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INTEGRATION OF CLIMATE CHANGE INTO NATIONAL PLANNING IN ASIA-PACIFIC

Current Status and Challenges

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World Scientists' Warning to Humanity (1992)

"We must bring environmentally damaging activities under control to restore and protect the integrity of the earth's systems we depend on.

We must, for example, move away from fossil fuels to more benign, inexhaustible energy sources to cut greenhouse gas emissions and the pollution of our air and water. Priority must be given to the development of energy sources matched to Third World needs -- small-scale and relatively easy to implement."

Integration of Climate Change into National Planning in Asia-Pacific – Background Paper

1. Introduction

Since the publication of the original Limits to Growth report in 1972 (Meadows et al 2004), there has been an underlying concern that our current development path is fundamentally unsustainable. In all reasonable scenarios, either resource or waste sink limitations would not only constrain growth but also lead to eventual declines in the quality of life. To meet the quality of life aspirations of developing countries at anything like the current consumption patterns of the average US citizen would require 3-5 additional planets to supply the necessary resources (WWF 2008).

Humans already take up 83% of the Earth's land surface to live on, farm, mine or fish. Of the land suitable for farming rice, wheat and corn, 98% is already used, and much of that is being degraded from overexploitation. Humans have appropriated 40% of the planet's net primary productivity, 35% of the productivity of the oceanic shelf, and 60% of freshwater runoff. Virtually all fish stocks are overexploited and the oceans have multiple, vast anoxic dead zones and swirling gyres of plastic waste. Forests and biological diversity in the tropics continue to disappear at alarming rates. Combine these stark statistics with the realization that humans are now so dominant a species on the planet that fossil fuel energy consumption, livestock production, rice cultivation, and loss of forest cover are causing potentially irreversible climate change and it should be obvious that we have to change our thinking about sustainable development planning. In particular, the rapid emergence of climate change as a global concern has added to and revitalized the urgency of striving to find a sustainable development path, especially in relation to the way fossil fuels underpin and are closely coupled to the dominant paradigm of economic growth.

Greenhouse gas (GHG) emissions covered by the Kyoto Protocol increased from 28.7 to 49.0 gigatonnes of carbon dioxide equivalent ($GtCO_2$-eq) from 1970 to 2004 (Barker et al 2007). These emissions would have been higher if not for the Montreal Protocol and the accelerated phase out of ozone depleting substances (falling from 7.5 $GtCO_2$-eq in 1990 to 1.5 $GtCO_2$-eq in 2004). Atmospheric concentrations of CO_2 have increased by about 100 parts per million (ppm) since their pre-industrial level (from 280 ppm to about 387 ppm today). Adding in other GHGs and subtracting cooling aerosols, the effective concentration is 311-435 ppm CO_2-eq, with the wide range reflecting some uncertainty over the influence of land use/land use change and aerosol emissions. Approximately 40% of the GHG emissions are from the energy and transport sectors, which are anticipated to continue growing at an accelerating rate, as the global population continues on its path to 9 billion.

The Intergovernmental Panel on Climate Change (IPCC) in its fourth Assessment Report (AR4) notes that under all assessed stabilization scenarios, 60-80% of the needed GHG emissions reductions would have to come from energy supply and use, and industrial processes (IPCC 2007). For stabilization at the lower levels, IPCC scenarios put particular emphasis on low-carbon energy sources, such as renewable energy, nuclear power, and carbon dioxide (CO_2) capture and storage (CCS), plus making development more sustainable by changing

development paths. As energy and industry are critical elements of any national development plan, all countries need to re-think their development strategies and incorporate more robust sustainable development approaches in their national plans.

The 64th session of the Economic and Social Commission of Asia and the Pacific (ESCAP) in Bangkok in April 2008 emphasized the need to make a paradigm shift towards a sustainable energy security path. A Low Carbon Sustainable Development Plan (LCSDP) is one modality that could best meet this paradigm shift. This background paper provides a preliminary analysis of the theoretical basis of a LCSDP, discusses current institutional arrangements (laws, policies, organizations, strategies, plans, programs, and projects) that may contribute to a LCSDP, draws on experience from the few pioneering countries that have decided to adopt climate change mitigation and adaptation measures in their national plans, and identifies critical issues and challenges for other countries in Asia-Pacific to move in the same direction. A country survey, based on a simple questionnaire, covering Bangladesh, Cambodia, China, Maldives, Philippines, Republic of Korea, Samoa, Singapore, and Vietnam provided first-hand information from planners in those selected countries (Appendix 1). All other material was sourced from the literature.

2. Theoretical Basis of LCDP

2.1 Definitions

Sustainable development has been the overarching goal of most countries since the first Earth Summit in 1992. While climate change has added extra urgency to the sustainable development agenda, in some cases it has been treated as separate issue and not mainstreamed into sustainable development (IGES 2008). A LCSDP offers one way for climate change responses and sustainable development to find a mutually reinforcing synergy. In that context, LCSDP should be viewed as part of, but not necessarily synonymous with, sustainable development.[1] According to the literature, a LCSDP (or a low carbon economy (LCE) or low carbon society (LCS) that would result from such a plan) is variously defined as:

(i) A development path that simultaneously restrains energy demand growth, drives new production towards low carbon sources, and provides sufficient, secure energy supply for global economic growth (Renewable Energy and Energy Efficiency Partnership 2007);
(ii) Using low carbon substitutes to fossil fuels to reduce emissions of GHGs significantly, while at the same time ensuring economic growth and development and enhancement of human welfare (EREC 2008); and
(iii) Sustainable growth which helps reduce GHG emissions and environmental pollution (Cho 2008).

[1] Sustainable development includes a broader agenda than energy and climate change, as outlined in Agenda 21 (http://www.un.org/esa/sustdev/documents/agenda21/index.htm).

Historically, one of the first national government references to a LCE was in the United Kingdom's (UK) 2003 White Paper on Energy (Secretary of State for Trade and Industry 2003).[2] Here, a LCE was viewed as a development path where "higher resource productivity – producing more with fewer natural resources and less pollution – will contribute to higher living standards and a better quality of life." Central to this commitment was a target to achieve a 60% cut in GHG emissions by 2050, with real progress by 2020. Other goals of the UK energy policy were to (i) maintain the reliability of energy supplies; (ii) promote competitive markets; and (iii) ensure that every home is adequately and affordably heated.

The Japan-UK Low Carbon Society project (Skea and Nishioka 2008) offers the following definition of a LCS, as one which should:

(i) "Take actions that are compatible with the principles of sustainable development, ensuring that the development needs of all groups within society are met;
(ii) Make an equitable contribution towards the global effort to stabilize the atmospheric concentration of CO_2 and other GHGs at a level that will avoid dangerous climate change, through deep cuts in global emissions;
(iii) Demonstrate a high level of energy efficiency and use low-carbon energy sources and production technologies; and
(iv) Adopt patterns of consumption and behavior that are consistent with low levels of GHG emissions."

The Ministry of Environment, Japan identifies three principles that define a LCS: (i) carbon minimization in all sectors; (ii) a simpler lifestyle that realizes a richer quality of life; and (iii) coexistence with nature (MOEJ 2007).

From these various attempts at defining a LCDP, there are some common elements that should be included in a consensus definition, comprising an optimal mix of (i) reducing energy demand; (ii) moving away from carbon-intensive fossil fuels and their associated GHG emissions; (iii) continuing to meet the development needs of all groups in society, but especially those that are poor and/or vulnerable; (iv) ensuring energy security; and (v) adoption of appropriate technology and policies that continuously lead toward a LCS. The emphasis on energy distinguishes LCDP from more general sustainable development paths, which would have to meet three conditions (i) rates of use of renewable resources below rates of regeneration; (ii) rates of use of non-renewable resources below the rate at which sustainable renewable substitutes are developed; and (iii) rates of polluting emissions below the assimilative capacity of nature (Meadows et al 2004). There are, however, many points of commonality between LCDPs and the prior concepts of sustainable development.

2.2 Planning Methodologies

[2] Amory Lovins was one of the first to refer to a viable alternative future based on energy efficiency and renewable energy sources, rather than centralized energy supply from fossil fuels and nuclear energy. Lovins, A. (1977) Soft Energy Paths: Towards a Durable Peace. Ballinger, Cambridge, Mass.

Goal setting - For all development plans, it is important to set specific goals because if we don't know where we are headed then any path will do. To set such goals, countries, sectors, and communities may need to go through a participatory visioning process, so that a consensus on a desirable future can be glimpsed in the collective "mind's eye." One such vision was provided by the founder of the Rock Mountain Institute, Amory Lovins in 2007.

> "*Imagine a world, a few short generations hence, where spacious, peppy, ultra safe, 120- to 200-mpg cars whisper through revitalized cities and towns, convivial suburbs, and fertile, prosperous countryside, burning no oil and emitting pure drinking water -- or nothing; where sprawl is no longer mandated or subsidized, so stronger families eat better food on front porches and more kids play in thriving neighborhoods; where new buildings and plugged-in parked cars produce enough surplus energy to power the now-efficient old buildings; and where buildings make people healthier, happier, and more productive, creating delight when entered, serenity when occupied, and regret when departed*."

Another, more prosaic, vision statement was provided by the former Japanese Prime Minister, Yasuo Fukuda, in June 2008, comprising (i) transition from a fossil fuel dependent industrialized society; (ii) stepping forward with confidence, as an LCS will bring new business opportunities and is based on Japan's traditional ability to live in harmony with nature; (iii) setting up a long-term goal to reduce CO_2 emissions by 60-80% by 2050; (iv) peaking out emission levels in the next 10-20 years; (v) developing innovative technology and diffusing existing technologies; (vi) setting up enabling institutions such as emissions trading and tax reform; (vii) implementing local government measures like producing and consuming locally; and (viii) behavioral change at all levels (NIES 2008b).

Alternative pathways - Once long-term goals of a sustainable development plan are set, then there may still be alternative pathways to those goals, so interim targets or milestones are needed along the way. With defined goals and interim targets, the task then turns to defining strategies and programs to achieve these. One way to conceptualize these pathways is to map them visually (Figure 1), so that the magnitude of the task becomes obvious to decision makers and the public.

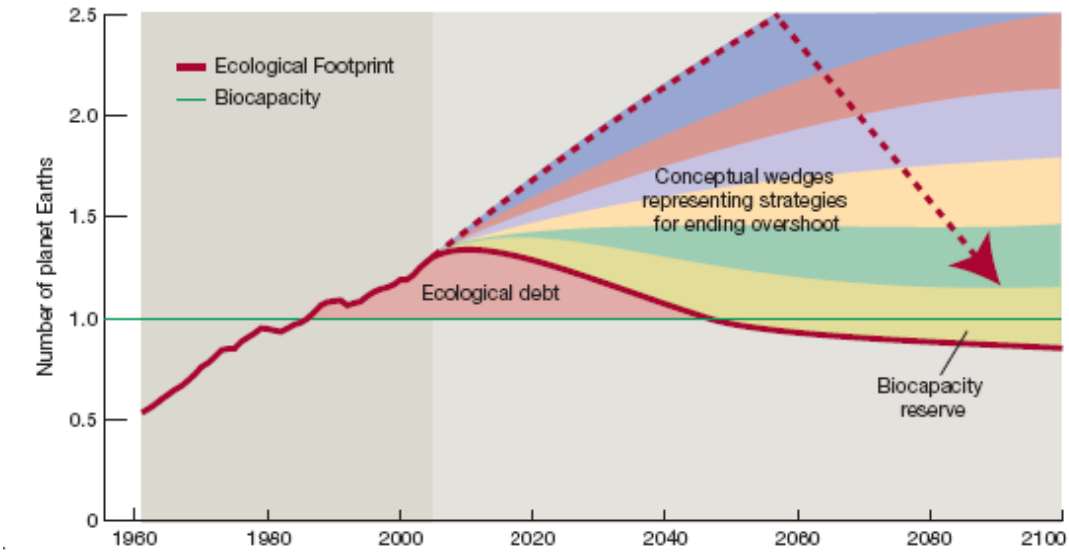

Figure 1 Ecological Overshoot and Strategies for Ending Overshoot (WWF 2008)

For many countries, commitment to specific goals and targets can only be assured if the government has tested each of the alternative paths and is sure that the preferred path is practicable, and economically and socially acceptable. The use of scenarios and various models are often adopted as planning tools to test these alternative paths. The World3 model in the updated Limits to Growth study, for example, tested 11 scenarios, where a few key factors are changed to see what would happen if the world chose different policies, ethics or goals (Meadows et al 2004). For most models, a reference scenario accommodates a "business as usual" narrative with no unusual technical or policy assumptions. Other narratives describe essential differences that can be tested in the models. It should always be remembered, however, that all models are imperfect mathematical descriptions of reality and that it is often preferable to use more than one model to make sure that the resulting trends are consistent.

The scenario narratives are evocative of an imagined future and need to be sufficiently different to allow decision makers to understand the consequences of their policy choices. In the latest Global Environment Outlook (GEO-4), for example, four scenarios are defined: Markets First, Policy First, Security First, and Sustainability First (UNEP 2007). Selected indicators are used to illustrate the probable difference in outcomes of each scenario. For example, the range of atmospheric concentrations of CO_2 in 2050 is over 560 ppm in Markets First compared to 475 ppm in Sustainability First (Figure 2). Note that these are not predictions, but rather comparisons of scenarios that are as limited as the models that generate the quantitative outputs (primarily IMAGE 2.4 in the case of GEO-4).

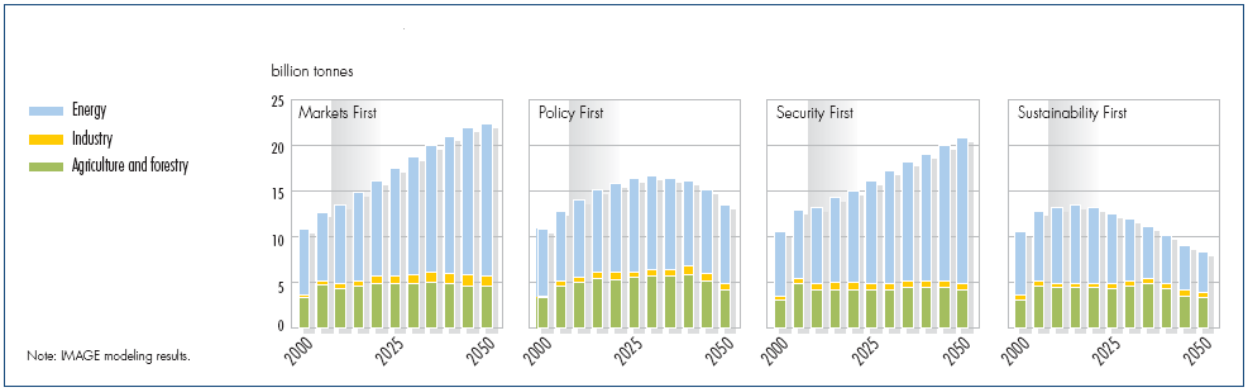

Figure 2 Modeling Results of GHG Emissions under GEO-4 Scenarios (UNEP 2007)

Modeling – With the upsurge in interest on how best to deal with climate change without causing massive economic damage, many new models have emerged; too many to examine in detail here. The Japan-UK Low Carbon Society project undertook an international modeling exercise to compare a range of different models (macro-economic, technology-based and hybrid models) and scenarios towards 2050 in the UK, Japan, USA, Canada, Thailand, and India. Core model runs were the base case, a carbon price case (where traded CO_2 would be worth $100 per tonne by 2050), and a carbon-plus case which assumed a 50% reduction in global CO_2 emissions by 2050 (Skea and Nishioka 2008). A common finding of the nine national teams involved was that LCS scenarios are technologically feasible but the social, economic, and political challenges are daunting, especially for developing countries. The implied cost of carbon (or marginal cost of abatement) at $100-$330 per tonne of CO_2 (much higher than current traded prices) raises questions about the political viability of establishing an appropriate market signal or carbon price, such as through taxation (Strachan et al. 2008).

Generally the scenario approach involves forecasting, starting from a current baseline and projecting forward under various assumptions and constraints. An alternative approach involves back-casting, where the future (desired) condition is assumed and alternative paths are available to reach this goal. For example, Fujino et al. (2008) used a back-casting approach to show that it would be possible for Japan to reach a 70% reduction in CO_2 emissions through (i) demand-side reductions (40-50%), involving efficiency improvements, decreasing population, and more rational use of energy; and (ii) supply-side reductions through low-carbon energy sources (including CCS) and energy efficiency. Using a dynamic optimization model, the path of minimum economic loss was found to depend strongly on adopting available energy savings as early as possible. Delaying energy conservation would mean that higher marginal cost technologies would have to be used, thus increasing economic losses (NIES 2008b).

Significantly, as part of this study, two possible development paths were examined (broadly Scenario A – fast-paced, urban, technology-based, growing at 2% per annum and Scenario B – slow-paced, decentralized, nature-based, growing at 1% per annum) and both were found to be consistent with achieving the 70% emissions reduction. The mix of technologies under each

scenario, however, would differ significantly, especially in relation to transportation and electricity production. The technology-oriented society would rely on nuclear power, fossil fuels with CCS, and hydrogen for fuel cell driven vehicles. The nature-based society would rely more heavily on biomass for electricity generation and biofuel use in hybrid vehicles. The visioning process is essential, therefore, to decide on what kind of LCS is desired, as there is no pre-determined endpoint.

Plan building blocks – Given that there is no "silver bullet" solution and a LCS will need to be painstakingly built up from many complementary actions, the most effective building blocks need to be identified. Both top-down (building from a national target) and bottom-up (combining sectoral plans) approaches are needed.

Princeton University's Carbon Mitigation Initiative sets a goal of avoiding 200 billion tonnes of carbon emissions, or eight 25 billion tonne "stabilization wedges", over the next 50 years (Pacala and Socolow 2004). Some 15 strategies have been identified, each with a potential to reduce global carbon emissions by at least 1 billion tonnes per year by 2054, or 1 wedge (Socolow and Pacala 2006).

Examples of wedges include (i) doubling fuel efficiency of 2 billion cars; (ii) using best efficiency practices in all residential and commercial buildings; (iii) replacing 1,400 coal-fired electricity plants with natural gas powered facilities; (iv) installing 2 million large windmills; (v) using 40,000 sq. km. of solar panels to produce hydrogen for fuel cell powered cars; (vi) driving 2 billion cars on ethanol; (vii) stopping all deforestation; (viii) doubling today's nuclear output to replace coal; (ix) cutting electricity use in homes, offices and stores by 25%; and (x) expanding conservation tillage to 100% of cropland (Figure 3 and 4). The advantage of this approach is that decision makers can compare the feasibility of applying each wedge and decide on the number of wedges of each type that should be implemented. Princeton University has even developed a board game based on this simple concept that anyone can play.

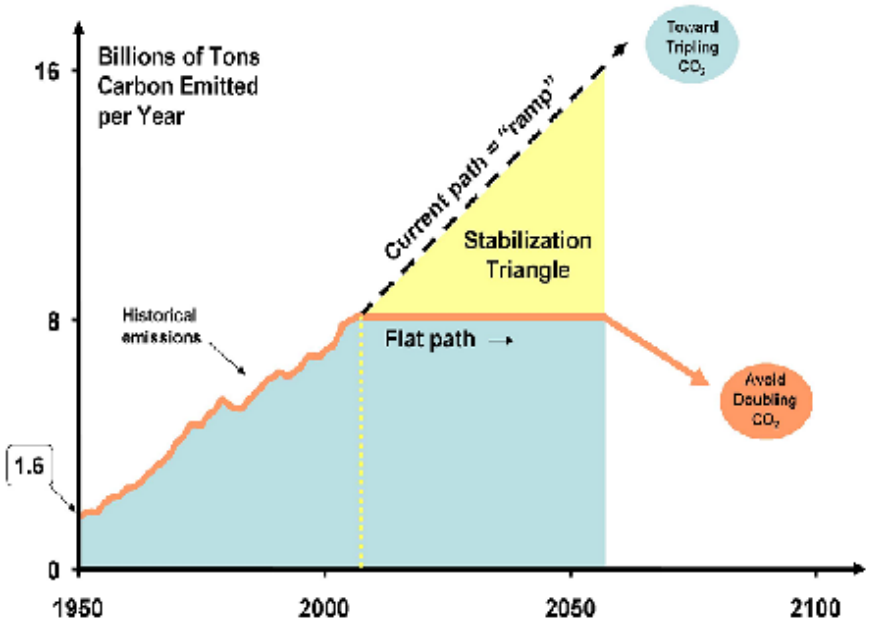

Figure 3 Princeton's Carbon Mitigation Initiative Stabilization Triangle

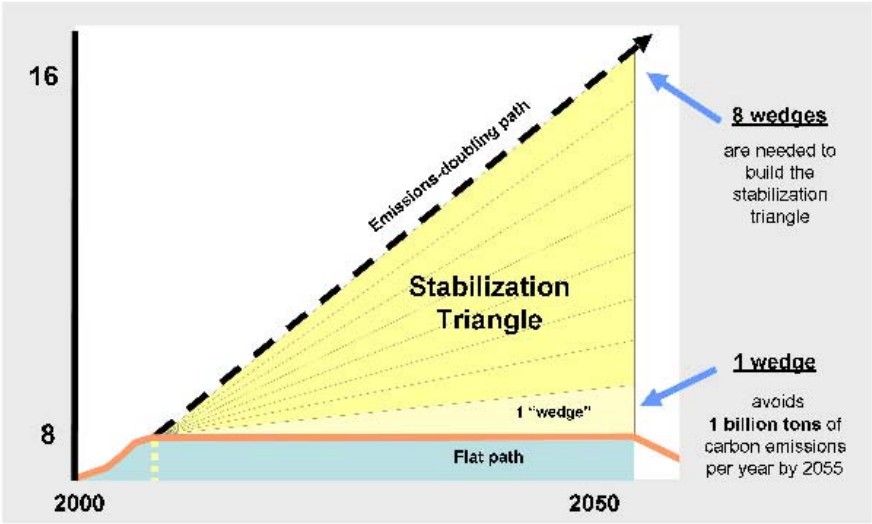

Figure 4 Princeton's Carbon Mitigation Initiative Stabilization Wedges

Societal changes - There is no doubt, however, that technology and carbon pricing alone will not dictate the ultimate form of LCS or ensure that the global community can make the transition fast enough to keep temperature increases below 2^{o}C above that of the pre-industrial period (Hourcade and Crassous 2008). Technological hubris needs to be replaced with a humble recognition that a LCDP cannot be slow and incremental, or left to reactive processes once the damage is done. Far reaching institutional, individual and societal changes will be required, as fossil fuel energy is deeply embedded in the structure of modern societies. To reach peak GHG emissions in a 10-15 year time frame requires societies to change faster than they have ever

done in history. In most models to date, the required extent of decarbonization is only possible with the simultaneous deployment of nuclear energy, CCS, and renewable energy and high prices for CO_2 (up to \$330/tCO_2 by 2050), plus robust efforts to minimize demand.

The good news from the modeling work to date is that politicians should not be too concerned about the cost of the transformations associated with a LCDP, as they tend to range from only 1-2% of GDP. The bad news for politicians is that there will be some short-term economic and social costs, inertia in labor markets and capital stocks, and significant political and social challenges. In Canada, for example, non-pricing policies may contribute almost half of the required emission reductions in 2035 (Hourcade and Crassous 2008). For developing countries, specific contributions to the Millennium Development Goals and improvements in the Human Development Index must be estimated in addition to the reduced carbon emissions.

Consider some of the social changes required to achieve a global convergence of the precursors to a LCS, such as (i) parallel tax reform; (ii) technology spillover to developing countries; (iii) relaxing patents and intellectual property rights to low-carbon technologies; (iv) institutions facilitating technology transfer; (v) eliminating security concerns over nuclear weapons development and permanent disposal of radioactive wastes; (vi) accepting stillborn consumerism in emerging economies and reducing consumption in developed economies; (vii) changes in individual values and lifestyle choices; (viii) funding research and development on dematerialization in production processes (such as nanotechnology); (ix) low-carbon choices in urban and transportation planning, building design, and material substitution and recycling; and (x) linking poverty reduction and a LCDP. These are non-trivial changes, with transition costs not easily captured by the general equilibrium models that have characterized the LCS analysis to date (Hourcade and Crassous 2008). Accordingly, much more social science research is required on the non-price factors that will govern the transition to a LCDP. Given the historic dimensions of the transformations required, much greater knowledge of the psychological and sociological factors that will lead to permanent changes in human behavior is needed.

Pilot and demonstration projects - Pilot projects will be needed as proof-of-concept measures. For example, Ota City's Pal Town, in Japan, has had solar panels placed on the roof of 75% of residences, at a cost to the government of about \$20,000 per house. The village is now completely self-reliant in electricity and sells a surplus to the grid. The 550 households involved want to keep the solar panels after the pilot project finishes in March 2010. The real challenge is in scaling up successful projects to the national level. Japan has budgeted 9 billion yen (\$92 million) for solar panels for households to March 2009. The Ministry of Economy, Trade and Industry is seeking an additional 24 billion yen (\$246 million) for subsidies in the year starting April 2009, and estimates that, with the subsidy, about 100,000 homes would install solar panels next year (Reuters 2008). Assuming that Japan has about 20-30 million homes, the challenge of up-scaling is obvious, and has not been helped by the government's on-again, off-again approach to subsidies for solar generators.

Economic tools – As an LCDP essentially involves a fundamental change in economic structure, economic modeling (e.g. computable general equilibrium models) and use of economic tools (e.g. cost-benefit analysis) play key roles in analyzing the optimal mix of elements of a LCDP, and economic policy instruments (e.g. carbon tax, subsidies for renewable energy, tax rebates etc.) are crucial in implementing LCDP plans.

2.3 Elements of LCSDP

As indicated above, there are multiple pathways towards a LCS, so there is a multiplicity of elements which are considered essential for a LCSDP by various actors. Moreover, many of these elements, such as energy efficiency, are achievable at low or zero costs, so these should have priority. The IPCC found that mitigation opportunities with net negative costs have the potential to reduce emissions by around 6 Gt CO_2-eq per year by 2030, accounting for about 10% of projected global emissions by 2030 (IPCC 2007).

In general, the most promising elements can be categorized according to the key components of the LCSDP definition: (i) reducing energy demand; (ii) moving away from fossil fuels and their associated GHG emissions; (iii) continuing to meet the development needs of all groups in society (often referred to as co-benefits); and (iv) ensuring energy security. Note, however, that these elements are not mutually exclusive and a combination of approaches will be required.

Energy demand – Reducing energy demand is possible by reducing consumption (and therefore production) and increasing energy efficiency (in both production and consumption). The US, for example, could achieve a 50% reduction in GHG emissions by 2050 by combining electricity end-use efficiency, other end-use efficiency, passenger vehicle efficiency, other transport efficiency, plus increased renewable energy and CCS, all with existing technologies (Socolow and Pacala 2006). The possibility of rebound effects, however, needs to be addressed as there is little point in achieving greater fuel economy in automobiles if that leads to more kilometers being travelled, or more efficient appliances if households just buy more appliances.

Some observers believe that an equitable approach to global GHG emissions reduction would be to focus on emissions intensity targets in the energy sector and heavy industry (e.g. cement, lime, iron and steel, oil refining, pulp and paper, and aluminium) as many of these sectors are (or could be) just as efficient in developing as in developed countries and collectively account for about 35% of total global GHG emissions (Schmidt et al 2008).

Reducing demand is possible by combining voluntary approaches (e.g., modal shifts in transportation, household insulation, adjusting thermostats, wearing appropriate clothing in winter and summer, daylight saving, and reducing consumerism) and economic policy instruments (e.g., carbon taxes, fuel taxes, rebates and subsidies) designed to change behavior. Changes in values and behavioral changes that underpin reduced demand

assumptions are, however, notoriously difficult to quantify (Hourcade and Crassous 2008) and many of the available economic tools are very blunt instruments.

The list of measures that offer significant reductions in energy demand is very long, but a partial list would include:

(i) Residential buildings – install full floor and attic insulation, install weather sealing, retrofit energy recovery ventilators, insulate and seal frames of non-opening windows, provide insulating curtains for windows, install sink aerators, retrofit high efficiency showerheads, install heat recovery systems from hot water going down drains, replace energy inefficient appliances, replace incandescent and halogen lights, turn off and unplug appliances when not in use, install ground source heat pumps and other passive energy systems, and use solar hot water heaters.
(ii) Commercial buildings – install solar heaters and chillers and/or ground source heat pumps, double glazed windows, piped lighting rather than windows, retrofitting insulation, energy efficient equipment and air conditioning, greenery on the roof or balconies, and use of stairs rather than elevators (e.g., for 1-3 floors).
(iii) Transportation – smaller and lighter passenger vehicles, improved fuel efficiency, electric-hybrid cars, modal shift to public transport, bicycles, or walking, reduced distance travelled, telecommuting, teleconferences, electric recharging at parking bays, car-pooling, no-car days, sail-assisted shipping, and improved urban planning.
(iv) Industry – energy audits, detecting and stopping fugitive emissions, leak detection, staff incentives for process improvements, factory insulation and ground source heating and cooling, heat recovery systems, and waste minimization.

Table 1 Technologies Included in LCS Modeling - Japan

Sector	Technology
Residential and Commercial	Efficient air conditioners, electric water heaters, gas/oil water heaters, solar water heaters, gas cooking appliances, electric cooling appliances, lights, visual displays, refrigerator, cool/hot carrier system; fuel cell co-generation; photovoltaics; building energy management systems; efficient insulation; eco-life navigation; and electronic newspapers/magazines.
Transportation	Efficient reciprocating engine vehicle; hybrid engine vehicles; bio-alcohol vehicle; electric vehicle; plug-in hybrid vehicle; natural gas vehicle; fuel cell vehicle; weight reduction in vehicles; friction and drag reduction in vehicles; efficient railways, ships, and planes; intelligent traffic systems; real-time and security traffic system; supply chain management; and virtual communication (e.g. teleconferencing).
Industrial	Efficient technologies for boilers and industrial furnaces; independent power plant; efficient coke ovens and eco-cement; fluidized catalytic cracking of naptha; methane coupling; and gasification of black liquid.
Energy	Efficient coal-fired generation, gas-fired generation, and biomass

Transformation	generation; wind power (offshore and onshore); nuclear power,; hydropower; by-product hydrogen; natural gas reforming hydrogen production; biomass reforming hydrogen production; electrolysis hydrogen production; hydrogen fuelling stations, pipelines and tankers; and carbon capture and storage.

Source: NIES 2008b

Japan's Low-Carbon Society Project reports that there are some 600 technology options available from their Environmental Options Database and those chosen for their modeling work are summarized in Table 1 (NIES 2008b).

Fossil fuel alternatives – The wide range of renewable energy options and emerging economies of scale suggest that wind, wave, solar, geothermal, hydropower, biomass and other renewable energy sources are competitive with coal-fired power plants, provided the full life cycle cost of each source is considered. In the transition phase, however, natural gas and coal combined with CCS may be necessary to provide base-load electricity (Socolow 2005). Nuclear energy remains problematic until the issues of wastes and potential military uses are resolved. Fusion energy may offer a long-term solution.[3] Hydrogen for use in fuel cells is attractive because the waste product is benign, but hydrogen needs to be sourced from renewable energy to be regarded as a true alternative to fossil fuels. Biofuels have proven to be controversial because of competition with food production, but second generation biofuels from cellulosic waste appear to be very attractive.

Co-benefits – The IPCC's AR4 states that "It is very likely that significant synergies can be exploited in bringing climate change to the development community, and critical development issues to the climate-change community" (IPCC 2007). Examples of co-benefits abound but include (i) rural electrification and distributed, renewable energy (like micro-hydropower or solar lighting); (ii) community-based management of forests and carbon sequestration; (iii) flood prevention and mitigation and climate change adaptation; (iv) sustainable fisheries management and reduced bleaching of coral reefs and ocean acidification; and (v) control of disease vectors and reducing atmospheric temperature increases. Not all climate change response measures, however, are consistent with sustainable development objectives. For example, using prime agricultural land to produce biofuels may displace poor farmers and lead to increased deforestation. Hence, specific measures contributing to a LCDP need to consider not only climate change benefits but also quality of life and economic livelihood benefits (Davidson et al. 2002).

[3] The International Thermonuclear Experimental Reactor (ITER) is the largest international cooperation project ever undertaken, supported by China, EU, India, Japan, Republic of Korea, Russia, and the US, at a cost of about Euro 10 billion. Constructed in Cadaranche, France, ITER will generate 500 MW of fusion power for extended periods of time, ten times more than the energy input needed to keep the plasma at the right temperature, and will be the first fusion experiment to produce net power (http://www.iter.org).

Energy security – The final rationale for moving away from a heavy reliance on fossil fuels is due to the uneven global distribution of oil, gas, coal, and tar sands. Some countries that are major sources of fossil fuels have used their geological advantages to create geo-political conflicts, while others have suffered from the Dutch disease and have not used windfall profits to benefit the poor population. The oil shocks of the 1970s triggered some early attention to energy security but this faded as oil prices retreated to very low levels. The rapid increase to $150 per barrel of oil in 2008 and the prospects (some claim current reality) of "peak oil" (where half of the available oil reserves have already been consumed) have renewed interest in energy security and possibly long term independence from energy imports (Roberts 2004). An acceptable LCDP, therefore, must consider local sources of energy and minimize energy "insecurity."

Green jobs and poverty reduction – For the developing world, the number one priority remains poverty reduction, improved quality of life, and decent work. A LCDP becomes more attractive if it contributes to new, "green" jobs and poverty reduction. There is some evidence that green jobs (in renewable energy, buildings and construction, transportation, basic industry, agriculture and forestry) are increasing in response to the challenges of climate change (Worldwatch Institute 2008). Of course, some workers in "dirty" fossil-fuel based industries that need to be phased out may lose their jobs, so the challenge is to increase the new green jobs faster than the loss of employment in the sunset industries and carefully manage a just transition. The current global market for environmental products and services is about $1,370 billion and is projected to grow to $2,740 billion by 2020. About 2.3 million people are employed in the renewable energy sector, which is projected to grow rapidly. Greening the building industry worldwide could create more than 10 million jobs. Tens of millions of people are involved in recycling, often under dangerous and dirty conditions. Converting these jobs to cleaner and safer, "decent" employment could make a huge difference. About 1.6 billion people depend on forests for their livelihood, so increasing forest cover and rewarding forest managers for their carbon sink services could create new jobs and new revenue for forest-dependent people (Worldwatch Institute 2008). Of course, appropriate policies and investment will be needed to realize these new green jobs and their contribution to poverty reduction.

Building an LCDP portfolio – Every major investment decision made from here on that does not consider an alternative with lower carbon intensity is a missed opportunity. However, putting together the optimal elements of a LCDP is a challenge because decision makers must consider economic, social, and environmental barriers for each element, plus the interactions between each element. In the current financial crisis, some observers start from the perspective of how one would sensibly allocate a major economic stimulus package. An analysis of the current US unemployment situation, where 8.8 million people are unemployed in a 154.6 million labor force, shows that a $100 billion stimulus package spent on retrofitting buildings, expanding mass transit and freight rail, constructing "smart" electricity grids, wind power, solar power and second generation biofuels would create 2 million new jobs. By way of comparison, the same amount of

money provided for household consumption or supporting the oil industry would generate 1.7 million and 542,000 jobs respectively (Pollin et al. 2008).

From 1995-1998, an Asian Development Bank (ADB) and Global Environment Facility (GEF) Project, Asia Least-Cost Greenhouse Gas Abatement Strategy (ALGAS), analyzed GHG abatement options in 12 countries (Bangladesh, China, Democratic People's Republic of Korea, India, Indonesia, Republic of Korea, Mongolia, Myanmar, Pakistan, Philippines, Thailand, and Viet Nam) (ADB 1998). Each country study formulated a national GHG abatement strategy consistent with national development priorities, as well as preparing a portfolio of projects and national action plan that would contribute to a LCDP. These excellent studies were perhaps a little ahead of their time and have not received the attention that they deserve. While just one example, Thailand, is described here, the series of final reports deserve renewed attention.

In the case of Thailand, two major GHG emitting sectors were examined—energy and primary production (forestry, rice, and livestock). Three scenarios were used—business as usual, baseline mitigation, and environmental abatement. For the energy sector, an Energy Flow Optimization Model-Environment (EFOM-ENV), a quasi-dynamic linear programming model that optimizes the energy system, was used. The options included (i) co-generation in industry; (ii) increased boiler efficiency; (iii) efficient motors in industry; (iv) lighting in residences; (v) efficient air conditioners and demand management in residences; (vi) refrigerators; (vii) lighting in the commercial sector; (viii) cooling in the commercial sector; (ix) increased fuel economy in cars; (x) switching from coal to natural gas for power generation; and (xi) switching from gas to nuclear power generation (ADB 1998). A portfolio of fifteen financially viable projects was proposed, based on the least-cost options examined. These projects included (i) fuel switching for city buses; (ii) biomass electricity in Southern Thailand; (iii) energy audits of commercial buildings; (iv) boiler efficiency for small and medium enterprises; (v) efficient stoves to reduce fuelwood demand; (vi) market development for the solar cell industry; (vii) efficient batteries; (viii) fuel switching on small islands; (ix) micro-hydropower; (x) reforestation for fuelwood production; (xi) collaborative forest management; (xii) private sector reforestation; (xiii) urban forestry; (xiv) afforestation to control salinity; and (xv) methane reduction in rice production. Many of those projects remain apposite today.

Learning from past mistakes - For over more than a century there has been a long history of visionaries (e.g., Le Play, Henry David Thoreau, Patrick Geddes, Lewis Mumford, Fritz Schumacher, Paul Erhlich, Ian McHarg, Amory Lovins and many others), who have propounded the basic elements of a LCDP. This is not the place to review the history of all such proposals and how each has built on a solid foundation of earlier concepts and research, but rather to question why the current social, political and economic system has been so resistant to such change, and why this constant sub-current of an alternative development path has had to be re-invented with every new generation. How can we avoid LCDP becoming yet another development fad destined to the same scrapheap of wonderful ideas as biopolis, industrial ecology, small is beautiful, design with nature, eco-development, factor 10, green growth, and soft energy paths?

In the Rocky Mountains Institute's (RMI) work on "natural capitalism", four major shifts in business practice are proposed (i) increasing the productivity of natural resources, by reducing the wasteful flow of resources from depletion to pollution; (ii) shifting to biologically inspired production models; (iii) moving to a solutions-based business model, where value is delivered as a supply of services rather than products; and (iv) re-investing in natural capital (Lovins et al. 1999). RMI has shown how simple design changes can lead to drastic reductions in energy demand (e.g. fatter pipes in industry to reduce friction loss and pumping costs, shifting from ordinary lighting ballasts to automatically dimming ballasts, installing windows that let in more daylight and energy efficient air conditioners, cutting paper flows in offices, improved insulation in houses and offices, and RMI's light-weight, hybrid Hypercar).

These innovations are listed not only to show what should be done, and can be done profitably, but also to point out that such changes have been proposed for a very long time but industry has been very slow to respond. The US automobile industry, for example, has continued to manufacture large, gas guzzling vehicles, despite the alternatives that have been available for several decades. RMI believes that the fundamental reason is that our economic compass points business in the wrong direction—as if people were still scarce and nature abundant, as at the start of the industrial revolution. At the outset of the industrial revolution, mechanization (such as steam engines and the spinning jenny) was introduced in Europe to increase productivity and industrial output, because there was not an adequate industrial labor force for labor-intensive production. At that time, no limits were foreseen on bounteous Nature, and most people lived close to nature in rural areas. At some point over the past 200 years, people became abundant and nature (particularly waste sinks) became scarce, but the fundamental model of economic growth did not adjust. By re-integrating ecological and economic goals, natural capitalism provides a new paradigm of production (Lovins et al. 1999) and there are hopeful signs that some industry leaders finally "get it" (WBCSD 2007).

According to the World Business Council for Sustainable Development (WBCSD), "the solutions lie in creating framework conditions with the right incentives to cause a large scale technological shift toward a lower carbon and more energy efficient economy that also delivers affordable energy solutions for the 2.4 billion people who are currently without basic energy services" (WBCSD 2007). They claim that governments need to understand how to create the right set of incentives for capital markets and corporate investment strategies to invest in a LCDP, especially in developing countries where an additional $20-30 billion per year needs to be invested in low-carbon energy solutions to stabilize GHG emissions at today's levels. Among the major changes needed, WBCSD lists (i) increased public research and development on low carbon energy technologies; (ii) further support for new technologies in the demonstration phase; (iii) sharing the risk of early deployment of new technologies, for example through public procurement or insurance; (iv) improvement of regulatory regimes to stem the anti-competitive behavior of monopolies; (v) multilateral or mutual funds that combine private sector, international financial institutions, and domestic banks to spread risks over a broad portfolio of projects; (vi) capacity building in developing countries, especially on the legal frameworks and

investment incentives; (vii) simplifying and expanding the clean development mechanism; and (viii) establishing a clear and strong expectation of a carbon price that will encourage long-term investment.

3. Institutional Arrangements for Mainstreaming Climate Change into National Development Plans in Asia-Pacific

Given the piecemeal nature of institutional arrangements that contribute to a LCSDP, this brief review of institutional arrangements cannot be comprehensive. Instead, it provides some good examples of laws, policies, plans, programs, and institutions that illustrate possible approaches that other countries may wish to emulate or adapt to their own circumstances.

3.1 Legislation and Regulations

To date, no country in Asia-Pacific has legislated to completely overturn current development paths in favor of a LCSDP. Nevertheless, many countries have begun legislating for elements of a national plan that will enable them to move towards a LCS by default.

For example, Japan's Climate Change Policy Law supplements the 1993 Basic Environment Law, which set out the national goal of establishing a sustainable society. The Law Concerning the Promotion of the Measures to Cope with Global Warming (or Climate Change Policy Law), which was enacted in 1998, provided for the Kyoto Protocol Target Achievement Plan, subsequently approved by the Cabinet in 2005. This plan not only aims at ensuring the 6% reduction in GHG emissions under the Kyoto Protocol but also pursues long-term, continuous emissions reduction. The enabling legislation, however, focuses on the short-term objectives and does not stipulate a legal requirement to achieve a LCS.

Japan has also legislated for (i) energy conservation (1979 Law Regarding Rationalization of Energy Use, revised in 1998, 2002 and 2005); and (ii) renewable energy (2002 Law Concerning Special Measures for the Use of New Energy etc. by Electric Utilities).

Although the Bush administration refused to ratify the Kyoto Protocol, the US has been actively pursuing elements of a LCDP that will benefit the rest of the world. For example, the US Congress enacted the Hydrogen Future Act of 1996 that directs the Secretary of Energy to "conduct a research, development, and demonstration program leading to the production, storage, transport, and use of hydrogen for industrial, residential, transportation, and utility applications." The Act established a Hydrogen Technical Advisory Panel and authorized the appropriation of over $200 million for hydrogen research and demonstration and integrating fuel cells with hydrogen production. By 2003, President Bush's State of the Union address said that "our scientists and engineers will overcome obstacles to taking (hydrogen powered) cars from laboratory to show room, so that the first car driven by a child born today could be powered by hydrogen and pollution free." Others are not so sure, however, as according to UNEP, building

enough centralized hydrogen plants to run all the vehicles in the world would cost around $8 trillion at current costs.

Faced with dwindling domestic oil and gas reserves and unfriendly nations controlling much of the world's remaining fossil fuel resources, the US is increasingly concerned about energy security and the cost of maintaining access in countries like Iraq. The US passed the Energy Independence and Security Act in 2007, which requires an increase in vehicle fuel efficiency, promotes domestic production of biofuels, introduces economy-wide efficiency solutions, and promotes increased research and development. Combined, these measures are estimated to save American consumers $400 billion (Caruso 2008).

Also in the US, Senators Bingaman and Specter introduced bipartisan legislation entitled the Low Carbon Economy Act of 2007, which would target reducing GHG emissions to 2006 levels by 2020 and 1990 levels by 2030. With sufficient international progress in reducing GHG emissions, the US could then aim at achieving further reductions of at least 60% below current levels by 2050. If other countries are deemed to be making insufficient progress, then the US could require importers to submit special emission allowances to cover the carbon content of their products. The bill provided for cost mitigation measures, periodic adjustment, advanced energy technology deployment, an adaptation program, and assistance to low-income people hit by the costs of climate change and mitigation measures. Unfortunately, this bill was not passed and Senator Bingaman (Chairman, Committee on Energy and Natural Resources) has indicated that a simpler, partial bill may be better to get started on the key elements of a LCE (Bingaman 2008).

Concerned that the federal government was not treating climate change with sufficient urgency, several US states have taken pre-emptive action, none more so than California under Governor Arnold Schwarzenegger. The US State of California passed the Global Warming Solutions Act in 2006 which requires the California Air Resources Board (CARB) to develop regulations and market mechanisms that will reduce California's GHG emissions by 25% by 2020, with mandatory caps for significant sources starting in 2012. This was followed up in 2008 with subsequent legislation (Senate Bill 375) to curb urban sprawl, by setting regional emissions reduction goals, setting regional GHG emission reduction targets for transportation for 2020 and 2035, and aligning transportation, housing and land use plans to prepare a sustainable communities strategy. California also requires all fuel providers to reduce the carbon content in transportation fuels by at least 10% by 2020, and more thereafter.[4] Other initiatives include (i) the one million solar roofs initiative; (ii) a renewable portfolio standard (Senate Bill 107) that requires 20% of California's energy to come from renewable sources by 2010; (iii) a low emissions vehicle program that requires 10% of sales by 2003 and 16% by 2018 to be zero emissions vehicles; and a 2002 Assembly Bill that requires CARB to adopt by 2005 a maximum CO_2 pollution standard for light duty vehicles (currently being blocked by the US Environment Protection Agency).

[4] Other US and Canadian states have adopted similar legislation modeled on California.

The UK passed a revised Energy Act and a Climate Change Act in 2008, which makes the government commitment to reduce carbon emissions by 80% by 2050 a legal requirement, binding future governments. The Climate Change Act paves the way for introduction of an emissions trading scheme. The Energy Act provides for feed-in tariffs, a renewable heat incentive, increased weight to be given to sustainable development, and other measures. The details of how these laws will be implemented, however, have yet to be released. The Energy and Climate Change Secretary reported that aviation and shipping emissions will be included in the national emissions calculations for the first time.

In November 2008, the European parliament and member states agreed on a new Fuel Quality Directive that will limit the carbon content of transport fuels. The revision will require fossil fuel suppliers to cut the GHG emissions of their fuels throughout their life-cycle by 1% per year between 2011 and 2020. The new law also obliges the oil industry to reduce flaring and venting, two widespread practices causing unnecessary GHG emissions, and contains specific incentives for electrification of transport. In September 2008, the Parliament's Industry, Research and Energy Committee clarified that only biofuels produced in accordance with certain sustainability criteria would count towards the renewable energy target for road transport under the parallel Renewable Energy Directive.

British Columbia, Canada, adopted a Greenhouse Gas Reduction Targets Act in 2007 that requires a an emissions reduction target 33% below 2007 level by 2020 and 80% below 2007 levels by 2050. All public sector organizations are required to become carbon neutral by 2010 and to report on their emissions, actions taken, and future plans towards carbon neutrality.

Although until recently aligned with the US in its refusal to ratify the Kyoto Protocol (signed as the first act of the incoming Labor government), Australia enacted a National Greenhouse and Energy Reporting Act in 2007, plus associated regulations. The Act requires reporting of GHG emissions, energy consumption and production by large companies and public disclosure, to underpin the planned Carbon Pollution Reduction Scheme. The State of South Australia jumped the gun and introduced their Climate Change and Greenhouse Emissions Reduction Act on 3 July 2007. This legislation sets a target of reducing GHG emissions to 40% of 1990 levels by 2050, increase the proportion of renewable energy generated and consumed in the state to at least 20% by 2014.

The Republic of Korea has issued notice that it will legislate a basic law on climate change, including formulation of a comprehensive plan, introduction of carbon trading and a GHG database, and obliging companies to report on their emissions. The legislation is intended to lay the foundation for a low carbon and green growth society. An enforcement ordinance will be added to oblige major emitters to report to the government. It will also lay out financial incentives to cope with a post-2012 climate change regime.

China intends to quadruple its economy between 2001 and 2020 but without major changes this would entail a six-fold increase in energy use. To counter this trend, China enacted its Renewable Energy Law in 2005, to boost renewable energy to 20% of the total energy mix. China is also reported as drafting a basic energy law which would possibly reinstate the Ministry of Energy, define responsible levels of authority, and cover energy conservation, energy emergencies, and energy supply infrastructure. The draft law, to be approved in 2009, has 15 chapters and 140 articles that define energy management, strategy, development, supply, storage and conservation, energy technology, international cooperation, fiscal and tax policies, among other issues.

China's Circular Economy Law, which comes into force on 1 January 2009, requires (i) the government to closely monitor energy consumption and pollution emissions in heavy consuming and polluting industries including the steel and non-ferrous metal production, power generation, oil refining, construction, and printing industries; (ii) government departments to promote recycling and improve energy-saving and waste-reutilization standards and develop policies to divert capital into environment friendly industries; (iii) industrial enterprises to introduce water-saving technologies, strengthen management, and install water-saving equipment in new buildings and projects; (iv) crude oil refining, power generation, steel and iron production plants to stop using oil-fired fuel generators and boilers, in favor of clean energy, such as natural gas and alternative fuels; (v) enterprises and government departments to adopt renewable products in new buildings, such as solar and geothermal energy; (vi) enterprises to recycle and make comprehensive use of coal mine waste, coal ash, and other waste materials; and (vii) farmers and rural administrators to recycle straw, livestock waste, and farming by-products to produce methane. This law now needs to be developed into a national circular economy plan.

3.2 Strategies, Plans and Policies

Sustainable development plans – The World Summit on Sustainable Development called on all countries to prepare sustainable development plans by 2005 and a large number of countries have responded. By the end of 2007, 82 countries were implementing some form of national sustainable development strategy. The Rio Declaration on Environment and Development in 1992 outlined 27 principles to guide sustainable development planning, which are equally important for a LCDP. Of particular importance in pursuit of a LCDP are:

Principle 2 – "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."

Principle 4 – "In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it."

Principle 7 – “States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities.”

Principle 8 – “To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.”

Principle 15 – “In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.”

A review of 46 national sustainable development strategies that are under implementation found that only 8 did not directly refer to climate change (UNDESA 2007). Most countries address climate change directly and indirectly, with developing countries emphasizing co-benefits and developed countries more focused on mitigation strategies. Adaptation features less prominently in the national strategies. Few countries make specific reference to a LCDP in their national strategies for sustainable development, indicating that this is a more recent concept in most cases.

One of the most vulnerable countries in the world, Bangladesh, in its most recent National Sustainable Development Strategy (2008) identifies climate change as a strategic priority and specifically refers to the Bangladesh Climate Change Strategy and Action Plan (2008) as a guiding document to address climate change. It also refers to the National Adaptation Program of Action and the National Capacity Self Assessment, plus other national strategies as containing “noteworthy strategies and action plans.” Bangladesh’s National Strategy for Accelerated Poverty Reduction (2009-2011) also recognizes climate change as one of the emerging issues. A multi-donor trust fund to deal with climate change adaptation and mitigation has been set up, with the Government contributing $43 million.

The Republic of Korea’s National Strategy for Sustainable Development (2006-2010) deals extensively with climate change (on 14 pages of a 209 page document). Anticipating future global pressure for Korea to do more than other “developing” countries beyond 2012, it states that “it is necessary to formulate a systematic and comprehensive plan to change to a type of the economic structure that produces a low level of greenhouse gas emissions so as to realize sustainable development of the national economy and prevent and minimize damages caused by climate change.” In relation to adaptation, the proposed actions include (i) collecting information and natural disaster planning; and (ii) research on the impacts of climate change on ecosystems and health. Many other priority activities would provide climate change co-benefits (such as water conservation, sewage water re-use, sustainable groundwater management, flood management, a national land management system, sustainable forest management,

expansion of urban forests, “green” transport, green building certification, insurance for storm damage, and conversion to a low energy consumption economy).

Singapore’s sustainable development strategy (A Lively and Livable Singapore: Strategies for Sustainable Growth 2009) mentions climate change in several places. It refers to the need to “do our part in global efforts to address climate change and reduce greenhouse emissions.” Contributing co-benefits include empowering consumers to make resource smart choices, setting minimum performance standards, expansion of the National Recycling Program, incentives for “green” buildings (Green Mark Certified), more eco-friendly public housing (including solar test-beds and improved resource efficiency), a cleaner and greener transport system, improved resource efficiency, and a city “nestled in greenery.”

Climate change action plans – Most countries have either completed or are preparing a climate change action plan, which can be regarded as a proxy for a LCDP plan. In the least developed countries, almost all have prepared a National Adaptation Program of Action (NAPA) with GEF-funding (see below).

US President Clinton’s Climate Change Action Plan (1993) was one of the first and aimed to return US GHG emissions to their 1990 levels by 2000. It included 50 new and expanded initiatives, backed by $1.9 billion in new and redirected funding (from 1994 to 2000), as well as leveraging $60 billion in private investment. The subsequent Bush Administration’s decision not to ratify the Kyoto Protocol derailed this early start towards a LCDP.

As one of the more recent plans by a developed country, Australia’s climate change strategy is based around (i) reducing GHG emissions; (ii) adapting to unavoidable climate change; and (iii) helping to shape an acceptable global solution. The main target is to reduce GHG emissions by 60% below 2000 levels by 2050, partly through a cap and trade scheme. Adaptation measures such as the $200 million Great Barrier Reef Rescue Plan and the $12.9 billion Water for the Future Plan are the first steps to deal with the likely impacts of climate change in Australia.

The Australian Government’s proposed Carbon Pollution Reduction Scheme will place a cap on the amount of carbon pollution that industries can emit. Starting in 2010, around 1,000 of Australia’s largest companies (producing more than 25,000 tCO_2-eq per annum)[5] will be required to purchase a pollution permit for each tonne of GHG emitted, thus providing a financial incentive to reduce their emissions. The funds raised will be used to help households and businesses to adjust to the scheme (e.g. by cutting fuel taxes and providing some free pollution permits and direct assistance to affected industries) and to invest in clean energy. As 99% of companies and all households will not be directly affected and many other sectors like

[5] Australia has about 7.6 million registered enterprises, so 99% will have no obligations under the scheme.

tourism are not required to participate, it is unlikely, however, that these measures will be sufficient to move Australia towards its stated goal of a "low pollution future" (Treasury Department 2008).

As an example of a developing country climate change action plan, India released its National Action Plan on Climate Change on 30 June 2008, after considerable delay. The plan gives overriding priority to economic development and raising living standards, while also yielding co-benefits that will help address climate change. Eight national missions are identified (solar, energy efficiency, sustainable habitats, water, sustaining the Himalayan ecosystem, reforestation, sustainable agriculture, and strategic knowledge for climate change), with a government agency charged with developing detailed actions for each of these missions (for the period 2008-2017). The GHG target merely asserts that India's per capita GHG emissions "will at no point exceed that of developed countries, even as we pursue our development objectives."

China's National Program on Climate Change was released in June 2007 and like India was very vague on setting GHG emission targets, arguing strongly for the priority of economic growth and poverty reduction. Specific targets for 2010 that were included in the plan were (i) reducing energy consumption per unit of GDP by 20%; (ii) raising the proportion of renewable energy to 10% (from 7%); and (iii) increasing the forest coverage rate to 20% (from 18%). Key measures included are increasing nuclear power, promoting clean coal technology, developing biofuel, and international collaboration in technology transfer and capacity building.

Bangladesh's Climate Change Strategy and Action Plan (2009-2018) recognizes the specific needs of the poor and vulnerable, including women and children, with six priority areas in the first five year period (i) food security, social protection and health; (ii) comprehensive disaster management; (iii) infrastructure; (iv) research and knowledge management; (v) mitigation and low carbon development; and (vi) capacity building and institutional strengthening.

In several instances, States have developed their own climate change action plans independently of the national government. One US example is the Arizona Climate Change Action Plan (Arizona Department of Environmental Quality 2006). This plan contains 49 policy recommendations for addressing and reducing GHG emissions. These focus on energy efficiency, renewable energy, mainstreaming climate considerations into infrastructure, and cleaner transport modes, technologies and fuels. The State goals are to reduce GHG emissions to 2000 levels by 2020 and to 50% below 2020 levels by 2040.

Climate change action plans have also been prepared for the city level. For example, the Mayor of London's Climate Change Action Plan (Greater London Authority 2007) notes that to tackle climate change we don't need to reduce our quality of life, but we do have to change the way we live. It refers to the need to move from a high energy using, wasteful economic model to one that conserves energy and minimizes waste. The plan is notable because it includes aviation emissions, which are usually omitted from national GHG inventories. London set a CO_2 target at

60% below 1990 levels by 2025 (i.e., more stringent than the national targets) but set an interim 10-year target (2016) and achievable emission reductions.

Adaptation plans - Nearly all countries in Asia-Pacific have embarked on some form of climate change strategy plan. UNDP and GEF funding has been provided for most least developed countries to prepare NAPAs and many of them are also preparing National Capacity Self-Assessments (NCSA). To date, 38 NAPAs have been received by the UNFCCC Secretariat, including Bangladesh, Bhutan, Cambodia, Kiribati, Maldives, Samoa, Tuvalu, and Vanuatu in Asia-Pacific. NCSAs, which evaluate capacity to implement the key multilateral agreements, including the UNFCCC, have been completed by Afghanistan, Bhutan, Cambodia, China, DPR Korea, Indonesia, Malaysia, Maldives, Mongolia, Philippines, Samoa, Sri Lanka, Timor Leste, and Vietnam in Asia-Pacific.

As just one example, Cambodia's NAPA identifies the country's vulnerability to climate change, the links with the national development strategy, key adaptation needs, and 39 priority projects (MOE 2006). Project profiles for the 20 most urgent activities are included as an annex, although many of these appear to be priority development projects that should be undertaken anyway (such as rehabilitation of multiple use dams, water supply, flood protection, health projects and promotion of integrated agriculture). Countries that have not received the UNDP and GEF assistance have generally recognized the need for adaptation plans but have been much slower in preparing them.

National Economic (and Social) Development Plans – Typical of many developing countries, Cambodia's National Strategic Development Plan (2006-2010) has only brief direct reference to climate change, by cross-referencing the NAPA and priority adaptation actions in agriculture, water resource management, coastal zone management, and human health. Indirectly, co-benefits from priority actions in agriculture, forestry, water resources, and health are included in the plan, but equally there are planned actions that may have negative impacts on climate change. For example, increasing livestock production, building new roads, increasing electricity supply from coal-fired power plants will add to global GHG emissions.

Among the most vulnerable countries to climate change are the Pacific islands. One of the more competently managed countries, Samoa, has recently prepared its Strategy for the Development of Samoa (2008-2012), which specifically relates climate change and disaster management, especially in relation to implementation of the Disaster Management Act 2007. The Strategy states that "resilience to the adverse impacts of climate change will be address through continuation of work on coastal management and adaptation programs for vulnerable villages and other coastal locations and through such activities as promotion of energy efficient building design."

3.3 Plan Elements

As for climate change strategies and plans, the potential list of programs and projects that will constitute a contribution to a LCSDP is too long to be dealt with here, so the emphasis is on a few projects or programs that are relatively unique or likely to be copied by other countries. The main international funding sources are described briefly.

The World Bank has been funding innovative projects dealing with all aspects of climate change through a series of carbon funds, including the Prototype Carbon Fund, the Community Development Carbon Fund, the BioCarbon Fund, the Netherlands CDM and Joint Implementation Facilities, the Italian Carbon Fund, Danish Carbon Fund, and Spanish Carbon Fund (World Bank 2006). These and similar funding arrangements by GEF and the ADB are providing developing countries with seed funding to make the transition to a LCDP and to enable Kyoto Protocol Annex 1 countries to meet their GHG reduction commitments by investing in more cost-effective, low-carbon energy projects in developing countries.

The clean development mechanism (CDM) project pipeline submitted to the CDM Executive Board comprises 4,200 projects (with certified emissions reduction amounting to 3 billion tCO_2-eq) of which 1,258 are already registered. Of the registered projects, 836 are in Asia-Pacific (66.45%), mostly in China and India. The GEF Least Developed Countries Fund, Special Climate Change Fund, and the Adaptation Fund under the Kyoto Protocol provide about $250 million per year to climate change projects, which cover renewable energy, energy efficiency, sustainable transportation, adaptation, new low-carbon energy technologies, and capacity building.

ADB is providing access to financing for energy efficiency, renewable energy, sustainable transport, and other GHG mitigation projects through its Energy Efficiency Initiative, Carbon Market Initiative, and Sustainable Transport Initiative. To reduce fugitive emissions, ADB is promoting investment in the capture and use of methane from coal mines, landfills, and agricultural waste, and gas transmission networks (ADB 2007).

In the Greater Mekong Subregion (GMS), the ongoing ADB-supported Core Environment Program plans on addressing climate change in its next phase of projects. Planned components as part of the integrated spatial and strategic approach to facilitate sustainable development in the East-West Economic Corridor, include (i) capacity building for energy sector planning and energy trade coordination; (ii) application of land use management and spatial land use decision support tools; (iii) climate change mitigation through carbon sequestration and offsetting GHG emissions from freight traffic; and (iv) climate change impacts on agricultural production for food security, among others.

ADB is also assisting with a range of adaptation projects, particularly in low-lying countries likely to be affected by sea level rise. One innovative project is the ADB-World Bank-Japan Bank for International Cooperation Initiative on Climate Impact and Adaptation in Asian Coastal

Megacities, covering Bangkok, Ho Chi Minh, Jakarta, Karachi, Kolkata, and Manila. Projects related to adaptation, such as the coastal mega-cities project, illustrate the daunting nature of the challenges in attempting a transition to a LCS. For developing countries likely to suffer most from the impacts of climate change, should they invest in adaptation to protect their population or use scarce capital to invest in energy efficiency, renewable energy, and sustainable transportation?

Several countries have initiated domestically funded innovative programs to implement government policy on climate change. For example, Japan's Top Runner Program was established under the 1998 revision of the Energy Conservation Law. It is a mandatory scheme designed to trigger continuous improvement in energy efficiency of household appliances, office equipment, and vehicles. The "top runner" or most efficient product in its class is set as the standard and manufacturers and importers are required to meet that standard by target years, with the standards set by a consultative process involving the regulated groups.

As outlined elsewhere in this paper, one of the most significant LCS research projects has been the Low-Carbon Society Research Project in Japan and several other collaborating countries, which started in 2004 (Strachan et al. 2008). This research, based on a range of quantitative models and policy analysis, shows that halving global GHG emissions by 2050 is technically feasible by combining reduced energy demand, decarbonization of the energy supply, and significant shifts in transportation modes and technologies. As indicated by several commentators on the results to date, this research now needs to turn to the political, social, and behavioral changes that such fundamental reorientation of society demands (Hourcade and Crassous 2008; Sugiyama 2008).

3.4 Planning Institutions

Apart from various research committees and think tanks, there is no evidence of countries establishing specific institutions to prepare a LCSDP. Generally, the broad goals of setting up a LCE or LCS are handled either by national councils for sustainable development (NCSD) or by national councils on climate change, with implementation delegated to energy, environment, and sector agencies. Specific national planning that incorporates elements of a LCSDP is undertaken by the national planning agency or Ministry of Finance and Planning.

For example, in Japan, immediately after adopting the Kyoto Protocol in December 1997, the Government set up the Global Warming Headquarters (GWH), chaired by the Prime Minister and with all line ministries represented (Figure 5). The GWH drew up Guidelines on Measures to Prevent Global Warming in 1998 which allocated responsibilities to each sector to reach specific emission reduction targets, backed by the Climate Change Policy Law. These guidelines were revised in 2002 and allow three phases of implementation (2002-2004, 2005-2007, and 2008-2012) which allow interim targets to be revised if progress is too slow. While the guidelines clearly refer to activities which will assist in moving Japan towards a LCS, this is not a specific mandate or objective of the GWH (Tamura 2008).

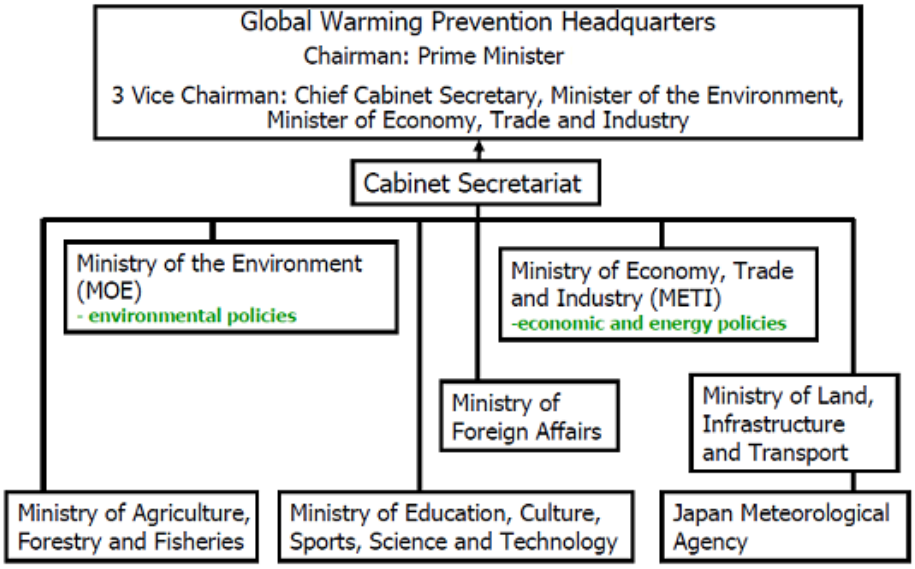

Figure 5 Global Warming Headquarters, Japan (Tamura 2008)

In India, the need for integrated environmental planning has been recognized for over 30 years, as the National Committee on Environmental Planning and Coordination was created in 1972. India responded to the oil shocks of the 1970s by creating a Commission for Additional Sources of Energy in 1981, followed by a Department of Non-Conventional Energy in 1982 (converted to a Ministry in 1992) and then re-naming it as the Ministry of New and Renewable Energy in 2006. The National Energy Policy 2005 stipulates that the share of renewable energy in the country's energy mix must be increased. A National Action Plan on Climate Change was released in July 2008 and envisages India moving towards a less carbon-intensive growth pattern as well as renewable sources of energy and high energy efficiency. Eight "missions" have been identified in the plan, with a specific ministry identified for delivering on each mission and reporting to the Prime Minister's Council on Climate Change (Desai 2008).

In 2007, the Communist Party's National Congress set a goal of accelerating the transformation of China's development pattern and quadrupling the year 2000 per capita GDP by 2020 through optimizing the economic structure while reducing consumption of energy resources and protecting the environment. In that same year, a National Program on Climate Change was released, which specifically adopted a LCE as China's approach to sustainable development[6], along with China's Scientific and Technological Actions on Climate Change. While the development path may be clearer, the institutional arrangements are still confused, however, with (i) a National Climate Change Leading Group; (ii) National Energy Conservation and Emission Reduction Leading Group; and (iii) an Administrative Center for China's Agenda 21, all

[6] China's initial approach to sustainable development dates back to China's Agenda 21, A White Paper on Population, Environment and Development in the 21st Century released in 1994.

jostling for primacy. Among the powerful bureaucracies involved, the National Development and Reform Commission has taken the lead role to date (IGES 2008).

In 2007, Thailand created a National Board on Climate Change, headed by the Prime Minister, with 17 government departments represented. National strategies for climate change management (2008-2012) and the Bangkok Metropolitan Administration's Action Plan on Global Warming: Mitigation (2007-2012) lay out the broad strategies for implementation by sector agencies. Reflecting Thailand's concern to optimize the Kyoto Protocol's CDM funding opportunities, a new Thailand Greenhouse Gas Management Organization (TGO) was created in 2007, taking over some of the former responsibilities of the Ministry of Natural Resources and Environment (Mallilkamarl 2008).

The Republic of Korea established a Ministerial Committee on the Global Environment in 1992, but it never met and was abolished in 1996. After signing the Kyoto Protocol in 1997, an Inter-Ministerial Committee (IMC) on the UNFCCC was established in 1998, chaired by the Prime Minister, supported by five taskforces and an expert pool drawn from nine research institutes. This arrangement was expanded in 2001 to include a new taskforce on general coordination, headed by the Office for Policy Coordination. Separate from and working independently of the IMC, a Presidential Commission on Sustainable Development was established in 2000. The new government in 2007 has emphasized that the climate change crisis can be converted into an opportunity for green economic growth, although the institutional arrangements do not yet reflect this change in thinking (IGES 2008).

Due to its uncontrolled forest fires, Indonesia is regarded as possibly the world's third largest emitter of GHGs, but the Indonesian parliament refuses to ratify the ASEAN Agreement on Transboundary Haze Pollution on the grounds that it may not be in Indonesia's best economic interests. The 2007 National Action Plan on Climate Change sets out institutional arrangements for implementing Indonesia's commitments (and opportunities for development funding) under the Kyoto Protocol, such as the National Committee for the Clean Development Mechanism established under a Ministry of Environment decree in 2005. However, as there is no supreme climate change body, institutional arrangements are uncoordinated with the ministers of environment, forestry, energy and mineral resources, and national development planning all playing a role.

This brief review of the institutional arrangements surrounding climate change and its relationship to sustainable development planning, for the major GHG emitting countries in Asia, is fairly reflective of other regions. Almost all countries have recognized that sole responsibility for climate change and moving towards a LCS cannot be relegated to their environmental agency alone (Table 2). As these are cross-cutting issues, requiring inputs from almost all ministries, generally an intergovernmental climate change committee or commission has been created under the office of the head of state (Table 3). Significantly, the global negotiations on UNFCCC and the Kyoto Protocol have been instrumental in facilitating government action on

the institutional front, with major plans and programs announced at or just prior to landmark meetings at the global level.

Table 2 Country characteristics and focus of plans on climate change

Country	GDP per capita (US dollars)[1]	Plan*	Year	Direct link to climate change	Conflict with climate change abatement	Primary focus on
Bangladesh	494	NSDS	08	Many	Few	Adaptation
Cambodia	651	SDP	06-10	Few	Few	Adaptation
China, P.R.	2,912	SDP	06-10	None	Few	Adaptation
Lao PDR	875	SDP	06-10	None	Few	Adaptation
Maldives	4,065	SDP	06-10	Many	Few	Adaptation
Philippines	1,847	SDP	04-10	Few	Few	Adaptation
Samoa	2,874	SDP	08-12	Many	Few	Adaptation
Singapore	37,600	NSDS	09	Many	None	Mitigation
Korea, Rep.	19,115	NSDS	06-10	Many	None	Mitigation

Source: [1]Divide the GDP by Population using data from World Development Indicators database, World Bank, 1 July 2009

* NSDS = national sustainable development strategy; SDP = socio-economic development plan

Figure 6 Elements of development plans related to climate change responses

Country	Elements of the plan related to climate change responses										
	Agriculture	Coastal Protection	Water Resource	Health	Education	Disaster management	Biodiversity	Resettlement	Energy Efficiency	Renewable Energy	Forestry
Bangladesh	■	■	■	■	■	■	■	■	■	■	■
Cambodia	■	■	■	■	■	■	■	■	■	■	■
China, P.R.	■	■	■	■	■	■	■	■	■	■	■
Lao PDR	■	■	■	■	■	■	■	■	■	■	■
Maldives	■	■	■	■	■	■	■	■	■	■	■
Philippines	■	■	■	■	■	■	■	■	■	■	■
Samoa	■	■	■	■	■	■	■	■	■	■	■
Singapore	■	■	■	■	■	■	■	■	■	■	*
Korea, Rep.	■	■	■	■	■	■	■	■	■	■	■

Note: ■ = more focus ■ = less focus ■ = not mentioned

*The word “greenery area” is used instead of forest management.

4. Experience from Pioneering Countries

This section summarizes the experience of a few countries and the European Union that can be regarded as trailblazers in moving towards a LCDP. Lessons learned from the early experience of these countries will be invaluable for guiding other countries as they struggle to find their own LCDP.

Denmark – Portraying itself as the second most energy efficient nation on Earth (after Japan), Denmark's total energy consumption has not increased since 1980, despite a 50% increase in GDP, and renewable energy comprises 14% of the total energy mix. Denmark's Climate Strategy, released in 2003, is designed to enable Denmark to fulfil its international commitments under the Kyoto Protocol and the EU burden sharing agreement. Under that agreement, Denmark is committed to reducing average GHG emissions for 2008–2012 by 21% in relation to the 1990 level. This will be difficult as the early "low-hanging fruit" opportunities have mostly been taken already (Figure 7).

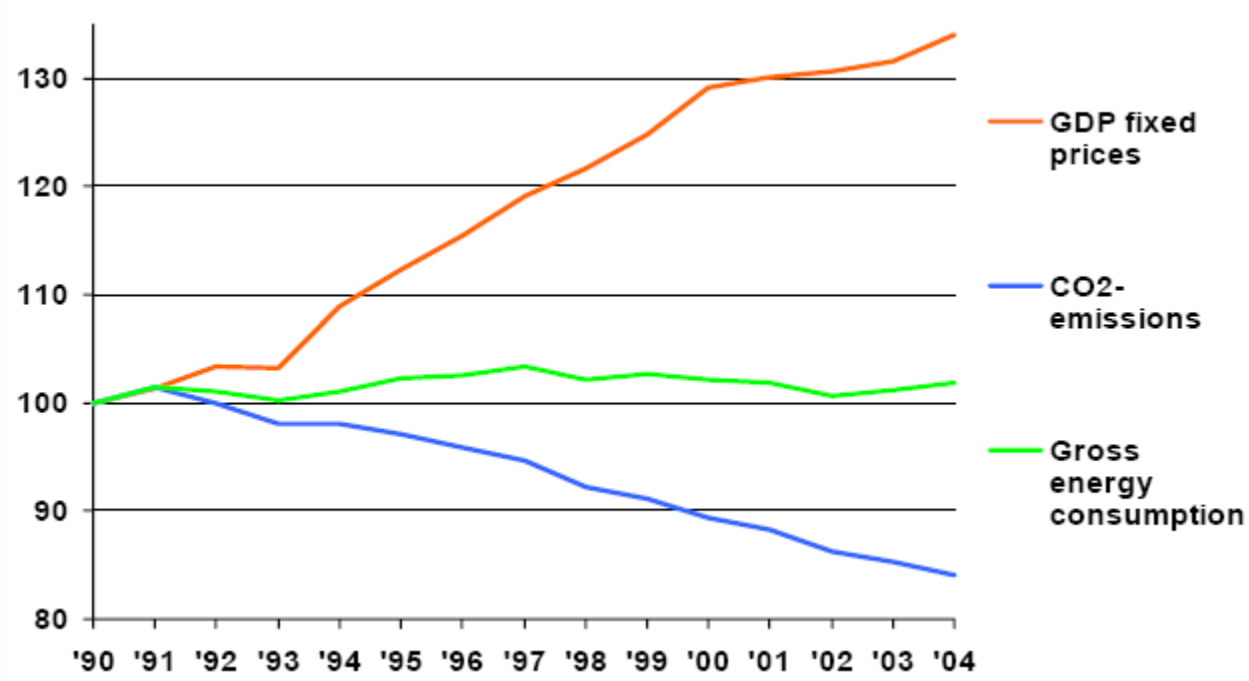

Figure 7 Denmark's Experience in Decoupling Economic Growth and GHG Emissions

Denmark claims to be a front-runner in eco-efficient technology and plans to continue to lead in this area by establishing clear goals, targeted investment, and regulatory incentives (Danish Government 2007). Eco-efficient technologies include wind turbines, flue gas cleaning, water treatment, enzymes for animal feed and washing powder, biofuel production, energy-efficient pumps, replacements for phthalates, LED traffic lights, efficient ship engines, environmentally

sound salmon farms, and precision spraying equipment for agriculture. Denmark's eco-efficient technology action plan supports the EU Environmental Technologies Action Plan and focuses on 9 initiatives (i) partnerships for innovation; (ii) targeted and enhanced export promotion; (iii) research; (iv) consultancy, information and knowledge building; (v) targeted promotion of eco-efficient technology in the EU; (vi) climate and energy technology; (vii) eco-efficient agricultural technology; (viii) a clean and unspoiled aquatic environment; and (ix) a healthy environment.

Iceland – Iceland has been promoted as potentially the world's first hydrogen economy and currently 70% of its primary energy comes from either geothermal or hydropower sources. The remaining 30% comes from oil and gasoline (with coal and gas negligible) (Valfells 2005). Iceland currently uses only 17% of its hydropower and geothermal potential, so transport fuel could be easily replaced by electricity or hydrogen. Hydrogen has been produced by electrolysis in Iceland since 1952, mainly for fertilizer production, so the production technology is well established. In 1999, the Iceland New Energy joint venture was established to develop hydrogen and fuel cells in various applications. One of the first demonstration projects was the Ecological City Transport System, using hydrogen powered buses in the capital, Reykjavik. The Government's vision is to transform Iceland into a hydrogen economy by 2050. Other demonstration projects have been undertaken with passenger vehicles and shipping (a major contributor to Iceland's economy is fishing).

Japan – In 1990, the Meeting of the Council of Ministers for Global Environmental Conservation prepared a 20-year Action Program to Arrest Global Warming (1991-2010) by stabilizing CO_2 emissions per capita at the 1990 levels by 2000 (Tamura 2008). Also, the 1994 Basic Environment Plan, and its three subsequent revisions, recognized climate change as a priority issue. Like many plans in Asia, however, the policies and measures proposed were not prioritized and implementation depended on sectoral ministries agreeing on priorities and freeing up budget resources. Prior to the 1997 Conference of the Parties (COP3) in Kyoto, the Keidanren (Japan's main business federation) released a Voluntary Action Plan on Environment which committed to a target of stabilizing its GHGs at 1990 levels by 2012. After the Kyoto Protocol entered into force in 2005, the Kyoto Protocol Target Achievement Plan was approved, setting emissions reductions targets for major industrial emitters and curbing growth in emissions from offices, households, and the transport sector. This plan was revised in 2008, but the overall target of a 6% reduction in emissions over 1990 levels by 2010 remains. This sequence of plans shows that Japan, along with many other countries, is constantly adjusting its climate change plans, driven largely by international obligations on one hand and the constraints of industry acceptance on the other.

In June 2008, prior to the Tokyo G8 Summit, then Prime Minister Fukuda announced his vision for a LCS, also floating introduction of a domestic emissions trading scheme and the possible creation of an environment tax. As he resigned a few months later and the global financial crisis has intervened, it is unclear how far his proposed reforms will go. However, the iron and steel sector has agreed to a trial run of the emissions trading scheme, despite their longstanding opposition to the concept.

Japan's Action Plan for Achieving a LCS, released in July 2008, comprises (i) target setting; (ii) development and dissemination of innovative technologies; (iii) a regulatory and policy framework; and (iv) support for regional and citizen's initiatives (Government of Japan 2008). In relation to setting targets Japan will (i) work towards a fair, equitable, and effective post-2012 climate regime by COP15 in Copenhagen in 2009; (ii) set quantified national and sectoral targets; and (iii) support other countries efforts through the sectoral approach and co-benefits. This support includes the Cool Earth Partnership, the multilateral Climate Investment Funds in the World Bank, the Clean Asia Initiative, the Asia-Pacific Partnership on Clean Development and Climate (APP), and Climate Change Official Development Assistance Loans. On the technology front, Japan is developing innovative technologies under the Low Carbon Technology Plan and the Cool Earth-Innovative Energy Technology Program. Japan is also working toward an International Partnership for Environment and Energy to expand investment in energy research and development. Existing advanced technologies such as solar power generation and other zero-emission energy sources, next generation vehicles, energy efficient lighting and home appliances, energy efficient houses and office buildings (including the Kasumigaseki LCS at the heart of government), and nuclear power will be disseminated widely. In relation to regulations and policy development, Japan will price CO_2 and make use of market mechanisms to reduce emissions, through emissions trading, "green" taxes, environmental labeling, carbon offsets, and creating an enabling environment to facilitate the flow of investment into environmental businesses. Support to citizen's initiatives include biomass towns, low-carbon cities and regions, improved transportation networks, promoting lifestyle changes, and education for sustainable development under the 21st Century Environmental Education Plan.

The Japan Low-Carbon Society Project, back-casting to a 70% reduction in emissions below 1990 levels by 2050, points out that Japan's projected declining population (from 120 million in 2000 to below 100 million in 2050) will assist it in achieving its emissions targets. About 4-5 million fewer households will make a significant difference in household demand depending on the average increase in energy demand per household. While the total annual direct cost of achieving the 70% target would be Yen 7-10 trillion ($80-110 billion), it would only account for around 1% of the estimated GDP in 2050. The average abatement costs are $250-400 per tCO_2. The reductions in energy demand (relative to 2000) in individual sectors would vary: (i) industry – 30-40% from structural changes and energy-saving technologies; (ii) passenger transport – 80% due to land use planning and improved energy efficiency and reduced carbon intensity; (iii) freight transport – 50% from better logistics management and fuel-efficient vehicles; (iv) households – 40-50% reduction from rebuilding with highly insulated houses and energy-saving home appliances; and (v) commercial sector – 40% reduction due to building renovation and rebuilding with heavy insulation, and energy-saving office devices. In addition, decarbonization of energy supplies is possible by choosing renewable energy, nuclear energy, hydrogen and CCS instead of fossil fuels (NIES 2008b). Many of the proposed changes will be deployed anyway, to increase Japan's competitiveness, to cope with an aging and declining population, and to design safe and secure communities.

South Africa – As an example of a less developed country's response to climate change, South Africa is often cited by the United Nations as a leading country among developing nations. In 2002, South Africa issued a White Paper on the Promotion of Renewable Energy and Clean Energy Development (Department of Minerals and Energy 2002). It issued a national climate strategy in 2004 that focused on renewable energy, establishment of a designated national authority (DNA) for CDM projects, a climate change monitoring network, assessment of technologies, and education, training, and public awareness. The DNA was subsequently launched at a National Climate Change Conference in October 2005. Currently, two CDM projects have been registered—a low cost urban housing energy upgrade and conversion of a brick kiln from coal to natural gas. An Energy Security Master Plan – Electricity (2007-2025) sets security of supply standards and proposes interventions such as accelerated demand side management, universal access to electricity, transmission expansion, and independent power producers (Department of Minerals and Energy 2007). A similar master plan was prepared for liquid fuels and a National Energy Bill was passed in 2008.

Sweden – From 2009-2011, Sweden is investing Kronor 7 billion ($900 million) on combating climate change. Sweden aims to be a "leading international model of a modern society that is environmentally sound and based on sustainable resources" (Ministry of Environment, Sweden 2008). Between 1990 and 2006, Sweden's GHG emissions fell by 9%, while GDP increased by 44%. Fuel switching from oil to non-fossil fuel energy sources has allowed Sweden's emissions to fall by more than 40% since the mid 1970s. Current initiatives include climate research, energy efficiency, pilot and demonstration projects for second generation biofuels, a network for wind power, sustainable biomass energy from agriculture and forestry, and sustainable cities. A climate tax package was included in the 2008 budget, estimated to raise about $400 million, through a tax on carbon dioxide at about 4 cents per litre of petrol. A climate change bill has been prepared for late 2008. Sweden will hold the Presidency of the EU when the final package for the new global climate agreement beyond 2012 is approved in Copenhagen in 2009.

United Kingdom - The UK White Paper on Energy (Our Energy Future – Creating a Low Carbon Economy) scenario development envisages a much more diverse energy system in 2020 (Secretary of State for Trade and Industry 2003). While much of the electricity supply will remain grid-based, some of the large power stations will be offshore marine plants (wave, tidal and wind). There will be much more local generation from biomass, locally generated waste, local wind, wave and tidal generators, feeding local distributed networks. Micro-generation, using fuel cells or photovoltaics, will generate excess capacity from time to time and be sold back into the local distributed network. Energy efficiency improvements will reduce demand and new homes will be designed to need very little energy inputs (and perhaps zero carbon emissions). Gas will form a large part of the energy mix, while coal fired generation will either play a smaller role or be linked to CCS. Fuel cells will play a greater role in the economy, with hydrogen generated from non-fossil fuel electricity. In transport, hybrid vehicles and increasing use of low carbon biofuels will reduce emissions. People will be more aware of the challenge of climate change and the role they can play in reducing carbon emissions. As the cost of carbon

is built into pricing, carbon content will become a commercial differentiator as people deliberately choose lower carbon options.

Projected CO_2 emissions in 2020 are about 135 MtC[7] and the White Paper aims for a cut of 15-25 MtC below that, comprising (i) energy efficiency in households (4-6 MtC); (ii) energy efficiency in industry, commerce and the public sector (4-6 MtC); (iii) continuing voluntary agreements on vehicles and use of biofuels for road transport (2-4 MtC); (iv) increasing renewable energy (3-5 MtC); and (v) the European Union carbon trading scheme (2-4 MtC).

European Union – The vision for Europe's energy future is to turn towards security and sustainability, through (i) increasing efficiency and reduced energy intensity; (ii) diversification of the energy mix in favor of renewable energy and low-carbon conversion technologies for electricity, heating and cooling; (iii) decarbonization of the transport system through fuel switching; and (iv) liberalization and interconnection of energy systems. The envisaged LCDP for energy technology is as follows:

(i) By 2020, 20% renewable energy market penetration, increased share of offshore wind, second generation biofuels, and clean coal technologies, 20% improvement in energy efficiency, and widespread use of hybrid vehicles;
(ii) By 2030, progress with decarbonization of electricity and heat production, including large scale offshore wind farms and near-zero emission fossil fuel power plants; and fuel diversification in transport, with second generation biofuels and hydrogen fuel cells; and
(iii) By 2050 and beyond, completion of a paradigm shift in how energy is produced, distributed and used, with the energy mix largely comprised of renewable energy, sustainable coal and gas, sustainable hydrogen, generation IV fission, and fusion energy.

In November 2008, the EU released a new energy package, likely to be approved in 2010, comprising (i) a strategic energy review to guide decision makers; (ii) new rules and standards on energy efficiency in buildings and fuel consumption ratings for tyres; (iii) a green paper on energy networks; (iv) a policy paper on offshore windpower; and (v) a revised nuclear program. The EU has stated that it intends to take a leadership position in tackling climate change and developing technologies to ensure that future energy supplies are cleaner and more sustainable (European Commission 2008).

The EU's strategy for climate change proposes the following actions by 2020, which would reduce GHG emissions by at least 20% compared to 1990 levels, and up to 30% depending on successful international negotiations[8]:

(i) Improve energy efficiency by 20%;

[7] To express emissions in terms of carbon dioxide rather than the carbon convention used here, the factor is 3.67 (Walsh 2007).
[8] Under the Kyoto Protocol, the 15 EU countries in 1997 agreed to cut emissions by 8% below 1990 levels by 2012.

(ii) Increase the share of renewable energy to 20%;
(iii) Construct 12 large-scale CCS demonstration plants by 2015;
(iv) Strengthen the EU emissions trading scheme, to cover more than 45% of emissions by 2013, extend the range of gases covered, and link the scheme to other compatible trading schemes; and
(v) Limit transport emissions.

The 20% target, requiring a reduction of 1,100 Mt CO_2-eq by 2020, could be reached by a combination of (i) further reductions in non-CO_2 GHGs (160-170 MtCO_2-eq); (ii) increased share of renewable energy to 20% by 2020 (500 MtCO_2-eq); and (iii) increased energy savings (525-630 MtCO_2-eq) (Wesselink et al. 2008).

Beyond 2020, the EU anticipates emissions reductions of 60-80% by 2050, to achieve a global reduction of 50% compared to 1990 levels. The overall goal is to limit the increase in global average temperature to 2^{o}C compared to pre-industrial levels, with GHG concentrations stabilized below 450 ppm (European Commission 2007).

5. Critical Issues and Challenges

A common vision – As we have seen in the negotiations for the Kyoto Protocol and for its successor regime beyond 2012, there are massive differences in perspectives, not just between developed and developing countries but also within groups of countries that could be expected to have a common view (such as the EU, OECD and G-77 groups). To vastly oversimplify, the differing, but not mutually exclusive, visions can be expressed as:

(i) Economic development first and worry about climate change later;
(ii) Entitlement to a global equal per capita quota of GHGs;
(iii) Cumulative GHG emissions and historic responsibility for global climate change, rather than penalizing late-comers;
(iv) Large countries with small populations and high transport cost need higher emissions allowances than small, densely populated countries;
(v) Low-lying countries are victims and need to be compensated by the polluters for the damage; and
(vi) Oil and coal exporters need to be compensated for damage to their economies, if fossil fuel consumption is artificially constrained.

As climate change is a global problem and only a global solution will be sufficient, these differing perspectives pose a real challenge. The evidence suggests that stabilization of GHG concentrations at 450 ppm, or preferably below, is only possible if developing countries such as China and India are full participants, sooner rather than later. Portraying a common vision of a global LCDP where legitimate economic growth aspirations, full employment, poverty alleviation and reduced GHG emissions not only co-exist but also reinforce each other remains a high priority. National studies need to be scaled up to regional and global levels with a powerful

narrative of what a future low-carbon world will look like and which countries are the winners or losers.

Agreement on goals and targets – Once this common vision is expressed in sufficiently simple and powerful language and images, backed by extensive economic, social, and environmental studies, the global community can move on to set appropriate long-term and short-term goals and targets.[9] The long-term targets need to focus on stabilization of the global atmosphere, so that human influence no longer threatens runaway climate changes. The short-term targets have to focus on the allowable peak GHG concentrations, as the larger the peak and the greater the delay in reaching it, the longer the atmosphere will need to re-adjust. There is even a possibility that positive feedback loops (e.g., melting of the polar ice-caps and increased release of methane from the tundra) will trigger irreversible changes that could threaten the survival of some countries and possibly humanity. Melting ice sheets and glaciers could raise sea levels to the extent that the world will have to deal with hundreds of millions of environmental refugees. Ocean acidification could see the world's coral reefs and associated ecosystems devastated by as early as 2030. In many ways, therefore, the height of the peak and the number of years to reach it are even more important than the long-term target for stabilization.

The race to the peak – Defining the height of the peak is one thing, while the race to get to the peak is another. Many models show that the peak needs to be reached by about 2010-2015 if atmospheric concentrations of GHGs are to be stabilized by the end of the century. The average lifetime of CO_2 pumped into the atmosphere is a few centuries, with about 25% essentially lasting forever (Archer 2008). Temperatures will take longer to fall than GHG concentrations. Even if all GHG emissions were stopped tomorrow, the climate change impacts already in the global atmospheric system would last for many decades, if not hundreds of years (Nature 2008). Once we stop burning fossil fuels, within a few decades the planet will settle at a new, higher temperature and stay there for 500-1,000 years.

The race to this peak level of emissions within a few short years, however, seems to be impractical, bearing in mind that the small group of countries that ratified the Kyoto Protocol could only agree on a very minor cut in emissions below 1990 levels for the first commitment period (2008-2012) and some will not make it. Much deeper cuts beyond 2012 may or may not be agreed at Copenhagen in 2009, but it is almost certain that developing countries will be allowed more "breathing room" so that their economic growth trajectory is not disrupted. Therefore, the chances of GHG emissions peaking in the 2010-2015 timeframe appear to be a major or even unrealistic challenge.

[9] None of the targets on the negotiating table at present, including the EU's 20% by 2020, the US return to 1990 levels, China's pledge of a 40% reduction in "carbon intensity" (the amount of carbon produced per unit of GDP), or India's no more per capita GHG emissions than developed countries will be enough to stave off dangerous climate change.

Reliance on modeling – Despite the consensus views of the hundreds of scientists contributing to the IPCC assessment reports, there is still a very active group of climate skeptics and climate "denialists" who manage to capture media coverage in the interests of "fair and balanced" reporting (US Senate Environment and Public Works Committee 2008). Alternative explanations of global warming include sunspot activity, the El Niño Southern Oscillation, increasing water vapor in the atmosphere, volcanic activity, or just part of the cosmic cycle of cooling and warming. In their view, promoting a LCS is not only economic suicide but it is also unethical. Much of the skepticism stems from the belief that all projections of future climate change are based on partial, flawed, or unproven mathematical models. There is an undoubted need to improve the coupled global change models and to break the modeling down to national and local levels. Downscaling is necessary so that responses such as adaptation are based on more accurate projections of future changes. Multiple models that show equivalent trends are also important.

A further major challenge, however, is to document current biophysical and ecological changes that can be reliably attributed to climate change (and indicate where these changes are consistent with past modeling projections). Unfortunately, there has been a tendency to blame most unexplained recent phenomena on climate change. One website monitoring these claims has listed almost 600 types of impacts attributed to climate change.[10] Politicians faced with relatively short-term horizons seize on such expressions of uncertainty as an excuse to delay action.

Technological advances – Many of the elements of a LCSDP are dependent on technological breakthroughs. Among these, possibly the most important are (i) better batteries for electric cars; (ii) financially viable second generation biofuels; (iii) carbon capture and carbon storage, including scrubbing CO_2 from the atmosphere[11]; (iv) clean coal technologies; (v) zero emission buildings; (vi) wave energy; and (vi) fusion energy. Global cooperation on these technological advances in the same manner as ITER will accelerate the pace at which technological solutions advance. In addition to the technological advances referred to above, additional expenditure is needed in many of the basic science areas, such as quantum computing, nanotechnology, biotechnology, and new materials, focused on decarbonization and dematerialization. Additional research is also warranted in the social sciences associated with technology so that realistic assessments on the promises and perils of specific technologies can be made.

Technology transfer – Developing countries have been complaining vociferously that the technological advances that would enable them to contribute to reduced GHG emissions are not transferred to them in a timely manner. While there are many reasons why technology transfer is a cumbersome process, the urgency of the situation demands that new and improved mechanisms for technology transfer need to be found. For example, an international fund could be established to become a repository of all technologies that could contribute to combating

[10] This list is at http://www.numberwatch.co.uk/warmlist.htm.

[11] Sir Richard Branson has offered a $25 million Earth Challenge Prize for the best method to remove at least 1 billion tCO_2 per year from the atmosphere.

climate change and provided with adequate funding to disseminate these technologies to developing countries.[12] In addition, the time from laboratory to commercial application to global access for promising low carbon technologies needs to be accelerated.

Intellectual property rights and patents – A major stumbling block in the transfer of technology has been the long-established system of intellectual property rights and technical patents. Inventors and companies funding research and development maintain that these protections are necessary to allow them to risk the investment of time and capital in new inventions and knowledge and provide sufficient time for them to recover these costs under patent protections. For the similarly urgent global issue of HIV/AIDS, developing countries have challenged these protections for drug companies and now manufacture "generic" versions of the same drugs, while drug companies have responded by offering discounted prices to developing countries. A similar response is needed in relation to LCDP technologies. One possibility is for governments to compensate the private sector for giving up patent protections on crucial technologies, as part of the future climate regime beyond 2012 (Oliva 2008).

Competition in trade – Trade negotiators in the Doha Round of multilateral trade negotiations under the World Trade Organization have considered various proposals for liberalizing the provision of goods and services that provide climate change benefits. However, an outstanding challenge is to gain a better understanding of the trade-related barriers and extent of global trade in those sectors. The World Trade Organization is considering how to ensure that trade agreements do not inhibit or conflict with multilateral environment agreements, but much more work needs to be done before negotiators will be ready to reach agreement on climate change and trade.

Policy effectiveness – Most of the work completed to date on low carbon plans demonstrates that policy choices really matter. However, demonstrating which policies are most effective in accelerating the transition to a LCS remains a major challenge. Scenarios that include selected policies do provide some evidence but the difficulties (and major simplifications) of incorporating specific policy choices into climate models often prohibit comprehensive analysis. Lessons learned from pioneering countries remains a major mechanism for policy transfer and diffusion. Case studies and data bases containing best practices need to be expanded so that all options can be reviewed systematically.

Urbanization – One of the obvious global mega-trends that will influence the LCDP is the inexorable progress of urbanization. For the first time in human history, more people live in cities and towns than in rural areas. Some observers take the view that urbanization and high densities of population will actually make the transition to a LCS easier than a more distributed, rural population. Others, perhaps envisaging a return to an earlier stage of human development, believe that the future lies in a retreat to rural lifestyles and living "closer to nature." It seems

[12] The G77-China group has proposed a two-pronged mechanism, comprising an Executive Body and a Multilateral Climate Technology Fund, both operating under the Conference of the Parties to UNFCCC, to implement a Technology Action Plan.

unlikely that the urbanization trend will reverse any time soon, so design of an LCDP needs to focus on sustainable cities.

UN-HABITAT and UNEP established a Sustainable Cities Program in the early 1990s and have developed a set of sustainable city principles in 2002. Known as the Melbourne Principles, they (i) "provide a long term vision for cities based on sustainability; (ii) empower people and foster participation and inter-generational equity; (iii) recognize and build on the characteristics of cities including their human, cultural, historic and natural systems; (iv) build on the characteristics of ecosystems; (v) achieve long-term economic and social security; (vi) expand and enable cooperative networks to work towards a common sustainable future; (vii) enable communities to minimize their ecological footprint; (viii) enable continual improvement, accountability and transparency; (ix) require effective demand management and appropriate use of environmentally sound technologies for cities; and, (x) recognize the intrinsic value of biodiversity and natural ecosystems and their protection and restoration." Turning these principles into more tangible form as a sustainable urban LCS remains an outstanding challenge, given the continuing tendencies for urban sprawl and informal slum settlements in mega-cities across the globe.

Consumerism – Possibly one of the greatest challenges is to redirect consumerism towards low-carbon alternatives. Understandably, most developing countries reject the notion that their citizens should be denied the "right" to consume as much as the average American or European. Even governments in developed countries, such as Australia, when faced with the current global financial crisis, have urged their citizens to spend up big to stave off recession. Among developing countries, Bhutan's emphasis on gross national happiness rather than gross national income is a rare exception. Among developed countries, Japan's promotion of the traditional notion of "mottanai" (a cultural tradition of using a product for many different purposes as its quality declines—so an expensive kimono may end up as cleaning rags at the end of its life) is also a rare exception. Nevertheless, reduced consumption remains one of the critical avenues to reduced material and energy consumption and a potential route to a LCS. Campaigns such as "no buy" or "no car" days help to drive this message home, but anti-consumerism appeals to only a small minority of the population in most countries. Leasing and provision of other services needed, instead of purchasing goods, may offer an alternative in many instances.

Human nature – Jared Diamond in his classic book titled "Collapse", draws parallels between past societies that have collapsed due to environmental damage and the current situation globally (Diamond 2005). He lists 12 emerging environmental issues that are approaching tipping points, any one of which could plunge humanity into an irreversible trend towards diminished, if not fatal, environmental quality: (i) destruction of natural habitats; (ii) loss of fish stocks; (iii) biodiversity loss; (iv) soil degradation; (v) fossil fuel energy; (vi) freshwater depletion; (vii) photosynthetic capacity; (viii) toxic chemicals; (ix) alien species; (x) depletion of the ozone layer; (xi) human population growth; and (xii) consumption levels. He suggests that human nature is "hard-wired" to cut the last tree, just as the Easter Islander's did.

In many ways, climate change is a typical example of the “tragedy of the commons” where no one owns the resource (i.e., the atmosphere) but everyone maximizes their use of it, in the belief that if they don’t use it, someone else will (Hardin 1968). Evidence suggests that it is possible to create sustainable institutions to manage a commons like the global atmosphere and the open oceans, but such institutions tend to be quite fragile and break apart as soon as one participant breaks the rules and is not punished (Ostrom 1990).

Social scientists claim that the way humans are hard-wired psychologically and socially conditioned to respond to crises makes us ill-suited to respond with urgency to climate change, which appears to be an abstract and remote threat (Bennett 2008). We tend to respond to threats based on our emotions rather than through a logical assessment of risks. These emotions stem from evolutionary fears (like strangers in the dark) or personal experience (like nearly drowning as a child), but we have no innate experience of climate change so our minds have not adjusted to such remote risks removed in space and time. As climate change is perceived as a distant risk, we discount it in favor of more immediate benefits (like driving our cars). Cultural values and worldviews also shape our perception of risk. Research suggests that any evidence that clashes with our worldview is simply likely to be rejected. Two archetypical worldviews are “egalitarians”, who are more likely to be concerned about environmental risks, and “hierarchists”, who believe that their leaders will respond when necessary. People typically spin information to keep their worldview unscathed. Evoking societal fear about tipping points and global disasters, however, may be counterproductive, as people may simply freeze and believe that there is nothing they can do. Small, incremental changes may be more acceptable (e.g. banning incandescent light globes) but it is not clear that such incremental change will be sufficient or fast enough.

Political will - The IPCC and Al Gore’s Nobel Peace Prize (and his award-winning movie An Inconvenient Truth) have gone a long way in raising public awareness of climate change issues and the need for policy change, although there remains some public skepticism. The intergovernmental negotiations that lead to the UNFCCC and the Kyoto Protocol are now entering a phase where courageous political leadership is needed. The real challenge is to summon the political will to avoid short-term political gains at the expense of a long-term sustainable future. Political science suggests that this is only possible if all interest groups concur on the goals and strategies (Oates and Portney 2001). By setting specific targets for each sector and then allowing the sector to work out how best to achieve those goals in a most cost-effective manner has proven to be a successful strategy in the Netherlands Environmental Policy and Plan and in Japan’s Keidanren voluntary environmental action plan.

The level of policy effort required by politicians to meet the deep cuts in emissions beyond 2012 should not be underestimated. One estimate shows that without strong environmental policies between 1990 and 2005, the EU’s GHG emissions would have been 7% higher in 2005 (an explicit reduction of 380 $MtCO_2$-eq due to environmental policies) (Wesselink et al. 2008). As the EU’s 20% target by 2020 relative to 1990 requires a further 1,100 $MtCO_2$-eq reduction, and

many of the "easier" policy objectives for non-CO_2 GHGs (such as fluorocarbons) have already been taken, a five-fold level of effort over the period 2006-2020 will be required.

Economics, carbon price and market flaws – Sir Nicholas Stern states that climate change is "a result of the greatest market failure the world has seen" (Stern 2007). One could equally state that the failure to appropriately price all ecosystem services and natural capital is a colossal market flaw that even dwarfs climate change (Costanza et al. 1997). Translating this realization into efficient markets without massive disruption of current economies, however, is a far from simple transition. Nevertheless, a viable LCS will have to address these market flaws in a sustainable manner.

The various emissions trading schemes that have been set up to date have not been particularly successful. For example, according to one review, in the first three years of the EU emissions trading scheme the price of carbon collapsed to almost zero, due to over-allocation of permits, creating no incentive to reduce pollution (Open Europe 2007). To counter these problems, the UK conducted its first auction of carbon allowances under the second phase of the EU emissions trading scheme in November 2008 and plans to auction 7% of its allowances over the period 2008-2012. Japan's voluntary emissions trading scheme has also failed to make a significant dent in the country's Kyoto Protocol obligations, as there were very few participants, despite generous government subsidies. Many observers now prefer a revenue-neutral carbon tax to a trading scheme, but most industry sectors are very cautious regarding any new taxes. In principle, either system should work, but a lot depends on whether one believes that the government can accurately assess the carbon cap and allocate permits efficiently.

Transition costs – An LCSDP has a wide range of transition costs that must be carefully considered by governments before deciding on a particular pathway. For example, imposition of a carbon tax could double the cost of coal, quickly making the coal industry uncompetitive with other energy sources. Should the companies involved be compensated by the government, or simply allowed to slip into bankruptcy? Should the coal miners receive special compensation and training to allow them to access the new "green" jobs? How should the government handle long-term procurement contracts for coal with importers or foreign governments? Should there be tax differentiation between clean coal, brown coal, and black coal? How should coal bed methane capture be treated in the tax regime? Each industry affected is likely to have similar concerns that need to be analyzed and discussed with industry representatives before the changes are made.

Financial architecture – The Kyoto Protocol's flexible financing mechanisms were designed to ensure that the least cost emission reduction options were accessed by Annex 1 countries, as well as providing an international transfer of funds from developed to developing countries to support their sustainable development objectives. Due to a range of institutional and scale factors, most of the CDM financing has gone to the largest developing countries like China and India, with smaller, least developed countries not very attractive to the purchasers of certified emissions reductions. The international finance institutions, such as the World Bank and ADB,

are able to address the climate change financing needs of these smaller countries, but again most of their funding will go to the larger countries. These organizations are also beginning to estimate the carbon footprint of their investment portfolios and offer considerable potential for investment in low-carbon alternatives. An equitable financial architecture that addresses the adaptation and mitigation needs of all countries remains a challenge to be addressed in the post-2012 period.

The International Energy Agency estimates that up to $20 trillion will be required for global energy investment by 2030, of which $10 trillion will flow to China, India, and Brazil. Assuming that developed countries eventually agree to reduce GHG emissions by 60-80% over 1990 levels by 2050 and half of these emission reductions will be met through investing in developing countries, emission reduction purchases could generate up to $100 billion per year, over and above the current flows of official development assistance of a similar level (IGES 2008). China has suggested that developed countries should provide up to 1% of GDP into assisting developing countries to meet global climate change objectives (compared to current pledges of 0.7% of GDP for official development assistance—actually met by few countries).

Implementation capacity – In addition to funding constraints, most small, developing countries have extremely limited implementation capacity, even if the funding could be made available by the international financing institutions and bilateral donors. The national capacity self-assessments clearly show that the majority of developing countries have signed up to multilateral environmental agreements without any prior assessment of their capacity to implement the large number of such agreements. Many environmental staff are found attending the ever-expanding number of international and regional meetings preparing for, or reporting on, multilateral agreements rather than working at home on more pressing environmental issues (e.g., safe water supplies). Additional funding for capacity building (from the GEF and UNDP, in particular) often removes the few key environmental staff available in the national agency from their daily duties to participate in a continuing sequence of training workshops, study tours, and/or overseas training opportunities. Long-term, sustainable approaches to capacity building remain a significant challenge.

Scaling up from pilot projects – New technologies and approaches definitely need to be approached first as pilot or demonstration projects, with careful monitoring of the experience and documentation of lessons learned. However, scaling up from a small pilot project to a provincial or national level is not a simple undertaking. Pilot projects tend to have a very high ratio of staff costs to other implementation costs and this ratio cannot be replicated during up-scaling. High levels of subsidies at a pilot stage, such as the solar city in Japan, cannot be entertained at the national level. A significant challenge, therefore, is to design pilot projects in the expectation that they will need to be expanded in future, with a monitoring system that will capture the essential features for successful up-scaling.

Equity, environmental refugees and environmental justice – A LCSDP is an unprecedented revolution and like all revolutions will impact on individuals in differing ways. Potential winners

and losers need to be identified very early in the process and governments need to consider equity issues in relation to where the burden of these impacts falls. Some of the proposed measures that will contribute to a LCSDP, such as nuclear energy, are likely to fall prey to the "not in my backyard (NIMBY)" phenomenon. Care needs to be taken that environmental justice is not trampled on in the cause of seeking urgent solutions and unpopular solutions imposed on poverty stricken neighborhoods or countries. For example, communities in some Asian countries have protested against new thermal power stations and hydropower dams in their own backyard, but are quite willing to allow the private sector to build these facilities in poor areas of neighboring countries, and import the electricity.

Environmental refugees are a future challenge that countries in Asia-Pacific are just beginning to address. Small island developing states like Tuvalu and the Maldives are beginning to make contingency plans to abandon their island homes if sea levels continue to rise. The Maldives is even considering setting aside part of its revenue from tourism to buy a new "country." These small signs, however, mask a potentially larger problem of hundreds of millions of environmental refugees from low-lying countries and cities, if deep GHG emissions reductions are not implemented over the next few decades. The international community has yet to prepare comprehensive plans for this eventuality.

Energy security – A central tenet of a LCSDP is that new, non-fossil fuel energy sources should generally be locally sourced. Considerable amounts of electricity are lost in transmission, so distributed power systems or smart transmission systems may help to reduce losses. The emphasis on energy security, however, should not become a disguised trade barrier. In fact, for some countries like landlocked Lao PDR and Bhutan, steep topography and high rainfall (or glacial melt) may allow these countries to become the power source for neighboring countries, more cost-effectively than other alternatives within national boundaries. The outstanding challenge is for each country to conduct a comprehensive assessment of its own energy resources (e.g., wind mapping, solar energy, wave energy, geothermal sources, biomass, and energy embodied in solid waste) as a basis for deciding on which technological path to choose in pursuing energy security.

LCSDPs as just another fad – The final challenge is that a LCSDP could become unfashionable as new issues emerge and as solutions to the climate change crisis begin to be implemented. If the fundamental drivers (like culture, values, attitudes, consumerism, population growth, and urbanization) are not addressed at root, then the rebound effect could negate any benefits from energy efficiency and fuel switching. If driving behavior, for example, is governed by an individual's willingness to pay then fuel efficiency gains may be offset by increased kilometers traveled. Shifting to non-fossil fuels too hastily may create other environmental concerns that will bring LCEs into disrepute, as has happened with biofuels. Discovery of major health problems associated with the rapid expansion of nuclear energy in developing countries, for example, could trigger a shift back to less dangerous "dirty" coal. A technological breakthrough in fusion energy could remove concerns over energy entirely and shift global environmental concern towards dematerialization and the need to reduce the rate at which non-

renewable resources are used. The ultimate challenge, therefore, is to ensure that any LCE is firmly embedded in a long-term, sustainable development framework that will transcend any development fads.

6. Conclusions and Recommendations

The alternative paths to a LCS are increasingly clear and at least one nation, Iceland, has laid claim to being the first country to pursue a LCSDP. The basic elements of a LCSDP can be categorized as (i) reducing energy demand; (ii) moving away from carbon-intensive fossil fuels and their associated GHG emissions; (iii) continuing to meet the development needs of all groups in society; and (iv) ensuring energy security. As the emphasis is primarily on energy, LCSDP is a sub-set of a national sustainable development plan, and is not synonymous.

There is a multitude of elements that could contribute to an LCS and each country will probably need to find the mix that makes maximum sense within their own national objectives and constraints. The main sectors where low-carbon solutions abound are energy, industry, transportation, and commercial and residential buildings.

Policies clearly matter. The EU would have had GHG emissions 7% higher in 2005, if it were not for strong environmental policies through the 1990s, but a five times greater effort will be required by 2020. In Canada, non-pricing policies may contribute about 50% of the required GHG emission reductions in 2035. In developing countries, finding the right policy balance between development co-benefits and climate change mitigation is crucial to the overarching goal of poverty reduction. The challenge for both developed and developing countries is to make the right policy choices from the large “menu” available. A key element of the policy package is getting the carbon price right by creating markets where none existed before. A basic choice faced by most countries is between a revenue-neutral carbon tax and a cap-and-trade emissions trading scheme.

Pricing and market-based approaches, however, are only part of the solution. Some of the global social changes required, and their consequent transition costs, are (i) parallel tax reform; (ii) technology spillover to developing countries; (iii) relaxing patents and intellectual property rights to low-carbon technologies; (iv) institutions facilitating technology transfer; (v) eliminating security concerns over nuclear weapons development and permanent disposal of radioactive wastes; (vi) accepting stillborn consumerism in emerging economies and reducing consumption in developed economies; (vii) changes in individual values and lifestyle choices; (viii) funding research and development on dematerialization in production processes; and (ix) low-carbon choices in urban and transportation planning, building design, and material substitution and recycling. Increased social science research is needed on these transitions, as a LCDP will not depend on technologies and pricing alone.

Increased attention needs to be paid to pilot and demonstration projects, so that they are designed and implemented with the challenges of scaling up to provincial or national levels

included from the outset. The lessons learned and best practices need to be made accessible to all nations, possibly through a UNFCCC clearinghouse function.

The leading nations with pioneering experience to share globally include Japan's explicit adoption of a LCS goal, Iceland's renewable energy and hydrogen economy experience, Sweden's switching from oil to non-fossil fuel sources, Denmark's energy efficiency and exports of environmental technologies, the UK's policy to create a LCE, and the EU's "20-20-20" strategy (20% improvement in energy efficiency, 20% share of renewable energy, and 20% reduction in GHG emissions by 2020). The evidence suggests that these countries can make the necessary transitions to a LCS with minimal impact on GDP.

The critical questions facing the global community in pursuit of a LCS are:

(i) How to bridge the vast differences between countries regarding a common global vision;
(ii) How to handle major differences on goals and targets and viable timeframes;
(iii) How to accelerate the urgent race to a peak in GHG emissions in the next 10-15 years;
(iv) How to provide unequivocal evidence of biophysical and ecological changes due to climate change;
(v) How quickly technological breakthroughs can be achieved in areas like (a) better batteries for electric cars; (b) financially viable second generation biofuels; (c) carbon capture and carbon storage, including scrubbing CO2 from the atmosphere; (d) clean coal technologies; (e) zero emission buildings; (f) wave energy; and (g) fusion energy;
(vi) How to satisfy developing countries requests for improved mechanisms for technology transfer;
(vii) Is it possible to relax intellectual property rights and technical patents for low-carbon solutions;
(ix) Can the trade of goods and services that provide climate change benefits be liberalized;
(x) Lessons learned from pioneering country policy experience to underpin policy transfer and diffusion;
(xi) In the face of global urbanization trends, can sustainable cities be built according to a low carbon framework;
(xii) Is it possible to change global attitudes regarding consumerism and focusing on non-material quality of life aspects;
(xiii) What can we learn from past societal collapses and why human nature allows such collapses to occur;
(xiv) How to promote courageous political leadership looking to the long-term rather than the next election;
(xv) Is it possible to address market failures with viable economic policy instruments that facilitate deep cuts in GHG emissions;
(xvi) How to make "hidden" transition costs more transparent;
(xvii) How to redesign the global financial architecture to address the adaptation and mitigation needs of all countries;
(xviii) How to build long-term, sustainable national capacity to formulate and implement a LCDP;

(xix) How to design pilot projects as if they will need to be expanded in future;
(xx) How to identify potential winners and losers from a LCSDP and provide equitable compensation and environmental justice;
(xxi) How to ensure that energy security does not become a disguised trade barrier; and
(xxii) How to firmly embed a LCE in a sustainable development framework or national sustainable development strategy that will transcend any development fads.

In many ways, this very long list of questions is daunting. However, humanity is facing the greatest global crisis in history and failure to pursue a low carbon trajectory is unthinkable. But all of the elements are either available or close at hand, so there is no need to sink into pessimism. The evidence suggests that a LCE is technologically feasible and affordable, but socially and politically difficult. Countries in Asia-Pacific, both developed and developing, can do more to make a LCS a reality. Hopefully the insights discussed in this paper will help to educate and inform decision makers as they systematically address the opportunities and challenges that a LCSDP will pose.

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Appendix 1 - Survey of integration of climate change into national sustainable development strategies

<table>
<tr><td>Country</td><td colspan="2">……</td><td>Title of Plan</td><td colspan="2">……..</td></tr>
<tr><td>Type of plan</td><td colspan="5">☐ National Economic and Social Development Plan
☐ National Sustainable Development Strategy
☐ National Energy Plan
☐ National Climate Action Plan
☐ Other (specify) ……..</td></tr>
<tr><td rowspan="3">Direct reference to climate change mitigation</td><td>Chapter/Section ……</td><td colspan="4">Insert copy of the relevant text</td></tr>
<tr><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td rowspan="4">Direct reference to climate change adaptation</td><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Indirect reference to climate change (e.g. food security, extreme storms, drought, floods, disease incidence, renewable energy etc.)</td><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Cross-reference to climate change in other national plans (e.g. sector plans, poverty reduction strategies etc.)</td><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td>Chapter/Section ……</td><td colspan="4"></td></tr>
<tr><td>Number of pages devoted to climate change (approx.)</td><td>……</td><td>Number of references to climate change in bibliography</td><td colspan="3">☐ Less than 5
☐ 5 to 10
☐ More than 10</td></tr>
<tr><td>Comments/Observations</td><td colspan="5"></td></tr>
</table>

Countries covered: Bangladesh, Cambodia, China, Maldives, Philippines, South Korea, Samoa, Singapore, and Vietnam.