TABULA Scientific Report

Ireland

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M Badurek, M Hanratty, W Sheldrick

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Research Report written by:

Marcin Badurek
Michael Hanratty
Bill Sheldrick
(In-house Consultants, IHER Energy Services)

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1. Introduction to Irish TABULA project

The purpose of this report is to document the work undertaken by the Irish partners (Energy Action Limited) in the Intelligent Energy Europe TABULA Project 2009-2012.

The aim of the Intelligent Energy Europe TABULA project (2009-2012) is to create a building typology in each of the member states participating in the project. The participating countries are Germany, France, Italy, Denmark, Sweden, Belgium, Poland, Austria, Czech Republic, Greece, Slovenia, Ireland and Bulgaria. Associated partners from Spain and Serbia are also participants. The project is co-ordinated by IWU (Institut Wohnen and Umwelt GmbH – the Institute for Housing and Environment) based in Darmstadt, Germany.

The objective of TABULA was to develop a library of energy-related data for typical building types in each country. For example, in Ireland the national building typology will display the energy related properties (envelope areas, U-values, heating system efficiencies) for each building type. The typical building types would be selected based on representing particular construction periods and sizes of buildings. Also any regional variations would be highlighted where relevant in member states. Furthermore it was proposed to estimate the number of buildings in the national housing stock represented by each building type. (This task was undertaken by some TABULA partners but was not a formal task for the Irish project.) In the long run, the national building typology can be used and developed for forecasting and evaluating the energy savings and carbon dioxide reductions for each country.

The main outputs from TABULA were defined as follows:

- Development of a harmonised (EU) structure for demonstrating national building typologies.
- Population of the harmonized building typology structure (TABULA.xls) with national data by each partner showing heat loss and heating system performance for each typical building type, and the frequency of each type
- Development of a building typology webtool that will take the form of a matrix with photographs of typical buildings arranged by construction period and building size and showing typical energy performance (e.g. its BER). Clicking on a building type will give access to building data sheets and sub-typologies with detailed information about building elements (e.g. wall types). Online calculations can then be performed showing the impact of applying one or several energy saving measures for each building type. The webtool will also serve as a data source for scenario calculation activities (within and beyond the proposed project).
- Brochures will also be produced for each participating country giving an overview of the energy performance of typical buildings and the possible energy saving by two stages of refurbishment measures, standard and advanced.

In short, for Ireland, the building typology aims to identify the most common residential building types and to provide relevant building energy information for each type via the webtool and brochures that will be of use to home owners and building professionals alike.

This scientific report will outline:

- how the Irish typology was defined and selected
- how the Irish buildings and refurbishment measures were coded and entered into the typology structure (an excel application, TABULA.xls)
- the TABULA building typology webtool
- the format of the Irish brochures giving an overview of the energy performance of typical buildings and the possible energy savings by refurbishment measures.

It should be noted that the webtool analysis is based on a common EU methodology defined for the TABULA project whereas the energy analysis within the brochures is based on the Irish national Building Energy Rating (BER) method known as Dwelling Energy Assessment Procedure (DEAP).

At the beginning of the Irish TABULA project, the knowledge base on the range of housing types in Ireland was still relatively limited. However, this knowledge base would increase during the years of the project from 2009 to 2012 following the requirement that Building Energy Rating certificates would be required for existing buildings when offered for sale or rental arising from the full implementation of the Energy Performance of Buildings Directive in 2009.

The creation of the Irish building typology within the TABULA project is elaborated in the next sections of this report.

2. Selection of Irish Building Types for the Irish Typology

At the beginning of the TABULA project, a quick survey of the partners showed that very limited typology data was available in the participating member countries and this finding also applied in the case of Ireland. Prior to the TABULA project, no formal building typology has been compiled in Ireland on either a national or regional level.

However, several reports published within the last 10 years such as 'Homes for the 21st Century' in 1999 (UCD Energy Research Group/ Energy Action) and 'The Irish National Survey of Housing Quality 2001-2002' (ESRI) contained useful building typology data. The Irish Census also contains some building-related national statistics. The introduction of the Irish Building Energy Rating (BER) method known as Dwelling Energy Assessment Procedure (DEAP) by the Sustainable Energy Authority of Ireland (SEAI) in 2007 following implementation of the Energy Performance of Buildings Directive provides a natural reference point for the development of an Irish typology. In addition, the natural growth of BER data within SEAI's central Irish database of BER certificates over the duration of the project from 2009 to 2012 could prove a further source of reference data.

The Irish building typology was developed by combining data from both existing research sources and from new sources, many of which have evolved since the legal requirement for the production of BER certificates for existing dwellings when sold or rented from 1 January 2009.

At the outset, it was accepted that the Irish building typology would focus on identifying dwelling types primarily based on:

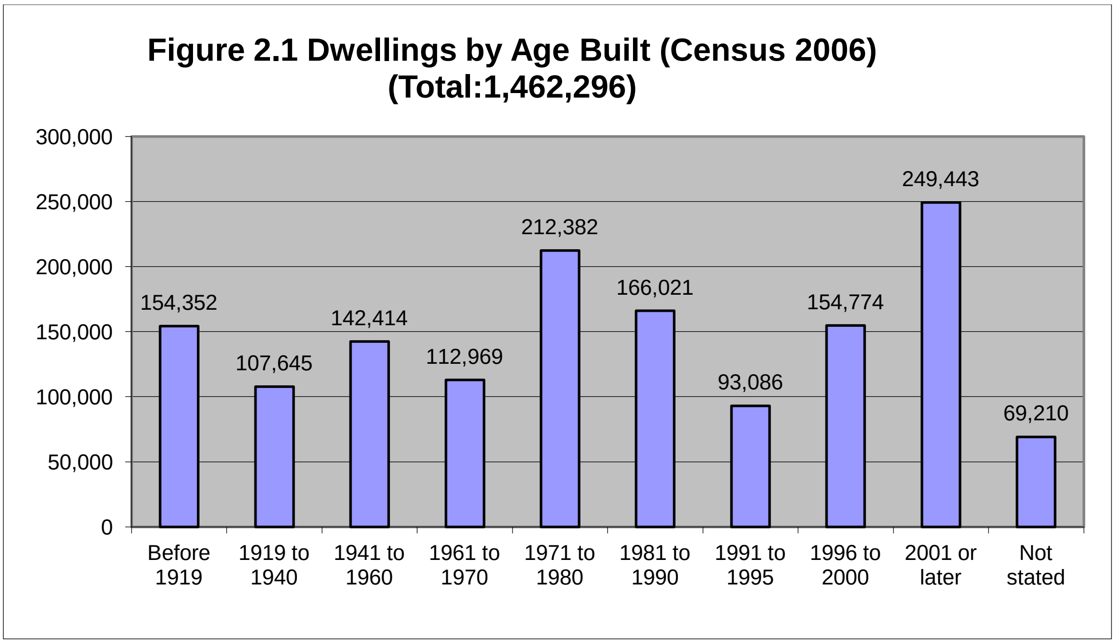
- single dwellings or apartments/ flats
- age on construction
- wall types
- single storey, two storey and dormer building types

Many older dwellings (especially those built before the 1980s) will have been refurbished to some extent by their owners. The most common measures would include replacement of windows, the installation of oil or gas boiler central heating systems and the installation of attic/roof insulation. The addition of wall insulation for the whole dwelling had been less common up until 2008, when grants became available through SEAI, due to the higher costs involved and the absence of any national promotion and/or grant support for this type of measure. Also, the addition of floor insulation would also have been less common due to the high costs involved and the difficulty of installation.

All available data sources were researched in order to create the Irish building typology as outlined in the following sections.

2.1. National Statistics

The Irish census (2006) gives a good summary of the number of Irish Dwellings based on year built. In addition to the 1.46 million Irish dwellings recorded in the 2006 census, approximately 160,000 further dwellings were built in the period 2007-2011.



The 2006 Irish census also gives a breakdown of the types of residential dwellings such as detached houses, semi-detached houses and apartments etc.. It is important to note, that the Irish approach is to record each individual apartment or flat as a single dwelling. Similarly, the Irish method for calculating the energy performance of buildings produces an individual rating for each apartment unlike the practice elsewhere in Europe, where the apartment building is given a rating rather than individual apartments or flats.

Table 2.1 shows the breakdown by dwelling type of Irish residential buildings for different age bands provided in the 2006 census.

Table 2.1 Dwelling Type by Age Band (Census 2006)

Dwelling Type	Total	Detached house	Semi-detached house	Terraced house	Flat or apartment in a purpose-built block	Flat or apartment in converted house or commercial building	Bed-sit	Not stated
Before 1919	154,352	82,951	15,748	37,111	3,037	11,235	2,678	1,592
1919 to 1940	107,645	48,394	22,056	29,146	2,552	3,339	978	1,180
1941 to 1960	142,414	49,140	40,935	43,461	4,634	2,300	661	1,283
1961 to 1970	112,969	41,777	40,435	22,727	5,248	1,369	486	927
1971 to 1980	212,382	98,182	67,698	37,306	5,763	1,348	417	1,668
1981 to 1990	166,021	85,700	45,064	24,337	7,977	1,134	396	1,413
1991 to 1995	93,086	43,071	30,232	8,341	9,604	927	243	668
1996 to 2000	154,774	71,973	51,327	11,455	17,093	1,450	355	1,121
2001 or later	249,443	94,408	71,378	32,957	44,991	2,230	783	2,696
Not stated	69,210	10,392	13,487	10,681	8,967	4,674	1,754	19,255
Total	1,462,296	625,988	398,360	257,522	109,866	30,006	8,751	31,803

Source: Census 2006-table 32A

National energy efficiency programmes which part fund or fully fund thermal upgrades have been under way in Ireland for more than 10 years. Data on measures completed from 2000-2011 is provided in the table below.

Typically low incomes homes will have received one or two measures, e.g. roof insulation and cavity wall insulation. Private homes and social housing units will have received typically two to three upgrade measures, e.g. roof insulation, wall insulation and heating boiler and controls.

Table 2.2 Refurbishment Levels

	Low Income Houses	Private Houses	Social Housing Units	Total	Measures as % of Total Housing (1.6m)
2000-2006	11,000			11,000	0.7%
2007	4,000			4,000	0.3%
2008	5,000			5,000	0.3%
2009	15,000	20,000	1,200	36,200	2.3%
2010	20,000	40,000	1,800	61,800	3.9%
2011	25,000	50,000	3,000 (est.)	78,000	4.9%
Totals	**80,000**	**110,000**	**6,000**	196,000	12.3%

Source: SEAI (2012) and DOECLG (2012)

The 2006 Census provides data on the number of dwellings with and without central heating systems. Overall 90% of Irish houses have central heating systems as shown in Table2.3 below. 22% of pre 1919 houses do not have central heating systems compared to 5% of dwellings built after 2001.

Table 2.3 Central Heating System Installations in Irish Dwellings

Dwelling Age	With Central Heating	Without Central Heating	Total
Before 1919	118,907	32,713	151,620
1919 to 1940	87,971	17,708	105,679
1941 to 1960	124,459	15,672	140,131
1961 to 1970	102,622	8,554	111,176
1971 to 1980	196,251	13,210	209,461
1981 to 1990	152,031	11,814	163,845
1991 to 1995	85,534	6,232	91,766
1996 to 2000	144,823	7,932	152,755
2001 or later	233,104	12,585	245,689
Not stated	42,559	9,735	52,294
Total	1,288,261	136,155	1,424,416

Source: Census 2006 - Table 34

The Census does not provide data on the fuel types used for heating.

Using iterations from the household budget survey, the proportion of households with central heating increased from 52% in 1987 to 90% in 2005 (Table2. 4). By 2005, 74% of homes had either natural gas fired or oil-fired central heating systems installed. The remainder used solid fuel, dual systems and electricity.

Table 2.4 Penetration of Central Heating by Fuel Type

Fuel Type %	1987	1995	2000	2005
Solid Fuel	31	21	9	8
Electricity	1	2	4	3
Oil Fired	12	25	39	46
Natural Gas Fired	4	14	25	28
Dual System	4	6	7	5
Total Central Heating	52	68	84	90

2.2. Research Reports in Ireland linked to Typologies

Several reports have been produced in the recent past that examined the energy performance of Irish dwelling types. The Homes for the 21st Century report in 1999 developed a computer model to estimate the energy performance of the existing Irish housing stock. The model used 1,824 representative dwelling types each representing a percentage of the national dwelling stock. The computer model considered 8 dwelling forms. The purpose of the report was to analyse the social, health and financial impact of bring the existing Irish housing stock to the 1997 building standards. However, this scope of this study did not include publication of the typologies in brochure format for energy advice purposes.

The Irish National Survey of Housing Quality (2001-2002) gathered detailed information on the Irish Housing Stock based on a representative sample of 40,000 householders. This report contains much useful energy-related information such as stating the percentages of dwellings by building age with roof insulation, wall insulation, double glazing, hot water cylinder insulation, low energy lighting etc..

Energy Action published the Ballyfermot Residential Energy & Fuel Poverty report in 2004. Ballyfermot is a district containing over 6,000 houses in Dublin City. This report identified over 40 residential building types. It modelled the energy performance of the 6,000 buildings and the impact of four separate energy saving packages.

2.3. Use of the National Building Energy Rating Method for Typology Development

The Republic of Ireland has one national building energy rating method for residential buildings known as the Dwelling Energy Assessment Procedure (DEAP). The development and ongoing management of DEAP is the responsibility of Sustainable Energy Authority of Ireland (SEAI).

For existing dwellings, Appendix S of the DEAP method (similar to the UK SAP method) has assigned the range of construction age bands for Irish dwellings. These age bands are used for the purposes of assigning U-values and other data.

Table 2.5 Construction Age Bands for Irish Dwellings

Age band	Years of construction
A	before 1900
B	1900-1929
C	1930-1949
D	1950-1966
E	1967-1977
F	1978-1982
G	1983-1993
H	1994-1999
I	2000-2004
J	2005 onwards

From the mid 1970s, the introduction of thermal insulation standards and subsequent revisions in standards has been primarily caused by amendments to draft or actual Building Regulations for the conservation of fuel and power. The age band dates in Table 2.5 above are generally two or three years after the date for changes in regulations (see Table 2.6 below). This delay accounts for the transition period from the introduction of revised regulations to built dwellings.

Table 2.6 Building Regulation Summary

Year of Regulations	Applicable age band	U values (W/m2K)		
		Roof	Wall	Floor
1976 (Draft)	F	0.4	1.1	0.6
1981 (Draft)	G	0.4	0.6	0.6
1991	H	0.35	0.45	0.45/0.6
1997	I	0.35	0.45	0.45/0.6
2002	J	0.25	0.27	0.37

U values of wall types are determined from the construction type and date of construction. Within the DEAP method, the U values of walls in existing residential buildings are determined with reference to Appendix S, which is influenced by the Building Regulation transition table in Table 2.6 above. Table 2.7 below provides the exposed wall U values for existing buildings provided in Appendix S.

Table 2.7 Exposed Wall U-values (Appendix S)

Age Band	A	B	C	D	E	F	G	H	I	J
Wall type	Before 1900	1900-1929	1930-1949	1950-1966	1967-1977	1978-1982	1983-1993	1994-1999	2000-2004	2005 onwards
stone	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37
225mm solid brick	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37
325mm solid brick	1.64	1.64	1.64	1.64	1.64	1.1	0.6	0.55	0.55	0.37
300mm cavity	2.1	1.78	1.78	1.78	1.78	1.1	0.6	0.55	0.55	0.37
300mm filled cavity	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.55	0.55	0.37
solid mass concrete	2.2	2.2	2.2	2.2	2.2	1.1	0.6	0.55	0.55	0.37
concrete hollow block	2.4	2.4	2.4	2.4	2.4	1.1	0.6	0.55	0.55	0.37
timber frame	2.5	1.9	1.9	1.1	1.1	1.1	0.6	0.55	0.55	0.37

The most notable distinction between the energy performances of Irish dwellings can be made based on wall type. For example, houses built in 1950 in Ireland will have different energy performances if the walls were constructed with any of hollow block (U=2.4), solid block/stone (U=2.1), 300mm cavity (U=1.78) or 325mm brick (U=1.64). While other features such as number of storeys, being detached, semi detached or mid terrace and say roof conversions can also create different dwelling types, the identification of the Irish building types will begin by identifying building types based on wall type and construction age.

Thus, the exposed wall U values table from Appendix S (Table 2.7 above) was deemed to provide the most logical starting point for development of the Irish residential building typology as it addresses all Irish wall types and takes account of all step changes in Building Regulations in Ireland.

2.4. Standard and Advanced Refurbishment Measures for the Irish Building Typology

As well as indentifying national residential building types, two stages of refurbishment of each dwelling type are examined in TABULA. Each member state involved in TABULA was given the freedom to define its own refurbishment measures.

The first stage of refurbishment for Irish dwellings is broadly based on the SEAI Better Energy Homes (BEH) standard for roof and wall insulation and heating system upgrades. The Stage 1 refurbishment also includes measures which are not part of the SEAI BEH standard but which would be recommended for comprehensive refurbishment of existing buildings, namely the replacement of uninsulated wooden floors, the replacement of windows and the provision of spray foam cylinder insulation. The Stage 1 refurbishment measures are listed in Table 2.8.

Table 2.8: Stage 1 Refurbishment

Stage 1 Measures	Upgrade Standards
Roof U-Value	0.13W/m^{2}K
Flat roofs	0.22 W/m^{2}K
Wall U-Value	0.27 W/m^{2}K
Wooden Floor (replace)	0.25 W/m^{2}K
Windows U-Value	2 W/m^{2}K
Doors (PVC)	2 W/m^{2}K
Space heat generator efficiency	90% gas, 90% oil
Water heat generator efficiency	90% gas, 90% oil
Heating controls	Full zone control
Cylinder Insulation	50mm, spray foam

The second stage of refurbishment is for a more advanced level of refurbishment. The measures for the stage 2 refurbishment are detailed in table 2.9 below. The U values for flat roofs, walls and windows have been reduced to match the 2011 building regulations standards (Technical Guidance Document Part L) and renewable technologies are included for water heating and space heating. (Obviously, the range of renewable technologies available is far wider than those included in table 9 and different solutions would be recommended for individual houses.)

Table 2.9: Stage 2 Refurbishment

Stage 2 Measures	Upgrade Standards
Roof U-Value	0.13 W/m2K
Flat Roof U-Value	0.2 W/m^2K
Wall U-Value	0.21 W/m^2K
Window U-Value	1.3 W/m^2K
Door U -Value	2 W/m^2K
Space heat generator efficiency	Heat pump: 380% min air, 400% ground
Water heat generator efficiency	Heat pump: 380% min air, 400% ground
Plus Solar thermal ($4m^2$ to $6m^2$)	40% contribution of total energy (10% electric immersion)
Heating controls	Full zone control
Cylinder Insulation	50mm, spray foam
Mechanical Heat Recovery Ventilation	90% minimum efficiency

3. Coding the Irish Building Typology into TABULA.xls

3.1. Introduction to Tabula.xls

Each partner in TABULA conducted energy performance analysis on its typical residential building types by two methods:

i. The respective national energy balance procedure according to national EPBD implementation. In the case of Ireland, the SEAI DEAP method was used to determine the BER rating of all dwelling types within the Irish typology. These results would then form the data sources for the National Building Typology Brochures and other national applications.
ii. The Common Calculation Procedure within the TABULA typology structure, TABULA.xls. This is the harmonised approach for calculation of the energy use and the delivered energy by energy carriers. This common method is used in the Typology Webtool and for the purposes of cross-country comparisons. The common calculation was designed as a simple procedure in order to ensure transparency of the calculation (understandable in each country / comprehensible online calculation) and easy handling (Excel calculation for a large number of buildings). The calculation procedure is as far as possible defined in accordance with the relevant CEN standards and takes into account standard values for climates and utilisation, fixed on a national level. In general, existing harmonised definitions (CEN, DATAMINE, etc) were taken into account, if applicable.

The common typology structure TABULA.xls was developed by the project co-ordinators IWU for the following purposes:

- To enable all partner countries enter the energy performance data of their typical national dwelling type data into one common database and calculation engine.
- To conduct building energy performance calculations for all building and heating system combinations for dwellings in their original state and the standard and advanced refurbishment stages (as outlined Section 2.4)

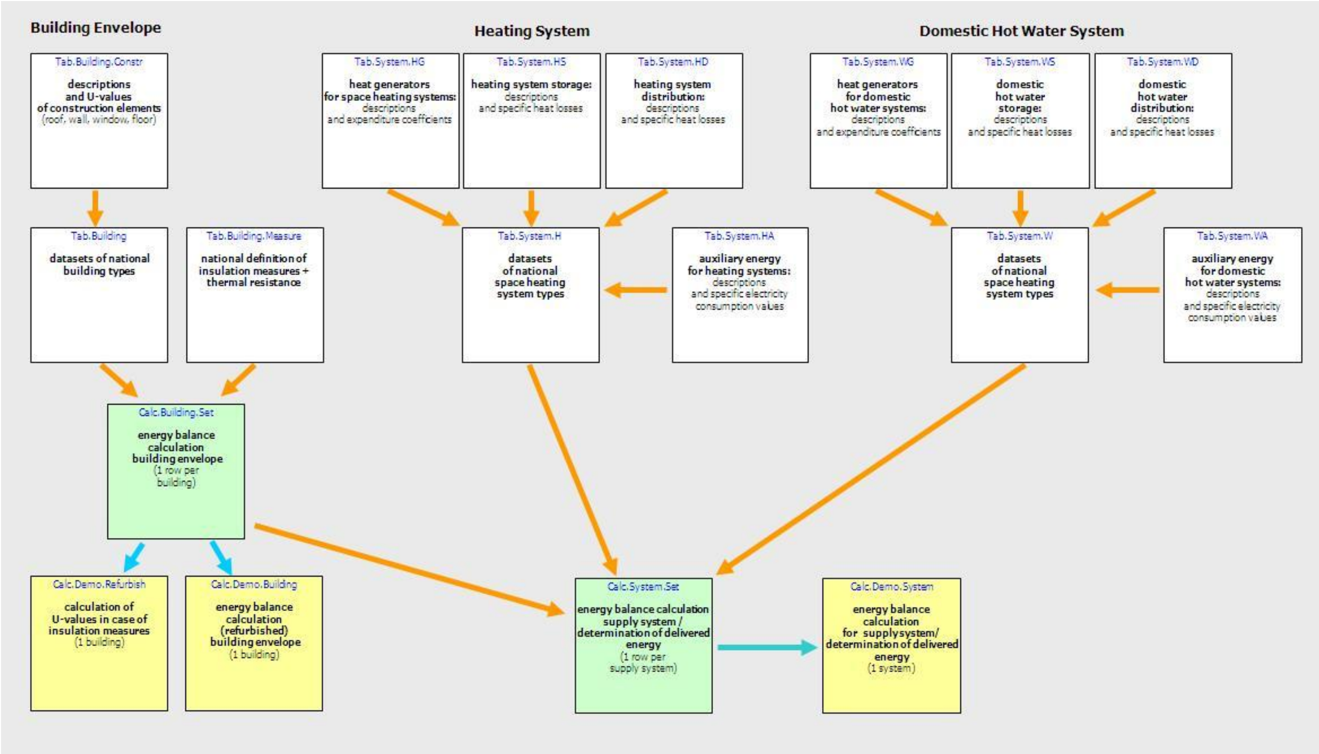
In Figure 3.1 overleaf, the flowchart of the TABULA database and calculation engine, TABULA.xls, is shown. All partner countries followed the coding format to enter their typical building and heating system data under the categories Building Envelope, Heating System and Domestic Hot Water System. The following sections outline how the Irish typical dwelling types were selected and organised under the TABULA.xls data entry categories.

The energy balance calculations are performed in Calc. Building.Set and Calc.System.Set later in the TABULA.xls process.

The calculation results are presented in the Calc.Demo.Refurbish, Calc.Demo.Building and Calc.Demo.System tabs respectively dealing with transmission losses (e.g. U values) for the original and refurbished building envelope, with net energy demand for space heating and with primary energy consumption, carbon dioxide emissions and energy costs both for space heating and hot water production.

The entire operation of TABULA.xls from the Irish project perspective is outlined in detail in Section 3.

Figure 3.1: Flowchart of TABULA.xls Structure



3.2. Construction Year Classes

The first step in determining the typical Irish dwelling types and entering associated data into TABULA.xls is to determine the construction year class, i.e. to categorise Irish dwelling types by logical age bands, and to enter these year classes in Tab.ConstrYearClass.

As indicated earlier, the Irish dwelling type age bands would most logically be derived by referring to the wall U value table in Appendix S of the National DEAP method and the Building Regulation transition dates shown in Table 2.6.

Draft Building Regulations were first introduced in 1976 (see Table 3 above) and there were revisions in 1981 (draft also), 1991, 1997, 2002, 2005 and 2008. Allowing for a two year transition interval, there were no building standards applying to dwellings built before 1977. Thus, the Appendix S wall U value table for specific age bands shown in Table 3.1 was created for the Irish DEAP method.

Table 3.1. Appendix S – Wall U values

Age Band	A	B	C	D	E	F	G	H	I	J
Wall type	Before 1900	1900-1929	1930-1949	1950-1966	1967-1977	1978-1982	1983-1993	1994-1999	2000-2004	2005 onwards
stone	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37
225mm solid brick	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37
325mm solid brick	1.64	1.64	1.64	1.64	1.64	1.1	0.6	0.55	0.55	0.37
300mm cavity	2.1	1.78	1.78	1.78	1.78	1.1	0.6	0.55	0.55	0.37
300mm filled cavity	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.55	0.55	0.37
solid mass concrete	2.2	2.2	2.2	2.2	2.2	1.1	0.6	0.55	0.55	0.37
concrete hollow block	2.4	2.4	2.4	2.4	2.4	1.1	0.6	0.55	0.55	0.37
timber frame	2.5	1.9	1.9	1.1	1.1	1.1	0.6	0.55	0.55	0.37

By clustering age bands with the same default wall U values (as shown above), five distinct building construction age bands were selected (Table 3.2) to categorise Irish dwelling types within TABULA. For example, the 1994-2004 age band code 04 combines both the 1994-1999 and the 2000-2004 periods as the element U values were the same in both the 1991 and 1997 Building Regulations.

These 5 age bands were entered into the worksheet **Tab.ConstrYearClass** in TABULA.xls as indicated in Table 3.2 below.

Table 3.2 Tab.ConstrYearClass

Construction Year Class	Code
1800-1977	1
1978-1982	2
1983-1993	3
1994-2004	4
2005-onwards	5

The next step involves entering all of the building element data (roofs, walls, floors and windows) into Tab.Building.Constr.

3.3. Defining the Irish Typology

Having determined the Construction Year Classes, the Appendix S wall table shows 8 wall types across 5 construction age bands, thus indicating 40 basic types. If variations of each were to be identified for detached houses, semi-detached/ terraced houses and apartments (excluding multi-family houses), then there could be 120 Irish types.

In order to examine the frequency of houses with wall types within all the Appendix S categories, data was provided from SEAI's BER National Administration System in September 2010 for 115,00 BER (EPC) certificates that has been published by that date. The data provided was aggregated for the 5 construction age bands selected and the results are shown in Table 3.3.

Table 3.3 Published Existing Dwelling BER Certificates by Wall Type (September 2010)

Age Band	A-E	F	G	H-I	J	
Wall type/ period	1800-1977	1978-1982	1983-1993	1994-2004	2005-onw	**Total**
stone	7,381	473	944	3,342	1,562	**13,702**
255mm solid brick	1,795	96	209	1,008	981	**4,089**
325 solid brick	2,178	81	203	463	220	**3,145**
300 mm cavity	5,944	2,754	5,808	18,210	14,267	**46,983**
300 mm filled cavity	1,579	877	1,649	7,334	6,203	**17,642**
solid mass concrete	2,194	69	185	1,191	2,783	**6,422**
concrete hollow block	1,902	557	753	1,421	884	**5,517**
timber frame	195	46	169	3,050	5,891	**9,351**
other	500	80	237	1,306	6,526	**8,649**
Total	**23,668**	**5,033**	**10,157**	**37,325**	**39,317**	**115,500**

If the same data is examined in percentage terms, it became possible to identify the most common and least common construction types as can be seen in Table 3.4.

Table 3.4 Published Existing Dwelling BER Certificates by Wall Type Percentages (Sept. 2010)

Age Band	A-E	F	G	H-I	J
Wall type/ period	1800-1977	1978-1982	1983-1993	1994-2004	2005-onw
stone	31%	9%	9%	9%	4%
255mm solid brick	8%	2%	2%	3%	2%
325 solid brick	9%	2%	2%	1%	1%
300 cavity filled/empty	32%	72%	73%	68%	52%
solid mass concrete	9%	1%	2%	3%	7%
concrete hollow block	8%	11%	7%	4%	2%
timber frame	1%	1%	2%	8%	15%
other	2%	2%	2%	3%	17%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

In table 3.4, in the first age band up to 1977, as each wall type has a distinct U value, most wall types were selected except timber frame which was not common. In the other 4 age bands, the wall U values are identical for different wall types. Thus, for these 4 age bands the 2 most common wall types were selected as the most representative to create the Irish typology.

In total, 29 Irish house types were created in TABULA and their distribution with the age bands and wall types are illustrated in Table 3.5 below.

Table 3.5 Distribution of the 29 House Types in the Irish Typology

Age Band	**A-E**	**F**	**G**	**H-I**	**J**
Wall type/ period	**1800-1977**	**1978-1982**	**1983-1993**	**1994-2004**	**2005-onw**
stone	3,4				
255mm solid brick	5,6				
325 solid brick	7,8				
300 cavity filled/empty	1,2	14,15	18,19	22,23	26,27
solid mass concrete	9,10				
concrete hollow block	11,12,13	16,17	20,21		
timber frame				24,25	28,29

One generic apartment types was created for each age band. The wall constructions selected were solid brick (1800-1977), cavity walls (1978-2004 inclusive), concrete (2005 onwards).

As flats & apartments are assessed on a whole building basis in most European countries for BER/ EPC purposes, TABULA.xls was designed to only enable coding and data entry for apartments on a whole building basis. However, the national Irish BER calculation method assesses flats/ apartments on a single unit basis only. Therefore, in order to complete the Irish datasets in TABULA.xls, the 5 generic Irish apartment types were modelled on a whole building basis and entered into TABULA.xls on that basis.

A TABULA brochure in the national methodology has been created for one Irish apartment type (pre 1977) based on a single dwelling unit to meet the need of the Irish audience.

3.4. Wall Types

Typical wall types for Irish dwelling types were identified by the Irish project team and were entered into the worksheet *Tab.Building.Constr* of TABULA.xls using the coding structure shown in Table 3.3.

The age class in the table 3.3 below refers to the construction age band. The variant number is used to distinguish different wall types (e.g. stone or solid brick etc) within an age class. The U-values were taken from Table S3 of the SEAI DEAP 3.2.0 manual.

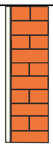
Table 3.3. Typical Wall types

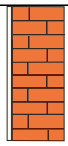
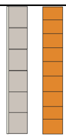
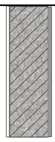
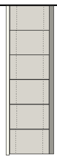
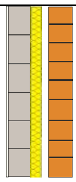
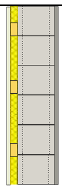
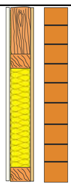
Age Class Code	Construction variant number	Construction element description	U-value	Age Band
01	1	Stone	2.1	1800-1977
01	2	225mm solid brick	2.1	1800-1977
01	3	325 solid brick	1.64	1800-1977
01	4	300mm cavity	1.78	1900-1977
01	5	mass concrete	2.2	1800-1977
01	6	concrete hollow block	2.4	1800-1977
02	1	300mm cavity partially filled	1.1	1978-1982
02	2	concrete hollow block	1.1	1978-1982
03	1	300mm cavity partially filled	0.6	1983-1993
03	2	concrete hollow block	0.6	1983-1993
03	3	Timber frame	0.6	1983-1993
04	1	300mm part filled cavity	0.55	1994-2004
04	2	Timber frame	0.55	1994-2004
05	1	300mm cavity partially filled	0.37	2005-2010
05	2	Timber frame	0.37	2005-2010
05	3	Solid concrete	0.37	2005-2010

As well as coding the typical Irish wall constructions, sectional drawings and sketches of these constructions were entered into TABULA.xls for display in the TABULA webtool.

A selection of the sectional drawings and sketches for Irish wall construction are shown in Figure 3.1.

Figure 3.1 Irish Wall Sections

Description	Illustration
stone wall	
225mm solid brick	

325mm solid brick	
300mm cavity	
mass concrete	
concrete hollow block	
300mm cavity partially filled	
concrete hollow block (insulated)	
timber frame	
reinforced concrete wall, externally insulated	

3.5. Roofs

Typical roof types for Irish dwelling types were identified and were entered into the worksheet *Tab.Building.Constr* of TABULA.xls using the coding structure shown in Table 3.4.

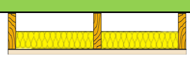
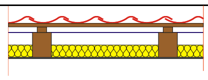
The age class code in the table below refers to the construction age band. The variant number is used to distinguish different roof types within an age class. For each construction age band, roof insulation thicknesses were assigned based on what would be typical in dwellings of that period. The depth of insulation at ceiling level reflects the fact that a certain level of refurbishment will have taken place in the intervening years since the dwellings were built. Thus, while homes built before 1977 will not have had any roof insulation installed at the time of construction, it is predicted that a typical dwelling of that age will have had approximately 50mm of ceiling level insulation installed at some stage. The flat roof and rafter insulated roof U-values are taken from the DEAP manual 3.2.0 Appendix S, table S5. As the insulation thickness cannot normally be observed for flat roofs and rafter level insulation, default U-values are used.

Table 3.4 Typical Roof Types

Age Class code	Construction variant number	Construction element description	Insulation thickness	U-value	Age Band
01	1	Pitched roof insulated on ceiling	50	0.68	1800-1977
01	2	Pitched roof insulated on Rafter		2.3	1800-1977
01	3	Flat Roof		2.3	1800-1977
02	1	Pitched roof insulated on ceiling	100	0.4	1978-1982
02	2	Pitched roof insulated on Rafter		0.4	1978-1982
02	3	Flat Roof		0.4	1978-1982
03	1	Pitched roof insulated on ceiling	100	0.4	1983-1993
03	2	Pitched roof insulated on Rafter		0.4	1983-1993
03	3	Flat Roof		0.4	1983-1993
04	1	Pitched roof insulated on ceiling	150	0.26	1994-2004
04	2	Pitched roof insulated on Rafter		0.35	1994-2004
04	3	Flat Roof		0.35	1994-2004
05	1	Pitched roof insulated on ceiling	200	0.2	2005-2010
05	2	Pitched roof insulated on Rafter		0.25	2005-2010
05	3	Flat Roof		0.25	2005-2010

A selection of the sectional drawings and sketches for Irish wall construction entered into TABULA.xls are shown in Figure 3.2.

Figure 3.2 Irish Roof Sections

Description	Illustration	U-Value
Pitched roof, insulated on ceiling		0.68
Pitched roof, insulated on rafter		0.4

3.6. Window Types

Typical window types for Irish dwelling types were identified and were entered into the worksheet *Tab.Building.Constr* of TABULA.xls using the coding structure shown in Table 3.5.

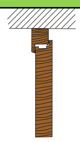
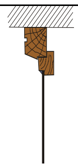
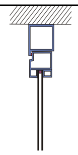
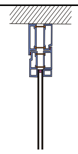
The age class code in the table below refers to the construction age band. The variant number is used to distinguish different roof types within an age class. For each construction age band, just one or two window types were assigned for that period. The typical window types selected reflect the likelihood that a certain level of refurbishment will have taken place in the intervening years since the dwellings were built.

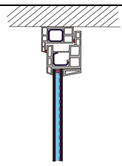
Table 3.5 Typical Window Types

Age Class Code	variant number	Construction element description	U-value	Age Band
01	1	Single glazed, metal no thermal break	5.7	1800-1977
01	2	Single glazed, wood or PVC	4.8	1800-1977
02	1	Double-glazed, air filled with 6mm gap, metal no thermal break.	3.7	1978-1982
03	1	Double-glazed, air filled with 12mm gap, metal with 4mm thermal break.	3.4	1983-1993
03	2	PVC Double-glazed, air filled with 6mm gap,	3.1	1983-1993
04	1	Double-glazed, air filled with 12mm gap, Wood/PVC	2.8	1994-2004
05	1	Double-glazed,(low-E,en=0.15, hard coat) air filled with 16mm gap, Wood/PVC	2.0	2005-onwards

A selection of the sectional drawings and sketches for Irish windows and doors entered into TABULA.xls are shown in Figure 3.3.

Figure 3.3 Irish Windows & Doors Sections

Description	Illustration	U-Value
solid wooden door		3
Single glazed, metal no thermal break		5.7
Single glazed, wood or PVC		4.8
Double-glazed, air filled with 6mm gap, metal no thermal break		3.7
Double-glazed, air filled with 12mm gap, metal 4mm thermal break		3.4

Double-glazed, argon filled (low-E en=0.1 soft coat) air filled with 16mm gap, Wood /PVC		1.8

3.7. Floor Types

Typical floor types for Irish dwelling types were identified and were entered into the worksheet *Tab.Building.Constr* of TABULA.xls using the coding structure shown in Table 3.6.

The age class code in the table below refers to the construction age band. Within each age band, solid floor and suspended timber floor are listed as typical types. As the U value is also influenced by the perimeter to area ratio as well as insulation levels within the floor construction, then floor U values will be lowest for terraced houses and highest for detached houses. Analysis was done to determine typical perimeter/ area ratios for terraced, semi-detached and detached houses in each age band. Based on the findings of this analysis, it was decided to allocate low, medium and high categories of perimeter/ area ratios to cover the range of Irish dwelling floor layouts. Thus, six floor variants have been selected in age band analysis as indicated in Table 3.6.

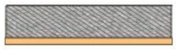
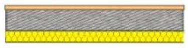
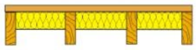
The only exception is for dwellings post 2005 where the floor U value at design stage must not exceed 0.25.

Table 3.6 Typical Floor Types

Age Band		Age Class Code	Variant	Floor and P/A type:	U-value
1900	1977	**ie.01**	1	Solid ground floor. Low PA ratio (0.2 to 0.3)	**0.54**
1900	1977	**ie.01**	2	Solid ground floor. Medium PA ratio (0.4 to 0.5)	**0.79**
1900	1977	**ie.01**	3	Solid ground floor. High PA ratio (0.6 to 0.7)	**0.98**
1900	1977	**ie.01**	4	Suspen. ground floor. Low PA ratio (0.2 to 0.3)	**0.5**
1900	1977	**ie.01**	5	Suspen. ground floor. Medium PA ratio (0.4 to 0.5)	**0.69**
1900	1977	**ie.01**	6	Suspen. ground floor. High PA ratio (0.6 to 0.7)	**0.83**
1978	1982	**ie.02**	1	Solid ground floor. Low PA ratio (0.2 to 0.3)	**0.43**
1978	1982	**ie.02**	2	Solid ground floor. Medium PA ratio (0.4 to 0.5)	**0.61**
1978	1982	**ie.02**	3	Solid ground floor. High PA ratio (0.6 to 0.7)	**0.72**
1978	1982	**ie.02**	4	Suspen. ground floor. Low PA ratio (0.2 to 0.3)	**0.44**
1978	1982	**ie.02**	5	Suspen. ground floor. Medium PA ratio (0.4 to 0.5)	**0.58**
1978	1982	**ie.02**	6	Suspen. ground floor. High PA ratio (0.6 to 0.7)	**0.66**
1983	1993	**ie.03**	1	Solid ground floor. Low PA ratio (0.2 to 0.3)	**0.43**
1983	1993	**ie.03**	2	Solid ground floor. Medium PA ratio (0.4 to 0.5)	**0.61**
1983	1993	**ie.03**	3	Solid ground floor. High PA ratio (0.6 to 0.7)	**0.72**
1983	1993	**ie.03**	4	Suspen. ground floor. Low PA ratio (0.2 to 0.3)	**0.44**
1983	1993	**ie.03**	5	Suspen. ground floor. Medium PA ratio (0.4 to 0.5)	**0.58**
1983	1993	**ie.03**	6	Suspen. ground floor. High PA ratio (0.6 to 0.7)	**0.66**
1994	2004	**ie.04**	1	Solid ground floor. Low PA ratio (0.2 to 0.3)	**0.33**
1994	2004	**ie.04**	2	Solid ground floor. Medium PA ratio (0.4 to 0.5)	**0.43**
1994	2004	**ie.04**	3	Solid ground floor. High PA ratio (0.6 to 0.7)	**0.48**
1994	2004	**ie.04**	4	Suspen. ground floor. Low PA ratio (0.2 to 0.3)	**0.35**
1994	2004	**ie.04**	5	Suspen. ground floor. Medium PA ratio (0.4 to 0.5)	**0.44**
1994	2004	**ie.04**	6	Suspen. ground floor. High PA ratio (0.6 to 0.7)	**0.48**
2005	2010	**ie.05**	1	All floors	**0.25**

A selection of the sectional drawings and sketches for Irish floor constructions entered into TABULA.xls are shown in Figure 3.4.

Figure 3.4 Irish Windows & Doors Sections

Description	Illustration	U-Value
Solid ground floor - uninsulated		1.58
Suspended ground floor - uninsulated		1.38
Solid ground floor - insulated		0.86
Suspended ground floor - insulated		0.88

3.8. Ventilation Types

To account for ventilation losses, two ventilation type codes have been developed. The first is for natural ventilation and the second is for mechanical heat recovery ventilation. Codes for both ventilation types are entered into Tab.System.Vent.

3.9. Building Refurbishment Measures

Rather than taking the next normal step of deciding on the heating systems for each building type, this step was delayed in TABULA as the impact of two stages of building refurbishment are firstly analysed for each typical dwelling. This analysis was done on all house types using both the TABULA common calculation method and the official Irish calculation method DEAP.

In order to assess the impact of building fabric refurbishment in TABULA.xls, all measures had to be entered into TABULA.xls in coded format. Each partner country in TABULA was free to determine its own refurbishment measures and determine its own coding system.

The measures and codes for both building fabric and heating systems are outlined in the following sections.

3.10. Wall Measures

Typical wall refurbishment measures suitable for Irish wall types were determined by the Irish project team and were entered into the worksheet *Tab.Building.Measure* of TABULA.xls using the coding structure shown in Table 3.7.

The code is automatically generated in TABULA.xls by firstly selecting the country code and element type from drop down menus and then deciding on the measure type and entering it under Code_MeasureType and Description_Measure in free text as shown in Table 3.7.

Table 3.7 Creation of Wall Measures

TABULA Column	Code Entries
code_country	IE
code-element type	wall
Code_MeasureType	fill bead 10cm
Number_variant measure type	1
Description_Measure	fill bead 10cm

For the purposes of the Irish project, 14 wall improvement measures have been defined as shown in Table 3.8. The resultant U value from the measure is shown in column L (U_construction) of worksheet *Tab.Building.Measure.*

TABULA gives three options for refurbishment U values (see worksheet Tab.Const.Measure). The three options are:

- to add insulation, (e.g. add insulation to a wall)
- to replace the existing construction, (e.g. to replace a single glazed metal window)
- to replace the existing insulation with new insulation (e.g. to replace 50mm of old roof insulation fibre with 300mm of new fibre insulation)

The Irish project uses the 'add insulation' option in the case of walls, roofs and floors and the 'replace the existing construction' option in the case of windows. The full list of wall refurbishment measures shown in Table 3.8 below shows the U value of the additional insulation and not the U value of the refurbished wall. These values were calculated by dividing the conductivity of the insulation material (k or lambda) by the thickness of the material in metres, i.e. U= k/thickness.

TABULA.xls automatically calculates the improved U-value of the refurbished element by combining the original construction U-value and the added insulation U value. This calculation is performed within the Energy Balance Calculation in worksheet Calc.Demo.Building that will be explained in more detail later in this report.

Table 3.8 Wall refurbishment Measures

	Wall Refurbishment code	Description	U value
1	IE.Wall.Fill Bead 12cm.01	Cavity fill 120mm	0.28
2	IE.Wall.Fill Bead10cm.01	Cavity fill 100mm	0.33
3	IE.Wall.Fill Bead 6cm.01	Cavity fill 60mm	0.55
4	IE.Wall.Fill Bead 5cm.01	Cavity fill 50mm	0.66
5	IE.Wall.82.5 mm Drylining .01	Drylining 82.5 mm	0.30
6	IE.Wall.77.5 mm Drylining .01	Drylining 77.5 mm	0.32
7	IE.Wall.50 mm Drylining .01	Drylining 50 mm	0.48
8	IE.Wall.30 mm Drylining .01	Drylining 30 mm	0.80
9	IE.Wall.Ext cladding 100 mm .01	External cladding 100 mm	0.21
10	IE.Wall.Ext cladding 90 mm .01	External cladding 90 mm	0.23
11	IE.Wall.Ext cladding 80 mm .01	External cladding 80 mm	0.26
12	IE.Wall.Ext cladding 70 mm .01	External cladding 70 mm	0.30
13	IE.Wall.Ext cladding 60 mm .01	External cladding 60 mm	0.35
14	IE.Wall.Ext cladding 50 mm .01	External cladding 50 mm	0.42
15	IE.Wall.Ext cladding 45 mm.01	External cladding 45 mm	0.48

3.11. Roof Measures

Typical roof refurbishment measures suitable for Irish roof types were determined by the Irish project team and were entered into the worksheet *Tab.Building.Measure* of TABULA.xls using the coding structure shown in Table 14.

The code is automatically generated in TABULA.xls by firstly selecting the country code and element type from drop down menus and then deciding on the measure type and entering it in free text under Code_MeasureType and Description_Measure as shown in Table 3.9.

Table 3.9 Creation of Roof Measures

TABULA Column	Code Entries
code_country	IE
code-element type	Roof
Code_MeasureType	Insulation25cm
Number_variant measure type	1
Description_Measure	Add 250mm to roof at ceiling level

The full list of roof refurbishment measures created in TABULA.xls for the Irish typology in Table 3.10 below shows the U value of the additional insulation only (as for walls above) and not the U value of the refurbished roof. These values were calculated by dividing the conductivity of the insulation material (k or lambda) by the thickness of the material in metres, i.e. U= k/thickness.

TABULA.xls automatically calculates the improved U-value of the refurbished element by combining the original construction U-value and the added insulation U value. This calculation is performed within the Energy Balance Calculation in worksheet Calc.Demo.Building that will be explained in more detail later in this report.

Table 3.10 Roof Refurbishment Measures

	Measure Code	Description	Measure U Value
1	IE.Roof.Insulation25cm.01	Mineral wool 250mm	0.16
2	IE.Roof.Insulation20cm.01	Mineral wool 200mm	0.20
3	IE.Roof.Insulation15cm.01	Mineral wool 150mm	0.26
4	IE.Roof.Insulation10cm.01	Mineral wool 100mm	0.38
5	IE.Roof.Insulation rafter upgrade (75mm additional drylining) + plasterboard.01	Insulation rafter upgrade (75mm additional drylining) + plasterboard	0.42
6	IE.Roof.Flat roof insulation 110mm (rigid urethane).01	Rigid urethane insulation 110mm	0.24
7	IE.Roof.Flat roof insulation 60mm (rigid urethane).01	Rigid urethane insulation 60mm	0.46

3.12. Windows and Doors Measures

As for walls and roofs, typical window refurbishment measures were decided by the Irish project team and were entered into the worksheet *Tab.Building.Measure* of TABULA.xls using the coding structure shown in Table 3.11.

The code is automatically generated in TABULA.xls by firstly selecting the country code and element type from drop down menus and then deciding on the measure type and entering it in free text under Code_MeasureType and Description_Measure as shown in Table 3.11.

Table 3.11 Creation of Window Measures

TABULA Column	Code Entries
code_country	IE
code-element type	Window
Code_MeasureType	2p-LowE_arg
Number_variant measure type	1
Description_Measure	Double glazed, 12mm gap, argon filled, low E, 0.5mm, soft coat

The list of window refurbishment measures in Table 3.12 below shows the U value of the replacement windows.

Table 3.12 Window and doors Refurbishment Measures

	Measure Code	Description	Measure U Value
1	IE.Window.PVC air 2G lowE hard c.15, 16mm gap.01	PVC air filled 2-glazed lowE, hard coat 0.15, 16mm gap	2.00
2	IE.Window.PVC arg 2G lowE soft c 05, 16 mm gap.01	PVC argon filled, 2-glazed lowE, soft coat 0.05, 16 mm gap	1.70
3	IE.Window.PVC arg 3G lowE soft c 05, 16 mm gap.01	PVC argon filled 3-glazed lowE, soft coat 0.05, 16 mm gap	1.30
4	IE.Door.PVC door.01	PVC door U-v 2	2.00

The U values of the replacement windows are entered into U-construction (column L) within the worksheet Tab.Building.Measure.

3.13. Heating System Types

In typical Irish dwellings the performance of the space heating system and the hot water system generally depends on many factors, namely:

- heat generator (i.e. boiler) efficiency
- heat generator boiler type
- main and secondary energy carrier
- space heating/ hot water controls, e.g. room and cylinder thermostats, programmers etc
- size of hot water cylinder
- hot water cylinder insulation type and thickness
- insulation of the primary pipework
- number of pumps and fans

All space heating and water heating system types for typical Irish dwellings were identified and entered into TABULA.xls in a series of worksheet tabs in the *System Type Definition* series of worksheets in TABULA.xls as indicated in Table 3.13 below.

Table 3.13. Space & Water Heating Tabs

Code	Description	Comment
Tab.System.HG	Space heating system generator types	
Tab.System.HS	Space heating system storage types	None entered for Irish dwelling types
Tab.System.HD	Space heating distribution systems	
Tab.System.HA	Space heating auxiliary systems	e.g. pumps, fans
Tab.System.WG	Water heating system generator types	
Tab.System.WS	Water heating system storage types	
Tab.System.WD	Water heating distribution systems	
Tab.System.WA	Water heating auxiliary systems	

All these factors have different variants and different performance indicators. They are explained further in this section.

In TABULA, performance indicators of storage and distribution losses and auxiliary losses depend on the floor area of the building. Therefore, to avoid having a large number of variants for typical Irish dwellings, these indicators have been calculated based on an average dwelling floor area of 88 sq. metres.

3.13.1. Space Heating Coding

The space heating codes developed for typical Irish dwelling types are set out in the next section.

3.13.2. Space Heating System Generators: Tab.System.HG

When determining typical space heating generators (e.g. boilers and associated efficiencies) for Irish dwellings, a range of heating system generators were selected based on typical systems that would be found today in dwellings within the Irish age band classes.

The code is automatically generated in Tab.System.HG by selecting the country code and the type of heat generator (e.g. B_NC_CT, i.e. boiler non-condensing constant temperature), the relevant type of building where it is used, and its description (SysHG) in free text as shown in Table 3.14.

Table 3.14 Creation of Space Heating Generator Codes

TABULA Column	Code Entries
code_country	IE
Code_Type_SysHG	B_NC_CT
Code_Building SizeClass_System	SUH
Number_variant measure type	2
Description_SysHG	Constant temperature non-condensing boiler 70% efficient

The full range of Irish space heating generator codes are set out in Table 3.15 below. Assumptions were made on average boiler efficiencies for a given age period based on conservative end of life replacement patterns. For instance, it is assumed that dwellings in the 1983-1993 age bands would have older boiler types with 70% efficiency. Single room heaters such open fires and electric room heaters are included also. The heating systems for single unit houses (SUH) and multi-unit houses (MUH) are coded separately.

Table 3.15 Tab.System.HG Codes

TABULA Code	Description
IE.OpenFire.SUH.01	open fire 30%
IE.B_NC_CT.SUH.01	constant temperature non-condensing boiler 65% efficient
IE.B_NC_CT.SUH.02	constant temperature non-condensing boiler 70% efficient
IE.B_NC_CT.SUH.03	constant temperature non-condensing boiler 75% efficient
IE.B_NC_CT.SUH.04	constant temperature non-condensing boiler 80% efficient
IE.B_C.SUH.01	condensing boiler, 90% efficient (was 86%)
IE.B_C.SUH.02	condensing boiler, 90% efficient
IE.E_Storage.SUH.01	Electric storage heaters
IE.E_SH.SUH.01	Electric room heater
IE.HP_Air.SUH.01	Heat Pump (Air) 380% efficient
IE.HP_Ground.SUH.01	Heat Pump (Ground) 400% efficient
IE.Other.SUH.01	Gas fire coal effect 20% efficient
IE.B_NC_CT.MUH.01	constant temperature non-condensing boiler 65% efficient
IE.B_NC_CT.MUH.02	constant temperature non-condensing boiler 75% efficient
IE.B_C.MUH.01	condensing boiler, 90% efficient
IE.HP_Air.MUH.01	Heat Pump (Air) 380% efficient
IE.E_Storage.MUH.01	Electric storage heaters

3.13.3. Space Heating System Storage Losses: Tab.System.HS

As there are no commonly found space heating systems in Ireland with storage losses, no codes have been developed for this category.

3.13.4. Space Heating System Distribution Losses: Tab.System.HD

A range of heating system distribution loss categories has been selected to represent those found in typical Irish dwellings.

The code is automatically generated in Tab.System.HD by selecting the country code and the type of heat distribution (all are C_Ext for Irish dwellings, i.e. central distribution completely within the thermal envelope), the variant number (there are 4 for Irish dwellings) and its description in free text as shown in Table 3.16.

Table 3.16 Creation of Space Heating Distribution Losses Codes

TABULA Column	Code Entries
code_country	IE
Code_Type_SysHD	C_Ext
Code_Building SizeClass_System	SUH
Description_SysHD	Central distribution, completely in the thermal envelope
Number_Variant_SysHD	2
Description_National_SysHD	Programmer and room thermostat or room thermostat only

In typical Irish dwellings, the space heat is generated inside the thermal envelope of a building. Therefore, the typical heat loss of the distribution system depends on the heating controls installed and is determined by dividing the value for heat emissions due to non ideal control (from the DEAP calculation) by the floor area of the building.

Table 3.17 shows the typical space heating control types that have been selected as representative of those found in Irish dwellings.

Table 3.17 Tab.System.HD Codes

TABULA Code	Type of Controls
IE.C_Int.SUH.01	no time and thermostatic temperature control
IE.C_Int.SUH.02	programmer and room thermostat or room thermostat only
IE.C_Int.SUH.03	programmer, room thermostat and TRVs (or 2 thermostats)
IE.C_Int.SUH.04	full time and temperature zone control
IE.C_Int.MUH.01	programmer and TRVs
IE.C_Int.MUH.02	full time and temperature zone control
IE.D.MUH.01	decentralised system: i.e. storage heaters

3.13.5. Space Heating Auxiliary Systems: Tab.System.HA

A range of space heating auxiliary system categories has been selected to represent those found in typical Irish dwellings.

The code is automatically generated in Tab.System.HA by selecting the country code, the type of auxiliary system (e.g. C for central heating system), the Building Size Class (SUH), the variant number (there are 4 categories for Irish dwellings) and its description in free text as shown in Table 3.18.

Table 3.18 Space Heating Auxiliary System Codes

TABULA Column	Code Entries
code_country	IE
Code_Type_AuxH	C
Code_Building SizeClass_System	SUH
Number_Variant_AuxH	1
Description_AuxH	Gas/ oil central heating system with central heating pump

This tab takes account of the energy used by pumps and fans included in the space heating system. Table 3.19 shows four variants of different auxiliary systems that represent those found in typical Irish dwellings.

Table 3.19 Tab.System.HA Codes

Code	Type
IE.C.SUH.1	gas/oil central heating system with c.h. Pump
IE.C.SUH.2	gas central heating system, c.h. pump, flue fan
IE.C.SUH.3	oil central heating system, c.h. pump, oil boiler pump
IE.C.SUH.4	ch pump + solar wh pump
IE.C.MUH.1	gas central heating system, c.h. pump, flue fan

3.13.6. Space Heating Combinations: Tab System H

In Tab System H, typical space heating system types are created by combining heat generators for primary and secondary heat generators, fuel types, controls and auxiliary system.

This is done by selecting from a series of drop down lists in Table 3.20 below within Tab.System.H that includes coded options for all components of a full heating system.

Table 3.20 Codes options for creation of Tab.System.H

System Element Code	Description
Code_SysH_EC1	Code of the energy carrier1
Code_SysH_EC2	Code of the energy carrier2
Code_SysH_EC3	Code of the energy carrier3
Code_SysH_G1	Code of heat generator1
Code_SysH_G2	Code of heat generator2
Code_SysH_G3	Code of heat generator3
Fraction_SysH_G2	Generated heat fraction of heat generator 2
Fraction_SysH_G3	Generated heat fraction of heat generator 3
Code_SysH_S	Code of the heat storage (not applicable in Irish codes)
Code_SysH_D	Code of the heat distribution and controls
Code_SysH_AuxD	Code of the auxiliary system

The heating system combination codes selected are then grouped into unique codes for heating systems. The description for the selected combination is entered into Tab.System.H in column H titled Description_SysH.

The full list of space heating system combination codes for typical Irish dwellings created in Tab.System.H is shown in Table 3.21.

Table 3.21 Tab.System.H Codes

Heating System Code	Description
IE.Gas+Coal.B_NC_CT+OpenFire.SUH.01	gas central heating, poor efficiency 65%, open/balanced flue, no room stat
IE.Gas+Coal.B_NC_CT+OpenFire.SUH.02	gas central heating, poor/medium efficiency 70%, open/balanced flue, no room stat
IE.Gas+Coal.B_NC_CT+OpenFire.SUH.03	gas central heating, medium efficiency 75% fan flue, no room stat
IE.Gas+Coal.B_NC_CT+OpenFire.SUH.04	gas central heating, improved efficiency 75% fan flue, room thermostat
IE.Gas+Coal.B_NC_CT+OpenFire.SUH.05	gas central heating, good efficiency 80% fan flue, room thermostat
IE.Gas+Coal.B_NC_CT+OpenFire.SUH.06	gas central heating, good efficiency 80% fan flue, room thermostat+TRVs or 2 stats
IE.Gas.B_C.SUH.01	gas central heating - condensing boiler, v. good efficiency 90% fan flue, full zone control (time and thermostatic)
IE.Oil+Coal.B_NC_CT+OpenFire.SUH.01	oil central heating, poor efficiency 65%, no room stat, oil boiler pump
IE.Oil+Coal.B_NC_CT+OpenFire.SUH.02	oil central heating, medium efficiency 75%, no room thermostat, oil boiler pump
IE.Oil+Coal.B_NC_CT+OpenFire.SUH.03	oil central heating, improved efficiency 75%, room thermostat, oil boiler pump

IE.Oil+Coal.B_NC_CT+OpenFire.SUH.04	oil central heating, good efficiency 80%, room thermostat, oil boiler pump
IE.Oil+Coal.B_NC_CT+OpenFire.SUH.05	oil central heating, good efficiency 80%, room thermostat + TRV's or 2 thermostats, oil boiler pump
IE.Oil.B_C.SUH.01	oil central heating - condensing boiler, v. good efficiency, 90%, oil boiler pump, full zone control (time and thermostatic), chimney sealed
IE.Gas+El.B_NC_CT+E_SH.SUH.01	gas central heating + electric heater, 80% efficient fan flue, room thermostat
IE.El.HP_Air.SUH.01	Heat pump system (air), 380%eff, with SWH, full zone control, insul. Pipework
IE.El.HP_Ground.SUH.01	Heat pump system (ground), 400%eff, with SWH, full zone control, insul. Pipework
IE.Gas.B_NC_CT+Other.SUH.01	gas central heating, medium efficiency 70% bal flue, no room stat + coal effect fire
IE.El.E_Storage.SUH.01	Storage heaters
IE.Bio_WP.B_C.SUH.01	Wood pellet boiler, v. good efficiency 90%, full zone control (time and thermostatic)
IE.Coal.OpenFire.SUH.01	decentral system - open fires
IE.Gas.B_NC_CT.MUH.01	Gas boiler 65% efficient, programmer and TRVs
IE.Gas.B_NC_CT.MUH.02	Gas boiler 75% efficient, programmer and TRVs
IE.Gas.B_C.MUH.01	Gas condensing boiler 90% efficient, full zone control
IE.El.HP_Air.MUH.01	Air Source Heat pump
IE.El.E_Storage.MUH.01	Electric storage heaters

3.14. Water Heating Coding

The water heating system codes developed for typical Irish dwelling types are set out in the next section. This follows a similar approach to that used for space heating system codes.

3.14.1. Tab System WG

When determining typical water heating generators (e.g. boilers, electric immersion, solar thermal, heat pumps and associated efficiencies) for Irish dwellings, a range of water heating system generators were selected based on typical systems that would be found today in dwellings within the Irish age band classes.

The code is automatically generated in Tab.System.WG by selecting the country code and the type of heat generator (e.g. E_Immersion or B_NC_CT, i.e. electric immersion or constant temperature non-condensing boiler) from the drop down options, the relevant type of building where it is used (e.g. SUH), the variant number and its description (SysWG) in free text as shown in Table 3.22.

Table 3.22 Creation of Water Heating Generator Codes

TABULA Column	Code Entries
code_country	IE
Code_Type_SysHG	B_NC_CT
Code_Building SizeClass_System	SUH
Number_variant measure type	3
Description_Measure	Constant temperature non-condensing boiler 75% efficient

The full range of Irish water heating generator codes are set out in Table 3.23 below. Assumptions were made on average boiler efficiencies for a given age period based on the same conservative end of life replacement patterns as for space heating (as it would be the same boiler for both space and water heating). For instance, it is assumed that dwellings in the 1994-2004 age bands would have older boiler types with 75% efficiency.

Table 3.23 Tab.System.WG Codes

Code	Description
IE.E_Immersion.SUH.01	Electric immersion
IE.B_NC_CT.SUH.01	constant temperature non-condensing boiler 65% efficient
IE.B_NC_CT.SUH.02	constant temperature non-condensing boiler 70% efficient
IE.B_NC_CT.SUH.03	constant temperature non-condensing boiler 75% efficient
IE.B_NC_CT.SUH.04	constant temperature non-condensing boiler 80% efficient
IE.B_C.SUH.01	condensing boiler 90% efficient (was 86%)
IE.B_C.SUH.02	condensing boiler 90% efficient
IE.HP_Air.SUH.01	380% efficient Heat pump (air)
IE.Solar.SUH.01	Solar Panels
IE.HP_Ground.SUH.01	400% efficient Heat pump (ground
IE.B_NC_CT.MUH.01	constant temperature non-condensing boiler 65% efficient
IE.B_NC_CT.MUH.02	constant temperature non-condensing boiler 75% efficient
IE.B_C.MUH.01	condensing boiler 90% efficient
IE.E_Immersion.MUH.01	Electric immersion
IE.Solar.MUH.01	Solar Panels

3.14.2. Water Heating System Storage Losses: Tab.System.WS

Typical water heating storage systems for Irish dwellings are set out in Tab.System.WS.

The code is automatically generated in Tab.System.WS by selecting the country code and the type of heat storage (e.g. central hot water storage or cylinder) from the drop down options, the relevant type of building where it is used, the variant number and its description (SysWS) in free text as shown in Table 3.24.

Table 3.24 Creation of Water Heating Storage Codes

TABULA Column	Code Entries
code_country	IE
Code_Type_SysHG	S-C_Int
Code_Building SizeClass_System	SUH
Number_variant measure type	2
Description_Measure	Hot water cylinder without thermostat, no separated controls, 25mm lagging jacket

The full range of Irish water heating storage codes are set out in Table 3.25. Factors taken into account were the types of hot water cylinder insulation, i.e. lagging jacket or factory fitted spray foam, the thickness of insulation (in mm), the presence of a cylinder thermostat and whether or not the hot water system has independent time control. All calculations are based on average cylinder volume of 120 litres.

Table 3.25 Tab.System.WS Codes

Variant	Code	Separate DWH control	Cylinder Stat?	Insulation type	Insulation thickness
1	IE.S_C_Int.SUH.01	no	no	Loose jacket	0
2	IE.S_C_Int.SUH.02	no	no	Loose jacket	25
3	IE.S_C_Int.SUH.03	no	no	Loose jacket	30
4	IE.S_C_Int.SUH.04	no	no	Loose jacket	50
5	IE.S_C_Int.SUH.05	no	yes	Loose jacket	50
6	IE.S_C_Int.SUH.06	yes	yes	Spray foam	35
7	IE.S_C_Int.SUH.07	yes	yes	Spray foam	50
8	IE.S_C_Int.SUH.08	yes	yes	Spray foam	50
9	IE.S_C_Int.MUH.01	no	no	Loose jacket	30
10	IE.S_C_Int.MUH.02	yes	yes	spray foam	50
11	IE.S_C_Int.MUH.03	yes	yes	spray foam	50

3.14.3. Water Heating System Distribution Losses: Tab.System.WD

A range of water heating system distribution loss categories has been selected to represent those found in typical Irish dwellings.

The code is automatically generated in Tab.System.WD by selecting the country code and the type of heat distribution (all Irish types are central heating systems with no circulation – apartment houses in Europe would often have circulation systems), the relevant type of building where it is used, the variant number (there are four for Irish dwellings) and its description in free text as shown in Table 3.26.

Table 3.26 Creation of Water Heating Distribution Losses Codes

TABULA Column	Code Entries
code_country	IE
Code_Type_SysWD	C_NoCirc_Int
Code_Building SizeClass_System	SUH
Description_SysWD	Central system with no circulation
Number_Variant_SysWD	1
Description_National_SysWD	Boiler with uninsulated primary pipework and no cylinder thermostat

In typical Irish dwellings, hot water is generated inside the thermal envelope of a building. Therefore, the typical heat loss of the water distribution system depends on the heating system types (e.g. boiler or immersion), the controls installed and heat losses from the primary pipework (boiler to cylinder) and in the pipework from the hot water cylinder to the taps. The distribution losses are determined by dividing the primary pipework losses and the adjusted primary circuit loss (from the DEAP calculation) by the floor area of the building.

Table 3.27 shows the typical water heating distribution types that have been selected as representative of those found in Irish dwellings.

Table 3.27 Tab.System.WD Codes

Code	Type
IE.C_NoCirc_Int.SUH.1	boiler with uninsulated primary pipework and no cylinder thermostat
IE.C_NoCirc_Int.SUH.2	boiler with uninsulated primary pipework. Cylinder thermostat present
IE.C_NoCirc_Int.SUH.3	boiler with insulated primary pipework. Cylinder thermostat present
IE.C_NoCirc_Int.SUH.4	electric immersion (no primary circuit losses)
IE.C_NoCirc_Int.MUH.01	boiler with uninsulated primary pipework and no cylinder thermostat
IE.C_NoCirc_Int.MUH.02	boiler with insulated primary pipework. Cylinder thermostat present
IE.C_NoCirc_Int.MUH.03	electric immersion (no primary circuit losses)

3.14.4. Water Heating Auxiliary Systems: Tab.System.WA

The Irish EPC calculation method, DEAP, does not separately identify an auxiliary system for water heating. Thus, no equivalent codes have been developed for the Irish TABULA inputs.

3.14.5. Water Heating Combinations: Tab System W

In Tab System W, typical water heating system types are created by combining water heating, fuel types, storage types and controls.

This is done by selecting from a series of drop down lists in Table 3.28 below within Tab.System.W that includes coded options for all components of a full water heating system.

Table 3.28 Codes options for creation of Tab.System.W

Water Heating Element Code	Description
Code_SysW_EC1	Code of the energy carrier1
Code_SysW_EC2	Code of the energy carrier2
Code_SysW_EC3	Code of the energy carrier3
Code_SysW_G1	Code of heat generator1
Code_SysW_G2	Code of heat generator2
Code_SysW_G3	Code of heat generator3
Fraction_SysW_G2	Generated heat fraction of heat generator 2
Fraction_SysW_G3	Generated heat fraction of heat generator 3
Code_SysW_S	Code of the water heat storage
Code_SysW_D	Code of the heat distribution including controls
Code_SysW_AuxD	Code of the auxiliary system (not applicable in Irish codes)

The water heating system combination codes selected are then grouped into unique codes for water heating systems. The description for the selected combination is entered into Tab.System.W in column H titled Description_SysW.

The full list of water heating system combination codes selected for typical Irish dwellings and created in Tab.System.W are shown in Table 3.29 overleaf.

Table 3.29 Tab.System.W Codes

Water Heating System Code	Description
IE.Gas+El.B_NC_CT+E_Immersion.SUH.01	gas central dhw system, poor efficiency 65% (cyl uninsulated) (immersion supplementary)
IE.Gas+El.B_NC_CT+E_Immersion.SUH.02	gas central dhw system, poor efficiency 65% (cyl insul 25mm) (immersion supplementary)
IE.Gas+El.B_NC_CT+E_Immersion.SUH.03	gas central dhw system, poor/medium efficiency 70% (cyl insul 30mm) (immersion supplementary)
IE.Gas+El.B_NC_CT+E_Immersion.SUH.04	gas central dhw system, medium efficiency 75% (cyl insul 50mm) (immersion supplementary)
IE.Gas.B_NC_CT.SUH.01	gas central dhw system, improved efficiency 75% (cyl insul 50mm) cyl stat, Can heat water separately in summer
IE.Gas.B_NC_CT.SUH.02	gas central dhw system, good efficiency 80% (cyl fac insul 35mm) 05-10 cyl stat, separated DHW controls
IE.Gas.B_C.SUH.01	gas central dhw system, very good efficiency, 90% condensing boiler (cyl fac insul 50mm) 05-10 cyl stat, insul pipework, separated DHW controls
IE.Oil+El.B_NC_CT+E_Immersion.SUH.01	oil central dhw system, poor efficiency 65% (cyl uninsulated) (immersion supplementary)
IE.Oil+El.B_NC_CT+E_Immersion.SUH.02	oil central dhw system, poor efficiency 65% (cyl insul 25mm) (immersion supplementary)
IE.Oil+El.B_NC_CT+E_Immersion.SUH.03	oil central dhw system, poor/medium efficiency 75% (cyl insul 30mm) (immersion supplementary)
IE.Oil.B_NC_CT.SUH.01	oil central dhw system, improved efficiency 75% (cyl insul 50mm) cyl stat, can heat water in summer
IE.Oil.B_NC_CT.SUH.02	oil central dhw system, good efficiency 80% (cyl fac insul 35mm) cyl stat, insul pipework, separated DHW controls
IE.Oil.B_C.SUH.01	oil central dhw system, very good efficiency, 90% condensing boiler (cyl fac insul 50mm) cyl stat, insul pipework, separated DHW controls
IE.El+-.HP_Air+Solar+E_Immersion.SUH.01	Heat pump (air) system, 380%eff, with Solar Panels, full zone control, insul. Pipework, 200Ltr split cylinder
IE.El+-.HP_Ground+Solar+E_Immersion.SUH.01	Heat pump (ground) system, 400%eff, with Solar Panels, full zone control, insul. Pipework, 200Ltr split cylinder
IE.El.E_Immersion.SUH.01	Electric immersion, loose jacket 50mm, cyl stat
IE.Bio_WP.B_C.SUH.01	Wood pellet boiler, very good efficiency, 90% (cyl fac insul 50mm) cyl stat, insul pipework, separated DHW controls
IE.Gas+El.B_NC_CT+E_Immersion.MUH.01	Gas boiler, 65% efficient, cylinder lagged, no cylinder stat, no separated HW controls
IE.Gas+El.B_NC_CT+E_Immersion.MUH.02	Gas boiler, 75% efficient, cylinder lagged, no cylinder stat, no separated HW controls
IE.Gas.B_C.MUH.01	gas central dhw system, very good efficiency, 90% condensing boiler (cyl fac insul 50mm) cyl stat, insul pipework, separated DHW controls
IE.El.E_Immersion.MUH.01	Electric immersion, cylinder lagged (30mm)
IE.El.E_Immersion.MUH.02	Electric immersion, spray foam 50mm

3.15. Ventilation Types: Tab.System.Vent

Two ventilation types have been created for typical Irish dwellings. Natural ventilation accounts for 99% of Irish residential buildings. In a small number of newer or refurbished dwelling types, balanced whole-house ventilation with heat recovery ventilation can be found.

The code is automatically generated in Tab.System.Vent by selecting the country code and the type of system ventilation, the relevant type of building where it is used, the variant number (there are two for Irish dwellings) and its description in free text as shown in Table 3.30.

Table 3.30 Creation of Ventilation Codes

TABULA Column	Code Entries
code_country	IE
Code_Type_SysVent	Bal_Rec
Code_Building SizeClass_System	SUH
Number_variant measure type	2
Description_Measure	Balanced whole-house with heat recovery

Note that the code for natural ventilation is simply a blank (-).

Table 3.31 shows the typical ventilation codes that have been selected as representative of those found in Irish dwellings.

Table 3.31 Tab.System.Vent

Code	Type	Single/multi	Description
IE.-.SUH.01	-	SUH	natural ventilation
IE.Bal_Rec.SUH.01	Bal_Rec	SUH	Balanced whole-house with heat recovery, 90% efficient
IE.-.MUH.01	-	MUH	natural ventilation
IE.Bal_Rec.MUH.01	Bal_Rec	MUH	Balanced whole-house with heat recovery 90% efficient

3.16. Building Types in TABULA: Tab.Type.Building and Tab.Building

The building types in TABULA are built in two separate worksheets. In Tab.Type.Building, individual building types are simply defined and described as shown in Table 3.32 below.

Table 3.32 Creation of Tab.Type.Building

TABULA Column	Code Entries
code_country	IE
Code_Typology Region	IE.N
Code_Building SizeClass_System	SUH
Code_ConstructionYearClass	IE.01
Code_Additional Parameter	IE.HBlockFBF
Description_Building Type	Semi detached house

For the Irish typology, the building types are primarily defined by the construction year class and the wall type. In the example in table 3.32, the wall type is defined within the additional parameter which in this case is a hollow block wall house with a half brick front.

In Tab.Building, the building type code that was created in Tab.Type.Building is then populated with all fabric elements codes and dimensions relating to that type such as:

- Building size
- Floor area
- Volume

- Roof types & U value & areas
- Thermal bridging
- Floor types & areas
- Wall types & areas
- Window types & areas by orientation

The main codes and data entries in Tab.Building for a hollow block house with a full brick front are shown in Table 3.33 below.

Table 3.33 Creation of Tab.Building

TABULA Column	Code Entries
Code Utilisation Type	Single family house
A_C_National (Floor area)	120
V_C (conditioned volume)	308
N_storey	2
Code_RoofType	tr
Code_AttachedNeighbours	B_n1
Code_ThermalBridging	High
Code_Roof_1	IE.Roof.01.01
Code_Wall_1	IE.Wall.01.08
Code_Wall_2	IE.Wall.01.02
Code_Floor_1	IE.Floor.01.02
Code_Window_1	IE.Window.02.01
Code_Door_1	IE.Door.00.01
Code_ConstructionBorder_Roof_1	Ext
Code_ConstructionBorder_Wall_1	Ext
Code_ConstructionBorder_Floor_1	Soil
A_Roof_1	56.6
A_Roof_2	6.7
A_Wall_1	82.7
A_Wall_2	8.8
A_Floor_1	63.4
A_Window_1	29.3
A_Window_Horizontal	0
A_Window_East	13
A_Window_South	1.4
A_Window_West	14.1
A_Window_North	.7
A_Door_1	2

By repeating this data entry process for all of the main Irish dwelling types, a range of typical Irish dwelling types have been created in Tab.Building. The 29 typical Irish house types and 5 apartment types that represent the Irish typology are listed in Table 3.34 overleaf.

Table 3.34. Tab.Building Codes

Irish Building Codes	Description
IE.N.SFH.01.Gen.ReEx.001	detached bungalow, empty cavity walls 300mm
IE.N.TH.01.Gen.ReEx.001	end of terrace, empty cavity walls, converted garage
IE.N.SFH.01.Stone.ReEx.001	Pre 1900 detached house, solid stone, with mass concrete extension. Walls uninsulated
IE.N.TH.01.Stone.ReEx.001	1900, Stone, End of terrace, extension
IE.N.SFH.01.225SB.ReEx.001	Rural bungalow, 225 Solid brick, walls uninsulated
IE.N.TH.01.225SB.ReEx.001	Solid brick 225mm, End of terrace
IE.N.SFH.01.325SB.ReEx.001	Detached house, 325 solid brick
IE.N.TH.01.325SB.ReEx.001	Solid brick 325 mm, end of terrace
IE.N.SFH.01.MassConc.ReEx.001	Bungalow, solid concrete walls, uninsulated, rural areas
IE.N.TH.01.MassConc.ReEx.001	mass concrete terraced house, walls uninsulated
IE.N.SFH.01.HBlock.ReEx.001	Detached bungalow +extension, hollow block
IE.N.TH.01.HBlockFBF.ReEx.001	Semi detached house/ terraced, hollow block, full brick front
IE.N.TH.01.HBlockHBF.ReEx.001	terraced house + internal garage and extension, hollow block/half brick front
IE.N.SFH.02.Gen.ReEx.001	detached house, partially filled cavity walls
IE.N.TH.02.Gen.ReEx.001	terraced house, cavity walls partially filled
IE.N.SFH.02.HBlock.ReEx.001	bungalow, hollow block
IE.N.TH.02.HBlock.ReEx.001	Semi detached house
IE.N.SFH.03.Gen.ReEx.001	rural detached bungalow, partially filled cavity walls
IE.N.TH.03.Gen.ReEx.001	Semi detached house, sun room, garage
IE.N.SFH.03.HBlock.ReEx.001	Detached bungalow + room in roof, hollow block
IE.N.TH.03.HBlock.ReEx.001	terraced house, hollow block
IE.N.SFH.04.Gen.ReEx.001	Detached bungalow, partially filled cavity walls
IE.N.TH.04.Gen.ReEx.001	Terraced 2 storey house, partially filled cavity walls
IE.N.SFH.04.Tframe.ReEx.001	detached bungalow, timber frame
IE.N.TH.04.Tframe.ReEx.001	semi detached 2 storey house, timber frame
IE.N.SFH.05.Gen.ReEx.001	detached house, partially filled cavity walls
IE.N.TH.05.Gen.ReEx.001	terraced house, cavity walls partially filled
IE.N.SFH.05.Tframe.ReEx.001	detached house, timber frame
IE.N.TH.05.Tframe.ReEx.001	Semi detached house, timber frame
IE.N.AB.01.Gen.ReEx.001	Apartment block , solid brick
IE.N.AB.02.Gen.ReEx.001	Apartment block, cavity walls
IE.N.AB.03.Gen.ReEx.001	Apartment block, partially filled cavity walls
IE.N.AB.04.Gen.ReEx.001	Apartment block, partially filled cavity walls
IE.N.AB.05.Gen.ReEx.001	Apartment block, concrete

At this stage of the coding process, the building construction elements and measures have been fully coded. The energy balance calculations for these houses and apartment may be observed in the worksheet Calc.Demo.Building that will be explained in more detail later in this report.

3.17. Defining Refurbishments for Building Types: Calc.Building.Set

As outlined in Section 3.15, in Tab.Building, the construction characteristics of typical Irish dwelling types have been created by combining many of the building elements codes in TABULA.

Within Calc.Building.Set, specific building measures are set out for each of the individual typical building types defined in Tab.Building and the energy needed for heating the buildings in the original dwelling state and in their state following the two stages of refurbishment are calculated.

The process is as follows:

- In Calc.Building.Set (column D –Code Building), select building type from drop down menu, e.g. IE.N.TH.01.HBlockFBF.ReEx.001
- In Number_Variant_Building, insert a variant number 1, 2 or 3. The variant Number 1, 2 and 3 will define the original state of the building and the state of the building for the two stages of refurbishment respectively. By selecting variants 1, 2 and 3, three building datasets will be created in Code_BuildingVariant in Columns A, namely:
  - IE.N.TH.01.HBlockFBF.ReEx.001.001
  - IE.N.TH.01.HBlockFBF.ReEx.001.002
  - IE.N.TH.01.HBlockFBF.ReEx.001.003
- Then, for variant 2 and variant 3 upgraded dwelling types, go to columns BW to CF to select the refurbishment measure for roof 1 etc, wall 1 etc, floor1 etc, window1 etc and door1. (These individual measures were created earlier in Tab.Building.Measure).
- Then, go to columns CS to DC and select from the dropdown menu whether the measure is in the “add” or “replace” category.
- The final columns of Calc.Building.Set then contain the energy balance Calculations showing the U values after refurbishment and the calculated energy needed for heating (q_h_nd, see column FX) based on the Tabula calculation method.

In the case of the dwelling type, IE.N.TH.01.HBlockFBF, the energy needed for heating for the three variants stages calculated in Calc.Building.Set are summarised in Table 3.35 below.

Table3.35 Calc.Building.Set Results

Code of Building	**Delivered Energy Needed for Heating (KWh/m^2/a)**
IE.N.TH.01.HBlockFBF.ReEx.001	252.9
IE.N.TH.01.HBlockFBF.ReEx.002	93.2
IE.N.TH.01.HBlockFBF.ReEx.003	77.20

These results will also be displayed in Calc.Demo.Building as outlined in the upcoming Section3.18 where the showcasing of results in explained.

3.18. System Energy Calculation / Total Energy Balance: Tab.Type.System, Tab.System.Measure and Calc.System.Set

In Tab.Type.System, space and water heating system types and ventilation system types are combined together via drop down menus to create complete heating systems for one building.

Table 3.36 Codes options for creation Tab.Type.System

Code	Description
Code_Country	IE
Code_SysH	IE.Gas+Coal.B_NC_CT+OpenFire.SUH.01
Code_SysVent	IE.-.SUH.01
Code_SysW	IE.Gas+El.B_NC_CT+E_Immersion.SUH.01
Description	Gas central heating system supplying DHW, with open fire. Poor efficiency, DHW cylinder with no insulation. Supplementary water heating via electric immersion.

In Tab.System.Measure, each system created in Tab.Type.System is combined with the two variants of heating system refurbishment, i.e. standard and advanced, as shown in Table 3.37. The last entry in the table provides a description of the heating systems for all three variants.

Table 3.37 Measure variants in Tab.System.Measure

Code	Description
Variant 1 (Existing)	IE.<Oil+Coal.B_NC_CT+OpenFire.SUH.01>.<Oil+El.B_NC_CT+E_Immersion.SUH.01>.<-.SUH.01>.<Gen>
Variant 2 (Standard)	IE.<Oil.B_C.SUH.01>.<Oil.B_C.SUH.01>.<-.SUH.01>.<Gen>
Variant 3 (Advanced)	IE.<El.HP_Air.SUH.01>.<El.HP_Air+Solar+E_Immersion.SUH.01>.<Bal_Rec.SUH.01>.<Gen>
Description	1.Oil boiler, poor efficiency and controls / 2: oil condensing boiler + full controls / 3: Air source heat pumps + solar thermal panels + Mechanical ventilation with heat recovery

In Calc.System.Set, individual building variants are selected via drop down menus and are then combined with heating systems measure variant from Tab.System.Measure to create complete building and heating systems combinations.

The delivered and primary energy values associated with each selected building / heating systems typology are displayed in Calc.System.Set as shown in Table 3.38 below.

Table 3.38 Calc.System.Set Options & Results

Calc.System.Set Code	Options Selected
Code_BuildingVariant	IE.N.SFH.01.Gen.ReEx.001.001
Code_System Type	IE.<Oil+Coal.B_NC_CT+OpenFire.SUH.01>.<Oil+El.B_NC_CT+E_Immersion.SUH.01>.<-.SUH.01>.<Gen>
Primary Energy Results	515.5 kWh/m2/year (Column FK)

The combinations selected and results generated in Calc.System.Set are not automically transferred to the showcasing of results in Calc.Demo.System (as the case for Calc.Demo.Building). Calc.Demo.System will be explained further in Section 3.18.

In addition, it should be noted that the TABULA webtool provides the best facility for combining building variants with heating system variants and for the displaying of results. Within the Webtool, it is possible to combine all 34 Irish dwelling types (29 + 5) and the 3 variants of each type giving 102 building variants. When the building variants are combined with the 31 Irish heating system variants, the results from a total of 3162 combinations can be displayed.

Finally, it should also be noted that Calc.System.Set has automatic option of combining all house types with all system types, creating a huge number of variants. This function was designed by IWU, the project co-ordinators, for overall project management purposes. It is of limited analytical benefit to individual partner countries. All results are stored only in Calc.System.Set.

3.19. Showcasing of Calculation of Building and System Performances

The detailed calculations conducted in Calc.System.Set are displayed in a report format in three separate reports formats:

- Calc.Demo.Refurbish
- Calc.Demo.Building
- Calc.Demo.System

For each of these reporting sheets, one Code_Building (e.g. IE.N.TH.01.HblockFBF.Ref001) can be displayed at any time. The reporting sheet displays all key data in a single A4 sheet.

3.19.1. Calc.Demo.Refurbish

This tab presents a summary of the U value refurbishment results for the specific house types and their associated improvement measures defined in Calc.Building.Set.

For example, when building code IE.N.SFH.01.HblockFBF.Ref00 is selected from the dropdown options, the original U values for the roof, walls, floors, windows and doors are shown. As Ref00 shown the building in its original state no refurbishment measures are shown.
When building code IE.N.SFH.01.HblockFBF.Ref01 is selected from the dropdown options, the original U values for the roof, walls, floors, windows and doors are shown. Then the thermal resistance of the additional refurbishment measures are shown. The actual U values post refurbishment are then displayed at the bottom of the sheet.

The results for Ref00, Ref01 and Ref02 for IE.N.SFH.01.HblockFBF are summarised in Table 3.39 below.

Table 3.39 Summary: Calc.Demo.Refurbish

	Roof 1	Wall 1	Wall 2	Floor 1	Window 1
IE.N.TH.01.HblockFBF.Ref00	0.68	2.4	1.78	1.58	5.7
IE.N.TH.01.HblockFBF.Ref01	0.13	0.27	0.48	1.58	2
IE.N.TH.01.HblockFBF.Ref02	0.13	0.21	0.20	1.58	1.3

A print out of Calc.Demo.Refurbish for IE.N.TH.01.HblockFBF.Ref01 is shown overleaf.

Figure 3.5 Calc.Demo.Refurbish

Thermal Insulation Measures — U-values

TABULA

building — code: IE.N.TH.01.HBlockFBF.ReEx.001

		Roof 1	Roof 2	Wall 1	Wall 2	Wall 3	Floor 1	Floor 2	Window 1	Window 2	Door 1	
envelope area	$A_{env,i}$	70	0	90	10	0	70	0	29	0	0	m²

Construction Element

		Roof 1	Roof 2	Wall 1	Wall 2	Wall 3	Floor 1	Floor 2	Window 1	Window 2	Door 1	
code		IE.Roof.ReEx.01.01		IE.Wall.ReEx.01.06	IE.Wall.ReEx.01.04		IE.Floor.ReEx.01.02		IE.Window.ReEx.01.01			
U-value original state	$U_{original,i}$	0.68		2.40	1.78		1.58		5.70			W/(m²K)
included insulation thickness	$d_{insulation,i}$	5.0		0.0	0.0		0.0					cm
border type		Ext	Ext	Ext	Ext		Soil					
additional thermal resistance	$R_{add,i}$	0.00		0.00	0.00		0.00					m²K/W

Refurbishment Measure

		Roof 1	Roof 2	Wall 1	Wall 2	Wall 3	Floor 1	Floor 2	Window 1	Window 2	Door 1	
code		IE.Roof.Insulation 25cm.01		IE.Wall.Ext cladding 90 mm .01	IE.Wall.Ext cladding 90 mm .01				IE.Window.PVC arg 3G lowE soft c 05, 16			
thermal resistance of refurbishment measure	$R_{measure,i}$	6.25		4.35	4.35		0.00		0.77			m²K/W

Result

		Roof 1	Roof 2	Wall 1	Wall 2	Wall 3	Floor 1	Floor 2	Window 1	Window 2	Door 1	
type of refurbishment		Add		Add	Add				Replace			
thermal resistance before measures	$R_{before,i}$	1.47		0.42	0.56		0.63		0.18			m²K/W
	$R_{actual,i}$	7.72		4.76	4.91		0.63		0.77			m²K/W
	$U_{actual,i}$	0.13		0.21	0.20		1.58		1.30			W/(m²K)

[TABULA]Calc.Demo.Refurbish 23/04/2012 14:49

3.19.2. Calc.Demo.Building

As explained in Section 3.17, within Calc.Building.Set, specific building measures are set out for each of the individual typical building types defined in Tab.Building and the energy needed for heating of the buildings in the original dwelling state and in their state following the two stages of refurbishment are calculated.

The final columns of Calc.Building.Set then carry out the energy balance calculations showing the U values (both original and after refurbishment) and the calculated energy needed for heating (q_h_nd, see column FI) based on the Tabula calculation method.

The results for each building type, e.g. IE.N.TH.01.HblockFBF.Ref001 are displayed in a single results summary A4 sheet in Calc.Demo.Building when that building type is selected.

All kWh values shown are delivered energy values.

This effectively represents the showcasing of the first half of the EPC calculation relating to building construction and heat loss.

A print out of Calc.Demo.Building for IE.N.TH.01.HblockFBF.ReEX.001.003 is shown overleaf (Figure 3.6) with an Energy Needed for Heating $Q_{H,nd}$ value of 77.2 kWh/year as indicated in Table 3.35.

3.20. Calibration Factors

The calculation engine within TABULA.xls is a common method for all TABULA partners and so does not match the national calculation method in each country.

An adaptation feature was incorporated into TABULA.xls so that the TABULA calculated results could be calibrated to match, where possible, the known actual energy consumption. The results calculated by these adaptation factors are shown at the end of Call.System.Set calculation sheets.

As calculated (asset-based) to measured consumption calibration factors are not known in Ireland, the Irish project used the calibration factor to match, as closely as possible, the TABULA.xls calculated result to the expected energy performance (BER) result for the same building using the Irish DEAP national calculation method.

The adaptation factors derived by comparative analysis of DEAP and TABULA.xls calculation for different typologies are indicated in Table 3.40 below for the range of primary energy values shown.

Table 3.40 Tab.CalcAdapt Factors

Primary Energy Range (kWh/m2/a)	Adaption Factor
0-100	1.2
100-200	0.9
200-300	0.8
301-400	0.8
401-500	0.7
501 & over	0.65

Figure 3.6 Calc.Demo.Building

TABULA

Energy Balance Calculation — Building Performance

Standard Reference Calculation - based on: EN ISO 13790 / seasonal method

building	IE.N.TH.01.HBlockFBF.ReEx.001 (0...1977)	reference area (conditioned floor area)	$A_{C,ref}$	120.0 m²
climate	IE.N (national / whole country)			

code construction element	original U-value $U_{original,i}$ W/(m²K)	measure type	applied refurbishment measure	actual U-value $U_{actual,i}$ W/(m²K)		area (basis: external dimensions) $A_{env,i}$ m²		adjustment factor soil $b_{tr,i}$		$H_{tr,i}$ W/K	annual heat loss related to $A_{C,Ref}$ kWh/(m²a)
Roof 1	0.68	Add	IE.Roof.Insulation25cm.01	0.13	×	69.6	×	1.00	=	9.0	4.8
Roof 2					×		×		=		0.0
Wall 1	2.40	Add	IE.Wall.Ext cladding 90 mm .01	0.21	×	90.4	×	1.00	=	19.0	10.2
Wall 2	1.78	Add	IE.Wall.Ext cladding 90 mm .01	0.20	×	9.7	×	1.00	=	2.0	1.1
Wall 3					×		×		=		0.0
Floor 1	1.58			1.58	×	69.6	×	0.50	=	55.0	29.5
Floor 2					×		×		=		0.0
Window 1	5.70	Replace	IE.Window.PVC arg 3G lowE soft c 05, 16 mm gap.01	1.30	×	29.3	×	1.00	=	38.1	20.4
Window 2					×		×		=		0.0
Door 1					×		×		=		0.0
thermal bridging: surcharge on the U-values				ΔU_{tb} 0.10	×	$\Sigma A_{env,i}$ 268.5	×	1.00	=	$H_{tr,tb}$ 26.8	14.4

Heat transfer coefficient by transmission H_{tr} — sum **150** — **80.3**

	volume-specific heat capacity air $c_{p,air}$ Wh/(m³K)		air change rate by use $n_{air,use}$ 1/h		by infiltration $n_{air,infiltration}$ 1/h		$A_{C,ref}$ m²		room height (standard value) h_{room} m		W/K	
Heat transfer coefficient by ventilation H_{ve}	0.34	× (	0.40	+	0.10	) ×	120.0	×	2.50	=	**51**	**27.3**

		internal temp. ϑ_i °C		external temp. ϑ_e °C		heating days d_{hs} d/a		Kd/a
accumulated differences between internal and external temperature	(	20.0	−	7.6	) ×	243	=	3006

		H_{tr} W/K		H_{ve} W/K		temperature reduction factor F_{red} (h_{tr}= 1.25 W/(m²K))		× 0,024 kKh/a		kWh/a	
Total heat transfer Q_{ht}	(	150	+	51	) ×	0.89	×	72.1	=	**12918**	**107.7**

window orientation	reduction factors: external shading F_{sh}		frame area fraction F_F		non-perpendicular F_W		solar energy transmittance $g_{gl,n}$		window area $A_{window,i}$ m²		solar global radiation $I_{sol,i}$ kWh/(m²a)		kWh/a	
1. Horizontal	0.80	× (1 -	0.30	) ×	0.90	×	0.57	×		×	475	=		0.0
2. East	0.60	× (1 -	0.30	) ×	0.90	×	0.57	×	13.1	×	306	=	861	7.2
3. South	0.60	× (1 -	0.30	) ×	0.90	×	0.57	×	1.4	×	485	=	143	1.2
4. West	0.60	× (1 -	0.30	) ×	0.90	×	0.57	×	14.1	×	306	=	932	7.8
5. North	0.60	× (1 -	0.30	) ×	0.90	×	0.57	×	0.7	×	185	=	29	0.2

Solar heat load during heating season Q_{sol} — sum **1965** — **16.4**

	kh/d		internal heat sources φ_i W/m²		heating days d_{hs} d/a		$A_{C,ref}$ m²		kWh/a	
Internal heat sources Q_{int}	0.024	×	3.00	×	243	×	120.0	=	**2100**	**17.5**

internal heat capacity per m² $A_{C,ref}$: c_m = 45 Wh/(m²K)

time constant of the building: $\tau = \frac{c_m \cdot A_{C,ref}}{H_{tr} + H_{ve}}$ = 27 h

parameter: $a_H = a_{H,0} + \frac{\tau}{\tau_{H,0}}$ = 1.70

heat balance ratio for the heating mode: $\gamma_{h,gn} = \frac{Q_{sol}+Q_{int}}{Q_{ht}}$ = 0.315

gain utilisation factor for heating: $\eta_{h,gn} = \frac{1-\gamma^{aH}}{1-\gamma^{aH+1}}$ = 0.90

Energy need for heating $Q_{H,nd}$: $Q_{ht} - \eta_{h,gn} \times (Q_{sol} + Q_{int})$ = **9264** kWh/a — **77.2**

[TABULA]Calc.Demo.Building 23/04/2012 09:27

3.20.1. Calc.Demo.System

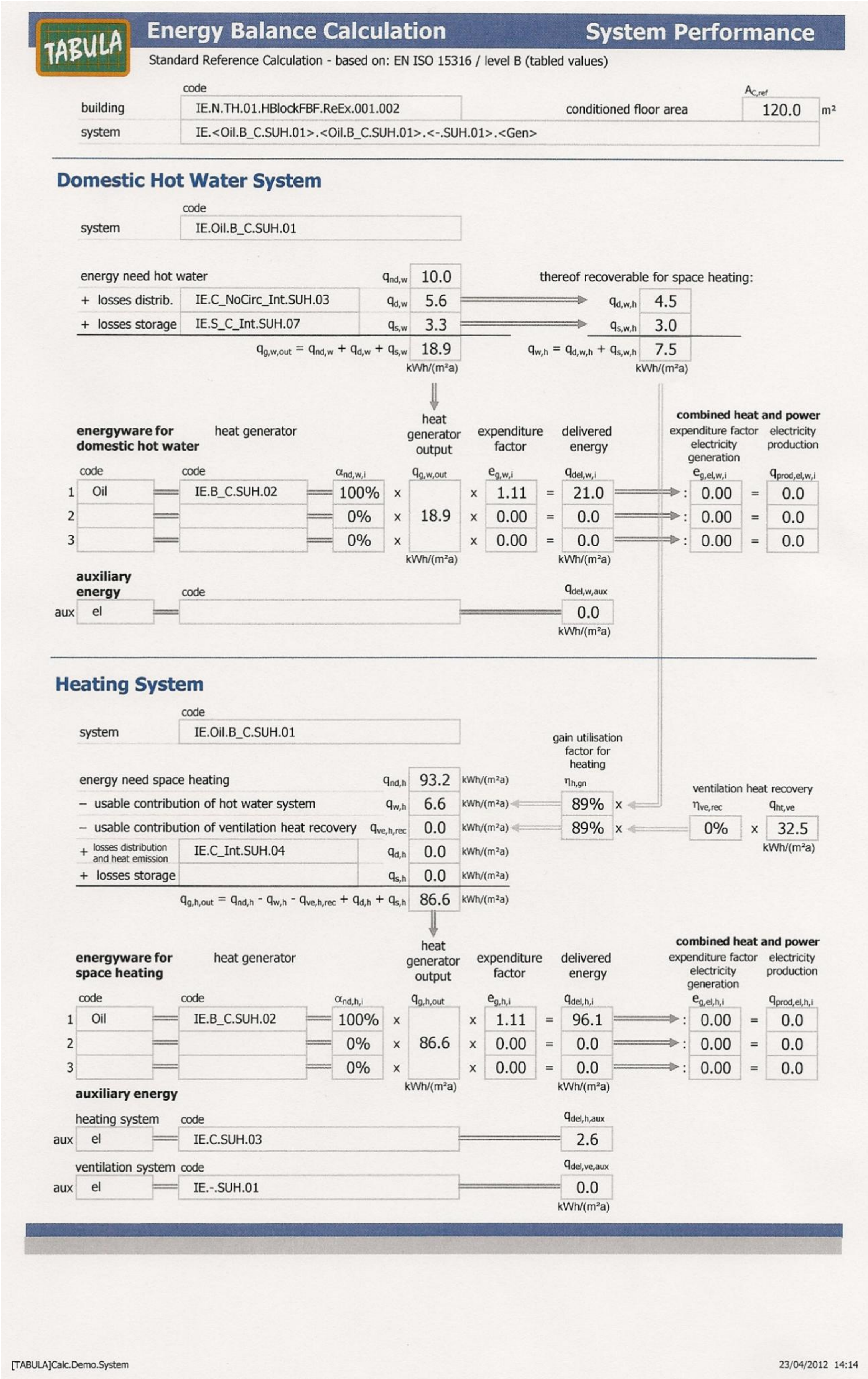
Calc.Demo.System completes the second part of the EPC calculation. This computes the delivered and primary energy needed for space and water heating.

To create the TABULA webtool EPC calculation for a building and heating system combination, the building type must first be selected in the Calc.Demo.Building, e.g. IE.N.TH.01.HBlockHBF.ReEx.001.002.

Then, in Calc.Demo.System, the preferred heating system code should be selected, e.g. IE.<Oil.B_C.SUH.SUH.01>.<Oil_C_SUH.01>.<-.SUH.01>.<Gen>.

The full Energy Balance Calculation is then displayed for that combination in Calc.Demo.System as shown in Figure 3.7 on the following two pages.

Figure 3.7 Calc.Demo.System



TABULA

Energy Balance Calculation **System Performance**

Standard Reference Calculation - based on: EN ISO 15316 / level B (tabled values)

	code		$A_{C,ref}$	
building	IE.N.TH.01.HBlockFBF.ReEx.001.002	conditioned floor area	120.0	m²
system	IE.<Oil.B_C.SUH.01>.<Oil.B_C.SUH.01>.<-.SUH.01>.<Gen>			

Domestic Hot Water System

	code
system	IE.Oil.B_C.SUH.01

	code		value		thereof recoverable for space heating:	
energy need hot water		$q_{nd,w}$	10.0			
+ losses distrib.	IE.C_NoCirc_Int.SUH.03	$q_{d,w}$	5.6	⇒	$q_{d,w,h}$	4.5
+ losses storage	IE.S_C_Int.SUH.07	$q_{s,w}$	3.3	⇒	$q_{s,w,h}$	3.0
		$q_{g,w,out} = q_{nd,w} + q_{d,w} + q_{s,w}$	18.9		$q_{w,h} = q_{d,w,h} + q_{s,w,h}$	7.5
			kWh/(m²a)			kWh/(m²a)

energyware for domestic hot water

	code	heat generator code	$\alpha_{nd,w,i}$		heat generator output $q_{g,w,out}$		expenditure factor $e_{g,w,i}$		delivered energy $q_{del,w,i}$		combined heat and power: expenditure factor electricity generation $e_{g,el,w,i}$		electricity production $q_{prod,el,w,i}$
1	Oil	IE.B_C.SUH.02	100%	x		x	1.11	=	21.0	:	0.00	=	0.0
2			0%	x	18.9	x	0.00	=	0.0	:	0.00	=	0.0
3			0%	x		x	0.00	=	0.0	:	0.00	=	0.0
					kWh/(m²a)				kWh/(m²a)				

auxiliary energy

		code	$q_{del,w,aux}$
aux	el		0.0
			kWh/(m²a)

Heating System

	code
system	IE.Oil.B_C.SUH.01

	code		value	unit	gain utilisation factor for heating $\eta_{h,gn}$		ventilation heat recovery $\eta_{ve,rec}$		$q_{ht,ve}$
energy need space heating		$q_{nd,h}$	93.2	kWh/(m²a)					
− usable contribution of hot water system		$q_{w,h}$	6.6	kWh/(m²a)	89%	x			
− usable contribution of ventilation heat recovery		$q_{ve,h,rec}$	0.0	kWh/(m²a)	89%	x	0%	x	32.5
+ losses distribution and heat emission	IE.C_Int.SUH.04	$q_{d,h}$	0.0	kWh/(m²a)					kWh/(m²a)
+ losses storage		$q_{s,h}$	0.0	kWh/(m²a)					
		$q_{g,h,out} = q_{nd,h} - q_{w,h} - q_{ve,h,rec} + q_{d,h} + q_{s,h}$	86.6	kWh/(m²a)					

energyware for space heating

	code	heat generator code	$\alpha_{nd,h,i}$		heat generator output $q_{g,h,out}$		expenditure factor $e_{g,h,i}$		delivered energy $q_{del,h,i}$		combined heat and power: expenditure factor electricity generation $e_{g,el,h,i}$		electricity production $q_{prod,el,h,i}$
1	Oil	IE.B_C.SUH.02	100%	x		x	1.11	=	96.1	:	0.00	=	0.0
2			0%	x	86.6	x	0.00	=	0.0	:	0.00	=	0.0
3			0%	x		x	0.00	=	0.0	:	0.00	=	0.0
					kWh/(m²a)				kWh/(m²a)				

auxiliary energy

		code	
heating system			$q_{del,h,aux}$
aux	el	IE.C.SUH.03	2.6
ventilation system			$q_{del,ve,aux}$
aux	el	IE.-.SUH.01	0.0
			kWh/(m²a)

[TABULA]Calc.Demo.System 23/04/2012 14:14

Energy Balance Calculation — Energy Carriers

	code		$A_{C,ref}$	
building	IE.N.TH.01.HBlockFBF.ReEx.001.002	conditioned floor area	120.0	m²
system	IE.<Oil.B_C.SUH.01>.<Oil.B_C.SUH.01>.<-.SUH.01>.<Gen>			

Assessment of Energywares

version of energy carrier specification — code: Gen

Standard Calculation

	delivered energy	total primary energy		non-renewable primary energy		carbon dioxide emissions		energy costs	
	$q_{del,i}$	$f_{p,total,i}$	$q_{p,total,i} = q_{del,i} \cdot f_{p,total,i}$	$f_{p,nonren,i}$	$q_{p,nonren,i} = q_{del,i} \cdot f_{p,nonren,i}$	$f_{CO2,i}$	$m_{CO2,i} = q_{del,i} \cdot f_{CO2,i}$	p_i (energyware price)	$c_i = q_{del,i} \cdot p_i$
Heating (+ Ventilation) System									
Oil	96.1	1.40	134.6	1.40	134.6	433	41.6	6.0	5.77
	0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
	0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
Auxiliary Electricity	2.6	3.31	8.7	3.14	8.3	617	1.6	15.0	0.39
Electricity Production / Export	0.0	1.30	0.0	1.30	0.0	420	0.0	8.0	0.00
Domestic Hot Water System									
Oil	21.0	1.40	29.4	1.40	29.4	433	9.1	6.0	1.26
	0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
	0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
Auxiliary Electricity	0.0	3.31	0.0	3.14	0.0	617	0.0	15.0	0.00
Electricity Production / Export	0.0	1.30	0.0	1.30	0.0	420	0.0	8.0	0.00
	kWh/(m²a)								

Summary and Expenditure Factors

	heat need q_{nd}	Σq_{del}	$e_{p,total} = \frac{q_{p,total}}{q_{nd}}$	$q_{p,total} = \Sigma q_{p,total}$	$e_{p,nonren} = \frac{q_{p,nonren}}{q_{nd}}$	$q_{p,nonren} = \Sigma q_{p,nonren}$	$f_{CO2,heat} = \frac{m_{CO2}}{q_{nd}}$	$m_{CO2,i} = \Sigma m_{CO2,i}$	$p_{heat} = \frac{c}{q_{nd}}$	$c = \Sigma c_i$
heating (+ ventilation) system	93.2	98.7	1.54	143.3	1.53	142.8	464	43.2	6.6	6.16
domestic hot water system	10.0	21.0	2.94	29.4	2.94	29.4	910	9.1	12.6	1.26
total	103.2	119.8	1.67	172.7	1.67	172.2	507	52.3	7.2	7.42
	kWh/(m²a)	kWh/(m²a)		kWh/(m²a)		kWh/(m²a)	g/kWh	kg/(m²a)	Cent/kWh	Euro/(m²a)

Typical Values of the Measured Consumption - Empirical Calibration

code: IE.C.01

The empirical calibration factor describes a typical ratio of the energy uses determined by measurements for a large number of buildings and by the TABULA method for the given value of the TABULA method.

application field	Dwelling Energy Assessment Procedure (DEAP)
determination method	The procedure takes account of the energy required for space heating, ventilation, water heating and li
accuracy level	0 =

	empirical relation							current value
delivered energy (without auxiliary electricity) according to standard calculation method	0	100	200	300	400	500		117.1
adaptation factor	1.20	0.90	0.80	0.80	0.70	0.65	2	0.88

Summary (including subcategories)		Standard Calculation heating	dhw	sum	Typical Measured Consumption heating	dhw	sum
Gas	$q_{del,\Sigma gas}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Oil	$q_{del,\Sigma oil}$	96.1	21.0	**117.1**	84.9	18.6	**103.4**
Coal	$q_{del,\Sigma coal}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Bio	$q_{del,\Sigma bio}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
El	$q_{del,\Sigma el}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
DH	$q_{del,\Sigma dh}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Other	$q_{del,\Sigma other}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Auxiliary Electricity	$q_{del,\Sigma aux}$	2.6	0.0	**2.6**	2.3	0.0	**2.3**
Produced / Exported Electricity	$q_{exp,\Sigma el}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**

4. Building Type Matrix

An overview of the all national building typologies in TABULA is initially provided by the "Building Type Matrix" that forms the presentation format of the TABULA webtool.

According to the TABULA conventions, there are 4 building size classes and each partner country can select their own construction year classes.

In the Irish Matrix only the most relevant three size classes have been developed as indicated in the image below. There were no Irish entries made under multi-family houses. The generic types of single family houses, terraced/semi detached houses and apartment blocks are presented on the first page of the building type matrix as shown below.

The generic building is a typical representative of the building type, meaning that it has features which can commonly be found in houses of the respective age and size class.

Figure 4.1 Building Type Matrix: Page 1, Generic types

	Region	Construction Year Class	Additional Classification	SFH Single-Family House	TH Terraced House	MFH Multi-Family House	AB Apartment Block
1	national	... 1977	generic	IE.N.SFH.01.Gen	IE.N.TH.01.Gen		IE.N.AB.01.Gen
2	national	1978 ... 1982	generic	IE.N.SFH.02.Gen	IE.N.TH.02.Gen		IE.N.AB.02.Gen
3	national	1983 ... 1993	generic	IE.N.SFH.03.Gen	IE.N.TH.03.Gen		IE.N.AB.03.Gen
4	national	1994 ... 2004	generic	IE.N.SFH.04.Gen	IE.N.TH.04.Gen		IE.N.AB.04.Gen
5	national	2005 ...	generic	IE.N.SFH.05.Gen	IE.N.TH.05.Gen		IE.N.AB.05.Gen

As explained in the chapter 3.2, the first age band of Irish typology covers extends period of time (1800-1977) due to the absence of Building Regulations. Therefore, to cover the various types of Irish houses with different wall types, a second page was created to include these types in the Building Type Matrix in addition to the generic matrix types.

The second page of the Matrix shows a more detailed breakdown of the construction types in the specific age bands. Special attention has been given to the houses built before 1978, where 7 different wall construction types have been distinguished. In the remaining age bands, one extra wall construction type has been added in addition to the generic wall type from the first page.

Figure 4.2 Building Type Matrix: Page 2, Further Building Types

6	national	... 1977	Stone	 IE.N.SFH.01.Stone	 IE.N.TH.01.Stone		
7	national	... 1977	225SB (225mm solid brick)	 IE.N.SFH.01.225SB	 IE.N.TH.01.225SB		
8	national	... 1977	325SB (325mm solid brick)	 IE.N.SFH.01.325SB	 IE.N.TH.01.325SB		
9	national	... 1977	MassConc (mass concrete)	 IE.N.SFH.01.MassConc	 IE.N.TH.01.MassConc		
10	national	... 1977	HBlock (hollow block)	 IE.N.SFH.01.HBlock			
11	national	... 1977	HBlockFBF (hollow block -full brick front)		 IE.N.TH.01.HBlockFBF		
12	national	... 1977	HBlockHBF (hollow block-half brick front)		 IE.N.TH.01.HBlockHBF		
13	national	1978 ... 1982	HBlock (hollow block)	 IE.N.SFH.02.HBlock	 IE.N.TH.02.HBlock		
14	national	1983 ... 1993	HBlock (hollow block)	 IE.N.SFH.03.HBlock	 IE.N.TH.03.HBlock		
15	national	1994 ... 2004	Tframe (Timber Frame)	 IE.N.SFH.04.Tframe	 IE.N.TH.04.Tframe		
16	national	2005 ...	Tframe (Timber Frame)	 IE.N.SFH.05.Tframe	 IE.N.TH.05.Tframe		

5. DEAP Analysis of the Irish House Types

All of the Irish house types were analysed using the Irish national Building Energy Rating (BER) method known as Dwelling Energy Assessment Procedure (DEAP).

The result of the DEAP analysis on the 29 house type and the one pre 1977 apartment type (entry no. 14) are shown in Table 5.1 below.

The stage 1 refurbishment brings the houses (and apartment) to C1-B2 range. The stage 2 refurbishment brings the houses (and apartment) to B3-A3 range.

Table 5.1: BER Results Summary

no	Age Band:	House type	Current State	Stage 1	Stage 2
1	1900-1977	SFH.01.Gen	G	B3	B1
2	1900-1977	TH.01.Gen	G	B3	B1
3	1900-1977	SFH.01.Stone	G	C1	B1
4	1900-1977	TH.01.Stone	G	C1	B2
5	1900-1977	SFH.01.225SB	G	C1	B3
6	1900-1977	TH.01.225SB	G	B3	B1
7	1900-1977	SFH.01.325SB	G	B2	B1
8	1900-1977	TH.01.325SB	G	C1	B2
9	1900-1977	SFH.01.MassConc	G	C1	B3
10	1900-1977	TH.01.MassConc	F	B2	B1
11	1900-1977	SFH.01.Hblock	G	B3	B1
12	1900-1977	TH.01.HBlockFBF	G	B3	B1
13	1900-1977	TH.01.HBlockHBF	G	B2	B1
14	1900-1977	AB.01.Gen	G	B3 (Var 1)	C1 (Var 2)
15	1978-1982	SFH.02.Gen	E2	B3	B1
16	1978-1982	TH.02.Gen	E1	B2	B1
17	1978-1982	SFH.02.Hblock	E1	B3	B1
18	1978-1982	TH.02.Hblock	E2	B2	B1
19	1983-1993	SFH.03.Gen	E1	B3	B2
20	1983-1993	TH.03.Gen	D2	B3	B2
21	1983-1993	SFH.03.Hblock	D1	B2	B1
22	1983-1993	TH.03.Hblock	D2	B2	A3
23	1994-2004	SFH.04.Gen	D2	C1	B3
24	1994-2004	TH.04.Gen	C2	B2	B1
25	1994-2004	SFH.04.Tframe	C3	B3	B2
26	1994-2004	TH.04.Tframe	C3	B3	B2
27	2005-onw	SFH.05.Gen	C1	B2	B1
28	2005-onw	TH.05.Gen	B3	B2	B1
29	2005-onw	SFH.05.Tframe	C1	B2	B1
30	2005-onw	TH.05.Tframe	B2	B2	B1

6. The Irish TABULA Brochure

As indicated in Section 1, each partner was given the task to develop brochures for each participating country giving an overview of the energy performance of typical buildings and the possible energy savings by refurbishment measures.

Individual brochures have been prepared for the 30 Irish dwelling types within the Irish typology in the form of double sided A4 sheets. All 30 individual brochures have also been compiled into one National Irish Typology brochure that also contains an introduction to TABULA and the brochure concept.

The energy analysis within the brochures is based on the Irish national Building Energy Rating (BER) method known as Dwelling Energy Assessment Procedure (DEAP). For each building type, sectional drawings and sketches are provided to illustrate many of the typical wall and roof constructions for both the original state and the refurbished state. These sectional drawings and sketches should provide homeowners, in particular, with some basic information relating to their dwelling that will enable them engage fully with potential refurbishment projects.

As well as indentifying these national house types, data on the 2 stages of retrofit are contained in each of the 30 brochures.

The impact of the refurbishment measures are shown in each of the individual dwelling brochures in terms of reductions in primary energy use, carbon dioxide emissions and the corresponding BER grade (i.e. A to G rating band). The impact of each individual measure is shown separately to show the likely results from partial upgrades.

For each dwelling type, the cost of the recommended measures is shown as well the associated payback periods. The cost of measures are full costs and do not include any possible grants that may be available. The costs used are average industry costs gathered from a short survey of market prices in 2011. It was decided to use payback periods and not to include actual yearly running costs as the former can vary with regular energy price movements and make the brochure appear less relevant. The payback information can give a better impression of the value for money aspect of particular refurbishment measures.

In the case of the apartment, a different approach was adopted for refurbishment analysis. Two variants on the main heating system were used, namely a gas boiler and an electric storage heating system. Standard refurbishment details for both heating systems are contained in the brochure for this dwelling type only.

Observations

The development of this suite of brochures of typical Irish dwellings will hopefully act as a useful information source both Irish householders and building professionals.

The National Energy Efficiency Action Plan 2009 -2020 NEEAP) includes the aim to retrofit 1million residential buildings in Ireland with energy efficient measures by 2020. The Stage 1 and Stage 2 refurbishment measures outlined in the TABULA brochures broadly cover the spectrum of works needed for the Irish housing stock.

The Irish TABULA project hopes that this brochure will make a positive contribution to the long term goal of retrofitting 1 million Irish dwellings by making the subject more accessible and more easily understood by a wider audience, most particularly, the Irish homeowners.

Figure 6.1 Front Page of Brochure

Description

1950s detached bungalow with uninsulated 9 inch (225mm) hollow block walls, uninsulated suspended timber floors and a standard pitched roof insulated at ceiling level between the attic joists. This house type is located in the Dublin and east coast areas in particular.

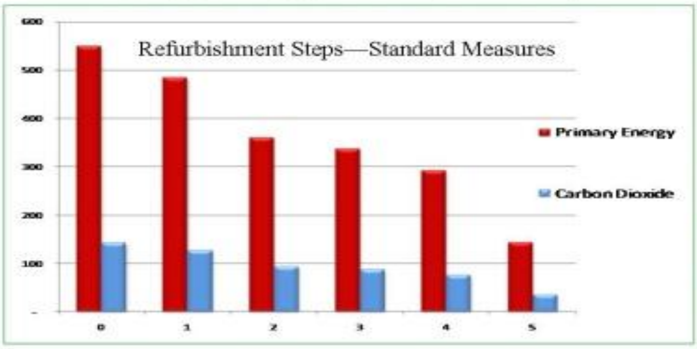
Bungalow, hollow block, 1950's

Building elements :		Insulation	U - value
Walls	Concrete hollow block	none	2.4
Roofs	Main roof insulated on ceiling Flat roof over the extension	50mm none	0.68 2.3
Floors	Suspended wooden floor, unsealed	none	0.69
Windows	Single glazed, wooden frame Single glazed, metal frame	n.a. n.a.	4.8 5.7
Doors	Solid timber doors	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipework uninsulated	Heating oil	65%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated with 25mm thick loose jacket, no thermostat		
Controls	Time clock only		

Refurbishment steps — standard					Prim. energy $kWh/m^2/y$	Carbon Dioxide $kgCO_2/m^2/y$	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**549** (actual state)	**142** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists.	0.13	485	126	G
2	**Wall insulation**	Add	70-90 mm external insulation, main and extension walls (phenolic/urethane)	0.24-0.27	360	93	E2
3	**Flat roof insulation**	Add	External insulation or drylining boards (urethane/ phenolic) , 100-110 mm	0.22	337	87	E1
4	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap, Insulated doors	2.0	292	75	D2
	Systems upgrade:						
5	**Space and water heating system and controls**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating. Hot water cylinder insulated with 50 mm spray foam		**143**	**35**	**B3**

*also includes draughtstripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: $kWh/m^2/y$, Carbon Dioxide emissions: $kg/m^2/y$

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 2,360	3.1
Step 2	€ 13,050	8.5
Step 3	€ 1,900	6.7
Step 4	€ 9,150	16.5
Step 5	€ 3,500	2.0
Total:	**€ 30,000**	**6.1**

Standard upgrade summary

Consumption of primary energy reduced by:	**406 $kWh/m^2/y$**
Emission of carbon dioxide reduced by:	**107 $kgCO_2/m^2/y$**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

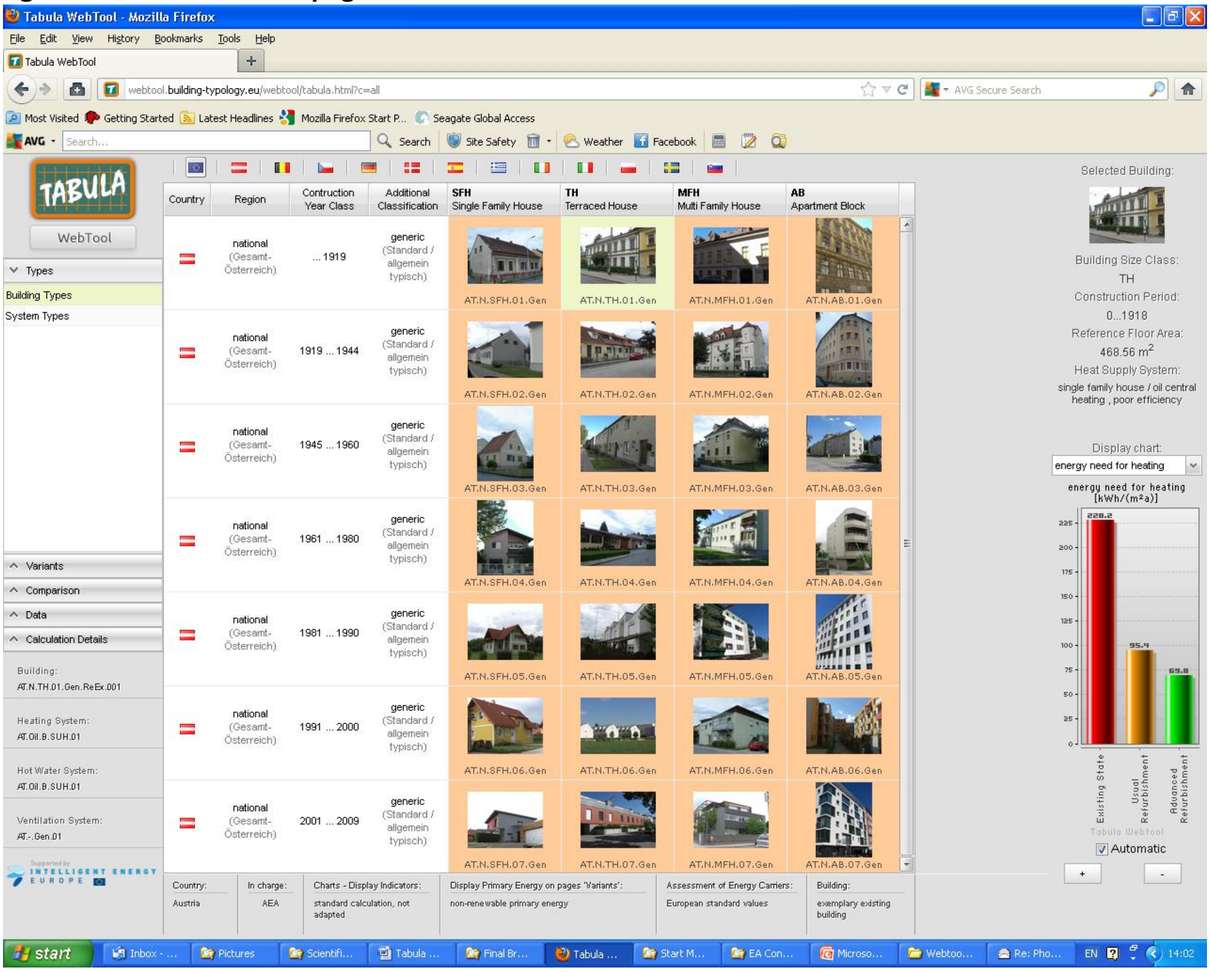
7. The TABULA Webtool

The TABULA webtool has been developed to showcase all of the national building typologies developed by the 13 partner countries involved in the TABULA project.

The webtool is located at the following URL:
http://webtool.building-typology.eu/webtool/tabula.html?c=all

A short description of the webtool is provided here giving an overview of the tool and its functions. The homepage is shown on the image (Figure 7.1) below. By clicking on the country flag icon on the tool bar you can see building photo matrix for each country. The Danish types are shown in this instance.

Figure 7.1 Webtool Homepage



The default setting showing the photos in ***Building Types***. By clicking on an individual building images, it becomes the selected building whose energy characteristics are displayed on the right hand side of screen. A range of charts are available for selection beneath the display chart text.

On the left hand side of the homepage, different options can be selected:

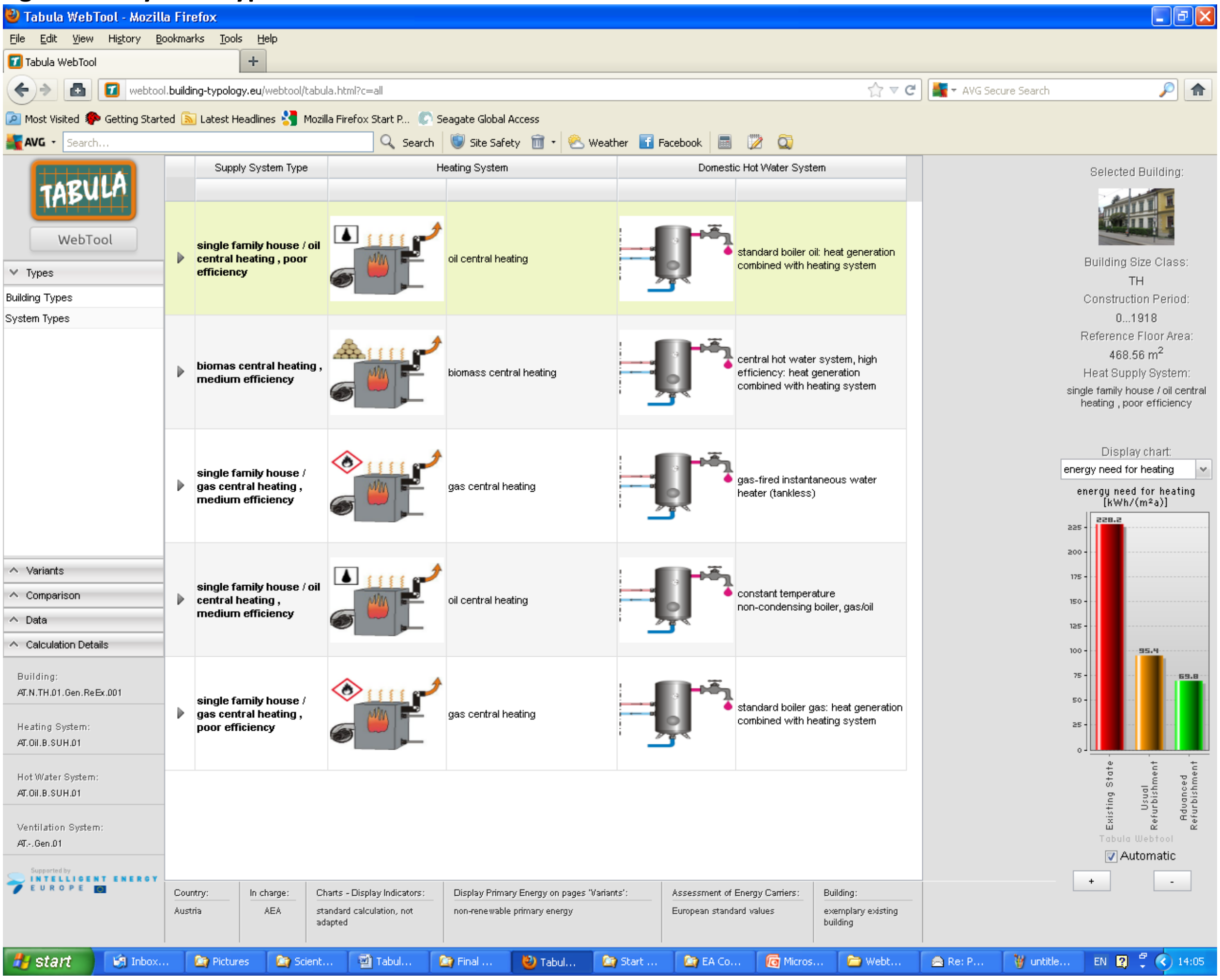
- Building Types
- System Types
- Variants

- Comparison
- Calculation Details

Figure 2 below demonstrates the System Types that are available for selection. The heating system combinations are shown on each row including a general description, an image and description of the space heating system and an image and description of the water heating system.

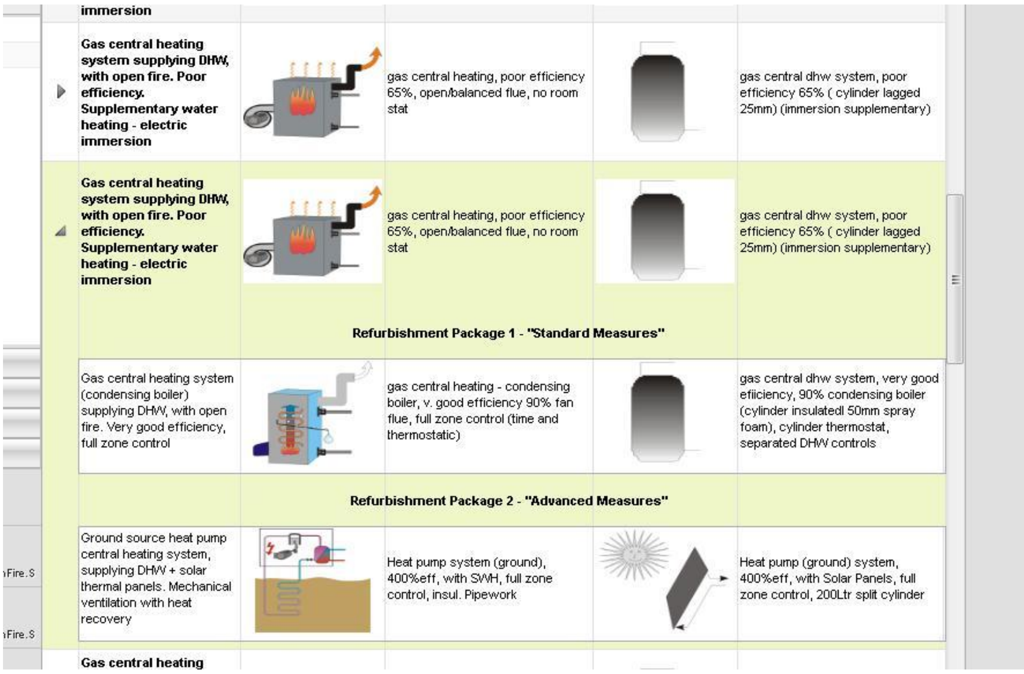
As different heating systems are selected, the energy values in the Display Chart can be seen to change**.**

Figure 7.2 System Types



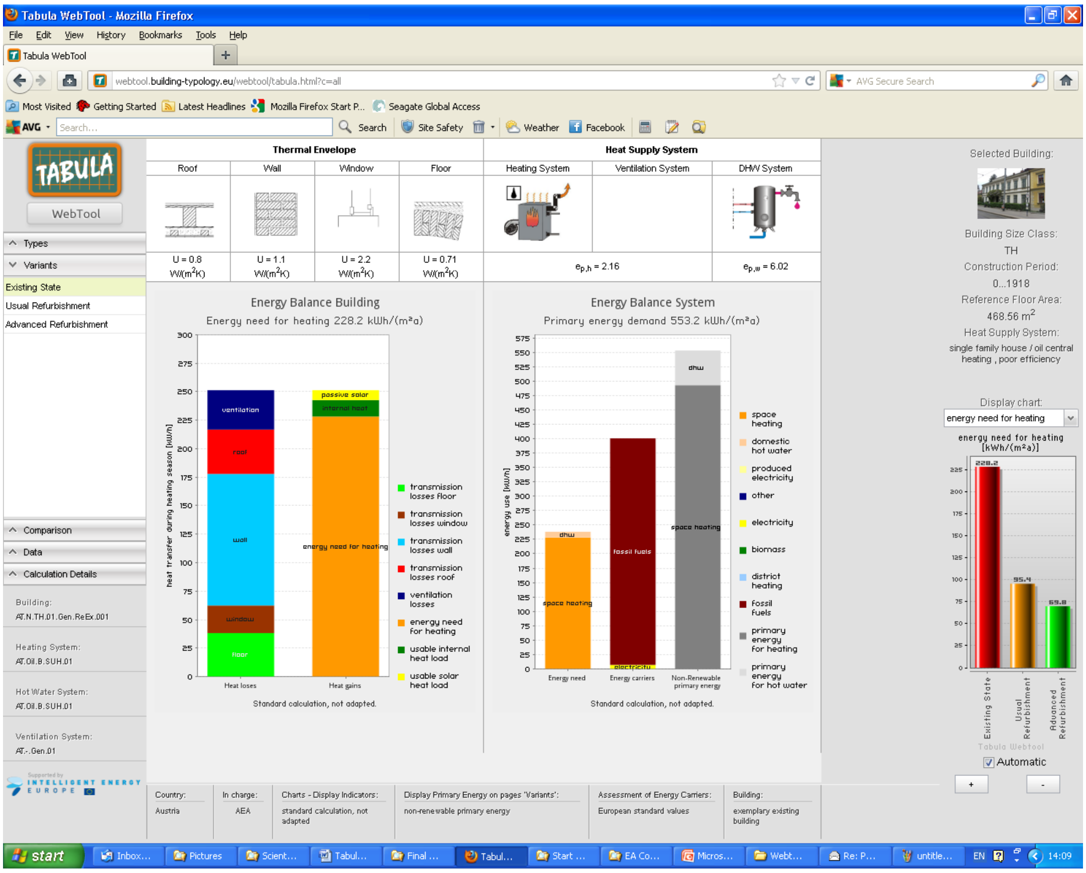
Also, when an individual heating system is selected, and the arrow on the left hand side is clicked on, the refurbishment heating systems for standard and advanced measures appear. In all cases, images of the systems are provided.

Figure 7.3 Heating System Refurbishment Packages in Webtool



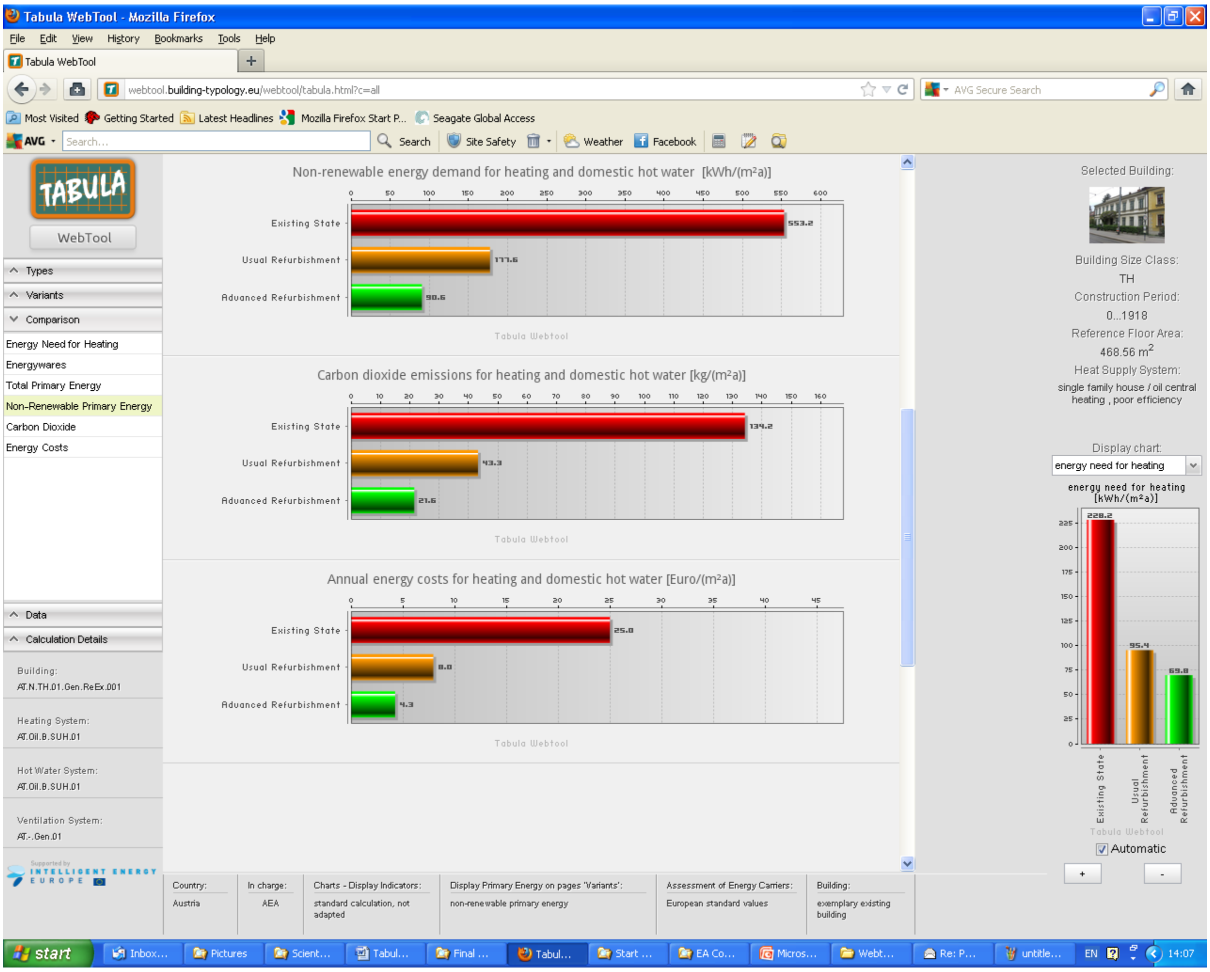
The ***Variants*** tab (Figure 7.4) then demonstrates the energy balance of the building and the energy balance of the heating supply system for the Existing State, Usual Refurbishment and Advanced Refurbishment.

Figure 7.4 Variants Tab



The ***Comparisons*** tab (Figure 7.5) presents display chart information on the right side of the homepage in horizontal bar chart format showing the different energy values, carbon dioxide and running costs.

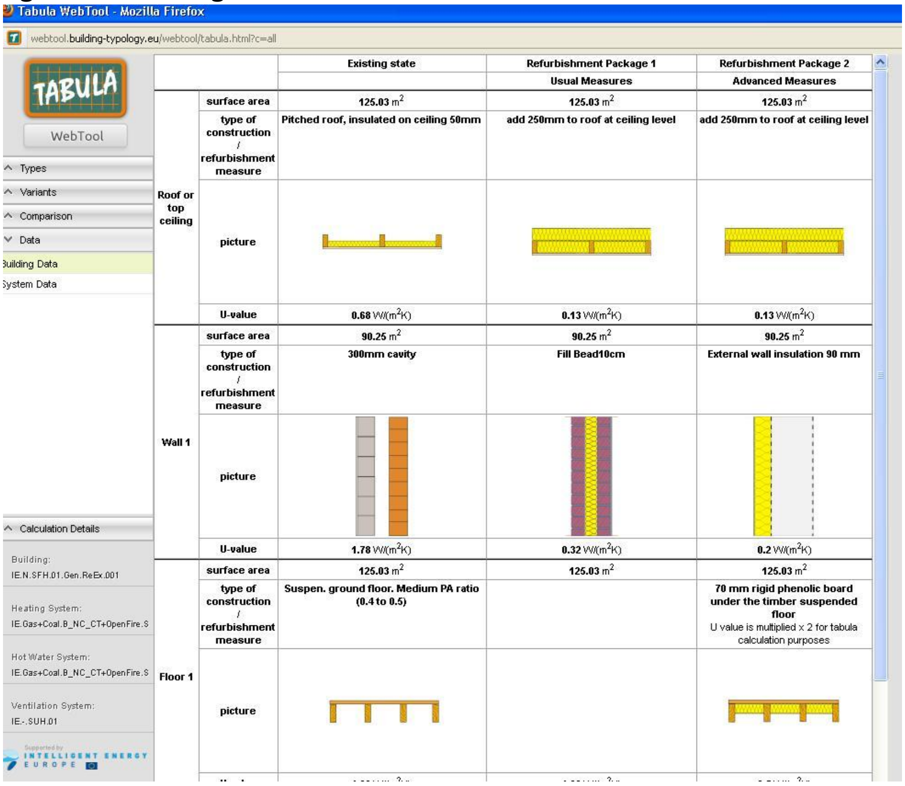
Figure 7.5 Comparisons Tab



The **Data** tab provides a full summary of Building Data and System Data information including relevant images.

The next image (Figure 7.6) overleaf shows the Building Data for the existing state, refurbishment package 1 and refurbishment package 2.

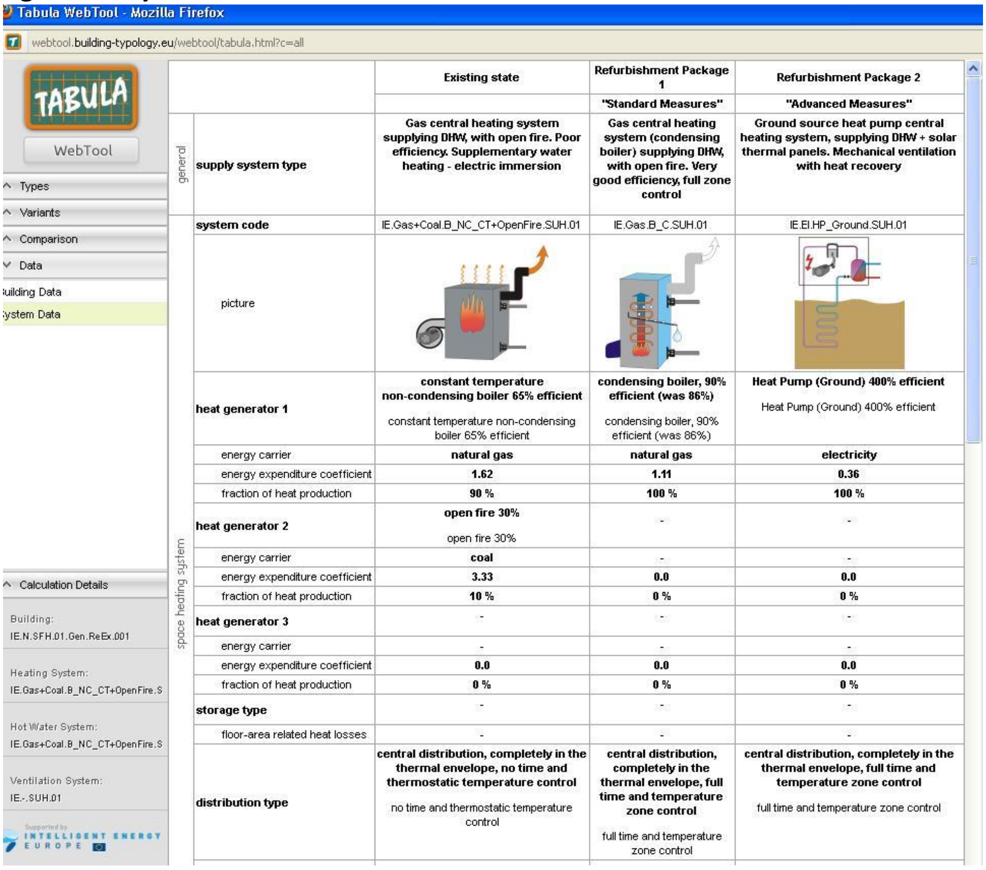
Figure 7.6 Building Data



		Existing state	Refurbishment Package 1	Refurbishment Package 2
			Usual Measures	Advanced Measures
Roof or top ceiling	surface area	125.03 m²	125.03 m²	125.03 m²
	type of construction / refurbishment measure	Pitched roof, insulated on ceiling 50mm	add 250mm to roof at ceiling level	add 250mm to roof at ceiling level
	picture			
	U-value	0.68 W/(m²K)	0.13 W/(m²K)	0.13 W/(m²K)
Wall 1	surface area	90.25 m²	90.25 m²	90.25 m²
	type of construction / refurbishment measure	300mm cavity	Fill Bead10cm	External wall insulation 90 mm
	picture			
	U-value	1.78 W/(m²K)	0.32 W/(m²K)	0.2 W/(m²K)
Floor 1	surface area	125.03 m²	125.03 m²	125.03 m²
	type of construction / refurbishment measure	Suspen. ground floor. Medium PA ratio (0.4 to 0.5)		70 mm rigid phenolic board under the timber suspended floor U value is multiplied x 2 for tabula calculation purposes
	picture			

The System Data is shown in Figure 7.6 below for the existing state, refurbishment package 1 and refurbishment package 2.

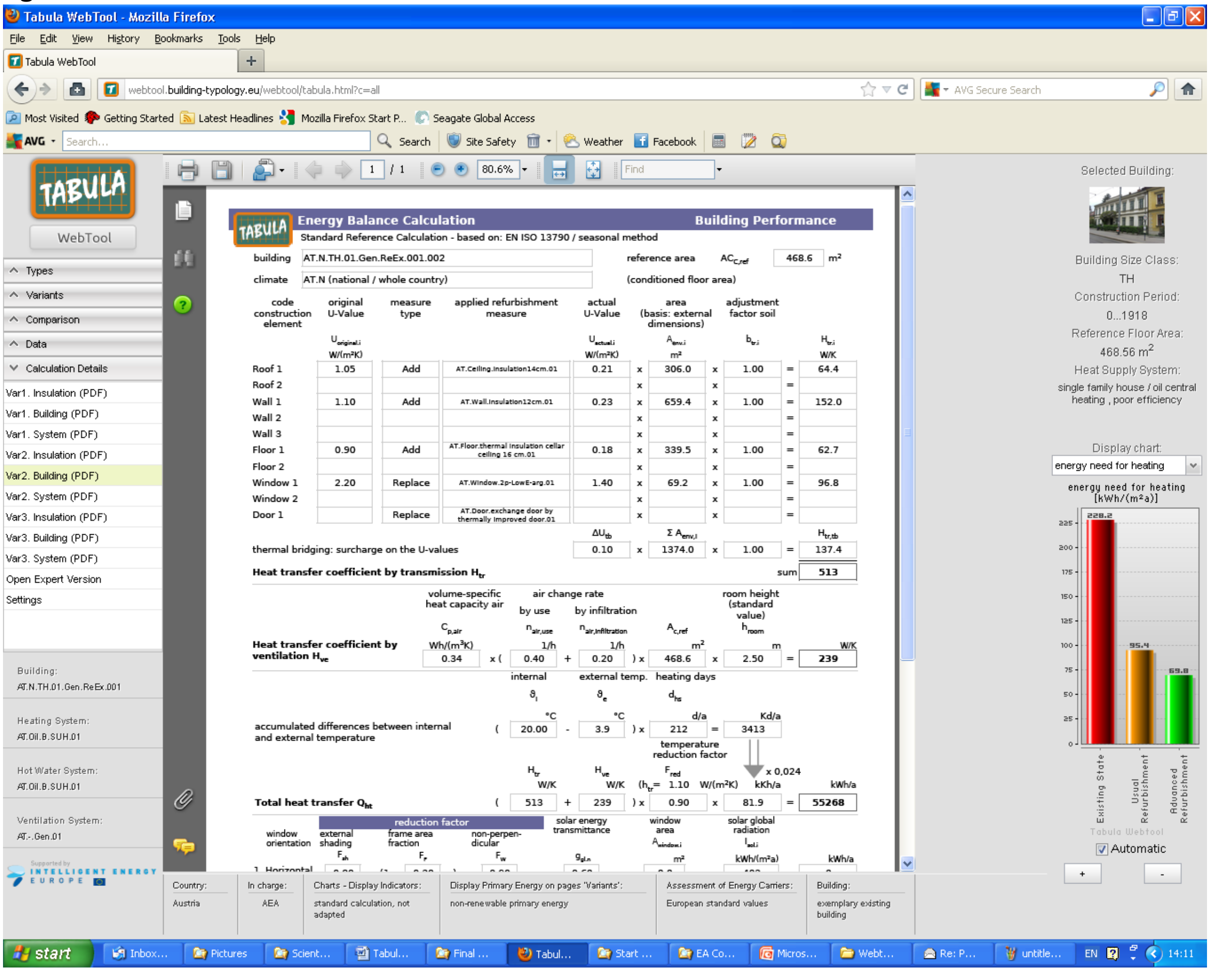
Figure 7.6 System Data



		Existing state	Refurbishment Package 1	Refurbishment Package 2
			"Standard Measures"	"Advanced Measures"
general	supply system type	Gas central heating system supplying DHW, with open fire. Poor efficiency. Supplementary water heating - electric immersion	Gas central heating system (condensing boiler) supplying DHW, with open fire. Very good efficiency, full zone control	Ground source heat pump central heating system, supplying DHW + solar thermal panels. Mechanical ventilation with heat recovery
space heating system	system code	IE.Gas+Coal.B_NC_CT+OpenFire.SUH.01	IE.Gas.B_C.SUH.01	IE.El.HP_Ground.SUH.01
	picture			
	heat generator 1	constant temperature non-condensing boiler 65% efficient constant temperature non-condensing boiler 65% efficient	condensing boiler, 90% efficient (was 86%) condensing boiler, 90% efficient (was 86%)	Heat Pump (Ground) 400% efficient Heat Pump (Ground) 400% efficient
	energy carrier	natural gas	natural gas	electricity
	energy expenditure coefficient	1.62	1.11	0.36
	fraction of heat production	90 %	100 %	100 %
	heat generator 2	open fire 30% open fire 30%	-	-
	energy carrier	coal	-	-
	energy expenditure coefficient	3.33	0.0	0.0
	fraction of heat production	10 %	0 %	0 %
	heat generator 3	-	-	-
	energy carrier	-	-	-
	energy expenditure coefficient	0.0	0.0	0.0
	fraction of heat production	0 %	0 %	0 %
	storage type	-	-	-
	floor-area related heat losses	-	-	-
	distribution type	central distribution, completely in the thermal envelope, no time and thermostatic temperature control no time and thermostatic temperature control	central distribution, completely in the thermal envelope, full time and temperature zone control full time and temperature zone control	central distribution, completely in the thermal envelope, full time and temperature zone control full time and temperature zone control

In calculation details (figure 7.7), access is provided to the Calc.Demo.Refurbish, Calc.Demo.Building and Calc.System.Set calculation sheets for the original state, refurbishment package 1 and refurbishment package 2.

Figure 7.7 Calculation Details



8. Use of Energy Certificate Databases for National Building Typologies

Ireland has one national EPC methodology for residential buildings (Dwelling Energy Assessment Procedure or DEAP) and one national EPC methodology for non-residential buildings (Non-Domestic Energy Assessment Procedure).

All of the EPCs (known as Building Energy Rating certificates or BERs in Ireland) for the residential and non-residential buildings are registered and stored on the National Administration System (NAS). The NAS is managed by the Sustainable Energy Authority of Ireland (SEAI) which is Ireland's energy authority. BER assessors must be registered with SEAI in order to conduct surveys and issue EPCs. All EPCs are generated via the DEAP software on the web-based NAS system.

As SEAI has full management control of the EPC database, it holds accurate data on the numbers of EPCs generated. SEAI produces monthly reports on the status of the public register. At the beginning of September 2011, the summary of residential EPCs published was as follows:

Table 8.1. Total Residential EPCs (September 2011)

Residential EPCs	Existing Buildings	New Buildings	Total
2007		50	50
2008		3,042	3,042
2009	69,547	14,546	84,093
2010	72,196	6,862	79,058
2011*	65,491	2,198	67,689
Total (* to 06.09.11)	207,234	26,698	233,932

Thus, EPCs had been published for about 15% of the national housing stock by September 2011. (Note that multiple EPCs have been produced for the same building in some instances so the actual percentage may be fractionally lower).

In the non-domestic sector, at the end of September 2011, there were 7,385 EPCs on the public register. There is no accurate record of the number of non-domestic buildings.

For public sector buildings, where Display Energy Certificates (DECs) are required, 333 valid DECs had been produced by the end of September 2011.

8.1. Representativeness of the Datasets

In this section, we examine if the EPC Database in Ireland is representative of the whole Irish building stock.

As Ireland has one national EPC database (rather than several regional databases as in other countries), the Irish EPC database gathers EPC data on the whole Irish residential building stock.

The Irish TABULA project team has been working in partnership with the SEAI management team responsible for the National EPC database (NAS) to examine how the EPC database resource can enhance the Irish building typology created within TABULA.

As a result of information requests placed by the Irish TABULA project, SEAI undertook a redesign of its NAS database query tool in mid 2011 to meet these requests. This redesigned query function produced some interesting results in October 2011 that allowed TABULA results to be cross-referenced with the national EPC database.

The Irish TABULA project created its typical buildings from an existing store of research data. The EPC database was not used as the data available from that source was limited in the early stages of the TABULA project in 2009.

With the data provided from the National EPC database in October 2011, it was possible to compare the research-based primary energy values (in kWh/m2/year) for each of the 29 house types (note that the Irish apartment type was not considered in this analysis) within the Irish building typology to average primary energy values (in kWh/m2/year) for those house types extracted from EPC database[4]. (Table 8.2).

Table 8.2: TABULA & EPC Primary Energy Comparisons (DEAP method)

TABULA House type	TABULA Typical Primary Energy Value (kWh/m2/a)	EPC Database Av. Primary Energy Value (kWh/m2/a)	Variation	Variation as % of TABULA typical Primary Energy Value
SFH.01.Gen	483.85	365.91	117.94	24%
TH.01.Gen	489.08	314.14	174.94	36%
SFH.01.Stone	618.18	440.14	178.04	29%
TH.01.Stone	607.41	410.36	197.05	32%
SFH.01.225SB	634.04	443.34	190.70	30%
TH.01.225SB	463.56	390.24	73.32	16%
SFH.01.325SB	453.53	383.00	70.53	16%
TH.01.325SB	631.70	381.47	250.23	40%
SFH.01.MassConc	656.59	507.00	149.59	23%
TH.01.MassConc	398.14	364.00	34.14	9%
SFH.01.Hblock	549.40	398.18	151.22	28%
TH.01.HBlockFBF	499.43	333.92	165.51	33%
TH.01.HBlockHBF	456.75	333.92	165.51	33%
SFH.02.Gen	365.73	237.96	127.77	35%
TH.02.Gen	317.67	262.15	55.52	17%
SFH.02.Hblock	321.72	258.70	63.02	20%
TH.02.Hblock	346.16	270.13	76.03	22%
SFH.03.Gen	302.52	271.60	30.92	10%
TH.03.Gen	293.97	260.88	33.09	11%
SFH.03.Hblock	250.87	232.27	18.60	7%
TH.03.Hblock	265.12	267.16	-2.04	-1%
SFH.04.Gen	292.27	244.87	47.40	16%
TH.04.Gen	179.55	227.11	-47.56	-26%
SFH.04.Tframe	214.70	265.98	-51.28	-24%
TH.04.Tframe	203.99	220.44	-16.45	-8%
SFH.05.Gen	171.12	162.20	8.92	5%
TH.05.Gen	149.74	167.26	-17.52	-12%
SFH.05.Tframe	162.37	147.36	15.01	9%
TH.05.Tframe	123.21	154.26	-31.05	-25%

Source: SEAI NAS (2011)

Table 8.2 shows the primary energy values for the 29 Irish house types created for TABULA along with the average primary energy value for each of these 29 house types derived from the EPC database in October 2011.

For the 13 dwelling types in the first age band (1800-1977), the average primary energy values of the EPCs within the NAS database are 27% lower than the TABULA typology values for the same dwelling types. In the next age band (1978-1982), the difference is similar at 24%. For the three most recent age bands, the variance is within 10% approx. and is less significant.

The differences of 27% and 24% in the two older age bands arise due to several factors including:

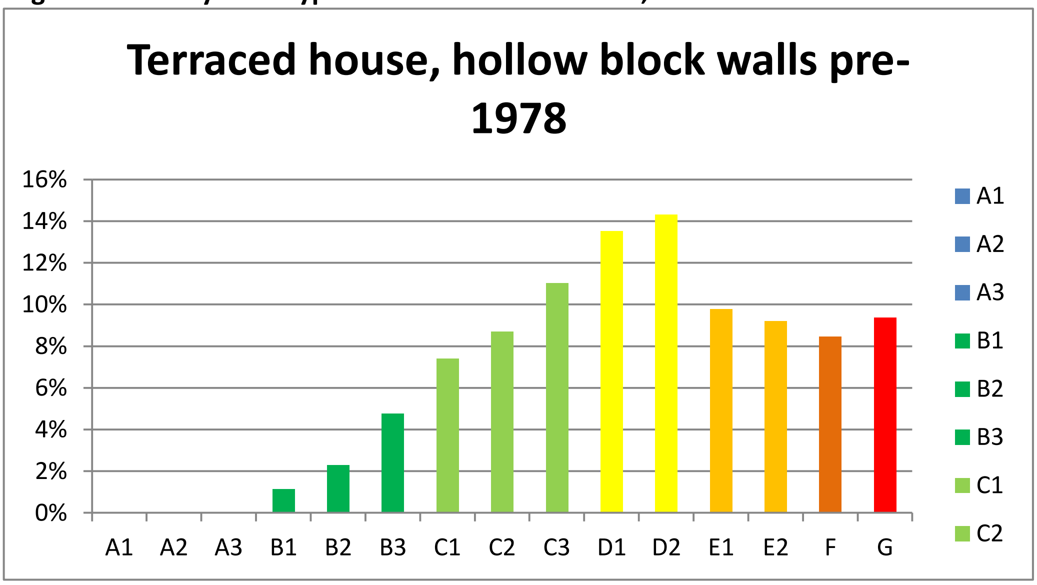
- The EPC database includes EPCs for many dwellings that have been retrofitted with energy upgrades. (In order to avail of grants from the Government for refurbishment works, post works EPCs are required.) Thus, many of the EPCs for the old dwellings will have better primary energy values than typical buildings of this age would have.
- each TABULA house type is based on a selected primary heating fuel type only. The EPC Database average primary energy value includes all fuel types.

For the years 2007-2011, approximately 196,000 Irish dwellings had refurbishment measures installed under SEAI's energy efficiency programmes. Approximately 50% of these dwellings will have had EPCs published based on the post works primary energy values.

The chart in figure 8.1 shows the range of published BER (EPC) scores (source SEAI: October 2011) for a Type 11 house, a pre 1978 terraced hollow block wall house. It is interesting to note that many of these dwellings have B, C and D ratings indicating that these properties will have already had some refurbishment measures carried under the current energy efficiency schemes. It is notable that there is a spike in the numbers of published BER certificates at the D1, D2 grades and a falling off thereafter. It is also interesting to note that within the brochure for type 11, the standard refurbishment of the building fabric brings the TABULA dwelling from a G to a D1 rating.

This pattern showing a spike of published BER certificates at the D1, D2 bands was consistent for all thirteen pre1977 dwelling types.

Figure 8.1: Analysis of Type 11 BER Scores from NAS, October 2011



8.2. Conclusions on Use of Energy Certificate Databases for National Building Typologies

The Irish BER (EPC) database will provide a rich ongoing and growing source of information that can enhance the Irish building typology developed in TABULA.

The following conclusions and recommendations are made as to how the national EPC database can further enhance the Irish building typology.

- **National EPC Database:** The statistics produced from the EPC database in October 2011 for 233,000 EPCs specifically for the TABULA project are extremely interesting and require deeper analysis, especially when cross-referenced to TABULA dwelling types.

  The Irish EPC database is a growing data source. However, it must be noted that it is not a scientific source of research data and indeed it is skewed in terms of the overall stock of dwellings because many of the EPCs refer to refurbished dwellings. (Note: More than 50% of EPCs published for existing dwellings in 2010 were for refurbished dwellings). A revised version of the Irish EPC software (DEAP) was issued in December 2011 that will enrich future EPC database information. In future, EPCs can be categorised by their purpose, e.g. if they were required for sale or rental purposes, for public housing or for grant purposes.

  Recommendation: A further study should be carried out in December 2012 or soon after as the automatic categorisation of EPCs by purpose will have been in effect for one year. This should demonstrate the average BER scores for refurbished and non-refurbished buildings respectively. The study should then examine what additional refinements should be made to the Irish building typology analysis conducted within TABULA.

- **National Energy Balance**: Further studies will be required to enable the creation and updating of national energy balance calculations as outlined above. Most importantly, as Ireland embarks on a major retrofit programme of its housing stock over the next 10 years, it is critical that a robust national energy balance calculation methodology is established.

  Recommendation: A national energy balance calculation should be completed by combining Irish building typologies developed in TABULA with frequency data for individual building types.

- **Irish Census Housing Data:** The building type related data in the Irish Census does not correspond to the Irish EPC methodology (DEAP) in terms of age bands. It also fails to query fuel types used for heating. This should be rectified in any future Irish Census. The Irish building type Census data as it currently stands has very limited use when conducting meaningful analysis on the energy performance of the Irish housing stock.

  Recommendation: The 2016 Irish Census should, as a minimum, revise the building age bands to match those in DEAP. The 2016 Irish Census should also include questions on the fuel used for heating. These two extra pieces of information will greatly enhance future national energy balance and typology studies.

- **House Condition Survey:** In order to get an accurate snapshot of the energy performance of Irish dwellings, a national house condition survey needs to be established and be conducted at regular intervals, e.g. every 5 years. The Scottish House condition was based on a survey of 15,000 dwellings every 5 years. This is now done via an annual rolling survey of 3,000 housing units.

Recommendation: A national Irish House Condition Survey should be design and implemented on an ongoing basis to get an accurate assessment of the energy performance of the Irish housing stock.

9. Modelling the Irish Residential Building Stock

A selection of the Partners in TABULA used their building typologies to model their national building stock. This task was not undertaken by the Irish TABULA project.

However, at the conclusion of the Irish TABULA projects, there are some clear indications on how this task could be undertaken.

As indicated above, data became available from the National EPC database in October 2011. This EPC data can be used either separately or with the Irish building typology (and other data sources) to develop a national energy balance calculation.

In fact, the data provided from the EPC database in October 2011 for the 239,000 dwellings was classified on a wider basis than the 29 TABULA typical buildings, as indicated below.

The EPC database has been categorised for 39 dwelling types defined by:

- age band and wall type
- energy value (kWh/m^2/year)
- floor area (m^2)
- number of storeys
- dwelling type (apt, detached house, mid-terrace house etc)

By conducting further and ongoing analysis of results from the EPC database and cross-referencing these results with the Irish TABULA building typology and other data sources such as the Irish Census, national energy balance calculations can be created and refined.

10. Conclusions & Recommendations

The Irish TAULA project has established an Irish Residential building typology within the context of a wider European building typology framework containing 30 typical Irish house and apartment types.

Information on TABULA is available via two key channels, namely through (1) the TABULA building typology webtool, http://webtool.building-typology.eu/webtool/tabula.html?c=all, and (2) brochures for each participating country giving an overview of the energy performance of typical buildings and the possible energy savings by refurbishment measures

This typology information should prove to be a very resource for homeowners, building energy experts, housing managers, policy strategists and researchers.

With regards to the further development of the Irish building typology, the following key recommendations are proposed.

- **National EPC Database:** The statistics produced from the EPC database in October 2011 for 233,000 EPCs specifically for the TABULA project are extremely interesting and require deeper analysis, especially when cross-referenced to TABULA dwelling types.

  The Irish EPC database is a growing data source. However, it must be noted that it is not a scientific source of research data and indeed it is skewed in terms of the overall stock of dwellings because many of the EPCs refer to refurbished dwellings. (Note: More than 50% of EPCs published for existing dwellings in 2010 were for refurbished dwellings). A revised version of the Irish EPC software (DEAP) was issued in December 2011 that will enrich future EPC database information. In future, EPCs can be categorised by their purpose, e.g. if they were required for sale or rental purposes, for public housing or for grant purposes.

  Recommendation: A further study should be carried out in December 2012 or soon after as the automatic categorisation of EPCs by purpose will have been in effect for one year. This should demonstrate the average BER scores for refurbished and non-refurbished buildings respectively. The study should then examine what additional refinements should be made to the Irish building typology analysis conducted within TABULA.

- **National Energy Balance**: Further studies will be required to enable the creation and updating of national energy balance calculations as outlined above. Most importantly, as Ireland embarks on a major retrofit programme of its housing stock over the next 10 years, it is critical that a robust national energy balance calculation methodology is established.

  Recommendation: A national energy balance calculation should be completed by combining Irish building typologies developed in TABULA with frequency data for individual building types.

- **Irish Census Housing Data:** The building type related data in the Irish Census does not correspond to the Irish EPC methodology (DEAP) in terms of age bands. It also fails to query fuel types used for heating. This should be rectified in any future Irish Census. The Irish building type Census data as it currently stands has very limited use when conducting meaningful analysis on the energy performance of the Irish housing stock.

  Recommendation: The 2016 Irish Census should, as a minimum, revise the building age bands to match those in DEAP. The 2016 Irish Census should also include questions on the fuel used for heating. These two extra pieces of information will greatly enhance future national energy balance and typology studies.

- **House Condition Survey:** In order to get an accurate snapshot of the energy performance of Irish dwellings, a national house condition survey needs to be established and be conducted at regular intervals, e.g. every 5 years. The Scottish House condition was based on a survey of 15,000 dwellings every 5 years. This is now done via an annual rolling survey of 3,000 housing units.

  Recommendation: A national Irish House Condition survey should be designed and implemented on an ongoing basis to get an accurate assessment of the energy performance of the Irish housing stock.

- **Typology of Irish Commercial Buildings:** A typology of commercial buildings in Ireland has not been developed. Several European partners in TABULA have developed non-residential building typologies.

  Recommendation: An initial scoping study should be conducted to examine the parameters relating to a building typology of commercial buildings in Ireland.