Savings Estimation in the Italian Scheme

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Can energy savings be metered?

Energy savings can't be directly metered, but are

" (…) determined by measuring and/or estimating consumption before and after implementation of one or more energy efficiency improvement measures, whilst ensuring normalization for external conditions that affect energy consumption"

Directive 2006/32/EC on energy end-use efficiency and energy services (art. 3d)

White Certificates are issued to a project after the evaluation of savings made by means of an approved procedure

⇩

Evaluation Procedures are needed

Requisites of the Evaluation Procedures (1)

Requisites guarantee the quality of the commodity “White Certificate”:

- Take into account only measures driven by the energy efficiency project

- Separate changes in energy demand due to efficiency improvements from those affected by other factors

- Make sure estimated savings don’t exceed the real ones

Requisites of the Evaluation Procedures (2)

- Comply with prescriptions for products eligibility ("Decrees" art. 6)
- Facilitate on-site verification, as random controls are foreseen *(i.e.: refer savings to installed equipment, "before" situation is rarely verifiable)*
- Easy to understand and use

Be a reasonable trade-off between simplicity and accuracy

General Principles

- Additionality of savings

- *Baseline* definition

- *Target line* definition

Additionality principle

Certified Energy Savings are net of those obtained in any case: if the project itself is not implemented, because of technology and market evolution, mandatory compliance to law and regulations

The *Baseline*

Represents the avoided consumption due to the efficiency project, typically it corresponds to:

1. In case of either a replacement or the installation of new equipment, the baseline is the consumption of the average-on-the-market appliance *(the "before" situation matters only when early replacement is encouraged)*

2. In case of addition of an energy saving product or component to an existing facility (VSD to a motor, thermal insulation and PV generator to a building, …), the baseline is the energy consumption without the measure

3. When applicable, the baseline is the maximum consumption allowed by laws or regulations

The *Target line*

Is the consumption either of the installed appliance or of the original equipment after the improvements:

- It must represent an actual energy improvement with respect to the *Baseline*
- Mandatory compliance to law prescriptions is not eligible
- In principle, voluntary compliance to new standards and regulations is accepted

Requirements for equipment eligibility

- Efficiency Class A (or better) for domestic electric appliances
- Efficiency class = ★★★★ rating for boilers
  (*Boiler Efficiency Directive - 92/42/EEC*)
- Efficiency > 82% for biomass boilers exceeding 300 kW
- EFF I efficiency class for electric motors
- For other products, appliances or components, the minimum energy performance and the performance certification instructions are to be specified case by case
- Enforcement of *ErP* Directive expected to allow appearance on the market new products with higher energy performance

Available procedures

Type of procedures for the quantitative assessment of Energy Savings (AEEG, Decision n. 103/03 → EEN 9/11)):

a)	Default method (no on-field measurement)	Ex-ante
b)	Analytic method (some on-field measurement)	Ex-post
c)	Metered baseline method	Ex-post

Default method

- Gives ex-ante energy savings per "physical unit of equipment" installed
- Typically available for "mass" projects where reliable averages can be determined

<u>Applicable when:</u>

- phenomena driven by a few "key factors"
- cause and effect relationship clearly individuated
- common equipment is installed (domestic appliances, electric motors, boilers, thermal insulation, …)
- "on field" energy performances are known for the considered technologies

Problems with default methods

- *Baseline* selection
- Analysis of the energy process and algorithm definition
- Set default values for relevant computation parameter

Note: *compliance with all technical and safety rules is taken for granted under designers' and installers' responsibility.*

Analytic Method

- Is an “open” default method
- Savings are assessed after on-site metering the relevant parameters
- Justified for peculiar projects having relatively large unit size (cogeneration, VSD pumping systems, road lighting, etc.)

Problems with analytic methods

- Definition of the engineering model
- Selection of parameters to be metered on field
- Metering criteria (little intrusive, simple, reliable, inexpensive)

Metered baseline Method

- Used when energy savings are the results of measures involving complex interactions among several different variables and equipment

- Savings are based on the difference between energy consumption measured 'before' and 'after' the implementation. Measurements may be normalized to other process variables.

- Recommended for very large projects

Problems with metered baseline methods

- Individuation of the energy flows, and level of service/production to meter

- Selection of metering criteria (little intrusive, simple, reliable, not expensive)

- Need for adjustments

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Role of Technical Bodies

- Individuate the general requirements for savings evaluation
- Analyze end-use demand and technologies
- Develop evaluation procedures case by case
- Build and update technology databases
- Monitor market transformation and revise procedures when needed
- Be a *Liaison Officer* among regulators, regulated parties, energy users, and equipment manufacturers
- Verify and certificate savings

Independence and expertise are major assets

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- Began assisting AEEG in 2001, when the White Certificates mechanism was conceived:
  - Contributed to individuate and refine the evaluation criteria
  - Developed the initial set of procedures

- Since then:
  - Develops and finalizes procedures based both on own and others' proposals
  - Monitors the efficient technology market
  - Meters on site energy performance
  - Regularly interacts with institutions, stakeholders, and industry associations

Case study: default method

Sector: Street Lighting
Project: Lamp Replacement

Base: Mercury Vapour Lamp (MV)
Target: High Pressure Sodium Lamp (HPS)

Reference Physical Unit: Installed Lamp (HPS)
Measure: One to one lamp replacement

MV

HPS

Savings estimation

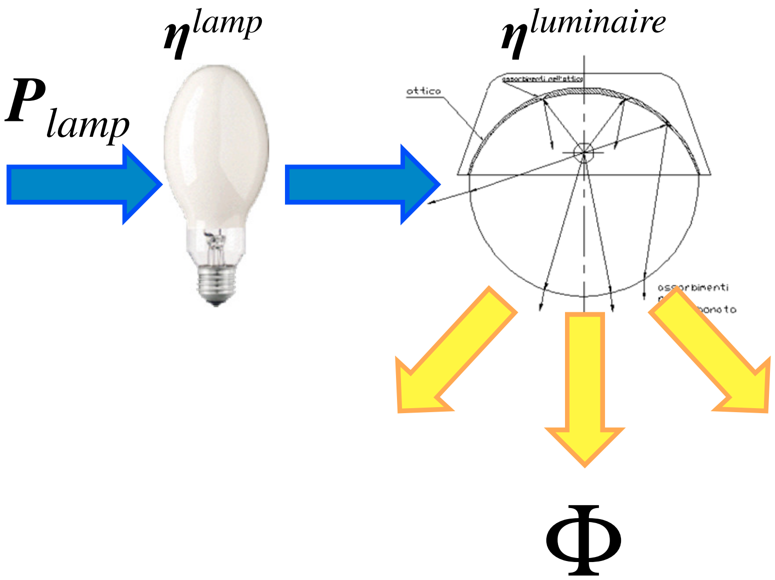
$$RSL = (P_{MV} - P_{HPS}) \times h \times f_e$$

RSL	gross specific saving	[toe/year]
P_{MV}, P_{HPS}	lamp nominal power	[W]
h	operation time	[4,200 hour/year]
f_e	primary energy conversion factor	[0.187×10^{-6} toe/Wh]

Condition: equal luminous Flux "before and after"

$$\Phi_{MV} = \Phi_{HPS}$$

Savings estimation



$\eta = efficiencies$

$d = lamp \quad decay \quad factors$

$$P_{MV} \times \eta_{MV}^{lamp} \times d_{MV} \times \eta_{MV}^{luminaire} = P_{HPS} \times \eta_{HPS}^{lamp} \times d_{HPS} \times \eta_{HPS}^{luminaire}$$

$$P_{MV} = \frac{\eta_{HPS}^{lamp}}{\eta_{MV}^{lamp}} \times \frac{d_{HPS}}{d_{MV}} \times \frac{\eta_{HPS}^{luminaire}}{\eta_{MV}^{luminaire}} \times P_{HPS} \cong 1.7 \times P_{HPS}$$

Case study: default method

$$RSL = (P_{MV} - P_{HPS}) \times h \times f_e$$

P_{HPS} [W]	RSL [10^{-3}toe/yr/lamp]
70	38.1
100	54.2
150	80.6
250	132.2
400	206.3

Savings in parasitic consumptions included

Case study: updating an existing methodology

Default method currently in use: Lamp replacement in road lighting systems

Pros:

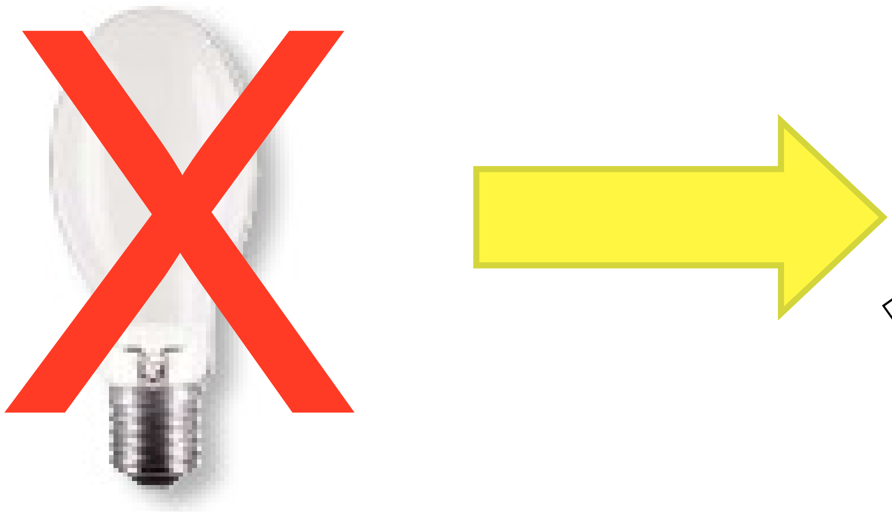
- Ex-ante estimation of the possible savings
- Minimum data and information requirement

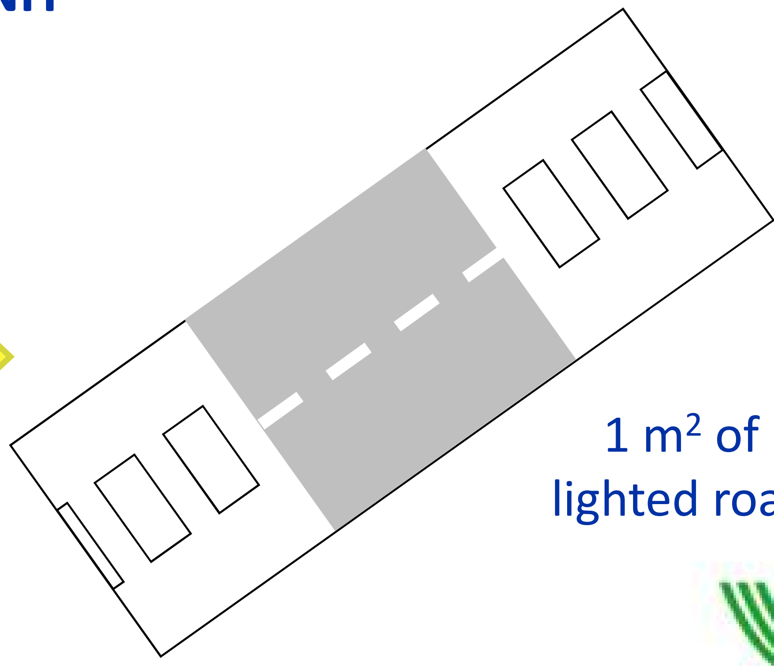
Cons:

- *Target line* no longer BAT on the market
- Limited implementation range (retrofits only);
- Replacement of the whole luminaire not considered;
- Change in lighting requirements due to Color Rendering Index of the replacing lamp not considered;
- Reference lighting standards updated

Innovations in the new method

1. **DEFAULT → ANALYTIC**
2. **ACCEPTANCE TEST REQUIRED**
3. **APPLICABILITY:**
   a) New lighting systems
   b) Complete retrofit of existing systems;
   c) Partial retrofit
4. **REFERENCE PHYSICAL UNIT**





1 m^2 of lighted road

Definition of the baseline

Project	Baseline technology
a) New lighting systems	High Pressure Sodium
b) Complete retrofit of existing systems; c) Partial retrofit of luminaires	Mercury Vapour or High Pressure Sodium (*)

(*) In general the same as existing lamps, except:

- equal to MV if existing lamps efficiency below the MV
- equal to HPS if existing lamps efficiency above VM and below HPS

If existing lamps efficiency above HPS, the method is not applicable as it overestimates the savings (retrofit not recommended)

New lighting systems

Baseline technology: efficiency requirements (HPS)

P_{HPS} [W]	Minimum **lamp** efficiency [lumen/W]	Minimum **system** efficiency [lumen/W]
70	90	51
100	102	61
150	115	71
250	125	82
400	139	99

Savings Calculation

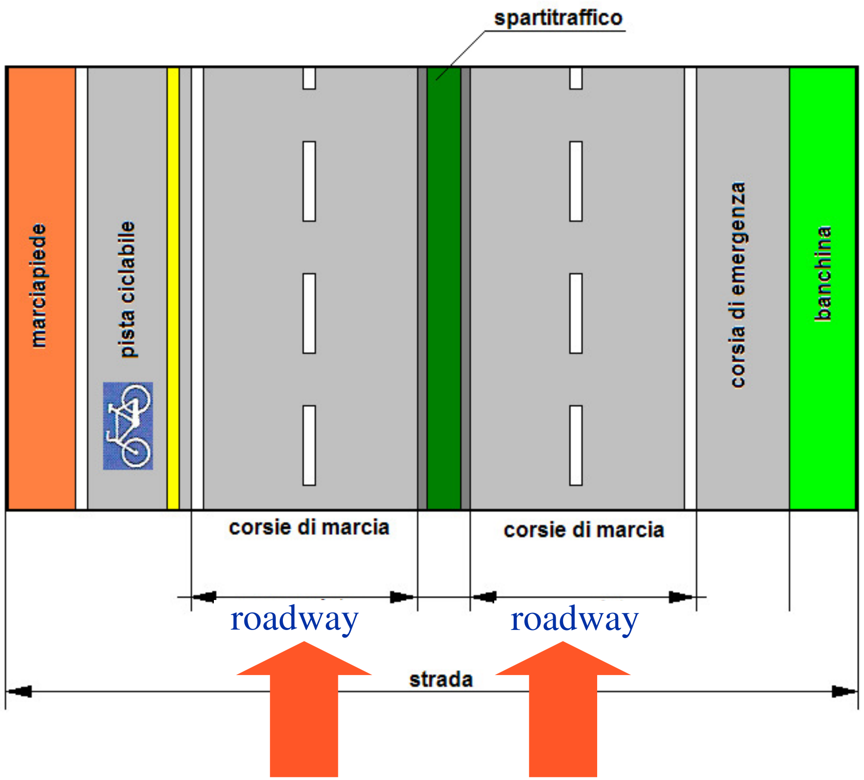
$$\mathbf{RN} = a \times \mathrm{RSL} \times A_T \qquad \text{[toe/year]}$$

a : additionality coefficient (=100%)

RSL: Gross Specific Primary Energy Saving [toe/m²/year]

$\boldsymbol{A_T}$: lighted roadway area (portion of the road reserved to motor vehicles) [m²]

RN : Net Primary Energy Saving [toe/year]



Source: Italian Code of the Road Traffic

Savings Calculation

The Gross Specific Primary Energy Saving is calculated with:

$$RSL = f_E \cdot h \cdot \left[P_B \cdot \left(1 + 0{,}2 \cdot \frac{A_C}{A_T} \right) - \frac{PT_E}{A_T} \right]$$

[10^{-3} toe/m²/year]

f_E : conversion factor of electricity into primary energy, = ***0.187x10^{-6} toe/Wh***

h : operation time, = ***4,200 h/yr***

P_B : baseline specific power [W/m²]

PT_E : total power absorbed by the new system (lamps + auxiliaries) metered during acceptance test [W]

A_C : "conflict" area [m²]

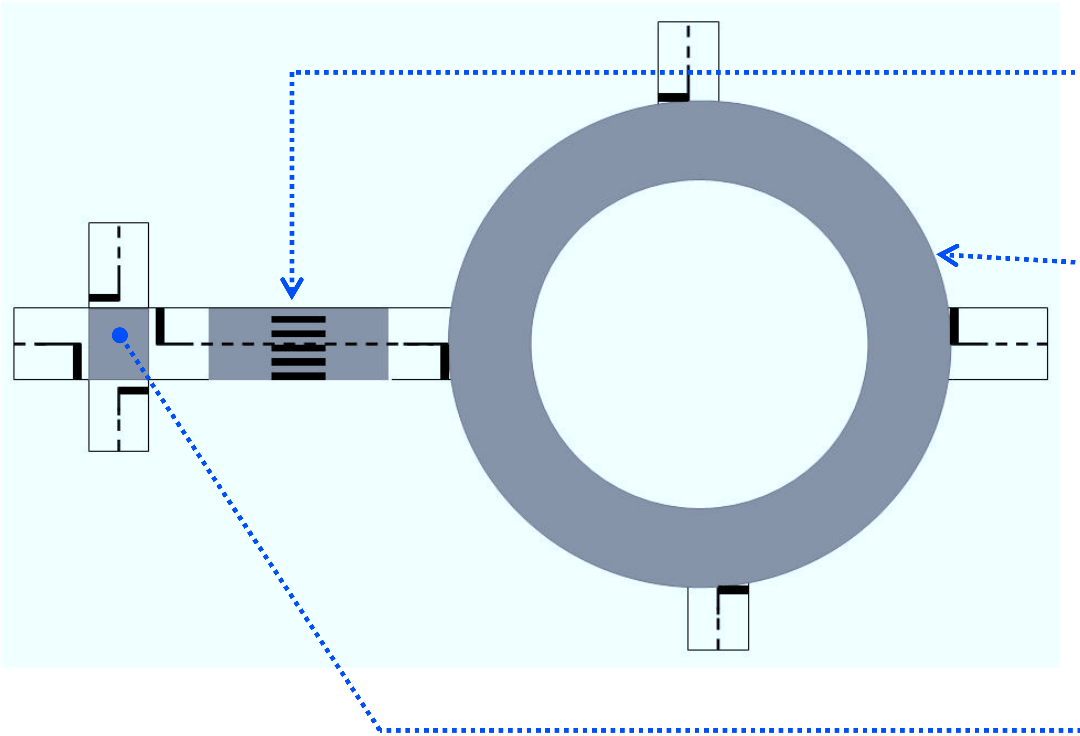
A_T : total lighted roadway area (includes A_C) [m²]

NOTE: acceptance test needed to:

- *guarantee compliance to laws and standards on safety, and*
- *directly meter the electric power absorbed by the lighting system*

Conflict Areas

A_C – aknowledged «conflict» area [m²]:



- **crosswalks**: area is 3 times net crossing area;
- **traffic roundabouts**: area is equal the annulus traveled by vehicles;
- **intesections**: area equals the intersection itself

Not considered: speed breakers and security areas

Baseline values

Specific power resulting from an optimized lighting design

Class D, urban flowing street	P_B [W/m²]	
	MV Lamp	HPS lamp
2+2 lanes	1,139	0,703
3+3 lanes	0,996	0,568
2+2 lanes and bus lane	0,971	0,554
2+2 lanes, service lane and bus lane	0,947	0,564
Class E, urban district street	P_B [W/m²]	
	MV Lamp	HPS lamp
1+1 lanes	1,171	0,782
2+2 lanes and 1+1 bus lanes	1,155	0,612
2+2 lanes and side parking lane	0,813	0,458
Class F, local street (suburban area)	P_B [W/m²]	
	MV Lamp	HPS lamp
2 lanes (F1)	1,338	0,732
2 lanes (F2)	1,317	0,737
Class F, local street (urban area)	P_B [W/m²]	
	MV Lamp	HPS lamp
2 lanes (F1)	1,245	0,740
2 lanes (F2)	1,034	0,806

Software: CALCOLUX Road ver. 7.5.0.1 (Philips Lighting)

Thank you !

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