Water Data	Many nations lack an adequate understanding of water supply, use, and flows. All major efforts in recent years of national water policy reform included priorities and funding to improve water data collection and availability.
10. Integrate Climatic Change Risk and Impact Assessment	Unmitigated climate change risks causing significant changes to hydrological rainfall patterns in many nations. In Australia funding through NCCARF has improved understanding of these issues especially at the local and state government level. Yet, in some countries, due to lack of resourcing this is not being included in planning decisions. For instance in the USA, The Government Accountability Office reports that although many federal resource managers understand that climate change impacts are important to the resources that they manage, they have not yet incorporated climate change projections, mitigation, or adaptation efforts into planning (GAO 2009).

(Adapted from Gleick, P et al)

Step #3 Doubling Resource Productivity by 2030

3.1 The Technical Potential and Economic Benefits of Doubling Resource Productivity

Increasingly experts are calling for nations to commit to a doubling of resource productivity by 2030. For instance, the European Resource Efficiency Platform (EREP) in 2014 called upon the EU Commission to set a target to double – at least – resource productivity by 2030 in order to boost competitiveness and improve the quality of life of our citizens.[80] Recent studies show that this is technically possible and would save EU$600 Billion as well as creating between 1.4 and 2.8 million jobs for the EU[81]. Other studies show[82] that if the world shifted to a circular economy this could result in a boost of US$1 trillion each year for the global economy by 2025.

Improving resource productivity through material efficiency, diversifying supply chains, product stewardship and onsite recycling can help business reduce both resource input costs and waste disposal costs. It is in business's interests to minimise these costs, and hence the amount of raw materials and other inputs they need to create their product or provide their service.

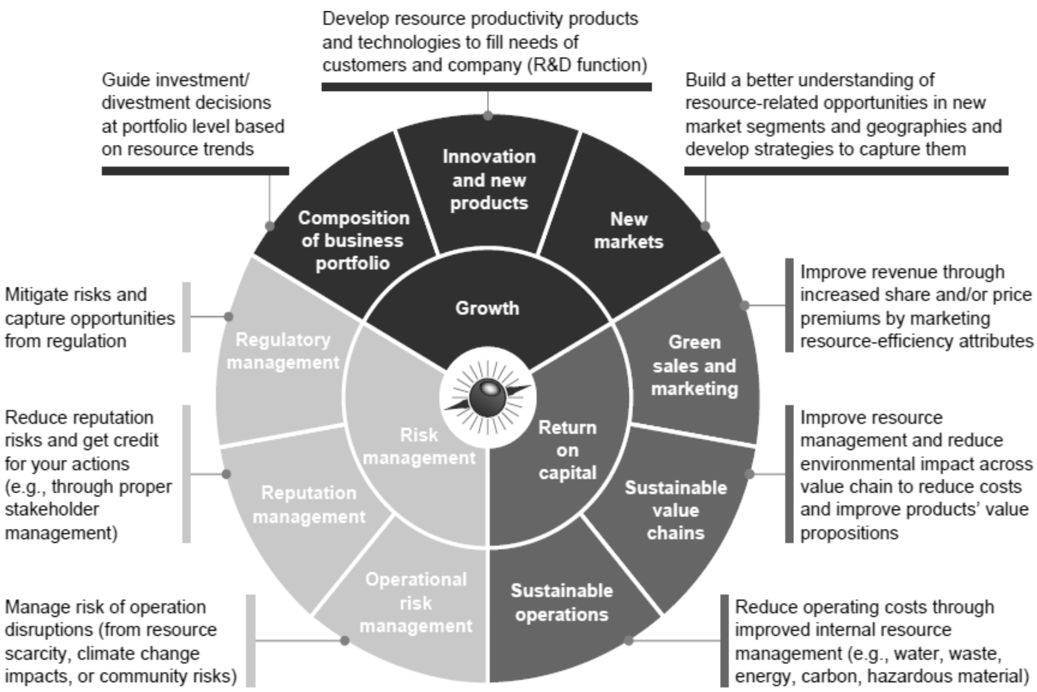

Figure 3 Business competitiveness improved through resource productivity. Source: McKinsey Global Institute (2011)

Business produces useful products and services and waste. It is in individual business's interests to find markets for this 'waste' and/or design industrial processes so that waste is minimised and that which is produced can be used or sold elsewhere. It also makes sense for business to design products and processes so that waste produced can be easily recycled. Diversifying supply chains to increase use of locally recycled materials also helps reduce vulnerability to disruption of increasingly complex global supply chains. Recent extreme weather events have shown that business cash flow is more at risk from supply chain disruption than previously thought. [83] In 2011, a study found that 51% of business supply chains were affected by adverse weather over the past year. Over the previous year, 49% of businesses lost productivity from such disruption, while their cost increased by 38% and their revenue decreased by 32%.[84] For these reasons, there was found to be a strong correlation between competitiveness data and resource productivity (Domestic Material Consumption) from 26 countries by the World Economic Forum which gave a positive relationship between competitiveness index scores and the material productivity of economies.[85] As a result McKinsey Global Institute is recommending now that all businesses focus on improving their resource productivity for pure competitiveness reasons. This has been formally accepted by over 100 large businesses that have committed to transitioning to the circular economy within three years.

Potential to Improve Resource Productivity

There is much evidence to suggest that there is still significant potential to improve resource productivity through strategies such as the following;

- **Firstly, reducing demand for material inputs through greater material efficiency and eco-design:** For instance, enabling technologies such as 3D printing will enable manufacturers this century to make a wide array of products using over 90% less raw materials. Industries increasingly draw on 3D manufacturing for the development of end-use parts. Some 6,500 industrial additive manufacturing production units were shipped to manufacturing customers in 2011, nearly twice as many as in 2005 (McKinsey 2012)[86].
- **Secondly, through remanufacturing:** Remanufacturing produces new goods using a tiny fraction of resources, water and energy compared to manufacturing from scratch using raw materials. Already, it is a global market worth over $600 billion, yet this represents a small percentage of total manufacturing. Hence the potential for growth in re-manufacturing this century is significant especially given the minimal financial and material input into production, remanufacturing services provide lower prices to consumers, typically in the order of 30 to 40 per cent less than comparable new products (Shumon 2010)[87].
- **Thirdly, lifting recycling rates**: Also, globally, there is significant scope to lift recycling rates. Currently, only 25% of the 4 billion tonnes of municipal waste produced each year is recovered or recycled.[88] Only 15% of all e-waste is recycled. Only 1% of rare earth metals are recycled. UNEP research has found that "*On a global scale, the recycling rate in 2050 could be more than three times the level projected under business as usual, and the amount of waste destined for landfills would be reduced by more than 85%.*"[89]
- **Fourth, reducing waste:** A focus on resource productivity can pro-actively address potential long term resource bottlenecks in the 21st century in areas such as food security, water, rare earth metals and phosphorus. For instance, currently,

  - over 30-40% of all food produced globally is wasted.[90] (See BOX below)

  - less than one percentage of all rare earth metals are recycled

  - the global overall recycling rate is 25%, well below national best practice of recycling 70%+ of all waste.

  - less than 10% of all the phosphorus produced in sewerage is recovered.

BOX 5 - Reducing Food Waste

Evidence of the significant potential to improve resource productivity is shown in stark terms by the fact that globally 30-40% of all food produced is lost or wasted.

Significant amounts of natural resources, soil, and freshwater are consumed in the production of food. The Food and Agriculture Organisation published calculations of costs associated with food waste;

> *"In addition to the USD 1 trillion of economic costs per year, environmental costs reach around USD 700 billion and social costs around USD 900 billion. Particularly salient environmental and social costs of food wastage include:*
>
> - *3.5 Gt CO2e of greenhouse gas emissions. Based on the social cost of carbon, these are estimated to cause USD 394 billion of damages per year.*
> - *Increased water scarcity. Globally, this is estimated to cost USD 164 billion per year.*
> - *Soil erosion due to water is estimated to cost USD 35 billion per year through nutrient loss.*
> - *Risks to biodiversity including the impacts of pesticide use, nitrate and phosphorus eutrophication, pollinator losses and fisheries overexploitation are estimated to cost USD 32 billion per year.*
> - *Increased risk of conflict due to soil erosion, estimated to cost USD 396 billion per year.*
> - *Loss of livelihoods due to soil erosion, estimated to cost USD 333 billion per year.*
> - *Adverse health effects due to pesticide exposure, (which) cost USD 153 billion per year."*[91]

This wastes natural resources and reduces the net contribution to nation's productivity from the agricultural sector. Globally the costs of food waste are staggering, as is its contribution to global greenhouse gas emissions. If food waste was a country, it would be the third largest emitter after China and the USA. In January 2012, the European Parliament adopted a resolution to reduce food waste by 50 percent by 2020 and designated 2014 as the "European year against food waste."

Far from being something completely new, a renewed focus on improving resource productivity represents a logical next step building on progress made in the 20th century. In the 20th century, global resource productivity increased roughly 3 fold. The global economy grew 22 fold whilst resource consumption grew 8 fold. And importantly, in the OECD, the rate of resource productivity improvement has increased significantly. By the year 2000, according to the OECD "global per capita material consumption had stabilized".[92] From 1980 to 2007 the material intensity of the global economy decreased from around 1.3 kg per USD (constant 2005 PPP) to just over 0.9 kg/USD. Resource productivity in both G8 and OECD countries has also improved between 1980 and 2008. Between 1980 and 2008 the material intensity of the G8 economies decreased by over 47% while in OECD countries material intensity declined by 42%. Amongst these nations there are some impressive achievements. The OECD has found that "*Since 1980 Canada, Germany, Italy and Japan have experienced an absolute decrease in the level of domestic material consumption (ignoring indirect material imports from trade). Consumption remained relatively flat in France and the United Kingdom. In per capita terms, consumption decreased or remained flat in all G8 countries with the strongest gains made in Japan, Germany, Italy and Canada, respectively. However, there have been significant improvements since 2000. With the exception of biomass for food and agriculture and fossil fuels, absolute decoupling has taken* *place in all material groups, with wood, metals and industrial minerals experiencing the strongest decoupling.'*[93]

There is now a significant difference between the material/resource productivity of these leading countries compared to laggards.

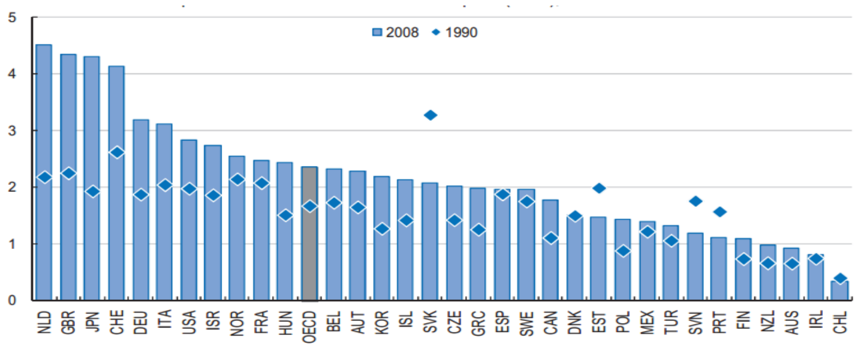

Figure 4: Domestic Material/Resource Productivity, OECD Countries, 1990 and 2008 (Source: OECD: 2011[94])

3.2 Other National Productivity, Health and Job Co-Benefits

Pursuing resource productivity makes broader national economic sense, because the societal risks and potential long term costs of inaction are not insignificant.

3.2.1 Reduces public health and environmental risks from landfill.

Waste decomposing in landfills threatens waterways and drinking water supplies and contaminates the land with a range of chemicals, some toxic and hazardous. Waste in landfill also produces methane gas, a recognised greenhouse gas, when municipal rubbish rots and degrades. Therefore, there are significant societal and environmental benefits from decoupling economic growth from waste production through reducing, reusing and recycling waste. Local government and city councils also gain significant economic benefits from implementing recycling programs, due to the reduced landfill costs.[95] In the economic literature, when these externality costs of waste to landfill are taken into account, recycling has been found to almost always be economically efficient.[96] For instance, a study conducted by the Technical University of Denmark found that in 83% of cases, recycling is the most efficient method to dispose of household waste.[97]

Recycling can also create jobs.[98]

Product life-cycle expert Walter Stahel showed, thirty years ago, that such approaches can also save significant amounts of energy whilst creating more jobs. In his 1981 report *Jobs for Tomorrow: The Potential for Substituting Manpower for Energy,* Stahel showed that: *"Roughly three quarters of all industrial energy consumption is associated with the extraction or production of basic materials, while only about one quarter is used in the transformation of materials into finished goods such as machines or buildings. The converse is true of labour, about three times as much being used in the conversion of materials to finished products as is required in the production of materials."*[99] Hence by shifting to a focus of remanufacturing and a closed loop economy it is possible to both reduce energy and material flows whilst also increasing employment.

Contribution to national GDP:

Recycling industries also contribute significantly to national GDP. Recycling employs over 1.5 million employees in more than 50 countries with an annual turnover exceeding US$160 billion dollars. Recycling processes over 600 million tonnes of commodities annually. A recent international review of life-cycle analysis work on key materials that are collected for recycling clearly demonstrated that recycling usually has more environmental benefits and lower environmental impacts than other waste management options. From 188 scenarios that included recycling, the overwhelming majority (83%) favoured recycling over either landfilling or incineration.[100]

Reduces exposure to resource commodity price shocks:

Despite a general outlook of global abundance in stocks of most resources there are significant risks to the reliable global flows of those resources, in particular:

- Geopolitical risk factors linked to control over resources such as rare earth metals, phosphorus and water. Most of the world's resources in rare earth metals and phosphorus are controlled by just a few countries.
- Commodity price spike risk factors.
- Increasingly frequent, more intense and damaging extreme weather events or drought preventing production and flow of key resources.

3.3 Resource Productivity - Energy Productivity Co-Benefits

Just as there are significant synergies with pursuing water and energy productivity outlined above, there are also strong synergies between pursuing energy and resource productivity. In fact, it is essential that nation's improve resource productivity long term through material efficiency and recycling, to achieve long term energy productivity targets. This is for several reasons.

- Firstly, energy inputs into mineral extraction is rising exponentially due to ore grade concentration declines. Once ore grades reach below 1%[101] the amount of energy, water and material flows required to extract each unit of valuable mineral rises exponentially.[102] Hence, if nations simply rely on extracting their mineral resources from traditional mining, then this will contribute negatively to national energy productivity. Over the last 30 years, the average grade of mined Australian ore bodies has halved[103]. This has already led to a 70% increase in energy consumption per tonne of minerals. (Figure 5)

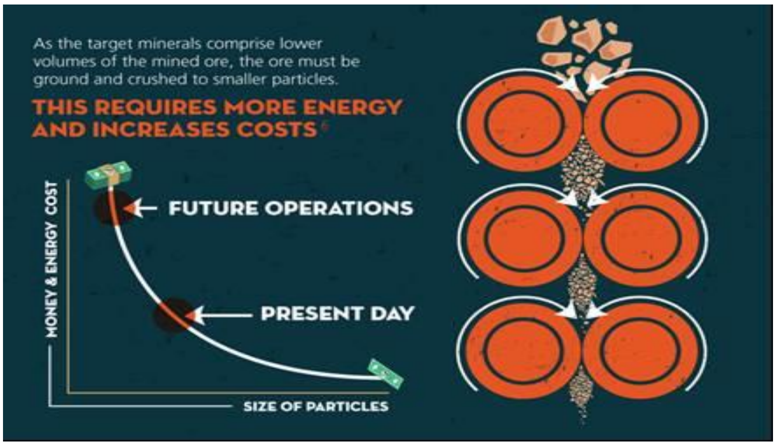

Figure 5: As ore concentrations decline energy requirements increase exponentially. (Source: CEEC, 2012[104])

- Secondly, strategies to improve resource productivity through lifting recycling rates also improve energy and water productivity over the lifecycle of production. Recycling metals and materials yields large energy savings including[105]: Aluminium (95 per cent), Copper, (70-85 per cent), Lead, (60-80 per cent), Zinc, (60-75 per cent), Magnesium, (95 per cent), Paper, (64 per cent), Plastics, (up to 80 per cent)[106] and Glass (60-70 percent)[107]. Such are the potential energy savings that globally, integrated waste management and recycling can contribute an entire "Stabilisation Wedge" (1GtC) to efforts to achieve stabilization of greenhouse gas emissions.[108]
- Thirdly, rare earth metals such as lithium are essential to make cost effective batteries for ultra-energy efficient hybrid vehicles. Rare earth metals are also needed for other low carbon energy systems. Currently, less than one percentage of all rare earth metals are recycled.
- Fourth, the embodied energy and related greenhouse gas emissions of producing construction materials – cement, steel and aluminium, for 3 billion extra people's homes and workplaces by 2050 – would use up 1/3 to 60% the remaining global carbon budget available to avoid crossing two degrees warming.

Clearly, improving resource productivity is essential to also meeting energy productivity and greenhouse gas reduction targets long-term.

3.4 Nations, Regions and Cities Committing to Resource Productivity Related Targets

In recognition of the above, many nations, regions and cities are committing to ambitious resource productivity targets. Japan, China, parts of Europe have formally committed to creating a circular economy. Some parts of Europe have already achieved significant progress. For instance, in Treviso, Northern Italy, 554,000 inhabitants have achieved recycling rates of 85% whilst generating only 53kg of non-recyclable waste per inhabitant and year. By comparison, the EU average level of source separation is 42% and a 285kg per inhabitant and year of residual waste. Their goal is to recycle 96,7% of the waste by 2022 and reduce the residual fration to 10kg per inhabitant that year. Other nations, regions and cities have committed to achieving zero-waste by certain dates. (See Table 6) All represent useful long term targets to provide clear signals to business and the community to encourage uptake of resource efficient technologies and strategies.

Table 6: Examples of Resource Productivity related Targets

Targets	Examples
Circular Economy	**Japan, China, and some EU nations/regions have previously committed to creating a Circular Economy**. For instance, Scotland has joined the Ellen McArthur Foundation's CE100 circular economy group setting a waste reduction goal of 25% (from 2011 levels) by 2025. The EU Circular Economy policy initiative aims to o Increase recycling/re-use of municipal waste to 70% in 2030; o Increase packaging waste recycling/re-use to 80% in 2030 with material-specific targets set to gradually increase between 2020 and 2030 (to reach 90 % for paper by 2025 and 60% for plastics, 80% for wood, 90% of ferrous metal, aluminium and glass by the end of 2030); o Phase out landfilling by 2025 for recyclable (including plastics, paper, metals, glass and bio-waste) waste in non hazardous waste landfills – corresponding to a maximum landfilling rate of 25%; o Reduce food waste generation by 30% by 2025.[109]

Resource efficiency or productivity	**Japan's Sound Material Cycle Society Target** Resource productivity (yen/ tonnes) calculated as GDP divided by amount of natural resources, etc. invested, to be increased from 210,000 in 1990 to 390,000 in 2010 **London Waste Targets from London Plan Draft, Mayor of London** 85% regional self-sufficiency by 2020 (meaning dependency on only local and recycled resources **UK Paper Consumption and Recycling Rates-** The UK paper industry produced 14 per cent less than the previous year. Consumption declined by 10 per cent. The paper recycling rate rose to 90 per cent in 2009 and the collection rate increased by 2 per cent year on year.
Recycling rate/target	**Belgium, Netherlands and Switzerland –** In some EU countries for some materials collection rates for recycling approach 95%, such as for glass where Belgium, the Netherlands and Switzerland exceed 90%.[110] **Singapore -** 60% of household waste to be recycled by 2012 and recycling rate of 70% by 2030 **London Waste Targets from London Plan Draft, Mayor of London** ○ 45% municipal waste recycling/composting by 2015 ○ 70% commercial/industrial waste recycling/composting by 2020 ○ 95% re-use and recycling of C&D waste by 2020 **Denmark's** resource strategy, passed in 2013, aims to lift recycling 50% of all waste by 2022". "Today, only 23% is recycled and the rest incinerated."
Waste landfilled	**New Zealand** became the first country in the world to adopt a national policy of Zero Waste in 2002 **Taiwan** – They aim to achieve 70% MSW minimization and 85% industrial waste minimization by 2020. **Singapore Green Plan 2008-2012 -** Strive towards "zero landfill" and "close the waste loop". **Local Governments adopt Zero Waste Targets and Policies-** Half of all New Zealand local governments, Seven UK local councils, 7 Californian local governments, Toronto, Canada and the Australian Capital Territory, Australia have adopted "zero waste" to landfill targets.[111]

(Source: Adapted and expanded from UNEP, 2011)

3.5 Policy Options to Underpin Doubling Resource Productivity by 2030

3.5.1 Reform national waste policies to incentivise material efficiency, product stewardship, and waste prevention.

To transition to higher levels of resource productivity, the OECD has argued that such targets also need to be supported by traditional national waste policy reform:[112] The OECD has stated that

> *With continuous growth in the global demand for materials and the amounts of waste generated and disposed of, conventional waste policies alone are not be enough to improve material efficiency and offset the waste-related environmental impacts of materials production and use. New integrated approaches – with stronger emphasis on material efficiency, redesign and reuse of products, waste prevention – could be used to counterbalance the environmental impacts of waste throughout the entire life-cycle of materials.*

A number of national waste/resource policy reforms by the following are heading in this direction. European Union's Thematic Strategies on Sustainable Use of Natural Resources[113] and on Waste Prevention and Recycling,[114] Japan's Sound Material-Cycle Society,[115] and China's Circular Economy policy reforms.[116] Common elements of these integrated policies are:

- Targeting primarily the environmental impacts rather than material use per se
- Taking an integrated life-cycle approach
- Increasing use of economic instruments, such as taxes and tradable permits; and
- Building partnerships with stakeholders, rather than using command-and-control approaches.[117]

These integrated policies normally target the most environmentally harmful products, materials and activities. They place stronger emphasis on material efficiency, redesign and reuse of products, recycling of end-of-life materials and products (i.e. considering end-of-life materials and products as resources rather than waste), and environmentally sound management of residues (management standards).

3.5.2 Build markets for recycled products.

Commissioning a study into relevant policy tools to drive local markets for recycled content products is needed to stabilise demand and recyclate commodity price. As a recent report for the Australian Department of Environment found *"Investigating and supporting local markets for recyclate requires:*

- *addressing legislative and perception barriers to using recycled content products*
- *producing 'standards that include recycled materials*
- *researching innovative uses for recycled materials to replace virgin feedstock*
- *introducing specification of recycled content products into government purchasing policies."*[118]

3.5.3 Work with business to help reduce resource input and "waste to landfill" costs through improving knowledge, skills and economic incentives for materially efficient product design and the use of recycled materials.

Fund the development of sectoral business guides to assist business identify and implement cost effective resource efficiency and waste reduction strategies.

3.5.4 Either increase landfill levies or explore policy tools to restrict landfilling of recyclables.

The Commonwealth Department of Environment in Australia published a report recently which found that *"It remains easy for waste generators and collection service providers to dispose of readily recyclable materials to landfill.* Governments *should explore the introduction of restrictions on the landfilling of recyclables. There is significant experience internationally in restricting landfilling of specific materials or products."* [119]

Before restrictions are implemented, another option is to increase landfill levies. This also provides revenue to government which can go into improving incentives to improve overall resource productivity in the economy. In most European countries landfill levies are significantly higher than for most USA and Australian cities which has resulted in higher levels of recycling. Northern Ireland introduced a high levy on plastic bags that reduced their usage by 90% within 6 months. Twenty-five years ago South Australia implemented a levy on soft drink, beverages and milk cartons that has resulted in 85% being recycled

In addition to a levy increase, setting clear timelines for banning categories of waste to landfill gives business time to adjust and the recycling industry time to invest in new infrastructure; this has been shown to rapidly increase recycling rates and be highly economically efficient. 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. [120]

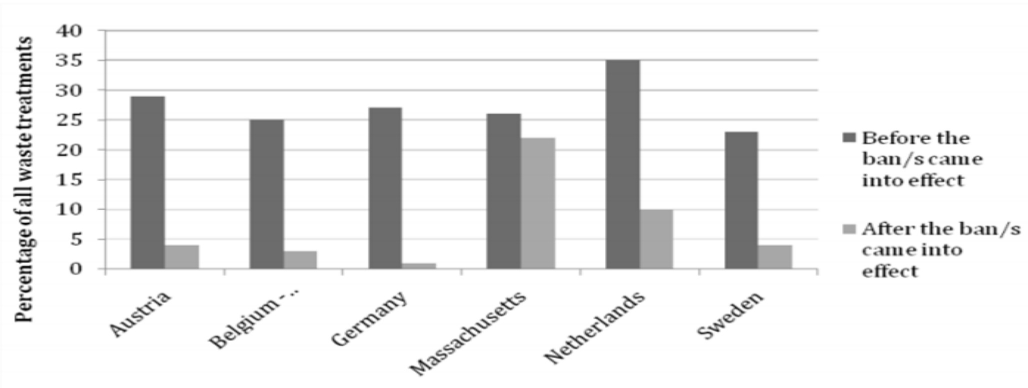

Figure 6: Percentage of Waste Going to Landfill Before and After Bans on Particular Waste Streams. (Source: WRAP, 2012[121])

Government 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.

3.5.5 To underpin the above, build knowledge and understanding of resource and material flows in the national economy to improve identification of resource productivity opportunities.

The OECD is working on two concurrent streams of activity:

1. Improving the quantitative knowledge base, by providing guidance to countries on how to construct material flow accounts and indicators in a coherent framework and by compiling material flow information from existing data sources.

2. Improving the analytical knowledge base, by using material flows information in policy analysis and evaluation, including in OECD country environmental performance reviews, in work on sustainable materials management and in 3R (reduce, reuse, recycle) activities[122].

This is important because existing information is often insufficient to give a coherent view of how different materials flow through the economy (from their extraction or import to their final disposal). Knowledge gaps also remain about waste and recyclable materials. This is why the OECD countries have established a common knowledge and information base on material flows and resource productivity. The objective is to enable sound, fact-based material flow analysis at the national and international level and to inform related policy debates.

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