POST CARBON PATHWAYS

REVIEWING POST CARBON ECONOMY TRANSITION STRATEGIES

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The authors would welcome your comments on this report, suggestions for other post carbon transition strategies that we could review, and ideas on how to strengthen public understanding of post carbon pathways. We also invite you to visit the *Post Carbon Pathways* website which provides a platform for ongoing information sharing and debate about the most promising pathways towards a just and sustainable post carbon future. http://postcarbonpathways.net.au

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All conclusions and any errors that remain are the authors' own.

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Key Messages

1. Around the world, detailed policy and research initiatives are demonstrating that a rapid transition to a post carbon economy is both technologically and economically feasible. However, the latest climate science shows that the window for effective action is rapidly closing. Strategies to reduce emissions at the required scale and speed will need to be implemented in the next five to ten years if they are to significantly reduce the risk of runaway climate change.

2. A fair and swift transition to a sustainable post carbon economy will require:

    - rapid reductions in energy consumption and improvements in energy efficiency
    - rapid replacement of fossil fuels by renewable energy
    - the drawdown and sequestration of carbon into sustainable carbon sinks
    - game changing investment in social and technological innovation
    - economic policies which recognise the full costs of failing to reduce emissions and of the multiple co-benefits of the transition program
    - a significant shift towards economic paradigms and priorities which focus on improving social and ecological wellbeing rather than unconstrained growth in material consumption.

3. The difficulty of securing and sustaining broad social and political support is widely recognised as the greatest barrier to a swift transition to a post carbon economy. The lack of detailed game plans for mobilising the required level of political leadership and public support is the most significant gap in post carbon economy transition strategies.

4. The crucial difference between transition strategies that advocate a pragmatic and evolutionary approach and those that advocate more rapid and transformational change highlights two challenging and urgent questions:

    - For less ambitious plans and strategies (generally government-led): Given that the proposed actions do not match the physical requirements of action needed to prevent runaway climate change, what can be done to bridge this gap?
    - For more ambitious plans and strategies (generally non-government authored): Given that political and social support for the rapid implementation of these proposals remains challenging, what can be done to bridge this gap?

5. A rapid transition to a post carbon economy will require strong leadership by national and local governments in setting and achieving clear long term emissions reduction targets, combined with broad grassroots mobilisation and enhanced global cooperation. It will be crucial to develop and communicate inspiring stories of a just and sustainable post carbon future.

6. The Australian Government's 2020 emissions reduction target (a 5 per cent decrease on 2000 levels) is clearly still far from the level required for Australia to make a responsible and fair contribution to global emissions reductions. While Australia's 2050 target (an 80 per cent decrease on 2000 levels) is more robust, there is no detail as yet as to how this target will be achieved.

7. Key policy and research priorities include further clarification and communication of scientifically informed knowledge on:

    - the scale and speed of the global, national and local emissions reductions required to significantly reduce the risk of runaway climate change
    - the most effective strategies for encouraging, sharing and deploying large-scale technological and social innovation
    - robust, transparent methodologies for calculating the net costs of large-scale transition strategies and fair mechanisms for mobilising the necessary resources
    - political, social and cultural change strategies that could lead to rapid implementation of the policies needed to drive a swift transition to a post carbon economy.

Summary

1. Project Aim

1.1. This report provides a concise overview of the key goals and priorities of eighteen of the most promising and innovative large-scale post carbon economy transition plans and strategies, from both government and non-government sources. The report is the first stage in an ongoing *Post Carbon Pathways* project, which aims to strengthen understanding of ways to overcome barriers to the rapid implementation of large-scale post carbon economy transition strategies.

1.2. The *Post Carbon Pathways* project is informed by the view that while increased public acceptance of the *necessity* of urgent climate change action is crucial, the transformational changes required to rapidly reduce greenhouse gas emissions also depend on broad recognition that alternative, more desirable futures and pathways are indeed *possible*.

1.3. The conceptual framework and language of 'post carbon pathways' and 'post carbon economy transition strategies' are being used in an increasingly broad range of settings and contexts to emphasise the importance of systemic transformations leading to 'a world in which we are no longer dependent on hydrocarbon fuels, and no longer emitting climate-changing levels of carbon into the atmosphere.'[i]

2. Scope

2.1. This report focuses particularly on large-scale post carbon economy transition plans and strategies, which are defined, for the purposes of this report, as 'documents which identify one or more integrated, plausible pathways for achieving dramatic reductions in greenhouse gas emissions, within a national or supra-national jurisdiction'.

2.2. Although this report has focused on large-scale, integrated strategies, the authors are conscious that there are also a wide variety of innovative and influential post carbon transition strategies that are being developed and implemented at local and regional levels, as well as in specific metropolitan contexts. While they are beyond the scope of this report, they should be the subject of further comparative research and analysis.

2.3. Nine strategies from non-government sources and nine from government sources have been analysed. **Tables 1 and 2** provide an overview of the post carbon economy transition strategies summarised in this report.

2.4. The selected strategies differ in the geographic jurisdiction and sectors of the economy with which they are concerned. They have been organised according to whether they focus on: (i) the global economy as a whole; (ii) the global energy sector only; (iii) a multi-country, regional economy (European Union); (iv) a national economy; (v) a national energy sector only; and (vi) a large, sub-national economy (California, US).

Table 1: Post carbon economy transition strategies – Non-government sources

NON-GOVERNMENT POST CARBON ECONOMY TRANSITION STRATEGIES			
Scope	**Strategy or plan**	**Source**	**Link**
Global – All sectors	World in Transition: A Social Contract for Sustainability	German Advisory Council on Global Change	http://www.wbgu.de/en/flagship-reports/fr-2011-a-social-contract/
	World on the Edge: How to Prevent Environmental and Economic Collapse	Lester R. Brown, Earth Policy Institute	http://www.earth-policy.org/books/wote
	Our Choice: A Plan to Solve the Climate Crisis	Al Gore	http://ourchoicethebook.com/
	One Degree War Plan	Paul Gilding and Jorgen Randers	http://www.emeraldinsight.com/journals.htm?articleid=1860356
Global – Energy sector only	Powering a Green Planet: A Path to Sustainable Energy by 2030	Mark Z. Jacobson and Mark A. Delucchi	http://www.scientificamerican.com/article.cfm?id=a-path-to-sustainable-energy-by-2030
	The Energy Report: 100% Renewable Energy by 2050	WWF International	http://wwf.panda.org/what_we_do/footprint/climate_carbon_energy/energy_solutions/renewable_energy/sustainable_energy_report/
National – All sectors	Zero Carbon Britain 2030	Centre for Alternative Technology	http://zerocarbonbritain.org/
	Low Carbon Growth Plan for Australia	Climate Works Australia	http://www.climateworksaustralia.org/Low%20Carbon%20Growth%20Plan.pdf
National – Energy sector only	Zero Carbon Australia 2020 – Stationary Energy Plan	Beyond Zero Emissions and Energy Research Institute, The University of Melbourne	http://beyondzeroemissions.org/zero-carbon-australia-2020

Table 2: Post carbon economy transition strategies – Government sources

GOVERNMENT POST CARBON ECONOMY TRANSITION STRATEGIES			
Scope	**Strategy or plan**	**Source**	**Link**
Regional – All sectors	A Roadmap for Moving to a Competitive Low Carbon Economy in 2050	European Commission	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0112:FIN:EN:PDF
National – All sectors	The Carbon Plan: Delivering our Low Carbon Future	Government of the United Kingdom	http://www.decc.gov.uk/en/content/cms/tackling/carbon_plan/carbon_plan.aspx
	National Strategy for Green Growth	Government of the Republic of Korea	http://www.greengrowth.go.kr/english/en_main/index.do
	China's 12th Five-Year Plan *and* White Paper of China's Policies and Actions in Responding to Climate Change	Government of the People's Republic of China	http://cbi.typepad.com/china_direct/2011/05/chinas-twelfth-five-new-plan-the-full-english-version.html and http://www.gov.cn/english/official/2011-11/22/content_2000272.htm
	National Action Plan on Climate Change *and* Low Carbon Strategies for Inclusive Growth: An Interim Report	Government of India	http://pmindia.nic.in/Pg01-52.pdf and http://planningcommission.nic.in/reports/genrep/Inter_Exp.pdf
	Securing a Clean Energy Future	Government of Australia	http://www.cleanenergyfuture.gov.au/clean-energy-future/our-plan/
National – Energy sector only	Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply	Government of Germany	http://www.bmu.de/files/english/pdf/application/pdf/energiekonzept_bundesregierung_en.pdf
	Our Future Energy	Government of Denmark	http://www.ens.dk/Documents/Netboghandel%20-%20publikationer/2011/our_future_energy_%20web.pdf
Sub-national – All sectors	Climate Change Scoping Plan *and* California's Clean Energy Future	Government of California	http://www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm and http://www.cacleanenergyfuture.org/

3. Post carbon economy transition strategies: Lessons and implications

Comparative analysis of the key features of the post carbon economy transition strategies considered in this report leads to the following key lessons and implications.

3.1. Emissions reduction, energy demand and energy supply targets

3.1.1. The most ambitious strategies produced by non-government sources aim for emissions reduction and renewable energy targets that are broadly consistent with limiting global temperature rise to below 2°C above pre-industrial levels. Further work is required to sharpen understanding of the relationship between emissions reductions and global temperatures and to specify detailed policy priorities and implementation strategies.

3.1.2. While some government-authored strategies (from industrialised countries) include 2050 emissions reduction targets of 80–100 per cent, few of them yet provide a clear pathway for achieving the scale and scope of emissions reductions required by 2020 in order to meet 2050 goals.

3.1.3. The Australian Government's current target of reducing GHG emissions by 5 per cent by 2020 on 2000 levels clearly remains far from the speed and scale required, and from the targets being set by a range of comparable industrialised economies. It is unclear how its immediate actions relate to the longer term target of 80 per cent emissions reductions by 2050.

3.1.4. The wide variety of terms used to communicate emissions reduction and energy targets makes comparison between strategies difficult and is an ongoing barrier to effective communication to broader, non-technical audiences. It may be particularly useful for transition strategies to consistently report on periodic 'carbon budgets' and annual rates of decarbonisation.

3.1.5. Key research priorities include further clarification and communication of scientifically informed knowledge about the global, national and local emissions reduction, energy consumption, renewable energy and carbon sequestration targets required to significantly reduce the risk of runaway climate change.

3.2. Technology and innovation implications and priorities

3.2.1. Technological barriers are not the major obstacles to the transition to a post carbon economy at the speed and scale required to significantly reduce the risk of runaway climate change.

3.2.2. The overall suite of technological and systemic changes needed to achieve a just and sustainable post carbon future is now well understood. It includes:

- rapid reductions in energy consumption and improvements in energy efficiency
- rapid replacement of fossil fuels by renewable energy
- drawdown and sequestration of carbon into sustainable carbon sinks
- implementation of policies needed to ensure fair and timely adaptation.

3.2.3. It will be vital to tailor energy efficiency and energy supply solutions to maximise their potential in specific national and regional contexts.

3.2.4. Important differences in approaches between strategies include the extent to which they assume that behavioural and cultural change can drive large-scale reduction in consumption and energy usage, and the assumptions made about the potential speed and scale of innovation and commercialisation of different technologies.

3.2.5. While most non-government-authored strategies do not support nuclear energy, some government-authored strategies continue to assume a transitional, ongoing or expanded role for nuclear energy.

3.2.6. While some strategies (especially government-authored) continue to prioritise carbon capture and storage (CCS) as a way of continuing to use fossil fuels, there is increasing scepticism about the extent to which CCS is likely to become technologically and financially viable in the near future.

3.2.7. The most promising solutions for reducing energy consumption and increasing energy efficiency include:

- information, education and social marketing programs
- zero waste economy and 'cradle to cradle' product design systems
- energy efficient buildings and planning
    - retrofit existing buildings to maximise energy efficiency
    - zero emissions standards for new buildings
    - maximise insulation
    - wide rollout of passive solar, combined heat and power and decentralised heating and cooling systems
    - improve efficiency of all heating, cooling, lighting and appliances
    - integrated land use, housing and transportation planning to reduce distances travelled and facilitate the shift to energy efficient transport.
- energy efficient industry
    - investment in resource and energy efficient industrial processes and equipment
    - reduce impact of energy intensive industries (e.g. aluminium, cement, iron, plastics)
    - upgrade inefficient electric motors, lighting and heating systems
    - recycle heat energy from electricity generation through co-generation
    - reduce fugitive methane emissions from mining
    - improve recycling and abatement technologies for non-CO2 emissions.
- energy efficient transport
    - set and achieve higher vehicle fuel economy standards
    - reduce carbon intensity of transportation fuels
    - reduce distances travelled through urban planning, traffic congestion taxes, increased use of video conferencing, etc
    - replace fossil fuel cars with electric and plug-in hybrid vehicles
    - improve access to electric vehicle charging stations
    - encourage a shift from private cars to public transport, high-speed rail, bicycles and walking
    - expand the use of second-generation biofuels (e.g. algal biodiesel and lingo-cellulosic ethanol)
    - hydrogen (from renewable electricity) to be used for some shipping
    - significantly reduce airline travel.

3.2.8. The most promising solutions for promoting a rapid shift from fossil fuels to renewable energy include:

- significantly expanding innovation, investment and deployment in the following energy sources:
    - solar: concentrated and photovoltaic (PV)
    - wind: on- and off-shore
    - wave and tidal
    - hydroelectricity
    - geothermal: directly to heat buildings and at high temperatures for electricity generation
    - bioenergy: traditional biomass; sustainable residues and waste; sustainable energy crops; and sustainable algaes
    - the use of spare wind, water and solar energy to produce electrolytic hydrogen
    - liquefied hydrogen combustion for aircraft.
- designing and building interconnected 'smart' grids.

3.2.9. The most promising solutions for reducing land use emissions and improving the role of land use in carbon sequestration include:

- reducing livestock production and consumption
- increasing local food production and distribution

- reducing cropland soil emissions: reducing tillage; improving fertiliser and nutrient management; and restoring degraded farmland
- improving pasture and grassland management: optimising grazing intensity; expanding planting of deep-rooted perennial grasses; and improving fire management
- reducing livestock emissions: active livestock feeding; anti-methanogenic treatments; and improving manure management
- bio-gasification of organic manure; capture or burning of agricultural methane
- more efficient use of on-farm energy and fuel
- cropland carbon sequestration
- ending and reversing deforestation
- improving forest management (weed and pest control).

3.3. Economic policy and financial implications and priorities

3.3.1. The financial costs and social impacts of economic and industry restructuring represent significant but not insurmountable obstacles to the transition to a post carbon economy at the speed and scale required to significantly reduce the risk of runaway climate change.

3.3.2. Many strategies note the importance of strengthening understanding of the financial, economic and social costs of failing to take action to reduce emissions, and of the multiple employment, health and social equity co-benefits of a swift transition to a post carbon economy.

3.3.3. All of the strategies considered in this report include some mix of market-based and regulatory policies. Most also include a range of more direct government incentives and actions to improve energy efficiency and shift energy production and consumption away from fossil fuels to renewable energy.

3.3.4. Regulatory, taxation and financial incentive policies commonly recommended include:

- regulations and/or taxes designed to reduce fossil fuel use in transport (e.g. cars, aviation and shipping) and fossil fuel-intensive industries (e.g. aluminium, cement, iron and plastics)
- strong, binding energy efficiency standards for buildings, vehicles and energy consuming products
- tax incentives, low interest loans and loan guarantees to encourage investment in renewable energy enterprises and R&D.

3.3.5. There is strong ongoing support for both 'cap and trade' and carbon tax policies for setting a price on carbon. A number of strategies that are more focused on science-based timeframes for transition note that a rapid increase in the global carbon price (towards US$100–US$200 a tonne) is likely to be required if the price of carbon is to be the primary mechanism driving the transition to a post carbon economy.

3.3.6. Some strategies remain cautious of over-reliance on carbon pricing, placing stronger emphasis on additional measures to drive a rapid transition from fossil fuels to renewable energy, including:

- elimination of all fossil fuel subsidies
- introduction of feed-in tariffs
- regulation, and sometimes funding, to close fossil fuel power stations
- binding renewable energy targets.

3.3.7. Those strategies that call for rapid renewable energy deployment highlight the fundamental difference in the economics of renewable energy compared to existing fossil-fuel-based energy systems, particularly when considered in the medium to long term. Building renewable energy infrastructure requires significant upfront investment, but costs are rapidly decreasing and will continue to do so over time, while fossil fuel prices are likely to continue to increase.

3.3.8. Strategies with emissions reductions targets that are more strongly informed by climate science generally include a strong emphasis on the need to rethink and reframe current assumptions about the nature and level of economic growth, and to rapidly explore alternatives to current economic paradigms and policy settings.

3.3.9. The strategies analysed differ in their assumptions about the possibility and desirability of maintaining current material consumption levels and ensuring continuing economic growth. Some place greater emphasis on rapid reduction in emissions (at the required scale and speed), while others only consider levels of emissions reductions that will not cause significant changes to, or limitation of, material consumption.

3.3.10. Strategies concerned with developing country economies, such as China, India and South Korea, all assume an important role for continued economic growth in helping to meet human development goals. These strategies highlight concepts of 'green growth' and 'low carbon growth', and emphasise the need for economic development to be linked to, or driven by, development in 'low carbon' industries and programs.

3.3.11. Costing of policies to achieve global and national emissions reductions at the required scale and speed remains an inexact science. The strategies reveal a wide variety of approaches to calculating and reporting the financial costs of post carbon economy transition policies. Key differences and variables include:

- time frames over which costs and benefits are considered (see point 3.3.12 below).
- assumptions about future trends in prices of different technologies and fuel sources (e.g. fossil fuel resource availability and prices, cost trajectories for renewable energy technology and deployment)
- the extent to which they factor in the costs of inaction and incorporate savings from avoiding climate change impacts.
- the way cost estimates are reported (e.g. total amount, amount per year, as a proportion of GDP, investment additional to current levels, etc.) and who they are attributed to (e.g. overall cost to society, public funding, private investment, total investment, etc).

3.3.12. While most strategies emphasise the importance of 'cost effectiveness' there is considerable diversity in the time frames over which costs and benefits are calculated. For example, the UK *Carbon Plan* notes the significant implications of prioritising 'static' cost effectiveness of particular technologies (based on short-term conditions, such as the current carbon price) and 'dynamic' cost effectiveness' (considering actions required to meet longer term targets). A longer term view may require higher upfront investments in order to optimise longer term impacts and savings.

3.3.13. Noting the wide variation in scope and costing assumptions, ballpark estimates of the costs of actions required to rapidly decarbonise the global economy include:

- World in Transition: US$200 to US$1,000 billion p.a. to 2030
- World on the Edge: US$200 billion p.a.
- One Degree War Plan: US$2,500 billion p.a.
- Powering a Green Planet: US$100 trillion over twenty years
- The Energy Report: €1,000 billion p.a.

3.3.14. Indicative national level costings (again, noting significant differences in the scale and speed of proposed actions and costing assumptions) include:

- Europe (European Commission): €270 billion p.a. over 40 years (1.5 per cent of EU GDP p.a. above overall 2009 investment levels)
- UK (Zero Carbon Britain): £50 billion p.a.
- UK (UK Government): Average cost between 0.4 and 0.6 per cent of UK GDP p.a.
- Australia (Zero Carbon Australia): AU$37 billion p.a. over ten years (approx. 3 per cent of Australian GDP)
- Germany (German Government): €20 billion p.a. over 40 years
- South Korea (South Korean Government): $US 83 billion over five years
- Denmark (Danish Government): $US 952 million to 2020 (net costs of 0.25 per cent of Danish GDP).

3.3.15. To give some sense of perspective, the US Government funds allocated to the 2011 Troubled Asset Relief Program (TARP), supporting the 'bail-out' of the US banking system, was $700 billion. The UK Independent Commission on Banking estimates that as of July 2011 the total amount committed to provide financial support to UK banks was €456 billion. In September 2011 the amount allocated to the European Financial Stability Facility was €780 billion, with Germany alone pledging €253 billion.

3.3.16. Strategies for raising the required level of funding include:

- global, national or regional carbon price schemes (with strategies that are more focused on science-based timeframes for transition noting the need for a carbon price of between US$100 and $200 a tonne).
- collection of a 'Tobin tax' on international financial transactions
- redirection of current taxation revenue
- a variety of national and local level 'green bond' schemes
- for developing economies, financial assistance from developed countries.

Table 3 on the following page summarises key targets and technology, economic and financial elements of the strategies.

Table 3: Post carbon economy transition strategies: Summary of key features

Strategy or plan	Energy and emissions targets	Energy supply assumptions and priorities	Significant questioning of current economic paradigm	Approximate cost of transition policies
World in Transition	Decarbonise global energy system by 2050	Renewables; no nuclear; possibly CCS	Yes	Additional net investment US$200 and $1000 billion p.a. by 2030
World on the Edge	Cut global CO_2 emissions by 80% by 2020 (on 2006 levels)	Renewables; no nuclear or CCS	Yes	Net cost US $200 billion p.a.
Our Choice	Rapid reduction to 350ppm atmospheric CO_2 concentration	Renewables, nuclear, CCS all considered	Yes	Does not include detailed costings
One Degree War Plan	Cut global GHG emissions to zero over 15 years; negative emissions for rest of century	Renewables. Low possibility of nuclear and CCS	Yes	Carbon tax expected to generate US$2,500 billion p.a. by year 5 to spend on transition
Powering a Green Planet	Switch global energy system to 100% renewable energy (wind, water, solar) by 2030	100% renewables: wind, water and solar sources only	No	Ballpark figure of US $100 trillion over 20 years in gross investment to construct global renewable energy systems. BAU will cost approx US$10 trillion (not inc. mounting social costs)
The Energy Report	Peak and decline global GHG emissions within five years, reduce by 80% by 2050 (on 1990 levels); 100% renewable energy by 2050	Renewables; no nuclear or CCS; 5% fossil fuels	No	Total cost of achieving targets approx €1 trillion p.a. Investment expected to have paid itself off by around 2040 at latest
Zero Carbon Britain 2030	Reduce net UK GHG emissions to zero by 2030	Renewables; no CCS; no *new* nuclear	Yes	Ballpark figure of £50 billion p.a. required for initial investment program
Climate Works Low Carbon Growth Plan for Australia	Reduce Australian GHG emissions by 25% by 2020	Fossil fuels; CCS; renewables	No	AU$1.8 billion per year. Strong emphasis on net savings to business.
Zero Carbon Australia Stationary Energy Plan	Reduce net Australian GHG emissions to zero by 2020; 100% of stationary energy from renewables by 2020	100% renewables	No	AU$37 billion p.a. for ten-year period, or approx 3% of Australian GDP. Net present costs over longer time period (2010–40) roughly equiv to BAU (not inc. transport savings)

Strategy or plan (continued)	Energy and emissions targets	Energy supply assumptions and priorities	Significant questioning of current economic paradigm	Approximate cost of transition policies
European Commission: Roadmap 2050	Reduce EU GHG emissions by 20% by 2020 and 80 –95% by 2050 (on 1990 levels)	Renewables; CCS; nuclear	No	Approx. €270 billion p.a. over 40 years (approx 1.5% of EU GDP p.a. above 2009 investment levels). Savings between €175–320 billion p.a. (not incl. saving on social costs)
UK: Carbon Plan	Reduce UK GHG emissions by 34% by 2020 and 80% by 2050 (on 1990 levels)	Fossil fuel (shift to gas); nuclear; CCS; renewables	No	Total net present cost over lifetime of policies in past carbon budget periods approx £9 billion. Average cost approx 0.4% of UK GDP p.a. in period 2008–22 and 0.6% of UK GDP per year over 2023–27
South Korea: Green Growth Strategy	Reduce Korean GHG emissions by 30% below projected 2020 levels (equivalent to 4% reduction on 2005 levels)	Fossil fuels; nuclear; renewables	No	Total investment announced as part of Five-Year Plan (2009–13) US$83.6 billion
China: 12th Five-Year Plan & Climate Change White Paper	Reduce Chinese CO_2 emissions per unit of GDP by 40–45% by 2020 (on 2005 levels)	Fossil fuels (incl. unconventional oil and gas); CCS; nuclear; renewables	No	Total investment (both public and private) in 'new energy' of approx RMB 5 trillion (US$760 billion) over next 10 years
India: National Action Plan & Low Carbon Growth Report	Reduce India's emissions intensity of GDP by 20–25% by 2020 (on 2005 levels)	Fossil fuels; possibly CCS; nuclear; renewables	No	Does not include detailed costings
Australia: Clean Energy Future	Reduce Australian GHG emissions by 5% by 2020 and 80% by 2050 (on 2000 levels)	Fossil fuels; CCS; renewables	No	Carbon price and related measures to raise approx AUD$25.5 billion in the period 2011–15. Further $3.9 billion public funds to augment
Germany: Energy Concept	Reduce German GHG emissions by 40% by 2020 and at least 80% by 2050 (on 1990 levels)	Renewables; possibly CCS; phase-out nuclear	No	Additional investment €20 billion p.a., offset by energy cost savings
Denmark: Our Future Energy	100% renewable energy in all Danish energy supply by 2050	100% renewables	No	Cost to 2020 approx DKK 5.6 billion (US$952 million). Immediate net costs of < 0.25% GDP in 2020. Average additional costs to Danish households approx DKK 1,700 (US$289) in 2020
California: Scoping Plan & Clean Energy Future Plan	Reduce GHG emissions to 1990 levels by 2020 and 80% of 1990 levels by 2050; 33% of electricity from renewable energy by 2020	Fossil fuels; possibly CCS; renewables	No	Ongoing costs approx US$ 36 million p.a. Benefits by 2020 (compared to BAU) inc. increases in economic production of US$33 billion and overall gross state product of US$7 billion

3.4. Social equity implications and priorities

3.4.1. While all strategies are informed by some implicit commitment to improving outcomes for future generations there is a surprising absence of explicit or detailed discussion of intergenerational equity or of future discounting assumptions and trade-offs. This suggests that there is a need for more robust frameworks for understanding how a socially just approach to climate change translates into actions at national and international levels, in order to hold the strategies and their authors accountable to claims of concern for equity.

3.4.2. There is widespread recognition that broad political support for a rapid transition to a post carbon economy will depend on the implementation of policies that address and overcome key social equity challenges. The primary concern of many of the government-led strategies is on overcoming social equity at the national rather than international level.

3.4.3. Many strategies note the potentially severe impacts on disadvantaged and low income communities and individuals of failing to take timely and effective action to reduce the risks of runaway climate change.

3.5. Governance implications and priorities

3.5.1. A rapid transition to a post carbon economy is likely to require strong leadership by national governments in setting and achieving clear long-term emissions reduction targets, combined with strengthened grassroots mobilisation, active support from the private sector, and enhanced global cooperation.

3.5.2. Some of the strategies focused on science-based timeframes for transition emphasise the unprecedented scale of action required and consider dramatic shifts in current governance arrangements, with a particular emphasis on strengthened global institutions and cooperation (see *World in Transition*, for example). Less ambitious (typically government-led) strategies appear to assume that existing governance arrangements will suffice.

3.5.3. While many strategies note an important role for government in encouraging and driving investment in key infrastructure and green economy projects (e.g. smart grids, high-speed rail and electric vehicle recharging stations), a number of strategies also emphasise the importance of encouraging distributed and decentralised energy systems and reinvigorating local economies.

3.5.4. Most strategies emphasise the importance of an integrated mix of market-based and government-led policy initiatives.

3.5.5. Promising options for strengthening national government leadership include:

- national climate protection targets enshrined in constitutions and legislation
- climate protection and decarbonisation objectives embedded in all national and local government policies and programs
- deliberative 'future' chambers of parliament providing an opportunity for informed consideration of the impact of policy decisions on future generations.

3.5.6. Promising options for strengthening global cooperation include:

- a commitment to continue to work towards a global climate change action compact committing all nations to an internationally verifiable decarbonisation road map and a shared approach to carbon pricing
- the development of sub-global, regional alliances and collaborations involving nation states and sub-national regions, provinces and cities
- the design and construction of international smart electricity grids and networks
- a strengthened role for international governance institutions, such as the International Energy Agency and the International Renewable Energy Agency
- renewable energy investment priorities embedded at the heart of all international aid and development programs.

3.5.7. Promising options for strengthening grassroots citizen mobilisation include:

- an extension of opportunities for citizen participation, including legislative obligation for governments to provide citizens with opportunities to participate in informed debate
- an increased role for local government and local community organisations in exploring and implementing innovative post carbon economy transition solutions
- increased support for decentralised local systems of economic production and distribution and for distributed energy systems.

3.5.8. Key policy and research priorities include clarification and implementation of the most effective governance strategies for achieving:

- binding and verifiable emissions reduction agreements at global, regional, national and local levels
- informed public debate about climate change challenges and solutions
- the encouragement and mobilisation of local community innovation and activism.

3.6. Political and social change assumptions and priorities

3.6.1. The need to secure and sustain broad social and political support is widely recognised as the greatest obstacle to taking the actions needed to drive a rapid and effective transition to a post carbon economy.

3.6.2. The lack of strategies for achieving broad social and political support and for driving transformational social change is the most significant gap in most post carbon economy transition plans and strategies. This frequently reflects an implicit assumption of a reasonably rational policy-making process in which the objective merits of the strategy provide a sufficient basis for driving change.

3.6.3. There is a crucial difference between those post carbon economy transition strategies that emphasise the need for a pragmatic and evolutionary approach (generally government-led) and those that prioritise the need for more rapid and transformational change (generally non-government authored). This highlights two challenging and increasingly urgent questions:

- For less ambitious plans and strategies (generally government-led): Given that the proposed actions do not match the physical requirements of action needed to prevent runaway climate change, what can be done to bridge this gap?
- For more ambitious plans and strategies (generally non-government authored): Given that political and social support for the rapid implementation of these proposals remains challenging: what can be done to bridge this gap?

3.6.4. Most strategies are informed by a strong recognition of the importance of finding a complementary balance between the design and implementation of integrated, 'top-down' strategic plans and the encouragement and facilitation of more diverse and diffuse, 'bottom-up' approaches to social and technological innovation.

3.6.5. The most common theories of transformational change emphasise the need for visionary political leadership combined with broad community mobilisation. Many also highlight the potential for one or more dramatic 'tipping point' events, whether directly arising from climate change or not, to trigger a swift, large-scale shift in political values and responses.

3.6.6. Of all the strategies presented in this report, the *World in Transition* report from the German Advisory Council on Global Change (WBGU) presents the most comprehensive assessment of the social change dynamics that could underpin broad public acceptance and support for transition. It emphasises:

- knowledge-based, shared visions and the importance of advocating desirable futures, rather than triggering anxiety
- the important role of change agents, social and economic megatrends and 'shocks'
- proactive states and supportive global governance structures.

3.6.7. The lack of detail within existing strategies about how to achieve the political leadership and public support for rapid transitions is problematic, particularly in the context of the unprecedented threat that runaway climate change presents to economic and social wellbeing.

Table 4 summarises the theories of social and political change contained within the selected post carbon transition strategies.

Table 4: Post carbon economy transition strategies: Theories of social and political change

Strategy or plan	Theories of social and political change
World in Transition	Key conditions for creating social dynamics for change: knowledge-based, shared visions of desirable future; strong and effective change agents and champions; social and economic 'shocks; proactive state and supportive global governance structures. Strategic opportunities for overcoming barriers to transformational change: rapid advances in low carbon technology innovation; recognition that required investments are viable when compared with greater costs of inaction; changing values towards sustainability; global knowledge networks; and recognition of co-benefits of transformational change.
World on the Edge	Transition requires decarbonisation at 'wartime speed'. Three social change models: • Pearl Harbor: Dramatic event leads to fundamental change (too risky?) • Berlin Wall: Social tipping point reached after gradual change in thinking and attitudes (too slow?) • Sandwich: Grassroots movement strongly supported by political leadership (preferred).
Our Choice	Overcoming social, political and attitudinal barriers to climate action requires visionary leadership combined with broad community mobilisation. Need to hold self-interested corporations to account and ensure higher standards in media.
One Degree War Plan	Prevention of catastrophic climate change requires broad support for comprehensive and integrated action at scale and speed comparable to Second World War mobilisation. At some point (before 2020?) one or more critical ecological, economic or social tipping point events likely to occur, leading to shift in public support for action required.
Powering a Green Planet	Obstacles to implementation of 100% global renewable energy system by 2030 'primarily social and political, not technological'; need for strong leadership to avoid dominance of industry-preferred technologies.
The Energy Report	Reduction in energy demand from energy efficiency savings, rather than restrictions on human activities; emphasis on human ingenuity, technological innovation and behaviour change as key drivers of transition.
Zero Carbon Britain 2030	Notes dynamic nature of politics and role of sudden, unexpected events in driving dramatic political shifts; importance of having plans in place to avoid predictable, but uncertain, shocks (e.g. peak oil). Importance of behaviour change plus promotion of wider societal dialogue on values, structures and processes that have led to overconsumption, climate change and resource depletion.
Climate Works Low Carbon Growth Plan for Australia	Focus on winning support from key industry sectors as a basis for winning broader social and political support.
Zero Carbon Australia Stationary Energy Plan	Need for 'decisive leadership' from government, business, academia and the wider community to implement the plan. Focus on contributing to settling debate on technical feasibility of 100% renewable energy in Australia to enable social and political changes to occur.

Strategy or plan (continued)	Theories of social and political change
European Commission: Roadmap 2050	Political and social change factors not covered in detail, although notes importance of policy innovation, behaviour change and public education programs.
UK: Carbon Plan	Importance of UK Government, industry and citizens to be 'pulling in the same direction' in order to achieve low carbon transition.
Korea: Green Growth Strategy	Emphasis on education and raising public awareness about need for lifestyle change needed to support green growth.
China: 12th Five-Year Plan & Climate Change White Paper	Underlying assumption of strong and ongoing role for co-ordinated government planning and intervention, consistent with overall Chinese economic and political governance arrangements.
India: National Action Plan & Low Carbon Growth Report	Political and social change factors not covered in plans considered. Interim report notes need for the final report to include discussion of barriers to implementation or adoption by people and firms of Indian climate change policies.
Australia: Clean Energy Future	Carbon price as central driver of change. Strong emphasis on limited impact of policy measures on Australian economy and lifestyles.
Germany: Energy Concept	Importance of public understanding and support for transition to ensure its success. Measures include provision of comprehensible information, transparent decision making and opportunities for public dialogue.
Denmark: Our Future Energy	Elements contributing to social and political acceptance of Denmark's energy transition not covered in the plan. Assumes strong ongoing role for government in encouraging innovation and community education.
California: Scoping Plan and Clean Energy Future Plan	Active public participation essential. Emphasis on role for market forces and growing environmental awareness to shift individual choices and attitudes. Calls for targeted public outreach, marketing and education programs.

4. Implications for Australian climate change policies and strategies

4.1. The Australian Government's 2020 emissions reduction target (a 5 per cent decrease on 2000 levels) is clearly still far from the level required for Australia to make a responsible and fair contribution to global emissions reductions at the scale and speed required to significantly reduce the risk of runaway climate change. Australia's 2050 target (an 80 per cent decrease on 2000 levels) is more robust, but no detailed proposals have yet been produced outlining how this target might be achieved.

4.2. A high level of political leadership will be required in order to drive an Australian climate change debate informed primarily by scientific evidence about the required speed and scale of emissions reductions rather than short-term calculations of political and economic costs.

5. Future research and policy development priorities

5.1. The aim of this report is to provide an overview of the key assumptions, priorities and lessons from the most promising large-scale post carbon economy transition strategies developed by government and non-government organisations.

5.2. Key policy and research priorities arising from the analysis of transition strategies considered in this report include further clarification and communication of scientifically-informed knowledge on:

- the scale and speed of global, national and local emissions reductions required to significantly reduce the risk of runaway climate change
- economic and social policies providing the most effective and fair basis for achieving emissions reductions at the required speed and scale
- political and social change strategies leading to rapid implementation of the policies needed to drive a swift transition to a just and sustainable post carbon economy.

5.3. The second phase of the *Post Carbon Pathways* research project will focus on the following questions:

- Which large-scale post carbon economy transition strategies have been most effective in:
  - influencing public debate
  - influencing the attitudes and actions of key stakeholders and decision makers
  - driving rapid implementation of post carbon economy policies
  - and driving rapid reductions in GHG emissions?
- What have been the major barriers limiting the effectiveness and preventing the rapid implementation of large-scale post carbon economy transition strategies?
- What have been the most effective strategies for overcoming these barriers?

1. Introduction

This report aims to provide a concise overview of the key goals and priorities of eighteen of the most promising and innovative large-scale post carbon economy transition strategies from both government and non-government sources. The report is the first stage in a larger, ongoing *Post Carbon Pathways* project designed to strengthen understanding of the most effective ways of overcoming barriers to the rapid implementation of large-scale post carbon economy transition plans and strategies.

The necessity and possibility of a rapid transition to a just and sustainable post carbon future

The *Post Carbon Pathways* project is informed by the view that, while increased public acceptance of the *necessity* of urgent climate change action is crucial, the transformational changes required to rapidly reduce greenhouse gas emissions also depend on broad recognition that alternative, more desirable futures and pathways are indeed *possible.*

The overall suite of technological and systemic changes needed to achieve a just and sustainable post carbon future is now well understood. Essential actions will include: dramatic improvements in energy efficiency and reductions in energy consumption; the swift replacement of fossil fuels by renewable energy; the drawdown and sequestration of carbon into sustainable carbon sinks; and the implementation of fair and timely adaptation policies.

These actions will need to be underpinned and driven by new policy-making and financial institutions and arrangements that can deliver rapid implementation while also maintaining or improving social equity and democratic governance. The hard work begins when the debate turns to the challenge of turning promising ideas into scaled-up work plans, capable of galvanising and mobilising the necessary economic resources, political leadership and social innovation.

The growing array of integrated post carbon transition strategies provides an important starting point for meeting this challenge. These strategies vary substantially in their assumptions about feasible targets and time frames, technologies and policies to be prioritised and in their reliance on top-down versus bottom-up governance. While often either silent or unsatisfying on the question of the political strategy needed to drive adoption and implementation, these integrated plans provide the essential ingredients for detailed public discussion of specific options, costs, obstacles and priority actions.

Several of these projects also provide impressive demonstrations of the potential of open-source policy making and innovation, drawing on the energy and creativity of a diverse coalition of volunteer researchers, writers and designers. Most importantly, they can reframe political discourse by breaking open the assumption that alternative, scaled-up energy pathways and systems are simply not feasible.

There is much to be learnt and shared about the innovative and inspiring ways in which the rapidly expanding array of post carbon transition strategies have been designed and developed. The next crucial challenge is to embed post carbon transition planning at the heart of political debate and public policy, leading to the system-wide actions required to achieve a rapid reduction in greenhouse gas emissions.

This report, and the broader *Post Carbon Pathways Project*, aim to assist in this process by providing an overview of key features and learning from the development and implementation of post carbon transition strategies in order to provide a resource for policy makers, practitioners and activists working on the actions needed to build a just, sustainable and safe post carbon future.

Scope, scale and methodology

The conceptual framework and language of 'post carbon futures' is being used in an increasingly broad range of settings and contexts to communicate and emphasise the importance of systemic transformations leading to 'a world in which we are no longer dependent on hydrocarbon fuels, and no longer emitting climate-changing levels of carbon into the atmosphere'.[ii]

A number of obvious caveats apply to the use of the term 'post carbon'. Aside from the self-evident observation that carbon is the core building block for life on Earth, it is also important to recognise that CO_2 is only one of a number of greenhouse gasses driving global warming and dangerous climate change.

There are also a range of alternative terms commonly used to frame the overarching challenges of climate change and ecological constraints, including *zero emissions, safe climate* and *social and ecological sustainability*. All have value – and we certainly are keen to ensure that 'post carbon pathway' proposals and strategies are informed by and are consistent with the broader values and goals of social and ecological sustainability, as well as social and economic justice. However, we have settled on the term 'post carbon pathways' as a useful shorthand way of capturing and communicating the importance and urgency of moving beyond a fossil-fuel-driven economy and of reducing greenhouse gas emissions at emergency speed.

While understanding of the scale and speed of emissions reductions required to avoid runaway climate change continues to evolve, the most prudent and precautionary approaches emphasise the need to maintain the Earth's climate within the boundaries of the Holocene conditions that have sustained human life over the last 10,000 years.[iii] That would probably require a rapid reduction of CO_2 concentrations to below 350 ppm.[iv] Given that current global warming is already over 0.8 degrees above pre-industrial levels and CO_2 levels continue to climb beyond 385 ppm there is a clear need for rapid action to halt and reverse the rise in CO_2 emissions and to implement efficient and prudent mechanisms for drawing down CO_2 already in the atmosphere.

The selection of plans and the analysis of emissions reduction strategies in this report is also informed by the conclusions of two other recent comprehensive reviews of the actions needed to achieve the less ambitious – and therefore less prudent – '2 degrees guard rail' target agreed by the United Nations Framework Convention on Climate Change (UNFCCC) conference in Cancun in 2010.

In their comprehensive recent review of 'emissions pathways consistent with a 2°C global temperature limit' published in *Nature Climate Change* in October 2011, Rogelj et al. arrived at the following conclusions. 'We find that in the set of scenarios with a 'likely' (greater than 66 per cent) chance of staying below 2°C, emissions peak between 2010 and 2020 and fall to a median level of 44 Gigatonnes of CO_2 equivalent [$GtCO_2e$] in 2020'.[v] The current level of pledged ambitions falls short of that 2020 goal. In the most optimistic case, the emission reduction pledges that countries put forward internationally as part of the Copenhagen Accord and Cancun Agreements will lead to annual emissions of roughly 49 $GtCO_2e$ by 2020 and could be much higher (around 53 $GtCO_2e$ if the lowest ambition pledges are implemented).[vi]

The 2011 review of national emissions reduction pledges published by Climate Analytics, Ecofys and the Potsdam Institute for Climate Impact Researchtakes a similar view: [vii]

> *'Overall, the aggregated emission-reduction pledges of all Parties fall far short of what is needed to get the world on track for limiting global warming to 2 and 1.5°C above pre-industrial levels. The emission levels needed to meet both temperature targets overlap in 2020: Global emissions need to be at about 44 GtCO2e/year by 2020,and to steeply decline afterwards. Reductions for 1.5°C need to decline more rapidly than the 2°C pathway after 2020. Given the 'pledge level' of 55 GtCO2e/year in 2020, a gap of 11 GtCO2e remains to reach the reduction level required.*

The bottom line therefore remains the need for CO_2e emissions to peak before 2020 (reaching a total of about 44 $GtCO_2e$/year). Between 2020 and 2050 a rapid decline to close to zero emissions combined with carbon sequestration would then be needed in order to achieve the goal of returning atmospheric CO_2e to 350 ppm or below. Longer turnarounds in emissions reductions are likely to lead to strengthened advocacy for planetary cooling (geo-engineering) solutions, which bring their own significant risks and dangers.

The focus of this report is on comprehensive and integrated large-scale post carbon strategies based on achieving emissions reductions targets that provide a reasonable prospect of preventing runaway climate change. For the purposes of this report, 'comprehensive and integrated' refers to strategies that cover all components of an integrated approach to emissions reductions – or at least all energy sectors. Large-scale generally refers to strategies at global or national scale, although we have included California because of the size and significance of its economy in absolute terms.[viii] A wide variety of innovative and influential post carbon transition strategies are, of course, being developed and implemented at local and regional levels, as well as in specific metropolitan contexts. While they are beyond the scope of this report, these could and should be the subject of further comparative research and analysis.

The post carbon economy transition strategies considered in this survey have been developed by both non-government and government auspices and organisations. The following filter was used to select transition strategies developed by non-government organisations and authors.

Innovative plans or strategies that meet some or all of the following criteria:

- Goals and targets calibrated at scale and speed broadly consistent with outcomes needed to prevent runaway climate change
- Significant potential to be rapidly accelerated and/or scaled up
- Significant potential to inform the development and implementation of post carbon transition strategies in other jurisdictions.

The first step in selecting government-led post carbon transition strategies was to identify nations with the most ambitious emission reduction targets and pledges, based on analysis undertaken by Climate Action Tracker.[ix] The next step was to identify strategies articulated in detailed and comprehensive implementation plan documents and which are consistent with some or all of the following criteria.

1. Goals and targets calibrated at scale and speed broadly consistent with outcomes needed to prevent runaway climate change
2. Significant potential to be rapidly accelerated and/or scaled up
3. Significant potential to inform the development and implementation of post carbon transition strategies in other jurisdictions.

The Australian Government's low carbon economy transition strategy, *Securing a Clean Energy Future*, has been included because of its central role in setting current policy and political agendas in the Australian context.

For each of the selected strategies, the relevant published documents have been analysed and compared according to a framework of questions and issues, displayed in Table 5.

Table 5: Framework for analysis of selected post carbon economy transition strategies

Source, aims and scope	
Who is responsible for developing and implementing this strategy? What are the overall aims of this strategy? To what extent does this strategy involve a comprehensive and integrated approach, or is it primarily focused on one or more specific sectors? What is the geographical and/or jurisdictional scale at which this strategy aims to have an impact?	
Emissions reduction and energy targets	
What assumptions are made about the speed and scale of emissions reduction needed to reduce the risks of catastrophic climate change? What level and speed of emissions reduction is this strategy aiming to achieve?	
Assumptions and priorities	
Technology and innovation	What assumptions are made about the extent to which technological solutions can achieve the proposed emissions reduction targets? What assumptions are made about the use of existing or new technologies? What are the main technological investments and outcomes proposed? What are the key assumptions about the potential for encouraging and driving technological and social innovation? How are these goals to be achieved?
Economics and finance	What assumptions does this strategy make about the effectiveness and desirability of market-based, regulatory and direct investment tools and mechanisms? What assumptions are made about the speed and scale of reductions in consumer demand and improvements in energy efficiency? How are these goals to be achieved? What assumptions are made about the possibility and desirability of redefining and/or reducing current rates of economic growth? How are these goals to be achieved? How much will the proposals in this strategy cost? How will these funds be raised?
Social equity	What assumptions are made about the balance to be struck between intra- and intergenerational equity? How are these goals to be achieved? What assumptions are made about the importance of supporting and financing a fair process of sustainable resource usage and post carbon transitions for developing societies and economies? How are these goals to be achieved?
Governance	What are the key assumptions about governance mechanisms and arrangements?
Social and political change	What are the key assumptions about the scale and speed of behavioural, societal and political transformation required? How will this transformation be achieved?

The impact on public debate and policy making of these transition strategies and the extent to which they have been effectively implemented will be the subject of the next stage of the *Post Carbon Pathways* project, informed by interviews and conversations with key transition plan authors and stakeholders.

The selection and analysis of strategies in this report has been based on an extensive desktop survey augmented by consultation with a range of researchers and policy makers with relevant experience and expertise. However, we are very conscious that this is a large and rapidly evolving field, and that there will inevitably be gaps in the list of plans selected. We therefore welcome further suggestions about additional ambitious and innovative initiatives.

It should also be noted that the post carbon economy transition strategies selected for analysis in this report each represent a static analysis or a snapshot of a point in time (the documents were all released between 2008 and 2011). Many of the plans are iterative with new versions and updates appearing periodically. Wherever possible, relevant updates are referred to in the summaries.

2. Summaries of 18 post carbon economy transition strategies

2.1. Non-government strategies and plans

The following section includes summaries of nine post carbon economy transition strategies from non-government sources.

1. World in Transition: A Social Contract for Sustainability, German Advisory Council on Global Change
2. World on the Edge: How to Prevent Environmental and Economic Collapse, Lester R. Brown, Earth Policy Institute
3. Our Choice: A Plan to Solve the Climate Crisis, Al Gore
4. One Degree War Plan, Paul Gilding and Jorgen Randers
5. Powering a Green Planet: A Path to Sustainable Energy by 2030, Mark Z. Jacobson and Mark A. Delucchi
6. The Energy Report: 100% Renewable Energy by 2050, WWF International
7. Zero Carbon Britain 2030, Centre for Alternative Technology
8. Low Carbon Growth Plan for Australia, Climate Works Australia
9. Zero Carbon Australia 2020 – Stationary Energy Plan, Beyond Zero Emissions and Energy Research Institute, University of Melbourne

World in Transition: A Social Contract for Sustainability

German Advisory Council on Global Change

Source, aims and scope

World in Transition: A Social Contract for Sustainability is a 400-page report produced and published by the German Advisory Council on Global Change (WBGU) in 2011. The WBGU is an independent scientific advisory body established in 1992 by the German federal government to analyse and report on critical and emerging global environment and development issues.

The report aims to provide a comprehensive overview of actions needed to ensure a reasonable chance of staying within the global 2°C climate protection 'guard rail'. More broadly, the report aims to provide the basis for a new 'global social contract' for a low carbon and sustainable global economic system, describing the transformative actions necessary in terms of relationships between individuals, civil societies, nation states and the global community of states.

World in Transition includes a summary for policy makers and chapters covering: earth system and global economic and social megatrends; changing values associated with sustainability; concepts and historical examples of societal transformations; the technical and economic feasibility of transformation to a low carbon, sustainable global economy; governance imperatives; agents of transformation; recommendations for action; and the specific role for research and education sectors.

Three key 'Transformation Fields' are identified: The Energy System, Urbanisation and Land Use. The report outlines key barriers to be overcome and strategic opportunities that need to be taken in order to achieve transformational change at the required scale and speed across these three fields.

Emissions reduction and energy targets

The report advocates for the global energy system to be largely decarbonised by the middle of this century. This goal is seen as critical to allow the world to restrict global warming, with a probability of at least two thirds, to a mean temperature change of 2°C above pre-industrial levels. In order to achieve this target, the maximum global budget for CO_2 emissions from fossil sources is calculated to be no more than 750 Gigatonnes (Gt) of CO_2 by 2050.

Assumptions and priorities

Technology and innovation

The report emphasises the need for comprehensive decarbonisation of the global energy system and major improvements in energy efficiency. It discusses a range of energy sources and technical priorities, ultimately concluding that the technologies required already exist or are under development, and therefore do not present a major barrier to enacting the transformation.

In terms of energy sources, the report emphasises the need for a massive extension of renewable energies and the

associated infrastructure required. Nuclear energy is rejected; indeed it is argued that existing nuclear should be phased out.[x] Carbon capture and storage (CCS) is not ruled out, although a range of limiting factors is explored.

World in Transition calculates that renewable energy could, technologically speaking, meet global energy demand by 2050. However, these initiatives need to be coupled with efficiency measures in heating, cooling and transport sectors, and reduced growth in demand for electricity. Measures highlighted include: the introduction of electro-mobility; increased thermal insulation of buildings; use of heat pumps; industrial efficiency measures; and lower-emission fuels.[xi] The report also includes discussion of potential emissions reductions from agriculture and forestry, noting the need for improved forest protection and management, increased carbon sequestration in soils, improved cropland and pasture management, as well as the substantial emissions reduction that could be achieved via changed dietary habits.

The report notes that the most important precondition for accelerating investments into low carbon technologies and infrastructures are long-term, stable climate and energy policy frameworks with ambitious targets. In addition to carbon pricing and phasing out of subsidies for fossil fuels, the report also proposes technology-specific funding and tax incentives to encourage investment in sustainability innovation research and development.

Economics and finance

The report acknowledges the need for individual countries to develop their own specific paths and, in that context, discusses a wide range of policy measures to be undertaken at global and national levels.

While noting that 'carbon pricing is the most important political measure for decarbonisation', the report also argues that 'the price of carbon has to be at a level high enough to achieve the transformation impact called for' (p. 10). The preference is for a 'cap and trade', rather than a tax-based system. The report argues that feed-in tariffs are an essential tool for encouraging the rapid expansion of renewable energy technologies and for overcoming fossil fuel path dependencies.

Overall, the report estimates that the additional investment required by 2030 for the global transformation to a low carbon society would be between US$200 and US$1,000 billion p.a. Significant additional investment would be required between 2030 and 2050. While recognising the scale of the investment mobilisation required, the report also notes the extensive savings which would flow from a transition away from fossil-fuel-based energy sources, as well as the importance of avoiding the immense costs of runaway climate change.

Other possibilities for raising and redirecting funds to assist the transformation include:

- levies on international shipping and aviation and the introduction of a tax on international financial transactions (i.e. a 'Tobin tax')
- the establishment of a global emissions trading system as an international financing instrument for the transformation
- further encouragement for reallocation of private investment funds, including through suitable framework conditions and government measures to raise the rate of return for investments (e.g. low interest loans), and to minimise the risks (e.g. credit guarantees)
- the establishment of national green investment banks to encourage mobilisation of institutional investors with a long-term investment horizon (e.g. pension funds and insurance companies)
- the expansion of microfinancing approaches to promote decentralised energy generation from renewable sources
- promotion of new sustainable, low carbon business models in fields such as car sharing and energy contracting.

Social equity

The *World in Transition* report is primarily concerned with ensuring joint responsibility and coordinated action to avoid the worst consequences of global climate change and adopt a trajectory of sustainable development. In this way, principles of intergenerational equity are central. The framing of the report recommendations also underlines the importance of ensuring that decarbonisation does not entrench existing global inequity. Many of the measures discussed highlight the need for developing countries to be assisted by more developed economies in undertaking transformative actions, including through additional funding for mitigation, adaptation, technology transfer and capacity building.

Governance

Governance challenges and priorities are given significant attention in the report, with a strong emphasis placed on measures to improve cooperation and coordination of transformation tasks in national, regional (especially EU) and international realms. There is also a strong emphasis on citizen and community empowerment and innovation.

Proposed actions include:

- national climate objectives enshrined in the Constitution and targets legislated
- a significant extension of opportunities for citizen participation in decision making
- the mainstreaming of climate change policies in all facets of policy making and program implementation, including climate impact assessments for all legislative proposals
- the establishment of a new deliberative 'future' chamber of parliament with responsibility to consider longer term policy options and impacts, particularly those with sustainability and climate implications
- a legislative obligation for governments to advise citizens of environmentally related projects and provide them with opportunities to participate in informed debate and to obtain legal recourse and information.

Ten 'Bundles of Measures with Strategic Leverage' are identified, with actions that relate to strengthened norms, institutions and governance arrangements featuring heavily in the detailed set of proposals under each. They include the following objectives:

1. Improve the proactive state with extended participation opportunities
2. Advance carbon pricing globally
3. Promote a common European energy policy
4. Accelerate expansion of renewable energies on a global level
5. Promote sustainable energy supply services in developing and newly industrialising countries
6. Steering the world's rapid urbanisation towards sustainability
7. Advance climate friendly land use
8. Encourage and accelerate investments in a low carbon future
9. Reinforce international climate and energy policy
10. Pursue a revolution in international cooperation

Social and political change

World in Transition includes extensive discussion of the role of social and political factors in the transition process, especially in sections on value systems and conceptual and historical examples of transformative social change.

The report argues that for a sustainability transformation to be successful it must have broad public acceptance and consent, and it must also invite people's participation. It also notes that social and political mobilisation cannot rely solely on triggering anxiety about the future, but rather must involve a widely shared and attractive agenda for a desirable future (p. 67). It summarises the considerable evidence that value systems supportive of

moving to a more sustainability society are already widespread, both in rich countries and among opinion-leading groups in newly industrialising countries.

At the same time, the report notes significant barriers to public support for a sustainability transformation, including a lack of long-term orientation in decision making and aversion to short-term effects. In addition, there is a vast array of political, institutional, economic and technological path dependencies, including interest structures and veto players impeding change. This is evident, for example, in the major subsidies supporting fossil fuel industries globally, the pressure for modification of the existing fossil–nuclear energy system, rather than transformation to a renewable energy system and the preference for incrementalism in general. Additional barriers to achieving the transformation described include: the tight timeframe, the difficulties in global cooperation, rapid urbanisation and the availability of cheap coal supplies.

Theories shedding light on how transformations occur in 'socio-technical regimes' are considered in the report. Grin et al. (2010) use a multilevel model describing three independent action levels (megatrends, socio-technical regimes and niche level). The dynamic interactions within and between these action levels create the possibility and scope for transformative change. Further insights include that (pp. 93–4):

- transformative change is not possible without change agents, such as: climate protection oriented entrepreneurs; scientists; architects; NGO members; journalists; or those operating in ministries or international organisations. Change agents and 'niches' emerge at the grassroots level and create a dynamic pressure for change
- social and economic megatrends (e.g. technological inventions, global power shifts, wars, major disasters or financial crises) are difficult to influence but act to hinder or support transformation processes
- 'Shocks' occurring at the macro level can have a far-reaching impact on transformation dynamics.

World in Transition sees two political strategies, both difficult but equally promising and needing to be pursued simultaneously (p. 270). The first involves the bundling and scaling-up of the myriad climate protection endeavours already being undertaken in different sectors and regions. Taken together, these measures could achieve a societal tipping point, leading to diminished resistance, increased political resolve and accelerated action. The second concentrates efforts on a few major course changes with a high transformative impact.

The key conditions that can create the 'social dynamics for change', derived from analysis in the report of historical examples of large-scale societal changes, include (p. 271):

- knowledge-based, shared visions informed by the precautionary principle
- heavy reliance on change agents who, initially marginalised, test ideas and present alternative visions
- a proactive state to set frameworks and implement structural change
- the cooperation of the international community and establishment of supportive global governance structures.

Key references, sources and links

- German Advisory Council on Global Change (WBGU) (2011) *Flagship Report: World in Transition: A Social Contract for Sustainability*, Berlin: WBGU Secretariat, accessed Feb 2012 at http://www.wbgu.de/en/flagship-reports/fr-2011-a-social-contract/

World on the Edge: How to Prevent Environmental and Economic Collapse

Lester R. Brown, Earth Policy Institute

Source, aims and scope

World on the Edge: How to Prevent Environmental and Economic Collapse is a book by Lester R. Brown, founder of the Earth Policy Institute (EPI), a non-profit environmental research organisation based in Washington D.C. It was published in 2011 and builds on EPI's *Plan B* series, which includes numerous publications and regular updates about global environmental challenges and responses.

World on the Edge is global in scope and written in four parts. Parts I and II explain the problematic trends in current global patterns of resource use and the consequences of these trends respectively. *Plan B*, which constitutes the response strategy, is the subject of Parts III and IV of the book. *Plan B* has four components or overarching objectives, considered mutually dependent: cutting global carbon dioxide emissions by 80 per cent by 2020; stabilising world population at no more than 8 billion people by 2040; eradicating poverty; and restoring the Earth's natural support systems such as forests, soils, aquifers and fisheries.

Plan B outlines the scale and nature of tasks that need to be undertaken to achieve these aims on a global scale, drawing on examples and case studies from around the world.

Emissions reduction and energy targets

The target of a reduction in global carbon dioxide emissions of 80 per cent by 2020 (on 2006 levels) is linked to the need to reduce global atmospheric concentrations of carbon dioxide to 350ppm. The book explains that achieving this target by 2020 would allow CO_2 concentrations to peak at around 400ppm in 2020, then decline. It is noted this target is informed by scientific evidence of the scale and speed of emissions required rather than judgements about political feasibility.

Assumptions and priorities

Technology and innovation

Drawing on multiple examples of innovative technologies and policies across different sectors and in different parts of the world, *Plan B* argues that access to appropriate technology is not the major barrier to achieving a rapid transition to a post carbon economy.

Wind, solar and geothermal are the three main sources of renewable energy highlighted as being crucial to meeting the *Plan B* goal of replacing all carbon-intensive sources of energy. Both nuclear power and carbon capture and storage (CCS) are rejected, the former on the basis that it is economically non-viable using full-cost pricing (i.e. including costs of waste disposal, end-of-life decommissioning and appropriate insurance costs); the latter on the basis that it is unlikely to be economically viable by 2020, if ever. The plan also includes supportive roles for bio-fuels, although it suggests they are relatively inefficient, as well as hydropower and tidal power,

which are projected to expand. While the plan includes aggregate figures for the proposed global rollout of renewable energy sources, there is limited detail on the precise geographic distribution of different types of renewable energy. The underlying assumption is that deployment at the scale required is possible, with sufficient global effort and determination.

Key technological priorities and investments within *Plan B* include:

- energy efficiency measures to be implemented in order to more than offset the projected growth in global energy use to 2020
- 90 per cent of fossil-fuel-generated electricity to be replaced with renewable energy between 2008 and 2020 (displacing all coal and oil, and 70 per cent of natural gas currently used to generate electricity)
- 4000 gigawatts (GW) of wind generating capacity to be developed around the world by 2020. In a *Plan B* economy this is estimated to cover more than half the world's electricity consumption and would require a near doubling of capacity every two years. This is considered feasible given wind capacity has doubled every three years over the last decade
- 200,000 megawatts (MW) of solar thermal power plant capacity installed worldwide by 2020
- further development of geothermal power technology enabling the production of 200,000 MW of electricity by 2020
- expansion of hydroelectric power from 980 GW in 2009 to 1,350 GW by 2020.

Economics and finance

Plan B emphasises the importance of restructuring the economy in order to allow for 'full cost pricing', ensuring that the ecological costs of producing goods and services are reflected in the prices paid for them and that the limitations of natural systems are recognised.

It calls for a worldwide carbon tax to be rapidly phased in, reaching US$200 per tonne of CO_2 by 2020. The transition from fossil fuels to renewable energy within the strategy is driven primarily by taxing carbon emissions while steadily lowering income taxes.

Projected ongoing increases in global economic growth are criticised as misguided and unsustainable because the types of national accounting systems currently in use do not take into account the erosion of natural ecosystems, which underpin all economic activities.

The total cost of implementing *Plan B* is estimated to be less than US$200 billion additional annual global expenditure. It points out that this amount is equivalent to one-eighth of current global military spending. In fact, it is argued that expenditure on *Plan B* should be considered the 'new security budget' because its aim is to prevent the collapse of civilisation (p. 17).

Social equity

Responsibility to future generations is a core principle informing *Plan B*'s commitment to the prevention of civilisation's collapse. There is also a strong focus on intragenerational equity, poverty eradication and improving the livelihoods of people in developing countries. A social equity fund of US$75 billion is proposed in order to achieve a range of international development objectives, including universal primary education; the eradication of adult illiteracy; school lunch programs; aid to women, infants and preschool children; reproductive health and family planning; and universal basic health care.

Governance

The two key policy cornerstones of *Plan B* – to shift taxes away from income generating towards carbon-emitting activities, and to reallocate fiscal priorities according to a redefinition of 'security' (as focused on threats to the ecosystems that underpin our societies) – imply a high degree of leadership from national governments and international cooperation. The plan notes that further work is required to specify the governance institutions and mechanisms required to achieve these aims.

Social and political change

Plan B invokes the metaphor of 'wartime speed' to emphasise the need for decarbonisation at a scale and speed comparable to US mobilisation in the Second World War. The rapid mobilisation and restructuring of the US economy upon entering the Second World War is used to underscore the possibility of such dramatic transitions, as well as the importance of high level leadership: 'If we could restructure the US industrial economy in months, then we can restructure the world energy economy this decade' (p. 198).

Three different models of social change that could help to bring about a *Plan B*-scale transition are considered. They include:

1. Pearl Harbor model: a dramatic event leads to fundamental change
2. Berlin Wall model: a social tipping point is reached after a period of gradual change in thinking and attitudes
3. Sandwich model: a dedicated grassroots movement is strongly supported by political leadership.

Relying on the 'Pearl Harbor' model is considered to be by far the riskiest strategy, while the 'Berlin Wall' model is likely to be too slow. The 'sandwich model' is considered the most attractive, due to its potential for rapid progress in harnessing the benefits of both 'bottom-up' and 'top-down' actions.

Key references, sources and links

- Brown, L. R. (2011) *World on the Edge: How to Prevent Environmental and Economic Collapse*, Earth Policy Institute, accessed Feb 2012 at http://www.earth-policy.org/books/wote

Our Choice: A Plan to Solve the Climate Crisis

Al Gore

Source, aims and scope

Our Choice is a book written by former US Vice President and chair of the Alliance for Climate Protection, Al Gore, and published in 2009. Informed by a series of high level 'Solutions Summits' with leading international climate experts, *Our Choice* is global in scale, although some sections are pitched at a US audience.

The book aims to present a global 'blueprint for action' by bringing together a range of climate change solutions considered most effective and promising. It is separated into sections covering the climate crisis; energy sources; living systems; energy use; key obstacles to action; and the need to respond swiftly as a society.

Emissions reduction and energy targets

Our Choice does not adopt a specific target or timeline for global reductions in greenhouse gas emissions. However, it does emphasise the climate science evidence pointing to the need to reduce atmospheric carbon dioxide to at least 350ppm (p. 34) and a sense of urgency is implicit in the discussion of the need to 'go far quickly'.

Assumptions and priorities

Technology and innovation

Our Choice argues that the wide variety of possible solutions makes it 'abundantly clear that we have at our fingertips all of the tools that we need to solve three or four climate crises' (p. 15). It maintains that the only missing ingredient for responding to climate change at the speed and scale required is 'collective will'.

Much of the book focuses on existing or promising technological solutions to reduce global carbon emissions. It does not recommend a particular mix of technologies; instead it presents and describes the strengths and weaknesses of a range of different options in relation to energy sources, energy use and land use.

In the set of chapters on energy sources to replace fossil fuels, *Our Choice* considers examples of existing projects and infrastructure, costs, benefits and challenges related to: solar power (concentrated solar thermal (CST), photovoltaic, passive design); wind power; geothermal; biomass; carbon capture and sequestration (CCS); and nuclear power. In chapters that consider forest and soil systems, attention is given to biochar, and other soil and land management strategies.

Energy efficiency improvements are highlighted as particularly cost-effective ways of addressing climate change. The opportunities for efficiency gains are spread over many different technologies in different settings with the following actions said to present some of the greatest savings:

- Recycling wasted heat energy from electricity generation, including an emphasis on gas-powered co-generation or combined heat and power (CHP).
- Upgrading inefficient industrial electric motors.
- Adequate insulation in all buildings.
- Upgrading inefficient lighting and heating systems, appliances and other electronics.
- Higher vehicle fuel economy standards (pp. 245–7).

The book includes a strong argument for the development of 'super grids', or national, unified smart electricity grids, noting that all the necessary technology is already fully developed and available. Elements discussed include more efficient, higher-voltage transmission lines, 'smart' distribution networks connected by the Internet to smart meters in homes, as well as improved electricity storage technology and electric vehicles.

Emphasis is also given to the potential for ongoing developments in information technology – both the technology itself and the way it is used – to contribute to climate action efforts in diverse ways. Examples discussed include finding more sophisticated visualisation, modelling and monitoring techniques, through the use of supercomputers, smart meters and new software.

Economics and finance

Our Choice promotes a mix of market-based and regulatory mechanisms for implementing the proposed suite of decarbonisation solutions. There is a strong emphasis on the need to put a price on carbon emissions in order to both (i) help realise the potential of different energy efficiency measures or technological changes, and (ii) allow the market to determine which solutions will be the most viable and cost effective.

The book argues, for example, that market forces will finally resolve the question of whether CCS technology makes economic sense (p. 148) and suggests that pricing carbon will drive the implementation of biochar strategies or other more effective ways to sequester carbon (p. 220). A range of other economic policy instruments are also canvassed including regulations, incentives, national standards and tax credit schemes, to support the implementation of climate solutions.

Gore also points to significant flaws in market capitalism which he argues are illuminated by the climate crisis. In a chapter entitled 'The true cost of carbon', Gore suggests that GDP is 'woefully incomplete in its assessment of value' (p. 324), contrasting it with a genuine progress indicator (GPI), and discusses the importance of understanding the value of ecosystem services. He highlights problems associated with prevailing reliance on short-term measures of business success e.g. short-term profit and earnings projections, concluding that: 'we need a more long-term and responsible form of capitalism. We must develop sustainable capitalism' (p. 346).

While *Our Choice* does not attempt to calculate the aggregate cost of the proposed range of technological and policy initiatives, costs of some specific technologies are referred to, and cost effectiveness is considered throughout in discussions of the pros and cons of different solutions.

Social equity

Neither intra- nor intergenerational equity is discussed in great detail. However, the book's introduction and core framing deals with the need to collectively choose to act to avoid the worst impacts of climate change for current and future generations, suggesting an underlying concern for intergenerational equity. There is acknowledgement

of the different circumstances facing developed and developing countries and the obstacles this presents to achieving progress on global agreements, although strategies are not offered to address this.

Governance

Our Choice argues for political institutions to shift their priorities to focus on building a low-carbon economy. Alongside the need for nations to put a price on pollution, the book emphasises the critical role of a global treaty for climate action, which it argues could be strengthened over time. It also emphasises the role for grassroots networks of NGOs around the world, connected via online platforms. Examples of global governance initiatives such as the Montreal Treaty addressing atmospheric ozone depletion, and US leadership in instigating the Marshall Plan in post-Second World War Europe, are drawn upon to suggest that there are precedents for actions at the required global scale.

Social and political change

The book argues that the social and political will to take action are, fundamentally, the only factors holding back the implementation of solutions to climate change. It calls for vision, focus and determination by national leaders to drive major changes. The book includes discussion of how to help promote the social will and overcome ingrained political obstacles.

Gore highlights the critical role played by human behaviour in the chapter entitled 'Changing the way we think', stating that 'the only meaningful and effective solutions to the climate crisis involve massive changes in human behaviour and thinking' (p. 351). Recommendations about how to communicate about climate change to promote behaviour change include: the need to couple messages about the dramatic nature of the problem with solutions; the need to use language and messages which are relevant to people's lives; emphasising shared values and promoting new social norms.

The importance of overcoming political obstacles is heavily underscored. Particular attention is given to the orchestrated promotion of confusion and doubt about the science of global warming, amounting to a 'massive political campaign of intentional deception on the part of many corporate carbon polluters' (p. 350). Job loss fears in industrialised nations and concentrated media ownership are also noted as key political challenges. The book argues that priority actions in response need to include grassroots activism focused on building a base of support for climate action, holding self-interested corporations to account and the achievement of higher standards in media reporting.

Key references, sources and links

- Gore, A. (2009) *Our Choice: A Plan to Solve the Climate Crisis*, London: Bloomsbury Publishing
- See also: http://ourchoicethebook.com/press/

One Degree War Plan

Jorgen Randers and Paul Gilding

Source, aims and scope

The 'One Degree War Plan' was originally developed by Paul Gilding and Jorgen Randers and published in the *Journal of Global Responsibility* in 2010.[xii] The core ideas in the plan have been further expanded and developed in Paul Gilding's subsequent book, *The Great Disruption,* published in 2011.

The aim of the 'One Degree War Plan' is 'to present the idea of a global crisis plan that will be demanded when global society finally decides that the climate challenge is a real threat, requiring immediate and strong policy action at the super national level'.

The plan outlines the broad scope of an integrated set of actions designed to keep global temperature increases in 2100 to less than 1°C above pre-industrial levels.[xiii] It is argued that this can be achieved by: i) reducing global greenhouse gas emissions by 50 per cent over five years; and ii) reducing global emissions to zero in the ensuing decade and then running negative emissions of 6 Gt CO_2e per year for the rest of the century.

Emissions reduction and energy targets

Three phases of action are proposed:

1. Climate war (years 1–5). The aim in this phase is to reduce global emissions by 50 per cent.
2. Climate neutrality (years 5–20) with the aim of moving to zero net emissions.
3. Climate recovery (years 20–100). During this period the focus would be on restabilising the global climate and establishing a sustainable global economy.

The main focus of the 'One Degree War Plan' and of the notes provided here is on the actions proposed for Phase 1.

Assumptions and priorities

Technology and innovation

The plan assumes and argues that achievement of the 'one degree' target is technologically possible. There is strong emphasis on the view that the greater challenges are associated with achieving sufficiently broad political support to drive action.

High priority investments and actions for achieving the plan's initial five-year goals include:

- cut deforestation and other logging by 50 per cent
- close 1,000 dirty coal power stations within five years
- retrofit 1,000 coal fired power plants with CCS

- retrofit buildings to reduce energy use, including though improved insulation, energy efficient lighting and heating
- erect a wind turbine or solar plant in every town of more than 1,000 people
- create large-scale wind and solar farms in suitable deserts and offshore locations
- ensure all used materials are recycled and reused
- limit production of new aluminium, cement, iron, plastics and forest products
- replace fossil fuel powered cars with chargeable electric vehicles
- reduce airline capacity by 10 per cent per year through regulation and pricing
- capture or burn methane from agricultural production
- significantly reduce livestock production and consumption
- bind 1 gigatonne of CO_2 in the soil through new investment in forestry and agriculture
- reduce consumption through social marketing (e.g. 'shop less/live more') and other behavioural change strategies.

Phase 1 of the plan also includes consideration of some geo-engineering measures such as 'white roofs' initiative to paint most of the world's upward sloping roofs with white or reflective material to increase the planet's reflectivity.

Economics and finance

The plan advocates a mix of market-based, regulatory, social marketing and public investment strategies. An initial carbon tax of $US20 per tonne is proposed, to be raised by US$20 per tonne each year until it reaches US$100 per tonne in year 5. This tax would raise US$800 billion in the first year rising to US$1900 billion p.a. by year 5. A variety of specific purpose taxes and price signal initiatives are also suggested as part of the strategy for reducing fossil-fuel-based car and aviation travel.

An extensive range of regulatory strategies are envisaged including direct rationing to reduce the use of fossil-fuel-based car and aviation travel, electricity usage and the production and consumption of new aluminium, cement, iron, plastics and forest products.

The plan is expected to generate US$2,500 billion p.a. by year 5, which would be available to spend on compensation, economic structural adjustment and adaptation planning (p. 184).

Social equity

The 'One Degree War Plan' argues that softening the impact on the most vulnerable citizens and communities will be one of the greatest challenges of the transition process. A significant proportion of the proceeds of the carbon tax would therefore be devoted to alleviating hardship and creating jobs, as well as for funding technological and social innovation.

Resettlement plans for millions of climate refugees, adaptation strategies for low-lying coastal areas and actions to address the likelihood of large-scale famine are also canvassed, alongside a 'well-functioning rationing system' to ensure minimum access to energy, food, transport and housing for each global inhabitant.

Governance

While there is some support for grassroots, bottom-up approaches the 'One Degree War Plan' gives primary emphasis to more top-down, command and control leadership including through the establishment of a global 'Climate War Command'. In the second phase of the plan a 'Climate Stability Commission' is envisaged.

The authors also take the view that, given the limited likelihood of a global agreement or compact, the first steps towards large-scale mobilisation will need to come from a small number of nations with the capacity to make a significant difference to emissions outcomes.

Social and political change

The theory of social and political change underpinning the *One Degree War Plan* is based on the following assumptions:

1. While climate change trends and impacts already built into the system mean that is too late to prevent major global disruption, it is still possible to prevent the complete collapse of civilisation.
2. The prevention of catastrophic climate change will require broad support for the design and implementation of comprehensive and integrated action at a scale and speed comparable to Second World War mobilisation.
3. At some point – probably before 2020 – one or more critical ecological, economic or social tipping point events are likely to occur that will lead to a broad shift in public support for action on the scale and speed required.

Key references, sources and links

- Randers, J. and Gilding, P. (2010) 'The One Degree War Plan', *Journal of Global Responsibility*, vol. 1, no. 1, pp. 170–88
- Gilding, P. (2011) *The Great Disruption*, London: Bloomsbury Publishing
- See also: http://paulgilding.com/the-great-disruption

A Plan to Power 100 per cent of the Planet with Renewables

Mark Z. Jacobson and Mark A. Delucchi

Source, aims and scope

'A Plan to Power 100 per cent of the Planet with Renewables' was published in *Scientific American* in 2009 by Mark Z. Jacobson and Mark A. Delucchi, two researchers based at Stanford University and the University of California respectively. Their research findings are also presented in an interactive, web-based resource called 'Powering a Green Planet', released in 2009, and a set of two journal papers in *Energy Policy*, published in 2011.

Jacobson and Delucchi's plan aims to show how all of the world's energy needs (electric power, transportation and heating/cooling) could be met by wind, water and solar (WWS) resources by as early as 2030. It cites climate change, alongside localised pollution and energy insecurity, as the reasons why such a plan is critically important.

The plan focuses only on the energy sector, specifically on shifting energy use from fossil fuel to renewable energy sources on a global scale, which it argues would be the most effective step to cut greenhouse gas emissions. It explores the characteristics of WWS energy systems, the availability of WWS resources and other critical materials, methods of addressing variability in energy supplies, economic aspects of WWS generation and transmission, use of WWS power for transportation, and policy measures needed to improve the viability of implementing a WWS system.

Emissions reduction and energy targets

The plan does not specify a target or timeframe for reducing global emissions in response to climate change. It investigates the technical dimensions of a transition by 2030 to a global energy system powered entirely by wind, water and solar sources.

Assumptions and priorities

Technology and innovation

The plan concludes that it is technically feasible for the world to be powered by 100 per cent WWS sources by 2030. However, it also notes that barriers to policy implementation may mean a more realistic timeframe would see all *new* energy produced from WWS sources by 2030, and full replacement of pre-existing energy with WWS by 2050.

There is a number of criteria underpinning the choice of technologies in Jacobson and Delucchi's plan. They consider only technologies that:

- have already been proven, or close to proven, at a large scale
- have near-zero emissions of greenhouse gases and air pollutants over their full lifecycle (including construction, operation and decommissioning)

- do not present significant waste disposal or terrorism risks, and have low impacts on wildlife, water pollution and land
- are based on primary resources that are indefinitely renewable or recyclable.

On these grounds, nuclear, coal with CCS, corn and cellulosic ethanols, soy and algae biodiesels, biomass for electricity, other biofuels, and natural gas are not included in the proposed energy mix. The plan includes detailed discussion of reasons for not considering nuclear power, including: problems with radioactive waste and risks of weapons proliferation; carbon emissions involved in construction, uranium refinement and transport; long timeframes between planning and operation of new plants; and the finite supply of uranium.

A major element of the plan is the electrification of heating and transport sectors through conversion to electric heating and appliances, and battery and fuel-cell-operated vehicles. For transportation, the technologies highlighted are battery electric vehicles (BEVs), hydrogen fuel cell vehicles (HFCVs) and hybrids of the two. Hybrid hydrogen fuel cell systems are recommended for ships and liquefied hydrogen combustion for aircraft. Heat pump air heaters, which can also be reversed to provide air conditioning, are recommended in order to meet building water and air heating demand. Combustion of electrolytic hydrogen is proposed for high temperature industrial processes.

Efficiency savings associated with electrification are assumed to reduce global energy demand below the levels projected for 2030 (16.9 terawatts (TW)), although the authors note that the amount of energy able to be supplied from WWS sources could still easily exceed these projected increases in energy demand[xiv].

The mix of technologies presented in the plan (put forward as only one of many possible combinations) includes (figures are approximate):

- 3.8million 5 MW wind turbines worldwide, accounting for 51 per cent of energy demand
- 40 per cent of energy demand met by solar, including rooftop solar PV and 89,000 photovoltaic and concentrated solar power plants (each averaging 300 MW)
- 5,350 × 100 MW geothermal power plants
- 900 × 1300 MW hydroelectric stations (of which 70 per cent are already in place)
- 720,000 0.75 MW wave devices
- 490,000 × 1 MW tidal turbines.

Jacobson and Delucchi discuss a range of options for ensuring that energy supply can reliably meet energy demand under a 100 per cent WWS system. Alongside the need for smart demand-response management and power sources such as hydroelectric power to fill gaps in more variable WWS energy sources, they highlight the importance of interconnected, long-distance transmission lines and the use of spare WWS energy to produce electrolytic hydrogen, and other energy storage options, such as using electric vehicle batteries to store energy, known as vehicle-to-grid (V2G) systems (pp. 1171–3, 2011b).

Economics and finance

The authors calculate costs of WWS electricity generation, transmission and decentralised storage, comparing it to conventional (mostly fossil-fuel-based) energy systems. They compare costs (in $/kWh) of different technologies, noting that power from conventional sources is projected to increase, whereas power from renewable energy sources is projected to continue decreasing. The plan also includes estimation of the social costs of different

energy sources (in terms of damage to human health, the local environment, the global climate and security costs) which, when taken into account, make WWS systems even more cost-competitive.

The overall costs for *constructing* WWS power systems globally are estimated to be in the order of US$100 trillion worldwide over 20 years. The authors point out that this calculation represents investment which could be paid back through the sale of the energy produced. The estimate is compared to the additional costs for expanding traditional fuel sources to meet increasing demand, estimated at roughly US$10 trillion, without factoring in the associated social costs, projected to escalate.

Subsidies for WWS power and carbon taxes are put forward as possible ways to enable the switch in energy supply, prior to WWS energy sources reaching price parity with current energy sources. Policies highlighted include:

- feed-in tariffs (FiTs), which they suggest are especially effective at scaling up new technologies
- mechanisms that support the phase-out of FiTs over time by providing incentives for developers to lower costs over time. For example, so-called 'declining clock auctions', which involve granting the right to sell power to the grid to the lowest bidder
- taxes on fossil fuels to reflect the environmental damage they inflict
- elimination of fossil fuel subsidies
- halting the promotion of alternatives which are less desirable than WWS, which they argue delays their deployment (e.g. stopping subsidies to biofuels).

In addition to policies affecting the economic viability of WWS energy systems, the authors point to the need for programs to encourage reduced energy demand and to support careful planning and management of the tasks involved in such a large-scale, long-term energy system restructure. They note that 'concerted social and political efforts beyond the traditional sorts of economic incentives outlined [in the plan]' may be required for a rapid transition to WWS to be successful (p. 1178, 2011b).

Social equity

The plan focuses on technical and financial rather than social equity aspects of a global transition to renewable energy.

Governance

The authors acknowledge the importance of strong government policies in mobilising changes associated with replacing current energy systems with WWS-based energy systems at a much faster speed than would occur if it were left to the private market.

Social and political change

The plan emphasises that the obstacles to implementation of a 100 per cent WWS global energy system by 2030 are 'primarily social and political, not technological or even economic' (p. 1170, 2011b).

Societal and individual level behaviour change are not considered in detail within the plan, however, the importance of reducing energy demand is briefly discussed with reference to the need for measures such as improving the efficiency of vehicles, buildings and lighting, as well as design and planning policies that direct people to low-energy modes of transport (p. 1157, 2011a).

Recognising the massive scale of the transition, the authors point to historical examples where society has addressed seemingly insurmountable challenges (e.g. Second World War mobilisation of American productive capacity) and visionary public infrastructure projects (e.g. interstate highway system) (p. 1, 2009).

The need to overcome political challenges is acknowledged with the authors noting, for example, the need for policy makers to 'find ways to resist lobbying by the entrenched energy industries' (p. 4, 2009). They conclude that:

> *with sensible policies, nations could set a goal of generating 25 per cent of their new energy supply with WWS sources in 10 to 15 years and almost 100 per cent of new supply in 20 to 30 years. With extremely aggressive policies, all existing fossil-fuel capacity could theoretically be retired and replaced in the same period, but with more modest and likely policies full replacement may take 40 to 50 years. Either way clear leadership is needed, or else nations will keep trying technologies promoted by industries rather than vetted by scientists* (p. 4, 2009).

Key references, sources and links

- Jacobson, M. A. and Delucchi, M. Z. (2009) 'A Plan to Power 100 Percent of the Planet with Renewables', *Scientific American*, Nov 2009 issue, accessed Feb 2012 at: http://www.scientificamerican.com/article.cfm?id=a-path-to-sustainable-energy-by-2030
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- Jacobson, M. A. and Delucchi, M. Z. (2011b) 'Providing all global energy with wind, water, and solar power, Part II: Reliability, system and transmission costs, and policies', *Energy Policy*, 39, pp. 1170–90.

The Energy Report: 100% Renewable Energy by 2050

World Wide Fund for Nature (WWF) International

Source, aims and scope

The Energy Report was released in 2011 by conservation organisation World Wide Fund for Nature (WWF) International in collaboration with energy consultancy Ecofys and the Office for Metropolitan Architecture (OMA).[xv] It was put together by a team of researchers and reviewers with funding from ENECO, a Dutch energy company.[xvi] *The Energy Report* is global in scope and presents a scenario in which all of the world's energy needs are met by 95 per cent renewable energy sources by 2050.

The report contains two parts: the first emphasises both the necessity and possibility of a world powered by 100 per cent renewable energy and raises a set of challenges that need to be addressed to realise the transition to that scenario. These challenges fall into categories of: energy conservation, electrification, equity, land and sea use, lifestyle, finance and innovation. Part 2 presents a detailed global energy scenario, modelled by Ecofys, which is described as just one possible pathway, rather than a prescriptive plan. The question underpinning the scenario is: Is a fully sustainable global energy system possible by 2050? The energy scenario covers energy demand from industry, buildings and transport sectors.

Emissions reduction and energy targets

Climate change is discussed as one of several major reasons a global transition to renewable energy is urgently needed. The report points to climate science warnings of the need to keep global warming below 1.5°C compared to pre-industrial temperatures in order to avoid devastating consequences. It states that global greenhouse gas emissions must begin to peak and decline within five years, and globally we must achieve emission reductions of at least 80 per cent by 2050 (from 1990 levels), and further reductions after that. The energy sector is seen as critical, given that it accounts for two-thirds of emissions globally, and the stated goal is to achieve 100 per cent renewable energy globally by 2050.

Assumptions and priorities

Technology and innovation

Despite the report's goal of achieving 100 per cent renewable energy globally by 2050, the energy scenario presented shows a technical pathway to 95 per cent renewable energy. Discussion of challenges within the report suggests that technology and availability of renewable energy sources are not the main hurdles to a transition of this scale.

The approach to developing the Ecofys energy scenario includes the following steps (p. 107):

1. Reducing energy demand to the minimum required to provide energy services
2. Providing energy by renewable and, where possible, local sources first
3. Providing remaining energy from 'traditional' energy sources as cleanly as possible.

The authors note that they 'tried to rely solely on existing technologies or technologies for which only incremental technological development is required' (p. 109). Where assumptions were made about future technological developments, these are explained.

The report assumes that it will be possible to reduce global energy demand by 15 per cent below 2005 levels by 2050, despite increases in population, industrial output and transport occurring as projected.[xvii] The two main priorities for achieving this are improved energy efficiency and electrification. The report stresses that this reduction in energy demand arises from improved efficiency rather than any restriction on human activity. Priorities include:

- industry – more energy efficient processes
- buildings – retrofitting (insulation, heat pumps, local renewable energy systems, and passive solar design)
- transport – passenger modal shift towards human-powered, efficient and shared modes, less aviation, freight modal shift towards rail (high-capacity and well-managed rail network), plug-in hybrid and electric vehicles, providing fuel from sustainable biomass (as a last resort), hydrogen (produced from renewable electricity) for some shipping
- smart grids – increased capacity and range of transmission lines.

The energy sources included in the mix for 2050 are:

- wind: both onshore and offshore
- water: hydropower (noting the need to avoid ecological and societal side effects), wave and tidal
- solar: photovoltaic (PV), concentrating solar power (CSP), concentrating solar high temperature heat for industry (this is not yet commercialised, so only a small potential is included in the scenario)
- geothermal (used directly to heat buildings, and at high temperatures for electricity generation)
- bioenergy: a variety of forms, prioritised in the following order: traditional biomass; sustainable residues and waste from industries such as agriculture, forestry and food processing; sustainable complementary fellings; sustainable energy crops; and sustainable algae (not yet a proven technology at commercial scale). Largely used to supply transport fuel and industrial fuel and heat, rather than electricity
- conventional fossil energy sources (coal, natural gas and oil): phased out over the period to 2050, but 5 per cent assumed to remain to perform industrial processes that rely on the energy content and mechanical properties of fossil fuels (p. 152).

CCS is expected to mature too late to be either useful or viable and therefore is not included in the energy scenario. Nuclear power is also not included for reasons including: health and safety risks; long-lasting waste products; risk of nuclear weapons proliferation; and high expense and inaccessibility for poorer, developing countries.

Economics and finance

The Energy Report emphasises the need for major investment and a wide variety of policy mechanisms to support the global transition to renewable energy. Economic policy tools proposed include: national and global standards; energy taxes; legal controls; voluntary programs for businesses; feed-in-tariffs to support renewable energy; redirecting fossil fuel subsidies to renewable energy (particularly in developing countries); and global emissions 'cap and trade' schemes.

The authors note the need for initial public funding to support technologies in their early stages and the need for governments to build a level playing field for renewable energy (currently competing with heavily subsidised fossil fuels) (p. 216). They highlight different roles for public and private sector actors, arguing that the key priorities should be:

- public bodies: these create the framework for enabling the energy transition (e.g. mandating performance standards, levelling the playing field for all energy sources, providing incentives for deployment of renewable energy technologies) and invest in large infrastructure projects (e.g. public transport and power grids, early stage R&D and innovation)
- private actors (both consumers and companies): these operate under a long-term perspective and channel investments into the most efficient renewable energy options.

The Ecofys energy scenario 'is founded on an assumption of increasing living standards and continuing economic development', which includes increasing global population growth and GDP growth (pp. 116–17). The report implies that the implementation of the energy scenario is compatible with ongoing global economic growth. Further, it argues that investment in renewable energy could act to stimulate jobs and economic growth (p. 73).

It is estimated that by 2050 the new energy system will be saving €4 trillion per year in reduced fuel costs, compared to the costs of continuing to use a fossil-fuel-based energy mix. There are, however, significant upfront costs associated with building new energy infrastructure. The report estimates that making the transition implied by the Ecofys energy scenario would require global capital expenditure (additional to a business-as-usual case) of around €1 trillion to €3.5 trillion per year over the next 25 years.[xviii] Due to steadily increasing savings in operating costs, net savings are estimated by around 2040 at the latest (earlier if the prices of conventional fuels rise faster). These calculated savings do not take into account the additional, potentially enormous, cost savings associated with avoiding major climate disruption and other social costs.

Social equity

Equity considerations – especially concerns about differences between developed and developing countries today – are part of the framing of *The Energy Report* and presented as a key reason for the need to switch to renewable energy. The report states, for example, that one-fifth of the world's population still has no access to reliable electricity, and that 'finite and increasingly expensive fossil fuels are not the answer for developing countries' (p. 13).

Priorities noted in the report to address equity issues while transitioning to renewable energy include (pp. 56–7):

- the need for technology advances to be shared by rich countries with poorer countries
- replication of successful projects such as small scale renewable energy projects (seen as particularly important in areas where energy poverty is currently a major concern)
- the phase-out of the unsustainable use of biomass (widely used for heating and cooking in poorer areas without alternatives), which also causes health and local environmental damage.

Governance

The report acknowledges the role for strengthened governance at local, national and regional levels. It highlights the crucial importance of international cooperation, at an 'unprecedented level' (p. 43) and points to priorities, including a stable and effective global 'cap and trade' scheme for greenhouse gas emissions and cooperation to build and co-manage connecting electricity grids and networks across regions.

Social and political change

In a section called 'Changes in Lifestyle', *The Energy Report* stresses that 'moving to a renewable energy future doesn't mean sacrificing our quality of life ... Indeed, quality of life for many will improve immeasurably with access to electricity and clean energy.' The reduction in energy demand necessary to achieve the Ecofys energy scenario is assumed to come from energy efficiency savings, rather than any restrictions on human activities.

However, the section does canvas a number of societal and behavioural changes that will support the transition including, for example: limiting meat consumption in rich countries; decreasing food waste, decreasing distances travelled; and flying less.

There is no explicit discussion of political barriers to implementation of the energy scenario or action at the speed implied. There is an emphasis on ensuring policy frameworks provide incentives for individuals to make decisions that minimise their impact on emissions.

There is also a strong emphasis placed on human ingenuity, technology and innovation as important drivers of the necessary societal transition. This is supported by references in the report to the rapid, transformative shifts arising from technological leaps made in aviation and the Internet in recent history (p. 79).

Key references, sources and links

- World Wide Fund for Nature (WWF) (2011) *The Energy Report: 100% Renewable Energy by 2050*, Gland, Switzerland: WWF, accessed Feb 2012 at: http://wwf.panda.org/what_we_do/footprint/climate_carbon_energy/energy_solutions/renewable_energy/sustainable_energy_report/

Zero Carbon Britain 2030: A New Energy Strategy

Centre for Alternative Technology

Source, aims and scope

Zero Carbon Britain 2030: A New Energy Strategy was developed and written by a team coordinated through the Centre for Alternative Technology (CAT), Wales.[xix] The strategy document was published in 2010 by CAT with the support of a diverse mix of sponsors and partners including think tanks, charitable trusts, businesses and academic institutes.

The *Zero Carbon Britain 2030* strategy (*ZCB* 2030) aims to provide a fully integrated solution to the challenge of reducing the net greenhouse gas emissions of the United Kingdom to zero by 2030.

ZCB 2030 is divided into four sections covering different elements of an integrated transition:

1. 'Power Down' considers ways to decrease energy demand from buildings, land use and transport sectors including roles for greater efficiency, technological improvements and individual and community behaviour change
2. 'Land Use and Agriculture' presents a scenario with dramatically different food production systems, higher food security and carbon sequestration strategies
3. 'Power Up' reviews the sources and mix of renewable energy that can be deployed to meet UK energy demand
4. 'Framework' considers how international and national policy interventions could support the implementation of the strategy, as well as economic benefits and employment opportunities arising from it.

Emissions reduction and energy targets

Choices about the target and timeframe for emissions reductions within the strategy are informed by analysis of recent climate science and calculations of a global greenhouse gas budget, allowing for an 84 per cent chance of the world staying within 2°C warming relative to pre-industrial temperatures. This analysis, combined with consideration of the obligation of the UK as a highly industrialised country to cut emissions faster than developing countries, has led to the conclusion that the target should be for the UK to get to zero emissions 'as fast as possible'. No additional explanation is provided for the choice of a 2030 deadline.

Assumptions and priorities

Technology and innovation

Explanations of the potential for deployment or scaling up of new and improved technologies are interwoven into each of the sections that describe sectoral changes. At the same time, there is a strong emphasis throughout the strategy on the need for policy drivers and business models to facilitate behaviour change to underpin the

transition. The overall message of the strategy is that technological change is crucially important, but not sufficient to achieve the *ZCB 2030* vision.

The 'Power Up' section describes a new energy scenario for Britain using only renewable energy and biomass. It does not include CCS on the grounds that it is more expensive, has a much higher carbon footprint than renewable energy sources (as not all emissions are captured), and is unlikely to be deployable prior to 2020. The *ZCB* 2030 strategy also excludes additional nuclear power (beyond the existing stock in Britain) for reasons including cost, short- and long-term safety and international security.

ZCB's proposed electricity generation mix for 2030 depends largely on offshore wind (615 terawatt hours (TWh)). Other energy sources include: onshore wind (75 TWh); fixed tidal (36 TWh); wave and tidal stream (39.5 TWh); hydro (7.23 TWh); solar PV (4.4 TWh); biogas (24.14 TWh); biochar (2.19 TWh); biomass combined heat and power (CHP) (31.4 TWh); and nuclear (7.5 TWh).

Major investment is proposed for development of the UK offshore wind industry. Estimated annual financial investment for deployment from 2009 to 2030 would peak at £30 billion in 2022 (equivalent to 2.2 per cent of UK GDP in 2008), and would deliver an electricity generation system with very low fuel costs (especially in comparison to fuel costs for operations of coal and gas over the same time period) (p. 268).

While the strategy largely focuses on national-scale actions, a chapter on distributed energy and microgrids also points to the importance of decentralised and small-scale renewable energy networks as 'part of the solution'. The potential advantages and disadvantages of energy production at small scales are presented, such as the lower cost-effectiveness, ability for local authorities, communities, organisations or individuals to fast-track changes in their energy use and potential for improved efficiency of larger-scale renewable energy systems.

The 'Power Down' section of the strategy outlines ways in which Britain's energy demand could be decreased by over 50 per cent by 2030 without any reduction in available services. It looks at options for reducing energy demand from buildings, land use and transport,[xx] including, for example, retrofitting houses, the electrification of transport and modal shift away from private cars, and decreased production of livestock products.

Modelling of the UK transport sector completed for the strategy shows how a combination of modal shift, increased vehicle occupancy, technology improvements and fuel shifting would enable a reduction in demand for energy from transport of 74 per cent below the predicted 2030 level (equivalent to a 63 per cent reduction on 2008 levels), while still providing the required services.

Economics and finance

A wide range of market-based, regulatory and direct investment mechanisms are discussed throughout the strategy. In the 'Framework' section, a set of Green New Deal policies are outlined, including reforms and options for financing the green economy involving both private and public money, such as local authority bonds and major changes to tax and domestic financial systems to redirect investment funds toward green infrastructure projects. A 'Robin Hood' or Tobin tax applying to international financial transactions is also recommended to collect funds for the post carbon transition.

In 'Power Up', attention is drawn to the crucial difference in the economics of renewable energy compared to traditional fossil fuel power plants. In the former, most of the cost is ongoing (particularly deriving from fuel costs) and dependent on the amount of energy produced. Renewable energy, on the other hand, requires large up-front costs, with operating costs remaining constant regardless of output (p. 276). However, it does not

recommend one ideal approach, instead referring to a range of policy mechanisms, including the existing Renewable Obligation Certificates (ROCs) and Feed-in Tariff (FIT), and issues for future policy makers to consider in incentivising renewable energy in the UK.

The strategy is critical of the 'current neoliberal economic model', which, it argues, continues to deliver 'inequity, volatility and crises' (p. 330). This leads the authors to emphasise the importance of government regulation to ensure socially just outcomes. The strategy points to public attitudes research and policy initiatives that reflect a shifting emphasis from GDP to broader indicators of social progress and includes a discussion of the possible alternative of a steady-state economy, and the need to reinvigorate local economies as a first step.

There is no overall price tag provided for achieving a zero carbon Britain in accordance with this strategy. Rather, cost estimates are put forward for specific policies throughout the discussion of potential changes to transport, buildings, land use and electricity generation sectors. A ballpark figure of £50 billion per year is provided as an estimate of the kind of funds for an initial crash investment program in line with the 'Power Down' and 'Power Up' scenarios outlined (p. 316).

Social equity

ZCB 2030 is explicit about the need for equity concerns to be at the heart of responses to climate change. While there is limited direct discussion of inter-generational equity, the adoption of a zero net emissions target suggests that burdening future generations with dramatic projected consequences of climate change is considered unacceptable.

There is more detailed discussion of intra-generational equity implications of a climate change response, as a major framing issue of the strategy. Both national and international equity dimensions are considered. The strategy outlines ways in which decarbonisation policies can work to prevent further increases in inequality in British society and even contribute to reducing inequality. To achieve this, the strategy points to measures including: ensuring carbon pricing mechanisms are progressive; tailoring energy efficiency measures to low-income households; and re-skilling and green jobs programs in deprived regions. Different international frameworks for global responses to climate change are considered, with the establishment of per capita emissions allowances within a global cap clearly favoured.

Governance

The strategy assumes a strong role for government in legislating and providing a policy framework for progressive decarbonisation policies.

Social and political change

It is recognised that the speed at which a zero carbon Britain can be achieved will be affected by the public response to new technologies and policies. The importance of public engagement and behaviour change is therefore highlighted in the strategy, alongside a sophisticated overview of many of the factors influencing public attitudes and willingness to adopt or support green behaviours at the individual level. The complexity of these factors is explored and attention is also drawn to the need for wider societal dialogue on values, structures and processes that have led to the challenges with overconsumption, climate change and resource depletion that we currently face. Suggested strategies include targeted communication for different groups, programs to help draw out the importance of intrinsic, community-oriented values, and the promotion of role models and norm leaders.

The strategy notes the dynamic nature of politics and the role of sudden, unexpected events in influencing dramatic political shifts, citing the 9/11 terrorist attacks in the United States, the 1980s oil shock and the recent

2008 global financial crisis as examples. It draws attention to the importance of having plans in place to avoid particular shocks that are predictable but also uncertain, highlighting peak oil as an important example.

Key references, sources and links

- Kemp, M. And Wexler, J. (eds) (2010) *Zero Carbon Britain 2030: A New Energy Strategy*, *The second report of the Zero Carbon Britain project*, Centre for Alternative Technology, Wales: CAT Publications, accessed Feb 2012 at http://zerocarbonbritain.org/

Low Carbon Growth Plan for Australia

ClimateWorks Australia

Source, aims and scope

The *Low Carbon Growth Plan for Australia* was developed by ClimateWorks Australia, a partnership between The Myer Foundation and Monash University, and released in March 2010.[xxi] It was developed in conjunction with various government departments and business consultancy, McKinsey & Company, drawing on input from a wide range of other organisations.

An update to the *Low Carbon Growth Plan for Australia* was released in April 2011 [see: http://www.climateworksaustralia.org/ClimateWorks%20Australia%20Low%20Carbon%20Growth%20Plan%202011%20update.pdf]. This summary is based only on the original plan.

The aim of the plan is to identify and explain the lowest cost greenhouse gas emissions reduction opportunities for businesses and the community across all sectors of the Australian economy.

The sectors analysed include: power, forestry, industry, agriculture, buildings and transport. The plan summarises key opportunities for each sector and then presents an integrated roadmap with implementation issues and options. Analyses of the effects of different opportunities are integrated both within and between sectors. For example, improving energy efficiency in buildings means that emissions saved by shifting to cleaner electricity generation are lower (p.12).

Fifty-four opportunities are identified, with the emissions reduction potential and estimated cost or savings to society calculated for each. The measures chosen represent a range of options identified in relation to: renewable energy sources, new technologies, alternative production processes, afforestation, waste management and energy efficiency measures (p. 102).

Emissions reduction and energy targets

The plan concludes that Australia can potentially reduce emissions by 249 $MtCO_2e$, which represents a 25 per cent reduction on emissions levels in 2000 by 2020, without significant changes to current lifestyles or the composition of the Australian economy. The plan does not include explicit discussion of the scientific rationale for setting a 25 per cent emissions reduction target.

Assumptions and priorities

Technology and innovation

The full range of opportunities identified across sectors is presented via a cost curve in order of lowest to highest cost with the magnitude of the emissions reduction potential associated with each opportunity also indicated.

For inclusion in the plan the technology associated with the emissions reduction opportunity had to be 'commercially available, or on the path to commercialisation' (p. 9). New technologies had to meet the following four criteria (p. 102):

- The technology is at least in the pilot stage
- The measure's technical and commercial viability in the medium term, starting by 2025 at the latest, is widely accepted
- Technological and economic challenges are well understood
- The technology is supported either by policy or industry, or is expected to lead to attractive economics.

CCS, for example, is assumed to be on the path to commercialisation (p. 12), and described as a 'critical technology due to the dominance of coal-fired power plants in Australia' (p. 37). Geothermal power is assumed to be commercialised by 2020. Biochar and underground coal gasification are excluded on the grounds of high current technical uncertainty (p. 12).

The analysis of opportunities is limited to assessment of 'realistic reduction potential' rather than the full technical potential, reflecting assumed input constraints in terms of labour, capital and stock.

Opportunities for emission reductions highlighted for different sectors include:

- power
    - largest opportunities include onshore wind, shift from coal to gas, and solar thermal power with storage; opportunities for net savings include improved coal and gas plant thermal efficiencies, reduced transmission and distribution losses; and other key technologies include CCS and geothermal
- forestry
    - reforestation; reduced deforestation and re-growth clearing; forest management (e.g. weed and pest control)
- industry
    - energy efficiency; new technologies e.g. in aluminium smelting, in reducing fugitive methane emissions from underground mines, CCS, etc; and cogeneration (combined heat and power (CHP))
- agriculture
    - reducing cropland soil emissions e.g. reducing tillage, improved nutrient management; reducing livestock emissions (e.g. active livestock feeding, anti-methanogenic treatments); pasture and grassland management (e.g. optimising grazing intensity and timing, increasing prevalence of deep-rooted perennial grasses, managing fire, increasing fertiliser use); cropland carbon sequestration; and degraded farmland restoration
- buildings
    - increasing energy efficiency of new commercial and residential buildings (e.g. design and orientation, insulation, heating, ventilation and cooling); improving energy efficiency of lighting, appliances etc., in commercial and residential buildings; and energy waste reduction (e.g. removing unnecessary or unused equipment)
- transport

- improved efficiency of internal combustion engines; alternative power technology e.g. hybrid and electric vehicles; and biofuels (e.g. second-generation biofuels, such as algal biodiesel and lignocellulosic ethanol (expected to be commercialised by around 2020))

Economics and finance

The ClimateWorks analysis assumes key roles for both government and business. There is a strong emphasis on the need for a carbon price as well as a range of other policies designed to help overcome non-price barriers to uptake of different emissions reduction opportunities.[xxii] Market-based policy mechanisms are generally favoured over direct government investment or regulation, although the importance of governments creating market conditions for opportunities to be exploited is also seen as crucial:

> *In general, where profit potential already exists, businesses should be encouraged to develop solutions in preference to top-down government action … In other cases, when timing is critical and when the barriers are too high for individual investors to overcome, government support may be required to create incentives for businesses and consumers to take action.* (p. 31)

The authors conclude that 'a combination of well-planned and targeted actions from business and government can overcome most, if not all barriers' to achieving the full emissions reduction potential described in the report (p. 31).

The report focuses on the lowest cost measures for emissions reductions and argues for market signals and incentives to be created to facilitate their uptake. Continuation of current economic growth assumptions and economic models are taken as givens.

The ClimateWorks plan calculates that the opportunities presented to reduce Australia's emissions by 25 per cent below 2000 levels in the period 2010–20 can be implemented at a cost of 0.1 per cent of projected GDP per household in 2020 (p. 92). This is equivalent to AU$1.8 billion per year.

The opportunities offering net savings to society primarily arise from energy efficiency measures in buildings, transport and industry sectors. Those of moderate cost are primarily in the forestry and agriculture sectors, while those with costs upwards of AU$30 per tonne of emissions abated are mainly related to shifts in the power sector (pp 13–14).

Costs for the different emissions reduction opportunities are calculated from an investor perspective and also a societal perspective, meaning that taxes and subsidies are not included and the cost of capital is assumed to be close to the long-term government borrowing rate. Transaction and program costs associated with rolling out the different opportunities are not included and co-benefits of different measures (e.g. improved health, reduced traffic congestion, etc.) are also not analysed. Costs are aggregated upwards from the estimates for each opportunity, but the authors indicate that costs are broadly consistent with 'top down' economic modelling. They conclude that effective government and business policy to complement a price on carbon could also lower net societal costs (p. 12).

Social equity

Inter and intragenerational social equity considerations are taken as given, but are not a major focus of the plan.

Governance

The plan strongly emphasises the importance of business-led climate change responses. The analysis underscores the business case for action and points to opportunities which are already being missed or risk being missed in the future.

Social and political change

Lifestyle changes are not factored into the opportunities presented in the plan, with the example given that the use of more energy efficient lighting is within scope, whereas reducing the average time that lights are on is not (p. 102). Assuming little or no change to current industry structures and ways of life allows the authors to present conclusions about emissions reduction outcomes without needing to present arguments for changes to the way Australians 'live, travel and consume on a day-to-day basis' (p. 15).

Key references, sources and links

- ClimateWorks Australia (2010) *Low Carbon Growth Plan for Australia*, accessed Feb 2012 at http://www.climateworksaustralia.org/Low%20Carbon%20Growth%20Plan.pdf
- ClimateWorks Australia (2011) *Low Carbon Growth Plan Update*, accessed Feb 2012 at http://www.climateworksaustralia.org/ClimateWorks%20Australia%20Low%20Carbon%20Growth%20Plan%202011%20update.pdf

Zero Carbon Australia 2020 – Stationary Energy Plan

Beyond Zero Emissions and *Melbourne Energy Institute, University of Melbourne*

Source, aims and scope

The *Zero Carbon Australia 2020 – Stationary Energy Plan* was developed by a team of researchers[xxiii] at Beyond Zero Emissions[xxiv] and the Melbourne Energy Institute at the University of Melbourne, and was released in 2010.

The *Stationary Energy Plan* is the first report to be released as part of the *Zero Carbon Australia 2020 (ZCA 2020)* research project, which aims to develop a fully integrated blueprint for transitioning Australia to net zero carbon emissions by 2020.[xxv]

The specific aim of the *Stationary Energy Plan* is to provide a detailed analysis of the technical and resource requirements for completely decarbonising the Australian stationary energy sector within a ten-year timeframe, using only commercially available, proven and reliable technologies. While it acknowledges that there are potentially different ways of achieving this, the approach taken is to show one possible pathway in comprehensive detail.

Emissions reduction and energy targets

ZCA 2020 adopts a target of achieving net zero greenhouse gas emissions within a ten-year timeframe. In accordance with that scale and speed of action, a goal of 100 per cent renewable energy is adopted for the *Stationary Energy Plan*. The emissions reduction target is based on analysis of climate science and the global per capita carbon budget, which considers the necessary emissions paths for different countries to enable a two-in-three chance of remaining below 2°C of global warming relative to pre-industrial temperatures. The analysis implies that a highly industrialised country such as Australia, with high per capita emissions needs to achieve net zero carbon emissions by 2020.

Assumptions and priorities

Technology and innovation

Only existing, commercially available technologies were considered as part of the *ZCA 2020 Stationary Energy Plan*.[xxvi] The target of zero emissions and the rapid ten-year transition period precludes the use of 'transition fuels' such as natural gas, which is seen as both an unnecessary and unconstructive diversion of investment that could otherwise be directed to renewable energy. Similarly, approaches involving 'transition technologies', such as more efficient petrol-driven cars, are excluded because they would divert funding and attention from overarching priorities, such as the electrification of transport, powered by a renewable energy grid.

In summary, the reasons for inclusion or exclusion of various energy sources in the plan are:

- wind, solar photovoltaic, and concentrating solar thermal with storage are all commercially available and able to be scaled up
- biomass and hydro power are limited in their ability to be scaled up but useful for supplying back-up to wind and solar
- wave, tidal and enhanced geothermal power have all not yet been demonstrated at an appropriate scale
- carbon capture and storage (CCS) has also not yet been proven, is not expected to be demonstrated at scale prior to 2020 nor is it expected to ever be zero-emissions
- nuclear power, not currently operating in Australia, is highly unlikely to be able to be implemented within the ten-year timeframe.

The plan sets out what a new Australian electricity grid would look like and includes the following technological and infrastructure priorities:

- Concentrated solar thermal (CST) power towers with molten salt heat storage to meet 60 per cent of Australia's electricity demand (42,500 MW capacity)
- Wind power to meet the remaining 40 per cent of energy demand (50,000 MW capacity)
- Crop waste biomass and hydroelectricity to provide back-up for 2 per cent of the demand where there are shortfalls in supply
- A national energy grid to flatten demand peaks, integrate renewable energy sources and provide reliable supply.

In the 2020 energy scenario described in the plan, overall energy demand is half that of business-as-usual projections for Australia, without any reduction in the provision of energy services. This is achieved through energy efficient technologies and fuel switching, including the replacement of oil-based transport, gas heating and industrial use of fossil fuels with electricity provided from renewable sources. Under this scenario, demand for electricity rises by more than 40 per cent (to 325 TWh/yr) with the proposed renewable energy infrastructure designed to meet these future needs.

The plan provides specifications, proposed locations, costs and installation timelines for its proposed renewable energy infrastructure, as well as an explanation of transmission network upgrades and detailed modelling demonstrating the reliability of the upgraded national grid. It also explains the scale and nature of material and human resources required. It concludes that implementation of its proposed technology mix could indeed achieve the target of a 100 per cent renewable energy-powered stationary energy sector in Australia within a decade.

Economics and finance

The plan highlights the basic difference between fossil-fuel-based energy projects and building large-scale renewable projects. Relative to the former, the latter requires high up-front costs but has very low ongoing costs (p. 144). While it does not offer a view on the best mechanisms for enacting the transition, the plan does refer to a number of different policy options to support renewable energy deployment, including: ongoing subsidies (e.g. feed-in tariffs) or upfront subsidies (e.g. direct investment, government loan, investment tax credits).

The total cost of implementing the *Stationary Energy Plan* is calculated to be AU$370 billion, averaging AU$37 billion annually for the ten-year period, or approximately 3 per cent of Australian GDP. It is noted that this investment will allow for significant savings in the future, particularly when compared to the default costs of major ongoing capital investments required for energy infrastructure (AU$35 billion over the 2011–20 period) and increasing costs of fossil fuels (AU$300 billion over the 2011–20 period). The plan highlights that energy sales will compensate up-front capital costs over time, as with any energy infrastructure project, and that up-front costs need only be paid by investors, not the Australian public.

Due to cost reduction curves associated with the renewable energy technology featured in the plan, net present costs over a longer time period (2010–40) make implementation of the plan roughly equivalent to business-as-usual cost projections, even without including savings in transport costs.

The plan does not present and assess possible financing mechanisms. However, it does provide a preliminary analysis of one scenario where the scheme is funded solely through electricity retail revenue, which it presents as merely a useful indication of the potential cost implications for households. This modelling suggested an electricity price rise similar to that already projected for Australia's electricity market under business-as-usual energy supply of around AU$8 per household per week by 2020.

Social equity

Maintaining or enhancing social equity during the transition to zero emissions is one of the overarching principles guiding the plan. It invokes both inter- and intragenerational equity goals, noting its aims are to provide fair access to energy for all Australians today at the same time as ensuring costs are not being deferred to future generations. The adoption of a ten-year transition to a net zero emissions national economy is in accordance with Australia accepting its responsibility as a wealthy country with high per capita emissions, while allowing developing countries more time to peak and reduce emissions within the context of a global carbon budget.

Governance

The plan does not include significant detail on governance, given that the focus is on the technical and financial aspects of transition. While it is not prescriptive about the specific policy settings required to implement the plan it is clear that implementation would depend on strong leadership, coordinated top-down planning and investment from public and/or private sectors.

Social and political change

The social and political dynamics of a transition of this speed and scale are not within the scope of the *ZCA 2020 Stationary Energy Plan*, however, it is clear that implementation depends on significant political and social support and the need for decisive leadership, especially from policy makers, is highlighted. Implicitly, there is acknowledgement that widespread acceptance of the technical and financial feasibility of a transition to a net zero economy is at least one important prerequisite for taking steps towards such a transition. As the authors note:

> *Societal and political barriers are quite different from technical barriers. This report is aimed at demonstrating the technical and financial feasibility of rolling out a 100% renewable energy system in Australia over the next ten years … [It] does not address the political and social impediments to beginning such a Plan. It is aimed at concluding the debate about whether renewable energy has the capability to keep the wheels of industry turning, in order to enable the social and political changes that will lead to the transition …* (p. 2).

Key references, sources and links

- Wright, M. and Hearps, P. (2010) *Zero Carbon Australia 2020 – Stationary Energy Plan, Melbourne:* Beyond Zero Emissions and University of Melbourne Energy Research Institute, accessed Feb 2012 at http://beyondzeroemissions.org/zero-carbon-australia-2020

2.2. Government strategies and plans

The following section includes summaries of nine post carbon economy transition plans from government sources.

1. A Roadmap for Moving to a Competitive Low Carbon Economy in 2050, European Commission
2. The Carbon Plan: Delivering our Low Carbon Future, Government of the United Kingdom
3. National Strategy for Green Growth, Government of the Republic of Korea
4. China's 12th Five-Year Plan *and* White Paper of China's Policies and Actions in Responding to Climate Change, Government of the People's Republic of China
5. National Action Plan on Climate Change *and* Low Carbon Strategies for Inclusive Growth: An Interim Report, Government of India
6. Securing a Clean Energy Future, Government of Australia
7. Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply, Government of Germany
8. Our Future Energy, Government of Denmark
9. Climate Change Scoping Plan *and* California's Clean Energy Future, Government of California

A Roadmap for Moving to a Competitive Low Carbon Economy in 2050

European Commission

Source, aims and scope

A Roadmap for Moving to a Competitive Low Carbon Economy in 2050 is a fifteen-page document produced by the European Commission in 2011 as a communication to other European Union (EU) institutions. As part of the Europe 2020 flagship initiative for a resource-efficient Europe,[xxvii] it outlines a long-term policy framework for actions to be taken across the EU region to ensure that 2050 greenhouse gas reduction targets are met.

The roadmap aims to present 'key elements that should shape the EU's climate action helping the EU become a competitive low carbon economy by 2050' (p. 3). It summarises a range of priorities across different sectors including: power, transport, the built environment, industry, and land use. While it does not contain substantial detail, it makes reference to, and should be considered in the context of, a wide range of complementary policies and strategies developed by the European Commission in relation to climate change. Where relevant, these policies and strategies are mentioned in this summary.

The roadmap is based on scenario modelling and analysis that considered increasing global population, increasing global GDP and different trends in levels of climate action globally, as well as energy and technological developments. The analysis sought the most cost-effective pathways and includes milestones for checking that the EU is on track to achieve its 2050 targets, policy challenges and investment priorities in different sectors.

Emissions reduction and energy targets

The EU is committed to reducing domestic greenhouse gas emissions by 80–95 per cent by 2050, compared to 1990 levels, which it links to an objective of ensuring global warming does not exceed 2°C above pre-industrial temperatures. The roadmap also notes the following EU targets for 2020, adopted by the European Council in 2007:

- a 20 per cent reduction in greenhouse gas emissions (on 1990 levels) by 2020[xxviii]
- a 20 per cent increase in the share of renewable energy in the energy mix by 2020
- a 20 per cent increase in energy efficiency by 2020.

The analysis undertaken for the roadmap suggests that the most cost-effective pathway towards meeting its 2050 target would be for the EU to achieve interim emissions reductions of 40 per cent by 2030 and 60 per cent by 2040. It notes that the EU is currently on track to achieve its 20 per cent by 2020 emissions reduction target, but that current policies will not be enough to meet the energy efficiency goal for 2020,[xxix] nor will current policies suffice to achieve the longer term emissions reductions.

Assumptions and priorities

Technology and innovation

The analysis of cost-effective pathways assumes that annual emissions reductions will gradually increase over the decades to 2050 due to a wider set of cost effective technologies becoming available over time. It emphasises the need for significant investment in research, development, demonstration and early deployment of low carbon technologies.

Reference is made to the *Strategic Energy Technology Plan* adopted by the EU in 2008, which lists key technology priorities.[xxx] It is also noted that the European Commission is developing an *Energy 2050 Roadmap* building on the EU's established energy policy, *Energy 2020: A strategy for competitive, sustainable and secure energy*[xxxi].

Priorities under each of the sectors considered in the roadmap include:

- power
    - electrification of transport and heating; energy efficiency improvements; increasing the share of 'low carbon technologies' in the electricity mix to 75–80 per cent by 2030 and nearly 100 per cent by 2050; investment in smart grids
- transport[xxxii]
    - improved fuel efficiency (expected to remain the key driver of sectoral emissions reductions up until 2025); measures such as congestion pricing schemes, intelligent city planning, better public transport etc; facilitation of large-scale hybrid and electric vehicle penetration; and advances in second and third generation biofuels
- built environment
    - new buildings from 2021 to be nearly zero-energy; refurbishment of existing building stock; further examples of relevant low carbon electricity noted include heat pumps, storage heaters, solar heating, biogas, biomass and district heating systems
- industrial sectors
    - more advanced resource and energy efficient industrial processes and equipment, recycling and abatement technologies for non CO_2 emissions (nitrous oxide and methane) could see the industrial sector overall reduce emissions by up to 87 per cent by 2050; need for sector-specific roadmaps to be developed; and need for broad deployment of CCS technology after 2035 to capture emissions from industrial processes (e.g. cement and steel production) (p. 9)
- land use[xxxiii]
    - agriculture sector could make further reductions in non-CO_2 emissions of nearly 50 per cent by 2050; emphasis on efficient fertiliser use, bio-gasification of organic manure, improved manure management, better fodder, local diversification and commercialisation of production and improved livestock productivity
    - the importance of agriculture in terms of EU climate policy is expected to increase over time, particularly in light of growing global demand for food.

Economics and finance

The roadmap acknowledges that significant investment is required to implement the changes outlined. It calculates that the increase in public and private investment would need to average around €270 billion per year over the next 40 years, equivalent to around 1.5 per cent of EU GDP per annum above overall current investment levels (19 per cent of EU GDP in 2009). The scenario analysis completed for the roadmap reveals that less ambitious emissions reduction pathways could result in higher overall costs for the EU over the period to 2050.

The EU's established Emissions Trading Scheme (ETS) is seen as a critical driver for the development and uptake of low carbon technologies to 2050, noting the need to ensure a sufficient carbon price signal and long-term predictability. A range of additional policy measures are also mentioned, including energy taxes, direct technology support, and the enforcement of energy performance standards. The need to unlock investment from the private sector and individual consumers is seen as a major challenge requiring new financing models, with several options canvassed.[xxxiv]

Economic and employment benefits associated with the roadmap's 2050 transition are highlighted, especially in renewable energy, manufacturing, construction, energy efficiency, technical, engineering and research industries. Reducing the EU's dependency and expenditure on fossil fuels (estimated to save between €175–€320 billion per year) is noted as a key benefit, as well as financial savings from improved air quality and health. Noting patterns of investment in emerging economies such as China, India and Korea, low carbon technology is highlighted as a major competitive frontier for the future.

Social equity

Social equity dimensions of the EU's low carbon transition are not covered in detail in this roadmap.

Governance

The long-term, regional focus of the roadmap belies the European Commission's regard for integrated forward planning to align and improve the overall effectiveness of national climate policy and planning efforts by EU Member States. The roadmap also has a strong focus on the importance of global climate action in order for the EU to maximise the benefits of improving its competitiveness for a low carbon economy.

Social and political change

Political and social change elements of the EU's low carbon transition are not covered in this roadmap, although the significance of behaviour change and education programs is briefly noted.

Key references, sources and links

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The Carbon Plan: Delivering Our Low Carbon Future

Government of the United Kingdom

Source, aims and scope

The Carbon Plan: Delivering Our Low Carbon Future was presented by the UK Government to its parliament in December 2011. It provides an integrated policy framework and set of initiatives to achieve the UK national emissions reductions targets, focusing particularly on its fourth carbon budget period, 2023–27.

The document includes sectoral plans covering: buildings; transport; industry; electricity; agriculture, forestry and land management; and waste and resource efficiency. Details are provided for where each sector is up to in terms of emissions reductions, where it should be in 2050, and key transition initiatives over the next decade, including a timeline of critical decision points in the period to 2030.

Noting the many uncertainties in trends over the timeframe being considered, the plan includes scenario analysis showing different combinations of measures and outcomes for meeting its emissions reductions objectives as cost-effectively as possible.

Policy agendas for the devolved administrations of Northern Ireland, Scotland and Wales are included and there is discussion of complementary policy commitments and leadership required by the EU and other national governments.

Emissions reduction and energy targets

The UK Government has national emissions reductions targets, legislated in the *UK Climate Change Act 2008*, of 34 per cent by 2020 and 80 per cent by 2050 (from 1990 levels). The legislation provides for the setting of five-yearly carbon budgets. In June 2011 the Coalition government set a target of 50 per cent emissions reductions to be achieved within the fourth carbon budget period (2023–27).

The UK also has a target of achieving more than 30 per cent renewable energy in total electricity generation by 2020.[xxxv]

Assumptions and priorities

Technology and innovation

The plan emphasises the crucial role of technological innovation in reducing costs associated with the transition. It points to the need for continued public funding for low carbon energy innovation, as well as the opportunities for the UK if it can capture a greater share of the growing global market for low carbon technologies.

The scenario analysis reveals some flexibility and uncertainty about which technologies will be most important for the UK over the next few decades, including scenarios that emphasise a greater or lesser role for renewable energy, energy efficiency, nuclear, CCS and bioenergy.

The implementation of energy efficiency measures will continue to be a major focus across all sectors. Further priorities outlined in the sectoral plans include:

- buildings
    - particular focus on efficiency measures, including ensuring all cavity walls and lofts are insulated over the next decade
    - laying the foundations for district heating networks and mass installation of air and ground source heat pumps.
- transport
    - sustainable biofuels likely to form a major component of UK commitment to source 10 per cent of transport energy from renewable sources by 2020
    - focus also on electric batteries, hydrogen fuel cells and plug-in hybrid technology to cut vehicle emissions
    - emphasis on encouraging modal shifts to public transport and rail freight.
- industry
    - focus on efficiency in energy and material use, as well as design of industrial processes, bioenergy and electrification to replace fossil fuels, and CCS technology (beyond the 2020s).
- electricity
    - gas and nuclear energy will continue to play a role in electricity supply in coming decades
    - fossil fuel power stations assumed to be fitted with CCS technology by 2050
    - continued development of renewable energy largely from wind and marine sources, including support for industry to reduce costs in offshore wind
    - UK electricity grid will be extended and upgraded to improve transmission capacity and flexibility.
- agriculture, forestry and land management
    - focus on improved crop nutrient management, improved livestock productivity and more efficient use of on-farm energy and fuel. There is also an ongoing commitment to expanding woodland cover.
- waste and resource efficiency
    - combination of actions to reduce the production of waste, as well as recycling and the expansion of investment in anaerobic digestion, designed to work towards a zero waste economy
    - generating heat and power from waste treatment.

Economics and finance

The initiatives outlined in the UK Carbon Plan include a variety of market-based, regulatory, direct investment and social marketing approaches. Key policy initiatives include continued involvement in the EU Emissions Trading Scheme, the 'Green Deal' enabling households and businesses to invest in energy efficiency improvements at no upfront cost; and the establishment of a green investment bank to support investment in emissions reduction infrastructure and projects.

Several scenarios were developed to show different ways in which emissions can be reduced depending on the success of different policies and technologies over the UK's fourth carbon budget period. These scenarios variously emphasise: high emissions abatement in low carbon heating; high abatement in transport and bioenergy demand; a focus on high electrification; and a more significant role for the purchase of international carbon credits.

The plan includes cost-effectiveness as a key principle and favours the creation of competitive market conditions, rather than 'picking winners', to drive innovation and cost reduction in the low carbon technologies required. At the same time, the need for the government to take a long-term view is seen as critical to ensuring cost-effectiveness in the long-run, as it is likely that a cost optimal transition will require deployment of technologies in the medium term that may not be the most cost effective if considered only in light of short-term conditions (e.g. a carbon price) (p. 16).

The factors taken into account in developing the scenarios included:

- static cost effectiveness (against the forecast carbon price in the short term)
- dynamic cost effectiveness (considering actions required to meet the 2050 target)
- technical feasibility
- practical deliverability and public acceptability.

The total net present cost over the lifetime of the policy measures described in earlier carbon budget periods (which will continue to deliver emissions reductions during the fourth budget period) is estimated at £9 billion (p. 112).[xxxvi] The costs of meeting the fourth carbon budget will depend heavily on the combination of policies implemented in coming decades. The net present values range from a net benefit of £1 billion to a net cost of £20 billion. Putting these costs into perspective the plan notes that this amounts to an estimated average cost of around 0.4 per cent of UK GDP per year over the first three carbon budget periods (2008–22) and 0.6 per cent of UK GDP per year over the 2023–27 period. Compared to costs of not tackling climate change, this is considered easily favourable.

The plan does not explicitly discuss options or priorities for reducing overall consumption, restructuring production or reframing economic growth in order to improve emissions reduction outcomes.

Social equity

The *UK Carbon Plan* includes a commitment to ensure fair distribution of the costs of the low carbon transition. It points to measures to target assistance for energy efficiency programs and reduce the impact of emissions reduction policies on vulnerable and low income individuals and communities as evidence.

The plan also refers to the UK's commitment to providing finance to support mitigation and adaption in developing countries.

Governance

The *UK Climate Change Act 2008* requires the UK Government to set five-yearly carbon budgets three budget periods in advance. This plan is primarily an overview of policies to be led and implemented by the UK government in the fourth carbon budget period (2023–27), although it includes measures from the previous three budget periods and also considers the long-term view to 2050. The plan builds on advice from the independent Committee on Climate Change, and displays a sophisticated level of integration and coordination of responsibilities between different government departments and authorities.

There is also strong commitment expressed in the plan to working cooperatively with other EU member states to ensure the EU provides leadership and builds momentum internationally for a low carbon transition.

Social and political change

The plan acknowledges the need for industry and the public to be 'pulling in the same direction' as the Government in order to achieve the transition outlined (p. 12). It claims to show that, with public acceptance, it is possible for the UK to 'move to a sustainable low carbon economy without sacrificing living standards, but by investing in new cars, power stations and buildings'.

Key references, sources and links

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National Strategy for Low Carbon, Green Growth

Government of the Republic of Korea

Source, aims and scope

The Government of the Republic of Korea announced a national vision and strategy for 'low-carbon, green growth' in 2008. The strategy is underpinned by the *Framework Act on Low Carbon, Green Growth*, passed by Korea's National Assembly in early 2010. This summary is based on the policies and actions to which the Republic of Korea is committed, as collated in the United Nations Environment Program (UNEP) report entitled *Overview of the Republic of Korea's National Strategy for Green Growth*, released in 2010.

The *National Strategy for Green Growth* represents an integrated and comprehensive strategy for the Republic of Korea to achieve its vision to 'move away from the traditional "brown economy" growth-at-any-cost model to a 'green economy' model where long-term prosperity and sustainability are the key objectives' (UNEP, 2010, p. 6).

The strategy brings together three key policy objectives for 2050:

1. Mitigation of climate change and energy independence, focused on: reducing greenhouse gas emissions; reducing fossil fuel use and enhancing energy independence; and strengthening capacity to adapt to climate change
2. Creation of new engines for economic growth, focused on: developing green technologies; 'greening' existing industries, promoting green industry; advancing industrial structure; and developing the structural foundations for a green economy
3. Improvement in quality of life and enhancement of international standing, focused on: 'greening' the land and water; creating green transport infrastructure; bringing the green revolution into daily life; and becoming a role model for green growth.

The strategy includes a series of targets for meeting these objectives, outlined in detail for the period 2009–13 in the *Five Year Action Plan for Green Growth*.

Emissions reduction and energy targets

The Republic of Korea has a target to reduce its greenhouse gas emissions by 30 per cent below its projected emissions growth by 2020 (equivalent to a 4 per cent reduction on 2005 emissions levels). This is considered a strong commitment, given South Korea's status as a developing nation.[xxxvii]

The strategy's *Five Year Action Plan* also includes a target of an increased share of renewable energy in total energy supply from 2.7 per cent in 2009 to 6.08 per cent in 2020.

Assumptions and priorities

Technology and innovation

The development of green technology is considered a crucial pillar of Korea's economic transformation in the medium and long term, expected to generate 1.18 million jobs by 2020 (UNEP, 2010, p. 38). The strategy's *Five Year Action Plan* includes a target to increase Korea's share of the global green technology market from 2 per cent in 2009 to 8 per cent by 2013 and 10 per cent by 2020. Technologies noted for development include: solar cells, bioenergy, light water reactors, fuel cells, coal gasification and smart grids. Further development of information technology is also a major focus.

Priorities put forward in the strategy include:

- energy sources
    - development of renewable energy sources, especially: waste; bioenergy (installation of 48 facilities by 2013); wind; solar thermal; tidal (increased share from nil in 2008 to 5.2 per cent in 2020); hydroelectricity (42 hydro plants to be constructed); solar PV; and geothermal.
    - increased share of nuclear energy (from 26 per cent in 2009 to 32 per cent in 2020).
    - CCS earmarked for development.
- energy efficiency
    - from a relatively high base (compared to the OECD average), energy efficiency set to improve from 0.317 toe/US$1,000 in 2009 to 0.233 toe/ US$1,000 in 2020.
- transport
    - increasing mass transit (from 50 per cent in 2009 to 65 per cent in 2020), bicycles as a share of transport (from 1.5 per cent in 2009 to 10 per cent in 2020) and hybrid electric vehicles.
    - fuel efficiency standards to be applied to all automobiles sold by 2015.
    - mandatory Renewable Fuel Standard (RFS) for fuel suppliers to offer biodiesel, bioethanol, and biogas, and to supply 7 per cent of transport fuel from biodiesel sources by 2020.
- buildings
    - measures including efficiency ratings, incentives for green buildings, applying green building codes for public buildings and stricter heat insulation standards for buildings.
- green urban planning
    - measures including increasing green centres (four major rivers, reclaimed land, and coastal areas) and expanding nature reserve areas.
- smart grid system developed by 2030
- industry
    - improved processes in steel, fibre and textile, petro-chemistry and shipbuilding industries (p. 36)
- water and ecological infrastructure
    - measures including the 'Four Major Rivers Restoration Project'.
- establishing green homes, towns, villages and industry complexes, with targets including: 1.5 million 'green households' by 2020 (from 160,000 in 2009), 500 green village centres by 2020 (from zero in 2009), and the inclusion of 1,000 categories of goods in the carbon footprint labelling system by 2020 (from 50 categories in 2009).

Economics and finance

The strategy includes a program of regulatory and fiscal reform measures for Korea, and investment in large infrastructure projects, aimed at supporting a transition to a green economy. It builds on Korea's 'green stimulus'

response to the global financial downturn in 2008, creating a longer term strategy for green growth which incorporates its national climate change response. The long-term strategy relies on the development of green technologies and there is a strong focus on stimulating private sector investments.

Some of the key priorities underpinning Korea's development of its green economy include:

- introduction of a national carbon emissions trading system
- adoption of a legal and regulatory framework for achieving emissions reductions and national greenhouse gas inventory and reporting system
- extending public assistance and encouraging investment in 'green enterprises'
- public credit guarantees for green technology and green industry sectors
- tax incentives for emissions reduction, energy efficiency and green economy-related initiatives
- reducing the ratio of 'energy-poor' households through targeting low-income households for improvements in energy efficiency and recognising the basic right to a minimum level of energy use
- long-term, low interest green bonds and savings
- creation of a 'green fund to facilitate access to credit for SMEs
- mobilising investment from pension schemes
- the launch of a green private equity fund
- incentives to increase the use of solar energy in households and small buildings
- adoption of a Renewable Portfolio Standard (RPS) from 2012 requiring a proportion of energy supply to come from new and renewable energy sources, with the proportion increasing annually up to 10 per cent by 2022
- standards in fuel efficiency and buildings.

The total investment by the Korean Government for the period covered by the Five-Year Plan (2009–13) is US$83.6 billion (UNEP, 2010, p. 45).

Social equity

The *Framework Act on Low Carbon, Green Growth* notes the need for targeted policies to support low income households and to ensure that 'every citizen can benefit from low carbon, green growth equally' (p. 61). It also includes, as a principle, that the government shall seek 'balanced development between regions in promoting low carbon, green growth and shall provide low-income groups with support and care to protect them from being neglected' (p. 26).

Governance

The strategy presents coordinated national actions to be taken by the Government of the Republic of Korea across all major portfolios to promote a transition to a green economy. An inclusive, cross-institutional approach was taken to its formulation, involving all ministries of government and representatives from the private sector, academia and civil society. The strategy reflects recognition that all sectors of society have a role to play in enacting the transition.

The strategy includes detail about ways in which the efforts of existing government institutions can be directed towards mitigating climate change and building a green economy, as well as the creation of new institutions, such as the Presidential Committee on Green Growth and the *Framework Act on Low Carbon, Green Growth*.

The importance of international cooperation is also underscored within the strategy, with several initiatives aimed at ensuring South Korea becomes an international role model for green growth. These include active engagement

in international climate change negotiations, assistance to, and cooperation with, developing countries in Asia, and support for multilateral organisations to promote green growth in the region.

Social and political change

Raising public awareness about the need for lifestyle change in support of green growth is a key pillar of the Republic of Korea's *National Strategy on Green Growth*. Examples of government measures to this effect include:

- a public awareness campaign called the 'Green Start Movement' launched by the Korean Ministry of Environment in 2008 (UNEP, 2010, p. 21)
- establishment of a 'Carbon Point System', involving approximately 400,000 households in 2009, providing incentives for purchases of low carbon products
- development of education programs to give information about green growth, raise awareness and encourage behaviour change (UNEP, 2010, p. 42)
- improving labelling and certification regarding carbon footprints
- eco-tourism pilot projects, infrastructure and training.

Key references, sources and links

- United Nations Environment Programme (UNEP) (2010) *Overview of the Republic of Korea's National Strategy for Green Growth*, prepared by UNEP as part of its Green Economy Initiative, April 2010, accessed Feb 2012 at http://www.greengrowth.go.kr/english/en_information/en_report/userBbs/bbsView.do
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China's 12th Five-Year Plan *and*

White Paper on China's Policies and Actions for Addressing Climate Change

Government of the People's Republic of China

Source, aims and scope

China's *12th Five-Year Plan (2011–15)*, which constitutes its foremost national social and economic development planning document, was adopted by the National People's Congress of the Chinese Government in March 2011. It includes a strong focus on addressing climate change and energy challenges with a commitment to achieving low carbon development.

The *12th Five-Year Plan* (12th FYP) provides a policy framework and sets overarching national goals, including in areas of energy conservation and support for 'emerging strategic sectors', which include new energy, electric vehicles and environmental protection. However, it does not provide detailed policy and implementation plans, nor does it specify costs associated with the measures proposed.

The *White Paper of China's Policy and Actions in Responding to Climate Change* (White Paper) was released in November 2011. It aims to assist the international community to better understand China's policies by bringing together both the existing and planned actions of the Chinese Government to address climate change domestically. The White Paper outlines China's priorities for addressing climate change across eleven main areas:

- strengthening the legal basis and strategic planning for addressing climate change
- accelerating economic restructuring to promote development of low carbon industries
- promoting development of technology to lower emissions from fossil-based energy sources and developing clean energy sources
- implementing energy conservation projects
- developing a circular economy and increasing the productivity of resources
- launching low carbon pilot projects in selected provinces, autonomous regions and municipalities
- establishing a carbon emissions trading market
- enhancing the capacity of carbon sinks
- building capacity to adapt to climate change impacts
- strengthening capacity to monitor Chinese emissions, undertake climate change programs and communicate with the Chinese public
- engaging cooperatively in international climate change negotiations, including providing support to other developing countries.

This summary is based on the climate change policies expressed in both documents, supplemented by information from independent analyses (see reference list below) of the 12th FYP and other plans released by the Chinese Government, including the *Comprehensive Working Plan for Energy Conservation and Emission Reduction* and the *Working Plan to Control Greenhouse Gas Emissions*, both released in the second half of 2011 and not publicly available in English.

Emissions reduction and energy targets

In 2009 the Chinese Government announced its intention to reduce national carbon emissions intensity (carbon dioxide emissions per unit of GDP) by 40–45 per cent by 2020 (on 2005 levels). The 12th FYP sets an interim target for 2015 of a 17 per cent reduction in carbon emissions intensity (on 2010 levels).

Additional targets related to emissions reduction and energy in the 12th FYP include:

- a reduction in energy consumption per unit of GDP by 16 per cent by 2015 (on 2010 levels).
- an increased proportion of non-fossil energy sources – including nuclear and renewable energy – to 11.4 per cent of total energy consumption by 2015 (up from 8.3 per cent in 2010).

Assumptions and priorities

Technology and innovation

China's policies to address climate change include a strong focus on technological development and innovation, with particular attention given to several new strategic industries. These industries are: new energy; energy conservation and environmental protection; biotechnology; new materials; new IT; high-end equipment manufacturing; and clean energy vehicles. Priority actions related to reducing emissions through development of these industries include:

- new energy industry (includes, nuclear, gas and renewables)
    - construction of industrial bases, equipment and utilisation technologies for new-generation nuclear power, wind power, solar power and heat utilisation, biomass energy, and intelligent power grids
    - implementation of large-scale demonstration projects for marine wind power, solar power and biomass energy.
- energy conservation and environmental protection industries
    - development of key technologies for energy efficiency and resource recycling
    - implementation of major demonstration projects in energy conservation and environmental protection
- clean energy vehicles
    - R&D and large-scale demonstration projects to be undertaken for plug-in hybrid electric vehicles, pure electric vehicles and fuel cell technologies.

The 12th FYP continues the emphasis on energy efficiency, which saw the Chinese Government achieve a 19.1 per cent reduction in energy intensity of GDP over the 11th FYP period (2006–10). Priorities include:

- promotion of energy conservation in key sectors of industry, construction and transport
- remodelling of boiler and kiln systems, savings and optimisation in motor and energy systems, utilisation of residual heat and pressure, economic use and substitution of oil, and energy conservation in buildings and lighting
- retrofit programs requiring local governments to install heat-measuring systems and complete energy efficiency retrofits for 35 per cent of residential buildings in the northern provinces by 2015 (The Climate Group, 2011, p. 16)
- an emphasis on the goal of developing a resource-efficient 'circular' economy
- a new program for energy efficiency referred to as the 'Top 10,000', modelled on the success of the 'Top 1,000' program that targeted approximately 1,000 companies during the 11th FYP (Lewis, 2011)
- plans to continue closures of inefficient power and industrial facilities (during the 11th FYP 72.1 GW of thermal power was reportedly closed) (Lewis, 2011).

Attention is given to energy supply, with developments outlined including:

- coal, oil and gas
  - accelerated development of 'clean coal' technology
  - promotion of rapid growth in natural gas output
  - accelerated development and utilisation of non-conventional oil-gas resources (including coal-bed gas and shale gas).
- nuclear
  - accelerated development of nuclear power and construction of projects with a total installed capacity of 40 GW.
- renewables
  - construction of 120 MW of new hydropower projects
  - plans to build at least 70 GW of new wind farms (including onshore, coastal and offshore) and 5 GW of new solar farms, representing increases of 225 per cent and 715 per cent on 2010 figures, respectively (Finamore, 2011).
  -
- power grids
  - accelerated construction of power transmission channels, trials of intelligent power grid technologies, and construction of electric vehicle charging facilities.
  - rollout of 300 million smart meters by 2018 (around 70 million were installed in 2011 alone) and a decade-long investment program in transmission network upgrades as part of establishing a national smart grid (Buckley, 2012).

Priority measures related to transport include the construction of 35,000 km of high-speed rail and a goal to ensure rail connection between every city with a population of more than 500,000 people (Lewis, 2011).

Priorities related to land use include:

- increased acreage of new forests by 12.5 million hectares by 2015, with the forest coverage rate increased to 21.5 per cent
- pilot projects in carbon sink afforestation and measures to increase areas of farmland and grassland carbon sinks
- protective farming projects and converting grazing area back to grassland.

Economics and finance

The actions to address climate change through China's 12th FYP include a strong focus on regulatory and fiscal policies and an increasing role for market-based mechanisms.

The 12th FYP includes reference to the goal of establishing a carbon trade market, although it does not provide details about design and implementation. The White Paper points to the intention to standardise voluntary trading in emissions reduction rights and to establish trans-provincial and trans-regional emissions trading systems. In this context the Chinese Government highlights the need to 'give full play to the fundamental role of the market mechanism in optimising the allocation of resources, and realise the objective of controlling greenhouse gas emission at minimum cost' (White Paper, p.8).

Strong policy support is outlined for new strategic industries including, for example:

- access to dedicated government funds, preferential loans and R&D funds
- increased access to private capital
- tax support to improve and encourage innovation
- the establishment of industrial standards and technical standards for products
- encouragement of financial institutions to strengthen credit support.

A national feed-in-tariff for the solar industry (RMB 1.15/kWh) was announced in August 2011, falling to RMB 1.00 /kWh in 2012, as well as additional direct 'one-off' subsidies to help meet solar project costs and speed up deployment (Buckley, 2012, p. 3).

The 12th FYP document does not include detailed costing of policy measures or overall estimates of the costs of transforming to a low carbon development path. However, the following points and estimates have been made in related documents and analyses, which help to give a sense of the scale of Chinese investment:

- During the 11th FYP period (2005–10), total investment in China's energy saving and emissions reduction initiatives reached approximately RMB 2 trillion (US$301 billion), of which more than RMB 200 billion came from the Chinese Government (according to China's National Development and Reform Commission (NDRC)) (Embassy of the People's Republic of China in the United States, 2010).
- The market for energy savings and emissions reductions industries in China is projected to grow from about 1.71 trillion RMB (US$268 billion) in 2009 to over 3 trillion RMB (US$470 billion) by 2015. (Finamore, 2011).
- China leads the world in renewable energy investment, attracting US $49 billion in 2010 (more than a third of global investment in renewable energy) (Ren21, 2011, p. 35).
- China expects to see investment (both public and private) in 'new energy' of around RMB 5 trillion (US$760 billion) over the next ten years, with renewable energy and grid investments taking the largest shares: wind (US$230 billion), smart grid (US$210 billion) and solar (US$30 billion) (Finamore, 2011).
- Goldman Sachs estimates subsidies for clean energy in China will double from RMB 21 billion in 2011 to RMB 42 billion in 2012 (US$6.5 billion p.a.), due to increased funds in the National Clean Energy Fund (sourced from an increase in the thermal power tariff) (Buckley, 2012, p. 4).

Economic growth has been very strong in China in recent years, with annual GDP growth rates averaging 10.6 per cent over the period of the 11th FYP (2006–10) (The Climate Group 2011, p. 6). The 12th FYP includes growth targets of 7 per cent p.a. (which may require efforts to slow the Chinese economy), and sees economic growth as central to improving living standards for the 1.3 billion Chinese people. However, there has been an increasing emphasis on sustainable development in recent years and the 12th FYP represents continued recognition from Chinese leadership of the crucial need to closely link climate change responses and low carbon development with economic development goals (Finamore, 2011).

Social equity

China stresses that it is committed to cooperative participation in international climate change dialogue and negotiations, in accordance with the principle of 'common but differentiated' responsibilities. While the White Paper expresses China's view that developed countries should 'take the lead in shouldering the historical responsibilities to substantially reduce emissions', and should provide financial support and technology transfers to developing countries, it is also clearly noted that developing countries should pursue mitigation measures as far as they can while pursuing development and poverty alleviation goals (p. 9).

Discussion of the equity implications within Chinese society of measures to address climate change are not covered in detail in the 12th FYP or the White Paper.

Governance

The White Paper notes the importance of strengthening Chinese regulatory frameworks for addressing climate change, including revising relevant laws, regulations, rules and standards (p. 8).

While clearly favouring a 'top-down' approach to addressing climate change through centralised decision-making, the Chinese Government has plans to encourage selected provinces and cities to draft locally tailored plans for medium- and long-term low carbon development (Ma, 2012). There is also a section in the White Paper that highlights the measures being taken to ensure 'participation of the whole society' in China's response to climate change and recognises the role played by a range of non-government organisations in planning and implementing their own energy conservation initiatives and, in some cases, running publicity and education campaigns to engage the Chinese public.

The need for international cooperation on climate change and the pursuit of globally binding emissions reduction commitments, by developed countries in the first instance, through United Nations institutions is also strongly emphasised in the White Paper.

Social and political change

The elements of the 12th FYP and White Paper considered here represent the Chinese Government's actions to address climate change. Neither document includes detailed discussion of elements of social or political change that may influence national low carbon development pathways.

Key references, sources and links

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National Action Plan on Climate Change *and* Low Carbon Strategies for Inclusive Growth: An Interim Report

Government of India

Source, aims and scope

The Government of India released its *National Action Plan on Climate Change* (NAPCC) in 2008. The plan, produced by the Prime Minister's Council on Climate Change, provided the first comprehensive statement of the Indian Government's plans and policies to tackle climate change domestically, outlining existing and proposed actions across eight national priority areas. Known as 'missions', these focus on: solar power, energy efficiency, sustainable habitat, water, the Himalayan ecosystem, afforestation, sustainable agriculture, and strategic knowledge for climate change.

This summary explains elements of the NAPCC, supplemented by more recent indications of India's climate change policies provided in *Low Carbon Strategies for Inclusive Growth: An Interim Report*. The interim report, published in May 2011, was produced by the Expert Group on Low Carbon Strategies for Inclusive Growth (LCSIG), established by the Indian Government's Planning Commission to develop strategic input to India's Twelfth Five-Year Plan (2012–17), due to be launched in April 2012.

The Expert Group on LCSIG is working towards providing a low carbon growth roadmap for India, including an action plan of critical initiatives, timelines and targets to feed into the national Twelfth Plan process. The interim report provides a menu of options to reduce emissions intensity across different sectors of the Indian economy including power, transport, industry, buildings and forestry. Neither the NAPCC nor the LCSIG interim report include full costing of the measures outlined, nor are the macroeconomic feedback effects of implementing different policies factored in, however the forthcoming final report of the Expert Group on LCSIG is expected to take these into account.

Emissions reduction and energy targets

In December 2009, the Indian Government announced that it would reduce the emissions intensity of its GDP by 20–25 per cent by 2020 (on 2005 levels).[xxxviii] It has also pledged, in 2007, that India's per capita emissions will 'at no point exceed that of developing countries even as we pursue our development objectives' (NAPCC, p. 2).

Assumptions and priorities

Technology and innovation

The sectoral strategies for minimising emissions included in the interim report on LCSIG are presented in the context of strong projected economic growth rates for India and two different scenarios termed 'Determined Effort' and 'Aggressive Effort'. The two scenarios represent the range of emissions savings under consideration and are based on different assumptions about technological development and the extent of financial support. The lower end of savings, associated with 'Determined Effort' assumes effective implementation of existing and

proposed policies, requires upgrades to current technology and both public and private financing. The 'Aggressive Effort' scenario, resulting in higher emissions savings, would require new policies, new technology and new finance, including significantly increased contributions from the private sector and international financial assistance.

There is a strong focus on energy efficiency measures in both the NAPCC and the LCSIG Interim Report, albeit in the context of dramatic projected increases in energy demand driven by strong economic growth scenarios. The Indian Government estimates, for example, that primary energy supply will need to increase by four to five times and electricity generation capacity by six to seven times (on 2003–04 levels) (LCSIG, pp. 10–11). Measures to improve energy efficiency include: increasing adoption of more energy efficient domestic and commercial appliances (seen as the biggest area for energy savings); enforcement of the Energy Conservation Building Code; improved efficiency in agriculture (e.g. replacing inefficient motors in irrigation pumps); and improved efficiency in industry, particularly iron, steel and cement manufacturing.

In relation to transport, an 'avoid-shift-improve' paradigm[xxxix] is adopted with a focus on increasing the share of rail in freight transport, increasing or retaining current modal share of public and non-motorised transport and improving fuel efficiency.

According to the LCSIG interim report, the mix of energy sources to be relied upon in India, at least to 2020, is expected to include:

- coal – to continue to be the main source of power in 2020, with current coal-based power generation assumed to expand to 230 GW by 2020. Upgrading existing inefficient coal power plants (based on sub-critical technology) to operate at higher temperatures (super-critical) is seen as important to reduce emissions intensity. Technologies not yet available at scale or considered too costly, including ultra-super critical power plants, Integrated Coal Gasification Combined Cycle (IGCC) and carbon capture and sequestration (CCS), are all noted as potentially important, with research or monitoring of technological development in other countries recommended
- gas – generation capacity could grow to 25,000 MW by 2020, despite uncertainty about availability and competing demand for use in other sectors
- hydropower – almost fully exploited, but could grow to 50,000–65,000 MW by 2020
- wind – could see increased capacity to 30,000 MW by 2020
- biomass – considered promising for rural decentralised generation and could contribute at least 4,000 MW
- solar – including both centralised and decentralised technologies – seen as critical for India's long-term energy security. It is being pursued through the National Solar Mission and could grow to 20,000 MW by 2020
- nuclear power – forecast to grow from the current installed capacity of 4,780 MW to up to 17,500 MW by 2020.

In relation to land use, implementation of the Green India Mission, which aims to undertake substantial afforestation activities, is seen as crucial to enhancing carbon sequestration in India. However, while the NAPCC includes a focus on sustainable agriculture, the LCSIG interim report makes no recommendations for reducing emissions from agriculture 'given the needs of inclusive growth' and understanding that 'much reduction may not be practically possible in this area up to 2020' (p. 107).

Economics and finance

Within the LCSIG interim report measures to reduce emissions are discussed in the context of strong economic growth in India, which is the overarching national priority as it is linked to improving livelihoods of the Indian

population and meeting human development objectives. Growth rates in average real GDP of 8 per cent and 9 per cent to 2020 are the only two scenarios considered.

The authors of the interim report stress that costs associated with different low carbon policies and measures to meet India's emissions intensity reduction goals have not been included and that further detail and estimation of relative cost-effectiveness will be an essential and crucial addition in the preparation of their final report.

While the interim report does not put forward recommendations for specific new policies, it does canvass a range of market-based and regulatory mechanisms across different sectors and refers to policies that have previously been announced, such as the Perform Achieve and Trade (PAT) scheme which created a trading scheme for energy efficiency certificates among manufacturing industries (pp. 34–5). The need for India to introduce a price for fossil-fuel-based emissions is mentioned only as a future possibility, although it is suggested that, in the absence of an externality tax on fossil fuels, the Indian Government should at least acknowledge their full costs in economic calculations informing choices about mitigation policy (p. 111).

Various co-benefits of low carbon policies are highlighted, particularly in relation to the transport sector where they are noted to include: greater accessibility for all citizens through improvement of public, non-motorised transport modes, reduced air pollution, greater energy security through reduced reliance on imported fuel, improved safety and the possibility of 'technical leapfrogging' or advantages for Indian industry in global low carbon technology markets (p. 56).

While sources of finance are not described in detail in the interim report, it is clear that the Indian Government sees international assistance as a crucial variable in achieving domestic emissions reductions at or beyond current levels of ambition. For example, it is noted that while the measures underpinning the 'determined effort' scenario could achieve India's target of a 23–25 per cent reduction in energy intensity by 2020 (on 2005 levels), implementation of the 'aggressive effort' scenario could increase the reduction to 33–35 per cent. The latter scenario is provisional on adequate international assistance in terms of both technology and finance.

Social equity

Equity considerations, both within India and between India and the international community, are central to the framing of the LCSIG interim report. The per capita emissions of Indians are low by international standards and the Indian Government maintains that industrialised countries have historical responsibility for climate change and they must provide the leadership to respond to it, while developing countries should be able to meet their development objectives with any emissions reduction commitments being voluntary (Rastogi, p. 129). India's voluntary commitments include their emissions intensity reduction target and ensuring they never exceed the average per capita emissions level of developed countries.

The LCSIG interim report views India's goal of sustaining an economic growth rate of 9 per cent over the period to 2031–32 as necessary in order to eradicate poverty and meet national human development goals.[xl] Rising incomes are expected to lead to more energy-intensive lifestyles and the objective for India is to effectively minimise its emissions growth in this context. As the report concludes:

> *if India is to sustain an 8–9 per cent real GDP growth rate over the next decade, despite its efforts at improving emission intensities, the total GHG emissions in 2020 are expected to be at least double of the absolute levels in 2007; and this carbon space must be made available to it to achieve inclusive growth and eliminate poverty* (p. 111).

The conceptualisation of low carbon inclusive growth, at the heart of India's approach to addressing climate change domestically, involves recognition of the differential impacts of climate change mitigation measures on development objectives such as poverty alleviation, distributional justice, industrial growth and quality of the local environment (pp. 12–13). The report highlights the need to quantify the additional burdens and differential impacts on different social groups of measures to reduce emissions intensity and to embed effective internal burden-sharing mechanisms into adopted policies.

Governance

The release of the NAPCC in 2008 included provision for a comprehensive set of institutional arrangements to manage India's domestic climate change initiatives, including the Prime Minister's Council on Climate Change and various advisory and coordination units with broad representation from across government ministries, industry and civil society.

In the more recent LCSIG interim report several principles for designing a supportive institutional set-up for implementation of low carbon growth strategies are put forward, including:

- policies that create incentives for people to self-regulate, and to harness the creative potential of non-government actors (e.g. business, professional associations and civil society)
- promotion of innovation, especially green technology, requiring investment in research and development and policy interventions to support the adoption and absorption of new technology
- the need for actions to come from multiple levels including government, industry, institutions and individuals
- the need for institutions to be knowledge-based and have built-in flexibility to handle the substantial uncertainties around climate change impacts, collective global action, technology development and behavioural change from emitters.

Social and political change

The LCSIG interim report represents a suite of options for the incorporation of policy measures and actions to reduce India's emissions intensity. It does not provide detail about elements of social and political change required in order to either implement the measures described or take further steps to reduce India's emissions. It does, however, note the importance of further analysis of the most attractive policy measures and the need to take into account the barriers to their implementation or adoption by people and firms, discussion of which is flagged for inclusion in the final report.

Key references, sources and links

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Securing a Clean Energy Future:

The Australian Government's Climate Change Plan

Government of Australia

Source, aim, scope and speed

Securing a Clean Energy Future – The Australian Government's Climate Change Plan was released in July 2011 by the Commonwealth Government of Australia. The plan highlights actions to be taken by the Australian Government in four main areas: carbon pricing, renewable energy, energy efficiency and land use. It also provides information about actions to support Australian households, businesses and communities in the clean energy transition, with further detail provided in accompanying documents: *Supporting Australian Households – Helping Households Move to a Clean Energy Future* and *Clean Energy Australia – Investing in Clean Energy Sources of the Future*.

Emissions reduction and energy targets

The Australian plan brings together new and existing policies designed to achieve the Australian Government's commitment to 'reduce carbon pollution by 5 per cent from 2000 levels by 2020, irrespective of what other countries do, and by up to 15 or 25 per cent depending on the scale of global action' (p. xi). While the Government has also committed to a 2050 target to reduce emissions by 80 per cent compared to 2000 levels the focus of this plan is on actions designed to meet the 2020 emissions reduction target.

The plan also includes commitments for producing 20 per cent of electricity from renewable energy by 2020 and a 30 per cent improvement in energy efficiency between 2020 and 2030.

Assumptions and priorities

Technology and innovation

While the primary focus of *Securing a Clean Energy Future* is on supportive policy settings and institutional arrangements rather than recommendations in relation to specific technological priorities, it is assumed that technological barriers are not the primary obstacles to achieving a 5 per cent reduction in Australian emissions by 2020. As the plan notes: 'Australia needs to transform its energy sector from its current high-pollution mix towards a greater reliance on clean energy sources. This is achievable' (p. 71).

The plan makes an important distinction between 'renewable energy' and 'clean energy', which includes gas and other low emissions co-generation technologies, as well as a potential role for CCS. CCS is not, however, eligible for funding through the initiatives covered in the plan.

There is a substantial focus on encouraging investment in technological innovation, research, development, demonstration and commercialisation. Key measures proposed to support technological innovation leading to the expansion of renewable energy and improved energy efficiency include:

- Clean Energy Finance Corporation: investing in renewable energy, low pollution and energy efficiency technologies (AU$10 billion)
- Australian Renewable Energy Agency: streamlined governance of government support for renewable energy innovation (AU $3.2 billion)
- Clean Technology Innovation Program: grants for R&D proof of concept and early stage commercialisation of clean technology
- Renewable Energy Target: ensuring that 20 per cent of Australia's electricity supply comes from renewable sources by 2020
- continuing existing support for clean energy innovation (AU $2 billion)
- the establishment of an Energy Security Fund and related actions to facilitate the closure of around 2000 MW of coal-fired power stations by 2020
- a national energy savings initiative providing incentives to encourage and reward energy efficiency.

Improvements in land-based emissions are to be achieved through a Carbon Farming Initiative (creating a system of tradeable credits for carbon sequestration and emissions reduction activities), a Carbon Farming Futures research and development program and the establishment of a $946 million Biodiversity Fund.

Economics and finance

The key policy mechanism for achieving the Australia Government's 5 per cent emissions reduction target is the introduction of a carbon price, initially set at AU$23 a tonne (commencing from July 2012). This will transition to a fully flexible price set through an emissions trading scheme on July 1 2015. The price will cover stationary energy, transport, industrial processes, non-legacy waste and fugitive emissions. Changes in fuel tax credits and excise will be used to set a carbon price for domestic aviation, domestic shipping, rail transport and non–transport fuel use. There will be no carbon price on household transport fuels, light vehicle business transport and off-road fuel use by agriculture, forestry and fishing industries. A carbon price for heavy on-road liquid fuels is foreshadowed for 2014.

The carbon price will be augmented with a range of programs designed to:

- encourage innovation and commercialisation of promising renewable energy and energy efficiency technologies
- assist emissions intensive and trade exposed industry sectors manage the transition to a clean energy economy
- support famers and land managers to reduce land-based emissions, improve carbon sequestration and encourage biodiversity.

The Australian plan assumes a continuation of current economic growth trends with no discussion of alternative growth or consumption patterns.

It is envisaged that the carbon price and related measures will raise approximately AU$25.5 billion in the period 2011–15. This will be augmented by a further $3.9 billion of new government expenditure.

Social equity

Intergenerational equity issues remain largely implicit, as does Australia's international obligations in contributing its 'fair share' of emissions reductions. While *Securing a Clean Energy Future* does not include specific reference to funding to assist developing countries achieve fair mitigation and adaptation outcomes, funding for this purpose has been announced in a range of related and subsequent commitments.

However, there is an extremely strong emphasis on minimising the impact of the carbon price on Australia households. Over 50 per cent of carbon price revenue will be spent on compensating households with a particular focus on pensioners, low and middle income earners. Treasury costings suggest that the carbon price will add to price increases for the average household of $9.90 per week with assistance of $10.10 per week to be provided to the average household.

Governance

A number of new institutions will be established to govern, manage and support the implementation of *Securing a Clean Energy Future*. These include:

- Climate Change Authority, to provide independent advice to government on future emissions targets and mechanisms
- Clean Energy Regulator, to administer the carbon pricing scheme
- Clean Energy Finance Corporation, to facilitate and encourage investment in renewable energy, low pollution and energy efficiency technologies
- Australian Renewable Energy Agency, to streamline governance and funding arrangements for encouraging the development and deployment of renewable energy innovation.

The Productivity Commission will also play an important role in reviewing industry assistance and taxation measures, as well as providing ongoing advice on comparable international emissions reduction initiatives.

A Low Carbon Communities program will be introduced to assist local communities and local government take action to improve energy efficiency and address social equity issues.

Social and political change

The Australian Government has been keen to argue that implementation of the measures contained in *Securing a Clean Energy Future* will have a very limited impact on the Australian economy and way of life, and will therefore require very limited social and political change.

Key references, sources and links

- Australian Government (2011a) *Securing a Clean Energy Future – The Australian Government's Climate Change Plan*, accessed Feb 2012 at http://www.cleanenergyfuture.gov.au/clean-energy-future/securing-a-clean-energy-future/
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Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply

Government of Germany

Source, aims and scope

The *Energy Concept* was developed by Germany's Federal Ministry of Economics and Technology and Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, and adopted by the German Government in September 2010. It constitutes the German Government's long-term strategy to 2050 for designing and implementing a national energy supply system that is considered environmentally sound, reliable and affordable.

The strategy begins by stating the need for Germany to 'radically transform' present energy supply structures in the medium to long term in order to achieve energy security, value for money and the country's climate protection targets. It aims to provide a 'development path' with a long-term orientation rather than concrete, specific steps, so as to maintain flexibility and allow for the incorporation of new technical and economic developments.

The strategy draws on a set of scenarios that reveal different pathways and conditions under which the targets can be achieved. It describes measures, many of which are already being implemented, in a range of key components or fields of action. These include: renewable energy; energy efficiency; nuclear and fossil-fuel power plants; an efficient grid infrastructure for electricity and integration of renewables; buildings; mobility; research into innovation and new technologies; energy supply in the European and international context; and issues of transparency and public acceptance.

Emissions reduction and energy targets

Germany has a target for cutting greenhouse gas emissions by 40 per cent by 2020 and at least 80 per cent by 2050 (on 1990 levels). It is acknowledged that the objectives of national energy, climate and budget policies need to be harmonised, but the *Energy Concept* deals only with energy supply and use. It specifies targets for the amount of renewable energy as a proportion of gross final energy consumption of 18 per cent by 2020, 30 per cent by 2030, 45 per cent by 2040, and 60 per cent by 2050. Targets are also specified for gains in energy productivity so that primary energy consumption is to be reduced from 2008 levels by 20 per cent by 2020, and 50 per cent by 2050.

Assumptions and priorities

Technology and innovation

The strategy emphasises the huge innovation potential associated with transforming Germany's energy supply structure. While it outlines the measures being undertaken to advance the transition, it also aims for flexibility to incorporate technological developments in the longer term.

Although the focus of the strategy is on the cost-efficient expansion of renewable energy sources and energy efficiency measures, it also considers the role of existing fossil fuel and nuclear power. Within the *Energy Concept*

document, nuclear power is considered a bridging technology and provision is made for the extension of the operating lives of Germany's seventeen existing nuclear power plants by an average of twelve years. Importantly, this aspect of the *Energy Concept* has since been overturned by the German Government, marking a dramatic shift in their position on nuclear power as a cornerstone to Germany's transition to renewable energy.[xli] The new approach is to phase out nuclear power as fast as possible.

The *Energy Concept's* main policy priorities, either planned or being implemented, include:

- continued amendments to existing policies to support solar photovoltaic power
- improving grid integration of renewable energy sources and acceleration of German energy grid expansion, including planning for a national target grid for 2050, integration with the European network, and increasing storage capacity
- faster expansion of offshore wind farming, including investment of €75 billion to boost capacity to 25 GW by 2030
- expansion of onshore wind farming, including improving the relevant legal and planning frameworks
- promotion of the sustainable use of bioenergy for heating, electricity and fuel, with measures to avoid conflict with land use or issues with efficiency
- targeted energy efficiency measures for households, industry and the public sector
- endorsement of testing of CCS technology in Germany and active support through research and development
- termination of subsidies for domestic hard coal
- upgrading the energy performance of building stock, in particular reducing demand from heating
- promotion of electric vehicles, in order to meet the goals of one million electric vehicles on German roads by 2020 and six million by 2030, and biofuels
- continued development of the National Hydrogen and Fuel Cell Technology Innovation Programme.

Economics and finance

The strategy strongly reiterates the role for market mechanisms as key drivers of energy sector transitions. Strengthening competition through liberalisation of electricity and gas markets remains a critical goal for the German government. At the same time, the strategy clearly implies a strong role for government to lay the foundations and set the rules for a future-oriented, market-based energy policy framework (p. 15).

There is a focus on cost-efficient expansion of renewable energy, with a strong emphasis on innovation to both bring down costs of more energy efficient technologies and facilitate new developments. The strategy incorporates a push to make the policy support for renewable energy more market-oriented and for the expansion of the sector to be driven to a greater degree by markets than it has previously been (p. 7).

Different pathways analysed as part of the development of the *Energy Concept* all assumed that additional investment, in the order of €20 billion per year, will be required to achieve Germany's 2050 emissions reduction targets. It is acknowledged that this level of investment will be offset by lower energy imports and energy cost savings, and will bring additional benefits in terms of job creation, growth and reinforcing Germany's competitiveness as leaders in environmental and energy-related technology (p. 5).

The strategy notes the need for harmonisation of its objectives with broader national climate and budget policies. While full details of how the policy is to be financed are not included, provision is made for the establishment of a new 'climate and energy' fund, supported by contributions from existing power plant operators and revenue, after 2013, from the auctioning of excess emission allowances.

Social equity

Although the strategy does not include a detailed discussion of its social equity implications, it does note that one of its guiding principles is the utilisation of modes of financing which ensure intergenerational fairness.

Governance

The *Energy Concept* is primarily a statement of the strategic priorities and measures being implemented by the German Government. It provides a framework intended to inform the actions of German businesses and households, but does not extensively discuss the roles of non-government actors in bringing about the energy transition.

The critical importance of aligning and strengthening European and international efforts to combat climate change is underlined within the strategy. It notes that the German Government is committed to working towards the establishment of reliable and effective international frameworks for climate protection and continued cooperation within the European region, including integration of the EU's electricity and gas markets and an interconnected EU electricity grid.

Social and political change

The strategy acknowledges that successfully achieving an energy transition in Germany of the nature described is ultimately dependent on the level of understanding and support of citizens. The document briefly describes the role of government in promoting public acceptance, including providing comprehensible information, ensuring transparency in decision making and creating opportunities for open public dialogue.

Key references, sources and links

- Federal Ministry of Economics and Technology and Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Government of Germany (2010) *Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply*, accessed Feb 2012 at http://www.bmu.de/files/english/pdf/application/pdf/energiekonzept_bundesregierung_en.pdf

Our Future Energy

Government of Denmark

Source, aims and scope

Our Future Energy is a package of energy policy initiatives developed and released by the Danish Government in November 2011. It represents the Government's contribution to negotiations in the Danish Parliament for an energy agreement up to 2020, but also covers a range of targets and milestones related to Denmark's energy sector in the period to 2050.

The initiatives presented in the *Our Future Energy* plan build on those put forward in the previous government's *Energy Strategy 2050: From coal, oil and gas to green energy*, released earlier in 2011,[xlii] which set out the guiding principles and immediate policy actions for the Danish Government to achieve its goal of a fossil-fuel-free national energy system by 2050.[xliii] *Our Future Energy* presents a higher level of ambition for the achievement of an energy system transition in Denmark, although the nature of recommended actions is closely aligned with the previous government's strategy.

Emissions reduction and energy targets

Denmark has committed to reducing its greenhouse gas emissions by 40 per cent by 2020 (on 1990 levels). Implementation of the initiatives for transitioning the energy sector put forward in *Our Future Energy* is expected to deliver the bulk of the 2020 emissions reductions (35 per cent).

Denmark also has a target, which forms the core objective of the *Our Future Energy* plan, to reach 100 per cent renewable energy in all energy supply (electricity, heat, industry and transport) by 2050. In order to meet this goal a number of interim targets have also been developed, including:

- by 2020:
  - wind power to meet half of all traditional consumption of electricity
  - renewable energy to account for 36 per cent of final energy consumption and 10 per cent of energy from transport
  - reduction of almost 14 per cent in gross energy consumption (relative to 2006).
- by 2030:
  - coal to be completely phased out from Danish power plants
  - oil burners (typically used in Danish buildings) to be phased out.
- by 2035:
  - all electricity and heat supply to be covered by renewable energy.

Assumptions and priorities

Technology and innovation

The goal of achieving a conversion of the Danish energy sector to 100 per cent reliance on renewable energy by 2050 without ruining the economy, is considered 'entirely possible technologically'. The plan notes that Denmark is already highly competitive in green technology and in a strong position to benefit from investing in further innovation.

The plan includes the following central elements for action, outlining a set of specific policy initiatives for each:

- more efficient energy consumption
- an electrified energy system (i.e. electrification of transport, industry and heating)
- intelligent electricity consumption, increased storage and cross-border trade in energy
- conversion to renewable energy in electricity and heat production:
    - especially wind power (both on and offshore)[xliv] as it is to cover 50 per cent of all electricity production by 2020 (from a base of 22 per cent in 2010).
    - wind power to be supplemented by other renewable energy technologies, such as solar PV and wave power.
- promotion of biogas
- conversion to renewable energy in heating, industry and transport:
    - including: no new buildings to have oil and gas-fired installations by 2013; requirement for 10 per cent biofuels in transport by 2020; and increased use of district heating and individual heating systems based on renewable energy.
- conversion of the transport sector, while not covered in detail, noted to be a strong focus between 2035 and 2050, involving electrification and biofuels, but possibly also hydrogen
- energy research, development, demonstration and innovation, including in solar and wave power technologies and the establishment of test environments such as Samsø, a 100 per cent renewable energy island.

Economics and finance

At the heart of *Our Future Energy* is an acceptance of the long-term economic benefits of switching to a renewable energy system and the need to make investments now in order to ensure Denmark can avoid increasing energy insecurity and price increases associated with fossil fuel energy sources.

> *We have to avoid becoming trapped with inefficient and non-renewable technologies. Otherwise we will be caught with an expensive and outdated energy sector in 30–40 years.* (p. 8)

The strategy assumes global energy supply constraints will worsen and an ongoing trend towards decarbonisation of national economies. It concludes that the best approach for Denmark is to establish a green growth economy and underscores the opportunities for participation in a rapidly growing market for renewable energy and energy efficiency technologies. The initial costs of a transition to renewables are acknowledged, but the fact that implementing the plan avoids higher costs in the longer term and constitutes an insurance policy against increasing energy prices is emphasised.

The cost of fully implementing the measures in *Our Future Energy* to 2020 is estimated to be DKK 5.6 billion, equivalent to around US$952 million.[xlv] This figure covers expenditure on energy efficiency improvements, expanded renewable energy supply, as well as the state revenue lost due to reduced fossil fuel use. On the other hand, the plan is expected to save DKK 6.9 billion in energy costs, and notes that immediate net costs will be less than 0.25 per cent of GDP in 2020 (p. 5).

The Danish Government describes three key sources of public financing for the plan:

- A 'security of supply' tax on all fuels to compensate state revenue losses due to reduced consumption of fossil fuels
- Public Service Obligation (PSO), which is a supplement to the price of electricity charged through electricity bills and also soon to be introduced for gas
- Grid tariffs, applicable to energy companies and passed on via bills to consumers.

Taken together, the additional cost for Danish households is expected to average around DKK 1,700 (approximately US$289) in 2020.

The economic benefits of undertaking the transition are noted to include:

- reduced expenses for fossil fuels
- positive effect on the global climate effort; Reductions in greenhouse gas emissions
- improved energy supply security for households
- immediate, positive impact on employment (taking effect in 2012–13)
- further growth and export opportunities in green products and technology.

Social equity

The plan is underpinned by acceptance that immediate investment in a transition to renewable energy is necessary to avoid higher future costs. It recognises that it is unacceptable for Denmark to leave a very large unpaid bill for future generations and that, as a wealthy country with a stable economy it can and must provide leadership. The implications of the plan for social equity within Danish society are not covered in the document.

Governance

Our Future Energy emphasises the need for Denmark to influence and encourage cooperation in the EU and beyond, outlining several initiatives to this effect, including continuing to play a constructive role in UN climate change negotiations. The plan deals primarily with government actions and does not discuss the role of other sectors of society.

Social and political change

Elements contributing to social and political acceptance of Denmark's energy transition are not described in detail as part of the *Our Future Energy* plan.

Key references, sources and links

- The Danish Government (2011) *Our Future Energy*, accessed Feb 2012 at http://www.ens.dk/Documents/Netboghandel%20-%20publikationer/2011/our_future_energy_%20web.pdf

Climate Change Scoping Plan *and* California's Clean Energy Future

Government of California

Source, aims and scope

The *Climate Change Scoping Plan* was produced for the state of California by the California Air Resources Board. It was approved in 2008 and again, in an amended and updated version, in August 2011. The complementary implementation plan, *California's Clean Energy Future* (CCEF), was produced as a collaborative project by a range of Californian Government agencies, led by the *California Air Resources Board* and published in September 2010.[xlvi]

The *Climate Change Scoping Plan and CCEF Implementation Plan* are the Government of California's roadmaps for achieving the greenhouse gas emissions reduction targets set in the *Californian Global Warming Solutions Act 2006* (AB 32). The *Scoping Plan* is a high-level, comprehensive framework describing measures to be taken to reduce California's emissions across all sectors of its economy. The CCEF plan provides detail specifically relating to the transition of the Californian electric power sector. The following summary draws on key priorities from both documents.

Emissions reduction and energy targets

California's emissions reduction targets include reducing emissions to 1990 levels by 2020 and to 80 per cent of 1990 levels by 2050.[xlvii] The state has also adopted a target of providing 33 per cent of electricity from renewable energy sources by 2020.

Assumptions and priorities

Technology and innovation

The *Scoping Plan* emphasises the importance of technological innovation, noting that California's ambitious climate change policies have already helped establish the state as a leader in green technology research and development, attracting significant venture capital investment.

Taken together, the *Scoping Plan* and CCEF draw attention to a number of key priorities and measures for California to implement. These include:

- energy efficiency
    - energy efficiency improvements are California's highest priority means for reducing emissions
    - California aims to reduce electricity use (13,200 to 18,000 gigawatt hours (GWh)) and natural gas use (800 million therms) by 2020
    - key commitments include regulatory measures and large-scale, long-term investment to improve building and appliance efficiency across residential, commercial and agricultural sectors

  - key measures include retrofitting programs; zero emissions standards for new buildings; accelerating the introduction of Combined Heat and Power (CHP) generation; supporting the roll out of solar hot water heating technology and the achievement of a 'zero waste' economy.

- energy sources
  - Renewable Electricity Standard, approved in October 2010, requiring all electricity producers to phase in the use of qualifying renewable electricity, reaching 33 per cent by 2020[xlviii]
  - action to achieve this target will be supported by feed-in tariffs; incentives and subsidies to support the accelerated rollout of wind and solar technology; and accelerated processes for approving sites for renewable energy projects
  - Californian Solar Initiative, implying a strong commitment to distributed energy systems including a target of achieving one million solar rooftops by 2020
  - 5,000 MW of installed renewable distributed generation state-wide at the right locations on the power grid to support reliability and provide economic value
  - natural gas generation is to continue to be essential
  - research into CCS technology and development of at least one large-scale CCS generating facility in California
  - Emissions Performance Standards for conventional power plants and phasing-out 'once through cooling' (OTC).[xlix]
- transport
  - full implementation of new car emissions regulations (introduced by the Air Resources Board in 2004) leading to a reduction, by 2016, of 30 per cent of emissions from this source, compared to the 2002 fleet[l]
  - Low Carbon Fuel Standard designed to reduce the carbon intensity of California's transportation fuels by 10 per cent by 2020[li]
  - developing enough charging stations at home, work, and in public areas to accommodate one million electric and hybrid vehicles
  - expanding the Californian high-speed rail system.
- Energy transmission, distribution and storage
  - Renewable Energy Transmission Initiative, initially approved in 2007, providing a state-wide conceptual plan for enabling rapid transition to electricity sourced from renewable energy
  - 1,000 MW of additional storage capacity to be brought into the electricity system by 2020
  - investment in advanced metering, smart grid technology and dynamic pricing programs.

Other measures flagged in the *Scoping Plan* include addressing emissions from industrial processes, forest carbon sequestration measures, and more energy and fuel efficient agricultural practices, reducing methane emissions from landfill and moving towards zero waste systems.

Economics and finance

Implementation of the Californian *Climate Change Scoping Plan* involves an integrated package of market-based mechanisms (notably the Cap and Trade scheme), regulatory measures, consumer and business incentives and subsidies, as well as feed-in-tariffs.

The Californian Cap and Trade scheme signed off by the Air Resources Board in October 2011 will establish a declining level of emissions permits designed to ensure that the state achieves its 2020 emissions goal. California is also working with partner jurisdictions to link 'cap and trade' programs in order to maximise the efficiency and

cost effectiveness of the scheme.

Economic analysis included in the *Scoping Plan* points to the following specific benefits of its implementation to be realised in California by 2020 (compared to business-as-usual):

- increased economic production of US$33 billion
- increased overall gross state product of US$7 billion
- increased overall personal income by US$16 billion
- increased per capita income of US$200
- increased jobs by more than 100,000.

There is also discussion of additional benefits including better air quality and public health outcomes.

Ongoing costs for the Air Resources Board and other state agencies to implement the measures included in the *Scoping Plan* are estimated at around US$36 million per year. A range of financing mechanisms are canvassed for redirecting revenue collected via the Cap and Trade scheme and other components of the plan to meet the funding requirements, including the establishment of a California Carbon Trust to manage public funds and leverage additional private funds.

Social equity

The social equity implications of the measures are not discussed in detail in the plan, although it is noted that implementation of the plan will be saving low and middle income households hundreds of dollars each year by 2020, primarily due to energy efficiency improvements.

Governance

A coordinated, integrated approach to governance and policy implementation is a key feature of the Californian Government's planning for emissions reduction. The *CCEF Implementation Plan* and its accompanying Inter-Agency Roadmap[lii] includes detailed mapping of key elements required to achieve its objectives including: one-off and cyclical activities; metrics; decision and course correction points; outputs; dependencies; and critical inputs.

While the plans focus primarily on the actions of State Government and partnering local authorities, there is also emphasis given to the important role of business groups and communities in taking action. It notes that 100 Californian cities and counties have signed the US Conference of Mayors Climate Protection Agreement, and that 350 companies, municipalities, community organisations and corporations are members of the Climate Action Registry which requires reporting of GHG emissions on annual basis.

The Californian Government is also committed to playing a leadership role beyond its jurisdiction, working towards stronger regional coordination. The state is an active member of the *Western Climate Initiative*,[liii] which involves Canadian, Mexican and US provincial level governments and aims to maximise collaboration and innovation in the development and implementation of renewable energy and energy efficiency.

Social and political change

The *Scoping Plan* clearly acknowledges that the active participation of the people of California will be essential to the implementation of the emissions reduction measures described. It suggests that 'shifts in individual choices and attitudes drive changes in the economy and in institutions' (p. 99), emphasising the role for market forces and growing environmental awareness. Alongside this, the *Scoping Plan* calls for targeted public outreach, marketing and education programs, including, for example, energy efficiency-related workforce programs and the

development of online toolkits to provide information about technical and financial resources for small and medium-sized businesses.

Key references, sources and links

- California Air Resources Board (2008) *Climate Change Scoping Plan*: *A framework for change (Pursuant to AB 32, The California Global Warming Solutions Act of 2006),* prepared for the State of California, accessed Feb 2012 at http://www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm
- State of California (2010a) *California's Clean Energy Future Implementation Plan*, accessed Feb 2012 at http://www.cacleanenergyfuture.org/documents/CCEFImplementationPlan.pdf
- State of California (2010c) *California's Clean Energy Future: An overview on meeting California's energy and environmental goals in the electric power sector in 2020 and beyond,* accessed Feb 2012 at http://www.cacleanenergyfuture.org/documents/CACleanEnergyFutureOverview.pdf

3. Lessons from post carbon economy transition strategies

Comparative analysis of the key features of the post carbon economy transition strategies considered in this report leads to the following reflections on key lessons and implications.

3.1. Emissions reduction, energy demand and energy supply targets

Table 6 provides an overview of the global temperature, emissions reduction and renewable energy targets for all of the summarised strategies and plans. Key lessons and implications include the following:

3.1.1. The most ambitious strategies produced by non-government sources aim for emissions reduction and renewable energy targets broadly consistent with limiting global temperature rise to below 2°C above pre-industrial levels. However, further work is required to sharpen understanding of the relationship between emissions reductions and global temperatures, and to specify detailed policy priorities and implementation strategies.

3.1.2. While some government-authored strategies (from industrialised countries) include 2050 emissions reduction targets of 80–100 per cent, few of them yet provide a clear pathway for achieving the scale and scope of emissions reductions required by 2020 in order to meet 2050 targets.

3.1.3. The Australian Government's current target of reducing GHG emissions by 5 per cent by 2020 on 2000 levels clearly remains far from the speed and scale required, and from the targets being set by a range of comparable industrialised economies. It is unclear how its immediate actions relate to the longer term target of 80 per cent emissions reductions by 2050.

3.1.4. The wide variety of terms used to communicate emissions reduction and energy targets makes comparison between strategies difficult and is an ongoing barrier to effective communication to broader, non-technical audiences. It may be particularly useful for transition plans and strategies to consistently report on periodic 'carbon budgets' and annual rates of decarbonisation.

3.1.5. Key research priorities include further clarification and communication of scientifically informed knowledge about the global, national and local emissions reduction, energy consumption, renewable energy and carbon sequestration targets required to significantly reduce the risk of runaway climate change.

Table 6: Emissions reduction and energy targets and timetables in selected post carbon economy transition strategies

Strategy or plan	Key emissions reduction and energy targets and timetables
Non-government	
World in Transition	Decarbonise global energy system by 2050 Global carbon budget of 750 Gt CO_2 by 2050 for a two-thirds chance of staying within 'guardrail' of

	2°C above pre-industrial global temperature
World on the Edge	Cut global CO_2 emissions by 80% by 2020 Need to peak atmospheric concentrations at 400 ppm CO_2 by 2020, then decline to 350 ppm
Our Choice	Rapid reduction to 350 ppm CO_2
One Degree War Plan	Limit global temperature rise to <1°C above pre-industrial levels by 2100 Reduce global GHG emissions by 50% over 5 years; to zero over 15 years; and negative emissions of 6 Gt CO_2e/year for rest of century
Powering a Green Planet	Global energy system powered by 100% renewable energy (wind, water and solar sources) by 2030
The Energy Report	Limit global temperature rise to 1.5°C above pre-industrial levels Peak and decline in global GHG emissions within 5 years and an 80% reduction by 2050 (on 1990 levels) 100% renewable energy by 2050
Zero Carbon Britain 2030	Limit global temperature rise to <2°C above pre-industrial levels Reduce UK net GHG emissions to zero by 2030
Climate Works Low Carbon Growth Plan for Australia	25% reduction in Australian GHG emissions by 2020
Zero Carbon Australia Stationary Energy Plan	Zero net GHG emissions in Australia by 2020 Enable a two-thirds chance of limiting global temperature rise to 2°C above pre-industrial levels 100% of Australian stationary energy from renewables by 2020
Government	
European Commission: Roadmap 2050	Limit global temperature rise to <2°C above pre-industrial levels Reduce EU GHG emissions by 80–95% by 2050 (on 1990 levels) By 2020: 20% reduction in GHG emissions; 20% increase in share of renewable energy; 20% increase in energy efficiency
UK: Carbon Plan	Reduce UK GHG emissions by 34% by 2020 and 80% by 2050 (on 1990 levels) >30% UK electricity from renewables by 2020
South Korea: Green Growth Strategy	Reduce Korean CO_2e emissions by 30% below projected emissions growth by 2020 (equivalent to 4% reduction on 2005 emissions levels) 6% share of renewables in Korean energy supply by 2020
China: 12th Five-Year Plan & Climate Change White Paper	Reduce Chinese emissions intensity (CO_2 emissions per unit of GDP) by 40–45% by 2020 (on 2005 levels) Reduce Chinese energy intensity (energy consumption per unit of GDP) by 16% by 2015 (on 2010 levels) Increase proportion of non–fossil energy sources to 11.4% of total energy consumption by 2015
India: National Action Plan & Low Carbon Growth Report	Reduce India's emissions intensity of GDP by 20–25% by 2020 (on 2005 levels) Ensure that Indian per capita emissions never exceed the level of per capita emissions in developed countries

Australia: Clean Energy Future	Reduce Australian GHG emissions by 5% by 2020 and 80% by 2050 (on 2000 levels) 20% of Australian electricity from renewables by 2020 30% improvement in energy efficiency between 2020 and 2030
Germany: Energy Concept	Reduce German GHG emissions by 40% by 2020 and at least 80% by 2050 (on 1990 levels) Renewable energy as proportion of gross final energy consumption of 18% by 2020, 30% by 2030, 45% by 2040, and 60% by 2050 Primary energy consumption reduced by 20% by 2020 and 50% by 2050 (on 2008 levels)
Denmark: Our Future Energy	100% renewable energy in all Danish energy supply by 2050 By 2020: Wind power to meet half of electricity consumption; renewables to meet 36% of final energy consumption and 10% of transport energy; gross energy consumption reduced by almost 14% (on 2006 levels) By 2030: Complete phase-out of coal power and oil burners By 2035: All electricity and heat supplied by renewable energy
California: Scoping Plan and Clean Energy Future Plan	Reduce GHG emissions to 1990 levels by 2020 and to 80% of 1990 levels by 2050 Provide 33% of electricity from renewable energy by 2020

3.2. Technology and innovation implications and priorities

Table 7 provides an overview of the technological assumptions and priorities for all of the summarised strategies. Key lessons and implications include the following.

3.2.1. Technological barriers are not the major obstacles to the transition to a post carbon economy at the speed and scale required to significantly reduce the risk of runaway climate change.

3.2.2. The overall suite of technological and systemic changes needed to achieve a just and sustainable post carbon future is now well understood. It includes:

- rapid reductions in energy consumption and improvements in energy efficiency
- rapid replacement of fossil fuels by renewable energy
- draw down and sequestration of carbon into sustainable carbon sinks
- implementation of policies needed to ensure fair and timely adaptation.

3.2.3. It will be vital to tailor energy efficiency and energy supply solutions to maximise their potential in specific national and regional contexts.

3.2.4. Important differences in approach between strategies include the extent to which they assume that behavioural and cultural change can drive large-scale reduction in consumption and energy usage and the assumptions made about the potential speed and scale of innovation and commercialisation of different technologies.

3.2.5. While most non-government-authored strategies do not support nuclear energy, some government-authored strategies continue to assume a transitional, ongoing or expanded role for nuclear energy.

3.2.6. While some strategies (especially government-authored) continue to prioritise CCS as a way to continue to use fossil fuels, there is considerable scepticism, largely within non-government-led strategies, about the extent to which CCS is likely to become technologically and financially viable in the near future.

3.2.7. The most promising solutions for reducing energy consumption and increasing energy efficiency include:

- information, education and social marketing programs
- zero waste economy and 'cradle to cradle' product design systems
- energy efficient buildings and planning
  - retrofit existing buildings to maximise energy efficiency
  - zero emissions standards for new buildings
  - maximise insulation
  - wide rollout of passive solar, combined heat and power and decentralised heating and cooling systems
  - improve efficiency of all heating, cooling, lighting and appliances
  - integrated land use, housing and transportation planning to reduce distances travelled and facilitate the shift to energy efficient transport.
- energy efficient industry
  - investment in resource and energy efficient industrial processes and equipment
  - reduce impact of energy intensive industries (e.g. aluminium, cement, iron, plastics)
  - upgrade inefficient electric motors, lighting and heating systems
  - recycle heat energy from electricity generation through co-generation
  - reduce fugitive methane emissions from mining
  - improve recycling and abatement technologies for non-CO_2 emissions.
- energy efficient transport
  - set and achieve higher vehicle fuel economy standards
  - reduce carbon intensity of transportation fuels
  - reduce distances travelled through urban planning, traffic congestion taxes, increased use of video conferencing, etc
  - replace fossil fuel cars with electric and plug-in hybrid vehicles
  - improve access to electric vehicle charging stations
  - encourage a shift from private cars to public transport, high speed rail, bicycles and walking
  - expand use of second-generation biofuels (e.g. algal biodiesel and lingo-cellulosic ethanol)
  - hydrogen (from renewable electricity) to be used for some shipping
  - significantly reduce airline travel.

3.2.8. The most promising solutions for promoting a rapid shift from fossil fuels to renewable energy include:

- significantly expanding innovation, investment and deployment in the following energy sources:
  - solar: concentrated and photovoltaic (PV)
  - wind: on- and off-shore
  - wave and tidal
  - hydroelectricity
  - geothermal: directly to heat buildings and at high temperatures for electricity generation
  - bioenergy: traditional biomass; sustainable residues and waste; sustainable energy crops; and sustainable algaes
  - use of spare wind, water and solar energy to produce electrolytic hydrogen
  - liquefied hydrogen combustion for aircraft.
- designing and building interconnected 'smart' grids.

3.2.9. The most promising solutions for reducing land use emissions and improving the role of land use in carbon sequestration include:

- reducing livestock production and consumption
- increasing local food production and distribution
- reducing cropland soil emissions: reducing tillage; improving fertiliser and nutrient management; and restoring degraded farmland

- improving pasture and grassland management: optimising grazing intensity; expanding planting of deep-rooted perennial grasses; and improving fire management
- reducing livestock emissions: active livestock feeding; anti-methanogenic treatments; and improving manure management
- bio-gasification of organic manure; capture or burning of agricultural methane
- more efficient use of on-farm energy and fuel
- cropland carbon sequestration
- ending and reversing deforestation
- improving forest management (weed and pest control).

Table 7: Technology and innovation assumptions and priorities in selected post carbon economy transition strategies

Strategy or plan	Key technology and innovation assumptions and priorities
Non-government	
World in Transition	Concludes that technologies required for decarbonising global energy system already exist or are under development **Energy efficiency** Priorities include: electro-mobility, building insulation, heat pumps, industrial efficiency measures and lower emissions fuels **Energy supply** • Need for massive extension of renewable energy sources • Nuclear power is rejected • CCS not ruled out **Land use** Priorities include: sustainable urbanisation, ending deforestation, 'climate friendly' agriculture and eating habits
World on the Edge	Argues that access to appropriate technology is not the major barrier to achieving rapid decarbonisation **Energy efficiency** Energy efficiency measures to more than offset projected growth in global energy use to 2020 **Energy supply** • 90% of fossil-fuel-generated electricity replaced with renewable energy between 2008 and 2020 • 4,000 GW of wind generating capacity to be developed around the world by 2020 (more than half global electricity consumption) • 200,000 MW of solar thermal power plant capacity installed worldwide by 2020 • Geothermal power technology enabling production of 200,000 MW of electricity by 2020 • Expansion of hydroelectric power from 980 GW in 2009 to 1,350 GW by 2020 • Nuclear power and CCS not in energy supply mix
Our Choice	Argues that wide variety of possible solutions reveal technology is not a barrier to action at climate change at speed and scale required **Energy efficiency** • Recycle wasted heat energy from electricity generation through gas-powered co-generation • Upgrade inefficient industrial electric motors; lighting and heating systems; and appliances

	• Adequate insulation in all buildings • Higher vehicle fuel economy standards **Energy supply** • Considers costs, benefits and challenges related to: solar thermal, solar photovoltaic, wind, geothermal, biomass, CCS and nuclear • Large-scale investment in 'super grids' **Land use** • Significant investment in forest and soil sequestration • Considers role for biochar
One Degree War Plan	Argues that achieving 'one degree' target is technologically possible **Energy efficiency** • Retrofit buildings (insulation, combined heat and power) • Limit aluminium, cement, iron, plastics and forest production • Replace fossil fuel cars with electric vehicles. • Reduce airline capacity by 10% p.a. • Recycle all used materials • Reduce consumption through social marketing **Energy supply** • Close 1,000 dirty coal power stations • Retrofit 1,000 coal-fired power plants with CCS • Erect wind turbine or solar plant in every town of more than 1,000 • Create large-scale wind and solar farms **Land use** • Capture or burn agricultural methane • Reduce livestock production and consumption • Bind 1 Gigatonne of CO_2 in soil • 50% reduction in deforestation
Powering a Green Planet	Concludes that it is technologically feasible for the world to be powered by 100% renewable energy sources (wind, water and solar only) by 2030 Considered only technologies proven or close to proven at large-scale, with near-zero lifecycle GHG emissions, without significant waste disposal or terrorism risks, and using primary resources which are indefinitely renewable or recyclable **Energy Efficiency** Efficiency measure, especially electrification, assumed to reduce global energy demand below projected 2030 levels **Energy supply** • Energy mix focuses on wind (51%), solar (40%) (photo-voltaic and concentrated); water (wave, hydro, tidal and geothermal) • Battery and hydrogen fuel cell vehicles • Hybrid hydrogen fuel cell systems for ships • Liquefied hydrogen combustion for aircraft • Heat pump air heaters for water and air heating • Use of spare wind, water and solar energy to produce electrolytic hydrogen • Combustion of electrolytic hydrogen for high temperature industrial processes • Interconnected, long-distance transmission lines • Nuclear, coal with CCS, ethanols, biodiesels, biomass, biofuels and gas not included in energy supply mix
The Energy Report	Energy scenario developed shows one possible technical pathway to reach 95% renewable energy globally by 2050 **Energy efficiency** • Assumes 2050 global energy demand can be reduced by 15% below 2005 levels through

	increased energy efficiency and electrification. • Priorities include: o more recycling and energy efficient industrial processes o retrofitting buildings (insulation, heat pumps, passive solar design) o shift to rail and human powered transport; Plug-in hybrids and electric vehicles, Reduce aviation travel, Hydrogen (from renewable electricity) for some shipping **Energy supply** • Wind: onshore and offshore • Water: hydropower, wave and tidal • Solar: photovoltaic; concentrated solar power • Geothermal: directly to heat buildings and at high temperatures for electricity generation • Bioenergy: traditional biomass; sustainable residues and waste; sustainable energy crops; sustainable algaes • Smart grids • Nuclear and CCS not included in mix • 5% fossil fuel energy sources (coal, gas and oil) to remain by 2050 to perform certain industrial processes
Zero Carbon Britain 2030	Technological change seen as crucial but not sufficient, without significant behaviour change, to achieve the ZCB2030 vision **Energy efficiency** • UK energy use to decrease by over 50% by 2030 without reduction in services • Retrofitting existing buildings plus maximise energy efficiency in new construction • Electrification of transport; shift away from private cars **Energy supply** • Rapid transition from fossil fuel to renewable energy and biomass • Strong reliance on offshore wind • Emphasis on national scale actions plus strong support for small scale renewable energy networks • Excludes CCS and new nuclear power **Land use** • Decreased production of livestock products
Climate Works Low Carbon Growth Plan for Australia	Focused on technologies that are 'commercially available, or on the path to commercialisation' **Energy efficiency** • Opportunities include: o industry: encourage investment in new technologies (e.g. in aluminium smelting), reduce fugitive methane emissions from mines o buildings: increase energy efficiency of new commercial and residential buildings (e.g. design and orientation, insulation, heating, ventilation and cooling, efficiency of lighting and appliances); energy waste reduction (e.g. remove unnecessary or unused equipment) o transport: improve efficiency of internal combustion engines; hybrid and electric vehicles o power: improved coal and gas plant thermal efficiencies; reduced transmission and distribution losses **Energy supply** Opportunities include: shift from coal to gas; onshore wind; solar thermal power with storage; geothermal; CCS; co-generation (combined heat and power); biofuels (e.g. second-generation biofuels such as algal biodiesel and lingo-cellulosic ethanol) **Land Use** Opportunities include: • forestry: reforestation/reduced deforestation; improved forest management (weed and pest control) • agriculture: reduce cropland soil emissions (reduce tillage, improve nutrient management);

	reduce livestock emissions (active livestock feeding, anti-methanogenic treatments; Improve pasture and grassland management (optimise grazing intensity, deep-rooted perennial grasses, fire management, improved fertiliser use); cropland carbon sequestration; degraded farmland restoration
Zero Carbon Australia Stationary Energy Plan	Concludes that achieving 100% renewable energy-powered stationary energy sector in Australia within a decade is technologically possible Considers only existing, commercially available technologies **Energy efficiency** Assumes 2020 energy demand is half that of business as usual projections for Australia. Met through efficiency technologies and fuel switching – from fossil fuels to electricity from renewable sources **Energy supply** • Concentrated solar thermal power towers with molten salt heat storage to meet 60% of demand • Wind power to meet 40% of demand • Crop waste biomass and hydroelectricity to provide back-up • National energy grid to flatten demand peaks, integrate renewable energy sources and provide reliable supply • Excludes nuclear, CCS and natural gas
Government	
European Commission: Roadmap 2050	Assumes wider set of cost-effective technologies will become available over time Emphasises need for investment in R&D and early deployment of low carbon technologies **Energy efficiency** • New buildings from 2021 to be nearly zero-energy • Refurbish existing building stock • Heat pumps, storage heaters, solar heating, biogas, biomass, district heating systems • Resource and energy efficient industrial processes and equipment, Recycling and abatement technologies for non carbon dioxide emissions • Improve fuel efficiency • Congestion pricing and 'Intelligent city' planning. • Electrification of transport and heating • Hybrid and electric vehicles **Energy supply** • Renewables target of 75–80% by 2030, nearly 100% by 2050 • Broad deployment of CCS **Land use** • Efficient fertiliser use; bio-gasification of organic manure • Improved manure management; better fodder • Local diversification of production • Improved livestock productivity
UK: Carbon Plan	Emphasises importance of technological innovation to reduce costs of low carbon transition Scenarios used due to uncertainty about which technologies will be most important over next decades **Energy efficiency** Major focus on efficiency measures including: retrofitting existing homes (insulation; air and ground source heat pumps); district heating networks; tougher building standards; electric batteries, hydrogen fuel cells and plug-in hybrid to cut vehicle emissions; encouraging modal shift to public transport, rail freight; more efficient industrial processes; reducing waste **Energy supply** • Gas and nuclear to continue to play a role

	• CCS assumed to be fitted to all fossil fuel power stations in 2050 • Renewable energy largely from offshore wind and marine sources • Electricity grid upgrade and extension • Sustainable biofuels for transport energy • Generating heat and power from waste treatment **Land use** Focus on improved crop nutrient management, improved livestock productivity, efficiency in on-farm use of energy and fuel, expansion of woodland cover
South Korea: Green Growth Strategy	Green technology considered a crucial pillar of Korean economy in medium to long term **Energy efficiency** • Energy efficiency improved from 0.317 toe/US$1,000 in 2009 to 0.233 toe/US$1,000 in 2020 • Increase mass transit (from 50% in 2009 to 65% in 2020); bicycles (from 1.5% in 2009 to 10% in 2020); hybrid electric vehicles; strengthened fuel efficiency and Renewable Fuel Standards • Efficiency ratings; incentives for green buildings, green building codes for public buildings; stricter heat insulation standards **Energy supply** • Share of renewable energy from 2.7% in 2009 to 6.08% in 2020 • Key priorities: bioenergy (install 48 facilities by 2013); wind; solar thermal; tidal (from nil in 2008 to 5.2 % in 2020); hydroelectricity (42 hydro plants); solar PV; geothermal • Increased share of nuclear energy from 26% in 2009 to 32% in 2020 • Smart grid system by 2030 **Land use** • Green urban planning measures and expansion of nature reserves • Water and ecological infrastructure projects (e.g. Four Major Rivers Restoration Project')
China: 12th Five-Year Plan and Climate Change White Paper	Strong focus on building technological development and innovation capacity, especially in strategic emerging industries, including new energy, energy conservation and clean energy vehicles **Energy efficiency** • Target to reduce energy consumption per unit of GDP by 16 per cent in the period 2010–2015 • Promotion of energy conservation in key sectors of industry, construction, transport and residential buildings, including target to retrofit 35% of homes in northern provinces by 2015 and energy efficiency program targeting 'Top 10,000' companies • Closure of inefficient power and industrial facilities **Energy supply** • Share of non-fossil energy sources to increase to 11.4% of total energy consumption by 2015 (includes both nuclear and renewables) • Accelerated development of 'clean coal' technology • Promotion of rapid growth in natural gas output • Accelerated development and utilisation of non-conventional oil-gas resources (including coal-bed gas and shale gas) • Accelerate development of nuclear power and construction of projects with a total installed capacity of 40 GW • Construction of 120 MW of new hydropower projects • Construction of at least 70 GW of new wind farms (including onshore, coastal and offshore) • Construction of 5 GW of new solar farms • Accelerated construction of power transmission channels, trials of intelligent power grid technologies, and construction of electric vehicle charging facilities • Rollout of 300 million smart meters by 2018 (around 70 million were installed in 2011 alone) **Land use** • Increased acreage of new forests by 12.5 million hectares by 2015, with the forest coverage

	rate increased to 21.5 per cent • Pilot projects in carbon sink afforestation and measures to increase areas of farmland and grassland carbon sinks • Protective farming projects and converting grazing area back to grassland
India: National Action Plan & Low Carbon Growth Report	**Energy efficiency** • Strong focus on energy efficiency measures albeit in context of dramatic projected increases in energy demand driven by strong economic growth scenarios • Measures to improve energy efficiency include: increasing adoption of more energy efficient domestic and commercial appliances (seen as the biggest area for energy savings); enforcement of the Energy Conservation Building Code; improved efficiency in agriculture (e.g. replacing inefficient motors in irrigation pumps); improved efficiency in industry, particularly iron, steel and cement manufacturing; and upgrading existing inefficient coal power plants (based on sub-critical technology) to operate at higher temperatures (super-critical) **Energy supply** • Coal to continue to be the main source of power in 2020, with current coal-based power generation assumed to expand to 230 GW by 2020. Technologies not yet available at scale or considered too costly including ultra-super critical power plants, Integrated Coal Gasification Combined Cycle (IGCC) and carbon capture and sequestration (CCS), to be monitored • Gas generation capacity could grow to 25,000 MW by 2020, despite uncertainty about availability and competing demand for use in other sectors • Hydropower almost fully exploited but could grow to 50,000–65,000 MW by 2020. • Wind could see increased capacity to 30,000 MW by 2020 • Biomass considered promising for rural decentralised generation and could contribute at least 4,000 MW • Solar – including both centralised and decentralised technologies – seen as critical for India's long-term energy security. It is being pursued through the National Solar Mission and could grow to 20,000 MW by 2020 • Nuclear power forecast to grow from the current installed capacity of 4,780 MW to up to 17,500 MW by 2020 **Land use** Afforestation activities through the Green India Mission seen as crucial to enhancing carbon sequestration in India
Australia: Clean Energy Future	Technological aspects of transition not the primary focus of the plan, but assumed not to be a barrier to achieving 'greater reliance on clean energy sources' Emphasis on encouraging investment in technological innovation, R&D and commercialisation of clean energy **Energy efficiency** National energy savings initiative to encourage and reward energy efficiency **Energy supply** • Emphasis on 'clean energy' including renewable energy, gas, CCS • Facilitation of closure of 2,000 MW of coal-fired power by 2020 **Land use** Carbon Farming Initiative to create system of tradeable credits for carbon sequestration and emissions reductions in agriculture
Germany: Energy Concept	Emphasis on innovation potential related to transition of energy supply structure Aims for flexibility to incorporate future technological developments **Energy Efficiency** • Targeted energy efficiency measures for households, industry and the public sector • Upgrading building stock, reducing demand from heating • Promotion of electric vehicles – to meet target of one million on German roads by 2020

	Energy supply • Solar photovoltaic power • Faster expansion of offshore wind farming • Expansion of onshore wind farming • Sustainable use of bioenergy for heating, electricity and fuel • Testing of CCS technology • Termination of subsidies for domestic hard coal • Grid integration of renewable energy sources • Nuclear power no longer seen as bridging technology • Improved grid integration for renewables, integration with European network, and increased storage capacity
Denmark: Our Future Energy	Converting Danish energy system to 100% renewable energy by 2050 seen as 'entirely possible technologically' **Energy efficiency** • Electrification of transport, industry and heating • Conversion of the transport sector involving electrification and biofuels, but possibly also hydrogen **Energy supply** • Wind power (both on and offshore) to cover 50 per cent of all electricity production by 2020 (from a base of 22 per cent in 2010) • Solar PV, wave power, and biogas • Intelligent electricity consumption, increased storage and cross-border trade in energy • Increased use of district heating and individual heating systems based on renewable energy • No new buildings to have oil and gas-fired installations by 2013 • Establishment of test environments such as Samsø, a 100% renewable energy island
California: Scoping Plan and Clean Energy Future Plan	Emphasises importance of technological innovation **Energy efficiency** • Regulation and investment to improve building and appliance efficiency • Retrofitting of existing buildings; zero emissions standards for new buildings • Accelerate combined heat and power generation • Solar hot water heating technology • 'Zero waste' economy • Full implementation of new car GHG emissions regulations; a low carbon fuel standard to reduce carbon intensity of transportation fuels by 10 % by 2020; improve access to electric vehicle changing stations; expand high-speed rail **Energy supply** • Cap and trade to drive declining level of emissions permits • A renewable electricity standard requires all electricity producers to phase in use of qualifying renewable electricity (33% by 2020) • Feed in tariffs • Incentives and subsidies to support accelerated rollout of wind and solar technology • Accelerated approval process for siting of renewable energy projects • Aim of one million solar rooftops by 2020 • Significant investment in high voltage transmission network and smart grids; increased transparency of hourly pricing **Land use** • Forest carbon sequestration measures • More energy and fuel efficient agricultural practices • Reducing methane emissions from landfill and moving towards zero waste systems

3.3. Economic policy and financial implications and priorities

Table 8 provides an overview of the economic policy assumptions and priorities for all of the summarised strategies. **Table 9** provides an overview of assumptions about financial costs and funding mechanisms. Key lessons and implications include the following:

3.3.1. The financial costs and social impacts of economic and industry restructuring represent significant but not insurmountable obstacles to the transition to a post carbon economy at the speed and scale required to significantly reduce the risk of runaway climate change.

3.3.2. Many strategies note the importance of strengthening understanding of the financial, economic and social costs of failing to take action to reduce emissions – and of the multiple employment, health and social equity co-benefits of a swift transition to a post carbon economy.

3.3.3. All of the strategies include some mix of market-based and regulatory policies to be implemented by governments. Most also include a range of more direct government incentives and actions to improve energy efficiency and shift energy production and consumption away from fossil fuels to renewable energy.

3.3.4. Regulatory, taxation and financial incentive policies commonly recommended in the strategies include:

- regulations and/or taxes designed to reduce fossil fuel use in transport (e.g. cars, aviation and shipping) and fossil fuel-intensive industries (e.g. aluminium, cement, iron and plastics)
- strong, binding energy efficiency standards for buildings, vehicles and energy consuming products
- tax incentives, low interest loans and loan guarantees to encourage investment in renewable energy enterprises and R&D.

3.3.5. There is strong ongoing support for both 'cap and trade' and carbon tax policies for setting a price on carbon. A number of the strategies that are more focused on science-based timeframes for transition note that a rapid increase in the global carbon price (towards US$100–US$200 a tonne) is likely to be required if the price of carbon is to be the primary mechanism driving the transition to post carbon economy.

3.3.6. Some strategies remain cautious of over-reliance on carbon pricing, placing stronger emphasis on additional measures to drive a rapid transition from fossil fuels to renewable energy including:

- elimination of all fossil fuel subsidies
- introduction of feed-in tariffs
- regulation, and sometimes funding, to close fossil fuel power stations
- binding renewable energy targets.

3.3.7. Those strategies that call for rapid renewable energy deployment highlight the fundamental difference in the economics of renewable energy compared to existing fossil fuel-based energy systems, particularly when considered in the medium to long term. Building renewable energy infrastructure requires significant upfront investment, but costs are decreasing rapidly and will continue to do so over time, while fossil fuel prices are increasing over time.

3.3.8. Strategies with emissions reductions targets that are more strongly informed by climate science generally include a strong emphasis on the need to dramatically rethink and reframe current assumptions about the nature and level of economic growth – and to rapidly explore alternatives to current economic paradigms and policy settings.

3.3.9. The strategies analysed differ in their assumptions about the possibility and desirability of maintaining current material consumption levels and ensuring continuing economic growth. Some place greater emphasis on rapid reduction in emissions (at the required scale and speed), while others only consider levels of emissions reductions that will not cause significant changes to, or limitation of, material consumption.

3.3.10. Strategies concerned with developing country economies, such as China, India and South Korea, all assume an important role for continued economic growth in helping to meet human development goals. These strategies highlight concepts of 'green growth' and 'low carbon growth' and emphasise the need for economic development to be linked to, or driven by, development in 'low carbon' industries and programs.

3.3.11. Costing of policies to achieve global and national emissions reductions at the required scale and speed remains an inexact science. The strategies reveal a wide variety of approaches to calculating and reporting the financial costs of post carbon economy transition policies. Key differences and variables include:

- time frames over which costs and benefits are considered (see point 3.3.12 below)
- assumptions about future trends in prices of different technologies and fuel sources (e.g. fossil fuel resource availability and prices, cost trajectories for renewable energy technology and deployment)
- the extent to which they factor in the costs of inaction and incorporate savings from avoiding climate change impacts
- the way cost estimates are reported (e.g. total amount, amount per year, as a proportion of GDP, investment additional to current levels etc) and who they are attributed to (e.g. overall cost to society, public funding, private investment, total investment etc).

3.3.12. While most strategies emphasise the importance of 'cost effectiveness', there is considerable diversity in the time frames over which costs and benefits are calculated. The *UK Carbon Plan* notes, for example, the significant implications of prioritising 'static' cost effectiveness of particular technologies (based on short-term conditions, such as the current carbon price) and 'dynamic' cost effectiveness' (considering actions required to meet longer term targets). A longer term view may require higher upfront investments in order to optimise longer term impacts and savings.

3.3.13. Noting the wide variation in scope and costing assumptions, ballpark estimates of the costs of actions required to rapidly decarbonise the global economy include:

- World in Transition: US$200 to US$1,000 billion p.a. to 2030
- World on the Edge: US$200 billion p.a.
- One Degree War Plan: US$2,500 billion p.a.
- Powering a Green Planet: US$100 trillion over twenty years
- The Energy Report: €1,000 billion p.a.

3.3.14. Indicative national level costings (again, noting significant differences in the scale and speed of proposed actions and costing assumptions) include:

- Europe (European Commission): €270 billion p.a. over 40 years (1.5 per cent of EU GDP p.a. above overall 2009 investment levels)
- UK (Zero Carbon Britain): £50 billion p.a.
- UK (UK Government): Average cost between 0.4 and 0.6 per cent of UK GDP p.a.
- Australia (Zero Carbon Australia): AU$37 billion p.a. over ten years (approx. 3 per cent of Australian GDP)
- Germany (German Government): €20 billion p.a. over 40 years
- South Korea (South Korean Government): US$83 billion over five years
- Denmark (Danish Government): US$952 million to 2020 (net costs of 0.25 per cent of Danish GDP).

3.3.15. To give some sense of perspective, the US Government funds allocated to the 2011 Troubled Asset Relief Program (TARP) supporting the 'bailout' of the US banking system was US$700 billion. The UK Independent Commission on Banking estimates that as of July 2011 the total amount committed to provide financial support to UK banks was €456 billion. In September 2011 the amount allocated to the European Financial Stability Facility was €780 billion, with Germany alone pledging €253 billion.

3.3.16. Strategies for raising the required level of funding include:

- global, national or regional carbon price schemes (with strategies that are more focused on science-based timeframes for transition noting the need for a carbon price of between US$100 and $200 a tonne).
- collection of a 'Tobin tax' on international financial transactions
- redirection of current taxation revenue
- variety of national and local level 'green bond' schemes
- for developing economies, financial assistance from developed countries.

Table 8: Economic policy assumptions and priorities in selected post carbon economy transition strategies

Strategy or plan	Key economic policy assumptions and priorities
Non-government	
World in Transition	It is possible to attract sufficient investment, enact policy tools and develop finance models required for transition Carbon price most important, but must be high enough to achieve required transformation Other policies advocated include: • global emissions trading system • long-term climate and energy policy framework with ambitious targets • funding and tax incentives to encourage sustainability innovation R&D • levies on international shipping and aviation • tax on international financial transactions • national green investment banks • micro-financing to promote decentralised renewable energy
World on the Edge	Worldwide carbon tax to reach US$200 a ton by 2020 (replacing income-based taxes) All prices to reflect full environmental costs Reframe economic growth definitions and priorities
Our Choice	Recommends mix of market-based (carbon price) and regulatory mechanisms Need for 'sustainable capitalism' based on full cost valuation of ecosystem services and replacement of GDP with 'Genuine Progress Indicator'
One Degree War Plan	Recommends mix of market-based, regulatory, social marketing and public investment strategies Initial carbon tax of US$20 per tonne raised by US$20 per tonne per year until it reaches US$100 per tonne Specific purpose taxes and regulations to reduce use of fossil-fuel-based car and aviation travel; electricity usage and production and consumption of new aluminium, cement, iron, plastics and forest products Social marketing to reduce energy consumption
Powering a Green Planet	Recommends carbon tax, renewable energy subsidies and feed-in tariffs to support rapid transition to renewable energy Elimination of fossil fuel subsidies and replacement with taxes to reflect full environmental costs Encourage reduced energy demand Acknowledges favourable cost trajectories for renewable energy compared to fossil fuels Argues that accounting for full social costs of energy sources (human health, local environment,

	climate change and security costs) makes renewables even more cost-competitive
The Energy Report	Assumes renewable energy and emissions targets can be achieved with 'increasing living standards and continuing economic development' Priorities include: national and global targets and compacts; national and global 'cap and trade' schemes; energy taxes, legal and regulatory controls, voluntary programs for businesses, feed-in-tariffs; redirecting fossil fuel subsidies to renewable energy Increased role for public sector in mandating performance standards, levelling playing field for all energy sources, providing incentives for deployment of renewable energy, and investing in large infrastructure projects (e.g. public transport and power grids)
Zero Carbon Britain 2030	Advocates strong role for government in providing financial support and incentives for renewable energy investment (e.g. Renewable Obligation Certificates and Feed-in tariffs), given large up-front but low ongoing costs Recommends Green New Deal policies such as Local Authority Bonds, major tax reforms directing investment to green infrastructure projects, and tax on international financial transactions Stronger regulation of national and international finance systems Strong critique of neoliberal economic model that delivers 'inequity, volatility and crises' Support for considering alternative measures of progress and shift to steady-state economy Strong support for reinvigoration of local economies
Climate Works Low Carbon Growth Plan for Australia	Strong emphasis on market-based policies, particularly carbon price Important government role in overcoming non-price barriers (e.g. transaction costs, split incentives, contract structures, information gaps and capital constraints) Strong emphasis on business opportunities from reducing GHG emissions Assumes continuation of current economic growth assumptions and models
Zero Carbon Australia Stationary Energy Plan	Strong support for feed-in tariffs, up-front subsidies, government loans, tax credits and direct investment in renewable energy, given high up-front but low ongoing costs Emphasis on employment benefits of expansion of renewable energy
Government	
European Commission: Roadmap 2050	Carbon price (through EU Emissions Trading Scheme) and long-term predictability seen as critical drivers of investment in low carbon technologies Tax incentives and subsidies for renewable technologies also supported Emphasis on need to unlock private sector investment Low carbon technology highlighted as major competitive frontier for future economies
UK: Carbon Plan	Variety of market-based, regulatory, direct investment and social marketing strategies to improve energy efficiency and shift energy production and consumption away from fossil fuels to renewable energy Priorities include: carbon price (through EU ETS), establishment of green investment bank and 'Green Deal' to promote household energy efficiency Scenarios developed to consider cost-effectiveness of different technologies and policy measures in the short and long term
Korea: Green Growth Strategy	Builds on Korean 'green stimulus' response to GFC with longer-term 'green growth/green economy' strategy Major focus on creation of carbon market and emissions trading scheme Tax incentives to favour consumption of low carbon goods, energy efficiency and investment in 'green enterprises' Incentives for private sector investors include: tax benefits to individual investors; long-term, low

	interest green bonds and savings; 'green fund' to facilitate access to credit for SMEs; mobilising investment from pension schemes; green private equity fund Stronger reporting requirements and standards for fuel efficiency, green buildings and transport sector
China: 12th Five-Year Plan and Climate Change White Paper	Strong focus on regulatory and fiscal policy measures, with an increasing role for market mechanisms, including possibility of establishing national emissions trading scheme Significant financial support and policy incentives directed to strategic emerging industries, which include new energy and energy conservation and clean energy vehicles National feed-in tariff and 'one-off' direct subsidies to support solar deployment Economic growth a priority, although efforts may be required to slow growth to meet the target rate of 7% p.a. over the 2011–15 period. Emphasis on sustainable development and recognition that economic development goals need to be closely linked to low carbon development and climate change responses
India: National Action Plan & Low Carbon Growth Report	A mix of regulatory and market-based mechanisms are discussed Recognition of the need to consider full costs of fossil-fuel-based energy production, but introducing a price on carbon emissions only considered a future possibility Emphasis on the need for strong economic growth rates (target of 8–9% p.a. to 2020) in order to improve livelihoods and meet human development objectives in India
Australia: Clean Energy Future	Carbon price initially set at AU$23 per tonne as key policy mechanism Assumes continuation of current economic growth trends Range of funding bodies and initiatives to support 'clean energy' innovation
Germany: Energy Concept	Market mechanisms (particularly carbon price and increased competition in gas and electricity markets) as key drivers of transition to high employment, decarbonised green economy Focus on 'cost-efficient expansion' of renewable energy, with a strong emphasis on innovation Government to lay foundations and set rules for market-based energy policy framework
Denmark: Our Future Energy	Strong emphasis on long-term economic benefits of eliminating fossil fuels and switching to 100% renewable energy Benefits include: reduced costs and exposure to volatile fossil fuel prices, employment benefits and growth and export opportunities Public expenditure on energy efficiency programs and expansion of renewable energy provided through set of taxes on energy consumption
California: Scoping Plan and Clean Energy Future Plan	Includes mix of market-based and regulatory measures, including 'cap and trade' scheme, consumer and business incentives, and feed-in tariffs Emphasis on economic benefits of coordinated action (e.g. increased economic activity, gross state product, per capita income and jobs)

Table 9: Financing assumptions and priorities in selected post carbon economy transition strategies

Strategy or plan	Key financing assumptions and priorities
Non-government	

World in Transition	Additional net investment required by 2030 for global transformation into a low carbon society between US$200 and 1000 billion p.a.
World on the Edge	Net cost $200 billion p.a.
Our Choice	Does not include detailed costings
One Degree War Plan	Carbon tax would be expected to generate US$2,500 billion p.a. by year 5, which would be available to spend on industry restructuring, structural adjustment, compensation and adaptation planning
Powering a Green Planet	Overall investment required for construction of global renewable energy systems (not including transmission) in the order of $100 trillion over 20 years Additional costs for expanding conventional (fossil fuel) energy sources to meet increasing demand approximately $10 trillion (not including health, environment and security costs)
The Energy Report	Total cost of achieving targets approximately €1 trillion p.a. Investment expected to have paid itself off by around 2040 at latest
Zero Carbon Britain 2030	Ballpark figure of £50 billion p.a. required for initial investment program Green New Deal investment options include direct intervention to shift public and private investment, introduction of Tobin tax on international financial investments and 'green bonds' at national and local levels
Climate Works Low Carbon Growth Plan for Australia	Policies needed to reduce Australia's emissions by 25% below 2000 levels between 2010 and 2020 can be implemented at a cost of 0.1% of projected GDP per household in 2020. This is equivalent to approximately AU$1.8 billion per year.
Zero Carbon Australia Stationary Energy Plan	Total cost of implementing *Stationary Energy Plan* of AU$370 billion, (AU$37 billion annually for ten-year period, or approximately 3% of Australian GDP This can be seen as investment creating significant future savings compared with default costs of major ongoing capital investments required for energy infrastructure (AU$135 billion over 2011–20) and increasing costs of fossil fuels (AU$300 billion over the period 2011–20) Net present costs over longer time period (2010–40) make renewable energy investment roughly equivalent to BAU, not counting savings in transport costs
Government	
European Commission: Roadmap 2050	Increase in public and private investment would need to average around €270 billion per year over the next 40 years, i.e. around 1.5% of EU GDP p.a. above 2009 investment levels Reducing the EU's dependence on fossil fuels is estimated to save between €175 and €320 billion per year. Savings also will be made from improved air quality and public health
UK: Carbon Plan	Total net present cost over lifetime of policy measures described in earlier carbon budget periods estimated at £9 billion Costs of fourth carbon budget will depend heavily on combination of policies implemented in coming decades. Net present values range from a net benefit of £1 billion to a net cost of £20 billion Amounts to estimated average cost of around 0.4% of UK GDP per year over first three carbon budget periods (2008–22) and 0.6% of UK GDP per year over 2023–27 Compared to costs of not tackling climate change, this is considered easily favourable
Korea: Green Growth Strategy	Total investment announced as part of Five-Year Plan (2009–13) US$83.6 billion
China: 12th Five-Year Plan and Climate Change White Paper	China expects to see investment (both public and private) in 'new energy' of around RMB 5 trillion (US$760 billion) over the next ten years, with renewable energy and grid investments taking the largest shares: wind (US$230 billion), smart grid (US$210 billion) and solar (US$30 billion) (Finamore, 2011)

	Goldman Sachs estimates subsidies for clean energy in China will double from RMB 21 billion in 2011 to RMB 42 billion in 2012 (US$6.5 billion p.a.) (Buckley, 2012, p. 4)
India: National Action Plan & Low Carbon Growth Report	Cost estimates associated with low carbon policies and measures to meet India's emissions intensity reduction goals are not included in either the National Action Plan on Climate Change (2008) or the interim report on Strategies for Low Carbon Inclusive Growth (2011) While sources of finance are not described in detail, it is clear that the Indian Government sees international assistance as a crucial variable in achieving domestic emissions reductions at or beyond current levels of ambition
Australia: Clean Energy Future	Carbon price and related measures expected to raise approximately AU$25.5 billion in the period 2011–15 Further $3.9 billion of new government expenditure to augment this
Germany: Energy Concept	Assumes additional investment of €20 billion p.a. to achieve Germany's 2050 targets This investment to be offset by lower energy imports and energy cost savings and will reinforce position of German companies as leaders in environmental and energy related technology
Denmark: Our Future Energy	Cost of implementing measures to 2020 estimated to be DKK 5.6 billion (equivalent, at Jan 2012, to around US$952 million). This covers expenditure on energy efficiency improvements, expanded renewable energy supply, and state revenue lost due to reduced fossil fuel use The plan is expected to save DKK 6.9 billion in energy costs Immediate net costs of less than 0.25 per cent of GDP in 2020 and additional costs for Danish households expected to average around DKK 1,700 (approx. US$289) in 2020
California: Scoping Plan and Clean Energy Future Plan	Ongoing costs to implement measures estimated at around US$ 36 million per year Economic analysis points to benefits for California by 2020 (compared to business-as-usual) including: • increased economic production of US$33 billion • increased overall gross state product of US$7 billion • increased overall personal income by US$16 billion • increased per capita income of US$200 • increased jobs by more than 100,000. Discusses additional benefits including better air quality and public health outcomes

3.4. Social equity implications and priorities

Table 10 provides an overview of the social equity implications and priorities for all of the summarised plans and strategies. Key lessons and implications include the following.

3.4.1. While all strategies are informed by some implicit commitment to improving outcomes for future generations, there is a surprising absence of explicit or detailed discussion of intergenerational equity or of future discounting assumptions and trade-offs. This suggests that there is a need for more robust frameworks for understanding how a socially just approach to climate change translates into actions at national and international levels, in order to hold the strategy documents and their authors accountable to claims of concern for equity.

3.4.2. There is widespread recognition that broad political support for a rapid transition to a post carbon economy will depend on the implementation of policies that address and overcome key social equity

challenges. The primary concern of many of the government-led strategies is on overcoming social equity at the national rather than international level.

3.4.3. Many strategies note the potentially severe impacts on disadvantaged and low income communities and individuals of failing to take timely and effective action to reduce the risks of runaway climate change.

Table 10: Social equity implications and priorities in selected post carbon economy transition strategies

Strategy or plan	Key social equity assumptions and priorities
Non-government	
World in Transition	Central idea of social contract as crucial foundation for large-scale transition Financing systems to overcome energy related poverty, consistent with rapidly reducing energy intensity and emissions levels Improved sustainability financing for developing countries Funds for mitigation, adaptation, technology transfer and capacity building additional to official development assistance (exceeding US$100 billion p.a.) Agree access to modern energy services by 2030 for all people as additional Millennium Development Goal
World on the Edge	Strong emphasis on intra- and intergenerational equity $75 billion p.a. for primary education; adult literacy; school lunches; reproductive health; family planning; universal basic health care
Our Choice	Strong recognition of the need to address intra- and intergenerational implications of climate change Need to ensure adequate support for developing countries
One Degree War Plan	Softening impact on most vulnerable citizens and communities is most crucial transition challenge Significant proportion of carbon tax to be used to alleviate hardship and create jobs Resettlement plans for climate refugees, adaptation strategies for low-lying coastal areas and to address likelihood of large-scale famine
Powering a Green Planet	Equity issues not explicitly addressed
The Energy Report	Strong emphasis on intragenerational equity, particularly between developed and developing countries Priorities to address equity goals while transitioning to renewable energy include: • funding for technology transfers from developed to developing countries • funding for small-scale renewable energy projects – particularly to address energy poverty • phase-out of unsustainable use of biomass cooking and energy
Zero Carbon Britain 2030	Equity concerns need to be at heart of responses to climate change. Decarbonisation crucial to prevent further increases in inequality in British society and contribute to reducing inequality Ensuring carbon pricing mechanisms are progressive, energy efficiency measures tailored to low-income households, re-skilling and green jobs programs in deprived regions Accepting UK has much greater responsibility, both currently and historically, for climate change

	than other poorer nations
Climate Works Low Carbon Growth Plan for Australia	Equity issues not explicitly addressed
Zero Carbon Australia Stationary Energy Plan	Social equity during transition to zero emissions economy is a core principle guiding the plan. Aim is to provide equitable access to energy for all Australians today at same time as ensuring costs are not being deferred to future generations
Government	
European Commission: Roadmap 2050	Equity issues not explicitly addressed
UK: Carbon Plan	Commitment to ensure fair distribution of the costs of the low carbon transition. Measures to target assistance for energy efficiency programs and reduce impact of emissions reduction policies on vulnerable and low income individuals and communities Commitment to providing finance to support mitigation and adaption in developing countries
Korea: Green Growth Strategy	Recognises need for targeted policies to support low income households and to ensure that 'every citizen can benefit from low carbon, green growth equally' Includes principle that the government shall seek 'balanced development between regions in promoting low carbon, green growth and shall provide low-income groups with support and care to protect them from being neglected'
China: 12th Five-Year Plan and Climate Change White Paper	Commitment to the principle of 'common but differentiated responsibilities' in terms of international climate change action. Noting that developed countries should take the lead in emissions reductions and assist developing countries through finance and technology Equity issues with domestic climate change policies not explicitly addressed
India: National Action Plan & Low Carbon Growth Report	Equity issues, both within Indian society and between India and the international community, are central to the framing of Indian actions Emphasis on the need for industrialised countries to provide the leadership to respond to climate change, given their historical responsibility for it. Developing countries should be able to meet their development objectives with only voluntary emissions reduction commitments Emphasis on achieving 'low carbon inclusive growth' domestically. Recognition of the need to quantify additional burdens and differential impacts on different social groups of measures to reduce Indian emissions intensity and to embed effective internal burden-sharing mechanisms into adopted policies
Australia: Clean Energy Future	Intergenerational equity issues remain largely implicit, as does Australia's international obligations in contributing its 'fair share' of emissions reductions This plan does not cover Australian Government commitments to assist developing countries achieve fair mitigation and adaptation outcomes Strong emphasis on minimising impact of carbon price on Australia households. Over 50 per cent of carbon price revenue will be spent on compensating households, with particular focus on pensioners, low and middle income earners
Germany: Energy Concept	Guiding principle is utilisation of modes of financing which ensure intergenerational fairness
Denmark: Our Future Energy	Underlying acceptance that immediate investment in a transition to renewable energy is necessary to avoid higher future costs Considered unacceptable for Denmark to leave a very large unpaid bill for future generations, especially as it is a wealthy country with a stable economy Implications of the plan for social equity within Danish society are not covered in the document

California: Scoping Plan and Clean Energy Future Plan	Implications of the plan for social equity not discussed in detail, although implementation of the plan is expected to save low and middle income households hundreds of dollars per year by 2020, primarily due to energy efficiency improvements

3.5. Governance implications and priorities

Table 11 provides an overview of the governance assumptions and priorities for all of the summarised plans and strategies. Key lessons and implications include the following:

3.5.1. A rapid transition to a post carbon economy is likely to require strong leadership by national governments in setting and achieving clear long-term emissions reduction targets combined with strengthened grassroots mobilisation, active support from the private sector, and enhanced global cooperation.

3.5.2. Some of the strategies focused on science-based timeframes for transition emphasise the unprecedented scale of action required and consider dramatic shifts in current governance arrangements, with a particular emphasis on strengthened global institutions and cooperation (see *World in Transition*, for example). Less ambitious (typically government-led) strategies appear to assume that existing governance arrangements will suffice.

3.5.3. While many strategies note an important role for government in encouraging and driving investment in key infrastructure and green economy projects (e.g. smart grids, high-speed rail and electric vehicle recharging stations), a number of strategies also emphasise the importance of encouraging distributed and decentralised energy systems and reinvigorating local economies.

3.5.4. Most strategies emphasise the importance of an integrated mix of market-based and government-led policy initiatives.

3.5.5. Promising options for strengthening national government leadership include:

- national climate protection targets enshrined in constitutions and legislation
- climate protection and decarbonisation objectives embedded in all national and local government policies and programs
- deliberative 'future' chambers of parliament, providing an opportunity for informed consideration of the impact of policy decisions on future generations.

3.5.6. Promising options for strengthening global cooperation include:

- continuing to work towards a global climate change action compact committing all nations to an internationally verifiable decarbonisation road map and a shared approach to carbon pricing
- development of sub-global, regional alliances and collaborations involving nation states and sub-national regions, provinces and cities
- the design and construction of international smart electricity grids and networks
- a strengthened role for international governance institutions such as the International Energy Agency and the International Renewable Energy Agency
- renewable energy investment priorities embedded at the heart of all international aid and development programs.

3.5.7. Promising options for strengthening grassroots citizen mobilisation include:

- an extension of opportunities for citizen participation, including legislative obligation for governments to provide citizens with opportunities to participate in informed debate
- an increased role for local government and local community organisations in exploring and implementing innovative post carbon economy transition solutions
- increased support for decentralised local systems of economic production and distribution and for distributed energy systems.

3.5.8. Key policy and research priorities include clarification and implementation of the most effective governance strategies for achieving:

- binding and verifiable emissions reduction agreements at global, regional, national and local levels
- informed public debate about climate change challenges and solutions
- the encouragement and mobilisation of local community innovation and activism.

Table 11: Governance assumptions and priorities in selected post carbon economy transition strategies

Strategy or plan	Key governance assumptions and priorities
Non-government	
World in Transition	Makes case for a 'new global social contract' describing actions to transform relationships between individuals, civil societies, nation states and the global community of states to support the low carbon transition Strong emphasis on the need for cooperation and coordination at national, regional and international levels, including strengthened roles for international agencies Calls for states to be proactive in legislating climate protection targets, extending opportunities for citizen participation, and mainstreaming climate policies in all policies and programs
World on the Edge	Importance of shifting tax burden from income to carbon emissions Redefine security from protection from armed aggression to protection from eco-system threats Broad support for increased global cooperation
Our Choice	Need for a global climate change compact, combined with networked grassroots action
One Degree War Plan	First steps towards large-scale mobilisation will need to come from small number of key nations Primary emphasis on top-down, command and control leadership including global 'Climate War Command' and 'Climate Stability Commission'
Powering a Green Planet	Emphasis on strong leadership from national governments to mobilise support and drive transition to renewable energy
The Energy Report	Need for 'unprecedented' level of international cooperation. Priorities include establishing a stable and effective global 'cap and trade' scheme for greenhouse gas emissions and cooperation to build and co-manage connecting electricity grids and networks across regions
Zero Carbon Britain 2030	Assumes strong role for government in legislating and providing a policy framework for progressive decarbonisation policies
Climate Works Low Carbon Growth Plan for Australia	Strong emphasis on business-led climate change responses and opportunities, and on the role of government in creating favourable investment context
Zero Carbon Australia Stationary Energy Plan	Main focus is on technical and financial aspects of transition; however, implementation of the plan assumes strong leadership and coordinated top-down planning
Government	
European Commission: Roadmap 2050	Strong focus on importance of global climate action in order for benefits for EU competitiveness to be realised

UK: Carbon Plan	Sophisticated level of integration of policy measures between range of UK government departments and agencies Strong commitment to working in cooperation with other EU member states to show leadership and build momentum for international action
Korea: Green Growth Strategy	Comprehensive, cross-institutional approach to design and implementation of National Green Growth Strategy involving representatives from all government ministries, private sector, academia and civil society Creation of Framework Act on Low Carbon Green Growth and Presidential Committee on Green Growth Aim of embedding climate change response within overall social and economic development policy South Korea to become international role model for green growth, including through active engagement in international climate change negotiations and promotion of green growth among developing countries in Asia
China: 12th Five-Year Plan and Climate Change White Paper	Highlights the need to strengthen Chinese regulatory frameworks, including revising relevant laws, regulations, rules and standards Chinese Government clearly favours centralised, 'top-down' approach to addressing climate change, although recognises need for locally tailored planning in provinces and cities and role for non-government organisations and other sectors of society in planning and implementing measures Strong emphasis on need for international cooperation through existing UN institutions
India: National Action Plan & Low Carbon Growth Report	Comprehensive set of institutional arrangements established to manage Indian climate change initiatives alongside release of the National Action Plan on Climate Change in 2008 Emphasis on the need for policies that allow people to self-regulate and non-government actors at multiple levels of society to respond creatively to meet emissions saving imperatives, and the need for institutions to be knowledge-based and flexible in the face of uncertainties about climate change impacts, technology development and behaviour change, for example.
Australia: Clean Energy Future	Creation of several new institutions to govern and support implementation of the plan, including Climate Change Authority, Clean Energy Regulator, Clean Energy Finance Corporation and Australian Renewable Energy Agency Measures to assist local communities and local government level actions to reduce emissions
Germany: Energy Concept	Commitment to working cooperatively within the EU region and internationally to establish effective and reliable frameworks for climate protection
Denmark: Our Future Energy	Emphasis on the need to influence and encourage cooperation in the EU and internationally, including playing a constructive role in UN climate change negotiations
California: Scoping Plan and Clean Energy Future Plan	Strong emphasis on coordinated, integrated approach to governance and policy implementation with range of collaborating regulatory and planning agencies Emphasis on the need for state bodies to partner with local authorities, business groups and communities. Significant support already shown by Californian cities and counties signed on to US Conference of Mayors Climate Protection Agreement and company, municipality and community organisation members of Climate Action Registry reporting annually on GHG emissions California also active member of *Western Climate Initiative* involving Canadian, Mexican and United States provincial governments in maximising innovation in development and implementation of renewable energy and energy efficiency

3.6. Political and social change assumptions and priorities

Table 12 provides an overview of the political and social change assumptions and priorities for all of the summarised plans and strategies. Key lessons and implications include the following:

3.6.1. The need to secure and sustain broad social and political support is widely recognised as the greatest obstacle to taking the actions needed to drive a rapid and effective transition to a post carbon economy.

3.6.2. The lack of strategies for achieving broad social and political support and for driving transformational social change is the most significant gap in post carbon economy transition strategies. This frequently reflects an implicit assumption of a reasonably rational policy-making process in which the objective merits of the strategy provide a sufficient basis for driving change.

3.6.3. The crucial difference between transition strategies that emphasise the need for a pragmatic and evolutionary approach and those which prioritise the need for more rapid and transformational change highlight two challenging and urgent questions:

- For less ambitious plans and strategies (generally government-led): Given that the proposed actions do not match the physical requirements of action needed to prevent runaway climate change, what can be done to bridge this gap?
- For more ambitious plans and strategies (generally non-government authored): Given that political and social support for the rapid implementation of these proposals remains challenging: what can be done to bridge this gap?

3.6.4. There are also important ongoing debates and differences about the most effective balance between the design and implementation of integrated, 'top-down' strategic plans and the encouragement and facilitation of more diverse and diffuse 'bottom-up' approaches to social and technological innovation.

3.6.5. The most common theories of transformational change emphasise the need for visionary political leadership combined with broad community mobilisation. Many also highlight the potential for one or more dramatic 'tipping point' events, whether directly arising from climate change or not, to trigger a swift, large-scale shift in political values and responses.

3.6.6. Of all the strategies considered in this report, the *World in Transition* report from the German Advisory Council on Global Change (WBGU) presents the most comprehensive assessment of the social change dynamics that could underpin broad public acceptance and support for transition. It emphasises:

- knowledge-based, shared visions and the importance of advocating desirable futures rather than triggering anxiety
- the important role of change agents, social and economic megatrends and 'shocks'
- proactive states and supportive global governance structures.

3.6.7. The lack of detail within existing strategies about how to achieve the political leadership and public support for rapid transitions is problematic, particularly in the context of the unprecedented threat that runaway climate change presents to economic and social wellbeing.

Table 12: Political and social change assumptions and priorities in selected post carbon economy transition strategies

Strategy or plan	Key political and social change assumptions and priorities
Non-government	
World in Transition	Emphasis on the need for broad public acceptance and consent for transition and understanding key conditions for creating 'social dynamics for change', including: • knowledge-based, shared visions and the importance of advocating desirable future rather than triggering anxiety • the important role of change agents, social and economic megatrends and 'shocks'

	• proactive state and supportive global governance structures Strategic opportunities for overcoming barriers to transformational change include: • rapid advances in low carbon technology innovation • recognition that investments required to achieve necessary transformation, while massive, are viable, particularly when compared with even greater costs of inaction • changing values towards sustainability • global knowledge networks • increasing recognition of potential co-benefits of transformational change.
World on the Edge	Transition requires decarbonisation at 'wartime speed' Three social change models : • Pearl Harbour: dramatic event leads to fundamental change (too risky?) • Berlin Wall: social tipping point reached after gradual change in thinking and attitudes (too slow?) • Sandwich: grassroots movement strongly supported by political leadership (preferred)
Our Choice	Social and political will the only barriers to implementing climate change solutions Overcoming social, political and attitudinal barriers to climate action requires visionary leadership combined with broad community mobilisation. Need to hold self-interested corporations to account and ensure higher standards in media
One Degree War Plan	Theory of social and political change involves recognition that: • climate change trends and impacts built into the system mean it is already too late to prevent major global disruption. It is still possible to prevent complete civilisational collapse • prevention of catastrophic climate change requires broad support for comprehensive and integrated action at scale and speed comparable to Second World War mobilisation • at some point (before 2020) one or more critical ecological, economic or social tipping point events is likely to occur, leading to shift in public support for the actions required
Powering a Green Planet	Concludes that obstacles to implementation of 100% global renewable energy system by 2030 are 'primarily social and political, not technological' Emphasises the need for clear leadership to avoid dominance of industry-preferred technologies, rather than those vetted by scientists
The Energy Report	Required reduction in energy demand assumed to come from energy efficiency savings, rather than restrictions on human activities Emphasis on human ingenuity and technological innovation as key drivers of transition, and policy incentives to support behavioural change
Zero Carbon Britain 2030	Notes dynamic nature of politics and role of sudden, unexpected events in influencing dramatic political shifts (e.g. 9/11 terrorist attacks in the US). Draws attention to importance of having plans in place to avoid predictable, but uncertain, shocks (e.g. peak oil) Focus on importance of behaviour change alongside promotion of wider societal dialogue on values, structures and processes that have led to overconsumption, climate change and resource depletion Suggested strategies include targeted communication, drawing out the importance of intrinsic, community-oriented values, the use of role models and social norm leaders
Climate Works Low Carbon Growth Plan for Australia	Lifestyle changes not considered in the analysis (e.g. use of more energy efficient lighting is within scope; reducing the average time that lights are on is not) Assuming no change to current lifestyles allows authors to present conclusions about emissions reductions without need to propose changes to way Australians 'live, travel and consume on a day-to-day basis' Also assumes no significant changes to current industry mix in Australia
Zero Carbon Australia Stationary	Does not address social and political dynamics of the transition process. However, notes strong need for 'decisive leadership' from government, business, academia and the wider community to

Energy Plan	implement the plan Focuses on contributing to settling the debate on technical feasibility of 100% renewable energy in Australia to enable social and political changes to occur
Government	
European Commission: Roadmap 2050	Political and social change factors not covered, although notes importance of behaviour change and public education programs
UK: Carbon Plan	Notes importance of UK Government, industry and citizens to be 'pulling in the same direction' in order to achieve low carbon transition
Korea: Green Growth Strategy	Raising public awareness about need for lifestyle change in support of green growth seen as key pillar. Priorities include: • education programs to give information, raise awareness, and encourage behaviour change • green lifestyle index for citizens – including incentives to purchase low carbon products • labelling and certification of carbon footprints of products and services • voluntary low carbon 'smart village' movement • eco-tourism pilot projects, infrastructure and training
China: 12th Five-Year Plan and Climate Change White Paper	Underlying assumption of strong and ongoing role for co-ordinated government planning and intervention, consistent with overall Chinese economic and political governance arrangements
India: National Action Plan & Low Carbon Growth Report	Political and social change factors not covered in the plans considered, although the interim report on LCSIG notes the need for the final report to include discussion of barriers to implementation or adoption by people and firms of Indian climate change policies
Australia: Clean Energy Future	Strong emphasis on the limited impact of policy measures on Australian economy and lifestyles
Germany: Energy Concept	Acknowledges importance of public understanding and support for transition to ensure its success. Measures include provision of comprehensible information, transparent decision making and opportunities for public dialogue
Denmark: Our Future Energy	Elements contributing to social and political acceptance of Denmark's energy transition not covered in the plan. Assumes strong ongoing role for government in encouraging innovation and community education.
California: Scoping Plan and Clean Energy Future Plan	Active participation of Californians seen as essential Emphasis on role for market forces and growing environmental awareness to shift individual choices and attitudes Calls for targeted public outreach, marketing and education programs

4. Implications for Australian climate change debates and policies

The Australian Government's 2020 emissions reduction target (a 5 per cent decrease on 2000 levels) is clearly still far away from the level required for Australia to make a responsible and fair contribution to global emissions reductions at the scale and speed required to significantly reduce the risk of runaway climate change. Australia's 2050 target (an 80 per cent decrease on 2000 levels) is more robust, but no detailed proposals have yet been produced outlining how this target might be achieved.

While the increased financial and organisational support for renewable technology innovation and deployment is welcome, the target of 20 per cent of electricity production from renewable energy by 2020 falls well short of the level required to drive a rapid transition away from fossil fuel-based energy systems. Current policy directions in fact continue to assume ongoing growth in coal production and export as well as increased reliance on gas for energy provision.

The introduction of mechanisms for setting a price on carbon (carbon tax followed by an emissions trading scheme) is also a positive step. However, the main impact of a carbon price at or close to AU$23 per tonne is likely to be increased investment in gas-fired power stations rather than a rapid shift to renewable energy. Evidence from a range of other Australian and international transition plans and strategies suggest that a rapid shift from fossil fuels to renewable energy will require some mix of a far higher carbon price, sustained support for feed-in tariffs, the phase-out of fossil fuel subsidies, and a range of strong financial incentives and regulatory measures encouraging rapid investment in renewable energy.

Evidence from the most promising transition strategies in other jurisdictions suggests that emissions reduction at the required speed and scale will also require opening up an informed and thoughtful debate about the kind of economic growth and industry mix that Australia should be aiming for, along with the fairest approaches to mobilising the required levels of financial, human and social capital.

While strategies for maximising the social equity of the Australian post carbon economy structural adjustment and adaptation process will continue to be crucial, it will also be important for Australia to demonstrate a far stronger commitment to contributing to fair transition and adaptation policies on a global scale.

Most importantly, a far more visionary level of political leadership will be required in order to drive an Australian climate change debate informed primarily by scientific evidence about the required speed and scale of emissions reductions rather than short-term calculations of political and economic feasibility.

5. Future policy and research priorities

The aim of this report has been to provide a concise overview of the key goals and priorities of a range of the most influential and innovative large-scale post carbon economy transition plans and strategies. Learning from initial analysis of these strategies leads to the following reflections on future policy and research priorities.

Emissions reduction and energy targets

- Further sharpening, clarification and communication of scientifically-informed knowledge about the scale and speed of global, national and local emissions reductions required to significantly reduce the risk of runaway climate change.

Technology and innovation

- Strengthening understanding of policies and programs likely to maximise potential for rapid technological innovation and for dissemination and scaling up of the most promising technologies in relation to:
    - reducing energy consumption and demand
    - energy efficient buildings
    - energy efficient industrial processes
    - energy efficient transport
    - renewable energy
    - carbon sequestration
    - low emissions agriculture and forestry.

Economics and Finance

- Strengthening understanding of:
    - the most effective economic tools and mechanisms for reducing energy demand and facilitating the transition from fossil fuel to renewable energy
    - the impact of current and alternative economic growth priorities on emissions trends
    - alternative methodologies for measuring and reporting on improvements in wellbeing and sustainability
    - fair structural adjustment policies appropriate for both developed and developing economies
    - robust methodologies for costing the large-scale economic transformations required to achieve rapid reductions in emissions at national and global levels
    - effective and fair mechanisms for raising and allocating required levels of funding and investment capital.

Social equity

- Strengthening understanding of:
    - the fairest systems of carbon pricing
    - the most effective strategies for mobilising and distributing investment in core social development priorities (e.g. food security, employment, housing, health and education)
    - the most effective strategies for reducing energy related poverty including the equitable phase out of biomass cooking and heating
    - the most effective strategies for enabling the safe and equitable resettlement of climate refugees
    - the fairest climate adaptation strategies with a particular focus on the most vulnerable populations and communities.

Governance

- Strengthening understanding of the most effective governance strategies for achieving:
    - binding and verifiable emissions reduction agreements at global, regional, national and local levels
    - informed public debate about climate change challenges and solutions
    - the encouragement and mobilisation of local community innovation and activism.

Social and political change

- Strengthening understanding of the most effective governance strategies for:
    - successfully communicating the necessity and urgency of action to prevent runaway climate change
    - successfully communicating the technological and economic feasibility of a rapid transition to a post carbon economy
    - successfully communicating the desirable co-benefits of a rapid transition to a just and sustainable post carbon economy
    - identifying and challenging the role of vested interests in opposing and undermining support for post carbon economy transition strategies
    - imagining and visualising plausible and desirable post carbon economy futures and pathways.

This report is also the first stage in an ongoing *Post Carbon Pathways* project which aims to strengthen understanding of the most effective ways of overcoming barriers to the rapid implementation of large-scale post carbon economy transition plans and strategies. The next phase of this project will therefore include further exploration of the following questions:

- How effective have these post carbon transition plans and their associated communication and implementation strategies been in:
    - influencing public debate
    - influencing the attitudes and actions of key stakeholders and decision makers
    - driving rapid implementation of post carbon economy policies
    - driving rapid reductions in GHG emissions?

- What have been the major barriers limiting the effectiveness and preventing the rapid implementation of large-scale post carbon economy transition plans and strategies.
    - What have been the most effective strategies for overcoming these barriers?

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Appendix 1

Table 13: Additional useful sources of learning and ideas about post carbon transition plans

Document/Organisation	Link
Potsdam Institute for Climate Impact Research	http://www.pik-potsdam.de/
Governance, Infrastructure, Lifestyle Dynamics and Energy Demand: European Post-Carbon Communities	http://www.gildedeu.org/
Post Carbon Reader, Post Carbon Institute	http://www.postcarbon.org/book/161233-the-post-carbon-reader
350.org	http://www.350.org/
Victorian Eco-Innovation Lab, University of Melbourne	http://www.ecoinnovationlab.com/
Post Carbon Cities	http://www.postcarboncities.net/
Forum for the Future	http://www.forumforthefuture.org/
Wuppertal Institute for Climate, Environment and Energy	http://www.wupperinst.org/en/home/
Tällberg Foundation	http://www.tallbergfoundation.org/
Low Carbon Trust	http://www.lowcarbon.co.uk/
Sustainability Transitions	http://sustainabilitytransitions.info/
Transition Towns, The Transition Network	http://www.transitionnetwork.org/
Transition Pathways to a Low Carbon Economy	http://www.lowcarbonpathways.org.uk/
PACT: Pathways for Carbon Transitions	http://www.pact-carbon-transition.org/
Climate Works Foundation	http://www.climateworks.org/
Centre for Policy Development - Sustainable Economy program	http://cpd.org.au/category/all-articles/sustainable-economy/
Australian Conservation Foundation – New Economics program	http://www.acfonline.org.au/default.asp?section_id=378
New Economics Foundation	http://www.neweconomics.org/
New Economics Institute	http://neweconomicsinstitute.org/
Post Carbon Toronto	http://www.postcarbontoronto.org/
Post Carbon Living	http://www.post-carbon-living.com/
World Changing	http://www.worldchanging.com/
Institute for Global Environmental Strategies	http://www.iges.or.jp/en/index.html
Japan for Sustainability	http://www.japanfs.org/en/aboutus.html
EU Roadmap 2050, European Climate Foundation	http://www.roadmap2050.eu/
Low carbon society scenarios	http://2050.nies.go.jp/LCS/index.html
A roadmap towards low carbon Kyoto, Sustainable	http://2050.nies.go.jp/report/file/lcs_japanlocal/

Society Kyoto	kyotolcs.pdf
Controlling Climate Change, Dr Bert Metz	http://www.controllingclimatechange.info/
Reinventing Fire, Rocky Mountain Institute	http://www.rmi.org/ReinventingFire
INFORSE Europe	http://www.inforse.dk/europe/

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[viii] California has been included within the scope of this survey given that its economy is in fact the eighth largest in the world. Sub-national, regional and local post carbon transition plans are also clearly highly significant and we will give consideration to preparing a follow up report on these initiatives in the future.

[ix] http://www.climateactiontracker.org/; http://sei-international.org/mediamanager/documents/Publications/Climate/sei-workingpaperus-1107.pdf

[x] For reasons including risks of serious damage, unresolved waste storage issues and the danger of uncontrolled proliferation.

[xi] Transport is considered the most difficult sector to transition to renewables. It is argued that liquid biofuels should not be used for transport, as bioenergy is best used in reducing emissions from electricity.

[xii] Paul Gilding is a sustainability activist, author and social entrepreneur. He is a former CEO of Greenpeace International and Ecos Corporation. Jorgen Randers is Professor of Climate Strategy, Norwegian School of Management, Oslo and one of the original authors of 'The Limits to Growth'.

[xiii] The authors note that the 1°C target is also consistent with the target of reducing atmospheric CO_2e to below 350 ppm.

[xiv] Jacobson and Delucchi cite figures of 40–85 Terawatts (TW) of accessible energy available from wind and 580 TW for solar, to support their claims that supply of these energy sources is not a limitation.

[xv] The Office for Metropolitan Architecture is an international partnership specialising in architecture, urbanism and cultural analysis.

[xvi] ENECO works on generation, transmission, trading and supply of electricity, gas and heat, and related products and services.

[xvii] This is contrasted to the conventionally projected doubling of global energy demand over the same time period.

[xviii] The report notes that the Ecofys energy scenario is not necessarily the most cost-efficient means of switching to a largely renewable energy powered world by 2050. After deriving the possible physical energy scenario, the net costs and upfront investments required to achieve the scenario were then considered.

[xix] Executive Editor: Martin Kemp. Project Director: Paul Allen.

[xx] Modelling of the UK transport sector completed for the strategy shows how a combination of modal shift, increased vehicle occupancy, technology improvements and fuel shifting would enable a reduction in demand for energy from transport of 74 per cent below the predicted 2030 level (equivalent to a 63 per cent reduction on 2008 levels), while still providing the required services.

[xxi] An update to the *Low Carbon Growth Plan for Australia* was released in April 2011 [see: http://www.climateworksaustralia.org/ClimateWorks%20Australia%20Low%20Carbon%20Growth%20Plan%202011%20update.pdf]. This summary is based only on the original plan.

[xxii] Non-price barriers raised in the report include: market structure and supply (high transaction costs, split incentives and contract structures); information gaps and decision making; and capital constraints and investment priorities (p.22).

[xxiii] Lead authors: Matthew Wright and Patrick Hearps.

[xxiv] Beyond Zero Emissions is an independent, non-profit climate change solutions think tank. See: http://beyondzeroemissions.org/

[xxv] *ZCA 2020* involves concurrent research, and the development of comprehensive plans related to each of the following sectors or key sources of Australia's emissions: stationary energy; transport; land use; buildings; industrial processes; and replacing coal export revenue. The plans, while separate, are inter-related and will ultimately be combined into one document.

[xxvi] It is, however, noted that new technological developments that reach commercial application are able to be incorporated into future iterations of the plan as part of the ongoing *ZCA 2020* research initiative.

[xxvii] See: http://ec.europa.eu/resource-efficient-europe/

[xxviii] The European Council notes that this could rise to 30 per cent if certain conditions are met relating to emissions reduction commitments from other developed and economically advanced developing countries.

[xxix] An *Energy Efficiency Plan 2011* explaining actions required to meet the 2020 target is presented alongside the Roadmap: http://ec.europa.eu/energy/efficiency/action_plan/action_plan_en.htm

[xxx] See: http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm. Priority technologies include: advanced fossil fuel production, carbon capture and storage (CCS); biofuels, bioenergy; cement energy efficiency, road transport efficiency; cogeneration of heat and power (CHP); concentrated solar power, solar heating and cooling, solar PV; smart electricity grids, electricity storage, fuel cells and hydrogen; geothermal; hydropower, ocean wave power; nuclear fission and fusion; and wind power.

[xxxi] See: http://ec.europa.eu/energy/strategies/2010/2020_en.htm

[xxxii] The roadmap refers to the European Commission's forthcoming White Paper on Transport.

[xxxiii] The roadmap refers to EU Common Agriculture Policy proposals for 2013 and forthcoming European Commission Communications on the Bio-economy and on Land Use, Land Use Change and Forestry.

[xxxiv] Instruments discussed for leveraging public finance include: revolving funds; preferential interest rates; guarantee schemes; risk-sharing facilities and blending mechanisms.

[xxxv] See: http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

[xxxvi] This does not include the benefits of emissions savings in the sectors not covered by the EU carbon permit market, estimated to deliver a net benefit to the UK of £45 billion over the lifetime of the policies.

[xxxvii] See Climate Action Tracker assessment at: http://climateactiontracker.org/countries/southkorea.html

[xxxviii] India's GHG emissions are projected to increase by about 47 per cent between 2011 and 2020 (Rastogi, 2011, p.127).

[xxxix] Where 'avoid' relates to system design and planning so as to minimise the need for transport, 'shift' aims to prioritise usage of transport modes that are less carbon intensive and 'improve' aims to use the most carbon efficient technologies available for a given form of transport (LCSIG Interim Report, p. 48).

[xl] About 40 per cent of India's population is below the poverty line and about 400 million do not have access to electricity (Rastogi, 2011, p. 128).

[xli] The amendment came in April 2011 after a political backlash against the ruling party in a key regional election, which was widely attributed to strengthened public concern over nuclear power in the wake of Japan's Fukushima nuclear power plant disaster. See e.g. Jungjohann A. And Rickerson W. (2011) 'No nukes, No problem? Germany's race for a renewable future,' 13 May, http://www.renewableenergyworld.com/rea/news/article/2011/05/no-nukes-no-problem-germanys-race-for-a-renewable-future and Spiegel Online, (2011) 'Merkel takes first steps towards a future of renewables', 15 April, http://www.spiegel.de/international/germany/0,1518,757371,00.html

[xlii] Elections in Denmark in September 2011 saw the centre-left alliance led by the Social Democrats take over from the Liberal-Conservative party alliance, which had been in power for ten years.

[xliii] *Energy Strategy 2050* provided a detailed, energy sector specific follow-up to the findings and recommendations presented in 2010 by the Danish Commission on Climate Change Policy.

[xliv] The plan notes that the primary, though surmountable, challenge in the continued development of wind power is finding suitable sites. Financial aspects are considered highly attractive, to the point that the Danish Government proposes phasing out subsidies for wind turbines from 2014.

[xlv] Conversion to US dollars at January 2012 (DKK 1 = US$ 0.17).

[xlvi] Collaborating agencies included: The Office of the Governor; California Public Utilities Commission, California Energy Commission, California Air Resources Board, Californian Environment Protection Agency and the Californian Independent System Operator.

[xlvii] Achievement of the 2020 goal would require cutting approximately 30 per cent from business-as-usual emissions levels projected for 2020, or about 15 per cent from 2010 levels. This would require an annual per capita emissions reduction target of approximately 14 tonnes.

[xlviii] The 33 per cent standard is expected to reduce greenhouse gas emissions by about 13 million metric tons of carbon dioxide equivalent per year in 2020, in addition to the approximately 8 million metric tons of reductions from the 20 per cent requirement.

[xlix] A practice whereby power plant operators withdraw large quantities of coastal and estuarine water to cool turbines, then return the water to the environment at higher temperatures.

[l] This will reduce greenhouse gas emissions by about 28 million metric tons of carbon dioxide equivalent per year state-wide in 2020.

[li] 'Carbon intensity' is defined as the lifecycle greenhouse gas emissions, per unit of energy of fuel delivered. Fuel producers and importers are required to reduce the average carbon intensity for their fuel starting in 2011 through 2020. This program is estimated to achieve reductions of about 16 million metric tons of carbon dioxide equivalent per year in 2020.

[lii] See: http://www.cacleanenergyfuture.org/documents/CCEFRoadmap.pdf

[liii] See: http://www.westernclimateinitiative.org/


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