Tackling the Challenge of CLIMATE CHANGE

A NEAR-TERM ACTIONABLE MITIGATION AGENDA

COMISSIONED BY THE REPUBLIC OF NAURU, CHAIR OF THE ALLIANCE OF SMALL ISLAND STATES (AOSIS)

23 SEPTEMBER 2014

The Republic of Nauru chairs the Alliance of Small Island States (AOSIS), a coalition of 44 low-lying and coastal nations among the most vulnerable to the impacts of climate change. www.aosis.org

FRONT COVER PHOTOS

top: Storm in the Yasawa Islands, Fiji (iStockphoto.com/MikaelEriksson)

left: Solar panels in Seychelles (iStockphoto.com/bischy)

right: Wind turbine in Jamaica (iStockphoto.com/Sofimanning)

Hurricane Tomas causes massive flooding on the streets of Gonaives, Haiti in 2010.

UNITED NATIONS

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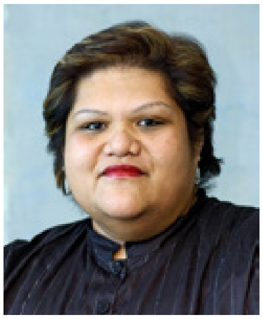
JÜRGEN FROM SANDESNEBEN, GERMANY—FLICKR/WIKIMEDIA COMMONS

As our demand for energy increases, so will the need for renewable sources, such as wind turbines in a rapeseed field in Sandesneben, Germany.

Prologue



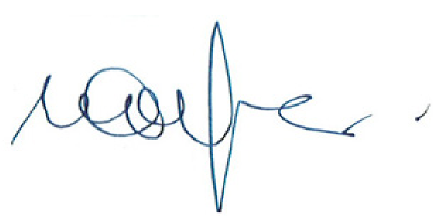
AMBASSADOR MARLENE MOSES, Permanent Representative of the Republic of Nauru to the United Nations and Chair of the Alliance of Small Island States (AOSIS)

With the recent release of the Fifth Assessment Report by the Intergovernmental Panel on Climate Change, there can be no doubt that the Earth is warming and human beings are responsible. For most scientists and small islands, like my country of Nauru, this debate was settled decades ago. The urgent need for action could not be clearer, and has been articulated by the international community in a single goal to limit the rise in average global surface temperature to below 1.5 or 2 degrees C.

Less appreciated is what it means in terms of the speed and scale of action required to achieve this goal. The time for incremental change has long since passed. We must begin an economic and political transformation of a magnitude far beyond anything countenanced by world leaders thus far. And that transformation must begin today.

Thankfully, the United Nations Secretary General has called on world leaders to do just that at the U.N. Climate Summit, and as this report illustrates, we are not without the tools to begin this ambitious (and admittedly daunting) undertaking. Countries, communities, and companies around the world have developed and deployed successful strategies for rapidly and affordably reducing greenhouse emissions. We need to learn from these models for action and radically scale up their implementation around the world.

This report highlights the things we can do *today.* They are proven technologies and practices, they are affordable, and many even bring other benefits that make them worth doing in their own right—things like improved health, increased energy security, economic competitiveness, and fiscal responsibility. That is not to say it will be easy. It will require enacting supportive policy environments, directing financial resources to where it is needed, and in many cases, taking on entrenched interests. But the alternative is not an option, for my country or for yours.



SAKAORI/WIKIMEDIA COMMONS

Solar Power Plant in Kofu, Japan

Executive Summary

United Nations Secretary General Ban Ki-moon has invited world leaders to come to the Climate Summit on September 23, 2014 to deliver "bold pledges" to tackle climate change. This paper was prepared at the request of the Republic of Nauru, Chair of the Alliance of Small Island States, as part of their answer to that call.[1] We believe the path to the global low-carbon transformation needed to tackle the climate crisis is within reach, but requires decisive political action from leaders around the world, now.

This paper is unabashedly prescriptive on the need for action, but recognizes that there are multiple approaches and models from around the world that can be scaled up and adapted to national circumstances. Cost-effective technologies for a low-carbon economy are being implemented throughout the world, but at nowhere the scale and speed necessary. Emissions continue to rise. With every year of delay, human suffering, biodiversity loss, and the costs of mitigation and adaptation increase. We are running out of time.

- We can and must act boldly now to reduce greenhouse gas emissions to keep the politically agreed 1.5–2°C goal within reach, avoid increased costs of mitigation and adaptation and technological lock-in, provide universal access to modern energy, and realize multiple health and development co-benefits.
- The scale of the challenge is beyond anything we have yet considered. Success is essential for current and future generations but is only achievable if we tackle the technological, institutional, financial and political inertia now. Despite the rise in profile of climate change as a critical issue, emissions since 2000 have been increasing at a rate almost three times faster than they did in the last decade of the nineties. Our current pathway will not achieve the deep decarbonization we need. Time is running out.
- There is major cost-effective potential to rapidly increase efficiency in the transportation, building, industrial, agricultural, waste management and water sectors with existing commercially available technologies and use of best practice, given appropriate policy support.
- There is significant scope for the early deployment at scale of renewable energy technologies (e.g., wind and solar), if supported with policies (e.g., affordable capital, feed-in tariffs, elimination of fossil-fuel subsidies and de-risking investments) and increased public and private sector financing.
- An effective price on carbon to reflect the health and environmental costs of emissions for current and future generations would send the right price signal to drive investment in clean technology.
- A systems-wide transformation towards a low-carbon economy requires policies to catalyze behavioural change across societies as a complement to low carbon technologies.
- The least efficient coal plants should be retired and no more coal plants without Carbon Capture and Storage (CCS) should be built.

1 Author team: Robert Watson, Nebojsa Nakicenovic, Erika Rosenthal, José Goldenberg, Leena Srivastava, Kejun Jiang, Dirk Messner, Kevin Anderson, Diana Ürge-Vorsatz, Louis Verchot, Mark Grobmyer, Dan Calverley, Daniel Murdiyarso, David Griggs, Doug Arent, Eric Suzman, Hugh Sealy, Hussein Alfa (Seyni) Nafo, I H Rehman, Jasper Inventor, Kazuhisa Koakutsu, Kentaro Tamura, Markus Amann, Michael P. Walsh, Naderev Sano, Robert Williams, Shonali Pachauri, Sivan Kartha, Steve Sawyer, Tosi Mpanu-Mpanu, Zheng Li

Imperative for transformative actions to a low-carbon economy

- There is an urgent near-term need to drastically reduce greenhouse gas emissions to meet the politically agreed goal of limiting increases in global mean surface temperature to below 2°C relative to pre-industrial levels.
- The impacts and costs of delaying action on climate change have been underestimated and increase with every year—the "lock-in" of additional high-carbon infrastructure makes achieving the 2°C climate change goal more expensive and much less likely, and increases the threat of triggering tipping points and run-away climate feedbacks.
- Significant additional actions are necessary to reduce GHG emissions beyond those in place today; without additional actions the projected emissions growth is expected to result in global mean surface temperature increases in 2100 from 2.5°C to 7.8°C when climate uncertainties are included. Full implementation of the Cancun pledges will not set the world on a pathway to achieve the 2°C goal, but is more closely aligned with temperature increases closer to 3°C or much greater.
- All energy systems will need substantial upgrading or complete replacement over the next few decades. Low-carbon technologies offer increasingly cost competitive, viable options in many countries and offer significant economic and other benefits in terms of reduced vulnerability to volatile fuel prices, improved energy security and human health.
- Limiting the warming caused by anthropogenic carbon dioxide emissions to less than 2°C (with a 66% probability of success) will require cumulative emissions from all anthropogenic sources since pre-industrial times to stay below 1000 GtC (or 790 GtC, allowing for the emissions of non-carbon dioxide gases)[2] according to the lowest emission scenario in the Fifth Assessment Report of the UN Intergovernmental Panel on Climate Change (Representative Concentration Pathway , RCP 2.6). We have already emitted between 470 and 640 GtC of carbon dioxide alone, and current anthropogenic emissions are nearly 11 GtC per year. To stay within our carbon budget, decarbonisation of the energy sector and a drastic reduction in emissions from land-use practices is needed on a scale never before attempted—basically we are running out of time.
- Climate-friendly urbanization, *i.e.,* the creation of resilient low carbon energy, mobility, water, buildings and waste infrastructures is both possible and an imperative given rapid urbanization, especially in developing countries.
- Tackling the unacceptably high existing levels of modern energy services deprivation (1.5 billion people without electricity and 3 billion without clean cooking) will have a transformative social impact through multiple development (e.g., poverty alleviation and improved livelihoods, productivity, human health, and energy security), and environmental (e.g., indoor and outdoor air pollution, climate and ecosystem) co-benefits.

Transformational actions are needed and possible

- We have models of transformational programs that reduce GHG emissions while reflecting national contexts and capabilities of countries. For example: (i) on a sunny day, Germany can generate more than half its electricity from solar power; (ii) Brazil produces a significant fraction of its liquid fuel for transportation from sugar cane-based ethanol (between 2004 and 2013, 30–45% of fuel for light-duty vehicles); (iii) Vienna uses nearly zero energy for heating and cooling; (iv) California›s three large independently operated utilities collectively served 22.7% of their 2013 retail electricity sales with renewable power; and (iv) in 2013 Denmark and Spain produced 33% and 21%, respectively, of their electricity from wind.

2 1 GtC = 3.7 GtCO2

- Every country, consistent with the principle of Common but Differentiated Responsibilities, can and must embrace transformative changes that go far beyond simple marginal adjustments to business-as-usual, and the incremental uptake of low-carbon technologies. This transformation will need to include: (i) the use of policies (government action is critical) (ii) institutional changes, (iii) increased financing (public and private sector) and (iv) changes in behaviour ("new ways of thinking" by governments, private sector and society).
- Two complementary approaches can help accelerate the transformation: (i) a focused strategy concentrating on major decarbonization initiatives such as the huge investments in renewable energy in China and the German energy transformation, or cities such as Copenhagen moving toward low or zero carbon; and (ii) an ambitious scaling-up and expansion of current initiatives such as efficiency standards, energy conservation and feed in tariffs, and city and subregional strategies, that together can have great synergistic impact.

Technological opportunities that can and must be taken now

Rapid implementation of existing, commercially available and cost-effective energy efficiency and renewable energy technologies, decarbonization of fossil-fuel energy, waste minimization, changes in agricultural and forestry practices, and reducing short-lived climate pollutants—combined—will not only reduce greenhouse gas emissions, but also provide multiple development, environmental and energy security co-benefits.

Energy efficiency

- Reducing greenhouse gas emissions from the transportation, building, industry, agricultural, water and waste management sectors through improved efficiency is feasible in the near-term using current cost-effective technologies and best practices; such changes provide multiple co-benefits.
- Energy performance standards for lighting, appliances, ICT equipment, buildings, industry and vehicles have been successfully implemented in many developed and developing countries; are among the most cost effective tools to cut emissions; and have large mitigation potentials in the near and medium-term, mostly at negative net cost.
- There is major low-cost potential to be captured in every country by strengthening performance standards and increasing the range of goods and services to which they are applied. Coordinating multiple policies, such as fuel-economy standards for new vehicles coupled with zero sulphur fuels to enable the cleanest most efficient engines, is key.
- In rapidly urbanizing developing countries, urban design enabling low mobility needs and a high share of low-emission transport in the modal mix is critical. In developed countries retrofitting existing building stock to high energy efficiency levels is a priority, as is investment in strengthening efficient public transport systems; given the high lock-in risk it is crucial that retrofits aim at the best performance levels achievable, typically a 70–90% reduction in heating and cooling energy consumption.

Renewable energy

- Power systems continue to evolve to accommodate more renewables—variable sources such as wind and solar can contribute up to 40% of the energy generated without major modifications in most electricity systems and periodically higher percentages.
- The costs of wind and solar power have decreased significantly in recent years. Wind competes directly with conventional energy sources today on the wholesale market in an increasing number of countries, and solar is competitive now in many retail markets as the price continues to decrease rapidly.
- Promoting renewable energy (wind, solar, geothermal, modern biomass and hydropower) through smart centralized and decentralized grids is particularly important for serving local communities.

- Increased policy and financial support would increase the potential contribution of wind and solar technologies in the next decade, e.g., renewable energy portfolios, feed-in tariffs, which could, where needed, be financed through international institutions such as the Green Climate Fund.

- Currently electricity provides around 20% of global final energy use; this proportion needs to increase significantly to effectively substitute low-carbon energy options for current high-carbon fuels (for example, increased electrification of transport, heating and industrial processes and introduction of renewable-based synthetic energy gases).

- Wind and solar PV will result in ~1.4 billion tonnes of avoided CO_2 emissions per annum by 2020, however, with proper support this could increase by an additional 1 billion tonnes per annum in that time frame. The technical and economic potential of renewable energy can fully supply the world's energy needs, while significantly reducing greenhouse gas emissions.

- More than 138 countries have renewable energy support policies offering considerable experiences. Today 13 countries in Africa, and more than 65 countries world-wide, are planning or pursuing feed-in tariff systems at the national level.

Fossil fuel-based energy

- Significant emissions reductions could be achieved by enacting measures aimed at: (i) retiring or limiting the use of the least efficient coal plants, prohibiting the construction of coal-fired plants without CCS and promoting CCS retrofits for existing coal plants; and (ii) expanding use of natural gas where so doing will lead to significant emissions reduction, e.g., substituting natural gas for more carbon-intensive fuels for power, industrial, and other applications (including combined-cycle heat and power cogeneration) and as a flexible generating capacity for balancing electric grids, (iii) minimizing methane losses from extraction to end use for fossil energy and encouraging CCS for natural gas power plants. Eventually all fossil energy needs to be decarbonized and CO_2 emissions of the global energy system will have to be zero or negative.

- Deep reductions in GHG emissions will not be possible for fossil energy without widespread adoption of CCS. Moreover, deep decarbonization of the global energy system is likely to be more costly and perhaps less feasible without CCS as a viable carbon-mitigation option. While there has been significant progress in advancing CCS, the global effort falls far short of what is needed to demonstrate the commercial viability of the technology.

- Priority over the next decade should be given to exploiting low-cost CCS opportunities including: (a) gaining experience and buying down costs of promising near-term CO_2 capture technologies in conjunction with enhanced oil recovery opportunities (especially in the US); and (b) gaining experience with geological storage of CO_2 by exploiting low CO2 capture cost opportunities at chemical and synthetic fuels plants (especially in China).

Land-use practices

- There is significant potential for reducing emissions from the agricultural sector with appropriate policy support, including incentive mechanisms to promote wider adoption of best practices. Agricultural GHG mitigation options (e.g., cropland and grazing land management, restoration of degraded lands and cultivated organic soils, rice and livestock management) are cost competitive with options in other sectors, some at very low cost ($5 per tCO_{2eq}).

- Carbon sequestration in agroecosystems holds great promise as a tool for climate change mitigation and offers opportunities for synergy with development objectives. High rates of sequestration can be achieved by introducing more productive grass species and though agroforestry, the introduction of trees into farming systems which produces longer term carbon storage.

- Emissions of GHGs from the forestry sector can be significantly reduced by 2020 and beyond by reducing the rates of deforestation and forest degradation, coupled with conservation, sustainable management of forests and enhancement of forest carbon stocks (afforestation and reforestation), *i.e.,* REDD+ activities which are cost-effective and have substantial co-benefits for local communities and biodiversity.

- Much of the REDD+ architecture is already in place and a number of countries can probably implement immediately, but to be successful, REDD+ activities require inter-ministerial/agency cooperation or collaboration, as well as legal, policy and institutional reforms, addressing issues such as the drivers of deforestation, land tenure, permanence of carbon storage and ecosystem functioning.

Short-lived climate pollutants and hydroflourocarbons

- Acting now to reduce atmospheric concentrations of short-lived climate pollutants particularly black carbon, ozone precursors and methane, and also hydroflourocarbons (HFCs) using well proven and readily available technologies offers a cost-effective opportunity to slow the rate of near-term climate change, while improving air quality and public health and reducing crop-yield losses.

- By reducing near-term increases in temperature, SLCP emission reductions also lessen the risk of dangerous climate feedbacks such as accelerated Artic melting and sea level rise. It is essential that efforts to reduce short-lived pollutants complement and do not detract from mitigation efforts on carbon dioxide.

Policy considerations

- There are many successful models around the world that can be adapted to national circumstances and scaled depending on regional differences in opportunities, priorities and approaches to the necessary transitions to a low-carbon economy. Developed countries must show leadership by demonstrating that GHG emissions can be significantly reduced in a cost effective manner while stepping up provision of the means of implementation (finance, technology transfer, and capacity building) which is essential for this transition to occur in many developing countries.

- Incentive programs should be urgently designed and implemented to drive sustainable consumption, coupled with appropriately designed education and awareness programs.

- Effective energy-focused policies must be coordinated and integrated with policies addressing socioeconomic development and environmental protection in other sectors, and will require a combination of instruments, including regulatory frameworks (e.g., emissions targets, efficiency standards, renewable portfolio standards) and investment policies (e.g., putting an effective price on carbon, and the elimination of fossil-fuel subsidies), as well as measures for strengthening capacity development and stimulating innovation.

- If the Intergovernmental Panel on Climate Change (IPCC) emissions budget range for a "likely" chance of not exceeding the 2°C goal is to be adhered to, policy responses will need to take equity considerations into account, not just between but also within nations.

Financial and economic considerations

- Putting an effective price on carbon to reflect the health and environmental costs of emissions for current and future generations would send the right price signal to further stimulate market penetration of renewable and other low-carbon energy technologies and end-use efficiency.

- Public and private finance, must, and can, be scaled up quickly—hundreds of billions of additional dollars annually will be required. Current investments in the energy sector are around US$ 1.3 trillion per year. To stay below the 2°C goal it has been estimated that this will need to be increased to between US$ 2.0 and 2.6 trillion per year. The enormous wealth and long-term horizons of pension, sovereign wealth and insurance funds make them prime sources of potential investment in commercially viable enterprises.

- Fossil fuel production subsidies need to be eliminated, and consumption subsidies reformed and eliminated where possible given many are inefficient and slow the uptake of renewables and energy efficiency, encourage wasteful consumption, are expensive for taxpayers, and harm the environment and public health by increasing emissions of GHGs and other air pollutants. However, given the importance of access to modern energy services, social safety nets should be in place for the most economically disadvantaged.

- There are many proven low carbon and clean technologies that can be currently deployed at scale profitably, yet rapid deployment at sufficient scale to address the urgent mitigation need is not happening in part because: (i) of significant up-front capital costs and lower short-term rates of return compared to other investments; (ii) small, innovative companies often lack the working capital and knowledge to accelerate deployment; (iv) the perceived risk to investors and the challenges in bundling projects to sufficient scale to attract major investors; and (v) powerful vested interests are working to maintain the status quo fossil fuel industry.

Actions underway or planned must be significantly scaled up now

- Delivering near-term emissions reductions demands decisive action and political courage from leaders around the world. If the elements of the near-term actionable agenda laid out in this paper are adapted to national circumstances and implemented and scaled at speed around the world, we will have a fighting chance. We have no time to lose.

- Although a number of governments and businesses have already started to implement elements of strategies to transition to a low-carbon economy much more is needed, given the ever-increasing emissions of GHGs:
  - Where Governments have made the climate issue a policy priority, there has been an increased share of power production from renewable energy technologies and an increase in end-use efficiency;
  - It is recommended that every Government prepare and submit a technology road map, which includes techno-economic, institutional and social feasibility assumptions, for transitioning to a low-carbon economy; and
  - A growing number of companies are already working within shadow carbon pricing systems and are developing expertise in managing their emissions. It is recommended that corporate and public financial accounts be accompanied by an inventory of GHG emissions.

- Behavioural change at the individual level and transitions to low energy consuming habits within institutions are needed across society. Governments must make climate change a high priority policy issue and promote this message throughout society. The private sector must seize profitable opportunities in a low-carbon economy, get ahead of new climate policies, and, encouraged by growing consumer and social movements, be socially responsible.

- Vested interests trying to maintain the status quo need to be overcome and increased voice and agency given to those constituencies most vulnerable to the impacts of climate change.

- Additional research and education initiatives are need to accelerate the transformation to a low-carbon economy by spurring development of low-carbon alternatives; increasing the diffusion of innovations; and, developing effective political strategies and policy instruments.

- Increased international cooperation, such as Work Stream 2 of the UNFCCC, a solutions-oriented technical process to catalyze and scale-up near-term emissions reduction initiatives around the world, is imperative to accelerate the transformation to a low-carbon economy.

Preface

This report brings together contributions from 30 experts from around the world laying out a menu of what is possible. The report was chaired by Dr. Robert Watson (Strategic Director of the Tyndall Center at the University of East Anglia, Visiting professor at Monash University, Australia, and former Chair of the Intergovernmental Panel on Climate Change). A small group worked with Dr. Watson and Ambassador Marlene Moses of Nauru in New York in August 2014 to draft the paper, including Dr. Nebojsa Nakicenovic (Deputy Director of IIASA, and Director of the Global Energy Assessment); Erika Rosenthal (attorney with Earthjustice, a public interest environmental law firm), Dr. José Goldemberg (Chair of the first Rio Summit and former Environment Secretary and Education Minister of Brazil), Dr. Leena Srivastava (Vice Chancellor, TERI University, New Delhi); Dirk Messner (German Development Institute) and Dr. Kejun Jiang (Energy Research Institute, National Development and Reform Commission of China). The paper was then reviewed and endorsed by all 30 contributors. The team wishes to thank the Republic of Nauru for their leadership in the development of this paper and Earthjustice and IslandsFirst for their collaboration.

This paper summarizes the contributions from the 30 experts and contains a number of Annexes: (i) Annex I lists the contributors with their affiliation; (ii) Annex II summarizes a limited number of country profiles where countries have either assessed near-term options to reduce greenhouse gas (GHG) emissions and/or are already implementing actions; (iii) Annex III summarizes some key relevant conclusions from the Intergovernmental Panel on Climate Change (IPCC) and the Global Energy Assessment (GEA); and (iv) Annex IV summarizes key papers and statements made by leading scientific and energy experts.

The 30 authors' contributions to this paper can be found in Annex (v) available on-line at www.aosis.org.

MOHAMED SHAREEF/SHUTTERSTOCK

Male, the capital of Maldives, will be devastated if sea levels continue to rise in the face of a warming planet.

Ferocious waves batter the sea walls of Havana, Cuba.

(KAMIRA/SHUTTERSTOCK)

I. Introduction

United Nations Secretary General Ban Ki-moon has asked world leaders to come to the Climate Summit on September 23, 2014 to deliver "bold pledges" on tackling climate change. This paper was prepared at the request of the Republic of Nauru, Chair of the Alliance of Small Island States (AOSIS), as part of their answer to that call. The paper sets out a feasible near-term actionable agenda to reduce emissions and take critical steps to avoid lock-in of new high-carbon fossil fuel infrastructure. Drafted by 30 experts from around the world, and chaired by Dr. Robert Watson, former chair of the IPCC, the paper builds on the myriad excellent reports from the IPCC, International Energy Agency and others to lay out an action plan for what can and must be done in the near term to keep the politically agreed 1.5 to 2°C goal within reach.

The good news is that where governments have made climate a priority, smart policies have facilitated the transformative scaling up of renewable energy and end-use efficiency to achieve emissions reductions in the near term. Businesses around the world are beginning to see tackling climate change as an economic opportunity, investing in green technologies and calling for a price on carbon. Communities are implementing solutions and reaping health, energy, security and development benefits.

Yet emissions continue to rise, with the actual rate of annual growth since the start of the millennium three times higher than during the 1990s. With every year of delay, human suffering, biodiversity loss, and the costs of mitigation and adaptation increase. The path to global transformation is within reach, but needs decisive political action from leaders around the world, now. If the 2°C goal is to be respected, there can be no delay.

Like African nations and Least Developed Countries, AOSIS countries contribute little to the climate crisis but suffer early and greater climate impacts, derailing development gains. While many AOSIS members have committed to significant emissions reductions and are scaling up the share of electricity provided from renewable energy,[3] their national actions alone will not protect their citizens from the storms and rising tides that threaten their economies and way of life, and in some cases, their very existence.

AOSIS has exercised great leadership on climate change, particularly on the urgency of deep emissions reduction and the launch of the Work Stream 2 process in the United Nations Framework Convention on Climate Change (UNFCCC) to focus on solutions in the near-term. This paper, a feasible near-term mitigation action agenda for the consideration of global leaders, is the AOSIS chair's contribution to the Secretary General's Climate Summit. The world can and must act boldly to tackle the challenge of climate change, without delay.

3 Please see The Barbados Declaration on Achieving Sustainable Energy for All in Small Island Developing States, Listing of Voluntary Commitments by SIDS aimed at promoting Transformational Activities in the Areas of Renewable Energy, Energy Efficiency, Energy Access and Low-Carbon Development in the Context of Sustainable Development available at: (SIDS)http://www.sids2014.org/content/documents/258Barbados%20Declaration.pdf

2. Imperative for transformative actions to a low-carbon economy

Total anthropogenic emissions of greenhouse gases have increased significantly since pre-industrial times. Despite the rise in profile of climate change as a critical issue, emissions since 2000 have been increasing at a rate almost three times faster than they did in the last decade of the nineties. This recent increase is occurring even when many countries are implementing actions to lower their emissions. These emissions of greenhouse gases have resulted in an unambiguous human influence on the climate system, *i.e.,* human activities are the dominant cause of the observed warming since 1950 (IPCC Working Group I). This has been a consistent and increasingly urgent message across all IPCC reports over the last quarter century.

In recent decades, human-induced changes in climate have caused impacts on natural and human systems on all continents and across the oceans (IPCC Working Group II). Unmitigated climate change poses a severe threat to any future Sustainable Development Goals suggested by the UN Open Working Group Report (July 2014), in particular poverty eradication, food and water security, human health, terrestrial and marine biodiversity and ecosystem services.

There is an urgent need to drastically reduce greenhouse gas emissions from the production and use of fossil fuels and land-use practices to meet the politically agreed goal of limiting increases in global mean surface temperature to no more than 2°C relative to pre-industrial levels. While staying within the planet's safe operating space, it is essential that universal access to modern energy services is achieved (see, e.g., Sustainable Energy for All), especially access to electricity.

A recent analysis by Dietz and Stern argues that the impacts and costs of delaying action on climate change have been underestimated, even by the IPCC, and increase with every year we fail to deliver real reductions in absolute emissions. The "lock-in" of additional high-carbon infrastructure makes achieving the 2°C climate change goal much more expensive and far less likely, and increases the cost of adaptation and the threat of crossing tipping points and triggering run-away climate feedbacks.

The IPCC fifth assessment report concluded that limiting the warming caused by anthropogenic carbon dioxide emissions to less than 2°C (with a 66% probability of success) will require cumulative emissions from all anthropogenic sources since pre-industrial times to stay below 1000 GtC (or 790 GtC, allowing for the emissions of non-carbon dioxide gases)[4] according to its lowest emission scenario in (Representative Concentration Pathway, RCP,2.6). We have already emitted between 470 and 640 GtC of carbon dioxide alone, and current anthropogenic emissions are nearly 11 GtC per year. To stay within our carbon budget, decarbonisation of the energy sector and a drastic reduction in emissions from land-use practices is needed on a scale never before attempted—basically, we are running out of time.

To stay within our carbon budget requires industrialised nations to begin an immediate programme of radical mitigation at rates far beyond anything yet countenanced (the IPCC budget range for a "likely" chance of 2°C would require ~10% per year for Annex 1 nations[5]) delivered in the near-term by radical and immediate reductions in energy demand. Baseline scenarios, those without additional mitigation actions, are expected to result in global mean surface temperature increases in 2100 from 3.7°C to 4.8°C compared to pre-industrial levels (median values: the range is 2.5°C to 7.8°C when including climate uncertainty). The current and projected energy pathways and land practices,

4 1 GtC = 3.7 GtCO2

5 This is based on the IPCC budget range for a "likely" chance of 2°C, taking account of current emissions and deforestation and assuming a weak equity framing whereby non-Annex 1 nations (on aggregate) peak their emission by 2025 and then mitigate at 6–8%p.a. thereafter.

even with full implementation of the Cancun pledges, are more closely aligned with temperature increases closer to 3°C or much greater.

Developed countries, in particular, and major emerging economies will need to significantly increase ambition levels. Without additional efforts to reduce GHG emissions beyond those in place today, emissions growth is expected to persist, driven by growth in both global population and economic activity. At the same time, it is imperative to provide access to modern energy services that can have a transformative social impact through multiple development and environmental co-benefits, e.g., poverty alleviation, improved livelihoods, human health, and energy security and reducing indoor and outdoor air pollution. Energy access needs to include livelihoods-based energy provisioning, with end-use service delivery the key determinant of access. Social entrepreneurship is increasingly recognized and supported through policy and regulatory frameworks, making private sector participation in energy access an attractive proposition.

Nellis Solar Power Plant located within Nellis Air Force Base, northeast of Las Vegas, Nevada, United States. The power plant occupies 140 acres, contains about 70,000 solar panels and generates 14 megawatts of solar power for the base.

3. Transformative actions are needed and possible

The conditions for the low-carbon transformation already exist, because many elements of change have emerged: many different low-carbon technologies and practices are already available and their costs are decreasing rapidly; major cities and companies are now addressing their carbon footprint; low-carbon research alliances are multiplying; international organizations, including the World Bank, are shifting towards low-carbon investment strategies; and numerous governments have taken actions to reduce their emissions.

Yet while these important examples of lower-carbon development exist, the emissions of greenhouse gases, especially carbon dioxide, continue to increase. There is a real danger that the dynamics between change and dogged insistence on the status quo will lead to a lock-in of the current technologies and development pathways. The low-carbon transformation that is both necessary and possible could yet fail before it has really begun in earnest. The biggest challenge is overcoming political, institutional, cultural and economic path dependencies and barriers.

Every country can and must embrace transformative changes that go far beyond simple marginal adjustments to business-as-usual, and the incremental uptake of low-carbon technologies. Such transformation, consistent with the principle of Common but Differentiated Responsibilities and Respective Capabilities, will need to include: (i) strong policies (government action is critical); (ii) institutional changes; (iii) increased financing (public and private sector); (iv) changes in behaviour ("new ways of thinking" by governments, private sector and society); and (v) capacity building that can foster a rapid diffusion, scale-up and adoption of low-carbon technologies and practices throughout energy systems and the economy as a whole.

Developed countries should show leadership by developing and implementing a strategic plan to transform their energy economies by 2025, demonstrating that the transformation to a low-carbon economy can be achieved in a cost effective manner. Spreading this transformation globally will require transcending differing political systems and mistrust between nations, and cooperating politically, technologically and financially at the scale necessary to enable much more than marginal deviations from business as usual. While it will affect diverse societies and economic sectors, it can also bring multiple development, human health, energy security and ecosystem benefits.

Two complementary approaches are needed to accelerate the transformation and provide flexibility to adapt to national circumstances: (i) an ambitious incremental strategy; and (ii) a focused strategy.

- The ambitious incremental strategy scales up and expands current initiatives such as efficiency standards and feed-in tariffs, and city and sub-regional strategies that together can have a greater synergistic impact that would be expected from the simple addition of individual ad-hoc sectoral activities. This strategy can be implemented immediately, by any developed country, region or city, and with existing resources. It is realistic for those with the courage to embrace change. With international cooperation, developing countries too can follow suit soon after. Measures which, taken on their own, have little transformative impact can, through clever mixing and skilful integration, have a far greater impact and generate unexpected movement far more than a simple addition might lead us to believe. Taken in total, a societal tipping point can be reached, beyond which resistance to the transformation significantly decreases, the requisite political willingness grows, and the transformation gains considerable momentum.
- The focused strategy concentrates on just a few major changes—e.g., heavy

investments in renewable energies; putting a reasonable price on carbon; massive energy efficiency investments in buildings; and stringent emission standards on vehicles and appliances—that can have a major transformative impact. Many protagonists across many countries will likely view such transformations as unrealistic, especially in the face of powerful forces insisting on preserving the status quo, so they will need major political movement to push them through. The German energy transformation, the huge investments in renewable energy in China, the Chinese experiments with sub-regional emission trading schemes, and cities such as Copenhagen moving toward low or zero carbon are examples of focused strategies with potentially significant impacts on decarbonisation dynamics.

Children in Haiti hold up signs urging the international community to take action on climate change

In combination, the ambitious incremental strategy and focused transformation strategies aim for a fundamental transformation, charting a distinct course from the incremental policies of short term crisis management. Decisive action toward transformation to a low-carbon economy must be taken within the next decade if the conversion to a low-carbon economy is to succeed within the next 20 to 30 years.

There are models of national programs that have initiated transformational changes in specific sectors, reducing GHG emissions while reflecting national contexts and capabilities of countries. For example: (i) on a sunny day, Germany can generate more than half its electricity from solar power; (ii) Brazil produces a significant fraction of its liquid fuel for transportation from sugar cane-based ethanol (between 2004 and 2013, 30–45% of fuel for light-duty vehicles); (iii) one-third of new buildings in Vienna use nearly zero energy for heating and cooling; (iv) California's three large independently operated utilities collectively served 22.7% of their 2013 retail electricity sales with renewable power; and (v) in 2013, Denmark and Spain produced 33% and 21%, respectively, of their electricity from wind.

The transformation will rely heavily on stakeholders who can change the system (change agents), who can test and advance the options and help develop new visions and business models. Initially, the change agents are involved as marginalized protagonists; they could, however, develop into an effective force, greatly advancing the transformation. The transformation needs proactive governments to provide the policy framework to set the course for structural change, and to guarantee the implementation of climate friendly innovations. Finally, the transformation requires the cooperation of the international community and a commitment from all governments to ensure, wherever possible, that the changes implemented reduce social and economic inequalities.

Experience in Germany showed that empowering the state as a driver of the low-carbon transformation requires action on four interconnected levels, which were put in place based on a reform package prepared by the German Advisory Council on Global Change. These levels are: (i) constitutional reforms to define climate protection as a national political goal; (ii) creating climate protection legislation; (iii) improving citizen participation; and (iv) mainstreaming climate policies.

4. Technological opportunities that can and must be taken now

Rapid implementation of energy efficiency and renewable energy technologies, decarbonisation of fossil-fuel energy, waste minimization, changes in agricultural and forestry practices, and reducing short-lived climate pollutants will not only reduce greenhouse gas emissions, but also provide multiple development, environmental and energy security co-benefits. These technical opportunities must be pursued in tandem as rapidly as possible.

Near-term mitigation is achievable across many realms of energy demand using existing and commercially available technologies that require no infrastructure investment and impose little-to-no price premium. At a system level, such technologies may offer substantial economic benefit in terms of reduced national fuel consumption, reduced dependence on imports, improved energy security and better local indoor and outdoor air quality. The total cost of addressing climate change mitigation, energy security and indoor and outdoor air pollution mitigation separately would be about 1.5% of the total world economic output of about US$70 trillion. Combining all three into a single integrated strategy would reduce the costs to about 1.1% of the global economic output. The benefits for human heath alone would be enormous: for example, about four million people die prematurely each year from energy-related indoor pollution, affecting mostly children and women in developing countries.

It is imperative that all countries immediately scale-up efficiency measures and forgo (or decarbonize the impact of) fossil fuels as quickly as available financial and technological resources allow. These actions should supplement scaled investment in renewable energy, which should be the energy of choice for all countries, thus reducing the risks and costs associated in technological lock-in to fossil fuel technologies. GEA (2012), Deep Decarbonisation Pathways Project (2014) and a number of other initiatives indicate that technically there are alternative development pathways that lead to decarbonisation not only regionally but also globally. They all have in common a larger role of renewable energy and vigorous efficiency improvements, but differ to what extent carbon capture and storage (CCS), nuclear and other options are deployed. A portfolio of options provides more flexibility in achieving decarbonisation; while a loss of one or two options does not undermine the process it does necessitate even more ambitious efficiency improvements.

All power systems will need upgrading or replacing over the next few decades. Renewable energy offers an increasingly cost competitive, technically viable option in many countries, given they continue to advance technically with significant cost reductions (especially in wind and solar photovoltaics (PV)) and increasing market growth. Some of the power systems already generate more than 50% of their electricity from renewable energy, while most will need to evolve to accommodate more renewables and higher efficiencies.

For many countries, the barriers to transitioning to a low-carbon economy are not technological, but reflect limited national capabilities and capacities, lack of finance, and lack of appropriate regulatory and fiscal policy. Greater provision of means of implementation by the international community will be necessary for these countries to transition to a low-carbon pathway.

Energy efficiency

Improving energy intensity and reducing carbon emissions in the transportation, building and industry sectors is both feasible in the near to medium-term and essential to reaching the long-term climate goal. This includes: (i) more efficient heating and cooling systems in residential and commercial buildings through building codes and minimum energy performance standards for new buildings and equipment, and technology switching, such as through greater use of heat recovery and better use of automation and control systems; (ii) more efficient appliances and lighting in residential and commercial buildings; (iii) use of more efficient electric motor systems in industrial applications; and (iv) fuel-economy standards and fuel-economy labelling for new passenger light-duty vehicles and freight trucks in road transport; (v) electric-mobility; and (vi) use of biofuels or other alternative low-carbon fuels; (vii) shifting to or preventing the shift away from more energy-efficient modes of transportation (public transport, non-motorised mobility); and (viii) using innovative and systemic solutions that build on the recent information and communication technology (ICT) communication revolution, such as telecommuting.

Minimum energy performance standards for appliances, ICT equipment and other electricity-using products (and components) in both buildings and industry have among the largest mitigation potentials in the short- to medium term, mostly at negative net cost. These policy instruments have already been implemented in many countries worldwide, including in many developing countries, and have been demonstrated to be among the most attractive tools to cut emissions from a cost perspective globally. However, the range of goods and the ambition levels to which these can still be extended in every country around the world represents major low-cost emissions reduction potential still to be captured.

As of 2012, 81 countries had Minimum Energy Performance Standards (MEPS) in place; approximately 40 countries have banned incandescent lighting, with 20 more in advanced stages of phase out. In many European countries new buildings are required to consume less than a third to a fifth of the energy for heating a unit floor space than two decades ago, and by 2021 all new buildings are mandated to use "nearly zero" energy for heating and cooling.

While there is a very broad range of opportunities to cut emissions in the short term, this should not be done at the expense of locking in relatively higher emissions for the longer term. Infrastructure such as buildings, transport systems and urban design determine emissions on the multiple-decadal or even century scale, so poor decisions in the near future may lock in a high emission pathway in transport and buildings for long periods that will not be possible to change.

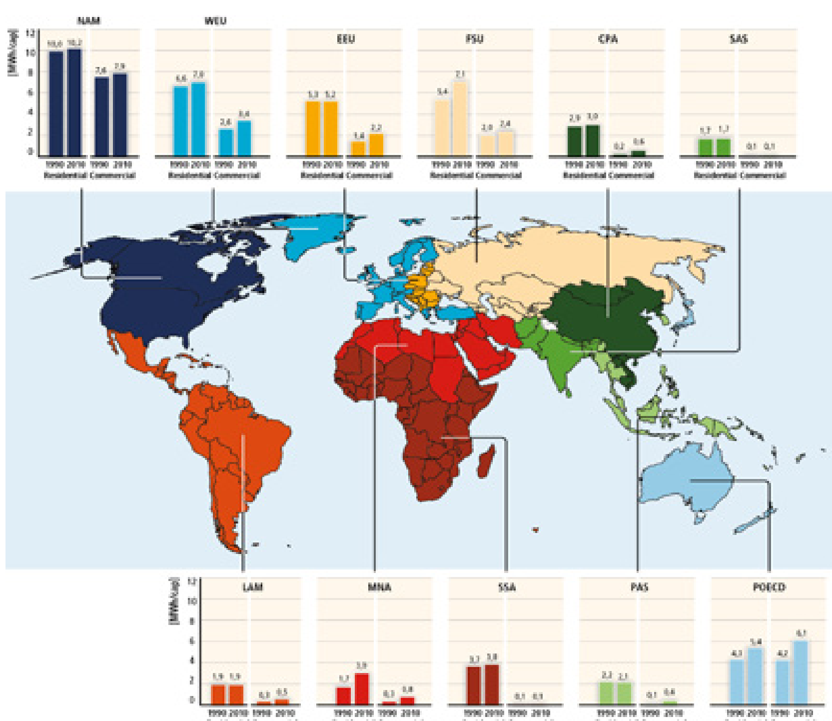
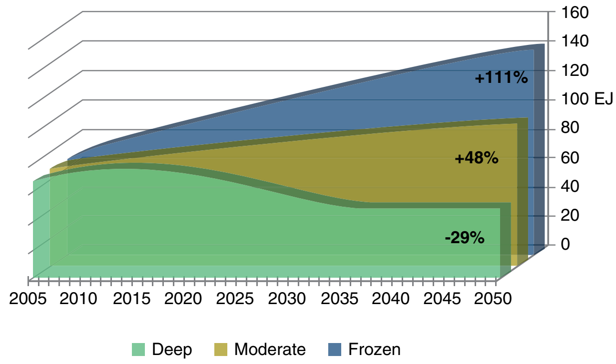


FIGURE 1.
Annual per capita final energy use of residential and commercial buildings for eleven regions (GEA RC11, see Annex II.2.4) in 1990 and 2010. Data from (IEA, 2013). Lucon and Urge-Vorsatz et al, Mitgation in Buildings, in Chapter 9—Buildings, in "Climate Change 2014: Mitigation of Climate Change," Intergovernmental Panel on Climate Change Working Group III (2014);. Available at: http://report.mitigation2014.org/drafts/final-draft-postplenary/ipcc_wg3_ar5_final-draft_postplenary_chapter9.pdf



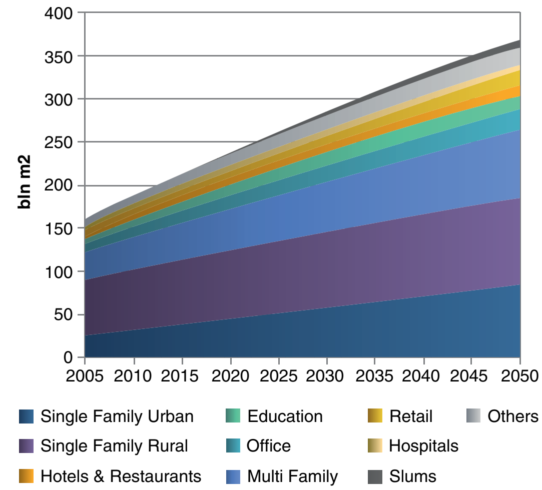


FIGURE 2.

Heating and cooling are responsible for over 50% of building energy use. This graph represents three scenarios. The top, blue line is frozen efficiency levels and rising emissions. The bottom, green line assumes ubiquitous proliferation of 2014 state-of-the-art efficiency measures for each climate zone, geographic region, and building type, i.e. assumes that the best practice becomes the standard for construction and retrofit after a decade of transition time. Source: Diana Urge-Vorsatz et al, Energy use in buildings in a long-term perspective, Current Opinion in Environmental Sustainability 2013, 5:141–151. Available at: www.sciencedirect.com.

More than half of the global population lives in cities, accounting for about 80% of global GHG emissions, including those emitted indirectly in the hinterland. Continuation of the powerful urbanization trends beyond the middle of the century is likely to double the population in cities, leaving the rural population at approximately current levels. Low-carbon urbanization is therefore a major challenge. GEA (2012) and IPCC (2014) have assessed that climate-friendly urban settlements can reduce the GHG emissions fivefold compared to current practices. Due to the fact that urban development will be extremely rapid in many developing countries in the next two decades, it is crucial that these new urban areas develop in a manner where urban design facilitates low mobility needs and a high share of low-emission transport modes in the modal mix, as well as the use of low-carbon, energy intensive and durable construction materials that do not compromise the operational energy efficiency of the new buildings. Developed countries will need to renew their depreciated and aging infrastructure, and should do so to ensure zero net-carbon emissions.

In developed countries, retrofitting the existing building stock to high energy efficiency levels also needs to have a very high priority, with a step change increase in the annual retrofit rate. Such an agenda offers significant co-benefits in terms of high levels of skilled, semi-skilled and low-skilled employment. However, due to the high lock-in risk it is crucial that retrofits aim at the highest performance levels achievable for the climate and building type, and apply a holistic perspective. These can typically achieve a 70–90% reduction in energy consumption for heating and cooling. Partial or suboptimal retrofits will only lock high emissions for many decades. Because these are cost-effective at the societal level and are crucial for keeping emissions low, but are less attractive at the individual decision-maker level, financial instruments or incentives need to be in place, possibly coupled with climate finance.

Figure 2 above shows that energy use can be turned down without any sacrifice in services and growth and comfort level of building. The scenario even assumes poverty alleviation such that everyone has full thermal comfort, *i.e.* enough heating and/or cooling to maintain a healthy indoor temperature, along with a corresponding enormous growth in world building floor space, to show the no compromise in affluence.

The world is moving rapidly to adopt near zero sulphur gasoline and diesel fuels to enable the cleanest and most efficient motor vehicle combustion engine technologies, while reducing smog-forming NO_X emissions (due to better catalyst performance). There is also a shift underway to alternative fuels and electric vehicles. Advanced battery electric and fuel cell powered vehicles are starting to enter the marketplace. In combination with renewable energy, these technologies have tremendous potential in the next several decades to dramatically reduce the transportation contribution to climate change and bring about substantial health co-benefits.

Energy efficiency has already made a major contribution to reducing emissions in many countries but has orders of magnitude larger role to play. For instance, largely due to various efficiency gains, the UK was using 12% *less* energy in 2012 as in 2000, while its GDP *increased* by 58% in the same period. Despite a major increase in the ownership and use of electricity-using devices such as iPads and various other ICT and media equipment, per capita electricity use has *decreased* by 10% over the same period. In fact, per capita domestic final energy consumption has been stagnating for two to three decades in all the key large world regions, including North America, EU, China, India, and Africa, in spite of household income multiplying several times over the period. These trends underline that improving energy efficiency can make a major difference in decoupling growth from energy consumption in all regions, including developing countries; and that if such efforts are substantially scaled up, they could reverse many trends in GHG emissions in most world regions.

Delivering deep and near-term reductions (i.e. in one to ten years) is pivotal to remaining within the IPCC's 1.5°C to 2°C carbon budgets. Although increasing penetration of new low-carbon alternatives in existing energy supply market is happening in many countries, construction of new energy infrastructure and grids can take time. In comparison, cars and many domestic appliances have 'natural' replacement schedules that offer rapid stock turnover. Moreover, best available technologies in such sectors consume only a fraction of the energy of the average car or appliance in use today, and yet are commercially viable and provide identical levels of service. Currently the best available car and appliance models comprise only a very small proportion of new purchases, offering substantial opportunities for more stringent and tightening emission standards to deliver rapid and deep reductions in emissions.

In many developed countries, vehicle distances travelled and appliance use are beginning to saturate, opening up unparalleled scope for absolute reductions in emissions using commercially available technologies that require no infrastructure investment and impose little-to-no price premium. Stringent and tightening emission standards applied to cars and appliances in the European Union and the USA could deliver emission reductions of between 50% and 70% in these two sectors within a decade.

In many developing nations there is rapid growth in the uptake of both cars and appliances, such that tightening emissions standards could both help lessen lock-in to high-carbon technologies and hasten the transition to alternative low-carbon infrastructures. At a system level and in both developed and developing nations, efficient cars, appliances and other best-in-class technologies may offer substantial economic benefit in terms of reduced national fuel consumption, reduced dependence on imports, improved energy security and improved local air quality and health.

Energy Access, Renewable Energy and Efficiency

About 20% of the global population does not have access to electricity and about 40% has no access to clean cooking. Many households without electricity access already spend a significant fraction of their meagre incomes on inefficient kerosene or other fuel-based lighting sources, with their severe attendant health and environmental externalities. Using efficient appliances rather than wasteful ones may allow two to three times higher levels of energy services from the same limited energy budget (such as a high-efficiency lighting technology using solar-produced light). In many instances, renewables, particularly solar lighting technologies, or high-efficiency appliances and lighting, are already competitive on an annualized cost basis, but do involve higher upfront outlays. This present a barrier to uptake, particularly for low income groups. Additionally, providing access to modern fuels and/or technologies to replace the existing inefficient burning of biomass can significantly reduce the emissions of the short-lived climate pollutant (SLCP) black carbon, thereby improving air quality and enlarging the window of opportunity for bringing down carbon emissions at a global level. Finally, it is well recognized that the higher the human development index of a society or country, the lower will be its climate vulnerability and the higher its adaptive capacity. For human health, climate and sustainable development, it is imperative for the global community to urgently address the challenge of providing universal energy access where possible by leapfrogging to state-of-art energy forms and technologies. Most notably the Sustainable Energy for All initiative of UN SG pursues three related goals, universal access by 2030, doubling of renewable share to 30% by 2030 and doubling the rate of energy efficiency improvement. (Please see: www.se4all.org)

Renewable energy

Promoting renewable energy (wind, solar, geothermal, waste-to-energy, modern biomass and micro-hydropower) through smart centralized and decentralized grids (which are particularly important for serving local communities) not only reduces GHG emissions and local pollution, but also lessens the impact of fuel-price volatility. Power systems continue to evolve to accommodate more renewables—wind and solar can contribute up to 40% of the energy generated without major modifications in most electricity systems at little or no extra cost, with some systems already generating more than 50% renewable electricity. Small island nations with isolated grids are proving to be effective testing grounds for achieving 100% renewable energy in the electricity sector.

STEVE FAREHAM/WIKIMEDIA COMMONS

The costs of wind and solar power have decreased significantly in recent years. Wind competes directly with conventional energy sources today on the wholesale market in an increasing number of countries—in most places without a carbon price, and even where there are massive subsidies to fossil fuels. Solar is competitive now in the retail market and the price continues to come down rapidly. Wind and solar PV will result in ~1.4 billion tonnes of avoided CO_2 emissions per year by 2020, however, with proper support this could increase by an additional 1 billion tonnes per year in that time frame. The technical and economic potential of renewable energy is more than adequate

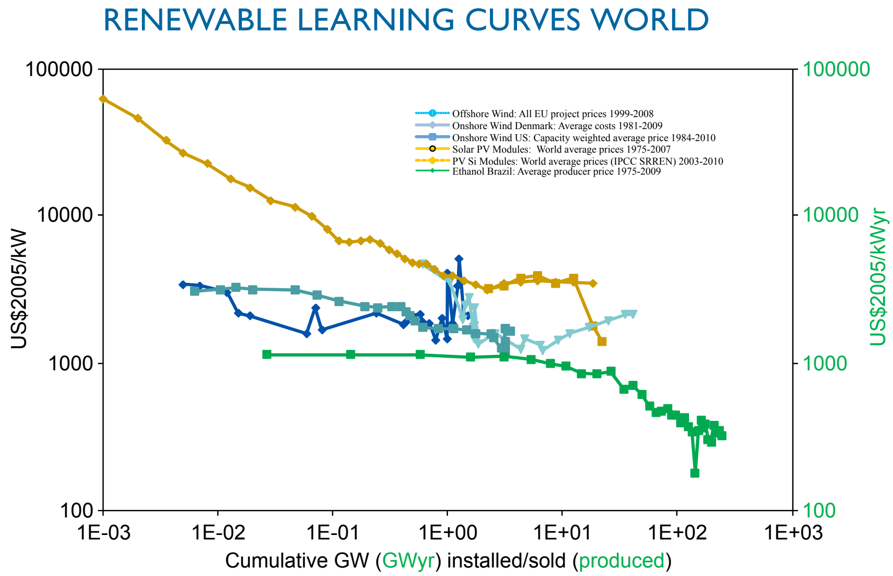


FIGURE 3. shows cost decreases of renewable energy technologies as a function of the global installed capacity. PV, on and offshore wind and the Brazilian ethanol program demonstrated cost reductions of about 30% per doubling of cumulative capacity. Many other renewable technologies portray similar cost improvement rates. Sources: GEA (2012) and Goldemberg paper (see Annex III).

Biofuels

Ethanol produced through the fermentation of agricultural products such as sugarcane, corn, and manioc is used as a high-octane fuel in vehicles. In Brazil, 90% of new vehicles produced are flex-vehicles and may run either with 100% ethanol (E-100), gasoline or any blend ethanol gasoline as a result of a government program (PROALCOOL) to make ethanol from sugarcane since the 70's. It was established in response to the oil crises, aiming to reduce oil imports, as well as to address the problem of volatile sugar prices on the international market. The program has had strong positive environmental, economic and social aspects, and has become the most important biomass energy program in the world. In 2011–2012, Brazil produced 600 million metric tons of sugarcane in 10 million hectares, half of it used for sugarcane ethanol (producing more than 20 billion liters of ethanol).

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Because ethanol in Brazil is produced from sugarcane, it presents the lowest production cost in the world. This is due to the favourable energy balance of the alcohol production (10–1). In the US there is a similar program and the number of vehicles using ethanol is increasing, but as this ethanol is produced from corn and presents higher consumption of fossil fuels, with lower energy balance (2–1). Because of this, the Brazilian national biofuels program which has been enormously successful is not a universally replicable solution.

(Alternative Transportation Fuels. S. T. Coelho and J. Goldemberg. In Encyclopedia of Energy. 2004, University of São Paulo, São Paulo, Brazil)

A Proposed Renewable Energy Partnership Between the EU and North Africa

An African-European energy alliance could be an important step both to decarbonise the EU and bring renewable energy to the African continent. Decarbonisation of the EU energy system by 2050 can be achieved more cost-effectively if Europe cooperates with its neighbouring countries. A core element would be the initiation of energy partnerships between the EU and North Africa, to capitalize on favourable local conditions for wind and solar power in the region. A European-African energy partnership should first help establish sustainable energy supply infrastructures in Africa to effectively increase energy access and combat poverty, and secondly contribute to the European clean energy supply. A future project such as this could also put any cooperation between Europe and Africa on a completely new footing on the basis of common interests. In future development, energy and stability policies could be bundled. Africa would thus gain entirely new, long-term development opportunities. EU development policy should consistently combine the poverty reduction target system (Millennium Development Goals) with decarbonisation strategies.

The challenges, though, must be acknowledged. With little or no energy demand growth in Europe, it is already difficult to get new renewable capacity into the grid as it requires shutting down fossil energy generators which is not happening in enough countries; this is a primary reason renewable deployment has already slowed down in Europe. Further, there is a major transmission bottleneck for the only existing connection, Spain–Morocco, where there is a small interconnector but the electricity flows north to south rather than the other way around. These are challenges that can be overcome, if Europe is committed to: a) a real single electricity market; and b) a continental transmission network. Otherwise, the current bottleneck between the Iberian peninsula and the rest of Europe, and the lack of willingness to take fossil fuel energy generators off the grid, leaves no place in Europe for energy generated in Africa to go, and a significant opportunity to reduce emissions and boost the North African economy will be lost.

to fully supply the world's energy needs many times over, while significantly reducing greenhouse gas emissions.

Increased policy and financial support would increase the potential contribution of wind and solar technologies in the next decade (e.g., renewable energy portfolios and feed-in tariffs).

Promoting renewable energy (wind, solar, geothermal, modern biomass and hydropower) through smart centralized and decentralized grids is particularly important for serving local communities. Off-grid, community oriented and controlled electricity, which can be set up in areas far away from national grids will be a major part of the future energy system. With adequate support mechanisms, such as feed-in tariffs, which could be financed through the Green Climate Fund and other sources, decentralized grids could bring effective energy services to rural and other communities very quickly. As of 2014, thirteen countries in Africa, and more than 65 countries world-wide, are planning or pursuing feed-in tariff systems at the national level. More than 138 countries have renewable energy support policies offering considerable experiences. One key challenge is ensuring the upfront investments needed for infrastructure (grid and off-grid).

Currently electricity provides around 20% of global final energy use; this proportion needs to increase significantly if many of the low-carbon energy options are to substitute for current high-carbon fuels (for example, increased electrification of transport and industrial processes and introduction of renewable-based synthetic energy gases).

Fossil fuel-based energy

Significant emissions reductions could be achieved by 2020 and beyond by enacting measures aimed at: (i) retiring or limiting the use of the least-efficient coal plants, prohibiting the construction of coal-fired plants without CCS, and promoting CCS retrofits for existing coal plants; and (ii) expanding use of natural gas where so doing will lead to significant emissions reduction, e.g., substituting natural gas for more carbon-intensive fuels for power, industrial, and other applications (including combined-cycle heat and power cogeneration) and as back-up for balancing electric grids (*e.g.,* as a complement on electric grids to other low-carbon technologies as such as wind and solar energy); encouraging CCS for natural gas power plants, and (iii) minimizing methane losses from extraction to end use of fossil fuels.

The International Energy Agency (IEA) has estimated the emissions reduction potential by 2020 for some of these opportunities: (i) limiting the use of the least-efficient coal plants and banning the construction of new subcritical coal-fired plants would reduce emissions by 640 $MtCO_2e$ while simultaneously reducing local air pollution; (ii) reducing methane emissions in upstream oil and gas production would reduce emissions 570 $MtCO_2e$. Near-term measures aimed at advancing CCS would yield modest emissions reduction by 2020 but could facilitate huge emissions reductions in the longer term.

Several carbon-intensive economies are already substituting gas for coal and improving carbon efficiency across sectors, including China, India, and South Africa. The recently proposed EPA carbon mitigation regulation for existing US power plants [Existing Source Performance Standard (ESPS) for CO_2 emissions] calls for, *inter alia,* operating natural gas power plants more of the time and coal power plants less of the time as one of its four proposed "technology building blocks" for implementing the ESPS. However, recent developments in the opposite direction must also be noted, for example in Europe where coal is replacing natural gas in power generation because gas prices are four times higher in Europe than in the US. This has led to increased emissions, for example in Germany, despite rapid and continued diffusion of renewable energy.

Deep reductions in GHG emissions will not be possible for fossil energy without widespread adoption of CCS. Moreover, deep decarbonisation of the global energy system is likely to be much more costly and perhaps less feasible without CCS as a viable carbon-mitigation option—a judgment that is reflected in the recent literature ranging from work of IEA, GEA and IPCC AR5. In general, CCS could be a key technology for emissions mitigation in economies dependent on domestic fossil resources—such as dependency of China on coal. For example, the critical importance of CCS for China is underscored by the finding that even in a low-carbon scenario China might be using 1.8 billion tonnes of coal annually by mid-century (Jiang et al, 2010). Also, CCS for natural gas energy conversion is needed to enable low-carbon energy futures, and CCS is likely to be an important factor in the realization of negative emissions energy systems. A potential net negative emissions option involves making energy from sustainable biomass grown with CCS: uptake of atmospheric CO_2 through biomass growth in combination with carbon capture and subsequent underground CO_2 storage leads to negative emissions.

In advancing CCS, governments and industry have committed tens of billions of dollars for R&D, scale-up and deployment. As of the end of 2013 there were 12 large-scale, integrated CCS projects in operation; eight more are in construction. The first three commercial-scale power projects with CCS are scheduled to come on line during 2014–2016. But the 20 large-scale integrated CCS projects already operating or under construction are only one fifth of the number of such projects that the IEA estimated in 2009 should be up and running by 2020 as part of a package of measures, including significant increases in energy efficiency and renewable energy, and decreases in fugitive methane emissions to keep the 2°C goal within reach.

A promising approach to getting the global CCS enterprise back on track is to focus on exploiting over the next decade low-cost CCS opportunities based on technologies near at hand while simultaneously carrying out R&D on advanced CCS technologies for the longer term. One set of such opportunities involves storing CO_2 in conjunction with enhanced oil recovery (CO_2 EOR). Another involves gaining experience with CO_2 storage (in deep saline formations as well as via EOR) by capturing pure streams of CO_2 that are currently vented at chemical and synfuel plants.

Among promising capture technologies for which early market launch utilizing the CO_2 EOR opportunity might be feasible by in the United States, is capture for natural gas combined cycle power plants, for retrofits of existing coal power plants, and for the coproduction of synthetic liquid fuels and electricity. The latter would be based on the co-processing of biomass with coal that would exploit the negative emissions associated with photosynthetic CO_2 storage to offset positive emissions from coal. This is an option that could realize ultra-low, system-wide GHG emission rates (low, zero or even negative) for both the synthetic fuel and electricity co-products of such systems.

China has a unique opportunity to develop extensive experience with CO_2 storage in deep saline formations as well as via EOR at ultra-low cost as a result of its having hundreds of existing and planned chemical and synfuel projects that vent streams of near-pure CO_2, many of which are near potential CO_2 storage sites. Capturing, transporting and storing these CO_2 streams probably represent some of the least-cost CCS opportunities on the planet. Because such projects would not be carried out in the absence of a significant price of carbon, co-financing by government and industry will be necessary. What can be learned about the challenges and opportunities of underground CO_2 storage via such projects in China would be widely applicable throughout the world. Consideration should be given to multilateral collaboration for such projects, including consideration of technology sharing and co-financing.

Land-use practices

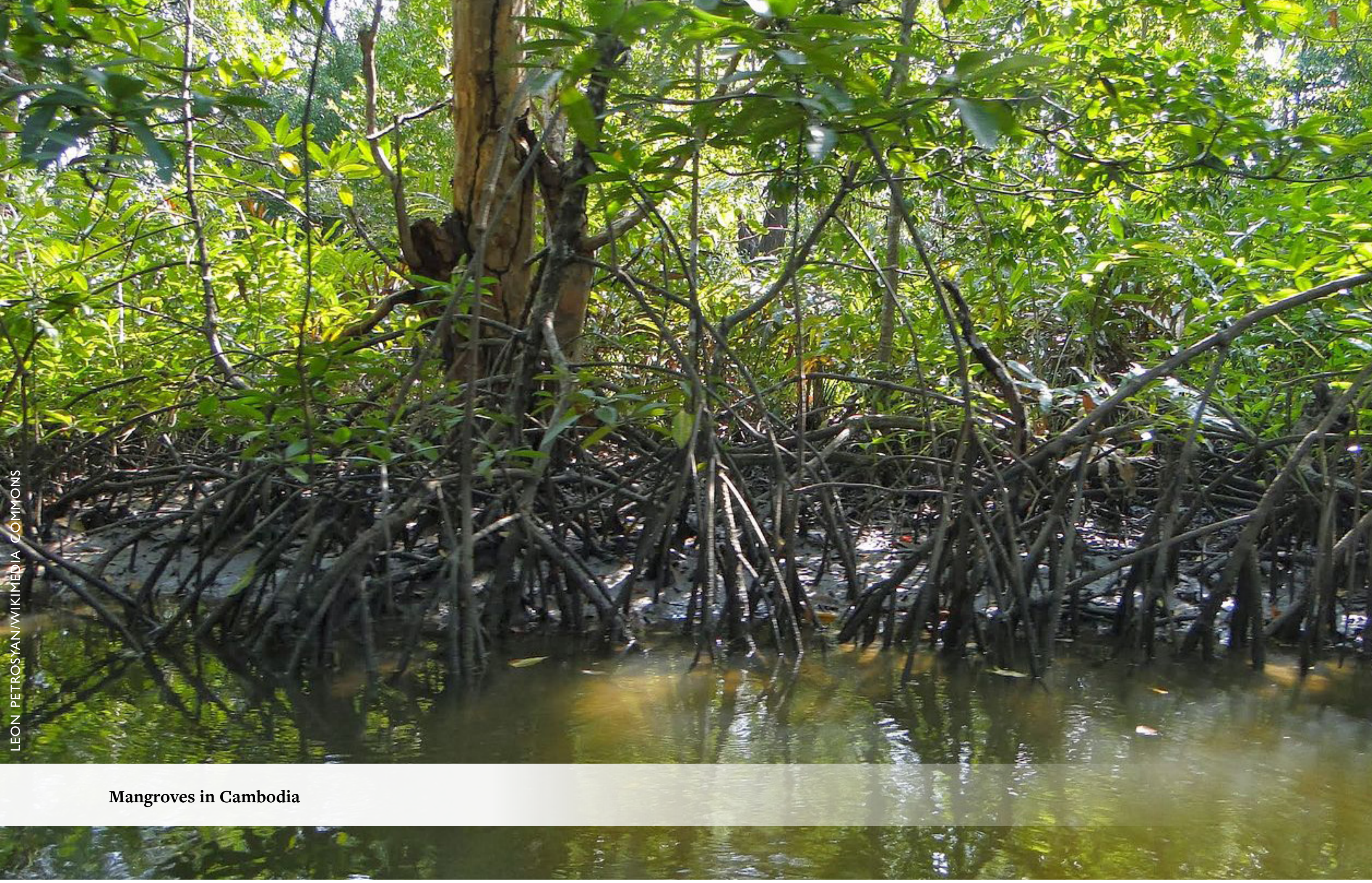
There is significant potential for reducing emissions from the agricultural sector with appropriate policy support, including incentive mechanisms to promote wider adoption of best practices. The technical mitigation potential of agriculture (considering all gases and sources) by 2030 is estimated to be between 4.5 and 6 Gt CO_2e per year. However, the economic potential is considerably lower than the technical potential. About 30 per cent of the technical potential can be achieved in developed countries and 70 per cent in developing countries. Agricultural GHG mitigation options (e.g., cropland and grazing land management, restoration of degraded lands and cultivated organic soils, and rice and livestock management) are cost competitive with options in other sectors (e.g., energy, transportation, forestry) in achieving long-term (*i.e.,* 2100) climate objectives, some at less than \$5/tCO_2e.

Emissions of GHGs from the forestry sector can be significantly reduced by 2020 and beyond by reducing the rates of deforestation and forest degradation, coupled with conservation, sustainable management of forests and enhancement of forest carbon stocks (afforestation and reforestation, *i.e.,* REDD+ activities which are cost-effective and have substantial co-benefits for local communities and biodiversity. Much of REDD+ architecture is already in place. A number of countries are already in the pilot phase and should be able to implement REDD+ by 2020. Brazil and Costa Rica can probably implement immediately, and Costa Rica, Ghana, Chile, Mexico, DRC, and Congo Brazzaville have been accepted into the Carbon Fund for the pilot phase.

To be successful, REDD+ activities require inter-ministerial/agency cooperation or collaboration, as well as legal, policy and institutional reforms addressing issues such as the drivers of deforestation, land tenure (particularly indigenous land rights), permanence of carbon storage and ecosystem functioning. High-carbon reservoirs found in coastal marine ecosystems, including mangroves offer huge potentials for climate change mitigation and should be included in the new climate agreement.

Coastal Marine Ecosystems (CMEs) present important mitigation potential; vegetated CMEs (mangroves, salt marsh, seagrass) are high-carbon reservoirs and mangrove is among the most carbon-rich forests in the tropics. Conservation and restoration of mangroves and other CMEs constitute an important carbon sink. Integrated sylvofishery approaches, such as shrimp ponds restored by planting mangrove trees around their borders in Vietnam, can improve water quality and harvests as well as sequester carbon.

Carbon sequestration in agroecosystems holds great promise as a tool for climate change mitigation especially because they also offer opportunities for synergy with development objectives. For improved grasslands, high rates of sequestration can be achieved by introducing more productive grass species and legumes. Improved nutrient management and irrigation can also increase the productivity of grazing animals and sequester more carbon.



LEON PETROSYAN/WIKIMEDIA COMMONS

Mangroves in Cambodia

Grazing land management and agro-forestry offer significant potentials for carbon sequestration. Grazing land management, despite the low-carbon densities in these lands, has potential because of the large areas of land available. Sequestration can be achieved through introduction of more productive grass species and legumes. Improved nutrient management and irrigation can also increase productivity and sequester carbon. It should also be noted that many grassland species have developed adaptation mechanisms resulting to both the vegetation and soil carbon being relatively resistant to moderate destructions from grazing and fire.

Agroforestry also offers the potential for synergies between expanding the role of agroforestry in mitigation programs and adaptation to climate change . Then introduction of trees into farming systems produces longer term carbon storage in these systems. In humid climates agroforestry systems can store as much as 10 times the carbon of annual cropping fields. In many instances, improved agroforestry systems can reduce the vulnerability of small-scale farmers to inter-annual climate variability and help them adapt to changing conditions.

Given the importance of the agricultural sector to GHG emissions mitigation, and the vulnerability of agriculture to climate change and climate variations, it will be essential to find ways to produce more food while emitting less GHGs. While the debate is often couched in terms of a tradeoff between climate change mitigation and food security, it is useful to note that food security is rarely an issue of food production and more often a question of availability and access to food. In many parts of the world the causes of inadequate food access are poverty, environmental stressors and conflict, not production.

The science of mitigation in agricultural production systems is maturing and progress can be made if the right incentives are put in place. Those incentives should also include support to national scientific organizations to generate more country and region specific knowledge to support better, less polluting agricultural practices. Policymakers need to consider the full range of policy measures including the establishment of financial incentive mechanisms to promote wider adoption of best practices in agriculture that reduce GHG emissions. For emissions abatement, incentives could be created through modalities such as the Clean Development Mechanism (CDM) and Nationally Appropriate Mitigation Actions (NAMAs). Agricultural mitigation options are gaining importance in the CDM already, and sectoral approaches could also be considered.

Short-Lived Climate Pollutants

Reducing atmospheric concentrations of short-lived climate pollutants (SLCPs)—particularly black carbon, ozone precursors and methane—using well proven and readily available technologies offers a cost-effective opportunity to slow the rate of near-term climate change and slow Arctic melting, while improving air quality and public health and reducing crop-yield loss.

SLCPs have atmospheric lifetimes ranging from a few days to several decades and are responsible for a substantial fraction of the radiative forcing to date. Because of their short atmospheric lifetimes, emissions reductions provide fast climate benefit. SLCPs include black carbon, methane, tropospheric (*i.e.,* ground level) ozone and some hydroflorocarbons (HFCs).

A small number of well-proven and readily available emission reduction measures targeting black carbon and methane have been identified that could immediately begin to protect climate, public health, water and food security, and ecosystems. These emission reduction measures include the recovery of methane from coal, oil and gas extraction and transport, methane capture in waste management, use of clean-burning stoves for residential cooking, diesel particulate filters for vehicles and the banning of field burning of agricultural waste.

Recent studies by UNEP and WMO have estimated that the adoption of such measures by 2030 would reduce the warming expected by 2050 by 0.4–0.5°C (and, in the Arctic, by about 0.7°C by 2040), while preventing more than two million premature deaths each year, as well as over 30 Mt of crop losses. Black carbon, produced by the incomplete combustion of fossil fuels and biomass, is a primary component of particular matter and air pollution. Household air pollution and ambient outdoor particulate matter pollution were estimated to have caused, respectively, over 3.5 and 3.2 million premature deaths in 2012 . Technology exists to virtually eliminate black carbon emissions from diesel vehicles for example The health co-benefits would also be immense. Tropospheric ozone causes more damage to plants than all other pollutants combined and can cause significant crop-yield loss.

Widespread implementation is achievable with existing technology but would require significant strategic investment and institutional arrangements. About 50% of both methane and black carbon emission reductions can be achieved through measures that result in net cost savings (as a global average) over their technical lifetime. Many countries have introduced complementary approaches to mitigating long-lived greenhouse gases and short-lived climate pollutants (SLCPs) that could contribute to low-carbon development. They lead to more efficient infrastructure, *i.e.,* they are beneficial on economic reasons, even without their substantial air quality and climate benefits.

Action now to reduce SLPC emissions now can help slow the rate of climate change and improve the chances of staying below the 2°C goal in the near term. By reducing near-term increases in temperature, SLCP reductions also lessen the risk of dangerous climate feedbacks such as accelerated Arctic melting and sea level rise. Nevertheless, strategies that reduce emissions of SLCPs must complement CO_2 mitigation; long-term climate protection depends on ambitious and rapid reductions in CO_2 emissions.

5. Policy considerations

There are many successful models around the world that can be adapted to national circumstances and scaled depending on regional differences in opportunities, perceived priorities, and approaches to the necessary transitions to a low-carbon economy. Developed countries must show leadership by demonstrating that GHG emissions can be significantly reduced in a cost effective manner, and must step up provision of the means of implementation (finance, technology transfer, and capacity building) which is essential for this transition to occur in many developing countries.

Every nation presents unique opportunities, perceived priorities, and approaches to the necessary transitions to a low-carbon economy, reflecting the differences in energy systems between regions and economies, and between developing and industrialized countries. Although transformation paths will differ, each country, region or city can and must immediately start to put a price on carbon, incentivise energy efficiency, and create and scale-up renewable energy infrastructure.

Many transformative energy policy options are already competitive in the short run (and some are competitive even given fossil fuel subsidies). If designed and implemented carefully, they will help promote sustainable development, create competitive advantages and spur innovation in the mid and long-term. Policy responses must take equity considerations into account, not just between but also within nations.

Effective energy-focused policies must be coordinated and integrated with policies addressing socioeconomic development and environmental protection in other sectors, and will require a combination of instruments, including regulatory frameworks (e.g., emissions targets, efficiency standards, waste and material use reduction policies, renewable portfolio standards) and investment policies (e.g., putting an effective price on carbon, and the elimination of fossil-fuel subsidies), as well as measures for strengthening capacity development, which stimulate innovation.

More than 138 countries have renewable energy support policies offering considerable experience and models that may be adapted to local circumstances. Off-grid, community oriented and controlled electricity, which can be set up in areas far away from national grids, is a major part of the future energy system. It can be initiated and boosted immediately, granted existence of adequate support mechanisms, such as feed-in tariffs, which could be financed through international cooperative institutions such as the Green Climate Fund. Already 13 countries in Africa and more than 65 countries world-wide are planning or pursuing feed-in tariff systems at the national level.

Improved energy efficiency in the transportation, building and industry sectors is feasible in the near-term using current technologies. It is cost-effective and provides multiple co-benefits. Minimum energy performance standards (MEPS) for appliances, ICT equipment, buildings, industry and vehicles have been successfully implemented in many developed and developing countries and are among the most cost effective tools to cut emissions. These policies have large mitigation potentials in the near and medium-term, mostly at negative net cost, providing investment capital is available.

There is major low-cost potential to be captured in every country by strengthening performance standards and increasing the range of goods to which they are applied. Effective energy efficiency policies such MEPS for new equipment, building codes and technology switching, such as through greater use of heat recovery and better use of automation and control systems, can facilitate a rapid transition to more efficient residential and commercial buildings.

Coordinating multiple policies is key. Examples include fuel-economy standards for new vehicles coupled with zero sulphur fuels to enable the cleanest most efficient engines and incentives for electric-mobility, or a global phase out of incandescent bulbs together with MEPS for low-energy lighting. In countries where energy efficiency policies already exist, including the European Union, Japan, China and the US, there is major low-cost potential to be captured by strengthening performance standards and increasing the range of goods to which they are applied. Other countries need to introduce and extend such policies. There are also many other policies to foster energy efficiency in buildings, industry and transport, and these complement pricing and MEPS effectively to capture more energy efficiency potentials. These include fiscal incentives, public leadership programs, educational and information initiatives, market transformation programs, and utility regulations, such as those that decouple energy sales from the profit of utilities.

Similarly, fossil fuel subsidies need to be significantly reformed and in some cases eliminated (e.g., oil and gas production subsidies and implicit subsidies such as low tax rates on coal). These subsidies encourage wasteful consumption, slow the uptake of renewables and energy efficiency, are expensive for taxpayers, and harm the environment and public health by increasing GHG emissions and other air pollutants. The G20 and Asia-Pacific Economic Cooperation (APEC) countries have committed "to rationalize and phase out inefficient fossil fuel subsidies that encourage wasteful consumption . . . ." Implementation of this pledge should be accelerated. Although most fossil fuel subsidies benefit wealthier segments of society, the poor are particularly vulnerable. Safety net programs should be put in place for vulnerable populations.

Putting an effective price on carbon to internalize the health and environmental costs of emissions for current and future generations is essential to send the right price signal to re-direct investment to clean technology and drive market penetration of renewables and end-use efficiency. Explicit policy options include carbon taxes (most efficient) and emissions trading systems. Policies that put an implicit price on carbon in subsectors of the economy include air quality measures, congestion and fuel taxes, renewable standards portfolios and energy efficiency standards. Overcoming vested interests is a major challenge. In addition to steps to limit the outsized power of these actors to obstruct climate action, predictable incentives schemes will be needed to support the new industries contributing to the transformation to a low-carbon economy, along with policies to support the adaptation and modernization of "old industries", even as these new ones take root.

According to the World Bank, in 2014 about 40 national and over 20 sub-national jurisdictions had already implemented or scheduled emissions trading schemes or carbon taxes. Together, emissions from these jurisdictions account for more than 22 percent of the global total. Many more countries and jurisdictions are advancing preparation for pricing carbon. If these programs are all adopted and effectively implement, they would, together, cover almost half of global GHG emissions.

Incentive programs should be urgently designed and implemented to drive sustainable consumption, coupled with appropriately designed education and awareness programs, supporting alternatives to material-intensive and environmentally costly lifestyles and consumption patterns. Efficiency gains of technologies at the micro level do not necessarily lead to sustainable consumption at macro level due to a 'rebound effect'. The IPCC Fifth Assessment Report (AR5) notes that the efficiency gains during 1970-2010 have only compensated for the impacts of the growth in population during this period, while overall consumption based emissions have . Experimental studies also show that sustained access to new information and analysis helps change the daily consumption practices at household level. Hence, to ensure that demand and supply equilibrium of technologies moves in the direction of sustainability, both innovation as well as demand patterns need carefully crafted systemic nurturing and policy support.

6. Financial and economic considerations

Putting an effective price on carbon to reflect the health and environmental costs of emissions for current and future generations would send the right price signal to further stimulate market penetration of renewable and other low-carbon energy technologies and end-use efficiency.

There are many proven low-carbon and clean technologies that can be currently deployed at scale profitably (high rates of returns to investors and low operating costs) to significantly reduce GHG emissions and advance sustainable development goals. However, rapid deployment is not happening in part because of:

- significant up-front capital costs coupled with the high cost of capital;
- lower short-term rates of return compared to other investments;
- small, innovative companies often lack the working capital to produce and market the products at scale, lack the contacts to find partners to help further development and distribution, and do not know how to access the many governmental and NGO related programs that could assist them in accelerating deployment;
- a lack of adequate information, understanding or awareness of these by all relevant stakeholders;
- major challenges in accessing finance in part due to the perceived risk to investors, in part due to lack of information, and in part to challenges in bundling projects to sufficient scale to attract major investors; and
- the efforts of very powerful vested interests working to maintain the status quo fossil fuel industry.

Public and private finance, must, and can, be scaled up quickly. Figure 2 shows how investments in renewable energy technologies have increased considerably in the last decade, especially in solar PV and wind. To limit an increase in global mean air temperature to 2°C will require hundreds of billions of dollars annually from public and private sources. Current investments in the energy sector are around US$ 1.3 trillion per year. To stay below the 2°C goal this will need to be increased to between US$ 2.0 and 2.6 trillion per year.

The enormous wealth and long-term horizons of pension and sovereign wealth funds make them a prime source of potential investment in commercially viable enterprises in emerging markets. Several encouraging initiatives are beginning to address the challenge of scaling up investment for accelerated technology deployment. The International Finance Corporation's (IFC) Catalyst Fund is already operational, and the Asian Development Bank has launched the Asia Climate Partners Fund.

Figure 4 (on page 20) shows that the investments in renewable energies have grown considerably in recent years to over US$279 billion in 2011, but declined to to US$214 billion in 2013. In 2012 the investments were in US$ billion: (i) solar (88.7 in developed countries and 51.7 in developing countries); (ii) wind (35.0 in developed countries and 45.3 in developing countries); (iii) hydropower, biofuels, geothermal and ocean energy combined (8.6 in developed countries and 7.3 in developing countries).

The impacts and costs of delaying action on climate change have been underestimated and increase every year. The "lock-in" of additional high-carbon infrastructure makes staying below the 2°C goal more expensive and less likely, and increases the threat of crossing tipping points and run-away climate feedbacks. Putting an effective price on carbon to internalize the health and environmental costs of emissions sends the right price signal to drive investment in clean technology. However, the price signal will need to be complemented by

FIGURE 4.
Global new investment in renewable power and fuels, developed and developing countries, 200–2013.

Source: REN21. 2014. Renewables 2014 Global Status Report (Paris: REN21 Secretariat).

a portfolio of other sectoral policies to encourage mitigation opportunities where price signals have not proven to be highly effective, especially in the short-to mid-term, such as residential energy use.

Fossil fuel production subsidies need to be eliminated and consumption subsidies reformed and eliminated where possible. Many are inefficient and slow the uptake of renewables and energy efficiency, encourage wasteful consumption, are expensive for taxpayers, and, harm the environment and public health by increasing GHG emissions and other air pollutants. Given the critical importance of access to modern energy services however, social safety nets for the most economically disadvantaged are critical. The integration of information technology in energy and financial systems has made it possible to optimize the design of energy service systems for greater cost effectiveness while empowering the poor through greater access to financial instruments.

7. Actions underway or planned must be significantly scaled and expanded now

Actions already underway around the world, if replicated, adapted to national circumstances and scaled up with speed, can move the world onto the path of global low-carbon transformation. While the categories below suggest urgently need steps for the near-term, they do not themselves constitute that transformation.

Ultimately, delivering near-term emissions reductions demands decisive action and political courage from leaders around the world. If the elements of the near-term actionable agenda laid out in this paper are adapted to national circumstances and implemented and scaled at speed around the world, we will have a fighting chance. We have no time to lose.

Government and Private Sector Actions

Although a number of governments and businesses have already started to implement elements of strategies to transition to a low-carbon economy much more is needed, given the ever-increasing emissions of GHGs.

Where governments have made the climate issue a high policy priority, there has been an increasing share of power production from renewable energy technologies and an increase in end-use efficiency (See country profiles in Annex X). The UK was the first to legislate an 80% reduction in greenhouse gases from all sources (CO_2e) by 2050. Germany has decided to reduce the greenhouse gas emissions of its energy system by 80% by 2050, investing heavily in renewable energies. Countries in the Caribbean and Latin America are moving in a similar direction. The US and China have also announced significant initiatives to reduce carbon emissions.

Every government should prepare and submit a low-carbon road map, which includes techno-economic, institutional and social feasibility assumptions for transitioning to a low-carbon economy.

Additionally a growing number of companies are already working within shadow carbon pricing systems and are developing expertise in managing their emissions. Corporate and public financial accounts should also be accompanied by an inventory of GHG emissions.

Behavioural Change

Behavioural change at the individual level and transitions to low energy consuming habits within institutions are needed across society. Governments must make climate change a high priority policy issue and facilitate behavioural change throughout society using a variety of measures such as information and educational initiatives. The private sector must seize profitable opportunities in a low-carbon economy and get ahead of new climate policies. Social movements and consumer preferences for sustainable consumption must successfully leverage greater corporate social responsibility. Robust democratic participation in building support for transformation change to more sustainable pathways is necessary to overcome vested interests that can subvert democratic process to maintain the status quo. Increased voice and agency must be given to those constituencies most vulnerable to the impacts of climate change

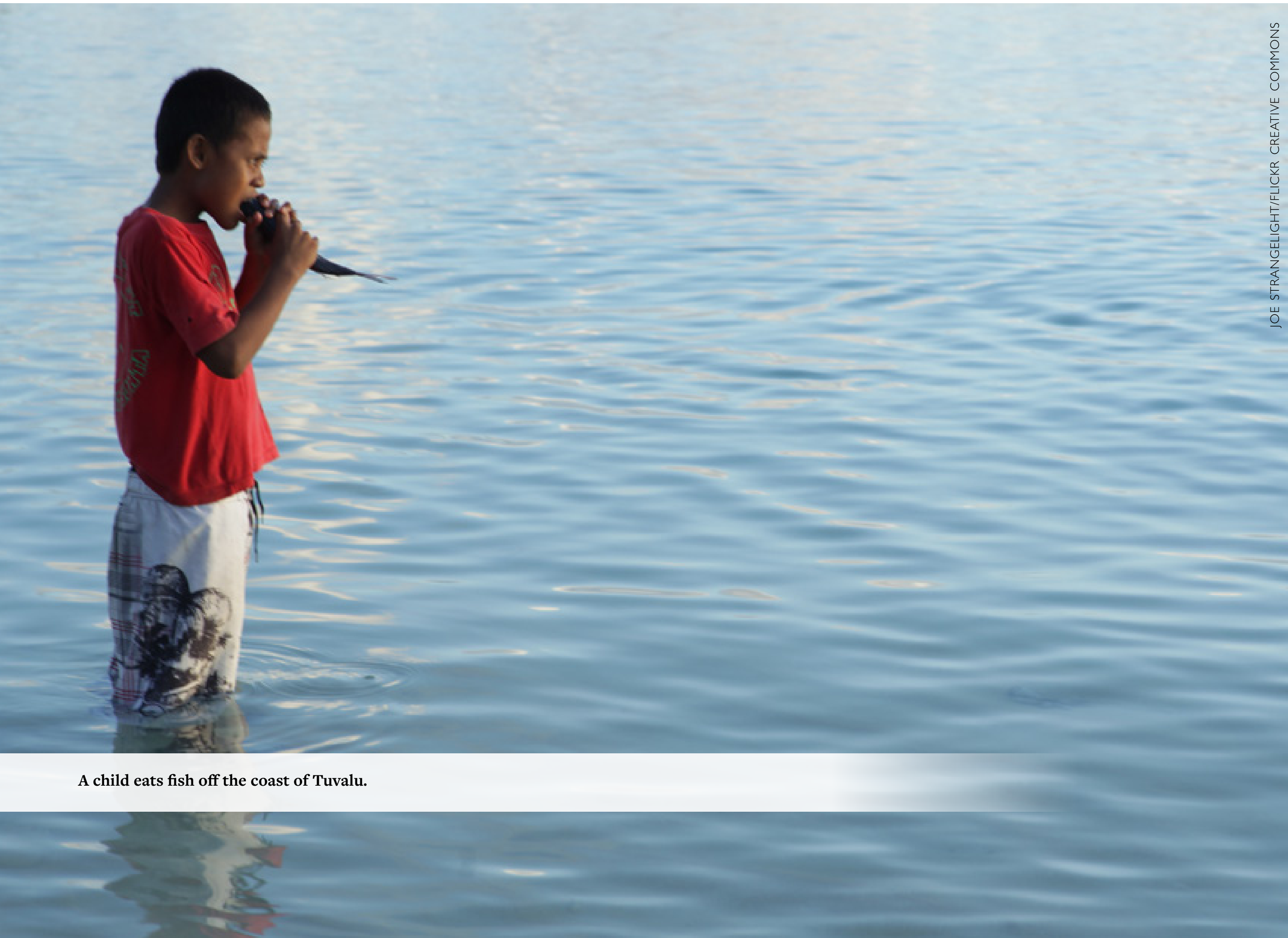
Research and Education

We have the information at hand to accelerate the low-carbon transformation immediately. But additional research and education are necessary to achieve the mid and long-term transformation towards low-carbon societies. Research helps both to clearly define the transformation's guiding principles as well as to develop low-carbon technologies and social innovations, facilitating acceleration of transformation processes. Ideally, further education and research initiatives will also lead to ground-breaking innovations inspiring further transformation. To enable education to support the transformation, scientific findings must be made comprehensible and accessible and communicated through education in all areas and to all age groups, from kindergarten to vocational training and university, and extend to lifelong learning via the media and public education programs.

International Cooperation

International cooperation should play a major role assisting developing countries to design and implement policies to accelerate the transformation to a low-carbon economy. OECD countries and intergovernmental organizations such as the multilateral banks should support ambitious low-carbon strategies in developing countries and move out of business-as-usual investments in high carbon sectors. Recent pledges by many development banks to cease support for coal-fired power plants are an encouraging start, but must more must be done.

Increased international cooperation, such as Work Stream 2 of the UNFCCC, a solutions-oriented technical process to catalyse and scale-up near-term emissions reductions initiatives around the world, is imperative to accelerate the transformation to a low-carbon economy.



JOE STRANGELIGHT/FLICKR CREATIVE COMMONS

A child eats fish off the coast of Tuvalu.

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Annex II: Country Profiles

Opportunities in the Electricity Sector for Caribbean Community and Common Market (CARICOM) Member Countries

- The Caribbean is on the cusp of an "energy revolution." In many nations the economics are favourable and the political will exists, as evidenced by several national energy policies and low-carbon development strategies. Relatively little financial support would be required to effect a paradigm shift in the energy sectors of these small islands and the sustainable development co-benefits are enormous.
- The cost of electricity for the majority of CARICOM countries is amongst the highest in the world and has become a severe constraint to further economic development. Fossil fuel imports are a drain on foreign exchange and affect national security.
- The region is blessed with abundant sources of local renewable energy, including solar, wind, geothermal, ocean energy, hydropower and biomass;
- Wind energy and distributed solar are now cost-competitive in the region with Feed-in-Tariffs set at avoided fuel costs. Geothermal presents an opportunity for some of the islands to achieve very high if not 100% renewable energy (RE) use for electricity generation, and an opportunity to bring the transport sector (which in some cases represents up to 50% of primary energy use) onto a "greened" grid.
- The barriers to wide scale deployment of RE in the Caribbean are financial, technological, institutional and legislative;
  - Two types of financial support are required:
    - Grants and concessionary loans to subsidize the capital costs of purchasing and installing the RE equipment, given that many countries in the region have very high debt to GDP ratios (>100%) and further borrowing is constrained by IMF programmes;
    - Financial assistance to compensate the electric utilities for loss of stranded fossil fuel assets and perceived loss of future earnings when the legislation is amended and existing monopolistic contracts are determined;
  - Technological assistance is required to design innovative storage to maximize grid penetration rates for variable RE and to create smart grids;
  - Institutional and legislative: Capacity building is required to assist CARICOM member countries to design project proposals, implement "bankable projects", and to amend their legislative and regulatory frameworks to make them more conducive to RE deployment.

Rapid Transition in Energy System for Low-Carbon Emission is Feasible: Perspective from China

- In 2012, China contributed nearly 28.8% of global CO_2 emissions from energy and cement manufacture.
- Coal dominates energy use in China, where it is a cheap source of energy. In 2013, coal use accounted for 65% in primary energy use, down from around 69% from 2000–2010.
- Low-carbon development is becoming an important policy issue. China is developing 42 low-carbon pilot cities and provinces with more than 250 million people, and 7 pilot cities and provinces for Emissions Trading Systems with more than 220 million people. There are national targets for 2015 and 2020 on carbon.
- China leads on newly installed renewable energy and nuclear power with surprising growth in renewable energy in last two years. Together, hydropower (including large hydro), wind and solar account for more than one third of newly installed capacity in 2012, and even more in 2013.
- With GDP growth rates projected to decrease in the future, the increased power demand could be supplied by renewable energy, nuclear, and natural gas fired power plants, with coal use peaking before 2020.
- Scenario analysis shows China's GHG emissions possibly peaking before 2025, and then following the emission pathway consistent with the global 2°C target.
- Technology learning is doing better than our model assumed. By the beginning of 2014, the cost of solar PV, wind turbine, LED lighting etc., had significantly decreased, making them much more competitive in the energy market, with or without subsidies. CCS technology, which is being developed through several pilot projects, could play an important role in future.
- The rapid GDP growth rate (2006–2011) provided strong support for low-carbon development. The investment needed for further development is modelled to be less than 2 to 4% GDP.
- China is launching a national campaign to control air pollution, which focusses on reduced coal use, with the co-benefit of reduced CO_2 emission reduction.

The United States New Source Performance Standards (NSPS) and Existing Source Performance Standards (ESPS)

- The Environmental Protection Agency (EPA) proposed New Source Performance Standard (NSPS) requires that CO_2 emissions from new power plants be no more than 1100 pounds of CO2 per gross MWh of electricity generated.
- The EPA's proposed Existing Source Performance Standard (ESPS) is a regulation of CO_2 emissions from existing power plants, with a focus on coal power plants. It also requires each state to submit a plan that it would pursue to meet that state's goals that have been set by the EPA. The proposed ESPS's overarching goal is to reduce CO_2 emissions from US power plants in 2030 by 30% relative to emissions in 2005. The proposed ESPS gives a state enormous flexibility in meeting its emissions reduction goal. The EPA suggested that states might consider constructing their plans to be made up of four building blocks: (i) investments to improve the energy efficiency with which plants generate electricity; (ii) operation of natural gas combined cycle power plants (which emit less CO_2 per MWh than coal plants) more of the time and coal plants less of the time; (iii) addition of new zero carbon power sources to the power supply (with an emphasis on wind and solar); and (iv) improvement in the efficiency of systems consuming electricity.

Australian persepctive

- Australia can reduce its GHG emissions to 25% below 2000 levels (a reduction of 240MTCO_2e) by 2020 at low cost and using technologies available today.
- The low-carbon Growth Plan identifies 54 separate opportunities—across all sectors—that can be implemented over the next 10 years to achieve these emission reductions.
- Reducing GHG emissions can be profitable for business.
- A combination of carbon price and targeted action is required to achieve the full potential of low cost emissions reductions.
- A portfolio of prompt action is required to implement the 54 opportunities, that takes account of the risk of "locking-in" emissions for the long-term and the ease of emissions reductions.
- Delaying action will mean some low cost opportunities are lost, ensuring greater cost to society and business in the long run.

(Source: ClimateWorks Australia: Low-carbon Growth Plan for Australia—Report summary. March 2010)

The German energy transition as an example of an ambitious low-carbon strategy

- The ambitious German energy transition requires the seven remaining nuclear power plants to be shut down by 2022, an extensive relinquishing of fossil fuel power generation by the middle of the century, and raising the share of renewable energy from approximately 25% today to 40% in 2020 and 80% by 2050, with a corresponding reduction in greenhouse gases of 80% by 2050.
- This radical shift requires that a new electricity system is created, in which conventional energy sources are adapted to the continuously increasing share of renewable energies.
- The fast-growing infrastructures for renewable energy (with fluctuating energy provision) are required to interact with fossil power plants and their gradually decreasing contribution to energy supply, still-to-be-expanded storage capacity, and intelligent grids that make optimal use of the volatile electricity supply. Pumped storage power plants could smooth out volatility in the generation of renewable energy.
- There are currently four challenges that need to be overcome:
  - First, the investors contributing to the development of the new energy system need predictability in planning processes for the expansion of renewable energies, storage capacities and grids need to be tailored to one another, and regulatory conditions and financing instruments must be developed in a transparent manner.
  - Second, the European emissions trading is in need of urgent reform. Surplus emissions certificates have led to a fall in the price of the certificates, which benefits lignite power plants that are able to produce at low prices, over gas-fired power plants.
  - Third, energy transition also comprises a second pillar, one that is currently neglected: the radical improvement of energy efficiency, for example in urban planning and the insulation of buildings, in transport and with vehicles as well as in industry. Regulatory reforms (e.g. ambitious energy efficiency standards for buildings and vehicles; tax breaks for climate protection-oriented building renovations) are required in order to make progress in this field.
  - Fourth, it is apparent just how important it is for the population to be involved in the restructuring of the supply of energy. The reforms affect the lives of many people. The construction of new wind and solar power facilities might change landscapes. New insulation regulations for buildings have impacts on rents. Energy efficiency reforms in transport are leading to new mobility concepts. The involvement of citizens, transparency in planning processes and efforts to follow the most economical paths in a decarbonised energy future all contribute to the legitimation of the energy transition.
- Germany is currently an ambitious laboratory for the transition to a low-carbon economy. If it proves possible here to demonstrate that climate protection, competitiveness and growing employment can be combined, other countries may be encouraged to implement comprehensive low-carbon strategies as well.

India: Mitigation Measures and Policy Actions

- India has undertaken various actions to reduce emissions including increasing fuel efficiency standards, adopting building energy codes, increasing forest cover to sequester about 10% of annual emissions, and increasing the share of renewable electricity.
- India launched the National Action Plan on Climate Change which outlines eight Missions, including the Jawaharlal Nehru National Solar Mission and the National Mission on Enhanced Energy Efficiency. The Green India Mission aims at doubling the area of afforestation/ restoration in India in the next 10 years, taking the total area to be afforested or restored to 20 million ha. The National Mission on Bio-diesel envisages a large area of land in 26 states to be brought under Jatropha plantations, with a second phase including the production of bio-diesel necessary to meet a 20% blending mandate.
- The Indian Government levied a clean energy cess on coal in 2010 at the rate of Rs 50/ton (doubled to Rs100/ton recently) applicable to both domestically produced and imported coal. The money generated will support a National Clean Energy Fund for research, innovative projects in clean energy technologies, and environmental remediation programmes.
- At a subnational level, Maharashtra has also created a Clean Energy Fund by levying a green cess on conventional power production for industrial and commercial establishments which will generate about Rs 100 crore annually. The cess funds support "Urja Ankur Nidhi," a fund to develop renewable energy in the state. The efficacy of the funds can only be judged once these become fully operational.
- The Government of India has also launched a renovation & modernization (R&M) program to improve the efficiency of existing thermal power stations. This initiative together with the three-phase programme called "Partnership in Excellence" has resulted in significant efficiency improvement in existing sub-critical thermal power plants. All new coal based power plants are now planned to be supercritical.
- Recognizing that electricity is a key drivers for poverty alleviation, the Electricity Act 2003 targeted electrifying villages which has provided a major push for renewable energy technologies. India has among the world's largest programmes for renewables. The wind power programme was started in India in the early 1980s with initial demonstration projects and now boasts more than 21,000 MW of installed capacity, led by Tamil Nadu, Maharashtra, Gujarat, Rajastan and Karnataka.
- In addition to the use of solar thermal energy for grid based power, solar PV systems have emerged as important power sources for applications such as lighting, water pumping, telecommunications and power for meeting the requirements of villages and hospitals. An Energy Conservation Building Code (ECBC) was launched in May 2007, which addresses the design of new large commercial buildings to optimise the building's energy demand. Many buildings are already following this code, and compliance with it has also been incorporated into the Environmental Impact Assessment requirement for large buildings.

Annex III: International Assessments

Key Findings: IPCC WG III Fifth Assessment Report (AR5)

- Total anthropogenic GHG emissions have continued to increase between 1970 and 2010 with larger absolute decadal increases towards the end of this period.
- Human influence on the climate system is clear, and is estimated to be the dominant cause of the warming observed since 1950.
- In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans.
- Annual anthropogenic GHG emissions have increased by 10GtCO_2e between 2000 and 2010, with this increase coming from energy supply (47%), transport (11%) and buildings (3%) sectors.
- Limiting the effects of climate change is necessary to achieve sustainable development and equity, including poverty eradication.
- Climate policy intersects with other societal goals creating the possibility of co-benefits or adverse side effects, however, these interactions, if well managed can strengthen the basis for undertaking action.
- Without additional efforts to reduce GHG emissions beyond those in place today, emissions growth is expected to persist driven by growth in global population and economic activities. Baseline scenarios, those without additional mitigation, result in global mean surface temperature increases in 2100 from 3.7°C to 4.8°C compared to pre-industrial levels (median values: the range is 2.5°C to 7.8°C when including climate uncertainty).
- Estimated global GHG emission levels in 2020 based on the Cancun pledges are not consistent with cost-effective long-term mitigation trajectories that are at least as likely as not to limit temperature change to 2°C relative to pre-industrial levels, but they do not preclude the option to meet that goal. The Cancun pledges are broadly consistent with cost-effective scenarios that are likely to keep temperatures below 3°C relative to pre-industrial levels.
- Mitigation scenarios reaching about 450 or 500 ppm CO_2e by 2100 show reduced costs for achieving air quality and energy security objectives, with significant co-benefits for human health and ecosystem impacts.
- Infrastructure developments and long-lived products that lock societies into GHG-intensive emissions pathways may be difficult or very costly to change, reinforcing the importance of early action for ambitious mitigation.
- Efficiency enhancements and behavioural changes, in order to reduce energy demand compared to baseline scenarios without compromising development, are a key mitigation strategy in scenarios reaching atmospheric CO_2e concentrations of about 450 or 500 ppmv by 2100.
- Decarbonizing electricity generation, through enhanced use of renewable energy, nuclear and carbon capture and storage) is a key component of cost-effective mitigation strategies in achieving low-stabilization levels (430–530 ppmv CO_2e).

- Since AR4, many renewable energy technologies have demonstrated substantial performance improvements and cost reductions.
- The most cost-effective mitigation options in forestry are afforestation, sustainable forest management and reducing deforestation. In agriculture, the most cost-effective mitigation options are cropland management, grazing land management and restoration of organic soils.

Key Findings : Global Energy Assessment

- Energy systems can be transformed to support a sustainable future, requiring (i) radical improvements in energy, especially in end-use; (ii) greater share of renewable energies and advanced energy systems with carbon capture and storage (CCS) for both fossil fuels and biomass. Large, early, and sustained investments, combined with supporting policies, are needed to finance change;
- An effective transformation requires immediate action to avoids lock-in of invested capital into existing energy systems;
- Energy efficiency is an immediate and cost-effective effective option with multiple benefits, e.g., health; (i) retrofitting buildings; (ii) new buildings with high energy performance; (iii) electricity powered transportation; and (iv) integration of spatial planning and travel;
- Renewable energies are abundant, widely available and increasingly cost-effective, and provide many benefits;
- Major changes in fossil energy systems are essential and feasible, albeit requiring strong policies, including effective pricing of GHG emissions; (i) carbon capture and storage; (ii) increasing share of natural gas; (iii) co-processing of biomass with coal or natural gas with CCS;
- An integrated energy system strategy is essential in which energy policies are coordinated with other policies, e.g., industrial, buildings, urbanization, transportation, etc.
- Energy options for a sustainable future bring substantial multiple benefits for society, e.g., health, decreased poverty, etc.;
- Socio-political changes as well as stable rules, regulations and investment regimes will be required

Annex IV: Additional Reports and Statements

International Energy Agency—Redrawing the Energy-Climate Map (2013)

- To keep open a realistic chance of meeting the 2°C goal, intensive action is required before 2020. "Energy is at the heart of this challenge: the energy sector accounts for around two-thirds of greenhouse-gas emissions, as more than 80% of global energy consumption is based on fossil fuels."
- The implementation of four policy measures "can help keep the door open to the 2°C goal through to 2020 at no net economic cost. Relative to the level otherwise expected, these policies would reduce greenhouse-gas emissions by 3.1 Gt Co_2e in 2020–80% of the emissions reduction required under a 2°C trajectory." "The four policies are:

  i. Adopting specific energy efficiency measures (49% of the emissions savings)

  ii. Limiting the construction and use of the least-efficient coal-fired power plants (21%)

  iii. Minimizing methane (CH4) emissions from upstream oil and gas production (18%)

  iv. Accelerating the (partial) phase-out of subsidies to fossil fuel consumption (12%)."
- Targeted energy efficiency measures could reduce global energy-related emissions by 1.5 Gt in 2020. Key policies include: energy performance standards in buildings for lighting, new appliances, and new heating and cooling equipment; in industry for motor systems; and in transport for road vehicles. Around 60% of the global savings in emissions are from the buildings sector. In countries where these efficiency policies exist they need to be strengthened or extended; other countries need to introduce such polices. All countries will need to take supporting actions to overcome the barriers to effective implementation. The additional global investment required would be more than offset by reduced spending on fuel bills.
- Ensuring that new subcritical coal-fired plants are no longer built, and limiting the use of the least efficient existing ones, would reduce emissions by 640 Mt in 2020 and also help efforts to curb local air pollution. Globally, the use of such plants would be one-quarter lower than would otherwise be expected in 2020. The share of power generation from renewables and natural gas increases. Policies to reduce the role of inefficient coal power plants, such as emissions and air pollution standards and carbon prices, already exist in many countries.
- Around 1.1 Gt CO_2e of methane, a potent greenhouse-gas, was released in 2010 by the upstream oil and gas industry through venting and flaring. Reducing such releases into the atmosphere represents an effective complementary strategy to the reduction of CO_2 emissions. The necessary technologies are readily available, at relatively low cost, and policies are being adopted in some countries such as the performance standards in the US.
- A partial phase-out of fossil fuel subsidies could reduce CO_2 emissions by 360 Mt in 2020 and enable energy efficiency policies. Fossil-fuel subsidies amounted to $523 billion in 2011, around six times the level of support to renewable energy. Currently, 15% of global CO_2 emissions receive an incentive of $110 per ton in the form of fossil-fuel subsidies while only 8% are subject to a carbon price. G20 and Asia-pacific Economic Cooperation (APEC) member countries have committed to phase out inefficient fossil-fuel subsidies and many are moving ahead with implementation.

Ditez and Stern—Cost of climate change (preliminary investigation)

- Nordhaus (1991) and its subsequent development into the dynamic DICE model, has built-in assumptions on growth, damages and risk, which together result in gross underassessment of the overall scale of the risks from unmanaged climate change. This criticism applies with just as much force to most of the other integrated assessment models that DICE has inspired.
- The DICE model was used to provide an initial illustration that, if the analysis is extended to take more strongly into account three essential elements of the climate problem: (i) the endogeneity of growth; (ii) the convexity of damages; and (iii) climate risk, optimal policy comprises strong controls.
- The first assumption we have relaxed is that the underlying drivers of economic growth are exogenous and unaffected by climate change. Instead we look at two models of endogenous growth, in which the damages from climate change affect the drivers of long-run growth, not just current output.
- The second assumption that was relaxed is that the damage function relating instantaneous climate damage to the increase in global mean temperature is only weakly convex. Instead we allow for the possibility that instantaneous damages increase rapidly, particularly once the global mean temperature reaches 4–6°C above the pre-industrial level.
- The third assumption we have relaxed is that the climatic response to greenhouse gas emissions is moderate and moreover is precisely understood. Most economic modelling is undertaken using only a single, central estimate of the climate sensitivity parameter, fixed in the centre of the distribution of available estimates from the science. We explore risk in this crucial parameter.
- It was show that, with the models extended in this way, business-as-usual trajectories of greenhouse gas emissions give rise to potentially large impacts on growth and prosperity in the future, especially after 2100.
- It was find that these models suggest the carbon price in a setting of globally coordinated policy, such as a cap-and trade regime or a system of harmonised domestic carbon taxes, should be in the range \$32–103/tCO_2 (2012 prices) in 2015—remember that the DICE model lacks adjustment costs, so the high end of the range should be interpreted cautiously. On the other hand and potentially of great importance, we have, notwithstanding our extensions, omitted important risks in relation to the distribution of damages, which could give higher carbon prices. Within two decades the carbon price should rise in real terms to \$82–260/tCO_2. Doing so would, according to the model, keep the expected atmospheric stock of carbon dioxide to a maximum of c. 425–500ppm and the expected increase in global mean temperature to c. 1.5–2°C above pre-industrial.

Key Findings from the 2014 Report from the US Council of Economic Advisors

- Immediate action substantially reduces the cost of achieving climate targets, sending a signal to the market that reduces long-run costs of meeting the target. An analysis of research on the cost of delay for hitting a specified climate target suggests that net mitigation costs increase, on average, by approximately 40 percent for each decade of delay.
- Climate change stemming from delayed action creates large estimated economic damages, e.g., if delayed action causes the mean global temperature increase to stabilize at 3°C above preindustrial levels, instead of 2°C, that delay will induce annual additional damages of 0.9 percent of global output. The next degree increase, from 3°C to 4°C, would incur greater additional annual costs of 1.2 percent of global output.
- The possibility of abrupt, large-scale, catastrophic changes in our climate increases the need to act.
- Enacting meaningful change in climate policy is analogous to purchasing climate insurance.

Australian perspective

- Australia can reduce its GHG emissions to 25% below 2000 levels (a reduction of 240MTCO2e) by 2020 at low cost and using technologies available today.
- The low-carbon Growth Plan identifies 54 separate opportunities—across all sectors—that can be implemented over the next 10 years to achieve these emission reductions.
- Reducing GHG emissions can be profitable for business.
- A combination of carbon price and targeted action is required to achieve the full potential of low cost emissions reductions.
- A portfolio of prompt action is required to implement the 54 opportunities, that takes account of the risk of “locking-in” emissions for the long-term and the ease of emissions reductions.
- Delaying action will mean some low cost opportunities are lost, ensuring greater cost to society and business in the long run.

(Source: ClimateWorks Australia: Low-carbon Growth Plan for Australia—Report summary. March 2010)

A Message on Climate Change to World Leaders
Co-ordinated by the Sustainable Development Solutions Network (SDSN)

- Human-induced climate change is an issue beyond politics. It transcends parties, nations, and even generations.
- For the first time in human history, the very health of the planet, and therefore the bases for future economic development, the end of poverty, and human wellbeing, are in the balance.
- The world has agreed to limit the mean temperature increase to less than 2°C. Even a 2°C increase will carry us to dangerous and unprecedented conditions not seen on Earth during the entire period of human civilization. Many scientists and some countries advocate for 1.5°C or even stricter targets.
- By holding the 2°C limit, we would retain the global option to adopt an even more stringent emission reduction limit in line with evolving scientific knowledge and technological capacities.
- The 2°C limit, or an even stronger target, can be met through long-term national strategies and concerted global cooperation.
- All countries must commit to a deep decarbonisation of their energy systems, shifting from high-carbon energy (coal, oil, and natural gas) to low-carbon energy of various kinds (e.g. wind, solar, nuclear, carbon capture and sequestration, known as CCS).
- Low-carbon electricity plus massive gains in energy efficiency and the electrification of vehicles, heating and cooling systems of commercial as well as residential buildings can lead to a dramatic reduction of carbon-dioxide emissions alongside a growing economy.
- Changes in lifestyle patterns and urban planning can make another important contribution.
- The many co-benefits of decarbonisation with the deployment of sustainable energy, information and communication technologies will include cleaner air and water, enhanced biodiversity, and security of domestic renewable energy resources.
- Targeted efforts are also required to decarbonize key industries.
- Finally, countries need to curb greenhouse gas emissions resulting from agriculture, livestock, and land-use change, such as deforestation. They must also manage and restore ecosystems to ensure they can serve as a significant net sink for greenhouse gas emissions.
- The technological transition during the first half of the 21st century is within reach, especially in light of massive advances in knowhow in recent years.
- In many parts of the world and in some contexts, solar and wind power are already at "grid parity." Large-scale deployment of electric vehicles, carbon-capture and sequestration, next-generation nuclear power plants for those countries deploying nuclear power, and other low-carbon energy technologies are all within reach. They can be pushed to commercial readiness and large-scale deployment through concerted public and private programs of research, development, demonstration, and diffusion (RDD&D) on a global scale.
- We have nearly exhausted the Earth's carbon budget, which measures the cumulative emissions of CO_2 that will likely keep the planet within the 2°C limit. Only through a drastic reduction of carbon emissions between now and 2050, en route to a zero-net emission economy in the second half of the century, can we meet the challenge of remaining below 2°C. Yet, deep decarbonisation can be accomplished.

(Source: http://unsdsn.org/climate-letter/)

Statement by leading climate and energy scientists
New unabated coal is not compatible with keeping global warming below 2°C

➤ Unabated coal is not a "low-carbon" technology.

- Even the most efficient coal-fired power plants emit more than 15 times the amount of CO_2 per unit of electricity compared to renewable energy systems, and more than twice the amount of efficient gas-fired plants. It is misleading to speak about high-efficiency low-emissions coal combustion technologies unless equipped with CO_2 capture and storage.

➤ Avoiding dangerous climate change requires that the majority of fossil fuel reserves need to stay underground.

- This is particularly true regarding coal for power generation. Coal is the fossil fuel that can most easily be replaced by near zero carbon alternatives, where-as liquid fossil fuels used in transport are much harder to substitute.

➤ Current trends in coal use are harbouring catastrophic climate change.

- The current global trend of coal use is consistent with and emissions pathway above the IEA's 6°C scenario. That risks an outcome that can only be described as catastrophic, beyond anything that mankind has experienced during its entire existence on Earth.

➤ To keep global warming to less than 2°C above pre-industrial, use of unabated coal has to go down in absolute terms from now on.

- There is no room in the remaining carbon budget for building new unabated coal power plants, even high efficiency ones, given their long lifetimes. Nor is there much room for upgrading existing coal plants with high efficiency technologies, since they will subsequently have even longer lifetimes.

➤ Alternatives are available and affordable.

- Electricity from renewable energy sources has become cost-competitive in most parts of the world. When the external costs of health and climate damage are taken into account, electricity from renewable sources is cheaper than fossil fuel-based electricity, including coal.

➤ Public financing institutions and regulatory agencies are reining in unabated coal, but more is needed.

A number of bilateral and multilateral finance institutions (World Bank, European Investment Bank, US Export-Import Bank (EIB)) have recently introduced policies that restrict the financing of unabated coal-fired power plants to exceptional circumstances. The EIB has introduced emissions performance standards that rule out financing unabated coal, and the US EPA has announced a similar regulatory standard for new plants. In its air pollution action plan, China is prohibiting new coal capacity in three coastal provinces, and reducing the proportion of coal in the energy mix. Such policies are good examples of what is required to achieve the 2°C pathway.

(Full statement is available at: http://www.europeanclimate.org/documents/nocoal2c.pdf)

World Bank: Putting a Price on Carbon

Climate change poses one of the greatest global challenges and threatens to roll back decades of development and prosperity.

The latest report from the United Nations Intergovernmental Panel on Climate Change makes clear the importance of putting a price on carbon to help limit the increase in global mean temperature to 2°C above pre-industrial levels.

Depending on each country's different circumstances and priorities, various instruments can be used to price carbon to efficiently and cost effectively reduce emissions, such as domestic emissions trading systems, carbon taxes, use of a social cost of carbon and/or payments for emission reductions.

Governments are taking action. In 2014, about 40 national and over 20 sub-national jurisdictions have already implemented or scheduled emissions trading schemes or carbon taxes. Together, these jurisdictions account for more than 22 percent of global emissions. Many more countries and jurisdictions are advancing preparation for pricing carbon. Together, these represent almost half of global GHG emissions.

Corporations are responding. A growing number of companies are already working within carbon pricing systems and are developing expertise in managing their emissions. Others are incorporating greenhouse gas reduction targets in their business planning. In 2013, over 100 companies worldwide publicly disclosed to CDP that they already use carbon pricing as a tool to manage the risks and opportunities to their current operations and future profitability. Businesses see that carbon pricing is the most efficient and cost effective means of reducing emissions, leading them to voice support for carbon pricing.

The momentum is growing. Pricing carbon is inevitable if we are to produce a package of effective and cost-efficient policies to support scaled up mitigation.

Greater international cooperation is essential. Governments pledge to work with each other and companies pledge to work with governments towards the long-term objective of a carbon price applied throughout the global economy by:

- strengthening carbon pricing policies to redirect investment commensurate with the scale of the climate challenge;
- bringing forward and strengthening the implementation of existing carbon pricing policies to better manage investment risks and opportunities;
- enhancing cooperation to share information, expertise and lessons learned on developing and implementing carbon pricing through various "readiness" platforms.

We invite all countries, companies and other stakeholders to join this growing coalition.

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above: Solar panels in St. Lucia

BACK COVER PHOTOS

top: Samoan women gather to address issues of poverty and empowerment. (AusAID)

bottom: PS10 and PS20 solar power towers in Andalusia, Spain (Koza1983/Wikimedia Commons)

COMISSIONED BY THE REPUBLIC OF NAURU, CHAIR OF THE ALLIANCE OF SMALL ISLAND STATES (AOSIS), ON THE OCCASION OF THE UNITED NATIONS CLIMATE SUMMIT