MODULE 5
Mitigation Scenarios

NAMAs in the refrigeration, air conditioning and foam sectors. A technical handbook.

On behalf of:

Federal Ministry
for the Environment, Nature Conservation,
Building and Nuclear Safety

of the Federal Republic of Germany

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Proklima is a programme of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Since 2008 Proklima has been working successfully on behalf of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) under its International Climate Initiative (IKI) to promote ozone-and climate friendly technologies.

Proklima provides technical assistance for developing countries since 1996, commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) to implement the provisions of the Montreal Protocol on substances that deplete the Ozone Layer.

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The International Climate Initiative

Since 2008, the International Climate Initiative (IKI) of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) has been financing climate and biodiversity projects in developing and newly industrialising countries, as well as in countries in transition. Based on a decision taken by the German parliament (Bundestag), a sum of at least 120 million euros is available for use by the initiative annually. For the first few years the IKI was financed through the auctioning of emission allowances, but it is now funded from the budget of the BMUB. The IKI is a key element of Germany's climate financing and the funding commitments in the framework of the Convention on Biological Diversity. The Initiative places clear emphasis on climate change mitigation, adaption to the impacts of climate change and the protection of biological diversity. These efforts provide various co-benefits, particularly the improvement of living conditions in partner countries.

The IKI focuses on four areas: mitigating greenhouse gas emissions, adapting to the impacts of climate change, conserving natural carbon sinks with a focus on reducing emissions from deforestation and forest degradation (REDD+), as well as conserving biological diversity. New projects are primarily selected through a two-stage procedure that takes place once a year. Priority is given to activities that support creating an international climate protection architecture, to transparency, and to innovative and transferable solutions that have an impact beyond the individual project. The IKI cooperates closely with partner countries and supports consensus building for a comprehensive international climate agreement and the implementation of the Convention on Biological Diversity. Moreover, it is the goal of the IKI to create as many synergies as possible between climate protection and biodiversity conservation.

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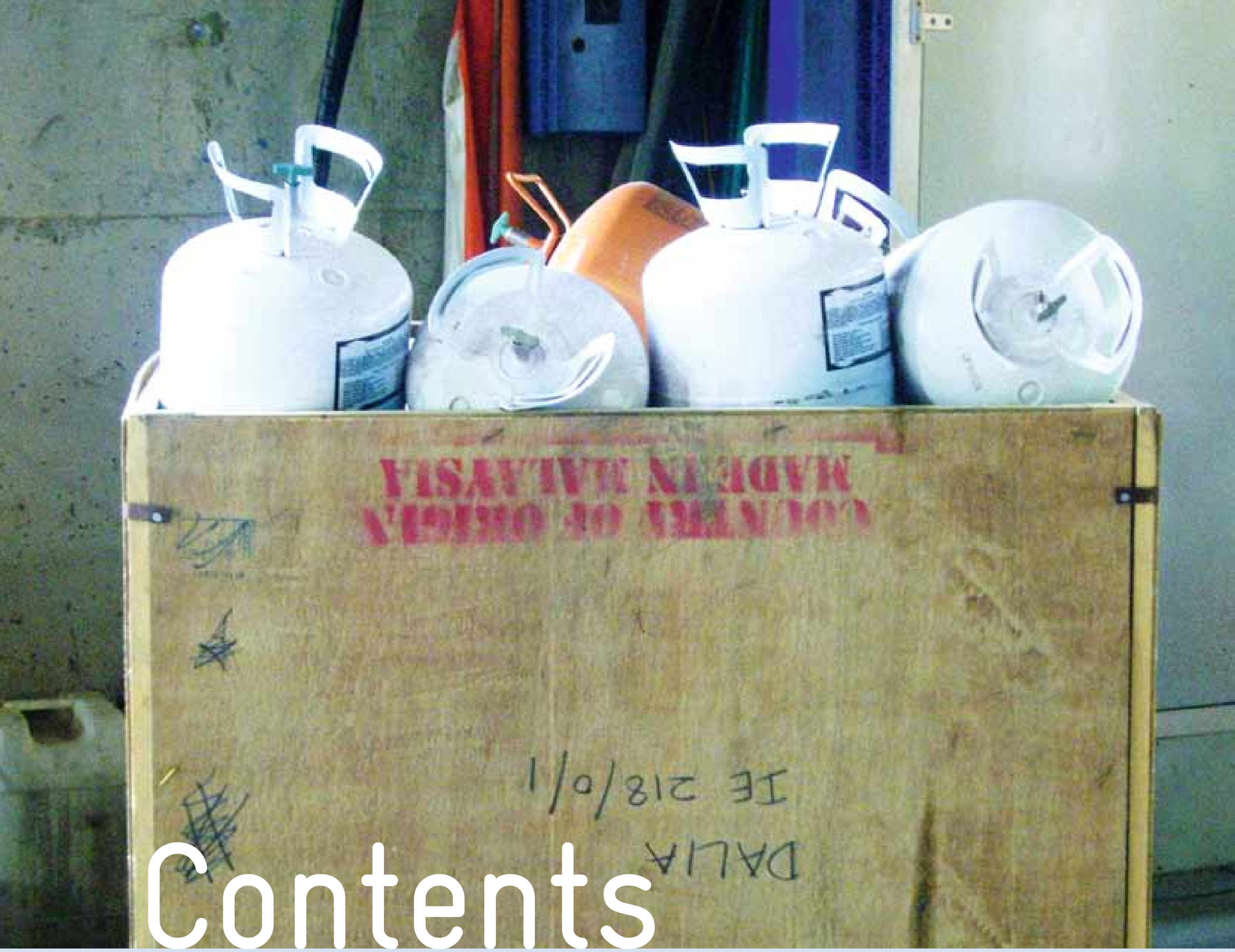

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Executive Summary

The purpose of nationally appropriate mitigation actions (NAMAs) is to achieve a reduction of emissions relative to a business-as-usual (BAU) emission scenario. Thus, the effect of a planned NAMA in a country can be demonstrated by comparing mitigation scenarios to the business-as-usual scenario. Mitigation scenarios show alternative emission pathways and highlight the emission reduction potential in the RAC&F sectors.

Mitigation options in the refrigeration, air conditioning and foam (RAC&F) sectors are any actions to reduce direct and indirect emissions. These emission reductions can be achieved by replacing the refrigerant or blowing agent (direct emission reduction) or by improving the energy efficiency of the RAC appliance systems (indirect emissions). Various technical options are available to achieve these emission reductions. Similarly, there are several policy options to enforce the introduction of technical options, which include non-regulatory approaches, improvement of regulations, the establishment of phase-down mechanisms or regulatory bans on the production and use of fluorinated gases (F-gases).

The first step is to generate a BAU scenario. This scenario is based on standardised systems, which build the so called baseline or reference. These standardised systems are defined by characteristic features regarding refrigerant leakage rates, initial charge, etc. or blowing agents in foam products. The future scenarios can be generated by using models (cf. module 1). These models make use of detailed bottom-up data from national inventories such as market and production data, in addition to technical parameters and market growth rates. The calculation steps which are implemented in the models to derive emissions demand and banks follow the formulas of the Intergovernmental Panel on Climate Change (IPCC) literature. Thus, the model results can be submitted to the United Nations Framework Convention on Climate Change (UNFCCC) for the purposes of reporting the current situation in a country. This is generally done in the common reporting format (CRF) which is, however, not obligatory for Non-Annex I countries.

In a second step, BAU future projections are generated. Finally, mitigation scenarios are created that include specific technical options. The technical options deviate from the standardised systems. They may introduce an alternative refrigerant or blowing agent or reduce leakage. These deviations are the basis for the mitigation scenarios. Comparing the BAU scenario with the mitigation scenarios highlights the mitigation potential.
This potential can be shown for any aggregated level, on the country level (high aggregation), the sector- and subsector level, and finally for single appliance systems (disaggregated). Determining the mitigation effect which will be achieved by NAMA measures provides policy-makers evidence on which they may base their choice of specific subsectors and technical options. A tool is provided together with this module, the so-called Mitigation and Cost tool. The tool shows the BAU and mitigation scenarios for specific appliances and various technical options, based on the inventory data from module 1. Additionally, the marginal abatement costs are given for each technical option.

While priority should be given for subsectors with a high overall reduction potential, costs also need to be considered. This is why both components are explored in combination and depicted in marginal abatement cost curves (MACCs, cf. module 4). These curves not only display the reduction potential but also display the costs that are involved by introducing certain technical options.

1. Introduction

The purpose of NAMAs is to achieve a reduction of emissions relative to a BAU emissions scenario. The effect of a planned NAMA can be demonstrated by comparing mitigation scenarios to the business-as-usual scenario. NAMAs incorporate various mitigation actions, i.e. actions that reduce greenhouse gas emissions.

Mitigation options in the RAC&F sectors are any actions to reduce direct and indirect emissions. Direct emission reductions can be achieved by replacing the conventional refrigerant or blowing agent, which will typically have high ozone depleting potential (ODP) and high global warming potential (GWP), by low-GWP or zero-GWP refrigerants, such as unsaturated HFCs or natural refrigerants like carbon dioxide (CO_2) or ammonia (NH_3). Indirect emissions may be reduced by improving the energy efficiency of the appliance systems (for RAC sectors), but also through decarbonisation of the energy market and supplying RAC appliances with renewable energy (cf. module 3). A NAMA in the RAC sectors focuses on direct and indirect emission reductions while a NAMA in the foam sector targets direct emissions only. The reduction of the carbon content of the energy supply is not further considered in this handbook.

There are diverse policy options to enforce the introduction of technical options which in turn reduce the overall emissions. These policy options include non-regulatory approaches, changes of regulations (e.g. the EU F-gas legislation), establishment of phase-down mechanisms or regulatory bans of production and use of F-gases. Often these policy options remove barriers (cf. module 3) that had interfered with the widespread introduction of a technical option until then. The focus of this module is on the mitigation effects that result from the introduction of technical options, irrespective of the underlying motivation.

Mitigation scenarios in the RAC&F sectors show future projections of demand, banks and emissions. Of these elements, emissions are of highest interest in the context of NAMAs. Mitigation emission scenarios show alternative emission pathways and highlight the emission reduction potential by comparing these projections with the business-as-usual projections. Mitigation scenarios make the reduction potential of different subsectors visible and quantifiable. This information may support policy-makers, providing them evidence on which they may base the choice of specific subsectors and technical options for a NAMA. While priority should be given for subsectors with a high overall reduction potential, costs also need to be considered. This is why both components are explored in combination (cf. module 4) and visualised in marginal abatement cost curves (MACC).

Mitigation scenarios might also represent a fundamental element of a Measurement, Reporting and Verification (MRV) system in the RAC&F sectors (cf. module 7), which is of major importance for setting up NAMAs.

Generally, either the most cost-effective technical option or any other pre-defined technical option can be used to generate emission scenarios. An alternative application of mitigation scenarios is to start with a climate vision. The vision might be defined as reducing the business-as-usual emissions in the RAC&F sectors by 60 % (cf. Heubes, et al. 2012). This roughly corresponds to the reduction target of the BLUE Map scenario, as formulated by the International Energy Agency (IEA) in 2008 for the transport, industry and buildings sector (Taylor, 2008). The BLUE Map scenario is in line with the 2°C target, which is now commonly accepted by most countries. The technical options – or combination of technical options – must then be defined in order to meet the 60 % reduction target.

In this module we focus on the general procedure of building mitigation scenarios. Scenarios can be shown at the country level but may easily be extended to the regional or global level.

2. Methodology

In this module we focus on mitigation scenarios which are derived from the application of alternative technical options (cf. module 3) and their respective emission abatement effects (cf. module 1 and annexes). Although the methodology here focuses on RAC systems, it is equally applicable for foam applications. The calculation steps follow the Tier 2a emission factor approach (IPCC 2006) and are based on a detailed inventory which was described in module 1. Firstly, the bottom-up data are used to build the BAU scenarios. In a second step mitigation scenarios are derived by modifying key parameters in the model settings. The parameter modifications correspond to the technical options as defined in module 3. Thus, detailed inventory data are essential to create mitigations scenarios. The underlying calculations of emissions are consistent with the UNFCCC guidelines (IPCC 2006).

In this handbook, we differentiate between two mitigation scenarios: The Direct Emission Reduction (DER) scenario introduces technical options which reduce direct emission only. The Direct Emission Reduction plus Energy Efficiency (DEREE) scenario additionally considers indirect emission reductions by improving the energy efficiency. Thus, we can separately highlight the effects of both emission sources and the corresponding reduction potential.

As already highlighted in module 4, one needs to define standardised systems as BAU systems in the RAC&F subsectors in order to estimate the baseline emissions. The design of the standardised system should be representative for the majority of systems found in the different subsectors. Important technical and market parameters that have to be defined and that influence direct and indirect emissions are:

- Initial charge (kg) and the dominant refrigerant that is used in the system,
- Dominant blowing agent used in polyurethane (PU)/polystyrene (PS) foam,
- Emission factors (%),
- Average cooling capacity (kW),
- Average coefficient of performance (COP),
- Annual growth rates,
- Runtime ratio of the systems (describing annual runtime hours),
- Emission factor for electricity and motor gasoline, respectively (t CO_2/MWh).

The last two parameters of the list above are necessary to calculate the energy consumption of the appliances and the associated indirect emissions. Key parameters for a standardised centralised system in the subsector commercial refrigeration are given in Table 1. In addition, the table comprises the modified values of these parameters relative to the standardised system for five technical options. The modified parameters build the basis for the mitigation scenario, exemplarily shown for systems that are commonly used in large supermarkets.

To derive the BAU scenario one needs additional information on the growth rates, i.e. how many of these systems will be sold and used in the country. The stock, i.e. the number of equipment in place in the country, as well as the domestic sales figures need to be determined. This information is gathered by national inventories (cf. module 1). The derived data on stock and sales figures, together with the defined technical parameters, are entered in a vintage bottom-up stock model. These types of models are powerful tools to simulate future emissions of fluorinated substances and indirect emissions. They are also used to simulate future banks and demand of refrigerants. Based on the defined standardised systems and the inventory data, the business-as-usual scenarios can be generated. They serve as reference scenarios to estimate the future potential for emission reductions, i.e. the mitigation potential.

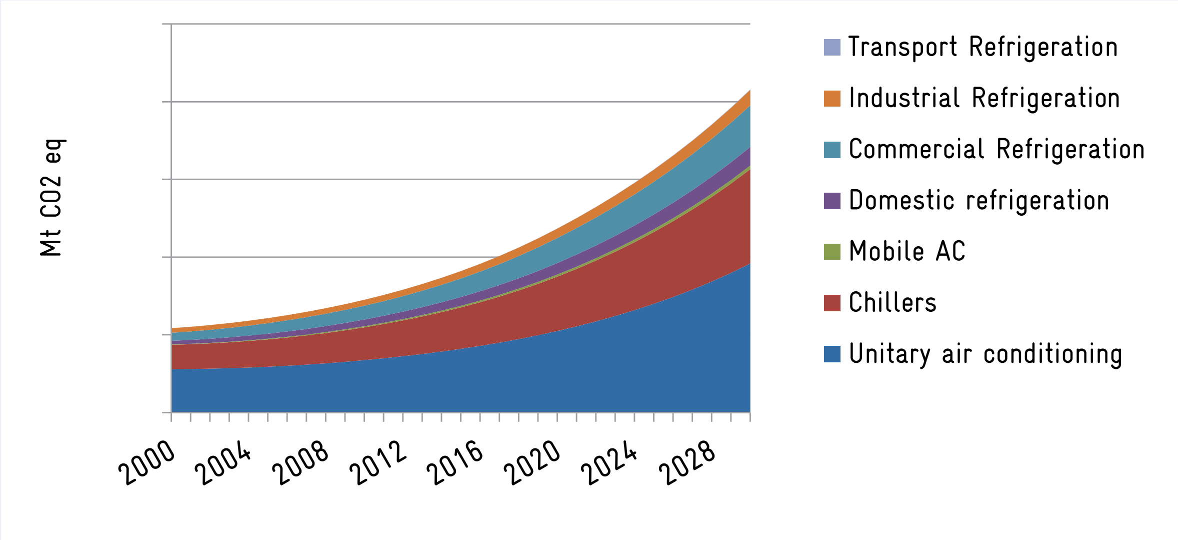
Several tools are provided together with this handbook: the HFC Inventory and Projection tool (see module 1), which not only allows calculating current HFC emissions, but also calculates future BAU emissions based on estimated growth rates. In case relevant stock data can not be collected during the inventory, the Country Cooling Needs Stock Forecasting Model (CCNSFM) might be used as a tool to close this gap. Finally, the Mitigation and Cost tool, provided with this module, shows appliance-specific BAU emissions and mitigation scenarios, which correspond to various technical options. Also the marginal abatement costs are shown in this tool.

TABLE 1
Key parameters of a standardised centralised system, as used in large supermarkets (light blue shading). The parameters are used to derive a BAU emission scenario. Below are the modified values of these parameters in percent relative to the standardised system for five technical options. The modified values are the basis for the mitigation scenario.

	Description of technical option (TO)	Refrigerant	Initial charge (kg)	Manuf. emission factor (%)	In-use emission factor (%)	Disposal emission factors (%)	Cooling capacity (kW)	COP	Max. techn. penetration rate
Standardised system		HFC-404A	230	5	35	100	100	2.5	100%
TO 1	R744	R744	50%	–	–	–	–	130%	90%
TO 2	Low-GWP + liquid secondary (centralised)	low-GWP	20%	–	–	–	–	130%	90%
TO 3	Low-GWP + evap secondary (centralised)	low-GWP	20%	–	–	–	–	130%	90%
TO 4	Low-GWP + cascade (centralised)	low-GWP	20%	–	–	–	–	130%	90%
TO 5	Low-GWP + distributed water-cooled (centralised)	low-GWP	30%	–	–	–	–	130%	90%

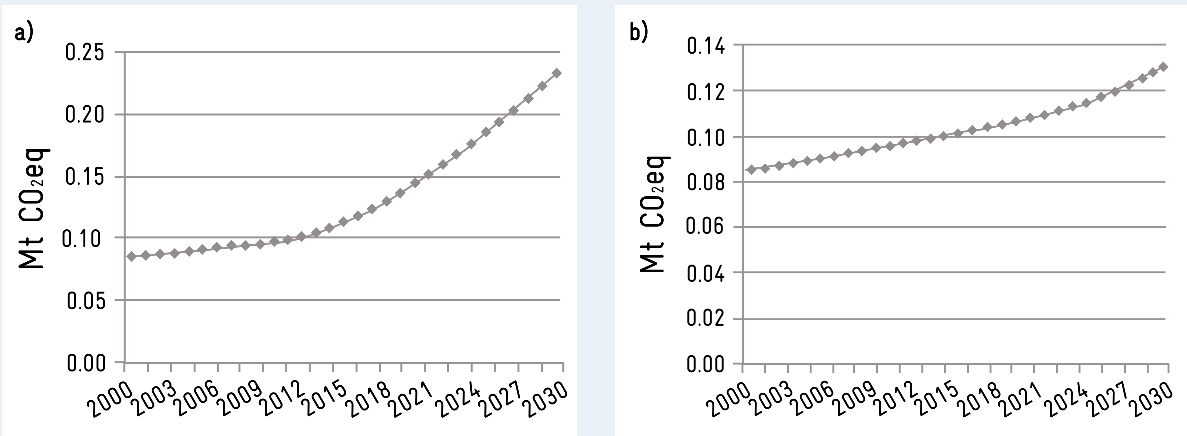
Using vintage bottom-up stock models, the mitigation potential can be demonstrated in a quantitative manner for each sector, subsector and appliance system. The detailed calculation steps to derive the business-as-usual emissions, demand and banks with the model are given in annex 1 to module 1. The BAU simulations for total emissions (CO_2eq) are shown for the RAC sectors of an exemplary Asian country with a growing economy (Figure 1). Unitary air conditioning and chillers contribute immensely to the overall emissions in this example. These simulations represent the BAU reference scenario and mitigation scenarios can be compared against it.

FIGURE 1
Total BAU emissions (direct plus indirect) in RAC subsectors; exemplary Asian country



The modelling results can also be shown for individual appliance systems. Figure 2 shows the business-as-usual emission projections that arise from centralised systems of the commercial refrigeration subsector. These emission projections can be split into direct and indirect emissions (Figure 2a) and b)). The BAU simulations represent the reference scenario and mitigation scenarios can be compared against it.

FIGURE 2
a) Direct and b) indirect BAU future emission projections of centralised systems (commercial refrigeration); exemplary Asian country



In a second step, we have to define technical options for the standardised systems (cf. module 3), which build the basis for the mitigation scenarios. Any of the technical options given in module 3 may be introduced here. However, we suggest pre-selecting a maximum of five technical options for each application system according to the country-specific situation (cf. module 3). A possible selection of technical options for each appliance system is shown in Table 2.

TABLE 2
Suitable technical options (TOs) and the corresponding alternative refrigerants for building mitigation scenarios in the RAC subsectors

Subsector	Appliance systems RAC	TO #	TO description	Alternative refrigerant
Unitary air conditioning	Self-contained air conditioners	1	HC R290/ R1270	HC-290
		2	unsat.-HFC	unsat.-HFC
		3	Low-GWP + liquid secondary (centralised)	low GWP
		4	Low-GWP + district cooling	low GWP
	Split residential air conditioners	1	Leak reduction (design/constr.)	no change
		2	HC R290/ R1270	HC-290
		3	Low-GWP + district cooling	low GWP
	Split commercial air conditioners	1	Leak reduction (design/constr.)	no change
		2	Leak reduction (maintenance)	no change
		3	HC R290/ R1270	HC-290
		4	Low-GWP + district cooling	low GWP
	Duct split residential air conditioners	1	Leak reduction (design/constr.)	no change
		2	Leak reduction (maintenance)	no change
		3	HC R290/ R1270	HC-290
		4	Low-GWP + district cooling	low GWP
	Commercial ducted splits	1	Leak reduction (design/constr.)	no change
		2	Leak reduction (maintenance)	no change
		3	HFC/unsat.-HFC blends	unsat.-HFC
		4	Low-GWP + liquid secondary (centralised)	low GWP
		5	Low-GWP + district cooling	low GWP
	Rooftop ducted	1	Leak reduction (design/constr.)	no change
		2	Leak reduction (maintenance)	no change
		3	Low-GWP + liquid secondary (centralised)	low GWP
		4	Low-GWP + district cooling	low GWP
	Multi-splits	1	Charge size reduction	no change
		2	unsat.-HFC	unsat.-HFC
		3	Low-GWP + liquid secondary (centralised)	low GWP
		4	Low-GWP + district cooling	unsat.-HFC
Chillers		1	Leak reduction (design/constr.)	no change
		2	Leak reduction (maintenance)	no change
		3	HC R290/ R1270	HC-290
		4	R717	R-717
		5	Low-GWP + district cooling	low GWP

TABLE 2
Suitable technical options (TOs) and the corresponding alternative refrigerants for building mitigation scenarios in the RAC subsectors

Subsector	Appliance systems RAC	TO #	TO description	Alternative refrigerant
Chillers	Process chillers	1	Leak reduction (design/constr.)	no change
		2	Leak reduction (maintenance)	no change
		3	HC R290/ R1270	HC-290
		4	R717	R-717
		5	unsat.-HFC	unsat.-HFC
Mobile AC	Car air conditioning	1	Leak reduction (maintenance)	no change
		2	HC R290/ R1270	HC-290
		3	R744	R-744
		4	unsat.-HFC	unsat.-HFC
	Large vehicle air conditioning	1	Leak reduction (design/constr.)	no change
		2	Leak reduction (maintenance)	no change
		3	Charge size reduction	no change
		4	Recovery and recycling	no change
Domestic refrigeration	Domestic refrigeration	1	Leak reduction (design/constr.)	no change
		2	Leak reduction (maintenance)	no change
		3	Charge size reduction	no change
		4	HC R600a	HC-600a
Commercial Refrigeration	Stand-alone equipment	1	Leak reduction (design/constr.)	no change
		2	Leak reduction (maintenance)	no change
		3	HC R600a	HC-600a
		4	HC R290/ R1270	HC-290
	Condensing units	1	Leak reduction (design/constr.)	no change
		2	R744	R-744
		3	unsat-HFC	unsat HFC
		4	Low-GWP + liquid secondary (discrete)	low GWP
	Centralised systems for supermarkets	1	R744	R-744
		2	Low-GWP + liquid secondary (centralised)	low GWP
		3	Low-GWP + evap. secondary (centralised)	low GWP
		4	Low-GWP + cascade (centralised)	low GWP
		5	Low-GWP + distributed water-cooled (centralised)	low GWP

TABLE 2
Suitable technical options (TOs) and the corresponding alternative refrigerants for building mitigation scenarios in the RAC subsectors

Subsector	Appliance systems RAC	TO #	TO description	Alternative refrigerant
Industrial Refrigeration	Integral	1	Recovery and recycling	no change
		2	HC R600a	HC-600a
		3	HC R290/ R1270	HC-290
		4	R744	R-744
	Condensing units	1	R717	R-717
		2	R744	R-744
		3	unsat-HFC	unsat HFC
		4	Low-GWP + liquid secondary (discrete)	low GWP
	Centralised systems	1	Low-GWP + liquid secondary (centralised)	low GWP
		2	Low-GWP + evap secondary (centralised)	low GWP
		3	Low-GWP + cascade (centralised)	low GWP
		4	Low-GWP + distributed water-cooled (centralised)	low GWP
Transport Refrigeration	Refrigerated trucks/ trailers	1	Leak reduction (design/constr.)	no change
		2	HC R290/ R1270	HC-290
		3	R744	R-744

When designing the mitigation scenarios, it is possible to choose specific technical options in advance. From the pre-defined set of five technical options per subsector, one may wish to decide which technical option is introduced. In case no choice is made, the decision can be made based on the cost-effectiveness (cf. module 4).

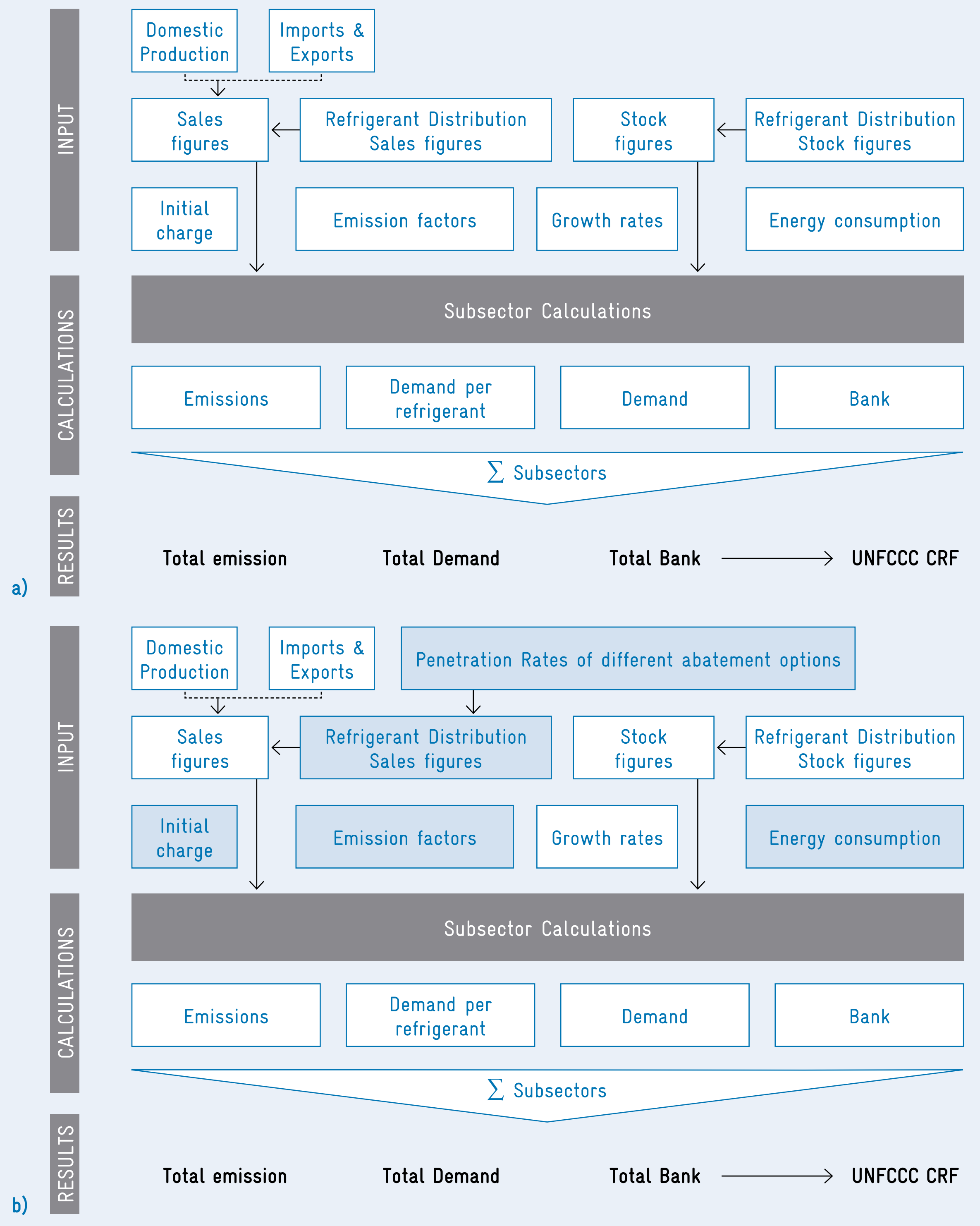
To derive the final mitigation scenarios, again the stock and sales figures have to be considered. It can be assumed that the introduction of technical options will not have any impact on the sales and stock figures and, thus, these parameters are kept constant in the simulations.

Figure 3 shows a schematic overview of the analytical framework to derive emissions, banks and demand with a vintage bottom-up stock model in the RAC sectors. Three steps are involved in defining the business-as-usual emission pathway (baseline):

1. The first step represents the inventory (cf. module 1) where activity data and technical data are collected. The domestic production of appliance systems, imports and exports build the domestic sales figure, which again builds up stock. Additionally, refrigerant distribution must be taken into account, which defines the percentage of the refrigerant in the systems of the sales and stock figures, respectively. The refrigerant distribution is known from the inventory. Further technical parameters, such as initial charge, emission factors, energy consumption of the appliances and growth rates must be gathered, since these strongly influence the output of the model simulations.
2. In a second step, the data is entered into the vintage bottom-up stock-model. Based on suggested calculation methods from the IPCC (IPCC 2007), emissions, demand and banks are calculated for each subsector (cf. annex 1 to module 1).
3. In a third step, these subsector results are summarised to derive the total national emissions, demand and banks. These results can be submitted to the UNFCCC for reporting over the current situation, which is generally done in the common reporting format (CRF).

When setting up a potential NAMA in the RAC&F sectors, the emissions scenario after the introduction of technical options is of greatest interest. To generate mitigation scenarios, we follow the same procedure and use the same calculation steps, but as we refer to technical options, some significant changes are involved. The technical options translate into modified model parameters. The difference between Figure 3a) and b) indicates the modifications that are made in the model. Modifications are indicated by blue shading in Figure 3b) and represent the basis to derive the mitigation scenarios.

FIGURE 3
Schematic overview of the analytical framework to derive simulations of emissions, demand and bank in the RAC sectors by a vintage bottom-up stock model under a BAU scenario and b) the modifications (blue shading) within this analytical framework by introducing technical options.



The penetration of technical options will directly impact the refrigerant distribution of the sales figures which in turn will modify the stock and its corresponding refrigeration distribution. The appliance systems with the newly introduced technical options may show altered initial charge, emission factors and energy consumption (cf. Table 1). These modifications result in reduced emissions. In case a single technical option is selected, which cannot entirely penetrate the market (e.g. due to barriers), conventional technology is maintained to some extent to guarantee market saturation.

When energy consumption of the RAC appliance systems is assumed to remain constant, the resulting scenario is the DER type. When a reduction of energy consumption by increasing the efficiency (realised by increasing the coefficient of performance in the model) is assumed, the resulting scenario is the DEREE type. The DEREE scenario covers both direct and indirect emission reductions.

Comparing the BAU scenario with the mitigation scenarios defines the mitigation potential. The mitigation potential can be shown for any aggregated level, on the country level (high aggregation), the sector- and subsector level, and finally for single appliance systems (disaggregated). The reduction potential is an important information for policy makers. Knowing the potential emission savings associated with the introduction of technical options in the RAC&F sectors will support them in determining the significance of certain subsectors and choosing technical options.

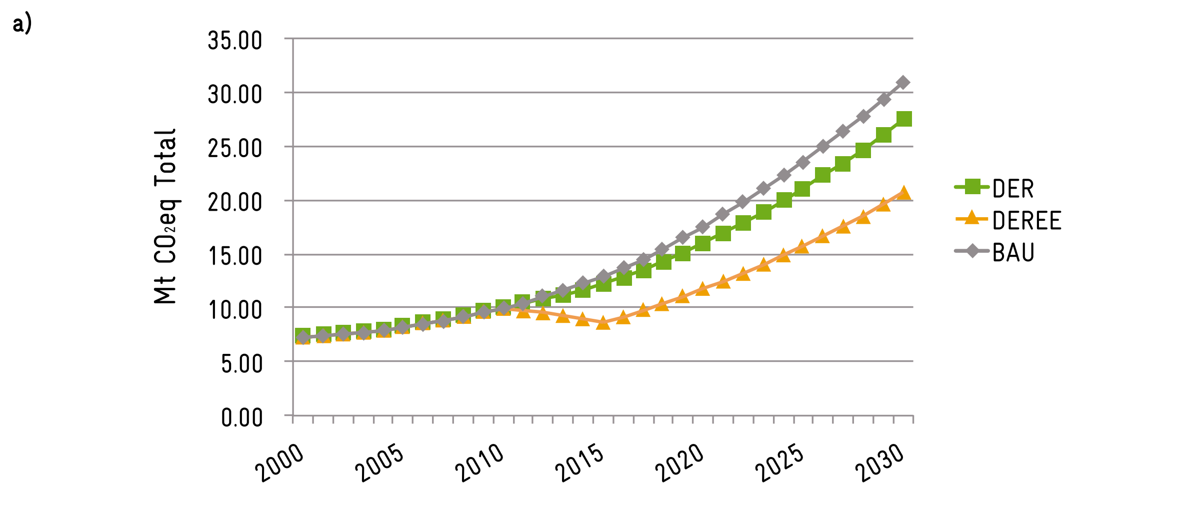
Mitigation scenarios differ with each technical option or combination of technical options. From an economic perspective, the choice for technical options should be based on the cost-effectiveness, expressed as costs per tonne reduced CO_2eq (marginal abatement costs, MACs) plus the co-benefits (see module 10). In that case, a cost threshold should be defined in advance, i.e. the maximum cost one is willing to spend for reducing one tonne of CO_2.

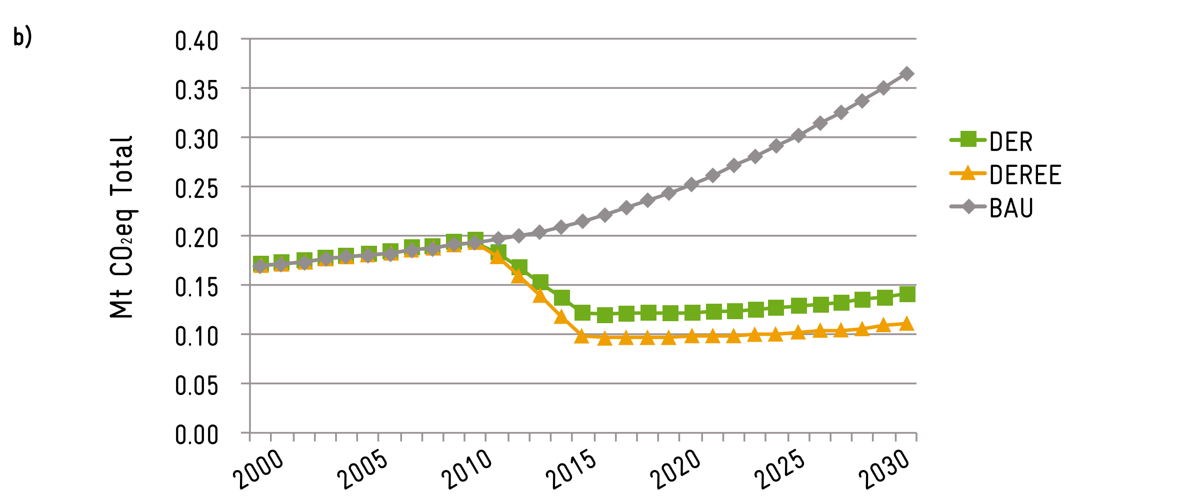
Figure 4 demonstrates the mitigation potential, when implementing a NAMA in selected RAC subsectors. The simulations are based on data which reflect the situation of a typical Asian country with a growing economy. Both the BAU and the mitigation scenarios are shown for two application systems: process chillers (Figure 4a) and centralised systems in the commercial refrigeration subsector (Figure 4b).

The future projections show that strong deviations from the business-as-usual scenario can be achieved by introducing alternative technology. As expected, higher emission reductions are achieved under the DEREE scenario, which additionally accounts for reduced indirect emissions. However, the emission reductions under the two scenarios do not show the same pattern in both appliance systems: Considering process chillers, higher emission reduction potential is given by focussing on indirect emissions rather than direct emission. In other words, the effect of improving the energy efficiency of the appliance systems is higher than the effect of replacing refrigerants or reducing leakages. This holds true for most of the appliance systems of the RAC sectors.

The opposite is found for centralised systems in the commercial refrigeration subsector. This is because centralised systems are characterised by large initial charges (~230kg) and high leakage rates (up to 80 % per $year^{-1}$ in developing countries). Thus, changing the design of these systems, for example by reducing the pipework to distribute the cooled liquid more effectively, and/or substituting the refrigerant, generally has a high mitigation potential and may be more important than improving the energy efficiency.

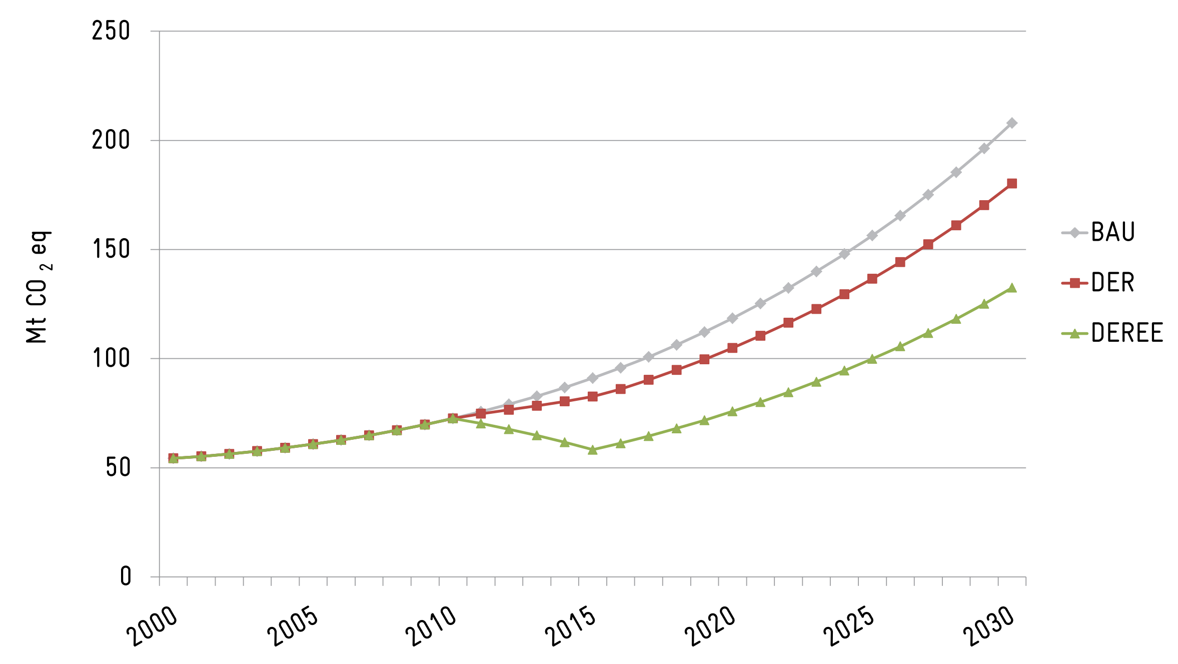
FIGURE 4
Future BAU and mitigation emission projections (CO_2eq) from process chillers a) and centralised systems in the commercial refrigeration subsector b). The emission pattern reflects the situation of an exemplary Asian country with a growing economy.





The emissions from various RAC appliance systems and subsectors can be summarised and displayed for entire countries (Figure 5). The emissions stem from the RAC sectors. The grey line represents the BAU scenario and the DER and DEREE scenario show mitigation scenarios. According to the simulations, the total annual emissions (direct plus indirect) will increase from 50 to around 200 $MtCO_2eq$ in this exemplary country. The two mitigation scenarios point to the strong reduction potential in the RAC sectors, whereby highest reductions are achieved under the DEREE scenario. Here emissions will also increase until 2030, but only reach a level of around 130 $MtCO_2eq$. These mitigation scenarios assume NAMA measures in all RAC subsectors. Although such a scenario is unlikely to be realised, it demonstrates the significance of the RAC sectors with regard to greenhouse gas emissions and the outstanding reduction potential that is possible with NAMAs in these sectors.

FIGURE 5
Future emission projections (CO_2eq) of an exemplary Asian country.



3. Practical application

The illustration below provides a step-by-step guide for setting up mitigation scenarios and deriving the reduction potential by comparing them to the baseline, i.e. the business-as-usual (BAU) scenarios[1].

Alternatively, make use of the tools that are provided with this handbook. The HFC Inventory and Projection Tool introduced in module 1 can be used to generate BAU scenarios for HFCs. In addition to this, a Mitigation and Cost Tool is provided together with this module. The scenarios in the Mitigation and Cost Tool should account for HCFCs and emissions from energy consumption, which is a key aspect for NAMAs in the RAC sectors. Based on inventory data from the DIS-Tool, the Mitigation and Cost Tool shows the BAU scenario as well as the mitigation scenarios for specific appliance systems and for various technical options. This tool also shows the marginal abatement costs that are associated with the different technical options. A detailed description of this tool is given in its cover sheet. Use the Mitigation and Cost Tool to explore different emission pathways. The Proklima team can assist you with creating the scenarios based on complete inventory data.

1 see also GIZ NAMA tool 8.2 Step 2 (GIZ 2012)

Steps for for setting up mitigation scenarios:

1. Define the business-as-usual reference systems for RAC&F sectors

↓

2. Combine stock data and sales figures with the BAU system to establish the BAU scenario

↓

3. Select the technical options for mitigation action

↓

4. Apply the cost threshold (Euro per reduced tonne CO_2eq) for selecting technical options

↓

5. Build the emissions reduction scenario (analogously to BAU scenario under step 2)

↓

6. Calculate the emission reduction potential

Step 1: Define the business-as-usual reference systems for RAC&F sectors

Define the design of standardised appliance systems or foam products for each subsector or application. Build on the reference systems that have already been defined in the chapter 'Practical application' of module 4. The list below shows the key parameters of the standardised systems:

- Initial charge (kg) and the dominant refrigerant that is used in the system
- Dominant blowing agent in PU/PS foams
- Emission factors (%)
- Average cooling capacity (kW)
- Average coefficient of performance (COP)
- Runtime ratio of the systems (describing annual runtime hours)
- Emission factor for electricity and motor gasoline, respectively (t CO_2/MWh)

Additionally, you need estimates of expected future growth rates in the subsectors. The completed DIS-Tool from the inventory (module 1) contains all necessary data to define the standardised appliance systems or foam products.

Step 2: Combine stock data and sales figures with the BAU system to establish the BAU scenario

Enter stock data and sales figures from the inventory (cf. module 1) into a vintage bottom-up model together with technical parameters of the standardised reference systems (from step 1). The calculation steps within the model should be based on the IPCC 2006 guidelines and are described in detail in annex 1 to module 1. The simulations will project the future BAU emissions, demand and bank, against which the mitigation scenarios will be compared. You can derive BAU projections for HFCs with the HFC Inventory and Projection Tool. For BAU projections that account for HCFC and energy consumption use the formulas from annex 1 to module 1. You can also ask GIZ Proklima for assistance with this.

Step 3: Select the technical options for mitigation action

Select five technical options per subsector (see module 3 for guidance). Define the technical option systems analogously to step 1. That is, the same key parameters that have been defined for the reference system, such as initial charge and emission factors, must be defined for the technical option systems. If you have already selected technical option systems in module 4 ('Practical Application, step 4) you may use those.

An example for the design of a reference system and various technical option systems is provided in Table 1 of this module.

Step 4: Apply the cost threshold (Euro per reduced tonne CO_2eq) for selecting technical options

Module 4 explains the different steps on how to calculate the marginal abatement costs which describe the cost-effectiveness (Euro per tonne reduced CO_2eq) of technical options. If you have defined a cost threshold in advance, i.e. the maximum amount that you are able or willing to spend for reducing one tonne of CO_2eq, you can now select the technical options accordingly.

Step 5: Build the emissions reduction scenario (analogously to BAU scenario under step 2)

Calculate emissions, now taking into account the characteristics of the systems for the mitigation scenario from step 3. Include stock and sales figures similar to step 2 using the formulas from annex 1 to module 1. Again, GIZ Proklima can provide assistance. Emission reductions are one of the most critical parameters to consider within a NAMA.

Step 6: Calculate the emission reduction potential

The emission reduction potential is given by the difference between BAU reference scenario and mitigation scenario. Therefore, subtract the emissions of the BAU simulations and the mitigation scenarios for the time series of interest. The example below illustrates this step for split residential air conditioning systems. Alternatively, the Proklima team can assist you on the basis of a completed DIS-Tool. BAU and mitigation scenarios will be created and entered in the Mitigation and Cost Tool. You can then use the Mitigation and Cost Tool to explore the mitigation potential of different technical options. The tool also allows an evaluation of marginal abatement costs for pre-defined technical options. Technical options which show low marginal abatement costs and high mitigation potential in the country should preferentially be considered for a NAMA.

TABLE 3
Mitigation potential results from the difference between the emission under the BAU scenario and the emission under the mitigation scenario.

	2010	2011	2012	2013	2014	2015	…	2020	…	2030
Emissions under BAU scenario (in tonnes of CO_2eq)	19.7	22.0	24.2	26.3	28.4	30.5		41.2		68.7
Emissions under mitigation scenario (in tonnes of CO_2eq)	19.7	21.9	23.7	25.4	27.0	28.5		38.0		62.9
Mitigation potential (in tonnes of CO_2eq)	0.0	0.1	0.5	0.9	1.4	2		3.2		5.8

4. References

GIZ (2012). Nationally Appropriate Mitigation Actions (NAMAs) – Steps for Moving a NAMA from Idea towards Implementation (GIZ NAMA tool). Version 8.6. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

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