Performance standards and residential energy efficiency in Egypt

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Abstract

The Egypt Organization for Energy Planning (OEP) has put in place energy efficiency labels and standards to increase energy efficiency in the residential sector. In the first phase, energy efficiency standards were put in place for three household appliances – refrigerators, washing machines and air conditioners. In the second phase, energy efficiency labels and standards are being considered for three more end use technologies – electric water heaters, electric lighting and electric motors. The purpose of this paper is to report on an impact evaluation of recent Egyptian minimum energy performance standards for residential appliances.
Keywords: energy conservation, program evaluation, energy efficiency, greenhouse gas emissions.

1 Introduction

Egypt has considerable endowments of energy resources including natural gas, petroleum and hydro-electric power. As a result of investments in the energy sector and strong and increasing demand, the rate of growth of primary energy production has more than kept pace with the growth of population over the past twenty years. The Government of Egypt has historically kept energy prices at below world levels to foster economic development and to provide economic benefits to residential energy consumers. As result, energy use is at a relatively high level compared to many other countries with similar levels of income or GDP per capita.

With respect to electricity prices, tariffs have been quite low although the Government of Egypt has made efforts to increase electricity prices to reduce the gap between selling prices and long-term supply costs. Various estimates suggest

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that the ratio of average price paid for electricity across all customer groups as a proportion of long term marginal cost is from 80% to over 100%. Not withstanding the overall price-cost situation, many residential electricity customers are still heavily subsidized.

There are significant opportunities to increase energy efficiency in the residential, commercial and industrial sectors in Egypt. The Government of Egypt has recognized the importance of these opportunities and passed enabling legislation in the form of the National Environmental Law of 1993. Subsequent activities included preparation of a National Climate Change Plan and National Strategy for Improving Energy Efficiency in Egypt. The objectives of these policies include: improving energy efficiency, reducing energy consumption and reducing greenhouse gas emissions.

A number of market barriers have been identified which limit the adoption of energy efficient technologies in Egypt. These include:

- Low residential, commercial and industrial customer awareness and knowledge of the nature and benefits of specific energy efficient techniques and practices;
- Relatively low residential, commercial and industrial customer interest in purchasing and adopting these technologies and practices;
- Reluctance to invest in capital projects even with paybacks as rapid as two or three years;
- Risk aversion towards the adoption of new technologies; and
- Inadequate market infrastructure in terms of the availability of efficient equipment and appropriate skills and knowledge for the support of installation and maintenance and use of high efficiency equipment.

To help overcome these barriers, the Organization for Energy Planning (OEP) has been established with a mandate to put in place energy efficiency labels and standards. In the first phase, energy efficiency standards were put in place for three household appliances – refrigerators, washing machines and air conditioners. In the second phase, energy efficiency labels and standards are being considered for three more end use technologies – electric water heaters, electric lighting and electric motors.

The purpose of this paper is to report on an impact evaluation of recent Egyptian minimum energy performance standards (MEPS) for residential appliances. Engineering analysis was used to estimate the impact of the program on incremental sales of efficient appliances, energy savings, and reductions in carbon dioxide emissions.

2 Overview of residential electricity use

Table 1 summarizes the key results of several surveys of residential electricity use that have been undertaken in Egypt over the past ten years. Average annual

consumption per household varies from about 1,800 kWh in Alexandria Governorate in 1994 to about 3,200 kWh in Luxor Governorate in 2002.

Table 1: Average residential energy consumption.

Governorate	Year of survey	Monthly consumption (kWh)	Annual consumption (kWh)
Alexandria	1994	149	1788
Suez	1995	208	2496
Port Said	1996	214	2568
Cairo	2000	239	2868
Luxor	2002	267	3204
Assuit	2002	225	2700
Average		217	2604

Source: Egypt Organization for Energy Planning.

Table 2 provides information on residential electricity consumption by end use, and this information may be viewed as broadly representative of the residential sector in Egypt. Important end uses by consumption level are lighting, refrigerators, water heating, television, and air conditioners.

Table 2: Residential end use consumption, Cairo, 2000.

Appliance	Unit energy consumption (kWh)	Saturation rate (%)	Average consumption (kWh)	Consumption share (%)
Television	303	96	290	10.1
Radio/cassette	172	92	158	5.5
Fan	137	90	123	4.3
Refrigerator	555	93	516	18.0
Washer	157	97	152	5.3
Water heater	1055	31	327	11.4
Air conditioner	1980	12	198	6.9
Iron	88	91	80	2.8
Lighting	872	100	872	30.4
Other	-	-	155	5.4
Total	-	-	2868	100.0

Source: Egypt Organization for Energy Planning.

3 Refrigerators

The basis for regulation of labeling and standards for refrigerators is Egypt (2003) Ministerial Decree 180/2003, Egyptian Energy Standards for Refrigerators, Refrigerator-Freezers and Freezers. The label allows the consumer to compare energy efficiency among refrigerators or freezers with the same

capacity. The labels include information on the manufacturer's name or trade mark; adjusted volume in liters; maximum energy consumption for similar products; minimum energy consumption for similar products; energy consumption of the specific unit; and efficiency grade on a five-point scale.

Several technologies can be used to improve the energy performance of refrigerators and freezers to meet the minimum energy performance standards. These include more efficient motors, improved compressors, more accurate temperature controls, higher quality insulation and improved gaskets and seals.

A key concept used in the minimum energy performance standards is that of adjusted volume. The adjusted volume for refrigerators is given by equation (1), and the adjusted volume for freezers is given by equation (3). Equation (2) provides the adjustment factor.

$$AV_R = V_R + A_F * V_F \quad (1)$$

$$A_F = (T_A - T_F) / (T_A - T_R) \quad (2)$$

$$AV_F = A_F * V_F \quad (3)$$

where,

AV_R = adjusted volume of the refrigerator in liters
A_F = adjustment factor
V_R = net volume of the fresh food compartment
V_F = net volume of the freezer
T_A = ambient temperature in the test area of 32 degrees Celsius
T_F = standard temperature of the freezer, typically –6 degrees.

Table 3: Refrigerator minimum energy performance standards.

Product Type	Maximum consumption in kWh per year	
	Year 2003	Year 2005
1-door refrigerator, manual defrost	0.48AV + 784	0.48AV + 627
2-door refrigerator, partial automatic defrost	0.37AV + 721	0.37AV + 577
2-door refrigerator, automatic defrost	0.57AV + 1130	0.57AV + 904
Upright freezer, manual defrost	0.36AV + 330	0.36AV + 264
Upright freezer, automatic defrost	0.53AV + 469	0.53AV + 375
Chest freezer	0.39AV + 979	0.39AV + 784
Compact refrigerator, less than 14 liters	0.48AV + 408	0.48AV + 326
Refrigerator without freezer	0.48AV + 300	0.48AV + 270

Source: Egypt Organization for Energy Planning.

Table 3 summarizes the maximum limit of energy consumption for various models of refrigerators and freezers. Initial performance requirements were

established for 2003 and these were made more stringent for 2005. Table 4 estimates customer energy savings due to minimum energy performance standards for refrigerators. The above MEPS share is the estimated share of product not meeting the minimum energy performance standard before program launch (that is, consumption is above MEPS). Annual added compliant units are the product of sales in millions of units (mn), the above MEPS share and the assumed compliance rate. Annual customer savings is the product of added sales and unit savings and this is cumulated to estimate the level of cumulative annual savings over time due to the gradual switch over in the capital stock to the efficient product.

Table 5 estimates generation and carbon dioxide savings. Annual customer savings times system loss factor (one plus the eight percent of electricity generated lost in transmission) gives cumulative annual system savings at the generation level. Cumulative annual system savings times the emissions factor provides the annual reduction in carbon dioxide.

Table 4: Customer refrigerator savings analysis.

Year	Sales (mn)	Above MEPS share	Compliance rate	Annual added compliant units (mn)	Unit saving (kWh per year)	Annual customer saving (GWh)
2003	1.068	0.60	0.75	0.481	64	30.8
2004	1.098	0.60	0.75	0.494	64	31.6
2005	1.135	0.80	0.75	0.681	120	81.7

Table 5: System refrigerator savings analysis.

	Annual customer saving (GWh)	Cumulative annual customer saving (GWh)	Loss	Cumulative annual system saving (GWh)	Emissions factor (kt per GWh)	Annual CO_2 reduction (ktonne)
2003	30.8	30.8	1.08	33.3	0.506	16.8
2004	31.6	62.4	1.08	67.4	0.506	34.1
2005	81.7	144.1	1.08	155.6	0.506	78.7
Total						129.6

4 Clothes washers

The basis for regulation of labeling and standards for washing machines is Egypt (2003) Ministerial Decree 4100/2003, Measurement and Calculation Methods of Household Clothes Washing Machines. The label includes the following information: manufacturer name or trademark; model; capacity in kilograms; maximum energy consumption for this type of product; minimum energy consumption for this type of product; energy consumption of the unit; efficiency grade. The minimum energy performance standard is 0.26 kWh per kilogram per load. The energy efficiency of clothes washers can be improved by using more

efficient motors, better sizing of the motor to the load, and more efficient transmissions.

Table 6 estimates customer energy savings for clothes washers due to minimum energy performance standards. Annual customer savings is the product of added sales and unit savings and this is cumulated to estimate the level of cumulative annual savings over time due to the gradual switch over in the capital stock to the efficient product. Cumulative annual savings times the system loss factor gives cumulative annual system savings (these are savings at the generation level). Finally cumulative annual system savings times the emissions factor provides the annual reduction in carbon dioxide.

Table 6: Customer clothes washer savings analysis.

Year	Sales (mn)	Above MEPS share	Compliance rate	Annual added compliant (mn)	Annual Unit saving (kWh)	Annual customer saving (GWh)
2003	0.368	0.70	0.75	0.193	50	9.7
2004	0.378	0.70	0.75	0.198	50	9.9
2005	0.391	0.70	0.75	0.205	50	10.3

As shown in table 7, cumulative annual savings times the system loss factor gives cumulative annual system savings or savings at the generation level. Cumulative annual system savings times the emissions factor provides the annual reduction in carbon dioxide.

Table 7: System clothes washer savings analysis.

Year	Annual customer saving (GWh)	Cumulative annual Customer saving (GWh)	Loss	Cumulative annual system saving (GWh)	Emissions factor (kt per GWh)	Annual CO_2 reduction (ktonne)
2003	9.7	9.7	1.08	10.5	0.506	5.3
2004	9.9	19.6	1.08	21.2	0.506	10.7
2005	10.3	29.9	1.08	32.3	0.506	16.3
Total						32.3

5 Air conditioners

The basis for regulation of labeling and standards for air conditioners is Egypt (2003) Ministerial Decree 4100/2003, Measurement and Calculation Methods of Household Clothes Washing Machines. The label includes the following information: manufacturer name or trademark; model; capacity in kilograms; maximum energy consumption for this type of product; minimum energy consumption for this type of product; energy consumption of the unit; efficiency grade. The minimum energy efficiency ratio (EER) for window type air conditioners is 8.5 and 9.0 for split type air conditioners. The energy efficiency

of air conditioners can be increased by using more efficient motors, using better compressors, and improving thermostats and air conditioner controls.

Table 8 estimates customer energy savings for air conditioners due to minimum energy performance standards. Annual customer savings is the product of added sales and unit savings and this is cumulated to estimate the level of cumulative annual savings over time due to the gradual switch over in the capital stock to the efficient product.

Table 8: Customer air conditioner savings analysis.

Year	Sales (mn)	Above MEPS Share	Compliance rate	Annual added compliant units (mn)	Unit saving (kWh per year)	Annual customer saving (GWh)
2003	0.577	0.60	0.75	0.260	165	42.8
2004	0.592	0.60	0.75	0.266	165	44.0
2005	0.610	0.60	0.75	0.275	165	45.3

As shown in table 9, cumulative annual savings times the system loss factor gives cumulative annual system savings or savings at the generation level. Cumulative annual system savings times the emissions factor provides the annual reduction in carbon dioxide.

Table 9: System air conditioner savings analysis.

Year	Annual customer saving (GWh)	Cumulative annual Customer saving (GWh)	Loss	Cumulative annual system saving (GWh)	Emissions factor (kt per GWh)	Annual CO_2 reduction (ktonne)
2003	42.8	42.8	1.08	46.2	0.506	23.4
2004	44.0	86.8	1.08	93.7	0.506	47.4
2005	45.3	132.1	1.08	142.7	0.506	72.2
Total						143.0

6 Conclusions

In this study, we have analysed the impact of the Government of Egypt's minimum energy performance standards for residential appliances. Key findings are as follows.

(1) Residential Energy Use. Average residential electricity use in Egypt is about 2,600 kWh per household per year. Unit energy consumption per year for major uses are 1980 kWh for air conditioning, 1055 kWh for water heating, 872 kWh for lighting, 555 kWh for refrigerators, 303 kWh for televisions, 172 kWh for radio/cassettes, 157 kWh for washers, 137 kWh for fans and 88 kWh for irons.

(2) Refrigerators. Refrigerator sales are about 1.1 million units per year, with about 60 percent of units in the base year 2001 not meeting the 2003 performance standards. Electricity saving for refrigerators was about 30.8 GWh in 2003, 62.4 GWh in 2004 and 144.1 GWh in 2005. Carbon dioxide savings were about 16.8 ktonnes in 3003, 34.1 ktonnes in 2004 and 78.7 ktonnes in 2005.

(3) Clothes Washers. Clothes washer sales are about 0.4 million units per year, with about 70 percent of units in the base year 2001 not meeting the 2003 performance standards. Electricity saving for clothes washers was about 9.7 GWh in 2003, 9.9 GWh in 2004 and 10.3 GWh in 2005. Carbon dioxide savings were about 5.3 ktonnes in 2003, 10.7 ktonnes in 2004 and 16.3 ktonnes in 2005.

(4) Air Conditioners. Air conditioners sales are about 0.6 million units per year, with about 60 percent of units in the base year 2001 not meeting the 2003 performance standards. Electricity saving for air conditioners was about 42.8 GWh in 2003, 44.0 GWh in 2004 and 45.3GWh in 2005. Carbon dioxide savings were 23.4 ktonnes in 2003, 47.4 ktonnes in 2004 and 72.2 ktonnes in 2005.

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