Call for inputs on technology road maps and action plans

18 June – 31 July 2012

Background

The Conference of the Parties (COP), by its decision 1/CP.16, requested the Technology Executive Committee (TEC), as one of its functions, to catalyse the development and use of technology roadmaps or action plans at the international, regional and national levels through cooperation between relevant stakeholders, particularly governments and relevant organizations or bodies, including the development of best practice guidelines as facilitative tools for action on mitigation and adaptation.

The COP, by its decision 4/CP.17, adopted the following modalities for the TEC in carrying out the function related to catalyse the development and use of technology road maps or action plans:

(a) Promoting and collaborating with relevant organizations, resources permitting, in organizing workshops and forums to increase the opportunities for sharing experience with experts in developing and implementing technology road maps and action plans as well as other technology-related activities;
(b) Making recommendations on best practices and relevant tools to develop technology road maps and action plans;
(c) Establishing an inventory of technology road maps and action plans;
(d) Making recommendations on concrete actions, such as an international process for the development of technology road maps and action plans as well as support required to enhance the development of these items, and in particular capacity-building programmes that may be appropriate.

The TEC, in its rolling workplan for 2012-2013, included the preparation of an inventory of existing technology road maps as one of the tasks to be completed by the end of 2020 and also the review of the inventory of technology road maps to be carried out in 2013.

Call for inputs

To facilitate the development of the inventory of existing technology road maps and action plans, the TEC, at its 3rd meeting, agreed to call for inputs from relevant organizations on this matter. Interested organizations are invited to provide their inputs, including their final products of technology road maps and action plans as well as their experiences and lessons learned from developing and using technology road maps and actions plans to: tec@unfccc.int.

The call for inputs will be open from 18 June – 31 July 2012 (24:00 GMT). The inputs from this call will be considered at the fourth meeting of the TEC.

Inputs received

Date received	Submission
31 July 2012	Business Council for Sustainable Energy
31 July 2012	International Council of Chemical Associations
31 July 2012	GIZ
1 August 2012	Asian Development Bank
6 August 2012	International Renewable Energy Agency
6 August 2012	Global CCS Institute
6 August 2012	World Business Council for Sustainable Development

Response to Call for Stakeholder Input by the UNFCCC Technology Executive Committee
July 31, 2012

The Business Council for Sustainable Energy (BCSE) represents the broad portfolio of existing clean energy business sectors, including renewable energy, supply-side and demand-side energy efficiency, natural gas and electric utilities in North America. The Council has represented the views of clean energy industries in the United Nations Framework Convention on Climate Change (UNFCCC) process since 1992.

In response to the UNFCCC's Technology Executive Committee's request, the Council would like to offer its comments in response to the following areas:

1) On technology road maps and action plans;
2) On ways to promote enabling environments and to address barriers to technology development and transfer, including on the role that the TEC could possibly play in this area of work; and.
3) On actions undertaken by accredited observer organizations relevant to the TEC in performing its functions

The companies and trade associations within the Council's membership offer their expertise and experience developing clean energy and energy efficiency projects in countries around the world as a resource to the TEC as it moves forward with its 2012-13 work plan.

1) On technology road maps and action plans

The Council would like to offer the following publications and materials as produced by two of its members – Johnson Controls and Center for Environmental Innovation in Roofing - as a resource to inform the process of creating technology road maps for clean energy industry sectors.

Driving Transformation to Energy Efficient Buildings, Version 2.0
http://www.institutebe.com/energy-policy/Driving-Transformation-Energy-Efficient-Buildings2.aspx

This policy toolkit, originally released at COP 17 in Durban, South Africa, was recently updated for the UNCSD Rio+20 Conference. This second-edition report reviews government policy options that can accelerate building energy efficiency improvements. New in this edition is a building efficiency policy assessment tool that provides a practical starting point for accelerating energy efficiency policy development. The tool offers a simple framework to help decision-makers set policy priorities with input from stakeholders. It outlines a workshop designed to support consensus-based, multi-stakeholder collaboration and uses visual tools to build consensus and prioritize building efficiency policy options and strategies.

This edition also includes new content on the private-sector's role and priorities around building energy efficiency, in particular describing how to create market conditions that support investment in energy efficient buildings and leverage private-sector capital, technology and services to scale up the market.

The publication was produced by the Institute for Building Efficiency at Johnson Controls, and in collaboration with the Business Council for Sustainable Energy, Center for Clean Air Policy, U.S. Green Building Council and World Green Building Council.

RoofPoint™ 2012
www.RoofPoint.org

RoofPoint is a voluntary, consensus-based green rating system developed by the Center for Environmental Innovation in Roofing (Center) to provide a means for policy makers, industry practitioners and building owners to select sustainable roofing strategies based on long-term energy and environmental benefits. RoofPoint outlines key, geographically appropriate strategies that address all critical environmental aspects of modern roofing systems and their impact on clean energy production and carbon reduction. Specific strategies include energy efficiency and renewable energy production, materials management, water management, and life-cycle and durability management. In addition to the continual improvement of RoofPoint, the Center is committed to making the program available to policy makers and practitioners in emerging economies.

2) On ways to promote enabling environments and to address barriers to technology development and transfer, including on the role that the TEC could possibly play in this area of work

The Council and its members believe that it is critical to invest resources and expertise into shaping enabling environments that will facilitate sustainable deployment of clean energy technologies. A suite of complementary policies and market structures, including effective and non-discriminatory financing mechanisms for technology transfer and deployment, non-discriminatory government procurement policies with respect to climate-change-related technology, and international trade regimes that promote cleaner, more energy-efficient and lower greenhouse gas emitting technologies, are necessary in order for clean energy technologies, products and services to take root. Furthermore, policies that reduce uncertainty as to potential gains that private business can anticipate from major research will enhance society's ability to achieve significant innovation in pursuit of a green economy.

As the Council represents different sectors within the clean energy industry, the Council recognizes that ultimately each technology often faces unique circumstances when trying to enter a new market. A particular industry may have different modalities for diffusion, as well as different financial needs and incentive structures, infrastructure constraints and end-user behaviors that must be addressed. At the highest level, however, an enabling environment that respects the rule of law, protects financial investments and provides a policy framework that creates an even playing field, is needed by all clean energy technologies.

Capacity building and the identification of technology needs and available solutions are other essential elements. The transition to a low carbon economy can not happen solely by government mandate; it also requires a partnership with the private sector and education of the general public. The Council is encouraged by the increased momentum to engage with the private sector, which today accounts for more than two-thirds of total investments in the research and development of adaptation and mitigation technologies, especially in regard to effective mechanisms for technology deployment, diffusion and transfer.

As the TEC examines through its work the key elements of enabling environments and barriers to technology transfer, the Council offers a fact sheet prepared for the technology discussions at the COP 17/CMP 7 in Durban. While this fact sheet references the Climate Technology Center & Network (CTC&N), its relevance to the TEC's work is that it provides a format through which the perspectives of private sector can be shared to demonstrate technology transfer in action and the necessary enabling environments required to do so.

BCSE Fact Sheet on Supporting Technology Transfer in Durban
http://www.bcse.org/images/2011International/bcse%20cop%2017%20technology%20fact%20sheet.pdf

3) On actions undertaken by accredited observer organizations relevant to the TEC in performing its functions

The Business Council for Sustainable Energy is a business coalition with twenty years of experience of coordinating industry expertise and providing policy input on behalf of the renewable energy, energy efficiency and natural gas sectors in North America. The Council's advocacy work and policy interventions have occurred at the state/regional, federal and international levels of government. As the Council is a coalition of companies and trade associations in these sectors, it can quickly disseminate information and solicit feedback from a broad network of voices from clean energy sectors. This network can also be extended internationally, as the Council is a founding member of the International Council for Sustainable Energy (ICSE), along with the Clean Energy Council of Australia and e5 of Europe. The Council offers the TEC the ability to connect to leading clean energy executives in the U.S. and abroad as needed, to review, comment and provide input on future materials produced by the TEC.

Additional information is provided in the requested templates.

INTERNATIONAL COUNCIL OF CHEMICAL ASSOCIATIONS

July 31, 2012

Technology Executive Committee
United Nations Framework Convention
on Climate Change
P.O. Box 260124
D-53153 Bonn
Germany
Via Email to tec@unfccc.int

RE: Technology Executive Committee call for inputs on technology road maps; experiences and lessons learned from road map development

Dear UNFCCC TEC Members:

CEFIC, the European Chemical Industry Council[1], and the International Council of Chemical Associations (ICCA)[2], are pleased to provide this input in response to the Technology Executive Committee's (TEC) request for input on the development of technology road maps. Our organizations have a significant interest in the development and use of technology road maps as a means of assessing the energy efficiency and greenhouse gas reductions that can be achieved by improving the use of existing technologies that rely on chemistry, as well as identifying emerging chemical technologies and products that can enhance those savings.

Background

CEFIC and the ICCA member associations are committed to reducing greenhouse gas emissions. We are working to meet this commitment in two ways: First, by reducing emissions in the industry's manufacturing facilities; and, second, by innovating new products that reduce emissions when used by other industries and consumers.

In our own facilities, chemical companies have significantly improved energy efficiency and reducing greenhouse gas intensity. The European chemical industry reports that overall greenhouse gas emissions have been curbed by 49% between 1990 and 2009, while production increased 60%. Between 1990 and 2010, the Japanese chemical industry improved energy efficiency by 17%, and reduced absolute greenhouse gas emissions (including HFCs, PFCs and SF6) by 29%. In the United States, the industry's absolute greenhouse gas emissions fell nearly 25% between 1990 and 2011, while industry output was up 28% (output declined between 2008 and 2011, reflecting the economic downtown).

[1] CEFIC is an accredited UNFCCC observer organization.
[2] ICCA has applied for accreditation as a recognized UNFCCC observer, but to date has not been informed of a decision on our application.

The products of the chemical industry are already enabling greenhouse gas emissions savings by industries and consumers; savings that are more than twice the emissions from manufacturing. The ICCA study "Innovations for Greenhouse Gas Emission Reductions" (July 2009) shows these savings across a range of more than 100 chemical products.[3]

ICCA's Technology Road Maps

ICCA's work on technology road maps supports the dual objectives of improving our production efficiency and contributing to reductions in energy use and GHG emissions. The work builds on our 2009 study by providing a bottom up assessment of future technology improvement options.

ICCA has focused its efforts in three areas: **Bio-fuels and Bio-energy, Efficiency/Catalysis and Building Energy Efficiency.** Industry experts from our global regions have been collaborating with the International Energy Agency (IEA) to identify and evaluate current and future contributions of chemicals and new materials to energy efficiency and greenhouse gas emissions improvements with a time horizon towards 2030/2050. Our work is being supported through international workshops led by ICCA and IEA. A summary of our work in each area is attached for your further information.

ICCA's contribution to the IEA's bio-fuels and bio-energy roadmap was completed in May, 2012, with the IEA's publication of its bioenergy for heat and power technology roadmap. Our work on the catalysis roadmap is nearing completion. We received input from technical experts and policy makers and conducted outreach on the topic during a working in China, held in May, 2012.

ICCA's building energy efficiency roadmap is continuing, and is expected to be completed by October, 2012. Using 2000 as a baseline year, the roadmap addresses the energy efficiency and greenhouse gas emissions savings from the use of chemically-derived products in the areas of insulation, house wrap, windows, roofing, and piping. The report specifically analyzes the achievable improvements in the residential and commercial building sectors of the United States, Europe, and Japan. The ultimate objective is to outline a strategic plan identifying options and prioritizing actions for how the plastics and chemicals industry can further contribute to achieving zero or low-emission buildings, and to address barriers to creating an enabling environment that facilitates technology development that result in low or zero emissions buildings. We anticipate that the energy savings and greenhouse gas emissions reductions attributable to the use of the products of chemistry in residential and commercial buildings will be significant.

Over the last two years, ICCA member companies and associations have gained some important insights into the development and possible use of technology road maps. For example, it is clear that developing and obtaining the data on which to base the roadmaps was the single largest challenge for our sector. Understanding the limitations of the available data, and articulating the assumptions on which the analysis could be conducted, were also among the important lessons we have drawn from the process.

[3] ICCA, "Innovations for Greenhouse Gas Reductions," (2009), available at http://www.icca-chem.org/ICCADocs/ICCA_A4_LR.pdf. Note that this is a large document. An Executive Summary of the report is also available at http://www.icca-chem.org/ICCADocs/QA_v6.pdf.

We understand that the TEC will consider the inputs at its fourth meeting, scheduled to take place from 6-8 September, 2012, in Bangkok. We would appreciate your positive recognition of this initial input, and look forward to the opportunity to follow up with more detailed information. In the meantime, please let us know if you require any further information.

Best regards,

Shigenoir Otsuka
Executive Consultant
Mitsubishi Chemical Holdings Corporation
Chairman, ICCA Energy & Climate Leadership Group

Peter Botschek
Director, Energy
CEFIC

Attachments

Biofuels Technology Roadmap: "Cleaner Transport: Powering Transportation with Cleaner Fuels"

- Biofuels enable considerable GHG reduction in the transportation sector and contribute sustainably to energy security and socioeconomic development.
- The chemical industry can play a role in realizing a sustainable future that is targeted toward biofuels and bioenergy production.

ICCA efforts to Develop Biofuels Technology Roadmap

⇒ ICCA helped develop a "Biofuels for Transport" roadmap with IEA to set up a potential scenario to meet CO_2 emission reduction goals.

⇒ The Roadmap clearly acknowledges the importance of the chemical sector both in terms of R&D investments and core technology components, such as tar-free syngas production and bioethanol from the conversion of cellulose to sugar.

Efficiency

- Membrane technologies reduce the energy required to recover ethanol from fermentation broth and makes the process more efficient.
- The chemical industry's ability to achieve and integrate heat transfer in processing plants reduces the cost of materials and operations.
- Incorporating such integration for combined heat, power and fuel production can improve the efficiency of biofuels manufacture and support energy crops from agriculture and aquaculture.

Technology

- The chemical industry developed and uses catalytic processes critical to biofuels production.
- As greater emphasis is placed on advanced fuels, increasingly production of biofuels will rely on technologies practiced by the chemical industry.

Economics

- The cost of feedstock is an impediment to expanded use of biofuels.
- Chemical pretreatment processes that simplify hydrolysis on cellulose markedly improve the economics of fuel production.

Technology roadmaps

ICCA is working closely with the International Energy Agency (IEA) as it is preparing technology roadmaps on climate issues.

ICCA

The International Council of Chemical Associations (ICCA) is the world-wide voice of the chemical industry, representing chemical manufacturers and producers all over the world. It accounts for more than 75 % of chemical manufacturing operations with a production exceeding USD 1,6 trillion annually. ICCA promotes and co-ordinates Responsible Care® and other voluntary chemical industry initiatives.

http://www.icca-chem.org/

RESPONSIBLE CARE®
OUR COMMITMENT TO SUSTAINABILITY

INTERNATIONAL COUNCIL OF CHEMICAL ASSOCIATIONS

Catalysis Technology Roadmap:

- The chemical industry contributes to reductions in energy usage and GHG emissions by continuing to invent and deploy new catalyst technology.
- More than 85% of chemical products are produced via catalytic processes.
- Newly developed catalysts allow processes to proceed via a lower energy pathway, which can allow process steps to be eliminated and streamline downstream processing, saving large quantities of energy and reducing GHGs.

ICCA efforts to Develop Catalyst Technology Roadmap

⇒ ICCA is working with IEA to show how catalysts can help meet CO_2 emission reduction goals.

⇒ The roadmap will show where catalysts can play a key role in chemical industry efforts to reduce energy consumption, enable adaptation to a changing feedstock mix, and allow production of unique advanced materials that help save energy for consumers.

Changing Hydrocarbons into Useful Products

- Catalysts play a key role in the efficient transformation of hydrocarbon precursors, such as methane, ethane and propane, into fuels and chemical products.
- The trends toward production of lower quality fuels, more stringent environmental regulations on fuels, and the advent of new fuel sources demand step changes in the development and application of new catalyst technology.

Alternative & Renewable Feedstocks

- The ability to change alternative or renewable feedstocks into useful precursors for chemical production is already a reality and will be vital to future production capabilities, and catalysis has a role to play in this area.
- Fuel cells, hydrogen production, and reuse applications of CO_2 are active areas of catalyst research.

Materials Development

- Catalyst innovations allow development of new materials used to make lighter-weight vehicles and aircraft, adhesives for advanced materials, and renewable energy structures such as wind turbines and solar panels.
- Advances in catalyst technology will be crucial to addressing the challenge of producing these materials from new monomers.

Technology roadmaps

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INTERNATIONAL COUNCIL OF CHEMICAL ASSOCIATIONS

Building Energy Efficiency Technology Roadmap:

- The chemical industry contributes to a reduction in GHG emissions and improved energy efficiency in buildings through advanced component technologies.
- Significant improvements in GHG emission and energy efficiency, both for new construction and retrofits for existing buildings, can be achieved in the following areas: insulation, plastic house wrap, windows, roofing and piping.

ICCA efforts to Develop Buildings Energy Efficiency Technology Roadmap:

⇒ ICCA is working with IEA to develop a "Low Emission Buildings" roadmap with IEA to help meet CO_2 emission reduction goals.

⇒ The roadmap clarifies the importance of the chemical sector both in terms of R&D investments and core technology components.

Building Technologies

Insulation

- Whether spray polyurethane foam (SPF) in the attic or rigid foam polyiso board on the roof, polyurethane-based systems offer durability, energy savings and moisture control. When used in retrofit situations, they also help reduce building waste sent to landfills.

- In walls, behind walls and under floors, polystyrene foams provide significant energy efficiency. Savings vary by material and products: rigid extruded polystyrene (XPS) is a builder favorite because it can be installed easily and effectively; structural insulated panels made with expanded polystyrene (EPS) can help homeowners save hundreds of dollars annually on heating and cooling bills.

Plastic House Wrap

- The advent of plastic house wrap technology has reduced infiltration of outside air into the average home by 10% to 50%, helping to drastically reduce the energy required to heat or cool the home. These plastic films have helped reduce GHG emissions in the United States by 120 million to 600 million tons of CO_2 since 1980 (assuming that all homes built in the U.S. since 1980 have some form of plastic barrier).

Technology roadmaps

ICCA is working closely with the International Energy Agency (IEA) as it is preparing technology roadmaps on climate issues.

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Windows

- Plastics rival traditional materials for window glazing. These clear, lightweight, shatter-resistant plastic products, such as polycarbonate used in windowpanes, have low thermal conductivity, which can help to reduce heating and cooling costs.

- Vinyl window frames are inherently energy efficient and save the U.S. nearly 2 trillion thermal units of energy per year, helping reduce GHG emissions associated with energy generation —all the while cutting maintenance time, materials and costs.

Roofing

- Reflective light-colored roofing membranes made of vinyl or thermoplastic olefin blends are key energy saving applications, especially for commercial buildings in warm climates.

Piping

- Plastic pipe and fittings are durable, easy to install and do not rust or corrode over time. Several types of plastics are used for piping, depending on the properties and performance required. Products like polyethylene, polypropylene, polyvinyl chloride (PVC), or acrylonitrile butadiene styrene (ABS) offer fusion integrity when joined properly, eliminating potential leak points where water could be wasted.

- In home building, flexible blue and red cross-linked polyethylene piping (PEX) is becoming a builders' favorite for hot and cold water delivery due to its flexibility, lightness, and ease of installation—enabling multiple feed lines throughout a house, to allow hot water to arrive more quickly to a sink or shower, with significant water savings.

Refrigeration, air conditioning and foam blowing sectors technology roadmap

GIZ Proklima

Authors: Jonathan Heubes, Maria Martin, Dietram Oppelt

Executive summary

The following technology roadmap and action plan for the refrigeration, air conditioning and foam blowing (RAC&FB) sectors is presented by the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ).

The German government programme Proklima, carried out by GIZ, focuses on the reduction of ozone depleting and greenhouse gas emissions. Since 1996 Proklima has supported more than 40 developing countries with over 250 projects. Proklima assisted mitigation actions of Non-Annex I countries on a national and regional level with capacity building, technology demonstration, sector strategies and policy dialogue. At present, Proklima has been requested by the International Climate Initiative of the German Ministry of Environment to implement the "Green Cooling Initiative", which aims to enhance networking and stakeholder participation under the technology mechanism of the UNFCCC in the field of RAC&FB.

The roadmap developed by Proklima incorporates 15 years of experiences by Proklima and other implementing agencies that have been active in the field, mainly under the Montreal Protocol, but also under the UNFCCC (e.g. CDM). Mitigation strategies for both direct and indirect emissions of the RAC&FB sectors have been utilised to develop low carbon strategies up to 2050. The establishment of an enabling environment is presented as an integral part of the technology roadmap.

Rationale for presenting a RAC&FB technology roadmap:

- Unabated emissions in the RAC&FB sectors will globally grow from currently about 4 Gt CO_2eq to 12 Gt CO_2eq by 2050. The growth of indirect emissions in the RAC&FB sectors are mainly driven by economic development, wealth effects and lifestyle, growing urbanization and increasing ambient temperatures. According to experts, effective mitigation of HFCs needs to cap emissions at least equal or below current emission levels in order to comply with the 2°C target.

- Since 1991, ozone-depleting substances (ODS) in the RAC&FB sectors have been successfully phased out by the Montreal Protocol. However, its mandate does not include the control of refrigerants or blowing agents with zero ozone-depleting potential or indirect emissions resulting from the energy use of appliances. Consequently, in the past a significant part of the ODS has been replaced with HFCs with a high global warming potential and there is a substantial risk that the phase-in of HFCs is further accelerated by the ongoing phase-out of HCFCs under the Montreal Protocol;

Key features of the RAC&FB technology roadmap:

- The technology roadmap will cap emissions at 4 Gt CO_2eq versus the baseline scenario that peaks at 12 Gt CO_2eq in 2030. The reduction of direct emissions

of high-GWP HFCs through low carbon alternatives offer the highest potential for immediate and sustainable action in Non-Annex I countries. In combination with technology and policy actions on energy efficiency, this will lead to substantial reductions of indirect emissions;

- The roadmap analyses nine sub-sectors[1] in a comprehensive manner for all major systems and applications. For each of the sub-sectors it evaluates the effect of available low carbon technologies that are market-ready or already placed in the market. In addition, the effects of an enabling environment, such as removing economic and regulatory barriers or providing incentives for the introduction of alternatives and best practices are considered in the roadmap. Based on these analyses, feasible milestones and targets for the global dissemination of alternatives are projected.

- The methodology applied in the roadmap builds on established procedures for emission projection and reporting under the UNFCCC. With regard to national control measures, such as import/export bans, national regulations, policy action and standard development, a proactive approach as historically applied under the Montreal Protocol has been used as a reference. In the analysis of the economic feasibility of mitigation action and its marginal abatement costs, incremental costs of technology investments are considered at the end of economic life of old equipment and its replacement.

The roadmap finally illustrates that depending on the range of support provided to Non-Annex I countries, the replacement of inefficient products and systems by low carbon alternatives and practices could be accelerated even beyond the proposed targets.

[1]Including domestic, commercial, industrial and transport refrigeration and stationary and mobile air conditioning, as well as 3 foam sectors (construction and refrigeration insulation and integral foam)

1. Rationale and scope

The deceleration of climate change is one of the greatest challenges across the world during this century. Despite an international climate regulation (the UNFCCC) to reduce GHG emissions, the global CO_2 emission growth rates have steadily increased in the past decades. The growth rates jumped from 1.1 %/yr in the 1990-2000 period to 3.0 %/yr in the following decade (IEA, 2010) . Thus, more effort is needed to slow down the emissions, which warm up our planet. The major part of the global emissions result from the energy sector (~60%), followed by land use change, agriculture, waste and industrial processes (WRI, 2005). The basket of the top 6 greenhouse gases from these sectors are addressed in the Kyoto Protocol. Important but often neglected chemicals from this list are F-gases (hydrofluorocarbons HFCs, perfluorocarbons PFCs and sulfur hexafluoride SF_6).

Among all F-gas emissions, HFC emissions account for large shares and are expected to increase strongly in absolute figures and their relative weight to other greenhouse gases (Gschrey & Schwarz, 2009). These substances are predominantly used as refrigerants and foam blowing agents in the refrigeration, air conditioning and foam blowing (RAC&FB) sectors. In general, there are two kinds of emissions in the RAC&FB sectors: direct and indirect emissions. The first kind results from the F-gases itself (e.g. leakage of the refrigerant during lifetime or end-of-life), whereas the latter are caused by energy consumption of the appliances during operation or the manufacturing process. Both types of emissions are likely to increase in the future. Direct emissions are expected to increase, because the high-GWP HFCs are replacing ozone-depleting substances, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which were widely used as refrigerants and blowing agents over the last decades. The chlorine containing chemicals are being phased out under the Montreal Protocol.

Another factor which will boost the direct and indirect emissions is climate change itself. Today, households (in buildings) consume globally about a third of all end-use energy and account for the respective CO_2 emissions. Heating, cooling and the supply of hot water are estimated to account for roughly half of the global energy consumption in buildings (IEA, 2011). In regions with temperate climate, this energy is predominantly used for heating (IEA, 2004). However, space cooling is rapidly growing in high-income countries, hot countries and in emerging economies. A growing (urban) population, increasing wealth and temperatures (due to climate change) will elevate the cooling demand, thus, there will be more AC and refrigeration systems running in future, contributing to higher overall emissions. On top of that, the cooling demand is growing rapidly in countries with very carbon-intensive electricity systems, pointing to the need of low-carbon technologies. Also the global building area is projected to triple by 2050 (IEA, 2011) which will cause a strong increase in the demand for foam for insulation with respective direct emissions from blowing agents.

Consequently, transformations in the RAC&FB sectors can strongly contribute to reach the CO_2 target in 2050, which aims to not exceed atmospheric CO_2 concentrations above 450 ppm (IEA, 2009). The 450 ppm scenario is in line with the 2°C target which is gaining widespread support around the world. It is assumed that a global temperature increase above 2°C will have irreversible and uncontrollable effects in the earth's system. Today, alternative technology is widely available for most applications in the RAC&FB sectors, however, more effort is needed to spread low-GWP and energy-efficient technologies and overcome existing barriers, in particular in developing countries. The accelerated dissemination of alternative technologies in the RAC&FB sectors promises the prospect of fast and low cost emission reductions to nearly eliminate all direct emissions and further to significantly lower indirect emissions from their business-as-usual (BAU) scenario.

The RAC&FB sectors have been a key area of the Montreal Protocol with its focus to phase out chlorine containing refrigerants and foam blowing agents. As such a broad range of measures, instruments, tools and institutional settings were established under the Montreal Protocol to initiate, execute and control mitigation actions. The global RAC&FB roadmap presented here builds on the experiences established under the Montreal Protocol.

GIZ Proklima has been active under the Montreal Protocol and implemented mitigation actions in the RAC&FB sectors since over 15 years. In that context GIZ Proklima, on behalf of Germany, is currently responsible for the implementation of sectoral HCFC Phase-out Management Plans (HPMPs) in more than 15 countries. The work includes the direct conversion of entire sectors from fluorinated, ozone depleting and climate damaging refrigerants to natural refrigerants.

The works carried out by Proklima include international policy consulting, the implementation of sectoral plans on national level, capacity building in developing countries, establishing of demonstration sites and the introduction and penetration of new technologies on the market. Proklima is actively promoting and leading the development of various industrial networks, such as the SolarChill network.

Further, Proklima has been active under the International Climate Initiative of the German Environmental Ministry (BMU) since many years to demonstrate climate mitigation projects in many Non-Annex I countries. As such Proklima is developing a NAMA (Nationally Appropriate Mitigation Action) handbook on mitigation actions in the RAC&FB sectors and is currently supporting NAMAs elaboration and implementation in various Non-Annex I countries.

GIZ Proklima has been awarded by the BMU with a project, the “Green Cooling Initiative” to support the Technology Mechanism of the UNFCCC and the TEC for an accelerated technology transfer in the RAC&FB sectors through

- the establishment of sectoral and regional cooperation networks
- policy recommendations
- support on enabling environments for a supporting regulatory and technology framework (as outlined under chapters 4.1 and 4.2)
- establishment of global, regional and - within the context of NAMAs - national technology roadmaps

Herewith, Proklima presents a global roadmap for the RAC&FB sectors, highlighting the dissemination of alternative technologies. The roadmap builds on the experiences of Proklima in carrying out over 250 projects, including sector mitigation plans on emission mitigation and technology transfer in over 40 developing countries. Proklima demonstrates that significant emission savings can be achieved by sector transformation in the RAC&FB sectors. In particular, it is possible to utterly prevent direct emissions by widely deploying low-GWP refrigerants and blowing agents instead of high-GWP refrigerants such as HFCs. In addition, through energy efficiency gains the emission path of indirect emissions can be altered, substantially below its BAU case.

2. Status of technologies in the RAC&FB

Direct emissions in the refrigeration and air conditioning sector stem from the use of HCFCs and HFCs as refrigerants. These compounds usually have a high global warming potential and thus take to warm the climate once emitted in the atmosphere during production, usage and/or deposition. Natural refrigerants (such as hydrocarbons), which are introduced only in a few subsectors and regions at the moment, are a preferable refrigerant alternative. They are present – as their name implies - in nature, and thus their interaction with the environment (which is usually neutral) is well known in opposite to that of synthetic formed refrigerants. Furthermore, they have a lower GWP than HCFCs or HCFs (see Table 5 in the Appendix). The main refrigerants used for each RAC&FB sub-sector are summarized in Table 1. Indirect emissions from the energy consumption of the units must be added to the direct ones and are usually the dominating emission factors. However, it is relatively easy to reduce direct emissions, which is in some cases done via the substitution of the momentarily applied refrigerant without complete system changes.

HCFCs and HFCs are used in the foam blowing sector as blowing agents in the production process leading to direct emissions. Currently, natural substances are partly applied, for example CO_2 in extruded polystyrene (XPS) insulation boards in China. The indirect emissions are minimal in this sector and are thus disregarded further on.

2,1 Refrigeration

The refrigeration sector can be divided into four sub-sectors:

Domestic refrigeration is used in private households for preserving food, drinks and medicine. Refrigerators, freezers as well as combined systems are covered here. Most of the devices are factory-assembled for an easy set-up and use. In total, around 1 400 million units are globally in stock. Direct emissions were estimated to be 20 Mt CO_2eq, and indirect emissions to be 147 Mt CO_2eq in 2010. (All emissions and stock numbers are taken from Ederberg et al., 2010.)

Commercial refrigeration is needed for cooling of stored or displayed food and beverages. Two temperature levels are applied, food is either kept frozen below 0°C or chilled above. Systems in use are stand-alone units, such as vending machines or beverage coolers, condensing units, which are often used in smaller supermarkets or bakeries, and centralised units. The latter are larger systems, where more cabinets are cooled by one refrigeration system. In 2006, the stock was globally around 90 million units. Direct emissions were estimated to be 314 Mt CO_2eq, and indirect emissions to be 272 Mt CO_2eq in 2010.

Industrial refrigeration implies the food processing, storing and distributing sector and the cooling in industrial processes. Industrial systems differ from others by size and their covered temperature range. Furthermore, they are very often specifically produced to fit a certain application[2]. Direct emissions were estimated at 158 Mt CO_2eq, and indirect emissions at 262 Mt CO_2eq in 2010.

Transport refrigeration covers cooling that is required during the transportation of goods. It is needed on roads within trucks and trailers, but also within trains, ships or airborne containers. The dominating sector is road transport with about 4 million units in stock. Direct emissions were estimated to be 56 Mt CO_2eq, and indirect emissions to be 113 Mt CO_2eq in 2010.

2.2 Air conditioning (AC)

AC is divided into the following two sub-sectors:

Stationary AC implies all applications that are used to cool one or more rooms in residential or commercial places. To achieve cooling, a large variety of systems are available including self-contained AC systems, where all components are built into one housing. Split AC systems consist of two separate elements, the one delivering the cooling is placed inside and the one ejecting the heat is placed outdoors. For multiple rooms, duct split or rooftop ducted AC systems are taken, where a ducting

[2] This is also the reason that no reliable stock number can be given here.

system distributes cold air inside the building. In AC chillers, which are mainly applied for commercial and light industrial purposes, a liquid is cooled and distributed to cooling coils within the building. In total 335 million stationary AC systems are globally in stock. Direct emissions were estimated to be 738 Mt CO_2eq, and indirect emissions to be 1 871 Mt CO_2eq in 2010. These are by far the largest direct as well as indirect emissions from all RAC&FB sub-sectors (see also Figure 2).

Mobile AC systems deliver cooling in vehicles, including passenger cars, trucks or buses and are usually belt driven by the engine. Around 900 million units were in stock in 2006. Direct emissions were estimated at 130 Mt CO_2eq, and indirect emissions at 212 Mt CO_2eq in 2010.

Figure 1 displays the units in stock in the refrigeration and air conditioning sub-sectors, displaying that domestic refrigeration is the most wide-spread sub-sector.

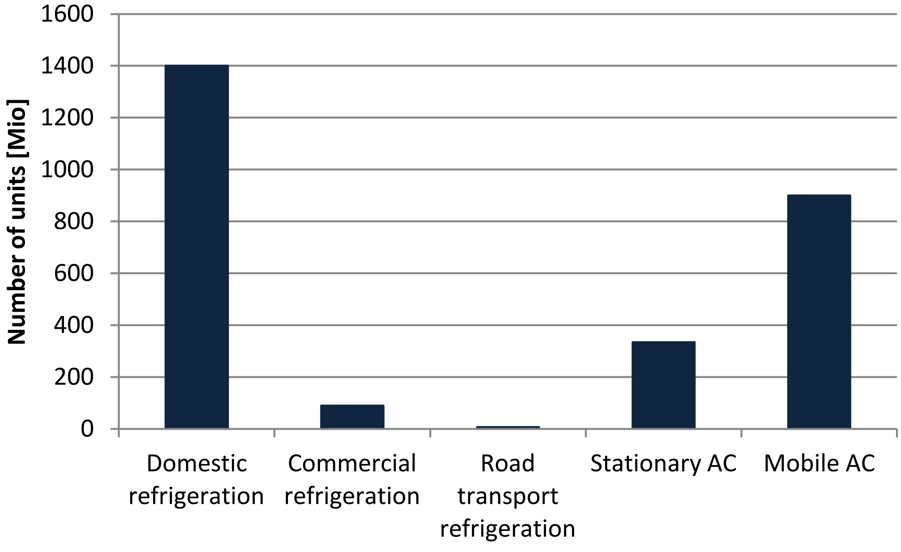


Figure 1: Units in stock in the refrigeration and air conditioning sectors.

2.3 Foam

Foam covers the following sub-sectors:

Insulation foam in the construction sector, where foam is used for insulating residential and commercial buildings. This can be achieved by using sandwich panels, XPS boards, spray foams, which are applied directly on surfaces, or one component foams for filling up applications with restricted access.

Insulation for refrigeration applications is needed in all refrigeration applications described above. In domestic refrigeration systems, foam is injected into the space between the outer metal shell and the inner plastic inline, in commercial and transport refrigeration systems, panels of different sizes are implemented.

Integral foams for the automotive and furniture sectors are used for performance and aesthetical purposes in steering wheels, armrests, shoe soles and many other applications. The foam is put into a mould during manufacturing to receive the shape needed for the specific product.

Total direct emissions in the foam sector were estimated to be 149 Mt CO_2eq. The indirect emissions of this sector are minimal, and will be disregarded therefore.

The following table provides an overview of the main refrigerants or blowing agents applied in the sub-sectors described above. More information about the characteristics (category, GWP, flammability, toxicity) of the main refrigerants used and in which sub-sectors they are preferably applied can be found in the Appendix.

Table 1: Summary of the main refrigerants / blowing agents applied in the different sub-sectors.

Sector	***Sub-Sector***	***Main refrigerants[3] / blowing agents used***
Refrigeration	Domestic	HFC-134a, HC-600a (in the majority of European products, also in China and other countries)
	Commercial	HFC-404A, R744, R717, HC-290, HC-600a, HFC-134a; HCFC-22 (Non-Annex I countries),
	Industrial	HFC-404A; HCFC-22 (Non-Annex I countries), R-717
	Transport	HFC-134a, HFC-404A, HFC-410A, HFC-407C
Air Conditioning	Stationary	HCFC-22, HFC-410A, HFC-407C, HFC-134a, HFC-404A, HC-290
	Mobile	HFC-134a
Foam	Construction sector	HC (N-, iso-pentane, isobutane), HFC-245fa, HFC-235fa, HFC-134a, HFC-152a, CO2, HFC-365mfc/227ea (Annex I countries); HCFC-141b, HCFC-142b, HCFC-22 (Non-Annex I countries)
	Insulation for refrigeration applications	HC (N-, isopentane, cyclopentane), HFC-245fa, HFC-365mfc/227ea (Annex I countries); HCFC-141b (Non-Annex I countries)
	Integral foams for automotive, furniture sectors	HFC-245fa, HFC-365mfc/227ea (Annex I countries); HCFC-141b (Non-Annex I countries)

The global direct and indirect emissions of all sectors are displayed below in Figure 2. It can be seen that with the exception of commercial refrigeration, the indirect

[3] The GWP of each refrigerant is shown in table 5 in the Appendix

emissions are always higher than the direct emissions. However, as discussed above, direct emissions are much easier to reduce than indirect emissions. The by far highest emissions stem from the stationary AC sector.

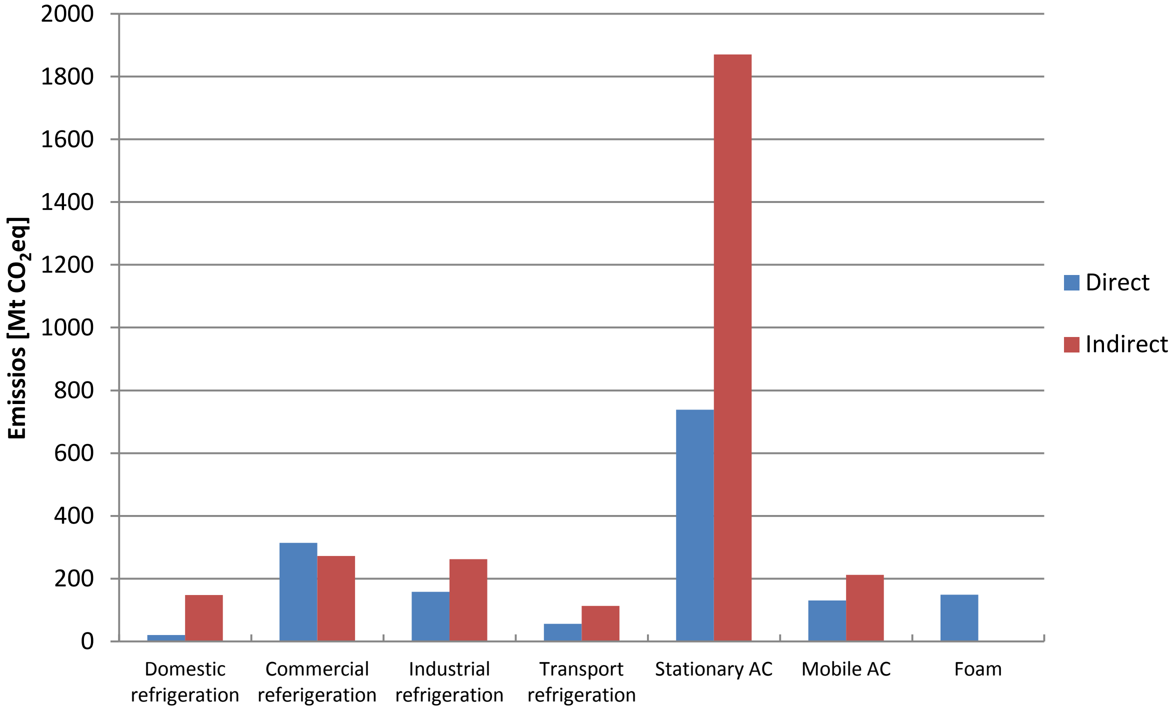


Figure 2: Direct and indirect emissions of the different sub-sectors of the RAC&FB sectors.

3. Vision for a RAC&FB roadmap

If emissions in the RAC&FB sectors just continue under a BAU scenario, they will rise up to 12 Gt CO_2eq in 2030 as illustrated in Figure 3 below. The vision of this roadmap is to show a pathway, where the RAC&FB sectors contribute to emission reductions in the magnitude of 7.2 Gt CO_2eq by 2030. This amount corresponds to the 60% reduction target (relative to the BAU scenario) of the BLUE Map scenario, as formulated by the IEA in 2008 for the transport, industry and buildings sector (Taylor, 2008), which is in line with the 2°C target.

Our roadmap scenario requires an accelerated spread of currently available alternative technologies. The transformation of the RAC&FB sectors will globally reduce direct emissions by 3.5 Gt CO_2eq due to the use of low/zero GWP refrigerants. A higher energy efficiency of the new technologies will reduce indirect emissions by 0.5 Gt CO_2eq, whereas the de-carbonization will contribute with ca. 3 Gt CO_2eq (Figure 3). Indirect emission savings due to improvements of the energy efficiency might be much higher than our conservative estimate. However, this is mainly influenced by measures such as labeling or rationing and also depends on the adopted systems and climate conditions of the considered world's region.

There are also co-benefits stemming from emission reductions, such as benefits for the economy (e.g. labour market, market growth), for technology development in related sectors (e.g. penetration rates, supply infrastructure), for socio-economic development (transport system, income and living situation) for end-users (e.g. customers) or policy impacts on a country level and on international level. Further there are substantial co-benefits from the migration from fluorinated substances to natural substances[4] due to the treatment of the substances at the end of their lifetime. Fluorinated substances are highly toxic and need at the end of the equipment lifetime to be extracted through technical complex processes and destructed through ultra-high temperature procedures with subsequent complicated waste water treatment processes. Most Non-Annex I countries entirely lack the

[4] Natural refrigerants and foam blowing agents are naturally occurring in the environment in contrast to refrigerants/blowing agents from fluorinated substances.

technological ability for the adequate treatment of fluorinated substances and therefore end up with highly toxic waste without suitable solutions for disposal.

The proposed CO_2eq emission reductions stem from a dramatic transformation in the markets which include the deployment of low-GWP and zero-GWP alternative technologies, introduction of appropriate policy measures (such as bans of high-GWP refrigerants as introduced in the EU for certain subsectors) (Schwarz et al., 2011), but also a continued phase-out of HCFCs. HCFC-22 with a GWP of 1 810 (100yr time horizon) is still massively used in developing countries. Direct transformations of sectors to low-GWP alternatives can, thus, strongly contribute to emission reductions. Our baseline consumption accounts for both HCFC and HFC use in the RAC&FB sectors, whereby the baseline is designed upon existing policies. This includes an accelerated phase-out of HCFCs as agreed upon by the Montreal Protocol Parties in September 2007 (UNEP, 2007).

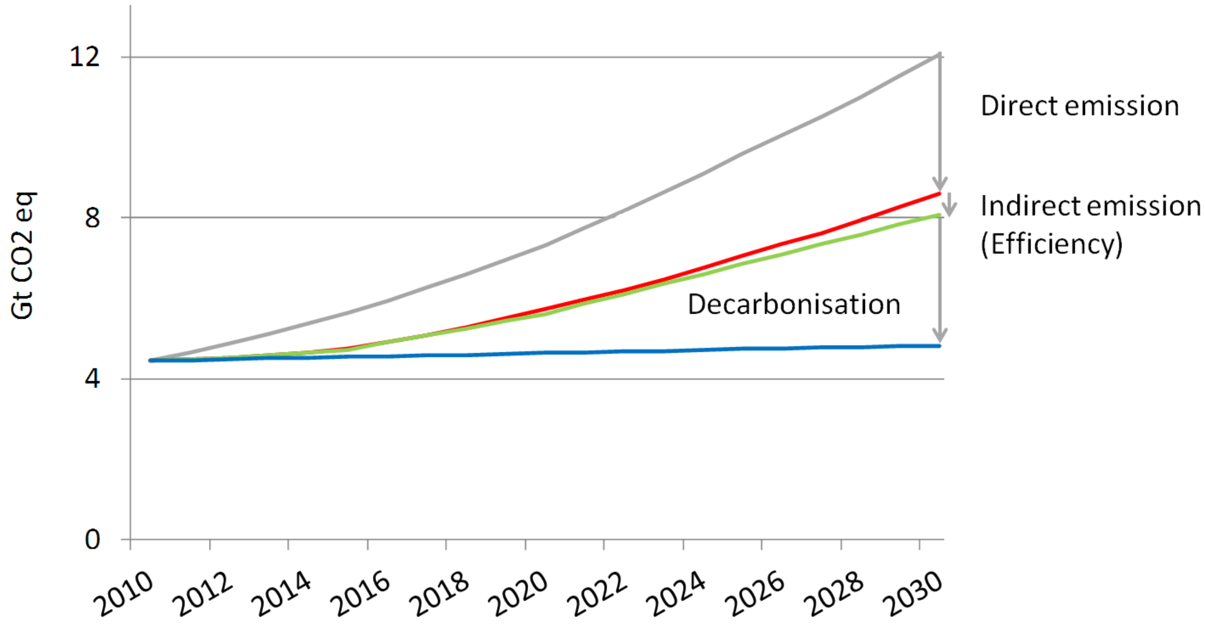


Figure 3: The roadmap for the refrigeration, air conditioning and foam blowing sectors allows emission savings of 7.2 Gt CO_2eq. Direct and indirect emission reductions equally contribute to the overall emission savings.

Figure 4 shows the different sub-sectors´ contribution in achieving the direct emission reductions of 3.5 Gt CO_2eq by 2030. Globally, the fastest growing sub-sectors in terms of demand and emissions are stationary air conditioning, industrial and commercial refrigeration. Accordingly, these sectors reveal the greatest reduction potential. Roughly 50% of the direct emissions can be reduced by a transformation of the stationary air conditioning sub-sector. Particularly, in developing countries the expected growing prosperity will increase the penetration and saturation of AC units, one of the most desirable household equipment in tropical and hot countries. The stationary AC sub-sector is followed by the industrial and commercial refrigeration sub-sectors in terms of reduction potential (together ~1 Gt CO_2eq).

Achieving these deep cuts in direct emissions is possible with the current available technologies and an appropriate policy framework. To meet the required reductions, also indirect emissions have to be reduced. This can be done via labeling, introducing energy efficiency standards or rationing. It furthermore requires a de-carbonization of the energy generation through a significant shift of the energy mix to low-carbon energy sources (e.g. renewable energy).

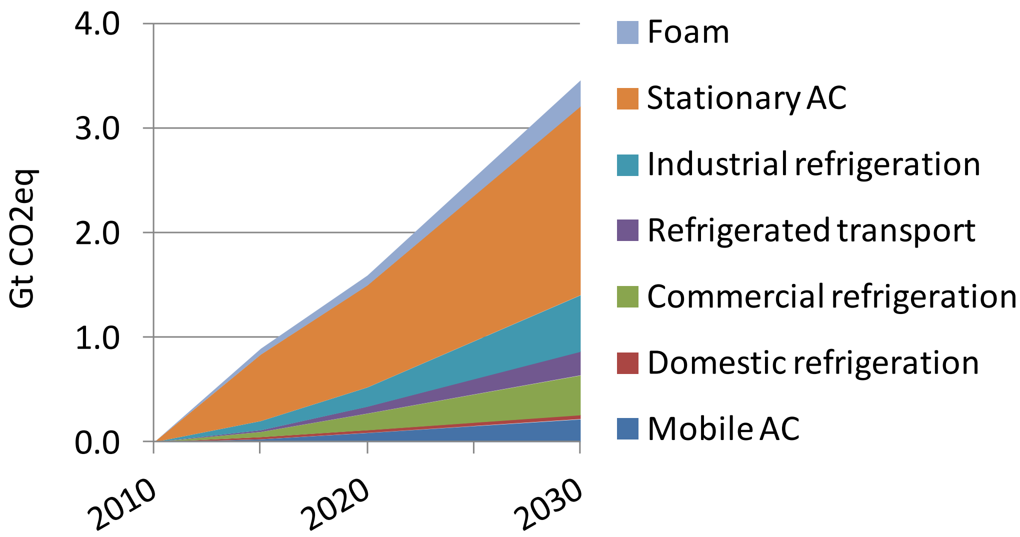


Figure 4: Sub-sectors´ contributions to global direct emission reductions.

Substantial market transformations are more likely to occur at moderate or even negative costs. “Green” technology must become affordable, otherwise it remains unattractive and won’t penetrate the market (as illustrated in chapter 4.2.2. in further detail).

Considering alternative technologies in the RAC&FB sectors, nearly half of the global direct emission savings can be achieved at negative costs when looking at the full lifecycle of the product (Figure 5). In other words the phase-in of “green” technologies implies a net welfare gain from an overall economy viewpoint. This highlights the particular suitability of the RAC&FB sectors in reducing CO_2eq emissions. However, it must be recognized that the choice of technology is not only based on lifetime costs, but that other factors (mainly high upfront costs) play an important role as well (see chapter 4.2.2). Negative costs are found for chillers, transport, commercial and industrial refrigeration (Figure 5). Taking the emission reduction potential into account, promising sub-sectors for transformation are commercial and industrial refrigeration, where no additional costs are involved. Figure 5 also depicts that the highest reduction potential is given by sub-sector transformations of Non-Annex I countries. With the development and dissemination of alternative technologies, these become more widely available and build up scale, and as a consequence, an increasing share of emissions can be abated at negative costs over time.

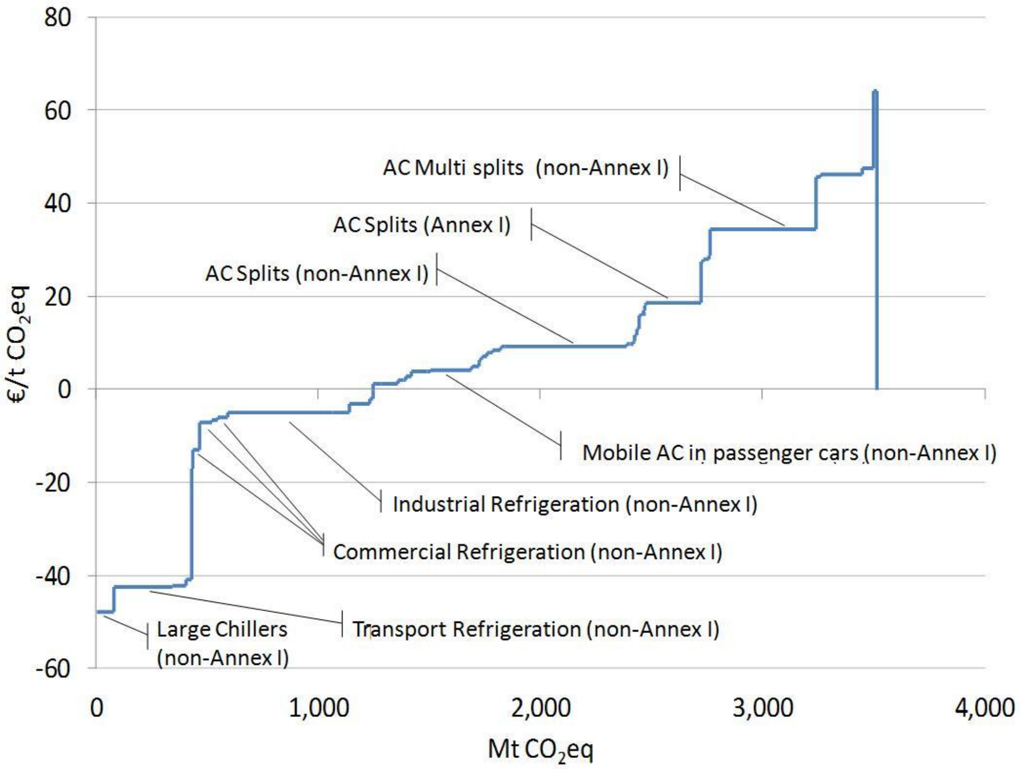


Figure 5: Global Marginal Abatement Cost Curve (MACC). Emission reduction costs associated with the phase-in of alternative technologies by 2030. The y-axis shows the costs (€) that must be spend to reduce one ton of CO_2eq, while the x-axis shows the amount of emissions that can be reduced by the phase-in.

4. Enabling environments for the implementation of the RAC&FB sectors roadmap: regulatory and technology framework

The enabling environments target the promoting of the use of low-GWP alternatives in the RAC&FB sectors and phase-out of high-GWP legacy systems.

The RAC&FB sectors suggested dividing the various promotion measures of low-GWP alternatives and removal of barriers under two categories, being

- **Regulatory framework** and support schemes
- **Technological framework** and market availability of low-GWP alternatives and good practices for their deployment

The enabling environments for the regulatory and technology framework should serve the overall strategic goal of freezing the carbon footprint of the RAC&FB sectors at current levels and reducing emissions from the RAC&FB sectors by two thirds from what they would be under a BAU scenario.

Key policy targets of the r**egulatory framework** under the RAC&FB sectors are

- The avoidance of **direct emissions** through a ban of high-GWP refrigerants and foam blowing agents latest by 2030
- The reduction of **indirect emissions** through the introduction of mandatory minimum efficiency standards, labeling and overall performance standards (including insulation and/or curbing the cooling demand[5]) latest by 2030

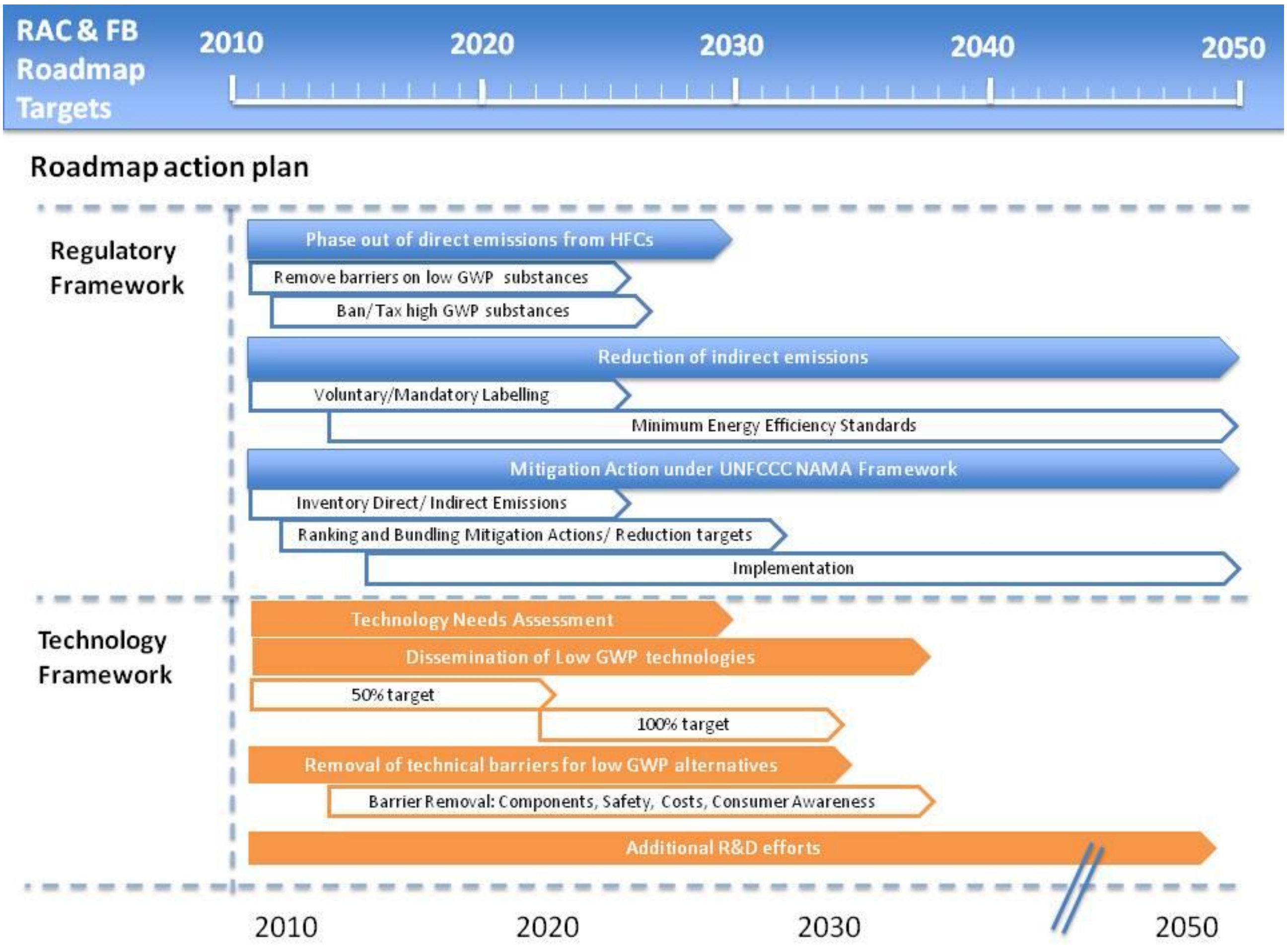
The Montreal Protocol foresees the phase-out of refrigerants with ozone-depleting potential (ODP), in particular HCFCs, by 2030. The roadmap suggests that high-GWP alternative refrigerants such as HFCs (which are part of the greenhouse gases within the basket of gases under the governance of the UNFCCC) are no later

[5] i.e. limiting the amount of air conditioning by permitting air conditioners only to operate above a certain ambient temperature level

phased out than 2030 as well (i.e. no later than the phase-out of the HCFCs in order to avoid that a phase-out of HCFC will lead to a phase-in of HFCs).

The **technology framework** addresses the extent of the use of alternative technologies in each of the main sub-sectors of the RAC&FB sectors. The enabling environments for the technology framework address the extent of required research and development (R&D) and deployment efforts to reach a high and significant penetration of low-GWP alternatives.

Table 2: Regulatory and technology framework under the enabling environments of the RAC&FB roadmap.



4.1. Enabling environments: regulatory framework

The regulatory framework in the RAC&FB sectors targets at eliminating direct emissions by 2030 and decreasing indirect emission by at least 10% from BAU emissions through accelerated introduction of energy efficiency measures. Another 40% of indirect emissions are reduced through the de-carbonization of the electricity supply[6].

4.1.1 Regulations on direct emissions: phase-out of high-GWP substances and removal of barriers for low-GWP substances

The RAC&FB roadmap suggests the phase-out of HFC as high-GWP substances in the same time frame as the phase-out of HCFCs as governed under the phase-out plan of the Montreal Protocol.

The Montreal Protocol has demonstrated the effectiveness of a mandatory, step-wise reduction and phase-out of consumption and production of HCFC and CFC with international support (funding from the multilateral fund and implementation assistance by agencies).

So far HFCs are only limited within the EU through a combination of various measures (bans/limitation of placing them on the market, taxing, import/export tax, GWP limits like the EU mobile air conditioning directive, minimum leakage rates (EU F-Gas regulation) or supportive legislation for alternatives).

In most cases alternative, low-GWP technologies are based on substances with a higher flammability. In many countries regulatory matters interdict the application of low-GWP substances, which are flammable and/or toxic. Peripheral regulations are sometimes negatively impacting the application of certain abatement options, such as certain requirements for transport and storage of flammable substances. These

[6] The de-carbonization of the electricity supply is assumed as a given external parameter. The analysis of the carbon content of the electricity supply is not further analyzed as part of the RAC&FB roadmap.

barriers are to be reduced through national authorities through the modification of regulation and standardisation which permit the use of flammable refrigerants while safeguarding safety requirements. Similar legislations have been introduced for example in the EU through the EU F-Gas directive and its implementing legislations in EU member states. The use of flammable substances in relation to the volume has further been included in the European technical standard norms, in particular in the EN378.

4.1.2 Regulations on indirect emissions

Indirect emissions are most effectively addressed through mandatory labeling of appliances (like the labeling in the EU for domestic refrigerators) and minimum energy efficiency standards. Labeling and minimum energy efficiency standards regulate the allowed energy consumption related to the cooling capacity of the devices and, in some cases, the permissible non-renewable generated cooling demand (i.e. China allows the air conditioning of public buildings only above a certain minimum ambient temperature threshold).

Most important technical measures within the RAC&FB sectors on energy efficiency are the optimization of the refrigeration cycle, the reduction of parasitic losses and the control of transient effects[7]. Within the refrigeration cycle substantial improvements are possible through i.e. an overall optimized system balancing, reduction of the refrigerant charge size, larger evaporator and condenser surface areas in combination with new surface textures and the application of alternative cooling cycles (e.g. Lorenz cycle, Stirling cycle). Parasitic losses are reduced through the reduction of required ancillary components or the application of more energy efficient components like fans and pumps. Energy losses within transients' effects are mitigated mainly through the application of variable speed compressors, optimized electronic controls and the application of expansion valves instead of capillary tubes.

[7] Colbourne, 2012, NAMA Workshop Thailand, 26.07.2012, RAC&FB NAMA Technical Options and Costs, p. 75.

4.1.3 Mitigation action under the UNFCCC NAMA framework

NAMAs (nationally appropriate mitigation actions) – a set of policies and actions tailored to the circumstances of individual countries – are suggested as an appropriate instrument to implement on a national level the suggested roadmap in the RAC&FB sectors. NAMAs have the potential to address both the baseline emissions (i.e. use of high-GWP substances like certain HFCs) and the migration to low-GWP substances as mitigation action.

An important aspect for the development of NAMAs is the appropriate reporting of HFCs within the National Communication of countries to the UNFCCC. So far only few Non-Annex I countries are reporting HFCs in a comprehensive way. Proklima has developed a comprehensive tool to assist Non-Annex I countries in the development of HFCs inventories and to address mitigation actions for direct and indirect emissions through the application of nationally appropriate low-GWP alternative technology options.

The RAC&FB sectors suggest to implement NAMAs in Non-Annex I countries through supported or unilateral NAMAs within the following steps:

- Capacity building (addressing NAMAs to the relevant national authorities, winning industrial and institutional support, information on alternative technologies)
- Institutional readiness (establishment of RAC&FB inventories and inclusion of HFC reporting into the National Communications; establishment of baseline emissions, BAU scenarios and mitigation pathways)
- Implementation (of pilot projects and roll out)

4.2 Enabling environments: technology framework

The RAC&FB roadmap suggests to build the required technological capabilities for the implementation of the roadmap through giz

- The dissemination of available alternative technologies
- The removal of technology barriers holding back the deployment of low-GWP alternatives
- Additional R&D in new and emerging technologies

4.2.1 Increased penetration of low-GWP technology options

A significant mitigation action both for direct and indirect emissions is achievable with the dissemination and deployment of available technologies. The RAC&FB roadmap suggests that a 50% market share of alternative low-GWP systems is reached by 2020 and a 100% market share by 2030.

Due to the early phase-out of CFCs and HCFCs, Europe, for example, has used alternative technologies at an early stage compared to other, especially Non-Annex I, countries. The table below highlights the difference of deployment of alternative low-GWP technologies in Europe compared to non-Annex I countries.

Table 3: Dissemination of alternative low-GWP technology options for key sub-sectors in Europe and Non-Annex I countries

Subsector	Alternative Technology	Alternative Technology Share EU 2015-20	Alternative Technology Share Non-Annex I 2015-20
Domestic Refrigeration	Hydrocarbons		
Commercial Refrigeration	CO_2, Ammonia, Hydrocarbons		
Industrial Refrigeration	Ammonia		
Transport Refrigeration and Air Conditioning	CO_2, Hydrocarbons		
Stationary Air Conditioning	Hydrocarbons; Solar Cooling		
Foams	CO2, Hydrocarbons		

In the following, the state of technologies and their dissemination of main subsectors with the RAC&FB are presented highlighting major measures to be implemented within the framework of the RAC&FB roadmap.

Domestic Refrigeration. The most effective option is to change the refrigerants to R-600a (hydrocarbon), which is a natural refrigerant and already widely established. Over 90% of this sub-sector can be converted to R-600a at negative or low costs by 2030. In non-tropical climates also R-744 (CO_2) can be used, whereas in warmer climates this would lead to lower system efficiency. Hydrocarbons are alternative, low-GWP substances, and are common in Europe and selected Non-Annex I countries (particular China). However, in most Non-Annex I countries the use of HFCs is still dominating.

Commercial Refrigeration. The most promising options are to replace the refrigerants with R-600a in stand-alone units or with R-290/R-1270 (both hydrocarbons) in stand-alone and condensing units. This can lead to significant emission reductions at negative costs. R-600a and R-290 are already widely available, R-1270 to a fewer extent as it is more expensive. Alternative systems for commercial refrigeration are less common than for domestic refrigeration. However, substantial experience exists with the implementation of the technology in industrialised countries. Similar to the domestic refrigeration sub-sector there is substantial mitigation action to be achieved through the dissemination of existing technologies.

Industrial Refrigeration. Using R-717 (ammonia) as refrigerant, which is already widely applied, can reduce direct emissions in the industrial refrigeration sector. More than 50% of the baseline emissions can be avoided at negative or zero costs. There is a wider deployment for ammonia systems in Annex I countries compared to Non-Annex I countries.

Road transport refrigeration. It is most favourable to replace the refrigerants with R-290/R-1270. This is also the best technical option, which needs less refrigerant charge and has lower energy consumption than existing systems. Prototype trucks using R-290/R-1270 have been built, and some systems are already in operation. A significant amount of emissions can be avoided at negative or zero costs. The technology has been successfully introduced in the market but requires additional efforts for wide global dissemination.

Mobile air conditioning (MAC). Introducing systems that use CO_2 and unsaturated HFCs as refrigerants are the best cost-effective options here. Concerning the use of CO_2, R&D still needs to progress further to resolve some technical issues before the systems can be introduced commercially. Once it is introduced on the market, its use will be especially favourable in vehicles with high efficiency (Diesel) engines or in electric cars.

MAC is the subsector with the highest emissions of HFCs globally through the use of R-134a with a GWP of 1 430. The EU has theoretically banned the use of R-134a through a GWP limit of 150 in MAC systems[8]. Still, in the use the deployment of alternative systems has not widely taken place. In some Non-Annex I countries hydrocarbons are used unofficially as alternative refrigerants. Globally additional R&D efforts are required for the development of alternative systems and their deployment.

Stationary air conditioning. Many different systems fall into this sub-sector, and thus also many different technical abatement options, covering a broad range of cost-effectiveness, exist. About one quarter of them can be implemented at negative costs. The best option is to transform the chiller sector using R-717 as refrigerant in new systems. Systems with R-290/R-1270 represent another option for chillers, but also for single split and factory sealed systems. The inclusion of architectural considerations for single buildings would reduce the amount of air conditioning required or for city districts through efficient district cooling systems.

[8] EU Mobile Air Conditioning Directive

Proklima has successfully undertaken R&D and deployment efforts with the largest split-type manufacturers in India and China (Godrej and Gree) for the development of R-290 based, low-GWP, split type air conditioning systems.

Most of the air conditioning systems are today installed in Asia. The migration of key Asian Non-Annex I countries such as China, India, Thailand, Malaysia or Indonesia to low-GWP air conditioning system will be key to a low carbon strategy in the AC sector.

4.2.2 Removal of technical barriers for the application of low-GWP alternatives

Conventional high-GWP fluorinated refrigerants and foam blowing agents such as HCFCs and HFCs are non-flammable. The introduction of low-GWP but flammable refrigerants such as hydrocarbons requires additional safety and related measures for their deployment. As such, the use of alternative, low-GWP refrigerants requires the removal of barriers. Below are the most important areas illustrated and explained where removal of barriers for the various subsectors is most relevant.

Table 4: Red-coloured arrays show the most significant barriers for the different sub-sectors of the RAC&FB sectors.

Barriers	**Domestic Refrigeration**	**Commercial Refrigeration**	**Industrial Refrigeration**	**Road Transport Refrigeration**	**Mobile AC**	**Stationary AC**	**Foam**
Component Availability							
Technician Competence		■	■				
Safety-related restrictions	■	■	■	■	■	■	
Implementation Costs	■	■	■		■		■
Consumer Awareness							
Technology Implications[9]		■			■		■

[9] discussed under 4.2.3

Safety-related restrictions can be a hindrance to introduce new technological options, as low-GWP refrigerants are often flammable and in the case of ammonia also toxic. Thus, for those refrigerants, in some countries safety standards may exist that impose restrictions on the allowed amount of refrigerant or on construction features. The RAC&FB roadmap suggests to overcome this by applying regulations which safeguard the use of flammable and natural refrigerants and foam blowing substances:

1) developing alternative national standards, permitting larger quantities or wider applications of the new refrigerants
2) introducing safety control systems to keep the same level of safety as before and
3) carrying out R&D activities to find alternative designs or to enable a lower specific charge.

Component availability is low in some regions for certain components. The RAC&FB roadmap suggests to overcome this by working with existing distributors/supplier to stock the desired components, develop importation channels from overseas producers and by setting up a distribution infrastructure. Furthermore, existing manufacturers could start to develop new components and adapt the production line.

The technician competence is insufficient in some regions as not enough technicians and engineers have been trained for working with the new technologies (and issues of flammability and toxicity). For the use of hydrocarbons technician training is essential. Possible interventions could include the carrying out of train-the-trainers schemes, widespread training at companies, working with training colleges, universities, etc. GIZ Proklima has gathered a fast experience in the training of air conditioning and refrigerant technicians. During the last 10 years more than 35,000 technicians have been trained. The development of codes of practices and national standards for design requirements is another suitable measure.

Implementation costs of alternative systems will be higher than conventional systems especially when alternative systems lack economies of scale both for the production equipment costs and higher system material costs. The first may be caused by the need for new production line equipment, safety systems or refrigerant storage and feed equipment. Funding the purchase of additional equipment and guidance documentation on best practice for its use may help to overcome this barrier. Higher system material costs will include the use of more expensive raw materials, additional components or more expensive refrigerants (although the higher system costs are in many cases offset over time through lower operating costs by reduced energy consumption and lower costs of the natural refrigerants compared with synthetically manufactured refrigerants). The RAC&FB roadmap suggest as possible interventions the funding of additional costs at least during the initial stage of market development.

Consumer issues include lack of awareness or missing acceptance for higher upfront costs. Whilst a system using a new technology may be available, the penetration rate of this technology can be low, because the consumers are not informed about the availability or the advantages. The RAC&FB roadmap suggests intervening by rolling out awareness programmes and through the introduction of (mandatory) labelling schemes together with authorities and NGOs. Furthermore, higher upfront costs can be a part of this barrier, especially if the consumer is indifferent to climate change issues. Possible interventions include the work with authorities to develop incentives/disincentives programmes for consumers of abatement/non-abatement systems or legislation to phase out products not using the new abatement technology.

4.2.3 R&D in new technologies

Limited technology development, including poor technological development and refrigerating system efficiency, may be another barrier. The first covers a fairly broad range of issues, differing with the particular abatement option and the region (i.e. the introduction of hydrocarbon technology, which is a widespread technology option with net benefits both in developing and industrialised countries). Poor refrigerating system efficiency can be exhibited by certain abatement options under particular conditions i.e. the provision of tight systems with lower leakage effects. Possible interventions for both barriers include the initiation of collaborative R&D projects at universities and manufacturers, the development of cooperation with enterprises that have already greater experience with the particular technology or the development of design guidelines.

Mitigation action within the RAC&FB sectors can be widely achieved with existing technologies and putting the key focus on the dissemination of existing low-GWP technologies. Still, there are interesting new technologies under development which are highlighted below.

In the RAC sector not-in-kind magnetic systems are widely researched, and a small number of prototype machines has been developed. This is a promising technique that can be applied widely. The cost is likely to be somewhat greater than conventional systems, but efficiency is also found to be potentially very high. Not-in-kind “Stirling” systems are already commercially available in niche applications from a small number of manufacturers. In theory, however, they can also be applied more widely. Efficiency is known to be high, especially for lower temperature levels.

HCFC- and HFC-free options for foam blowing agents are technically available. If their application is further promoted, they provide sufficient options for reducing emissions. The best cost-effective possibility is the introduction of low-GWP blowing agents in the XPS sector, followed by using them for insulation material in domestic refrigerators. Unsaturated HFCs are also researched as possible further abatement option.

5. Suggested near-term actions

GIZ Proklima has supported developing countries in their efforts to mitigate emissions on both ozone depleting and greenhouse gases. The projects were ranging from demonstration projects to entire sector plans, policy advice and supporting enabling environments. Based on these experiences Proklima has developed the global roadmap for the RAC&FB sectors. To implement the roadmap in the near future up to 2030, the following mix of national, regional and sector initiatives are suggested.

5.1 National action plans

Low carbon development strategies in the RAC&FB sectors can be implemented via NAMAs. As more than 50% of global emissions from the RAC&FB sectors are originated in Non-Annex I countries, the inclusion of NAMAs in key countries (in particular the emerging economies like China, Brazil, India, South Africa, Mexico) using RAC&FB equipment will be required for a globally successful strategy. Integrated NAMAs will be instrumental to set up and achieve sector targets. The phase-out of HCFCs could be combined with a supported NAMA to avoid the phase-in of HFCs as alternatives for HCFCs.

A project of Proklima with the government of Thailand is exemplary for such national action plans. The NAMA project includes capacity building for setting up capabilities for HFC Tier 2 reporting under the National Communication. It further supports a national needs assessment, the establishment of a baseline, business as usual (BAU) emission pathway and mitigation scenarios for the RAC&FB sectors and sub-sectors. For the establishment of the mitigation scenarios a set of more than 100 alternative low-GWP technology options is analysed. Based on this a selection of sub-sector specific implementation options is suggested.

5.2 Regional action

In addition to national actions under NAMAs, it is suggested to establish **regional initiatives under the TEC and CTCN**. Regional initiatives could be applied in situations, where regions suffer from a specific lack of supplies or infrastructure. For example, Africa has little or no adequate recycling capabilities for products containing toxic fluorinated refrigerants. The regional transition towards natural refrigerants has then significant environmental co-benefits next to emission mitigations. Also many regions in Africa have relatively poor access and use of advanced energy efficient technologies. These regions could particularly benefit from technologies like solar cooling that are specifically tailored to local circumstances.

5.3 Sector Action Plans

Sector action and technology networks are another supplementary way to promote low carbon strategies in the RAC&FB sectors. One outstanding example for such non-profit initiatives in the refrigeration sector is “Refrigerants, Naturally!” which includes several large multinational companies that substitute F-gases used in point-of-sale cooling applications with natural refrigerants. The initiative encourages suppliers and retailers in the commercial sector to follow their example or join the initiative. Based on their experience they offer technical advice and policy recommendations for public and private sector organisations.

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Appendix

In the following table, the categories and some characteristics of the main applied refrigerants are summarized.

Table 5 Table with characteristics about some refrigerants. Adopted from (Proklima International, 2008), Opportunities for the Application of Natural Refrigerants, D. Colbourne.

Type	Refrigerant	GWP	Flammability	Toxicity
HFC	R-407C	1770	None	Low
	R-404A	3920	None	Low
	R-410A	2140	None	Low
HFC-based “drop-in”	R-417A	2350	None	Low
	R-427A	2140	None	Low
	R-434A	3280	None	Low
Natural Refrigerant	R-717 (ammonia)	0	Low	High
	R-744 (carbon dioxide)	1	None	Low
	R-290 (propane)	<3	High	Low
	R-290/R-600a mix	<3	High	Low
	R-1270 (propene)	<3	High	Low

The following table displays several applications and equipment types in the RAC sector, the typical applied refrigerants and the possibilities to apply natural refrigerants.

Table 6 Applications in the RAC&FB sectors, their typical fluorocarbon use and the usable natural refrigerants. Table from (Proklima International, 2008), Opportunities for the Application of Natural Refrigerants, D. Colbourne.

Application	Equipment type	System type	Typical Flouorocarbon	Viable natural refrigerants		
				New refrigerant (retrofit/ retrofill)	New system (circuit and components)	New installation (circuit, components and layout)
Retail Refrigeration	Water coolers	Integral	R134a, R12	HC mix	R600a, R290	R600a, R290
	Chiller cabinets	Integral	R134a, R404A, R502	HC mix, R290	R600a, R290, R744	R600a, R290, R744
	Chiller cabinets	Remote	R22, R404A, R502		R290, R744	R290, R744
	Chiller cabinets	Distributed	R22, R404A, R502			R744, [R290, R1270, R717]*
	Chiller cabinets	Indirect	R22, R404A	R290, R1270	R290, R1270, R717	R290, R1270, R744, R717
	Freezer Cabinets	Integral	R22, R404A,	R290,	R290,	R290, R1270

			R502	R1270	R1270	
	Freezer Cabinets	Remote	R22, R404A, R502		R290, R744	R290, R744
	Freezer Cabinets	Distributed	R22, R404A, R502			R744, [R290, R1270, R717]*
	Freezer Cabinets	Indirect	R22, R404A	R290, R1270	R290, R1270, R717	R290, R1270, R744, R717
Cold Storage and Food Processing	Storage Cabinets	Integral	R22, R404A, R502	R290, R1270	R290, R1270, R744	R290, R1270, R744
	Cold Stores	Remote	R22, R404A, R502		R290, R1270, R744	R290, R1270, R744
	Cold Stores	Distributed	R22, R404A, R502			R744, [R290, R1270, R717]*
	Cold Stores	Indirect	R22, R404A	R290, R1270	R290, R1270	R290, R1270, R744, R717
	Process Cooling/Freezing	Remote	R22, R404A, R502		R290, R1270, R744	R290, R1270, R744, R717
	Process Cooling/Freezing	Distributed	R22, R404A, R502			R744, [R290, R1270, R717]*
	Process Cooling/Freezing	Indirect	R22, R404A	R290, R1270	R290, R1270	R290, R1270, R744, R717
Transport Refrigeration	Road Transport Trucks	Integral	R22, R404A, R502	R290, R1270	R290, R1270, R744	R290, R1270, R744
	Refrigerated Railcars	Integral	R22, R404A, R502		R744	R744
	Marine Refrigeration	Integral	R22, R404A, R502		R744	R744
Domestic Air Conditioners, Dehumidifiers and Heat Pumps	Portable Units	Integral	R22, R407C, R410A	R290, R1270	R290, R1270	R290, R1270
	Window Units	Integral	R22, R407C, R410A	R290, R1270	R290, R1270	R290, R1270
	Through-Wall Units	Integral	R22, R407C, R410A	R290, R1270	R290, R1270	R290, R1270
	Split Units	Remote	R22, R407C, R410A	R290, R1270	R290, R1270, R744	R290, R1270, R744
	Hot Water Heating	Integral	R22, R407C, R410A	R290, R1270	R290, R1270, R744	R290, R1270, R744

	Central Heating	Integral/Indirect	R22, R407C, R410A	R290, R1270	R290, R1270, R744	R290, R1270, R744
Commercial Air Conditioning and Heat Pumps	Split Units	Remote	R22, R407C, R410A	R290, R1270	R290, R1270, R744	R290, R1270, R744
	Mulit-Split/VRV	Distributed	R22, R407C, R410A			R744, [R290, R1270, R717]*
	Packaged Ducted	Remote	R22, R407C, R410A			R744
	Central Packaged	Remote	R22, R407C, R410A			R744
	Positive Displ´t Chillers	Integral/Indirect	R134a, R22, R407C	R290, R1270	R290, R1270, R717	R290, R1270, R717
	Centrifugal Chillers	Integral/Indirect	R123, R134a		R290, R1270, R717	[R290, R1270, R717]*
	Hot Water Heating	Integral	R134a, R22, R407C	R290, R1270	R290, R1270, R744	R290, R1270, R744
	Central Heating	Integral/Indirect	R134a, R22, R407C	R290, R1270	R290, R1270, R744	R290, R1270, R717
*Use of HCs and R-717 require the direct expansion system to be replaced with an indirect (secondary) system						

Table 7 List of Abbreviations

Abbreviation	Meaning
EN	European (industrial standard) norm
F-Gases	Fluorinated Gases
Gt	Gigatons
GWP	Global Warming Potential
HC	Hydrocarbons
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
MAC	Mobile Air Conditioning
NAMA	Nationally Appropriate Mitigation Action
R	Refrigerant
RAC&FB Sectors	Refrigeration Air Conditioning and Foam Blowing Sectors
UNFCCC	United Nation Framework Convention on Climate Change
VRV	Variable Refrigerant Volume

Submission by Asian Development Bank on technology road maps and action plans

30 July 2012

Technology Executive Committee (TEC) at it third Session made a decision to call for accredited Observer Organizations to provide their inputs, including their final products of technology road maps and action plans as well as their experiences and lessons learned from developing and using technology road maps and actions plans to help TEC facilitate the development of the inventory of existing technology road maps and action plans, Asian Development Bank (ADB) welcomes this opportunity and is pleased to submit its inputs as following.

ADB is providing technical assistance for the development of road maps for wind power, smart grid technology and carbon capture and storage (CCS) in a number of developing countries in Asia and the Pacific, including the Peoples' Republic of China (PRC), Mongolia, Philippines, Vietnam and Sri Lanka. The technical assistance is designed to help create enabling conditions for the development of technologies and accelerate their diffusion, and typically includes capacity building, analysis and pre-feasibility studies, and knowledge management. Since the projects are under implementation, the final technology road maps are not yet available.

1 People's Republic of China: Developing Smart Grid Technology for Efficient Utilization of Renewable Energy

This capacity development technical assistance (TA) for Developing Smart Grid Technology for Efficient Utilization of Renewable Energy in the PRC started implementation in 2011. By comprehensively analyzing issues surrounding poor grid integration of wind and other intermittent renewable energy sources, the TA will provide key enabling conditions for larger renewable energy utilization and can accelerate and intensify renewable energy development in the PRC. The TA is designed to help the state grid corporation develop smart grid technology for efficient utilization of renewable energy, and will result in the development of a smart grid road map for harmonizing renewable energy development with the grid expansion in a regional grid, the codification and upgrading of technical standards for the connectivity of renewable energy to the grid, and the upgrading and piloting of short-term day-ahead wind power forecasting systems. Furthermore, training activities are provided and lessons learned disseminated to other places and stakeholders, and a policy note on smart grid development will be prepared for high-level governmental officials.

2 Quantum Leap in Wind Power Development in Asia and the Pacific

The TA is starting implementation in 2012, and will draw up wind energy development road maps for better planning and to facilitate public-private partnerships in four countries, namely Mongolia, the Philippines, Sri Lanka, and Viet Nam. The participating

DMC governments are expected to achieve their targets for installed wind power capacity through the formulation of road maps, improved knowledge and capacity, better quantification of wind resource potential, and the identification of viable wind projects. The TA will assess wind resources to reduce start-up time and manage resource risk, prepare pre-feasibility studies, and develop business and financing models to make wind projects in participating countries more bankable.

3 Determining the Potential for Carbon Capture and Storage in Southeast Asia

Given the lack of information on CCS in Southeast Asia, the ADB is taking a phased approach to supporting CCS in the region. The expected outcome will be greater capacity to plan and manage CCS demonstration projects in the focus countries in Southeast Asia. The TA, which began implementation in 2012, will conduct an analysis of the potential for CCS, culminating in a road map for a CCS demonstration project in Indonesia, the Philippines, Thailand, and Viet Nam. It will be followed by a national TA project in each eligible country (i.e., a country with CCS potential and a willingness to commit resources for a demonstration or pilot project) to: (i) establish the enabling environment, (ii) examine the technical aspects related to capture and/or storage, (iii) identify and prepare prefeasibility reports for pilot projects, and (iv) carry out initial geological investigations for the storage aspects of the pilot projects.

4 People's Republic of China - Road Map for Carbon Capture and Storage Demonstration and Deployment

This TA, which will start implementation in 2012, will elaborate a comprehensive roadmap for CCS demonstration and deployment. In addition, it will produce key products for paving the way towards the realization of at least two large-scale integrated CCS demonstration projects in the short-term, each capturing and storing 2 million tons of CO2 per year. The first component will also produce: (i) recommendation on a set of appropriate policy, regulatory and incentive framework; (i) a shortlist and ranking of early stage CCS demonstration projects; (iii) suitable business models for implementing early stage projects; and it will deliver capacity development in the policy, regulatory, and techno-economic modeling for the CCS roadmap. The second component will further develop the capacity of Dongfang Boiler Co., Ltd. (DBC) in designing, planning, and implementing CCS with oxy-fuel combustion and support the roadmapping component with (i) techno-economic feasibility assessed of a 100 megawatt coal-fired power plant applying the oxy-fuel combustion technology; (ii) technical standards and pathways for future work prepared for applying the oxy-fuel combustion technology; (iii) a prototype model for CO2 storage site assessed; (iv) preliminary site characterization and identification of early demonstration project(s) prepared; and (v) capacity development in analysis, planning, and implementation of oxy-fuel combustion with CO2 capture technology. The outcome of the TA will be assessed techno-economic feasibility of selected early-stage demonstration projects, and the expected impact will be staged demonstration of CCS in the PRC.

IRENA's Road Mapping Activities

Introduction

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation dedicated to renewable energy. In accordance with its Statute, IRENA's objective is to "promote the widespread and increased adoption and the sustainable use of all forms of renewable energy". This concerns all forms of energy produced from renewable sources in a sustainable manner, which include bioenergy, geothermal energy, hydropower, ocean, solar, and wind energy. As of July 2012, the membership of IRENA comprises 159 States and the European Union (EU), out of which 101 States and the EU have ratified the Statute.

IRENA's road mapping activities

The aim of IRENA's road mapping activities is to assist governments in energy planning for more efficient and effective renewable energy technology innovation and energy technology deployment strategies. The road mapping exercise identifies prospects, technological barriers, financing, development and policy needs for the deployment of renewables within a given context between 2012 and 2050. The outcome of IRENA's roadmaps is the development of a list of activities and associated indicators to accelerate the sustainable deployment of renewables.

The road map activities can be grouped in three categories: 1) in-depth background analyses on the different regional and topical issues, 2) stakeholder engagement, and 3) dissemination and implementation. The background analysis reports provide a brief overview of existing literature, a quantitative analysis of a potential pathway towards increasing the deployment of renewables within the given sector, country or region, and a description of the technology road mapping activities and outcomes. This document forms the basis for stakeholder workshops.

The stakeholder workshops allow for engagement with a broad range of different stakeholders, and their objective is to identify and prioritise action items to accelerate the deployment of renewables. Furthermore, the stakeholders are asked to develop indicators to monitor progress regarding the different action items. Typically, around three workshops are organised per road map whereby each workshop discusses a different regional or topical issue. Each workshop consists of a group of 10 to 50 representatives from industry, government, consultancy, equipment suppliers, academics, NGO's, finance institutions and other international organisations which are invited to discuss the future opportunities for renewable energy within the given context. Based on input from these stakeholder workshops, a workshop output report is drafted. These workshop output reports, together with the background analysis, form the basis for the technology roadmap. The workshop output reports and the technology roadmap are sent back to the involved stakeholders, as well as a wider audience for feedback and additional comments.

The final step of the technology road map is a wider dissemination of the publication, and a broader discussion with policy makers and member states on how the action items within the technology roadmap can be implemented and materialized. Road maps are typically updated every couple of years to evaluate progress made, and adjust priority areas according to any external changes.

The roadmaps are developed by IRENA's Innovation and Technology Centre, but they complement and are supported by activities that are undertaken by the other programmes within IRENA. For example, IRENA's technology briefs and regional strategies and scenarios provide technical input for the road maps, and IRENA's Renewable Readiness Assessments assess the extent to which institutional systems are in place to put some of the road map activities into practice.

Given the road mapping activities of other organisations, IRENA's takes care that its road mapping activities create added value. IRENA's road mapping activities have a number of unique features:

- IRENA's membership has almost global coverage, which means that our global technology road maps consider a wide range of regional issues that impact the deployment of renewables. As such, IRENA's road maps have also increased involvement of developing countries.
- IRENA's road maps take a systemic approach, and consider how different renewable energy technologies interact within a given context. So far, IRENA is developing a number of road maps with a sectoral focus (manufacturing, cities, and grids and storage), which allows an investigation of the interaction between different renewable energy technologies, and how each technology can either reinforce or restrict the deployment of other renewable energy technologies.
- IRENA's road maps focus on areas where more information is required. For example, IRENA has two road maps that are focusing on the deployment of renewable energy in end-use sectors (manufacturing and cities), as these sectors have a high potential but limited information is available on how renewables deployment can be accelerated in these sectors.
- IRENA's road maps are based on active government engagements, and allow for the transfer of lessons, best practices and an understanding of each other's concerns and barriers across different countries, regions, and sectors.

IRENA's road maps overview

Up to July 2012, IRENA is developing or involved in the following road maps:

- Energy road maps for the islands of Tonga and Nauru;
- Sectoral road map on renewables deployment in the manufacturing sector;
- Sectoral road map on renewables deployment in cities;
- Sectoral road map on renewables, smart grids, and storage;
- Global road map on doubling the share of renewables in the context of United Nations Secretary-General initiative on Sustainable Energy for All.

IRENA's experiences and lessons learned

Since the start of IRENA's technology road map activities, a number of lessons are learned:

- Active engagement of stakeholders in the workshop is key in creating buy-in for the action points;
- Active country engagements of a wide geographical scope are of importance for global road maps on renewable energy issues, because many opportunities and barriers are determined by local conditions that need to be taken into consideration;
- A road map cannot be developed in isolation, but needs to be supported by a range of other activities within the organisation in order to provide input into the analysis, the stakeholder engagements, and the eventual implementation of the recommendations of the technology road map.

SUBMISSION TO
THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC) TECHNOLOGY EXECUTIVE COMMITTEE

Technology Executive Committee decision – Third Meeting:

- technology roadmaps and action plans;
- ways to promote enabling environments and to address barriers to technology development and transfer; and
- actions undertaken by observer organisations relevant to the TEC in performing its functions.

AUGUST 2012

Introduction

Announced by the Australian Government in September 2008, the Global CCS Institute (the Institute) was formally launched in April 2009. It became a legal entity in June 2009 when it was incorporated under the Australian Corporations Act 2001 as a public company and began operating independently and as a not-for-profit entity from July 2009. The Institute works collaboratively to build and share the expertise necessary to ensure that carbon capture and storage (CCS) can make a significant impact on reducing the world's greenhouse gas emissions. Please refer to the following website for further information on the Institute (www.globalccsInstitute.com/Institute).

As an accredited observer, the Institute welcomes the opportunity afforded by recent decisions arising from the Third Meeting of the Technology Executive Committee (TEC) held in Bonn over the period of 28-29 May 2012.

The TEC has called for inputs on:

- inventory on technology road maps and action plans;
- ways to promote enabling environments and to address barriers to technology development and transfer; and
- actions undertaken by accredited observer organisations relevant to the TEC in performing its functions.

The Institute hopes its views will positively assist the TEC in its deliberations on such issues at its Fourth Meeting expected to be scheduled in September 2012.

Overview

CCS is recognised by the United Nations Framework Convention on Climate Change (UNFCCC) as a technically legitimate mitigation option capable of delivering permanent abatement outcomes. It is also recognised as an eligible project level activity in the Clean Development Mechanism (CDM). This demonstrates that CCS activities can be readily and systematically institutionalised and rewarded in market-based mechanisms, and is internationally accepted as being consistent with the sustainability development requirements of developing countries.

CCS consists of four components:

- emissions sources (where CO_2 emissions are produced);
- CO_2 capture (where a physical or chemical separation process isolates CO_2 from other components in the source's exhaust gas);
- CO_2 transport (moving the captured CO_2 from point source to a sink); and
- CO_2 storage (where CO_2 is injected into a geological formation and subsequently isolated from the atmosphere).

CCS has the potential to deliver one of the single largest emissions abatement outcomes of all currently known mitigation options. The International Energy Agency (IEA) estimates that CCS could contribute about 19 per cent of the required abatement by 2050[1]. The Intergovernmental Panel on Climate Change (IPCC) estimates that CCS could contribute between 15 and 55 per cent of the required abatement by 2100.

[1] to hold atmospheric concentrations of greenhouse gases to about 450 parts per million (ppm)

CCS can also drive negative emissions (i.e. remove greenhouse gas emissions from atmosphere) when combined with carbon neutral energy feedstocks (i.e. sustainable biomass) and permanently storing the captured emissions deep into the geological sub-surface.

Third Meeting of the Technology Executive Committee

In May 2012, the Institute attended the TEC's Third Meeting in Bonn. The meeting included a dialogue on technology research, and while no specific discussion on CCS was held, much of what was discussed was directly applicable to the challenges of deploying large-scale clean energy technologies such as CCS.

The meeting included a discussion on the TEC's evaluation of the bids to host the Climate Technology Centre (CTC), noting that it will now begin negotiations with the United Nations Environment Programme (UNEP) whose application ranked the highest. The Institute acknowledges the critical role that the CTC can and must play in assisting the successful deployment and diffusion of environmentally sustainable large-scale clean energy technologies in developing countries, including CCS, and welcomes the decision to appoint UNEP as the host.

The Institute also supports the TEC's intent to continue with its thematic dialogues on technology at its meetings, complemented by consideration of various inputs by relevant public and private sector organisations. The TEC is examining how it might better engage with other UN (i.e. CTC, Green Climate Fund) and non-UN institutions (i.e. intergovernmental organisations such as the IEA and other similar organisations to the Institute).

The Institute strongly applauds the TEC's position of encouraging private sector expression on its capacity to support clean energy technology development and project implementation experiences, and it remains at the ready to enthusiastically engage as is deemed appropriate and allowed in all TEC processes. While no formal reporting relationship exists between the TEC and the CTC, the Institute is also committed to proactively support UNEP in its role as host of the CTC, especially as a potential participant in the supporting technology networks.

The TEC established an internal taskforce of Committee members to document existing roadmaps in a report to be potentially presented to the Eighteenth Meeting of the Conference of Parties (COP 18). This current call for submissions will inevitably help the TEC to compile such an inventory of relevant work.

The work of the TEC will be instrumental in providing the COP with the advice it needs to give effect to low-emissions technology (LET) decisions (including both mitigation and adaptation) that can further support and assist deployment in developing countries. The Institute's interest in the mitigation aspect of this agenda is to serve as a primary channel of information on CCS related matters, and influence the institutionalisation of CCS within UNFCCC processes through evidence-based advocacy.

As such, the Institute considers that several current UNFCCC agendas are important to the successful deployment of CCS technologies, including the:

- need for, and the evolution of, ever-increasing carbon constraints through the implementation of the Kyoto Protocol's second commitment period and the development of the Durban Platform for Enhanced Action;
- negotiations on the institutional arrangements supporting the UNFCCC's organisations and mechanisms such as the Green Climate Fund (GCF), the Technology Mechanism (including the CTC&N), and new market based mechanisms (NMBMs);
- finalisation of the outstanding issues affecting the institutionalisation of CCS in the CDM, including the approval of appropriate project level methodologies; and
- operationalisation of UNEP as the host of the CTC, and the processes that will underpin the selection and operation of the supporting technology networks.

Inventory on technology road maps and action plans

In the next decade, CCS technologies will have a significant impact on the ability of the global community to hold greenhouse gas emissions to an atmospheric concentration level where the dangerous impacts of climate change can be avoided.

The benefits of a successful deployment of CCS technologies as a primary mitigation option to prevent emissions to atmosphere will be apparent in terms of: provision of reliable and clean base-load energy; avoidance of many environmental issues that afflict other large-scale clean energy options (such as land-use, fracking processes, substantial water-use, radiation); prevention of many health problems (as a consequence of particulate pollution and/or climate change related impacts), and sustainable industrial production processes capable of supporting continued economic prosperity.

Most roadmaps offer readers analytical insights into the future prospects and transition pathways of technology solutions including: areas of convergence and complementarity with other technologies; development of new applications; and information that aims to inform future deployment strategies, technologies, markets and investment opportunities.

The development of technology roadmaps tend to bring together core stakeholders (governments, industry participants, research community, civil society) who have an interest in better understanding the potential of a particular technology/technologies to deliver on a broad range of stated policy objectives, as well as identifying key roles.

For CCS, roadmaps often cite the policy drivers as: ensuring base-load energy reliability, delivering large-scale, timely and dependable mitigation outcomes, and/or obtaining a social license for projects to operate through the public acceptability of industrial operations. Other potentially relevant global and national challenge considerations, other than those mentioned above, might include:

- capturing economic opportunity (such as optimising the value of natural resource endowments (such as fossil fuels) in a sustainably responsible manner;
- national security issues and energy independence; and
- global competitiveness and productivity of industry.

Roadmaps usually outline future transition pathways derived under varying scenarios, constraints and time horizons, and often include an exploration of variables such as:

- enabling drivers (market push versus market pull instruments);
- resources required (including nature and scale of financial investment);
- commercial opportunity (size of market potential or market penetration capacity);
- policy, regulatory, and technical barriers (including market failures);
- financial and technical risks (including contingency risk management and premiums); and
- potential to address global and national challenges (as referred to above).

Scenarios explored tend to include exogenous constraints as defined in terms of time, mitigation aspirations and/or share of energy contribution. Themes examined tend to include the potential of:

- technologies that are currently considered commercial or mature;
- technologies that are currently under development with expectation of commercialisation within say a decade; and
- long-term (often characterised as ‘blue sky’) technologies and applications – including step-change and/or disruptive technologies capable of materially impacting on existing production processes.

All roadmaps are products of the scope of their analytical frameworks including assumptions and data generation approaches. This can often call into question the extent to which the reports:

- capture all of the key technological developments and potential applications;
- reflect the most current published and unpublished data and intelligence relative to what is contained in the reports; and
- identify all key issues, opportunities, risks, barriers and potential of technologies to deliver on the stated policy objectives and/or constraints.

While roadmaps are mostly valued as a theoretical tool by policy makers to assist them propose and design approaches to better support technologies through their innovation chain (concept to commercial) and/or project lifecycle (planned to operational), they are also essential in determining the likelihood of global and national challenges being effectively addressed under current policy settings, what sorts of changes to the prevailing policy and regulatory environments may be deemed necessary, and the roles of key entities.

While the Institute has not produced a CCS roadmap, it has supported many organisations and governments in their consideration and development of their own roadmaps. For example, the IEA’s CCS Unit depends on substantial financial support from the Institute. The Institute is also a key participant in agendas such as the Carbon Sequestration Leadership Forum (CSLF), and capacity development efforts in many developing countries.

The following two tables represent a broad (not exhaustive) inventory of CCS related (possibly not specific) roadmaps known to the Institute. Table 1 includes roadmaps for specific countries, while Table 2 lists roadmaps of a generic nature. They have been prepared by national governments and/or non-government organisations (NGOs), intergovernmental organisations, or financial institutions.

The Institute is not in a position to express a view on the merits or value of these roadmaps and plans of action, and provides the inventory list on the basis of information purposes only.

Table 1: Country level CCS roadmaps

Country	CCS Technology Roadmaps and Action Plans
Australia	Carbon Storage Taskforce, National Carbon Mapping and Infrastructure Plan – Australia
	National Low Emission Coal Council, National Low Emission Coal Strategy: Accelerating Carbon Capture and Storage in Australia
Brazil	Centre of Excellence in CCS R&D, The Brazilian Atlas of Carbon Capture, Transport and Geological Storage (in process of being published)
Canada	Natural Resources Canada, Canada's Clean Coal Technology Roadmap
	Natural Resources Canada, Carbon Capture and Storage: CO2 Capture and Storage Roadmap
China	Asian Development Bank, People's Republic of China (PRC): Carbon Dioxide Capture and Storage (CCS) Demonstration - Strategic Analysis and Capacity Strengthening
Greece	Bellona, A Bridge to a Greener Greece: A Realistic Assessment of CCS Potential
Hungary	Bellona, The Power of Choice: CCS Roadmap for Hungary
Indonesia	Indonesia CCS Study Working Group, Understanding Carbon Capture and Storage Potential in Indonesia
Malaysia	Global CCS Institute, Ministry of Energy, Green Technology and Water, Clinton Climate Initiative, Malaysia CCS Scoping Study (not published)
Mexico	North American Carbon Storage Atlas (including Mexico)
	Secretariat of Energy, National Energy Strategy 2012-2026

Country	CCS Technology Roadmaps and Action Plans
Poland	Bellona, Insuring Energy Independence: CCS Roadmap for Poland
Romania	Bellona, Our Future is Carbon Negative: A CCS Roadmap for Romania
South Africa	Geological Atlas
	South Africa Centre for CCS, Roadmap Strategy
South East Asia	Asian Development Bank, Determining the Potential for Carbon Capture and Storage (CCS) in Southeast Asia (in process of being published)
United Kingdom	Department of Energy and Climate Change, CCS Roadmap: Supporting deployment of carbon capture and storage in the UK
	Scottish Government and Scottish Enterprise Carbon, Capture and Storage – A Roadmap for Scotland
	UK Energy Research Centre, The UKER/UKCCSC Carbon Capture and Storage Roadmap
USA	DOE/NETL, Carbon Dioxide Capture and Storage RD&D Roadmap
	NETL, Carbon Sequestration Technology Roadmap and Program plan

Table 2: Generic CCS roadmaps

Organisation/Agenda	Technology Roadmap and Action Plans
Asia Development Bank (ADB)	Asian Development Bank, Carbon Dioxide Capture and Storage Demonstration in Developing Countries—Analysis of Key Issues and Barriers
Carbon Sequestration Leadership Forum (CSLF)	Carbon Sequestration Leadership Forum, Technology Roadmap 2011: A global response to the challenge of climate change
Clean Energy Ministerial (CEM)	Global CCS Institute (in collaboration with a sub Working Group of the Clean Energy Ministerial), CCS Funding Mechanisms for Developing Countries
International Energy Agency (IEA)	IEA, Technology Roadmap Carbon Capture and Storage
	IEA, A Policy Strategy for Carbon Capture and Storage
IEA and United Nations Industrial Development Organisation (UNIDO) sponsored by the Institute	UNIDO/IEA, Technology Roadmap Carbon Capture and Storage in Industrial Applications
The World Bank	World Bank, Carbon Capture and Storage in Developing Countries: a Perspective on Barriers to Deployment

Ways to promote enabling environments and to address barriers to technology development and transfer

The Institute's flagship report on the global status of large-scale integrated CCS projects (LSIP), *The Global Status of CCS: 2012*, is expected to be publicly released in October 2012. The latest status of CCS projects, as at June 2012[2], indicates that there are currently 73 LSIPs around the world. This includes 15 LSIPs that are currently operating or in construction, and capturing some 35.4 million tonnes of CO_2 per year ($MtCO_2$). A further 58 LSIPs are in the planning stages of development (i.e. pre-financial investment decision stage, covering from concept identification to financial and technical feasibility evaluations), with an additional potential capture capacity of more than 115$MtCO_2$ per year.

These projects provide examples of viable business cases for CCS technology given specific circumstances. *The Global Status of CCS: 2011* revealed that a number of LSIPs had been cancelled or put on hold over the previous 12 month period, with reasons anecdotally given as adverse project economics under their current design, reflecting an insufficiency of prevailing policy environments rather than engineering failures.

The 2011 Report also indicated a healthy evolution of early stage CCS projects, in that there had been substantial movement over the two previous years between the early project lifecycle stages. The report cites: *that the low number of projects in the Identify stage should not … be viewed as an adverse development ... as projects are advancing through the project lifecycle out of the Identify stage*.

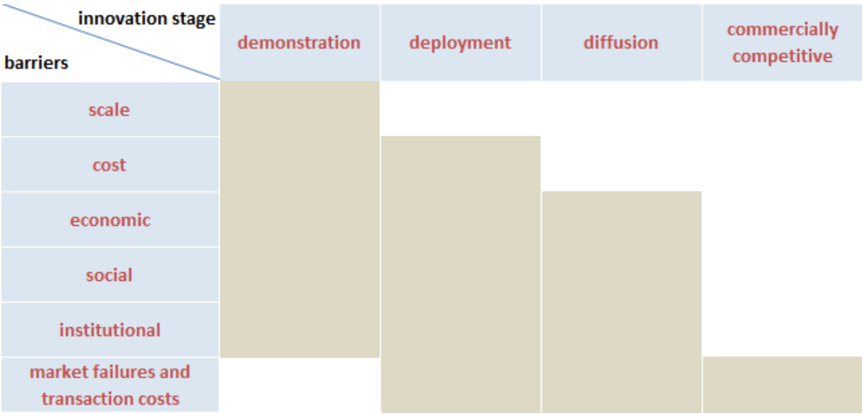
CCS project activity is predominantly in the demonstration phase, and this partly explains why the focus of many governments to date has been mostly on providing public funding for pilot and demonstration-scale projects. But it is vitally important that governments continue to send strong policy signals during the demonstration phase that the institutional arrangements (including legislative and regulatory frameworks) can and will be in place in a timely manner to efficiently support the early stages of commercial deployment.

In the absence of stable and predictable carbon regimes, private sector participation in CCS projects is typically reliant on the transitional pathways afforded by governments. These pathways need to be sufficient and robust enough to provide businesses with options to hedge their medium to longer term emission risks in a commercially attractive manner.

As illustrated in Figure 1 below, the nature of the barriers that afflict the demonstration and deployment of large-scale clean technologies, including CCS, change over the innovation stage. The efficiency and effectiveness of policy responses depend on the innovation stage being supported, and the extent to which complementarity between policies is implemented. It might be expected that as more market based policies are established, existing policies will be reviewed, revised and possibly even abandoned over time.

[2] http://www.globalccsinstitute.com/publications/global-status-ccs-update-june-2012

Figure 1: Barriers to deployment



source: UNFCCC/SB/2009/3 7 May 2009 (Figure 5)

Many countries are engaging in robust public policy discussions on major next generation climate change policies (refer to the Institute's *The Global Status of CCS* for updates on policy developments). There are also innovative industry led initiatives which aim to secure broad support for policies that increase energy security (i.e. domestic oil supply or electricity supply) while limiting and managing emissions through CCS.

As indicated, the current enabling environment for large-scale clean energy technologies such as CCS is largely reliant on governments adopting appropriate policy settings to: address inherent market failures; their public sectors to subsequently and efficiently implement the policy settings (i.e. policy in many cases drives the economics of projects); and the capacity and propensity of the private sector to respond to those settings.

There are a number of reasons why governments intervene to address market failures, including to:

- correct for externalities (i.e. either in terms of the harm caused by the release of CO_2 in the atmosphere or an inability to monetise the full benefit of investing in research and development activities);
- provide public goods (i.e. as learn-by-doing (LBD), information generation);
- address imperfect markets (i.e. monopolistic structures often found in distribution networks);
- address imperfect information (i.e. information asymmetry between decision makers and market participants); and
- oversee vertically integrated markets (i.e. different ownership structures between markets can result in the undersupply of a service or capacity).

The capacity of any bureaucracy to give effect to overarching policy settings and implement programmes is critical to the successful deployment of any technology. If implementation is inefficient (i.e. made overly administratively burdensome or prescriptive) or ineffective (i.e. insufficient or not dependable) then the policy objectives are unlikely to be met, and can often impose undue cost on related economic activities – further undermining and/or slowing the rate of LET deployment.

Capacity development for policy makers, regulators and project developers is very much a priority focus of the Institute's work program in its efforts to enhance the global capacity to accelerate the deployment of CCS (refer to the next section).

While government programs are often implemented on the basis of supporting technology development to deliver positive spillover effects (such as LBD), the success of large-scale clean energy projects is also linked to the: ability of project proponents to strike compelling business cases; and the extent to which proposals can deliver on a broad range of investor/s interests, such as (among others):

- investment viability under current and likely future policy regimes (including expected duration of policy frameworks);
- sovereign risk associated with changes to prevailing (or announced) policies or incentives, and the way this affects existing investments;
- financial attractiveness of projects relative to other investment opportunities (including outside the energy sector); and
- maturity and risk of the technologies being considered.

Investors (both private and public sector) often need to strike a balance between the likelihood of realising the benefits of risk-adjusted rates of return over time (i.e. risk premiums reflect the nature of the associated risks), with the ability to minimise the cost of delivering a broad range of objectives, such as sustainably operating in carbon constrained environments and/or satisfying eligibility requirements to claim project level abatement as tradable offsets. If investment hurdle rates rise unacceptably over time, project developers may decide to mothball a project completely or to put it on hold indefinitely.

As shown in Figure 1, government support for large-scale and pre-commercial demonstration projects (such as CCS, solar thermal with energy storage, geothermal) can help drive the benefits of scale. Most technologies have learning or experience curves which arise from the positive spillovers of experience and LBD at and across the various stages of a technology's lifecycle. This can often drive over time, as a technology's footprint globally expands and engineering efficiencies gained, material reductions in the price point per unit installed. This clearly has a subsequent positive impact on the future cost of mitigation efforts.

Positive LBD effects for CCS are currently being generated by countries with a high reliance on fossil fuels to drive economic activity, as well as high emitting sectors with either relatively low CCS costs (such as natural gas processing and enhanced oil recovery) and/or low trade exposure (such as the power sector). This is driven to a large extent by the common nature of CCS operational requirements such as geological site characterisation, emissions monitoring, reporting and verification (in both the surface and sub-surface), and project approvals processes (including risk assessments and securing public acceptability).

Evidence that positive spillovers result from these learning curves is demonstrated by the price of photovoltaic (PV) modules, which have fallen by some 60 per cent per megawatt (MW) since 2008, and wind turbine prices which having fallen by 18 per cent per MW over the period 2009 to 2010[3]. The potential economies of scale for CCS, especially for capture technologies (which can contribute between 60 to 80 per cent of the total cost of an integrated system) and CO_2 pipelines is significant, especially when considering the scale of

[3] Investment Grade Climate Change Policy - Financing the Transition to the Low Carbon Economy, p7 (2011)

opportunity to apply CCS to global industrial applications such as power generation and steel production, and the volume of CO_2 needing to be transported (i.e. the daily volume of CO_2 needing to be handled by 2050 could be some 2.5 times the current volume of oil being produced and transported[4]).

The IEA has recently released an information paper titled *A Policy Strategy for Carbon Capture and Storage* (January 2012), as a guide to policy makers to assist them in designing national and international policy related to CCS. It highlights that CCS policy needs to address: the creation of new markets (such as new mechanisms currently being explored under the UNFCCC agenda and national emissions trading/offset schemes); market barriers and failures, and promotion and regulation of infrastructure. The IEA observe that not only is the policy architecture (i.e. what the policy objectives are, such as addressing certain types of market failures) important but so too is the selection of policy instruments to address certain issues, and to support technologies as they inevitably evolve and mature over time.

The IEA examine a 'gateway' approach to CCS policy development that provides for changes in policy focus over time as CCS technology matures. For example, CCS is currently in a pre-commercial large-scale demonstration phase. This phase aims to not only firm up manufacturer engineering performance guarantees that can reduce the technical risk of commercial project investments, but also to enhance the LBD effects and information generation that ultimately helps drive down the cost of deployment over time.

Demonstration projects also provide time for the necessary institutional arrangements to be established such as appropriate regulations to govern industrial-scale activities, and the required distribution infrastructure (i.e. pipelines and other transport networks).

While first and second of a kind technology projects are less about providing short-term abatement, as large-scale and generally long-lived (40+ years) assets, many will ultimately need to transition to commercial operations after the demonstration phase is completed (say between 5 and 10 years).

A policy framework that can deliver on the needs of large-scale CCS demonstration projects is very different to the commercial needs of CCS deployment, and so a 'gateway' approach can help trigger a need to revise, and provide for, a predictable transitioning of a prevailing suite of policy settings to a new and more appropriate suite of policies in a timely manner.

Currently, CCS projects need policy support to generate LBD to drive the costs of construction and operation downwards. Over the short to medium-term, CCS projects will need the type of policy support that drives commercially attractive mitigation and energy. The former application may benefit from a policy portfolio of strong international collaboration and direct funding support to assist with the high upfront capital costs. The latter from more regulatory and/or market based approaches to assist with the longer-term operating costs. The IEA report provides a sound synopsis of the policy options at the various stages of CCS developments.

[4] M Bonner, Carbon Dioxide (CO_2) Distribution Infrastructure: The opportunities and challenges confronting CO_2 transport for the purposes of carbon capture and storage (CCS), Global CCS Institute

Actions undertaken by accredited observer organisations relevant to the Technology Executive Committee in performing its functions

The Institute has been engaged in the UNFCCC since 2010 (COP 16). The UNFCCC agenda continues to evolve since COP 16 (Cancun) and COP 17 (Durban) with many new agendas arising that either directly affects the ability of CCS to be deployed globally and/or national climate change policy settings capable of supporting the development of CCS.

The Institute has a number of work programs that aim to: leverage the LBD from the existing global fleet of planned and active CCS projects; enhance the capacity of policy and rule makers to implement policy architectures capable of efficiently supporting and effectively governing CCS activities; and a capacity development program aimed at facilitating the development of enabling environments in developing (non-Annex I) countries.

The Institute's focus on projects, policy and regulatory culminates in the release of its annual flagship report, *The Global Status of CCS*. The Institute regards the active interaction and dialogue between governments (for which it has 37 national and provincial Members), policy makers and regulators, and industry (for which it has over 310 Members) essential in distilling information to optimise the LBD effects, optimise planning and policy deliberations, and ultimately helping to bring down over time the cost of construction and operation of CCS plants and integrated systems.

The Institute's capacity development approach is tailored to the specific needs and situation of each country, and involves:

- conducting a needs-based scoping study, ideally with a key country stakeholder as the lead author;
- undertaking a capacity assessment, in consultations with key stakeholders;
- a tailored capacity development program of activities based on the scoping study and capacity assessment, as well as designed in consultation with key stakeholders;
- implementation activities, and evaluations and refinement of the capacity development program; and
- development of reports, case studies, webinars and the like that can be assessed by a broader audience.

In addition to the information provided in Attachment 1 (as the TEC requested), the Institute would be pleased to present to the TEC its current work plan in more detail and discuss ways in which the Institute may value-add to the TEC's decision making and functional operation.

wbcsd

Chair and Vice Chair
Gabriel Blanco and Anthony Plüger
Technology Executive Committee
UNFCCC

Geneva, July 27, 2012

Dear Sirs,

WBCSD, on behalf of the Energy and Climate working group and its Technology Task Team, would like to respond to the request from the recent Technology Executive Committee meeting in Bonn. WBCSD has input to provide on the three subjects relating to its work plan:

1. Inventory on technology road maps and action plans;
2. Ways to promote enabling environments and to address barriers to technology development and transfer;
3. Actions undertaken by accredited observer organizations relevant to the Technology Executive Committee in performing its functions.

The responses to the questions are attached as three Annexes.

We sincerely hope that this input may be useful to the work of the TEC.

If you have any queries please do not hesitate to let us know.

Best regards,

Barbara Black
Manager, International Process
WBCSD

cc Tanya Morrison, Shell, co-team leader Technology Task Team, WBCSD
Jean Yves Caneill, EDF Group, co-team leader Technology Task Team, WBCSD

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Annex I

Inventory on technology road maps and action plans.

WBCSD member companies may contribute to the development of road maps and action plans for particular technologies through their work with particular trade associations. This has the benefit of dealing with technology on issues which are of mutual interest and providing common benefit. Hence we would recommend that the TEC contacts these associations including the Cement Sustainability Initiative, Global Electricity Initiative, International Aluminium Association, International Council of Chemicals Associations, International Electricity Partnership, International Gas Union, World Energy Council, World Steel, IPIECA etc.

Individual company road maps or action plans would be part a company's strategy and most usually commercially restricted.

If the TEC requires assistance in contacting any of the above we would be happy to help.
