Energy Efficiency Guidelines for Office Buildings in Tropical Climate

Renewable Energy Strategies

Organization of American States

DIRECTIVE 2010/31/EU, European Parliament, 2010 (recast)

A European Union directive is on about energy efficiency in buildings, aiming at making new or existing, refurbished buildings, extremely energy efficient and meeting their energy needs with local production.

It will affect all public buildings from 2018 and the rest of buildings from 2020.
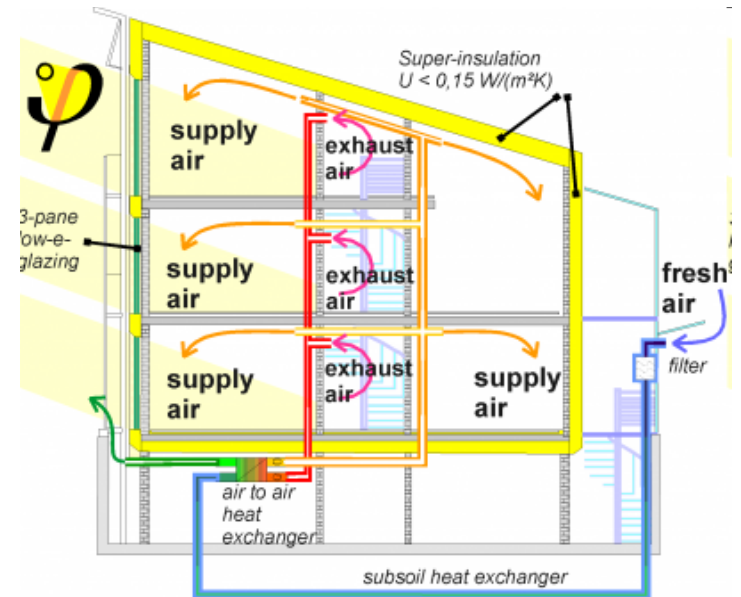
A "nearly zero energy building" is defined as "*a building that has a very high energy performance*" and the necessary energy, to a high extent, comes "*from renewable sources, including energy from renewable sources produced on-site or nearby*"

DIRECTIVE 2010/31/EU, European Parliament, 2010 (recast)

Concepts
net zero energy building (nZEB)
energy use of 0 kWh/(m² a) primary energy
nearly net zero energy building (nnZEB)
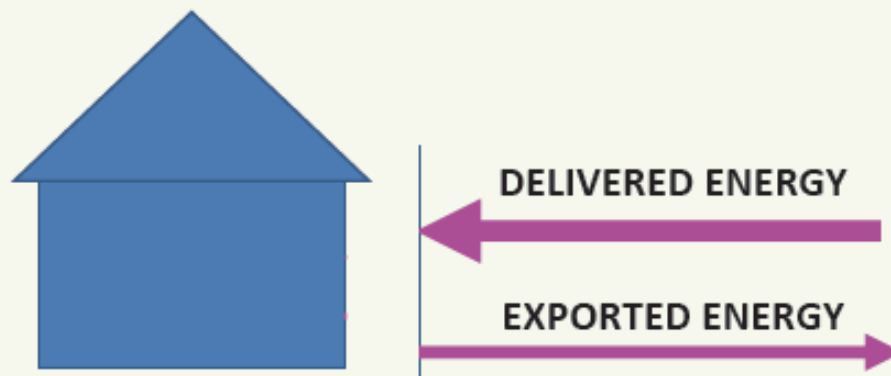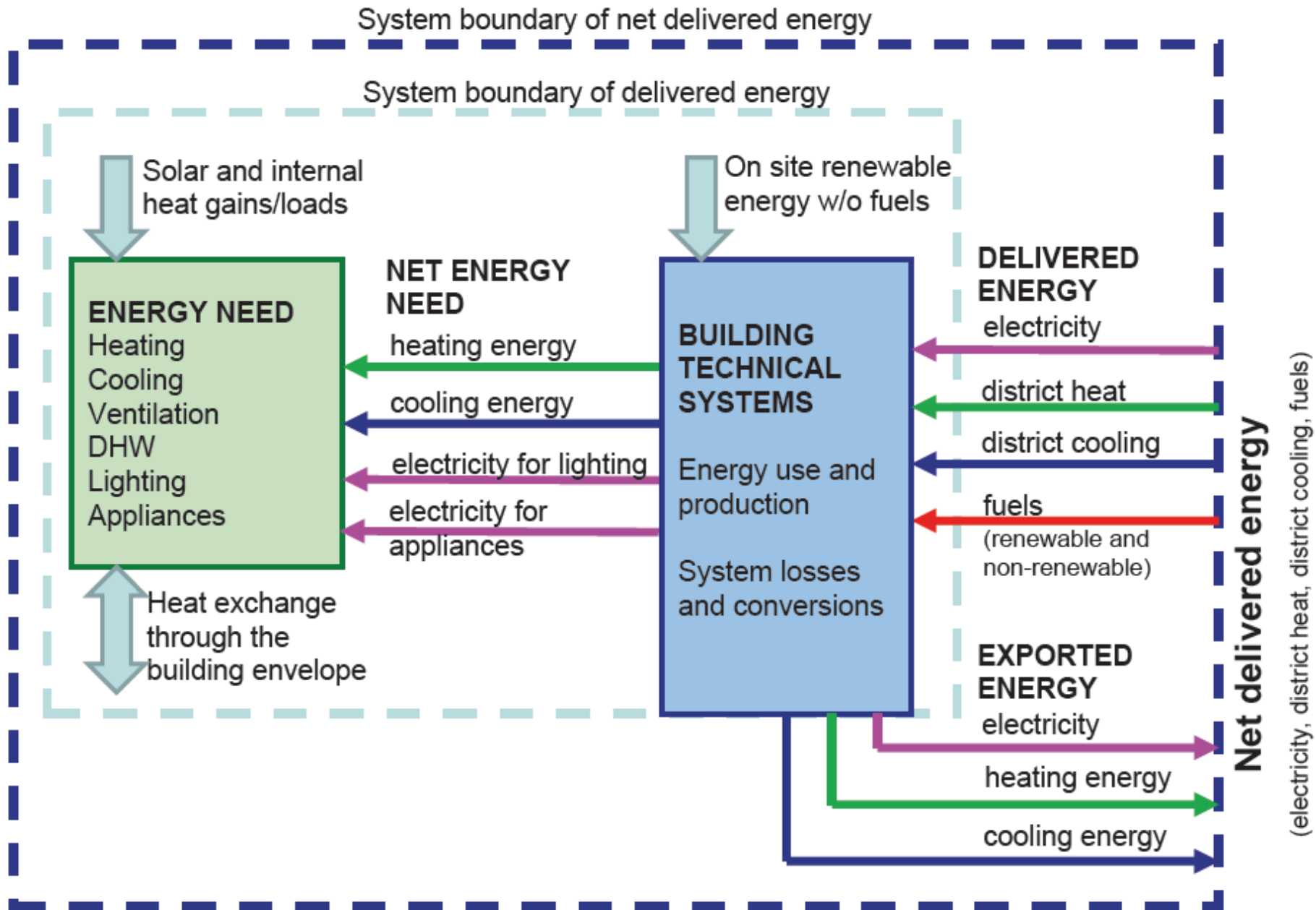national cost optimal energy use of > 0 kWh/(m² a) primary energy
energy + building
Positive balance between export energy and delivered energy
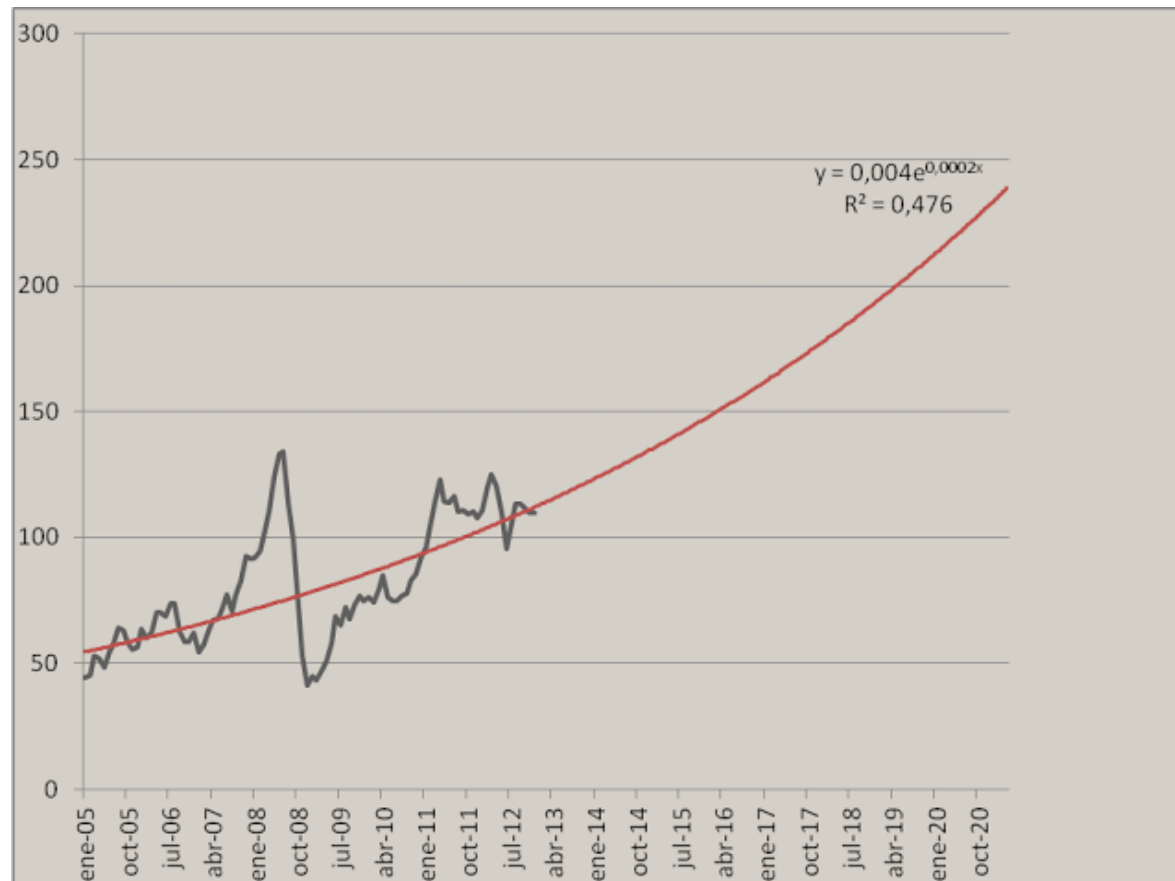
$$E = \sum_i \left(E_{del,i} - E_{\exp,i} \right) f_i$$

DELIVERED ENERGY

EXPORTED ENERGY

Why low energy demand buildings ?

Increase of energy prices

The chart shows oil price data from ene-05 to oct-20 with an exponential trend line.

$$y = 0,004e^{0,0002x}$$
$$R^2 = 0,476$$
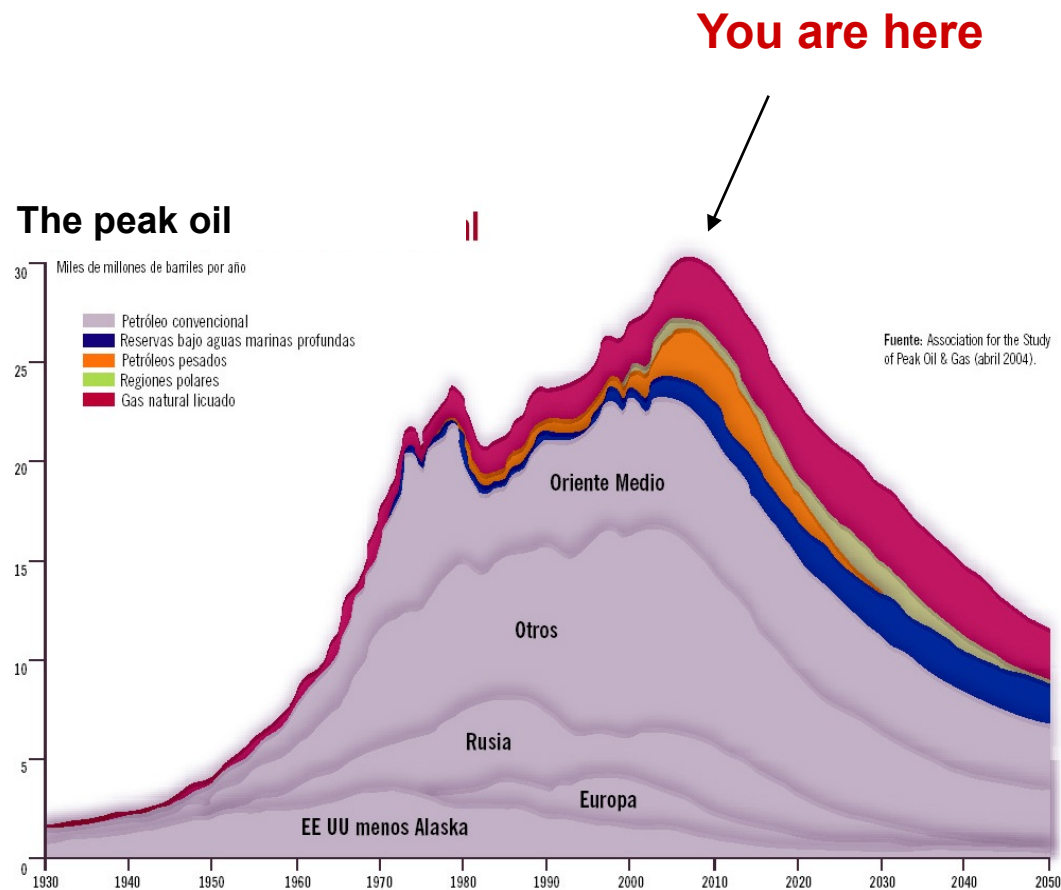
Oil Price Probable evolution

Fossil energy consumption environmental impact
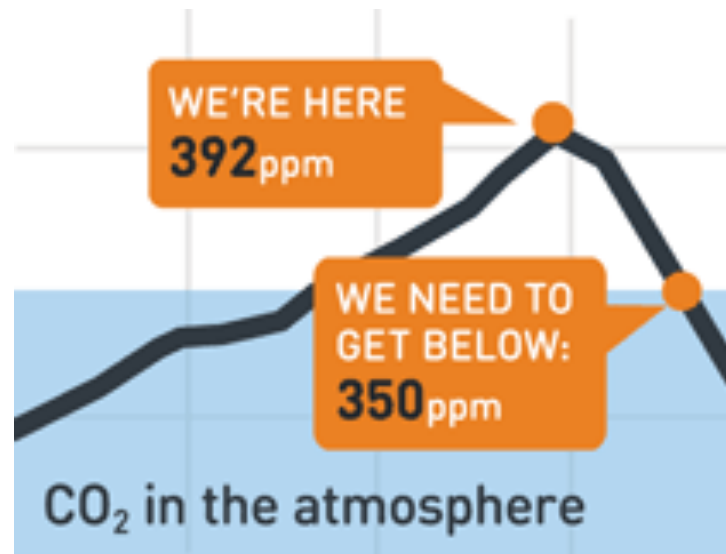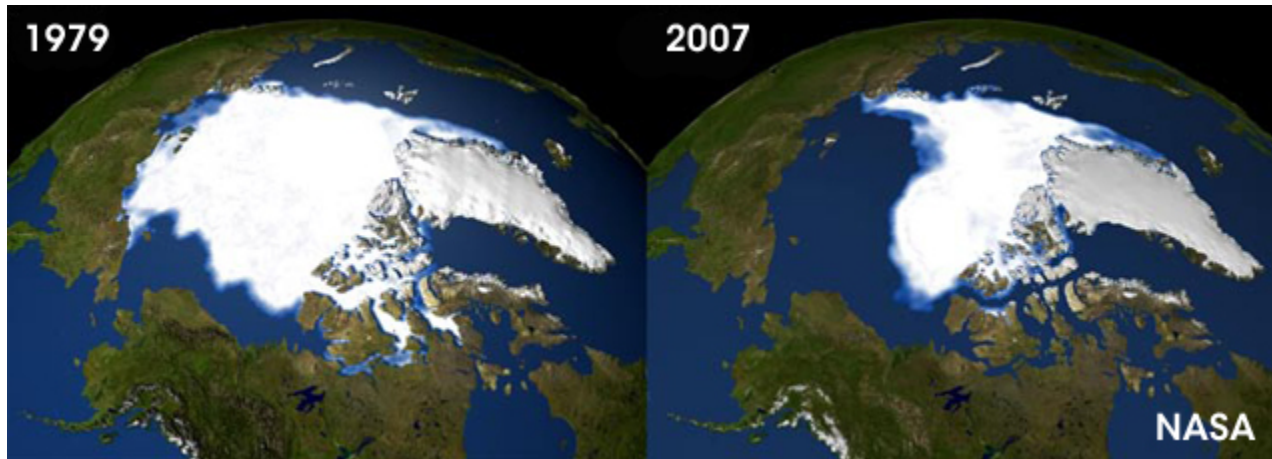
Depletion of conventional energy resources : the offer no meets demand

You are here

The peak oil

Miles de millones de barriles por año

- Petróleo convencional
- Reservas bajo aguas marinas profundas
- Petróleos pesados
- Regiones polares
- Gas natural licuado

Fuente: Association for the Study of Peak Oil & Gas (abril 2004).

Oriente Medio

Otros

Rusia

Europa

EE UU menos Alaska

30
25
20
15
10
5
0

1930 1940 1950 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050

Why Renewable Energies?

- **Volatile oil prices have put pressure on electricity prices** → **Energy price decreases**

- **Need for new generating capacity** → **New supply**

- **Many renewable energy sources have no - or low-cost fuels whose prices have little to no volatility** → **Energy price stabilization**

- **Transition to renewable energy will make Jamaica less dependent on foreign oil and would make the national economy more resilient to fuel disruptions** → **Energy security and independence**

Why Renewable Energies?

|	
Firm and intermittent generation can reduce T&D losses since energy is often produced closer to the point of consumption	**Grid Support**
Renewable energy is also a cost-effective solution to providing electrification to communities	**Access to electricity**
Renewable energy can reduce the environmental impact of the electricity sector	**Environmental goals**
The introduction of RET has already shown a positive impact in creating new jobs	**Local employment**

Distributed Generation and selfconsumption

+ In a scenario of rising prices of fossil fuels, design and build or refurbish buildings absolutely dependent on them for habitability is the worst investment you can make
+ With the price reduction of distributed generation technologies, the consumption of self-generated energy is economically viable reality in all Caribbean islands and many other regions.
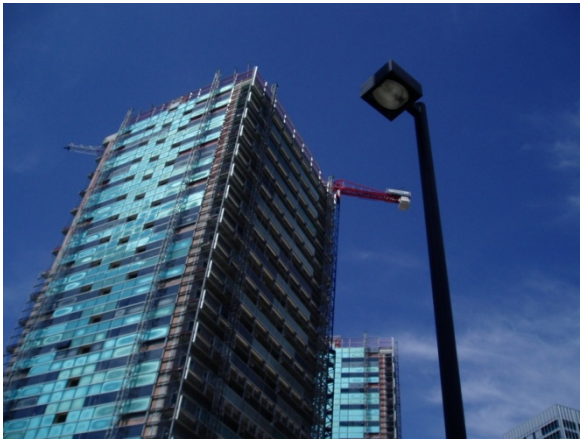
The buildings in the immediate future will require very little energy to provide a suitable degree of comfort, and this will come largely from local and renewable energies
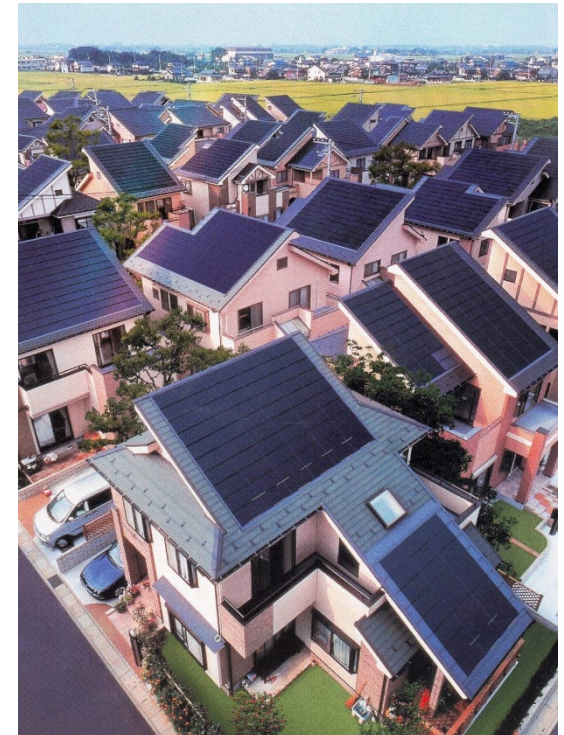
Distributed Generation and selfconsumption

SOLAR ENERGY

- Of all the renewable energy sources, solar energy is the most widely distributed.
- In Caribbean region 1 m2 of horizontal surface facing the sun receives in a year, the equivalent of a 1,2 barrels of oil
- The conversion rates of solar radiation into useful energy by technology, ranging from:

Energy source- Technology		useful energy	performance (%)	Building's integrability
Solar Thermal	Flat collector	hot water	45	***
Solar Thermal	Evac. Tube + absortion	cooling	38	***
Solar Thermal	Stirling dish	electricity	25 -30	**
Solar Thermal	parabolic trough solar collector	elect/heat	20	*
Photovoltaic	cristalline cell	electricity	15	***

Solar thermal: Hot water

Many kinds of buildings of the services sector, even big office buildings in warm regions, have hot water demand: hotels and hospitals, but also buildings with cafeteria, kitchen and dining room for the employees o clients. Solar energy is competitive in front electricity and fossil fuels

Residential buildings (Barcelona)

Hospital, Saida (Lebanon)

Solar thermal: Hot water

Sports Facilities: usually its hot water demand is very high

Barcelona

Solar thermal: Hot water

Installation on flat roofs – allows for optimal tilt and orientation

Solar thermal: cooling

Hot water and cooling for HVAC in a health care center, Barcelona

Solar thermal: cooling

Solar pergola on a flat roof: useful solar energy and roof shading

Evacuated tubes solar collectors to reach a high themperature, necessary for cool water generation by absorption cycle

Solar thermal: cooling
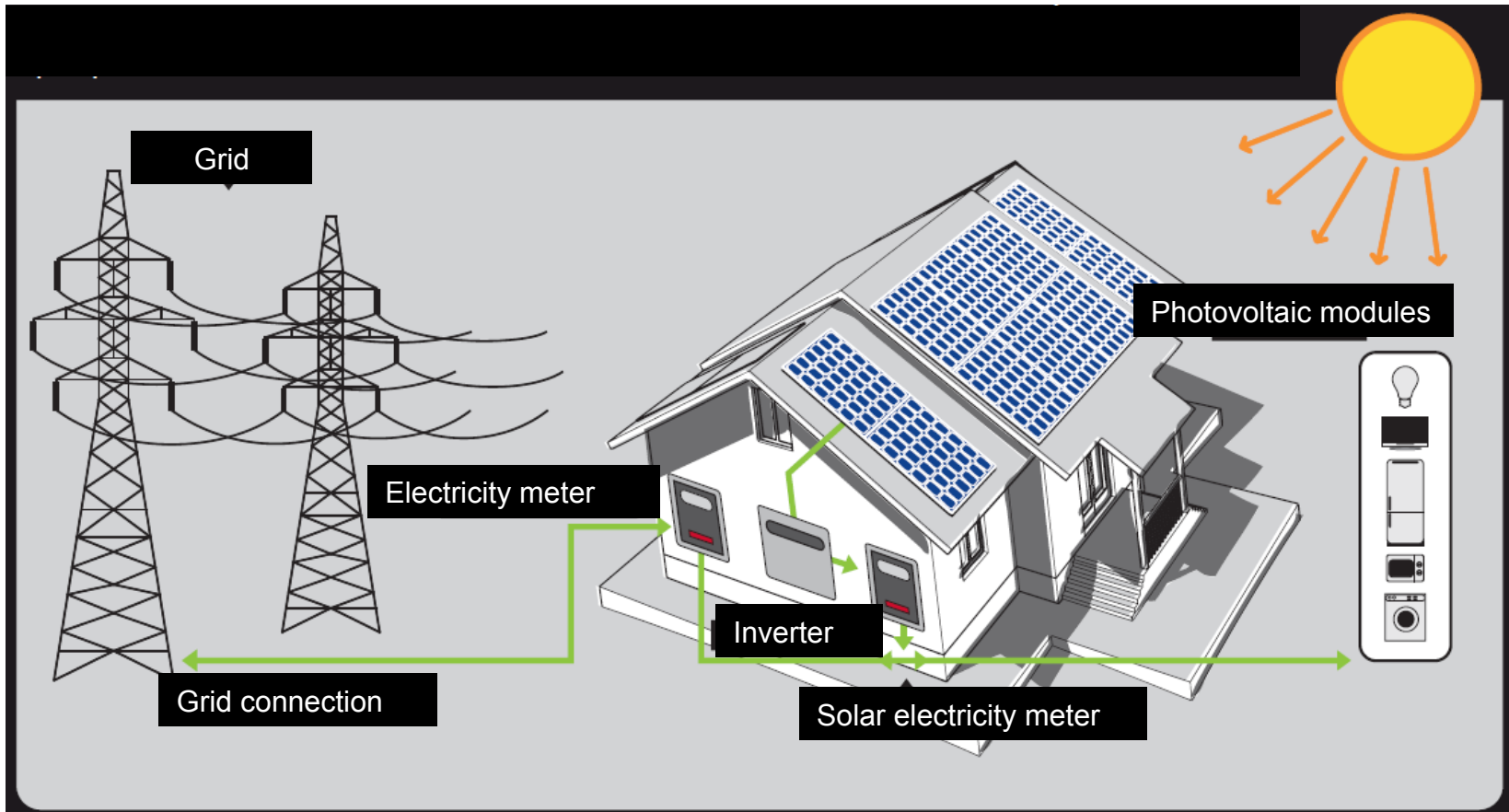
Evacuated tubes solar collectors

Absorption machine

Cooling tower

Distributed Generation and selfconsumption
Photovoltaic

Grid

Photovoltaic modules

Electricity meter
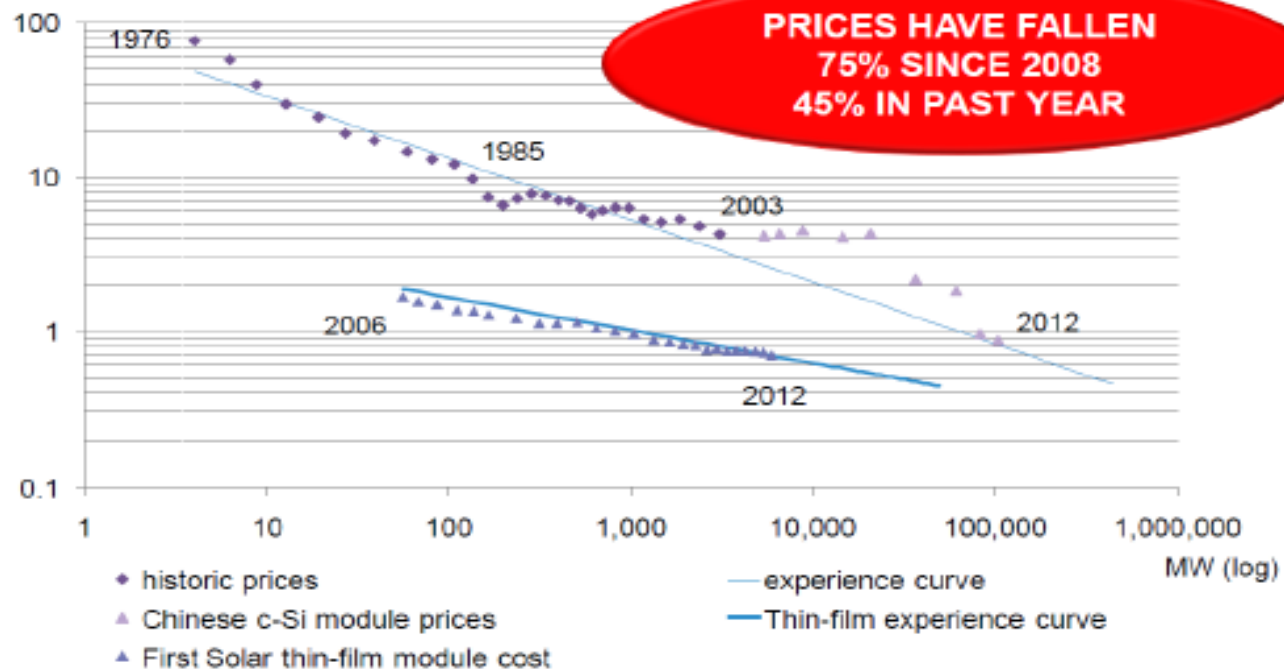
Inverter

Grid connection

Solar electricity meter

Solar electricity self consumption scheme: instantaneous consumption and exceeding generation is injected to the grid
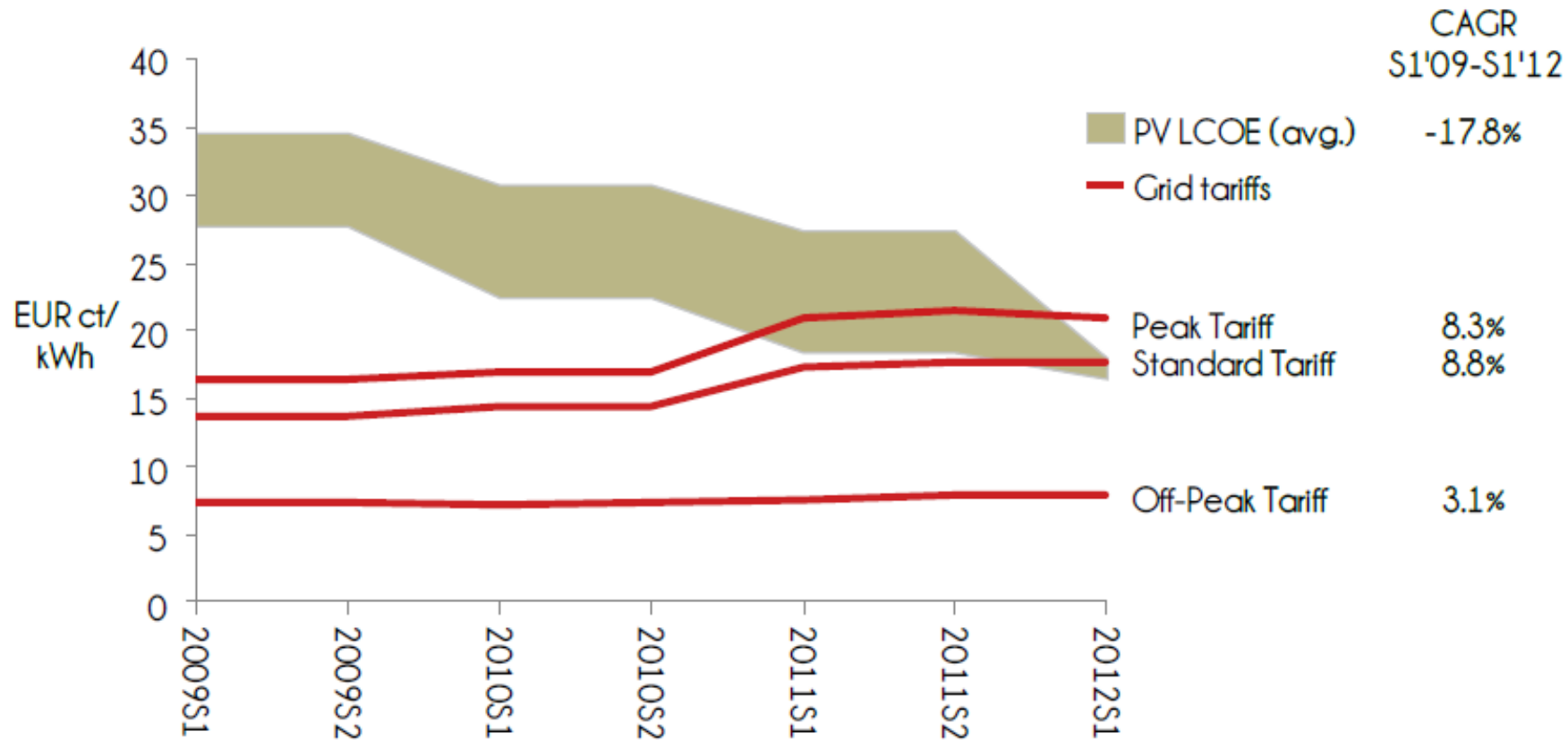
+ Photovoltaic

PV MODULE PRICES, 1976–2012
($/W)

PRICES HAVE FALLEN
75% SINCE 2008
45% IN PAST YEAR

- historic prices
- Chinese c-Si module prices
- First Solar thin-film module cost
- experience curve
- Thin-film experience curve

Notes: Inflation adjustment using US PPI, R2 of c-Si regression = 0.94, R2 of FSLR regression = 0.98;
data since 2007 based on Bloomberg New Energy Finance Solar Spot Market Price Index

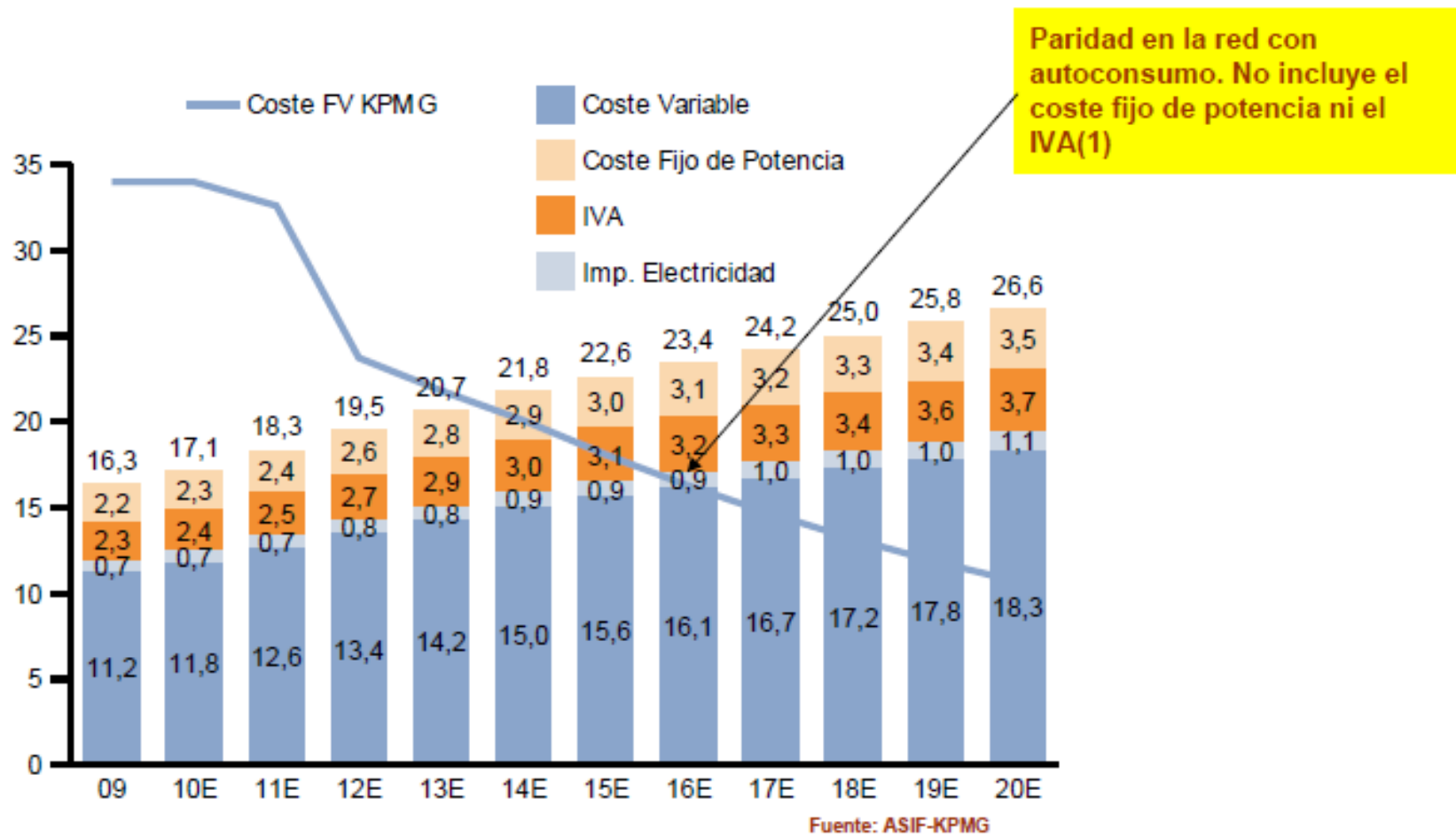Source: Paul Maycock, Bloomberg New
Energy Finance, FSLR filings
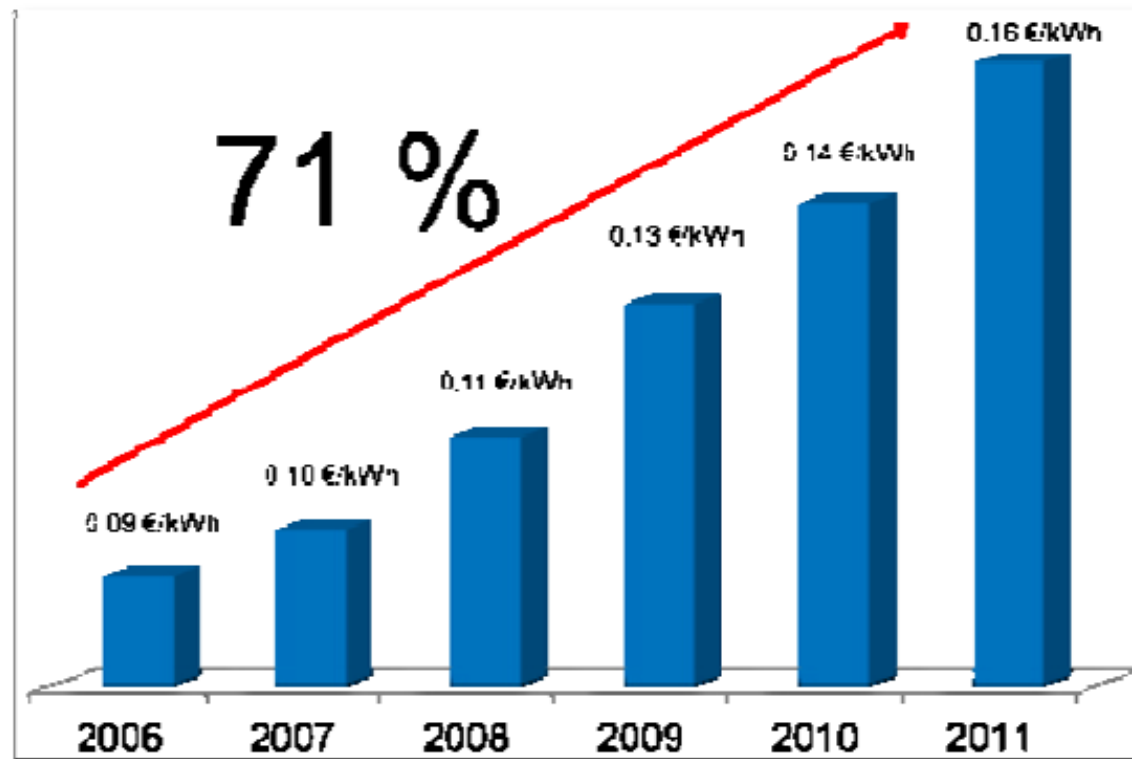
+ Photovoltaic Parity

PV electricity price evolution precio and electrical tariff (Spain)

(source: Eclaeron, 2012)

+ Photovoltaic Parity

Fuente: ASIF-KPMG

+ Photovoltaic Parity

Electricity tariff evolution in Spain (2006- 2011)

City Hall – Mollet del Vallès (Barcelona)

PV integrated on the façade and the roof

PV Roof waterproofing

ISE Fraunhoffer Institute (Freiburg- Germany)

Barcelona Public Library (Joan Miró)

Sklight shading with PV modules

Schoot Factory (Barcelona)
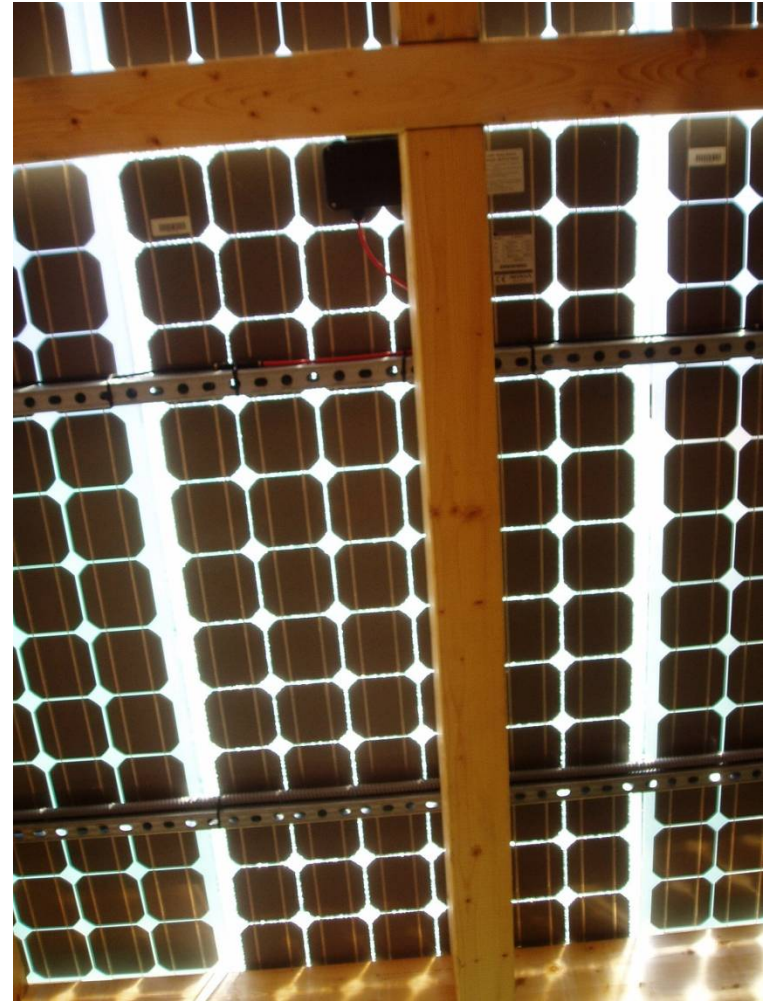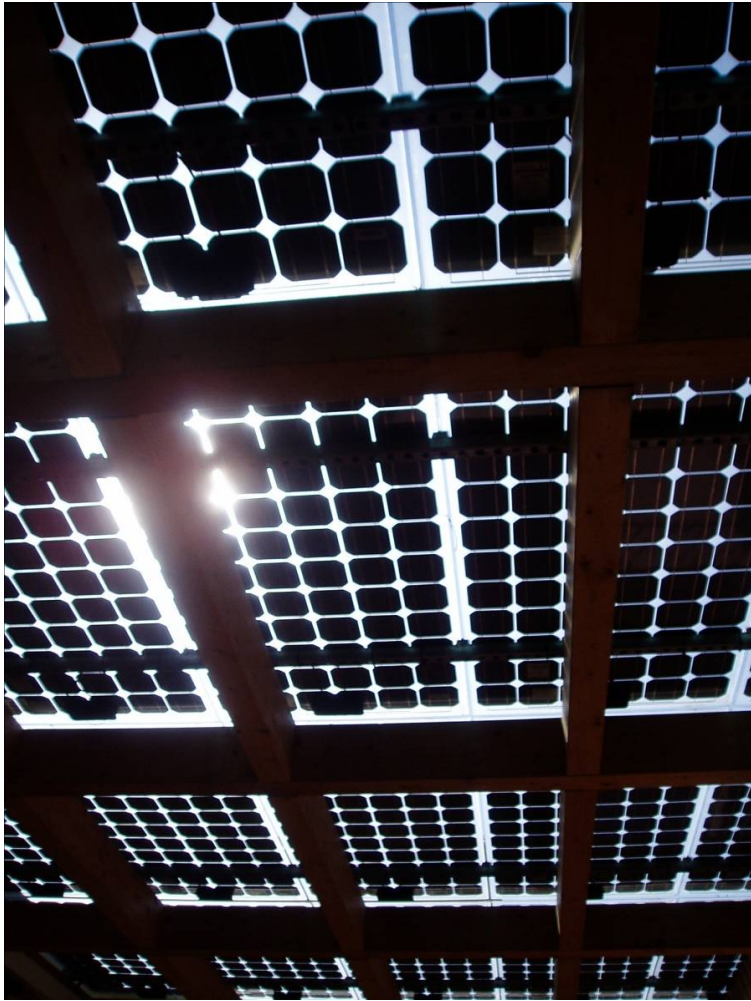

Coloured a-Si modules: solar shading on glass façade

Civic Center (Barcelona)

Semi-transparent PV pergola

Civic Center (Barcelona)

Semi-transparent Si cristalline modules

Civic Center (Barcelona)

Solar pergola on the building roof
(semi-transparent PV module)

Communication of results

Non building integrated PV, but a referent image of a big planning refurbishment

Showcase installations - Barcelona

+ Distributed Generation and selfconsumption

Wind micro turbines

+ Distributed Generation and selfconsumption

+ Wind micro turbines

Distributed Generation and selfconsumption :
+ Wind micro turbines
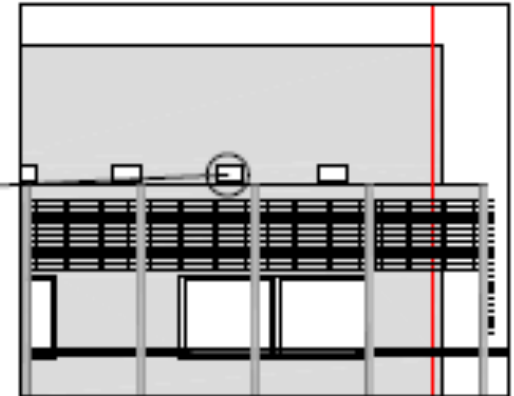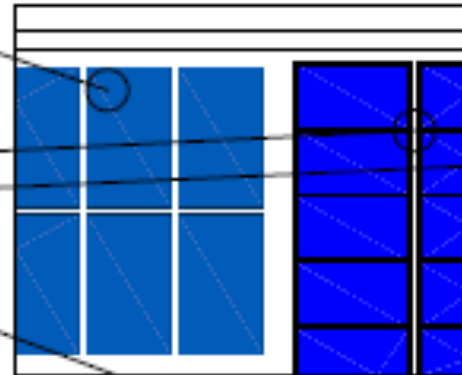
EED. Photovoltaics building integration

Using solar Thermal panels to supply
hot water to facilities like the kitchen.

Extreme conditions considerations
—PV array to minimize wind resistance.
—Passive, Ventilation for PV cooling.
—Photovoltaic panels protections.

Water considerations.
—Rain collection with the PV.
supplying cleaner water.
—Permeable floors.

Esc.1:100

Esc.1:100
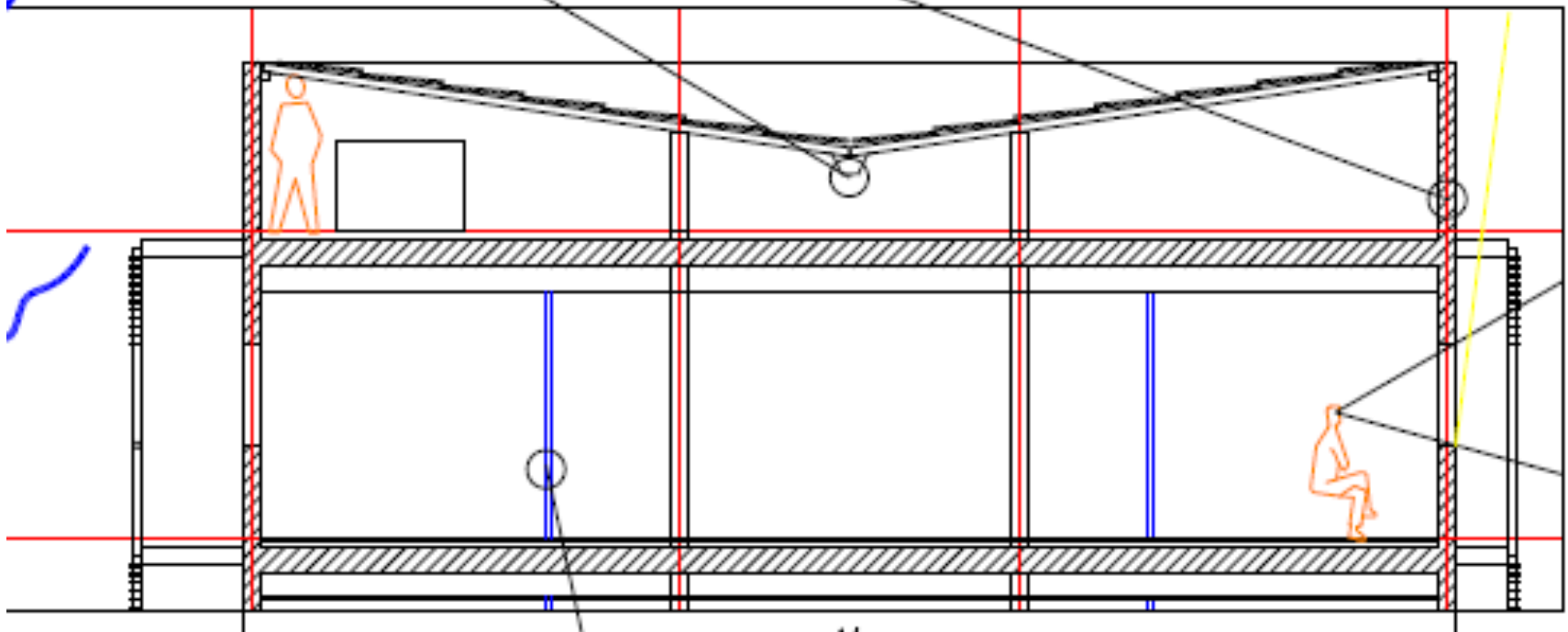
EED. Photovoltaics building integration

Photovoltaic array design

The solution adopted for both small and medium models consists of:

• A 2 m high support structure for the PV modules, to allow access of maintenance staff, over the flat roof.

•The PV system would be divided into two parts longitudinally with a 5º tilt to the center of the roof.

• A 2 m high perimeter wall above the flat roof is suggested in order to protect the whole installation from extreme winds.

•Each building has two tilted generators: one is slightly oriented NE (20º), the other 20º SW (-160º).

EED. Photovoltaics building integration

photovoltaic pergola
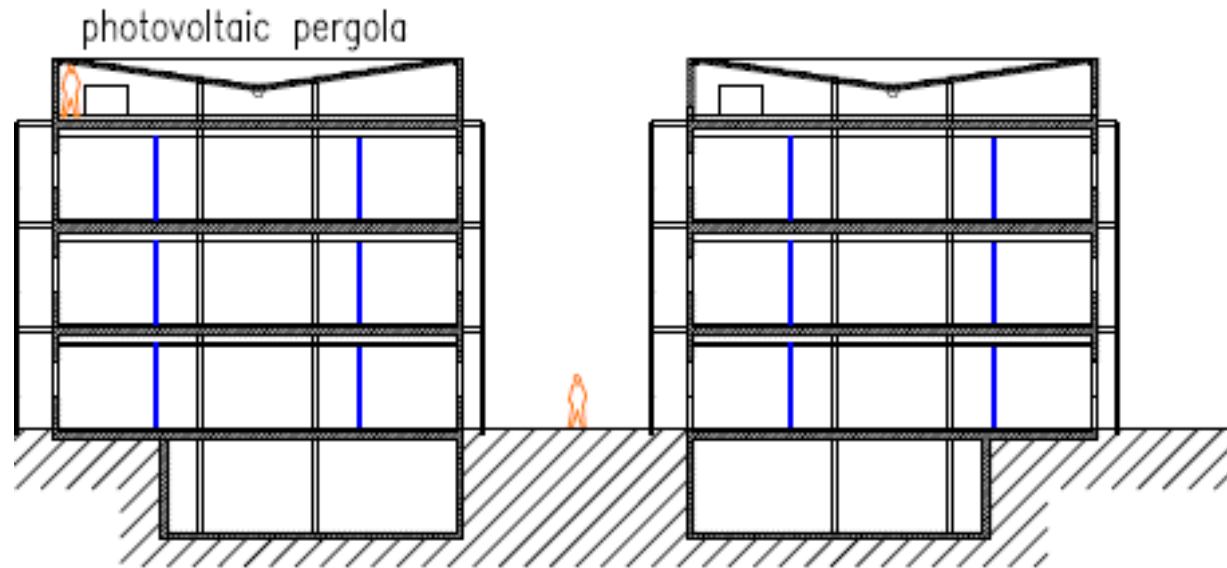
- PV generates electricity, the final energy most used in office buildings, in general, and almost the only one in the Caribbean.
- The electricity generation is simultaneous in time with a big share of the daily working hours of office buildings, thus on-site use is enhanced.
- The integration of the PV generator is made at the roof, thus using an existing built surface that commonly in other buildings has no added value.

EED- Photovoltaics building integration

Multifunctional PV Pergola

• The PV pergola provides shading to the roof, this being the very external surface of the building with the highest incident solar radiation throughout the year. Besides, it creates a ventilated space.

• This PV pergola installed on the flat roof replaces the heavy ventilated roof usual at most buildings

• The suggested tilted design allows for rainwater harvesting that can be stored and used to meet part of the non-drinking water needs of the building.

• ... And also, it generates electricity

EED- Photovoltaics building integration
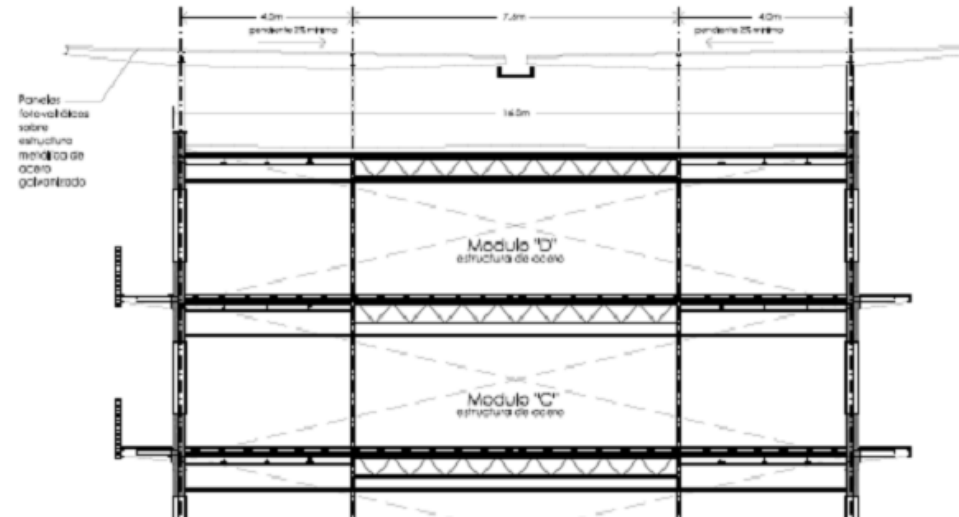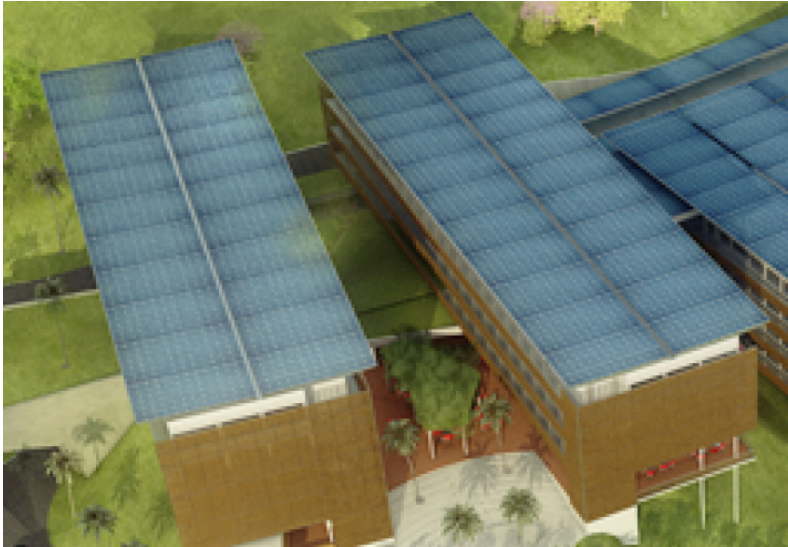
	PV power	Number of PV modules	PV module	Estimated PV generation	PV rating
	kWp	-	Wp	MWh/year	kWh/kWp
SW modules	41	165	250	75.8	1,837
NE modules	41	165	250	72.9	1,766
Small EE building	82	330	250	148.7	1,801.5
Medium EE building	164	660	250	297.4	1,801.5

Electricity generation from PV: 50 kWh/m2 year

EED- Photovoltaics building integration

2392 kWh/m² — **Horizontal global irradiation**

-2.3% — **Global incident in coll. plane**

-3.3% — IAM factor on global

2260 kWh/m² * 99 m² coll. efficiency at STC = 41.9% — **Effective irradiance on collectors** PV conversion

93862 kWh — **Array nominal energy (at STC effic.)**

-3.8% — PV loss due to irradiance level

-10.7% — PV loss due to temperature

-3.3% — Module quality loss

-2.2% — Module array mismatch loss

-2.2% — Ohmic wiring loss

74506 kWh — **Array virtual energy at MPP**

-2.2% — Inverter Loss during operation (efficiency)

0.0% — Inverter Loss over nominal inv. power

0.0% — Inverter Loss due to power threshold

0.0% — Inverter Loss over nominal inv. voltage

-0.0% — Inverter Loss due to voltage threshold

72857 kWh — **Available Energy at Inverter Output**

Thank you

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