Risk & Sustainable Management Group

Climate Change Working Paper: C06#1

Research supported by an Australian Research Council Federation Fellowship
http://www.arc.gov.au/grant_programs/discovery_federation.htm

Fiddling while carbon burns: why climate policy needs pervasive emission pricing as well as technology promotion

by

John C.V. Pezzey, Frank Jotzo

and

John Quiggin

Australian Research Council Federation Fellow, University of Queensland

Schools of Economics and Political Science
University of Queensland
Brisbane, 4072
rsmg@uq.edu.au
http://www.uq.edu.au/economics/rsmg

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Fiddling while carbon burns: why climate policy needs pervasive emission pricing as well as technology promotion

John C.V. Pezzey, Frank Jotzo and John Quiggin†

12 December 2006

Abstract:

Effective climate policy requires global emissions of greenhouse gases to be cut drastically, which in energy sectors can be achieved by lower emissions supply technologies, greater energy use efficiency, and substitution in demand. For policy to be efficient requires fairly uniform, pervasive emission pricing from taxes, permit trading, or hybrid combinations of the two, as well as significant government support for low-emission technologies. We compare the kind of technology-focused climate policies currently adopted by Australia and the USA, the 'Asia-Pacific Partnership on Clean Development and Climate' (AP6), against this ideal policy yardstick. We find that they omit the need for emission pricing to achieve abatement effectively and efficiently; that they over-prescribe which abatement actions should be used most; that they make unrealistic assumptions about how much progress can be achieved by voluntarism and cooperation, in the absence of either adequate funding or mandatory policies; and that they unjustifiably contrast technology-focused policy and the Kyoto Protocol approach as the only two policies worth considering, and thus ignore other important options.

Keywords: greenhouse gas emissions, abatement, emission taxes, emissions trading, technology policy, innovation, Asia-Pacific Partnership, AP6

† John (Jack) Pezzey (email: pezzey@cres.anu.edu.au) is a Senior Fellow at the Centre for Resource and Environmental Studies, Australian National University, Frank Jotzo (email: frank.jotzo@anu.edu.au) is a Postdoctoral Fellow at the Research School of Pacific and Asian Studies, Australian National University, and John Quiggin (email:jquiggin@uq.edu.au) is Australian Research Council Federation Fellow at the Department of Economics, University of Queensland.

1. Introduction

Recognition is growing that climate change is a serious issue that needs to be addressed, and that global greenhouse gas emissions will need to be cut drastically by mid-century (Stern, 2006). Disagreement persists however over who should take action, when, and what policy mechanisms to use.

Australia has been a key player in the Asia-Pacific Partnership on Clean Development and Climate (AP6, after the six countries in the partnership: Australia, China, India, Japan, South Korea, United States). AP6 essentially is a voluntary agreement to promote cleaner energy technology. Its principal stated purpose is to "create a voluntary, non-legally binding framework for international cooperation to facilitate the development, diffusion, deployment, and transfer of existing, emerging and longer term cost-effective, cleaner, more efficient technologies and practices" (DFAT 2006). Any contributions to funding are voluntary, and there are no commitments to specific outcomes, targets or timetables.

A focus on technology development is in line with a growing recognition that in order to achieve the deep cuts in global greenhouse emissions that will be necessary to stabilise atmospheric concentrations at 'safe' levels, fundamental shifts in energy systems will be necessary over the next 50 years or so (EFF 2006). However, the Australian government has excluded other key policy options. In particular, it has argued that the Kyoto Protocol approach of emissions targets and timetables is not working, and has ruled out the use of economic instruments such as permit trading or emissions taxes in Australia (DFAT 2006). Yet at the time of writing, Australian debate on climate policy has been greatly reinvigorated by developments such as the Stern Review in the UK on the economics of climate change (Stern 2006), the (Australian) Prime Minister's nuclear energy review (PM&C 2006), and the Prime Minister's indication of a task group to review emissions trading (Howard 2006). So Australian climate policy may well change rapidly.

Here we ask if technology-focused policy approaches, and current AP6 policy in particular, are on their own likely to be effective in reducing greenhouse gas emissions; and how they measure up against the yardstick of an effective and efficient climate policy. In Section 2 below we explain what we contend are the necessary elements of an effective and efficient climate policy, citing only supporting literature. Our arguments recognise that the Kyoto Protocol falls far short of effectiveness and efficiency, principally because it does not include all major emitters; that there is a key role for a substantial technology policy; and that there is no easy fix for global climate policy. In Section 3 we describe the typical elements of technology-focused climate policy, drawing from Australian government sources and the policy and economic literature as well as official AP6 documents; critically review these against the elements of an effective and efficient policy; and discuss any contentious points raised by Section 2. Section 4 concludes.

2. The elements of effective and efficient climate policy

2.1 Effectiveness: the need to cut total emissions of greenhouse gases

The starting point is that global, anthropogenic, net additions to greenhouse gas (GHG) emissions, of which most is carbon dioxide from fossil fuel burning, will cause and are already causing climate change, the speed and direction of which will be dangerous to most, if not all countries (IPCC 2001). This is no longer in serious dispute, though different shades of emphasis are noted below. Since GHGs are long-lived, global pollutants and since global GDP is growing, effective climate policy must achieve significant reductions in global GHG emissions, not just in GHG intensities (emissions per dollar of GDP). To stabilise global GHG concentrations at levels that limit the risk of severe future climate change damage, annual global emissions will need to be reduced substantially in the coming decades. Stabilisation of atmospheric concentrations at 550 parts per million (ppm) of CO_2 equivalent (around twice the pre-industrial level) is estimated to require a 25% reduction compared to current annual emissions by 2050, and a more ambitious target of 450 ppm a reduction of 70% below current levels (Stern 2006, xi). A halving in annual emissions by 2050 implies an average reduction of –1.4%/yr, compared to average global growth over the last three decades of 1.7%/yr for CO_2 from fossil fuels.[1] Combined with continued GDP growth, this means global economic activity must be rapidly 'de-carbonised'.

The need to reduce global emissions substantially means that all major emitters must play their part. The United States currently accounts for 23% of annual global CO_2 emissions, and China and the European Union for around 15% each. Historical contributions to greenhouse gases in the atmosphere are mainly from developed countries who also have much higher per capita emissions (average 11.3 tons of CO_2 per person/year in the OECD, compared to 2.3 t/person/year in the non-OECD). However, expected future annual emissions growth is predominantly from industrialising countries including China and India, so their involvement in efforts to reduce emissions is crucial. Quite how and when such involvement is to happen is the key conundrum of achieving strong collective action in global climate policy, with not all countries accepting the UNFCCC principle of 'common but differentiated responsibilities and capabilities', which requires developed countries to 'take the lead in combating climate change'. The need to include all major emitters of course cannot excuse small emitters, such as rich countries like Australia and Canada, from their responsibilities.

[1] Data for CO_2 emissions from fossil fuel combustion and cement production, 1972–2002, from World Resources Institute's *Climate Analysis Indicators Tool* database, version 3.

2.2 Efficiency, I: the need for emission pricing

A globally efficient policy requires emissions reductions at a similar marginal cost in all countries, and on all sources of emissions where control policies are practicable. To achieve this efficiency, we (and many others, such as Stern 2006, xviii) contend that climate policy needs to use *emission pricing* as its centrepiece, though there also needs to be significant government spending on research into and development of new, low-emission technologies. By emission pricing we mean creating a fairly pervasive, fairly uniform price incentive to reduce emissions. The price is created by governments using either an emissions permit trading scheme within an overall emissions cap ("cap-and-trade"), or an emissions tax (ideally charged only above some thresholds, as in Pezzey 2003), or some hybrid combination of the two. Two noteworthy hybrids are the idea of international emissions trading within a maximum permit price (the "trigger price" of Pizer 2002, or "safety valve" of Jacoby and Ellerman 2004); and the closely-related plan in McKibbin and Wilcoxen (2002) for an internationally coordinated emission price, but emissions trading only within countries. The initial distribution of permits or thresholds under any of these schemes has a critical effect on equity, and absolutely should not be free. A key, recent example of what not to do was the overwhelmingly free distribution of permits for the European Union's Emissions Trading Scheme (ETS), which has resulted in billions of euros of windfall profits to electricity companies (Sijm et al 2006). However, no further discussion of equity is warranted here, given our focus on effectiveness and efficiency. What matters for these latter two criteria is that any emission pricing scheme should be fairly pervasive, which means not exempting significant emission sectors.

Using such created (not free) market forces is particularly important in GHG control because of three technical reasons neatly (if perhaps unwittingly) summarised by the Australian Foreign Minister in the context of CO_2, the main GHG:

> "...a ton of carbon dioxide in the atmosphere has the same effect wherever it came from. And likewise, a ton avoided has the same impact whether it is from reduced energy use, carbon capture and storage, renewable energy, or from trapping carbon dioxide in vegetation." (Downer 2006)

The first reason to use emission pricing is thus that because GHGs have the same effect wherever they come from, it is fully efficient to use the same price incentive everywhere,[2] and the inevitably varied market response to this cannot cause any localised environmental damage. The second and third reasons are that there is a huge range of ways of abating GHG emissions and a correspondingly huge

[2] "The imposition of a carbon dioxide penalty provides an incentive for producers to reduce their carbon dioxide emissions up to the point where the marginal abatement cost equals the carbon dioxide penalty." (Matysek et al. 2005, p5)

range of marginal abatement costs, but no cheap, practicable and universal options for end-of-pipe abatement technologies. Together these mean that governments cannot know, but pervasive market forces can discover, where and how emissions should be reduced or abated most cheaply. Marginal abatement costs vary between sources of GHGs as well as between countries, as shown in sectoral modelling of abatement actions (Weyant 1999, Matysek et al. 2005). Reducing coal combustion, which has the highest GHG emissions per unit of energy, in many instances is among the least costly abatement options, but other options exist at all parts of the marginal cost curve. This includes demand-side energy efficiency improvements, which can present a large share of low-cost abatement options, as shown for Australia by Allen Consulting Group (2004) and globally by the International Energy Agency (2006). So an efficient policy requires that a broad-based emission price signal is somehow established. Note however our qualification that price incentives would need to be "fairly pervasive, fairly uniform", allowing for less than full application of this ideal.

An important but often overlooked part of the efficiency argument for using market forces is that consumers will be *better off* if the prices of the goods and services they consume reflect the GHG effects of consumption. This is a general result of allowing markets to work freely. A simple thought experiment shows how it works. Suppose emissions are increased by electricity use but decreased by spending on abatement; and that the government's existing policy is to spend a large sum directly on abating emissions, and raise the money for this from general taxation which leaves electricity consumption unaffected. Now consider a move to a second policy with a small tax on electricity (thus shifting consumption towards other goods), and a more than offsetting reduction in general taxation, of a size so that spending on abatement is lower, but emissions are unchanged overall thanks to the shift away from electricity. Society then benefits from the overall reduction in taxation.[3] And the benefits of market-led choices multiply when there are many different consumer products with different emission intensities, and many different ways of abating emissions.

However, the falls in fossil fuel output caused by pervasive emission pricing will inevitably be greatest for coal, the most carbon-intensive fuel. With 48% of its total energy consumption supplied by coal, Australia is the most coal-intensive country of the AP6, which is itself more coal-intensive (38%) than the world as a whole (26%) (figures from US Energy Information Administration 2004, *International Energy Annual*). So coal-intensive industries will inevitably exert pressure on governments to resist emission pricing. But because it is efficient, pricing remains an essential part of the best, long-run solution for any nation's economy, and can be made politically acceptable by giving adequate compensation to coal-intensive sectors.

[3] See the Appendix for a formal proof.

2.3 *Efficiency, II: the need for technology policy*

We have left a key element of an effective and efficient climate policy till last: that of achieving enough innovation and deployment of new low emission technologies, and enough deployment of existing low emission technologies.[4] Almost everyone agrees that such technological innovation and deployment is vital if deep long-term cuts in GHG emissions are to be achieved in the most cost-effective way. There is also near-universal agreement that governments must play a key role in supporting innovation, because its benefits to society cannot be fully captured by those undertaking costly research and development (R&D) leading to innovation. Government supports include patent laws; subsidies for private R&D, and perhaps prizes for innovation, and encouraging vertical R&D consortia to form (Montgomery and Smith 2006); and direct spending by government R&D agencies.

However, two important qualifications apply to adopting a focus on technology policy as the heart of climate policy. One is that it costs serious money – just how much we discuss in Section 3 – and cannot be just a legal framework and exhortation. The other is that vital as it is, technology policy is not enough on its own. Emission pricing remains vital in providing incentives for *deploying* low-emission technologies, whether old ones like insulation batts in construction, or the use of high-efficiency coal-fired boilers in new power stations in China and India; or new technologies like carbon capture and storage (CCS, also known as geosequestration, see Metz et al. 2005). Subsidised technology development can bring down the cost of CCS, but commercially the technology will be just as unattractive at $25/tonne as at $125/tonne, [5] if venting carbon dioxide to the atmosphere remains free.

Emission pricing can also induce significant amounts of *innovation*. After a wide-ranging review of the quite divergent literature on induced innovation, Popp (2006) concludes that earlier claims about the extent of innovation induced through emission pricing may have been over-optimistic, that support of R&D expenditure via subsidies or direct government financing will also be necessary, and that such expenditure will crowd out other R&D. But his central conclusion is that an emission pricing signal is still vital for innovation: "[among] several important lessons for policymakers tempted to rely on technology as a cure-all for climate change...first, and most obvious, is that these technological gains will not occur without some policy signal to innovators that energy efficiency research will be profitable".

---

[4] A third key element of policy is the removal of barriers to behavioural change (Stern 2006, xx), but this is not our focus here.

[5] All carbon prices are in 2000 US $ per tonne of CO_2.

In conclusion, an effective and efficient climate policy needs action by all major emitters, not excusing rich, small emitting countries from responsibility; a central role for emission pricing policies such as emissions trading, or an emission tax, or hybrids of the two; and significant government financial support for R&D of new, low-emission technologies. We now use the above principles to examine recent technology-focused climate policies to assess their effectiveness and efficiency.

3. A critical review of technology-focused climate policy and recent Australian research

What we depict as "technology-focused climate policy" is neatly summarised by the AP6's founding Vision Statement (AP6 2005), and by the Charter, Communique and Work Plan it issued after its Inaugural Ministerial meeting in Sydney in January 2006 (AP6 2006). However, given AP6's uncertain future, we refer also to other, mainly Australian writings which have an independent existence. We refer to current Australian climate policy as Australia's Position, as found in DFAT (2005), though this may of course have changed by the time the present paper is published; more durable are the press releases issued at the time and shortly after AP6 was announced (Howard et al. 2005 and Downer and Campbell 2005). Of greater technical interest is the 66-page ABARE technical report issued at the Inaugural Meeting (Fisher et al. 2006). In our assessment of AP6 against effective and efficient climate policy, we include some of the key literature cited by Fisher et al (2006), notably Matysek et al. (2005), an earlier ABARE report, and Montgomery and Smith (2006), a report by CRA International in Washington DC; and we have also considered Ford et al. (2006), a subsequent ABARE conference paper; and Ahammad et al. (2006), an ABARE report in July.[6]

The first point to discuss is how far the above literature recognises the risk of dangerous, anthropogenic climate change. The language used is very muted. The AP6 Vision Statement says "we will work together...to meet...climate change concerns" while Charter puts as only its third purpose to "facilitate attainment of our respective...climate change objectives". Only in the Communique is it stated: "We view climate change in particular as a serious problem". The need to achieve an *absolute* reduction in GHG *emissions* is omitted from much of this literature. In AP6 and

[6] This last report is the source of misleading statements in the public discussion that future emissions control policies to stabilise GHGs will cost Australia 10% of its GDP − misleading because this comes from an unrealistic scenario where Australia creates a carbon price 8 times higher than the rest of the world. However, it obviously emphasises the importance of a uniform global price, under which the same report estimates the impact on Australian and world GDP to be about 2-3% in 2050, comparable with a range around 1% for the world as a whole in Stern (2006).

Australian Government documents the dominant language is of "our increased energy needs and the associated challenges, including those related to greenhouse gas intensities" (AP6 2005), and there is not even a commitment to lowering intensities. The only mention of "the necessity of lowering global greenhouse emissions" is in DFAT (2005), though it is unclear whether this means lower emissions absolutely, or relative to a business-as-usual (BAU) projection. The importance of this is shown by the main results in Fisher et al. (2006, p34), where the most optimistic scenario achieves global emissions 23% lower than reference case levels: but these reference case levels increase from about 8 to 22 GtC/yr, so annual emissions more than double even under optimistic assumptions!

In general, technology-focused climate policy acknowledges fully the need for all major emitters to play their part and for rich small emitters to fulfill their responsibilities too. Specifically with regard to AP6, Australian policy pronouncements have emphasised that AP6 countries account for very nearly half of current global GHG emissions, and that "working together, this group can have a significant impact on global approaches towards climate change" (Downer and Campbell 2005). We can but agree, and point out that because of its size and political importance of its large members, if it joined serious negotiations for a post-Kyoto climate treaty, APP would transform them at a stroke. Despite the statement that APP is "intended to complement but not replace the Kyoto Protocol" (AP6 Charter), it has been argued that in reality it is a competing regime that may lead to obstruction (McGee and Taplin 2006). Regarding the Kyoto Protocol, Australian government sources at times seem to employ circular reasoning: in the same document, DFAT (2005) notes that AP6 "includes all major emitters", yet says that "Australia is not a party to the Kyoto Protocol as it does not provide an effective global framework for meeting long-term objectives. It does not include all major emitters". Ford et al. (2006) complete the circle by noting that "The rejection of the Protocol by the United States and Australia...seriously undermines its environmental effectiveness."

With regard to the need for efficient climate policy to use emission pricing as its centrepiece, the silence of the technology-focused climate policy literature is nearly deafening. Particularly noticeable is that while Matysek et al. (2005, p5, p55) fully acknowledged the least cost property of emission pricing and the wide range of abatement actions it leads to, there is no mention of emission pricing in Fisher et al. (2006) and Ford et al. (2006) - and all three papers have Fisher, Ford, Jakeman and Matysek as common authors - other than to downplay its effectiveness in stimulating innovation, as noted below. It is notable that ABARE publications on greenhouse policy until 2005 advocated the use of market mechanisms for greenhouse gas policy and recognised the potential role of price-induced innovation (see for example Jakeman et al. 2004), but from 2006 onwards – when the AP6 initiative became operational – they have strongly supported technology policy and questioned the effectiveness of price-based policies. It is also striking that by marginalising market mechanisms, technology-focused climate policy ends up being very dirigiste about long-run energy futures, that is, "picking winners". There are strong presumptions about which technologies, especially clean coal and carbon capture and storage (CCS), should be used to achieve "practical results" and hence emissions reductions, and which technologies and other actions should not be. CCS plays a major role in the lower-emissions scenarios up to 2050 in Fisher et al. (2006), but not demand-side energy efficiencies or substitution in demand.

As it stands, AP6 is however weakest in its self-declared heartland. As yet there are no commitments for serious money to achieve both the deployment of existing low-emissions options, and the development and deployment of new low-emissions technologies. AP6 documents seem to assume that just a few hundred million dollars spent on "working together", "enhanced cooperation" and "collaboration to promote and create an enabling environment", in the absence of any kind of mandatory policies, can work as if like magic in providing "practical results" from tackling the largest and most difficult technical, economic and political problem in environmental policy that the world has ever faced. The sums committed to AP6 are paltry by comparison: a total of 100 million A$ over 5 years by Australia (and separately 500 million A$ through the government's 'Low Emissions Technology Demonstration Fund'), and a mere 52 million US$ by the United States.[7] This compares to estimated average investment needs in the energy sector, without specific efforts to reduce greenhouse gas emissions, of almost 2 billion A$ *annually* in Australia until 2020 (ERIG 2006). The International Energy Agency (2003) estimated energy sector investment needs at over 100 billion US$ annually in North America, and over 500 billion US$ per year globally, averaged until 2030.[8] So any presumption that AP6 will achieve serious results in stimulating innovation in low carbon technologies seems no more than wishful thinking, unless funding was ramped up substantially.

In the light of this, it is vital to note the vagueness of the methodology stated in Fisher et al. (2006) (and also Ford et al. 2006, which gives the same projections). In particular, no costs of developing or deploying new technologies are given, and many quantitative assumptions remain implicit and inaccessible. So no explanation or R&D costing is given of how carbon capture technologies are expected to fall to an assumed $25-30/tonne, especially given the already noted absence of any carbon price or serious government spending on R&D (the reader is referred to Matysek et al. 2005, but there the figure is a pure assumption, on p4, p35 and p55). Finally, even if such technology would be available at $25-30/tonne, no reason is given why emitters would deploy it, rather than vent carbon dioxide freely to the atmosphere. It is therefore not surprising that all Fisher et

---

[7] White House "Fact Sheet: The Asia-Pacific Partnership on Clean Development and Climate", http://www.whitehouse.gov/news/releases/2006/01/20060111-8.html, 11 January 2006.

[8] The projections for Australia and North America/World respectively come from different sources with different underlying definitions and assumptions.

al.'s results are qualified as what AP6 policies "could" achieve rather than what they "will" achieve.

In Section 2 we noted that although significant government support for R&D is vital, emission pricing can also induce significant amounts of innovation. Central to the contrary view in the market mechanisms (that is, emission pricing) section of Fisher et al. (2006, p21) is a claim, directly based on Montgomery and Smith (2006), that "market mechanisms cannot send a credible and effective signal that would induce the funding required to develop the technologies necessary for achieving deep emissions cuts." This claim assumes there exists a single, as yet undisovered innovation, which once discovered and widely implemented will reduce CO_2 emissions, and hence their social cost, to low levels. But if such a technology had been discovered, the claim goes, there would be no reason *ex post* for governments to maintain a high emission price, and hence no market repayment of the fixed costs of discovering the technology. In reality, there is no reason to suppose that a single technological fix exists. For even if CCS is the "winner", there is no single CCS technology that will be suitable for all ages and locations of power stations. More significant for our purposes is Montgomery and Smith's acceptance that a "relatively low" emission price may be justifiable "to motivate emission reductions through changes in utilization of the existing capital stock, or new capital investments using existing technologies", even though they greatly downplay how much reduction can be thus achieved.

We contend that, whether or not it is considered "relatively low", a moderate emissions price, phased in soon, is vital in stimulating a large part of the economically available abatement. A significant piece of evidence for this view is Table M in Matysek et al. (2005), which identifies just over half the abatement in global CO_2 emissions in 2050 as coming from switching from higher to lower carbon-intensive fuels, improving energy efficiency, shifts in industry output towards less emissions-intensive commodities, and actions by households to reduce fuel use. Note the contrast to the AP6 launch report (Fisher et al. 2006), which put emphasis on supply-side technology measures such as CCS.

A final general feature of technology-focused climate policy documents is that they present false dichotomies. "Technology policy" is presented as self-evidently superior to a single other climate policy, when in fact many other, complex and continuous policy choices are available, overwhelmingly so if the time horizon stretches to several decades hence. A stark choice is often presented between a policy (like AP6) which is claimed to complement economic development and energy security goals and to move towards including all major emitters, and a policy (like Kyoto) which is claimed to both "frustrate" these goals and to be ineffective because it leaves out many major emitters (Downer and Campbell 2005, DFAT 2005). This ignores the countless developments which might follow on from Kyoto after 2012. It also ignores the facts that reducing economic growth does not necessarily mean abandoning growth altogether, and avoiding development being "frustrated" cannot mean ignoring environmental issues, since both economic output and environmental quality are vital aspects of overall development.

4. Conclusion

We have set out here the elements of an effective and efficient policy to tackle global climate change: the largest and most difficult problem in environmental policy the world has ever faced. For policy to be effective, global emissions of greenhouse gases need to be cut, which means involving all major emitters, while not excusing rich small emitters from meeting their responsibilities too. For policy to be efficient, at least two broad policy elements are required: fairly uniform, pervasive emission pricing from taxes, permit trading, or combinations of the two; and significant government support for innovation of new, low-emission technologies, via a mixture of patents, prizes, subsidies and direct spending. We have not pretended that such an ideal policy mix is remotely easy to achieve in practice: it remains by far the largest and hardest task that environmental policy has ever faced. But it does serve as a yardstick against which to compare various current policy initiatives.

Our comparison argued that the kind of technology-focused climate policy currently promoted by Australia and the USA under the AP6 umbrella falls far short of the ideal. Key inconvenient truths have been ignored about the economics of climate policy, especially the need to use emission pricing soon to stimulate both cost-effective abatement actions now and enough technological innovation for the future. Unrealistic assumptions have been made about how much innovation can be achieved by voluntarism and cooperation supported by only paltry funding, in the absence of either market price incentives or mandatory measures. Market flexibility has been rejected in favour of costly dirigisme, by over-prescribing which types of abatement should be used most. Technology-focused policy and the Kyoto Protocol approach have been falsely presented as incompatible, which ignores the possibility of combining them, and many other options worth considering for a suite of climate policies to last well into the 21st century. As a result, purely technology-focused climate policy will either be very inefficient or very ineffective. Given current funding, we fear the latter, meaning that countries exclusively following such policies will be literally fiddling while carbon burns.

That said, any climate initiative that has the United States, China and India on board of course has an immense potential to make a difference for global climate change, at least in principle. And it is clear that technology policy, including for carbon capture and storage, will need to play a vital part in efforts to reduce global greenhouse gas emissions into the future. Two things are needed to make current Australian and AP6 climate policy effective and efficient: devoting meaningful resources to the development of a broad range of technologies, and putting a significant, pervasive price on emissions.

References

Ahammad, H., Matysek, A., Fisher, B.S., Curtotti, R., Gurney, A., Jakeman, and G., H., E. and Gunasekera, D. (2006), "Economic Impact of Climate Change Policy: The Role of Technology and Economic Instruments", Research Report 06.7, ABARE, Canberra.

Allen Consulting Group (2004), "The Greenhouse Challenge for Energy", Report to Victorian Department of Infrastructure and Department of Sustainability and Environment.

AP6 (Asia-Pacific Partnership on Clean Development and Climate) (2005). *Vision Statement.* From www.asiapacificpartnership.org/APPResources.htm

AP6 (2006). Inaugural Ministerial Meeting, Sydney, January 2006. *Communiqué / Charter / Work Plan.* From www.asiapacificpartnership.org/APPResources.htm.

DFAT (Australian Government Department of Foreign Affairs and Trade) (2005). Climate change. From www.dfat.gov.au/environment/climate/ (downloaded June 2006).

DFAT (2006). Asia-Pacific Partnership on Clean Development and Climate: Inaugural Ministerial Meeting, Sydney, January 2006. From www.dfat.gov.au/environment/ climate/ap6/index.html.

Downer, The Hon. Alexander and Campbell, The Hon. Ian (2005). Joint Statement on Asia-Pacific Partnership on Clean Development and Climate. From www.foreignminister.gov.au/releases/2005/ js_cdc.html, 11 August.

Downer, The Hon. Alexander (2006). "International action to address climate change." Speech to the Energy Supply Association of Australia, Adelaide, 2 June. From www.foreignminister.gov.au/speeches/2006 /060602_esaa.html.

EFF (Energy Futures Forum) (2006), *The Heat is on: The Future of Energy in Australia*, CSIRO, Canberra.

ERIG (2006), "Issues Paper", Energy Reform Implementation Group, Canberra.

Fisher, Brian S., Melanie Ford, Guy Jakeman, Andrew Gurney, Jammie Penm, Anna Matysek and Don Gunasekera (2006). "Technological development and economic growth." Inaugural Ministerial Meeting of the AP6, Sydney, 11-13 Jan. *ABARE Research Report* 06.1. Canberra: Australian Bureau of Agricultural and Resource Economics.

Ford, Melanie, Anna Matysek, Guy Jakeman, Andrew Gurney and Brian Fisher (2006). "Perspectives on international climate policy." ABARE Conference Paper 06.3, presented to AARES Annual Conference, Sydney, February.

Howard, The Hon. John, et al. (2005). "Australia joins new Asia-Pacific Partnership on Clean Development and Climate." Joint Press Release, 28 July. From www.pm.gov.au/ news/media_releases/ media_Release1482.html.

Howard, The Hon. John (2006). Address at the Business Council of Australia Annual Dinner, 13 November. From www.pm.gov.au/news/speeches/.

International Energy Agency (2003), *World Energy Investment Outlook 2003*, Paris.

International Energy Agency (2006), *Energy Technology Perspectives: Scenarios and Strategies to 2050*, Paris: OECD/IEA

IPCC (2001). "Climate Change 2001: The Scientific Basis", Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press.

Jacoby, H. D. and A. D. Ellerman (2004). "The safety valve and climate policy." *Energy Policy*, 32(4), 481-491.

Jakeman, Guy, Kevin Hanslow, Mike Hinchy, Brian S. Fisher and Kate Woffenden (2004). "Induced innovations and climate policy." *Energy Economics*, 26, 937-960.

Matysek, Anna, Melanie Ford, Guy Jakeman, Robert Curtotti, Karen Schneider, Helal Ahammad and Brian S. Fisher (2005a). "Near zero emission technologies." *ABARE Research Report* 05.1. Canberra: Australian Bureau of Agricultural and Resource Economics, January.

McGee, J. and Taplin, R. (2006), "The Asia–Pacific Partnership on Clean Development and Climate: A Complement or Competitor to the Kyoto Protocol?" *Global Change, Peace and Security* 18(3): 173-192.

McKibbin, Warwick J. and Peter J. Wilcoxen (2002). "The role of economics in climate change policy." *Journal of Economic Perspectives*, 16(2), 107-129.

Metz, B., Davidson, O., Connick, H. d., Loos, M. and Meyer, L., Eds. (2005), *Special Report on Carbon Dioxide Capture and Storage*, Special Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Montgomery, D. and A. E. Smith (2006, forthcoming). "Price, quantity and technology strategies for climate policy." In M. Schlesinger, ed., *Human-Induced Climate Change: An Interdisciplinary Assessment.* Cambridge, UK: Cambridge University Press.

Pezzey, John C.V. (2003). "Emission taxes and tradable permits: a comparison of views on long run efficiency." *Environmental and Resource Economics*, 26(2), 329-342.

Pizer, William A. (2002). "Combining price and quantity controls to mitigate global climate change." *Journal of Public Economics*, 85, 409-434.

PM&C (Department of the Prime Minister and Cabinet) (2006). *Uranium Mining, Processing and Nuclear Energy Review (UMPNER)*. From www.dpmc.gov.ay/umpner/.

Popp, David (2006). "Innovation in climate policy models: implementing lessons from the economics of R&D." *Energy Economics*, 28, 596-609.

Sijm, Jos, Karsten Neuhoff and Yihsu Chen (2006). "CO_2 cost pass-through and windfall profits in the power sector." *Climate Policy*, 6, 49-72.

Stern, N. (2006), "Stern Review on the Economics of Climate Change", UK Treasury/Cabinet Office, London. www.hm-treasury.gov.uk/independent_reviews/.

Weyant, John (1999). "The costs of the Kyoto Protocol: a multi-model evaluation." *The Energy Journal,*

Special Issue.

Appendix: How a shift towards emission pricing can lower overall taxation and increase welfare

Suppose that c = constant marginal private cost of electricity, p = price of electricity = cost + tax (if any), $q(p)$ = quantity of electricity consumed ($q' < 0$), a = spending on abatement, $e(q,a)$ = rate of emissions ($e_q > 0$, $e_a < 0$), and I = consumers' income.

Under *Policy 1*, the government raises revenue a directly by general taxation which does not affect electricity consumption, and spends a on abatement. The price of electricity is $p_1 = c$. Consumers get $q_1 = q(c)$ electricity, $I–cq_1–a$ other goods, and emissions are $e_1 := e(q_1,a)$.

Under *Policy 2*, the government imposes a small tax of t on electricity, and reduces abatement spending (and hence total taxation) to $a-b$. The price of electricity is $p_2 = c+t$. Consumers get $q_2 = q(c+t) < q_1$ electricity. The government gets q_2t revenue from electricity tax, and now raises only $a–q_2t-b$ directly by general taxation. So consumers get q_2 electricity, $I - (c+t)q_2 - (a–q_2t-b) = I–cq_2–a+b$ other goods, and emissions are still $e_1 = e(q_1,a) = e(q_2,a-b)$. ($b$ is chosen so that this equality holds exactly.)

Then to first order, the net changes from Policy 1 to Policy 2 are:

- the value of the change in electricity consumption $q_2–q_1$ is $–c(q_1–q_2)$, since c is the price and therefore unit value of electricity;
- the value of changed spending on other goods is $I–cq_2–a+b - (I–cq_1–a) = c(q_1–q_2)+b$;

So the net effects of using Policy 2 instead of Policy 1 are to *increase the value of all consumer spending* by b, the reduction in overall taxation, while leaving emissions unchanged. So the overall effect must be to increase welfare.

(The above is a simple partial equilibrium model that, among other things, does not allow for a rising marginal cost of electricity. However, allowing for this would just add complexity without changing the basic conclusion.)

PREVIOUS WORKING PAPERS IN THE SERIES

CLIMATE CHANGE

C05_1	Counting the cost of climate change at an agricultural level, John Quiggin (October, 2005).
C06_1	Fiddling while carbon burns: why climate policy needs pervasive emission pricing as well as technology promotion, John C.V. Pezzey, Frank Jotzo and John Quiggin (December, 2006).
C07_1	Stern and his critics on discounting and climate change, John Quiggin (June, 2007).
C07_2	Declining inflows and more frequent droughts in the Murray-Darling Basin: climate change, impacts and adaption, John Quiggin (2007).
C07_3	Complexity, climate change and the precautionary principle, John Quiggin (2007).
C07_4	The practicalities of emissions trading, Joshua Gans and John Quiggin (August 2007).
C08_1	Equity between overlapping generations, John Quiggin (June, 2008).
C08_2	Uncertainty and climate change policy, John Quiggin (2008).
C08_3	The impact of climate change on agriculture, John Quiggin (August, 2008).
C08_4	Grandfathering and greenhouse: the roles of compensation and adjustment assistance in the introduction of a carbon emissions trading scheme for Australia, Flavio Menezes, John Quiggin and Liam Wagner (December, 2008).
C09_1	Agriculture and global climate stabilization: a public good analysis, John Quiggin (August, 2009).
C10_1	Climate change, uncertainty and adaption: the case of irrigated agriculture in the Murray-Darling Basin in Australia, John Quiggin, David Adamson, Sarah Chambers and Peggy Schrobback (2010).
C11_1	Stabilizing the global climate: a simple and robust benefit cost analysis, John Quiggin (2011).
C13_1	Carbon pricing and the precautionary principle, John Quiggin (March 2013).
C13_2	How I learned to stop worrying and love the RET, John Quiggin (May 2013).