Chapter 2
Challenge 2: Integrating Sustainable Development and Technology Transfer Needs

Abstract This chapter addresses the challenge of how sustainable development and climate goals could be aligned through technology transfers. It explains how this is an opportunity for maximising the benefits from investments at a time of constrained resources but large-scale low-emission technology transfers for mitigation and adaptation. This could facilitate developing countries' efforts to achieve Millennium Development Goals. The chapter reviews the development of technology transfer under the UNFCCC and the updated Technology Needs Assessment (TNA) process. How technologies and measures can be identified for achieving both climate and development goals using the new TNA process involving developing country stakeholders is described as a first stage in developing strategies and action plans for large-scale sector transformations.

2.1 Challenge 2: Introduction

Chapter 1 showed that the world is facing a serious challenge to bend global greenhouse gas (GHG) emission trends to pathways that limit the risks of irreversible damage to the world's ecosystems. International climate negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) have thus far not resulted in a global coalition that is capable of addressing this challenge. Negotiations have long focussed on agreeing on quantitative national GHG emission reduction commitments for industrialised countries, and attempts to broaden this coalition with developing countries have not been successful.

Since the failure of the 2009 Copenhagen Climate Conference, a different approach has been taken and further encouraged by the 2010 Cancun Agreements, whereby countries can report under the UNFCCC what they are planning to do in terms of GHG emission reductions ('pledges'). However, as explained by

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UNFCCC Executive Secretary Christiana Figueres, by mid-2011, the pledges submitted by countries in total amounted to only 60% of what is needed to reach the 2°C target (Figueres 2011). Scaling up the efforts towards achieving climate goals will, therefore, require a 'green industrial revolution'. Transfers of low-emission technologies will be required for this 'revolution' and for developing countries to be engaged, these transfers will have to be effected through alignment of climate actions with countries' sustainable development objectives. This brings us to the second challenge for this book, which is addressed in this chapter:

> To meet both countries' sustainable development and technology transfer needs by selecting technologies or measures for climate change mitigation and adaptation based on countries' sustainable development and climate goals.

In the past, several climate-friendly activities have already been carried out in support of developing countries' sustainable development, but most experience so far has been at the project level rather than sector or subsector level. Scarce resources to achieve this challenge will, therefore, need to be allocated to maximise the benefits from investments. We discuss this later on in this chapter.

We will first discuss the engagement of developing countries through sustainable development and poverty alleviation, before moving to how technologies and measures for achieving climate and development goals can be identified.

2.2 Engagement of Developing Countries Through Sustainable Development and Poverty Alleviation

To form a full global climate coalition to take on this challenge, integration of sustainable development priorities of developing countries into the planning of a *green revolution* will be important. The key reason for this is that developing countries are not interested just in climate change as was seen under the climate negotiations, but mainly focus on their country development and poverty alleviation. Therefore, full engagement of developing countries will require that their sustainable development priorities are addressed as well as action on climate change.

Focussing on getting the GHG emission levels lowered on the scale required should not mean that development issues such as energy access for the poor and equity concerns will become less relevant. On the contrary, not integrating climate policy actions and the processes required for sustainable development implies a risk that the climate solutions will not be lasting and that opportunities and resources are wasted. Climate actions delivering sustainable development benefits are likely to be successful, as stakeholders know that these actions are in support of their own interests and urgencies. This has been clearly demonstrated by literature on development co-operation success and failure stories. If we want successful climate policy action, people in the countries need to be properly engaged in the process.

In addition to the argument that aligning climate change mitigation action with sustainable development would enhance the probability that both objectives will be successfully achieved, the relationship between climate and development also becomes clear when looking at the possible consequences of climate change for sustainable livelihoods in developing countries. For instance, as explained by Anderson (2011), climate change makes achieving and sustaining development goals increasingly difficult, including increased problems for poor population groups to 'climb out and stay out of poverty'. He, therefore, recommends that policy instruments for poverty reduction and for adaptation to climate change impacts need to be integrated and that 'identifying how mitigation strategies can also reduce poverty and support adaptation is an important part of climate-resilient development'.

This is in line with Art. 4.9 of the UNFCCC (1992) which specifically addresses the case of the Least Developed Countries (LDCs):

> Parties shall take full account of the specific needs and special situations of the Least Developed Countries in their actions with regard to funding and transfer of technology.

As explained in Chap. 1, this focus on LDCs is an attempt to embed equity into the Convention as LDCs have contributed least to the emission of GHGs but are among the most at risk from climate change effects either because of the vulnerability of the region and/or low capacity to adapt to the changes.

In other words, the way the world deals with climate change today will have a direct bearing on the development prospects of large population groups in developing countries. Enabling adaptation to reduce vulnerability is a key part of the integration process for development and climate goals.

This has been recognised for some time with the LDC Expert Group of the UNFCCC (LDC Expert Group 2009) and the OECD Development Assistance Committee (OECD 2009) concerned with integrating development and adaptation. If these could also be combined with climate mitigation action, then there could be the elusive 'triple win'.

The question then becomes how climate change mitigation and adaptation measures can be identified in light of a developing country's sustainable development objectives and successfully implemented on the scale necessary to avoid serious climate change.

Of course, what is an urgent need in one country is likely to be different from that in another country. Therefore, the choice and design of actions need to be local to ensure that solutions are in line with local priorities. Nonetheless, some overall conclusions can be drawn from recent research conducted in developing country regions. For example, the recent *Poor People's Energy Outlook* by Practical Action (2010) presents some clear examples of current urgencies in developing countries.

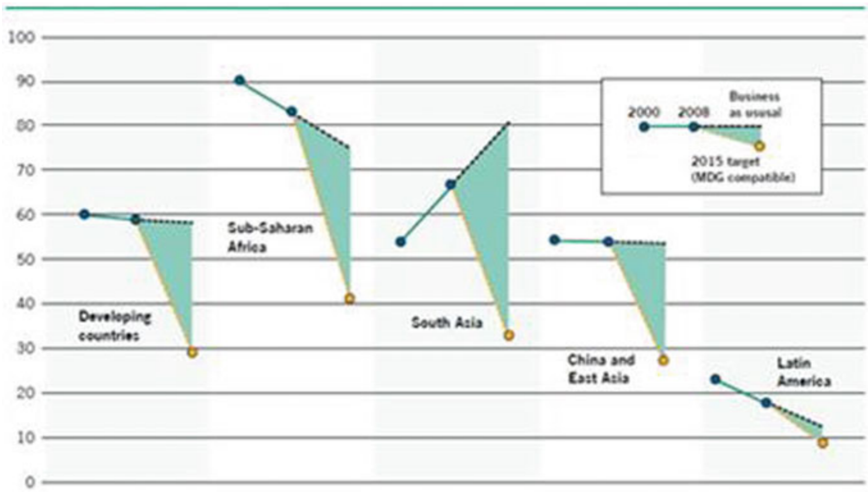

Fig. 2.1 Percentage of people without access to modern fuels for cooking; progress towards the MDG-compatible target (Practical Action 2010, taken from IEA 2002; Legros et al. 2009) (The *curves* show for each region, as well as for all developing countries on average, how access to modern fuel technologies for cooking has been increased or decreased. The *triangles* show the difference between the business-as-usual trends and the Millennium Development Goals for these regions)

The document clearly shows that in several developing country regions, still many serious problems exist with energy access for large groups of people. For instance, they conclude that one and a half billion of the world's population have no access to electricity and that three billion people rely on traditional biomass and coal for cooking. This energy access problem is an important reason why several regions are still far away from reaching the Millennium Development Goals (MDGs). Figure 2.1 illustrates this by showing for different regions what progress has been made between 2000 and 2008 in terms of reducing the number of people without access to modern fuels for cooking, but also by indicating how big the distance is between the present business-as-usual trends and the MDGs.

The figure shows that in Sub-Saharan Africa, access has improved (from 90% to around 75% of people without access to modern fuel cooking technologies), but that for reaching the MDG of 40% access, still much work remains to be done. For South Asian developing countries, the percentage of people without access to modern technologies has even increased, resulting in an almost 50%-point deviation from the MDG. For all developing countries, the average percentage of people without access is now <60%, whereas the MDG is <30% without access.

Without energy access, people would spend a lot of time on collecting biomass for daily cooking and heating services, time which they could have spent better on education, other types of labour, etc. Lack of access to modern energy, therefore, keeps these people in poverty.

In the next section, the role of technology transfer of low-emission technologies to meet both climate and development needs is discussed.

2.3 The Role of Technology Transfer

2.3.1 Why is Technology Important?

Technology transfer can be a powerful solution for simultaneously addressing the climate change and development challenges described earlier. This was recognised in Art. 4.5 of the UNFCCC. Also, as explained in Chap. 1, there are increasing insights that meeting a growing global energy demand with improved energy access for the poor can only go hand in hand with low GHG emission pathways. The recognition that these pathways involve rapid innovation of low-emission technologies has moved technology development and transfer to the heart of the climate negotiations and development debate.

Although technology transfer was discussed at succeeding sessions of the UNFCCC Conference of the Parties (COP) within the context of the Convention's Art. 4.5, it was not until 2001 that significant change occurred. At the seventh session of the COP (or COP 7), held in Marrakech (Morocco), a decision was made on a *Development and Transfer of Technologies* and the *Expert Group on Technology Transfer* (EGTT) was set up to facilitate transfers (UNFCCC 2002). The key themes of the framework adopted by the EGTT were (UNFCCC 2002):

- Assessment of technology needs;
- Technology information: technical and other information;
- Enabling environments: how to solve policy and legal barriers;
- Capacity building: identifying country needs; and
- Mechanisms: co-ordination of process and formulation of projects.

New areas introduced were:

- Innovative options for financing technology transfers; and
- Technologies for adaptation.

In 2009, the EGTT estimated the additional financing needs for low-emission technologies in developing countries at US$ 105–402 billion per year (which is 40–60% of global climate technology finance needs) (EGTT 2009). It was also concluded that:

> not all countries have the technologies needed or the ability to innovate new technologies to mitigate and adapt to climate change. Those countries that are lacking in the technologies or capacity, mainly the developing countries, need to be helped not merely to adopt the existing environmentally friendly technologies but also to develop the capacity to innovate new technologies and practices in co-operation with others.

As is discussed in detail in Chap. 3, it is important to underline that identification of technologies and possibly implementing them in projects may not be enough to initiate a system change for widespread technology innovation in a country. Although identification of technologies is an important step in low-emission and climate-resilient development, overarching strategies will be required to make sure that the technologies diffuse well within countries' systems or markets. The strategies may include activities such as organisational/institutional behavioural change, system-supporting services (e.g., finance and legal support), network creation and support, skills training, international co-operation and intellectual property rights and corresponding policies and measures.

This has been made clear by EGTT (2009, p. 11) as follows:

> Technology transfer includes not merely transfer of hardware but also of best practices, information and improvement of human skills, especially those possessed by specialized professionals and engineers. The acquisition and absorption of foreign technologies, and their further development, are complex processes that demand considerable knowledge and efforts on the part of those that acquire them. It is the capacity of the countries and the enabling environment in those countries that will enable them to change to a low-carbon economy.

2.3.2 Negotiation Context for Technology Needs Assessments

COP 7 encouraged 'developing countries…to undertake assessments of country-specific technology needs, subject to the provision of resources, as appropriate to country-specific circumstances' (UNFCCC 2002). These Technology Needs Assessments (TNAs) were defined as:

> a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties other than developed country Parties…particularly developing country Parties (UNFCCC 2002).

To support countries in conducting TNAs, the United Nations Development Programme (UNDP) developed a TNA handbook.[1] After 2002, 92 developing countries received funding from the Global Environment Facility (GEF) for conducting TNAs.[2] About 78 of these assessments have been supported by UNDP, and 14 by the United Nations Environment Programme (UNEP).

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[1] This was done in collaboration with the Climate Technology Initiative (CTI), EGTT and the UNFCCC Secretariat (UNDP 2010, p. 4).

[2] Based on 68 TNA case studies, the UNFCCC secretariat prepared *the Second Synthesis Report on Technology Needs Identified by Parties not included in Annex I to the Convention* (UNFCCC 2009).

At COP 13, held at Bali (Indonesia) in December 2007, the importance of technology transfer under the Convention was further emphasised as a building block for a future climate policy regime (UNFCCC 2008a). The GEF was requested to elaborate a strategic programme to scale up the level of investments for technology transfer to help developing countries assess their needs for environmentally sound technologies. Part of this programme would be support for countries to conduct TNAs or update earlier assessments. The programme was adopted at COP 14 (Poznań, Poland, December 2008) as the *Poznań Strategic Programme on Technology Transfer* (UNFCCC 2008b). As explained in Chap. 1, it envisaged supporting 35–45 developing countries to prepare or update TNAs and formulate technology action plans as TNA output. For the resulting *TNA Project*, which is being implemented by UNEP, the GEF has provided funding of US$ 9 million (UNFCCC 2011).[3]

To support the continued TNA activities, COP 13 requested the UNFCCC Secretariat 'in collaboration with the EGTT, United Nations Development Program (UNDP), United Nations Environment Program (UNEP) and Climate Technology Initiative (CTI), **to update the handbook for conducting technology needs assessments**' (UNFCCC 2008a, bold added).

The updated handbook with the new TNA process was endorsed by the EGTT in November 2010 (UNDP 2010).

The GEF/UNEP TNA Project started in 2009 using an advanced version of the updated TNA handbook with a first round in which 15 developing countries participated (see Box 2.1).[4] These countries are supported by three regional centres through a help-desk facility, as well as by regional training workshops. The output from the TNA conducted under this project is expected to be a Technology Action Plan (TAP) which could be equivalent to a technology-level strategy under the new TNA process.

Box 2.1 TNAs under the Poznań Strategic Programme on Technology Transfer

The objectives of the GEF/UNEP TNA Project are:

- To identify and prioritise through country-driven participatory processes, technologies that can contribute to mitigation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities.
- To identify barriers hindering the acquisition, deployment and diffusion of prioritised technologies.

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[3] See for further details http://tech-action.org/. Accessed 19 September 2011.

[4] These countries were Senegal, Kenya, Mali, Morocco, Cote d'Ivoire from Africa, Cambodia, Indonesia, Viet Nam, Bangladesh and Thailand from Asia, Costa Rica, Guatemala and Peru from Latin America, and Georgia from the Commonwealth of Independent States.

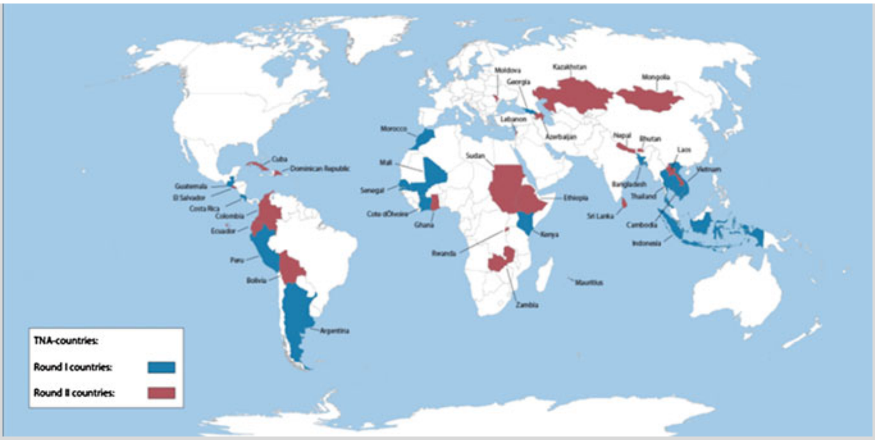

Fig. 2.2 Overview of TNA Project round 1 and round 2 countries (Agbemabiese and Painuly 2011)

- To develop Technology Action Plans specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption and diffusion of selected technologies in the participant countries.

An initial round of 15 developing countries from Africa, Asia, Latin America and the Caribbean and Europe have been supported in the first round since early 2010. An additional 21 countries were selected in the last quarter of 2010 (see Fig. 2.2).

2.3.3 *Starting the Process*

The provisions that have been developed under the UNFCCC and included in the Cancun Agreements, such as low-carbon development strategies (LCDS) and TNA, as well as nationally appropriate mitigation actions (NAMA) and national adaptation plans (NAP), all enable a developing country-specific identification of low-emission and climate-resilient development measures. As introduced in Chap. 1, of these provisions, LCDS and TNA aim at formulating sector and/or national strategies, whereas NAMAs and NAPs are actions that could result from such strategies and the policies and measures derived from these.

In this chapter, the process of identifying mitigation and adaptation technologies and measures in the light of a country's national development priorities will be illustrated with help of the TNA process.

As explained earlier, The TNA concept was initiated in 2001 as part of the Marrakech Accords' Technology Framework (UNFCCC 2002) and applied by more than 90 developing countries between 2001 and 2007. Based on experience gathered from these TNAs, the methodology was updated and extended from a mainly technology project orientation to a more technology innovation strategy point of view (UNDP 2010). So far, TNA is the *only* detailed methodology that has been adopted under the UNFCCC compared with the relatively new concepts of LCDS, NAMA and NAP.[5] Later in Chap. 4, links between the TNA approach and LCDS, NAMA and NAP will be explored.

The overall TNA process involves the formulation of strategies and action plans for enabling a change to low-emission sustainable development. It is considered in two main stages:

- The first stage is identification of the technologies or measures for a country that could be used to reduce GHG emissions and climate change vulnerability at the same time as delivering the required sustainable development benefits.
- The second stage is the identification of activities to accelerate the innovation into the country system by identifying actions for overcoming barriers and then formulating them into a strategy and action plan at the technology, (sub)sector or national level.

This chapter continues with an introduction and brief summary of the new TNA process in the updated TNA handbook (UNDP 2010). Comparisons are made with previous TNA exercises, and the key differences between the new and the previous approach are then highlighted. This is followed by a more detailed illustration of the first of the two TNA stages described earlier. The second stage will be discussed in Chap. 3.

2.4 Key Steps in the New Technology Needs Assessment

2.4.1 Overview of Steps

The main steps and issues for conducting a TNA are summarised in Fig. 2.3.

Integrating development and climate into climate strategies requires taking a developing country's sustainable development priorities as a starting point and using these priorities as criteria for identifying strategic sectors for climate change mitigation and adaptation and achieving development goals. After the initial organisation of the assessment, these are the second and third step in Fig. 2.3. As argued by CCAP (2010), embedding the action-based processes into such a long-term national framework would increase the coherence of the action portfolio.

In the fourth step in Fig. 2.3, stakeholders are familiarised with technologies within each of these priority sectors or measures for mitigation and adaptation using a range of approaches, including the online platform *ClimateTechWiki*

[5] At its sixth meeting on *Development and Transfer of Technologies* (Bonn, Germany, 19–20 November 2010), the EGTT endorsed the updated *Handbook for Conducting Technology Needs Assessment for Climate Change* (UNDP 2010).

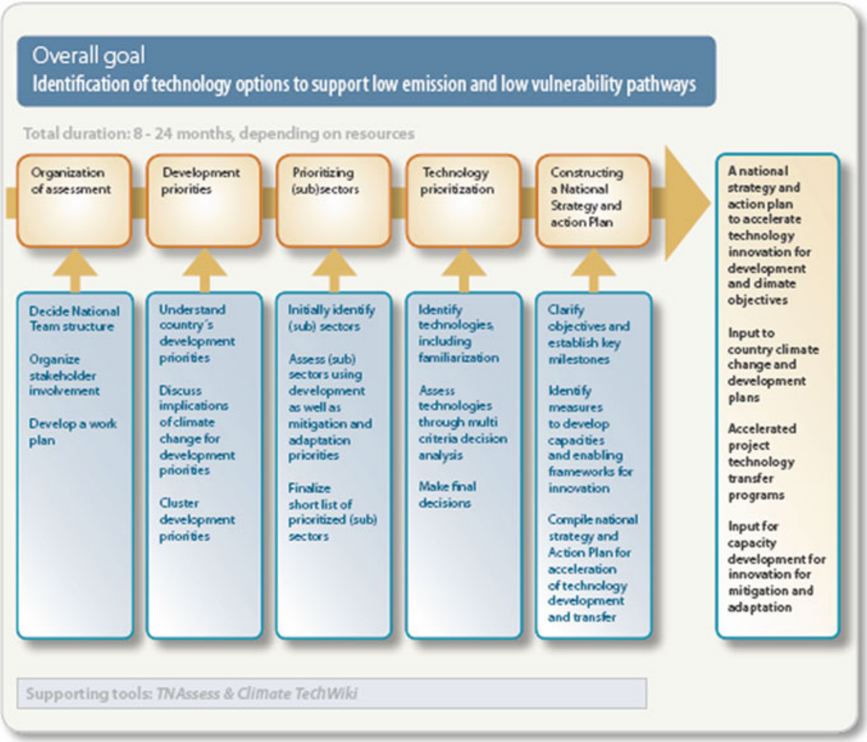

Fig. 2.3 Key steps of the TNA process (UNDP 2010, p. 8)

(see Sect. 2.4.2 and Fig. 2.4). An initial list of technologies is generated and then structured according to whether the technology or measure is available in the short term or the medium to long term and whether it is a small-scale or large-scale technology (these categories are further explained later in this chapter). A multi-criteria decision approach is then used to prioritise a portfolio of technologies and measures in the priority sectors in support of the country's sustainable development.

The prioritisation of technologies or measures within each priority sector is based on a benefit-to-cost ratio over all the sustainable development and climate and/or adaptation benefits. This produces a summary table of portfolios of technologies or measures per priority sector with their sustainable development benefits, costs of roll out and climate/adaptation benefits. This can be used for input to a national strategy and for meta-analysis across countries (see also Chap. 4). These steps are described in more detail later in this chapter.

Within the process, it is important that the voices of different stakeholder groups are heard so that stakeholders' knowledge and concerns are incorporated. Care is taken to have a participatory approach with stakeholders right from the start that supports their 'buy in' in the process, including their role in the eventual implementation of prioritised low-emission and climate-resilient technologies and actions.

Finally, it is important that the approach takes account of the uncertainties that surround the choices. Assessing development and climate change mitigation and adaptation needs implies that decisions are taken for a relatively long period of time, e.g., 20 years, so that stakeholders need to develop a feeling not only for what is happening now but also for what might happen in the future. For instance, a country with a relatively small tourist industry could expect this sector to become bigger in the next two decades and among the larger GHG emitters. Such expectations can be included in the analysis and stakeholders could identify options for making areas suitable for tourism more climate resilient.

The second stage, represented by the fifth step in Fig. 2.3 (described more fully in the next chapter), is to move from the technologies and measures to strategies and action plans. This is done by examination of the existing system for the innovation of the technology or measure followed by identification of barriers and blockages in the system by stakeholder groups. Activities to overcome these problems are then generated by the group, and these form the basis of strategies that are structured according to core elements, such as network creation, policies and measures, organisational and behavioural change, market support activities, education and training, and international co-operation and handling intellectual property rights. The activities can be prioritised and these form the basis of the action plan that provides information on:

- Why an activity is important?
- Who should do it?
- When?
- How it will be monitored and verified?
- How much it will cost?

This process is repeated for other priority technologies. The activities can then be aggregated and rationalised to form strategies and action plans at the (sub)sector or national levels.

2.4.2 What is Different in the 'New' TNA Process?

Before moving to a more detailed explanation of how the new TNA process works, first, it is explained what the differences are with the former TNA process and how the lessons learned from earlier needs assessments between 2002 and 2008 in developing countries (see Appendix A) have been incorporated. Principally, as explained earlier, the updated TNA process (UNDP 2010):

- is firmly based on the sustainable development priorities of the country; and
- Extended from a mainly technology *project* implementation orientation to a more technology *innovation* strategy point of view to accommodate the scale of action envisaged to lower GHG levels or increase climate resilience.

Fig. 2.4 Homepage ClimateTechWiki.org

Another addition in the new TNA process is the specific attention for country stakeholders' *familiarity with technologies* or lack thereof. As was concluded by the EU-funded study ENTTRANS (2008),[6] but also in UNFCCC (2009), there can be gaps in people's awareness of and familiarity with potentially useful technologies (see Box 2.2). Therefore, a new online platform, the *ClimateTechWiki*,[7] was devised that supplements other information sources to aid familiarisation

[6] The study "Promoting Sustainable Energy Technology Transfers: Converting from a Theoretical Concept to Practical Action" (ENTTRANS) was carried out for the European Commission during 2006–2007 by the consortium: Joint Implementation Network (JIN, the Netherlands), Cambio Climático y Desarrollo Consultores (CC&D, Chile), Practical Action (Kenya), Asian Institute of Technology (AIT, Thailand), Tel Aviv University (ICTAF, Israel), Kunming University of Science and Technology (KUST, China), Energy Delta Institute (EDI, the Netherlands), Power Production Company (PPC, Greece), and National Technical University of Athens (NTUA, Greece). ENTTRANS' objective was to analyse how transfer of low-emission energy sector technologies to developing countries could be promoted through the Clean Development Mechanism (CDM). The study was carried out in five countries: Chile, China, Israel, Kenya and Thailand.

[7] ClimateTechWiki is available at http://climatetechwiki.org. Accessed 21 September 2011.

(see Fig. 2.4). The platform contains a range of descriptions of technologies for mitigation and adaptation with practical examples and case studies. It presents additional information on technologies that are either in pilot or pre-commercialisation phases or newly emerging or established. Such information could cover cost data, technology performance (e.g., efficiency, capacity factors, lifetime and degree of technical sophistication required for manufacturing, installation and operation) and whether the technology can be sufficiently relied on.[8]

Box 2.2 Gaps in technology familiarity and awareness

There are two main aspects to lack of familiarity with or limited awareness of technologies, as discussed in ENTTRANS (2008) and UNFCCC (2009). First, some respondents in the ENTTRANS case study countries had never heard of some technologies or did not know anything about specific technologies, such as what it could deliver and whether it was available. This meant that they were not confident in making assessments so that potential technologies would not feature in the final lists.

Furthermore, stakeholders reported examples of how the assessment of technologies was coloured by historic experience. If a new technology had been badly implemented in the country before, for whatever reason, then this created an automatic bias against it for some respondents. Added to this is the fact that people tend to anchor in what they know and are familiar with, which implies that the adoption of new technologies has to overcome this resistance to change in the decision-making process. As Winksel et al. (2006) pointed out: 'Organisations operate in embedded socio-technical networks and tend to re-invest in established competences: disruptive technologies (e.g., renewable energy) rarely make sense to incumbents, so their development tends to be left to small outsider organisations'.

The new TNA process explicitly focuses on both *mitigation* and *adaptation*. By doing so, it is acknowledged that reducing developing countries' vulnerability to climate change is as much a priority as mitigation of climate change. Through adaptation measures, sustainable livelihoods can be ensured and ecosystems on which people depend protected. This will require adaptation measures to increase countries' resilience and for this both market and non-market technologies will be required. Potential areas where adaptation strategies will be necessary are health and social systems, agriculture, biodiversity and ecosystems and production system and physical infrastructure, including the energy grid. Although the process to prioritise measures for adaptation is largely similar to that for mitigation

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[8] Other sources for technology familiarisation that could be used are: UNEP guidebooks (http://tech-action.org/guidebooks.htm), IEA Technology Roadmaps (http://www.iea.org/subjectqueries/keyresult.asp?KEYWORD_ID=4156) and study tours, expert lectures and demonstration projects.

technologies (e.g., similar development context), a parallel process has been suggested to take into consideration that both processes may involve different stakeholders and could focus on different areas and sectors. Furthermore, contrary to mitigation technologies, it is not always clear and unambiguous what are technologies for adaptation. The TNA handbook underlines that 'for adaptation the issues of interest tend to impact across … sectors in particular ways. For example, for agriculture projected climate change may mean a water shortage and irrigation problems with implications for the location of agriculture, crop yields and livestock' (UNDP 2010, p. 31).

The updated TNA process uses *multi-criteria decision analysis* (MCDA) to support decision making for the stakeholders as they select the technologies (this is explained in further detail in the next section). For the purpose of the MCDA analysis, an online tool called *TNAssess* has been specially designed, for the sector and subsector prioritisation and for the technology prioritisation.[9]

A major difference compared to the 'old' TNA approach is that in the updated TNA, stakeholders prioritise technologies on the basis of their *benefits-to-cost* ratio. In this case, the *benefits* have been assessed using the sustainable development criteria and thus cover a range of issues not necessarily amenable to monetisation. Therefore, the new TNA maximises the benefits (including mitigation and adaptation benefits) for a given resource. It is thus in line with the need to deploy restricted resources for maximum benefit across a range of goals, including climate change mitigation, adaptation and sustainable development.

In the updated TNA process, technologies identified for the prioritised sectors are *categorised* according to whether they are available in the short term[10] or the medium to long term[11] and whether it is a small-scale or large-scale technology.[12] This categorisation is to allow ease of comparison of technologies as a small-scale technology cannot be easily compared with a large-scale technology, nor one under development with one that is market ready. Why this is important has been illustrated by ENTTRANS (2008) where a tendency among stakeholders could be observed to give lower scores to technologies that would be available only in the longer term as these were considered less important for the

[9] TNAssess can be downloaded from http://climatetechwiki.org.

[10] Short term means that the technology or measure is either very close to market or is already established in other markets or systems ready for diffusion.

[11] Medium to long term are those technologies that may be still at the RD&D stage with 10–15 years to deployment or are at the pilot or pre-commercial stage with up to 5 years for deployment. These longer term technologies may be considered useful over time as they could deliver more benefits than existing technologies and therefore (a) they will receive a demand push, and (b) they will be part of a longer term strategy for innovation.

[12] *Small-scale* technologies are described as those that are applied at the household and/or community level, which could be scaled up into a programme. *Large-scale* technologies are those that are applied on a scale larger than household or community level.

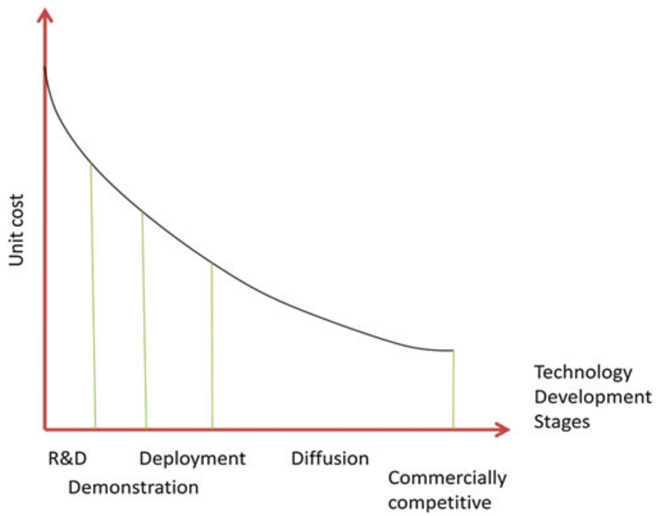


Fig. 2.5 Technology innovation learning curve (EGTT 2009)

time being. Furthermore, stakeholders may, because of their professional background, have a relatively strong focus on, e.g., small-scale technologies only. Categorisation of technologies could thus enable a better comparison of technologies and prevent a biased focus on one particular technology or measures category while overlooking other, also potential beneficial technologies or measures. As a caveat to identifying technologies within categories, it is acknowledged in the updated TNA handbook that the terms short, medium and long term, as well as small and large scale are context specific. For instance, a technology that is commercially viable in one market may not have reached this stage in another market (UNDP 2010, p. 41).

Finally, categorising technologies in terms of short-, medium- and long-term availability is also related to the facility in the new TNA process to formulate strategies for prioritised technologies that are in different development stages if required (this is explained in further detail in the next chapter). Figure 2.5 illustrates this by showing a learning curve for technology innovation:

- Technologies that are still in a process of research, development and demonstration (RD&D) have relatively high-unit costs (longer-term technologies).
- When a prototype has been successfully demonstrated and the technology been successfully deployed in the market, unit costs become lower (medium-term technologies); so that
- The technology could eventually be manufactured and sold commercially competitive (short-term technologies).

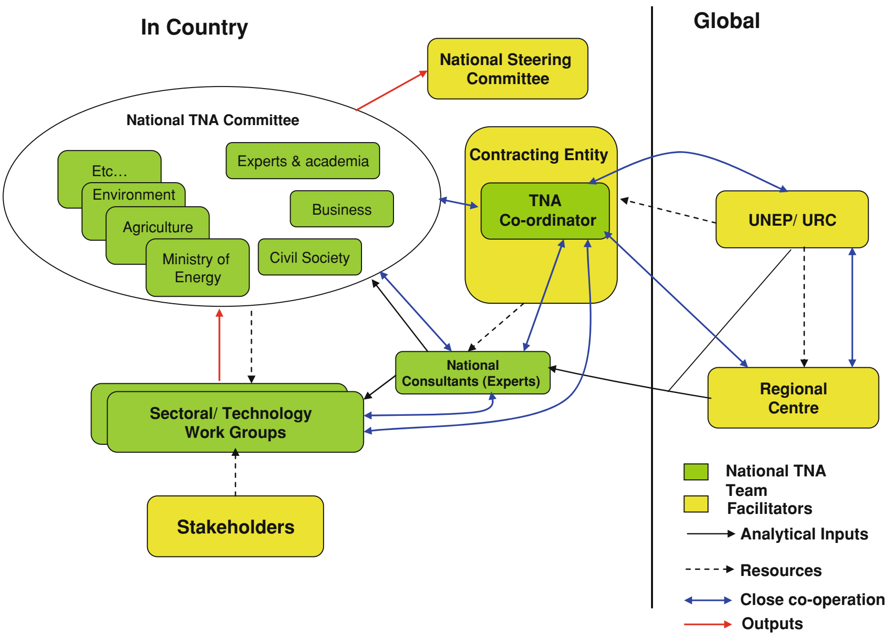


Fig. 2.6 TNA organisation in GEF/UNEP TNA Project (Agbemabiese and Painuly 2011)

2.5 Assessing Technology Needs: How Does It Work?

2.5.1 Organising the Process

A first step in a TNA is the organisation of the process. This includes a decision on who will be responsible for the process, such as a ministry or interministerial committee with experts from all relevant ministries and/or agencies (UNDP 2010; Agbemabiese and Painuly 2011). As an example, Fig. 2.6 shows how the TNA process conducted in the GEF/UNEP TNA Project is organised. It shows how stakeholders from different sectors are represented in sectoral and technology work groups and work on the assessment together with national experts (on, e.g., sectors, technologies and overall country strategies), a national TNA committee, a process co-ordinator and the steering committee. The figure also shows the international and regional support organised under the GEF/UNEP TNA project.

Organising the process in a participatory setting with stakeholders from a broad range of public and private sectors and supporting services has a number of advantages. It can lead to transfer of new, especially local, knowledge and insights on specific technology challenges and opportunities that might otherwise have been missed in a TNA. Furthermore, as mentioned earlier, exposing stakeholders to proposed actions for technology development and transfer in early decision-making stages and letting them actively take part in the process contribute to awareness building and provide some level of 'buy-in' into future technology strategies and action plans. For example, farmers and their communities would make use of technologies to adapt to climatic patterns that have resulted from the technology prioritisation process they have been involved in (UNDP 2010, Chap. 2). Box 2.3 presents an indicative list of possible stakeholders to participate in the TNA process.

Box 2.3 Possible stakeholder groups for TNA

1. Government departments with responsibility for policy formulation and regulation (e.g., power supply) and vulnerable sectors (e.g., agriculture).
2. Private and public sector industries, associations and distributors that are involved in the provision of GHG-emitting services or are vulnerable to climate change impacts.
3. Electric utilities and regulators.
4. Within the private sector, technology users and/or suppliers who could play a key local role in developing/adapting technologies in the country.
5. Organisations involved in the manufacture, import and sale of technologies for mitigation or adaptation.
6. The finance community, which will likely provide the majority of capital required for technology project development and implementation.
7. Households, communities, small businesses and farmers that are or will be using the technologies and who would experience the effects of climate change.
8. Non-Governmental Organisations (NGOs) involved with the promotion of environmental and social objectives.
9. Institutions that provide technical support to both government and industry (e.g., universities, industry RD&D, think tanks and consultants).
10. Labour unions, consumer groups and media.
11. Country divisions of international companies responsible for investments important to climate policy (e.g., agriculture and forestry).
12. International organisations/donors.

Source UNDP 2010, Chap. 2.

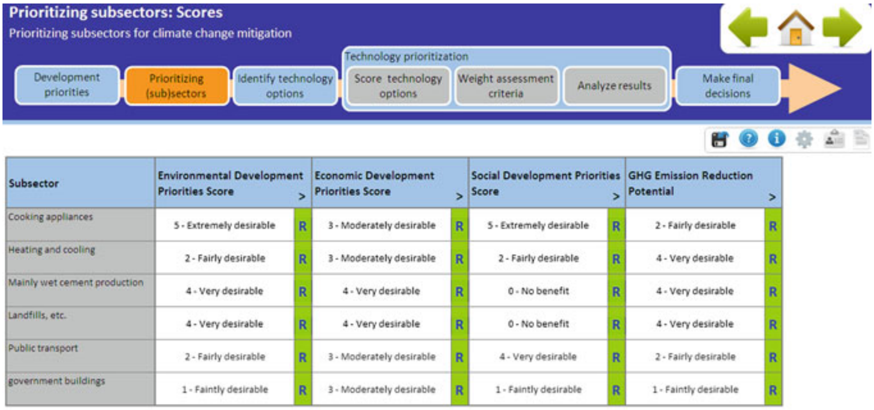
2.5.2 Awareness Building and Identifying Development Priorities

As explained earlier in this chapter, in the updated TNA process, a country's development priorities for the short, medium and longer term are used as criteria for selecting strategic sectors for low-emission and climate-resilient development

Fig. 2.7 Stakeholder group in discussion during a TNA (photo courtesy Jorge Rogat)

and for prioritising technologies within these sectors. Such priorities can be derived from several sources, such as already existing strategic documents on climate change measures and sustainable developments (e.g., Sustainable Development Strategies, 5 Year Plans and National Communications) (UNDP 2010, Chap. 3). Identification of these priorities enables country stakeholder groups to revisit existing views of what is important for the country's sustainable development, so that all further decisions in the TNA process can be related to this (Fig. 2.7).

In addition to identifying development priorities, it is also recommended in the updated TNA process that possible climate change impacts on the country are considered. This is obviously important for identifying required measures for climate change adaptation, but a changing climate could also have an impact on selecting priority technologies for mitigation and development goals. For instance, should because of a changing climate hydro resources in a country become smaller, then smaller scale hydro technologies may be more suitable than large-scale hydro power (UNDP 2010, Chap. 3). Given the large uncertainties that surround estimating climate change impacts on a country, a range of possible climate change outcomes may be analysed to develop a feeling for possible climate change impacts to the country and how this would affect technology choices.



Subsector	Environmental Development Priorities Score	Economic Development Priorities Score	Social Development Priorities Score	GHG Emission Reduction Potential
Cooking appliances	5 - Extremely desirable	3 - Moderately desirable	5 - Extremely desirable	2 - Fairly desirable
Heating and cooling	2 - Fairly desirable	3 - Moderately desirable	2 - Fairly desirable	4 - Very desirable
Mainly wet cement production	4 - Very desirable	4 - Very desirable	0 - No benefit	4 - Very desirable
Landfills, etc.	4 - Very desirable	4 - Very desirable	0 - No benefit	4 - Very desirable
Public transport	2 - Fairly desirable	3 - Moderately desirable	4 - Very desirable	2 - Fairly desirable
government buildings	1 - Faintly desirable	3 - Moderately desirable	1 - Faintly desirable	1 - Faintly desirable

Fig. 2.8 Prioritisation of (sub) sectors by scoring climate and development contributions (The figure shows an example of a scoring table for climate and development benefits within a (sub) sector. A stakeholder group can consider an improvement in a sector in terms of GHG emission reduction extremely desirable (score 5), in terms of economic development fairly desirable, etc. The highest score in this simple multi criteria decision analysis example is 5 (very desirable) and the lowest score would be 0 (no benefit))

2.5.3 Prioritising Technologies for Strategic Sectors

Once development priorities have been identified with a view to the short, medium and long run, stakeholder groups could identify sectors in the country where improvements (e.g., investments in new low-emission technologies) would result in the strongest combined climate and development benefits (Box 2.4 explains possible ways for sector categorisation). This could be done by first characterising the existing situation in sectors and exploring expected developments for the future. Subsequently, based on these characterisations, stakeholder groups could identify for each sector the potential GHG emission reductions and/or climate change vulnerability improvements, as well as potential economic, social and environmental development benefits. Figure 2.8 illustrates how the benefits could be 'valued' (scored) with help of a simple MCDA, including a rationalisation of values given. These scores could enable stakeholders to take decisions on what are strategic country sectors for low-emission and climate-resilient development.

> **Box 2.4** Possible sector categorisations for mitigation and adaptation
> In a TNA, sectors can be identified by using countries' own sector categorisation, such as, for instance, the sectors identified in the National Communications to the UNFCCC. Countries can also use the classification applied by the UNEP Carbon Finance Group for categorising projects under the Clean

Development Mechanism (CDM).[13] A third option is to follow the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006). The latter classification identifies the following main sectors: energy; industrial process and product use; agriculture, forestry and other land use; waste and other sectors.

These main sector categories are further divided into:

- Activities, e.g., 'fuel combustion activities' within 'energy', and 'product uses as substitutes for ozone-depleting substances' within 'Industrial processes and product use'; and
- Sub-sectors, e.g., transport, energy industries.

Possible sectors for adaptation as applied in past TNAs include health and social systems, agriculture and fisheries, coastal zones and water.

Once the priority (sub)sectors have been identified, stakeholders could move on with considering potential technologies (and measures) for mitigation and adaptation for these (sub)sectors. Within the different categories explained earlier,[14] technology options and measures can be identified and information on them gathered. The TNA process subsequently helps country stakeholders to 'personalise' this information to the country's decision context. For instance, stakeholders can estimate the technical potential of a technology option within the country (i.e., if there were no technical and implementation barriers) by concluding that, e.g., based on the country's water resources, hydro power could potentially produce 30% of the country's electricity needs.

The benefit of translating generic technology information to national contexts was also illustrated in the ENTTRANS (2008) study which showed that several stakeholders seemed to assume that technologies that had not been used in their country before would be more expensive than existing technologies and would therefore be more risky. This resulted in lower suitability scores for these technologies. 'Personalisation' would thus help stakeholders to obtain a clear view of the potential role of technology options and measures within each prioritised (sub)sector and related benefits.

At this stage of the assessment, stakeholders can use the information gathered to assess technology benefits, in terms of how they could contribute to the country's development goals, reduce GHG emissions or make the country less vulnerable for a changing climate. Again, just as with the (sub)sector prioritisation, the criteria used for scoring the benefits could be derived from the development priorities determined at the beginning of the process. In addition, financial performance and costs of technology options and measures can be assessed by, e.g., analysing internal rates of return.

[13] See http://cdmpipeline.org/cdm-projects-type.htm. Accessed 23 September 2011.

[14] Small scale/short term, small scale/long term, large scale/short term, and large scale/long term.

Fig. 2.9 Weighted scoring results for example technology options category (Example taken from the support tool *TNAssess,* available at http://climatetechwiki.org.)

After valuing (scoring) technology benefits, stakeholders can determine the relative importance of the criteria by weighting them. For example, if, for a particular criterion, the difference between the most and least preferred technologies is very small, stakeholders could give a low weight to this criterion, as it would not make much difference which technologies would eventually be chosen. However, if this small difference was thought to be still significant in effect, then a higher weight is given. Similarly when the difference between technology scores for one criterion is large, stakeholders can find this difference very important and therefore assign a large weight to it.[15]

Figure 2.9 shows an example of the possible outcome of the process of scoring the technology options or measures on the benefit criteria and weighting these criteria. The final assessment of an option is the sum, over all the criteria, of the weight times the scores.

[15] For instance, if in a country with high unemployment one technology will have strongly positive employment impacts, whereas another technology will have hardly any employment benefit at all, then stakeholders can give a large weight to these scores so that the technology with the strong employment benefit would eventually receive a higher ranking.

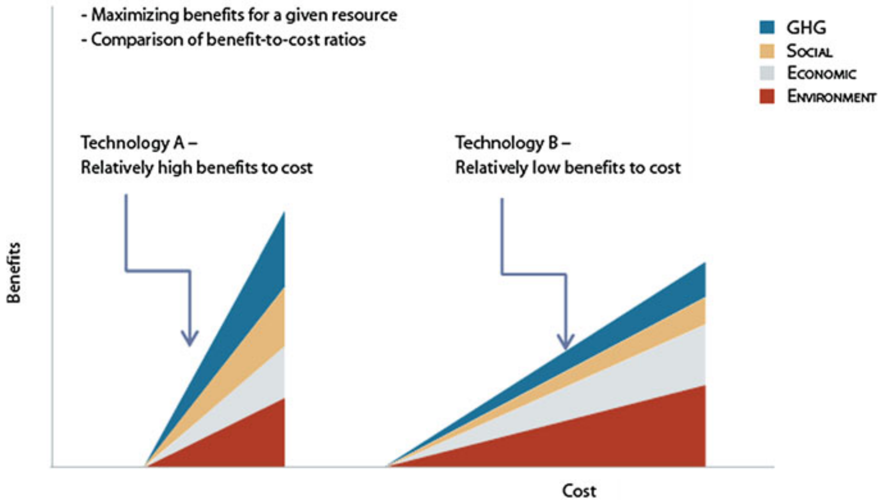


Fig. 2.10 Example of cost-benefit ratio in TNA (This diagram expresses benefits on a scale from 0 to 100 and the costs in monetary values. In this example, technology A is preferred over B as it has relatively low costs and high benefits. Other forms of cost-benefit assessments are also possible and further information about these and why this MCDA was chosen in the updated TNA process, can be found in UNDP (2010, pp. 53–55 and pp. 136–142).)

Not only does the diagram show which technologies within a sector (in this case, short-term and small-scale technologies in the Public transport subsector) have the highest weighted score but it also shows how this score has been built up with climate, environmental, economic and social development benefits.

The robustness of the resulting lists of prioritised technologies per category within a (sub)sector can be checked by sensitivity analysis on different opinions among stakeholders and by exploring uncertainties and the difference they make to the final result. Finally, for making final decisions on priority technology options, benefits from technology options can be compared with a technology's capital and operational costs. An example of such a benefit-to-cost analysis is presented in Fig. 2.10.

The main output of an assessment of low-emission and climate-resilient technology needs for sustainable development, such as in the new TNA process, is a portfolio of technology options and measures that have been assessed as potentially delivering the largest combined climate and sustainable benefits within the country's strategic sectors for low-emission and low-vulnerability development. Table 2.1 shows a hypothetical example of an output table for prioritised technologies for cooking in the subsector of *Residential and offices* in a developing country. The table shows the potential benefits and costs of technology options should they be implemented in the subsector at their technical potential.

Table 2.1 Example of TNA summary table for prioritised cooking technologies in subsector of 'Residential and Offices' in a developing country

Priority technologies identified for cooking in Residential and offices sector	Potential GHG abatement until 2025 at (sub)sector level	Benefits identified from multi criteria decision analysis for technology in TNA	Estimated lifetime costs per technology within (sub)sector (US$)
Short-term/small-scale technologies			
Biogas for cooking and electricity	3.4 Mt CO_2-eq	Improved health because of reduced in-house smoke Reduced drudgery for women and children because of reduced need of firewood Reduced poverty at farms	17,000,000
Charcoal production for cooking and heating	2.7 Mt CO_2-eq	Enhanced carbon sink and moisture reservoir Enhanced household energy security Greater entrepreneurial opportunities created through sales of poles and firewood Time spent daily on gathering fuel wood is saved for use in more productive activities	25,000,000
Short-term/large-scale technologies (none prioritised in this TNA)			
Long-term/small-scale technologies			
Solar cookers	3.8 Mt CO_2-eq	Time savings which results from the reduction in wood gathering Build and emphasise links with women's empowerment by creating new organizations led by women The impact of solar stoves on the household economy depends on the organisation of the household economy and the extent to which the household is linked to the wider economic network Improvement of health conditions, promotion on equitable access to energy and poverty alleviation	34,000,000
Long-term/large-scale technologies (none prioritised)			

Source authors' example based on UNDP (2010, Chap. 5, Tables 5.3–5.6).

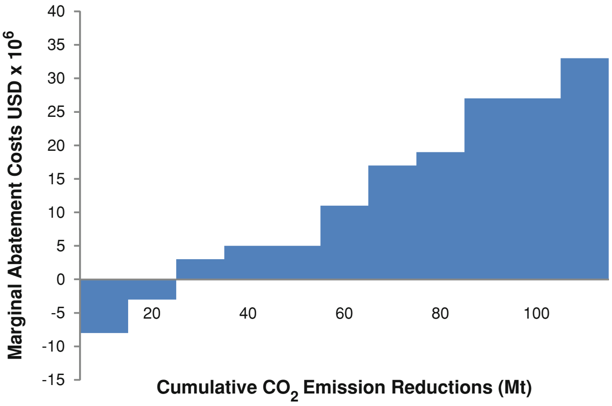


Fig. 2.11 Example of marginal abatement cost curve (*source* authors' example)

2.5.4 Comparison with Cost Curves for Prioritisation

As an alternative approach to selecting suitable technologies with help of an MCDA, marginal abatement cost curves have been used, even though these were originally designed for estimating abatement potentials. In essence the principle is simple. A graph is generated for a country where mitigation measures are costed and put in order of increasing cost for each next (marginal) tonne of GHG reduced (as shown in Fig. 2.11).

Technologies are selected basically in terms of cost efficiency for GHG emission reduction, with the cheapest option first. Some technologies can provide positive monetary savings and this is taken into account both in cost curves and in the MCDA benefit-to-cost approach explained earlier.

In comparison with the MCDA approach as described previously, there could be several problems with using cost curves because they explicitly rate on the cost efficiency for reduction of GHGs with no consideration of sustainable development benefits implying that only cost efficiency of reductions is important. They compare technologies with costs at a specific time which are soon outdated and compare, on the same curve, costs and reductions from, e.g., biogas compared with carbon capture and storage, etc., which are not readily comparable. There can also be large uncertainties in the calculation of reductions. Other problems that could occur in the generation and use of cost curves for technology prioritisation are summarised in Box 2.5.

It is also not clear how the development benefits are taken into account and traded off against this cost efficiency when cost curves are used for a low-emission strategic assessment. The new TNA process, by contrast, maximises over all the benefits for a given cost and is therefore more overall cost efficient for resource allocation.

It has always been recognised that cost curves have advantages and weaknesses and there has recently been some debate about the appropriateness of cost curves for some applications. They have recently been used in the context of Reduced Emission from Deforestation and Degradation schemes (REDD) and for carbon abatement assessment where their use has been strongly criticised for failing to take account of the complexity of many initiatives with negative consequences for deforestation (Greenpeace 2011). This complexity also applies to technologies to be transferred.

Box 2.5 Marginal abatement cost curves and project level assessment[16]
As an example of a Marginal Abatement Cost (MAC) curve, consider the case of energy supply technologies. A cost-effectiveness analysis will essentially develop a GHG abatement cost curve that will rank each technology in the order of its cost-effectiveness for reducing a tonne of CO_2-equivalent emissions. This ranking is typically represented in the form of a curve, as shown in Fig. 2.11.
The identification of priority (sub)sectors and technologies could use as a criterion US$/tonne GHG abatement or MAC curves. A MAC curve would calculate for a country or a group of countries the cost of an additional tonne of GHG emission reduction. These costs depend on the technology with which that marginal emission reduction is achieved. A cost-effectiveness analysis based on costs/tonne GHG abatement could be carried out at the project or plant level, and it would involve total capital costs and operating and management costs divided by the project's total GHG emission reduction. This could be expressed as an annual cost/GHG benefit.
Each point on this curve represents the cost-effectiveness of a given technology relative to the cumulative GHG emission reduction potential achieved when compared with the technology currently used in the country. The points on the curve appear sequentially, from most cost-effective in the *lower left area* of the curve to the least cost-effective options located higher in the cost curve in the *upper right area*.
There are several sources of MACs and it is important to be aware of the following caveats on their use:

1. MAC curves are generated by an analyst. They may not represent the full picture in terms of all abatement technology options to meet development needs. It may not be valid to use them out of the context and time in which they were derived.
2. Many MAC curves cover mainly CO_2 reduction and baselines against which reductions are calculated may be uncertain.[17]

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[16] This box has been reproduced from UNDP (2010, pp. 53–55).

[17] The US EPA (US 2006) study covers options for reducing GHGs other than CO_2, including methane. The MAC curve developed by Bakker et al. (2007) combines a large set of bottom-up country abatement studies and covers a large share of abatement options in all sectors and (sub)sectors, including electricity, industry, transport, buildings, waste, agriculture, forestry and land use for most non-Annex I countries. Inevitably, however, these cost curves do not include the full set of mitigation options. The McKinsey and Company (2009) cost curves also have a broad sectoral coverage.

2. In many other studies, mainly the electricity supply (sub)sector is analysed though some industry efficiency, transport, and forestry may also be included (e.g., Bakker et al. 2007). The focus tends to be mainly on large-scale technologies used in centralised grid systems. The decision on which technology is selected is made by the authors who have constructed the MAC curve graph.
3. In some studies, decisions are based on model simulations (Ellerman and Decaux 1998) and expert judgment to derive abatement potential and average costs. Technologies tend to be bundled (e.g., energy efficiency measures) so that individual technologies are not explicitly analysed.
4. Some data on which the MAC curves are based can be quite old. New technologies for low-emission and low-vulnerability development may not be included and studies can become out of date quite quickly.
5. The original data for calculations may cover a range of methods and assumptions that are not necessarily all robust or compatible.
6. In some cases, no-regret options are not identified so that these activities, which would save money and reduce emissions but face other implementation barriers, do not appear on the cost curve. However, not appearing on the MAC curve does not mean these options do not exist. In the case of demand side technologies to reduce GHG emissions from fossil fuel combustion, there are many technologies that have negative costs (i.e., there are net societal benefits from introducing the technology as opposed to net societal costs).
7. Traditionally, the cost calculations used in constructing MAC curves do not take into account co-benefits of mitigation options, e.g., for air quality. In a proper societal abatement cost assessment, these should be included, resulting in significantly lower abatement costs for many options (see Johnson et al. 2009). These are included in the MCDA.
8. Cost curves also compare technologies irrespective of size, e.g., biogas is compared with carbon capture and storage and irrespective of technology innovation stage (e.g., RD&D or diffusion). This is not useful in identifying technologies that currently may have high costs but that deliver multiple benefits of interest to the country and therefore may be subsidised until costs fall through dissemination into the market or system.

2.6 Meeting the Challenge: Transferring Technologies and Measures for Maximum Climate and Sustainable Development Benefits

In this chapter, we have explained the challenge of identifying low-emission and climate-resilient technologies in light of developing countries' short-, medium- to long-term sustainable development objectives.

We have discussed how climate and development policy making has increasingly become interrelated and that climate policy measures in developing countries will only stand a chance of success if in line with development goals. Finally, we have discussed the key role of technology development and transfer in low-emission and climate-resilient development.

The first stage of the TNA process was then described involving the alignment of sustainable development and climate goals for the selection of priority subsectors. The selection of priority technologies in each subsector categorised according to size and stage of development in terms of availability in the short or medium to long term was then described using an MCDA allowing estimation of overall benefits across climate and sustainable development goals. These benefits were then compared with costs and technologies selected on the basis of maximising the benefit-to-cost ratio. The new tools of ClimateTechwiki and TNAssess to support the selection process were described. Where possible some comparisons with other approaches such as cost curves have been made.

The main outputs from this first stage of the TNA process are a portfolio of priority technologies in priority subsectors; an assessment of their overall sustainable development and climate benefits; the costs of the technology at the unit and potential in the subsector, and a comparison of the costs of the technology at the relevant scale to the benefits for maximising the benefit-to-cost ratios for final selection as shown in Table 2.1.

However, we have also underlined, based on earlier experience with TNAs conducted in developing countries, that identifying technologies alone is not the whole story but will need to be supported by overarching strategies for creating an enabling environment for successful deployment and diffusion of the prioritised technologies. At this stage of a needs assessment, country groups can take different perspectives.

For example, the groups could mainly aim at implementing the prioritised technologies as projects. In that case, the main focus would be on identifying technology project barriers and how to address these barriers in the technology project level strategy.

Obviously, when the number of such projects is sufficiently large within a country, it can have an effect on the rest of the economy; such projects could help to improve the overall investment climate in the country for low-emission and low-vulnerability development. However, a project-level perspective runs the risk that projects become stand-alone initiatives and that the diffusion of the technology innovation at the required scale will not occur (ENTTRANS 2008, Chap. 8).

Instead of a project perspective, a country could in their TNAs also take a more strategic perspective by looking at a technology's technical or economic potential and analyse what would be needed to make application of the technology at that scale possible.

The description of the process continues in the next chapter with an analysis of what would be needed to make a priority technology work in the country, either as a project or diffused through a sector or at the national level. For a technology project, barriers would need to be identified and addressed to make a project work, whereas for a sector or country-level strategy, the analysis would focus on improving systems and markets so that priority technologies can be applied at the desired scale.

In the next chapter, how the actions can be identified for addressing technology barriers and bottlenecks and how they can form inputs for formulating technology development and transfer strategies for a technology, within a sector and nationally, will be explained as well as capacity building and finance needs for that.

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