Accuracy of ABARE Energy Projections

By
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August 2010

Introduction

The Australian Bureau of Agricultural and Resource Economics (ABARE) is an Australian government economic research agency that provides analysis and forecasting of, among other things, our energy production and usage. ABARE's projections have been criticized by some hoping for large scale changes in our energy sector as unreliable biased towards the fossil fuel industry, and as underestimating the contributions that will be achieved in the future by renewable energy, energy efficiency, smart grids and the like.

To test these criticisms I have compared ABARE's projections[1] for the year 2004-05 with the actual figures for 2004-05 [2] [3] [4] [5] [6]. I have compared the following: primary energy production, electricity consumption, resource reserves, and CO_2 emissions. I also comment on what was being advocated by green energy proponents in 1990, and point out how little has changed. The same arguments are being repeated again now by the same sorts of groups with similar beliefs and agendas.

The reason I've used the year 2004-05 for the comparison is because ABARE's 1991 projections were for the period 1990-91 to 2004-05. I have my own hard copies of that and earlier reports but not of later reports so I used this readily available source.

I make two points:

1. ABARE's projections are the best we have to work with. We can't do better than follow their projections.

2. The arguments about what can really be achieved with renewable energy, energy efficiency improvements, smart grids and the like, have all been had before. Twenty years later, nothing has changed.

These ideas proved excessively optimistic in the past, as shown here, and people with sound engineering judgement and experience are warning against repeating the same mistakes. The effective solution is not to try to apply draconian methods. The priority should be on developing rational policies, largely aimed at facilitating rational fuel switching.

Primary energy production

Table 1 compares ABARE's 1991 projection of Australia's 2004-05 primary energy production with the actual production in 2004-05.

Table 1: Primary Energy Production 2004-5: ABARE 1991 Projection, and Actual Production

Source	Projected Production (PJ)	Actual 2004-5 Production (PJ)	Overshoot (Undershoot)
Black coal	5,739	8,074	41%
Brown coal	496	657	32%
Wood, Wood waste	125	92	-27%
Bagasse	100	108	8%
Crude oil and NGL	1,127	1,039	-8%
LPG	78	123	58%
Natural gas	1,519	1,622	7%
Hydroelectricity	69	56	-18%
Uranium	4,700	5,207	11%
Total	13,961	16,994	22%

Points to note:

ABARE's 1991 projections of Australia's primary energy production in 2004-05:

- underestimated total energy production by 22%
- significantly underestimated the 2004-05 production of fossil fuels except oil. It overestimated the production of oil by 8%, which most would consider good forecasting for a 15-year projection.
- underestimated uranium production by 11%
- overestimated the hydro-electricity production by 18%

Electricity generation

Table 1 compares ABARE's 1991 projection of Australia's 2004-05 electricity generation with the actual generation in 2004-05.

Table 2: Electricity Generation 2004-5: ABARE 1991 Projection, and Actual Generation

	Projected Generation (PJ)	Actual Generation (PJ)	Overshoot (Undershoot)
Electricity generation (net)	701	773	10%
Electricity generation (gross)	823	904	10%
Thermal Electricity	754	842	12%
Hydro Electricity	69	56	-18%
Other renewables	0	6	
Total	2347	2581	10%

Points to note: ABARE's 1991 projections of the electricity demand in 2004-05

- underestimated the electricity demand in 2004-05
- overestimated the amount by which energy efficiency improvements would reduce demand growth.
- underestimated the fossil fuel generated electricity by 12%
- overestimated hydro-electricity generation by 18%

Resource reserves

Table 3 compares our known economically recoverable energy resources in 1989 and 2009. This is not a comparison of ABARE's projections but is interesting to see how our estimated energy resources have changed over that 20 year period.

Table 3: Known, economically recoverable energy resources in 1989 and 2009 (PJ).

Economic recoverable resources	at 1989	at 2009	Change
Black coal	1,447,800	883,400	-39%
Brown coal	405,460	362,000	-11%
Oil and condensate	14,023	19,515	39%
LPG	3,021	4,611	53%
Natural gas	38,200	122,100	220%
Coal seam methane	0	16,180	
Uranium (in Gen II and Gen III reactors)	265,440	651,280	145%
Uranium (used in a breeder reactor)[1]	*26,544,000*	*65,128,000*	*145%*

Points to note:

- ABARE's figures for known mineral and energy reserves in 1989 were based on reports by the Bureau of Mineral Resources (BMR) and Department of Primary Industries and Energy (DPIE). Now they come from Geoscience Australia (formerly BMR). ABARE does not undertake its own estimates of resource reserves, so are not accountable for errors.
- Over the intervening 20 years, our estimates of known economically recoverable resources have been revised. Coal has been revised down and oil, natural gas and uranium have been revised up by 39%, 220% and 145% respectively.
- Known uranium resources have increased by a factor of nearly 2.5 in 20 years and we've hardly even looked. There is little activity in uranium exploration being undertaken. Most of Australia is locked up against uranium exploration.

[1] Calculated assuming breeder reactors extract 100 times more energy than Gen II and Gen III light water reactors (http://en.wikipedia.org/wiki/Energy_density)

CO2 emissions

Table 4 compares ABARE’s 1991 projection with the actual CO_2 emissions from Australian energy consumption for the year 2004-05. ABARE’s 1991 projection of 379 Mt is for the ‘Business as Usual’ (BAU) case. ABARE also defined what we’d have to do to achieve the government’s target (20% below 1988 levels by 2005) and what would be needed to achieve a ‘half way’ target.

Table 4: ABARE’s 1991 forecast with the actual CO2 emissions in 2004-05 from Australia’s energy consumption.

	Targets		Projection	Actual	Overshoot
	20% Reduction	‘Half way’ target	BAU		
CO_2 emissions (Mt)	206	298	379	396	4%

Points to note:

- ABARE underestimated by 4% (based on BAU). This is excellent given the state of knowledge 20 years ago.
- The government set an extremely low target but made it impossible to achieve by banning nuclear power from being an option. Nuclear was not even to be considered in analyses by government departments.
- There was strong pressure by the green lobby groups at the time to set lower targets and for governments to mandate stringent regulations for energy efficiency improvements and renewable energy, but no nuclear.
- The same groups are still advocating the same failed policies now.
- Some people never learn!

See Attachment 4, an extract from the 1991 ABARE report. It is fascinating to be reminded how much we knew, the policies, the CO2 emissions reduction targets, and the realities. It demonstrates little has changed in 20 years.

Conclusions

ABARE’s projections are good. I am not aware of any organisation that has made consistently better forecasts of Australia’s energy demand and supply.

I believe the consistently optimistic pressure from green advocacy groups, pushing for projections that align with their beliefs of what governments should do, influenced ABARE to underestimate energy demand, underestimate fossil fuel demand, overestimate renewable energy contribution and over-estimate how much energy efficiency improvement can be achieved over the projection period.

References

[1]ABARE (1991) Projections of Energy Demand and Supply; Australia 1990-91 to 2004-05, ISBN: 0 664 13716 9

[2] ABARE (2006) *energy update* http://www.abare.gov.au/publications_html/energy/energy_06/energyupdate_06.pdf

[3] ABARE (2006), *Australian energy: national and state projections to 2029-30* http://www.abare.gov.au/publications_html/energy/energy_06/nrg_projections06.pdf

[4] ABARE (2007), Table A Update 07, Table *A1 Australian energy supply and disposal, 2004-05 – energy units*, http://www.abare.gov.au/interactive/energy_july07/excel/Table_A_update_07.xls

[5] ABARE (2009), *Energy in Australia 2009* http://www.abareconomics.com/publications_html/energy/energy_09/auEnergy09.pdf

[6] ABARE (2010), *Energy in Australia 2010* http://www.abare.gov.au/publications_html/energy/energy_10/energyAUS2010.pdf

Attachment 1

Extract from: ABARE (1991)
Projections of Energy Demand and Supply: 1990-91 to 2004-05, pp 31-37.
"*4. Greenhouse gas reduction: an illustrative scenario*"

Below I attach a chapter "Greenhouse gas reductions: an illustrative scenario" extracted from the 1991 ABARE report. It makes fascinating reading. It shows:

1. how much we knew back then;

2. how little has changed;

3. we knew the targets were impossible given the policies being advocated;

4. we knew that renewable energy and energy efficiency could not make significant improvement over and above what was already included in the Business as Usual (BAU) projections;

5. we knew then that if we wanted to really cut GHG emissions we had to go nuclear.

But politics dictated nuclear could not be on the agenda. The reason was Labor needed the Green vote to hold onto power.

Many conclude the Greens have been the cause of the delay all along!!

Extract from: ABARE (1991)
Projections of Energy Demand and Supply: 1990-91 to 2004-05, pp 31-37.

4. Greenhouse gas reduction: an illustrative scenario

The ‘business-as-usual' scenario discussed in chapter 3 would result in energy sector carbon dioxide emissions in 2004-05 of 379 Mt, representing an annual average growth rate of 2.0 per cent from the 1989-90 level. If the energy sector is assumed to contribute proportionately to the achievement of the government's 'interim planning target', carbon dioxide emissions in 2004-05 would have to be reduced to about 206 Mt – that is 46 per cent below the business-as-usual outcome.

The purpose in this chapter is to indicate the implications for the energy sector of achieving such a reduction in carbon dioxide emissions. The options available can be broadly classified as:

- increasing the efficiency with which energy is used;
- inter-fuel substitution toward fuels with lower carbon dioxide emission per unit energy;
- reducing the demand for the services which energy provides; and
- trapping emissions at source to prevent them entering the atmosphere.

Here, the emphasis is on determining the potential of the first two of these options. Reducing the demand for energy services, whether by regulation (such as mandatory new car fuel efficiency standards) or by changing energy prices, would entail fundamental changes to the structure of the economy and could impose substantial costs on society. It is obviously preferable if greenhouse gas emissions can be reduced without diminishing the level of services supplied to consumers. Carbon trapping technology is not yet well developed, and is therefore not considered in this report.

4.1 Method and assumptions

There have been several major studies of the potential for reducing greenhouse gas emissions from the Australian energy sector, and many more dealing with individual sub-sectors such as electricity generation or energy use in the manufacturing sector. As regards what is feasible by way of efficiency gains or energy conservation, the approach taken here is to use the results of these other studies rather than deriving original estimates. The central assumption is that the most energy-efficient technologies currently reported to be applicable and cost-effective are universally adopted in Australia. In contrast, the business-as-usual scenario is based on survey participants' stated plans and expectations and on econometric models estimated using historical data.

Judgments have been made as to the extent to which efficiency gains claimed in some studies could be achieved in the time frame to 2004-05. Only those measures which appear to be cost-effective from a new purchaser's viewpoint without tax or regulatory changes are included. (Even where measures are cost-effective in this sense, there might be a net cost to individual consumers and to society from implementing them fully in the period to 2004-05. For example, due to the cost of the new equipment it may not be economic to bring forward the replacement of long-lived capital equipment which is less energy efficient than the best available.)

The business-as-usual scenario for the year 2004-05 was used as the starting point for the analysis. Estimates were made of the energy conservation or energy efficiency improvements which are feasible on a cost-effective basis in the residential, commercial services, manufacturing and transport sectors, in addition to those improvements already implicit in the business-as-usual scenario. Possible gains in other sectors were ignored, as their overall contribution would be relatively small.

In addition to the above changes in energy efficiency, some limited interfuel substitution toward lower carbon fuels was also assumed in these sectors. Fuel substitution, in this context, is the replacement of fuels from which relatively high levels of greenhouse gases are emitted in combustion by those giving low emission or none. Natural gas is the fossil fuel with the lowest level of greenhouse gas emissions per unit of energy produced. Energy sources which do not directly involve greenhouse gas emissions are uranium and renewables such as wind, solar and hydropower. Renewable fuels such as wood and other plants may also be included here: they emit gases when they are burnt, but if grown at the same rate at which they are harvested, no net carbon dioxide emissions result except to the extent that other forms of energy are used in operations such as harvesting.

The assumptions made concerning the efficiency potential available (beyond that assumed in the business-as-usual scenario) were based on those in Walker (1990) and Wilkenfeld *et a1.*(1991). These are generally well below the potential assumed to exist by Greene, Gavin, Armstrong, O'Dwyer and Braddick (1990). Greene *et a1.*give little detail of how their assumptions were derived, but seem to assume the universal adoption of the best technology available overseas. Adoption of the best available technology may not always be economic, however, and can reduce the level of energy service. For example, measures included by Greene et a1.include downsizing of cars, which involves a distinct change from current consumer preferences, and the replacement of incandescent lighting by compact fluorescent lights, which are not particularly suited to, nor economic in, many low use household applications. The building improvement program envisaged by Greene *et a1.* would involve very large expenditures. Overall, Greene *et a1.*'s measures were considered to go beyond the concept of cost-effectiveness used here.

In the residential sector, all black coal used directly, briquettes and most petroleum products were assumed to be substituted by natural gas, and about 80 per cent of hot water heating was assumed to be by solar energy. An efficiency improvement of 25 per cent was assumed for other residential appliances. In the commercial sector, across-the board efficiency improvements of 40 per cent were assumed. These assumptions imply that more efficient technology and practices will be universally adopted. The manufacturing sector was examined on an industry-by-industry basis. In the iron and steel and clay and clay products industries, 10 percent efficiency improvements were assumed. In the basic non-ferrous metals and basic chemicals industries, a 10 per cent improvement was assumed for use of primary fuels, and 5 per cent for electricity use. The cement and basic non-ferrous metals industries are the only two for which significant potential for fuel substitution exists, and it was assumed that 80 per cent of the black coal currently used in these industries is substituted by natural gas. For all other industries, efficiency improvements of 30 per cent for primary fuels and 20 per cent for electricity were assumed.

Following these assumed efficiency improvements, electricity consumption projected for 2004-05 fell. Accordingly, fuel inputs to electricity generation in the business-as usual scenario for that year were reduced by slightly more than the proportional reduction in electricity demand (since the business-as-usual hydroelectric contribution could be retained), keeping the market shares of the fuels unchanged.

The fleet average car fuel efficiency figure for 2004-05 implicit in the business-as-usual scenario is about 10.9 L/100 km, compared with about 11.8 L/100 km at present. It was assumed that a further 20 per cent improvement in the fleet fuel efficiency could be achieved by 2004-05 without radical downsizing. The fleet average fuel efficiency would then be 8.7 L/100 km, a little below the present new car average fuel consumption. This estimate is broadly consistent with the potential identified in Cronin (1990). The same proportionate fuel efficiency improvement was assumed for other segments of the road transport sector. The effect of fuel substitution on greenhouse gas emissions from road transport is uncertain. Le Cornu (1990) concludes that there is little net benefit from fuel switching to compressed natural gas or LNG, and Walker (1990) concludes similarly in regard to methanol. Other alternative fuels are not cost-effective (Cronin 1990).

Finally, the assumption was made that no new black-coal- fired electricity generating capacity would be commissioned after 1989-90, and that all additional electricity demand would be met by natural gas combined-cycle units. (Brown coal use in power stations in 2004-05 would be less than the present level even without such an assumption.)

4.2 Results

The assumed conservation and fuel substitution measures in the residential, commercial manufacturing and transport sectors result in a reduction in greenhouse gas emissions of about 22 per cent in 2004-05 (table 7). These energy efficiency and conservation measures could thus achieve about half of the target level of reduction. Of the total 22 per cent, road transport fuel efficiency improvements account for 6 percentage points. The assumption that no new black-coal-fired electricity generating capacity be constructed reduces the emissions by only about 2 per cent. This is largely because, in the business-as-usual scenario, much of the new electricity generating capacity is gas-fired and little new black-coal-fired capacity is needed.

It is not clear why efficiency measures which are said to be both available and cost-effective are not currently being implemented. It may be that there is some form of energy market failure, so that either consumers are not aware of the potential benefits from adopting more energy-efficient technologies and practices, or that they do not know the full costs of continuing to use inefficient technologies and practices. On the other hand, it may be that not all of the measures referred to in the literature as cost-effective in fact are. This would appear to be an important area for further research. But even if these measures were adopted, they would go only halfway to meeting the government's target.

Table 7: Energy supply and disposal, 2004-05: greenhouse gas reduction

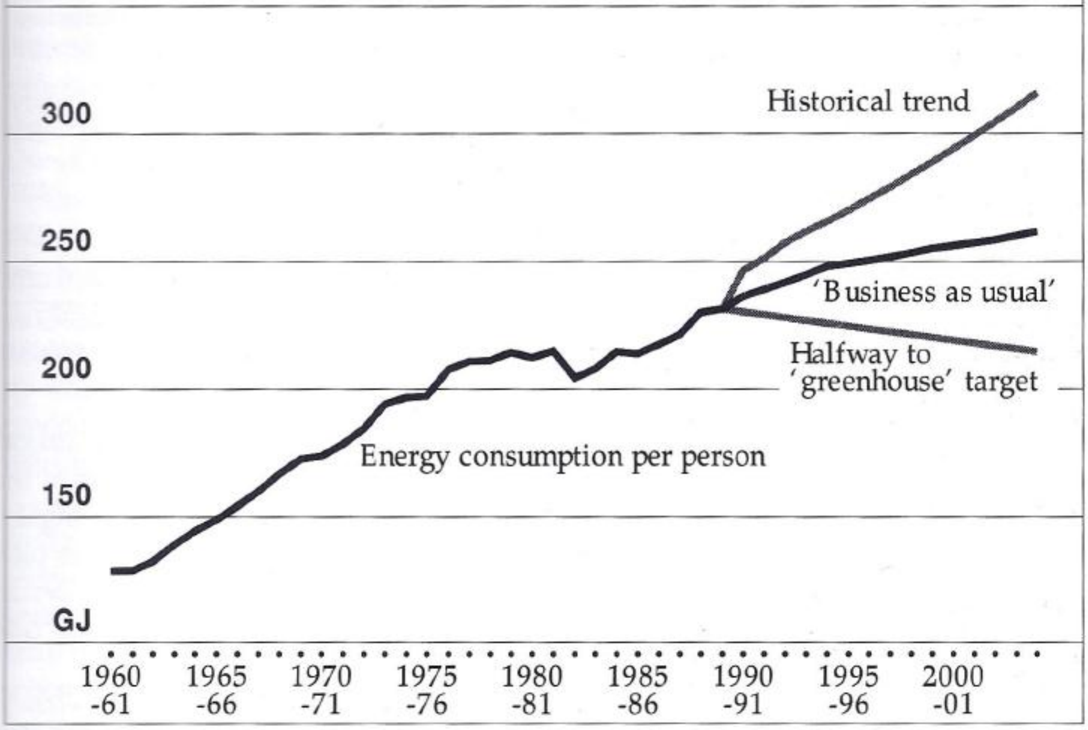
End use	Unit	Black coal (a)	Brown coal (b)	Renew-ables (c)	Oil	Gas	Elect-ricity (d)	Total
Iron and steel	PJ	56.1		0.2	1.4	27.5	20.3	105.5
Chemical	PJ	11.3	4.0		55.1	70.0	17.8	158.2
Other industry	PJ	48.7	7.3	133.5	103.9	320.0	198.4	811.8
Commercial	PJ			0.5		44.9	101.5	146.9
Residential	PJ			162.3		93.5	123.0	378.8
Road transport	PJ				804.8	29.5		834.3
Other	PJ	11.7			528.2	115.2	61.3	716.4
Total final energy consumption	PJ	127.8	11.3	296.5	1493.4	700.6	522.3	3151.9
Change from 'business-as-usual' case	%	-42.3	-18.7	27.0	-14.2	-7.6	-25.5	-14.1
Conversion industry								
Electricity generation	PJ	950.2	343.8		22.6	192.4	-520.4	988.6
Other conversion	PJ	100.7	0.1		81.5	27.0	67.0	276.3
Total energy consumption	PJ	1178.7	355.2	296.5	1597.5	920.0	68.9	4416.8
CO2 emissions	Mt	105.4	33.5		107.4	51.9		298.2
Change from 'business-as-usual' case	%	-29.0	-28.3		-14.8	-12.9		-21.7
Change from 1987-88	%	+15.8	-16.0		+17.2	+50.9		+16.1

(a) Includes coke and coal by-products. (b) Includes brown coal and briquettes. (c) Includes wood, woodwaste, bagasse and solar. (d) Includes contribution from hydroelectricity of 68.9 *PI*, unchanged from business-as-usual case.

It should also be noted that even these 'halfway' measures involve an unprecedented rate of change in the way energy is used in Australia. For example, the level of energy consumption in 2004-05 consistent with the 22 per cent reduction in greenhouse emissions is 12 per cent below the 1989-90 level on a per person basis (figure 13). Yet the only occasions in the past when Australian energy consumption per person has fallen have been associated with major economic shocks, such as the energy price increases of 1980, the recession of 1982-83 and the currency fluctuations of 1985-86. Indeed, it has been noted in chapter 3 that the moderate rate of per person energy consumption growth projected in the business-as-usual scenario is itself well below what would be predicted solely on the basis of expected income growth (the 'historical trend' in figures 13 and 14). Similarly, the average annual rate of decrease in the energy intensity of the economy over the period to 2004-05 implied by the 'halfway' greenhouse measures is about 55 per cent greater than that over the period 1977-78 to 1985-86, the previous most pronounced period of decrease (figure 14). Here again, previous decreases in energy intensity have been associated only with economic slowdowns or energy price increases, or both, and the rate of decrease in the business-as-usual scenario is higher than that predicted solely on the basis of income growth.

On the basis of historical experience, then, achieving the rate of increase in energy efficiency necessary to go even halfway toward meeting the government's interim

13 **Projected energy consumption per person**



14 **Projected energy intensity**

Table 8: Effect on carbon dioxide emissions of large scale natural gas substitution in electricity generation

	Natural gas consumption PJ	Total carbon dioxide emissions Mt
2004-05		
• business-as-usual case	1056	379
• ‘halfway' scenario (a)	920	298
• natural gas as sole fuel for electricity generation (b)	1987	239
1987-88	611	257
Target level of emissions (c)		206

(a) Incorporating efficiency and substitution gains outlined in the text. (b) Assuming all electricity demand in the 'halfway' scenario is met by natural gas combined-cycle plant. (c) 20 per cent reduction from actual 1987-88 emission level.

target for greenhouse gas reductions would appear to be difficult in the absence of major price changes or other government intervention. Achievement of the full target by relying on cost-effective gains in energy efficiency alone would seem to be highly improbable. The results of this analysis seem to indicate that major efforts at fuel substitution, or pricing or regulatory measures to reduce demand for energy services or to induce further changes in energy intensity, would be required to meet the full greenhouse target.

As an illustration of the extent to which fuel substitution, in addition to efficiency gains, would have to occur in order for the greenhouse target to be achieved, the scenario developed above was supplemented by the assumption that by 2004-05 all electricity demand would be met by natural gas combined-cycle plant. That is, it was assumed that all existing black- and brown-coal-fired power stations were closed, together with existing natural-gas-fired stations, and replaced with more efficient units burning natural gas. Even under this extreme assumption, the level of carbon dioxide emissions in 2004-05 would be 239 Mt - that is, 16 per cent above the target level (table 8).

There are several points to note in considering this 'greenhouse' scenario. First, the underlying population and income growth expected for Australia creates a basic pressure for energy consumption to rise over time, which will prevail unless there are continual efficiency improvements sufficient to offset this tendency. Second, efficiency improvements in themselves will reduce the amount that consumers in aggregate must spend on energy for a given level of services. This reduction in effective energy costs, in turn, could be expected to lead to consumers increasing their demand for energy services, as energy is then perceived to be a lower cost commodity. Thus, efficiency improvements alone are unlikely to reduce energy consumption per person proportionately, as has been assumed above. Finally, no assessment has been made of the effects on Australia's energy exports of actions taken by other countries toward 'greenhouse' targets. The potential effects of such actions are considerable.

5. Conclusions

Australian energy consumption has grown strongly in recent years, and this trend is expected to continue in the medium term. Among primary fuels, natural gas has shown the highest rates of consumption growth in recent years. Use of black coal has also grown strongly, as a result of continuing high demand growth for electricity.

Environmental factors, and in particular concern over possible climate change due to increasing concentrations of greenhouse gases in the atmosphere, are becoming much more important in the outlook for the energy sector. In October 1990 the Australian government adopted an interim planning target of a 20 per cent reduction in greenhouse gas emissions from the 1988 1evel, to be achieved by 2005. While the means by which such a reduction might be achieved are not yet clear, any measures adopted could be expected to have major effects on the pattern and level of Australian energy demand and exports.

In a scenario in which it is assumed such a target had not been adopted, Australian energy consumption is projected to grow by an average of 2.1 per cent a year between 1989-90 and 2004-05. Only small changes to the structure of the Australian energy sector are expected in this scenario. Petroleum products are projected to remain the most widely used fuels, with consumption growth concentrated in the transport sector where they dominate energy consumption. The consumption growth rate projected for petroleum products is, however, less than those for both natural gas and black coal. The growth rate of natural gas consumption is projected to be well down from its historical average, but still higher than those for other primary fuels. Particularly strong growth in natural gas consumption is projected for the early years of next century, when much new electricity generating capacity is assumed to be gas fired. The projected growth in brown coal consumption is quite low. The overall share of renewable forms of energy in total consumption is projected to fall in this scenario.

Conceptually, at least, there are several ways in which a greenhouse gas target can be met by an energy sector. The costs of those various methods are still highly uncertain, but the least costly route is likely to be one in which available opportunities for improving efficiencies of energy use are exploited without altering demand for the services which energy provides. Several studies have analysed the potential for efficiency gains; but it appears that even the universal adoption of measures to improve energy efficiency using apparently cost-effective technologies and practices will only go about halfway to meeting the government's target for greenhouse gas emission reductions. It is not clear whether such gains can be achieved without government action, as they represent a substantial change from historical experience and previous expectations regarding the relationship of energy consumption to population and income. Achieving the target would seem to require major changes to the structure of the Australian energy sector and economy, involving large scale fuel substitution or considerable changes to energy markets and pricing regimes. There is a clear need for further research into how a greenhouse gas emission target can be achieved, and the consequences of meeting such a target.