Use of Building Typologies for Energy Performance Assessment of National Building Stock.

Existent Experiences in Spain

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VALENCIAN INSTITUTE OF BUILDING

Av.Tres Forques, 98 - 46018 Valencia
Tlf.: 0034 96 398 65 05 - Fax: 0034 96 398 65 04
www.five.es - ive@five.es

ÍNDICE

1. Introduction

Spain is a country and member state of the European Union located in south-western Europe on the Iberian Peninsula. Its mainland is bordered to the south and east by the Mediterranean Sea; to the north by France; and to the northwest and west by the Atlantic Ocean and Portugal.
With an area of 504,030 km², it is the second largest country in European Union after France.
Spain is a democracy organised in the form of a parliamentary government under a constitutional monarchy. It has the ninth or tenth largest economy in the world by nominal GDP, and very high living standards (15th highest Human Development Index), including the tenth-highest quality of life index rating in the world, as of 2005.

Figure 1. Spain Location. Source: Wikimedia Commons

Administrative divisions

Spain is a nation organized territorially into 17 Autonomous Communities and two Autonomous Cities. The basic institutional law of the Autonomous Community is the Statute of Autonomy. The autonomous communities have wide legislative and executive autonomy, with their own parliaments and regional governments. The distribution of powers may be different for every community, as laid out in their Statutes of Autonomy.
Autonomous Communities are composed of provinces. In turn, provinces are composed of municipalities.

Figure 2 Spain map. Source: Barcelona Doctor Association

Autonomous Communities	Population 2004	Surface Km²
Andalucía	7.687.518	87.599
Aragón	1.249.584	47.729
Asturias	1.073.761	10.610
Balears	955.045	5015
Canarias	1.915.540	7.455
Cantabria	554.784	5.320
Castilla y León	2.493.918	94.193
Castilla-La Mancha	1.848.881	79.412
Cataluña	6.813.319	32.229
Comunidad Valenciana	4.543.304	23.280
Extremadura	1.075.286	41.679
Galicia	2.750.985	29.675
Madrid	5.804.829	8.020
Murcia	1.294.694	11.315
Navarra	584.734	10.383
País Vasco	2.115.279	7.242
La Rioja	293.553	5.044

Table 1. Source: INE (National Statistical Institute)

Climate

Spain has a very diverse climate throughout its territory. The Mediterranean character is predominant in most of its geography. The climate of the coasts of southern and eastern is called Mediterranean coast climate: mild temperatures and abundant rainfall except in summer. As we move into the interior the climate is more extreme, we find the Continental Mediterranean climate, which covers almost the entire peninsula: low winter temperatures, high and irregular rainfall in summer. In general, Western communities receive more precipitation than the eastern. Thus, Galicia and Cantabria have a Maritime climate characterized by an abundance of rainfall throughout the year especially in winter and cool temperatures. The mountain climate can be seen in high altitudes where there are very cold winters) and abundant rainfall.

Figure 3. Spain climates zones. Source: ISFTIC Images banc

Arid or semiarid climates are found in certain eastern peninsular points: Almería, Granada, Murcia, or Alicante. The subtropical nature is characteristic of the Canary Islands, with warm temperatures throughout the year and little precipitation. However, this atmosphere also occurs in the southern coasts of the peninsula (Málaga, Granada and Almería), where temperatures are relatively mild throughout the year, although rainfall is more abundant than in the Canaries.

Autonomous Communities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Andalucía	10,3	11,4	13,2	15,2	18,6	22,5	25,8	25,9	23,4	18,6	13,8	10,7	17,4
Aragón	5,0	6,6	8,8	11,2	15,0	19,4	23,0	22,4	19,5	14,1	8,5	5,5	13,3
Asturias	7,5	8,5	9,5	10,3	12,8	15,8	18,0	18,3	17,4	14,0	10,4	8,7	12,6
Balears	11,6	11,8	12,9	14,7	17,6	21,8	24,6	25,3	23,5	20,0	15,6	13,0	17,7
Canarias	17,7	17,8	18,4	18,9	20,2	21,8	23,8	24,5	24,1	22,5	20,5	18,5	20,7
Cantabria	9,7	10,3	10,8	11,9	14,3	17,0	19,3	19,5	18,5	16,1	12,5	10,5	14,2
Castilla y León	3,5	4,9	6,8	8,9	12,5	16,8	20,3	19,9	17,2	12,1	6,8	4,0	11,1
Castilla-La Mancha	5,3	6,7	9,0	11,3	15,4	20,3	24,3	23,9	20,4	14,4	9,0	5,8	13,8
Cataluña	7,4	8,9	11,0	13,1	16,8	20,7	24,0	23,7	21,2	16,5	11,0	8,0	15,2
Comunidad Valenciana	10,6	11,6	12,9	14,7	17,6	21,4	24,3	24,8	22,5	18,5	14,0	11,3	17,0
Extremadura	8,3	9,7	11,9	13,6	17,3	22,3	25,7	25,2	23,1	17,4	12,1	8,9	16,3
Galicia	8,0	8,9	10,1	11,5	13,8	17,0	19,2	19,4	18,0	14,5	10,8	8,6	13,3
Madrid	6,2	7,4	9,9	12,2	16,0	20,7	24,4	23,9	20,5	14,7	9,4	6,4	14,3
Murcia	10,6	11,4	12,6	14,5	17,4	21,0	23,9	24,6	22,5	18,7	14,3	11,3	16,9
Navarra	4,5	6,5	8,0	9,9	13,3	17,3	20,5	20,3	18,2	13,7	8,3	5,7	12,2
País Vasco	6,8	7,8	8,8	10,4	13,4	16,3	18,8	19,0	17,6	14,4	9,8	7,4	12,5
La Rioja	5,8	7,3	9,4	11,5	15,1	19,0	22,2	21,8	19,2	14,4	9,1	6,3	13,4

Table 2. Distribution of monthly and annual average temperatures in Spain by Autonomous Communities. Source: Own work

Dwelling

At the end of 2006, Spain had a stock of 24.677.227 dwellings, according to the Bank of Spain. Taking in account that there were 16,03 million homes, these figures indicate an average of 1,54 homes per dwelling. According to the sources only 15% were rented.

	Before 1900	1900-1920	1921-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2001
Single Unit Houses	1,47	1,46	1,59	1,58	1,73	1,91	1,75	2,19	2,36
Multi Unit Houses	1,67	1,74	1,80	1,86	1,95	2,06	2,13	2,08	1,67

Table 3. Number of persons per dwelling. Source: INE (National Statistical Institute)

The average price of new housing in Spain is 2.510 €/ m^2, according to the Pricing Society to December 31, 2005. The price of housing, however, varies markedly depending on the regions and provincial capitals.

Autonomous Communities	2001	2002	2003	2004	2005	2006	2007	2008
Andalucía	3.554.198	3.677.608	3.806.819	3.922.607	4.032.264	4.163.281	4.288.016	4.408.278
Aragón	657.555	672.438	687.679	699.563	713.854	727.517	740.896	759.921
Asturias	524.336	533.877	543.960	556.612	569.923	583.858	595.413	607.620
Balears	504.041	516.757	529.088	539.826	551.480	562.372	575.292	587.918
Canarias	855.022	884.064	910.671	937.084	962.896	990.461	1.014.885	1.045.184
Cantabria	286.901	294.039	302.697	311.303	317.695	327.718	337.047	345.145
Castilla y León	1.455.050	1.487.057	1.514.294	1.543.748	1.576.866	1.618.567	1.657.603	1.695.579
Castilla-La Mancha	988.555	1.005.293	1.023.217	1.045.585	1.072.011	1.110.140	1.163.713	1.214.458
Cataluña	3.328.120	3.403.260	3.477.698	3.571.897	3.658.330	3.740.376	3.829.026	3.923.033
Comunidad Valenciana	2.558.691	2.628.135	2.692.389	2.767.763	2.862.658	2.952.338	3.037.589	3.123.236
Extremadura	575.284	584.471	596.487	606.080	616.274	625.425	638.997	651.406
Galicia	1.312.496	1.344.733	1.372.715	1.405.098	1.437.554	1.470.805	1.507.380	1.544.625
Madrid	2.482.885	2.524.353	2.567.758	2.635.616	2.706.368	2.781.631	2.841.352	2.890.229
Murcia	595.319	609.285	624.403	646.435	670.134	712.148	745.298	778.815
Navarra	261.147	267.293	272.666	278.103	284.801	293.811	301.381	310.175
País Vasco	892.009	910.390	922.705	936.935	952.202	966.649	983.211	997.294
Rioja	156.769	161.349	165.484	169.612	174.709	181.011	186.804	193.904
TOTAL	21.033.759	21.551.426	22.059.220	22.623.443	23.210.317	23.859.014	24.495.844	25.129.207

Table 4. Total dwellings by Autonomous Communities. Source: Housing Ministry

In the following paragraphs different data about the Spanish housing stock are exposed :

Building TYPE	Number of buildings	Number of dwellings
Single Unit Houses	6.682.591	6.682.591
Multi Unit Houses	1.930.825	14.140.864
Building Stock total	8.613.416	20.823.455

Table 5. S-1.1 Frequency of building types of the national buildings stock 2001. Source: INE (National Statistical Institute)

	1 room	2 rooms	3 rooms	4 rooms	5 rooms	6 rooms	7 rooms	8 rooms	9 rooms	10 or more
Number of dwellings	77.431	34.6131	136.0974	2.838.537	5.413.152	2.811.754	742.915	321.495	131.370	143.410

Table 6. Dwellings by number of rooms. Source: INE (National Statistical Institute)

	Before 1900		1900-1920		1921-1940		1941-1950		1951-1960		1961-1970		1971-1980		1981-1990		1991-2001	
Single Unit Houses	767.656	11%	354.954	5%	405.196	6%	435.942	7%	679.882	10%	761.201	11%	1.084.141	16%	1.096.051	16%	1.097.568	16%
Multi Unit Houses	554.412	4%	369.027	3%	498.539	4%	548.948	4%	1.305.565	9%	2.910.774	21%	3.888.633	27%	1.781.978	13%	2.282.988	16%
Total	554.412	4%	369.027	3%	498.539	4%	548.948	4%	1.305.565	9%	2.910.774	21%	3.888.633	27%	1.781.978	13%	2.282.988	16%

Table 7. Total dwellings by type of building from different periods. Source: INE (National Statistical Institute)

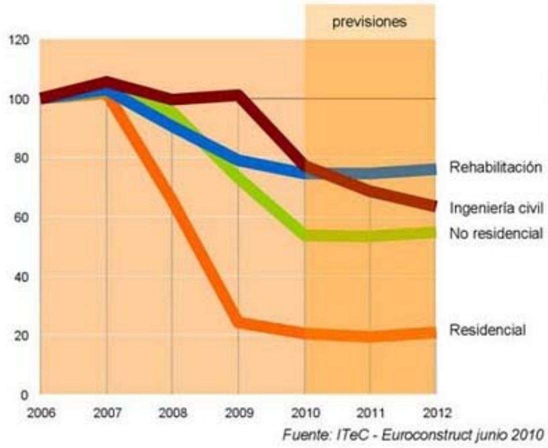
	Before 1900		1900-1920		1921-1940		1941-1950		1951-1960		1961-1970		1971-1980		1981-1990		1991-2001	
Single Unit Houses	767.656	11%	354.954	5%	405.196	6%	435.942	7%	679.882	10%	761.201	11%	1.084.141	16%	1.096.051	16%	1.097.568	16%
Multi Unit Houses	132.086	7%	71.292	4%	91.147	5%	102.782	5%	205.484	11%	327.792	17%	418.935	22%	262.965	14%	318.342	16%
Total	899.742	10%	426.246	5%	496.343	6%	538.724	6%	885.366	10%	1.088.993	13%	1.503.076	17%	1.359.016	16%	1.415.910	16%

Table 8. Total buildings by type and year of construction. Source: INE (National Statistical Institute)

	Buildings to construct		Buildings to rehabilitate	Buildings to demolish
	Residential	Non-residential		
2005	184.218	19.159	33.086	20.997
2006	208.631	21.413	35.856	28.480
2007	166.322	20.825	33.359	26.141
2008	79.752	13.926	34.807	14.573
2009	39.564	12.180	33.267	7.984

Table 9. Number of buildings to construct, rehabilitate or demolish.

Source: INE (National Statistical Institute)



Autonomous Communities	Single Unit Houses	Multi Unit Houses
Andalucía	19	15
Aragón	28	16
Asturias	34	17
Balears	20	13
Canarias	21	14
Cantabria	29	17
Castilla y León	28	16
Castilla-La Mancha	23	14
Cataluña	17	20
Comunidad Valenciana	21	15
Extremadura	23	14
Galicia	32	15
Madrid	12	16
Murcia	22	14
Navarra	26	17
País Vasco	29	19
La Rioja	28	15
Total	24	15

Table 10. Average age of residential buildings by Autonomous Communities. Source: INE (National Statistical Institute)

Number of dwellings	Single unit houses	Multi unit houses	Total
Room heating systems	1.796.449	3.495.573	5.292.022
Dwelling heating systems	1.534.781	3.900.316	5.435.097
Building heating system	82.312	1.243.172	1.325.484
Without heating system	826.613	1.219.168	2.045.781

Table 11. S-2.1 Centralisation of the heat supply (for space heating) 2001. Source: INE (National Statistical Institute)

Number of dwellings	Before 1900	1900-1920	1921-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2001
Gas	194.822	128.698	181.892	191.891	445.965	925.240	1.118.434	583.567	918.644
Electricity	212.026	137.888	181.744	203.075	469.054	942.000	1.094.406	595.262	631.959
Petroleum or derivates	108.609	47.396	63.601	71.973	147.092	287.215	562.001	370.890	322.740
Wood	54.078	22.160	24.121	24.615	36.920	43.851	54.794	54.798	42.326
Coal or derivates	76.215	32.425	38.741	41.043	67.862	88.391	88.783	60.311	38.603
Others	3.441	2.001	2.166	2.515	5.040	8.954	11.720	5.847	5.095

Table 12. S-3.2 Heat generation of space heating systems. Source: INE (National Statistical Institute)

Number of dwellings	Before 1900	1900-1920	1921-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2001	Not applicable	TOTAL
There is air condition system	53.619	41.836	64.019	72.699	177.927	399.218	578.587	361.385	440.250	12.465	2.202.005
There is no air condition system	753.754	412.684	533.795	577.866	1.220.930	2.284.083	2.826.422	1.561.091	1.765.683	48.856	11.985.164
TOTAL	807.373	454.520	597.814	650.565	1.398.857	2.683.301	3.405.009	1.922.476	2.205.933	61.321	14.187.169

Table 13. S-2.8 Air conditioning systems. Source: INE (National Statistical Institute)

	UE	Spain
Coal	217,64	20,24
Oil	599,53	70,85
Natural Gas	386,56	31,6
Nuclear	232,37	14,36
Electric balance	4,91	-0,5
Renewable energies	102,38	10,23
Primary energy Consumption	1.543,39	146,78

Table 14. Primary energy Consumption in 2007 (Mtep) . Source: AVEN (Valencia Energy Agency)

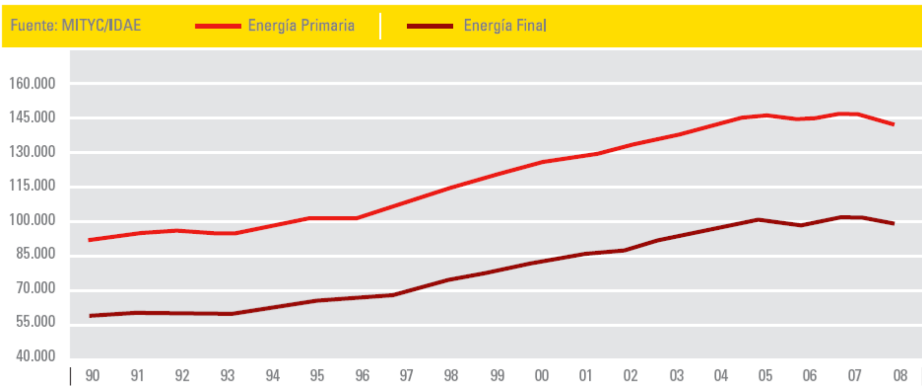


Figura.1. Energy consumption Evolution in Spain 1990-2008. Source: IDEA (Institute for the Diversification and Saving of Energy)

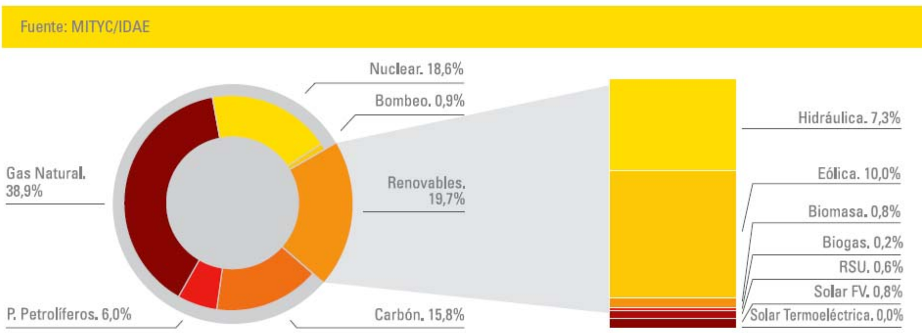


Figura.2. Structure of electricity production 2008. Source: IDAE (Institute for the Diversification and Saving of Energy)

	1980	1982	1984	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2007
INDUSTRY	24306	23130	22683	21787	22853	24423	23594	24923	26581	30420	32826	33080	35561	33889	35260
Coal	3191	5094	4873	4131	3766	3893	3248	2847	2306	2414	2466	2432	2360	2240	2467
P.Oil	15731	12725	11879	11375	11363	11306	10857	12123	12720	13804	13350	12551	12112	10027	9871
Gas	720	722	1024	1417	2635	3677	4000	4333	5650	7604	9602	10135	12318	12406	13384
Electricity	4664	4589	4907	4864	5088	5547	5491	5620	5906	6599	7408	7963	8771	9215	9537
TRANSPORT	14570	14929	15663	16365	19537	22716	23904	25233	27461	30306	32276	34320	37832	39803	40702
Coal	11	8	2	2	1	0	0	0	0	0	0	0	0	0	0
P.Oil	14414	14769	15486	16168	19333	22478	23643	24967	27166	29981	31913	33910	37384	39343	40229
Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	146	152	174	195	203	238	261	266	295	324	362	410	448	461	473
OTHER	11332	11006	11850	12902	13204	13531	15135	15293	16680	19488	21671	24131	26837	27463	28265
Coal	302	443	568	650	470	378	263	130	158	140	80	55	46	25	31
P.Oil	7592	6983	7216	7678	7631	7109	7981	7735	8221	9897	10365	10793	12123	11549	11726
Gas	500	456	525	587	518	854	1154	1315	1675	2084	2690	3905	4024	4024	4395
Electricity	2938	3124	3541	3987	4585	5190	5737	6114	6627	7367	8536	9378	10645	11864	12112
TOTAL	50208	49065	50196	51054	55593	60669	62634	65449	70723	80214	86772	91531	100230	101155	104226
Coal	3504	5545	5443	4783	4237	4271	3511	2977	2464	2554	2546	2486	2405	2265	2498
P.Oil	37737	34477	34581	35221	38328	40893	42481	44826	48107	53682	55628	57253	61619	60919	61826
Gas	1220	1178	1549	2004	3153	4531	5154	5647	7325	9688	12292	14040	16342	16430	17779
Electricity	7748	7865	8622	9046	9876	10974	11488	11999	12827	14290	16306	17751	19864	21540	22122

Table 15. Final energy consumption Evolution in Spain. 1980-2007. (Unit: ktoe) Source: AVEN (Valencia Energy Agency)

	1980	1982	1984	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2007
Population (million inhab.)	37,39	37,96	38,34	38,67	38,81	38,96	39,11	39,31	39,67	39,85	40,5	41,84	43,2	44,71	45,2
Coal/capita	0,36	0,45	0,47	0,48	0,39	0,49	0,49	0,46	0,4	0,46	0,55	0,54	0,51	0,44	0,48
Oil/capita	1,34	1,17	1,07	1,05	1,14	1,23	1,29	1,32	1,4	1,55	1,6	1,61	1,64	1,58	1,57
Natural Gas/capita	0,04	0,05	0,05	0,06	0,09	0,13	0,15	0,16	0,21	0,3	0,38	0,45	0,57	0,68	0,7
Nuclear/hab.	0,04	0,06	0,16	0,25	0,34	0,36	0,37	0,37	0,37	0,39	0,4	0,39	0,38	0,35	0,32
Hydraulic/capita	0,07	0,06	0,07	0,06	0,08	0,06	0,04	0,06	0,09	0,08	0,07	0,07	0,1	0,09	0,11
PRIMARY ENERGY/capita	1,84	1,79	1,82	1,9	2,04	2,26	2,35	2,38	2,47	2,78	3	3,07	3,2	3,14	3,16

Table 16. Primary energy consumption Evolution per capita 1980-2007 (toe / capita). Source: AVEN (Valencia Energy Agency)

	1980	1982	1984	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2007
Population (million inhab.)	37,39	37,96	38,34	38,67	38,81	38,96	39,11	39,31	39,67	39,85	40,5	41,84	43,2	44,71	45,2
Coal/capita	0,09	0,15	0,14	0,12	0,11	0,11	0,09	0,08	0,06	0,06	0,06	0,06	0,06	0,05	0,06
P.Oil/capita	1,01	0,91	0,9	0,91	0,99	1,05	1,09	1,14	1,21	1,35	1,37	1,37	1,43	1,36	1,37
Gas/capita	0,03	0,03	0,04	0,05	0,08	0,12	0,13	0,14	0,18	0,24	0,3	0,34	0,38	0,37	0,39
Electricity/capita	0,21	0,21	0,22	0,23	0,25	0,28	0,29	0,31	0,32	0,36	0,4	0,42	0,46	0,48	0,49
FINAL ENERGY/ capita	1,34	1,29	1,31	1,32	1,43	1,56	1,6	1,67	1,78	2,01	2,14	2,19	2,32	2,26	2,31

Table 17. Final energy consumption Evolution per capita 1980-2007. (toe / capita) Source: AVEN (Valencia Energy Agency)

2. Spanish energy legislations[1]

The regulation in force regarding energy saving is the “Basic Document: Energy Saving” titled CTE-HE from the “Technical Code of Buildings (CTE)”. The CTE is a comprehensive legislation on building regulations that come into force in 2006. The regulation in force regarding thermal building systems is the ‘Regulations for thermal systems in Buildings (RITE)’. The previous Spanish legislation regarding energy saving in buildings dates from 1979 and the previous regulation on thermal building systems from 1998.
The “Technical Code of Buildings (CTE)” was the answer to the Energy Performance of Buildings Directive that gave the Spanish Government the chance to include more stringent energy criteria into this review, not just for the fulfilment of the EU obligations, but also for the implementation of other National Energy Policies, such as the National Energy Efficiency Plan – Energy Strategy E4 - and the Renewable Energy Plan.

Legal context

The EPBD was transposed in Spain by means of three royal decrees:

› Royal Decree approving the ‘Technical Code of Buildings (CTE)’, approved by the Council of Ministers on the 17th of March 2006 and published in the Official Gazette on the 28th of March 2006.

› Royal Decree on the Basic Procedure for Energy Performance Certification of new buildings, approved by the Council of Ministers on the 17th of January 2007, and published in the Official Gazette on the 31st of January 2007.

› Royal Decree approving the review of the current ‘Regulations for thermal systems in Buildings (RITE)’, which was approved by the Council of Ministers on the 20th of July 2007 and published in the Official Gazette on the 29th of August 2007.

Calculation procedures

The CTE includes a ‘Basic Document’ on energy saving, titled CTE-HE. This document is in line with the new requirements for energy performance in buildings described in the framework given by the EPBD, including energy saving and RES.
The Spanish calculation procedure is presented in the document ‘HE-1 Energy Saving’ of the CTE. This Basic Document also includes a software tool, LIDER, designed to fulfil the energy demand limitation requirements as a general option. As an alternative to the general case, there is a simplified option following a prescriptive approach, to be used in the case of dwellings and within certain limitations, as described below.

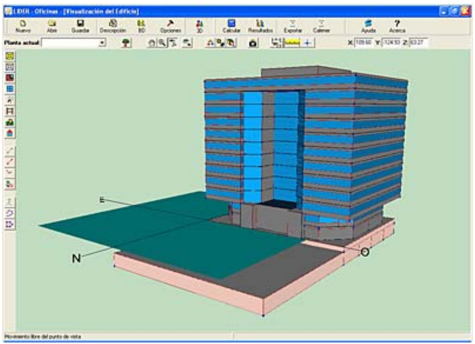


Figure 4. LIDER user interface

Energy Requirements for new buildings

The CTE prescribes minimum energy requirements for new buildings. The requirements apply to building permits requested after the 17th of September 2006.
The type and level of the performance requirements depend on the climatic zone where the building is located and cover:

› Maximum U-values for different building components;
› Solar factors for windows, roof lights, etc;
› Minimum Efficiency performance for thermal systems, depending on ‘solar zones’ (see below);
› Minimum Efficiency performance for lighting systems;
› Minimum natural lighting contribution;
› Minimum solar contribution to Domestic Hot Water (DHW);
› Minimum photovoltaic contribution to electric power.

Compliance with the requirements of ‘Energy demand limitation’ (HE1) can be checked using either a simplified procedure (comparing the real values with the limit values for roof, facades, floor and walls in contact with the ground, as a function of the orientation) or by a complex procedure. The complex procedure requires the use of software tools. LIDER, developed by the Government and available for free, is the official software.

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[1] Part of this section is a summary of the chapter “Implementation of the EPBD in Spain: September 2008” from the report: “Implementation of the Energy Performance of Buildings directive 2008: Country reports” draw up by the EPBD Buildings Platform.

Climatic zones

For limiting energy demand 12 climatic zones have been set identified by a letter corresponding to the division of winter (A, B, C, D,E), and a number corresponding to the splitting of summer (1,2,3,4).
Climate zone of any town is obtained from a table based on the height difference which exists between the locality and the reference height of the capital of their province.
The climatic severity combine degree-days and solar radiation, so that it can be shown that when two locations have the same severity of winter weather (SCI) the heating energy demand of the same building in both locations is equal. The same is applied for the climatic severity of summer (SCV).
For winter five different divisions are identified:

A	B	C	D	E
SCI ≤0,3	0,3 <SCI ≤0,6	0,6 <SCI ≤0,95	0,95 <SCI ≤1,3	SCI>1,3

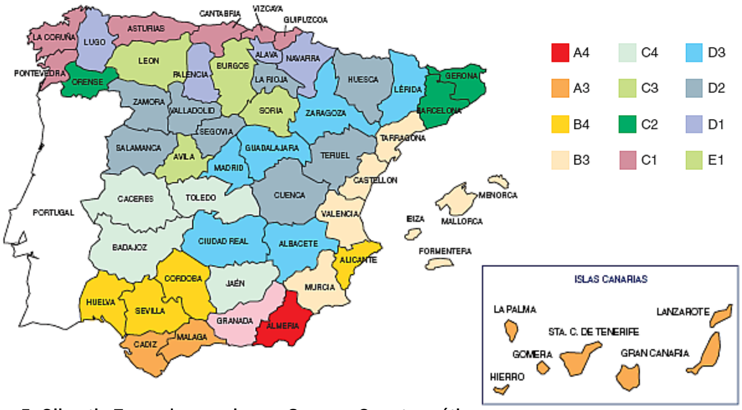
Table 1. Climatic severity of winter. Source: CTE

For summer, 4 different divisions are defined:

1	2	3	4
SCV ≤0,6	0,6 <SCV ≤0,9	0,9 <SCV ≤1,25	SCV>1,25

Tabla 2. Climatic severity of summer. Source: CTE

Combining the five divisions of winter with summer four would get 20 different areas, of which only 12 are possible.



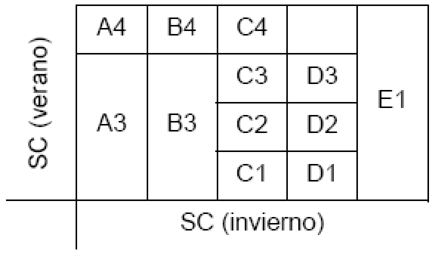
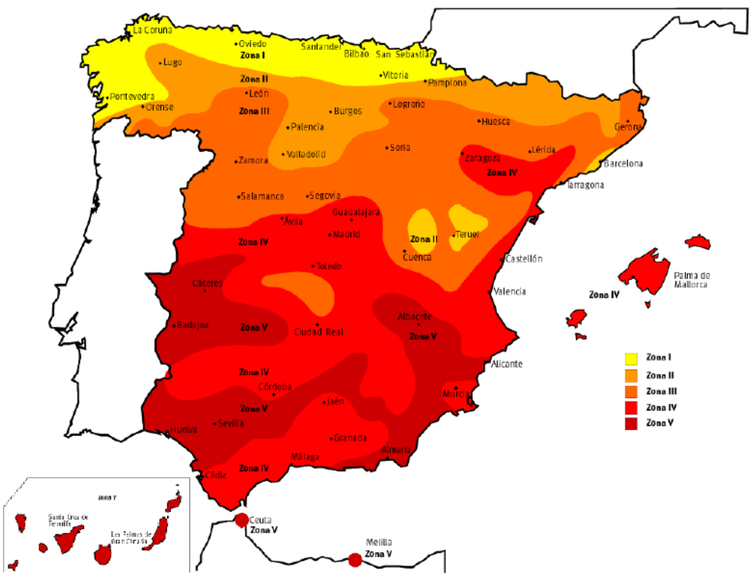


Figure 5. Climatic Zones by provinces. Source: Construmática

There is another climatic zone classification according to the annual solar radiation. A map with this classification is shown below:



Zone 1: H < 3.8

Zone 2: 3.8 ≤ H <4.2

Zone 3: 4.2 ≤ H < 4.6

Zone 4: 4.6 ≤ H<5.0

Zone 5: H ≥ 5.0

H is measured in kWh/m²

Figure.3 Spain CTE Climate zones. Source: INM. Generated from global annual solar radiation isolines on a horizontal surface.

Climatic zone	A3	A4	B3	B4	C1	C2	C3	C4	D1	D2	D3	E1	A3
Number of buildings	717.936	89.276	1.314.112	797.136	1.225.491	869.191	452.862	506.210	799.991	720.062	995.334	796.912	717.936
% of buildings	8%	1%	14%	9%	13%	9%	5%	5%	9%	8%	11%	9%	8%

Table 18. Number of existing buildings located in each climatic zone in 2001. Source: Own work

Requirements for existing buildings

Existing buildings have to comply with the same minimum requirements as new ones, when building retrofit, enlargement or renovation are carried out, the floor area exceeds 1.000 m^2, or more than 25 % of the building envelope undergoes renovation. As for new buildings, these requirements are mandatory as of September 17th 2006.

Certification of buildings

Certification is obligatory for new buildings when the application for a building permit was made to the Local Authorities after the 31st of October 2007. This applies to all types of buildings (residential, public, commercial etc.).

Certification of existing buildings is still in the process of administrative approval, with another relevant Royal Decree under way. As yet, it is not mandatory when selling or renting, but a ‘Basic procedure’ for the certification of existing buildings was expected to be ready and mandatory in 2011. As for the calculation of energy demands, the ‘National Basic Procedure’ for energy certification allows for two possible methods: a simplified method and a complex method. The latter requires the use of a software tool, there are currently four different official tools: CALENER, CERMA, CE2 y CES. Just some of the tools are available for certificating big tertiary sector buildings. All matters pertaining to the control, inspection and registration of the energy performance certificates of buildings are under the authority of Autonomous Communities Governments.

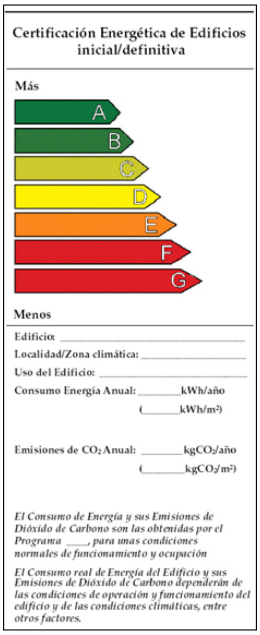


Figure 6. Energy certification label

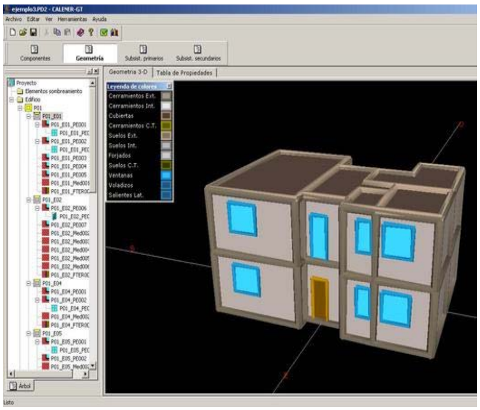


Figure 7. CALENER GT user interface

In this way, basic requirements for thermal systems and HVAC systems are defined at a national level by RITE. In it, inspection procedures and inspection deadlines are standardized. In addition, the Ministry of Industry, has already published 13 guidelines on inspection methodologies, developed a software insulation tool and created a ‘Subsidy Line’ for regular energy efficiency inspections. As in the case of the Energy Performance Certificates for buildings, RITE is put into practice by the Autonomous Communities Government administrations. They have the authority to strengthen the national basic requirements for inspections of boilers and HVAC systems (the full installation must be inspected) and are in charge of its practical implementation and data collection. Thus, the Autonomous Communities governments are in charge of the ‘practical implementation’.

IVE in collaboration with other entities, has developed one of the official tools that could be used for the aplication of new buildings certification.

CERMA is an HOURLY SIMULATION TOOL that takes 5 seconds to do the calculation based on presimulated thermal components. The model definition is non geometrical. It is devised for certification of new residential buildings. Features: It assigns fossile CO2 emissions to all the architectural components of the building, just to discover which is producing problems thus allowing the fixing of the problem. It makes a parametric study (in 30 seconds, 48 runs) on actions on the architecture to reduce the emissions (improve the letter) - i.e. increase de isolation 1cm, 2cm, 3cm, etc...- and on actions regarding the systems -i.e. changing for a condensing boiler, using a better heat pump, etc.

In addition, IVE has also worked in a version for existing buildings: CERMA R.

The most important is that it is a simple tool for the technicians to understand the energy performance of the building.

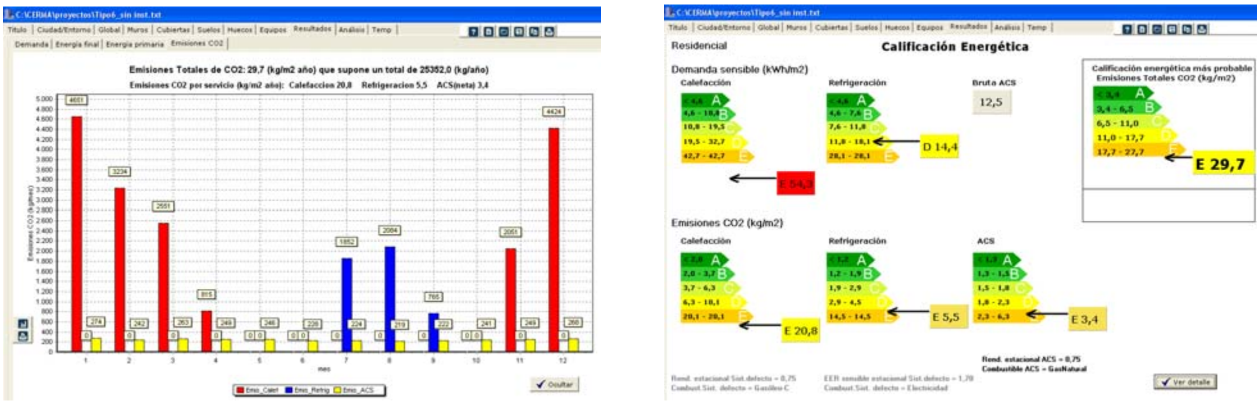


Figure 8. CERMA user interface

Legislation information

Official texts and software tools are available on the national websites:

› http://www.codigotecnico.org
› http://www.mityc.es/Desarrollo/Seccion/EficienciaEnergetica/CertificacionEnergetica/
› http://www.mityc.es/Desarrollo/Seccion/EficienciaEnergetica/RITE/
›http://www.mityc.es/energia/desarrollo/EficienciaEnergetica/CertificacionEnergetica/DocumentosReconocidos/Paginas/documentosreconocidos.aspx

3. Building typologies characterization

Level of current study

In relation to the typological characterization of the housing stock in Spain, there has been no too much detailed studies that includes the entire Spanish territory. As explained above, Spain is divided into autonomous regions that enjoy some autonomy. For this reason, studies carried out in typology characterization field usually are autonomous, i.e. encompassing only one Autonomous Community, not the country as a whole. The climate variety of Spanish territory also influences because the types are not exactly the same in the hall country, specially if you compare the south with the north. The differences in building typologies are more pronounced in the rural architecture, but not so much in the multifamily buildings. Although a typological characterization with real data about the volume of buildings that are currently of each typology has not been made, an approximation of possible typologies has been carried out in two different projects: Retrofit (Intelligent Energy) and Rehenergía (Spanish Ministry of housing). In terms of legislation, a new Technical Code on Retrofiting is developing, equivalent to the one in force in new buildings, but in terms of existing buildings. It aims to delve into the typologies of the building stock. The Valencia Institute of building is collaborating in the development of this publication.

Current Spanish typology studies: Rehenergía project

Rehenergia Project was a study to assess the existing building retrofit from an energy standpoint carried out in order to asses energy retrofit policies. It is an initiative promoted by the Institut Cerdá, along with various public and private institutions from different regions, including Comunidad Valenciana. The results of simulations carried out in 1730 buildings reflect very positive results: with a correct energy retofit we could achieve reductions in CO^2 emissions from 10 to 30% and energy savings from 5 to 20%, which can be equivalent to cost savings from 500 to 2000 € in the energy bill of each apartment building.

To accomplish the objective of the project was necessary to know the building housing stock. The definition of the building stock was based on the characterization of building both from the architectural point of view as existing facilities. Characterize all existing buildings was found impossible, so the most representative types were reflected in order to expedite the study and allow replication of results.
The criteria from which the types of building were established, responded to factors that can influence the energy demand of residential buildings as well as parameters that must be known to calculate the claim. There were established nine type buildings. The characterization of the type buildings was carried out by defining the components of the building envelope and their facilities.

Figure 9. Building typologies characterization. Rehenergía Project. Institut Cerdá

The materials of the facade vary by region and period construction of buildings, and with them their thermal behaviour. The most representative facades were established:

- F1: stone masonry
- F2: brick factory
- F3: cavity wall made of perforated or hollow brick
- F4: cavity wall made of perforated or hollow brick with thermal insulation in the cavity
- F5: concrete blocks
- F6: Precast concrete panels

The thermal transmittance constructive front sections considered were:

Sección fachada	Composición	U (W/m²K)
F11	Mampostería de piedra granítica	2.22
F12	Mampostería de piedra calcárea	1.98
F21	Ladrillo macizo	1.75
F31	Ladrillo perforado, cámara de aire y tabique cerámico	1.58
F32	Ladrillo hueco, cámara de aire y tabique cerámico	1.41
F41	Ladrillo perforado, cámara de aire, aislante térmico y tabique cerámico	0.63
F42	Ladrillo perforado, cámara de aire, aislante térmico y tabique cerámico	0.60
F51	Bloques de hormigón	1.52
F61	Paneles prefabricado de hormigón tipo sandwich (aislante incorporado)	0.43

Table 19 Façade U values. Rehenergía Project. Institut Cerdá

As in facades, in the project were established different types of roofing:

Heavy roofs:
C11. No isolated
C12. Isolated
C13. Ventilated with partition walls (only in the case of flat roof)

Light roofs:
C21. No isolated
C22. Isolated (only in the case of pitched roof)

The thermal transmittance of roofs were:

Sección fachada	Composición	U (W/m2K)
C11	Pesada y no aislada	0.68
C12	Pesada y aislada	0.34
C13	Pesada y ventilada	1.74
C23	Ligera y ventilada	1.94
C22	Ligera y aislada	0.49
Ci21	Inclinada, ligera y no aislada	1.7
Ci22	Inclinada, ligera y aislada	0.49

Table 20. Roofing U values. Rehenergía Project. Institut Cerdá

In the project they also performed the characterization of the doors and windows.

The result of the characterization is an array of building types:

<table>
<tr><th rowspan="3">Disposición del edificio</th><th rowspan="3" colspan="2">Forma arquitectónica básica</th><th colspan="5">Factores variables</th></tr>
<tr><th rowspan="2">Sección constructiva fachada</th><th rowspan="2">Sección constructiva cubierta</th><th colspan="3">Aperturas</th></tr>
<tr><th>Vidrio</th><th>Marco</th><th>Elementos exteriores</th></tr>
<tr><td rowspan="10">Entre Medianeras</td><td rowspan="10">Bajo (PB + 2)</td><td rowspan="10">T5</td><td>Mampostería de piedra granito F11</td><td rowspan="2">Ligera ventilada C23</td><td rowspan="10">Simple</td><td rowspan="4">Madera</td><td rowspan="4">Persiana madera</td></tr>
<tr><td>Mampostería de piedra calcárea F11</td></tr>
<tr><td rowspan="2">Fábrica de ladrillo macizo F21</td><td>C23</td></tr>
<tr><td>Pesada ventilada C13</td></tr>
<tr><td>Fábrica ladrillo hueco, cámara de aire, tabique cerámico F31</td><td rowspan="2">Pesada no aislada C11</td><td rowspan="6">Metálico sin rotura de puente térmico</td><td rowspan="6">Persiana blanca</td></tr>
<tr><td>Fábrica ladrillo hueco, cámara de aire, tabique cerámico F32</td></tr>
<tr><td>F31</td><td rowspan="2">C13</td></tr>
<tr><td>F32</td></tr>
<tr><td>Fábrica ladrillo perforado, cámara de aire, aislante térmico, tabique cerámico F41</td><td rowspan="2">Pesada aislada C12</td></tr>
<tr><td>Fábrica ladrillo hueco, cámara de aire, aislante térmico, tabique cerámico F42</td></tr>
</table>

Table 21. Building types characterization. Rehenergía Project. Institut Cerdá

The characterization of the facilities was focused on defining equipment and energy sources for heating, cooling, DHW and lighting of common areas. The characterization has been developed based on:

- Availability of facilities in the building stock
- Facility Type
- Type of equipment
- Energy source used

Current Spanish typology studies: Retrofit Project

Retrofit is an Intelligent Energy project carried out from January 2006 to December 2007. The aim of this project was to develop a web-based tool-kit for passive house retrofitting applied to social housing.

MAIN ACHIEVEMENTS

The main goals achieved in this project were:

- The web-tool is made for each of the 14 countries of: Austria-Belgium-Czech Republic-Denmark-Germany-France-Italy-Lithuania-Luxembourg-Portugal-Slovenia-Spain-The Netherlands-United Kingdom.
- For each country are described typical residential building categories.
- Typical energy saving measures, energy savings and economic feasibility are described passive house retrofitting "packet solutions" for each building category.
- When using the web-tool make evaluation of how similar your building is to the chosen building category of the webtool.

The web-tool can be seen on: www.energieinstitut.at/retrofit

NATIONAL BUILDING TYPES: SPAIN

The typologies outlined in the table below show building types used in the Retrofit project. Typical examples are given for three building types (big multifamily house, small multifamily house, terrace house) and for three periods of construction (before 1960, from 1960 to 1979 and after 1970).
In the project, they specified that, as outer appearance and floor plan may vary as well as the construction used, for each type a range of typical energy need for heating and cooling and delivered energy need is given.
They also say that as requirements concerning the energetic quality of Spanish buildings are regulated by the national building code, in each period, the same building type will have a different energetic quality.

	Big multifamily house	Small multifamily house (4storeys)	terrace house
- 1960	 1960 typical Multifamily house >4 storeis, compact	 1960 typical Multifamily house <=4 storeis, compact	 1960 typical terrace house, compact
1960 - 1979	 1960-1979 typical Multifamily house >4 storeis, compact	 1960-1979 typical Multifamily house <=4 storeis, compact	 1960-1979 typical terrace house, compact
1979 -	 1979 typical Multifamily house >4 storeis, compact	 1979 typical Multifamily house <=4 storeis, compact	 1979 typical terrace house, compact

Table 22. National Building Types. Retrofit project

THE OVERALL METHODOLOGY OF THE TOOL-KIT

The overall methodology of the tool-kit is to use a typology of buildings as the "entrance" into the "operative part" of the tool-kit. Passive House Retrofitting measures, energy and economy calculations and results are related specifically to the building category chosen.

When the right building category of the tool-kit has been identified, the tool-kit gives information on:

- Actual state
- Energy savings
- PHR-Measures
- Energy costs and incomplete PHR
- Summary

CONCLUSIONS

The conclusions with regard to Spain were:

> «For both energy savings for heating and cooling and for energy costs the oldest buildings included have the highest potential for savings due to bad energy standard before retrofitting.
> The poorest result on both energy savings for heating and cooling and for energy costs reductions is for more new compact buildings.»

EXAMPLE

Current state

Información general:

región	Andalucía
características, breve descripción	1960-1979 Bloque grande típico de más de 4 plantas, compacto
Periodo de construcción	1960 - 1979
Número de plantas	5-12
Número de viviendas	12-48
volumen	6000 - 14400 m³
Área climatizada	2000 - 4800 m²
ratio superficie/volumen	0.30 - 0.60

Elementos del edificio

muro exterior	1.37 W/(m²K)
tejado	2.10 W/(m²K)
suelo	2.06 W/(m²K)
ventana	5.7 W/(m²K)
ventilación	Sin sistema de ventilación nocturna
paneles solares	Sin captadores solares para ACS
protección solar	Sin protecciones solares en ventanas

Sistema de calefacción

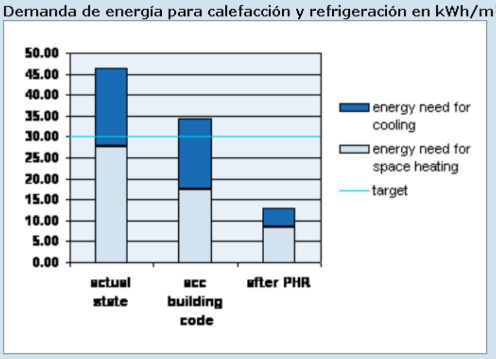
Tipo de generador de calor	Caldera, antigua y con mantenimiento pésimo
Eficiencia del sistema de calefacción	60% rendimiento anual

demanda de energía

demanda de energía (calefacción)	20 - 40 kWh/m²a 76800 - 153600 kWh/a
demanda de energía (refrigeración)	10 - 25 kWh/m²a

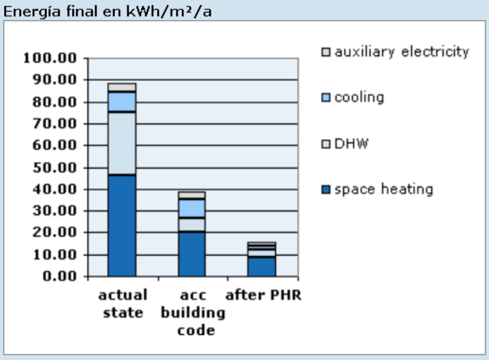
Energy Saving

Demanda de energía para calefacción y refrigeración en kWh/m²/a



Realizando una rehabilitación del edificio de acuerdo al código técnico de la edificación, la demanda total actual de 46 kWh/m2a se reduce hasta 33 kWh/m2a. Si la rehabilitación se lleva a cabo de acuerdo a los estándares del PHR, la demanda puede reducirse incluso hasta 13 kWh/m2a.

Energía final en kWh/m²/a



Realizando una rehabilitación del edificio de acuerdo al código técnico de la edificación, el consumo de energía final actual de 89 kWh/m2a se reduce hasta 39 kWh/m2a. Si la rehabilitación se lleva a cabo de acuerdo a los estándares del PHR, el consumo de energía final puede reducirse incluso hasta 16 kWh/m2a.

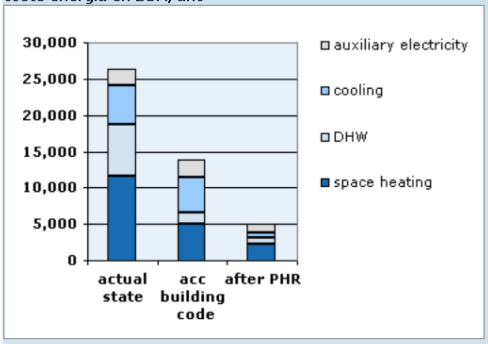
Mesures

Después del PHR

elemento del edificio	valor	esquema	descripción
muro exterior	U = 0.27 W/m2K		12 cm of brick (lambda 1.03), 1.0 cm of cement, 5 cm of air chamber, 5 cm hollow brick (lamda 0.23), 1cm plaster, 10cm external insulation (lambda 0.037)
ventana	U = 1.4 W/m2K		Double glazing U = 1.4 W/(m²K) and g-value 0.7
paneles solares	Cobertura solar: 80%		Captadores solares
calefacción y ACS	95% rendimiento anual		Caldera de alto rendimiento
protección solar - medidas sencillas	Factor solar para verano: 0.25 en ventanas con orientación sur, oeste y este		Toldos en ventanas con orientación sur, oeste y este
protección solar - ventilación nocturna	Más de 4 ren/h		Sistema de ventilación nocturna. Mas de 4 ren/h durante las noches de verano
protección solar - sistemas activos de refrigeración	COP=3.5		Sistema split de aire acondicionado

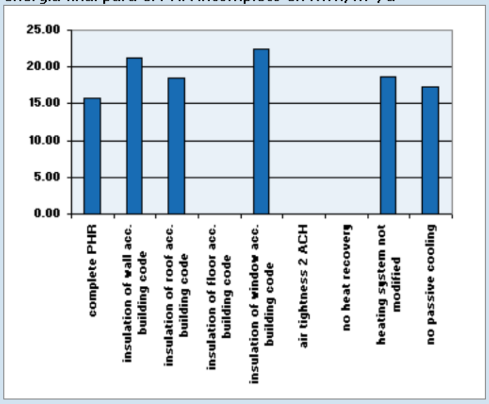
Energy Cost and incomplete PHR

coste energía en EUR/año



La factura energética actual de 26385 EUR/año puede reducirse hasta 13801 EUR/año para una rehabilitación térmica acorde al código técnico de la edificación. Si la rehabilitación se lleva a cabo de acuerdo a los estándares del PHR, la factura energética puede reducirse incluso hasta 5020 EUR/año.

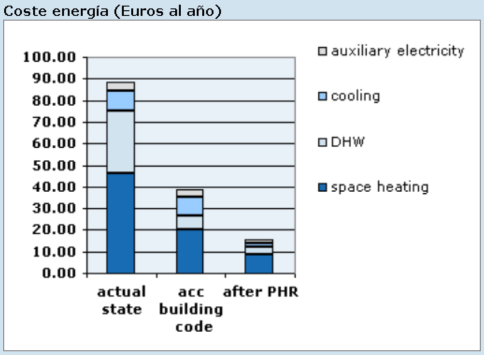
energía final para el PHR incompleto en kWh/m²/a



Si una medida de rehabilitación concreta no puede realizarse por razones técnicas o de cualquier otro tipo, no podrá alcanzarse el potencial de ahorro máximo del estándar del PHR. De esta manera, si el consumo de energía final para un PHR completo es de 15 kWh/m2/a, cuando se realizan todas las medidas de ahorro exepto una, el consumo de energía final varía entre 17 to 23 kWh/m2a.

Summary

Coste energía (Euros al año)



Realizando una rehabilitación completa según los estándares del PHR, el consumo de energía final puede ser reducido de 89 to 16 kWh/m²a. Ese mismo edificio rehabilitado de acuerdo al código técnico de la edificación tiene un consumo de energía final de 39 kWh/m²a.
Realizando una rehabilitación completa según los estándares del PHR, la factura energética total del edificio se reduce de 26385 EUR/a to 5020 EUR/a, teniendo en cuenta los precios actuales de la energía. Si consideramos que el precio de la energía aumentará en el futuro, los ahorros serán incluso mayores.
El periodo de retorno de la inversión está en torno a los 15 años, pero puede reducirse en algunos casos si consideramos incentivos.
El confort térmico se mejora sustancialmente, incluso a estándares mejores que los de viviendas de nueva construcción, lo cual mejora la calidad de vida.
Incluso si en el proyecto no pueden desarrollarse todas las medidas, pueden alcanzarse importantes ahorros energéticos.

Siguiente paso

La información suministrada aquí esta basada en datos con carácter general. Para su proyecto específico, por favor, contacte con una empresa consultoría/arquitectura especialista con conocimientos en rehabilitaciones de edificios con los estándares del Pasive House Renovation.

Current Spanish legislation proposes[2]

A new Technical Code on Retrofitting is being developed by the Ministry of Housing, equivalent to the one in force in new buildings, but in terms of existing buildings. It aims to delve into the typologies of the building stock. The Valencia Institute of building is collaborating in the development of this publication.

OBJECTIVES

- To contribute to the clarification of the limits and conditions for implementation of the CTE in retrofitting to avoid legal uncertainty
- To promote the improvement of the quality of retroftiting outcomes by facilitating compliance of current regulations.

[2] Information extracted from the conference “Políticas de intervención en edificios existentes: La adecuación del CTE a la rehabilitación” http://jornadarehabilitacion.wordpress.com/

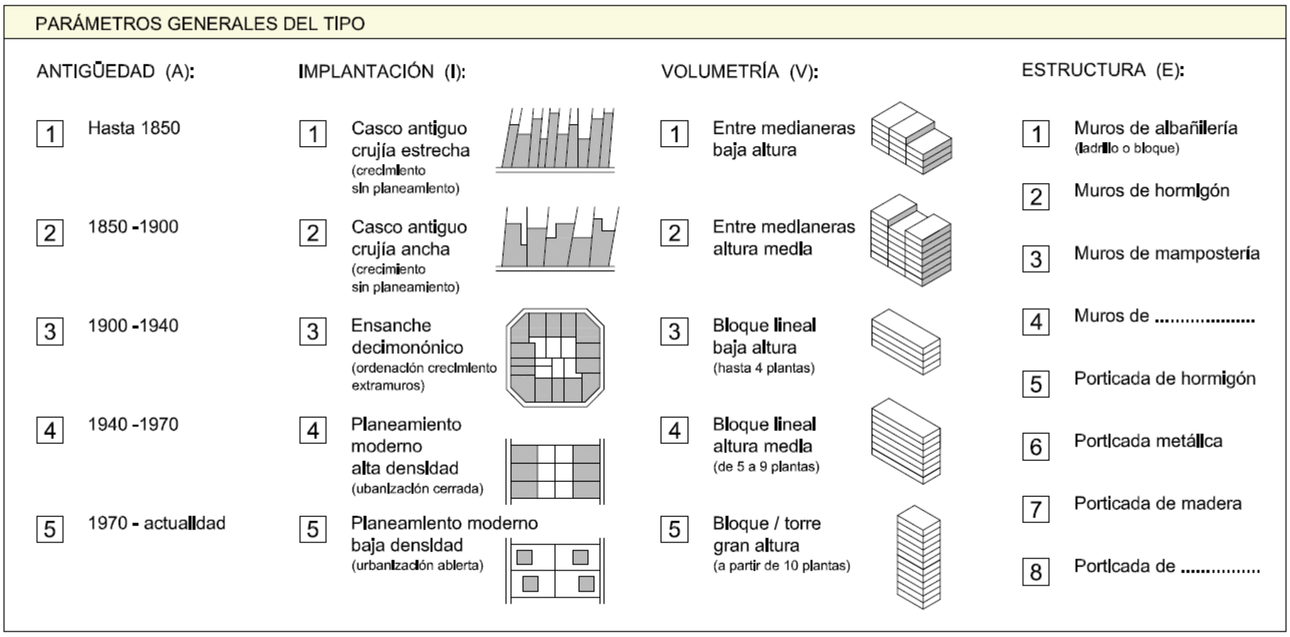
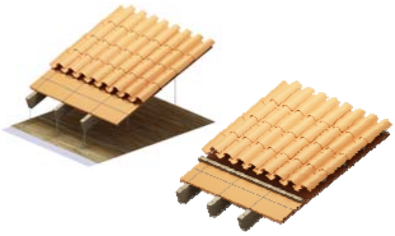
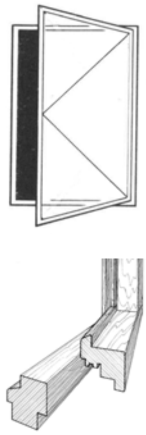
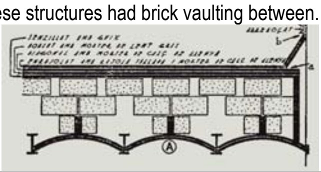
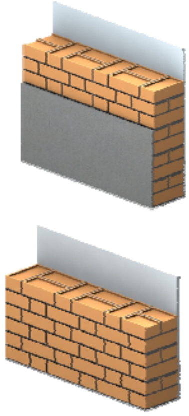
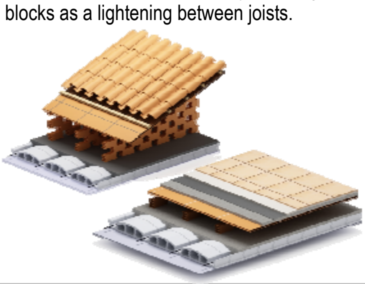
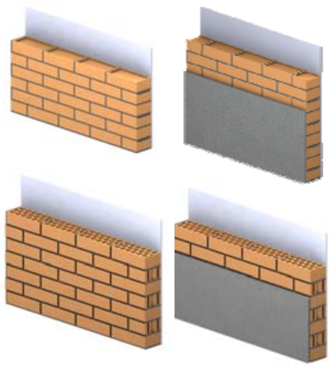
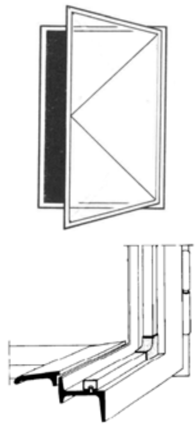
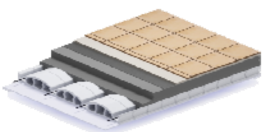
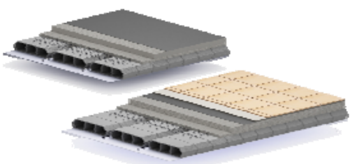
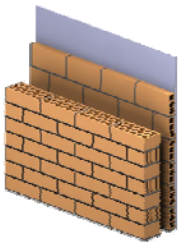
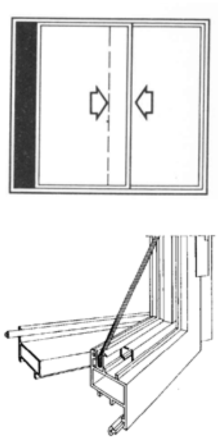
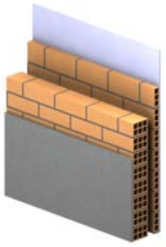


Figure 10. Building Typology characterization.

Of all the possibilities of the previous table, twenty options have been chosen. An example developed by the IVE is showed below:

IVE typologies characterization work

The Valencia Institute of Building from Comunidad Valenciana is working on retorfit guides for inspection and intervention. During the course of this research characterize the constructive components by periods has been necessary. Each component have been assigned a U value to permit an energy evaluation and thus to study the best energy saving measures. The table below shows a summary of the work carried out by IVE in this field:

YEAR	ROOFING		EXTERIOR WALLS		WINDOWS			
	Type	U W/m²K	Type	U W/m²K	Type	U glass W/m²K	U Frame W/m²K	g⊥
1900	In the early twentieth century the most common pitched roofs were a set of wooden trusses which supported one or more ceramic pieces layers, as support for the tiles. Often the attic space was closed with a straw ceiling covered with plaster to create a ventilated chamber. 	4,17	In the early twentieth century, especially in buildings of short height and in small towns, the load-bearing walls of stone are still been used, either limestone or granite. 	2,63	Wooden swing windows with monolithic glass.  When the metalwork window appeared, they came to be used in the main facade, placing the wooden windows in the courtyards facades.	5,7	2,2	0,80 - 0,85
	In the early twentieth century, the most common solution of flat roofs were the ventilated flat roofs generated by brick partitions. This brick partitions had hollows to permit ventilation and they were leaned on metal or wood structures. These structures had brick vaulting between. 	3,08	Although in Europe framed structures have been introduced, in Spain, the load-bearing walls are still in use until the 1940s. The facade usually consisted in a single wall of brick of a foot or a foot and a half, either coated or uncoated. The slab was supported by the entire sheet thickness. Sometimes a thin brick wall was built as an interior skin. 	2,63				
1940	After the reinforced concrete framed structures proliferation, the brick partitions of the ventilated flat or pitched roofs now lean on unidirectional slabs. These slabs had mostly plaster joist infill blocks as a lightening between joists. 	1,67	From 1940 framed structures are begun to be used, usually of reinforced concrete, with lights of 3-4 meters. From the sixties these structures were the most common. The facade is released from its structural function, so in most cases the thickness of the facade was reduced to half a foot of solid or perforated bricks. The slabs were supported by big beams in which the factory fully rested. There was no movement joints between structural components and facades which has caused numerous cracks and fissures in the brick walls. 	3,03	Folding steel window with monolithic glass. 	5,7	5,7	0,80 - 0,85
	In the forties, the advent of lightweight concrete, allowed the introduction of an insulating body which replaced in many cases the air chambers in flat roofs. The roof becomes a single sheet multi-layer: slab, concrete slope, waterproofing and protection. 	1,37						
1960	In the sixties, coinciding with the development of waterproofing, flat roof extends to populations with a tradition of pitched roof. The ceramic joist infill blocks take greater prominence to the time the concrete ones start to enter in the market. 	1,92	In the sixties the framed structures grow in height and raise the lights to 4-5 m. A hollow brick inner sheet is added to the existing brick wall, leaving a cavity in the middle. With the entry into force of the Standard NBE-CT-79 thermal insulating are into the air chambers. 	1,43	Aluminum sliding window with monolith glass. 	5,7	5,7	0,80 - 0,85
1980	Ventilated roofs are still used frequently. NBE-CT-79 Standard entry into force in 1979 and insulation begins to be putted in the air chambers of the ventilated roofs and under the pavement of non-ventilated roofs. 	2,33	The cheapest alternative to perforated brick was used in the outer sheet: a half foot hole brick wall covered and painted. In many buildings, combining both options. 	1,33				

4. Valencia Institute of building work: Comprehensive system of procedures for the Energy Assessment of existing buildings

The reason for energy evaluation procedures

Refurbishment guides for inspection and intervention are needed by the current stock of residential buildings for several reasons. Some of these are:

- In Spain, between the 50s and the 80s housing construction underwent an unprecedented growth. A considerable percentage of the total number of buildings were constructed throughout this period, without the support of innovative technical regulations in the field of sustainability. Besides, the almost complete absence of inspection and maintenance over those buildings lifespan has worsened their conservation state. This situation in Spain and in other European countries has led to excessive energy consumption and a progressive increase in CO_2 emissions.

- The existing technical regulations only focus on new building, so they can not be applied to building refurbishment. The technicians' intervention, dealing with refurbishment, must be contrasted with, not only their personal experience, but also with documents or systems which, with knowledge contribution and experiences, will guide and orient them objectively.

- Homogenize intervention criteria and benchmarking. Its absence causes that the Assessments and interventions proposed for the same building can be very different causing distrust of public and private developers.

- The need for technical reference to support refurbishment policies carried out by different authorities. The use of a reference procedure enables a continuous improvement, simplifying and making its application more efficient.

In this context arises a whole system of procedures for Energy Assessment of existing buildings, to analyse both the current state and the improved status of the building after refurbishment. This comprehensive energy assessment system includes documents and tools explained in the following pages.

IVE energy assesment procedures

To evaluate the current state of an inspected building, the IVE has developed the following procedures:

ICE
INFORME DE CONSERVACIÓN Y EVALUACIÓN ENERGÉTICA

CONSERVATION REPORT AND ENERGY ASSESSMENT

This report is based on a preliminary inspection of the existing building, which purpose is not only to achieve an understanding of the overall maintenance status of the building but also to carry out an energy assessment. It is a technical document designed to achieve an understanding of the overall maintenance status of the building on its security, functionality and energy efficiency aspects and analyzing deficiencies in order to adopt the necessary measures and priorities for action at a future refurbishment. The registry of the maintenance status of Buildings enables recording of the current state of existing buildings and provides a management system to establish the best criteria for the adaptation and rehabilitation of buildings.

CONSTRUCTIVE COMPONENTS CATALOG FOR BUILDING RENOVATION

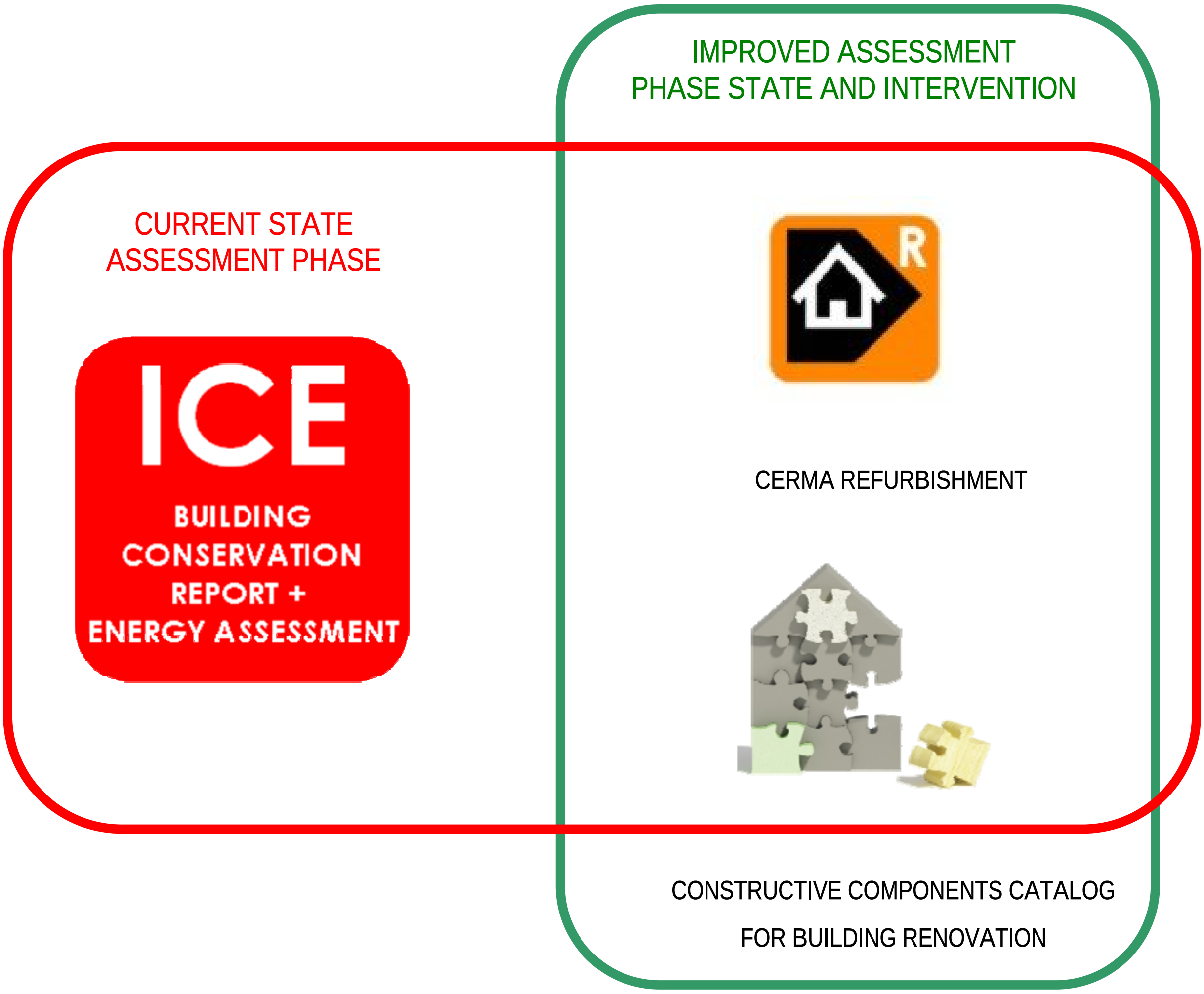
The Constructive solutions Catalog of energy building renovation arises as a tool to help engineers to deal with building renovations. In order to propose actions to improve existing buildings it is necessary to become familiar with the constructive solutions used in the past. In this regard, the catalog contains a wide range of constructive elements which make up the thermal envelope of buildings, used in building constructed in Spain from the 40s to the 80s. The catalog also includes typologies resulting from energy improvements of previous historic solutions, with information on the thermal performance achieved, including construction details and giving criteria for the selection of each proposed solution, not only from a technical point of view but also from an economic, and sustainability point of view.

CERMA REHABILITACIÓN

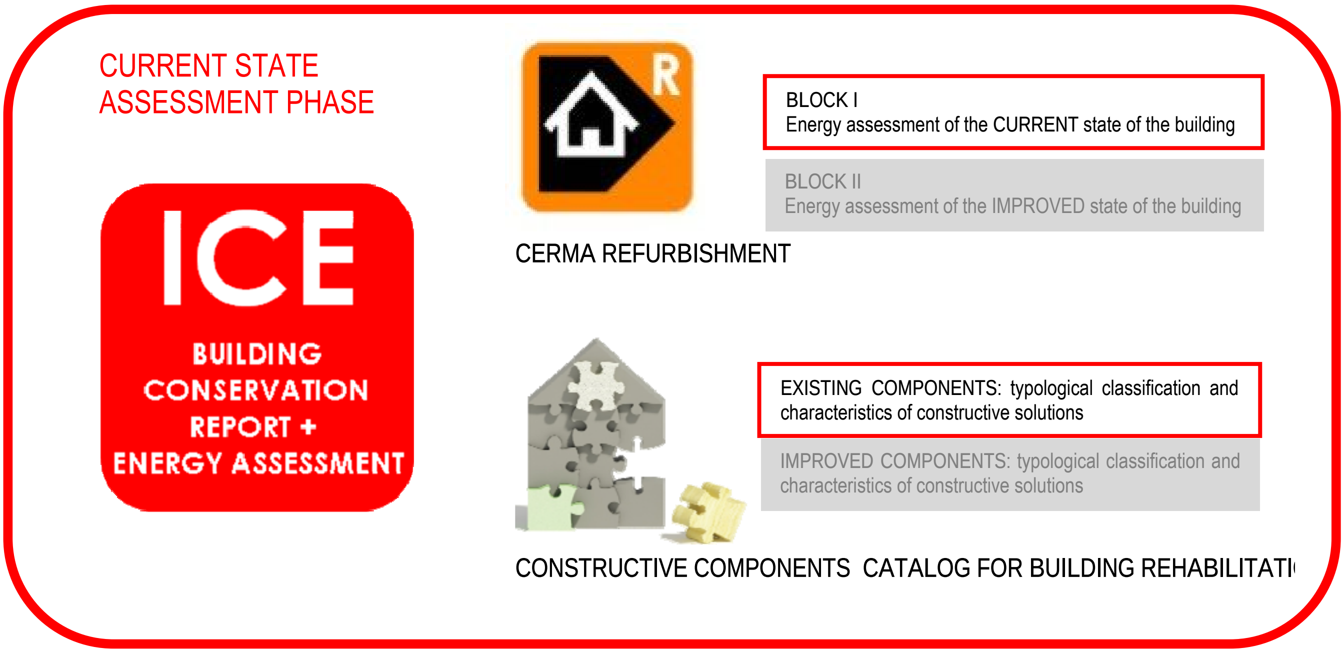
CERMA is an IT Tool which quantifies the energy demand and CO_2 emissions generated by the inspected building in its current state. The tool can guide the engineer/architect quantifying the future energy demand and future CO_2 emissions of a future envelope or systems intervention.

The final report issued by the tool is an aid for the engineers/ architects when they have to justify the intervention proposal for renovation works to be financed by the authorities.

IVE procedures within each of the phases of energy assessment



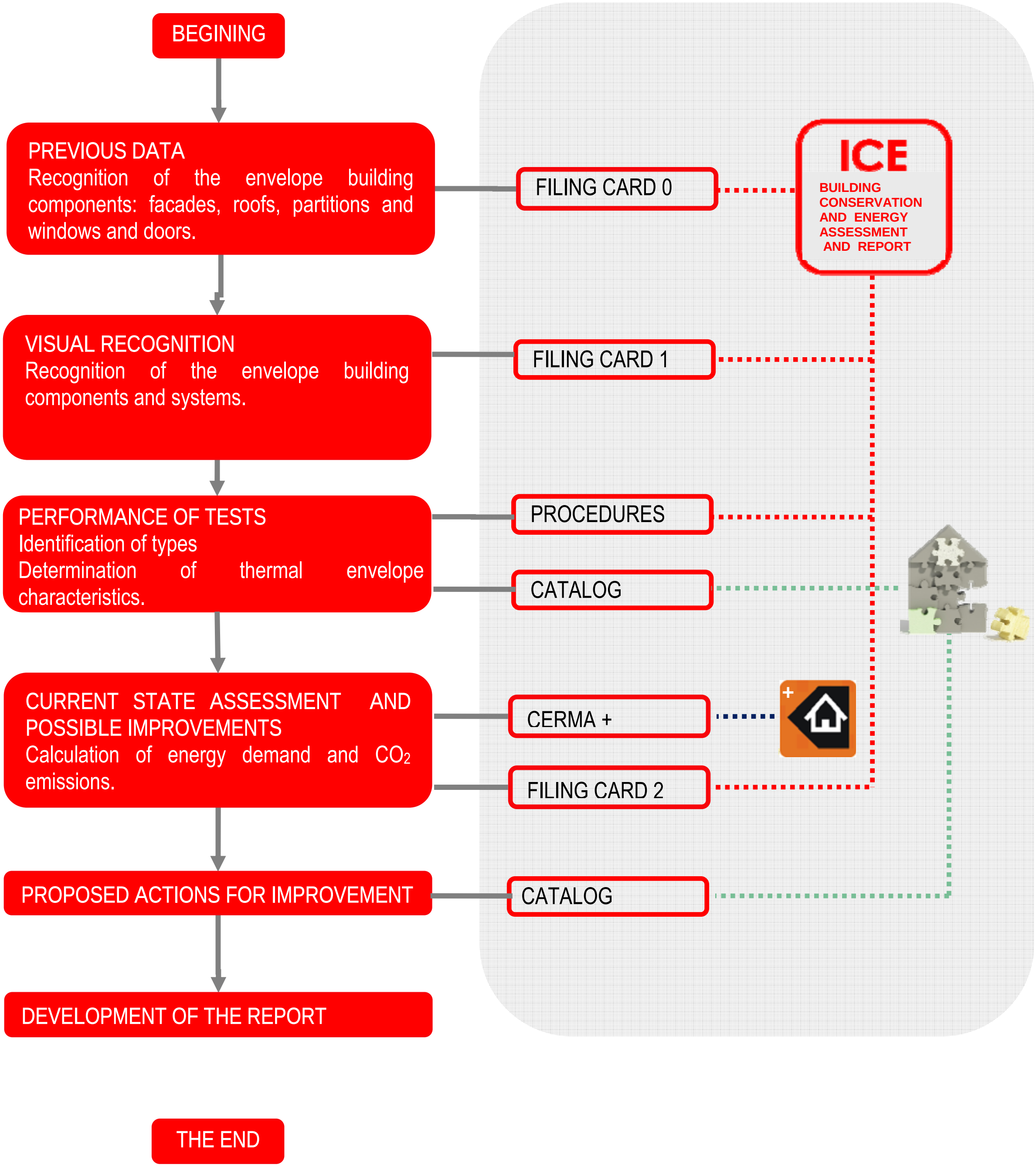
ICE report is a procedure which has integrated calculation engine CERMA + and constructive components catalog for building rehabilitation. Accordingly, the engineer/ architect performing an inspection just displays ICE's tool, but internally it works with two other procedures.



Conservation Report and Energy Assessment (ice)

OUTLINE OF THE PROCEDURE

APPENDICES AND APPLICATION ATTACHED



The "ICE" report includes a general guide, together with annexed user support, and a set of filing cards in a computer application. The filing cards are the following:

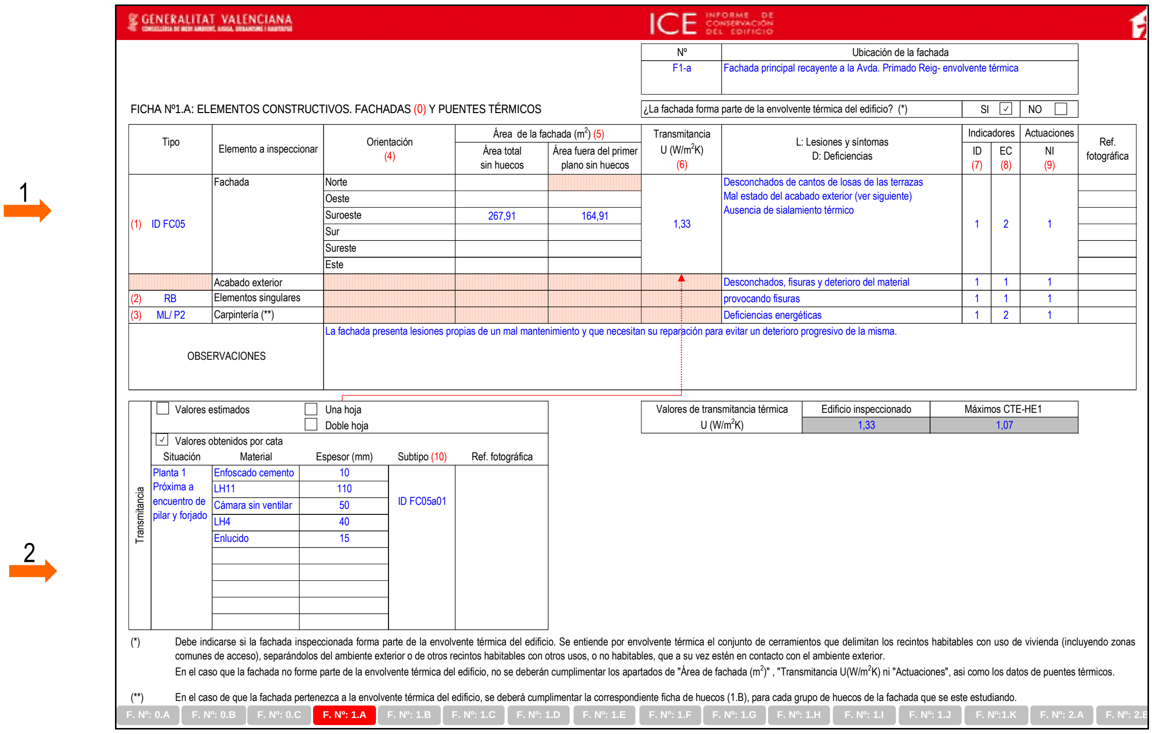
Filing card Nº 0: General information.
- Filing card Nº 0.A: General information. Graphic documentation
- Filing card Nº 0.B: General information. Administrative data
- Filing card Nº 0.C: General information. Building description

Filing card Nº 1: Inspection results
- Filing card Nº 1.A: Constructive elements. Facade
- Filing card Nº 1.B: Constructive elements. Windows and doors
- Filing card Nº 1.C: Constructive elements. Other walls
- Filing card Nº 1.D: Constructive elements. Roofs
- Filing card Nº 1.E: Constructive elements. Ceilings
- Filing card Nº 1.F: Constructive elements. Floors
- Filing card Nº 1.G: Constructive elements. Foundations and frame
- Filing card Nº 1.H: Systems. Water supply and drainage
- Filing card Nº 1.I: Systems. Electrical service
- Filing card Nº 1.J: Systems
- Filing card Nº 1.K: Common spaces. Accessibility

Filing card Nº 2: Inspection minutes
- Filing card Nº 2.A: Inspection minutes
- Filing card Nº2.B: Supporting certificate of energy savings in the renovation of existing buildings

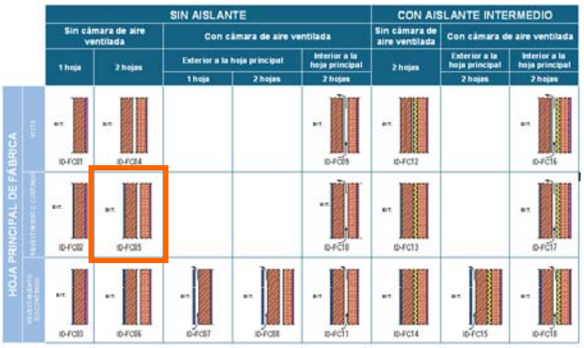
To carry out the report, first engineers/ architects must complete the "General information" of the building (Filing cards Nº 0), afterwards they will carry out the building inspection looking at the constructive solutions and systems (Filing cards N º 1).

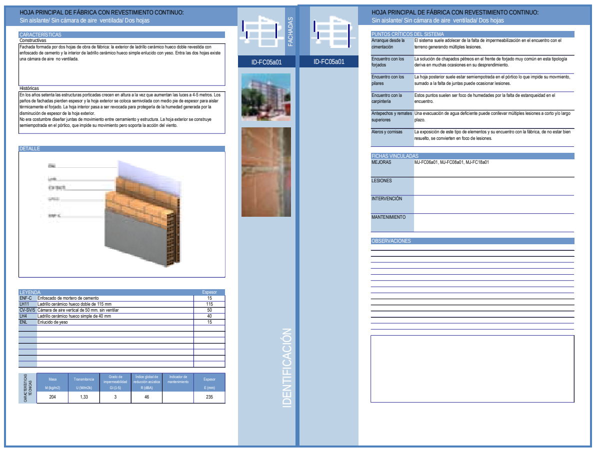
The Filing card Nº1A "Constructive elements. Facades" is presented as an example. In the example we can see how the Filing card interacts with the Constructive solutions catalog for building renovation.



From the "Constructive solutions catalog for building renovation" the engineer/ architect can choose the construction element typology under consideration, in this case, facades. The appropriate subtype can then be selected.

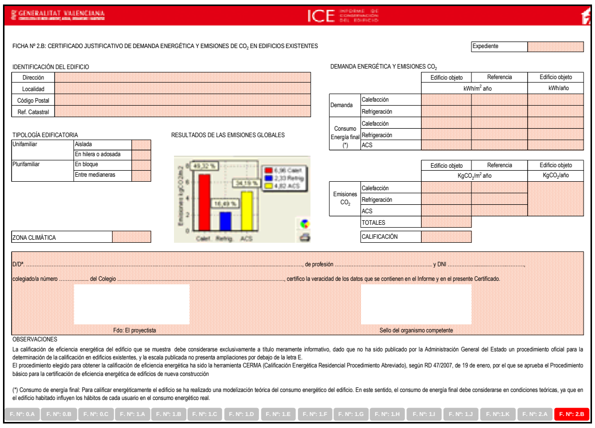
From the "Constructive solutions catalog for building renovation" the engineer/ architect can know the U value of the construction element, through the election of a subtype.



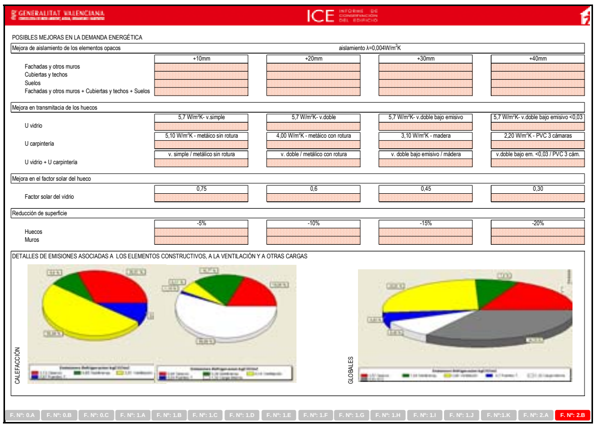


Once the initial inspection of the building has been completed by the engineer/ architect, the internal calculation engine CERMA+ will generate a supporting certificate of energy savings arising from the renovation of the building. It includes the following documents:

- Filing card Nº 2.A: Inspection minutes
- Filing card Nº2.B: Supporting certificate of energy savings in the renovation of existing buildings



Supporting certificate of energy savings



Possible improvements in energy demand

Constructive solutions catalog for building renovation

This document aims to provide information on two key areas within the field of energy refurbishment. On the one hand the characterization of building typologies of the elements that makes up the thermal envelope of buildings. To propose actions for improvement in existing buildings it is necessary to know how they were built in the past. On the other hand, to propose different solutions to improve the initial state of the building in the energy area.

The catalog also includes typologies resulting from energy improvements of previous historic solutions, with information on the thermal performance achieved, including construction details and giving criteria for the selection of each proposed solution, not only from a technical point of view but also economic, of execution and, of course, from the sustainability point of view.

This document has been developed, not only by consulting specific literature, but also builders and architects who worked in the period indicated have been interviewed. Official database containing information on building inspections and façade and roof renovation projects which are currently being developed has been consulted and analyzed.

The Constructive Solutions Catalog for Building Renovation is divided into two parts:

- PART 1: Typological classification of existing and improved building materials
- PART 2: Characteristics of existing and improved construction solutionsPART 1: TYPOLOGICAL

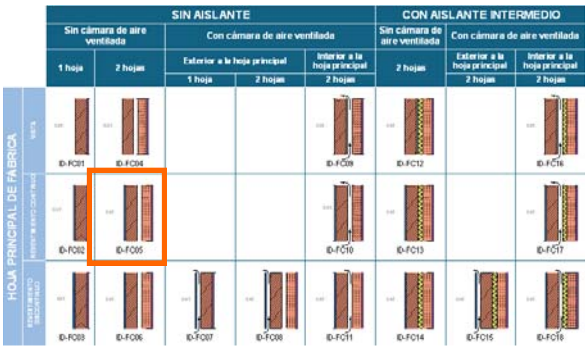
CLASSIFICATION OF EXISTING AND IMPROVED BUILDING MATERIALS

The first part is divided into different sections that correspond to the constructive components constituting the building thermal envelope, addressed in each of the following aspects:

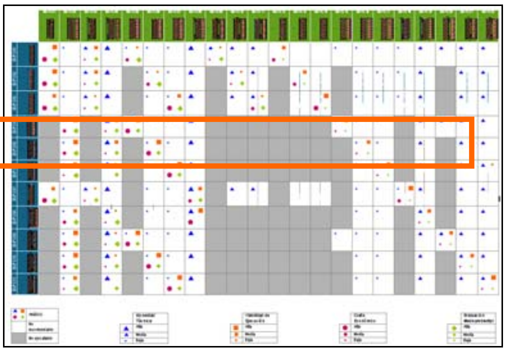
- Roofs
- Facades
- Windows and doors
- Partitions and dividing walls
- Floors

Historical review
Typological classification of pre-existing
Options for energy renovation
Typological classification of improvements
Technical specifications of the most common solutions

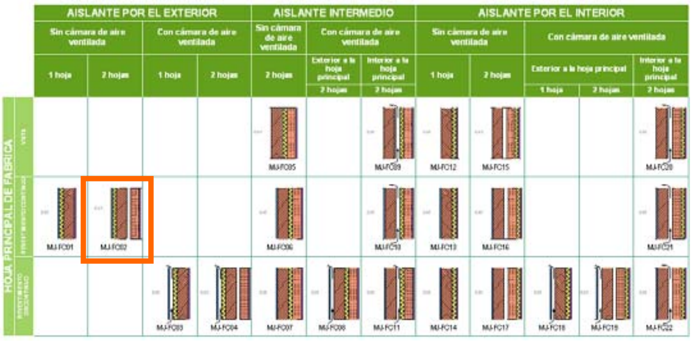
Historical review



Typological classification of pre-existing



Options for energy renovation



Typological classification of improvements

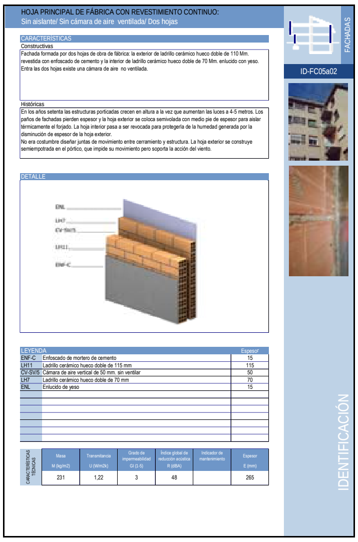
Pre-existing facade

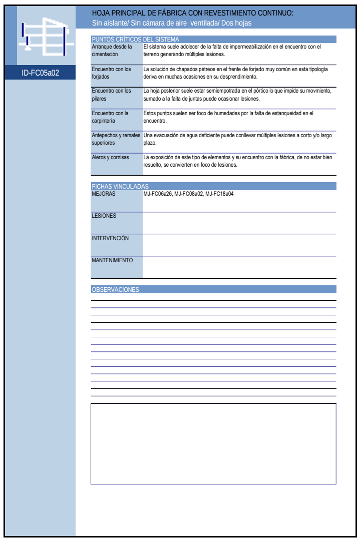
A proposal for an improved facade

Technical specifications of the most common solutions

PART 2: CHARACTERISTICS OF EXISTING AND IMPROVED CONSTRUCTION SOLUTIONS

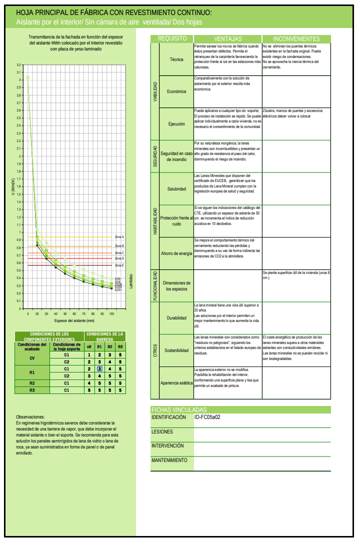
Part 2 of the catalog delves into the technical characteristics of the specific constructive solutions, corresponding to the preexisting constructive elements (Filing blue cards) and to the improved solutions (Filing green cards) proposed from the catalog





Technical characteristics of the constructive solution of an existing facade

The blue Filing cards contain information about the preexisting elements giving their technical characteristics, including, the U value. It also describes the critical points of the solution that may be conflicting in a future intervention.

Technical characteristics of the improved facade solution

The Filing cards associated with improvement solutions incorporate technical features depending on the thickness of insulation. They include a graph that allows the technician to determine the insulation thickness required for the regulations in force depending on the thermal characteristics of insulating itself. Green filing cards also provide advantages and disadvantages of proposed solutions from not only a technical point of view but also economic, implementation and, of course, from the sustainability point of view.

CERMA+ Simplified method for certification of existing residential buildings

The computer tool CERMA+ allows estimation of existing residential buildings energy qualification. The aim of CERMA is, through a simple process of entering data, to make a quick estimation of the Energy Efficiency Rating letter. The letter of the Energy Efficiency Rating is obtained using tools provided by the Ministry of Industry. CERMA+ provides users with better solutions to efficiently reduce the energy consumption of the building.

CERMA + is an advanced version of CERMA and it is adapted to existing buildings. Currently CERMA version for new buildings is being considered as a document recognized by the Ministry of Industry, Tourism and Trade.

Further information:

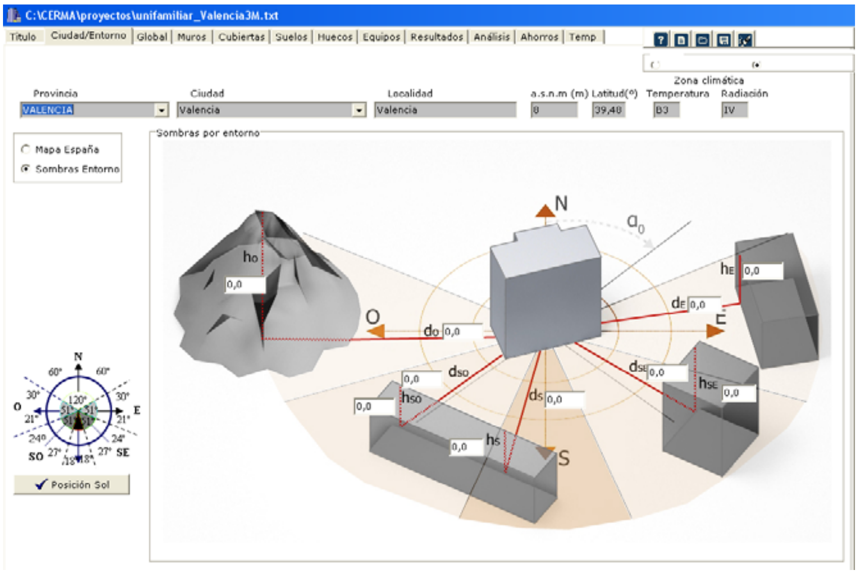
http://www.mityc.es/energia/desarrollo/EficienciaEnergetica/CertificacionEnergetica/propuestaNuevosReconocidos/Paginas/nuevos.aspx

CERMA can be found in the category of database tools. In the BUILDUP European platform to promote improved energy efficiency in EU Member States buildings:

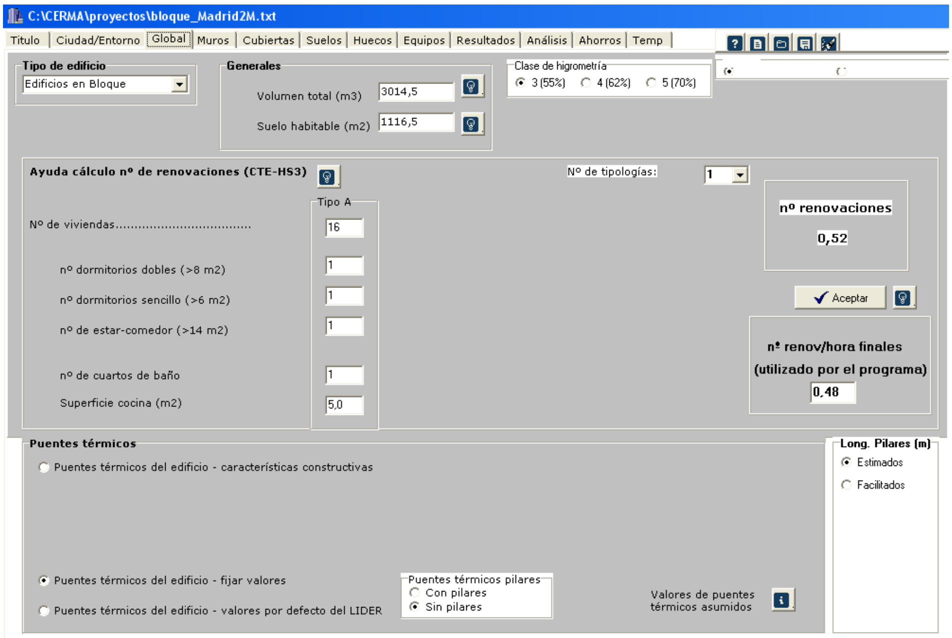
http://www.buildup.eu/tools/5794

ENTERING DATA

CERMA+ use easy data obtained from the drafting of the ICE report. The data used includes name, location, type of housing, renovations per hour and general aspects.

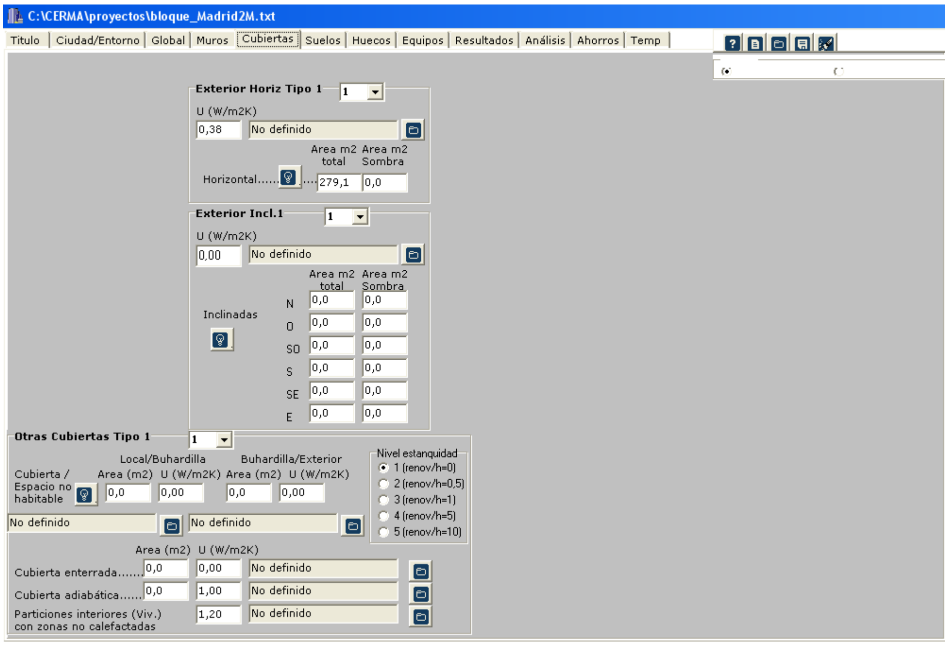


The figure shows the detail of the introduction remote objects that can cause shadows on the opaque part of the building. In a simple way with altitude and distance associated using the orientation, the program simulates the shadows throughout a year on the building under study.



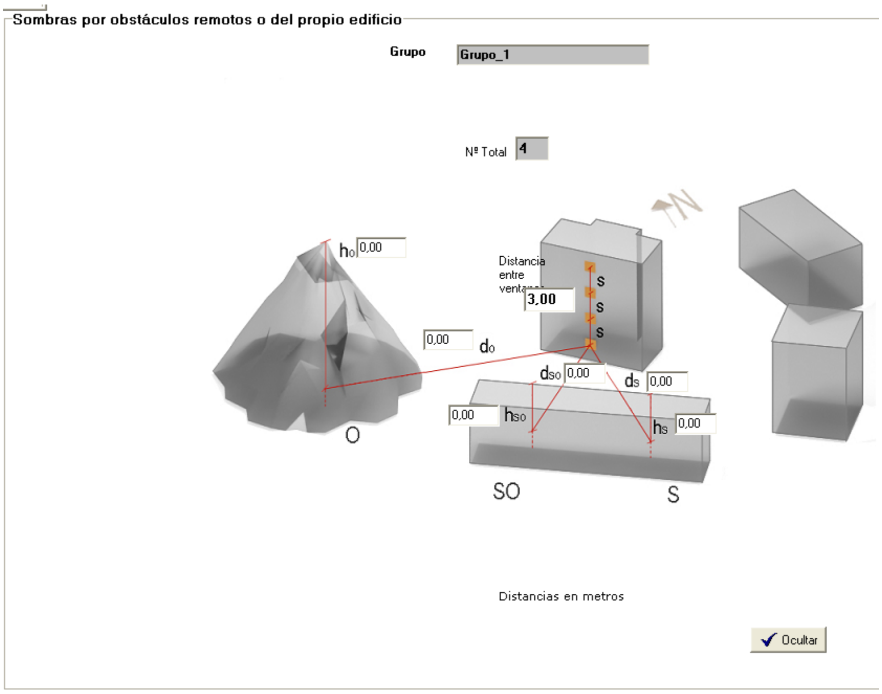
The General information screen has a simple inputting. Thermal bridges can be entered by default or according to the most detailed level of knowledge available on the building. For renovations / hour accepting the calculation according to the legislation in force, the program calculates automatically depending on the size and number of the rooms in the houses.

Regarding the definition of the geometry of the building, modelling the building is made from surfaces and orientations of the different walls that form the building envelope. CERMA+ takes this data from ICE report. The overall coefficient of heat transmission from the different constructive solutions in the "Constructive solutions catalog for building renovation ":



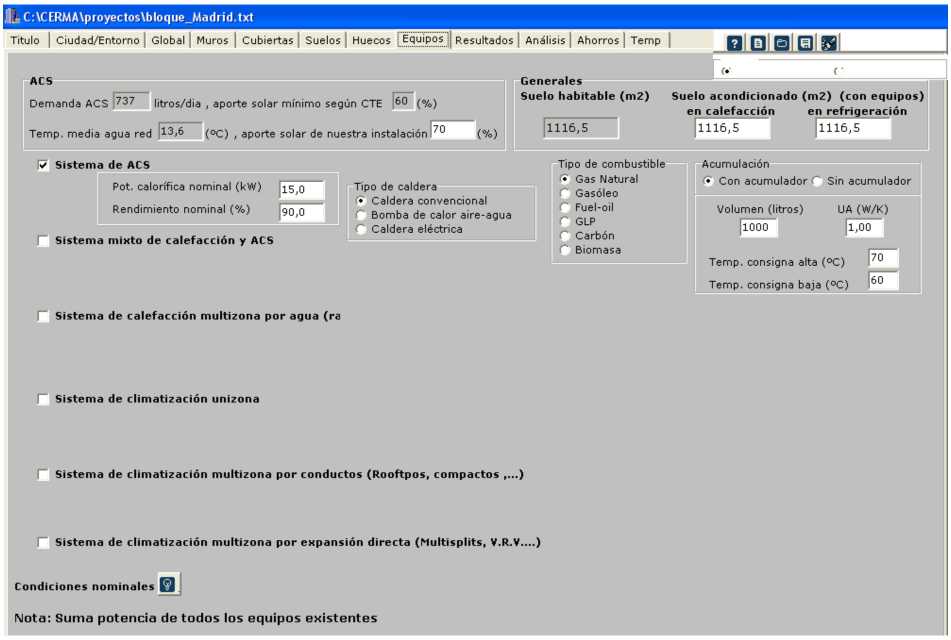
The figure shows the screen of "Roofs", the data are inputted easily from U-values and surfaces.

Windows and doors have great importance in the behaviour of buildings, their thermal characteristics and dimensions of them are required as well as areas according to orientations, allowing the calculation of possible shadows casted by other buildings or by it self. Due to the importance of permeability in existing buildings, it has been sought a relationship between the material-fit-type opening with the permeability of the window/door. This aspect is internally taken into account, as well as the permeability of the blind box if included. The technician from the ICE (with calculation engine CERMA +) only performs a technical description which is automatically translated into certain calculation values.



The figure shows the detail of introduction remote obstacles to study and simulate the shadow which can affect windows. This effect has a great impact on the performance of the building from a thermal standpoint.

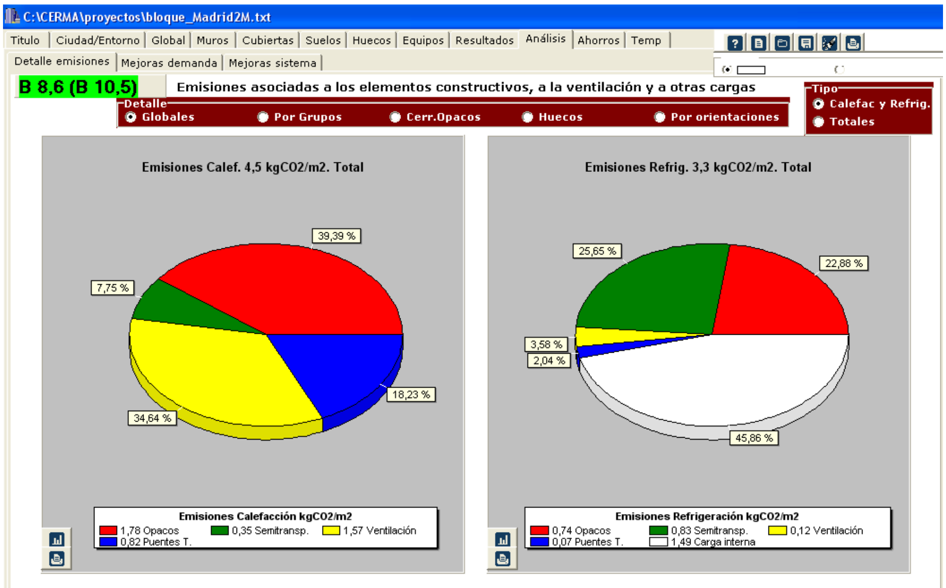
In the case of the systems the program lets the technician define the following systems: hot water, heating and cooling systems .When there is not any heating or cooling system, the program assumes certain "default" systems. It is imperative, however, the definition of the hot water.



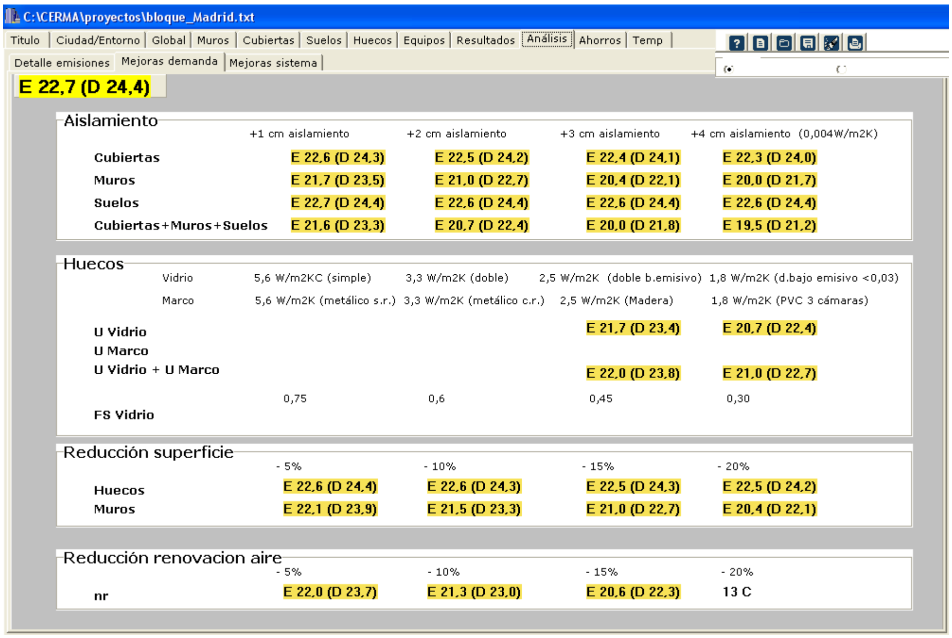
The figure shows the screen of "systems" where you can easily input the system data, if systems are not described they shall be by default: an oil C system for heating with and seasonal average performance of 0.75, and for cooling an electrical system with a seasonal average of 1.7 EER.

RESULTS PROVIDED BY THE TOOL

The most outstanding result that this procedure provides is the detail of the building energy effi-ciency qualification estimation. Also obtaining qualification assigned to heating, cooling and hot water separately, monthly and annual energy demand for heating, cooling and hot water, con-sumption of final energy monthly and annual energy for heating, cooling and hot water; monthly and annual CO2 emissions from heating, cooling and hot water, and information on reducing con-sumption that would be obtained using "standard" improvements in the constructive solutions and systems provided by the building.



The picture shows the screen "detail of emissions," which shows the emissions associated with the constructive elements, ventilation and other charges. This analysis is available globally, by group, by walls, by windows and by orientations, as well as by separate charges: heating, cooling or global.



The picture shows the screen "Demand improvements", showing standard default scenarios for improvement and emissions resulting from the implementation of these improvements. CERMA + only shows the results when the results of the improvement are positive, i.e. when there is a reduction in emissions.

5. Literature / Sources Spain (non-exhaustive)

La energía en España 2009	Gobierno de España, Ministerio de Industria, Turismo y Comercio, Secretaría general de energía, 2009
Consumo de energía y crecimiento económico	CJN Consultores, Comisición nacional de energía, Club español de la energía, 2002
Memoria anual 2008	Gobierno de España, Ministerio de Industria, Turismo y Comercio, Secretaría general de energía, Instituto para la diversificación y Ahorro de la Energía IDAE, 2009
Boletín Mensual de Estadística. Junio 2010	Instituto Nacional de Estadística INE, Junio 2010
CTE Plus. El potencial de ahorro de energía y reducción de emisiones de CO^2 en viviendas mediante incremento del aislamiento España 2005-2012	Cener Centro nacional de energías renovables
CTE - Documento Básico HE sección 1. Limitación de demanda energética	Gobierno de España, Ministerio de Fomento.
E-Retrofit-Kit. Tool-Kit for “Passive House Retrofit”	Intelligent Energy Europe