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

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Effective climate policy requires global emissions of greenhouse gases to be cut substantially, which can be achieved by energy supply technologies with lower emissions, greater energy use efficiency and substitution in demand. For policy to be efficient requires at least fairly uniform, fairly pervasive emission pricing from taxes, permit trading or combinations of the two; and significant government support for low-emission technologies. We compare the technology-focused climate policies adopted by Australia and the 'Asia–Pacific Partnership on Clean Development and Climate' (AP6), against this policy yardstick. We find that such policies omit the need for emission pricing to achieve abatement effectively and efficiently; they over-prescribe which abatement actions should be used most; 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 they unjustifiably contrast technology-focused policy and the Kyoto Protocol approach as the only two policies worth considering, and thus ignore important policy combinations.

Key words: Asia–Pacific Partnership, climate policy, pricing, technology.

1. Introduction

Recognition has grown that climate change is a serious issue that needs to be addressed, and that global greenhouse gas (GHG) emissions will need to be cut substantially by mid-century (Stern 2006; IPCC 2007). However, disagreement is widespread over who should act, when and with what policy mechanisms.

Australia has been a key player in the Asia–Pacific Partnership on Clean Development and Climate (referred to as AP6, after the six countries in the partnership: Australia, China, India, Japan, South Korea and the USA). AP6

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essentially is a voluntary agreement to promote cleaner energy technology. Its main 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' (AP6 2006, Charter, 2.1.1). Any contributions to funding are voluntary, and there are no commitments to emission 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 eventually needed to stabilise atmospheric concentrations at 'safe' levels, fundamental shifts in energy systems will be necessary over the next half century (EFF 2006). However, Australian federal climate policy, defined in March 2007 by DFAT (2007), excluded other key policy options. In particular, it argued that the Kyoto Protocol approach of emissions targets and timetables (which Australia did not ratify) is not working, and ignored the possible use of economic instruments such as permit trading or emissions taxes in Australia. But 2006 was a watershed year for global debate on climate policy, spurred notably by the UK Treasury's Stern Review on the economics of climate change (Stern 2006) and Al Gore's documentary film *An Inconvenient Truth.* Then in December, the Australian Prime Minister announced his Task Group on Emissions Trading (Howard 2006), starting a period of intense national debate about climate policy, after several years of stasis.[1]

Given this often fast-moving debate, we choose in most of the next section to examine the fundamentals of an effective and efficient climate policy, rather than the details of any Australian or world transition to such a policy, though at the end we acknowledge the importance and controversy of the latter. We thus identify a standard against which to compare any actual climate policy, past, current or future. We then focus in Section 3 on Australian policy in 2006, represented by government and AP6 documents, and ask if technology-focused policy approaches, and AP6 policy in particular, are *on their own* likely to be effective in reducing GHG emissions; and how they measure up against the yardstick of an effective and efficient climate policy. Our arguments recognise that the Kyoto Protocol falls far short of effectiveness and efficiency, mainly because it omits targets for many major emitters (Aldy *et al.* 2003); that there is a key role for a substantial technology policy; and that there is no easy fix for global climate policy. Section 4 concludes.

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[1] This paper was prepared during the debate before the Task Group's report was released on 1 June 2007 (PM&C 2007). On 3 June, Prime Minister Howard announced his acceptance of the report's key recommendation, that a carbon emissions trading system be introduced unilaterally in Australia by 2012 at the latest, but with no long-term target to be set until 2008 (Howard 2007). This represented Government acceptance of the key arguments of this paper about efficiency, but not yet about effectiveness. It also remained to be seen which of the report's detailed recommendations for trading system design would be implemented.

2. The elements of effective and efficient climate policy

2.1 Effectiveness: the need to cut total emissions of GHGs

The starting point, no longer in serious dispute, is that global, anthropogenic, net additions to GHG emissions, most of which is carbon dioxide from fossil fuel burning, will cause and are already causing climate change, the speed and direction of which will be damaging to most, if not all countries (IPCC 2001, 2007). Since GHGs are long-lived, global pollutants, and since global output (GDP) is growing, effective climate policy must achieve significant reductions in global GHG emissions, not just in GHG intensities (emissions per dollar of output). To stabilise global GHG concentrations at levels that limit the risk of severe future climate change damage, annual global emissions will need to be cut substantially in the coming decades. For example, stabilisation of atmospheric concentrations at 550 ppm of CO_2 equivalent (around twice the preindustrial level) is estimated to require a 25 per cent cut compared to current annual emissions by 2050 (Stern 2006, p. xi), an average cut of 0.6 per cent/year, compared to average global growth over the last three decades of 1.7 per cent/year for CO_2 from fossil fuels.[2] Combined with continued output growth, this means global economic activity must be rapidly 'de-carbonised'.

The need to cut global emissions substantially means that all major emitters must play their part. The United States currently accounts for 23 per cent of annual global CO_2 emissions, and China and the European Union for around 15 per cent each. Historical contributions to GHG concentrations in the atmosphere are mainly from developed countries, which also have much higher per capita emissions (average 10.3 tCO_2/person year in the OECD, compared to 2.1 tCO_2/person year in the non-OECD). However, expected future annual emissions growth is predominantly from industrialising countries such as China and India, so their involvement in efforts to reduce emissions is crucial. However again, the need to include all major emitters cannot excuse small, rich countries like Australia and Canada from their responsibilities.

2.2 Efficiency – I: the need for emission pricing

A globally efficient (i.e. cost-effective) policy requires emissions cuts 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 CBO (2006) and Stern (2006, xviii) contend that climate policy needs to use *emission pricing* as its centrepiece; though there also very much needs to be significant government support for research into and development

[2] Data for CO_2 emissions from fossil fuel combustion and cement production, 1972–2002, from the World Resources Institute's *Climate Analysis Indicators Tool* database, version 3, online at http://cait.wri.org/.

of new, low-emission technologies (Stern 2006, p. xix), and for removal of barriers to behavioural change, in particular to enable greater energy efficiency (Stern 2006, p. xx). By emission pricing we mean governments creating a fairly pervasive, fairly uniform price incentive to reduce emissions. Governments do this either by setting an overall emissions cap and allowing emissions permit trading within it ('cap-and-trade'); or by taxing emissions (if politically necessary, only above some emissions thresholds, as in Pezzey 2003); or with some hybrid combination of trading and taxation. Two noteworthy hybrids are international emissions trading within a maximum permit price, as in the 'trigger price' of Pizer (2002), or the 'safety valve' of Jacoby and Ellerman (2004); and the 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 arguably should not all be free (Bovenberg and Goulder 2001). As shown by Goulder *et al.* (1999), emission pricing is more efficient within one country than alternative, frequently adopted policies such as technology mandates and performance; however, in the international context, including all major emitting countries is probably more important for overall efficiency than the detailed control policies used (see again Aldy *et al.* 2003).

The technical reasons why emissions pricing are particularly important for CO_2 (or any GHG) control were neatly (if unwittingly) summarised by the Australian Foreign Minister:

> '. . . a ton of CO_2 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 CO_2 in vegetation.' (Downer 2006)

The first reason to use emission pricing is thus that true global pollutants like GHGs have the same effect wherever they come from, so it is fully efficient to use the same price incentive everywhere. The second and third reasons are that GHG emissions are indeed pervasive, coming from almost all sectors of the economy including consumption, so there are countless ways of abating emissions, and a correspondingly huge range of marginal abatement costs; but no cheap, practicable and universal options for end-of-pipe abatement technologies. This also means that governments cannot reliably know, but pervasive market forces can discover, where and how emissions should be reduced or abated most cheaply.

The variation of marginal abatement costs across sources of GHGs is highlighted by sectoral modelling of abatement actions (Weyant 1999; Matysek *et al.* 2005). Reducing coal combustion, which has the highest GHG emissions per unit of energy, is often among the least costly abatement options, but other options exist at all parts of the marginal cost curve. A fully efficient policy requires a pervasive, uniform emission price signal. However, in practice, full implementation of this ideal will prove impossible, hence our qualification that pricing should be 'fairly pervasive, fairly uniform'.

An important but often overlooked part of the efficiency argument for using market prices is that final consumers will actually be *better off* if the prices of the goods and services they consume include an element for embodied GHGs. This is a general result of allowing markets to work freely. As an example, 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 of consumers that leaves electricity consumption unaffected. From this starting point, now consider a two-part adjustment of policy. One part is introducing a small tax on electricity, which shifts consumption towards other goods, but causes a much smaller shift down in consumer welfare. The other part is a more than offsetting reduction in general taxation, of a size such that government 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 (see the Appendix for a formal proof).

The falls in fossil fuel output caused by pervasive emission pricing will inevitably be greatest for coal, the most carbon-intensive fuel. With 48 per cent 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 per cent) than the world as a whole (26 per cent) (figures from US Energy Information Administration 2004, *International Energy Annual*). Coal-intensive industries will inevitably exert pressure on governments to resist emission pricing. But pricing remains an essential part of the cost-minimising, long-run solution for any nation's economy, and can be made politically acceptable by giving adequate compensation to coal-intensive sectors.

2.3 Efficiency – II: the need for technology policy

We now consider another key element of an effective and efficient climate policy: that of achieving enough innovation and deployment of new low emission technologies, and enough deployment of existing low emission technologies. Almost everyone agrees that such technological innovation and deployment is vital if deep long-term cuts in GHG emissions are to be achieved cost-effectively. There is also near-universal agreement that governments must support 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 2007); and direct spending by government R&D agencies.

However, three important qualifications apply to adopting a focus on technology policy as the heart of climate policy. First, it costs serious money

– as noted below – and cannot be just a legal framework and exhortation. Second, it is inherently hard for governments to spend serious money on technology policy effectively and efficiently, because of ‘pork-barrelling’ problems such as overestimation of benefits by vocal, geographically concentrated recipients of spending, and lack of government expertise in evaluation (Jaffe *et al*. 2005). Examples of poor value from government technology spending readily spring to mind, such as US projects on the supersonic airliner, the breeder reactor and synthetic fuels from coal (Cohen *et al*. 1991). By creating a potential market for technology, emission pricing can greatly help government in the difficult task of ‘picking winners’, for example, by making proportional, technology-neutral subsidies more effective. Third, vital as it is, even an effective and efficient technology policy cannot be 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). 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, if venting carbon dioxide to the atmosphere remains free. Australia’s current reliance on coal makes it more important to recognise this. An AP6 policy without adequate incentives for deploying clean coal technology must eventually lead to big falls in global coal demand, and hence Australian exports, if emissions are to be cut to sustainable levels.

Emission pricing can also itself induce significant amounts of innovation. After a wide-ranging review of the quite divergent literature on induced innovation, Popp (2006) concluded 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. However, his central conclusion is that an emission pricing signal is still vital for innovation: ‘. . . these technological gains will not occur without some policy signal to innovators that energy efficiency research will be profitable’.

2.4 Efficiency – III: the need to remove barriers to behavioural change

The removal of barriers to behavioural change, particularly to encourage energy efficiency, is not a key focus of this paper, but it is important enough to deserve a separate mention. As many studies show, demand-side energy efficiency improvements form a large share of low-cost options for carbon abatement;[3] but consumers and producers often fail to take up options

[3] See, for example, Allen Consulting Group (2004, table 6.1) for Australia, and IEA (2006) globally.

already highly cost-effective at current energy prices. The reasons for this market failure include lack of reliable information, transaction costs, incentives being split between owners and users, and other behavioural factors like culture and inertia. There is thus a strong need, even with emissions pricing, for well-designed and targeted regulatory measures to gradually eliminate these reasons. Such measures include setting minimum standards for buildings and appliances; labelling, advertising and providing other information; subsidising selected energy efficiency investments; and educating schoolchildren and the general public in climate change issues (Stern 2006, chapter 17).

2.5 Efficiency – IV: the transitional need to minimise carbon leakage

We also briefly address here a key *transitional* issue in Australian climate policy debate. The intense controversy about it means that our conclusions here are tentative and subject to political as well as economic judgement. If Australia were to introduce emission pricing as part of any less-than-global climate treaty, would lower emissions and output from its trade-exposed, carbon-intensive industrial sectors be largely offset by ‘carbon leakage’? (This is higher emissions and output from foreign competitors not subject to emission pricing, which thus causes domestic economic pain in those sectors, for little global environmental gain.) An Australian test case for this fear is aluminium, the most carbon-intensive manufacturing sector and with 82 per cent of its output exported (Saddler *et al*. 2006, tables 3 and 5). This problem must be faced, since it is highly unlikely that all countries of the world, developed and developing alike, will simultaneously join a climate treaty, so some arrangements would be needed to minimise carbon leakage during a transitional phase when Australia is subject to emission controls and some of its key competitors are not.

Also, expectations about future emissions pricing are a key influence on carbon leakage. If a future climate treaty were to chart a clear path toward developing country commitments and thus foreshadow more global emission pricing, incentives to shift output away from Australia would be much reduced. Carbon leakage could also be minimised if sector targets for energy-intensive commodities could be agreed for the main producing countries.

But even without such provisions in a future treaty, in our view Saddler *et al*. have made a convincing case both that there are only a few, well-defined sectors like aluminium and steel that would be substantially affected by leakage; and that *border adjustments* (taxes on imports from, and rebates for exports to competing, uncontrolled countries) are well-established and efficient ways of preventing leakages for other commodities. Many details remain to be ironed out for the case of carbon, but for a reasonable emissions price, any localised economic cost caused by imperfections in border adjustments seems in our view greatly outweighed by the long-term political and economic benefits of Australia moving from laggard to leader in global climate policy.

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 like emissions trading, or an emission tax, or hybrids of the two; significant government financial support for R&D of new, low-emission technologies; government help to remove barriers to behavioural change, particularly to improve energy efficiency; and adequate transitional measures against carbon leakage, probably using border adjustments. We now use the first three of these four principles to assess the effectiveness and efficiency of recent technology-focused climate policies.

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

A good summary of 'technology-focused climate policy' is in the AP6s founding Vision Statement (AP6 2005), and its Charter, Communique and Work Plan (AP6 2006). Our source for Australian climate policy as at March 2007 is DFAT (2007) and the statements announcing AP6 (Downer and Campbell 2005; Howard *et al*. 2005). Of greater technical interest is the ABARE technical report for the AP6 January 2006 Inaugural Meeting (Fisher *et al*. 2006); and in our assessment of AP6, we include some of the key literature cited by Fisher *et al*. (2006), notably Matysek *et al*. (2005) and what is now Montgomery and Smith (2007). We have also considered Ford *et al*. (2006), a subsequent ABARE conference paper.

In general, technology-focused climate policy acknowledged fully the need for all major emitters to play their part, and for rich small emitters to fulfil their responsibilities too, although only DFAT (2007) explicitly acknowledged 'the need to lower global greenhouse gas emissions'. Specifically with regard to AP6, Australian policy pronouncements 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 AP6's size and the political importance of its large members, if it joined serious negotiations for a post-Kyoto climate treaty, it would transform them at a stroke. Despite the AP6 Charter statement that it is 'intended to complement but not replace the Kyoto Protocol' (AP6 2006), McGee and Taplin (2006) argued that it is really a competing regime that may lead to obstruction. Regarding the Kyoto Protocol, official Australian sources sometimes use circular reasoning: DFAT (2007) 'does not believe the Kyoto Protocol provides an effective global framework for meeting long-term objectives. [It] does not include all major emitters', and 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 in 2006 was striking. Matysek *et al.* (2005, p. 5 and p. 55) fully acknowledged the 'least-cost' property of emission pricing and the wide range of abatement actions it leads to, but 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 doubt its effectiveness in stimulating innovation, as noted below. ABARE publications on climate policy until 2005 advocated the use of emission pricing and recognised the role of price-induced innovation (see, e.g. Jakeman *et al.* 2004); but in 2006 – when the AP6 initiative became operational – they strongly supported technology policy and questioned the effectiveness of price-based policies. And by marginalising market mechanisms, technology-focused climate policy ends up 'picking winners': making strong assumptions about which technologies, especially clean coal and CCS, should be used to achieve 'practical results', but having next to no faith in markets to guide such decisions. CCS plays a major role in the low-emissions scenarios in Fisher *et al.* (2006), but demand-side energy efficiencies and substitution in demand are absent.

In March 2007, AP6 was however, weakest in its self-declared heartland. Its documents effectively assumed 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, could work like magic in providing 'practical results' in tackling the largest and hardest technical, economic and political problem ever faced by global environmental policy. For the sums then committed to AP6 were indeed paltry: a total of A$100 m over five years by Australia (and separately A$500 m through the government's 'Low Emissions Technology Demonstration Fund'), and a mere US$52 m proposed by the United States.[4] This compared to estimated average investment needs in the energy sector, without specific efforts to reduce GHG emissions, of almost A$2 b *annually* in Australia until 2020 (ERIG 2006). The IEA (2003) estimated energy sector investment needs at over US$100 b/year in North America, and over US$500 b/year globally, averaged until 2030.[5] So any presumption that AP6 will achieve serious results in stimulating innovation in low carbon technologies was and is no more than wishful thinking, unless funding is raised substantially.

In the light of this, it is vital to note that in Fisher *et al.* (2006) (and in Ford *et al.* 2006), no costs of developing or deploying new technologies are given, and many quantitative assumptions remain implicit and inaccessible. In particular, no costing is given of how carbon capture technologies are expected to fall to an assumed US$25–30/tonne, especially given the already noted absence of any carbon price or serious government spending on R&D (Matysek *et al.* 2005 is cited, but there the figure is a pure assumption, on

[4] 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.

[5] The respective projections for Australia, and for North America and globally, come from different sources with different underlying definitions and assumptions.

p. 4, p. 35 and p. 55). Finally, even if such technology would be available at \$25–30/tonne, no reason is given why emitters would deploy it, rather than vent CO_2 freely. So all Fisher *et al.*'s results are necessarily qualified as what AP6 policies 'could', rather than 'will', achieve.

In Section 2, we noted that although government support for R&D is vital, emission pricing can also induce significant amounts of innovation. Central to the contrary view in the emission pricing section of Fisher *et al*. (2006, p. 21) is a claim, from what is now Montgomery and Smith (2007), 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 assumes there exists a single, as yet undiscovered innovation, which once discovered and implemented will cheaply reduce emissions to low levels, giving no reason *ex post* for governments to maintain a high emission price, and hence no market repayment of the fixed costs of innovation. In reality, no single technological fix exists; even if CCS is a 'winner', as presumed by Fisher *et al.* there will be no one CCS technology suitable for all types of power stations. In any case, Montgomery and Smith accept that a 'relatively low' emission price may be justifiable 'to motivate emission reductions through changes in utilisation of the existing capital stock, or new capital investments using existing technologies'. A significant piece of evidence for the view that such reductions will be large 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.

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, alternative climate policy, when in fact many other, complex and continuous policy choices can be combined with it, overwhelmingly so if the time horizon stretches to 2050. 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 2007). This ignores the countless developments which might follow on from Kyoto after 2012, and the fact that slowing economic growth does not mean abandoning it altogether. And in this respect, we note the stress in the Terms of Reference of the Task Group on Emissions Trading (Howard 2006) on advising on design of a workable *global* trading system (our emphasis) that preserves Australia's 'major competitive advantages through the possession of large reserves of fossil fuels and uranium'. This seemed then to refute from the outset both the gradual decarbonisation of the economy that cost-effective emission control requires, and the global need for developed countries to take the lead in emissions control.

4. Conclusion

We have set out here the most fundamental elements of an effective and efficient policy to tackle global climate change. For policy to be effective, global emissions of GHGs 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, the key broad policy elements are 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, through 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 environmental policy has ever faced, and transitional arrangements are bound to be difficult. But it does serve as a yardstick against which to compare various policy initiatives.

We have argued that the kind of *exclusively* technology-focused climate policy promoted by Australia and the USA in 2006 under the AP6 umbrella fell far short of the ideal. Key inconvenient truths were 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 were 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 was rejected in favour of costly winner-picking, by over-prescribing which types of abatement should be used most. Technology-focused policy and the Kyoto Protocol approach were falsely presented as incompatible, ignoring the possibility of combining them and many other options, especially for the transition to more comprehensive global control, into a suite of climate policies to last well into the 21st century. Purely technology-focused climate policy will either be very inefficient or very ineffective. Without a very large increase in funding, we fear the latter, meaning that countries exclusively following such policies will be fiddling while carbon burns.

That said, since AP6 does include the United States, China and India, it has the potential to make a difference for global climate policy, at least in principle. And it is clear that technology policy, including for carbon capture and storage, must play a vital part in efforts to reduce global, long-term GHG emissions. Two things are necessary if not sufficient to make current Australian and AP6 climate policy effective and efficient: devoting meaningful resources to developing a broad range of technologies, and putting a significant, pervasive price on emissions.

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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 = unit 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' (fixed) 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 the electricity tax, and now raises only $a - q_2t - b$ 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 this holds exactly.)

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

1. The value of the change in electricity consumption from q_1 to q_2 is $-c(q_1 - q_2)$, since c is the price and therefore unit value of electricity.
2. 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 consumers spending* by *b*, the reduction in overall taxation, while leaving emissions unchanged. So the overall effect must be to increase welfare.

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