ENERGY TRANSFORMED:
SUSTAINABLE ENERGY SOLUTIONS FOR CLIMATE CHANGE MITIGATION

MODULE C

INTEGRATED APPROACHES TO ENERGY EFFICIENCY AND LOW EMISSIONS ELECTRICITY, TRANSPORT AND DISTRIBUTED ENERGY

This online textbook provides free access to a comprehensive education and training package that brings together the knowledge of how countries, specifically Australia, can achieve at least 60 percent cuts to greenhouse gas emissions by 2050. This resource has been developed in line with the activities of the CSIRO Energy Transformed Flagship research program, which is focused on research that will assist Australia to achieve this target. This training package provides industry, governments, business and households with the knowledge they need to realise at least 30 percent energy efficiency savings in the short term while providing a strong basis for further improvement. It also provides an updated overview of advances in low carbon technologies, renewable energy and sustainable transport to help achieve a sustainable energy future. While this education and training package has an Australian focus, it outlines sustainable energy strategies and provides links to numerous online reports which will assist climate change mitigation efforts globally.

CHAPTER 8: INTEGRATED APPROACHES TO ENERGY EFFICIENCY AND TRANSPORT

LECTURE 8.1: DESIGNING A SUSTAINABLE TRANSPORT FUTURE
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The Natural Edge Project (TNEP) is an independent non-profit Sustainability Think-Tank based in Australia. TNEP operates as a partnership for education, research and policy development on innovation for sustainable development. TNEP’s mission is to contribute to, and succinctly communicate, leading research, case studies, tools, policies and strategies for achieving sustainable development across government, business and civil society. Driven by a team of early career Australians, the Project receives mentoring and support from a range of experts and leading organisations in Australia and internationally, through a generational exchange model.
The International Energy Agency forecasts that if policies remain unchanged, world energy demand is set to increase by over 50 percent between now and 2030.\(^1\) In Australia, CSIRO has projected that demand for electricity will double by 2020.\(^2\) At the same time, The Intergovernmental Panel on Climate Change (IPCC) has warned since 1988 that nations need to stabilise their concentrations of CO\(_2\) equivalent emissions, requiring significant reductions in the order of 60 percent or more by 2050\(^3\). This portfolio has been developed in line with the activities of the CSIRO Energy Transformed Flagship research program; ‘the goal of Energy Transformed is to facilitate the development and implementation of stationary and transport technologies so as to halve greenhouse gas emissions, double the efficiency of the nation’s new energy generation, supply and end use, and to position Australia for a future hydrogen economy’.\(^4\) There is now unprecedented global interest in energy efficiency and low carbon technology approaches to achieve rapid reductions to greenhouse gas emissions while providing better energy services to meet industry and society’s needs. More and more companies and governments around the world are seeing the need to play their part in reducing greenhouse gas emissions and are now committing to progressive targets to reduce greenhouse gas emissions. This portfolio, *The Sustainable Energy Solutions Portfolio*, provides a base capacity-building training program that is supported by various findings from a number of leading publications and reports to prepare engineers/designers/technicians/facilities managers/architects etc. to assist industry and society rapidly mitigate climate change.

The Portfolio is developed in three modules;

**Module A: Understanding, Identifying and Implementing Energy Efficiency Opportunities for Industrial/Commercial Users – By Technology**

**Chapter 1: Climate Change Mitigation in Australia’s Energy Sector**

*Lecture 1.1: Achieving a 60 percent Reduction in Greenhouse Gas Emissions by 2050*

*Lecture 1.2: Carbon Down, Profits Up – Multiple Benefits for Australia of Energy Efficiency*

*Lecture 1.3: Integrated Approaches to Energy Efficiency and Low Carbon Technologies*

*Lecture 1.4: A Whole Systems Approach to Energy Efficiency in New and Existing Systems*

**Chapter 2: Energy Efficiency Opportunities for Commercial Users**

*Lecture 2.1: The Importance and Benefits of a Front-Loaded Design Process*

*Lecture 2.2: Opportunities for Energy Efficiency in Commercial Buildings*

*Lecture 2.3: Opportunities for Improving the Efficiency of HVAC Systems*

**Chapter 3: Energy Efficiency Opportunities for Industrial Users**

*Lecture 3.1: Opportunities for Improving the Efficiency of Motor Systems*

*Lecture 3.2: Opportunities for Improving the Efficiency of Boiler and Steam Distribution Systems*

*Lecture 3.3: Energy Efficiency Improvements available through Co-Generation*

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Module B: Understanding, Identifying and Implementing Energy Efficiency Opportunities for Industrial/Commercial Users – By Sector

Chapter 4: Responding to Increasing Demand for Electricity
Lecture 4.1: What Factors are Causing Rising Peak and Base Load Electricity Demand in Australia?
Lecture 4.2: Demand Management Approaches to Reduce Rising ‘Peak Load’ Electricity Demand
Lecture 4.3: Demand Management Approaches to Reduce Rising ‘Base Load’ Electricity Demand
Lecture 4.4: Making Energy Efficiency Opportunities a Win-Win for Customers and the Utility: Decoupling Energy Utility Profits from Electricity Sales

Chapter 5: Energy Efficiency Opportunities in Large Energy Using Industry Sectors
Lecture 5.1: Opportunities for Energy Efficiency in the Aluminium, Steel and Cement Sectors
Lecture 5.2: Opportunities for Energy Efficiency in Manufacturing Industries
Lecture 5.3: Opportunities for Energy Efficiency in the IT Industry and Services Sector

Chapter 6: Energy Efficiency Opportunities in Light Industry/Commercial Sectors
Lecture 6.1: Opportunities for Energy Efficiency in the Tourism and Hospitality Sectors
Lecture 6.2: Opportunities for Energy Efficiency in the Food Processing and Retail Sector
Lecture 6.3: Opportunities for Energy Efficiency in the Fast Food Industry

Module C: Integrated Approaches to Energy Efficiency and Low Emissions Electricity, Transport and Distributed Energy

Chapter 7: Integrated Approaches to Energy Efficiency and Low Emissions Electricity
Lecture 7.1: Opportunities and Technologies to Produce Low Emission Electricity from Fossil Fuels
Lecture 7.2: Can Renewable Energy Supply Peak Electricity Demand?
Lecture 7.3: Can Renewable Energy Supply Base Electricity Demand?
Lecture 7.4: Hidden Benefits of Distributed Generation to Supply Base Electricity Demand

Chapter 8: Integrated Approaches to Energy Efficiency and Transport
Lecture 8.1: Designing a Sustainable Transport Future
Lecture 8.2: Integrated Approaches to Energy Efficiency and Alternative Transport Fuels – Passenger Vehicles
Lecture 8.3: Integrated Approaches to Energy Efficiency and Alternative Transport Fuels - Trucking

Chapter 9: Integrated Approaches to Energy Efficiency and Distributed Energy
Lecture 9.3: Beyond Energy Efficiency and Distributed Energy: Options to Offset Emissions
Lecture 8.1: Designing a Sustainable Transport Future

Educational Aim

Already oil production has peaked in over 60 countries, peaking in the US in 1972. Today the US currently uses 150 billion gallons of petrol per annum for transportation. If other nations burned gasoline at the same rate, world consumption would rise by a factor of 10. Most of the world’s remaining oil supplies exist in politically unstable regions of the globe. The aim of this lecture is to explain the current and projected world oil supply/demand situation and the likelihood of world oil production peaking in the near future. This lecture seeks to explain the implications of world oil production peaking, as well as providing an overview of the low carbon options now available to reduce oil usage. This lecture suggests there needs to be an integrated approach to addressing both the need to reduce greenhouse gas emissions and oil dependency. The options to reduce oil dependency rapidly, and thus delay the peaking of world oil production, can either assist or harm efforts to reduce greenhouse gas emissions from the transportation sector. This lecture, and lectures 8.2 and 8.3 that follow, will outline the need for an integrated approach to both decouple transportation from greenhouse gas emissions and reduce oil dependency simultaneously.

Essential Reading

Reference Pages

Learning Points

Although new oil-production capacity additions from greenfield projects are expected to increase over the next five years, it is very uncertain whether they will be sufficient to compensate for the decline in output at existing fields and keep pace with the projected increase in demand. A supply-side crunch in the period to 2015, involving an abrupt escalation in oil prices, cannot be ruled out.


1. The International Energy Agency’s 2007 World Energy Outlook report states that, ‘Emissions of greenhouse gases will rise by 57 percent by 2030 compared to current levels (under business as usual).’ Fatih Birol, head of research at IEA, told the media that if governments do not take strong action to reduce greenhouse gas emissions, the world's temperature could eventually rise by up to six degrees Celsius. In order to meet society's need for mobility, transportation is responsible for 25 percent of all the global greenhouse gas emissions. Transportation is another important sector contributing to climate change. Figure 8.1.1 shows clearly that emissions of the major forms of transportation - passenger cars, freight, and air travel - are rising significantly and are forecast to continue to rise, leading to dangerously high levels of greenhouse gas emissions.

2. While there are many drivers for change in the transport sector currently, reducing greenhouse gas emissions needs to be the primary technical and policy goal of governments and business for the transportation sector, according to The Stern Review.

Increasing scarcity of fossil fuels alone will not stop emissions growth in time. The stocks of hydrocarbons that are profitable to extract (under current policies) are more than enough to take the world to levels of CO₂ concentrations well beyond 750ppm.

Nicholas Stern, The Stern Review, 2006

3. In addition to the need to reduce greenhouse gas emissions the other major drivers for change towards sustainable transport are as follows:

- Investment in sustainable transport has been shown to be better for the economy than more freeways.
- Reducing transportation costs to business and families.
- Reducing urban air pollution and health costs.
- Reducing congestion costs which are significant costs to citizens, business and the economy.
- Reducing dependence on overseas oil.
- The rapidly growing global market for ultra efficient hybrid vehicles and plug in hybrids from

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7 Ibid.
changing consumer demand is creating significant business and job opportunities for those companies and nations that invest in fuel efficient vehicles.

- Preparing for world oil production peaking.

Hence there are multiple benefits to business, governments and citizens when investing in sustainable transport options (i.e. ultra fuel efficient vehicles, public transport, cycling and walking paths) to reduce greenhouse gas emissions.

4. In addition to climate change, another major driver for change in the transport sector is the fact that oil production has peaked\(^\text{10}\) in over 60 countries around the world. A number of CEO’s of major oil companies and many experts argue that world oil production is peaking. The International Energy Agency’s 2007 World Energy Outlook confirms this. The Chief Economist of the International Energy Agency, Fatih Birol, stated in late 2007, ‘I can tell you that we, in the next seven to eight years, need to bring about 37.5 million barrels per day of oil into the markets, for two reasons. One, the increase in the demand, about one third of it, and two thirds, there is a decline in the existing fields [and there is a need] to compensate for the decline. What we expect [to be put in production] is 25 million barrels per day, and this is in the case of no slippages, no delays in the projects, and everything goes on time, which is very rare. So, there is a gap of 13.5 [sic] million barrels per day.’\(^\text{11}\)

5. The several main reasons why many experts are now concerned with the world oil production peaking such as:

a) There are few, if any, large oil fields left to find, let alone medium sized new fields. The last year that more oil was discovered than was consumed was 25 years ago. The last time a big oil field was discovered was in the 1970s. The peak of oil discovery was back in 1965. In, 2007, BP Chief Executive Tony Hayward stated that ‘about half’ the world’s oil has already been recovered.\(^\text{12}\) Many experts have argued that the world oil production will peak around this point.

b) There is not a lot of oil in storage relative to oil demand. Modern economies work on just-in-time delivery. Storing oil costs money. After the world’s first OPEC oil crisis in 1972, the International Energy Agency was set up. Member nations of the IEA agreed to all ensure that they maintain 90 day stockpiles of oil supplies. Australia is the only member of the IEA who does not do this.

c) Two thirds of the remaining oil reserves lie in the Middle East, a region that for many decades has seen conflict and instability. There are grounds to worry that parts of the Middle East are already pumping at close to their peak production rates. Also the reliability of the data of oil reserves is poor. As long as OPEC quotas are based on reserves and as long as quotas are not definitely abandoned, reserves as production data will be flawed.

d) Oil reserves are finite. Oil rich countries are not allowing all their reserves to be developed as rapidly as the non-oil rich countries would like.

\(^{10}\) Peaking of oil refers to the point when production in any oil well, field or region begins to decline. Typically, this point is reached when between one-third and one-half of the oil in a reserve has been extracted. The decline is the inevitable result of the loss of pressure in the oil reserve and despite the advanced drilling and extraction techniques now in use, it is irreversible once passed.


6. The peaking of world oil production could affect efforts to reduce greenhouse gas emissions from the transportation positively or negatively.

- The negative risk is that since economies are so dependant on oil, many nations may feel that they have to rapidly turn to ‘proven technologies’, such as coal conversation oil and oil shales production, before geo-sequestration technologies are commercial, leading to higher greenhouse gas emissions. This is the strategy recommended by Hirsch in his report for the US Department of Energy. Prepared by the Science Applications International Corporation (SAIC), and titled Peaking of World Oil Production: Impacts, Mitigation and Risk Management.

- The positive effect of peaking of world oil production is that ongoing and rising higher oil prices will convince business and government and citizens to seriously invest in better urban design and planning, public transport and cycling, rail, shipping, and broadband infrastructure. This is the strategy that is promoted by The Rocky Mountain Institute (RMI) in their Winning the Oil Endgame: Innovation for Profits, Jobs, and Security publication.

7. There needs to be an integrated approach to achieve the twin goals of rapidly reducing greenhouse gas emissions from the transport sector while also reducing oil dependency. There is no completely greenhouse gas emission free or climate-neutral form of land, sea or air vehicle transportation yet, neither are there any easy and climate change positive transport fuel alternatives. In addition, negative rebound effects from more highly efficient aircraft or vehicle/truck transportation can diminish the real reductions in greenhouse gas emissions from efficiencies in transportation systems. Therefore achieving sustainable transportation, with current technology, will require governments to work together with business and citizens to:

- Achieve better urban/regional design and planning to make it easier for more people to live closer to where they work and shop, and eliminate dependency on the car for most trips.

- Provide better public transport options to encourage a shift to low carbon emitting transportation modes, as well as better provision for cycling and walking within cities.

- Enable integrated transport and urban planning to design seamless transitions between public transport, cycling and walking paths. Also, we need legislature to require the provision of bicycle racks on the front of buses. Studies show that investment in public transport, urban cycling paths and facilities at work for cyclists to get changed could enable 80 percent of trips to be done by walking, cycling or on public transport. This would help to significantly reduce automotive dependence.

- Encourage a world class broadband roll-out to enable video conferencing and the provision of more services online such as medical advice to remote areas, which will dramatically reduce the need for air-travel.

- Design better and more reliable rail and shipping infrastructure to enable almost all freight to

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14 A negative rebound effect occurs when a more efficient motor car lowers the cost of the energy service (transport miles,) and thus allows more miles to be travelled. 'Indirect' rebound occurs when the monetary savings from the 'direct' effect allows a greater range of consumption activities e.g. a second car, an overseas airline trip. Technical specialists who deal with sectoral or direct rebound effects show that rebound can reach 20%, i.e. a new car that is 50% more efficient uses only 30% less fuel because 20% is taken up driving more kilometres.
be transported by rail and or shipping.\textsuperscript{15} France, as part of their green revolution, initiative have announced in 2007 a significant investment in rail infrastructure to enable freight trucking to become virtually completely unnecessary.

8. A report to the World Bank\textsuperscript{16} prepared by researchers at Murdoch University found that governments and cities that emphasise public transport, cycling and walking economically outperform those that don’t.

As one of the report’s authors, Professor Peter Newman, states,\textsuperscript{17}

We’ve found that cities which emphasise walking, cycling and public transport are healthier financially and spend less of their wealth on transport costs. The six cities that came out the best were cities like Zurich, Copenhagen, Stockholm - very wealthy cities now that spend only 4 or 5% of their wealth on transport, and yet they’re the cities that are putting their money into public transport. And the cities still pouring money into freeways use up to 17% of their wealth. Our data would really question that now and say unless you’re building up the rail system in a city like Perth you are not going to help it economically as well as pouring this money into big roads.

9. Professor Newman has explained some of the reasons for this result: ‘First there are direct costs (of freeways). They are expensive to build and to keep operating. They also spread cities out. As soon as you put in big roads the cities sprawl and sprawl it is very expensive. And if you build railways, particularly light rail, which concentrates a city and developers like building around it so it helps to stop the sprawl, then you get a whole lot of flow ons. The environment improves and you’ve got more money available for doing productive job creating in cities. And that's why I think the European and Canadian models are actually better and why, even in America now, they’re changing their laws to try and facilitate this.\textsuperscript{18}

10. Governments, business and civil society organisations can help their staff reduce carbon emissions from transportation and save money by:

- Encouraging staff to use public transport and cycle or walk to work by providing showers at work and secure bicycle storage facilities. Encouraging car pooling and the creation of car pooling databases to make car pooling easy for staff.
- Ensuring access to video-conferencing facilities to reduce interstate or overseas air travel.
- Using their purchasing power to buy locally made products wherever possible to reduce the miles products have to be transported.
- Purchasing fuel efficient cars for car fleets.

Freight transportation is also a significant contributor to greenhouse gas emissions. Governments could do much more to help shift freight transport from air transport and trucking to lower greenhouse emitting forms of transport, such as rail and shipping.\textsuperscript{19} France, as part of their green revolution,  

\textsuperscript{18} Ibid.
initiative have announced in 2007 significant investment in rail infrastructure to enable freight trucking to become virtually unnecessary.
**Brief Background Information**

Transportation to meet society's need for mobility is responsible for 25 percent of all global greenhouse gas emissions. Figure 8.1.1 shows clearly that many forms of transportation contribute to this; showing that passenger cars (non-OECD), freight trucking, and air travel are the major sources of rising greenhouse gas emissions in the transportation sector. Clearly, this is unsustainable. A transition to more lower carbon modes of transport will require investments to be made by government and business. Greater investments will be needed, for instance, to build fast and effective public transport systems and rail for freight. But the UK Stern Review\(^{20}\), which takes the costs of delayed action on climate change, and other studies suggest that these are wise investments.

![Figure 8.1.1. Global transport greenhouse gas emissions by transport type](source: WBCSD (2004))\(^{21}\)

**Multiple Benefits from a Shift to Sustainable Transportation**

There are multiple benefits to business, governments and citizens investing in and shifting to more sustainable forms of transportation, such as:

1) **Investing in Sustainable Transport leads to higher economic growth**: A report to the World Bank\(^{22}\) prepared by Professors Newman and Kenworthy at Murdoch University found that governments and cities that emphasise public transport, cycling and walking economically outperform those that don’t. Their study was based on data from over 50 cities. One of the best examples of this is Curitiba. In 1980 Curitiba’s per capita GDP was only just 10 percent above the national average. But by 1996 its per capita GDP was 65 percent above the national average, a remarkable

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increase in just 16 years. At a time when most cities were tearing up trams and railways to build more and more freeways, Curitiba instead chose to build more buses. Curitiba started with buses because that is all they had and all that they could afford. But the Curitiba engineers did innovate, and they designed a new type of bus that was far more effective than traditional buses. Locally assembled by Volvo these new buses were double or (since 1991) triple the length of traditional buses with pivot sections for rounding corners, and have up to five extra wide doors. Mimicking railways, on the express bus routes the Curitiba government has built ‘tube stations’—elevated glass cylinders parallel and next to the where the bus stops, displaying maps, and accessible for the disabled. Through such approaches the buses move quickly through the city transporting 2 million people daily, which is 70 percent of the cities population.

2) Reducing transportation costs to business: Transportation costs are a significant expense for business. In October 2005, the world’s largest retailer, Wal-Mart in the USA, announced a US$500 million climate change commitment, including initiatives to: reduce greenhouse gas emissions by 20 percent in seven years; increase truck fleet fuel efficiency by 25 percent in three years; and double truck fleet fuel efficiency in ten years. Wal-Mart is making this investment because the savings from reduced fuel use will provide a good return on investment. Better still most businesses would choose to use rail instead of trucking for transport of freight if rail was as reliable as trucking to deliver freight on time. In Australia, for instance, some organisations use trucks to freight a significant percentage of their freight, rather than train due what they guarantees rail can offer. If Australian Federal and State governments invested more in rail infrastructure a significant amount of freight could be shifted from trucking to rail. France is making this investment. France, as part of their green revolution, initiative have announced in 2007 significant investment in rail infrastructure to enable freight trucking to become virtually unnecessary.

3) Reducing transportation costs to families: Sustainable transport options can help families avoid needing to purchase a second car. Transport is the third largest item of household expenditure in Australia (14.3 percent), behind housing (20.5 percent) and food (18.4 percent). In NSW, the NRMA estimates that the cost of running a car for most people varies from AUD$108.70 to AUD$313.74 per week. This equates to between AUD$5,652 and AUD$16,314 a year. 51 percent of Australian households own two cars. Only 14 percent use public transport and less than 5 percent walk or cycle to work.

4) Reducing urban air pollution: Motor vehicles are a major contributor of air pollutants, accounting for well over half the emissions of oxides of nitrogen (NOx), carbon monoxide (CO), sulphur oxides (SOx), volatile organic compounds (VOCs), and particulates. CSIRO’s Tom Beer’s studies show that air pollution is responsible for more deaths among Australians than road accidents; each year, on average, 2,400 of the 140,000 Australian deaths are linked to air quality

and health issues - much more than the 1,700 people who are killed in crashes.\textsuperscript{29} Advanced technologies to improve fuel efficiency of transportation vehicles usually also produce less urban air pollution as well as helping to improve the health and quality of life for those living in cities. This is one of the key reasons why the fast growing economies of the world see the benefits of reducing greenhouse gas emissions in the transportation sector.

5) \textit{Reducing congestion costs}: Congestion costs are significant in all OECD nations. The 2007 Bureau of Transport Economics (BTE) report\textsuperscript{30} suggests that social costs of congestion to the Australian economy were approximately AUD$10 Billion per annum in 2005. The BTE predicts that, 'This is likely to rise, under base case demand growth assumptions, to a level of between 10 and 30 billion dollars by 2020, with a median projected value for the potentially avoidable social costs of congestion of around 20 billion dollars'. The often quoted figure of costs of congestion for the UK economy is 20 Billion pounds per annum.\textsuperscript{31} Many cities are also investigating congestion taxes to reduce the productivity lost due to traffic congestion, and thereby raise revenue to invest in public transportation systems and cycling pathways around cities.

6) \textit{Reducing dependence on overseas oil}: Australia is already importing 50 percent of its oil, a figure set to reach 100 percent by 2020, as the domestic oil supply risks running out, if no new economically viable oil reserves are found. This will have consequences for Australia's long term balance of payments figures. Obviously it is difficult to predict far ahead, but Mr Barry Jones, representing the Australian Petroleum Production & Exploration Association Limited (APPEA), has publicly commented that if current oil prices persist and the government's best supply forecast is met, imported oil would subtract 'about $30 billion a year to the national export bill by 2015'.\textsuperscript{32} Two thirds of the remaining oil reserves lie in the Middle East, a region that for many decades has seen conflict and instability. The International Energy Agency (IEA) has acknowledged the seriousness of these issues. In November 2005, the IEA wrote in its \textit{World Energy Outlook} that:\textsuperscript{33}

\begin{quote}
The world must change its energy habits or struggle with choking fumes, runaway oil demand and a growing dependence on the volatile Middle East for fuel. Energy demand and greenhouse gas emissions will soar by more than 50\% by 2030 if consumers keep burning oil unchecked. To keep pace with booming demand over the next 25 years, top producer Saudi Arabia and its neighbours would have to spend an annual $56 billion on rigs and refineries or oil prices will race higher.
\end{quote}

'These projected trends have important implications and lead to a future that is not sustainable', said IEA Executive Director Claude Mandil. 'We must change these outcomes and get the planet onto a sustainable energy path'.\textsuperscript{34} 'If investments do not come in a timely and sufficient manner, there will be higher oil prices, and global economic growth will suffer', said IEA Chief Economist Fatih Birol.\textsuperscript{35} Sweden, Iceland and the US state of Hawaii have all headed this advice and have committed to

\textsuperscript{34} Ibid.
\textsuperscript{35} Ibid.
becoming completely independent of foreign oil by 2020. Even the USA has also made a significant commitment.

America is addicted to oil, which is often imported from unstable parts of the world. The best way to break this addiction is through technology. Since 2001, we have spent nearly $10 billion to develop cleaner, cheaper, and more reliable alternative energy sources - and we are on the threshold of incredible advances… new technologies will help us reach another great goal: to replace more than 75 percent of our oil imports from the Middle East by 2025. By applying the talent and technology of America, this country can dramatically improve our environment, move beyond a petroleum-based economy, and make our dependence on Middle Eastern oil a thing of the past.

President George Bush, State of the Union Address, 2006

The Main Driver for Change – Reducing Greenhouse Gas Emissions

While there are many drivers for change in the transport sector, reducing greenhouse gas emissions needs to be the primary technical and policy goal of governments and business for the transportation sector, according to The Stern Review, which states that the, ‘Increasing scarcity of fossil fuels alone will not stop emissions growth in time. The stocks of hydrocarbons that are profitable to extract (under current policies) are more than enough to take the world to levels of CO₂ concentrations well beyond 750ppm.’ Developments in climate science and in events have convinced the IPCC that there needs to be a rapid reduction in greenhouse gas emissions in OECD countries so that by 2014 global emissions start to decrease. James Hansen, director of NASA's Goddard Institute for Space Studies, warned that the Earth is rapidly approaching a ‘tipping point’ beyond which climate change will become unstoppable. The authors discussed feedback mechanisms and argued that unless effective measures are put in place to control CO₂ emissions over the next ten years, the rise in the Earth’s temperature could set off self-reinforcing processes that would be beyond human control. Some critics said Hansen was overstating his case. But this was before the summer Arctic ice melt of 2007. This year, Arctic ice reached a minimum extent of 4.13 million square kilometres, compared to the previous record low of 5.32 million square kilometres in 2005. This represented a decline of 22 percent in just two years. This rapid disintegration will severely destabilise Greenland's ice pack - whose disappearance would cause sea levels to rise by several metres, inundating coastal cities, home to hundreds of millions. 2007 will go down in history as a significant year for climate science with events on the scale of the 2007 summer arctic melt significantly changing scientific estimates of how close the climate already is to dangerous climate change.

39 Richard Peltier, a University of Toronto physicist and the director of the Centre for Global Change Science, criticized the tone of the paper and the use of words such as ‘cataclysm’, saying that Hansen had moved ‘dangerously away from scientific discourse to advocacy’. See http://postcarboncities.net/node/1018 and http://postcarboncities.net/node/1018.
Managing Peak Oil

2007 will also go down in history as the year the International Energy Agency all but admitted that world oil production, for a range of factors, has peaked. The climate change and peak oil issues have forced experts to focus on the best ways to simultaneously address both problems.

As Ian Dunlop explains,

*Peak Oil* takes its name from the bell-shaped curve which typifies the production profile of any oilfield. Once an oilfield is discovered, oilwells are drilled and production rises until drilling saturation is reached, whereupon production levels off and reaches a peak. Production then begins to decline as reservoir pressure drops, following a ‘depletion curve’ which makes up the declining segment of the bell-shape. This profile may be disrupted by extraneous events such as shutdowns due to technical or geopolitical factors, but broadly it has been shown to apply to oilfields worldwide. The concept was originally developed in the 1950’s by M. King Hubbert, a senior oil geologist with Shell Oil in the USA, hence the curve is often known as the ‘Hubbert Curve’. This curve applies to an individual oilfield, but also, if production profiles are cumulated, to all oilfields in a region, a nation, and to the globe. It has been used to accurately predict regional peaks of oil production; the concern now is with the overall global peak.

![Graph illustrating when oil production has peaked in regions of the world and when it is forecast to peak globally](image)

**Source:** Robinson, B. (2002)

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43 Ian Dunlop was formerly an international oil, gas and coal industry executive. He chaired the Australian Coal Association in 1987-88, chaired the Australian Greenhouse Office Experts Group on Emissions Trading from 1998-2000 and was CEO of the Australian Institute of Company Directors from 1997-2001. He is Deputy Convenor of the Australian Association for the Study of Peak Oil


The peaking of world oil production could significantly affect efforts to reduce greenhouse gas emissions from transportation positively or negatively:

- The negative risk is that since economies are so dependant on oil, many nations may feel they have no choice but to rapidly turn to ‘proven technologies’, such as coal conversation to oil and oil shales production, before geo-sequestration technologies are commercial, leading to higher greenhouse gas emissions. China has already signed an agreement with a South African company to build two liquefaction plants, at US$3 billion each, producing a total of 440 million barrels a year. With 2007 oil prices topping US$100 a barrel, cost is no barrier to coal-liquid conversion with total costs at US$15 per barrel (ignoring externalised costs of increased climate change). The prospect of many such plants proliferating around the world is real, because so many countries use so much coal already in electricity, and reserves of coal are so vast. Australia, the US and China are among the countries with the largest coal reserves.

- The positive effect of world oil production peaking is that ongoing and rising higher oil prices will convince business, government and citizens to seriously invest in sustainable transport and changes to urban design and better infrastructure to manage a transition off oil over the coming decades.

There is mounting evidence that global oil production has already reached its peak, or if not, that it will within the next 10-15 years. The six main reasons why increasing numbers of experts (see Table 8.1.1) are concerned that the world oil production may be peaking now and entrenching high oil prices is as follows:

- Demand for oil is forecast to keep growing rapidly as China and Indian economies grow rapidly. As the Australian Senate reported, ‘The US Energy Information Administration in 2000 estimated a peak between 2020 and 2050 depending on assumptions about demand growth and the size of the ultimately recoverable resource. The US Energy Information Administration study found that widely differing estimates of the ultimately recoverable resource (URR) make surprisingly little difference to the timing of the peak. The exponential growth of demand is the dominating factor.’

- There are few, if any, large oil fields left to find, let alone medium sized new fields. The last year that more oil was discovered than was consumed was 25 years ago. The last time a big oil field was discovered was in the 1970s. The peak of oil discovery was back in 1965. The Australian Senate commented that, ‘New field oil discoveries have declined greatly since the 1960s. US Geological Survey estimates of future discoveries (which forecast increases), to be realised, would require a drastic turnaround of this declining trend. Peak oil commentators argue that the declining trend of oil discovery reflects geological fundamentals and should be expected to continue.’

- There is not a lot of oil in storage relative to oil demand. Modern economies work on just-in-time delivery. After the world’s first OPEC oil crisis in 1972, the International Energy Agency was set up. Member nations of the International Energy Agency (IEA) agreed to ensure that they maintain 90 day stockpiles of oil supplies. Australia is the only member of the IEA who does not do this.

- Peak oil commentators argue that estimates of remaining reserves are unreliable and most probably overstated, especially in the Middle East. In some OPEC countries, it is believed that reserve estimates were artificially inflated in the 1980s to maximise production under the OPEC

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46 Ibid.
47 Ibid.

quota arrangements in place at that time.\textsuperscript{48} National oil reserves estimates in the Middle East are not subject to the audit and disclosure requirements of publicly-listed international oil companies. Thus there may be considerably less conventional oil than previously anticipated.

- Forty nine of the sixty five oil producing nations have already past their peak oil production topping point and are in decline. Sixty out of sixty five have passed their discovery topping point. The world’s peak year of new oil discoveries was as far back as 1965, and the world’s biggest oil fields were discovered more than fifty years ago.

- Oil reserves are finite. There is now a wealth of experts and international bodies of repute that are predicting that the peaking of world oil production has either already occurred or will arrive very soon (see Table 8.1.1). The CEO of Conoco in 2007 provided new data about the world’s oil outlook that implies that world peak oil production is happening now. ConocoPhillips (COP) Chief Executive James Mulva in 2007 told a New York financial conference that he doubted that world oil producers would be able to meet forecast long-term energy demand growth. The International Energy Agency in 2007 has projected 2030 world oil demand of 116 million barrels a day. But Mulva said he doesn't believe oil supply will ever exceed 100 million barrels a day. ‘Demand will be going up, but it will be constrained by supply,’ Mulva said. ‘I don't think we are going to see the supply going over 100 million barrels a day and the reason is: Where is all that going to come from?’\textsuperscript{49}

Table 8.1.1: Predictions of Timing of World Oil Production Peak

<table>
<thead>
<tr>
<th>Prediction of World Oil Production Peak</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-2007</td>
<td>Bakhtiar, A.M.S. Oil Executive\textsuperscript{50} (Iran)</td>
</tr>
<tr>
<td>2006-2007</td>
<td>Simmons, M.R. Investment banker\textsuperscript{51} (US)</td>
</tr>
<tr>
<td>2006-200-8</td>
<td>Newman, P. Professor, Murdoch University.</td>
</tr>
<tr>
<td>2007-2008</td>
<td>ConocoPhillips (COP) Chief Executive James Mulva</td>
</tr>
<tr>
<td>2007-2008</td>
<td>CEO of Total, the French oil company, Mr de Margerie</td>
</tr>
<tr>
<td>2007-2015</td>
<td>International Energy Agency (IEA)\textsuperscript{52}</td>
</tr>
<tr>
<td>After 2007</td>
<td>Skrebowski, C. Petroleum journal editor\textsuperscript{53} (UK)</td>
</tr>
<tr>
<td>Before 2009</td>
<td>Deffeyes, K.S. Oil company geologist\textsuperscript{54} (retired., US)</td>
</tr>
<tr>
<td>Before 2010</td>
<td>Goodstein, D. Vice Provost, Cal Tech\textsuperscript{55} (US)</td>
</tr>
<tr>
<td>Around 2010</td>
<td>Campbell, C.J. Oil geologist\textsuperscript{56} (retired., Ireland)</td>
</tr>
</tbody>
</table>

\textsuperscript{52} DOE EIA (2000) Long Term World Oil Supply, DOE EIA, US, Appendix I.
2012
Pang Xiongqi[54] Petroleum Executive (China)

2012
Laheurre, J[55] Oil geologist (retired, France)

2013
Queensland Government Oil Vulnerability Taskforce

2020
Thierry Desmauret,[56] former CEO Total (France’s main oil company)

After 2020
CERA Energy consultants[57] (US)

2025 or later
Shell (UK)

Adapted from Source: Hirsch, R.L. (2005)[58]

Mr de Margerie, CEO of Total, the French oil company, agrees with Mulva, stating, ‘100 [million barrels per day] is difficult, because in the 100 you have already additional production in Iraq, in Venezuela, [and] in Nigeria; you have additional production everywhere. And we know that today those developments are not under way.’ World demand for oil is still increasingly rapidly, in 2007 consuming more than 80 million barrels of oil per day, 29 billion barrels a year. And although oil is being used more efficiently, the sheer increase in demand globally is swamping increases in vehicle efficiencies. The IEA in its 2004 Energy Outlook forecasted demand for 121 million barrels a day by 2010. This would clearly outstrip supply.

Those organisations in the past, who have argued that there was no risk of a short term peaking of world oil production, such as the US National Petroleum Council, now are, readily acknowledging that the era of cheap oil production is ending. In 2007, the National Petroleum Council[60] published a new report, titled ‘Facing the Hard Truths about Energy: A Comprehensive View to 2030 of Global Oil and Natural Gas’, investigating global oil and natural gas forecasts and projections. The US National Petroleum Council is a body of 175 organisations that reports to the US government. It includes the heads of the world’s big oil companies including ExxonMobil, Chevron, Conoco Phillips, Occidental Petroleum, Shell and BP. The National Petroleum Council’s new report has incorporated some of the peak oil argument from the Association for the Study of Peak Oil [ASPO]; that it will be hard to keep increasing world production of easy and cheap oil. Chevron, a leading member of the US Petroleum Council has very prominently stated on its web site that the era of easy oil is over. The report argues that there is a large resource of unconventional oil, coal and nuclear fuel and renewable energy that can keep large-scale energy production going for a long time after this tipping point. But the report acknowledges that non-conventional energy sources will be more expensive and that oil will be increasingly hard to recover, in engineering terms, as increasingly new non OPEC oil reserves lie in

the artic or deep water (see Figure 8.1.3). Also many of the substitute energy sources will have major environmental issues associated with them - especially in relation to global warming such as oil shales (see Figure 8.1.3).

![Figure 8.1.3. Oil cost curve including technological progress: availability of oil resources as a function of economic price](image)

The x axis represents cumulative accessible oil. The y axis represents the price at which each type of resource becomes economical.

**Figure 8.1.3.** Oil cost curve including technological progress: availability of oil resources as a function of economic price

*Source: IEA (2005)*

The report argues that carbon capture and sequestration will be needed to enable the continuation of the fossil fuel industry (oil including unconventional sources, fossil fuel gas and coal) and that even with these sources the supply side won't be able to keep pace with potential demand, thus major efforts must be put into energy efficiency measures.

**Serious Economic Consequences from Inaction of Peak Oil**

Clearly there are major uncertainties associated with the timing of the global oil peak, but the exact date of the peak is less relevant than acceptance of the principle. The changes the peak implies will fundamentally alter society as we know it. Solutions are available, but there is no one solution, rather a portfolio of solutions will be needed to address the problem. For example energy efficiency and conservation, transport mode shifts, urban design, pricing/taxation, and alternative fuel conversion can all be used together to provide an overall solution to the peak oil crisis rather than just a singular alternative. As Ian Dunlop points out, “Unfortunately these initiatives take time to implement, typically at least a decade. Thus prudent risk management suggests government, business leaders

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67 Ian Dunlop was formerly an international oil, gas and coal industry executive. He chaired the Australian Coal Association in 1987-88, chaired the Australian Greenhouse Office Experts Group on Emissions Trading from 1998-2000 and was CEO of the Australian Institute of Company Directors from 1997-2001. He is Deputy Convenor of the Australian Association for the Study of Peak Oil.
and citizens should be working and planning the necessary changes today.” The IPCC, in 2007, in their 4th assessment, urged governments and business to rapidly reduce greenhouse gas emissions from transport in the next ten years to reduce the serious risks of dangerous climate change. Both the risks of dangerous run away climate change and rising oil prices mean that there needs to be a shift rapidly to sustainable transport globally.

The economic case for significant investment today in sustainable transport is overwhelming. Higher long term oil prices have significant impacts for the global economy. Since 1965 there have been five peaks of world oil price, all of which were followed by economic recessions of varying degree. The first two oil price hikes led to the two worst recessions in 1973 and 1980. Oil price increases led to a double hit to the economy by causing both rising inflation and also reducing consumer spending. Inflation rose not simply because of rising oil prices but because most economies are so dependant on oil that a rise in prices leads to increasing prices of numerous consumer items. What is different about the current oil price hike is that it is the first time it has been driven by exponentially rising global demand. The previous price hikes were determined by major supply countries reducing the amount of oil being released onto the market.

The serious threat of peaking world oil production to the economies of the world has been recognised by a number of government reports. Their findings mirror the concerns and issues outlined in this lecture. In Australia there have been two inquiries; one by the Australian Senate and another by the Queensland government.

The Australian Senate’s Inquiry into Australia’s Future Oil Supply and Alternative Transport Fuels reported in February 2007. It found that that ‘The (peak oil) concept appears to be well accepted including by official agencies.’ It found that peak oil threatens the Australian economy because, ‘Demand for oil is relatively inelastic, because for its major use – transport – there are no easy substitutes. This means that a relatively small shortfall in supply can cause a large increase in price. This will increase the volatility of the price in response to small changes in supply when there is little spare capacity.’ The implications for Australia are well communicated at this Senate inquiry by Mr Barry Jones, representing the Australian Petroleum Production & Exploration Association Limited (APPEA), who publicly commented that if ‘current oil prices persist and the government's best supply forecast is met, imported oil would subtract about $30 billion a year from the national export bill by 2015.’ This inquiry concluded that, ‘Australia’s net self-sufficiency in oil is expected to decline significantly as future discoveries are not expected to make up for the growth in demand and the decline in reserves as oil is produced… The essence of the peak oil problem is risk management. The risks involved are high if peak oil comes earlier than expected, or if economies cannot adapt quickly enough to the post peak decline.’

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68 Dunlop, I (2007) Peak Oil and Investment. Responsible Investment News
The most comprehensive study at the state government level in Australia so far has been the Queensland Government Oil Vulnerability Taskforce report, *Queensland’s Vulnerability to Rising Oil Prices Taskforce Report*, which concluded that,

There are range of creditable predictions for a world peak oil situation run from 2005 to 2040, with the mean and standard deviations of all academic and industry predictions being 2013, ± 7. The Taskforce concludes that the overwhelming evidence is that world oil production will peak within the next 10 years. It is noted that Australian oil production (but not necessarily, natural gas) has already peaked, as has that of the rest of the world, excluding the former Soviet Union and some Middle East OPEC members. The Taskforce also notes that the world oil market is becoming increasingly supplied from politically and/or socially unstable areas, such as from many OPEC and Middle East nations. This means that, regardless of the global peak oil issue, the risks of supply disruptions are rising. These two factors mean that oil prices could rise substantially at some point(s) in the future, especially given the continuing growth in world demand for oil and its products. The Taskforce considers this to be a major risk, with impacts arising not only for transport but for many key parts of Queensland industry and the community.

Another Australian government program that addressed the risk of declining domestic oil supply and peak oil was the *National Hydrogen Strategy* developed by the Department of Industry, Tourism, and Resources. The 2005 Australian Department of Industry, Tourism and Resources report into hydrogen features a graph similar to Figure 8.1.2, with world peak oil production occurring in 2006-7 (see Figure 8.1.4).

![Figure 8.1.4. Predicted life cycles of oil production](source: DITR (2005))

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75 Ibid.
Many other national governments have commissioned studies into peak oil. Two US government reports have made serious warnings on this issue and recommended early action. These reports were the 2004 US Department of Energy’s Office of Naval Petroleum and Oil Shale Reserves report, Strategic Significance of America’s Oil Shale Resource,76 and a 2005 report commissioned by the US Department of Energy, titled Peaking of World Oil Production: Impacts, Mitigation, and Risk Management.77

The 2004 report outlined that, with oil, ‘A serious supply demand discontinuity could lead to world wide economic crisis’. In this report they argue for an emergency plan to keep US oil supply supplies strong and ensure that the US Naval fleet can remain effective. The 2005 report commissioned by the US Department of Energy was released by Robert Hirsch of the Science Applications International Corporation (SAIC) and delivered a blunt message; stating that the world has, at most, 20-25 years before world oil production peaks. The report argues that it will take economies over 20 years to adapt to a world of constant high oil prices, and therefore, humanity does not have a moment to lose. But will strategies to reduce oil dependence lead to higher or lower greenhouse gas emissions? The strategy to reduce oil dependence outlined by Hirsch is based on nuclear-hydrogen and coal-to-fuel options which are not a low greenhouse emission strategy. It would make the global warming problem much worse.78

Fortunately, a low carbon strategy has been written, and it shows that it would be highly profitable for nations to make the transition away from dependence on oil. Rocky Mountain Institute (RMI) has released Winning the Oil Endgame: Innovation for Profits, Jobs, and Security,79 a Pentagon co-funded blueprint for making the US oil-free. The plan outlines how US industry can restore competitiveness and boost profits by mobilising modern technologies and smart business strategies to displace oil more cheaply than buying it. Winning the Oil Endgame proves that the US can save half its oil usage through efficiency, then substitute competitive bio-fuels and saved natural gas for the rest - all this without taxation or new federal regulation. Furthermore, it shows that: by 2015, the US can save more oil than it gets from the Persian Gulf; by 2025, use less oil than in 1970; by 2040, import no oil; and by 2050, use no oil at all. The report makes the remarkable point that ‘It will cost less to totally displace all the oil the United States now uses than it will cost to buy that oil,’ and outlines how a US$180 Billion investment over the next 20 years would lead to US$130 Billion savings per annum by 2025. To reap the best return on investment, RMI recommends the following technical strategies:

a) Invest in technologies to double the efficiency of all transport vehicles.

b) Substitute oil with biofuels, natural gas and hydrogen fuels.

However there are risks in basing a strategy of reducing greenhouse gas emissions mainly on increases in efficiency of vehicles and aeroplanes that can run on alternative low carbon fuels. This is because, to date, efficiency gains in the transport sector have been swamped by rising demand for more and more vehicles and air flights globally. There is no completely greenhouse gas emission free or climate-neutral form of road, sea or air transportation yet. Even the greenest transportation vehicles still emit emissions over their lifetime of usage. Also, negative rebound effects from more

78 Ibid.
highly efficient aircraft of vehicle/truck transportation can diminish the real reductions in greenhouse gas emissions. More efficient aeroplanes are able to make longer flights which end up using just as much fuel. More fuel efficient cars cost their owners less to run and thus families can afford more long weekend drives and car trips away. These sorts of negative rebound effects can all but eliminate any real reductions in greenhouse gas emissions.

Therefore achieving sustainable transportation with what technology is currently available, will require governments, business and citizens to work together to reduce their transportation needs through better urban/regional design and a shift to low carbon emitting transportation modes – especially through increased public transportation, rail, cycling and walking. The personal choices we, as individuals, make with our transport decisions contribute to over 30 percent of total emissions from the transport sector. Hence many sustainable transport experts argue that to effectively reduce greenhouse gas emissions in the transport sector we need to transform our cities from their current automobile dependant design to a more automobile independent city.

**Additional Benefits of a Transition to Sustainable Urban Planning and Transport**

There are significant hidden benefits if government, business and civil society pursue this path. Driving your car contributes to global warming more than the appliances in your house. Each trip taken by car emits approximately seven times as much CO₂ as the same trip by rail and 8.5 times as much CO₂ as the bus. A car-reliant society leads to higher greenhouse gas emissions, urban pollution, obesity, congestion, health care costs and greater urban sprawl. The convenience of use means the car often becomes the default or automatic mode of transport, even for short trips. This is a significant public health issue, especially considering physical activity is the second greatest preventable risk factor contributing to Australia’s ill-health. Car-dependent families and communities, traffic management practices that discourage walking and cycling, the proliferation of electronic entertainment, schools focused on academic achievement, and time-saving devices have helped us create a more sedentary world. Physical inactivity is the second (after smoking) most significant behavioural cause of ill-health in society. Lack of exercise is also known to contribute to obesity, hypertension, cardiovascular disease, stroke, diabetes, cancer and depression. Studies show that almost 9 million Australian adults do not do enough physical activity on a daily basis. Not doing enough physical activity doubles the risk of cardiovascular disease, Type 2 diabetes, and obesity, and increases the risk of breast and bowel cancer, depression and anxiety. Physically inactive Australian adults are costing the healthcare system an avoidable AUD$1.5 billion a year according to a study commissioned by Medibank Private. Currently lifestyle induced illness is causing an increase in the utilisation of health services. Nationally, the obesity epidemic occurring in Australia is seeing overweight and obesity affect more than half of the population with resulting costs of to the nation as a whole of $21 Billion per annum according to Access Economics. In 2005, 3.24 million Australians were estimated to be obese.

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More people cycling more often (especially for shorter trips) could increase the total level of physical activity for these people, which would have flow-on benefits by reducing health services costs.85 Most of the alternatives to the automobile, including walking to the train or bus or cycling involve a form of exercise. The latest US research, where there is currently an epidemic of obesity, suggests that for every 60 minutes spent in the motor vehicle, the probability of a participant being obese increases by 6 percent. Studies are now showing that the automobile is having a detrimental effect on populations’ health. According to Lynn Sloman in *Car Sick*,86 a landmark study of OECD capital city transport systems, no matter where you live 40 percent of your current trips could be made by bicycle, foot or public transport. Another 40 percent could be made by bike or public transport if facilities were improved. Only the remaining 20 percent of trips need to be made by car. Nations such as Britain, Germany, Finland, the Czech Republic and Latvia have extensive cycling plans. London, Paris, Chicago, Bogotá and Seoul, Vancouver and Copenhagen have all embarked on major campaigns to incorporate the bicycle into traffic grids. Vancouver lost 40,000 vehicles/day and gained 100,000 walk/bike trips/day in the 1990’s. Copenhagen has reduced parking and road space each year for 30 years and now has just 27 percent people going to work by car and 33 percent by bike. The results have led to substantial shifts in fuel consumption, commuting times and even real estate values.

**Sustainable Transport, Not Highways Help Economic Growth**

In the past fears have been raised that investments and incentives to shift to more sustainable forms of transport would harm economic growth. Recent studies show this is not the case. A report to the World Bank87 prepared by researchers at Murdoch University is turning this way of thinking on its head. As one of the report’s authors, Professor Peter Newman, states,

> We’ve found that cities which emphasise walking, cycling and public transport are healthier financially and spend less of their wealth on transport costs. We now have major studies properly costing the the mechanisms driving this additional cost, include the following:

1. The land required to build the infrastructure and its subsequent requirements for parking; a single lane of railway can carry up to 50,000 persons per hour, a bus way can carry 7,000 persons per hour and a highway lane just 2,500 persons per hour.

2. The direct cost to households of owning a car is considerable, especially if it is a second or third car. A study in Australia showed that a household could save AUD$750,000 over a lifetime if a second car could be avoided.

3. The opportunity cost of such capital and land can be considerable if seen on a whole-city basis. The difference between the most competitive cities, in terms of their transportation costs as a proportion of city wealth, and the least competitive (5-8% compared to 12-18%) can be equivalent to an extra day a week of work in car dependent cities.88

A study of 84 cities undertaken by Kenworthy and Laube89 has shown that cities with well designed public transport systems have significantly less total transport costs, as a proportion of their city revenue.

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wealth, than those that have built heavy reliance on freeways and cars. Kenworthy et al. developed these arguments further in chapter 19, Section 4 of the book *The Natural Advantage of Nations*. What then, are the key options to transform automobile dependant cities into a Sustainable Cities?

**Sustainable Transport Checklist (1997 Engineers Australia Checklist for Sustainable Transport)**

*Ensure Access and Equity*
- Meet basic transport related needs of all people, including the poor, disabled, rural residents, women, young people and business.
- Increase options for access.

*Make Cities more Efficient and Liveable*
- Limit sprawl.
- Increase density of housing, particularly in and around town centres and transit stations.
- Encourage mixed land uses with permeable street layouts.
- Give priority to residential development that encourages neighbourhoods with services and employment opportunities accessible by pedestrians and cyclists.
- Develop transit-oriented urban villages.
- Implement traffic calming measures to reduce speed, improve safety and improve amenity.

*Integrate Transport Planning, Development and Operation*
- Integrate transport and land use planning.
- Develop government structures which can consider all transport needs.
- Design funding arrangements that can distribute funds in accordance with agreed strategic directions.
- Ensure that transport planning and decision-making reflects commitments to sustainability.

*Design and Operate Environmentally Sensitive Transport Systems*
- Ensure protection of ecosystems in design, construction and operation.
- Reduce noise.
- Ensure protection of historic and cultural sites.
- Minimise air and water emissions from transport.
- Protect biodiversity.
- Develop and maintain effective emergency spill response systems.

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Implement Travel Demand Management
- Adopt measures to reduce total vehicle miles travelled.
- Adopt measures to reduce the number of vehicle trips.
- Discourage car use through increased long-term parking rates, reduced parking availability, reallocating of road space, and vehicle restrictions.
- Ensure employer-government cooperation to promote car pools, telecommuting.
- Develop guaranteed ride home programs, and cash payments instead of paid parking.
- Provide appropriate priorities for buses and trams on streets, roads, and bridges.
- Give priority to car pools and high occupancy vehicles on highways and bridges.

Encourage Walking and Cycling
- Improve and expand pedestrian and cycle paths.
- Employers should provide facilities for cyclists.
- Link neighbourhood cycling facilities with public transport through provision of bike racks, storage lockers, and bike routes to transit stops.

Encourage Public Transport
- Provide an integrated system of direct transit routes, in all major cities.
- Ensure transit vehicles have priority over cars on all major transit routes.
- Ensure all transit vehicles are comfortable, easily accessible and well maintained.
- Encourage employers to provide free or subsidised transit passes instead of the car parking.
- Provide quality information on transit routes and schedules.

Ensure Safety and Reliability
- Design and operate transport systems in a manner that protects the health and safety of all people.
- Improve quality, reliability and safety of public transport.

Improve Energy Efficiency
- Reduce fossil fuel consumption through efficiencies and demand management.
- Promote the use of alternative and renewable energy sources.

Count All Costs
- Reflect true social, economic and environmental costs of each mode of transport in analysis.
- In moving to user-pays systems, ensure that prices reflect all costs, while taking account of equity considerations.

Provide for Open Decision-Making
- Involve stakeholders in transport planning.
- Inform the public about environmental and social impacts.
- Provide full information about alternatives.
- Ensure that people have full information about transport options so they can make sustainable choices about personal movement.

_Design and Operate Vehicles for Improved Efficiency_

- Use purchasing policies to give priority to efficient, low-polluting vehicles.
- Accelerate efforts to improve fuel efficiency of vehicles.
- Encourage further research into the development of super-cars (very high efficiency vehicles).
- Promote and adopt vehicle maintenance programs to maintain efficiency and encourage the use of available alternative fuels, e.g. LPG, CNG.
- Accelerate efforts to improve the viability of additional alternative fuels, e.g. ethanol, methanol, electric vehicles, and hydrogen.
- Expand programs for the recycling of cars and car components, choose materials to reduce their environmental impact, design for disassembly, tyre recycling and battery recycling.
Optional Reading


Key Words for Searching Online

CSIRO Energy Centre, National Solar Energy Centre, Green Buildings, On-site Distributed Generation