United for Efficiency Country Assessments

Methodology and Assumptions

Background

The United for Efficiency country assessments were first used under the UN Environment-Global Environment Facility United for Efficiency - en.lighten initiative to show the financial (US$), energy (TwH), and environmental savings (CO_2) of energy-efficient products. The assessments can be used to help build political commitment to develop national projects on energy-efficient lighting, appliances, and equipment.

The assessments were completed for 96 developing countries and emerging economies before COP21 climate negotiations in 2015 for energy-efficient refrigerators, air conditioners, electric motors, and distribution transformers. They were expanded to 150 countries at the end of 2016.

Policy Scenarios

Efficiency scenarios: Three scenarios have been conducted based on the level of energy efficiency of products sold on the market:

- **Business as usual (BAU) or base case scenario** – No policy intervention;
- **Policy scenario** – Assumes minimum energy performance standards (MEPS) are implemented in the year 2020 at a level equivalent to the current day best MEPS;
- **Best available technology (BAT) scenario** – Assumes MEPS are implemented in the year 2020 at a level equivalent to the current day best available technology.

Policy implementation date: It is assumed policies are implemented in 2020. This is a realistic time period for policy development and implementation.

Presentation of Results

The savings potential is calculated based on the difference between the Policy and BAT scenarios and that of the BAU scenario. Including:

1) National savings potential in 2030 for the Policy scenario versus that of BAU. The year 2030 was chosen as it is midterm time horizon that policymakers often use and as it allows for turnover of the product stock since the policy implementation in the year 2020.
    - Reduced electricity use (TWh), equivalent to per cent of future national electricity use (year 2030) and the number of power plants' power generation (assumes 88GWh/year for 20MW power plant, 438GWh/year for 100MW power plant and 2,19TWh/year for 500MW power plant);
    - Electricity bill savings (US$);

- CO_2 emissions reductions in million tonnes, equivalent to the number of passenger cars (assumes 1.8 tonnes of emissions/year/per car).

2) Percentage share of savings from each product (lighting, refrigerators, air conditioners, electric motors, and distribution transformers).
3) Other benefits achieved in 2030 for the Policy scenario:
    - Increased grid connections households (if a significant portion of the population lives off-grid, assumes 2000 kWh/yr/newly electrified household);
    - Reduced electricity subsidies (if the country subsidizes electricity tariffs);
    - Reduce greenhouse gas impact from by using more environmentally friendly refrigerants, and also safe capture of refrigerants currently used;
    - Reduced emissions of air pollutants (SO_2 and NO_x) if the countries have coal-fired power plants.
4) Additional information provided
    - Table showing savings in the first year (2020);
    - Cumulative energy, financial, and CO_2 savings (2020-2030);
    - Graph showing the savings electricity consumption for 2015 to 2030, showing the savings potential differential of BAU scenario vs Policy scenario vs BAT scenario

Assumptions and Approach for Different Appliances

Refrigerators

Product type: Combined fridge/freezer (configuration specified in Table 1)

Growth rate: Assumes a growth of sales in refrigerators based on macroeconomic indicators (such as future household income, grid connection) from present day until the year 2030. For example, the purchase and use of refrigerators is expected to significantly increase as large populations increase purchasing power.

Efficiency scenarios: Technical assumptions described in Table 2:

- **Business as usual or base case scenario** – Energy efficiency improves at 1 per cent per year.
- **Policy scenario** – In the case of refrigerators, the EU standard has been taken.
- **Best available technology (BAT) scenario** – The unite energy consumption (UEC) of the BAT scenario is equal to products that are already on the market, neither that of max technology nor that of non-commercialized products.

Product lifetime: 15 years – consistent with best available market information.

Table 1. Assumptions for Compartment Size of Fridge/Freezers (liters)

Base Case Model Characteristics	ASEAN and South Asia	China	MENA	LAC	Oceania	Other Regions	Sub-Saharan Africa	Turkey	Ukraine
Storage Volume	250	235	330	270	300	270	210	300	270
Gross Volume	280	250	350	300	325	300	225	330	300
Volume of Refrigerator Compartment	165	157	245	188	210	188	134	200	188
Volume of Freezer Compartment	85	78	85	82	90	82	76	100	82
Adjusted Equivalent Volume (Calculated Equation in E**uropean **U**nion **Standard)	417	398	513	437	484	437	357	498	437

Table 2. Country Assessments Assumptions for Refrigerators (combined fridge/freezer)

Region	Average Size	UEC (kWh/yr)		
		BAU	Policy Scenario	BAT
ASEAN	280 Liters	352	207	159
China	*250 Liters*	*235*	*200*	*139*
LAC	300 Liters	485	212	163
MENA	350 Liters	500	231	167
Oceania	*325 Liters*	*410*	*224*	*156*
Other Regions Income >10,000	*300 Liters*	*450*	*212*	*139*
Other Regions Income <10,000	*300 Liters*	*625*	*212*	*139*
South Asia	280 Liters	352	207	159
Sub-Saharan Africa	225 Liters	350	191	134
Turkey	*330 Liters*	*359*	*227*	*156*
Ukraine	*300 Liters*	*374*	*212*	*139*

Approach: The analysis uses CLASP and Lawrence Berkeley National Laboratory's Policy Analysis Modeling System to forecast the impacts of implementing policies that improve the energy efficiency of new household refrigerators. This is a bottom-up approach, in which the potential energy savings are obtained by defining the UEC of different scenario and estimating the stock and sales of the refrigerators in the assessment country; and financial and environmental savings and benefits are calculated by using the countries' macroeconomic indicators and other associated data.

Air Conditioners

Product scope: Room air conditioners, including portable, through the wall, window-mounted, and split systems; excluding secondary market.

Growth rate: Assumes a sales growth in air conditioners, based on macroeconomic indicators (such as future household income, grid connection) from present day until the year 2030. For example, the purchase and use of air conditioners is expected to significantly increase as large populations increase purchasing power.

Efficiency scenarios: Technical assumptions described in Table 3:

- **Business as usual or base case scenario** – Energy efficiency improves at 1 per cent per year;
- **Policy scenario** – For air conditioners the Japanese standard has been used;
- **Best available technology (BAT) scenario** – Assumes that MEPS are implemented in the year 2020 at a level equivalent to the current day best available technology.

Product lifetime: 12 years – consistent with best available market information.

Table 3. Country Assessments Assumptions for Air Conditioners

Region	Average Cooling Capacity (W)	EER		
		BAU	Policy Scenario	BAT
ASEAN	3500	3.1	3.8	5.8
LAC	3500	3.1	3.8	5.8
MENA	3500	3.1	3.8	5.8
Oceania	*3500*	*3.1*	*3.8*	*5.8*
Other Regions Income >10,000	*3500*	*2.7*	*3.8*	*5.8*
Other Regions Income <10,000	3500	*2.3*	*3.8*	*5.8*
South Asia	3500	3.1	3.8	5.8
Sub-Saharan Africa	3500	3.1	3.8	5.8
Turkey	*3500*	*3.1*	*3.8*	*5.8*
Russia	*3500*	*2.11*	*3.8*	*5.8*
Region	**Average**	**Annual Energy Consumption for Cooling (kWh)**		

	Cooling Capacity (W)	BAU	Policy Scenario	BAT
*China**	*3500*	*777*	*709*	*390*

*Different approach for China to account for the fact that the AC market in China is divided by fixed speed AC and variable speed drive AC.

Approach: The analysis uses CLASP and Lawrence Berkeley National Laboratory's Policy Analysis Modeling System to forecast the impacts from implementing policies that improve the energy efficiency of new household air conditioners. This is a bottom-up approach, in which the potential energy savings are obtained by defining the UEC of different scenarios and estimating the stock and sales of the air conditioners in the assessment country; and financial and environmental savings and benefits are calculated by using the countries' macroeconomic indicators and other associated data.

Electric Motors

Product scope: Three-phase induction motors, ranging from 0.75kW to 375kW, used in the industrial sector.

Growth rate: Assumes a growth of sales in motors based on macroeconomic indicators (such as future industrial GDP growth rate) from present day until the year 2030. For example, the purchase and use of motors is expected to significantly increase when a country has increased industrialization.

Efficiency Scenarios: Technical assumptions described in Table 4:

- **Business as usual or base case scenario** –Two different BAU scenarios were defined: IE1 scenario and IE0 scenario. IE0 is an estimated motor efficiency level, which is lower than IE1 and used to account for the fact that the average motor efficiency can be well below IE1 levels in less developed countries. IE1 Scenario is used for more developed countries where IE1 efficiency is assumed to be the base case motor efficiency. (Except some countries which have implemented higher MEPS)
- **Policy scenario** –For motors, IEC IE3 has been taken, which represents premium efficiency; below super premium efficiency.
- **Best available technology (BAT) scenario** –For motors, IEC IE4 has been taken, which represents super premium efficiency.

Product lifetime: 15 years – consistent with best available market information.

Table 4. Country Assessments Assumptions for Motors[1]

Region All regions	Average Size*	Full Load Efficiency % – BAU**	Full Load Efficiency % – Policy scenario	Full Load Efficiency % - BAT
0.75 - 375 kW (1 - 500 hp)	7.5 kW	IE1 or IE0	IE3	IE4

* Average motor size taken from the Bottom-Up Energy Analysis System (BUENAS) model.
** Except in Brazil, Mexico, Turkey and China where MEPS already in place require motors to be more efficient.

Approach: A top-down approach was used as the industrial electric motors' consumption data for many of the countries under analysis was not available. Motor sales were estimated by developing a relationship between the US$ value of a country's annual industrial or manufacturing output (sectoral GDP) and the amount of electricity consumed annually by Electric Motor - Driven Systems in that country's industrial sector. This was used to estimate historical Electric Motor - Driven Systems electricity consumption in industrial sector from historical industrial GDP data for countries under analysis.

A fixed percentage improvement in efficiency between BAU and Policy scenario, and between BAU and BAT scenarios for the countries was used. No efficiency improvement in the base case (business-as-usual scenario) during the period of analysis was assumed. The percentage improvements in efficiency for countries are shown in Table 5.

[1]For motors the International Electrotechnical Commission (IEC) levels are used. The Levels are IE1 (standard efficiency), IE2 (high efficiency),IE3 (premium efficiency), and IE4 (super premium efficiency)

Table 5. Percentage Efficiency Improvement in Best MEPS and BAT Scenarios

Country/ Region	BAU	Policy Scenario	BAT	Efficiency Improvement BAU to Best MEPS (%)	Efficiency Improvement BAU to BAT (%)
Mexico	IE2 (>150 kW output) IE3 (<150 kW output)	IE3	IE4	2.2	3.2
Brazil	IE2	IE3	IE4	2	4.4
China*	IE3	IE3	IE4	0	2.4
Turkey**	IE2	IE3	IE4	0	2.4
Countries with GDP per Capita > 10,000 US$	IE1	IE3	IE4	4.9	7.1
Countries with GDP per Capita < 10,000 US$	IE0	IE3	IE4	8.5	10.7

Sources: Efficiency levels for BAU case from Impact Energy Inc., "Motor MEPS overview," EMSA, 17 August 2015.
* China MEPS is currently set at IE2 levels, but will adopt IE3 as MEPS by June 2016;
**Turkey MEPS is currently set at IE2 levels, but will adopt IE3 as MEPS by 2017. (Ref: IEA-4E. 2015, Energy Efficiency Roadmap for Electric Motors and Motor Systems.)

It was assumed the motors' market grows in lock step with GDP throughout the period of analysis (2020–2030), and annual savings are calculated accordingly. With this approach, there is no need to estimate UECs or the number of motors sold in a given year in each country.

Distribution Transformers

Product scope: Distribution transformers.

Growth rate: Assumes a growth of sales in distribution transformers from present day until the year 2030, based on electricity demand projections. The growth rate of transformers will be determined based assumption on the transformer density per unit generation capacity and unit of electricity demanded. For example, as there is greater electricity consumption and a larger amount of the population is connected to the electricity grid; an increase in the number of distribution transformers will be required. Given the long lifetime of transformers (often over 30 years) the installed stock is not expected to turnover during this timeframe. However, given grid connection and electricity consumption are expected to increase in many parts of the world, it is expected large savings will be attained by 2030.

Efficiency scenarios: The scenarios use the Super-efficient Equipment and Appliance

Deployment Initiative's (SEAD)[2] distribution transformer energy efficiency tiers (technical assumptions are described in table 6). The scenarios for the analysis are:

- **Business as usual or base case scenario** – Energy losses in new transformer designs are reduced by 1 per cent per year.
- **Policy scenario** – For distribution transformers, SEAD Tier 3 has been taken (See Table 6).
- **Best available technology (BAT) scenario** – For distribution transformers, SEAD Tier 5 has been taken (See Table 6).

Product lifetime: 30 years – consistent with best available market information.

Table 6. Country Assessments Assumptions for Distribution Transformers

Type	Average Size	BAU	Policy Scenario	BAT
1-phase liquid	50 kVA	Variable; based on electric utilities and input from partners	SEAD Tier 3	SEAD Tier 5
3-phase liquid	1000 kVA			
3-phase dry-type	1000 kVA			

Approach: The calculation model is a stock model. Based on the historical distribution transformer sales and historical electricity consumption data, and the electricity demand projections, the national installed distribution transformer for all types is estimated (3-phase dry type, 3-phase oil-filled type, and 1-phase oil-filled type) from 2015 to 2030. Based on an assumed loading the transformer losses/consumptions were calculated by different defined efficiency scenarios (baseline, SEAD Tier3, SEAD Tier5) for each year. The savings for each country were obtained by comparing the results of different scenarios.

Lighting

Product scope: On-grid lighting including residential, professional and outdoor.

Efficiency scenarios: The scenarios for the analysis are:

- **Business as usual or base case scenario** – Allows for existing policies to remain in place, but no new policy measures adopted. Natural, but slower, market migration toward higher efficacy sources.

[2]Super-efficient Equipment and Appliance Deployment Initiative is an international initiative under the Clean Energy Ministerial and the International Partnership for Energy Efficiency Cooperation designed to accelerate the transition to a clean energy future through effective appliance and equipment energy efficiency policies and programs.

- **Policy scenario** – The scenario contemplates policies in place in 2020 that phase out tungsten and move the market toward efficient fluorescent/high-intensity discharge (HID) and light-emitting diode (LED) sources. The transition in the stock is gradual, meant to represent the actual rate of change in those countries.
- **Best available technology (BAT) scenario** – A shift directly to high-efficacy LED technology as quickly as possible.

Product lifetime: different depending on the lighting technology including: compact fluorescent lamp, fluorescent lamp, general lamp shape, halogen, HID, and LED – consistent with market information.

Growth rate and approach: This is a stock model, individually built up in 2014 and running until 2030. The model starts from the regional stock estimates for the individual lamp types in 2014. This stock is then converted to light service in 2014 (teralumen-hours) based on estimates of wattage and operating hours. Lighting service is then projected forward to 2030using the International Energy Agency's World Energy Outlook projection of electricity demand for commercial and residential buildings (which is a floor space projection), which takes the global lighting service from 182,000 Tlm-hr/yr in 2014 to 274,000 Tlm-hr/yr in 2030, an increase of 50 per cent in lighting service demand. The model then considers which countries have MEPS in place, and those that do move to a CFL level in the residential lighting market or a T8 level in the professional sector. The model then runs three scenarios:

- BAU scenario;
- Policy scenario; and
- BAT scenario.

The average efficacy values are calculated for each country for each year and each sector, and they are divided back into the lumen service stock model to calculate the electricity demand to provide that lighting service.

Avoided CO_2 emissions, electricity bill savings, and other benefits were calculated with the help of electricity consumption.

Main data resources

- Population and GDP per capita data (2014) come from the World Bank;
- Electrification levels come from the International Energy Agency World Energy Outlook 2014;
- Market size was determined by data provided by industry partners; UN Comtrade database; household penetration forecasts generated by Policy Analysis Modeling System from population, climate, and macroeconomic indicators;
- Future electricity consumption was calculated using current consumption figures provided by the International Energy Agency World Energy Outlook 2014 and the U.S. Energy Information Administration International Energy Outlook 2015;

- Baseline price, unit energy consumption (UEC), appliance lifetime were provided by country representatives (when available); industry partners; and Lawrence Berkeley National Laboratory;
- Electricity tariffs were provided by the International Energy Agency; and Internet research;
- Transmission and distribution loss factor is a regional average calculated from electricity production and consumption data published by the International Energy Agency;
- CO_2 emission factor comes from the International Energy Agency CO_2 Emissions Factor from Fuel Combustion Highlights: 2013; and extrapolations were made for countries lacking data;
- Consumer discount rate was derived from the Human Development Index, UN Development Programme (2012);
- The approach of calculating the potential direct emission saving of refrigerators and air conditioners: the typical current mix of refrigerants fillings, leakage rates and end of life emissions in the BAU compared to the best alternative with natural refrigerants (mostly R290 for splits and R600a for domestic refrigerators);
- In addition, a questionnaire was used to gather data from country officials.