Clean energy technology and the role of non-carbon price based policy: an evolutionary economics perspective

Eric Knight
Department of Geography and the Environment, University of Oxford

Nicholas Howarth
Department of Geography and the Environment, University of Oxford

CCEP working paper 2.11, February 2011

Abstract
Much academic attention has been paid to the role of carbon pricing in developing a market-led response to low carbon energy innovation. Taking an evolutionary economics perspective this paper makes the case as to why price mechanisms alone are insufficient to support new energy technologies coming to market. In doing so, we set out the unique investment barriers in the clean energy space. For guidance on possible approaches to non-carbon price based policies that seek to tackle these barriers we turn to case studies from Asia, a region which has experienced a strong uptake in climate policy in recent years.

Centre for Climate Economics & Policy
Crawford School of Economics and Government
The Australian National University
ccep.anu.edu.au

CLIMATE
Economics & Policy

The **Centre for Climate Economics & Policy** (ccep.anu.edu.au) is an organized research unit at the Crawford School of Economics and Government, The Australian National University. The working paper series is intended to facilitate academic and policy discussion, and the views expressed in working papers are those of the authors. Contact for the Centre: Dr Frank Jotzo, frank.jotzo@anu.edu.au.

Citation for this report:

Knight, Eric and Howarth, Nicholas (2011), *Clean energy technology and the role of non-carbon price based policy: an evolutionary economics perspective*, CCEP working paper 2.11, Centre for Climate Economics & Policy, Crawford School of Economics and Government, The Australian National University, Canberra.

1. Introduction

There is an argument emerging amongst economists that a carbon pricing mechanism alone is insufficient to transform the carbon-intensive base of the global economy (Stern 2009; Acemoglu et al. 2009). Although a transparent and robust carbon price (set through a carbon tax or emissions trading scheme) is vital for changing the production decisions of firms at the margin in favor of lower carbon intensive substitutes, the deployment of clean technologies into the market requires additional government intervention through non-price based policies (also called "technology" or "innovation" policies).

In this paper, we focus on those technology policies which would operate in conjunction with a carbon price to reduce barriers to private investment in clean technologies. These non-price fiscal policies, we argue, work best when they are targeted at overcoming *early-stage* market failures. Without these early-stage barriers sufficiently addressed, the introduction of a carbon price may be pre-mature in the sense of creating non-optimal social outcomes. This is because these barriers, which are independent of a carbon price, prevent new technologies from entering the market and competing with fossil fuel sources of energy generation.

The dual role for carbon pricing *and* technology policy in light of the multiple market failures at play has been recognized by Lord Stern and others. As the 2006 Stern Review on the Economics of Climate Change argues:

> "[T]he presence of a range of other market failures and barriers mean [sic] that carbon pricing alone is not sufficient…Technology policy, the second element of a climate change strategy, is vital to bring forward the range of low-carbon and high-efficiency technologies that will be needed to make deep emissions cuts."

There is international agreement that private investment will need to provide the bulk of financing for renewable energy projects globally (Doornbosch and Knight 2008). Given that we are yet to see private investment meet the scale and scope need for new clean energy investment in both developed and developing countries, governments may seek to introduce fiscal policies of the nature described in this paper.

Each sector and each country will face its own unique investment barriers for the financing and deployment of new technologies. In this paper, we take examples from the APEC region to examine of possible technology policy options. APEC is a worthwhile region to examine as it contains many of the world's major emitters and has been a focus of major climate policy innovation over the last decade.

2. Role of Evolutionary Economics in Climate Policy

Traditional economic analysis of climate change has most often been grounded in the standard welfare economics of A. C. Pigou (1912). This focuses on establishing the costs and benefits of an emissions target or level of pollution and the optimal or most cost effective way to achieve it usually through the comparison of the merits of either a system of tradable quotas (emissions trading) or through taxation of carbon intensive goods (eg. Nordhaus, 2007). Having 'internalised the externality of pollution' through establishing a price on carbon the problem of energy policy is usually reduced to ensuring that energy prices reflect the full social costs of energy production and utilization. This is on the basis that the world is far too complex for politicians to "pick winners" (see Helm, 2005) and, aside from providing some informational support or changing relative prices to correct for any externalities, it is best to leave people "free to choose" and let "the market decide" as much as possible.

Market mechanisms fit comfortably within the rubric of neoclassical equilibrium analysis, where well-informed consumers select products in a way that maximises their own welfare, and by extension, best promotes the interests of society at large. On the other hand, non-price based policies are often cast as 'political interventions' easily corrupted by the special interests of a powerful minority, thus working against society at large, represented by the consumer (see Olson, 1965). These policies are therefore liable to criticism as not being dynamic, leading to lock-in and smothering innovation.

There have been, of course, notable exceptions to this general attitude to non-price based policy. For example, several prominent economists have criticized standard welfare economics as paying too little attention to the historical, geographical, legal, cultural and political context of pollution abatement decisions (IPCC, 2007; Stern, 2006; Williams and Baumert, 2003; Victor, 2007, Carraro, 2007) and also sidestepping the problems of path dependency (Grübler, 1998; Brohé et al., 2009:39). For example, Nicholas Stern argues in his Review on the Economics of Climate Change:

> "Many commentators are skeptical about technology policy, saying it is wrong for bureaucrats to 'pick winners'. There is something in this, but it is also naïve or dogmatic in its underlying assumption that markets work perfectly unless distorted by government. In this case, markets do not work well unless assisted by government" (p111).

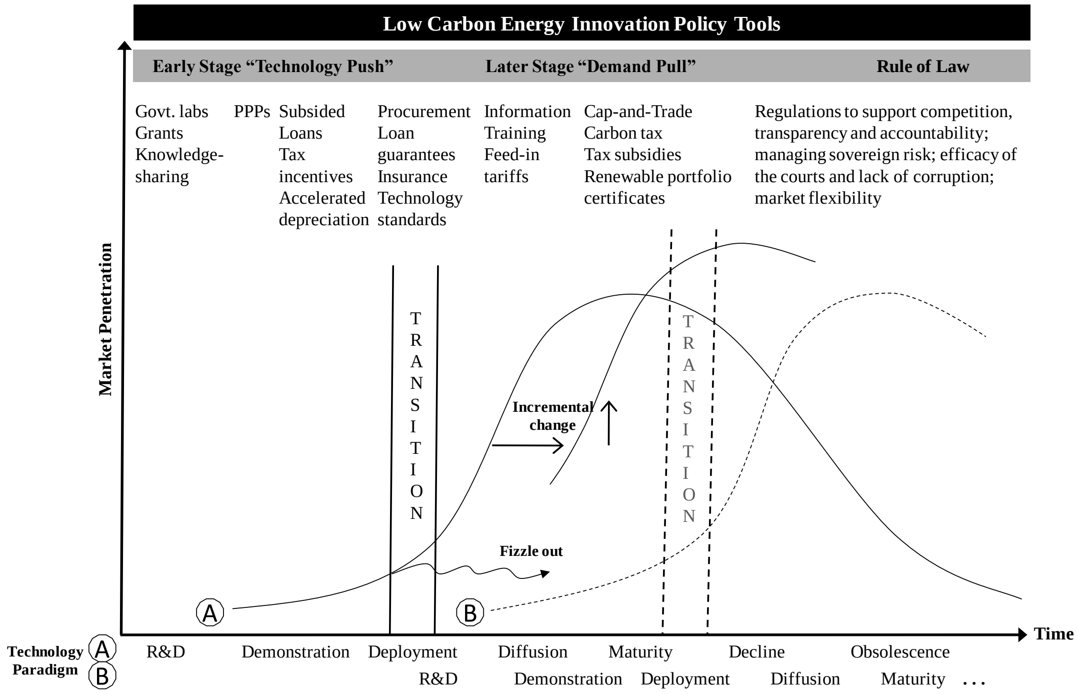
Michael Porter and Claas Van der Linde's (1995) work has also been influential in challenging the orthodox economic view (Palmer, Oates and Portney, 1995) by highlighting the positive role environmental regulations can play in promoting environmentally beneficial innovation and supporting economic competitiveness at the firm, sector and nation-state level. They argue that tighter environmental standards can not only reduce business costs directly, but also that they can spur cost reducing innovation further, thus boosting competitiveness. This has given rise to the so called Porter hypothesis which has inspired a large body of supportive empirical studies (eg. Lanoie et al. 2008; Horbach, 2007; Costantini, and Crespi, 2007; and Kriechel and Ziesemer, 2009). However, other economists have rejected such case-study based approaches by arguing the examples used are special cases and that across the economy it is just as likely environmental regulations come at a net cost, as well as embodying a significant opportunity cost. For example, Jorgenson and Wilcoxen (1990) and Hazilla and Kopp (1990) use a dynamic general equilibrium model to show such regulations are necessarily cost adding because of the manner in which environmental regulations depress other "productive" investment. The Porter Hypothesis remains a highly controversial issue with price theorists strongly arguing that innovation is driven by changing the price of factors of production (see Newell, Jaffe, and Stavins 1999).

This paper argues that this dialectic between government "picking winners" on the one hand and providing price based incentives to allow "the market to decide" on the other can be usefully explored through an evolutionary economics perspective. Such an approach anchors its analysis in the observed reality of energy investment decisions which must be made in the presence of an existing set of institutions, distortions, technologies, power relationships and other contextual constraints that play out on clean technology investment decisions.

Under this approach, the market penetration of a clean technology is conceived as following an epidemic or sigmoid function of gestation, growth and decay (Figure 1). This evolution is not however guaranteed, as technologies must compete in a complex system of existing competing technologies, government policies, environmental constraints and socio-political attitudes. For a technology to avoid fizzling out, it is necessary for a range of institutions (the humanly devised incentives and constraints which shape decision-making) to align to allow it to break though to establish its place in the socio-technological milieu. Figure 1 depicts two different technological paradigms 'A' and 'B' characterizing different socio-technical systems based on fossil fuels and clean tech respectively.

We distinguish between two types of non-price fiscal policies used to address climate change mitigation in accordance with the academic literature (Burer and Wustenhagen 2009). Firstly, there are supply side (technology push) policies. These focus on R&D programs and the demonstration of new energy generation technologies. Secondly, there are demand side (demand pull) policies. These focus on market demand for the clean energy generation. These are aligned with points along the technology diffusion curve with supply side or "market-push" and demand side or "market pull" policies, positioned at early and later stages of the diffusion function respectively.

Figure 1 The evolution of clean energy technology and the role of innovation policy tools



Fischer et al (2003) argue that it is not possible to rank the cost-effectiveness of all climate change fiscal policies in general because the circumstances will change based on the economic settings within a particular country. Because of market failures and evidence of path dependency in energy systems there is growing recognition that social outcomes may be optimized when a mixture of both policy approaches is used strategically (Fisher 2008; Popp 2006a; Acemoglu et al 2009). For example, Economic modeling by Acemoglu et al (2009) show that relying on a carbon price alone leads to an excessive drop in consumption in the short term as clean energy alternatives are slow to compete in the market. There is also evidence that price-based mechanisms are more suited to marginal efficiency improvement within a specific technological paradigm, shifting the diffusion curve A up and to the left in Figure 1, and not well targeted at delivering paradigm represented by the shift from A to B.

In addition to applying a mix of policies, policy makers may need to pay regard to the timing and duration of policy options. On the issue of staging, given that technology policy is often focused on early-stage technologies it is important to introduce this measure early-on so that new technologies can emerge quickly. If carbon pricing is introduced in the absence of these "stage one" policies then there is a risk that carbon price inflation will be borne fully by electricity consumers because of a lack of viable energy alternatives. However, the strategic staging of these policies can ensure that a strong pipeline of new clean energy technologies will emerge to compete with coal-fired electricity once a carbon price arrives.

On the issue of duration, well-targeted non-carbon price innovation policy should aim to be temporary and be reduced once the market failure it is addressing abates and diffusion is underway. If measures are applied indefinitely then they may reduce the flexibility of the socio-technological system to adapt to changing priorities by locking-in certain technologies as well as causing an unnecessary drain on national budgets.

A final overarching element to the evolutionary model in Figure 1 is the role of general governance institutions which support flexibility in the socio-technological system. These measures include the fostering of competitive, transparent markets where firms and politicians are accountable to the citizens whom support them. A key element of effective government policy in general is that there also is effective rule of law in the country and that there is recourse to penalize law breakers in courts which are free of corruption. Such general measures should not be overlooked as they are not only important in fostering clean technology investment but also act as the foundation for reducing sovereign political risk and support economic activity across the economy.

3. What are the investment barriers?

In this section, we examine in greater detail the early-stage market failures for private investment in clean energy generation technologies. These failures are independent of a price on carbon.

From economic theory, private investors face two principal hurdles when making investment in new technologies. The first hurdle is the “adoption hurdle”. Because investors are uncertain about the adoption of a new technology in the market, they are unable to accurately predict the future cash flows from their investment. This leads them to under-invest in new ideas and deploy capital into to less risky projects where cash flows are more predictable.

The second hurdle is the “spillover hurdle”. Even if an investor is successful in selling a new technology into the market, they are not fully compensated for the public good or positive externalities derived from research and development (R&D) investment in that new idea. This is because the spill-over effects of this investment are captured by competitors who indirectly benefit by replicating the intellectual property and take advantage of new technological know-how. The presence of this incentive asymmetry creates a second barrier to private investment in new technology (Knight 2010).

The market failures in financing new technologies exist at some level across all technology sectors including the biotechnology and digital communications sectors. In many countries, venture capitalists typically have the highest risk appetite for new technology deals and play an important role in financing ideas out of universities and national laboratories and bringing them to market. However, there are a number of characteristics about renewable energy technologies which make the above market failures more acute than in other sectors.

The first characteristic is that renewable energy projects are very capital intensive compared to biotechnology and IT projects. The upfront cost of a renewable energy technology demonstration project is upwards of US$100 million per a project (Ministry of Finance Green Paper 2009). This is typically too big for venture capitalists who have relatively small funds under management (approximately US$100-500 million) (Shellenberger et al. 2008). In addition, renewable energy projects are competing with biotechnology and digital communications technologies which cost a fraction of this to demonstrate. By contrast, project financiers and commercial banks which would typically lend capital for deals of this size are highly risk-averse and unwilling to take on the technology risk involved. They will finance less risky deals (hospitals, toll roads, airports) ahead of renewable energy projects because the risk/return premium is more predictable and favourable. The result is that the "adoption hurdle" described above is more acute for renewable energy projects because private investors are required to make larger size risks in the sector.

The second characteristic of renewable energy projects which is unique is that the end product – electricity – is homogenous and directly substitutable with coal-fired electricity. This means that unlike new drugs or software applications which may earn a premium in the market, renewable energy competes on price with coal-fired electricity. Given that it is difficult for renewable energy to reach price parity in its production costs with coal-fired electricity, a price-directed intervention is required by government to guarantee an end-market for renewable energy generators. This also amplifies the "adoption hurdle" because investors have no sense of the future cash flows they may receive from a new technology.

Clearly a carbon price has an important role in changing the end market for renewable energy. However, a carbon price is technology agnostic and will favour later stage technologies which have already reached commercial scale. For early stage technologies, however, alternative fiscal support through technology-specific feed-in tariffs, direct investment, tax exemptions, accelerated depreciation rates and renewable energy standards all help reduce the capital costs facing an investor and guarantee an end market for their product. Without these measures in addition to a carbon price, new renewable energy technologies may struggle to compete with more established renewable energy technologies to reach some economies of scale.

The above analysis relates to the investment barriers facing technology investment in the clean energy sector. There are two additional points worth mentioning.

The first is that technology financing is not just a challenge for developed economies. Investors in renewable energy projects in developing economies will face high technology risk even if the technology is imported. This is because the yield which a particular renewable energy technology is able to achieve directly related to the local environmental conditions. Therefore the same technology will have a different yield in Jakarta, Indonesia as it would in Guangzhou, China. Also, different technologies may be better suited to the conditions in different geographies (Knight 2010). Leaving this to one side, however, close analysis of clean technology patent data indicates that a number of APEC economies are becoming leading net exporters of clean technologies. Amongst these the USA, Japan, China, and South Korea are most prominent (Dechezleprêtre et al. 2008). Indeed, China's recent strategic document *Medium and Long-term Development Plan for Renewable Energy in China (2007)* explicitly identifies the deployment of Chinese intellectual property domestically as a future policy objective.

The second point to mention is that in addition to the market failures identified above, investors in APEC developing economies face barriers to project finance related to the governance profile of these countries. These will be discussed briefly in Section 6 at the end of this paper. These barriers are not exclusive to the energy sector, but to effectively attract private investment, fiscal policy must be targeted to address these issues.

5. Supply side (technology push)

Supply-side measures refer to policies where the government financially supports the entry of a particular technology to market. This would be recorded as an expenditure on the government budget. Traditionally, this has been criticized as the "government picking winners". The reason why this may be a problem is because government may be motivated in its selection by criteria other than cost-effectiveness (Popp 2010). The private sector, at least in a well governed system, has more transparent incentives to make these kinds of judgments.

There may be reasons other than cost-effectiveness where the government has a strong case to offer supply side fiscal assistance to a particular technology. One reason might be the competitive advantages which a particular country has in a natural resource – such as geothermal resources in the case of Indonesia. If this exists but the technologies to utilize this advantage are immature and a long way from commercialization, a government may consider subsidizing research and developing funding into certain technologies directly. It is difficult to model the efficiency of public spending if this approach is taken, and R&D funding offers no guarantee that the innovations will be adopted in the market (Yang and Oppenheimer 2007). This suggests R&D policies should be adopted with caution. Politically, however, this approach is often desirable because it may have positive spillover effects for job creation and industry development in the local economy.

A more structural reason for government intervention is the high upfront capital costs of renewable energy technologies compared to their return on investment. The cost base for renewable energies is front-loaded with high capital investment and relatively low operating costs (Ministry of Finance Green Paper 2009). The main hurdle for renewable energy developers is finding bank finance to meet the upfront costs given the level of technology, operational and other project-related risks.

Box 1. Financing Indonesia's geothermal assets

Indonesia is host to 40% of the world's geothermal resources, which is more than what any other country in the world can lay claim to. However, only 3% of Indonesia's geothermal capacity is developed.

The Indonesian Ministry of Finance Green Paper (2009) identifies a number of investment barriers to commercializing Indonesia's geothermal resources. One barrier identified is the large up-front investment costs for geothermal projects combined with uncertainty about the value of each research. Because early drilling and exploration costs are high, private investors are unwilling to take on the risk of pre-tender field surveys and exploration studies. The report recommends a national Clean Technology Fund be set up to bear the initial costs for funding confirmation drilling.

If there is agreement that high upfront costs are a structural barrier to renewable energy investment, this is not a license to promote fiscal stimulus for any technologies. Some fiscal policies are arguably better targeted than others at addressing the investment barriers around high upfront costs. Examining current supply side policies within the APEC region it is possible to distinguish between those policies targeted at the investment costs of clean energy projects as opposed to the production costs of energy generation.

5.1 Policies for investment costs

Investment tax credit

Fiscal policies targeting investment costs are arguably best geared to address the high start-up costs of renewable energy technologies. A number of countries have identified high upfront costs in renewable energy projects as an area for fiscal reform. For example, the United States has set a federal 30% investment tax credit which will be maintained through until 2016 for solar PV, solar thermal power, solar hot water, small wind and geothermal. This tax credit is explicitly broad enough to cover utility companies. By providing a time limit on access to this credit, the government is attempting to avoid “lock-in” where new technologies come to depend on the tax credit over the long-run.

Accelerated depreciation

In India, the government has allowed accelerated depreciation for a number of key technologies. For example, small hydro and wind projects are allowed 80% accelerated depreciation on equipment and devices used in the first year of installation of the project. In the case of biomass power generation, this is 100% deprecation in the first year of the project for many of the key large-scale components including boilers and waste recovery equipment.

The purpose of accelerated depreciation is that it reduces taxable income in current years in exchange for increased taxable income in future years. This encourages businesses to purchase new assets upfront and helps with the initial costs of starting up these major projects.

Tax holidays

In China, the high upfront costs of clean energy projects are reduced by tax holidays for selective taxes which contribute to initial project costs. These include import duties which affect imported renewable energy technologies and value added tax. The tax holidays applied to renewable energy technologies in China are reported in Box 2 below.

Box 2. China's climate finance tax incentives

The Chinese government currently offers a number of tax incentives to reduce the upfront costs of deploying renewable energy projects. In China, the standard value added tax is 17&. However, for a selection of renewable technologies, the VAT is reduced. It is only 13% for biogas, 8.5% for wind, and 6% for small hydro-projects.

Import duties are also lower for renewable energy technologies (many technologies are imported). Average import duty is currently 23% but for renewable energy these rates are significantly later. It is 3% for the components of wind power plants, 6% for wind turbines, and 12% for photovoltaics (PV) systems). [1]

Loan schemes

It might be possible to offer loan guarantees to project developers who struggle to attract bank finance for large renewable energy projects. While there is a risk that these policies might result in underwriting bad loans to poorly conceived projects, there will also be instances where projects are indeed bankable but local financial service professionals lack the experience or risk appetite to complete these deals. The risks of the former may be mitigated by private-public co-financing models where both parties are financially exposed to default losses. This will help address some of the teething problems around the capital intensive nature of clean energy projects where the financial requirements are disproportionately high for the amount of project risk involved.

In the United States, a number of conditional loan guarantees were offered by the Department of Energy to promising venture-backed clean tech companies which were struggling to raise capital. Under the Energy Policy Act of 2005, sectors affected by these loan guarantees included a number of capital intensive clean technologies such as biomass, solar, wind, hydropower, carbon sequestration, and advanced fossil energy coal. Beneficiaries included Bright Source and Solyndra. The multilateral development banks have also positioned themselves to play a supportive role to major infrastructure project finance in developing countries (see Box 3).

Box 3. Publicly backed guarantees for infrastructure

A number of multilateral development banks have sought to deploy public finance to address the capital intensity challenge of renewable energy projects with high levels of technology risk. The presence of public sector bank guarantees or subordinate loans can assist with the commercial terms of project finance for new renewable

---

[1] See World Resources Institute website, available at http://projects.wri.org/taxonomy/term/8?page=3

energy projects. In the absence of these interventions, private investors may be unwilling to finance a project.[2]

The European Investment Bank offers equity financing and financial guarantees for selected large-scale infrastructure schemes. Examples of tools used include guarantees for pre-completion or early operational risk, subordinated loans or mezzanine finance.

The World Bank and Global Environment Fund have set up the Geothermal Energy Development Fund. It offers partial risk guarantees for risks such as the short-term upfront geological risk of exploration.

At a local level, a similar approach may be taken for home owners or building occupants seeking to finance climate-related installations. Mexico, for example, has established "green mortgages" for home owners seeking to finance solar hot water installations into their houses at favourable interest rates. In the Philippines, the United Nations Environment Programme and the Global Environment Fund have supported the Solar Home Systems Financing Programme in Palawan. That programme offers public-backed financial security to households seeking to purchase solar home systems. The security comes in the form of a loss reserve fund which offers assistance in the event of default.

5.2 Policies for production/ operating costs

A number of countries have begun to introduce fiscal policies to reduce the production costs of renewable energy generation. For example, the American Recovery and Reinvestment Act (2009) extended the eligibility of companies generating wind, solar, geothermal and "closed-loop" bioenergy for production tax credits (until 2013, and 2012 for wind). These tax credits last for the first ten years of the facility's operation.

In Indonesia, the government has also sought to introduce policies to tackle the production cost of renewable energy generation. Legislation has recently been put in place to subsidize the production costs of small scale renewable energy systems (Ministerial Decree No.1122/K/30/MEM/2002 on Small Distributed Power Generation Using Renewable Energy and Ministerial Regulation No. 2/2006 on Medium-Scale Power Generation Using Renewable Energy). The intention has been to offset the distortion in the market caused from subsidized conventional energy generation which makes it difficult for renewable energy to compete in the market.

However, it has been suggested that this Indonesian legislation has not been effective in attracting new investment into the market. As the Indonesian Ministry of Finance's Green

---

2 Further details on the structuring of publicly backed guarantees is available in the SEFI Alliance Report 'Publicly backed guranatees as policy instruments to promote clean energy.

Paper on *Economic and fiscal policy strategies for climate change mitigation in Indonesia* comments: "these production costs [of small-scale renewable energy plants] are not transparent, long, and difficult". Further, the Green Paper points out that "negotiations between the investor and utility are required to reach an agreement that will provide the necessary return for the investor." However, the state utility, PLN, has been unwilling to strike an agreement with the government because it regards renewable energy as unprofitable.

The situation in Indonesia suggests that this policy approach does not sufficiently address the underlying investment barriers in the development and deployment of renewable energy. It is more important for financiers and utility companies considering investment in new, risky technologies to have a long-term stable cash flow. Providing security on this issue is arguably better addressed through demand-side measures which create more certainty for demand of renewable energy in the market. These will be considered in the next section.

6. Demand side (technology pull)

One of the main investment barriers to new renewable energy capacity is the lack of certainty which private investors have in the end-market for clean technologies (the adoption hurdle). Without a clear expectation of demand for their product or service and therefore future revenue streams, private investors will typically under-invest in R&D or not take on the financing risks of commercial scale demonstration.

In the case of energy, renewable energy generation supplies a product (electricity) which is directly substitutable with fossil fuel based energy generation. In most cases renewable energy technologies are not at the stage where their production costs are at parity with coal, they are unable to compete on a price basis on the open market. Given the substantial historical (and often hidden) subsidies which have gone into establishing the incumbent fossil fuel based energy system (see Doornbosch and Knight, 2008), this presents public policy grounds for government intervention to assist the deployment of renewable energy technologies into the market.

Although a carbon price help supports demand in the market for renewable energy, renewable energy generator bear the risk of carbon price volatility. In the event that a carbon price falls too low, then renewable energy generators are unable to compete with coal-fired electricity to sell into the grid. This means that early stage investors in new renewable energy technologies may not have certainty in the end-market for their electricity. A problem with this is that it may result in an under-investment in R&D into new technologies as investors are unwilling to bear the market risk involved, as well as an under-deployment of proven renewable technologies into the market. The introduction of a floor price for carbon is one way in which this risk can be mitigated by government. However, additional non-price fiscal policies may be used in the short-run to give certainty to investors that there is demand for their new technologies in the market.

One example of a demand-side policy is the introduction of legislation which sets a minimum standard (renewable portfolio standard) for renewable energy generation in the national energy mix. This standard sets a clear threshold for environmental performance while remaining agnostic on which technologies are used to meet this performance.

Demand-side policies have been introduced in Europe and numerous APEC countries to address market demand for clean technologies. Typically, demand-side policies are expenditure neutral on the national budget. As such they do not fall under a strict definition of fiscal policies. Nevertheless they are important tools in the fiscal setting of a domestic economy because they directly influence the private investment landscape within an economy and are therefore considered in our analysis below.

6.1 Expenditure neutral demand-side measures

Targets and standards

National targets play an important role in setting out the policy direction and aspirations of macroeconomic policy around climate change investment. They can be either mandatory, supported by legislative penalties and incentives, or merely aspirational. Although targets do not directly provide investment certainty, they provide a framework within which the private sector can be confident the government is working towards more detailed fiscal and regulatory measures.

In the energy sector as of 2009, targets have been set in at least 73 countries globally on the basis of an agreement on the volume or proportion of the national energy mix which is to come from renewable energy sources.[3] In Table 1 a few examples of targets set by key APEC countries are presented. Targets may be set on a volume basis, a proportional basis, or on a technology-specific basis. For example, in Australia it is not mandated which renewable energy technologies will deliver the outcomes set by the government.

Table 1. Examples of renewable energy targets in APEC countries

Australia	45 Terawatt-hours (TWh) of electricity by 2020
Japan	14 GW of solar PV by 2020 and 53GW by 2030
Indonesia	9.5 GW of geo-thermal by 2025
China	15% of energy from renewable sources by 2020
Vietnam	3% of commercial energy supply by 2010 and 5% by 2025 and 11% in 2050

---

[3] See Renewable Energy World Website, available at http://www.renewableenergyworld.com/rea/news/print/article/2009/09/renewables-global-status-report-2009-update

Targets have also played a key role in the biofuels sector. Biofuels are a controversial sector because their environmental benefits are a contentious issue. Nevertheless, in terms of driving technological change, targets on the proportion of transport fuels which come from biofuels have been very effective. In most EU countries, biofuels targets are currently set at around 5.75% of transport fuels by 2010.

These specific targets give private investors certainty about the existence of a future market for biofuel products as well as help them evaluate the future size of this market. In the absence of biofuel blending targets, biofuels must compete with fossil-based fuels in the fuel market which is extremely price sensitive and where production costs price them out of the market. Table 2 contains example of biofuel targets for a number of APEC countries

Table 2. Examples of Biofuel targets in APEC countries

Australia	350 million litres by 2010
Indonesia	3% by 2015 and 5% by 2025
Japan	500 million litres by 2012
Vietnam	300 million litres by 2020

Renewable portfolio standards and certificates

Another example of using domestic regulation to reduce market risk for private investors is Renewable Portfolio Standards (RPS). A RPS mandates the supply of a certain percentage of electricity to come from renewable energy generators. This obligation can be placed on different entities in the electricity supply chain, but is typically placed on electricity supply companies (for example, in UK, Belgium, Netherlands). These suppliers are given a specific target on the target amount of renewable energy they must supply (10.4% target by 2010 in the UK) as well as the target power supply sources (for example, wind power, photovoltaics, geothermal etc).

RPS (or equivalent) regulation has been introduced in Australia, parts of Europe, the United Kingdom, a number of states in the USA, Japan, India and Chile. It has typically been more prevalent in developed countries because of the impact on prices for the end user but arguably has a greater role to play in APEC countries.

A RPS regulation does not in theory have a negative impact on the national budget. Rather, through regulation, it provides certainty in the market for a proportion of renewable energy to be generated and sold into the grid. Standards are usually fulfilled by issuing renewable energy generators with “credits” which can then be traded and purchased by utilities in fulfilment of the renewable portfolio standard mandate. This stimulates private investment because investors in renewable energy are now required to compete with each other rather than with coal-fired electricity where they have a structural price disadvantage.

Box 4. Examples of RPS-style standards in developing economies

India has introduced a national Renewable Energy Standard (RES) of 5% of grid power purchased by state utilities to come from renewable sources by 2010, with an increase to 15% by 2020. 17 of India's 28 states have also enacted RES mandates which vary between 1% to 20% for compliance in the period to 2011 or 2012. One weakness in the Indian system at present is that non-compliance with RES regulations does not result in strong penalties (REF).

In Chile, the new RPS starts at 5% for the period 2010-2014 and will increase incrementally to 10% by 2024.

In China, the national government has mandated that 15% of energy by 2020 will come from renewable energy.

As a result of being technology agnostic, a RPS policy will advantage those technologies which have the lowest costs, such as wind power (Johnstone, Hascic, and Popp 2010). However, it will also facilitate competition in the market as renewable energy technologies will now be required to compete against each other on a cost basis rather than with coal-fired electricity.

Feed-in tariffs

An increasingly popular policy amongst policy makers and the private sector to promote renewable energy generation has been feed-in tariffs. Feed-in tariffs are popular amongst private investors because they offer certainty in the end-market to renewable energy generators competing with coal-fired electricity to sell into the grid. Typically, feed-in tariff regulation guarantees grid access for renewable energy suppliers. In addition, it typically offers long-term contracts for the electricity which is produced.

Table 3. APEC countries with feed-in tariff policies

Australia		New Zealand	
Brunei		Papua New Guinea	
Canada	✓*	Peru	
Chile		The Philippines	
China	✓	Russia	
Indonesia	✓	Singapore	

Japan	✓*	Thailand	✓
Republic of Korea	✓	USA	✓
Malaysia		Vietnam	
Mexico			
✓* indicates that some states and provinces in these countries have feed-in tariffs.			

Although each jurisdiction has a very different mechanism for calculating the feed-in tariff rates, the cost of these policies draws down on the national budget. Some jurisdictions, such as China, differentiate the generosity of the tariff based on the technology it is seeking to promote. This is typically negotiated on a regional basis given the competitive industrial strengths of the area in question.

The disadvantage of technology-specific feed-in tariffs is that there are few spillover benefits for competing technologies. There is a risk that if this advantage persists for too long, it will have a "lock-in" effect whereby one technology becomes dominant . Short-term approaches to renewable energy feed-in tariffs have been applied in Europe. In Spain, the solar PV feed-in tariff was rapidly reduced after its 2010 targets were reached ahead of schedule. Although this created short-term pain for some companies it has helped grow a strong solar industry in Spain.

Box 5. Examples of feed-in tariffs in developing economies

A number of developing economies with APEC currently use feed-in tariffs. Thailand has adopted a feed-in tariff which affects particular technologies – wind, solar, biomass, and micro-hydro. In Indonesia, the new revised feed-in tariff is targeted at renewable energy projects of a particular size – only plants greater than 10 MW in size are included.

Consumption standards

Finally at a local level, a government may promote the use of certain technologies through amending regulation to mandate the uptake of certain technologies. These amendments are typically to environmental and planning regulation as well as fuel efficiency standards.

For example, Spain in 2008 became the first country to mandate solar water heating at both the national and local levels. This has been followed in a number of jurisdictions including India where solar hot water is now mandated for a variety of new institutional, corporate and residential buildings. In China, the regional authorities are moving towards stricter guidelines for technology and equipment use in new buildings.

7. Other investment barriers to project finance in developing countries in APEC

The discussion above covers a number of alternative approaches to carbon pricing to address investment barriers around the development and deployment of renewable energy technologies. However, when seeking to finance a renewable energy project in a developing country, project financiers and developers typically face barriers independent of the project being a clean technology. Addressing these barriers would help increase in-bound foreign investment in major infrastructure projects in APEC countries.

Some of the financing challenges facing major infrastructure projects in these developing economies include:

- Sovereign risk: government instability, lack of transparency in business dealings, legal enforcement. MIGA guarantees insuring against contract default, currency inconvertibility, expropriation and war and strife.
- Regulatory risk: change of regulatory and other fiscal conditions with the change of political administrations
- Currency risk: exchange rate fluctuations make returns volatile and could impact investment. Governments may seek to mitigate these effects for foreign investors.
- Deal flow risk: significant information asymmetry around possible deals available, geographies, and different agencies involved. Government may introduce a public body responsible for assisting in project development and offering technical assistance.
- Operational risk: delays to project construction and approval and transaction costs associated with corruption.

A number of APEC countries have introduced policies to try to strengthen governance and address these barriers. In the Philippines for example, the government has supported renewable energy trade missions domestically and internationally to try and attract business to the country. They have also offered investment kits to clarify the project approval process. Thailand has also recently established an investor relations office to specifically assist companies interested in operations and maintenance of energy assets.

Box 6. Insuring against sovereign risk

The Multilateral Investment Guarantee Agency (MIGA) is an affiliate of the World Bank Group. They are tasked with the role of promoting foreign direct investment into developing countries. One of their tools is to provide publicly funded insurance for inbound investment in projects exposed to high levels of political risk. Private investors are often unwilling bear this risk when considering the finance of the project. These risks can include war and civil disturbance, expropriation, currency transfer risks, and breach of contract.

In addition, renewable energy projects typically face a number of specific non-economic barriers which governments may seek to reduce in order to attract new investment. These hurdles are particularly around obstacles to grid access, poor electricity market design, and administrative hurdles in the process of the Clean Development Mechanism of the Kyoto Protocol in order to secure additional revenue streams.

A number of countries within Asia have recently focused on improving their grid transmission infrastructure. For example, the Asian Development Bank is helping fund an interconnected power system between Indonesia and Malaysia. Vietnam and Cambodia are also looking to boost investment cooperation on hydro-power plants between the two countries. In south Asia, discussions are underway to interconnect grids between India and Bhutan, India and Nepal and India and Sri Lanka. For renewable energy, the key challenge is finding a mechanism to accommodate decentralized producers into the power grid. Presently, decentralized producers are not permitted to feed overcapacity back to the grid and often face significant competition from conventional power plants around grid access. Easing these constraints would assist with many of the non-economic barriers to renewable energy deployment in APEC countries.

8. Conclusion

This paper has sought to lay out the basis for technology policy measures which can operate alongside carbon pricing for a well-balanced policy approach to low carbon economic transition.

The case for non carbon price policy approaches can be clearly made by taking an evolutionary economics perspective to clean technology investment. This emphasizes the historical embeddedness of incumbent fossil fuel technologies and the institutional barriers which impact project finance decisions. These include the underinvestment of the private sector in research and development for new technologies (the spillover hurdle); and uncertainty over future market penetration and cash flow (adoption hurdle). While carbon pricing is effective at driving marginal efficiencies it is argued here that non-carbon price based policy is better suited at supporting early stage technologies which are yet to find a substantial niche in the market and at moving the socio-technological system from one paradigm to another.

We seek to explain from theory and practice in the APEC region how non-price fiscal policies can be used to effectively facilitate economic transition. Two principles are worth emphasizing.

The first is that non-price fiscal policy needs to be *targeted* at the market failures it is seeking to address. This may vary across countries and sectors, but is typically focused in the renewable energy sector around high upfront costs to investment (supply side barrier), and uncertainty amongst new renewable energy utility companies about the amount electricity they will be able to sell into the grid (demand side barriers). We have provided a number of examples in this paper about how governments and multilateral development banks can begin to address these problems.

The second principle governing non-price fiscal policy is that it needs to be *temporary and coordinated with other policies.* Often the barrier which non-price fiscal policy seeks to address is “early on” in a technology’s development towards technological maturity and commercial demonstration. Once these barriers have been removed, it is important to re-calibrate policy to ensure that the utility companies and other service providers do not come to depend on unsustainable government interventions. An example of this might be the “lock in” effect if utility companies indefinitely depend on price-related subsidies. For example, implemented before climate change was a concern fossil fuel subsidies have become locked in and negatively distort the energy market in many countries. This leads to biases in energy investment and comes at a heavy cost to government finances. Finally, this paper makes the case for good governance as a crucial ingredient in fostering clean tech investment has examined some of the sovereign risk issues impeding private investment in major projects, especially within developing countries where the rule of the law may be problematic. These issues should not be underestimated because they may impact foreign direct investment across all sectors, not just renewable energy. Addressing each of these issues in strategic combination is necessary to remove the barriers to private investment and support the cost-effective transition to a low carbon economy.

References

Acemoglu, Daron, Philippe Aghion, Leonardo Burstyn, and David Hemous. 2009. The environment and directed technical change. In NBER Working Paper.

Brohé, A., N., Eyre, and N. A. A. Howarth (2009), Carbon markets: An international business guide, London: Earthscan/James and James.

Burer, Mary, and Rolf Wustenhagen. 2009. Which renewable energy policy is a venture capitalist's best friend? Empirical evidence from a survey of international cleantech investors. Energy Policy.

Carraro, C. (2007) ‘Incentives and Institutions. A Bottom-up Approach to Climate Policy.’ Working Paper, Department of Economics, University of Venice.

Costantini, V. and F. Crespi (2007), ‘Environmental regulation and the export dynamics of energy technologies’, Ecological Economics, 66 (2-3): 447- 460.

Dechezleprêtre, Antoine, Glachant, Mattheau, Ivan Hascic, Nick Johnstone, and Yann Ménière. 2008. Invention and transfer of climate change mitigation technologies on a global scale: a study drawing on patent data. CERNA Working Paper.

Doornbosch, Richard, and Eric Knight. 2008. What role for public finance in international climate change mitigation. OECD Roundtable for Sustainable Development, SG/SD/RT(2008)3.

Grübler, A. (1998), Technology and Global Change, Cambridge, Cambridge University Press.

Hazilla, M. and R. Kopp (1990) 'Social cost of environmental regulations: a general equilibrium analysis', Journal of Political Economy, 98 (4): 853-73.

Helm, Dieter. 2005. Economic instruments and environmental policy. The Economic and Social Review 36 (3):205-228.

Horbach, J. (2007), 'Determinants of environmental innovation: new evidence from German panel data sources', Research Policy, 37 (10): 163-173.

Indonesian Ministry of Finance Green Paper (2009), 'Economic and Fiscal Policy Strategies for Climate Change Mitigation in Indonesia'.

IPCC (2007), Working Group 3: Fourth Assessment Report, Intergovernmental Panel to the Convention on Climate Change, World Meteorological Organisation and United Nations Environment Program.

Jaffe, Adam, Richard Newell, and Robert Stavins. 2004. Technology policy for energy and the environment. In Innovation policy and the environment, edited by A. Jaffe, J. Lerner and S. Stern. Cambridge: MA: MIT Press.

Johnstone, Nick, Ivan Hascic, and David Popp. 2010. Renewable energy policies and technological innovation: evidence based on patent counts. Environmental Resource Economics 45 (1):133-155.

Jorgenson, D. W. and P., J. Wilcoxen (1990) 'Environmental Regulation and US Economic Growth', Rand Journal of Economics, Vol. 21 (2): 314-40.

Kriechel, B. and T. Ziesemer (2009), 'The environmental Porter hypothesis: theory, evidence, and a model of timing of adoption', Economics of Innovation and New Technology, 18 (3): 267-294.

Lanoie, P., M. Patry and R. Lajeunesse (2008), 'Environmental regulation and productivity: testing the Porter hypothesis', Journal of Productivity Analysis, 30 (2): 121-128.

Newell, Richard, Adam Jaffe, and Robert Stavins. 1999. The induced innovation hypothesis and energy-saving technological change. The Quarterly Journal of Economics 114 (3):941-975.

Nordhaus, W. (2007), 'To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming,' Review of Environmental Economics and Policy, 1(1): 26-44.

Olson, M. (1965), The Logic of Collective Action, Cambridge, MA: Harvard University Press.

Palmer, K., W. E. Oates and P. R. Portney (1995), 'Tightening environmental standards: the benefit cost or the no-cost paradigm', Journal of Economic Perspectives, 9 (4): 119-132.

Paper, Ministry of Finance Green. 2009. Economic and fiscal policy strategies for climate change mitigation in Indonesia.

Pigou, A. C. (1912), Wealth and Welfare, Macmillan, New York.

Porter, M. E. and C. van der Linde (1995), 'Toward a new conception of the environment-competitiveness relationship', Journal of Economic Perspectives, 9 (4): 97-118.

SEFI Alliance Report (2010), 'Publicly backed guranatees as policy instruments to promote clean energy'.

Shellenberger, Michael, Ted Nordhaus, Jeff Naviin, Teryn Norris, and Aden Van Noppen. 2008. Fast, clean, and cheap: cutting global warming's Gordian Knot. Harvard Law & Policy Review 2:93-118.

Stern, Nicholas. 2009. A blueprint for a safer planet: how we can save the world and create prosperity. London: Vintage.

Victor, D. G. (2007) 'Fragmented carbon markets and reluctant nations: implications for the design of effective architectures', in Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World, Resources for the Future, Cambridge University Press, Cambridge.

Williams, S. and Baumert, K. (2003) Institutional Capacity and Climate Actions, OECD, Paris.

Yang, Chi-Jen, and Michael Oppenheimer. 2007. A "Manhattan Project" for climate change? Climate Change 80:199-204.