PRESCRIPTIVE ENERGY EFFICIENT TECHNOLOGIES

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1. General introduction

Energy efficiency policies enable countries to alleviate the financial burden of oil imports on their balance of trade and also improve energy supply security. As many non-energy producing energy intensive countries are faced with low economic growth and high unemployment, energy efficiency is seen as the best strategy to improve the competitiveness of industry, by reducing energy cost and stimulating economic growth and job creation through the investments generated. Energy efficiency helps to reduce costs for low-income consumers and contributes to alleviating poverty.

In developing and emerging economies, energy efficiency enables a reduction in energy supply investment, and helps to make the best use of existing assets to improve energy access. In particular, improving the **efficiency of electricity usages** has two benefits:

- Supplying more customers using the same electricity production capacity thanks to grid losses reduction and reduced consumption per served customer, allows to provide **electricity access** to more people,

- Curbing the electricity **demand growth**, and so reducing the investment needed for expansion of the electricity sector is especially important in countries with high growth in electricity demand.

Energy service— not energy supply—is what accomplishes the goals of energy access. Thanks to energy efficiency, an increasingly affordable off-grid pico-size energy supply system can power more appliances and render more services. Energy efficiency also has many other benefits, such as reducing the impact of oil volatility on the balance of trade and on national budget, when prices are subsidised. Energy-producing countries have become concerned by energy-efficiency as they realise they are wasting valuable resources by not using them efficiently. Most of the energy efficiency investments are cost effective since they are paid back in a few years through lower expenditures on energy supply and other benefits.

Regarding the concrete actions to be implemented to reach the energy efficiency policy objectives, one category of actions consists of accelerating the dissemination of available off-the-shelf energy efficient appliances and equipment that will capture energy savings once installed and used. These actions will replace or improve mature and often cheap energy inefficient technologies. These actions are called **prescriptive** because they do not require much effort or studies to be deployed and enable to capture the low hanging fruits of energy savings.

The implementation of prescriptive actions is yet insufficient to capture the full potential for energy conservation that can be addressed in a second phase through **custom measures**: A complete redesign of a facility in view of minimizing energy consumption will reduce the energy consumption much further than a collection of prescriptive energy efficient equipment will do. Such effort to redesign a facility could avoid the use of certain equipment, should it be energy efficient. For example effective building orientation, natural ventilation and day lighting could reduce the required capacity of HVAC and lighting systems.

Organizing **access to finance** for prescriptive energy technologies is much easier than for custom technologies as prescriptive energy technologies have very little technology risk, if any, and have usually a lower investment cost.

2. General Principles

The overarching objective of a prescriptive energy efficiency technologies programme is to capture significant energy savings available through increased and sustained market share of energy efficient products and systems. To support this objective, one of the specific goals of the programme is that energy efficient products meet consumer expectations in terms of quality of service and energy performance. The proposed specifications have ultimately been designed to help support the overarching objective and goal by including metrics that are related to product quality of service in addition to energy consumption. These quality of service metrics are directly tied to the ability of energy efficiency programmes to claim sustained and persistent energy savings and maintain positive relationships with customers.

Prescriptive energy efficient technologies consist of a set of discrete standard options that most institutional, commercial or industrial facilities use to reduce energy consumption. Common prescriptive technologies consist of efficient lighting, efficient HVAC, efficient refrigeration, efficient electric motors, efficient transformers, etc…

Prescriptive energy efficient technologies are often considered easy to prescribe, implement, incentivize, reward and monitor because they go straight to the best energy efficient off-the-shelf products **part of a catalogue** and require **little analysis or study**, if any, on the part of the project designer.

While selecting prescriptive EE technologies from a catalogue, it is assumed that the equipment is installed correctly and performs as specified by manufacturers under a guarantee clause provided that

1. the energy supply quality standard to the equipment is compliant to the standard specified by the regulator

2. the manufacturer has adapted the technology to make it resilient to the variation of the energy supply quality, as often encountered in developing countries, and also to the specific climate environment (i.e. tropicalisation of technologies)

3. the technologies are properly serviced as per manufacturer's recommendations

The promotion and dissemination of prescriptive EE technologies accelerate the replacement of inefficient technologies in existing facilities and the shift towards the selection of EE technologies for new constructions. EE technologies picked on a catalogue can offer various levels of energy savings. The bundling of items can allow designers to achieve significant cumulated savings.

The overall energy saving of a collection of energy efficient equipment is often less than the sum of expected energy savings of each equipment. For example, efficient lighting reduce the heat load of the HVAC system and might make energy efficient HVAC technologies less attractive.

A catalogue of prescriptive energy technologies must be reviewed and updated continually as new technologies enter the market and may outdate technologies once considered as the best practice for energy efficiency. For example, programmes to replace inefficient lighting such as incandescent lamps by compact fluorescent lamps should now consider the emergence of LED lamps in order to reach an even lower energy consumption. The same applies for programmes that consist of replacing inefficient mercury vapour lamps for street lighting with more efficient high pressure sodium lamps.

3. Energy Efficiency Index and labelling

The identification of energy efficient appliances is often made through specific energy efficiency index reported in the documentation provided by the vendor. Those index are usually validated by recognized laboratories through the implementation of energy efficiency assessment protocols universally accepted. Those index are usually technical energy efficiency measurement that require a deep understanding of the design and operation of the equipment. In order to better inform the consumer, the efficiency index is converted into efficiency classes from "A" for the most efficient range of index, to "E" for the least efficient range of index. A few indices are defined hereafter.

3.1 Energy Efficiency Index (EEI) for lighting

For the calculation of the energy efficiency index (EEI) of a specific lamp of fixture, its power corrected for any control gear losses is compared with its reference power. The reference power is obtained from the useful luminous flux, which is the total flux for non-directional lamps, and the flux in a 90° or 120° cone for directional lamps.

The EEI is calculated as follows and rounded to two decimal places:

EEI = Pcor /Pref

where:

Pcor is the rated power (Prated) for models without external control gear and the rated power (Prated) corrected for models with external control gear. The rated power of the lamps is measured at their nominal input voltage.

Pref is the reference power obtained from the useful luminous flux of the model (Φuse) by the following formulae:

For models with Φuse < 1 300 lumen: Pref = 0,88√Φuse + 0,049Φuse

For models with Φuse ≥ 1 300 lumen: Pref = 0,07341Φuse

3.2 Energy Efficiency Ratio (EER) for cooling / refrigeration equipment

The energy efficiency ratio is used to evaluate the equipment's efficiency while in the cooling mode. EER is defined as the net cooling capacity (in Btuh) divided by the total electrical power input (in Watts). EER is calculated at a single very specific operating point and is typically only applied for commercial equipment > 6 nominal tons of refrigeration.

$$\boldsymbol{EER} = \frac{\boldsymbol{net\ capacity\ (Btuh)}}{\boldsymbol{Power\ Input\ (kW)}}$$

The EER rating evaluates how a unit will perform at one specific point. A higher value for EER represents a higher efficiency at standard conditions.

3.3 Seasonal Energy Efficiency Ratio (SEER) for cooling / refrigeration equipment

The Seasonal Energy Efficiency Ratio is similar to the EER in that its purpose is to represent the efficiency of the unit while in the cooling mode. However, there are two major differences between them. First, the SEER attempts to take into account the energy consumption due to the cycling of the fan motors and compressors. Second, EER is calculated only at one point where SEER is calculated at two different points that simulate operation at higher and lower humidity levels for entering conditions.

According to the industry definition, the SEER rating is only defined for units 5 tons and less that operate on single phase current. Nonetheless, it is industry convention to apply the SEER rating to single and three phase equipment that are < 5 tons. Also, just like an EER_{App} the SEER formula is sometimes calculated for larger equipment.

The SEER calculation requires performance testing and measurements at two different points, as outlined below. The first point is intended to simulate dry coil conditions and is evaporator entering air (EAT) of 80/57oF and ambient air of 82oF. The unit is operated at this point and performance measurements are taken. Next, the unit is cycled on and off and power measurements are taken. Then, the same procedure is done at EAT = 80/67oF with 82oF ambient, to simulate wet coil conditions.

Calculating SEER involves laboratory testing, in a similar manner to all other rating values, with the exception that SEER requires power measurements to be recorded while the unit is in steady state operation, upon start-up and while the unit is at rest (there can still be some amp draw even while the compressors are not running due to potential operation of the fan motor, crankcase heaters, etc). SEER is impossible to calculate without a considerable amount of specific test data. Similarly to EER, the SEER is not a dimensionless value, but is always quoted as a pure number (i.e. no units).

SEER ≈ weighted average of EER values at all four measurement conditions

3.4 Integrated Energy Efficiency Ratio (IEER)

IEER is intended to be used as a representation of part load performance for energy comparisons of similar systems. In a most simplistic form IEER is calculated by operating the system at 4 different capacities and applying a formula:

IEER = (0.02 * A) + (0.617 * B) + (0.238 * C) + (0.125 * D)

Whereas:

A = EER at 100% net capacity at AHRI standard condition (95 deg F)

B = EER at 75% net capacity and reduced ambient (81.5 deg F)

C = EER at 50% net capacity and reduced ambient (68 deg F)

D = EER at 25% net capacity and reduced ambient (65 deg F)

Full load EER (100% capacity) represents only 2% of the overall IEER rating because the system would rarely operate at this condition. As overall capacity is reduced the system EER increases significantly. A system operating at 50% part load could result in an efficiency increase of more than 70% over the rated full load EER value.

3.5 Coefficient of Performance (COP) for heat pumps

The coefficient of performance is used to measure a unit's efficiency while in heating mode and is applied to heat pumps. To evaluate a heat pump efficiency while in cooling mode, EER must be used. The COP is a dimensionless value defined as the energy produced by the heat pump (in Watts) divided by the energy consumed by the heat pump (in Watts). In an air to air heat pump, the evaporating refrigerant moves heat from the outside air (when in heating mode) and this heat plus the heat equivalent of the work of compression is rejected to the recirculated air flowing over the condenser coil and to the space to be heated. There is always heat energy in the outside air, however, at lower temperatures, it becomes more difficult to extract. Therefore the COP decreases at lower ambient temperature.

$$COP = \frac{\textbf{Net capacity (Watt)}}{\textbf{Power input (Watt)}} = \frac{\textbf{Gross heating capacity} + \textbf{supply fan heat}}{\textbf{Supply fan} + \textbf{compressor} + \textbf{cooling fan}}$$

COP represents the efficiency of a heat pump while in the heating mode. A higher value of COP reflects a higher heating efficiency.

4. How to build a catalogue of prescriptive EE technologies?

Top candidates technologies that qualify for a catalogue of prescriptive energy efficient technologies include the following:

- Energy efficient lighting
- Energy efficient cooling
- Energy efficient refrigeration
- Premium efficient electric motors
- Energy efficient electric transformers
- Power factor correction and harmonics filtering devices

Second tier candidate technologies include:

- Fans
- Refrigerators
- Cooking stoves
- Television sets
- Washing machines
- Industrial boilers
- Water heaters
- Etc.

A description of each top candidate qualifying technology is provided hereafter.

4.1 Energy Efficient Lighting

Energy efficient lamps are sources of artificial light that employ advanced technology to reduce the amount of electricity used to generate light with traditional incandescent light bulbs. Examples of energy efficient lamps include: Fluorescent lamps (regular or compact); Light-emitting diode (LED) bulbs; Light-emitting Electrochemical Cells; Electromagnetic induction bulbs.

Beyond incandescent lamps, the following fixtures are considered as inefficient lighting:

- high intensity discharge fixtures with either quartz or ceramic, pulse start metal halide fixtures (e.g. Mercury Vapour, Standard Metal Halide fixtures)
- T12 U-bent (U-tube) fluorescent lamps

An energy efficiency action related to lighting consists of:

- Replacing an inefficient lighting system with an efficient lighting system and, if advised, remove lamps in excess (retrofit action) or,
- Installing an efficient lighting system for new application (new construction action).

For retrofit actions, all ballasts, lamp fixtures and other materials shall be recycled or disposed of in compliance with local requirements. PCB ballasts and lamps are hazardous materials and should be disposed-off properly. Compliance to safety standards are mandatory where applicable. The following equipment qualify for being part of a catalogue of prescriptive energy efficient lighting equipment:

Table 4-1a Retrofit Energy Efficiency Actions with Prescriptive Lighting Technologies

	Equipment type	Unit
Lamp replacement	**Replacement of screw-in incandescent bulbs with high efficient bulbs [Section 4.1.1]**	
	100 W incandescent lamps	Lamp
	60 W incandescent lamps	Lamp
	Replacement of existing T8 fluorescent lamps with high efficient linear lamps [Section 4.1.2]	
	4-foot lamp replacement only (25W or 28W)	Lamp
	8-foot lamp replacement only (< 59W)	Lamp
	Replacement of existing fluorescent lamps with reduced wattage LED lamps [Section 4.1.6]	
	Single Fluorescent tube	Lamp
	Twin Fluorescent tube	Lamp
New Fixture/Fixture Upgrade	**Replacement of T12 lamps and ballasts with high performance T8 lamps w/electronic ballasts OR with reduced wattage T8 lamps w/electronic ballasts [Section 4.1.2]**	
	4-foot lamp and ballast upgrade	Lamp
	8-foot lamp and ballast upgrade	Lamp
	Replacement of existing fixtures with energy efficient linear fixtures [Section 4.1.2]	
	Total Existing Fixture Watts Less Total New Fixture Watts	Watts
	Replacement of incandescent lamps with hardwired compact fluorescent fixture [Section 4.1.4]	
	29 W or Less	Fixture
	30 W or Greater	Fixture
	Replacement of metal halide fixture with ceramic or quartz pulse start metal halide fixture	
	100 W or less	Lamp
	101 W - 200 W	Lamp
	201 W - 350 W	Lamp
	Replacement of metal halide fixture with LED fixture [Section 4.1.6]	
	Mercury vapour Lamp	Lamp
	High pressure sodium Lamp	Lamp
	Replacement of halogen fixture for security with LED floodlight fixture [Section 4.1.6]	
	Halogen Lamp	Lamp
	Replacement of incandescent exit sign fixtures with LED, electroluminescent or photo luminescent exit sign [Section 4.1.6]	
	LED or electroluminescent or photo luminescent exit sign	Fixture
Lamp Removal	**Permanent lamp removal of T12 or T8 lamps when upgrading remaining lamps**	
	Remove 4-foot fluorescent lamp	Lamp
	Remove 8-foot fluorescent lamp	Lamp
	Remove 4-foot fluorescent lamp with reflector addition	Lamp
	Remove 8-foot fluorescent lamp with reflector addition	Lamp
Lighting Control	**Addition of occupancy sensor controls (provide separate calculation of total fixtures and watts controlled by sensors) [Section 4.1.6]**	
	Occupancy Sensors	Watts Controlled
Off grid	**Pico solar PV [Section 4.1.7]**	
	Solar Portable Lights (SPL) or solar lanterns	Lantern

4.1.1 Energy Efficient Light Bulbs

The scope of the specification is limited to integral replacement lamps sold at retail, which includes both residential and commercial products, but excludes linear lamps (addressed in section 4.1.2). The replacement of lamps is of the highest priority due to their significant sales volume and per unit energy savings.

In contrary of all energy efficiency lighting programmes in the past that would favour compact fluorescent lamp (CFL) to replace incandescent lamps, the proposed specification is **technology neutral** in order to ensure that consumers have access to equivalent energy savings across the full range of available products. This will provide manufacturers with flexibility in designing and engineering products to achieve efficiency improvements and to preserve the opportunity for technological evolution.

The tiered approach is adopted in order to offer the opportunity to achieve greater savings than the accepted best practice. Tier 1 has been identified as a level that many efficiency programs are currently interested in promoting. It focuses heavily on product availability to enable sufficient participation in programmes. The higher tier levels reflect aspirational targets, given the rapid developments in efficient lighting technologies and the desire to meet consumer's high expectations with regard to product performance and quality. While both higher tier levels consider current product availability, tier 2 is more focused on product performance in the near term (e.g. for off grid lighting applications), while tier 3 is providing a stretch target for the future. This specification is intended to be forward looking and support evolution within the lighting market.

Table 4-1b High Performance light bulbs replacement

Performance requirements				
Tier		Tier 1	Tier 2	Tier 3
Efficacy (lm/W)	Omnidirectional	>65	>70	>70
	Directional	>52	>65	>64
	Decorative	>52	>62	>62
Correlated Colour temperature (K)	Omnidirectional	<5000	<5000	<5000
	Directional	<5000	<5000	<5000
	Decorative	<5000	<5000	<5000
Colour rendering index	Omnidirectional	>80	>83	>90
	Directional	>80	>83	>90
	Decorative	>80	>83	>90
Power factor	Omnidirectional	>0.7	>0.7	>0.9
	Directional	>0.7	>0.7	>0.9
	Decorative	>0.7	>0.7	>0.9
Dimmable	Omnidirectional	No	Yes	Yes
	Directional	No	Yes	Yes
	Decorative	No	Yes	Yes

Source: CEE Residential Lighting initiative 2015

4.1.2 Energy Efficient Linear Lamps and Fixtures

High-performance linear lamps (e.g., T5 and T8 linear fluorescent fixtures with electronic ballasts, LED) last longer, produce a better quality of light and are far more energy efficient than older, first generation T8 and T12 linear fluorescent fixtures with magnetic ballasts. Using these next-generation lamps with their improved lens design not only saves energy, but also reduces glare and improves visibility to create a better environment for customers, employees and tenants.

Table 4-1c High Performance T8 replacement lamps

Performance requirements				
Tier		Tier 0	Tier 1	Tier 2
Efficacy (lm/W)		90	95	100
Lamp life (hours of operation)		>24,000	>36,000	>50,000
Beam angle	Omni	omnidirectional		
	Directional	>129°		
Lumen Maintenance		94%		
CRI		>80		
Other required information		Nominal wattage Initial lumen output Aperture angle & finish Recommendation of dimming Ballasts evaluated for compatibility		

Source: CEE Commercial Lighting initiative 2015

4.1.3 Compact Fluorescent Lamps (Screw-in)

A compact fluorescent lamp (CFL) is a fluorescent lamp designed to replace an incandescent lamp; some types fit into light fixtures formerly used for incandescent lamps. The lamps use a tube which is curved or folded to fit into the space of an incandescent bulb, and a compact electronic ballast in the base of the lamp. Catalogue screw-in CFLs must be rated according to a recognized or imposed energy efficiency label (such as ENERGY STAR®). Electronic ballasts are required for lamps ≥18 Watts. Applications of CFL may be quantified by the number of available sockets at a specific facility. A X Watt incandescent lamp will be replaced by a 0.25X Watt screw-in CFL that will last much longer than the incandescent lamp.

Table 4-1c High Performance self-ballasted Compact Fluorescent Lamp

Performance Characteristics for bare lamps	
Mean system efficacy	≥ 45 Mean Lumens per Watt (MLPW) for lamps less than 15 W
	≥ 60 Mean Lumens per Watt (MLPW) for lamps more than or equal to 15 W
Minimum rated life duration	6000 hours

Source: Ghana regulation LI 1815

4.1.4 Hard-wired Compact Fluorescent Fixtures

Hard-wired compact fluorescent fixtures have a separate ballast and a plug-in replaceable lamp. To qualify as efficient lamp, the CFL ballast must be electronic and must be programmed start or programmed rapid start with a power factor (PF) ≥90 and a total harmonic distortion (THD) ≤20%.

4.1.5 Controls

Passive infrared, ultrasonic detectors or fixture-integrated sensors are eligible to the catalogue of prescriptive EE technologies. All sensors must control interior or exterior lighting fixtures. The efficiency impact is a function of the quantity of Watt controlled.

4.1.6 LED lamps

Rapid progress in solid-state lighting (SSL) research and development has resulted in the advent of light-emitting diodes (LED) for general lighting applications. LEDs offer a number of advantages over current lighting technology. In addition to significant energy savings, high-quality LEDs have been shown to last longer and require less maintenance than incandescent and most fluorescent products. Most LEDs contain no mercury, lead, or other known disposal hazards. They excel in cold applications such as outdoor signs, street and area lighting, along with refrigerated display cases. LED technology is advancing rapidly, with many bulb styles available as illustrated below.

Diffused bulbs are clusters of LEDs are covered by a dimpled lens which spreads the light out over a wider area. Available in standard bases, these bulbs have many uses, such as area lighting for rooms, porches, reading lamps, accent lamps, hallways and low-light applications where lights remain on for extended periods.

Tube Lights are designed to replace fluorescent tube bulbs. These LED tubes are available in 8 and 16 watts, which replace traditional 25-watt and 40-watt T8/T10/T12 fluorescent tubes. Because fluorescent lights are often installed in high ceilings in commercial sites, there are additional savings because the frequency of changing bulbs is greatly reduced.

4.1.7 Solar Portable Lights (SPL) or solar lanterns

Solar Portable Lights (SPL) or solar lanterns are single light source with or without mobile phone charging outlet. Entry level products have solar panels of 0.2 – 2 W. Price ranges from $10- to $40 (average $25). These typically consist of a complete in-build unit, comprising a battery, solar panel, wiring, power regulation and lighting bulbs or diodes, most often LED. These units are designed to be versatile and very tough to survive in remote and hostile conditions without requiring significant on-going maintenance.

4.1.8 Solar Street and parking lots lights, building exteriors, traffic lights

Solar street lights are raised light sources which are powered by photovoltaic panels generally mounted on the lighting structure. The photovoltaic panels charge a battery, which powers a fluorescent or LED lamp during the night.

Most solar street lights have light detectors that switch them on or off automatically depending on outdoor brightness. Solar street lights are particularly designed to have enough energy stored to stay bright until dawn. Solar lights placed in areas with high wind exposure generally utilize flat panels for a low wind profile. Solar street lights are generally classified into two types:

- Standalone solar street lights

Standalone solar street lights have photovoltaic panels mounted on the structure. Each street light has its own photovoltaic panels and is independent of the other lamps.

- Centrally operated solar street lights

In this type, the photovoltaic panels for a group of street lights are mounted separately. All the street lights in a particular group are connected to this central power source.

4.2 Energy Efficient Cooling

Unitary air-cooled air conditioning units, air or water-cooled chillers, room air conditioners, packaged terminal air conditioners (PTAC), and variable speed drives (VSDs) for heating, ventilation, and air conditioning (HVAC) motors, are eligible for the catalogue of prescriptive EE technologies.

The catalogue proposes the option to promote the full-load metric (EER) or part-load metric (IEER) or both metrics.

Table 4-2a Prescriptive Energy Efficient HVAC technologies

Equipment type	Size category	Qualifying Efficiency	
Unitary and Split Air Conditioning Units and Air Source Heat Pumps [Section 4.2.1]	< 65,000 Btuh (5.4 Tons)	Tier 1	14.0 SEER / 12.0 EER
		Tier 2	15.0 SEER / 12.5 EER
	≥ 65,000 Btuh (5.4 Tons) and <240,000	Tier 0	11.5 EER / 11.6 IEER
		Tier 1	11.5 EER / 12.3 IEER
		Tier 2	12.0 EER / 13.8 IEER
	≥240,000 Btuh (20 Tons) and <760,000	Tier 0	10.3 EER / 10.4 IEER
		Tier 1	10.3 EER / 11.1 IEER
		Tier 2	10.6 EER / 12.1 IEER
	≥ 760,000 Btuh (63.3 Tons)	Tier 0	9.7 EER / 9.8 IEER
		Tier 1	9.7 EER / 10.9 IEER
		Tier 2	10.2 EER / 11.4 IEER
Water-Cooled Chillers [Section 4.2.2]	ALL	Level 1 [Table 4-2b]	
		Level 2 [Table 4-2b]	
Air-Cooled Chillers [Section 4.2.2]	ALL	1.04 kW/ton or less	
PTAC/PTHP [Section 4.2.4]	ALL	See Table 4-2d	
Room Air Conditioners [Section 4.2.3]	ALL	Level 1 [Table 4-2c]	
		Level 2 [Table 4-2c]	

Source: CEE – High Efficiency Commercial Air Conditioning and Heat Pump Initiative 2015

4.2.1 Unitary and Split Air Conditioning Systems and Air Source Heat Pumps

New unitary air conditioning units or air source heat pumps that meet or exceed the qualifying Energy Efficiency Ratio (EER) or Integrated Energy Efficiency Ratio (IEER) shown in Table 4-2a are eligible for the catalogue of prescriptive EE technologies. They can be either split systems or single packaged units.

4.2.2 Water and Air-Cooled Chillers

Chillers are eligible for the catalogue of prescriptive EE technologies if they have a rated kW / ton for the Integrated Energy Efficiency Ratio (IERR) that is less than or equal to the qualifying Level 1 and Level 2 efficiency shown in the following table and they are used for HVAC cooling for human comfort. Qualifying efficiencies for chillers are summarized below. Conversion for kW/ton = 12/EER @ IEER

Table 4.2b Chiller Qualifying Efficiencies

Chiller type	Size (Tons)	Level 1 kW/ton IEER	Level 2 kW/ton IEER
Scroll or Helical-Rotary	< 150	0.61	0.54
	150 to 300	0.57	0.50
	≥ 300	0.51	0.46
Centrifugal	< 150	0.60	0.54
	150 to 300	0.54	0.48
	≥ 300	0.49	0.44
Reciprocating	ALL	0.63	0.56
Air-Cooled	ALL	1.04	NA

4.2.3 Room Air Conditioners

Room air conditioning units are through-the-wall or built-in self-contained units that have capacity ratings of 2 tons or less. There are two eligible efficiency levels as listed in table 4.2c below. A unit can either qualify under ENERGY STAR® standards or under Super-Efficient Home Appliance Tier 1 standards. These units are with and without louvered sides, without reverse cycle (i.e., heating), and casement.

Table 4.2c Room Air Conditioner Qualifying Efficiencies

Size (Btuh)	**Level 1 2000 ENERGY STAR® (EER)**	**Level 2 SEHA Tier 1 (EER)**
< 8,000	10.7	11.2
8,000 to 13,999	10.8	11.3
14,000 to 19,999	10.7	11.2
≥ 20,000	9.4	9.8

4.2.4 Package Terminal Air Conditioning Units (PTAC)

Package terminal air conditioners and heat pumps are through-the-wall, self-contained units. All EER values must be rated at 35ºC outdoor dry-bulb temperature. Minimum requirements are shown in the Table 4.2d.

Table 4.2d PTAC Minimum Efficiency Requirements

Capacity (Btuh)	Minimum Efficiency (EER)
≤ 7,000	11.3
7,001 - 8,000	11.0
8,001 - 9,000	10.8
9,001 - 10,000	10.5
10,001 - 11,000	10.3
11,001 - 12,000	10.0
12,001 - 13,000	9.8
13,001 - 14,000	9.5
14,001 - 15,000	9.4
≥ 15,000	9.2

4.2.5 Variable Speed Drive on HVAC Chillers, Cooling Towers, Fans, and Pumps

Variable-speed drives (VSD) installed on existing chillers, cooling towers, HVAC fans, or HVAC pumps used for human comfort are eligible for the catalogue of prescriptive EE technologies. The installation of a VSD must accompany the permanent removal or disabling of any flow control or throttling devices such as inlet vanes, bypass dampers, and valves.

4.3 Energy Efficient Refrigeration

The following measures are eligible for the catalogue of prescriptive EE refrigeration technologies.

Table 4-3a Prescriptive Energy Efficient Refrigeration technologies

Measure	Unit
Strip Curtains on Walk-In Coolers and Freezers [Section 4.3.1]	
	per square meter
Air Curtains and interlocks on Walk-In Coolers and Freezers	
	per door
Gaskets on Coolers and Freezers doors	
	per linear meter
Traps on drain pipes of Walk-In Coolers and Freezers	
	per drain
Anti-Sweat Heater Control (Section 4.3.2]	
	per linear meter
Electronically Commutated Motor for Walk-in [Section 4.3.3]	
	per motor
Electronically Commutated Motor for Reach-in [Section 4.3.3]	
	per motor
Evaporator Fan Control [Section 4.3.4]	
	per motor
Automatic Door Closers for Walk-in Freezers [Section 4.3.5]	
	per door

4.3.1 Strip Curtains on Walk-in Coolers and Freezers

New strip curtains or clear plastic swinging doors must be installed on doorways of walk-in boxes and refrigerated warehouses.

4.3.2 Anti-Sweat Heater Controls

A control device is installed that senses the relative humidity in the air outside of the display case and reduces or turns off the glass door (if applicable) and frame anti-sweat heaters at low-humidity conditions. Technologies that can turn off anti-sweat heaters based on sensing condensation (on the inner glass pane) also qualify.

4.3.3 Electronically Commutated Evaporator Fan Motor (Refrigerated Cases or Walk-ins)

This measure is applicable to the replacement of an existing standard-efficiency, shaded-pole evaporator fan motor in refrigerated display cases or fan coil in walk-ins. The replacement unit must be an electronically commutated motor.

4.3.4 Evaporator Fan Controls

This measure is for the installation of controls in medium temperature walk-in coolers. The controller reduces airflow of the evaporator fans when there is no refrigerant flow. The measure must control a minimum of 1/20 HP where fans operate continuously at full speed. The measure also must reduce fan motor power by at least 75% during the off cycle.

This measure is not applicable if any of the following conditions apply:

1) The compressor runs all the time with high duty cycle
2) The evaporator fan does not run at full speed all the time
3) The evaporator fan motor runs on poly-phase power
4) The evaporator fan motor is not shaded-pole or permanent split capacitor (PSC)
5) Evaporator does not use off-cycle or time-off defrost.

4.3.5 Automatic Door Closers for Walk-in Freezers

This measure is for installing an auto-closer to the main insulated opaque door(s) of a walk-in freezer. The auto-closer must firmly close the door when it is within one inch of full closure.

4.4 Premium Efficiency Electric Motors

Motors eligible for the catalogue of prescriptive EE equipment must be new three-phase AC induction motors, 0.75-150 kW, open drip-proof (open) and totally enclosed fan-cooled (closed) classifications. Rewound motors do not qualify. Savings are based on the motor's Nominal Full Load Efficiencies, tested in accordance with IEEE (Institute of Electrical and Electronics Engineers) Standard 112, method B, that meet or exceed the Premium efficiency standards shown in Table 4.4a.

Table 4.4a Prescriptive Premium Efficient Motors

	3000 rpm		1500 rpm		1000 rpm	
kW	Open	Closed	Open	Closed	Open	Closed
0,75	77,0%	77,0%	85,5%	85,5%	82,5%	82,50%
1	84,0%	84,0%	86,5%	86,5%	86,5%	87,5%
1,5	85,5%	85,5%	85,5%	85,5%	87,5%	88,5%
2	85,5%	86,5%	89,5%	89,5%	88,5%	89,5%
4	86,5%	88,5%	89,5%	89,5%	89,5%	89,5%
5,5	88,5%	89,5%	91,0%	91,7%	90,2%	91,0%
7,5	89,5%	90,2%	91,7%	91,7%	91,7%	91,0%
11	90,2%	91,0%	93,0%	92,4%	91,7%	91,7%
15	91,0%	91,0%	93,0%	93,0%	92,4%	91,7%
18,5	91,7%	91,7%	93,6%	93,6%	93,0%	93,0%
21	91,7%	91,7%	94,1%	93,6%	93,6%	93,0%
30	92,4%	92,4%	94,1%	94,1%	94,1%	94,1%
35	93,0%	93,0%	94,5%	94,5%	94,1%	94,1%

45	93,6%	93,6%	95,0%	95,0%	94,5%	94,5%
55	93,6%	93,6%	95,0%	95,4%	94,5%	94,5%
75	93,6%	94,1%	95,4%	95,4%	95,0%	95,0%
90	94,1%	95,0%	95,4%	95,4%	95,0%	95,0%
110	94,1%	95,0%	95,8%	95,8%	95,4%	95,8%
150	95,0%	95,4%	95,8%	96,2%	95,4%	95,8%

Motor efficiency varies with load. The efficiency of motors typically peaks at close to 75 percent of full load and is relatively flat down to a 50 percent load point. Most motors are operated at 60 to 75 percent of their rated capacity. Oversized motors have a lower rate of efficiency when they are in operation. A motor that is operating at a 35 percent load is less efficient than a smaller motor that is matched to the same load.

When motors operate near their rated load, the power factor (PF) is high. For lightly loaded motors, the PF drops significantly. In addition to increased electrical costs, a lower PF may reduce the voltage, increase electrical distribution system losses and reduce the system's capacity to deliver electrical energy.

Open drip-proof (ODP) and totally enclosed fan-cooled (TEFC) motors use different methods to remove heat from the windings:

- ODP motors have an internally mounted fan that allows air to blow directly through the motor and has a cover that prevents drops of liquid from entering (suitable for protected environments).

- TEFC motors use an externally mounted fan that draws air over the case to provide cooling and are designed to prevent outside air from flowing into the frame (motors can function outdoors and in dusty or contaminated environments).

4.5 Energy efficient Electric Transformers

The efficiency standard for electric transformers retained for the catalogue of prescriptive EE equipment is the European approach that specifies standards for no load loss (Po) and load loss (Pk)

- CENELEC HD428 (oil) with nine standard combinations
    - 3 Po class: A', B', C'
    - 3 Pk class: A, B, C

- CENELEC HD538 (dry) with one class for Po, Pk

Table 4.5 Transformer class in HD428/HD538

	Load Losses for Distribution Transformers				No-Load Losses for Distribution Transformers			
RATED POWER	OIL-FILLED (HD428) UP TO 24kV[2)]			DRY TYPE (HD538)	OIL-FILLED (HD428) UP TO 24kV[2)]			DRY TYPE (HD538)
	LIST A	LIST B	LIST C	12kV PRIMARY [3)]	LIST A'	LIST B'	LIST C'	12kV PRIMARY [3)]
kVA	W	W	W	W	W	W	W	W
50	1100	1350	875	N/A	190	145	125	N/A
100	1750	2150	1475	2000	320	260	210	440
160	2350	3100	2000	2700	460	375	300	610
250	3250	4200	2750	3500	650	530	425	820
400	4600	6000	3850	4900	930	750	610	1150
630	6500	8400	5400	7300	1300	1030	860	1500
1000	10500	13000	9500	10000	1700	1400	1100	2000
1600	17000	20000	14000	14000	2600	2200	1700	2800
2500	26500	32000	22000	21000	3800	3200	2500	4300

Transformers eligible as prescriptive energy efficiency technology must be of the following specification:

- oil-filled transformers: range C-C' (HD428.1) and D-E' (HD428.3)
- dry-type transformers up to and including 24kV: 20% lower than specified in HD538.1. HD538 mentions one list of preferred values, but explicitly allows the possibility for national standards to specify a second series with load and/or no-load losses at least 15% lower. Some transformer manufacturers offer dry-type transformers in normal and low-loss versions.
- dry-type transformers 36kV: 20% better than specified in HD538.2, analogous to the previous category.

The energy efficiencies of distribution transformers range

- from around 94% for a small A-A' transformer,
- to more than 99% for an amorphous-core distribution transformer with HD 428 C-level losses ('C-AMDT'), the most efficient type available.

On average, the loss in a distribution transformer is around 1.5 - 2.0% of the energy transferred. Considering that transformers are working continuously, significant losses can build up. By choosing the right technology, these losses can be reduced by up to 80%.

There are a number of practical considerations involved in deciding on the optimum choice of transformer for installation into a network. The energy losses of "energy-efficient transformers" are defined as follows:

Load losses (or copper losses, Pk) may be reduced by increasing the conductor section of the transformer windings, which reduces conductor resistance and thus load losses. To a lesser extent, the application of ribbon or sheet conductors also contributes to reducing load losses. The disadvantage of increasing the conductor section is the higher investment cost. Another disadvantage is the larger size of the transformer, which may exceed the maximum size specified by the purchaser. This is partially offset by the reduction of heat production in the transformer, which lowers the need for cooling.

No-load losses (or iron losses, Po) may be reduced by following technical design measures:

- increasing the core section, which reduces the magnetic field in the transformer core and thus the no-load losses. However, this results in higher investment cost. Another disadvantage is the larger size of the transformer, which may exceed the maximum size specified by the purchaser.
- application of high-grade modern transformer core steel. It should be noted that the C-C' level can be reached without applying laser-etched transformer steel, the latter being regularly used in large transformers.
- reduction of the thickness of the core laminations.
- application of amorphous core material.

Cooling loss (only in transformers with fan cooling) is caused by the energy consumption of a fan. The bigger the losses, the more cooling is needed and the higher is the cooling loss. These losses can be avoided if operational temperature is kept low by different loss reduction measures.

Safety and Environmental issues: Distribution transformers with conventional oil cooling and installed on indoor sites, for example the basement of a large commercial building, are considered to pose a possible fire risk. They are required by the building regulations in many countries either to use non-flammable coolants, or to be dry-type, without coolants. Polychlorinated biphenyls (PCBs), the principal coolant used in the past, have been linked with the production of highly toxic chlorine compounds, mainly dioxins, at high temperatures. Non-toxic coolants are now available, and cast resin clad transformers offer an alternative to dry-type construction.

Reliability is reported to be the main factor influencing the way in which distribution transformers are chosen by design engineers and non-utility sector customers.

The presence of non-linear loads in the network will lead to harmonic current components in the transformer. These harmonic currents tend to heat the transformer, but normally the transformer design allows for some harmonic contents of the load current. Normally, this effect is not taken into account, except in industrial or comparable installations with many distorting loads.

In the basic process of loss evaluation, three transformer figures are needed:

- purchase price
- load loss
- no-load loss

For the specified load loss of a transformer, the purchaser can assign a cost figure per W of loss (B) representing the capitalized value (net present value) of the load losses over the lifetime of the transformer or a shorter time scale e.g. 5 or 10 years. This cost figure is based on the expected transformer load over time, the average cost per kWh and the discount rate chosen by the purchaser.

Similarly, for the no-load loss of a transformer, the purchaser can assign a cost figure per W (A) of no-load loss representing the capitalized value of the no-load losses. This cost figure is also based on the average cost per kWh and the discount rate chosen by the purchaser.

As nearly all transformers are connected to the grid for 100% of the time, and the no-load losses are independent on the load, the load curve is not relevant. The average cost per kWh will tend to be lower than for the load losses, as the latter will tend to coincide with peak loads, at which time energy is very expensive.

Since different transformer users have different operating costs and cost of capital assumptions, the Total Cost of Ownership (TCO) is distinct for every user. Thus, TCO of a transformer can be further simplified and expressed as the sum of the purchase price (Ct), the cost of no-load losses and the cost of the load losses, or as a formula:

$TCO = Ct + A \times Po + B \times Pk$

where A represents the assigned cost of no-load losses per watt,
Po the value of the no-load losses per watt,
B the assigned cost of load losses per watt and
Pk the value of the load losses per watt.

This formula can also be found in the HD428 and HD538.

In fact, the loss levels established in HD428, HD538 and national standards reflect established practice of preferred designs with respect to loss evaluation values. It is then usual to select one category e.g. C-C' as the most appropriate, and omit the tedious evaluation process by purchasing the cheapest C-C' compliant transformer.

It can be concluded that the efficiency of transformers purchased is, directly or indirectly, controlled by the choice of loss evaluation figures: - if high loss evaluation figures A and B are used, energy-efficient transformers tend to be favoured.

A and/or B will be higher if a value is assigned to energy saving, an allowance is made for taxes on usage of natural resources. A low discount rate will yield higher A and B values, by valuing future energy savings to a greater extent. Low loss evaluation figures A and B, resulting of a high rate of return required, lead to cheap but relatively inefficient transformers. Merely evaluating the purchase price will lead to the cheapest transformers being chosen, which may be very inefficient. This policy corresponds to A and B equal to zero, and is regularly found with turn-key contracting firms or the project departments of utilities that are concerned only with direct project costs. The chosen values for A and B are also the key factor in the application of new technologies. Below the calculation of A and B

Life time (years)	30
Discount rate (%)	10%
Electricity price ($/kWh)	0.2
Load duration (%)	50%
A ($/W)	19.6
B ($/W)	4.9

4.6 Power factor correction and harmonics filtering devices

Implementing power factor correction and harmonics filtering solutions enable to:

- reduce the electricity bill where there is a power factor penalty in tariff
- reduce the electricity losses behind the meter and therefore the electricity bill
- reduce the investment cost of an electric network
- increase available power for a given supply contract
- reduce the impacts of harmonics

Moreover, energy savings produced by power factor correction help protecting the environment by reducing CO_2 emissions related to the share of fossil fuel in power generation.

The presence of inductive loads in an installation causes a phase shift between the current wave and the voltage. The angle φ represents this phase shift and gives the ratio between the reactive current (inductive) of an installation and its active current. The same ratio exists between the active and reactive energies or powers. The cosine φ therefore indicates the ratio between the active and apparent power of the installation (the maximum number of kVA that it can use) and that determines the power losses in the conductors. That is why cosine φ indicates the «**electrical efficiency**» of an installation.

Table 4.6a Power factor of the most common loads

Device	Load	Cos φ
Ordinary asynchronous motor	0%	0.17
	25%	0.55
	50%	0.73
	75%	0.8
	100%	0.85
Incandescent lamps		1
Fluorescent lamps		0.5
Discharge lamps		0.4 to 0.6
Resistance furnaces		1
Induction furnaces		0.85
Dielectric heating furnaces		0.85
Resistance welding machine		0.8 à 0.9
Single-phase static arc-welding centres		0.5
Rotary arc-welding sets		0.7 to 0.9
Arc-welding transformers/rectifiers		0.7 to 0.9
Arc furnaces		0.8

A high power factor optimises the components of an electrical installation by increasing the electrical efficiency. Installing capacitors reduces reactive energy consumption between the source and the loads. The capacitors supply reactive energy by discharging into the installation from the upstream connection point. The power available at the secondary of an MV/LV transformer can therefore be increased by fitting a power factor correction device in the low voltage part. The table in figure 4.6b shows the increased active power (kW) that can be supplied by a transformer by correcting the power factor up to cos φ = 1

Table 4.6b: increase in the power available at a transformer secondary according to the cos φ of the load

Initial cos φ	Increased available power
1	0 %
0.98	+ 2.0 %
0.95	+ 5.2 %
0.90	+ 11.1 %
0.85	+ 17.6 %
0.80	+ 25 %
0.70	+ 42.8 %
0.65	+ 53.8 %
0.50	+ 100 %

Installing a power factor correction device allows the cross-section of the conductors to be reduced, as less current is used from the compensated installation for the same active power. The table in figure 4.6c shows the multiplying factor for the cross-section of the conductor according to the cos φ of the installation.

Table 4.6c: multiplying factor for the conductor cross-section according to the cos φ of the installation

Initial cos φ	Cable cross-section multiplying factor
1	1
0.8	1.25
0.6	1.67
0.4	2.5

Installing capacitors allows the Joule effect losses (temperature rise) to be reduced in the conductors and transformers. The meter records these losses as consumed energy (kWh). The losses are proportional to the square of the current. The following formula can be used to determine the loss reduction according to the cos φ of the installation:

$$\frac{final\ losses}{initial\ losses} = \left(\frac{initial\cos\varphi}{final\cos\varphi}\right)^2$$

Installing capacitors allows the voltage drops to be reduced upstream of the point where the power factor correction device is connected.

4.6.1 Choice of power factor correction device

The nature of loads, their rate of fluctuations as well as the amount of reactive power to compensate on the network will determine the type of power factor correction device to be adopted. The position of the device on the network upstream or closer to the non-linear loads will also be critical.

4.6.1a Fixed power factor correction

The need for power factor correction of the network is constant over long periods. The device is adopted in the following cases:

- Power factor correction of electric transformers
- Individual power factor correction of electric motors
- Battery whose power capacity is greater than 15% of the electric transformer capacity

4.6.1b Automatic power factor correction

The need for power factor correction fluctuates slowly. This compensation is gradually adjusted as needed (response time less than a minute). An automatic power factor correction device must be adapted to the variations in reactive power of the installation in order to maintain the target cos φ of the installation. An automatic power factor correction device consists of three main components:

- Controller: Its function is to measure the cos φ of the installation and send orders to the contactors to ensure that the power factor is as close as possible to the target cos φ by linking the various reactive power steps.

- Capacitors: Capacitors are the components that supply reactive energy to the installation.

- External measurement: A current transformer will measure the consumption of the entire installation. Normally, voltage measurement is built into the capacitor bank itself so that this value is generated by the power connection of the capacitor bank.

The information about the installation (voltage and current) allows the controller to calculate the cos φ of the installation at any time and to take the decision to activate or deactivate the power steps. The device is adopted in the following cases:

- Compensation transformers
- Compensation TGBT
- Individual power factor correction of electric motors
- Battery whose power capacity is greater than 15% of the electric transformer capacity

4.6.1c Dynamic power factor correction

The need for power factor correction of the grid may fluctuate very quickly. The power factor correction is instantly adjusted if necessary (with response time less than 50 ms). The device is adopted in the following cases:

- Power factor correction of electric transformers
- Individual power factor correction of electric motors
- Battery whose power capacity is greater than 15% of the electric transformer capacity

4.6.2 Harmonics and quality of energy

In electrical systems, the voltage or current waves, whose frequency is an integral multiple of the fundamental frequency of the network (50 Hz), are called harmonics. The waves of different orders that make up a harmonic spectrum and result in distorted waves are generally found simultaneously. Harmonics are usually defined by two main characteristics:

- their amplitude: value of the harmonic voltage or current

- their order: value of their frequency with respect to the fundamental frequency (50 Hz).

Under such conditions, the frequency of a 5th order harmonic is five times greater than the fundamental frequency, i.e. 5 x 50 Hz = 250 Hz.

Industrial loads that generate harmonics are: power electronics devices (variable speed drives, rectifiers, UPS, etc.) and loads using an electric arc (arc furnaces, welding machines, fluorescent lamps, etc.; temporary harmonics are also generated when motors are started with an electronic starter and when power transformers come into service.

Residential loads that generate harmonics are TVs, microwave ovens, induction plates, computers, printers, fluorescent lamps, etc.

Immediate and short term effects of harmonics include:

- Unwanted tripping of protection devices,
- Induced interference from LV current systems (remote control, telecommunications),
- Abnormal vibrations and noise,
- Damage due to capacitor thermal overload,
- Faulty operation of non-linear loads.

Long-term effects of harmonics are associated with current overload that causes overheating and premature deterioration of the equipment.

The addition of a power factor correction device can amplify the existing level of harmonics on the network. In order to limit this phenomenon and increase the technical life duration of the equipment and facility as well as limit the malfunctions, solutions limiting these harmonics, called passive or active, may be necessary.

The ratio Sh / Sn is a simple rule of thumb for defining the most suitable power factor correction system.

Sh = apparent power capacity of the loads generating harmonics at the connection point

Sn = apparent power capacity of the transformer in kVA at the connection point

A measurement at nominal load without power factor correction enables to verify the actual harmonics conditions at the connection point (Total harmonics distortion rate in current THDi and in voltage THDu).

4.6.2a without anti-harmonics inductor

The level of harmonics pollution of the network is low and the risk of its increase, because of the compensation system, is acceptable. The compensation system is able to withstand the overload caused by harmonic pollution. The ratio Sh / Sn is less than or equal to 25%. Total harmonics distortion rate in current is less than 10%. Total harmonics distortion rate in voltage is less than 4%.

4.6.2b with anti-harmonics inductor

The degree of harmonics pollution of the network is medium and should not be amplified by the compensation system. The ratio Sh / Sn is greater than 25% and less than 50%. Total harmonics distortion rate in current is less than 20% (but more than 10%). Total harmonics distortion rate in voltage is less than 8% (but more than 4%).

4.6.2c with active or passive filtering

The level of harmonics pollution of the network is important and must be reduced by the compensation system. The ratio Sh / Sn is greater than 50%. Total harmonics distortion rate in current is more than 20%. Total harmonics distortion rate in voltage is more than 8%. Detuned reactors (DR) prevent the harmonics present on the network from being amplified and protect the capacitors.

5. Business models

In a context of budget constraints and to reach multiple consumers more directly, public policies rely more and more on the private sector such as energy utilities, energy services companies (ESCOs) or micro-finance services carried by commercial banks.

The involvement of utilities can be through negotiated or voluntary agreement or through regulations that mandate these utilities to make energy savings with their customers – energy savings obligations.

The involvement of ESCOs helps to spread technical and financial solutions that enable consumers improve the efficiency of their energy usage and therefore reduce their energy bills.

The involvement of commercial banks enables to channel to the market micro-financed products for the benefit of their customers.

The knowledge of system characteristics on which will be installed the device is essential to ensure the required level of performance and longevity of equipment. The user can ensure responsibility of the choice of device or transfer it to the vendor / utility / manufacturer / third party and possibly associate service commitment on a fixed term.

5.1 Product service

The customer defines the product by taking advice from the vendor / utility / manufacturer / third party. The documentation supplied with the product contains technical specifications, installation requirements, commissioning requirements and maintenance requirements, warranty conditions as well as compliance with standards and regulations.

5.2 Definition service

The manufacturer / vendor takes the responsibility for the product definition. The manufacturer / vendor provides a design study based on measurements representative of operating conditions of the facility. In the case of a new facility, modelling assumptions can substitute for measures and are subject of an agreement between the manufacturer / vendor and the customer.

5.3 Turnkey Service

The manufacturer / vendor takes responsibility for product definition and proposes a maintenance service contract. The manufacturer provides a design study under the provisions of "definition service" and provides a maintenance service to sustain the beneficial effects of the product on the facility. The services cover the supply of spare parts, periodic inspection, analysis of deviations, and the implementation of recommended solutions. The maintenance contract specifies the commitments of manufacturer over the life duration of the equipment, the scope and limits of service and the guaranteed the service quality provided by the equipment, as a function of evolution limits of the facility, specified in the agreement with the customer.

6. Economic incentive options

Economic incentives aim at encouraging investment in energy efficient equipment and processes by reducing the investment cost, either directly (financial incentives) or indirectly (fiscal incentives). Financial incentives include subsidies for energy surveys or investments and soft loans. Fiscal incentives include tax reduction, tax credit or accelerated depreciation, as well as tax on inefficient equipment (appliances). Economic incentives can be defined as a fixed amount, as a percentage of the investment (with a ceiling), or as a sum proportional to the amount of energy saved.

7. Key questions

Legal basis

Does the country / region have an energy efficiency law?

What areas are covered by the law?

What still needs to be covered?

Is there a legislation that affects the energy performance of products?

Is there any existing legislation to protect consumers against false product-performance claim?

How effectively is the law enforced?

Mandatory regulation

Does the country have Minimum Energy Performance Standards (MEPS), mandatory energy audits?

How, if any, building code is effectively applied?

Incentive regulation

Are the energy prices to final consumers at least covering the real cost of energy supply?

Is energy labelling applied in the country? How is it used by the final consumers? How efficient is it?

How relevant and efficient are the financial and fiscal incentive (subsidies for audit, investment subsidies, soft loans, tax credit, tax exemption, income tax reduction,…)

Are any energy efficiency funds available and how efficient are they?

Energy Efficiency awareness

Do consumers have a clear understanding of the impact of energy consumption on the environment?

Do consumers understand how they can optimize their energy consumption?

Do consumers feel social pressure to save energy?

Which organizations do consumers trust to inform them about actions they can take to optimize their energy consumption?

Are consumers aware of electricity management programs?

What are the drivers and barriers to adoption of electricity management programs?

How efficient are the energy efficiency campaigns?

Institutional setting

What is the degree of commitment to energy efficiency?

Are there institutions supporting the implementation of energy efficiency programmes?

Is any agency empowered to establish minimum energy performance standards or a mandatory energy-labelling programme?

Is there a standards agency that regulates the quality and performance of products, including products that consume energy?

Is there any agency empowered to develop energy-performance test procedures for energy-consuming products?

8. Useful references and links

DIRECTIVE 2010/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0030&from=EN

COMMISSION DELEGATED REGULATION (EU) No 874/2012 of 12 July 2012 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of electrical lamps and luminaires http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0874&from=EN

ECOWAS energy efficiency policy
http://www.ecreee.org/sites/default/files/documents/basic_page/081012-ecowas-ee-policy-final-en.pdf

Energy-Efficiency Labels and Standards: A Guidebook for Appliances, Equipment, and Lighting - 2nd Edition - Collaborative Labeling and Appliance Standards Program (CLASP) – http://clasp.ngo/Resources/Resources/PublicationLibrary/2005/SL-Guidebook-English#SLGuidebookEnglishFiles

Index of power factor correction – Gimelec - http://www.gimelec.fr/Publications-Outils/Indice-de-Compensation-d-energie-reactive

Power factor correction and harmonics filtering – Schneider Electric - http://www.schneider-electric.com.au/documents/electrical-distribution/en/local/electrical-installation-guide/EIG-L-power-factor-harmonic.pdf

Ghana – Energy efficiency standards and labelling (non-ducted air conditioners and self-ballasted fluorescent lamps) Regulations, 2005 - http://energycom.gov.gh/files/LI_1815.pdf

Consortium for Energy Efficiency - Residential Lighting Initiative 2015 - http://library.cee1.org/sites/default/files/library/12005/CEE_Residential_Lighting_Initiative.pdf

Consortium for Energy Efficiency - Commercial Lighting Initiative 2015 - http://library.cee1.org/sites/default/files/library/9539/CEE_Commercial_Lighting_Initiative_Jan2015_FINAL.pdf

Consortium for Energy Efficiency – High Efficiency Commercial Air Conditioning and Heat Pump Initiative 2015 -
http://library.cee1.org/sites/default/files/library/5347/CEE_CommHVAC_HECAC__InitDescip.pdf