MODULE 2

Cooling Needs Assessment

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

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Proklima

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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Executive Summary

A key element in Nationally Appropriate Mitigation Actions (NAMAs) is the determination of mitigation potential. Statistical models can be used to develop business-as-usual (BAU) scenarios based on inventory data (module 1 and annex 1 to module 1). These so-called stock models rely on stock data. In the refrigeration, air conditioning and foam (RAC&F) sectors, the stock is the number of appliances or systems in the country.

National F-gas inventories aim to collect the appropriate data. However, many developing countries face considerable difficulties in establishing accurate bottom-up inventory data, in particular stock data. To close this gap, this module describes how demographic and other key determining factors drive future demand for RAC products. It provides benchmarks on the ownership of RAC equipment in developing and developed countries. This information aids countries to verify inventory stock data and data provided by stakeholders as well as to predict future demand and stock data as the basis for determining future emissions. In cases where reliable stock data is insufficient, the benchmark figures provided may not only serve as top down-validation but may be the only reliable source of information. While this module focuses on the unit demand for RAC products, it can be roughly estimated that demand for foam, mostly for insulation purposes, will grow in similar proportions.

In contrast to the RAC sectors it is hardly possible to build generic models which forecast the demand for foam products in a specific country. The use of foam products is highly country specific. Foams are often used for the insulation of buildings, but there is a wide variety of insulation materials including foam and non-foam based products. Demand for RAC&F products will increase strongly in developing countries with their population growing from currently 5.5 billion to above 8 billion and the number of households more than doubling from currently below 1.5 billion to above 3 billion by 2050. With the growing demand it can be expected that RAC&F products will be a key driver for future energy and emission growth. Energy demand and emissions from cooling needs will outgrow the numbers related to heating by 2050.

With rising income levels and cheaper equipment prices, RAC&F products become increasingly affordable. Household ownership of refrigerators and air conditioners in developing countries could nearly double over the coming decades and will approach the levels of developed countries. Demand for equipment will grow rapidly once certain wealth thresholds are reached. The wealth threshold for domestic refrigeration equipment is just below an annual income of 10,000 USD per household. For air conditioning equipment it is just below 20,000 USD per household and year. Accordingly, the number of refrigerators in developing countries is predicted to grow from 0.6 billion to over 2.5 billion units, and the number of air conditioners is predicted to grow from below 0.5 billion to above 1.5 billion by 2050.

Besides population growth and increasing wealth, projections of equipment demand for individual countries need to consider additional country-specific parameters. Key country specific demand factors to consider are:

- Cooling Degree Days (CDD), expressed as the aggregated multiplier of days with temperatures beyond a certain threshold (typically 18°C) over a year: With increasing temperatures induced by climate change, the number of cooling degree days, and correspondingly the number of days when air conditioning becomes desirable, will grow.
- Urbanisation: With more and more people moving to cities, urbanisation levels in developing countries will grow from 46% in 2010 to 64% in 2050. With a higher degree of urbanisation, demand for RAC&F equipment will increase. For example, comparing urban areas to rural areas in India, ownership of refrigerators is twice as high in urban areas and 5 to10 times higher for air conditioners.
- Electrification: The level of electrification also factors into the demand for refrigeration and air conditioning equipment.
- Consumption patterns: Meat, fish and processed food consumption will drive the need for refrigeration both in domestic and commercial refrigeration within the food chain.

In chapter 3 a step-by-step approach and tool is provided to support countries in benchmarking and predicting their stock data and future demand.

1. Introduction

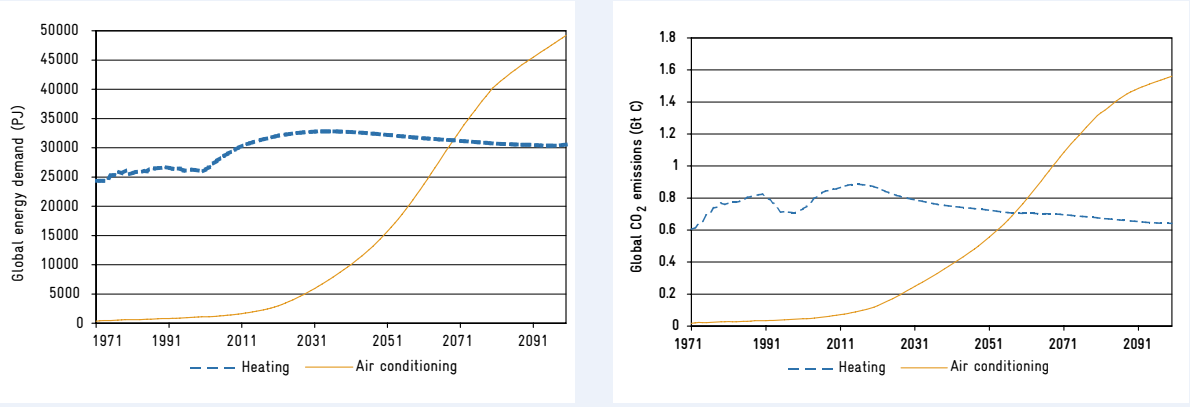
A key element of NAMAs is the determination of mitigation potential. Statistical models can be used to develop BAU scenarios based on inventory data (module 1 and annex 1 to module 1). These so-called stock models rely on stock data. In the RAC&F sectors, the stock is the number of appliances or systems in the country.

National F-gas inventories aim to collect the appropriate data. However, many developing countries face considerable difficulties in establishing accurate bottom-up inventory data, in particular stock data. To close this gap, this module describes how demographic and other key determining factors drive future demand for RAC products. It provides benchmarks on the ownership of RAC equipment in developing and developed countries. This information supports countries to verify inventory stock data and data provided by stakeholders as well as to predict future demand and stock data as the basis for determining future emissions. In cases where reliable stock data are insufficient, the provided benchmark figures may thus not only serve as top-down validation but may be the only reliable source of information. While this module focuses on the unit demand for RAC products, it can be roughly estimated that demand for foam, mostly for insulation purposes, will grow in similar proportions.

The need for cooling and, respectively, the demand for RAC&F products will grow significantly under the business as usual scenarios. The demand for RAC products and the need for better insulations are strongly connected to population growth and wealth. The demand for RAC&F products increases with the number of households. With increasing wealth, households in developing countries will typically buy a television, followed by a refrigerator and then air conditioning units. Household ownership of RAC products increases with increasing wealth up to a saturation point such as, for example, one AC per room.

Domestic ownership of RAC products accounts for over 75% of the global RAC equipment demand. It is estimated that appliance demand, especially for refrigeration and air conditioning, will be the main factor for future residential energy demand (World Bank, 2008). These findings are supported by Isaac and van Vuuren (2009) who estimated that primary energy demand and resulting CO_2 emissions for air conditioning will outstrip energy demand and CO_2 emissions for heating after 2050 (Figure 1). This is mainly driven by the air conditioning equipment demand from developing countries.

FIGURE 1
Predicted global energy demand from heating and cooling with resulting carbon emissions (Isaac and van Vuuren, 2009).



The saturation point depends on factors such as climate, urbanisation and food consumption habits. In hot and humid climates the need for air conditioning and the saturation point are above those of countries with colder climates. Globally, increasing temperatures, induced by climate change, will cause additional demand for RAC&F products (Isaac and van Vuuren, 2009).

Most of the developed countries have reached the saturation points with regard to equipment installations. This excludes the additional demand due to rising temperatures induced by climate change. In developing countries, however, demand continues to increase strongly with a growing population, urbanisation, increasing wealth and affordability of equipment. Typically, developing countries are still well below their saturation point and equipment ownership rates are considerably below those in developed countries. In the case of refrigerators, ownership per household in developing countries is less than half compared to developed countries. It can be expected that developing country ownership rates will increase and gradually come closer to those of developed countries over the next decades.

This module will show the main factors for appliance demand in the RAC sectors. For the main subsectors, key benchmarking metrics are provided for developed and developing countries. Demand drivers are identified in order to establish future demand growth projections. The metrics provided here are unit-based, i.e. they refer to systems and appliances, which is in line with the Tier 2a inventory approach as described in module 1. Energy demand and specific emission factors of appliances are not considered.

RAC&F stock data are of major importance to accurately estimate direct and indirect emissions. Their proper estimation and the forecasting of stock development is one of the first and most important steps in developing a NAMA. A four-step guide to apply benchmarking metrics and future stock projections for individual countries is provided in chapter 3.

2. Methodology for assessing the cooling needs

The key determining factors for the demand of RAC&F equipment are:
- Cooling Degree Days (CDD)
- Population and number of households
- Gross Domestic Product (GDP) / person
- Degree of urbanisation
- Other factors: electrification, food consumption patterns etc.

Table 1 provides an overview of the estimated influence of the demand factors for selected RAC subsectors.

TABLE 1
Influence of demand drivers for different RAC subsectors (dark blue: high influence; light blue: medium influence; grey: low influence).

	Domestic Refrigeration	Commercial Refrigeration	Industrial Refrigeration	Transport Refrigeration	Stationary AC	Mobile AC
CDD						
Households						
GDP/person						
Urbanisation						

2.1 Key demand factors

This chapter gives an overview of the key determining factors for the demand of RAC&F equipment. For the baseline, i.e. the year 2010, benchmarking figures are established on a worldwide basis for developed and developing countries.

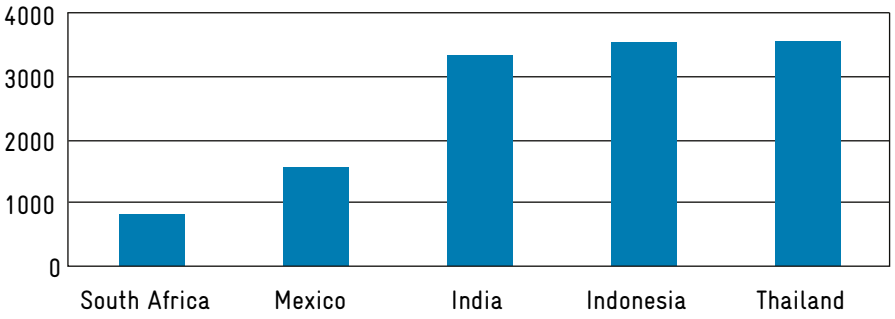
Cooling Degree Days

Climatic conditions are the key factor influencing demand for RAC&F equipment, especially air conditioning. In moderate climate zones, where the demand for air conditioning is currently relatively low, the demand increases with the number of hot days. The number of hot days can be quantified according to the CDD method. The use of air conditioners increases with room temperatures above a certain comfort temperature. Countries with a higher number of CDD have a higher demand for air conditioning equipment.

CDD are calculated by substracting the daily average temperature from the reference temperature of 18°C. For example, if the day's average temperature is 33°C, its CDD is 15. The daily CDDs are summed up over a month or year. For example, if each day per month (30 days) has an average temperature of 33°C, the month's CDD value would be 450 (15 times 30). Generally, annual CDD values are estimated for entire countries. CDD values are provided by the World Resources Institute and are currently available for 171 countries (Baumert and Selman, 2003).

In the following, the basic concept of the CDD methodology as a demand driver is explained for the air conditioning sector of selected countries (India, Mexico, South Africa and Thailand). Figure 2 shows the annual CDD of these countries.

FIGURE 2
Annual cooling degree days for selected countries with different climates.



The climate maximum saturation (CMS), i.e. where an increased temperature has no effect on the cooling demand anymore, is derived from the assumption that current saturation rates in the USA have reached the maximum (Isaac and van Vuuren, 2009) and represents 100 % for its given climate zone (Figure 3).

The possible maximum saturation of air conditioning equipment in other countries is measured against this benchmark and the CMS increases with the number of CDD (Figure 4).

FIGURE 3
Relationship between climate maximum saturation (CMS) and cooling degree days (CDD) (Isaac and van Vuuren, 2009).

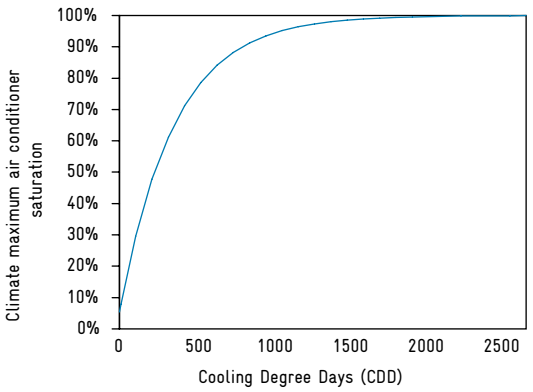
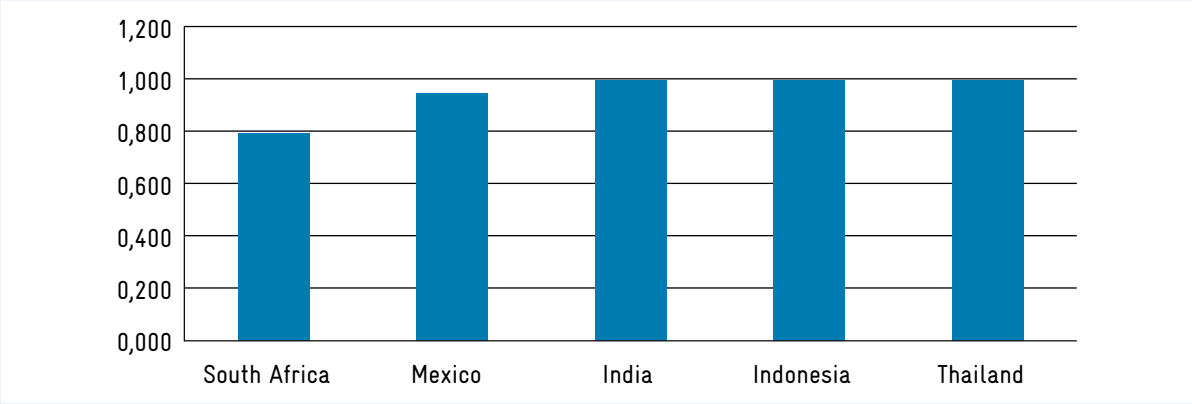


FIGURE 4
Climate Maximum Saturation (CMS) for selected countries.

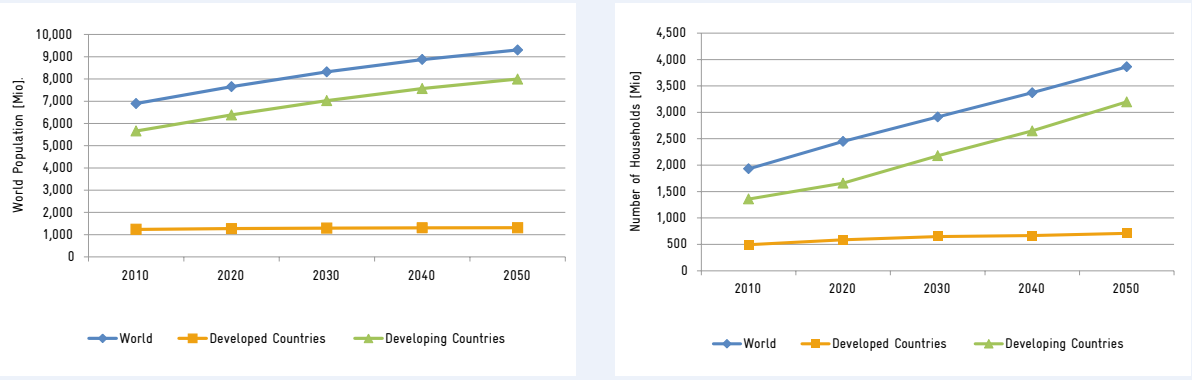


The demand for air conditioning equipment is then derived as a function of the CMS multiplied by affordability factors for a specific country.

Population and number of households

The population density in developing countries is predicted to increase heavily over the coming years. A growing population implies a growing number of households. At the same time, the number of households per 1,000 persons will increase from 240 in the year 2010 to 400 by 2050 (Ironmonger et al., 2000) Consequently, the number of households will increase disproportionately to the world's human population (Figure 5). This has major implications for estimating the number of domestic refrigerators or residential air conditioning equipment which is based on the number of households and not on population.

FIGURE 5
Increase of world population and the number of households for developing and developed countries (UN ESA; calculation of households according to Ironmonger et al., 2000).

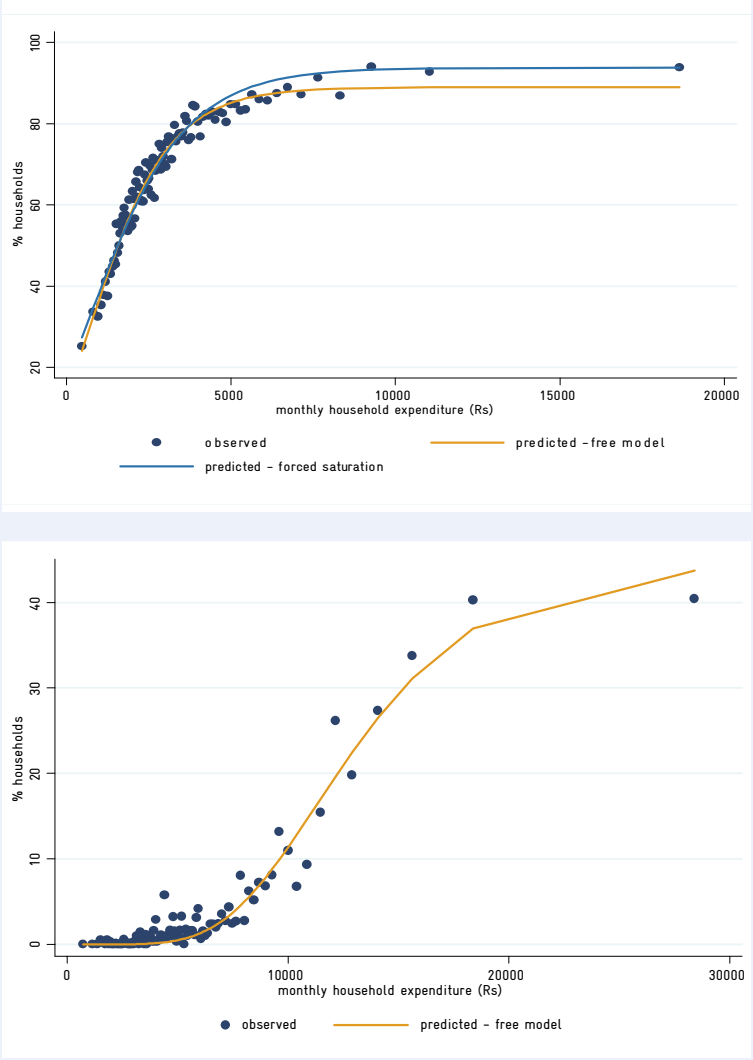


Gross Domestic Product (GDP) / person

Ownership and penetration of RAC&F equipment is directly related to the GDP per person. Ownership of household appliances will increase as household incomes increase. Demand for refrigerators will take off at monthly income levels of about 1,000 USD per household. For air conditioning it will take off at a GDP between 1,000 and 2,000 USD per household and month (McNeil and Letschert, 2008).

The sigmoidal curves in Figure 6 show that ownership of refrigeration and air conditioning equipment will strongly increase once certain income thresholds are exceeded. The threshold for refrigerators is at a monthly income of between 800 und 1,000 USD per household and for air conditioners at a monthly income around 2,000 USD.

FIGURE 6
Refrigeration (top) and air conditioning (bottom) ownership in urban India (World Bank, 2008[1]).



Urbanisation

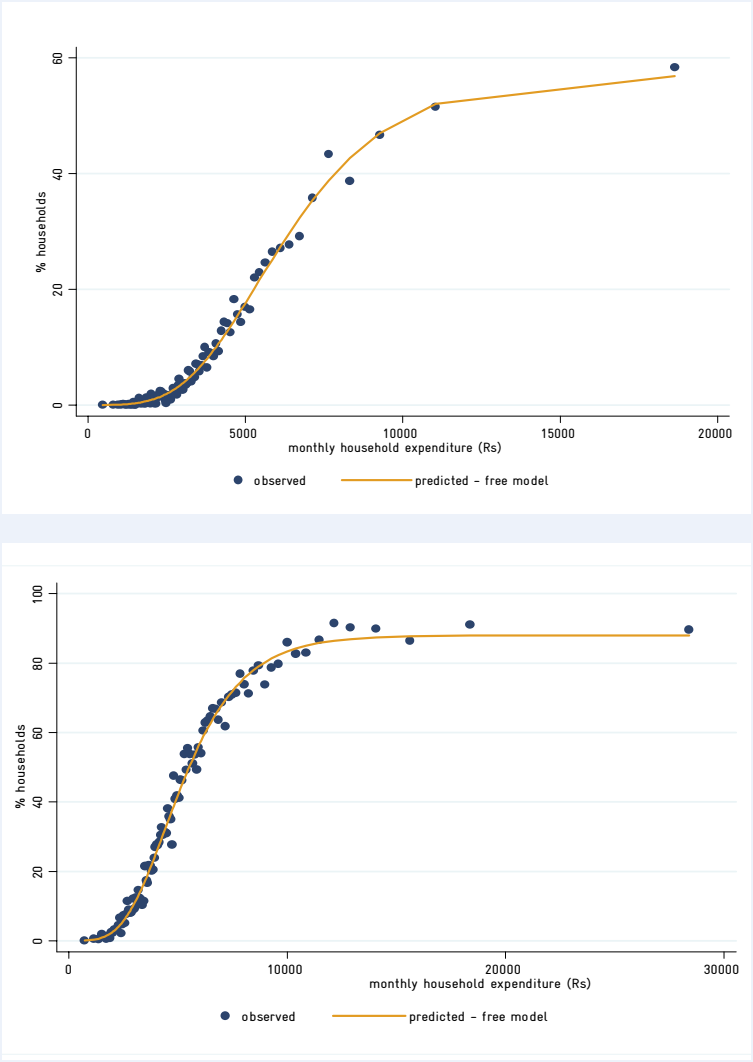
Urbanisation is another determining factor that needs to be considered when estimating RAC&F stock numbers. Various factors such as increased income, heat island effects of city dwellings, different consumption patterns, availability of appliances and grid connection all underline the assumption that a higher degree of urbanisation goes hand in hand with increased demand for RAC&F equipment.

The baseline level of urbanisation for the year 2010 is 52 % worldwide, 77 % for developed countries and 46 % for developing countries. The urbanisation is projected to increase to 67 % worldwide, 86 % in developed countries and 64 % in developing countries by 2050 (UN, 2008).

Figure 7 shows refrigeration ownership in rural and urban areas in India. At the same income level of about 800 USD[2] per household and month, rural ownership is below 20 % and urban ownership is at 40 %. At the same level of income, urban households tend to spend a higher portion of their income on electrical appliances such as refrigerators.

1 At a conversion rate of 1.6 USD = 10 INR
2 At a conversion rate of 1.6 USD = 10 INR

FIGURE 7
Refrigeration Ownership – Rural (top) versus urban (bottom) areas in India (World Bank, 2008[3]).

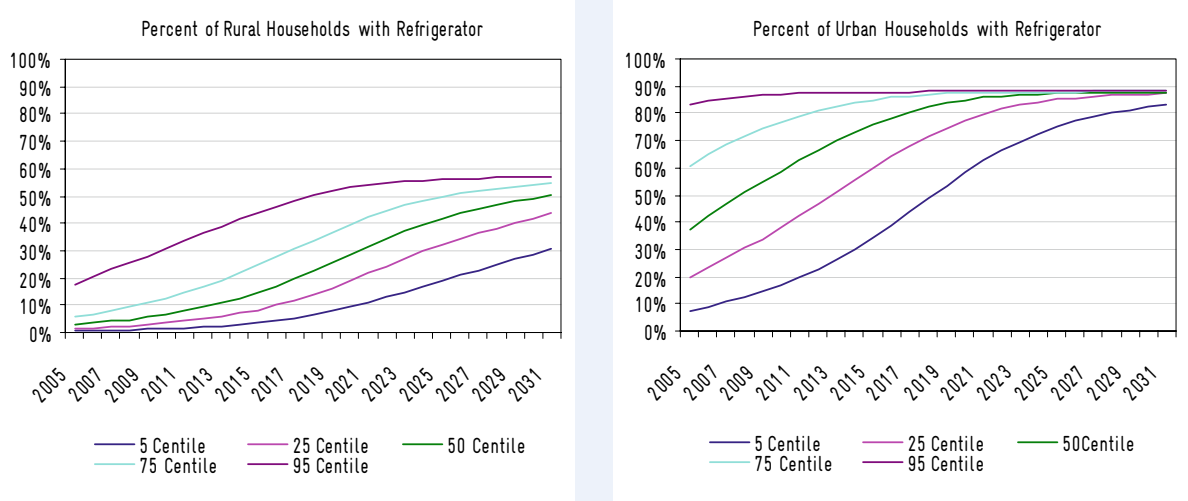


The gap between urban and rural ownership is even larger for air conditioning equipment where at a monthly income of approximately 1,600 USD per person and month, rural ownership is below 2 % and urban ownership is at a 10 % level.

3 At a conversion rate of 1.6 USD = 10 INR

Figure 8 projects that saturation points will remain different in rural and urban areas. Rural refrigeration ownership is expected to reach its maximum at 60 % while urban ownership is expected to rise up to 90 %.

FIGURE 8
Projected future refrigeration ownership in India (World Bank, 2008).



Other factors

Other factors for the demand of RAC&F equipment are the degree of electrification as well as dairy and meat consumption. RAC&F ownership tends to be higher with a higher degree of electrification and a higher percentage of processed and perishable food products. In her studies Garnett (2010) points out, that in addition to technology mitigation, for effective greenhouse gas (GHG) mitigation it will be necessary to shift patterns of consumption, in particular from GHG-intense meat and diary food. Garnett (2010) estimates that for the UK, manufacturing and retailing refrigeration (excluding the embedded coolness in imports) accounts for 2.5 % of domestically generated GHGs. It is pointed out that the increased ownership of refrigerators over the recent decades led to an increased consumption of food dependent on refrigeration.

2.2 Quantification of demand factors in the RAC&F subsectors

In comparison to developed countries, the penetration of RAC&F equipment is still significantly lower in developing countries. This difference is mainly explained by the lower average income levels in developing countries. The gap between developed and developing countries is projected to decrease over time with increasing GDP per capita, increasing urbanisation and electrification.

A further description of the specific RAC&F systems both in the business-as-usual case as well as alternative technologies are provided in module 3.

Table 2 shows average penetration rates of RAC&F equipment in developed and developing countries. The data is derived from stock data which the authors gathered during their work on a global vintage stock model (Schwarz et al., 2011).

TABLE 2
Benchmark figures on RAC ownership for main RAC sectors and subsectors in developing and developed countries (# = number/units, HH=Household, GDP=Gross domestic product per person).

Comparison Table	Benchmark	Developing Countries	Developed Countries	Comparison Developing (Orange) vs. Developed (Blue) countries	Demand Driver
Refrigeration/ Freezers	# for 1 Mio. HH	0.53	1.44		+++HH (Pop) ++ GDP + Urbanisation + Electrification + Consumption of refrigerant dependent products
Industrial Chiller	# of Ind. Chiller per 10 Mio. persons	0.07	0.57		++ GDP + Urbanisation + Consumption of refrigerant dependent products
Standalone Units	# of Standalone Units per 1,000 persons	4.64	42.51		++ GDP + Urbanisation + Consumption of refrigerant dependent products
Condensing Units	# of Condensing Units per 1,000 persons	3.53	11.34		++ GDP + Urbanisation + Consumption of refrigerant dependent products
Centralised Units	# of Centralised Units per 10 Mio. persons	0.25	1.13		++ GDP + Urbanisation + Consumption of refrigerant dependent products
AC Units (split and ducted)	# of ACs per HH	0.35	0.64		+++HH (Pop) ++ GDP ++ CDD + Urbanisation + Electrification
Multisplit	# of Multisplits per 1,000 HH	7.36	30.36		+++HH (Pop) ++ GDP ++ CDD + Urbanisation + Electrification
AC Chiller	# of Chillers per 1,000 HH	0.37	3.44		+++HH (Pop) ++ GDP ++ CDD + Urbanisation + Electrification
MAC Cars	# of MAC per HH	0.10	0.91		+++HH (Pop) ++ GDP ++ CDD + Urbanisation

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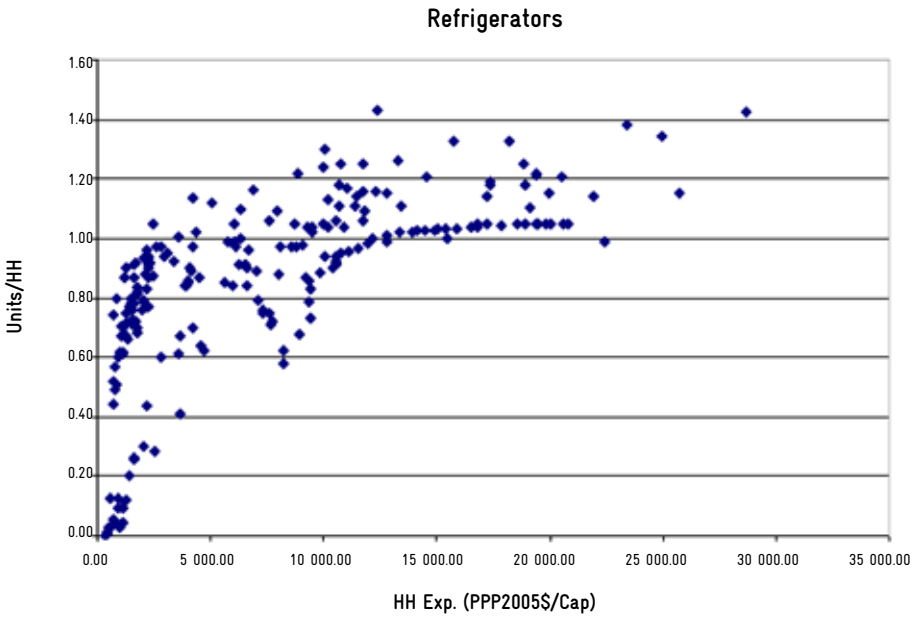
Comparison Table	Benchmark	Developing Countries	Developed Countries	Comparison Developing (Orange) vs. Developed (Blue) countries	Demand Driver
MAC Busses/ Trucks	# of truck/ bus MAC per HH	442	2510		+++HH (Pop) ++ GDP ++ CDD + Urbanisation
Refrigerated Trucks	# of Refrigerated trucks per 10 Mio. persons	1.41	26		++ GDP + Urbanisation + Consumption of refriger-ant dependent products

Domestic refrigeration

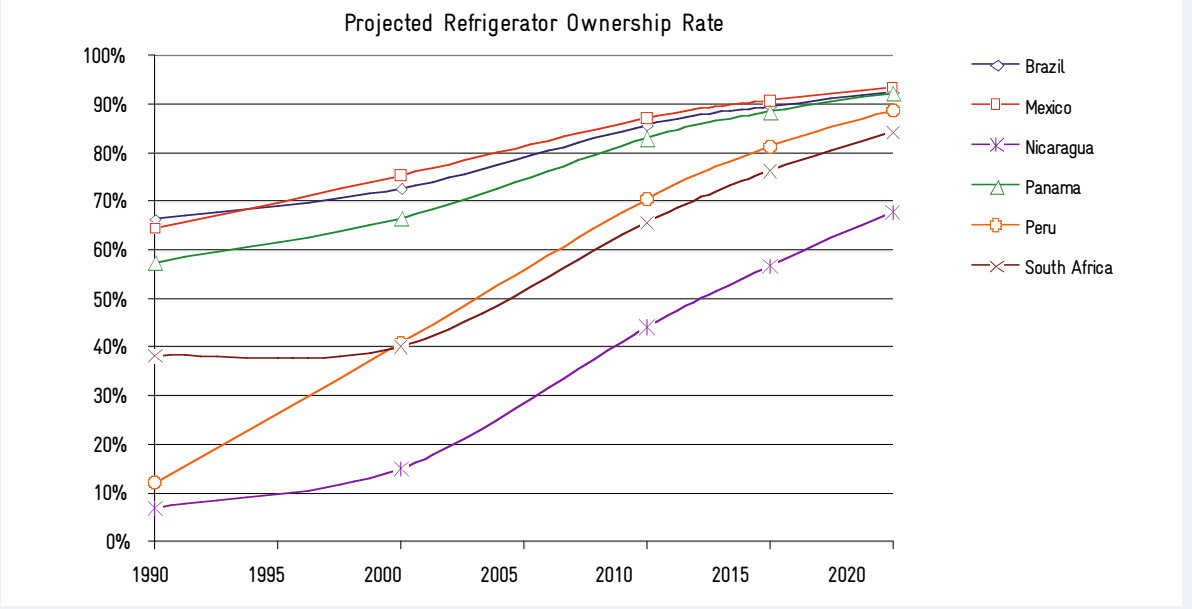
The basic assumption is that 53 % of all households in developing countries have a refrigerator/freezer while an average household in developed countries has more than one refrigerator, i.e. 1.4 refrigerators/freezers. The rate of refrigerators/freezers per household in developing countries goes up with higher degrees of urbanisation, GDP per capita, consumption of refrigerated food products and electrification (Figure 9). McNeil and Letschert (2008) report that refrigeration ownership is below 50 % at the very low income levels in developing countries, while saturation is reached at income levels of about 5,000 to 12,000 USD per household and month. Refrigerators have become more affordable both in investment and energy consumption. Through a higher affordability the penetration rate of refrigerators in households went up (Daioglou, 2010).

FIGURE 9
Increased ownership of refrigerators in developing countries with increasing household expenditure (World Bank, 2008).



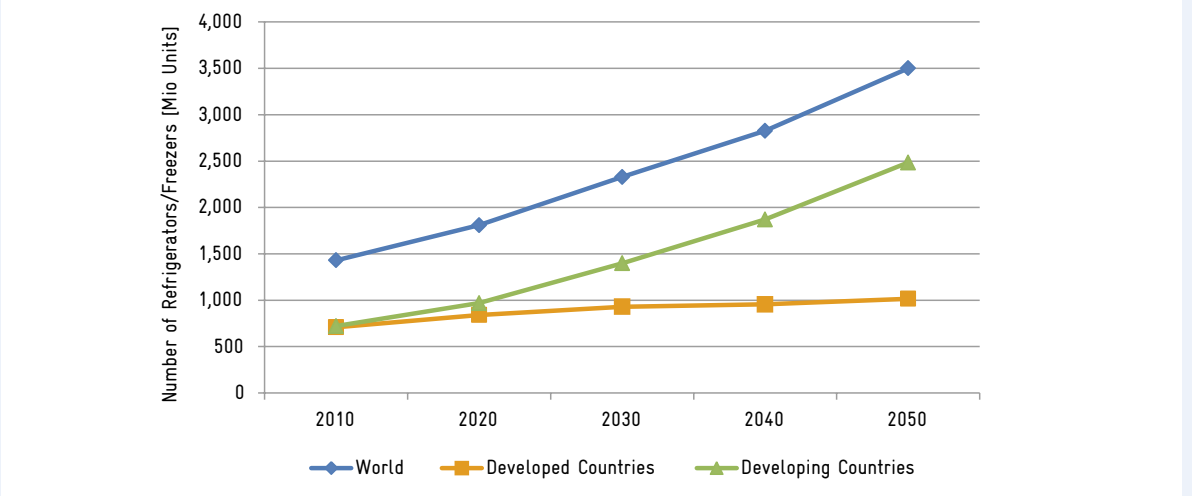
McNeil and Letschert (2005) have developed a model to predict the household ownership of refrigerators as a function of income. However, ownership cannot be explained entirely by income. For more accurate estimations, other factors such as urbanisation and electrification must also be considered. Countries with a higher degree of urbanisation and electrification, such as Mexico and Brazil, have a higher refrigeration ownership compared to countries with lower urbanisation and electrification, such as South Africa or Nicaragua. It is projected that by 2020 household ownership of refrigerators in many developing countries reaches levels between 60% and 90% (Figure 10).

FIGURE 10
Projected refrigeration ownership by 2020 (McNeil and Letschert, 2005).



Based on the analysis above, it is estimated that the household penetration of domestic refrigerators in developing countries will grow from around 0.5 to 0.8 in the coming decades. Figure 11 displays the global stock of domestic refrigeration units until 2050. The model results show that the number of domestic refrigerators and freezers will more than double from 2010 to 2050 to over 3.5 billion units.

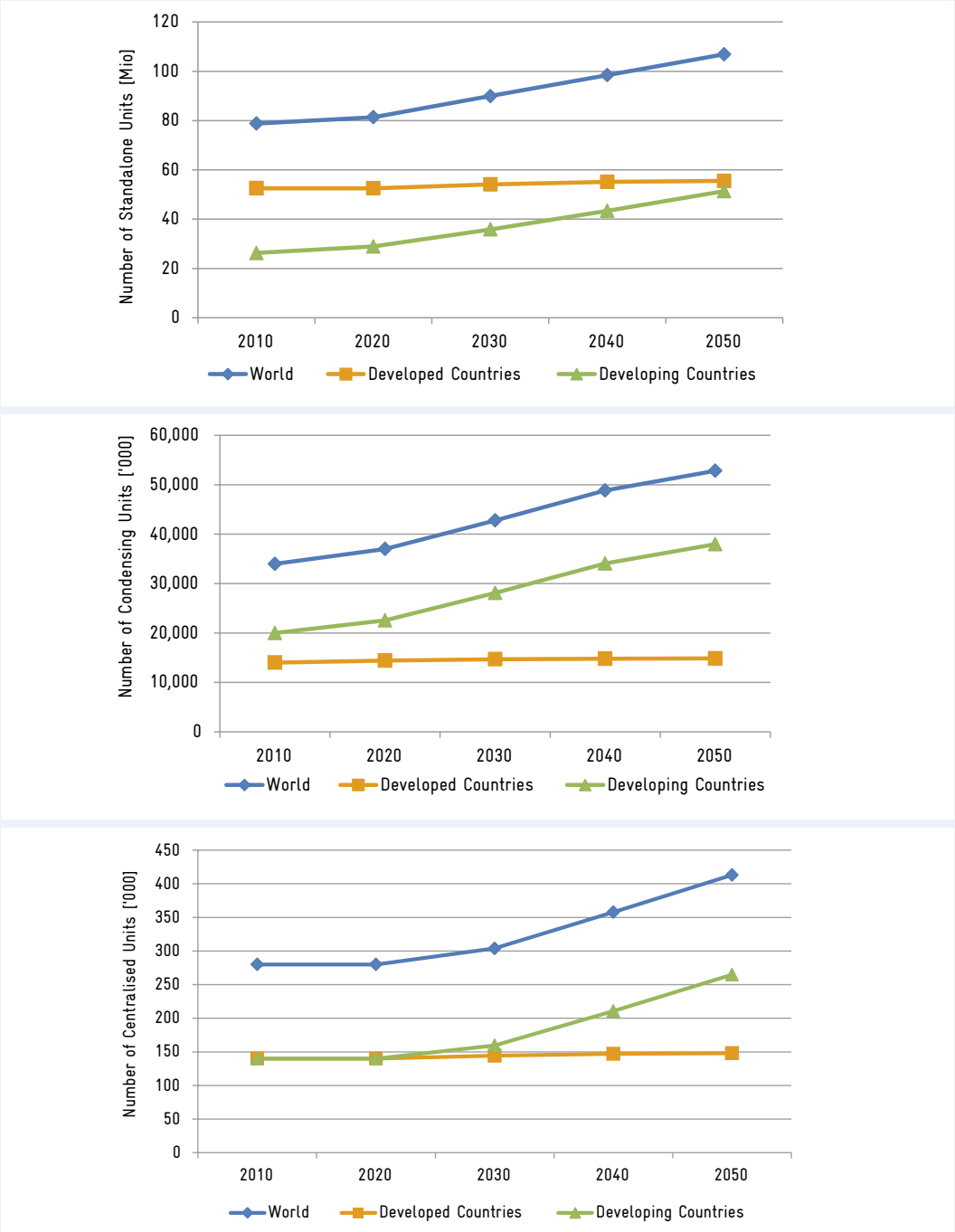
FIGURE 11
Projection of refrigeration ownership (worldwide, developing and developed countries).



Commercial refrigeration

The stock of commercial refrigeration equipment mainly depends on the number of small, medium and large stores and commercial shopping centers with food sections for dairy, meat and other perishable products. Stand-alone units are mainly deployed in small commercial outlets. They are a common sight in villages in rural Africa or India. Condensing units are deployed in larger supermarkets and are more common in larger agglomerations and cities. Centralised units are found in large urban shopping centers and food warehouses in more advanced developing countries. In the early stages of development of a country demand for stand-alone units will rise first whereas centralised units will start taking off with increased urbanisation and higher GDP per capita. Figure 12 shows the projected numbers of stand-alone, condensing and centralised units until 2050. Exceptionally high growth rates are expected in developing countries.

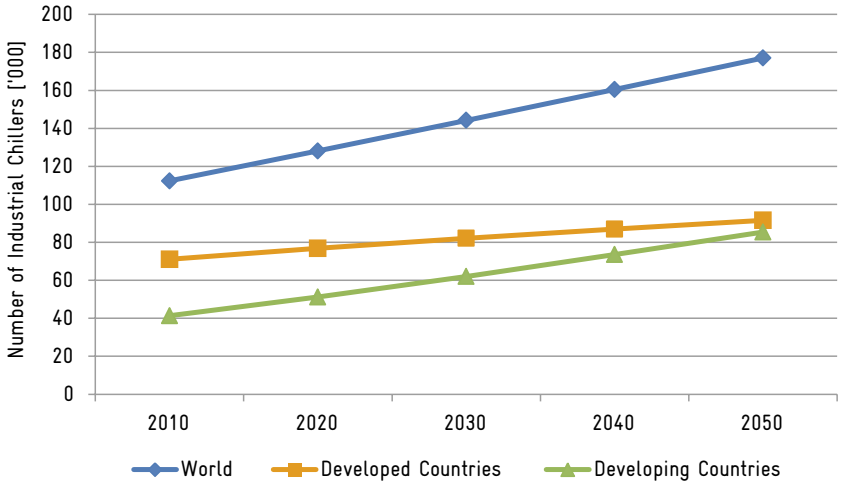
FIGURE 12
Projection of refrigeration ownership (worldwide, developing and developed countries).



Industrial refrigeration

The most significant application for industrial chillers is for refrigeration in the food industry (IPCC, SROC 2007). Other industrial refrigeration applications are the chemical industry, oil and gas industries, as well as industrial ice making, air liquefaction and other related industrial applications. Figure 13 shows the projection of the amount of industrial chillers over time.

FIGURE 13
Projection of industrial chillers stock data over time (worldwide, developed and developing countries).

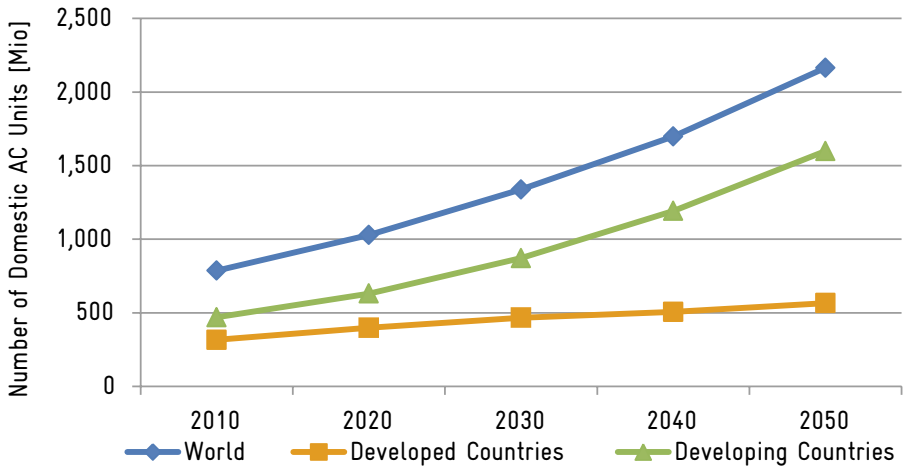


Air conditioning

The basic assumption is an ownership of 0.35 air conditioners per household in developing countries while developed countries currently have an average of 0.64 air conditioners per household. Key factors for influencing the demand are the number of households, urbanisation, the GDP and the CDD. Massive developments can be found for example in China where urban ownership of air conditioners increased from less than 1 % in 1990 to 62 % in 2008 (McNeil and Letschert, 2005). Similar growth rates can be expected in other developing countries, where particularly India is expected to become one of the largest buyers of air conditioning units.

With the installation of one or more air conditioners in a household, the household energy consumption increases significantly. In addition, air conditioners add significantly to peak load demand and may thereby drive the capacity of electricity grids to their limits. Specific demand projections have calculated future demand curves for air conditioning (Isaac and Van Vuuren, 2009): Regarding overall air conditioning unit numbers, developing countries are already surpassing developed countries (Figure 14). The demand in hot and humid developing countries will more than triple from 2010 to 2050 with increasing wealth and urbanisation.

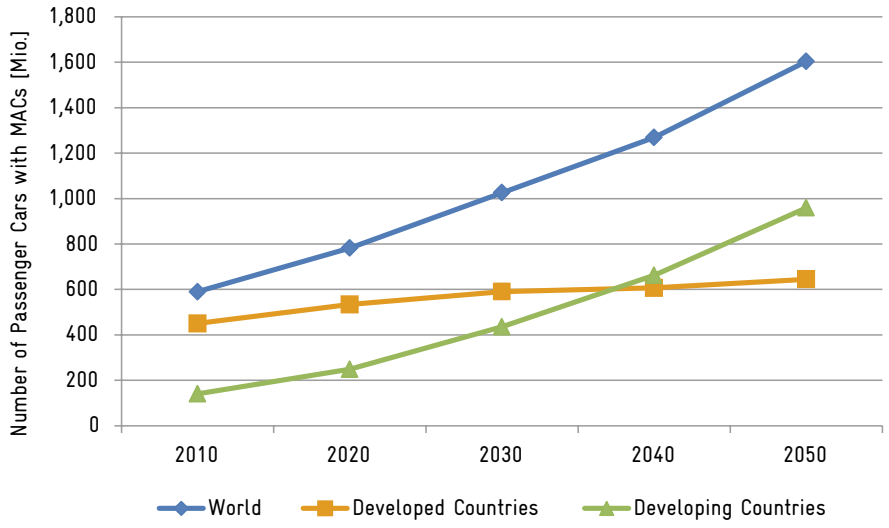
FIGURE 14
Projection of domestic AC units over time (worldwide, developed and developing countries).



Mobile Air Conditioning

The number of mobile air conditioning (MAC) units – along with the number of cars – will strongly increase with the number of households and wealth. The estimated number of MAC units in developing countries will quadruple from 2010 to 2050 to over 1 billion units by 2050. Today nearly all new cars in developing countries are supplied with MAC systems (Figure 15).

FIGURE 15
Projection of MAC over time (worldwide, developed and developing countries).



3. Practical application

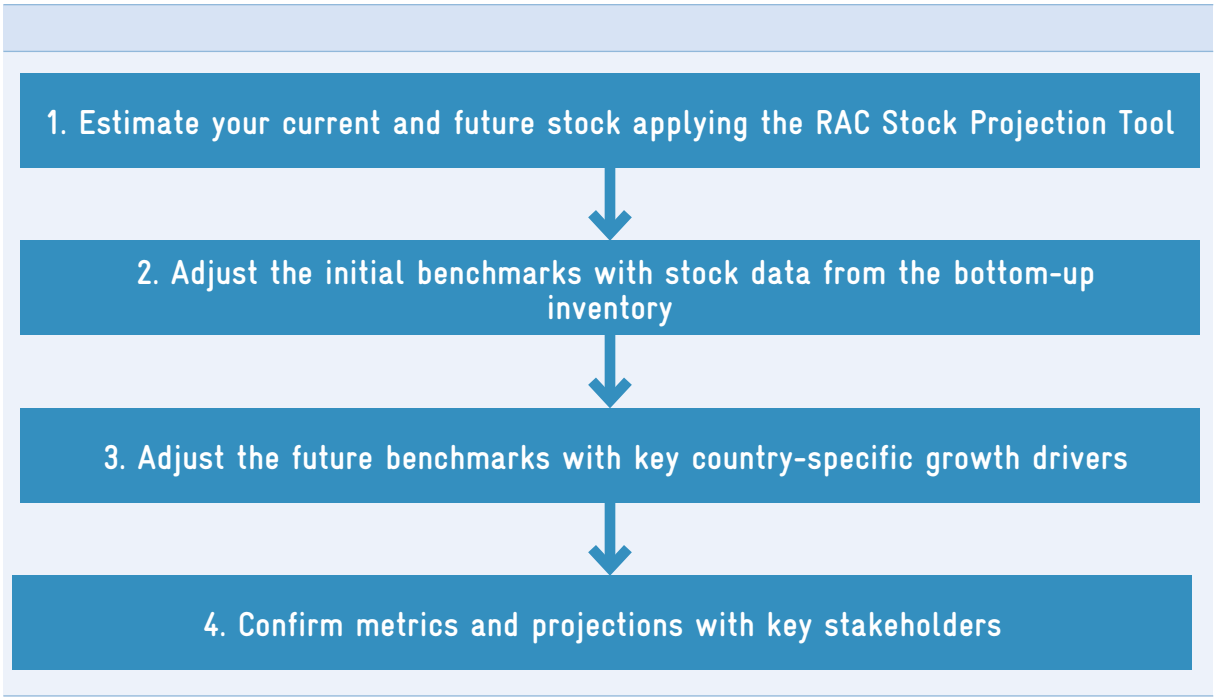
The estimation of the future appliance stock is one of the key elements for the development of business-as-usual (BAU) and NAMA emission reduction scenarios[4]. This chapter provides a step-by-step guide to set up projections for the future stock of RAC appliances in your country.

You can use the RAC Stock Projection Tool that is provided with this module. It lets you derive a first rough estimate on the future deployment of RAC appliance systems in your country based on population as a simple single predictor model: Demand of RAC appliances grows primarily with the population and the number of households. Therefore, the model multiplies the current and future population and number of households in your country with generic benchmarks for developing countries that are provided with the tool.

You can improve the results by adjusting the benchmarks with data that reflect the situation in your country more accurately than the generic benchmarks. To do so, you use current stock numbers from your bottom-up inventory as outlined in module 1 and other influencing growth factors relevant for your country as analysed in chapter 2 of module 2.

In addition to this, GIZ Proklima can also support your country's efforts for accurate stock projections.

Steps for estimating and setting the benchmark:



Step 1: Estimate your current and future stock applying the RAC Stock Projection Tool

The Stock Projection Tool is based on the input of country-specific projections of future population data. Such data are publicly available. Relevant data sources are indicated in the tool. As a first step, enter the population of your country into the excel tool. The model will automatically calculate the number of households by using generic assumptions for developing countries on the number of households relative to the population.

Table 3 illustrates the output of the Stock Projection Tool for a model country, i.e. the estimated future stock of major RAC subsectors.

4 see also GIZ NAMA Tool 8.2 Step 2 (GIZ 2012)

TABLE 3
Country ownership of major RAC products based on benchmarks.
"Stock Projection Tool"

	2010	2020	2030	2040	2050
OUTPUT					
Households (in million)	16.08	19.24	23.4732	26.95	30.56
Domestic fridges and freezers	8,534,806	11,233,248	15,075,276	19,039,012	23,748,254
Commercial refrigeration Standalone units	310,733	377,518	424,922	475,315	518,773
Commercial refrigeration Condensing units	236,749	296,000	340,740	365,750	382,000
Commercial refrigeration Centralised units	2	2	2	3	3
Industrial refrigeration Chillers	0	1	1	1	1
Domestic AC	5,551,767	7,311,200	9,389,280	12,127,500	15,280,000
Domestic AC Multisplits	118,375	155,801	209,088	264,064	329,379
Domestic AC Chillers	5,919	7,790	10,454	13,203	16,469
Domestic AC MAC	1,657,244	2,886,000	4,694,640	6,737,500	9,168,000
Truck MACs and Bus MACs	2,959	3,595	4,047	4,527	4,941
Refrigeration container	9	12	13	14	16

The estimate of stock data is based on generic benchmarks for the ownership of appliances per household in developing countries. For example, it assumes that there are 0.53 fridges and freezers per household in developing countries in 2010 and that this number will rise to 0.78 in 2050. The sector-specific benchmarks are illustrated in table 4.

Using global ratios for developing countries, the tool can only provide a very rough estimate. However, the projection can be adjusted to better reflect the situation of a specific country. The required adjustments are explained in the following steps.

Step 2: Adjust the initial benchmarks with stock data from the bottom-up inventory

To improve the stock projection, replace the starting year benchmarking figures with the stock numbers gathered from the bottom-up inventory as described in module 1.

In some countries bottom-up stock data are not available or the accuracy of these numbers is insufficient. In these cases, it is advisable to use the generic benchmarking data that are already provided in the tool. The generic data can also serve to validate the bottom-up inventory stock data.

Step 3: Adjust the future benchmarks with key country-specific growth drivers

Besides the population and number of households, there are many factors that influence the future demand of RAC appliances. Therefore, you should adjust the benchmarking figures for future years taking into consideration additional growth drivers and their development specifically in your country. As analysed in chapter 2 of module 2 these factors include

- GDP per capita (average of approximately USD 3,700 for developing countries)
- Annual cooling degree days (range from 800 to 3,500 cooling degree days)
- Urbanisation (with a current developing country average of 46% increasing to 64% in 2050)

TABLE 4
Country ownership of major RAC products based on benchmarks.
"Country Cooling Needs Stock Forecasting Model"

	2010	2020	2030	2040	2050
Country Input					
Population in million	67	74	76	77	76
General Defaults					
Households per 1,000 persons	240	260	310	350	400
RAC&F Defaults					
Domestic refrigeration fridges and freezers per household	0.53	0.58	0.64	0.71	0.78
Commercial Standalone units per 1,000 persons	4.64	5.10	5.61	6.17	6.79
Commercial Refrigeration Condensing units per 1,000 persons	3.53	4.00	4.50	4.75	5.00
Commercial Refrigeration Centralised units per 10m persons	0.25	0.25	0.30	0.35	0.40
Industrial Refrigeration Chillers per 10m persons	0.07	0.08	0.09	0.10	0.11
Domestic AC ACs per household	0.35	0.38	0.40	0.45	0.50
Domestic AC Multisplits per 1,000 households	7.36	8.10	8.91	9.80	10.78
Domestic AC Chillers per 1,000 households	0.37	0.40	0.45	0.49	0.54
Domestic AC per household	0.10	0.15	0.20	0.25	0.30
Truck MAC and Bus MACs per 10m persons	442	486	534	588	647
Refrigeration Container per 10m persons	1.41	1.55	1.71	1.88	2.07

Generally you can assume that your country-specific ratios will rise: If your country is below the average in the starting year, it is likely to approach the average benchmarks of developing countries.

If your country-specific sector ratio has already reached the average of developing countries, it is likely to approach the average of developed countries.

The rate at which these ratios are going to approach the higher level depends on estimates for the future development of these additional country-specific factors. Here the growth factors for the GDP per capita and the urbanisation are the most relevant factors. The growth factors for cooling degrees are more difficult to assess and are likely to remain a less dominant factor within the near term future.

With the adjustments done in steps 2 and 3, the result will be a customised, country-specific stock growth projection.

Step 4: Confirm metrics and projections with key stakeholders

Even with the calibration actions suggested in steps 2 and 3, the model represents a simplified approach that does not cover all country-specific factors in detail. Therefore, you should verify the projections with the most relevant stakeholders. This can take place in the form of a workshop. Relevant stakeholders include government agencies and ministries, industry representatives, universities and specialised institutes or consultants with relevant, sector-specific know–how.

Practical advice

- To support the four-step approach, the "RAC Stock Projection Tool" is provided online at www.giz.de/proklima.
- You can also contact GIZ Proklima for assistance to define a more elaborate approach on stock projections tailored to the specific needs for your country.

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