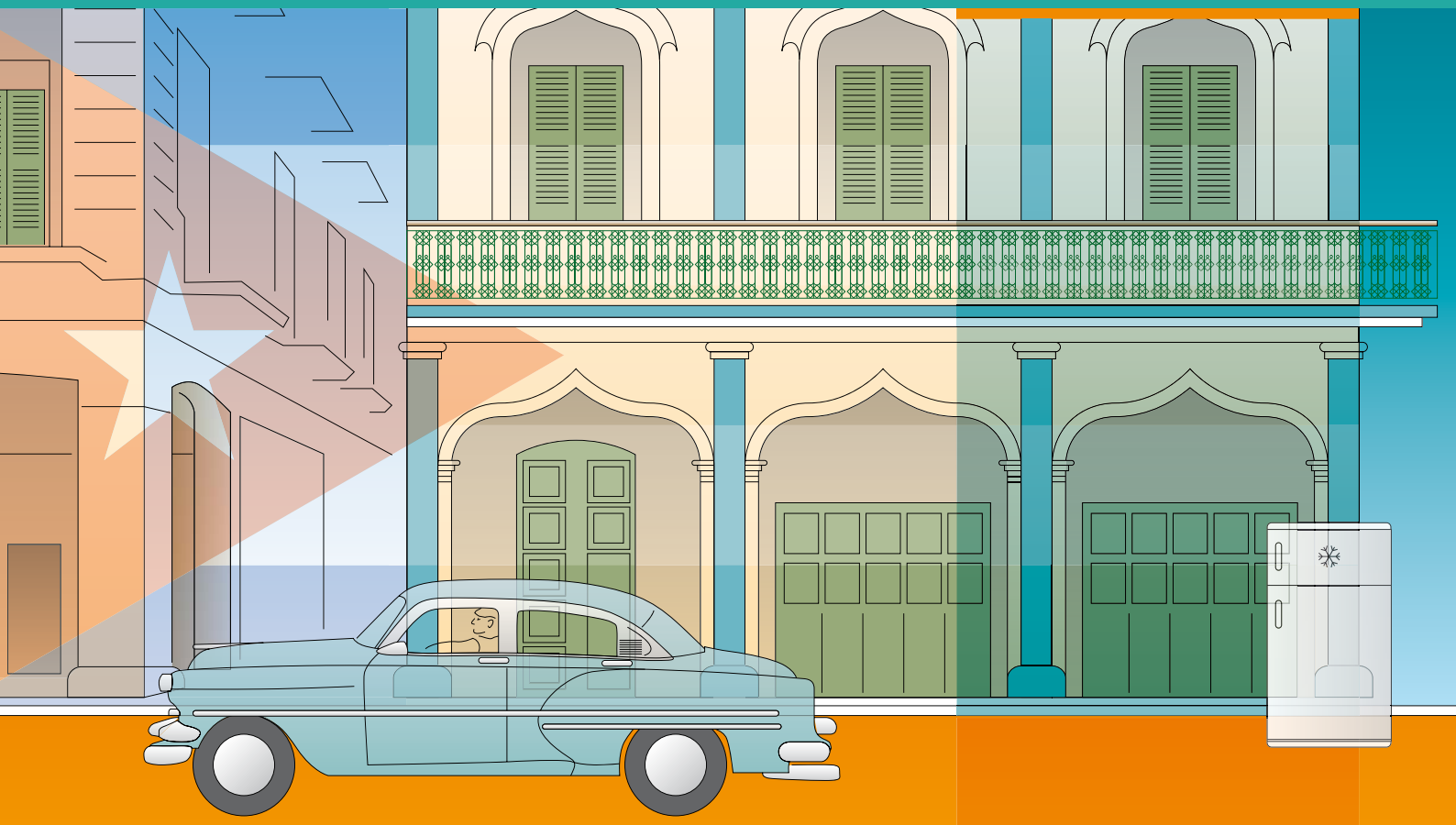
Cuban Energy Revolution –
A Model for Climate Protection?

Dieter Seifried



quadrat
ökologische und ökonomische konzepte

On the origin of the report

In October 2012, Büro Ö-quadrat conducted its own project in Cuba to investigate the results of the Cuban Energy Revolution. For this, Dieter Seifried (Büro Ö-quadrat) went on-site to hold talks with several organizations and to gather information. Even before the Cuban Energy Revolution, as part of the BMU-funded study „Sustainable Energy Policy Concepts (2002),“ Dieter Seifried had proposed a change of the cooling appliances to the Cuban government. In a later project in 2004, Büro Ö-quadrat offered the Cuban government to take charge, on top of the refrigerator-replacement, of its financing, through a contracting project. In this case, the cost of the high-efficiency refrigerators would be offset by the savings made on crude oil imports.

Content

The Disregarded Energy Revolution

1

The Building Blocks of the Cuban Energy Revolution	
1	Improving the energy efficiency in households and businesses through the replacement of inefficient appliances. At the same time, kerosene- and LPG-based cooking equipment was replaced with electric hotplates.
2	Complementing the large central power plants with distributed generation, and improving the transmission and distribution networks.
3	Developing renewable energy sources
4	Increasing exploration and production of own fossil deposits
5	Increasing international cooperation
6	Raising public awareness

Almost unnoticed by the public, but also by energy experts in Germany, an energy revolution took place in Cuba („revolución energética“) which, in some respects, goes further than the German energy shift (“Energiewende”). In 2005, Cuba‘s President Fidel Castro proclaimed the „revolución energética”, which included far-reaching measures: 2.5 million refrigerators were replaced with more efficient refrigerators through a government program. The complete changeover from incandescent bulbs to compact fluorescent lamps (CFL) was also made five years earlier than in Germany and the European Union.

Simultaneously, a surprising, fundamental change took place: while the power supply in Cuba - as in all planned-economy countries[1] - was previously based on large central power plants, during the Energy Revolution the country invested in distributed power plants. This change also cleared the way for further development of renewable energy sources, which had small chances of being implemented within a centrally planned energy system.

In Cuba, the motivation for this extensive renovation program was not so much the fight against climate change as a technical and economic necessity: because of the aging and poorly maintained power plants and grids as well as the impact of two hurricanes, during 2004 and 2005 there were power outages in big parts of the country almost on a daily basis. In 2005 alone, there were at least 224 days with extensive blackouts lasting more than an hour, which paralyzed the industry and households[2]. With the Energy Revolution, power outages caused by the lack of generation capacity were completely avoided by 2007.

The technical upheaval was supported by accompanying measures that might be of interest for Germany and other countries: inefficient appliances were replaced with more efficient equipment, and at the same time electricity rates were adjusted to a progressive tariff structure so that large consumers have to pay significantly more. In addition, the purchase of efficient appliances has been supported by so-called social credits. “Social credits” because the credit terms, such as interest rate and repayment period, are adjusted to the income and repayment capacity of the households.

The Cuban Energy Revolution can be characterized by six main building blocks (see page 2). The following presentation focuses on the first two blocks. The other blocks are only addressed and developed as far as considered necessary for the understanding of the whole process.

The following report is based on an analysis of Büro Ö-quadrat. For data acquisition, Dieter Seifried was on site and led discussions with various people and organizations.

(Source: Mario Alberto Arrastía Ávila, Cubaenergia)

[1] Germany and most industrialized countries were also based on a system of large power plants up until their energy transition

[2] UNE 2009

Power Supply in Cuba

2

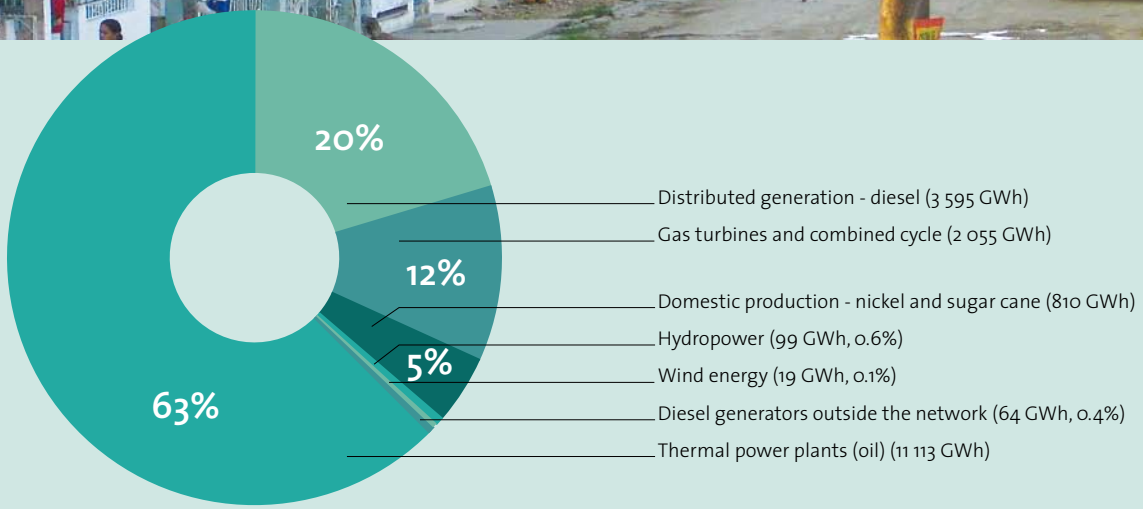


Figure 1:
Power generation by energy source in 2011. Total electricity generation 17 754 GWh (Source: Cubaenergía, www.cubaenergia.cu/index.php/en/energy-statistics)

A year before the successful Cuban Revolution in 1959, in which resistance fighters and the „26th of July Movement", under the leadership of Fidel Castro, dispossessed Cuban dictator Fulgencio Batista, only 56 percent of Cuban households had access to electricity. The power supply was limited mainly to a few cities. Today, some fifty years later, almost the entire country is electrified. Only 4 percent of households were still without electric power in 2007. In remote villages, isolated networks were installed, powered by diesel generators or renewable energy sources. In remote areas, individual buildings such as schools or hospitals are now supplied with solar energy or hydropower.

The residential power consumption rose from 1,500 gigawatt-hours (GWh) to 6,400 GWh between 1959 and 2008 and has thus more than quadrupled[3]. 47% of the total electricity generation in Cuba is consumed by households.

Electricity production in Cuba is based largely on petroleum products. Only slightly less than one percent of the energy supplied into the national grid comes from solar or wind energy[4]. The largest share of electricity generation still comes from oil-fired thermal power plants. Electricity generation from gas turbines and based on the combined cycle process has increased in recent years and accounted for 12% in 2011.

Because Cuba has no feed-in remuneration for solar electricity, and electricity prices are highly subsidized, photovoltaic systems are currently used mainly for off-grid power generation. Since 2001, Cuba has equipped 2,364 schools in remote areas with PV systems, which has also allowed the use of audio-visual programs.

Due to the economic turmoil, caused by various reasons, that Cuba has had to overcome in the past decades, the country has recurrently experienced serious shortages in various sectors of the economy. This has resulted, among other things, in the home-made repairs of appliances, such as fans or electric burners, in the Cuban households. Old, repeatedly repaired refrigerators (mainly of American or Russian origin) and their low energy efficiency shaped the electric bill of Cuban households.

The use of computers is taught even in the most remote spots, and in the smallest schools. (Source: Mario Alberto Arrastía Ávila, Cubaenergia)

[3] ONE 2009, Table 71

[4] The use of cane molasses in the sugarcane industry for their own electricity generation also plays a minor role.

PV power supply in remote hospital.

400 Wp for the supply of light, TV set, refrigerator and radio.

Thanks to the decentralized power supply with PV systems, all students can connect to the two Cuban learning channels. (Source: Mario Alberto Arrastía Ávila, Cubaenergia)

Investment into energy efficiency

3

(Source: Ariel Menniti)

During the efficiency revolution, about 2.55 million inefficient refrigerators were replaced with more efficient devices.

Replacement of Inefficient Household Appliances

The Cuban Energy Revolution started in July 2005 with an extensive lamp replacement program. In less than a year, social workers and student volunteers managed to unscrew over nine million incandescent bulbs from their lamp sockets and replace them with compact fluorescents (energy saving lamps). Assuming that two 60 watt light bulbs are turned on during an average of three hours per day in about 3.3 million households, this leads to an estimated annual saving of 354 million kWh, which represents about 3 to 4% of the total Cuban electricity consumption.

As energy saving bulbs have about ten times the lifespan of incandescent bulbs, the investment cost for these energy saving lamps is rather lower than the cost of ten times as many incandescent bulbs. The social costs associated with the workload of social workers and students to exchange the lamps are not taken into account here. It can be assumed, as an initial approximation, that the exchange of bulbs has incurred no additional cost to the national economy. Since the variable costs of electricity generation in Cuba are, given the current price of crude oil in the international market, of about 20 eurocents [5], the energy savings of this measure alone could result in annual savings of about 71 million euros in electricity generation costs. This simple calculation does not take into account that these energy savings also reduce network losses, the environmental impact of power plant emissions and the costs linked to the extension of the power plant fleet.

Today, Cuba is considering replacing the energy saving bulbs with LED lamps. Due to the longer lifespan of the LED bulbs and their higher light output per watt, this power-saving measure is also worthwhile in economic terms.

[5] Belt (o. Jahrgang) p. 17

Besides the light bulbs, the government has also replaced self-built fans with more efficient appliances for free. According to Unión Eléctrica (UNE), the state energy provider, 1.04 million units were replaced. While a reasonably efficient fan works with 30 to 40 watts, many homemade devices used before the Energy Revolution needed over 100 watts to run. If we consider a usage of 1,000 hours per year and per household, the result of this exchange is an annual saving of approximately 60 million kilowatt-hours. The initial investment of about 10 million euros should therefore be compared to annual savings of around 12 million euros.

The biggest energy consumers in Cuban homes were outdated refrigerators. The average annual electricity consumption of a Cuban household was 1,670 kilowatt-hours in 2004. As almost all households had a refrigerator and an average refrigerator required about 700 to 900 kWh per year, it was the refrigerator that shaped the electricity bill in most households.

In July 2005, about 9 million incandescent lamps were replaced with compact fluorescent lamps.

More than a million self-built fans were replaced with more efficient ones for free.

These refrigerators also presented the biggest energy savings potential in the overall conversion program. During the efficiency revolution, 2.55 million refrigerators were replaced with more efficient devices of Chinese design and, according to Cubaenergía, disposed of properly. If we make the conservative assumption that the old equipment has an average annual consumption of 800 kWh / unit (see Table 2) and that the Chinese refrigerators require about 350 kWh per year [6], the result is an annual saving of 450 kWh per unit. This means an annual energy saving of 1,148 million kWh or about 230 million euros saved in operating costs (primarily fuel costs).

Since the Cuban government has not released any information about the cost of the purchased equipment, the investment costs can only be roughly estimated. Assuming a purchase price of approximately 150 euros per unit [7], we have on one hand investment costs of around 383 million euros, and on the other hand an annual saving in fuel costs of about 230 million euros. From an economic perspective, this implies that the devices have been amortized in less than two years.

Refrigerator-type	Consumption/ day	Consumption/ year
Small (112W)	1.6 kWh	584 kWh
Medium (180W)	2.5 kWh	9 12 kWh
Large (220W)	3.1 kWh	1 132 kWh

Table 1:
Average consumption of Cuban refrigerators before the Energy Revolution (Source: Centro de Estudios de Energía y Medio Ambiente. Universidad de Cienfuegos y Grupo de Energía. Dirección de Economía y Planificación, Cienfuegos Cuba)

While the power-saving lamps and the fans were given to households free of charge, for the refrigerator exchange they had to raise around 6,100 Cuban pesos (about 180 euros) [8]. However, if they could not pay the amount directly, they had the possibility to take out a loan (see Section 4).

In addition to the aforementioned measures, 230,500 television sets, 268,000 water pumps and 266,000 inefficient air conditioners were also exchanged. For businesses, the priority was the exchange of 800,000 inefficient fluorescent tubes with magnetic ballasts for more efficient lamps with electronic ballasts. Also, energy analyses and saving measures were undertaken in state-owned enterprises.

In addition to these specific energy-saving measures, there were far-reaching changes in Cuban kitchens. While the vast majority of

[6] Mario Alberto Arrastía Ávila, Cubaenergía, (own interview)

[7] This value has been set deliberately high. The price actually paid should be closer to 100 euros per unit. Today, in China, one can buy comparable units for 120 euros in retail.

[8] It should be noted that the economic calculation looks different from the households perspective and, because of the progressive power tariff, very much depends on the total consumption of the household.

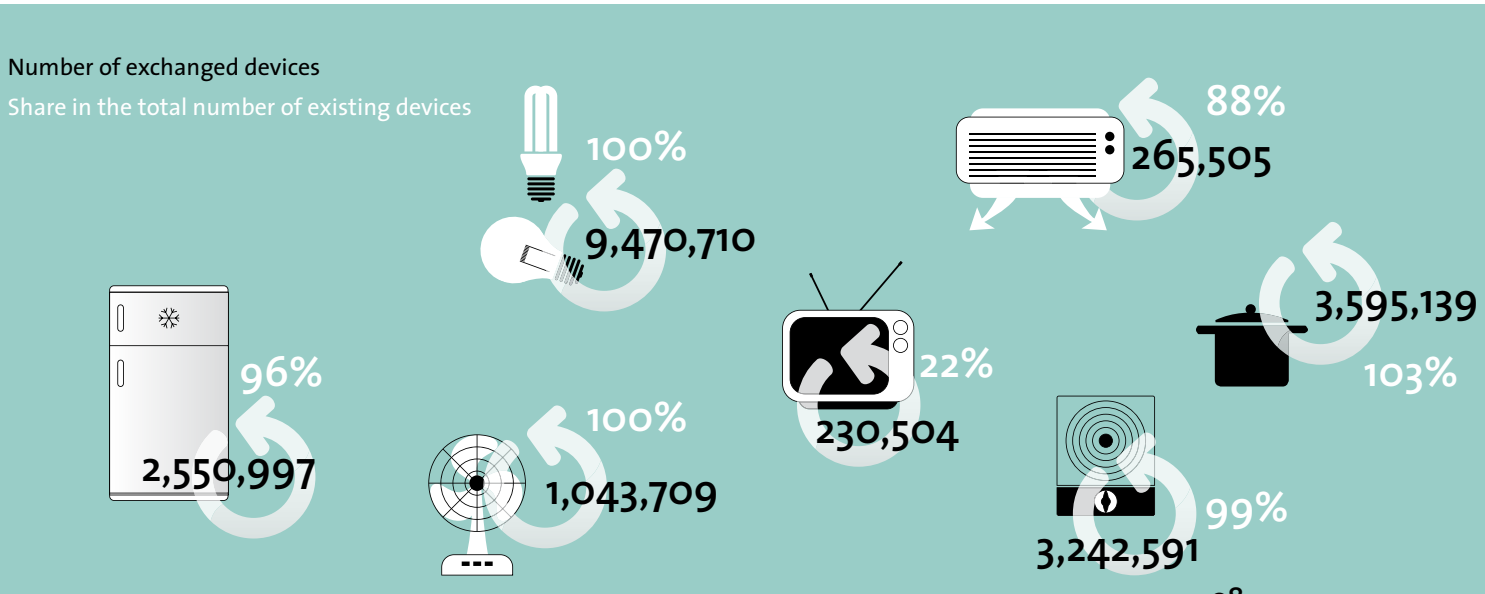


Figure 2:
Exchanged devices and their share in the total number of existing devices (Source: UNE 2009)

households cooked with kerosene and LPG until early 2006, within a few months some three million households [9] were converted almost completely to electric cooking. Gas stoves remained only in areas where there was a gas supply.

Households were provided with simple electric hotplates, a special rice cooker and a pressure cooker [10] (both electric), as well as immersion heaters and pots. These items were billed to the households.

From a health perspective, this change is certainly very advantageous. When kerosene is used for cooking and lighting, the indoor air is heavily contaminated with particulate matter. In addition, there is an increased risk of fire.

The disadvantage of this measure however is an increased peak power demand (in Cuba, there is a lunchtime peak and a pronounced peak in the evenings). Indeed, the peak load for the entire power demand rose by 33 percent between 2004 and 2008 [11], despite the load management measures taken by the industry.

During the Energy Revolution, 2.55 million refrigerators were replaced with more efficient devices of Chinese design.

[9] Fidel Castro, speech on 5/5/2006

[10] The energy-saving pressure cooker in Cuba is called "olla reina", the "pot queen"

[11] ONE 2009, Table 63

	Old Refrigerators	Efficient Refrigerators
Consumption refrigerator / year	800 kWh	350 kWh
Savings per refrigerator / year	-	450 kWh
Number of refrigerators	-	2 550 000
Annual energy consumption	2 040 000 000 kWh	892 500 000 kWh
Annual electricity savings	-	**1 147 500 000 kWh**
Variable costs of electricity generation	0.2 Euro/kWh	0.2 Euro/kWh
Annual electricity costs	408 000 000 Euro	178 500 000 Euro
Annual savings in electricity costs	**-**	**229 500 000 Euro**

Table 2: Electricity savings through refrigerator exchange in Cuba (Source: own calculations)

With the conversion of Cuban kitchens to electricity and the additional consumption resulting from the elimination of the shortage economy, the achieved energy savings have been compensated or even overcompensated: according to official statistics, between 2004 and 2007 the power consumption of Cuban homes increased from 1,668 kWh to 1,901 kWh per household and per year, representing an increase of 13% [12].

However, by switching to electric cooking and considering the related savings in kerosene and LPG, Cuba managed to save about 250,000 tons of oil equivalents annually [13].

Figure 3 shows the evolution of the daily electricity consumption per household during the implementation of the Energy Revolution. While the monthly values in Figure 3 show that, regardless of seasonal variations, annual consumption was relatively constant; the Central Statistical Office of Cuba estimated an increase of 13%. The difference between the values shown in Figure 3 and the official statistics [14] could not be clarified [15].

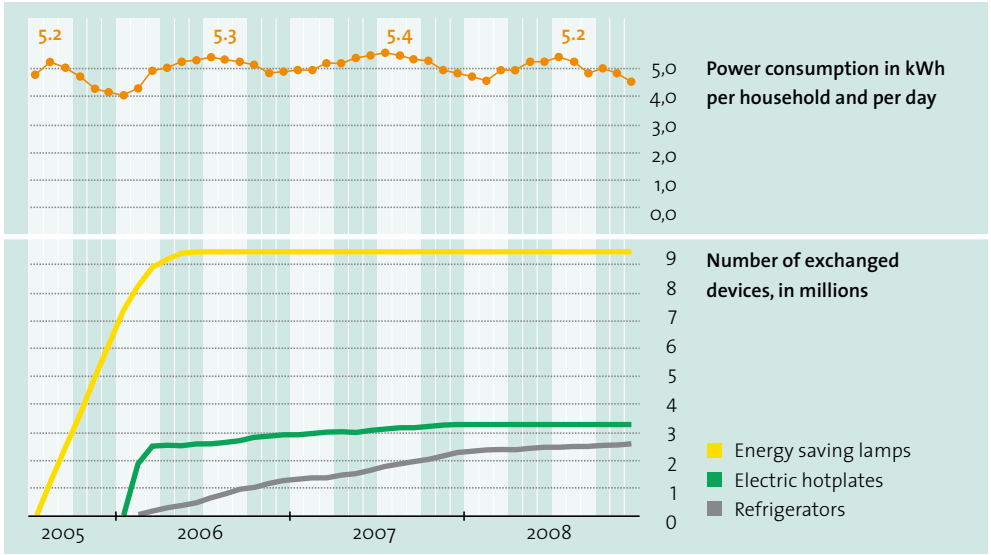


Figure 3:
Daily electricity consumption of Cuban households during the Cuban Energy Revolution (Source: UNE 2009)

The energy savings achieved through the exchange of inefficient equipment have been compensated by the increased consumption due to the electric cooking.

[12] ONE 2009, Table 70
[13] UNE 2009
[14] ONE 2009, p. 92
[15] Unfortunately, no reliable studies on the results of the Cuban Energy Revolution are publicly available. It could not be determined whether there was a failure to carry out the appropriate examinations or if the analyses are retained.

Costs of Energy Efficiency

It has already been shown that the savings in energy costs far outweigh the investments for household appliances. Summing up the three energy-saving measures (see Table 3); we obtain a benefit-cost ratio for the Cuban economy of about 10[16]. This exceptionally large advantage in favour of energy efficiency is partly due to the low efficiency standard before the Energy Revolution, and also to the high cost of power generation in the Cuban energy sector.

In Germany, the above-mentioned pilot project in low-income households yielded a benefit-cost ratio of about 3, considering only the initial technology cost in relation to the avoided generation, transmission and distribution costs.

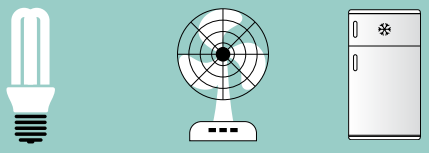
Excursion

In the pilot project in Freiburg and Berlin shown in Chapter 4, the cost per saved kilowatt hour of the direct actions „power strip“ and „timer“ is less than one cent per kilowatt hour. The lamp replacement costs 1.2 cents per saved kilowatt-hour, while the specific costs per saved kWh for the refrigerator exchange are 7 cents / kWh.

On average, the cost of all the applied saving technologies was around 3.7 cents / kWh. The cost of the energy analysis and the transaction costs are not considered here. If consulting fees of 120 euros per consulting service - and 160 euros per consulting service in case a refrigerator is exchanged - are taken into account, then the specific costs amount to 6.7 cents per saved kilowatt-hour.
(Source: Büro Ö-quadrat 2008)

[16] Due to the short payback period, the consideration of the cost of capital (interest on capital employed) was abandoned in favour of a better traceability.

Costs and benefits assessment



	Fluorescent lamps (CFL)	Fans	Refrigerators	Total or ratio
Investment (million euros)	0	10.4	383	393
Annual savings (MWh)	354 123	62 640	1 147 500	1 564 263
Lifespan (years)	8.3	7.0	15	
Total savings (MWh)	2 951 025	438 480	17 212 500	20 602 005
Benefits (million euros)	590	88	3 443	4 120
Benefits / Costs	-	8.4	9.0	10,5

Table 3:
Costs and benefits assessment of the appliance replacements during the Cuban Energy Revolution.

Tariff Restructuring and Social Credit as Accompanying Measures of the Energy Revolution

4

In connection with the equipment exchange, the residential electricity rates have been readjusted. While the prices for the lower consumption zones remained unchanged, the rates for large consumers increased significantly. The objective of this measure was, on the one hand, the partial removal of energy subsidies, and secondly to give an increased incentive to save power without the poorest households having to shoulder a heavier burden. The change in the tariff structure, which was completed by the beginning of 2006, is shown in Figure 4.

Households that consume less than 100 kWh per month (or less than 1,200 kWh per year) continue to pay 0.09 Cuban pesos (0.3 eurocents) per kilowatt-hour. Each additional kilowatt-hour cost 0.2 pesos before the Energy Revolution, up to a consumption of 300 kWh per month, beyond which one had to pay 0.3 pesos per additional kWh. With the newly-introduced tariff structure, the second rate band already starts with a consumption of 101, up to 150 kWh / month, for which the rate increases to 0.3 pesos. After that, it keeps increasing systematically for every additional 50 kWh per month, up to 1.3 pesos per kWh for a monthly consumption of 300 kWh.

In 2011 the rates for large consumers were updated again, from 1.3 pesos / kWh to 5 pesos / kWh for consumption higher than 5,000 kWh / month (see Table 4). In other words, the tariff in the highest rate band was now more than 50 times that of the lowest. Tariffs for households with low or medium power consumption (up to 3,600 kWh / year) remained constant.

With the new tariff structure, it is now interesting, mainly for large consumers, to invest in more efficient appliances. For households that are located in the first rate band, however, the equipment replacement does not pay off from the savings in electricity costs, because the price of electricity in this rate band is highly subsidized and the kilowatt-hour costs less than one eurocent. On the other hand, since their refrigerators were very old and needed repairs, and there was no other way to obtain a new one, the majority of households took part in the substitution program.

In July 2011, Cuba lifted the ban that was in place since 2003 for the sale of power-consuming devices [17].

[17] www.noticiaaldia.com/2011/07/cuba-levanta-prohibicion-a-venta-de-electrodomesticos-vigente-desde-hace-8-anos

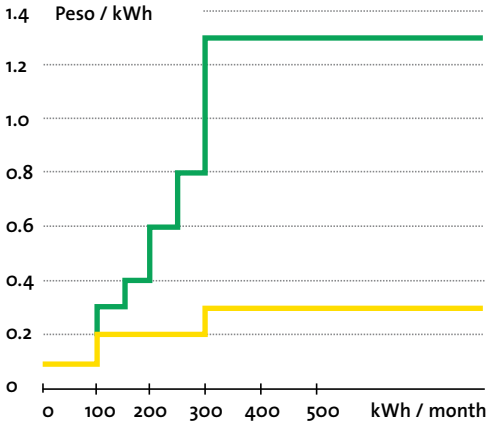


Figure 4:
Electrical tariff structure in Cuba before and after the Energy Revolution (Source: Castro, F. 2005; own illustration)

As the electricity price for consumption above 1,200 kWh per year increased significantly during the Energy Revolution, the state energy utility's average revenue from electricity sales to households rose from 0.140 pesos per kilowatt-hour in 2004 to 0.248 pesos in 2007[18]. The change in the electricity tariff structure presented above resulted in an additional burden for households with above-average electricity consumption. This burden could only be partially offset by the eliminated cost of kerosene and LPG.

The sharp increase in the electricity bill can also be explained by the fact that electricity rates had already increased in January 2006, but significant parts of the efficiency program, such as the replacement of refrigerators, were only completed by the end of 2008.

With this early tariff increase, the government wanted to increase the willingness to purchase new equipment and increase the level of consumer awareness. However, „For a broad social support for the „energy revolution", it would have certainly been more helpful to ensure the conversion first and then raise the price of electricity." (Helferich, 2008)

Table 4:
New power rates for households with a consumption exceeding 300 kWh per month, from 2011.

until 2011	consumption per month	today
1.3 Pesos per kWh	over 5000 kWh	5.00 Pesos per kWh
	1001 to 5000 kWh	3.00 Pesos per kWh
	501 to 1000 kWh	2.00 Pesos per kWh
	351 to 500 kWh	1.80 Pesos per kWh
	301 to 350 kWh	1.50 Pesos per kWh

[18] ONE 2009, Table 70

Excursion

Necessary Electricity Tariff Adjustment in Germany

While in Cuba the electricity price increases with increasing consumption, the opposite correlation can be observed in Germany: there, large consumers pay about 20 to 30% less per kilowatt-hour than households with low consumption. Yet it is no longer acceptable, in times of climate change, that households can cause the emission of any amount of greenhouse gases and even be rewarded with discounts.

A remedy could be provided by a simple rule as follows:

- The lump-sum fee should be abolished and included in the per-unit charge (linear rate). As a result, the kilowatt-hour rate increases slightly, the tariff's digressive effect is eliminated, and electricity prices are directly comparable. To cover the cost of the meter and service, a minimum invoice amount of e.g. 5 euros per month is due.
- If consumption exceeds a certain value, (which can be differentiated according to the number of persons and children in the household) then a surcharge is levied on the electricity price. For instance, for a two-person household with a consumption of more than 3,000 kWh / year, a 10% premium on the price per kilowatt-hour would apply [19].
- The additional revenue resulting from the surcharge must be used to improve energy efficiency

This tariff conversion could happen without any investment in new electricity meters and would improve price transparency, which would strengthen price competition among electricity providers.

[19] This proposal only shows the direction in which a restructuring of rates should go. The values are intended as an example and require appropriate analysis and testing.

Social Credits in Cuba

To enable the purchase of efficient appliances, Cuban households had access to a loan program during the Energy Revolution. This program was created specifically for the Energy Revolution, and is characterized in that the credit terms, such as the interest rate and the repayment period, were adjusted to the capacity of the borrower.

Overall, Cubans have financed 4.6 million items with a total value of 9 billion pesos through this loan program. The following credit terms have been agreed with the "Banca Cubana": For a monthly income of up to 225 Cuban pesos, an annual rate of 2% and a repayment period of 10 years were offered.

The conditions for the borrower became less favourable as his income rises (see Table 5). With an income of 1801 CUP and more, loans were no longer granted [20].

Table 5: Credit conditions for loans that were offered as part of the Cuban Energy Revolution (Source: see footnote 20)

Monthly income in Cuban pesos	Interest rate in %	Amortization period in years
Up to 225	2	10
226 to 450	3	10
451 to 600	4	10
601 to 800	5	5
801 to 1000	6	4
1001 to 1400	6	3
1401 to 1800	6	2
Over 1800	No credit	-

[20] www.juventudrebelde.cu/cuba/2007-12-04/banca-cubana-puede-asumir-todos-los-creditos-para-el-pago-de-los-equipos-electrodomesticos

Social Loans for Low-Income Households in Germany

The purchase of high-efficiency refrigerators and lamps would also be worthwhile for many low-income households in Germany. This has been proven by a field experiment in the city of Freiburg (Büro Ö-quadrat 2008). As part of the first field experiment, 80 households on welfare received free energy advice and an analysis of their electricity consumption. It was observed that it would be worthwhile to replace the refrigerator and/or the freezer in 36 households. In this case, an achievable reduction of at least 200 kWh per unit was set as a benchmark. 14 of the 36 households even had both a refrigerator and a freezer, which could be replaced by a new fridge-freezer. This means that instead of an old refrigerator and an inefficient freezer in the basement, a new efficient refrigerator-freezer combination would be installed in these homes. The anticipated average savings per household were 452 kWh / year, or 6,780 kWh over the appliance's lifespan [21].

Although the cooling appliance replacement is economically attractive for low-income households, they can usually not afford the higher cost of new high-efficiency refrigerators. To nonetheless exploit the potential savings, the following approach was applied during the pilot project: for a simple change of the old appliance for a refrigerator with an A++ efficiency class [22], customers received a bonus of 200 euros. By replacing a refrigerator and a freezer with a fridge-freezer (efficiency class A++), they were entitled to a bonus equal to 50 percent of the new equipment's price, up to 300 euros. The rest of the purchase prices (typically between 500 and 700 euros) could be financed through a loan at an interest rate of 4 percent. The maximum loan amount was 300 euros per customer.

Of the 36 considered customers, 30 had explicitly stated that they were interested in the purchase of a refrigerator with the granting of a premium, and that in this context, they would also make use of the loan to finance the remaining amount (price minus premium). In fact, 24 premiums and 17 loans were granted as part of the pilot project.

The experience of credit granting was positive: in 15 cases, all refund payments were made. However, the banks in Germany are not yet ready to give households that have no regular income a small loan to buy an efficient refrigerator.

The annex shows, through an example, that the purchase of new domestic appliances is a large, untapped potential for savings in Germany and in the EU. This potential should be exploited as part of the energy transition by replacing inefficient refrigerators and freezers, especially in low-income households, through appropriate measures. As studies have shown [23], targeted incentives for the purchase of highly efficient equipment for all households (e.g. through a rewards program) are advantageous both economically and ecologically.

[21] The possibility that the household could, at a later date, exchange the existing chiller with a more efficient refrigerator is not considered.

[22] At the time of project implementation, A++ was the highest class of the European energy label, as there was no A+++ efficiency class yet.

[23] Öko-Institut, dena, Büro Ö-quadrat 2008, Öko-Institut/Büro Ö-quadrat 2009 and 2012

Distributed Generation

5

Decentralized power plants have been built for a more reliable power supply.

The collapse of the power plant in Matanzas in 2004 and the coverage gaps caused by hurricanes led the Cuban government to decentralize power supply. This was to ensure that in case of a large power plant failure or an interruption of the transmission network, the power supply would be secured at a decentralized level. Therefore, in parallel to the power-saving measures, a significant decentralized power-generating capacity was built. 1,531 engines with a total output of 3,072 MW were imported and installed throughout the island [24]. At the same time, improvements in the transmission and distribution networks were made to reduce the transmission and distribution losses. While in 2007 the entire distribution and transport losses amounted to 15.7% of the produced electricity, they were successfully reduced to 14.8% by December 2008 [25].

Since the total capacity available from the central oil- and gas-fired power plants is approximately 1,500 MW, and the maximum power demand is about 2300 MW (in year 2005), the additional distributed generation capacity solves the capacity problem for the coming years, despite the conversion to electric cooking.

Because of the fuels used and the low energy efficiency of old thermal power plants, the Cuban power plant fleet shows high variable power generation costs. A study by the American aid agency U.S. Agency for International Development estimates the average variable costs in Cuba (mainly fuel costs), with a crude oil price of 100 U.S. $ / barrel, at 26 U.S. cents per kWh. Although Cuba obtains oil from Venezuela through alternate arrangements [26], if the world price for crude oil is taken to determine the savings in electricity costs, they can be estimated at approximately 20 eurocents per kilowatt-hour. At such high electricity generation variable costs, nearly all efficiency technologies can be implemented profitably.

[24] UNE 2009
[25] UNE 2008
[26] The oil is paid through some 23,000 Cuban doctors and nurses who provide medical services in the slums and disadvantaged villages of Venezuela, performing free eye surgeries for thousands of needy and conducting a literacy campaign for 1.5 million people. (Source: NZZ, 12/2/2007)

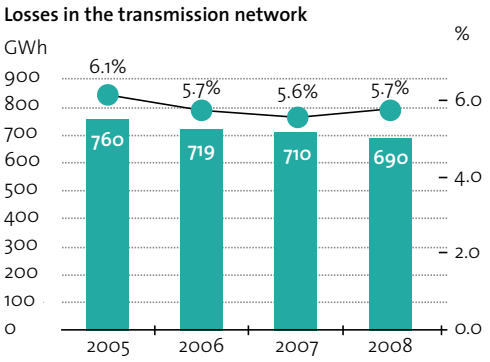


Figure 5: Improvements in the transmission and distribution networks were made to reduce losses.

Awareness Raising and Communication

6

The "**PAEME** Festival" promoted energy and environmental awareness of primary school children, teenagers, teachers and families through extra-curricular activities throughout the country

Before 1989, Cuba obtained oil from the Soviet Union on favourable terms. With the break-up of the Soviet Union and USA's increased boycott measures against Cuba, the country entered a state of economic crisis. The government tried to overcome the energy shortage through education and learning programs. The „energy advocates" trained for this purpose quickly learned that the change of behavioural habits required the introduction of new values in the society. However, they also realized that education and awareness are the most cost-effective measures to save energy.

The government program aimed to create a new energy culture for a sustainable development. But this is a long-term process: in 2006 the newspaper issued by the government, "Granma", reported that the energy problem is not so easily solved. Training 11.5 million inhabitants to save energy is a huge task [27].

During the implementation of the restructuring program in the years 2006 to 2008, the Cuban government made various efforts to inform households of the measures taken in the Energy Revolution and the opportunities for energy savings. Approximately 17,000 television spots and 5,200 radio spots were broadcasted, about 1,600 newspaper articles were printed and more than 1,100 discussions were conducted in various districts [28]. Furthermore, the Ministry of Education (Ministerio de Educación) launched the program PAEME (Programa de Ahorro de Energía del Ministerio de Educación), which brought the Energy Revolution to the schools and communities.

An example of this program is the "PAEME Festival". This program mobilized thousands of primary school pupils, teenagers and teachers across the country. During the festival, the children were encouraged to create songs, poems and theatre plays on the subject of energy. Thus, 564 festivals were held and 6,300 thematic works were written within the framework of the program [29].

The children with the best proposals presented their creative outputs at the local level. The winning contributions then competed at the provincial level and, at the following stage, at the national level [30].

564 festivals were held and 6,300 thematic works were written within the framework of the program PAEME.

[27] Mario Alberto, Arrastía Avila 2009
[28] UNE 2009
[29] UNE 2009
[30] Mario Alberto, Arrastía Avila 2009

Caught in the Loan Agreement with China?

7

Almost all products that were installed during the Cuban Energy Revolution were purchased as part of a comprehensive credit deal with China. In addition to the aforementioned items, such as refrigerators, fans, energy-saving lamps, cookers, pressure cookers, TVs, pumps and motors, the trade also included the purchase of distributed power generation systems, as well as vehicles for public transport and vehicles for state-owned enterprises. This type of procurement - which was also under pressure to acquire many products on a small budget - led, among other things, to the purchase of sub-optimal efficiency household appliances. This can be seen in part through the new refrigerators' wear, but also by a mere visual inspection of the electric hotplates [31].

Yet, considering the high cost of electricity generation in Cuba, it would have been worth to replace the old cooling refrigerators with the most efficient equipment available on the market. This is supported by a simple cost calculation: additional savings of 150 kWh per refrigerator per year, which would have been easily achievable and would have meant a further reduction in consumption (reaching 200 kWh per unit per year) would provide additional savings of 2,250 kWh, or 450 euros in 15 years. The additional costs, on the other hand, would have been significantly lower than 100 euros according to Büro Ö-quadrat's estimates.

However, the extent to which the Cuban economy's financial constraints conflicted with the Energy Revolution cannot be determined since the Cuban government withholds key relevant information.

Public criticism of government programs is not welcomed in Cuba and may result in disadvantages for the critics. This is especially true when the program is personally designed and implemented by Máximo Líder Fidel Castro, as was the case for the Energy Revolution.

Undoubtedly, the program has fundamentally stabilized Cuba's power supply, thus allowing the country to successfully avert the economic damages caused by the nationwide blackouts up to that date. Yet there has also been some criticism.

The conversion to electric cooking and the increased price of electricity in the higher tariff bands has led to households having to globally pay considerably more, which has undoubtedly caused displeasure among many. Issues were also reported with devices' quality, repairs and purchase of spare parts. This can be read in blogs on the Internet, but also emanates from the official economic plan: one of the priorities of the national plan for 2011 was to improve the quality of repair service for electric cooking appliances [32].

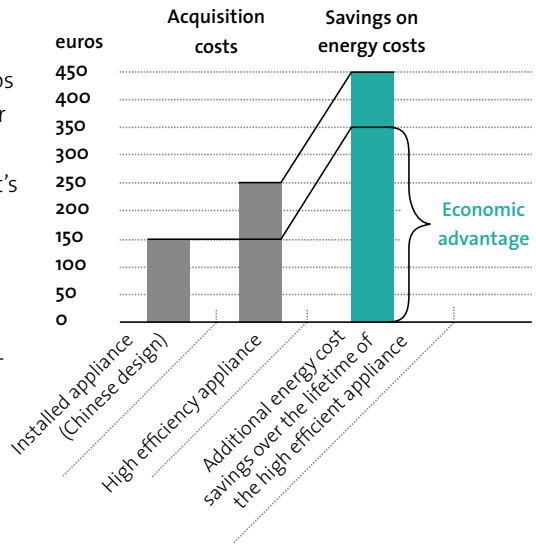


Figure 6: Comparison of the extra investment and additional energy costs savings through high efficiency appliances.

[31] For example, by the absence of insulation between the heating coil and the base of the cooking appliance.

[32] Elevar la eficacia de los servicios de reparación y mantenimiento de los equipos eléctricos de cocción con vistas a lograr su adecuado funcionamiento. Lineamientos de la Política Económica y Social del Partido y la Revolución. VI Congreso del Partido Comunista de Cuba. Aprobado el 18 de Abril de 2011.

8

"Hemos encontrado, afortunadamente, algo más importante, el ahorro de energía, que es como encontrar un gran yacimiento"

Fidel Castro

(Source: Agência Brasil)

„Cuba is not waiting for things to fall from heaven, because we have discovered something far more important: energy saving, which is worth as much as large oil deposits." [33]

This statement by Fidel Castro also applies to Germany. Even though the efficiency potential per refrigerator, light bulb or machine is slightly lower in Germany than in Cuba, there still is an important and cost-effective efficiency potential to tap into (see annex).

The Cuban Energy Revolution took place under extreme shortage of foreign currency of the Cuban state, and while facing elementary problems in meeting the basic needs of the population. The changes were primarily due to economic and technical requirements, in order to prevent the complete collapse of the power supply.

The necessary changes to the energy supply system in Germany are due to the fact that today's electricity and energy supply is not sustainable. Almost all scientists and energy politicians agree: in order to reach a state that can be considered "sustainable", tapping into the existing efficiency potential is a key challenge, if not the most important one [34].

A necessary shift in energy policy

However, this potential will not exploit itself (see annex); it requires a targeted energy policy shift. Cuba has carried out this reorientation with the Energy Revolution. There, the appliance replacement program was achieved mainly through strict central directives and forced conversion. Such an approach is neither possible nor desirable in Germany - even if it would bring considerable economic benefits. Rather, the right incentives have to be provided by policy-makers to mobilize exploitation of the energy efficiency potential. Differentiation by customer groups and by technologies must be provided. At the same time it is necessary to hedge the impact on low-income households.

Appropriate concepts for harnessing the efficiency potential and solution approaches have been presented by the Wuppertal Institute, the Energy Saving Fund and the Öko-Institut [35] as part of a program to promote the national initiative for climate protection launched by the BMU (German Ministry of Environment, Nature Protection and Nuclear Safety) [36]. So far, these approaches have not been realized. However, the European Energy Efficiency Directive adopted in Brussels in late 2012 improves the chances of an implementation.

The transition has to be done in a socially fair manner

As part of the Energy Revolution, Cuba has reduced the extreme subsidization of electricity consumption and, by increasing power rates for high-consumption households, has sent them a clear message. Simultaneously, the implemented investment measures were cushioned by social loans. Though the electricity prices are not subsidized in Germany, it's time to think about progressive tariffs and abolishing volume discounts and exemptions for large consumers. A simple tariff plan for Germany was sketched in chapter 4, and involves rates that can be structured and implemented in a socially fair manner. The tariff conversion would relieve small consumers and burden large consumers, and the overall power consumption and air pollution would be reduced by the initiated efficiency measures and behavioural changes. In addition, the proposed tariff structure would make the power companies' service more transparent and easier to manage for the consumer.

It is important to absorb the cost of the energy transition in a socially just fashion, especially because of the (necessary) further expansion of renewable energy sources and the electricity price increases expected in the medium term. The costs for the development of renewable energy sources are borne by all electricity customers through a surcharge on

[33] Guevara-Stone 2009

[34] Currently there is an intensive debate in Germany about network expansion, storage technologies, updating the law on renewable energies, introducing capacity markets, etc. The discussion is necessary. However, it should not obscure the easy savings potential that could substantially contribute to a solution to the problem and to cost savings.

[35] Wuppertal Institut 2006

[36] Öko-Institut/Büro Ö-quadrat 2009, 2012, 2012a

the price of electricity (EEG surcharge). Approximately 1,000 large industrial and commercial customers are exempt and thus do not contribute to these costs, or only to a very small proportion. Since the majority of investments in renewable energy sources is carried out by private companies and individuals, and these investors profit from the feed-in remuneration financed by all customers, there is redistribution from bottom to top: low-income households have to pay the EEG-fee, but have no possibility to benefit from renewable energy investments. High-income households also pay the EEG contribution, but they can offset these costs and even realize significant capital gains by investing in renewable assets or in their own solar systems. A targeted support policy backed by tariff policies, free energy-saving vouchers and social loans could make a significant contribution to the energy transition and to reducing the costs for power consumers.

The "Stromspar-Check-Projekt" [37] (power-saving voucher project), funded by the BMU for low-income households and implemented by the German Caritas Association and by the Federation of Energy and Climate Protection Agencies, leads the way. But it is not sufficient, as it reaches only a small percentage of low-income households. Ultimately, it would take a comprehensive efficiency program that reaches all residential customers and supports the market penetration of high-efficiency equipment (see annex).

Energy revolution in Cuba – an example for other countries

With the replacement of inefficient power-consuming devices, Cuba is an early example for other countries. In other Third World countries, such as India, Indonesia, South Africa, Brazil, Mexico, Iran, Costa Rica and other Central American countries, a very high potential for savings remains dormant in the inefficient refrigerators and should be exploited for the benefit of national economies but also for climate and environment protection. Targeted exchange and market transformation programs are of particular economic and environmental benefits, especially in countries where subsidized electricity prices override the market forces.

Cuba, as a socialist country with a centrally-planned economy, tapped into the efficiency potential out of national economic interest and necessity. In free market countries, where the credo is that the "invisible hand of the market" leads, through the competitive process, to an optimal economic solution, the large majority of the efficiency potential remains unexploited. However, and precisely in a context of rising electricity prices, it is urgent to reduce electricity costs for customers through targeted efficiency programs. In contrast to the German Minister of Environmental Protection Altmaier's proposal to introduce a "protection of electricity costs" by temporarily overriding the Renewable Energy Act (EEG), an efficiency strategy could reduce the electricity bills of households in the long term, without limiting the expansion of renewable energies.

It is obvious that the Cuban example and its approach cannot be copied in a market-oriented or a capitalist country. However, it raises the question of when the relevant policy instruments (see annex) will be used in Germany and other countries to exploit the "hidden treasures" of efficiency potential.

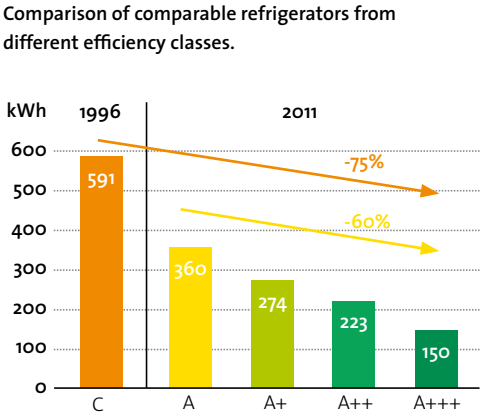
[37] www.stromspar-check.de


CUBA
HFW712

Annex

9

Figure 7: High potential for savings in refrigerator-freezer combinations (Source: Boehm, BSH)



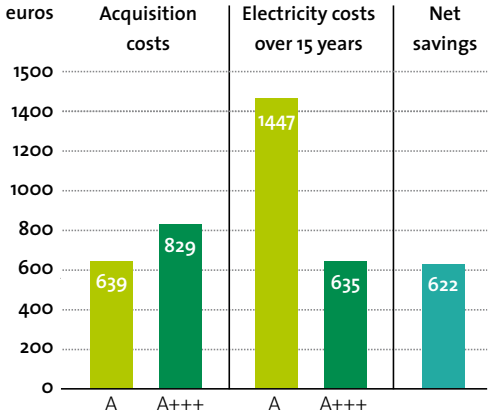


Figure 8: Additional investment for the purchase of an A+++ device instead of an A class device and net savings over the life cycle (Source: Büro Ö-quadrat, based on Boehm, BSH)

As shown in the main part of this booklet, there was a significant savings potential in the field of refrigeration in Cuba. Even though refrigerators in Germany are much more efficient, on average, an appropriate energy policy in Germany and the EU could lead to great savings and accelerate market penetration of high-efficiency devices. Figure 7 shows that the power consumption of an A+++ device is lower by about 60% than that of a comparable class A device.

Although the A+++ device in this example is 190 euros more expensive (see Figure 7 and 8), the buyer can achieve a net saving (savings on electricity costs less additional investment) of 622 euros over the device's lifespan (15 years). This represents an internal rate of return of 25% on invested capital. Nevertheless, high-efficiency appliances are purchased by relatively few households and only reach a small market share. Consumers are generally not well informed and the higher investment costs act as a deterrent.

The purchase of high efficiency appliances would also be advantageous from a macroeconomic perspective: the additional cost to produce a high-efficiency refrigerator can be estimated at less than 4 cents per saved kilowatt-hour of electricity. On the other hand, the cost of power generation, including transmission and distribution costs, is at least 10 eurocents per kWh. In addition, this electricity production has external costs, through the climate and environmental damages it causes, which are currently not covered by the electricity prices.

As demonstrated in the previous example, it would be beneficial for both consumers and the economy as a whole to accelerate the market penetration of high-efficiency appliances. This can only be achieved through a combination of different measures. One of the key measures is a targeted equipment premium that directs the attention of buyers towards high-efficiency equipment and, as experience shows, influences buying behaviour accordingly [38].

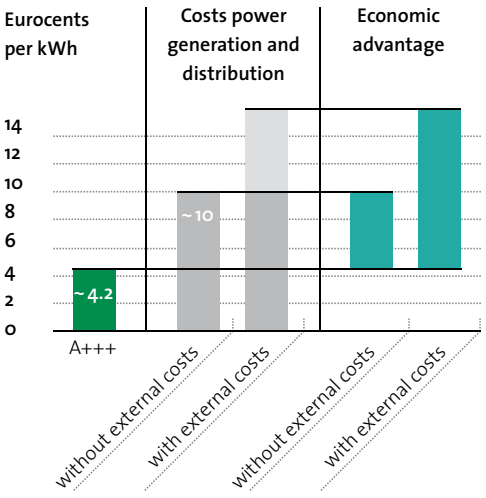


Figure 9:
The economic costs of the efficient technology are much lower than the costs of electricity generation and its external costs.
(Source: Büro Ö-quadrat, own calculations)

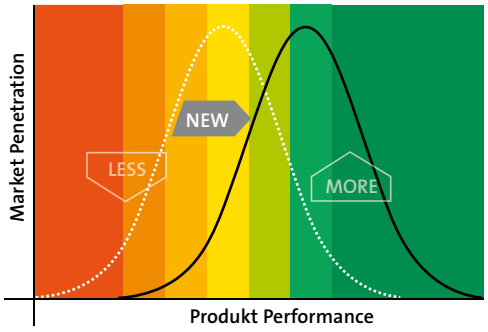


Figure 10:
Market transformation towards energy efficiency requires the use of various instruments
(Source: Büro Ö-quadrat)

LESS

Suppress inefficiency
- Minimum efficiency standards
- Product Testing
- Labelling
- Taxes on energy

MORE

Promote efficiency
- Life-Cycle Cost
- Procurement
- Premiums / impulse programmes
- Certificates / Efficiency Fund

NEW

Development
- R&D
- Efficiency Competition

[38] Öko-Institut, dena, Büro Ö-quadrat 2008 and Irrek among others 2012

References

10

Bauer, Richard (2007): Venezolanische Bruderhilfe für Kuba. NZZ. 12.02.2007

Belt, Juan A.B.: The Electric Power Sector in Cuba: Potential Ways to Increase Efficiency and Sustainability, o.J.

Boehm, P. 2011 (BSH Bosch und Siemens Hausgerate GmbH): Supereffiziente Hausgeräte: Breite Vermarktung statt Premiumstrategie. Vortrag im Rahmen Fachkonferenz : Stromsparen in privaten Haushalten, Berlin, 7. Juli 2011

Büro Ö-quadrat 2008: Umsetzung von Energieeffizienzmaßnahmen in einkommensschwachen Haushalten, in Kooperation mit der Energieagentur Regio Freiburg und Berliner Energieagentur, Freiburg, Berlin 2008

Castro Ruz, Fidel (2005): Medidas sobre las tarifas eléctricas, 25.11.2005.

Centro de Estudios de Energía y Medio Ambiente. Universidad de Cienfuegos y Grupo de Energía. Dirección de Economía y Planificación, Cienfuegos, Cuba: Incremento de eficiencia de los refrigeradores domésticos mediante mejoras en la transferencia de calor en el condensador. http://www.cubasolar.cu/biblioteca/Ecosolar/Ecosolar03/HTML/articulo04.htm

Environment & Poverty Times, 6/2009: Favela Cool against Global Warming

EU-Effizienzrichtlinie 2012: Legislative Entschließung des Europäischen Parlaments vom 11. September 2012 zu dem Vorschlag für eine Richtlinie des Europäischen Parlaments und des Rates zur Energieeffizienz und zur Aufhebung der Richtlinien 2004/8/EG und 2006/32/EG (COM(2011)0370 – C7-0168/2011 – 2011/0172(COD))

Guevarara-Stone, L.: Viva la Revolución Energética, in Quetzal, Politik und Kultur in Lateinamerika, Juli 2009

Helfrich, Silke: „Energierevolution" in Kuba – ein verordneter Paradigmenwechsel (ohne Jg.; http://commonsblog.files.wordpress.com/2008/09/sp_-_helfrich_kuba-energierev.pdf).

IAEA 2008: Cuba: A Country Profile on Sustainable Energy Development, Vienna 2008

Irrek, W.; Seifried, D.; Grießhammer, R. (2012): Finanzielle Unterstützung der Produktentwicklung und Vermarktung hocheffizienter, energieverbrauchender Produkte. Einzelstudie im Rahmen des Projektes „Energieeffizienter Klimaschutz bei Produkten", Freiburg 2012

ISES 2004: Improving Access to Sustainable Energy Sources in Developing Countries, im Auftrag des BMU

Mario Alberto Arrastía Ávila, Cubaenergia, Vortrag "Energy and Development"

Mario Alberto Arrastía Avila: Teaching Cuba´s Energy Revolution, in: SOLAR TODAY, January/February 2009

ONE 2009: Dirección de Industrias: Estadisticas Energeticas en la Revolución, Año del 50 Aniversario del Triunfo de la Revolución" Edición Septiembre de 2009

Öko-Institut/Büro Ö-quadrat 2012: Zielgruppenspezifische Förderprogramme; Einzelstudie im Rahmen des Projektes „Energieeffizienter Klimaschutz bei Produkten", Freiburg 2012

Öko-Institut/Büro Ö-quadrat 2009: Konzeption eines produktbezogenen Impulsprogramms im Rahmen der Nationalen Klimaschutz-Initiative – Erarbeitung von Programm-Modulen zur praktischen Umsetzung, Freiburg 2009

Öko-Institut, dena, Büro Ö-quadrat 2008: Konzeption eines produktbezogenen Impulsprogramms im Rahmen der Nationalen Klimaschutz-Initiative, Freiburg Berlin 2008

Sustainable Energy Policy Concepts (2002), German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) 2002

Television Camagüey: Nuevas tarifas eléctricas en sector residencial cubano, 29.10.2011 http://www.tvcamaguey.icrt.cu/index.php?option=com_content&view=article&id=4695:nuevas-tarifas-electricasen-sector-residencial-cubano&catid=3:newsflash&Itemid=114

Unión Electrica (UNE) 2009: La Eficiencia Energética en Cuba. Resultados y perspectivas, Vortrag, Dezember 2009

Unión Electrica (UNE) 2008: La Eficiencia Energética en Cuba. Resultados y perspectivas, Vortrag, Dezember 2008

Wuppertal Institut 2006: Der Energiesparfonds für Deutschland, Düsseldorf 2006

Other Sources:
Bridging the Energy efficiency gap (BigEE): http://www.bigee.net/

CUBAENERGIA: www.cubaenergia.cu

CUBASOLAR: www.cubasolar.cu

GRANMA: www.granma.cu

MINBAS: www.cubagob.cu/des_eco/minbas.htm

Oficina Nacional de Estadísticas Cuba: www.one.cu

Stromspar-Check: www.stromspar-check.de

Imprint

Autor
Dipl.-Ing., Dipl.-Volkswirt Dieter Seifried

Design
triolog – kommunikation mit energie
Freiburg, Germany
www.triolog-web.de

Photos
Dieter Seifried, triolog, cubaenergía

Translation
Alice Leparc

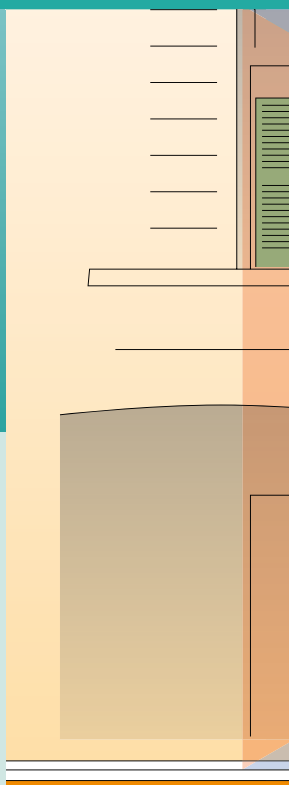
© 2013, Büro Ö-quadrat


TAXI

Cuba:
The Disregarded Energy Revolution

Almost unnoticed by the public and also most energy experts in Germany, an energy revolution took place in Cuba („revolución energética"). This energy revolution was initiated by Cuba´s President Fidel Castro in the year 2005 and in some aspects even surpasses the German Energiewende. Dieter Seifried was on site and reports about the realization and success of this energy revolution.

One example showcased in this report is the replacement program for refrigerators, which has created macroeconomic annual savings of over 200 Million Euros. The report also highlights the parallels and differences with the German energy efficiency policies and explains in which sectors the Cuban model can give interesting guidance and inspiration for the German Energiewende.



quadrat
ökologische und ökonomische konzepte

Büro Ö-quadrat
Turnseestr. 44
D 79102 Freiburg
Phone: 0049 761 707 9901
Fax :0049 761 707 9903
Email: seifried@oe2.de
www.oe2.de