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Climate Change Mitigation and Green Growth in Developing Asia

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Abstract

Developing Asia is the driver of today's emissions intensive global economy. As the principal source of future emissions, the region is critical to the task of global climate change mitigation. Reflecting this global reality and a range of related domestic issues, the governments of the People's Republic of China, India, Indonesia, Thailand, and Viet Nam have embarked upon an ambitious policy agenda. This report reviews the present and future policy settings for climate change mitigation and green growth in Asia's major emerging economies. Although recent targets and commitments will involve a fundamental change in emissions trajectories, the urgency and extent of necessary global action requires ambition to be raised even further in developing Asia. An additional transformation will be required for the trajectory of emissions and energy demand, as well as the future composition of the power generation mix. Achieving these transformations will not be easy. There are a substantial number of policy instruments available, yet significant obstacles stand in the way of their effective deployment. Governments face a number of policy challenges, including: energy sector reform, economic reform, strengthening institutional capacity, and securing international support. The principal conclusion of this analysis is that the task facing Asia's policymakers is not simply one of setting targets and pursuing narrowly focused policies to reach them. Rather, a broad–scale approach involving all sections of the economy and government will be required to achieve the shift to a sustainable, low-emissions development trajectory.

JEL Classification: O44, Q54, Q58, Q40, Q42, Q53, Q56, O10.

Contents

1. INTRODUCTION

The negative reportage of the 2009 United Nations Framework Convention on Climate Change conference in Copenhagen obscured an important outcome. In a substantial break with existing conventions, the governments of major developing economies announced quantitative national targets for climate change mitigation.

Nowhere is this shift more significant to global action than in the engine of the global economy: developing Asia. An unparalleled economic expansion is underway in this region that encompasses a third of the world's population. If this development followed the carbon intensive trajectory of today's high-income countries, catastrophic global climate change would seem unavoidable. Acknowledging this international reality and acting on related domestic concerns, governments in the region have begun developing an ambitious climate policy agenda.

To say that a start has been made, however, is not the same as saying the job is done. Though the present course in developing Asia may be encouraging, the urgency of extensive global action renders current efforts insufficient: the level of ambition will have to be raised even further. That the burden, financial or otherwise, of reaching higher objectives should not overly impinge economic development is well accepted; developed countries must provide substantial support. However, outside assistance will be a necessary but not sufficient condition for extensive mitigation activities; the relevant actions will primarily be developed internally and with specific, domestic policy considerations in mind.

This study provides an overview of the domestic policy settings for climate change mitigation and green, or environmentally sustainable, growth within the major economies of developing Asia: the People's Republic of China (PRC), India, Indonesia, Thailand, and Viet Nam. Though these countries possess different social and economic characteristics (see Table 1 below), they share a common role as driving forces within the global economy, today and for decades to come.

Table 1: Economic and Social indicators for Developing Asia in Context

	Population (billions)	% population <$2 a day	Median age (years)	Urban population (% of total)	GDP per capita	GDP	GDP growth 2009-2020 (2009-2035)
PRC	1.39	36%	35	44%	$7,535	$1.01*10^13	8.1% (5.9%)
India	1.17	75%	26	30%	$3,585	$4.20*10^12	7.7% (6.6%)
Indonesia	0.24	51%	28	52%	$4,428	$1.03*10^12	-
Thailand	0.07	27%	34	33%	$8,612	$5.87*10^11	-
Viet Nam	0.09	38%	27	28%	$3,129	$2.77*10^11	-
Japan	0.13	0%	45	66%	$34,012	$4.33*10^12	1.7% (1.4%)
Australia	0.02	0%	37	88%	$39,415	$8.65*10^11	-
Rep. of Korea	0.05	0%	38	82%	$27,133	$1.42*10^12	-
OECD	-	-		-	-	-	2.4% (2.2%)
Non-OECD Asia	-	-		-	-	-	7.4% (5.7%)
World	6.86	-	28	51%	$11,128	$7.63*10^13	4.2% (3.6%)

Notes: GDP is Gross Domestic Product, adjusted for purchasing power parity and measured in international dollars (see World Bank 2011 for further details). All data is current unless other-wise specified. GDP growth projections originate from the International Monetary Fund and are adapted from IEA (2011a). "% population <$2 a day" indicates the percentage of a country's population estimated to live off $2 dollars a day, adjusted for purchasing power parity.

Source: World Bank (2011), IEA 2011a, CIA 2011.

The potential surge in global emissions[1] from Asia's growth reflects the enormous rise in income, economic activity, and, consequently, energy consumption that is occurring (see Table 2). As incomes rise, consumers will use more energy-intensive goods and industry will require more energy to meet the heightened demands of the economy. Similarly, projections of motor vehicle ownership estimate a rise in vehicles on the PRC's roads of 130 to 413 million between 2008 and 2035, and a corresponding increase of 64 to 372 million in India (ADB/DFID 2006). Although emissions per capita are currently low in reference to developed countries, the PRC and India are respectively the first and third largest aggregate source of national emissions already. Developing Asia as a whole accounts for nearly one third of global emissions today; by 2035, even accounting for recent policy announcements, that figure is estimated to rise to 42%.

The challenge of shifting developing Asia's major economies towards a sustainable, low-carbon trajectory amidst rapid economic growth and burgeoning demand for energy is the focus of this study. Section 2 outlines the domestic motivations behind recent policy announcements. Section 3 surveys the climate change mitigation targets across the five study countries, including an assessment of their adequacy in the context of necessary global action. Section 4 outlines the additional transformation required with respect to emissions, the composition of the power generation mix, and energy demand. Section 5 reviews the available policy instruments and their use in developing Asia. Section 6 examines the challenges involved in expanding the deployment and effectiveness of technology-based and carbon pricing policies, including: energy-sector reform, economic reform, strengthening institutional capacity, and securing international support. Section 7 concludes.

Table 2: Summary of Indicators for Carbon Dioxide Emissions and Energy

	2009 CO_2 emissions (Mt)	2035 CO_2 emissions (Mt)	2009 CO_2 emissions per capita (t/capita)	2035 CO_2 emissions per capita (t/capita)	Emissions intensity 2009 (tCO_2/unit of GDP)	Electricity consumption per capita 2009 (kWh/capita)	2009 Total energy demand (Mtoe)	2035 Total energy demand (Mtoe)
PRC	6,877	10,253	5.14	7.39	0.60	2,648	2,271	3,835
India	1,548	3,535	1.37	2.34	0.35	597	669	1,464
Indonesia	376	-	1.64	-	0.40	609	198	-
Thailand	227	-	3.36	-	0.41	2,073	107	-
Viet Nam	114	-	1.31	-	0.38	904	59	-
Non-OECD Asia (ex. India, PRC)	1,565	2,899	1.49	2.11	-	-	784	1,472
Japan	1,088	918	8.58	-	0.32	7,833	472	478
Australia	395	-	17.87	-	0.56	11,038	130	-
Rep. of Korea	515	-	10.57	-	0.45	8,980	-	-
OECD Asia Oceania*	2,021	1,655	9.96	8.15	-	-	850	912
World	28,999	35,442	4.29	4.14	0.45	2,730	12,271	16,748

Notes: All emissions figures are for energy-related emissions only. Mtoe refers to million tonnes of oil equivalent. kWh refers to kilowatt-hour. Projections are for the "New Policies Scenario" from the IEA's World Energy Outlook 2011. For further details see Box 3. *OECD Asia Oceania reports aggregate data for Japan, Australia, the Republic of Korea, and New Zealand.

Source: IEA (2011a).

[1] This paper focuses on energy-related CO_2 emissions: the largest and fastest growing component of total greenhouse gas emissions (IPCC 2007a).

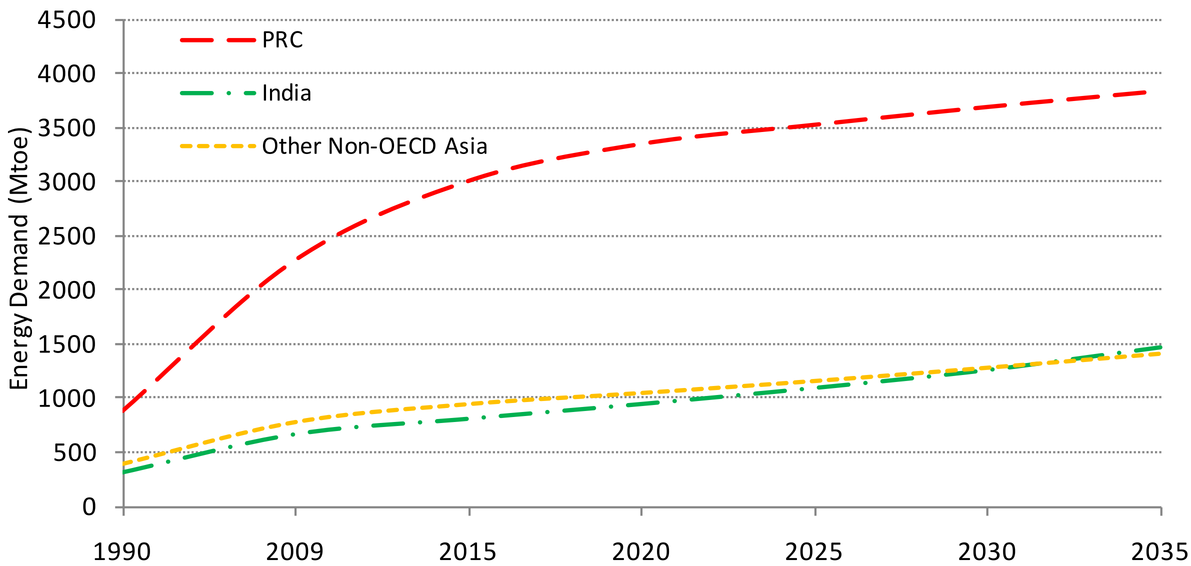
2. MOTIVATIONS FOR CLIMATE CHANGE MITIGATION AND GREEN GROWTH

In recent years climate change mitigation and green growth have progressively emerged on the agenda of governments in developing Asia. Rather than simply a contribution towards solving international environmental problems, policymaking in these areas reflects a range of motivations. National economic self-interest has dictated the need for policies that: promote energy security, pursue technological advantage, and address local environmental problems. In addition to being the principal source of future carbon emissions, emerging Asian economies are also highly vulnerable to climate change damages. The convergence of these, by and large, domestic concerns with global efforts to address climate change is certainly advantageous, but this convergence is not inevitable and trade-offs may sometimes be necessary, most notably between the broader objectives of climate change mitigation and green growth.

2.1 Energy Security

Access to sufficient and affordable energy is critical to the continued economic expansion of emerging Asia. Figure 1 shows substantial projected growth in energy demand over coming decades. Failure to meet this rising demand would seriously constrain economic growth and, in the domestic energy sector, undermine rising living standards. Domestic fossil fuel reserves will be insufficient to meet such expansion, and rising energy demand, without changes to the composition of the power generation mix, will increase dependency on energy imports.

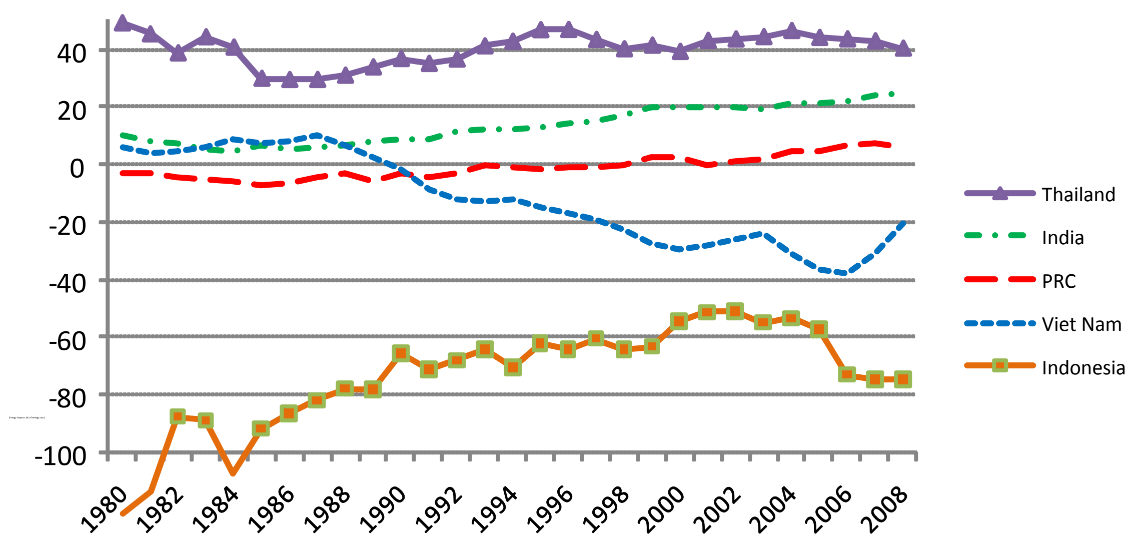
Figure 1: Projected Energy Demand in the PRC, India, and Other Non-OECD Asia



Notes: "Other Non-OECD Asia" refers to aggregate energy demand across non-OECD Asia minus the PRC and India. In 2009, Thailand, Viet Nam, and Indonesia comprised 47% of aggregate energy demand across these 32 countries (IEA 2011b). Projections are for the IEA "New Policies Scenario" which represents an extrapolation of recently announced policies concerning energy efficiency, climate change mitigation, and renewable energy (See Box 3 for further details).

Source: IEA (2011a).

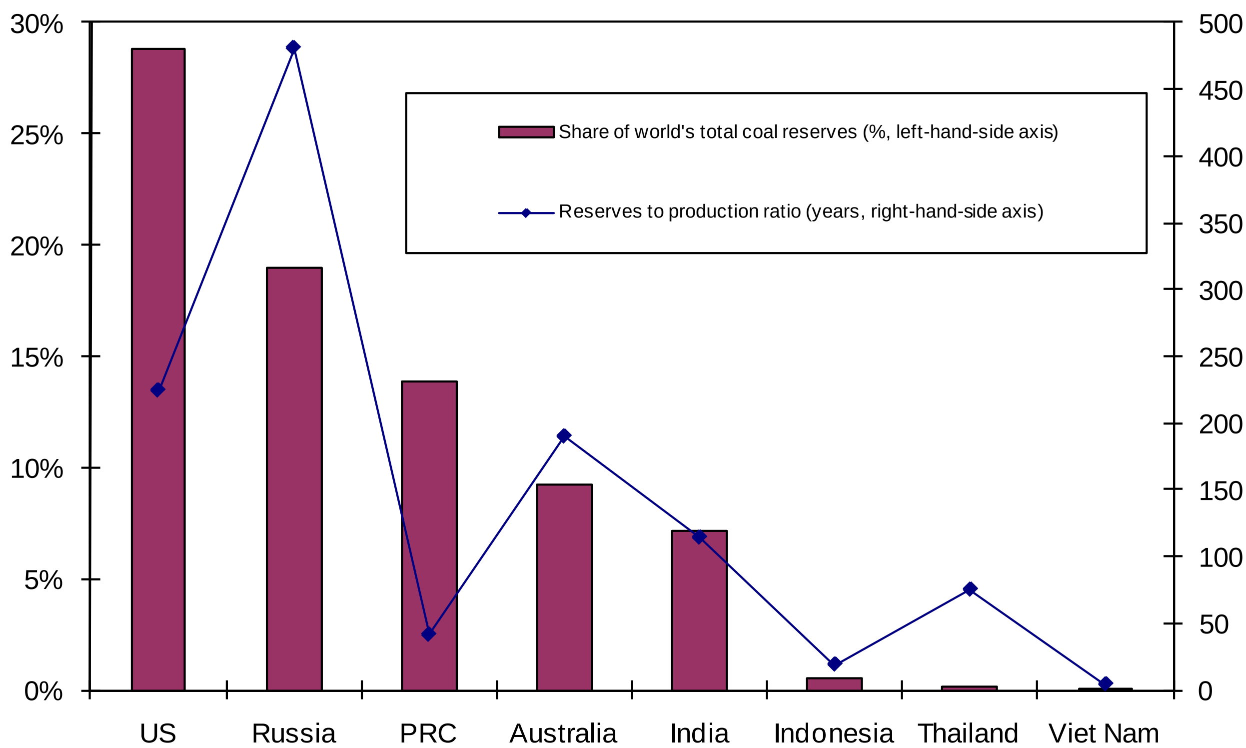
Figure 2: Energy Import Dependency in Emerging Asia



Source: World Bank (2011).

Over the last two decades, the PRC has joined India and Thailand in being a net importer of energy (see Figure 2). The other two study countries are likely to follow suit as their economies grow: Viet Nam's domestic oil production is declining, and Indonesia, already a net importer of oil, has limited reserves of coal. Concerns over energy security in emerging Asia have often centered upon oil, but coal has become increasingly important as a, or the, principal fuel in electricity sectors.[2] Figure 3 demonstrates that domestic coal supplies in all five countries are either limited in size, or won't last long. Domestic supplies can also be costly to access, such as the deposits in western PRC, and the extractable volume may be, in the case of India, significantly over-estimated (see TERI 2011).

Figure 3: Domestic Coal Reserves In Developing Asia are Limited and/or Depleting Rapidly



Notes: Reserves are proven reserves at end of 2008. Reserves to production ratio is the number of years proved reserves would last if production at 2008 rates continue. See Howes and Dobes (2011) for further details.

Source: Howes and Dobes (2011), Figure 1.9.

The major disadvantages of energy import dependence are two-fold. Firstly, securing foreign supplies is costly, in terms of logistics and also the lack of certainty that future domestic demand can be met[3]. Secondly, and perhaps more importantly, net energy importers are subject to the high volatility and upward trajectory of global fossil fuel prices (see Figure 4). Amongst other economic costs, rising energy prices can cause large, sudden, and damaging inflation. Given the progressive scarcity of total fossil fuel reserves, particularly oil, and continuing global growth in demand[4], energy

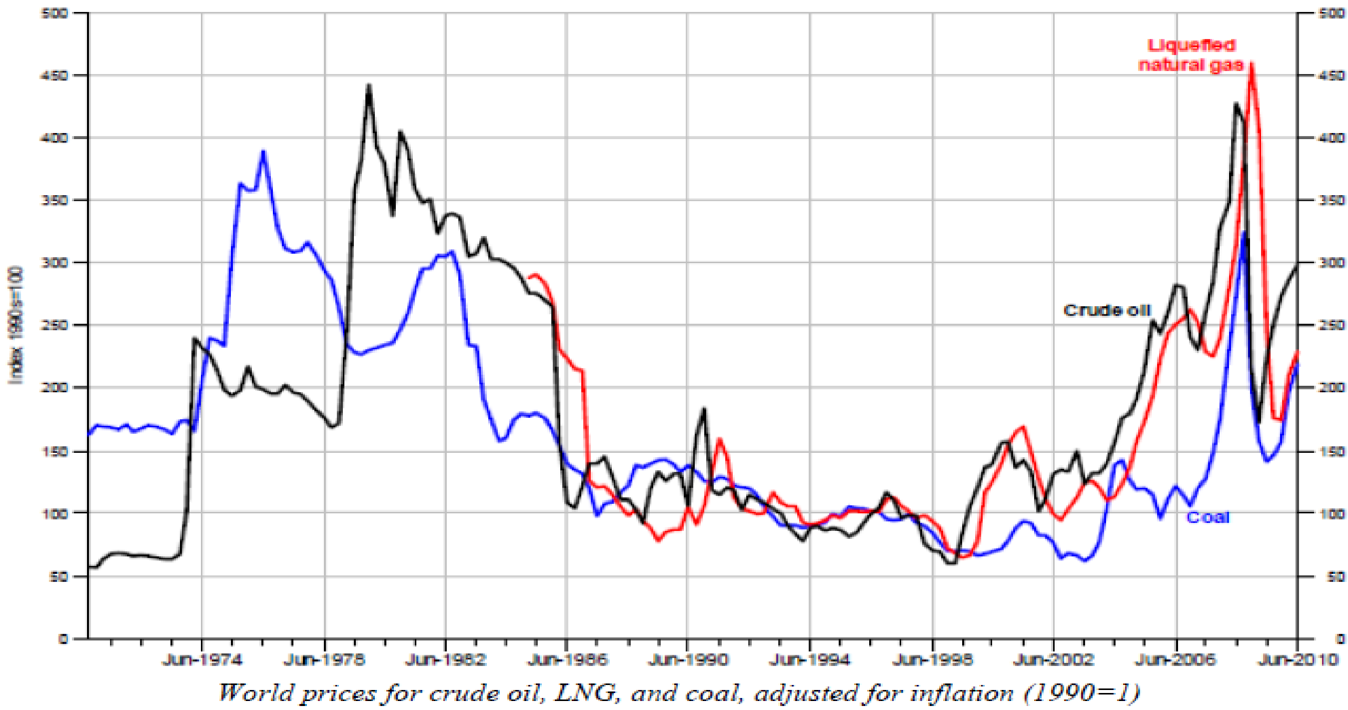
[2] Coal is currently the dominant fuel source for electricity generation in the PRC, India, and Indonesia, respectively comprising 79%, 69%, and 41% of total generation capacity (IEA 2011b). The situation is different in Thailand and Viet Nam where gas is more widely used, and coal has a share of around 21% in both cases.

[3] The issue of supply certainty is perhaps more pressing for oil than coal, as much of the remaining global reserves can be found in relatively "safe" exporting countries such as Australia and the United States (see Figure 3).

[4] The IEA projects that global demand for fossil fuels, even taking into account recent ambitious climate change targets, will continue rising to 2035. See IEA (2011a, p. 544)

price based economic instability looms as a significant future issue worldwide, not least in the rapidly expanding economies of Asia.

Figure 4: World Energy Prices: Volatile and Rising



Notes: Data is quarterly. See Howes and Dobes (2011) for further details.

Source: Howes and Dobes (2011), Figure 1.11

The risks inherent to fossil fuel import dependency highlight the great potential for renewable energy within developing Asia[5]. Both the PRC and India have large potential resources of solar and wind-based power generation. Elsewhere, Indonesia has the greatest potential geothermal capacity of any country worldwide, of which it has only exploited around 3% to date (MoF 2009), whilst Viet Nam and Thailand have considerable untapped hydropower potential, amongst other renewable resources available. It should not be overstated however the immediate likelihood of renewable sources to replace fossil fuels, the latter will certainly remain a substantial component of the power generation mix over the next three decades, even in the event of more ambitious climate change mitigation (see Figure 8 in Section 4 below). Regardless, exploiting such opportunities, in conjunction with improving the efficiency of energy use (see Box 1), will restricts the rise in energy imports and, consequently, reduce the exposure of these economies to energy insecurity as energy demand grows rapidly.

[5] See Krewitt et al. (2009) and IPCC (2011) for surveys of the large technical potential of renewable energy in developing Asia.

Box 1: Energy efficiency in developing Asia: A principal concern for economic growth, local environmental sustainability, and climate change.

Policies to promote energy efficiency are a major component of the economic and climate change agenda in developing Asia. If energy demand growth corresponds or rises with rapid increases in economic growth, then costly, and equally rapid, infrastructure investment is required. Short-term difficulties in matching surging energy demand with new supply create bottle-necks, market distortions, and act as a drag on growth. In the longer term, where supply is fossil-fuel intensive, spiraling demand increases exposure to energy insecurity, increases environmental pollution, and, of course, prompts swift growth in carbon emissions.

De-coupling the link between economic growth and energy demand through greater efficiency of energy usage therefore fulfils a range of economic, environmental, social, and climate change objectives. In addition to being very beneficial at the broad social level, energy efficiency measures often involve low or even negative costs because they have long-term economic benefits that eventually exceed the initial cost or investment that is required. For a consumer or business, roof insulation and other building efficiency measures will reduce all future energy bills. In transport and coal-based power production, investment in fuel efficient technology significantly reduces future fuel expenditure.

Given that energy efficiency measures often involve net economic benefits, rational economic analysis would expect that consumers and producers of energy would pursue such measures of their own accord. That this is not the case reflects a range of market and informational barriers, such as the ability to afford the initial investment, lack of awareness of potential benefits, technology unavailability, and psychological resistance to change. Government policy has an important role in correcting such distortions, particularly in developing Asia where action to achieve energy efficiency, despite concerted efforts in recent times, lags behind those in developed countries. Given the large co-benefits involved, energy efficiency measures are often referred to as 'low-hanging fruit' in the context of climate change mitigation, meaning that they are attractive, relatively easy to implement measures in the short term.

Consequently, much of the mitigation activity in developing Asia currently focuses on energy efficiency. This is particularly the case in the PRC, where energy intensity (i.e., the amount of energy used for a given unit of GDP) surged at the start of the century. A number of government initiatives were successful in reducing national energy intensity by close to the targeted 20% over the course of the 11th Five Year Plan (2006–2010). This success and the great potential to further reduce environmental and economic problems, as well as address climate change, are reflected in new energy intensity targets (see Table 4). The Indian government also has instituted substantial energy efficiency measures. Rai and Victor (2009) argue that there are very large efficiency gains to be made in India's power sector, particularly through transmission infrastructure improvements and greater efficiency of coal-fired power plants.

2.2 Technological Advantage and Renewable Energy as a "Growth Engine"

It is not only Asia's emerging economies recognizing the advantages of renewable energy, but much of the world. Clean energy and low-carbon technology is widely viewed as the driver of the next wave of innovation and economic growth. Most governments are acutely aware of the benefits of obtaining market share at an early stage, and many are taking action. For example, the Korean government sees offshore wind power as its next big export industry, and is vigorously investing in the establishment of Korean companies as major global players (see GGGI 2011). Many European countries have similar objectives, as does Australia, and even the United States and Canada have burgeoning renewables industries, despite the influence of the powerful oil lobby.

Emerging Asia is increasingly prominent in this "clean energy race". the PRC leads the world in renewable energy investment and in 2010 accounted for half of all global manufacturing of solar modules and wind turbines, with the majority of solar technology production made for export (PCT 2011). The government has frequently articulated its goal for PRC companies to dominate clean energy markets and demonstrated its sense of purpose through ambitious policies. Elsewhere, India is now ranked 10th globally in clean energy investment, and Indonesia had the 4th largest growth in this area from 2005–2010 (PCT 2011). Whether for export or to meet domestic expansion, growth in the renewable energy sector presents as an important stimulus for domestic manufacturing, and economic growth more generally.

At the domestic level, proliferation of renewable energy technology presents as a significant opportunity for increasing access to modern energy services. It is estimated that over 675 million people in developing Asia do not have access to electricity (IEA 2011a). Extending national grid infrastructure to remote areas is proving to be a difficult, costly, and time-intensive process in many countries, perpetuating poverty and the damages from traditional biomass cooking practices (see below). De-centralised, off-grid technologies such as small-scale solar and biogas present a very real opportunity for remote communities to share the rising living standards being experienced elsewhere, and further promote national economic expansion.

2.3 Local Environmental Problems and "Green Growth"

Much of developing Asia's recent economic growth has come at the expense of the environment. Heavy air pollution, degraded water resources, and clear-felled forests have become characteristic features of the natural landscape. Increasingly, policymakers are appreciating that long-term growth requires sustainable use of natural resources, and that pollution bears economic costs, even in the short-term.[6] What's more, the burden of environmental damage weighs far greater on low-income communities, whose welfare is disproportionately dependant on ecosystem services. Consequently, sustainable or "green growth" is now a central feature of the development agenda in the PRC, India, and other emerging Asian economies (see NDRC 2011, GoI 2009, ASEAN 2007).

In this arena the objectives of climate change mitigation and green growth frequently intersect. Urban air pollution from vehicles and industry causes major health damages, as well as increasing greenhouse gas emissions. Similarly, a vast proportion of the population in emerging Asia burn solid fuels for household energy (see Table 3), creating indoor air pollution that is estimated to cause over 1 million deaths every year (WHO 2011). These same emissions send black carbon particles into the atmosphere, a major driver of both global and regional climate change. In addition to releasing sequestered carbon, deforestation, where fire-clearing methods are used, can also create black carbon emissions. At the local level, tree-clearing degrades land and forest-based resources, causes flooding, and damages groundwater aquifers. Burning coal for energy produces acid rain, which, in turn, pollutes waterways and degrades land. As governments in emerging Asia have begun addressing the causes of these local environmental issues, particularly deforestation (see Table 3), a significant and extensively self-publicized co-benefit has been the advancement of the global climate change mitigation agenda.

[6] For example, the PRC government's single attempt to calculate "Green GDP" estimated that environmental pollution cost 3.05% of GDP in 2004, or around one-third of GDP growth in that year (GoC 2006). It is indicative of the true magnitude of damages that this particular figure encompassed only direct economic losses (such as agricultural production and health) and not natural resource degradation or long-term ecological damage (see GoC 2006).

Table 3: Summary Statistics for Air Pollution, Deforestation, and Land Degradation

Issue/Variable	Location	Description/Value	Source
Average PM_{10} concentration	230 Asian cities	89.5 μg/m^3 (WHO standard is 20 μg/m^3)	CAI (2010)
Percentage of Asian cities exceeding WHO SO_2 concentration standards	230 Asian cities	24%	CAI (2010)
Acid rain	PRC	258 of 488 cities experienced acid rain in 2009. In 53 of these cities >75% rainfall was acidic.	MEP (2010)
Proportion of population using solid fuels (2007)	PRC India Indonesia Thailand, Viet Nam	71% (rural), 48% (total) 88% (rural), 59% (total) 79% (rural), 58% (total) >45% (rural)	WHO (2011)
Annual rate of change in forest area (2000-2010)	PRC India Indonesia Thailand Viet Nam	1.6% (2,986,000 ha) 0.5% (304,000 ha) -0.5% (-498,000 ha) ~0% (-3,000 ha) 1.6% (207,000 ha)	FAO (2011a)
Percentage of national territory subject to land degradation (1981-2003)	PRC India Indonesia Thailand Viet Nam	22.86% 18.02% 53.61% 60.16% 40.67%	Bai et al. (2008)

Notes: The 230 Asian cities referred to in rows 1 and 2 are from the PRC; India; Indonesia; Thailand; Malaysia; Phillipines; the Republic of Korea; and Taipei,China. See CAI (2010) for further details. PM_{10} refers to particulate matter <10 μm in diameter. SO_2 refers to sulphur dioxide, the principal cause of acid rain.

2.4 Vulnerability to Climate Change Damages

Developing Asia is highly vulnerable to damages from climate change. Due to both geographic factors and past human activities, natural resources are characteristically sparse. Continuing population growth will compound this scarcity in the future. The region contains around two thirds of the world's poorest people, many of whom are already exposed to significant food and water insecurity, both of which are likely to intensify as the climate changes. Many major population centers are coastal and highly exposed to rising sea levels and storm surges. Ocean fisheries are a principal source of animal protein in coastal areas, and ocean acidification may prove the catalyzing factor for their complete depletion after a prolonged period of over-fishing.

Whilst the full force of impacts will not be realized for many decades, climate change adaptation is already a contemporary issue within the five study countries. Rising maximum temperatures and changing rainfall patterns are already affecting agriculture and food security, and the effect of these changes will escalate to 2030 (Lobell et al. 2008). For example, it is estimated that yields of important crops will decline in parts of Asia by 2.5% to 10% by the 2020s (IPCC 2007b). Within the study countries, commonly voiced concerns for the proximate future include: greater intensity of extreme weather events, increasing incidence of flooding and tropical disease, and decline of marine ecosystems (see ADB 2009, IPCCb 2007).

Looking towards 2050 and beyond, the scale of potential damages magnifies at an escalating rate (see IPCCb 2007). As principal sources of future global emissions[7], the PRC and India in particular will play a decisive role in how large these future damages become. Therefore, at some level, extensive climate change mitigation activities are a matter of self-interest. The process of lifting the

[7] See Table 2 in Section 1 and Figure 6 in Section 3.

standard of living in these countries, and developing Asia more generally, simply cannot follow the carbon-intensive trajectory laid out by today's high-income economies. Such a path would likely result in debilitating food and water insecurity, environmental refugees and conflict, among other damaging economic impacts from climate change. Therefore, assuming high-income countries play their part, domestic development objectives must also motivate climate change mitigation activities in the PRC and India (Hepburn and Ward 2010).

2.5 The Limitations and Benefits of Domestic Motivations for Climate Change Mitigation

Any discussion of the largely domestic motivations outlined above must be tempered by acknowledgement that they are not always aligned with the climate change agenda. Co-benefits are common across climate change mitigation and sustainable use of the local environment, but they are not inevitable and there are numerous examples where these objectives diverge. In the power generation sector, large-scale hydropower and hydraulic fracturing are two examples where climate change mitigation is pursued at great risk to the local environment (see Box 2). In transport, bio-fuel production is a major driver of deforestation and biodiversity loss, and can also cause land to be converted from food production, raising food prices and promoting food insecurity. Despite, by and large, being less-emissions intensive than fossil fuel use, the local effects of such activities can, in certain cases, be anything but sustainable or consistent with "green growth".

Aside from the divergences between climate change and green growth, it must also be recognized that the domestic motivations outlined in this section may not always lead to the same outcomes. For example, if energy security were the central concern then priority would be given to reducing oil consumption[8]. If climate change mitigation and the local environment took precedence, then reducing coal-use would be paramount. If technological advantage in global markets were most important, then domestic consumption of neither coal nor oil may be an issue, but rather the level of renewable energy consumption in export markets. Such divergence may at first glance appear a weakness. On the contrary, however, this mix of motivations can be a strength. Instead of being contingent upon a single driving force, the climate change mitigation agenda has several. In such a situation, a range of different targets and policy actions to achieve them is desirable, re-balancing responses to the various motivations back towards the climate change agenda. In fact, this is precisely the approach that has transpired in emerging Asia.

One cannot assume that the economic benefits of these domestic motivations will be sufficient to immediately stimulate the full scale of potential climate change mitigation activity. There will be a significant time delay in the full benefits being realized, yet the required up front-investments may be significant and immediate. Therefore future benefits are likely to be heavily discounted, especially when there still exist more immediate social welfare concerns in emerging Asia. It would be disingenuous to suggest that governments of countries with low per capita incomes, such as India, would or even could pursue climate change mitigation without regard for short-term costs to growth or social welfare. Strong climate change mitigation represents an opportunity for green jobs, but it also entails job losses in emissions intensive industry. Removing energy subsidies would increase the efficiency of energy consumption, but at the social cost of higher household prices. Such costs can be minimized or, perhaps, even avoided through well-designed policy, but only if the existence of potential trade-offs is acknowledged in the first place. Where a large gap exists between the required domestic investment in mitigation from a global perspective and the investment stimulated by domestic motivations, there is a strong case for international assistance.

[8] Oil combustion is less emissions intensive than combustion of most types of coal in the majority of industrial or commercial applications.

Box 2: Hydropower and hydraulic fracturing: Green growth?

Although hydropower involves the release of far less greenhouse gas emissions than fossil fuels, the local effects of dams can be far more damaging. Dams obstruct the fundamental processes underpinning river ecosystems, such as: water and sediment transfer, and species migration (particularly fish). Downstream erosion and alteration of natural flow regimes impacts on agriculture, with diminished fisheries further straining food security. The impacts are most keenly felt in developing countries, where riparian communities often subsist from river-based resources. Aside from flooding upstream areas, the broader impacts can extend hundreds of kilometers downstream. Recognition of these environmental hazards and their damaging social impacts prompted a significant global pause in large-scale dam construction for much of the first decade of the 21st century, except in the PRC. However, spiraling energy demand and the need for less-carbon intensive energy sources is now driving a major expansion in hydropower development across the world, particularly South-East Asia, the PRC, Africa, and South America.

Much less is known about the local environmental impact of hydraulic fracturing or “fracking” than dams, but the early indications are concerning. This process involves a mixture of water, sand, and chemicals being injected into the ground under high pressure to release natural gas from underground formations such as coal-beds. Though technically feasible in the past, this procedure has only recently become economically viable; consequently, the scale of fracking activities is expanding rapidly across the world. The United States has the largest fracking industry at present, but it is believed that there are large exploitable reserves in Australia, the PRC, India, and many other countries, including the United Kingdom. The local environmental damages largely relate to water. Although the injected liquid is removed from the bore-well during the extraction process, it also leaks into the soil and surrounding aquifers. Moreover, fracking alters the composition of the water table, connecting or releasing pressure from different aquifers, causing land subsistence, and reducing the productivity of groundwater outlets from affected aquifers.

A large volume of water is consumed during the process: it is estimated that drilling and fracking a single bore-well requires 19 million liters of water (Chesapeake Energy 2011). Such large volumes may be diverted from other uses, such as agriculture or the environment. Once the gas is extracted this now contaminated water has to be disposed. Recent studies by US environmental regulatory authorities show the contamination of drinking water by chemicals used in fracking and released methane (EPA 2011), and the devastating impacts that fracking fluids have on trees and plants across a wide area (Adams et al. 2011). There have also been reports of household bores yielding flammable water in the United States. Aside from concerns regarding local environmental damage, the benefits of fracking for climate change mitigation are also questionable. Howarth et al. (2011) estimate that the large volumes of methane which leak from fracking wellbores renders natural gas extracted by fracking at least, and potentially more, greenhouse gas emissions intensive than coal-burning.

3. COUNTRY PLEDGES AND TARGETS

The motivations outlined in the previous section have given rise to a range of pledges and targets relevant to climate change mitigation. Achieving these goals would represent a fundamental shift in the emissions and development trajectories of these economies. This section reviews these various goals, and concludes with a discussion of their adequacy.

3.1 Climate change mitigation targets

All five of the countries under review have articulated targets relevant to climate change mitigation. Table 4 summarizes these objectives across four major indicators: emissions, renewable energy, energy efficiency, and deforestation. Many of these broad objectives are accompanied by sector-specific or policy specific objectives which are unable to be reviewed in depth here due to space limitations. Following is a brief overview of policy developments in each country[9].

In recent years, the PRC has set increasingly ambitious targets across a variety of issues. Recognizing the unsustainable trajectory of soaring energy use and local environmental degradation, the 11th Five Year Plan (2006-2010) set out a number of targets relating to energy efficiency, renewable energy use, and afforestation. Of these, the most prominent achievement was the 19.1% reduction in energy intensity, just missing the target of 20%. Most notably, however, in the lead up to the UNFCCC Copenhagen conference, the PRC, for the first time, articulated a specific target for reducing carbon emissions. Subsequently, the 12th Five Year Plan revealed a further series of relevant targets to 2015. In addition to those shown in Table 4, the government aims to reduce nitrous oxide emissions (a greenhouse gas) by 10%, install extra capacity of non-fossil fuel power generation (i.e., wind, 70 GW; solar, 15 GW; hydropower, 120 GW; nuclear, 40 GW), amongst other quantitative targets (see NDRC 2011).

Over recent decades the Indian government has instituted a series of targets and plans to promote energy efficiency which have had co-benefits with respect to emissions reductions. Prior to its voluntary Copenhagen pledges, the Indian government announced its National Action Plan on Climate Change in 2008, covering both mitigation and adaptation issues. This document included the targets for renewable energy, energy efficiency, and deforestation shown in Table 4. A major focus is becoming a global leader in solar energy deployment through the extension of electricity access. Targets relating to this objective include: 2 GW of off-grid solar plants, and 20 million solar lighting systems to be created and distributed in rural areas, saving about 1 billion liters of kerosene every year.

Indonesia has voluntarily pledged to reduce its emissions from business-as-usual by 26% in 2020, and up to 41% with international support. At present, land-use and land-use change (particularly forestry and peatland) comprise 85% of national carbon emissions. Consequently, the government plans to achieve 87% percent of its emissions reductions for both higher and lower targets in these sectors. However, energy-based emissions are the largest source of emissions growth, and are projected to reach parity with land-based emissions by 2020. In response, the government has formulated the energy-specific targets shown in Table 4, and, in 2010, formulated the goal of tripling geothermal energy generation to 4 GW by 2015, and up to 9 GW by 2025.

As the energy requirements of Thailand's industrializing economy have grown, the government has instituted ambitious energy efficiency and renewable energy targets. For the economy-wide energy efficiency targets shown in Table 4, 44% of the savings are intended to be found in the transport sector, followed by industry (37%), and buildings (17%). For renewable energy, 3.7 GW of the targeted 5.6 GW of renewable energy is assigned to biomass, and then, in descending order, wind (0.8 GW), solar (0.5 GW), hydropower (0.32 GW), and methane from municipal waste (0.16 GW).

Viet Nam's government estimates that, under current policies, energy demand will grow four-fold and coal consumption will double between 2010 and 2030, with the country becoming a net energy importer by 2015. Consequently the government has passed several laws relating to energy efficiency and conservation, in addition to specific environmental laws and a National Target Plan to Respond to Climate Change, where the latter sets national ministries, provinces, sectors and cities with the task of developing concerted plans to reduce carbon emissions.

The discussion in this section has primarily focused on national-level actions. Our analysis is therefore incomplete due to two connected issues. Firstly, sub-national action is very important[10]:

[9] These summaries draw heavily on the country background papers of the ADBI Climate Change and Green Asia project: Chotichanathanwewong et al. (2011), Mathur (2011), Patunru (2011), Toan (2011), and Zhu (2011).

[10] See Ostrom (2010).

effective implementation of nation-wide policies and targets requires the participation of provincial and local authorities. What's more, co-benefits are more readily apparent at the local level and the cumulative impacts of consequent small-scale mitigation activities are very significant.

Secondly, sub-national action is already occurring and much more is being planned. For example, Chotichanathanwewong et al. (2011) outline the mitigation plans and actions of Bangkok and other Thai provinces and cities. At the sub-national level in India, a notable policy achievement has already occurred in Delhi where the city's fleet of three-wheeler taxis has been successfully converted to natural gas, concurrently reducing local air pollution and greenhouse gas emissions. Similarly, Delhi has recently introduced a modern rail transport system that is growing rapidly. The PRC is planning pilot emissions trading schemes in seven municipalities or provinces (Xinhua 2011). Moreover, the 12th Five Year Plan mentioned above contains specific targets for each province related to energy intensity and emissions of nitrous oxide, sulphur dioxide, and other air pollutants (see GoC 2011).

For the purposes of comparison across countries, targets are also shown in Table 4 below for the major OECD economies in Asia: Japan, Australia, and the Republic of Korea.

Table 4: Climate Change Mitigation Targets for Major Asian Economies

	Emissions	Renewable Energy Targets	Energy Efficiency	Deforestation
PRC	40% to 45% ↓ emissions intensity (2005→2020) 17% ↓ emissions intensity (2010→2015)	11.4% by 2015 15% by 2020 up from 8.3% in 2010	16% ↓energy intensity (2010→2015)	↑ forest cover by 40 million ha by 2020 from 2005 level ↑ forest cover to 21.7% by 2015, From 20.36% in 2010
India	20% to 25% ↓ emissions intensity (2005→2020)	15% by 2020 up from ~ 4% (2010) 20,000 MW solar by 2020	10,000 MW energy savings by 2020	↑ forest cover by 20 million ha by 2020 from 2010 level
Indonesia	26% to 41% ↓ emissions below BAU	15% by 2025 (incl. nuclear)	1% average annual ↓energy intensity (2005→2025) ↓elasticity of electricity/GDP to <1 (2025)	Forestry as net carbon sink by 2030
Thailand	30% ↓ energy emissions below BAU	20.3% by 2022	8% ↓energy intensity (2005→2015), 15% ↓ (2005→2020) 25% ↓ (2005→2030)	Forest cover to be 40% of total land mass (target introduced in 1991, 2010 level is 37%, up from 25% in 1998)
Viet Nam	–	5.6% by 2020 9.4% by 2030 up from 3% (2010)	↓elasticity of electricity/GDP from 2 (2010) to 1.5 (2015), to 1 (2020)	↑ forest cover to 16.2 million ha in 2020 from 14.3 million ha (2010)
Japan	Conditional 25% ↓emissions below 2000 levels	16.0 TWh by 2014	30% ↓energy intensity (2006→2030)	–
Australia	5% to 25% ↓ emissions below 2000 levels	20% by 2020, up from 8% in 2007	–	Planned offset scheme as part of domestic carbon market
Rep. of Korea	30% ↓ emissions below BAU in 2030	6.08% by 2020, up from 2.7% in 2009	–	–

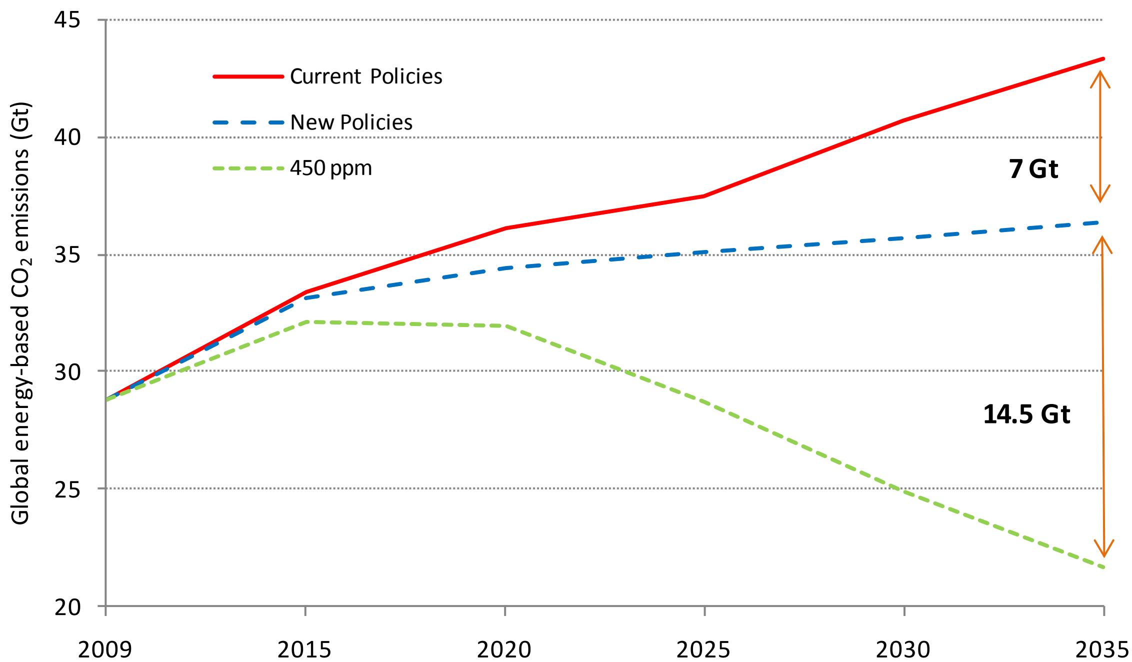
Notes: All emissions targets by 2020 unless stated otherwise. BAU refers to business-as-usual. Emissions intensity refers to the volume of carbon emissions produced per unit of gross domestic product (GDP). Energy intensity refers to the volume of energy consumed per unit of GDP. The absence of specific targets for particular issues does not indicate an absence of policy, rather the absence of a stated national target. For example, the Korean government is implementing a large number of policy actions relating to energy efficiency, but does not have a specific national target.

Sources: UNFCCC (2011), Howes and Dobes (2011), Chotichanathanwewong et al. (2011), Mathur (2011), Patunru (2011), Toan (2011), and Zhu (2011).

3.2 Adequacy of Current Climate Change Mitigation Targets

It is unambiguous that the various targets set by emerging Asian economies reflect a fundamental change in emissions and development trajectories. Conversion of the various pledges to common metrics demonstrates that the PRC in particular is embarking on mitigation activity commensurate, in both outcome and relative cost, with that being planned in developed countries (Jotzo 2010, McKibben et al. 2011). The important question is not, however, whether anything significant is being done, but is it going to be enough? Numerous studies have shown that the aggregate effect of the Copenhagen pledges by all countries will not be sufficient to avoid breaching what has become the international standard for dangerous climate change: 2 degrees Celsius of warming or atmospheric greenhouse gas concentration of 450ppm CO_2-equivalent[11].

Figure 5: Global Emissions Projections: The Gap Between Planned and Required Action



Notes: See Box 3 for a description of the different modeling scenarios and underlying assumptions of the IEA's World Energy Outlook 2011.

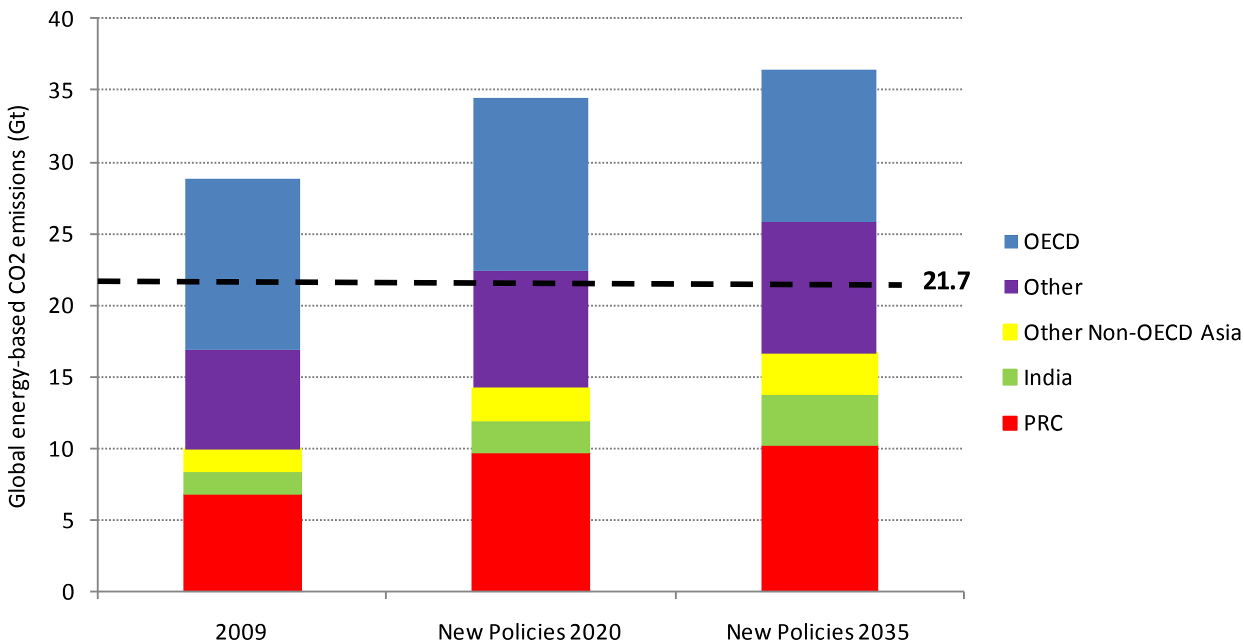
Source: IEA (2011a, Figure 6.2)

Recent International Energy Agency (IEA) projections of future global emissions in Figure 5 demonstrate the change in trajectories from anticipated, new policies (i.e.,, the difference between emissions in the "Current Policies" and "New Policies" scenarios), and the much bigger change that will be required (i.e.,, the gap between the "New Policies" and "450 Scenario"). Though future action is likely to reduce emissions substantially, twice the effort is required. The same study estimates that, under the "New Policies" scenario, emerging Asia as a whole will account for 46% of global energy emissions in 2035, and the combined value for The PRC and India will be 38%. Figure 6 shows that even if today's developing economies (i.e., members of the Organisation for Economic Cooperation and Development, or OECD) reduced their emissions to zero by 2035, this action would be insufficient to achieve the global target for a 450 ppm trajectory of annual emissions falling to

[11] For example, see UNEP (2010), Dellink et al. (2010), IEA (2010a), Nordhaus (2010).

21.7 Gt of carbon dioxide (see Figure 5). Given the world needs to act further, including developing countries, then it will be necessary for emerging Asia to upscale its ambition beyond existing targets.

Figure 6: Mitigation in Developing Economies Only will be Insufficient



Notes: See Box 3 for a description of the different modeling scenarios and underlying assumptions of the IEA"s World Energy Outlook 2011. Other Non-OECD Asia refers to developing Asia minus the PRC and India. In 2009 Indonesia, Thailand, and Viet Nam jointly comprised 46% of emissions from this group.

Source: IEA (2011a).

Box 3: Modeling of Alternative Scenarios in the World Energy Outlook 2011

The projections of emissions and other related variables used in this report originate from the IEA's *World Energy Outlook 2011*. The IEA models three different scenarios across 2010 to 2035.

The "Current Policies Scenario" envisages the world if policies enacted by mid 2011 continued in their present form without any additional policies. The generated emissions trajectory is consistent with long-term global warming of 6°C.

The "New Policies Scenario" incorporates all stated plans or commitments, even where there are not specific policy actions to implement them as yet. It acts as a baseline, or a business-as-usual scenario that incorporates anticipated changes. The generated emissions trajectory is consistent with long-term global warming of 3.5°C. As many stated plans extend only to 2020, extrapolation is made from 2020 to 2035 of emerging trends such as, for example, declining global energy intensity. Given the uncertainty surrounding implementation, the "New Policies Scenario" is a conservative interpretation of stated plans, for example the lower end of the Copenhagen commitments is assumed to be met.

The "450 Scenario" (or "450 ppm" in the current study) describes the least-cost pathway by which the world has a 50% chance of limiting greenhouse gas concentrations to 450 ppm CO_2-equivalent, analogous to 2°C of global warming above pre-industrial levels. The upper end of international pledges is assumed to be met. Potential mitigation measures are identified across countries and sectors and are implemented according to the greatest reductions per unit cost.

Other greenhouse gas emissions are included in the modeling, but are not the focus of policy constraints in the 450 Scenario. Emissions from land-use, land-use change, and forestry are assumed to decline at the same rate across all three scenarios.

Important policy assumptions for the different scenarios include:

Current Policies: realization of the energy targets in the PRC's 12th Five Year Plan; phasing out of fossil fuel subsidies in all non-OECD countries with current plans to do so.

New Policies: carbon pricing in the PRC covering all sectors by 2020, starting at $10 and rising to $30 in 2035 [1]; removal of fossil fuel subsidies in all non-OECD net energy importing countries by 2020, and all net-exporters with current plans to do so; a shadow price of carbon of $15 in the United States by 2015 affecting investment decisions; 70 to 80 GW of nuclear power in the PRC by 2020; 20GW of solar energy production capacity in India by 2022.

450 Scenario: carbon pricing for power and industry in US and Canada (2020—$20, 2035—$120), Japan (2020—$35, 2035—$120), the PRC, Russia, Brazil, and South Africa (2020—$10, 2035—$95); all trading schemes are linked at a regional level and all have access to carbon offsets (leading to some convergence in carbon prices); international sectoral agreements; widespread deployment of carbon capture and storage in power generation by 2020.

Whilst the discussion in the present study largely focuses on the transition from the New Policies to the 450 Scenario, it should be noted that even fulfilling the assumptions of the New Policies Scenario may turn out to be ambitious.

Whilst the World Energy Outlook specifically provides comprehensive results for some major countries, it does not provide them for all. Consequently, the presentation of IEA modeling for Indonesia, Thailand, and Viet Nam in the present study appears in a proxy referred to as "Other Non-OECD Asia". This grouping describes data aggregated across all Non-OECD Asian countries except for the PRC and India, of which the three other study countries accounted for 46% of carbon emissions and 47% of energy demand in 2009 (IEA 2011b).

For further details of the modeling assumptions and procedures see IEA (2011a, Chapter 1 and 6).

[1] All quoted carbon prices are in terms of US 2010 dollars per tonne of carbon dioxide.

4. ADDITIONAL TRANSFORMATION

This section outlines different elements of the additional transformation required in developing Asia to limit global warming to 2°C.[12] The principal topics covered are: emissions trajectories, the power generation mix, and energy demand. Additional focus is given to: energy subsidies, advanced coal technologies, and deforestation in Indonesia.

[12] The following draws heavily on the modeling undertaken in the IEA's World Energy Outlook 2011 which is described in Box 3 of the current study.

4.1 Emissions Trajectories

The observation that an additional transformation is required in developing Asia beyond the currently planned or contemplated level of mitigation prompts two questions. When should this additional action occur? And, perhaps more importantly, how substantial does this additional action need to be?

The answer to the first question is straightforward: as soon as possible. As well as making it more difficult to achieve the required transformation, delay makes the future rate of change more sudden and more expensive (Hepburn and Ward 2010). Given the massive expansion in energy demand in developing Asia, it is not so much the present sources of emissions that are the principal issue but the infrastructure that is yet to be constructed (Davis et al. 2010). Once built, infrastructure investments like power plants and factories have many years of use. If they had to be retired or retro-fitted before their useful life was over because they are emissions intensive, some proportion of the initial investment would be wasted. The IEA estimates that the world has only until 2017 to shift to a 450 ppm trajectory before the "lock-in" effect of existing infrastructure necessitates that all investments made between 2020 and 2035 must involve zero emissions (IEA 2011a). For every $1 needed to achieve the additional transformation that is not spent before 2020, the IEA estimates that another $4.30 will have to be spent afterwards to offset the increased emissions. Though the up-front cost to developing economies of immediate action is high, the costs of delay are even higher still. For example, Bosetti et al. (2009) estimates the additional cost to be as much 33%.

The natural counterpoint to the above discussion is that developing economies, particularly ones with low per capita income such as India, may be willing to incur the higher costs of retiring infrastructure at a later date; rapid economic growth and future wealth will render this adjustment more affordable. However, such an argument ignores the benefits of mitigation outlined in Section 2, as well as the emerging avenues for developed country assistance, and, of course, the declining window for stringent global action.

The importance of developed country assistance is also highly relevant to the second question: how substantial does the additional transformation need to be in developing Asia? The required shifts in emissions to a 450 ppm trajectory for the study countries shown in Figure 7 are steep. By 2035, the IEA estimates that the PRC would need to further reduce emissions by about half, with the corresponding reduction for India and the rest of developing Asia being around 32%. It is important to note that the IEA modeling allocates such large emissions reductions without regard for any notion of cumulative emissions, historical responsibility, or consumption based emissions accounting. Rather, it identifies from a global perspective the least-cost pathway to a 450 ppm trajectory. That large cuts are required in the PRC, India, and the rest of developing Asia does not mean the full burden of this transition has to fall on these developing countries. Since bringing about a plateau in India's emissions, from a global perspective, is likely to be cheaper than the adjustment involved in, say, achieving zero emissions in some OECD countries by 2020, there is a very strong case for developed countries to provide assistance.

The issue of seeking out the least cost emissions reductions is significant at a domestic level as well. Early identification of areas where mitigation produces co-benefits, such as those outlined in Section 2, will help achieved the forward momentum required for a large shift. Particular actions may be low cost in relative terms, or even have net benefits, such as greater energy efficiency (see Box 6) or addressing deforestation in Indonesia (see Box 5). But this "low-hanging fruit" will not be ever-present and extensive mitigation will unavoidably involve trade-offs with growth or social welfare at some point.

It should be emphasized that achieving such large, additional shifts in emissions trajectories is not going to be an easy task in developing Asia. That is not to say, however, that it is an impossible one. Rather, the large scale of the task befits an appropriate response. Narrowly-focused policies that avoid or do not address fundamental issues will not be sufficient. A whole-scale approach across all sectors will be required and is, in fact, beginning to emerge on the policy agendas of the study countries. In Section 6 of the present study the major policy challenges to achieving this additional shift in emissions trajectories are outlined.

Box 4: Deforestation and land-use change in Indonesia

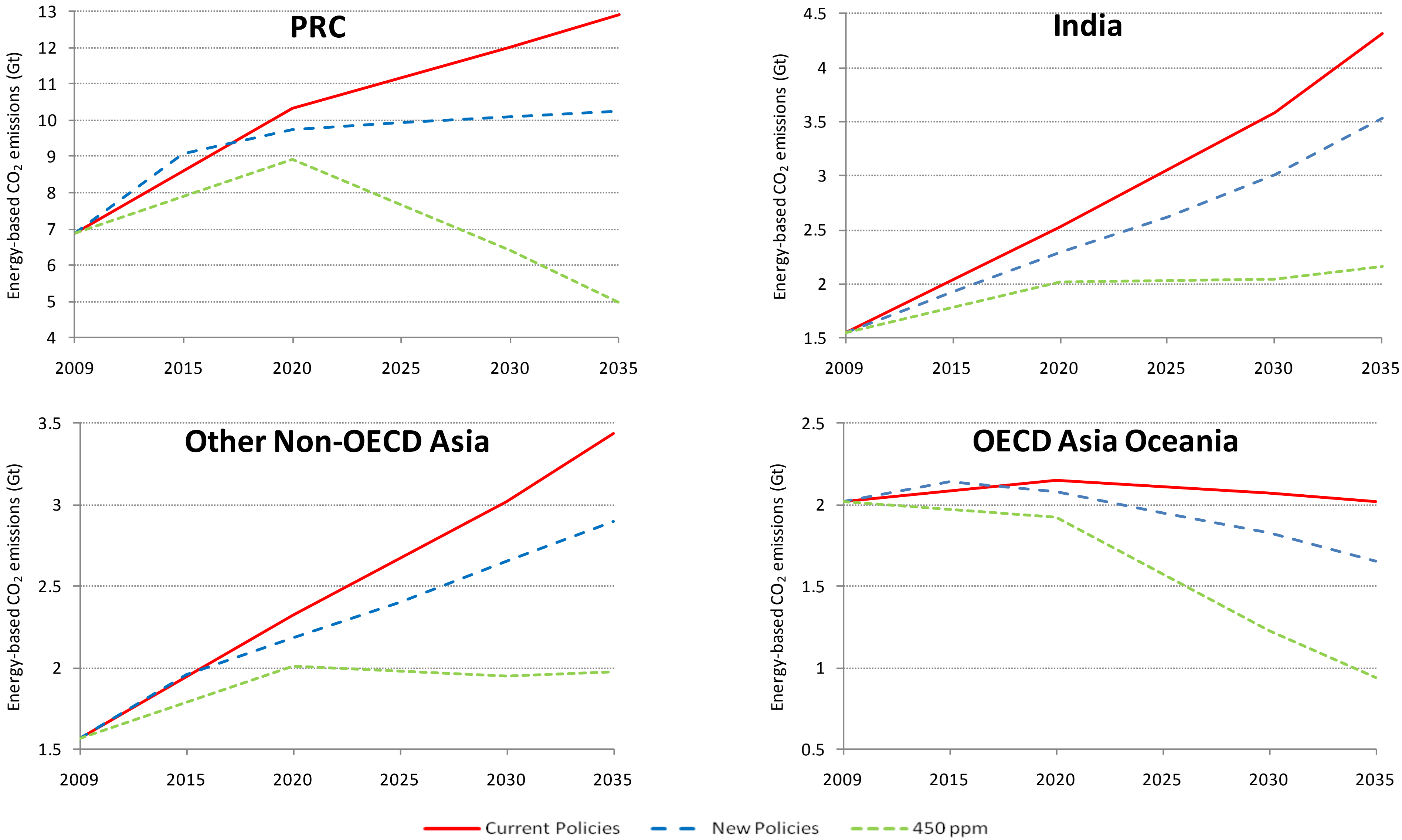
The present study focuses primarily on energy because this sector is the largest source of growth in carbon emissions, for the study countries and the world as a whole. However, emissions from land-use, land-use change, and forestry (LULUCF) are central to Indonesia's proximate mitigation activities. In the last twenty years the country's forested area has declined by 24 million hectares, equivalent to around 26% of the forest remaining today (FAO 2011).

It is not simply the loss of forest as a carbon sink that creates LULUCF emissions, but the way in which it occurs. Fire is commonly used to clear land for expansion of agricultural activities and to provide access to timber, sending black carbon particles into the atmosphere. When this practice occurs on carbon-rich peat-land, which is also often drained, the fires can burn underground for an extended period. The combination of peat fires, fire-clearing, and logging, caused LULUCF emissions to accounted for 85% of Indonesia's emissions in 2005 (Panturu 2011). Once land-based emissions are taken into account, Indonesia is in fact the world's third highest source of carbon emissions.

Given the prominence of this issue in its current emissions profile, it is unsurprising that the government plans for 88% of its planned emissions reductions to 2020 to be achieved within the LULUCF sector. What's more, the marginal cost per tonne of abatement from forestry and peat in Indonesia is much less than that in, say, transport and industry (see Panturu 2011). However, preventing deforestation has proved a very difficult task to date due to: institutional incapacity, including widespread corruption; local-level poverty encouraging unsustainable practices; illegal logging; and the decentralization of government authority following the Suharto regime's collapse. Moreover, strong action to reverse deforestation in nearby countries, such as the PRC and India, has essentially exported deforestation from those countries to Indonesia, particularly as demand for palm oil has risen.

The Indonesian government has targeted forestry to become a net carbon sink by 2030. Reversing deforestation will not be easy; at current rates, the 52% of its land mass still covered by forest will not last long. Encouragingly, the Reducing Emissions from Deforestation and Land Degradation (REDD) mechanism is progressing within the international climate policy architecture, and a recent bilateral agreement with Norway has produced a government moratorium on new clearing permits, with Indonesia to receive US $1 billion if deforestation rates decline within two years. Yet, in 2010 the forestry sector was estimated to be worth US$ 9.5 billion, or 2.5% of GDP (FAO 2011), not accounting for the goods produced on cleared land such as palm oil. As long as there are economic incentives for unsustainable forestry practices, and a lack of strong government regulation to constrain them, deforestation will likely retain its dominant position in Indonesia's emissions profile.

Figure 7: The Additional Transformation Required for Emissions Profiles Across Asia



Notes: See Box 3 for description of the different modeling scenarios. In some cases emissions appear higher in the "New Policies" scenario compared to the "Current Policies" scenario before 2020 due to missing data points for the latter scenario.Source: IEA (2011a).

4.2 Power Generation Mix

An important element of shifting emissions trajectories and avoiding the infrastructure 'lock-in" discussed earlier is the future composition of the power generation sector. At present this sector accounts for 48% of developing Asia's energy-related carbon emissions. In the PRC and India, the generation mix is currently dominated by coal (see Figure 8). In the rest of developing Asia, gas is the dominant fuel for power plants, though coal and oil are also prominent.

As electricity demand increases, investment decisions will be made regarding the deployment of different technologies. On the current trajectory (the New Policies Scenario), renewable and hydropower capacity will be greatly extended across the region. However, fossil fuel use, particularly coal, is also set to rise. In India the generation capacity of coal-fired power plants is projected to rise by 350% between 2009 and 2035, with the equivalent figure in the PRC being 178%, and in the rest of developing Asia, 311%. This trend does not necessarily mean the volume of emissions from coal-based power generation would rise in an identical fashion (see Box 5). But it does substantially undermine the mitigation benefits of an expanded deployment of renewable technologies.

Switching to a 450 ppm trajectory will require different transitions. In the PRC, wind power capacity would have to increase by 52% in 2035 compared to the current trajectory. Compared to the current value, the final capacity would be over 18 times higher. In India and the rest of developing Asia, hydropower expands greatly, in aggregate terms and with respect to total generation capacity.

Box 5: Increasing the efficiency of coal-fired power generation

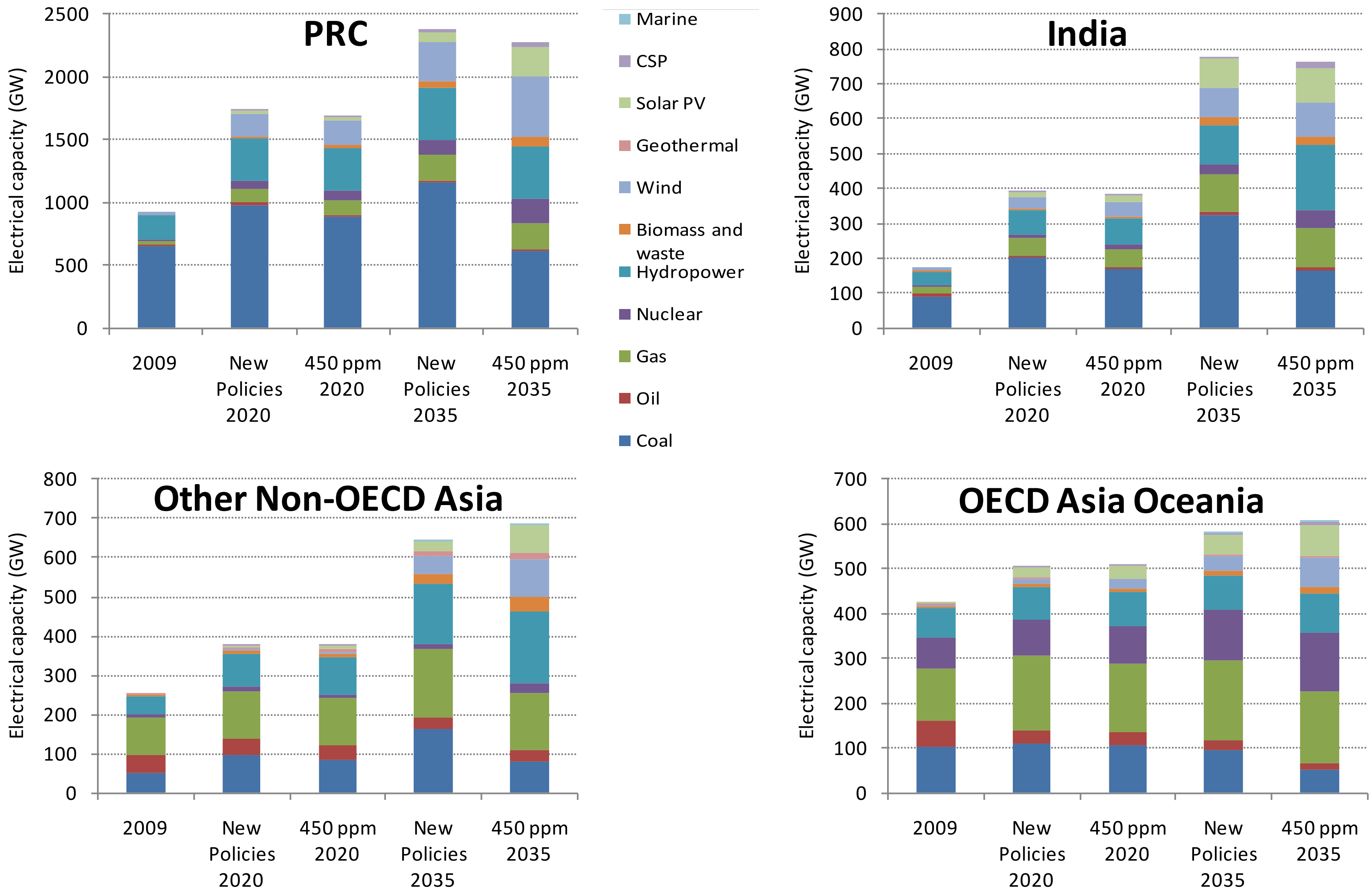
Aside from the expansion of renewable energy, the investment decisions made regarding coal-fire power generation technology are critical to developing Asia's future emissions trajectory. The PRC, India, and Indonesia all have significant domestic reserves of this cheap fuel. It is projected that these three countries will account for 80% of global growth in demand for coal to 2035 (IEA 2011a, p.380). Coal will likely remain a substantial component of the power generation mix in the region, even on a 450 ppm trajectory (see Figure 8).

There exist different types of coal-fired power plants, each with different characteristics. The least fuel-efficient, least infrastructure cost, and most emissions-intensive are subcritical plants. Better performing and higher cost technologies (on an ascending scale) include: supercritical, ultra-supercritical, and integrated gasification combined cycle (see IEA 2011a, Chapters 10 and 11 for an overview of the issues surrounding coal-based energy production).

Given the large expansion of coal-fired power generation underway in the PRC, India, and Indonesia, a priority for climate change mitigation must be investments in more efficient technologies. Although this is certainly occurring in the PRC, most newly built plants in India and Indonesia continue to be subcritical. Fuel efficiency and local environmental considerations dictate that altering this trend will have significant benefits beyond climate change mitigation.

A further consideration is the deployment of carbon-capture and storage (CCS). This technology is designed to collect and store CO_2 emissions from power generation or industry. There exist over a dozen pilot projects, but the technology is yet to be commercialized. Haszeldine (2009) argues that much greater investment in demonstration projects is required for CCS to play a significant role in emissions abatement in the near future. The IEA modeling of a 450ppm scenario discussed in the present study requires CCS to begin deployment by 2020, account for 22% of global mitigation by 2035 (see Figure 9). The same study estimates that a 10 year delay in deployment will increase the global cost of reaching a 450 ppm trajectory by 8%, due to large reductions in coal-fired power generation and more rapid expansion of renewable energy.

Figure 8: The Additional Transformation Required in the Power Generation Mix Across Asia



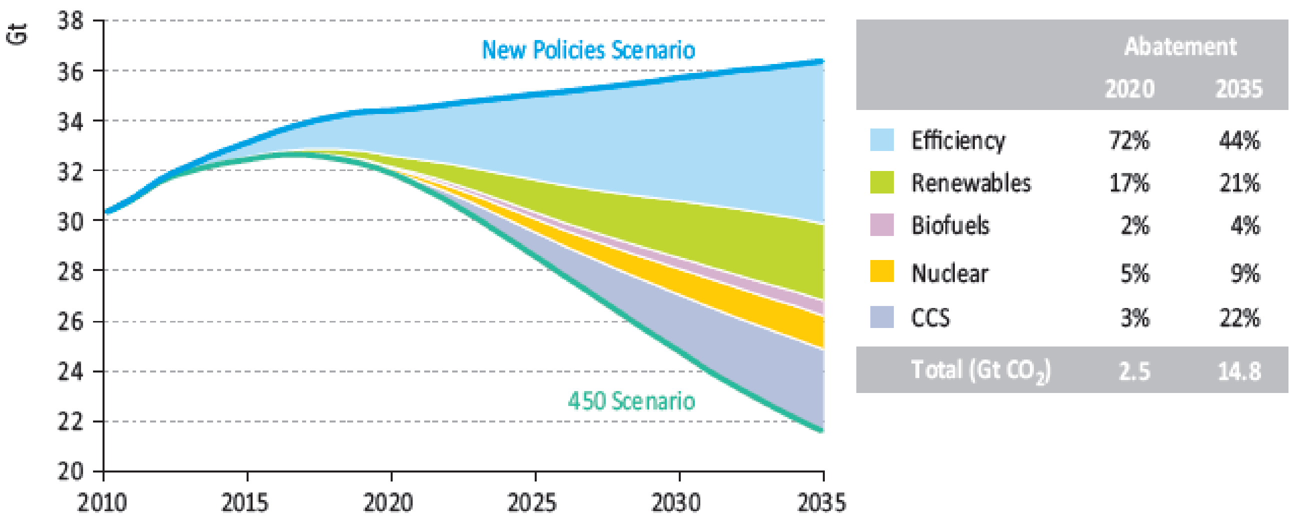
Notes: See Box 3 for a description of the different modeling scenarios and underlying assumptions of the IEA's World Energy Outlook 2011.

Source: IEA (2011a).

4.3 Energy Demand

A principal feature of developing Asia's economic expansion is substantial growth in industrial energy usage, power generation, transport, and all other components of energy demand. Figure 10 below shows the substantial shifts required under the different IEA modeling scenarios. As outlined in Box 1, reducing energy demand through more efficient usage is a prominent, low-cost measure that meets a range of economic and environmental objectives. This observation is supported by the dominant share of efficiency measures as a source of global abatement shown in Figure 9.

Figure 9: Global Emissions Reductions by Source

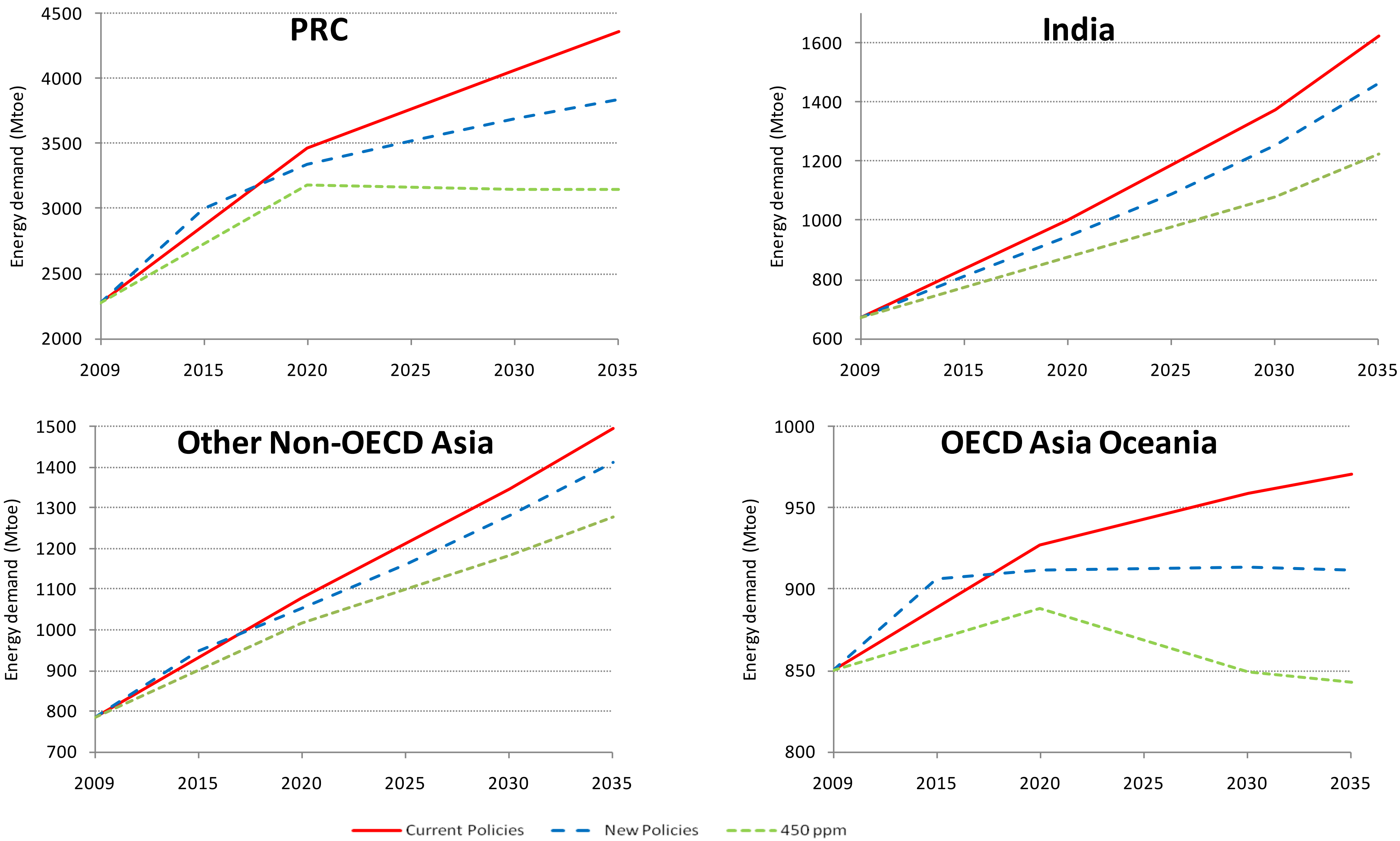


Notes: See Box 3 for description of the modeling and underlying assumptions of the IEA's World Energy Outlook 2011.

Source: IEA (2011a).

Although achieving greater energy efficiency is notionally a cheap form of mitigation, it will not always be easy to implement. This is particularly the case in developing Asia where fossil fuel and electricity subsidies have become entrenched. In all five of the study countries, cheap energy has generally been seen as a form of social welfare, providing a disincentive for conservation. However, less than 10% of the total value of fossil fuel subsidies in each study country benefits the poorest 20% of the population (IEA 2011a). Due to this leakage of subsidy benefits to the wealthy, Arze del Granado et al. (2010) argue that reform towards more effective forms of social welfare will generate high economic returns provided that short-term adjustment costs for the poor are compensated. From the perspective of government finances, this is particularly the case in net-energy importing countries (i.e., most if not all of the study countries in the near future) where governments currently adsorb international price rises. Moreover, any future move towards carbon pricing in the region (discussed in sections 5 and 6) will require energy prices to be liberalized and higher fossil fuel-based generation costs to be passed on to consumers.

Figure 10: The Additional Transformation Required for Energy Demand Profiles Across Asia



Notes: Mtoe refers to million tonnes of oil equivalent. See Box 3 for a description of the different modeling scenarios. In some cases energy demand appears higher in the "New Policies" scenario compared to the "Current Policies" scenario before 2020 due to missing data points for the latter scenario. Source: IEA (2011a).

4.4 Policy Instruments

This section reviews the policy instruments that governments in the study countries are using to meet the climate change mitigation targets set out in section 3. The sheer volume of different activities being undertaken prohibits a complete overview of all relevant policies in each country[13]. Rather, this section will review the most prominent instruments across countries, including the reasoning behind their application.

Following Howes and Dobes (2011), the following analysis is divided into a discussion of technology-based policies and carbon pricing policies. Technology-based policies are so-called because they typically favor the adoption of a particular technology or class of technologies. Whereas carbon pricing relinquishes decision-making to market forces on how emissions reductions occur, technology policies such as feed-in tariffs or research and development funding involve explicit intervention by the government in favor of a particular technology or project. Both carbon pricing and technology policies are designed to correct market failure, albeit in different ways. Carbon pricing policies are by definition fiscal (i.e., concern government revenue), while technology policies can be either fiscal or regulatory instruments (i.e., mandated laws specifying particular actions). Table 5 below lists a variety of common climate change policy instruments under this categorization. Complimentary policies or actions, discussed further in section 6, are likely to be critical to the effectiveness of these instruments.

Table 5: Classification of Climate Change Mitigation Instruments

Carbon pricing	Technology-based	
Fiscal	Fiscal	Regulatory
Emission trading Carbon tax Hybrid trading-tax schemes	Demonstration grants Public R&D Investment subsidies Preferential tax treatment Government investment in venture capital Public investment vehicles Feed-in tariffs Tax credits Public procurement Renewable energy certificate trading Subsidies for energy-efficiency purchases	Technology performance standards Renewable fuel/energy standards Building regulations Automobile regulations Information standards

Source: Howes and Dobes (2011).

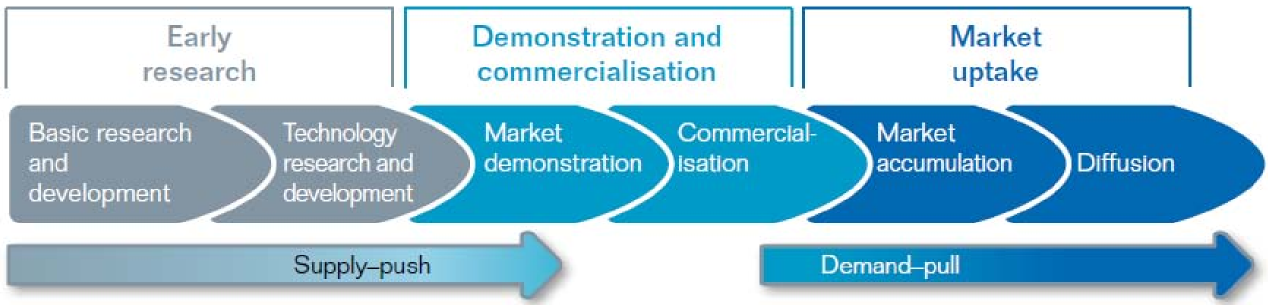
4.5 Technology-Based Policies

The already extensive deployment of technology-based policies in developing Asia reflects a range of factors. First and foremost, governments have acted on the more immediate motivations discussed in section 2 (i.e., energy security, local environmental problems, and technological advantage) by setting the targets shown in Table 4. As discussed further below, carbon pricing remains largely a prospective activity in developing Asia; therefore technology instruments are the only real means to pursue these targets at present.

13 For a complete overview of individual country policies see the country papers which this paper surveys: Chotichanathanwewong et al. (2011), Mathur (2011), Patunru (2011), Toan (2011), and Zhu (2011), and also the IEA Policies and Measures database (IEA 2011c), and government websites. For a thorough review of policy instruments for promoting renewable energy see IPCC (2011, Chapter 11).

There are multiple dimensions to the general rationale for applying these instruments[14]. The broadest is simply the correction of various market failures that arise along the innovation chain between early research and the extensive deployment of a climate change mitigation technology (see Figure 13). Such innovations generate social benefits that are external to the private costs and benefits of firms, financiers, and consumers. Government intervention can internalize these social benefits, or positive externalities, within the decision-making of the various economic agents involved.

Figure 13: The Innovation Chain for a New Mitigation Technology



Source: Garnaut (2008, Figure 18.1) adapted from Grubb (2004).

Private firms have strong disincentives to under-invest in research and development. Not only do they face uncertainty over whether their investment will yield sufficient private returns, any progress or invention they instigate may benefit competitors. Knowledge generated at the early stage of the innovation chain is often a non-excludable, public good, which can easily be adapted and used by other firms at little cost. Moreover, early stage research on a particular innovation generates a skills base which can be applied to other innovations. As the total social returns on developing new technologies exceed the benefit to an individual firm, there is strong case for public funding to make up for this under-investment in basic research.

The transition from research idea to demonstrated technology presents similar challenges. Demonstration projects for renewable energy projects typically involve large up-front costs and significant risk. Traditional lenders in capital markets are often unwilling to take such large risks. Firms also face disincentives similar to those during early research. “First-movers” generate knowledge about how and, perhaps more importantly, how not to convert an idea into a commercial project; knowledge that competitors can later use at low or no cost. Other upfront costs to first movers which generate externalities include: developing a skills base, negotiating new regulatory and legal frameworks with government, the development of support industries, and achieving social acceptance.

Even once a technology is demonstrated and commercially proven, it faces significant barriers to being disseminated in the market. In the absence of a carbon pricing, the consumer price of emissions intensive goods will not reflect their external social costs and, conversely, the price of mitigation technologies will not reflect their external social benefits. Therefore, governments can intervene to rebalance this relative cost differential in favor of higher social welfare. Stimulating demand for new technologies has the added effect of generating economies of scale and further driving their relative cost lower. In addition to addressing market failure with regards to prices,

[14] The following discussion draws heavily on Howes and Dobes (2011, Chapter 2.3.1), and Garnaut (2008, Chapter 18). See these earlier works for a more detailed discussion of these issues.

policy instruments can also address informational and agency barriers that prevent consumers from adopting known mitigation technologies, even though they are relatively cheaper[15].

The policy instruments used across the innovation chain can be divided into two varieties. Supply side, or "supply-push", measures reduce the private cost of producing a technology. Demand side, or "demand-pull", measures increase demand for a technology. Typically, supply-side policies aim to correct market failures that arise between the early stages of research and market demonstration, and demand side policies focus on market uptake (see Figure 13). The following discussion selectively reviews demand-pull technology policies (i.e., feed-in tariffs, renewable energy certificates, standards and regulations) and supply-push technology policies (i.e., investment subsidies and tax incentives, and public finance for research and development) that are being used in the major economies of developing Asia.[16]

4.5.1 Feed-in tariffs

Feed-in tariffs (FITs) are a commonly used instrument wherein renewable energy generators receive favorable terms. Although the exact arrangements can vary, FITs generally share three standard characteristics: guaranteed access to the electricity grid; long-term contracts; and generated power being purchased by grid companies at higher prices than that from fossil fuel sources, reflecting the relatively higher generation costs of renewables. Table 6 shows that FIT arrangements are already extensively used in the study countries. This instrument has played an important role in the rapid development of the PRC's wind power industry (Ma 2011), and the government has recently expanded their coverage by allowing them for non-tender solar power generators (IEA 2011b). The effectiveness of FITs however can be limited by inappropriate design. For example, the feed-in tariff may be too low to stimulate investment, or, as in the case of Indonesia, grid companies may be insufficiently compensated by government to incur the higher costs of an FIT and be unwilling to participate in the arrangement for financial reasons (see Howes and Dobes 2011, Box 4.2).

4.5.2 Renewable energy certificates and other market-based mechanisms

Renewable energy certificates (RECs) create a market mechanism for utility companies to meet mandated targets for renewable energy, or "renewable portfolio standards". Renewable energy generators are issued with credits proportional to the amount of electricity they produce, and these credits can then be purchased and/or traded by utilities in fulfillment of their portfolio obligations. This system provides incentives for renewable energy generators to compete with each other in lowering their costs. However, in the case that multiple forms of energy are covered by the same scheme, the lowest cost type of technology will generally be favored, often wind power. In 2011, India was the first of the study countries to launch an REC scheme, providing a means for states and utilities to meet previously set portfolio standards.

The implementation of RECs in India accompanies a similar scheme directed at energy efficiency, namely the Perform, Achieve, and Trade (PAT) Mechanism, wherein India's largest energy users are set benchmark efficiency levels, with trade occurring between participants who exceed their targets and those who fail to meet them. The PAT instrument echoes a voluntary mechanism developed earlier in the PRC, known as Generation Rights Trading (GRT), in which coal-based electricity generators are assigned tradable quotas and the efficiency of electricity

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[15] Howes and Dobes (2011) cite the examples of landlords not having an incentive to invest in energy efficient capital because tenants pay electricity bills, and consumers judging the cost of durable goods, such as electrical appliances, on the basis of their up-front cost and not the total cost of their use over time.

[16] See Azuela and Barroso (2011), IPCC (2011) Table 11.2, and REN21 (2011) for a more comprehensive overview.

production is increased. High efficiency generators are able to buy quota from low efficiency counterparts, achieving mutual profit, with the overall level of electricity production constant. In 2007, it is estimated that the use of GRT across 23 PRC provinces involved a total transaction quantity of 54TWh, saving 6.2 x 10^6 tonnes of coal equivalent (Ciwei and Wang 2010).

4.5.3 Regulations and standards

The governments of emerging Asia have introduced many different forms of regulations and standards relevant to climate change mitigation. As opposed to incentives which usually involve some element of voluntarism, regulations and standards are mandatory for affected parties. Such instruments are prevalent across various sectors, especially: transportation, construction, heating and cooling of commercial buildings, and the energy sector. Examples include: ethanol blending in fuel; emissions and fuel economy standards for cars; minimum efficiency standards and compulsory labeling of energy appliances; compulsory closure of small, inefficient fossil fuel based power plants; among many others.

There are numerous prominent examples of regulatory instruments in the study countries. In the PRC the Energy Saving Power Dispatch (ESPD) mechanism prioritizes dispatch to the energy grid by different generators, based on their efficiency and the emissions each produces. Priority is given to non-adjustable sources of renewable energy (such as solar and wind), then adjustable renewable sources (such as hydropower), nuclear, and so on, with coal and oil lowest in the ranking. In India, government regulations have been effective in the conversion of Delhi’s three-wheeler taxis to natural gas, among other policies to reduce urban air pollution.

4.5.4 Subsidies, tax incentives, and lending for deployment and creating market demand

A variety of subsidies and incentives are used to reduce the costs of investing in technology demonstration and deployment. Examples include: reduced taxes on inputs, tax holidays, accelerated depreciation, matched investment funding, and import duty exemptions. Governments can also offer concessional loans to reduce firm costs, or loan guarantees to reduce financier’s risks. For example, Thailand’s Revolving Fund provides capital to banks which is made available to borrowers at concessional rates, with the repayments from existing borrowers financing new projects.

Equally, subsidies and incentives can be used to create market demand. For example, government rebates on energy efficiency devices or domestic solar panels, low-interest “green” loans on retro-fitting projects, and, from above, feed-in tariffs. Government intervention brings the effective price down for users of a technology, which in turn can assist the accumulation of economies of scale by producers and place further downward pressure on prices, further stimulating demand.

4.5.5 Public finance for research, development, and deployment (RD&D)

The public good characteristics of research and development represent an attractive use of public finance. Various instruments can serve this purpose, such as: national research institutes, direct government grants, matched investment funding, student scholarships, tax subsidies, among many others. All of the study countries have some form of RD&D funding. Aside from developing new technology, it is also necessary for research to focus on adapting imported technology, a prominent issue in the later discussion of technology transfer (see Section 6).

4.5.6 Targets and policy processes as instruments

It is useful to recognize that targets and policy processes can also be described as instruments, insofar that they galvanize action. A strong example of this are the provincial targets set by the central PRC government for environmental and energy efficiency. Promotion for senior government officials within the bureaucracy has long been dependent upon the achievement of centrally determined targets. Until the 11th Five Year Plan (2006-2010) such targets almost exclusively focused on macroeconomic figures, such as GDP growth. However, today promotion requires achievement of environmental targets, thus building strong incentives for provincial officials to meet targets or follow through on central government initiatives. At the international level, for all of the study countries, targets are a means by which actions and progress can be judged externally, even if these targets or pledges are voluntary.

Of course, the effectiveness and desirability of all of these different technology instruments can vary greatly, across countries and time. In essence, these policies are designed to correct market failure; but they in turn can also result in government failure. Any situation where government finance and regulations create profit opportunities is susceptible to rent-seeking by lobby groups. Poorly designed programs may not be cost-efficient, such as high solar feed-in tariffs in Germany and Australia, or have unintended consequences, such as biofuel mandates encouraging deforestation and food insecurity. Whilst it is beyond the current scope to comment on the broad success or failure of technology-based policies to date, in developing Asia or otherwise, it is important to recognize their potential limitations, especially as this is the area where greatest progress has been made so far.

Table 6 below indicates the current application of the above instruments within each of the study countries.

Table 6: Technology-Based Climate Change Mitigation Policies in the PRC, India, Indonesia, Thailand, and Viet Nam

	Feed-in tariffs	Renewable energy certificates	Trading markets for energy efficiency	Renewable quotas/ portfolio standards	Mandated biofuel blending	Fuel economy/vehicle emissions standards	Capital subsidy, grants, or rebates	Tax incentives	Public R&D institutions	Public investment, loans, or grants
PRC	Wind, solar, Biomass	–	●	●	●	●	●	●	●	●
India	Wind, solar, biomass, small-hydro.	●	●	●	●	●	●	●	●	●
Indonesia	Renewable (incl. geothermal)	–	–	–	●	●	●	●	●	●
Thailand	Wind, solar, biomass/gas, waste	–	–	–	●	●	●	●	●	●
Viet Nam	–	–	–	–	–	●	●	●	●	●

Notes: Information accurate as of the middle of 2011. Planned policies are not included.

Sources: REN21 (2011), CAI (2011), IEA (2011c), Chotichanathanwewong et al. (2011), Mathur (2011), Patunru (2011), Toan (2011), and Zhu (2011).

4.5.7 Technology transfer

In addition to the above domestic technology policies, an important issue for developing countries is technology transfer from developed countries. The former have fewer resources to innovate and develop technologies than the latter, and, consequently, there are significant benefits to be had from the transfer of knowledge concerning renewable energy technologies. In essence, significant technology transfer would explicitly distribute many of the externalities involved in the supply-push phase (see Figure 13); in practice, there are significant obstacles to transferring intellectual property rights, not least of them being commercial concerns (see ICTSD 2008 for an overview). At present a Technology Transfer Mechanism is still developing under the auspices of the UNFCCC, although there exist other operational initiatives such as the Asia-Pacific Partnership on Clean Development and Climate.

4.5.8 Carbon pricing

This section focuses predominantly on technology-based policies simply because little progress has been made on carbon pricing in developing Asia, or, for that matter, in any major economy outside of Europe[17]. However, given the scale of the additional transformation that is required (see section 4), carbon pricing will have to become a major component of the policy agenda in the study countries at some stage, and preparations will have to begin soon.

Economists view pricing carbon as a necessary, albeit not sufficient, policy action to bring about strong mitigation of climate change. Technology-based policies may address distortions that carbon pricing may not completely overcome (e.g., under-investment in R&D, financial short-falls due to risk, or informational barriers), but the former will be insufficient to drive the substantial, necessary shifts in the behavior of industry and consumers: carbon pricing is essential. The OECD (2011: 47) summarizes the issue as follows: “only a strong and lasting carbon price signal will achieve the major transition required in carbon-intensive sectors”.

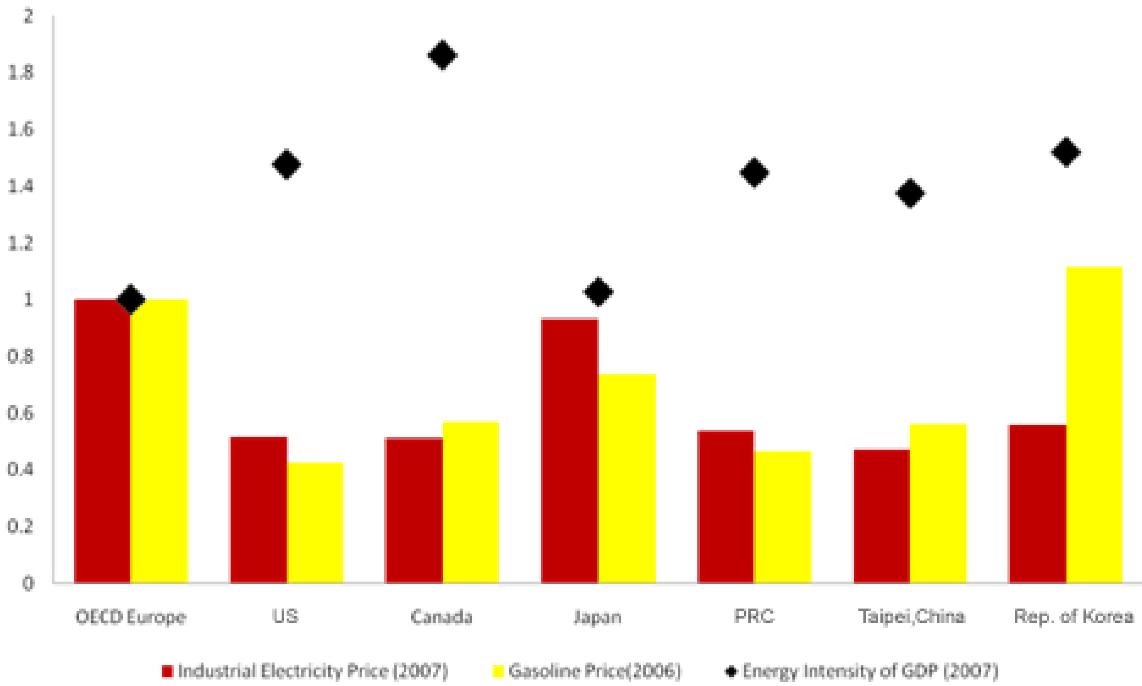
Well designed and well supported carbon pricing is the most efficient method to incorporate the social cost of greenhouse gas emissions into firm and household decision-making. Placing a value on emissions (and consequently raising the price of emissions-intensive inputs, goods, and services) shifts the preferences of consumers towards relatively cheaper low-emissions goods producers away from emissions intensive inputs, and investors towards low emissions projects with, now, relatively higher returns. What’s more, carbon pricing provides a signal for innovators to develop new technologies that will meet the preferences of the other three groups.

Placing a price on carbon would certainly seem to be critical to achieving greater energy efficiency, a principal part of the mitigation challenge outlined in section 4. Figure 14 compares the PRC (and Taipei,China and the Republic of Korea) to two sets of developed economies: the US and Canada on the one hand, and the EU and Japan on the other. The US and Canada have cheap energy (low electricity and petroleum prices) and a high energy/GDP ratio. By comparison, the EU and Japan have expensive energy and a low energy/GDP ratio. The PRC, with relatively low energy prices and high energy intensity, currently looks much more similar to the US and Canada than it does Europe and Japan. But the PRC’s mitigation objective requires that it ends up looking more like the Europe and Japan in terms of its energy to GDP ratio. It will not get there without higher energy prices.

[17] New Zealand and a group of North-American US States also currently operate emissions trading schemes. Australia and California have legislated carbon pricing to begin in 2012 and 2013 respectively, whilst legislation is currently under consideration in the Republic of Korea for an emissions trading scheme to begin in 2015.

Figure 14: The PRC's Future: Low Energy Prices or High Energy Efficiency?

Cross-Country Comparison of Electricity Prices, Gasoline Prices, and Energy Intensity (Ratio of Energy Use to GDP)



Notes: Energy prices measured in current USD, using market exchange rates. Energy intensity is the ratio of energy consumption to GDP measured using PPPs. All OECD Europe values are normalized to one.

Sources: IEA (2009, 2010a).

There are two main types of carbon pricing: a tax and an emissions trading scheme (ETS). Many variations or combinations of the two are possible and, in theory, the outcomes should be the same. In practice, the choice is between price certainty, or certainty over the final level of mitigation. A carbon tax fixes the increase in prices, but without knowing what the final reduction in emissions is going to be. An ETS involves a specific level of economy-wide emissions being set, with permits being allocated or sold to industry and businesses such that aggregate emissions equals the set level. Permits can be sold and bought by participants on the market, thus encouraging firms with low marginal mitigation costs to sell the right to emit to firms with relatively higher costs, with trade producing mutual benefits. The carbon price is determined by the market and the aggregate level of emissions can be reduced over time, encouraging successively greater mitigation.[18]

At present, experience with carbon pricing, whether a tax or trading scheme, is fairly limited worldwide.[19] This is particularly the case in the study countries, although proposals do exist and carbon price style instruments do exist, mostly in the form of levies on electricity or fossil fuels. Progress is being made, however, most notably in the PRC where pilot schemes are being set up, including in the nation's most industrialized region, Guangdong province, and also Beijing. Table 7 provides further details.

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[18] See Stern (2007), Garnaut (2008) for a more detailed explanation of carbon pricing mechanisms.

[19] See Howes and Dobes (2011, Box 2.2) for a review of real-world experience with carbon pricing.

Table 7: Status of Carbon Pricing in Developing Asia

	Policy Description
PRC	Pilot emission trading schemes occurring in seven provinces and cities, beginning in 2013 and covering energy production and other emissions-intensive industry. Government officials have indicated 2015 as a provisional starting date for a national scheme. Electricity levy of 0.002 CNY/kWh to subsidize renewable energy.
India	Coal producers pay a levy, or tax, of ~ US $1. Revenue is used to finance clean energy projects.
Indonesia	In 2009, Ministry of Finance Green Paper proposed carbon tax of ~ US $10 per tonne of CO_2, rising by 5% per annum to 2020. No legislation currently under consideration.
Thailand	Levy on petroleum products of Baht 0.04/liter which contributes to energy conservation fund.
Viet Nam	Proposed levy on petrol and diesel (between 500 to 4000 VND per liter), as well as coal (between 6000 and 30000 VND per tone).

Source: MoF (2009), Xinhua (2011), The China Daily (2011), Mathur (2011), Howes and Dobes (2011).

It is beyond the scope of the present paper to comprehensively examine the implications of carbon pricing for each of the five study countries. However, several issues require specific attention. The first is cost. Most modeling studies have shown that carbon pricing will be more costly to developing than to developed economies (see Howes and Dobes 2011 for a review). This is largely because, in general, lower income economies are more emissions intensive and greater adjustment occurs in response to a carbon price (Stern and Lambie 2010).

However, most modeling studies do not consider the revenue implications of a carbon price. Table 8 shows the hypothetical proceeds of a US$ 20 carbon price on emissions for the study countries in 2009. Clearly, the revenue implications would have been substantial, in terms of overall government revenue and when compared to developed countries in Asia. If carbon price revenues were used to reduce other taxes, or, for example, finance government spending in health and education, then the net costs of mitigation will be reduced, potentially even to the point of a net economic gain[20].

Table 8: Revenue from $ 20 Carbon Price and Government Revenue as a Proportion of GDP in Developed and Developing Asia, 2009

	$20 US Carbon Price Revenue as a % of GDP	Government Revenue as a % of GDP	Carbon Revenue as a % of Government Revenue
PRC	2.75	20	13.78
India	2.44	18.1	13.52
Indonesia	1.39	16.5	8.46
Thailand	1.72	20.1	8.56
Viet Nam	2.44	24.4	10.03
Australia	0.80	33.5	2.38
Japan	0.43	29.7	1.46
Korea	1.23	23	5.37

Notes: Korea = Republic of Korea. GDP denotes gross domestic product measured in US dollars, measured in market prices.

Source: IMF (2011), own calculation

[20] See Howes and Dobes (2011, p. 25) for an extended discussion of evidence concerning the welfare impacts of carbon pricing.

A further consideration is the likely benefits to energy importers of a global carbon price. IEA (2011a, p.227) analysis indicates that carbon pricing in major economies consistent with a 450ppm trajectory would significantly decrease international fossil fuel prices (before factoring in carbon pricing),and, consequently, decrease import bills and energy insecurity.[21] For example, the preceding analysis estimates that the PRC and India would reduce their oil-import bill by around one third in 2035.

As the deployment of carbon pricing draws closer to becoming a practical reality, further studies will need to consider the above issues on a country-level basis. An existing example is the Indonesian Ministry of Finance Green Paper (see MoF 2009). The results of this study indicate net gains in GDP growth and poverty reduction in 2020 from the imposition of a modest carbon price of approximately US$ 10/tonne CO_2 from 2013, with the size of the gains dependent upon how revenue is divided between sales tax reductions and income transfers, and also whether energy subsidies are removed.

Finally, the design of a carbon pricing mechanism is critical to its effectiveness. The over-allocation of free permits in the first two phases of the European Union emissions trading scheme has facilitated a characteristically low carbon price, reducing the environmental effectiveness of the scheme. Other considerations include: degree of coverage across emissions-intensive sectors, incorporation of carbon offset schemes, international linkages, and, of course, supporting infrastructure for monitoring and compliance. As the European Union experience has demonstrated, it will be more difficult to correct design flaws after the fact.

5. POLICY CHALLENGES

Achieving the additional transformations set out in section 4 will require expansion of the use of policy instruments set out in section 5. This will not be an easy task. The economies, institutions, and, particularly, energy sectors of developing Asia exhibit a number of characteristics which will present significant challenges to effective policy making. In this section we present some of the important challenges to up-scaling technology-based and carbon pricing policies and outline the issues which policymakers will have to engage with, namely: energy sector reform, economic reform, institutional reform, and international support.

5.1 Technology-Based Policies

Extensive climate change mitigation in developing Asia will require extensive transfer of intellectual property rights for renewable technologies. In the context of global mitigation, an outstanding and significant issue remains, at the time of writing, the prospect of extensive transfer of intellectual property rights (IPR) for renewable technologies. If patent protection limits the ability of domestic manufacturers in Asia to adapt externally developed technologies, then, of course, their dissemination is likely to be lower. In order to mitigate this obstacle, Mathur (2011) proposes that developing countries be involved in international collaborative partnerships from the research and development stage.

Effective technology transfer is conditional on sufficient adsorptive capacity in developing countries. Technology transfer is critical to the proliferation of renewable energy in developing

[21] Another important consideration is that a national carbon price would increase demand for energy from renewable sources and more efficient coal technology, as well as reducing overall demand through greater efficiency. These factors would also reduce total energy demand and, consequently, expenditure on fossil fuel imports. See also Howes and Dobes (2011, Box 1.1) for a discussion of the positive impact on the terms of trade for energy importers through pricing carbon.

Asia. This process involves much more than simply transferring technology blueprints from developed countries. Achieving widespread dissemination of a renewable technology in developing countries also requires: the development of a local manufacturing base and associated supply chains; systems for maintenance and marketing; a labour force that can build, use, and maintain the technology; and, in many cases, the adaption of technology to local conditions. Without the capacity to absorb and use transferred knowledge, the returns to technology transfer will be limited. Ockwell et al. (2008) therefore argue that domestic and international policy intervention must have a central role in building this capacity.

More research, development, and demonstration (RD&D) spending is required globally, including developing Asia. Globally, demand-pull policies have been more heavily favored by governments than supply-push policies; there is a strong case for a more balanced approach. In order to meet a 450ppm target, the IEA (2010b) estimates that an extra 40 to 90 billion dollars will have to be spent annually on clean energy RD&D to 2050. Whilst developed countries will likely account for the bulk of future expansion, increasing RD&D in developing Asia will like be necessary as well. From above, special local conditions, such as Indonesia’s vast geothermal resources, justify targeted investments. Domestic investments will diminish some of the difficulties associated with IPR transfer. Attaining commercial advantage provides another motivation; despite being a leader in production volumes and investment, much of the PRC’s wind turbine technology is well behind the technological frontier (see UNDP 2010).

Public-private partnerships are an important mechanism for leveraging private investment. Section 5 outlined the significant barriers to socially optimal private RD&D investment in clean energy technology. Public-private partnerships are an attractive option for leveraging this private investment. Government finance and support provides greater assurance of private returns. Private companies have a natural advantage in driving efficiency and cost reductions, thus increasing the prospects of commercialization as compared to a solely public financed and operated project. Public-private partnerships have been extensively used in the past to finance expensive public investments in developing Asia, such as major infrastructure projects, and the existing familiarity of governments and industry with this mechanism is highly advantageous.

Policy rigor is important: effectiveness and efficiency requires technology-based policies to be scrutinized. As noted in section 5, the environmental effectiveness and cost-efficiency of technology-based policies cannot always be guaranteed. Governments need transparent, independent processes to assess the costs and benefits of policies before, during, and after their implementation. Transparency will help to reduce rent-seeking activities. Post hoc analysis will yield important lessons for future policy, domestically and in countries pursuing similar policies. There are many different technology-based policies available to governments, picking the right ones, designing them well, and ensuring that they complement each other is critical.

In addition to these technology-specific factors, other issues that also relate to carbon pricing are outlined later in this section.

5.2 Carbon Pricing

Despite the existence of political obstacles today, the introduction of carbon pricing is a necessary, long-term concern across developing Asia. Given the scale of the additional transformation outlined in section 4, as well as the efficiency arguments discussed in section 5, carbon pricing is a necessary item on developing Asia’s climate change mitigation agenda. However, effective policy implementation will involve domestic and international political challenges. Domestically, carbon pricing will raise the cost of electricity and fossil fuels; a politically dangerous proposition given that many low-income households in developing Asia rely on energy subsidies, and that the welfare of the many without grid access, particularly in rural India, would benefit if they could switch from traditional biomass to cheap electricity. Significantly reducing the welfare of the domestic poor in the interests of international climate change mitigation is neither desirable nor feasible for regional governments. Moreover, energy is a luxury good in much of developing Asia: wealthier households are more likely to own cars and household electrical appliances. If the share of household expenditure on energy rises with income, then wealthier households, whom are likely to be more politically powerful, will also be opposed to rising prices.

From an international perspective, the ambition of developing country governments is unavoidably bound by progress on carbon pricing, and mitigation more generally, in developed countries. Outside Europe there remains little progress in rich countries, and within Europe itself carbon prices are, at present, very low. High and effective carbon prices would achieve significant mitigation; developing countries will, and perhaps should, follow developed countries progress on both issues. Therefore, unless significant progress is made elsewhere, the introduction of carbon prices in developing Asia would likely occur at a low level, rendering them less effective, if they were introduced at all.

Over time, however, the international obstacles will hold less importance. Though current action is relatively limited, developed countries will increasingly introduce carbon prices as climate change becomes more evident and they ramp up their mitigation activities; upon committing to substantial mitigation it is only natural to seek the most efficient means. Domestic political constraints may be more difficult to overcome. From the perspective of poor households, absolute welfare concerns may diminish as living standards continue to rise, but perhaps not if energy consumption continues to rise. For both poor and wealthier households, political support for carbon pricing may be contingent upon the development of compensation instruments, a topic considered in the discussion of economic reform further below.

Effective carbon pricing would require a range of supporting instruments and changes: a wholesale package of reforms will be needed. In an abstract sense, carbon pricing is a very straightforward proposition. Practical application is a much more complicated issue. Not only are there many design considerations, such as the coverage or size of a carbon price, but a range of supporting institutions and processes are also required. For example, electricity price rises must be passed through to consumers, generators must have incentives to switch to renewables, a capable bureaucracy must be present to measure emissions and ensure compliance, and so on. In the following sub-sections of this report, we argue that the underlying requirements for effective carbon pricing are, by and large, not yet present in developing Asia, particularly in the energy sector. What's more, economic reform, institutional reform, and greater international support from developed countries will be critical to the implementation of carbon pricing and, by extension, substantial mitigation in the region.

Although effective carbon pricing may be a longer-term objective, creating the necessary conditions is an immediate concern. Before turning to the specific policy challenges below, their immediacy must be highlighted. This report does not argue that carbon pricing should or could be implemented at once within developing Asia. Efficiency and effectiveness in the long-term will require the challenges outlined below to be addressed first. This preparatory reform will not be easy; therefore it must begin now to ensure that carbon pricing is a realistic policy option as soon as possible.

5.3 Energy Sector Reform

The structure of the energy sector in developing Asian economies would be critical to the effectiveness of carbon pricing. Howes and Dobes (2011) outline 12 general characteristics which distinguish the energy sector in developing economies from that in most developed economies, using the PRC, Viet Nam, and Indonesia as case studies.[22] For the purposes of the current discussion we focus on 10 of these:

- ***Rapid rate of energy growth*.** Energy demand grows rapidly in developing economies, with the electricity sector growing even more rapidly. Figure 10 in section 4 of the present report demonstrates the large projected rise of future energy demand in developing Asia.
- ***Presence of energy subsidies.*** Petroleum products, coal, and electricity are all commonly subsidized. Four of the study countries rank among the 15 countries with the highest expenditure on fossil fuel subsidies: India (4th, US$ 22 billion), the PRC (5th, US$ 21 billion), Indonesia (9th, US$ 15 billion), and Thailand (14th, US$ 8 billion). Consequently, subsidies are a significant claim on government budgets, increasingly so when international energy prices rise. Household electricity prices are significantly below those in developed countries, particularly in Indonesia where they are about half (see Howes and Dobes 2011, p.46). Lower household electricity prices are often funded by cross-subsidies wherein industrial prices are pushed up.
- ***Politicization of energy pricing.*** Price-setting is often conducted in an ad-hoc manner by governments. For example, electricity price rises in Indonesia have to be approved by Parliament and are, unsurprisingly, uncommon. Despite the existence of a formula to increase the electricity price if coal prices rise by 5% in 6 months, the PRC government changed it only thrice even though the condition was met 10 out of 12 times from the end of 2004. As a result of such circumstances prevailing in these and other study countries, price rises for petroleum or coal are not fully passed onto consumers.
- ***Presence of energy rationing.*** Power rationing is a common problem affecting the major economies of developing Asia. High growth in demand is a common problem, whilst subsidies can also limit the financial capacity of utilities to expand supply. Black-outs and brown-outs can consequently be an important constraint on business activity. In the PRC, power shortages have re-emerged recently as generators have chosen to withdraw from the market rather than endure losses arising from government-set electricity prices not keeping pace with rising coal prices.
- ***Reliance on captive power.*** Unreliable power supply and high prices arising from cross-subsidies can often drive industry to become self-reliant through captive power generation. It is estimated that captive power comprises 20% of total power generated in India (Joseph 2009); the corresponding figure for Indonesia is estimated to be 42% (Howes and Dobes 2011).
- ***Constraints on flexibility in dispatch.*** Weak transmission grids with limited inter-regional connectivity commonly constrain the ability to transfer generated electricity within developing economies. Furthermore, policy-induced inflexibility may be present; in the PRC, for example, generators sell to the grid under a quota system and no extra payments are made for providing additional capacity.
- ***Dominance by state-owned vertically-integrated utilities.*** The most common model for the electricity sector in the study countries is a state-owned monopoly responsible for generation transmission, and distribution, supplemented by private companies that can sell

[22] The degree to which these general characteristics apply will, of course, vary between countries, provincial regions, and across time. They are, however, broadly relevant to the current situation of the countries considered in the present report, including India and Thailand. See Howes and Dobes (2011, Chapter 3) for supporting evidence for these general characteristics with specific reference to the study countries; the following provides a summary of the key points.

into the grid. The PRC is something of an exception, having separated generation from transmission, but all the major grid companies and generators are state-owned.

- ***Reliance on central planning in the electricity sector.*** Investment decisions are commonly made through government-controlled sectoral plans, such as those contained within the PRC and India's respective Five Year Plans.
- ***Divergence from commercial orientation.*** A result of state involvement in the energy sector is that public enterprises, such as state-owned distribution companies, can be confident that the government will bail them out if they fail financially. That being said, energy companies will need to negotiate this assistance, with the likely result that governments will resist meeting the full divergence between costs and low consumer prices.
- ***Political difficulty of reform.*** Although attempts are being made to reform the power sector in the major economies of developing Asia, overcoming powerful interest groups and securing sustained political commitment has proved difficult.

The aggregate effect of the above features is to limit the likely impact of carbon pricing. We explore their collective role below, as well as the need for and potential impact of energy sector reform.

Insufficient mechanisms exist for cost-pass-through of carbon pricing. Given the politicization of energy pricing and ensuing subsidies, there would seem little certainty that a carbon price would be passed onto customers, in full or at all. In recent years, economies with regulated fuel prices have found it difficult to pass on rising global fuel prices into domestic retail prices. As mentioned repeatedly above, electricity price rises in developing Asia will meet fierce political resistance. The larger the carbon price, the greater the political consequences, and the less likely cost-pass-through would occur.

Carbon pricing will not be credible without cost-pass-through. Recall that one of the objectives of carbon pricing is to shift consumer preferences away from carbon intensive goods or activities. Without cost-pass-through, consumer prices do not change and there is no incentive for consumers to change behavior. What's more, if carbon prices are not passed through then energy companies will not be able to pay their carbon bill to government. Instead of receiving extra revenue, and as a consequence of the lack of commercial orientation, governments may be called upon by utilities to cover their extra costs. With the government covering extra costs through, for example, free permits in a trading scheme, utilities would lack incentives to reduce emissions.

Developing economies may have limited capacity for the dispatch order in the electricity sector to change in favor of less emissions-intensive sources. As noted earlier, shortage of supply is a common feature of the power sector in the study countries. In the short term, and where there is excess demand, any extra capacity will likely be used, whether it attracts a carbon price or otherwise. A further issue is that renewable energy technologies, such as wind and solar, often occur in remote areas and may only be available intermittently; weak transmission grids and/or inflexible dispatch may limit the capacity for renewable energy to receive priority over fossil fuels.

Governments are already shifting towards gas and renewable energy without a carbon price, if the latter is introduced, as is likely, at a low level then any additional effect on investment decisions may be negligible. Section 3 of the present report outlined just some of the national targets and planning processes committed to in developing Asia. These targets incorporate a range of environmental and economic motivations that assign an implicit carbon price, particularly on coal. Any explicit carbon price is likely to be low, and probably lower than the implicit price already driving energy investments.

Investment decisions made by utilities will not incorporate a carbon price, explicit or otherwise, if it is not credible. Utilities have significant discretion in implementing government plans. For their investment decisions to incorporate a carbon price then the utility must follow an investment plan which deviates from least financial cost. They are only likely to do so if the carbon price is credible. We argued above that utilities are unlikely to believe that they will be able to pass through the carbon price to customers. Given the lack of commercial orientation, they would probably be reliant on government subsidies, though there is a risk that these would only be partial and would not cover the full extent of the carbon price. The economy-wide pressure to expand supply and avoid shortages reassures loss-making utilities of continuing government support, but, given that support is likely to be only partial, utilities will still have strong incentives to pursue expansion at least financial cost (i.e., building new coal-fired power plants rather than wind farms). Without credibility, a carbon price does not change the financial reality facing utilities and their investment decisions are unlikely to change significantly, regardless of central planning directives.

The impact of carbon pricing will be heightened by energy sector reform. The characteristics of the energy sector in developing economies which limit carbon pricing are, therefore, important targets for reform. Energy sector reform, particular in the power sector, typically encompasses: the development of cost-pass-through mechanisms (through, for example, price liberalization or the establishment of independent regulators), privatization, and the introduction of competition to increase commercial orientation. Such reforms would encourage cost-pass-through, as well as making investment and dispatch decisions more responsive to a carbon price.

Energy sector reform is also important for technology-based policies. The weakness of the energy sector can also undermine the impact of technology-based policies. For example, captive power is prevalent in some economies; the costs of complying with renewable energy mandates typically fall on grid companies who, in turn, pass on these costs to industrial consumers, creating incentives for the latter to rely on captive power. Politicized pricing may undermine feed-in tariffs: utilities may have insufficient incentive to purchase renewable energy at a suitably high feed-in tariff if they are unable to pass on their higher costs to consumers and/or they do not believe that the government will compensate for these higher costs.

Reform of the energy sector will be difficult and some measures, on their own, could actually increase emissions. As noted earlier, reform of the energy sector has proved a difficult undertaking in the major economies of developing Asia, notwithstanding previous attempts. There is an economic case for continued reform efforts, which is now augmented by the issue of future carbon pricing. It should be noted however that reform, particularly in the power sector, will not be easy and, from the perspective of climate change mitigation, results may not always be desirable. For example, absent rationing price increases would be expected to reduce electricity demand. With rationing, however, price increases could stimulate investment in new fossil-fuel generation, increase total energy supply, and reduce rationing constraints, thereby fulfilling previously unmet demand and increasing emissions. Incomplete or only partial reform may, in some cases, be detrimental.[23]

5.4 Economic Reform

Factor market distortions in some economies are facilitating energy and emissions intensive growth. Figure 15 below shows that some developing Asian economies, particularly the PRC and Viet Nam, have very high levels of investment. In the case of the PRC, Huang (2010) explains high investment as a symptom of the limited liberalization of factor markets. Low interest rates and land and energy prices have encouraged capital-intensive production. The combination of low wages and limited social security encourages greater household saving at the expense of consumption, furthering lowering the cost of capital. Consequently, much of the PRC's recent economic growth has been led by the expansion of capital, energy, and emissions intensive heavy industry[24]. Energy use per unit of GDP, which fell by around 5% per year from 1970 to 2001, actually increased by 3.8% per year between 2002 and 2005 (Zhou et al. 2010); a considerable break with national and international trends which have almost always seen energy intensity fall as GDP rises.

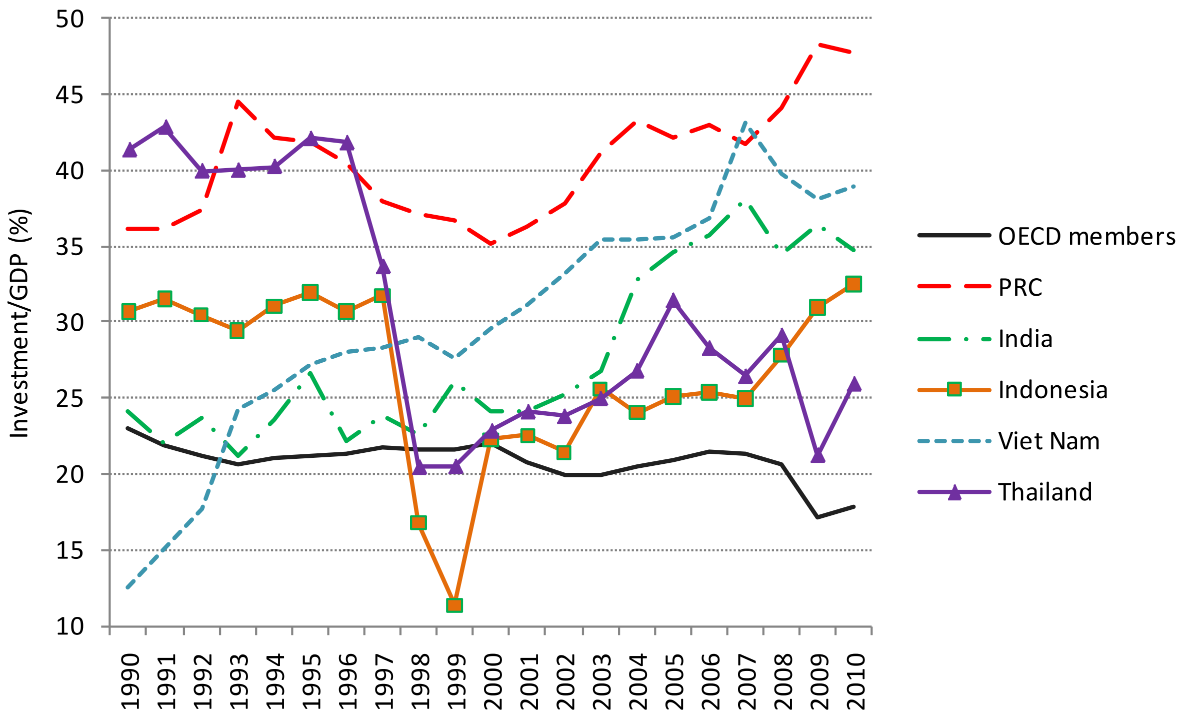
In recognition of this unsustainable trend, and the worrying consequences for energy security and the local environment, a centre piece of the PRC government's 11th Five Year Plan (2006–2010) was a successful, sectoral-based energy efficiency drive.[25] Despite success in increasing efficiency in, for example, steel manufacturing and coal-fired power plants, Howes and Dobes (2011) argue that a broader approach is needed. That is, rebalancing the entire economy towards services and away from export-oriented manufacturing will be crucial in reducing emissions. Indeed, the economic importance of this shift is well recognized in the PRC, as are the significant co-benefits for climate change mitigation.

[23] See Howes and Dobes (2011, p. 65-6) for a discussion of the negative environmental impacts of the PRC's partial reform of the electricity sector.

[24] See Rosen and Hauser (2007) for an overview of this trend.

[25] See Zhu et al. (2011) for a quantitative analysis of the success of the energy efficiency targets.

Figure 15: The Ratio of Investment to GDP for Developing Asia and the Average for OECD Economies



Notes: Investment is measured as gross capital formation. See World Bank (2011) for further details.

Source: World Bank (2011).

Whilst the PRC may be something of an extreme case in terms of the dominant position held by capital-intensive industry in the recent past, there are important lessons to be learnt for other economies in developing Asia. Viet Nam and Indonesia could be heading in a similar direction, and India, if large inefficiencies in the power sector are rectified, could find itself in a situation where manufacturing increasingly erodes the currently large economic share of the services industry.

Effective social security policy is critical to the feasibility of carbon pricing, as well as economic rebalancing. A principal consideration in the discussion of controlling investment is, of course, the importance of adequate social security to stimulate household consumption and reduce savings. This is an even more important issue if one considers the prospects for implementing carbon pricing. As mentioned earlier, there is likely to be significant political resistance to the higher prices for energy arising from a carbon price. Low energy prices are a common, albeit inefficient, form of social security. In order to secure political support for higher energy prices, governments will need adequate compensatory instruments; those which would be used in developed economies, such as lower income taxes or direct welfare payments, may not be available or have insufficient scope. The proposition that social welfare reform may be some necessary pre-condition for carbon pricing to be political feasible and socially desirable is a challenging one, but worthy of further research. This is particularly the case in the PRC, where a national emissions trading scheme is provisionally planned for 2015, and there exist significant gaps within the social welfare system, particularly for migrant workers, and in healthcare (see Huang 2011).

5.5 Institutional Reform

Effective and efficient operation of a carbon price, whether a tax or trading scheme, would demand substantial institutional capacity. A carbon price would be a fundamental reform affecting the entire economy; proper management of such large reform demands substantial institutional capacity. Not only would systems need to be put in place to design and manage the mechanism over time, government bureaucracy would need to monitor emissions by affected business entities, ensure compliance through credible enforcement, monitor the economic and social impact, and so on and so forth. Creating the necessary additional institutions in a developing country may be hard enough, doing so in developing countries where institutional capacity may already be lacking even harder still. A large body of skilled bureaucrats with ample resources would be required. Coordination between different government departments and provincial and local authorities would be necessary. In some cases, where government is based on a federalist system, fundamental changes may be necessary to responsibility for taxation arrangements and other domains of economic and social governance. None of these conditions or requirements are likely to come about easily; improved governance is a much sought after, yet difficult to attain objective in many developing economies. Fortunately, however, developing Asia is gaining increasing experience with market-based mechanisms within the domain of climate change mitigation—the Perform, Achieve, and Trade Mechanism in India, Generation rights trading and the pilot emissions trading schemes in the PRC, or the various fossil fuel taxes in all countries—and the lessons learned and extra capacity created will facilitate future institutional reform.

Corruption remains a common problem and will undermine future climate change mitigation policy. Public sector corruption is a significant issue in Asia's major developing economies. Transparency International's (2011) recent rankings of 182 countries on a scale of 0 to 10, with 0 being highly corrupt, represent all countries poorly: Thailand (rank 80, score 3.4), the PRC (75, 3.6), India (95, 3.1), Viet Nam (112, 2.9), and Indonesia (100, 3). It not necessary however to look to ratings by international think-tanks; the scale of the problem has been self-evident from, for example, large-scale public protests against government corruption in India and the PRC over recent years. Table 8 of the present report indicated the large potential increases in government revenue associated with carbon pricing; capture of this extra revenue by corrupt would reduce the benefits of extra revenue and increase the national costs of mitigation. Rent-seeking involving corrupt activities could generate inappropriate technology-based policies, or government investment decisions. The ability to avoid compliance may lead companies to under-report emissions. Though these propositions are generalized and hypothetical, the risks are clear. Moreover, corrupt practices may prove a disincentive to foreign investment and act as a barrier to acceptance into international markets for carbon offsets and emissions reductions, thereby limiting the economic benefits of a domestic carbon price.

5.6 International Support

Financial support from developed countries is necessary and justified. It is in the developed world's interests for developing Asia to cut emissions; therefore it is imperative for developed countries to finance the significant gap between the up-front benefits and costs of mitigation. The domestic motivations outlined in section 2 of this report, such as energy security and improved local environmental conditions, involve substantial benefits over time, but likely not enough in the short-term to drive the major, additional transformations required. Substantial additional investments in, for example, renewable energy need to occur soon to avoid locking-in future emissions. While the wherewithal, at least in the case of the PRC, may exist to pursue some of the large necessary investment independently, developing Asian economies have other, more immediate priorities than future climate change; chief amongst them is raising the standard of living. As arrangements for the UNFCCC Green Climate Fund progress in a risky global economic environment, it is important that developed countries fulfill their climate finance commitments; the major economies of developing Asia cannot and should not be expected to carry the full burden of their mitigation costs alone.

Non-financial forms of assistance could be, in some cases, even more important. Achieving extensive technology transfer will require new arrangements and, perhaps, willingness on the part of developed countries to forgo some commercial advantage for their own industries. Earlier discussion highlighted the significant institutional capacity requirements of carbon pricing; technical assistance from developed countries and multilateral organizations will therefore be very advantageous. Of course, developing countries would benefit greatly from the knowledge created by experience of carbon pricing and substantial mitigation activities in developed countries; a key driver for mitigation in developing Asia will therefore be the establishment of ambitious carbon pricing in developed countries.

Regional cooperation will promote climate change mitigation in developing Asia. International support extends beyond developed countries. Despite variability in economic structure and society, the major economies of developing Asia share two important characteristics: high rates of growth and the need to alter their development trajectories. Achieving the latter transformation amidst the former trend will throw up many policy challenges, above and beyond those mentioned in this report. The exchange of knowledge on how to overcome these many challenges will be mutually beneficial, particularly with regards to technology adoption, difficult reform processes, and minimizing mitigation costs. Coordination of national policies may reduce the prospect of intra-regional carbon leakage. If and when national carbon prices arise, regional linkages could reduce mitigation costs by exploiting areas of comparative advantage in reducing emissions, such as deforestation in Indonesia, agriculture in Viet Nam, or the efficiency of coal-fired power plants in India.

6. CONCLUSION

The preceding analysis of major policy challenges facing developing Asia may appear, at first glance, to cast a pessimistic light on the prospects for extensive action on climate change. This is not the intention of this report. Rather, the purpose is to highlight the importance of a broad-scale approach to mitigation that extends across all levels of the economy and government. Isolated or sector-focused policies will not be sufficient for the major switch to a low-carbon, environmentally sustainable trajectory. Carbon pricing, a transformative policy that will be necessary in the future, is instructive in this regard: a large number of complementary reforms will be required for extensive carbon pricing to even be a feasible policy option.

This report also emphasizes the importance of governments in developing Asia continuing to increase their level of ambition. It is certainly the case that recent policy announcements and targets have already transformed emissions trajectories and developing Asia is making a major contribution to collective global efforts. The problem is, however, that the current course remains insufficient.

Developing Asia is the engine of today’s emissions intensive global economy. The limits of the climate system prohibit a region containing one third of the world’s population, including the majority of the global poor, from following the same development path of today’s high-income countries. The countries considered in this report are the principal source of future emissions and, in the case of the PRC and India, among the largest contemporary sources. Analysis in this report shows that if zero emissions could be achieved in developed countries, and the current trajectory continued in developing Asia, aggregate global action would likely still be insufficient. Further action is needed, and quickly; to avoid locking-in emissions intensive infrastructure as Asia's energy demand surges, and to reduce the costs of mitigation.

The central role of the study countries in global mitigation efforts points towards the final central message of this report: considerable international support is required for developing Asia to reach a low-carbon trajectory. There are substantial domestic benefits to mitigation, but likely not enough to drive the large, up-front investments that, in the global interest, are needed in developing Asia's energy infrastructure. Given the necessity of meeting short-term social priorities, such as raising living standards, governments in developing Asia will not and should not bridge the gap between costs and benefits alone. If it is in the interests of developed countries to see extensive climate change mitigation in developing Asia, then it is in their interests to provide substantial assistance, financial or otherwise.

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