UNEP en.lighten

The Second Generation On-Grid Country Lighting Assessments

Modelling Methodology for Energy and Financial Savings Potential from Replacing All On-Grid Lighting in All Sectors

UNEP/GEF en.lighten initiative

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FOREWORD:

This report summarises the approach followed in developing an estimate of the energy savings potential from energy-efficient lighting in many countries around the world. The Excel model developed for this purpose generates energy savings estimates by scaling from larger regional databases and making estimates based on similar economies and/or locally sourced data. The authors respectfully request that any expert reviews of the model assess the reasonableness of the estimates and assumptions used as inputs to the model, particularly those relating to the market data.

For comments or questions about this model, please contact:

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1 INTRODUCTION

On 1st December 2010 the UNEP/GEF en.lighten initiative published the first generation of Country Lighting Assessments (CLA 1.0). CLA 1.0 provided estimates of potential energy savings, CO2 reductions, and financial benefits for countries shifting from inefficient incandescent lamps to energy-efficient CFLs. In an effort to quantify the energy savings potential from a broader programme on energy-efficient lighting, UNEP launched the development of a second generation of Country Lighting Assessments (CLA 2.0). CLA 2.0 revises and completes CLA 1.0 by differentiating various end-use sectors and lighting technologies.

The methodology followed in preparing the CLA 2.0 energy saving estimates are described in this report. The model itself is based around two separate approaches to arrive at the same estimated installed stock of lamps.

Due to a lack of specific country-level data regarding critical inputs such as wattages, operating hours, lamp lifetimes and lamp prices, we decided to clustered the countries modelled into groups according to purchasing-power parity (PPP) adjusted gross domestic product (GDP) per capita. This was used because it offers an adjusted income metric that reflects the purchasing power of the markets of each of these countries. Within each of these PPP-GDP groups, estimates of the properties associated with lighting technologies and characteristics of customer behaviour are applied to the group. In a few instances, we had data from a country for which good market data exists (e.g., the United States), but in most other instances, the inputs to derive the country estimates was estimated.

This approach of creating PPP-GDP groups is not perfect, however it does allow for some differentiation in the market with respect to the different countries and how lighting is used in those countries.

The output from the model is a series of over 130 country reports, each of which are six pages long, providing the country-level (i.e., national) savings potential, inputs and references used in the model. A screen capture showing the first two pages of one of the reports is given below.

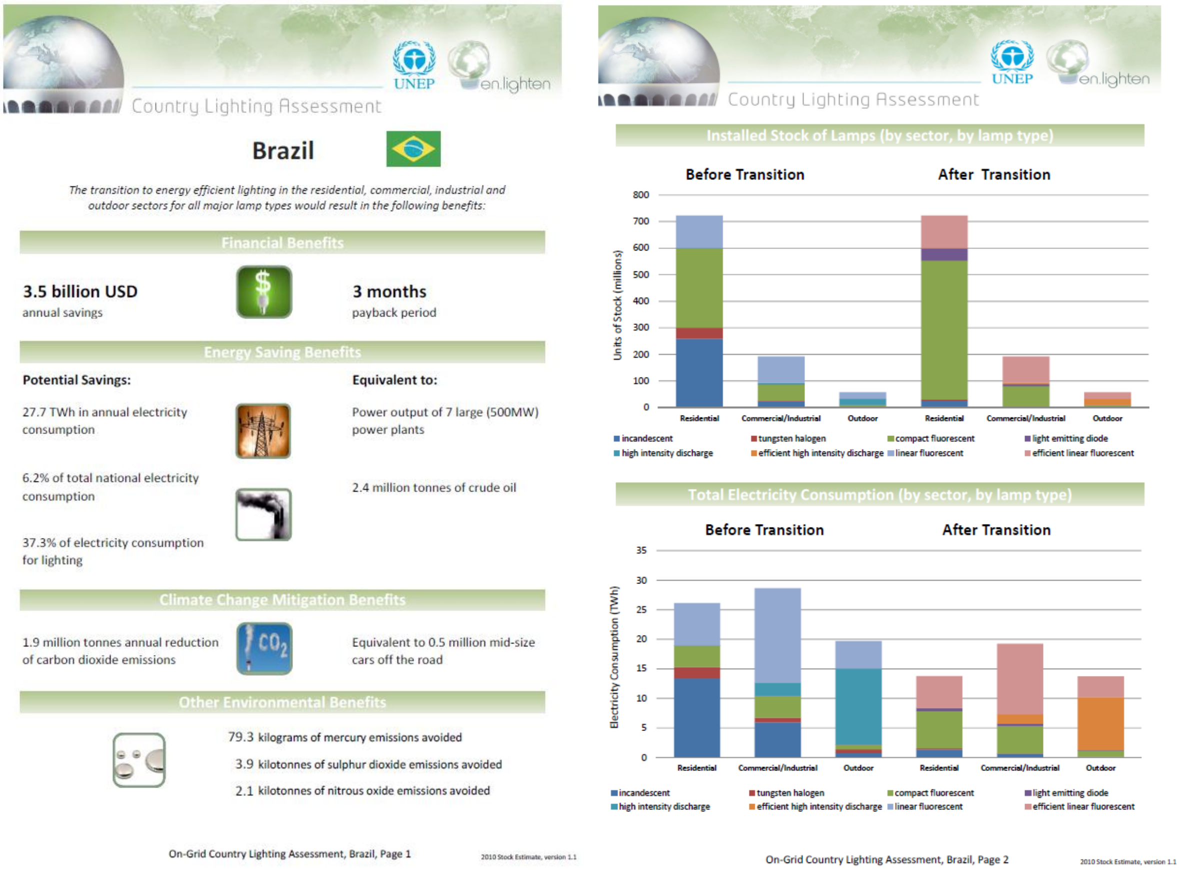

Figure 1-1. First Two Pages of an On-Grid Country Lighting Assessment Report

Country Lighting Assessment Reports have been prepared for the following list of countries:

Afghanistan
Albania
Algeria
Angola
Antigua and Barbuda
Argentina
Armenia
Australia
Austria*
Azerbaijan
Bahamas (the)
Bahrain
Bangladesh
Barbados
Belarus
Belgium*
Belize
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Botswana
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cambodia
Cameroon
Canada
Cape Verde
Central African Republic (the)
Chad
Chile
China
Colombia
Comoros (the)
Congo (the)
Costa Rica
Cote d'Ivoire
Croatia
Cyprus
Czech Republic (the)*
Democratic Republic of Congo (the)
Denmark*
Djibouti
Dominica
Dominican Republic (the)
Ecuador
Egypt
El Salvador
Equatorial Guinea
Eritrea
Estonia*
Ethiopia
European Union
Fiji
Finland*
France*
Gabon
Gambia (the)
Georgia
Germany*
Ghana
Greece*
Grenada
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hungary*
Iceland*
India
Indonesia
Iran (Islamic Republic of)
Iraq
Ireland*
Israel
Italy*
Jamaica
Jordan
Kazakhstan
Kenya
Kiribati
Kyrgyzstan
Lao People's Democratic Republic (the)
Latvia*
Lebanon
Lesotho
Liberia
Libya
Madagascar
Malawi
Mali
Mauritania
Micronesia (Federated States of)
Mongolia
Morocco
Mozambique
Myanmar
Namibia
Nepal
Nicaragua
Niger (the)
Nigeria
Pakistan
Papua New Guinea
Paraguay
Philippines (the)
Republic of Moldova (the)
Rwanda
Samoa
Sao Tome and Principe
Senegal
Sierra Leone
Solomon Islands
Sri Lanka
Sudan (the)
Swaziland
Syrian Arab Republic
Tajikistan
Timor-Leste
Togo
Tonga
Uganda
Ukraine
United Republic of Tanzania (the)
Uzbekistan
Vanuatu
Viet Nam
Yemen
Zambia

* Countries marked with a star are represented in the European Union report

2 MODEL INPUTS AND ASSUMPTIONS

This section describes some of the key input variables and assumptions used in the model. In the model, countries are clustered groups according to available data from the country and information relating to their purchasing-power adjusted gross domestic product per capita. Within each of these groups, estimates of the performance characteristics and cost of lighting technologies are developed and used as inputs. This chapter presents the input assumptions used

2.1 LAMP WATTAGES

The table below provides the wattages for the baseline and more energy-efficient (i.e., replacement) lamp types used in the model. The wattages used for each of the baseline lamp technologies are meant to represent the national sales-weighted average wattage of each lamp type.

The wattages used for the efficient replacement lamps were selected based on an equivalent lumen package, taking into account standard efficacy values for the different technologies. For example, a 60W incandescent lamp has approximately the same light output as a 52W Halogen lamp, a 14W CFL and a 13W LED lamp. Similarly, a 40W fluorescent lamp is replaced with a 30W lamp offering the same light output. The percentage improvements reflect the typical baseline and high efficiency models available in the market. Please note that the more efficient lamp values may not correspond to actual lamp models, these represent estimates of sales-weighted averages of actual lamp wattages.

Table 2-1: Estimated Average Wattages of Installed Stock of Lamps (2010)

	Sector	GLS	HAL	CFL	LED	FL	FL eff.	HID	HID eff.
Group #1	Residential	75	65	18	16	40	30	100	70
	Professional	80	69	19	17	42	32	170	119
	Outdoor	150	130	35	31	52	39	200	140
Group #2	Residential	70	61	16	15	40	30	90	63
	Professional	75	65	18	16	43	32	150	105
	Outdoor	150	130	35	31	52	39	180	126
Group #3	Residential	65	56	15	14	40	30	80	56
	Professional	70	61	16	15	44	33	130	91
	Outdoor	150	130	35	31	52	39	150	105
Group #4	Residential	60	52	14	13	40	30	70	49
	Professional	65	56	15	14	45	34	110	77
	Outdoor	150	130	35	31	52	39	120	84
Group #5	Residential	55	48	13	11	40	30	60	42
	Professional	60	52	14	13	46	35	90	63
	Outdoor	150	130	35	31	52	39	100	70

2.2 RETAIL LAMP PRICES

In the absence of actual data, retail lamp prices had to be estimated – however this can be different for different technologies and different brand names. For instance, most of the time, the price of the lamp does not mainly depend on the wattage but on the quality or on the brand. More sophisticated lamps types are generally more expensive. Therefore, a CFL is more expensive than a halogen lamp, which is more expensive than a GLS lamp.

For this analysis, we assumed that lamp prices in the various countries would reflect the level of affluence in those countries. Retail lamp prices are structured along these lines, with the highest prices in those countries with the highest PPP-adjusted GDP per capita and the lower prices in regions that have lower PPP-adjusted GDP per capita. Professional and outdoor prices were set to be equal, and are approximately 30% more expensive than the Residential sector. Please note that the values shown below do not correspond to actual lamp prices, these represent estimates of sales-weighted averages of actual lamp prices.

Table 2-2: Sales-Weighted Average Lamp Sales Price in USD by Type and Sector (2010)

	Sector	GLS	HAL	CFL	LED	FL	FL eff.	HID	HID eff.
Group #1	Residential	0.50	2.50	4.00	30.00	1.40	1.80	30.00	45.00
	Professional	0.65	3.25	5.20	39.00	1.82	2.34	62.00	75.00
	Outdoor	0.65	3.25	5.20	39.00	1.82	2.34	93.00	125.00
Group #2	Residential	0.40	2.00	3.20	25.00	1.12	1.44	30.00	45.00
	Professional	0.52	2.60	4.16	32.50	1.46	1.87	62.00	75.00
	Outdoor	0.52	2.60	4.16	32.50	1.46	1.87	93.00	125.00
Group #3	Residential	0.32	1.60	2.56	25.00	0.90	1.15	30.00	45.00
	Professional	0.42	2.08	3.33	32.50	1.16	1.50	39.00	58.50
	Outdoor	0.42	2.08	3.33	32.50	1.16	1.50	62.00	75.00
Group #4	Residential	0.25	0.80	1.85	25.00	0.80	1.15	30.00	45.00
	Professional	0.33	1.04	2.41	32.50	1.04	1.50	50.00	62.00
	Outdoor	0.33	1.04	2.41	32.50	1.04	1.50	62.00	74.00
Group #5	Residential	0.20	0.70	1.60	25.00	0.70	1.10	30.00	45.00
	Professional	0.26	0.91	2.08	32.50	0.91	1.43	50.00	62.00
	Outdoor	0.26	0.91	2.08	32.50	0.91	1.43	62.00	74.00

Note that the average selling price is important for the calculation of the total costs to the customer and the payback period, as mentioned above.

2.3 OPERATING HOURS

The operating hours are another important input parameter for which no global database exists. Operating hours in a household will be related to the number of lamps per household, the level of economic development and end-user behaviour. For a commercial / industrial or outdoor installation, there will tend to relate to hours that a facility is open and/or operational. In general, it is assumed that more affluent countries will have higher installed stock of lamps per capita when compared to less affluent countries, and that the more affluent countries will therefore tend to have lower operating hours in the household sector.

UNEP issued a series of questionnaires to countries, which included questions for data on operating hours. Where those were provided, they are used in the model. However, when no data was available, operating hours were assumed as shown in the table below, clustered according to the GDP-PPP group. The estimated average daily operating hours for the installed stock of each lamp type and sector are shown in the table below. Note that the model currently assumes the same operating hours in the Professional and Outdoor sectors across all GDP-PPP groups.

Table 2-3: Average Daily Operating Hours of Installed Stock of Lamps (2010)

	Sector	GLS	HAL	CFL	LED	FL	FL eff.	HID	HID eff.
Group #1	Residential	1.4	1.4	1.4	1.4	4.0	4.0	10.0	10.0
	Professional	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Outdoor	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Group #2	Residential	1.8	1.8	1.8	1.8	4.0	4.0	10.0	10.0
	Professional	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Outdoor	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Group #3	Residential	2.2	2.2	2.2	2.2	4.0	4.0	10.0	10.0
	Professional	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Outdoor	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Group #4	Residential	2.7	2.7	2.7	2.7	4.0	4.0	10.0	10.0
	Professional	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Outdoor	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Group #5	Residential	3.4	3.4	3.4	3.4	4.0	4.0	10.0	10.0
	Professional	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Outdoor	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

The model has the flexibility to change operating hours at the country level, the group level and within those, by the lighting technology. Comments and better data on this critical variable are welcome.

2.4 LIFETIME

Lamp lifetime varies with the lamp type and its manufacturing quality, which is associated with price. It can also be influenced by the quality of the power grid, where frequent outages and voltage sags and surges can result in premature failure in the lifetime of a lamp. For these reasons, the (national) average lamp lifetimes are expected to increase as the affluence level of a country increases. The estimated average lamp lifetimes are shown in the table below, and are based on lamp catalogues as well as interviews with industry and other experts.

Table 2-4: Average Lamp Lifetime for the Installed Stock of Lamps (2010)

	Sector	GLS	HAL	CFL	LED	FL	FL eff.	HID	HID eff.
Group #1	Residential	1000	2000	10000	25000	18000	18000	10000	10000
	Professional	1000	2500	15000	25000	18000	18000	12000	12000
	Outdoor	1000	2500	15000	25000	18000	18000	20000	20000
Group #2	Residential	1000	2000	9000	20000	16500	16500	9500	9500
	Professional	1000	2500	13000	20000	16500	16500	11500	11500
	Outdoor	1000	2000	13000	20000	16500	16500	18500	18500
Group #3	Residential	1000	1500	8000	18000	15000	15000	9000	9000
	Professional	1000	2000	11000	18000	15000	15000	11000	11000
	Outdoor	1000	2000	11000	18000	15000	15000	17000	17000
Group #4	Residential	1000	1000	6000	16000	13500	13500	8500	8500
	Professional	1000	1250	9000	16000	13500	13500	10500	10500
	Outdoor	1000	1250	9000	16000	13500	13500	15500	15500
Group #5	Residential	1000	1000	5000	14000	12000	12000	8000	8000
	Professional	1000	1250	8000	14000	12000	12000	10000	10000
	Outdoor	1000	1250	8000	14000	12000	12000	14000	14000

2.5 REPLACEMENT LABOUR

The model takes into account a modest charge for lamp replacement costs, which are driven by the operating hours and the catalogue life-times. For each of the lamp types, a fixed amount of time is associated with changing the lamp. These charges are only applied to the Professional and Outdoor sectors, as it is assumed there are no labour charges associated with lamp replacement in the Residential sector. The modelling team is developing better labour cost estimates, but our default labour costs are scaled according to the GDP-PPP group for a given country as follows:

- Group 1: US$35.00 per hour
- Group 2: US$20.00 per hour
- Group 3: US$10.00 per hour
- Group 4: US$5.00 per hour
- Group 5: US$2.00 per hour

Table 2-5: Average Number of Minutes to Change a Lamp

All Countries	GLS	HAL	CFL	LED	FL	FL eff.	HID	HID eff.
Residential	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Professional	5	5	5	5	10	10	20	20
Outdoor	5	5	5	5	10	10	20	20

2.6 MERCURY EMISSIONS

The model considers two sources of mercury (Hg) emission: emission from coal power stations and emission from the appropriate disposal of mercury-containing lamps. While there is a trade-off between Hg use in energy-efficient lamps and Hg emissions from coal-fired power plants, it is also important to recognize that the Hg contained in lamps and the Hg emitted from coal-fired power plants are not directly comparable from the perspective of risks posed to human health and the environment. The risk of Hg released when a lamp is broken in a room is different from that of Hg coming out of a power plant stack because the dispersion characteristics are different. Another important factor is how the lamps are managed at their end-of-life (i.e. landfilled, incinerated or sent for Hg recovery). The quantities would only be comparable when one assumes all the lamps containing Hg are burned and the Hg enter the atmosphere in the same manner as coal-fired power plants.

To determine possible mercury savings from the en.lighten programme, the following assumptions are used:

- Hg content of a CFL — 2.5 mg
- Hg content of a standard FL — 10 mg
- Hg content of an efficient FL — 5 mg
- Hg content from coal powerplant (global avg) — 0.11 mg/kWh
- Unrecoverable Hg emissions in disposal — 11%

The Hg content of CFL and FL is based on private sector information. The Hg content of coal combustion is based on the UNEP Mercury Toolbox, representing a global average. Actual Hg emissions in any specific country will vary with the chemistry of the coal and whether the coal-fired power stations have any scrubbers or pollution abatement equipment.

In the present analysis Hg emissions from coal power plants were differentiated from emission from lamps. The emissions were determined separately in the following manner:

$$HgE = ES \times HgC \times SC$$

Where:

HgE	Mercury Emission Reductions from Electricity Consumption
ES	Annual Electricity Savings
HgC	Mercury Emissions from Coal Power Stations
SC	Share of Coal Power Stations in the Electricity Mix

$$HgL = \frac{(FIB - CIB)}{LT} \times HgD$$

Where:

HgL	Mercury Emissions from lamps (CFL or FL)
FIB	Future Installed Base
CIB	Current Installed Base
LT	Life Time
HgD	Mercury Emissions released by disposal

2.7 CO2 EMISSION FACTORS

The model develops and takes into account the specific CO_2 emission factors for based on the IEA report "CO_2 Emissions from Fuel Combustion (2010 Edition)", which takes into account each country's typical electricity mix. Moreover, the data is only for energy-related CO_2 emissions, not for any other greenhouse gases. Thus these emission factors may differ from countries' official submissions of emissions inventories to the UNFCCC Secretariat.

The IEA's emission factors span a period of time, and the last five years in this dataset (2005-2009) are used to project the emission factor in 2010. The table below provides a small sample of the CO_2 emission factors in the model for five countries. The relative difference in value is important to note, such as for Australia which has a high proportion of electricity generation from coal (a carbon intensive fuel for generating electricity).

Table 2-6: Examples of CO_2 Emission Factors – Five Countries

Country	g CO_2/kWh
Argentina	381.24
Armenia	132.24
Australia	828.96
Austria	154.23
Azerbaijan	412.54

2.8 BASELOAD POWER STATION EQUIVALENTS

In order to make the total electricity savings more understandable to the audience, the savings are converted into the equivalent annual output of one of three different base load electric power stations. These power station equivalents are applied equally around the world, and therefore do not take into account any regional different practices around maintenance and reliability. The table below presents the three power station equivalents that are used, and the assumed annual electric power output from each. The availability (0.85) of these power stations is reflective of a baseload facility, that is, one that runs continuously throughout the year, except when it is taken off-line for maintenance.

Table 2-7: Equivalent Electric Power Plants

Size	Rating	Availability	TWh / Year
Small	20 MW	0.85	0.15 TWh
Medium	100 MW	0.85	0.74 TWh
Large	500 MW	0.85	3.72 TWh

2.9 OTHER INPUTS AND ASSUMPTIONS

In addition to the aforementioned inputs and assumptions associated with the lighting technologies and the electricity generating technologies, there are several other model inputs that were developed for use in the lighting market assessment model. For the most part, these input assumptions are sourced from the International Energy Agency, the World Bank and other programmes within the United Nations.

These other inputs and assumptions are listed below:

- Electricity prices for residential, professional and outdoor sectors
- Total national electric power generation and consumption
- Population
- Gross Domestic Product
- Labour cost for electrical contractor work
- Percentage of the population connected to the electricity distribution network
- Estimated share of national electricity consumption used by lighting
- Breakdown of electricity production by fuel type, including: coal, oil & gas, hydroelectric, nuclear and renewable
- Total national emissions of CO_2
- Other electricity production pollution emission factors for sulphur and nitrous oxides
- Average annual household electricity consumption for each country
- Global average CO_2 trading price

3 METHODOLOGY

There are two modelling approaches that are used to estimate the installed stock of lamps for each country. The first approach develops an installed stock base from three different data sources. The second approach estimates the installed stock of lamps based on an assumed proportion of national electricity consumption for lighting in a given country. These two approaches are combined to generate the total estimated installed stock of lamps for each country.

Approach 1: Estimate of Lamp Stocks

The first approach for estimating the installed stock of lamps in each country uses three methods:

1a: Estimating the installed stock of lamps based on apportioning regional estimates of the installed stock provided by en.lighten Partners OSRAM and Philips.

1b: Estimates of the national stock provided by the country through the use of a survey tool that was prepared and circulated. The questionnaire has seven parts, including detailed questions on the national lighting market.

1c: Stock model calculation based on imports and exports. The modelling team gathered a six-year time series for lamp shipment data to each country from the UNComtrade system. The team then applied estimates of lamp lifetime and operating hours, to convert the shipments into an installed stock.

Note: Approach 1c does not apply to countries with domestic production because data is not currently available on the proportion of domestic consumption derived locally or the proportion of exports.

Approach 2: Estimate of Electricity Share

The second assumes that lighting accounts for approximately 15 per cent of total national electricity consumption. Given this level of annual demand and estimates of the operating hours and lamp wattages, an installed stock of lamps is determined across the lamp technologies and end-use market segments which would be adequate to represent that level of electricity consumption.
Note: If a country already supplied en.lighten with its approximate share of electricity consumption for lighting, the starting estimate is adjusted to match the country's estimate.

The shares of the installed lamp stock of lamps by end-use market segment and technology for this approach were derived in two ways:

2a: Apportion electricity consumption for lighting using the country lighting questionnaire(s) for a given region.

2b: Apportion electricity consumption for lighting using the same proportions found Approach 1.

Combining Approaches 1 and 2

The results of the two approaches are averaged together for the installed stock of lamps in each country. The energy consumption associated with this baseline is calculated and then the baseline is converted to energy-efficient lamps according to the percentages shown in the Table below regarding the efficient lamps that will replace the existing stock of lamps. The Table shows the one-for-one lamp technology substitution for each lamp in the existing stock and each energy-efficient lamp that would replace it. Under the efficiency scenario, each lamp listed in the top row is replaced by a more energy efficient lamp (types listed in the left column), according to the percentages shown in the columns. For example, 10% of the existing incandescent lamps in a country are replaced with incandescent lamps, 85% are replaced with compact fluorescent lamps and 5% are replaced with light emitting diode lamps. These assumptions are applied equally to all sectors and all countries.

Table 3-1: Assumptions for Lamp Technology Substitution

Replacement Lamps (per cent share of total)	Existing Lamps (total stock)					
	Incandes-cent	Tungsten Halogen	Compact Fluorescent	Light Emitting Diode	High Intensity Discharge	Fluorescent
Incandescent	10%					
Tungsten Halogen		10%				
Compact Fluorescent	85%	80%	90%			
Light Emitting Diode	5%	10%	10%	100%		
Efficient High Intensity Discharge					100%	
Efficient Fluorescent						100%

4 REFERENCES USED FOR THIS MODEL

General Information

- **Population** data (data for 2010) comes from the World Bank.
- **Area** data comes from the United States Central Intelligence Agency (US CIA), 2012.
- **GDP per capita** (current USD) is calculated using GDP/population. GDP in current US $ (data for 2010) is taken from the World Bank. For countries without GDP value in 2010, an estimate is forecasted based on the trend from the previous five years (2005 through 2009). For countries without any GDP value from the World Bank, the US CIA data is used.
- **Electrification level** data is taken from the World Bank (data for 2009). For countries without the data from World Bank, data from Buckminster and World Bank's Databank are crosschecked and cited.

Electricity Data

- **Installed generating capacity** (estimates for 2010) is cited here, forecasted based on trend from the U.S Energy Information Administration (EIA) (2001 through 2005).
- **Total electricity production and consumption** (data for 2010) are sourced from the World Bank. For countries without total electricity production and consumption value in 2010, an estimate is forecasted based on the trend from the previous five years (2005 through 2009). For countries without any value from the World Bank, the US CIA data for electricity production and consumption are used.
- **Average electricity price** in residential and professional sector cited was provided by the International Energy Agency (IEA, data covers OECD countries in 2010). Electricity price in outdoor sector is set the same as electricity price in professional sector. For other countries where the IEA did not have an electricity price, market research was conducted to collect the information. The reference year (from 2002 to 2012) varies due to the quality of data available. (NOTE: due to the adjustment of electricity price

in individual country, the data shown here might not represent the most accurate value.)

- **Electricity production mix** data shown here comes from the World Bank (data for 2009). Five different sources are differentiate: coal, oil and gas (calculated using the Electricity Production from coal, oil and gas source minus the electricity production from coal source), hydroelectric, nuclear, renewable (excluding hydro electric). For country without data from the World Bank, the data is generated through crosscheck of US CIA and US EIA.
- **GDP/unit electricity consumption**, **share of lighting** and **annual coal power plant production** are calculated for each country from the above data.

CO_2 emissions Data

- **Total CO_2 emission** (estimates for 2010) is prepared based on data from the World Bank (2004 to 2008).
- **CO_2 emission factor** is taken from the IEA (estimates for 2010 covering 138 countries based on data from 2005 to 2009). For countries without CO_2 emission factors from the IEA, findings from a study "2010 Environment Performance Index" is used. For countries without CO_2 emission factor from either of these two sources, the value is calculated based on countries geographically nearby and then corrected using the electricity production mix data.
- **CO_2 trading price** cited represents a global average value for 2010.
- **CO_2 trading value** is calculated for each country.

Air and Ground Pollutants

- For countries with electricity production from coal source:
  -**Mercury emissions from coal combustion** (mg/kWh) are set based on UNEP toolbox global average.
  -**SO2 emissions from coal combustion** (g/kWh) are set based on a research paper.
  -**NOx emissions from coal combustion** (g/kWh) are set based on a research paper.
- **Mercury released during compact fluorescent and linear fluorescent lamp recycling** and **mercury content per lamp** were developed based on industry consultations.

Lighting Data

- Estimates of the installed stock of lamps were provided by OSRAM and Philips for all lamp types on a regional basis for the year 2010.
- Estimates of the typical lamp wattage, lamp price, operating hours, lamp lifetime, installation labour, and other factors were developed for countries based on industry consultations, internet research and country feedback.
- Several countries provided estimates of their own national markets based on their own research and available experts.
- For certain countries without domestic manufacturing of lamps, imports and exports of lamps from the United Nations' Comtrade database were used to calculate six years (2005 through 2010) of net imported lamps. Using these shipment data and taking into account typical operating hours and lamp lifetimes, a time-series stock model was developed and the installed stock of lamps for each country was estimated.

Others

- The average annual household electricity consumption is assumed to be 2000 kWh/year for countries with access to electricity (electrification rate) less than 60%.
- TWh of electricity savings are converted and reported in crude oil energy equivalents according to the conversion factor of 11.63 MWh/toe, or 1 TWh = 86 ktoe.
- A plant factor of 85% is assumed when converting the electricity savings to power plant electricity production equivalent.
- The annual CO_2 emission for a car are based on a mid-size car with a CO_2 emission factor of 160 g CO_2/km and a yearly distance of 25,000 km; emitting 4 tons of CO_2