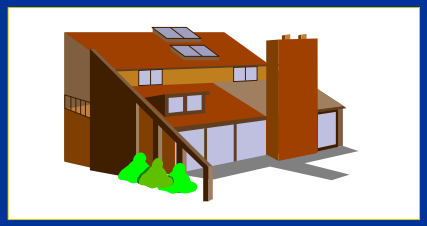
WORKSHOP: BUILDINGS ENERGY PERFORMANCE

ENERGY CERTIFICATION OF BUILDINGS IN SPAIN



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Index

- The EPBD
- Energy consumption and reglamentary options
- Minimum requirements
- Energy certification
- Prescriptive certification of low energy buildings

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EPBD (Objetives vs. Tools)

OBJETIVES	TOOLS
Stricter regulations	Minimum requirements (article 5)
The promotion of low energy new buildings	Energy certificate; (article 7)
Strong retrofit of existing buildings in a cost-benefit context	Inspection of boiler and air-conditioning systems; (articles 8 and 9 respectively)

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EPBD (Objetives vs. Tools)

OBJETIVES	TOOLS
Stricter regulations	Minimum requirements (article 5)
The promotion of low energy new buildings	Energy certificate; (article 7)
Strong retrofit of existing buildings in a cost-benefit context	Inspection of boiler and air-conditioning systems; (articles 8 and 9 respectively)

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Energy Efficiency in buildings
Final goal: reduce the energy consumption

- **THE ENERGY CONSUMPTION**

$$C = \frac{\text{ENERGY REQUIREMENTS}}{\text{EFFICIENCY OF THE SYSTEM}}$$

Heating
Cooling
DHW
Lighting

- **REDUCTION OF THE ENERGY CONSUMPTION**
  - **REDUCTION OF THE ENERGY REQUIREMENTS(DEMAND)**
  - **INCREASE OF THE EFFICIENCY OF THE SYSTEMS**
  - **USE OF ALTERNATIVE ENERGY SOURCES (RENEWABLE ENERGY)**

Energy consumption and reglamentary options

Level 0	Level 1	Level 2	Spanish Regulations
Overall consumption	Heating	Energy requirements Average C.O.P	HE1 HE2
	Cooling	Energy requirements Average C.O.P.	HE1 HE2
	Hot water production	Solar Contribution Average C.O.P	HE4 HE2
	Lighting	Solar Contribution Average Efficiency	HE5 HE3
	General use of electricity	Solar Contribution	HE5

Minumum requirements

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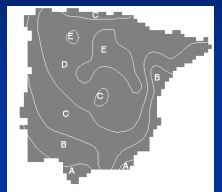
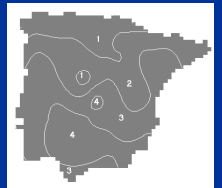
Climatic zoning



Winter Climatic Zones



Summer Climatic Zones

SCS

A4	B4	C4	D3	E1
A3	B3	C3		
		C2	D2	
		C1	D1	

WCS

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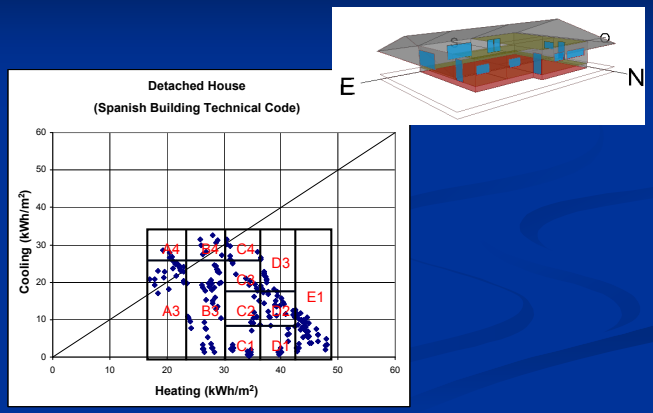
Climatic zoning



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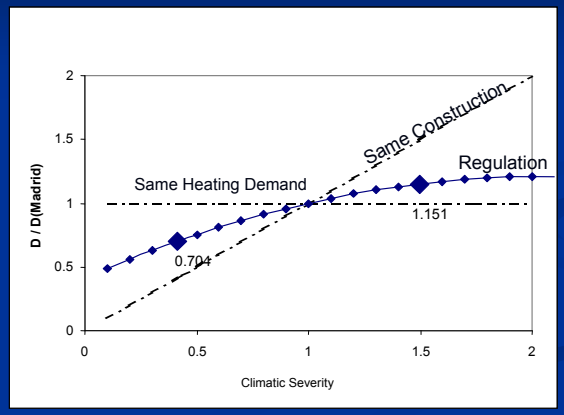
Variation of the minimum requirements with the climate



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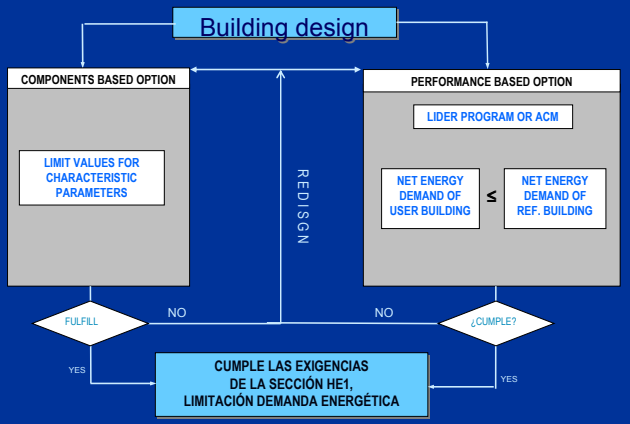
Two options for implementation



Limit values for Madrid (D3)

ZONA CLIMÁTICA D3

Transmitancia límite de muros de fachada y cerramientos en contacto con el terreno	U_{Mlim}: 0,66 W/m² K
Transmitancia límite de suelos	U_{Slim}: 0,49 W/m² K
Transmitancia límite de cubiertas	U_{Clim}: 0,38 W/m² K
Factor solar modificado límite de lucernarios	F_{Llim}: 0,28

	Transmitancia límite de huecos[1] U_{Hlim} W/m²K				Factor solar modificado límite de huecos F_{Hlim}					
					Baja carga interna			Alta carga interna		
% de huecos	N	E/O	S	SE/SO	E/O	S	SE/SO	E/O	S	SE/SO
de 0 a 10	3,5	3,5	3,5	3,5	-	-	-	-	-	-
de 11 a 20	3,0 (3,5)	3,5	3,5	3,5	-	-	-	-	-	-
de 21 a 30	2,5 (2,9)	2,9 (3,3)	3,5	3,5	-	-	-	0,54	-	0,57
de 31 a 40	2,2 (2,5)	2,6 (2,9)	3,4 (3,5)	3,4 (3,5)	-	-	-	0,42	0,58	0,45
de 41 a 50	2,1 (2,2)	2,5 (2,6)	3,2 (3,4)	3,2 (3,4)	0,50	-	0,53	0,35	0,49	0,37
de 51 a 60	1,9 (2,1)	2,3 (2,4)	3,0 (3,1)	3,0 (3,1)	0,42	0,61	0,46	0,30	0,43	0,32

[1] En los casos en que la transmitancia media de los muros de fachada U_{Mm}, definida en el apartado 3.2.2.1, sea inferior a 0,47 se podrá tomar el valor de U_{Hlim} indicado entre paréntesis para las zonas climáticas D1, D2 y D3.

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Limits for Winter

ZONA CLIMÁTICA D3

Transmitancia límite de muros de fachada y cerramientos en contacto con el terreno U_{Mlim}: 0,66 W/m² K
Transmitancia límite de suelos U_{Slim}: 0,49 W/m² K
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	Transmitancia límite de huecos[1] U_{Hlim} W/m²K				Factor solar modificado límite de huecos F_{Hlim}					
					Baja carga interna			Alta carga interna		
% de huecos	N	E/O	S	SE/SO	E/O	S	SE/SO	E/O	S	SE/SO
de 0 a 10	3,5	3,5	3,5	3,5	-	-	-	-	-	-
de 11 a 20	3,0 (3,5)	3,5	3,5	3,5	-	-	-	-	-	-
de 21 a 30	2,5 (2,9)	2,9 (3,3)	3,5	3,5	-	-	-	0,54	-	0,57
de 31 a 40	2,2 (2,5)	2,6 (2,9)	3,4 (3,5)	3,4 (3,5)	-	-	-	0,42	0,58	0,45
de 41 a 50	2,1 (2,2)	2,5 (2,6)	3,2 (3,4)	3,2 (3,4)	0,50	-	0,53	0,35	0,49	0,37
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Limits for Summer

ZONA CLIMÁTICA D3

Transmitancia límite de muros de fachada y cerramientos en contacto con el terreno U_{Mlim}: 0,66 W/m² K
Transmitancia límite de suelos U_{Slim}: 0,49 W/m² K
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Factor solar modificado límite de lucernarios F_{Llim}: 0,28

	Transmitancia límite de huecos[1] U_{Hlim} W/m²K				Factor solar modificado límite de huecos F_{Hlim}					
					Baja carga interna			Alta carga interna		
% de huecos	N	E/O	S	SE/SO	E/O	S	SE/SO	E/O	S	SE/SO
de 0 a 10	3,5	3,5	3,5	3,5	-	-	-	-	-	-
de 11 a 20	3,0 (3,5)	3,5	3,5	3,5	-	-	-	-	-	-
de 21 a 30	2,5 (2,9)	2,9 (3,3)	3,5	3,5	-	-	-	0,54	-	0,57
de 31 a 40	2,2 (2,5)	2,6 (2,9)	3,4 (3,5)	3,4 (3,5)	-	-	-	0,42	0,58	0,45
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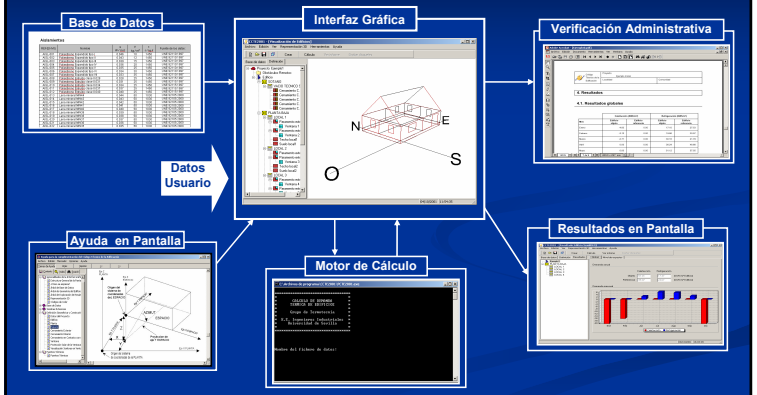
LIDER: The national common tool



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Elements of the certification scheme:

- *The energy performance indicators*
- *The comparison scenario*
- *The performance scale*
- *The procedure to get the indicators*

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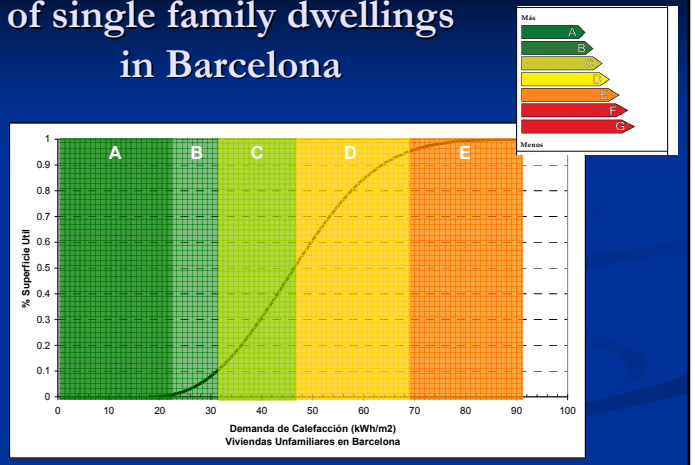
Example: Heating demand of single family dwellings in Barcelona



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Energy performance indicators

- Main indicators : Overall CO_2 emissions and primary energy consumption
- Complementary indicators:
  - Heating requirements
  - Cooling requirements
  - Heating primary energy consumption
  - …..

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The comparison scenario: How similar are the buildings compared

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The comparison scenario

a) Buidings of the same age
b) Buildings in the same climate
c) Buildings of the same use
d) c + same compactness
e) c + same shape and size
f) c + same shape, size, orientation and the same window to wall ratio.
g) f + same HVAC and HWP systems .

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The comparison scenario (residential buildings)

a) Buidings of the same age
b) Buildings in the same climate
c) Buildings of the same use
d) c + same compactness
e) c + same shape and size
f) c + same shape, size, orientation and the same window to wall ratio.
g) f + same HVAC and HWP systems .

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The comparison scenario (non-residential buildings)

a) Buidings of the same age
b) Buildings in the same climate
c) Buildings of the same use
d) c + same compactness
e) c + same shape and size
f) c + same shape, size, orientation and the same window to wall ratio.
g) f + same HVAC and HWP systems .

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Elements of the certification scheme:

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Reglamentación

CEN criteria

The limits of the energy clases are based on 3 energy performance indicators:

- The corresponding to the object building.
- The average indicator corresponding to similar new buildings that fulfull strictly the thermal regulations applicable in 2006 $I_{Reglamentación}$
- The average indicator corresponding to similar existing buildings according to the existing building stock in 2006

Methodology to calculate $I_{Reglamentación}$ in residential buildings

- Selection of the sample of buildings
- Obtention of the indicators for the sample provided that they fulfull strictly the 2006 thermal regulations
- Mathematical Caracterization of the result

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Mathematical Caracterization of the result: average value and deviation

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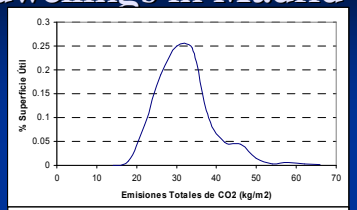
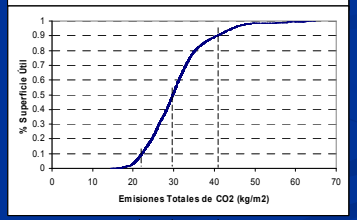
Example: CO_2 emissions for single dwellings in Madrid

Madrid

14849 values





21.5 29.9 40.1

$$R_{50/10} = \frac{29.9}{21.5} = 1.39$$

$$R_{90/10} = \frac{40.1}{21.5} = 1.87$$

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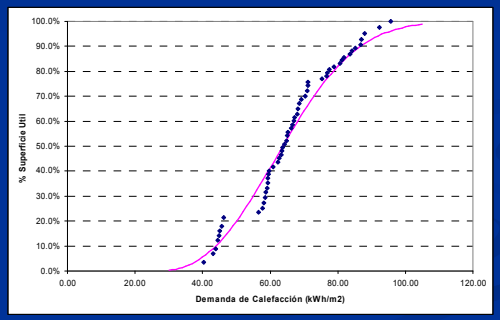
Weibull Probability distribution

$$F = 1 - \exp\left(-\left(\frac{\chi - c_0}{\sigma}\right)^{\lambda}\right)$$



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Limits of the scale : situation of the reference values and width of the classes

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Basic criteria

- The average value of $I_{Reglamentación}$ will be in the bound between class C y D
- Within C and D will be the 85 % of the buildings that fulfill strictly the regulations, 10 % in class B and 5% in class E
- Class B should be reachable by buildings initially placed in class C when optimized in a cost-benefit context withour recours to renewable energies.
- The effort to move from classB to class must be equivalent to the effort to move from class C to class B

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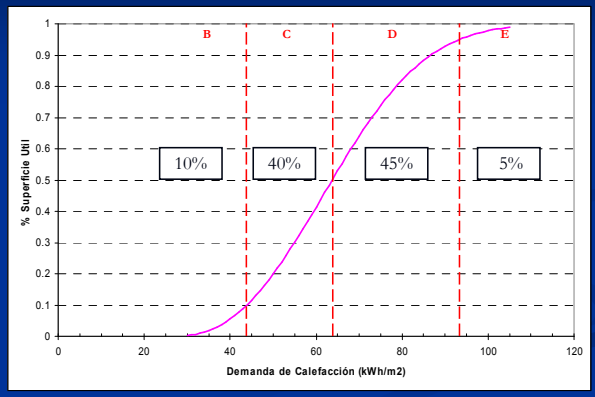
Width of classes C and D



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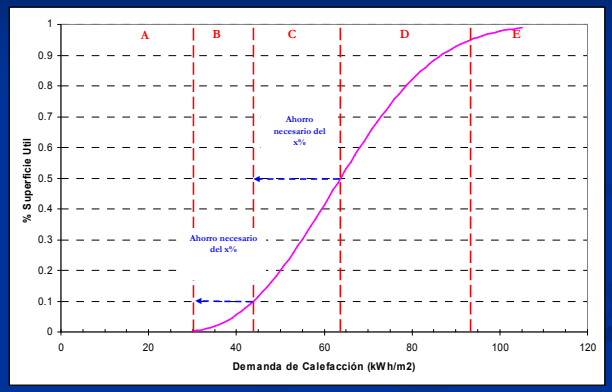
Class B



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Normalised scale: Classification Indicator

looking for a simple way to express the limits for the different indicators at the different building types and the different climates

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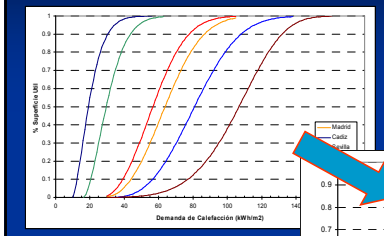
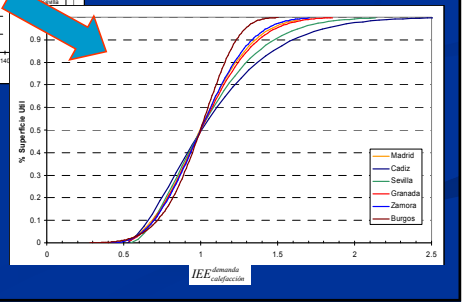
CEN proposal



$$IEE = \frac{I_{objeto}}{I_{Reglamentación}}$$



Not valid to determine the classes according to the criteria

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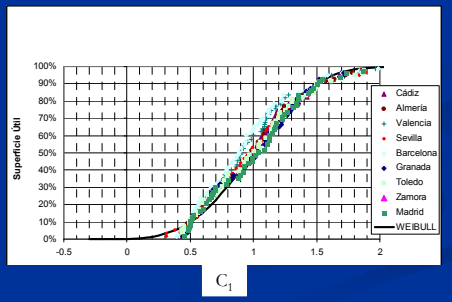
Spanish option

$$C_1 = \frac{IEE \cdot R_{50/10} - 1}{2(R_{50/10} - 1)} + 0.5$$



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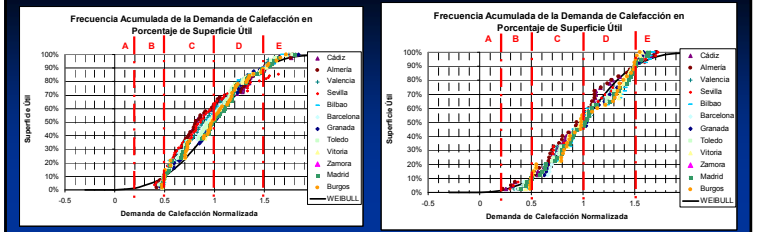

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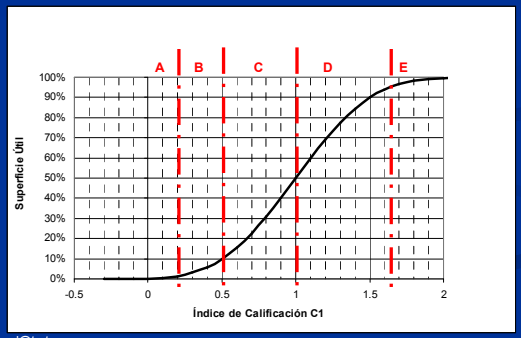
Normalisation of the limits

$$C_1 = \frac{IEE \cdot R_{50/10} - 1}{2(R_{50/10} - 1)} + 0.5$$

Clase A	si	C1 < 0.2
Clase B	si	0.2 ≤ C1 < 0.5
Clase C	si	0.5 ≤ C1 < 1.0
Clase D	si	1.0 ≤ C1 < 1.65



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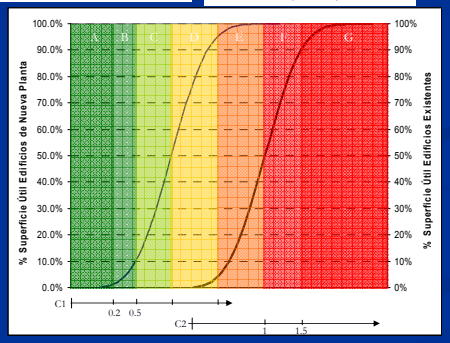
Extension to existing buildings

$$C_1 = \frac{IEE \cdot R_{50/10} - 1}{2(R_{50/10} - 1)} + 0.5$$

$$C_2 = \frac{\left(\frac{I_{objeto}}{I_{Stock}} R'\right) - 1}{2(R' - 1)} + 0.5$$



Clase A	si	C1 < 0.2
Clase B	si	0.2 ≤ C1 < 0.5
Clase C	si	0.5 ≤ C1 < 1.0
Clase D	si	1.0 ≤ C1 < 1.65
Clase E	si	C2 < 1.0
Clase F	si	1.0 ≤ C2 < 1.0
Clase G	si	1.5 ≤ C2

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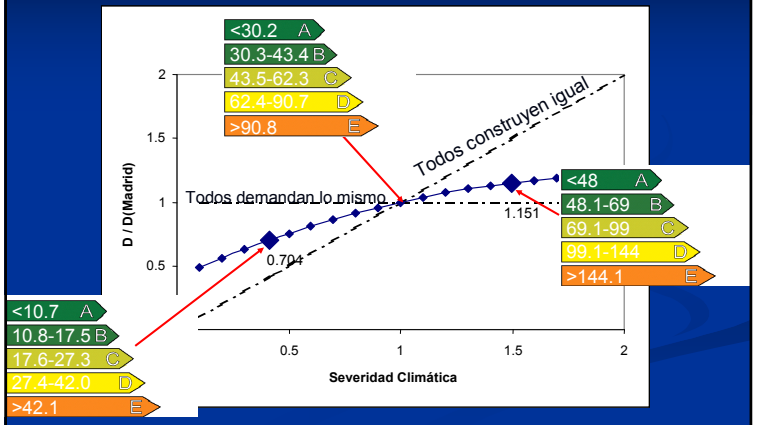
Variation of the scale with the climate for every energy performance indicator



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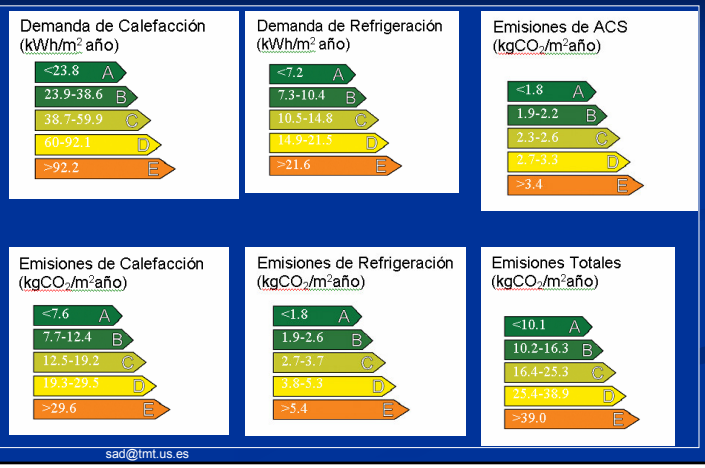
Set of scales for a given climate



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Conclusions about the scale

- The scale distinguishes clearly the energy efficient buildings from the non-efficient ones
- It is sensitive to the improvements in a certain building.
- It is possible for every building type end every climate to get the class A.
- The set of scales provides information about the reasons of a bad permormance and hence it suggests the corrective actions to be taken.
- It is stable enough so as to be applicable, at least, during the period of time between two updates of the regulation
- It is applicable to new and to existing buildings

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Elements of the certification scheme:

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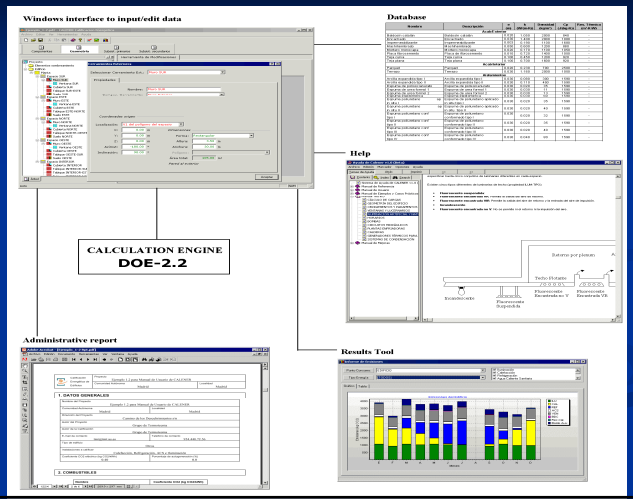
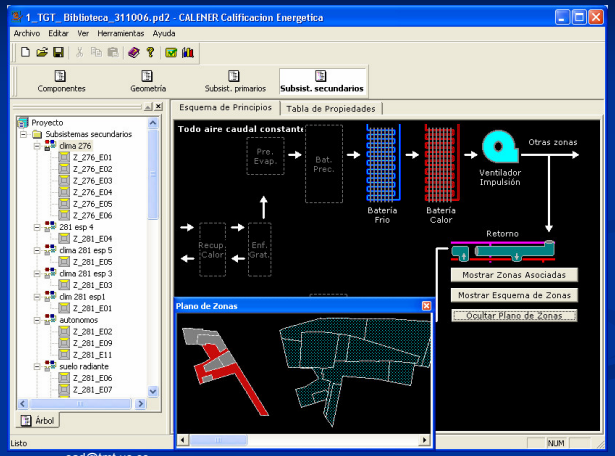
OPTION A: CALENER, THE OFFICIAL TOOL



Definition of systems in CALENER-GT



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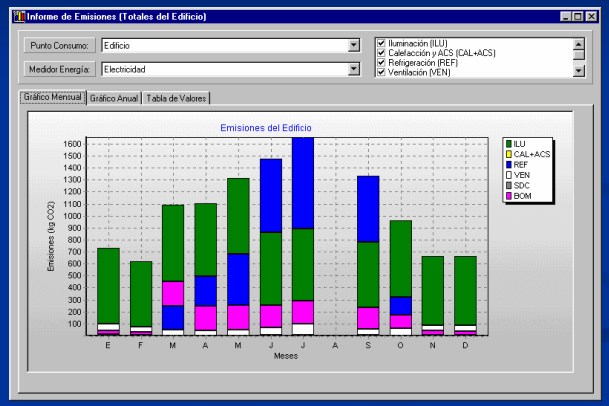
CALENER Output of the tool



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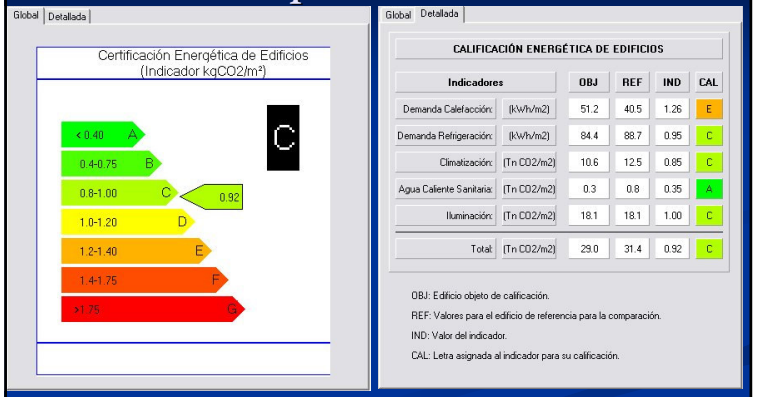
CALENER Output of the tool



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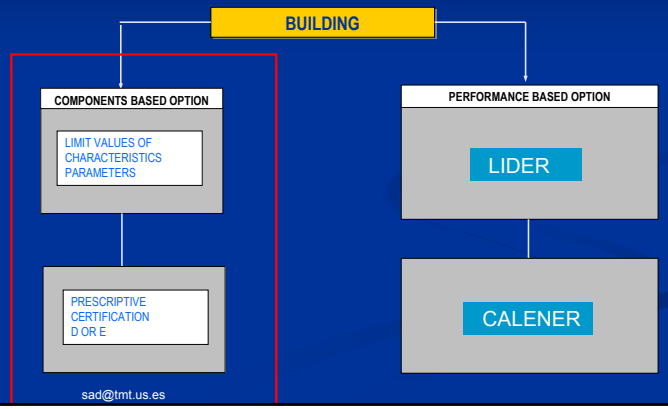
OPTION B: PRESCRIPTIVE CERTIFICATION FOR BUILDINGS THAT FULFILL THE REGULATIONS



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Class D dwellings in climatic zone A-3

CONCEPTO		OPCIONES DE OBTENCIÓN DE CLASE D				
		1	2		3	4
Envuelta						
	Compacidad	≥2	≥2		<2	<2
Instalación de calefacción						
	Bomba de calor-Aparatos Divididos	F	Todos		D	F
	Bomba de calor-AparatosCompactos	F	Todos		C	F
	Bomba de calor-Aparatos Conducto Único	D	F		B	D
	Caldera individual	GAS ****	GAS Todas	LIQ **	-	GAS ****
	Caldera ind. mixta con acumulación	GAS ****	GAS Todas	LIQ **	-	GAS ****
	Caldera ind. mixta sin acumulación	-	GAS **		-	-
	Caldera eléctrica efecto Joule	-	-		-	-
Instalación de refrigeración						
	Aire/Aire- Aparatos Divididos	Todos	D		Todos	A
	Aire/Aire- AparatosCompactos	Todos	C		Todos	A
	Aire/Aire- Aparatos Conducto Único	Todos	A		Todos	-
Instalación de agua caliente sanitaria						
	Caldera sin acumulación	Todas	Todas		Todas	Todas
	Caldera con acumulación	Todas	Todas		Todas	Todas
	Caldera eléctrica efecto Joule	Todas	Todas		Todas	Todas

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- The EPBD
- Energy consumption and reglamentary options
- Minimum requirements
- Energy certification
- Prescriptive certification of low energy buildings

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- The fact: Even if people are able to use properly the simulation tools, most of them are not able to get a low energy building under a cost-benefit basis at a reasonable time.
- The wrong message: To get low energy buildings the best option is to take more and more stricter values of the limits of characteristics parameter given by the regulation
- The inverse problem: Given a certain energy class, how to design the building?.

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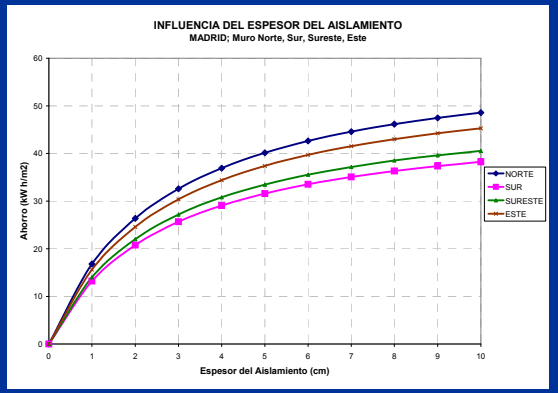
Example: Increase the insulation in walls



How to obtain the overall energy efficient indicator

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$IEE_{global} = IEE_{calefacción}\ \Phi_{calefacción} + IEE_{refrigeración}\ \Phi_{refrigeración} + IEE_{ACS}\ \Phi_{ACS}$

Weighting coefficients

f (climate zone)

IEE Dc IEE Sc

$$IEE_{calefacción} = \frac{D_{calefacción}|_{objeto}}{D_{calefacción}|_{reglamentación}} * \frac{coef.paso/\eta_{SC}|_{objeto}}{coef.paso/\eta_{SC}|_{reglamentación}}$$

$$\Phi_{calefacción} = \frac{Ecalefacción|_{reglamentación}}{Etotal|_{reglamentación}}$$

$$IEE_{refrigeración} = \frac{D_{refrigeración}|_{objeto}}{D_{refrigeración}|_{reglamentación}} * \frac{coef.paso/\eta_{SR}|_{objeto}}{coef.paso/\eta_{SR}|_{reglamentación}}$$

$$\Phi_{refrigeración} = \frac{Erefrigeración|_{reglamentación}}{Etotal|_{reglamentación}}$$

$$IEE_{ACS} = \frac{D_{ACS}|_{objeto}}{D_{ACS}|_{reglamentación}} * \frac{coef.paso/\eta_{ACS}|_{objeto}}{coef.paso/\eta_{ACS}|_{reglamentación}}$$

$$\Phi_{ACS} = \frac{E_{ACS}|_{reglamentación}}{Etotal|_{reglamentación}}$$

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IEE Total

IEEt = IEE calefacción Φcalefacción + IEE refrigeración Φrefrigeración + IEE ACS ΦACS

There are many combinations of the complementary enegy performance indicators that gives a certain value of the global energy performance indicator

Clase total	C	C	D	D	D	D	D	D	...
Clase Calefacción	C	C	C	C	C	C	C	C	...
Clase Refrigeración	D	D	D	D	E	E	E	E	...
Clase ACS	A	B	C	D	A	B	C	D	...

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Example: combination of heating demand (envelope) class and efficiency of the heating system class to get a certain class of the indicator for heating

Clase Energía	IEE Sc			
IEE Dc	A	B	C	D
E	C	D	E	E
D	C	C	D	E
C	B	C	C	D
B	A	B	C	C
A	A	A	B	C

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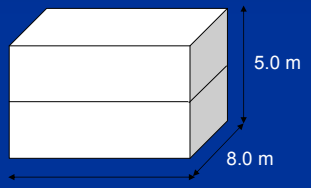
The inverse problem: example of use



- Seville
  - $U_{Wall} = 0.82\ W/m^2K$
  - $U_{Floor} = 0.52\ W/m^2K$
  - $U_{Roof} = 0.45\ W/m^2K$
  - $U_{Window} = 5.7\ W/m^2K$

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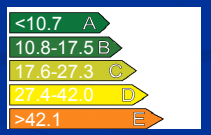
The inverse problem: example of use

S/N (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	D	C	C
75/25	D	D	D	D
50/50	D	D	D	D
25/75	E	E	E	E
0/100	E	E	E	E

Seville



Units: kWh/m² year

If Floor Area = 160 m² :

Glazing Area = 0.15 × 160 m² = 24 m²

South Glazing Area = 0.15 × 160 m² × 0.75 = 18 m²

North Glazing Area = 0.15 × 160 m² × 0.25 = 6 m²

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Example

S/N (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	D	C	C
75/25	D	D	D	D
50/50	D	D	D	D
25/75	E	E	E	E
0/100	E	E	E	E
E/O (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	D	E	E
75/25	D	D	E	E
50/50	D	D	E	E
25/75	D	E	E	E
0/100	D	E	E	E
NE/SO (%)	% Glazing			
	10%	15%	20%	25%
100/0	E	E	E	E
75/25	E	E	E	E
50/50	D	D	E	E
25/75	D	D	D	D
0/100	D	D	D	D
SE/NO (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	D	D	D
75/25	D	D	D	D
50/50	D	D	E	E
25/75	E	E	E	E
0/100	E	E	E	E

From $U_{Wall} = 0.82\ W/m^2K$ to $U_{Wall} = 0.66\ W/m^2K$

S/N (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	D	C	C
75/25	D	D	D	D
50/50	D	D	D	D
25/75	D	D	E	E
0/100	D	E	E	E
E/O (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	D	D	D
75/25	D	D	D	D
50/50	D	D	D	D
25/75	D	D	D	D
0/100	D	D	D	D
NE/SO (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	E	E	E
75/25	D	D	E	E
50/50	D	D	D	D
25/75	D	D	D	D
0/100	D	D	D	D
SE/NO (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	D	D	D
75/25	D	D	D	D
50/50	D	D	D	D
25/75	D	D	E	E
0/100	D	E	E	E

From $U_{Window} = 5.7\ W/m^2K$ to $U_{Window} = 2.7\ W/m^2K$

S/N (%)	% Glazing			
	10%	15%	20%	25%
100/0	C	C	B	A
75/25	C	C	C	B
50/50	D	D	C	C
25/75	D	D	D	D
0/100	D	D	D	D
E/O (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	D	D	D
75/25	D	D	D	D
50/50	D	D	D	D
25/75	D	D	D	D
0/100	D	D	D	D
NE/SO (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	D	D	D
75/25	D	D	D	D
50/50	D	D	D	D
25/75	D	C	C	C
0/100	D	C	C	C
SE/NO (%)	% Glazing			
	10%	15%	20%	25%
100/0	D	C	C	C
75/25	D	C	C	C
50/50	D	D	D	C
25/75	D	D	D	D
0/100	D	D	D	D

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OPTION C: Prescriptive certification of low energy buildings

- An energy class can be automatically assigned to a building pertaining to a certain building family, provided that this building satisfies a number of conditions regarding the envelope and the HVAC and DHV systems.
- The set of conditions to be fulfilled is called a Technical Solution.
- The technical solutions are climatically dependent
- Different alternatives of technical solutions are possible for a given building family and climate.
- The use of technical solutions elliminates the verification of the minumum requirements and elliminates also the use ofsimulation methods.
- There is an official procedure to demonstrate, document and use the technical solutions.

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Advantages of the prescriptive certification of low energy buildings

- The use is very simple (based on tables, points, compact packages …).
- Simplifies the training required compared to the trainig needed for using the calculation tools.
- There is no limit regarding the energy class that can be obtained
- Simplifies the management, control and inspection of the certification (check list)
- Can be used as design guidelines providing the starting point for further improvements based on the use of the calculation tools at a reduced scale.

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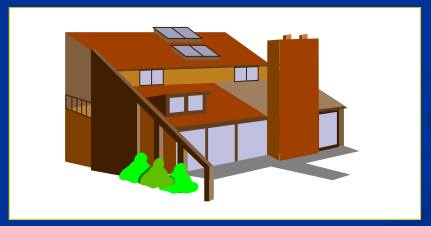
WORKSHOP: BUILDINGS ENERGY PERFORMANCE

ENERGY CERTIFICATION OF BUILDINGS IN SPAIN



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