National Report of the Irish EPISCOPE Pilot Action

Monitoring the energy refurbishment rates for the housing stock of the Northside of Dublin City

(Deliverable D3.1)

Final Report, 4th April 2016

EPISCOPE Irish Project Team

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Authors	Partner	City / Country
M. Hanratty, B. Sheldrick, C. Roarty, M. Badurek	Energy Action Limited	Dublin / Ireland

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EPISCOPE website: www.episcope.eu

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1 Introduction

A major objective of the EPISCOPE project is to lay a basis for tracking the energy refurbishment progress of housing stock entities in the field of thermal protection and heat supply (heating and hot water) against the background of energy saving and climate protection needs. During the project different residential building stocks are analysed in 16 European countries – from local housing portfolios to regional or national housing stocks.

The EPISCOPE model project for Ireland has focussed on monitoring refurbishment rates for the Northside of Dublin City. Dublin City and County comprises four Local Authority areas - Dublin City and the three county based local authorities to the north, south-west and south-east, namely Fingal, South Dublin and Dun Laoghaire Rathdown County Councils respectively. Dublin City is split to the north and south by the River Liffey. The housing stock examined in the Pilot Action is that on the Northside of Dublin City which consists of 133,431 dwellings [Census 2011]. The geographical area includes the Dublin postal districts 1, 3, 5, 7, 9, 11, 13 (parts of) and 17.

Figure 1: Map of Northside of Dublin City

Map Data [© OpenStreetMap contributors]

With regard to the dwelling stock of the Northside of Dublin City, key details on its composition are as follows:

- 133,431 dwellings in total, comprising 96,183 houses and 37,248 individual apartments/ flats
- 14,060 dwellings are owned by Dublin City Council and a further 2,000 to 3,000 dwellings are owned by Housing Associations. Thus, approximately 12.5% of the stock is social/ public housing.
- Energy Performance Certificates (EPCs) / Building Energy Rating (BER) certificates have been published for circa 30% of the housing stock nationally. EPCs for 40,797 dwellings within the selected pilot action stock were published on the National EPC database as of 11th February 2015 and provide a valuable data source for this study.

While some refurbishment of the housing stock has taken place, especially in the last 5 years due to Government initiatives for both private owner-occupied housing and for local authority housing, the scale of refurbishment conducted to date and the predicted future rates of refurbishment are not established. The aim of the pilot action is to establish the current energy status of the stock, the refurbishment conducted to date, the current annual

refurbishment rates and to assess the current and predicted trends against the national targets set for 2020, 2030 and 2050.

In addition, the Irish Pilot Action includes the development of an EPC (BER) mapping tool to demonstrate that mapping of EPC data can provide a valuable resource in planning and accelerating refurbishment of the housing stock.

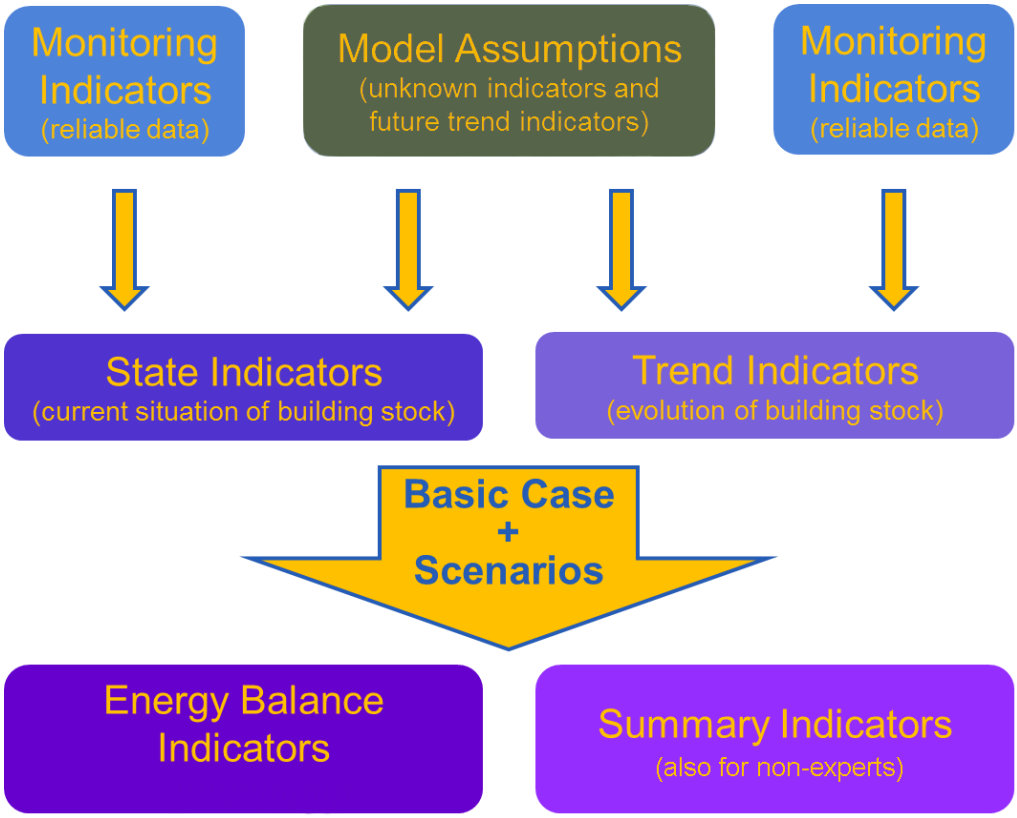
Several refurbishment programmes have influenced the energy performance of the selected housing stock. Since 2008, there has been a significant increase in refurbishment activity arising from national programmes managed by the Sustainable Energy Authority of Ireland (SEAI) and local authority programmes delivered by Dublin City Council. These programmes include:

- SEAI Better Energy Homes Scheme: This scheme provides grant support to privately-owned dwellings for wall insulation (cavity, internal and external), roof insulation, boiler and heating controls upgrades and solar thermal systems. It has operated nationally since 2008.
- SEAI Better Energy Warmer Homes Scheme: This scheme mainly provides roof insulation, cavity wall insulation, hot water cylinder insulation and low energy lighting to targeted low income households. On a very limited scale, the scheme provides insulation to solid wall properties and for the installation of high efficiency heating systems and heating controls. It has continued to operate nationally since 2001 and is normally arranged on a single dwelling basis.
- SEAI Areas Scheme: This scheme provides a range of measures to clusters of lower income housing (typically local authority or housing association stock) including roof insulation, cavity wall insulation, boiler and heating control upgrades, heat pumps, high efficiency stove room heaters, solar thermal systems, hot water cylinder insulation and low energy lighting.
- SEAI Better Energy Communities Scheme: This scheme is similar to the SEAI Areas scheme, except that the programme enables the dwelling upgrade projects to be coupled with the upgrade of commercial and community buildings. This approach enables the commercial project partner to supplement the grant support to the residential dwelling upgrade works.
- Dublin City Council (DCC) refurbishment programme: Individual dwellings belonging to the DCC were refurbished on an individual basis when vacant up to 2012. In 2013, Phase 1 of a planned refurbishment of all local authority housing stock commenced starting with roof insulation and wall insulation for properties with cavity wall construction. Phase 2 will start during 2015 and will focus on wall insulation for solid wall properties, replacement of all single-glazed windows and high efficiency boiler and heating control upgrades.
- There are several Housing Associations within the Pilot Action area. The Housing Associations will have also undertaken some refurbishment measures in recent years and many of these will be included in the SEAI Community and Areas schemes listed above.

Outside of the established schemes listed above, many individual home owners will have carried out refurbishment measures on their dwellings. The scale of this activity is not well known and is difficult to quantify.

The following picture provides a more detailed overview of the different types of indicators that will be a feature of the EPISCOPE pilot actions.

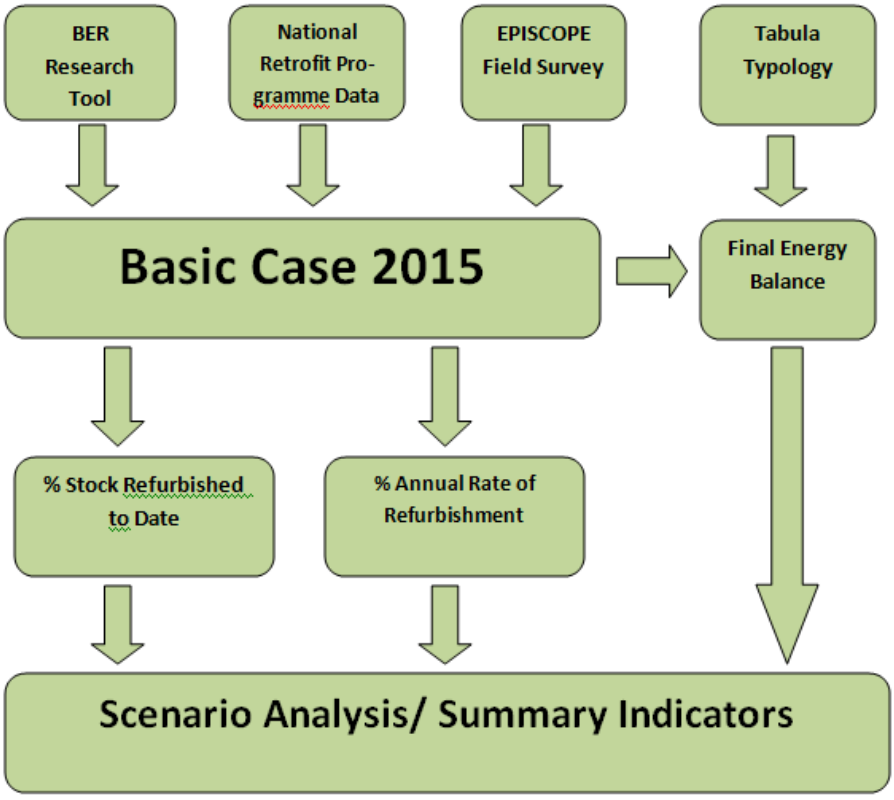
Figure 2: Overview of the EPISCOPE scheme of building stock energy performance indicators



The monitoring indicators (blue boxes) provide a reliable data basis for the establishment of building stock modelling, but they will have to be accompanied by model assumptions to close information gaps and to describe the future development. The complete indicator set describing the building stock in its actual state ("the basic case") and in future states is called the scenario indicators (purple boxes). They include the "structural" data of the building stock, which means information about the state of the stock in a certain year (state indicators) as well as the development of the stock over time in certain periods (trend indicators) of thermal building insulation and heat supply systems. This structural data is a basis for modelling of the total energy balance (including greenhouse gas emissions), which results in the energy balance indicators. Whereas state, trend and energy balance indicators deliver quite detailed information, the results will also be presented in the form of summary indicators, which are also aimed at non-experts.

Figure 3 outlines the approach being proposed, including the data sources, for the Irish pilot action in order to develop the basic case and summary indicators.

Figure 3: Overview of the Irish Pilot Action inputs to the building stock energy performance indicators



2 Description of Data Sources

A number of reliable data sources are available that can contribute to understanding the energy performance of pilot action housing stock and the rate of refurbishment within that stock. There is no single data source currently available that provides all of the information required to produce the desired results. Thus it was necessary to review all of the available sources of data that provide some of this data and to analyse it in detail to reach conclusions on the energy performance of the selected housing stock and the associated rates of refurbishment.

2.1 Data from the National EPC Database for the selected stock

Ireland's national EPC database is managed by the Sustainable Energy Authority of Ireland (SEAI). Out of a national housing stock of 1.6 million dwellings, 528,000 dwellings (33%) have EPCs (based on data at 11.02.2015). As indicated in Section 1, data from the National EPC database is available via the SEAI BER Research Tool (BRT) [BER Research Tool] and gives a rich source of data for the Irish pilot action.

While EPCs are issued for sale and rental transactions, the SEAI and Local Authority grant-support programmes also require EPCs to be produced as part of funding/ grant-support process. Thus, the EPC database does not scientifically represent the entire stock. However, by making a range of assumptions, the EPC database information, when carefully considered, can be interpreted to provide key data on the energy performance and refurbishment activity within the selected stock.

2.2 Data from Existing Energy Upgrade Programmes

As indicated in Section 1, firm data is available on known measures carried out within SEAI Schemes and Local Authority schemes. These data sources can provide data related to energy efficiency measures conducted within the Pilot Action Area.

The availability of data for measures carried out in the Pilot Action area from the following sources:

- SEAI Better Energy Warmer Homes Scheme
- SEAI Better Energy Homes Scheme
- SEAI Areas Scheme
- SEAI Better Energy Communities Scheme:
- Dublin City Council Refurbishment Programme
- Housing Association stock works (outside of SEAI schemes)

Data from the National Census 2011 and National Household Budget Survey was not sufficiently detailed to in developing the Pilot Action study.

Data for state indicators was provided by Dublin City Council for their dwellings. Data for trend indicators was secured from the two SEAI Better Energy schemes. Both datasets are detailed in Section 3. Data was not available in sufficient detail from the other listed sources.

2.3 Data from Pilot Action Survey

In addition to analysing the data sources in Sections 2.1 and 2.2, a specific survey of dwellings was conducted as part of the EPISCOPE Pilot Action.

A specific survey form was prepared for the EPISCOPE Pilot Action to establish survey-based data on the current levels of refurbishment carried out to date, the recent modernisation trends and future plans for refurbishment.

The survey work commenced in December 2014 and was completed in April 2015. The services of the Economic and Social Research Institute (ESRI) were engaged to assist with designing the survey process. The ESRI generated the list of dwellings to be surveyed from a random selection of the geo-directory. Letters were sent to an initial 200 addresses in early December 2014, informing dwelling occupants about the upcoming survey and inviting them to make appointments.

Surveyors called to 200 addresses over the 5-month period in order to successfully get 100 survey forms completed through interviews with home occupiers. The survey work presented a considerable challenge due to the random processes associated with a sampled survey. In many cases, the dwelling occupant was at home or was unwilling to participate. Normal research methods were applied in terms of the number of visits made to each address. The formal process requires 4 visits to be made to a dwelling (morning, afternoon, evening, weekend) if no response is achieved during the earlier visits. After the fourth unsuccessful visit, the addressed is removed from the survey list.

In total, 450 visits to the selected dwellings were made in order to reach the target of 100 completed surveys, i.e. 4.5 visits per successful survey. The most difficult dwellings to access were individual apartments that have keypad bell systems at street level. A gift of 4 low energy saving light bulbs donated by the energy efficiency company ENPROVA was introduced mid-way during the field work and this helped to increase the response rate.

Initial survey data was collated from the first 50 surveys and the findings were included in the Draft Report that issued in February 2015. The survey data was cross-checked with the state and trend indicators developed from analysis of the SEAI BRT data. Final results based on 100 completed surveys are presented in Section 3 of this report.

The final field survey results and the grant programme data will be used to further refine the state and trend indicators and the energy balance calculations.

2.4 Energy Consumption

A comprehensive national study of measured energy consumption of dwellings has not been conducted in Ireland and so available data is quite limited.

A number of smaller scale studies have been conducted and were reviewed within the Irish Pilot Action. It was hoped to secure measured energy data on a small sample (approximately 20) of dwellings during the survey task of the Irish Pilot Action. As the survey process itself proved to be more difficult to complete, it was only possible to find a handful of participants willing to participate. However, for those participants, metered energy consumption data was analysed and temperature monitoring was conducted over 3 months of the Winter Heating season. The energy consumption conclusions are presented in Section 3.

3 Development of the Building Stock Model

3.1 State Indicators of building insulation and heat supply

As outlined in Section 2, data for pilot action analysis was provided from three key sources, namely:

(a) the National EPC database (via the SEAI BRT) [BER Research Tool]

(b) statistics from National Energy Efficiency Programmes including Local Authority retrofit works programmes

(c) a site survey conducted during Winter 2014/ Spring 2015

a) State Indicators based on EPC Data

Data from the National EPC database is available publicly via the SEAI Building Energy Rating Research Tool (BRT) [BER Research Tool].

At the end of 2013, 30,720 EPCs (referred to as Building Energy Rating certificates or BER certs in Ireland) were published on the SEAI National Administration system (NAS) for the geographical area covered by the Pilot Action. Thus, 23% of the dwelling stock had EPCs.

EPC data relating to the pilot action area (for the 30,720 EPCs) was analysed to establish an initial set of state and trend indicators regarding refurbishment status.

A second analysis of the SEAI BRT (40,011 EPCs published by 11th February 2015) was conducted. This dataset formed the basis of further work including the building stock energy balance calculations and average buildings analysis.

SEAI allows accessibility to the EPC data via its BER research tool. A detailed examination and analysis of the BER research tool was undertaken to provide the state indicators outlined in Table 1, 2 and 3 for the EPC available for housing stock in the pilot area. Most of the national energy efficiency programmes require that an EPC is produced upon completion of the upgrade works so it is almost certain that the EPC database does not currently represent the entire stock of 134,000 dwellings. However, the BER tool does provide a rich source of data.

Data from the EPC database provided the EPC-based set of state indicators as shown in Table 1.

Table 1: State Indicators (1) of the Basic Case

Basic Case *(Starting Point of Trend and Scenario Calculation)* **:**			
Basic Data	Complete building stock	Old building stock	Data based on EPCs
	bs...2013/2013	bs...2010/2013	Census dwelling nrs are:
number of dwellings	30720	30552	133,431
number of houses	16965	16848	96,183
number of apartments	13755	13704	37,248
national reference area [m²]	84	83.92	
TABULA/EPISCOPE reference area [m²]			
Building insulation: state of modernisation			
walls			percentages related to ....
insulation improved (from original state)	14.2%	13.9%	building number
insulation improved (area-weighted)	16.7%	16.4%	elemental area
roofs / upper floor ceilings			percentages related to ....
insulation improved (from original state)	34.7%	34.9%	building number
insulation improved (area-weighted)	34.4%	34.5%	elemental area
ground floors / cellar ceilings			percentages related to ....
insulation improved (from original state)	6.0%	5.5%	
insulation improved (area-weighted)	6.2%	5.7%	
windows			percentages related to ....
insulation improved (from original state)	76.2%	75.7%	building number
insulation improved (area-weighted)	78.7%	78.2%	elemental area
Building insulation: Detailed information			
levels of wall insulation (area-weighted):			percentages related to....
level 0 (U > 0,6 W/m²K)	49.0%	49.3%	elemental area
level 1 (0,6 W/m²K >= U > 0,27 W/m²K)	40.2%	40.3%	elemental area
level 2 (0,27 W/m²K >= U > 0,21 W/m²K)	9.6%	9.5%	elemental area
level 3 (U <= 0,21 W/m²K)	1.2%	0.9%	elemental area
levels of roof/upper floor ceiling insulation (area-weighted):			percentages related to....
level 0 (U > 0,4 W/m²K)	36.1%	36.4%	elemental area
level 1 (0,4 W/m²K >= U > 0,16 W/m²K)	50.5%	50.5%	elemental area
level 2 U < 0,16 W/m²K)	13.4%	13.1%	elemental area
levels of ground floor / cellar ceiling insulation (area-weighted):			percentages related to....
level 0 (U > 0.25 W/m²K)	92.3%	92.8%	elemental area
level 2 (U <=0,25 W/m²K)	7.7%	7.2%	elemental area
levels of window insulation (area-weighted):			percentages related to....
level 0 (U > 3,7 W/m²K)	15.3%	15.4%	elemental area
level 1 (3,6 W/m²K >= U > 2,2 W/m²K)	56.5%	56.8%	elemental area
level 2 (U <= 2.2 W/m²K)	28.2%	27.9%	elemental area

Numbers are given for the complete and the old building stock. For the Irish pilot action, the old building stock includes all dwellings constructed up to the end of 2010. While dwellings after the year 2000 are likely to have reasonably good building fabrics, experience would indicate that the space and water heating systems and controls installed up to 2010 would not, in many instances, meet optimum energy performance standards.

The additional state indicators for space heating, water heating and special systems are shown in Tables 2 and Table 3.

Table 2: State Indicators (2) of the Basic Case

Basic Case *(Starting Point of Trend and Scenario Calculation)*:			
Basic Data	Complete building stoc	Old building stock	
	bs...2013/2013	bs...2010/2013	
Main Heat Supply Systems for Space Heating			
Centralisation of space heating system			percentages related to....
district heating	0.00%	0.00%	building number
building / apartment heating	75.39%	75.26%	building number
room heating	24.61%	24.74%	building number
Main energy carrier for space heating			percentages related to....
district heating	0.00%	0.00%	
gas (natural / liquid gas)	63.95%	63.76%	building number
oil	4.93%	4.96%	building number
coal / other solid fuels	0.91%	0.91%	building number
wood/biomass	0.08%	0.08%	building number
electricity	24.32%	24.44%	building number
community heating	5.81%	5.84%	building number
Main heat generation system for space heating			percentages related to....
combustion of fossil fuels: "level 0" systems: gas / oil non-condensing boilers	44.46%	44.71%	building number
combustion of fossil fuels: "level 1" systems: gas/oil condensing boilers	23.90%	23.50%	building number
yet	0.00%	0.00%	building number
direct electric heating / storage heating	24.24%	24.37%	building number
solid fuel non-centralised system (room heating)	0.65%	0.66%	building number
biomass systems	0.08%	0.08%	building number
electric heat pumps	0.08%	0.07%	building number
community heating	5.81%	5.84%	building number
Special Systems			percentages related to....
solar thermal systems			
...for hot water supply only	*1.60%*	*1.50%*	building number
...for heating and hot water supply			
photovoltaic systems			
ventilation systems *(for buildings/apartments, not only kitchen/WC ventilation)*			building number
....with heat recovery	*0.88%*	*0.88%*	building number
...without heat recovery	*0.35%*	*0.04%*	building number

Table 3: State Indicators (3) of the Basic Case

Basic Case *(Starting Point of Trend and Scenario Calculation)*:			
Basic Data	Complete building stoc	Old building stock	
	bs...2013/2013	bs...2010/2013	
(optional): Main Energy carrier for hot water supply			percentages related to....
district heating	0.00%	0.00%	building number
gas	63.16%	62.97%	building number
oil	4.78%	4.81%	building number
coal/ other solid fuels	0.48%	0.48%	building number
wood/biomass	0.08%	0.09%	building number
electricity	25.69%	25.82%	building number
community heating	5.81%	5.84%	building number
(optional:)Main heat generation system for hot water supply			percentages related to....
hot water generation combined with heating syster	98.56%	98.54%	building number
separate system of hot water generation:			building number
- direct electric heat generation	1.33%	1.34%	building number
- electric heat pump	0.00%	0.00%	building number
- combustion of fossil fuels	0.05%	0.05%	building number
- other	0.00%	0.00%	building number

In order to establish what level of refurbishment had taken place from the BER research tool data at the end of 2013, a series of qualifier levels based on U-values associated with improved building fabrics, for example, were defined for the Irish project.

In the case of walls having been modernised, the qualifiers listed in Table 4 were applied to conduct the analysis that generated the relevant figures in Table 1.

Table 4: Improved Walls Qualifiers

Age Band	Wall U value (default)	Wall improvement qualifier (U=<)
1700-1977	2.1	0.6
1978-1982	1.1	0.6
1983-1993	0.6	0.45
1994-1999	0.55	0.37
2000-2005	0.55	0.27
2005-2010	0.37	0.21
2011 onwards	0.27	0.21

For the age band up to 1977, before any building regulations applied and when wall insulation would have not been installed as part of the original construction, any dwelling with an average wall U value less than or equal to 0.6 W/m^2K was deemed to have its walls insulated. For later years, the minimum wall U values required by the building regulations are listed, as are the U values that are deemed to represent a substantial insulation improvement.

In the case of roofs having been modernised, the qualifiers listed in Table 5 were applied to conduct the analysis to generate the relevant fs in Table 1.

Table 5: Improved Roofs Qualifiers

Age Band	Roof U value (default)	Roof improvement qualifier (U=<)
1700-1977	2.3	0.4
1978-1982	0.49	0.26
1983-1993	0.49	0.2
1994-1999	0.4	0.2
2000-2005	0.36	0.13
2005-2010	0.25	0.13
2011 onwards	0.25	0.11

For windows having been modernised, the qualifiers listed in Table 6 were applied to conduct the analysis to generate the relevant figures in Table 1.

Table 6: Improved Window Qualifiers

Age Band	Window improvement qualifier (U=<)
1700-1977	4.8
1978-1982	4.8
1983-1993	3.8
1994-1999	3.1
2000-2005	2.2
2005-2010	1.6
2011 onwards	1.4

With floors, a universal U value of 0.25 W/m^{2}K is the qualifier used to define an improved floor. This U value is equivalent to fitting 100mm of fibre insulation beneath a suspended timber floor.

Table 7: Improved Floor Qualifiers

Age Band	Floor improvement qualifier (U=<)
1700-1977	0.25
1978-1982	0.25
1983-1993	0.25
1994-1999	0.25
2000-2005	0.25
2005-2010	0.249
2011 onwards	0.249

b) State Indicators based on National Energy Efficiency Programmes

A Status Report by IHER Energy Services on the housing stock of Dublin City Council (DCC) using available EPC data was published in December 2014. This report was commissioned by the Department of Environment, Community and Local Government. This report was based on an analysis of 5,088 published EPCs of DCC dwellings. DCC has approximately 25,000 dwellings on both the Northside and Southside of Dublin City.

Table 8: Summary of Key Aspects of DCC Stock (31 October 2014)

	Total Number/ Acceptable Standard	Acceptable Standard	Dwellings Needing Upgrade
Total Dwellings with BER Certs	5088		
Walls insulated to U=0.6 or better	4044	79%	21%
Roofs with minimum 200mm insulation	2665	73%	27%
Windows (U value <2.8) - double glazed 12mm PVC/ timber	2816	55%	45%
Boilers (with efficiencies > 86%)	1613	34%	66%

It is planned to repeat this EPC-based analysis on an annual basis to provide both status and trend reports for the DCC dwelling stock.

c) State Indicators based on EPISCOPE Field Survey

The EPISCOPE field survey provided the state indicator results shown in Table 9.

Table 9 Field Survey – State Indicator Results

Element	% refurbished to date
Walls	16.0%
Roofs	45.2%
Windows	58.0%
Floors	2.0%
Boilers	25.0%
Heating Controls	7.0%

3.2 Trend Indicators of building insulation and heat supply

Like the state indicators of chapter 3.1, the trend indicators of modernisation were assessed using the same three data sources.

a) Trend Indicators based on EPC Data

Trend indicators were established firstly from the BER Research tool, based on published EPCs at the end of 2013. The modernisation trends for elements of building fabric and heating systems were established by examining data from the BRT (2013) for the years 2009-2013 as detailed in Table 10.

Table 10: Modernisation Trends: Walls (2009-2013)

Walls Modernisation				
Year	All stock	Old stock	all stock trend	old stock trend
2009	8344	8344		
improved	308	308		
ratio 2009	3.69%	3.69%		
2010	13360	13360		
improved	829	829		
ratio 2010	6.21%	6.21%	**2.51%**	**2.51%**
2011	18336	18317		
improved	2050	2046		
ratio 2011	11.18%	11.17%	**4.98%**	**4.96%**
2012	23653	23553		
improved	3301	3228		
ratio 2012	13.96%	13.71%	**2.78%**	**2.54%**
2013	30480	30341		
improved	4181	4096		
ratio 2013	13.72%	13.50%	**-0.24%**	**-0.21%**
avg annual trend			**2.51%**	**2.45%**

This process was repeated for roofs, floors, windows, heating fuels and heating systems though supporting tables for these factors are not presented in this report.

One interesting observation from analysing outputs from the BRT from 2 different time periods, namely one from end October 2013 and one from end December 2013, is that it was noticed that several hundreds of EPCs from earlier years were superseded in later months as additional upgrades were completed on the same dwellings. Thus, the EPCs for those dwellings disappeared from totals in earlier years and the count of the modernisations carried out in earlier years was similarly affected. Thus, in order to establish trends, the October 2013 BRT data was used.

Table 11 shows the EPC-based modernisation trends for walls, roofs, floors and windows.

Table 11: Wall, Roof, Floor & Window Modernisation Trends (EPC data)

M.2.1 Building insulation: Basic information state and trends of modernisation		
	Complete building stock	Old building stock
walls		
insulation improved (from original state)	14.2%	13.9%
insulation improved (area-weighted)	16.7%	16.4%
average thickness of improved insulation	8.8cm	
annual rate of insulation improvement	2.51%	2.45%
annual rate of insulation improvement (area-weighted)	2.99%	2.93%
average thickness of insulation (recent modernisation)	8.9cm	
roofs / upper floor ceilings		
insulation improved (from original state)	34.7%	34.9%
insulation improved (area-weighted)	34.4%	34.5%
average thickness of improved insulation	17cm	
annual rate of insulation improvement	2.60%	2.65%
annual rate of insulation improvement (area-weighted)	2.64%	2.69%
average thickness of insulation (recent modernisation)	18.1 cm	
ground floors / cellar ceilings		
insulation improved (from original state)	5.99%	5.47%
insulation improved (area-weighted)	6.18%	5.69%
average thickness of improved insulation	100	
annual rate of insulation improvement	xx	xx
annual rate of insulation improvement (area-weighted)	xx	xx
average thickness of insulation (recent modernisation)	100	
windows		
insulation improved (from original state)	60.3%	60.2%
insulation improved (area-weighted)	63.8%	63.0%
average quality of improved windows	2.75	2.76
annual rate of insulation improvement	2.18%	2.17%
annual rate of insulation improvement (area-weighted)	2.87%	2.86%
average quality of improved windows (recent modernisations)	U = 1.6 W/m2K	

The EPC based trend data for boiler upgrades is shown in Table 12 below.

Table 12: Boiler Modernisation Trends (EPC data)

M.3.1.3. Main heat generation system for space heating				gross modernisation rates	
combustion of fossil fuels: "level 0" systems: gas / oil non-condensing boilers	44.46%	44.71%	0.00%	0.40%	0.45%
combustion of fossil fuels: "level 1" systems: gas/oil condensing boilers	23.90%	23.50%	97.62%	1.98%	1.90%
combustion of fossil fuels: "level 2" - not defined yet	0.00%	0.00%	0.00%	0.00%	0.00%
direct electric heating / storage heating	24.24%	24.37%	0.00%	-1.76%	-1.73%
solid fuel non-centralised system (room heating)	0.65%	0.66%	0.00%	0.04%	0.04%
biomass systems	0.08%	0.08%	0.00%	ple is too small to establish tr	
electric heat pumps	0.08%	0.07%	2.38%	ple is too small to establish tr	
community htg	5.81%	5.84%	0.00%	-0.68%	-0.67%
other	0.77%	0.78%	0.00%		
	100.0%	100.0%	100.0%		

b) Trend Indicators based on National Energy Efficiency programmes

Trend data from two SEAI national programmes that have been in operation during the last 5 years is presented in Table 13 and Table 14.

The SEAI Better Energy Homes Scheme provides grants to private home-owners for a range of wall and roof installation measures, heating controls and boilers upgrades and solar thermal installations. The measures installed under the BEHS in the pilot action area over the years 2009-2013 for the northside of Dublin City are shown in Table 13.

.

Table 13: Better Energy Homes Grant Measures (2009-2013)

Number of measures grant aided (2009-2013)	*Cavity*	*Dry-Lining Insulation*	*External Insulation*	*Heating Controls Upgrade only*	*High Efficiency Gas Boiler with Heating Controls*	*High Efficiency Oil Boiler with Heating Controls*	*Roof Insulation*	*Solar Heating*	*Grand Total*
Dublin 1	757	24	8	1	36	6	733	1	***1566***
Dublin 11	224	76	175	32	422	22	339	23	***1313***
Dublin 13	132	82	148	57	535	50	275	14	***1293***
Dublin 17	139	13	16	9	99	5	161	3	***445***
Dublin 3	50	147	112	33	502	18	232	23	***1117***
Dublin 5	264	109	251	61	686	23	444	24	***1862***
Dublin 7	60	141	165	47	519	15	224	23	***1194***
Dublin 9	111	155	212	54	724	39	356	29	***1680***
Grand Total	***1737***	***747***	***1087***	***294***	***3523***	***178***	***2764***	***140***	***10470***

The SEAI Better Energy Warmer Homes Scheme also provides roof insulation and cavity wall insulation measures to private homeowners on low incomes nationwide. The measures installed under the BEWHS in the pilot action area over the years 2009-2013 are shown in Table 14. (As SEAI provided data on the total number of measures for Dublin City and County combined, the pro rata proportion for the Northside of Dublin at circa 25% are shown in Table 14).

Table 14: Better Energy Warmer Homes Grant Measures (2011-2014)

BEWHS - Dublin Northside	**2011**	**2012**	**2013**	**2014**	**Total**
Roof insulation	747	566	542	406	2,261
Cavity Wall Insulation	206	208	306	233	953

In addition, along with all Local Authorities in Ireland, Dublin City Council (DCC) began a planned energy refurbishment programme of its housing stock in 2013 commencing with roof insulation for most dwellings and wall insulation for dwellings with cavity wall construction. Data on the number of measures installed by DCC was provided for 2013 and 2014. The proportion of measures installed in the pilot action area by DCC was calculated and is included in Table 15.

The number of measures installed under the three main energy upgrade programmes (BEWHS, BEHS and the DCC) are combined in Table 15 to show the average annual trend based on this data source.

Table 15: Annual Refurbishment Rates – Combination of BEHS, BEWHS andDCC works

	Better Energy Homes 2008-2013	Better Energy Warmer Homes 2011-2014	DCC Upgrades 2013 & 2014	Total (from all 3 Schemes)	% of stock upgraded over 6 years	Average Annual Rate
Wall Insulation	3,768	2,518	2,261	8,547	6.37%	1.06%
Heating Controls only	323			323	0.24%	0.04%
Boiler & Controls	4,133			4,133	3.08%	0.51%
Roof Insulation	2,934	2,258	953	6,145	4.58%	0.76%
Solar thermal	162			162	0.12%	0.02%

(right click - Autofit to window)

c) Trend Indicators based on EPISCOPE Field Survey

The survey work commenced in December 2014 and was completed in April 2015. The key results from the field surveys are presented in Table 16.

The refurbishment rates from the field survey are shown for both the state (% refurbished to date) and the trend (annual rate %) indicators. In addition, for the dwellings that had reported refurbishment measures, the ownership of thee dwellings was noted plus the funding sources for the measures. It is important to note that much of the works undertaken were conducted outside of any grant support measures. Most notably, 84% of boiler upgrades, 67% of roof insulation upgrades and 38% of wall insulation upgrades were self-funded by the dwelling owner or occupant.

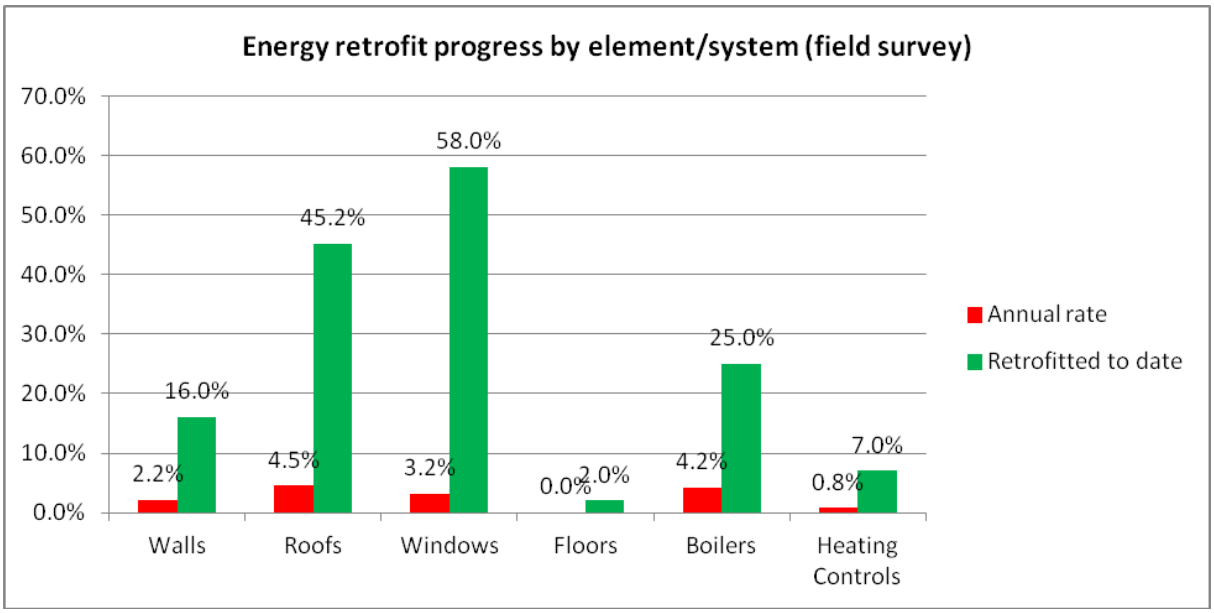
Table 16: Field Survey Trend Indicators

Field Survey Summary									
Element	Refurbishment rate:		Ownership of refurbished dwellings (%			Funding (%)			
	% to date	Annual rate (%)	Housing Assoc./ Local Authority	Owner occupied	Private rented	SEAI Grant since 2008	Warmer Homes Scheme	Local Auth./ landlord upgrade	Outside grants
Walls	16.0%	2.2%	25.0%	68.8%	6.3%	25.0%	12.5%	25.0%	37.5%
Roofs	45.2%	4.5%	11.9%	85.7%	2.4%	9.5%	14.3%	9.5%	66.7%
Windows	58.0%	3.2%	13.8%	75.9%	10.3%	0.0%	N.A.	20.7%	79.3%
Floors	2.0%	0.0%	0.0%	100.0%	0.0%	0.0%	N.A.	0.0%	100.0%
Boilers	25.0%	4.2%	4.0%	88.0%	8.0%	4.0%	N.A.	12.0%	84.0%
Controls	7.0%	0.8%	0.0%	100.0%	0.0%	14.3%	N.A.	0.0%	85.7%

Figure 4 presents the field survey results in graph format. The relative heights of the red and green bars show that the annual rate (over the last 5 years) for boiler replacement is 4.2% and that 25% of boilers have been replaced overall – thus much of the refurbishment is very recent. In the case of windows, the annual rate (over the last 5 years) for window upgrades is

3.2% with 58% replaced overall – thus much of the refurbishment took place over a much longer period of time.

Figure 4: Field Survey State and Trend Indicators



d) Aggregate Trend Indicators

The annual refurbishment trends from the three sources are summarised in Table 17. As the rates reported from the national programmes (BEWHS etc) are much lower than the EPC or filed survey results, these inputs will be ignored when determining the aggregate trend for scenario purposes.

The EPC-based trends and the field survey trends thus provide the data for the aggregate trend shown in Table 17.

Table 17: Aggregate Trend Indicators

Aggregate Trend (annual):				
Element	3 * National Progr'mes	Field survey	BER Research Tool	Aggregate trend
Walls	1.06%	2.20%	2.50%	2.50%
Roofs	0.76%	4.50%	2.60%	3.60%
Windows	**N.A.**	3.20%	2.20%	2.70%
Boilers	0.51%	4.20%	2.00%	3.10%
Controls	0.04%	0.80%	**N.A.**	0.80%

With the exception of wall insulation, the field survey shows higher annual rates of refurbishment. As was shown in Table 16, many of the upgrade works recorded during the field survey were done outside of grant schemes and thus would not be reflected in EPCs for

those dwellings (should EPCs exist for those dwellings). Thus it is quite logical that the field survey would record higher refurbishment rates than the EPC-based analysis.

However, given the relatively small field survey sample, it was decided that the aggregate trend should be based on the average rate of the field survey and the BRT data, where the field survey rate is the highest. The aggregate trends are shown in Table 17 and these values provide the trend indicator values for the scenario analysis.

3.3 Scenario Approaches & Trend Indicators to 2020, 2030 and 2050

Description of the Basic Case and Two Alternative Future Scenarios

Three scenarios form the basis for modelling the primary energy demand the associated CO_2 emissions out to 2050. These scenarios are based on the following assumptions:

- The National Reference area for the Pilot Action stock (2015) is estimated at 11,142,100 m^2. This estimate is based on extrapolating the EPC dataset for houses and apartments pro rata based on Census 2011 proportions.
- The growth in reference areas to 2050 for all three scenarios is based on a prediction that 1,000 new dwellings will be built per annum out to 2050. Given the introduction of the NZEB standard by 2021, the model assumes all new dwellings will have an average primary energy value of 43 kWh/m^2/year.
- The CO_2 benchmark is on an estimate of 619.97 ktCO_2 benchmark for the pilot action stock in 1990. A 17% reduction from this benchmark had been achieved by 2013. [EPA 2011].
- The primary energy demand benchmark is based on the reported achievement of 38% of the 20% energy saving targets at the end of 2012, (i.e. 7.6%).

Scenario A (Current Trend): The trend scenario is based on energy use predicted from the current EPC Database. From the BER research tool, the average BER for the pilot action stock has a primary energy of 270.2 kWh/m2/yr, (D2). This is calibrated by 0.8 to reflect an average measured primary energy of 216.57 kWh/m2/yr per dwelling.

The calibration factors are shown in Table 18 below. These calibration factors have been developed within the Episcope Pilot Action Study by combining data from a range of data sources which, although were somewhat limited, were deemed sufficiently robust for modelling purposes.

Table 18: Calibration Factors (EPC to measured energy consumption)

Primary Energy (kWh/m2/yr)	0-100	>100-200	>200-300	>300-400	>400-500	>500
Calibration to measured energy	1.1	0.90	0.80	0.6	0.55	0.5

The current trend assumes that the existing stock will continue to be refurbished at the aggregate rates (from EPC and field survey) defined in table 16. The current trend also assumes 1,000 new dwellings to NZEB standard will be added to the stock each year.

Scenario B (Mid Range): This scenario assumes 25% of the stock will have undergone a deep retrofit by 2050 (spread equally over the 35 year period from 2015) by adopting ambitious fabric upgrades and switching to renewable technologies including heat pumps for space and water heating. It also assumes that the carbon content of the electricity supplied will have been reduced gradually by 30% by 2050.

Scenario C (Optimum): This scenario assumes 75% of the stock will have undergone a deep retrofit by 2050 (spread equally over the 35 year period from 2015) by adopting ambitious fabric upgrades and switching to renewable technologies including heat pumps for space and water heating. It also assumes that the carbon content of the electricity supplied will have been reduced gradually by 60% by 2050.

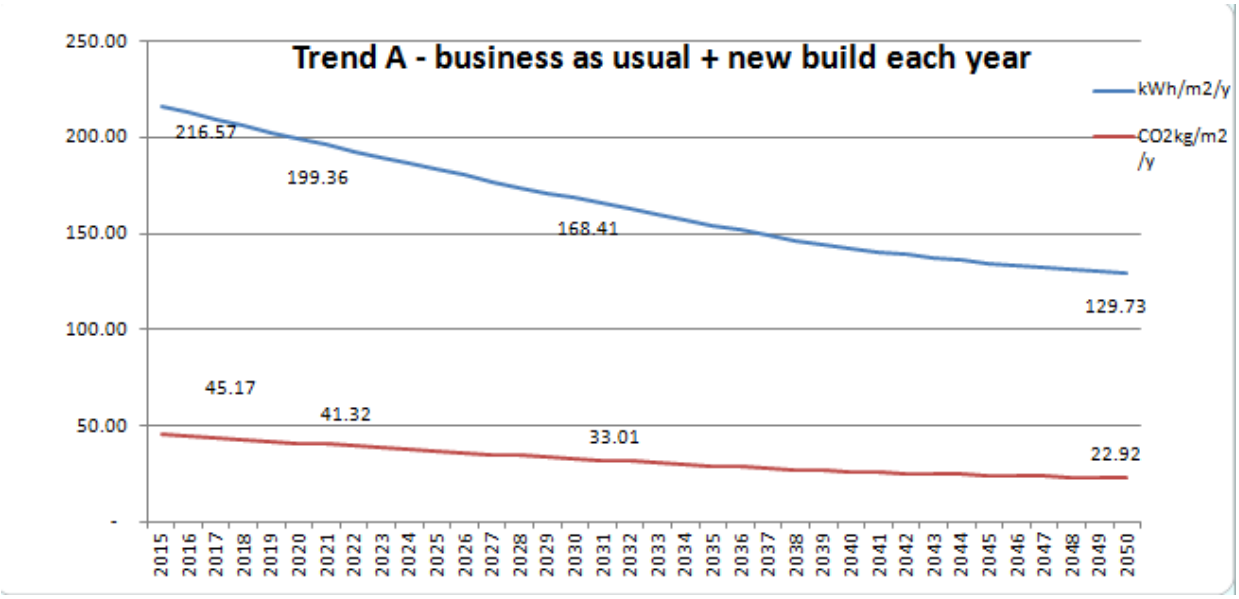
3.4 Scenario Results

The results for the three scenarios are presented below.

Scenario A (Current Trend):

The reductions in primary energy demand and CO_2 emissions per m^2 per year (including existing and new stock) is shown in Figure 5 for the current trend.

Figure 5: Scenario A (Current Trend)



The related reductions in total primary energy demand and CO_2 emissions for the total pilot action stock are shown in table 19.

Table 19: Scenario A (Current Trend)

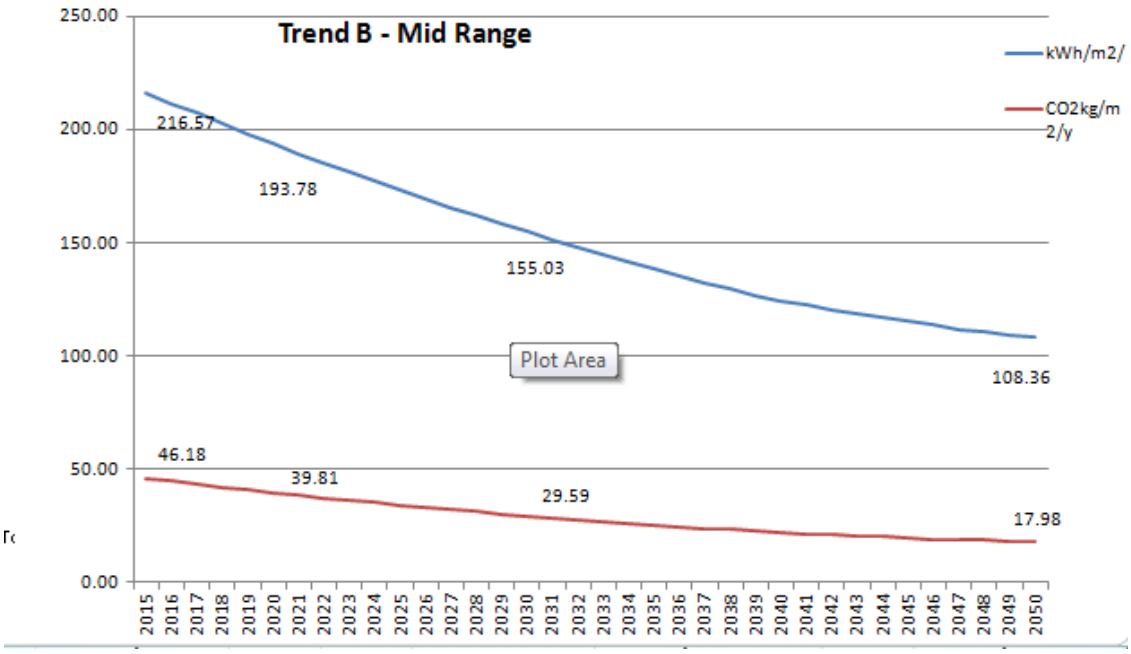
Trend A	Energy Reduction (base 2005)	CO2 Reduction (base 1990)
2015	-8%	-17%
2020	-12%	-23%
2030	-20%	-34%
2050	-30%	-48%

If the 80% reduction in CO_2 emissions by 2050 target is applied specifically to space, water heating and lighting energy use (EPC related) in the residential sector, then this target will not be achieved by the current trend which represents business a usual. A 48% reduction in CO_2 emissions by 2050 from 1990 levels only would be achieved.

Scenario B (Mid Range): 25% Deep Retrofit, 30% Decarbonisation

The reduction in primary energy demand and CO_2 emissions for Scenario B is shown in Figure 6 for the mid range trend.

Figure 6: Scenario B (Mid Range Trend)



The related reductions in primary energy demand and CO_2 emissions for the total pilot action stock are shown in table 20. The primary energy demand and the CO_2 emissions values represent the total pilot action stock.

Table 20: Scenario B (Median Trend)

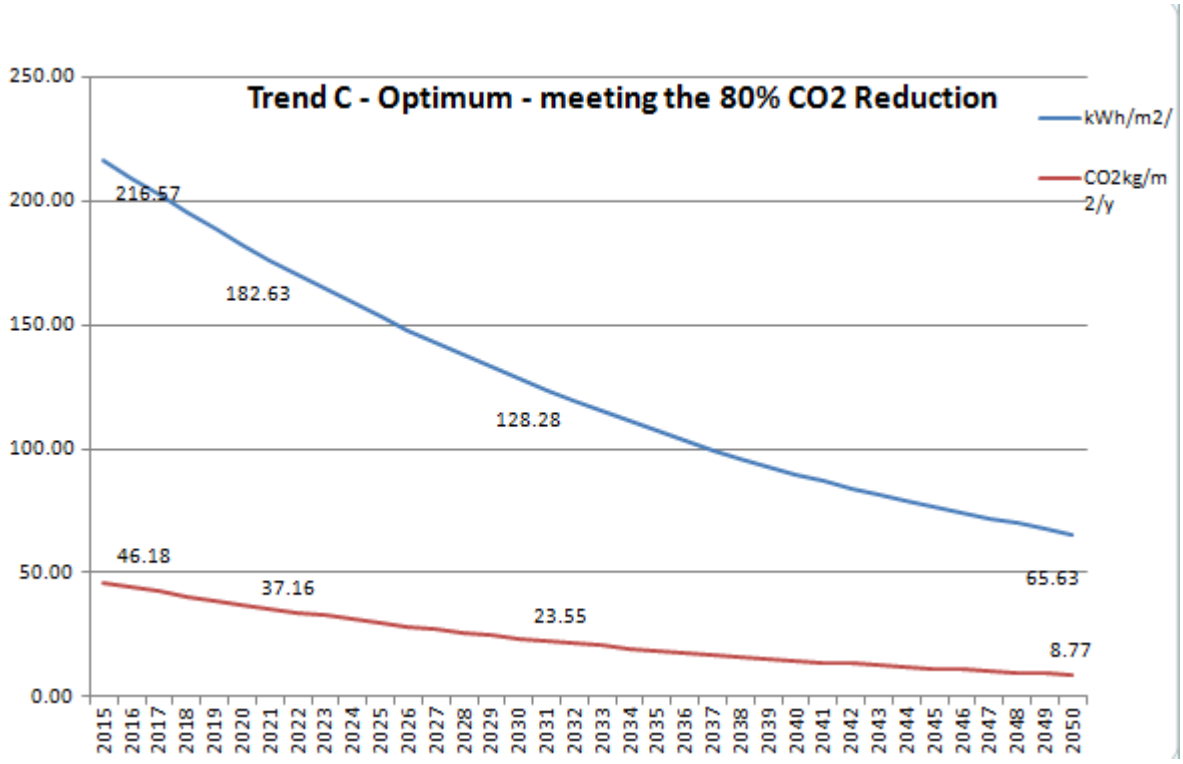
Trend B	Energy Reduction (base 2005)	CO2 Reduction (base 1990)
2015	-8%	-17%
2020	-14%	-26%
2030	-26%	-43%
2050	-42%	-59%

For the mid range scenario, a 59% reduction in CO_2 emissions by 2050 from 1990 levels would be achieved, still short of the 80% reduction target. The average EPC rating by 2050 would be 108 kWh/m^2/annum, (B2).

Scenario C (Target Trend): 75% Deep Retrofit, 60% Decarbonisation

The reduction in primary energy demand and CO_2 emissions for the average dwelling (including existing and new stock) for scenario C is shown in Figure 7 for the 80% target trend, which is set to achieve the 2050 target.

Figure 7: Scenario C (Target Trend)



The related reductions in total primary energy demand and CO_2 emissions for the total pilot action stock are shown in table 21.

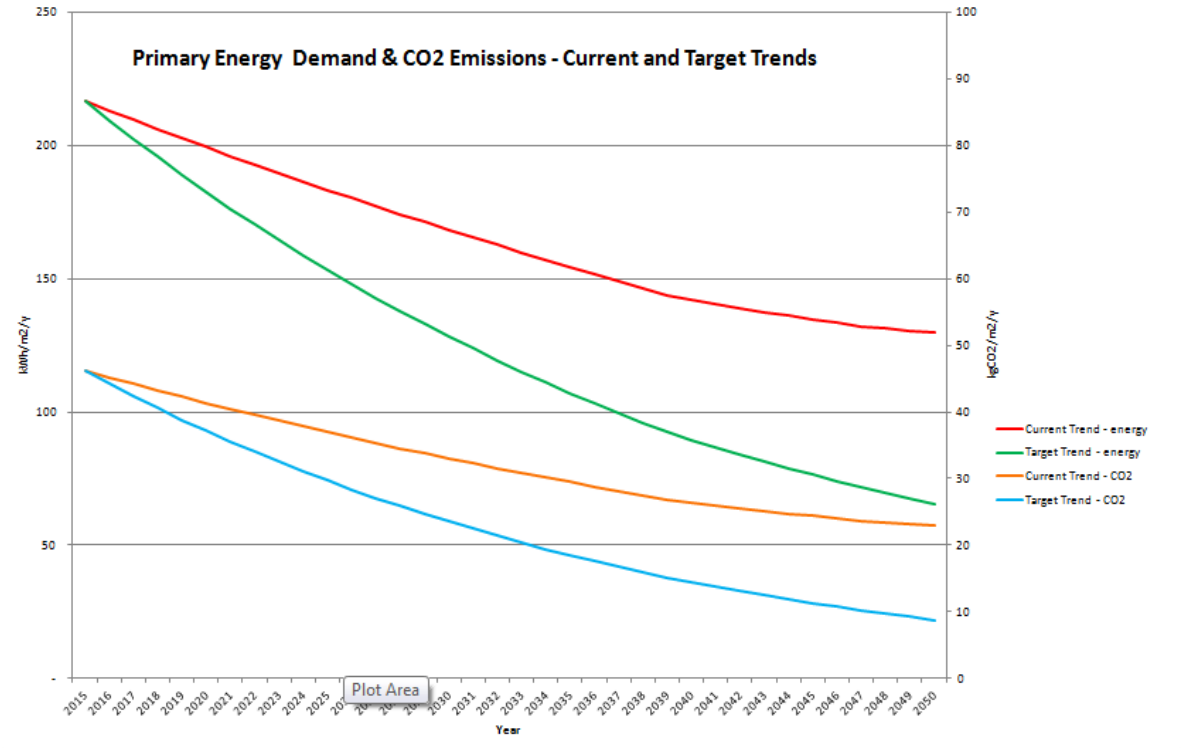
Table 21: Scenario C (Target Trend)

Scenario C	Energy Reduction (base 2005)	CO2 Reduction (base 1990)
2015	-8%	-17%
2020	-19%	-31%
2030	-39%	-54%
2050	-65%	-80%

With the optimum target scenario, the 80% reduction in CO_2 emissions by 2050 from 1990 levels only would be achieved. Energy demand would be reduced by 65% from the 2005 base level. The average EPC rating by 2050 would be 66 kWh/m^2/annum, (equivalent to an A3 rating).

The current trend and the target trend are combined in figure 8, which again indicates the gap to be addressed in the next 35 years.

Figure 8: Current & Target Trend



4 Energy Balance Indicators

4.1 Summary of Scenario Indicators

The scenario results are presented in the standard EPISCOPE format in the tables below.

Table 22: Summary Indicators

Reference area [10^6 m²]	**2015**		**2020**		**2030**		**2050**		Comment
National Reference Area	11.142		11.764		13.01		15.50		
TABULA Reference Area									
CO_2 Emissions [kg/(m²yr)]	heat supply	cooling	heat supply	cooling	heat supply	cooling	heat supply	cooling	
Trend Scen	46.2		41.3		33.0		22.9		Aggregate BRT/field survey
Scen B			39.8		28.3		18.0		25% deep retro/30% decarb
Scen C			37.2		23.2		8.8		75% deep retro/60% decarb
EPISCOPE Benchmark			42.3		29.1		9.2		
Individual Benchmark			42.9		30.0		8.8		EPA
Total Heat Demand [kWh/(m²yr)]									
Trend Scenario	217		199		168		130		Aggregate BRT/field survey
Scen B			194		155		108		25% deep retro/30% decarb
Scen C			183		128		66		75% deep retro/60% decarb
CO_2 Emission Factor Heat Supply [kg/kWh]									
Trend Scenario	0.21		0.21		0.20		0.18		
Scen B			0.21		0.18		0.17		
Scen C			0.20		0.18		0.13		

The summary indicators are a tabular presentation of the three trend scenarios shown in Figures 5, 6 and 7.

4.2 Summary Energy Balance (EPC based)

The summary energy balance calculation for the pilot action stock in 2015 is indicated in Table 23. This summary energy balance has been calculated using the EPC-based building stock model.

Table 23: Summary Energy Balance – Pilot Action Stock 2015

M.4 Final Energy balance: Measured values	Complete building stock
energy consumption in TWh/a (10^9 kWh/a)	(133,431 dwellings)
gas	1.11
oil	0.12
coal	0.03
wood/biomass	0.00
electricity	0.16
Total	1.42
sources / remarks SEAI BER Research Tool calibrated for measured energy use	

4.3 Energy Balance Indicators

The energy balance calculations for the modelled scenarios by final energy use are indicated in table 24.

Table 24: Final Energy by Use, gross calorific values, [kWh/yr]

	2015	2020			2030			2050		
	Trend Scenario	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C
natural gas & LPG	1,110.40	1,079.20	1,041.70	966.60	1,016.70	916.90	717.30	971.00	777.80	391.50
oil	118.70	112.40	108.40	100.30	99.60	89.00	67.60	82.60	62.00	20.70
coal	29.20	27.70	26.70	24.70	24.50	21.90	16.60	20.30	15.30	5.10
wood / biomass	0.40	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.20	0.10
electric energy (used for heat supply)	160.90	152.30	156.90	166.10	135.00	150.70	182.20	111.90	154.40	239.50

This energy balance model shows a decrease in energy use for all fossil fuel except for electricity. The scenario B and C models assumes a greater use of electrical energy through the use of application of heat pumps for space and water heating as a result of a deep retrofit programme.

While the scenario variables can be modified to enable multiple iterations to be carried out, the final energy use prediction in Table 24 indicates the types of trends that can be expected out to 2050.

5 Conclusions for Establishing Continuous Monitoring

Quality of the Data

Of the three data sources used, the EPC database and the field survey were the most valuable.

However, the EPC database is not designed primarily as a stock monitoring tool. If it is to be used for ongoing monitoring of the housing stock, the following needs to be considered:

- In order to establish annual trends via the EPC database, it would be necessary to set up a formal process to save a version of the EPC database each year at a set date. Otherwise, revised EPCs for the same address in a current year will overwrite records in previous years thus skewing the results.
- From the field survey, it is known that many householders carry out energy upgrade work outside of grant schemes and hence these works are not reflected via EPCs. (The dwelling has either no EPC or its existing EPC is not updated to reflect the improvement). Hence, the EPC database will not provide the same quality of data that a comprehensive field survey could achieve in terms of tracking refurbishment rates.

The EPISCOPE field survey was conducted to cross-check the EPC database analysis and to get hands-on experience of a building stock refurbishment survey. The field survey achieved both of these aims.

Approaches / Concepts for Establishing a Continuous Monitoring

Arising from the EPISCOPE Pilot Action, it is recommended that:

- A national housing energy efficiency/ house condition survey be established to comprehensively track the energy efficiency of the residential housing stock and enable scenario forecasting to 2020, 2030 and 2050.
- A detailed study should be conducted to record measured energy use in residential buildings on an ongoing basis. The study needs to take account of the wide variation in building types and BER ratings for both new and existing dwellings. This will enable calibration rates of predicted energy use (via EPC/BER) to actual energy use to be established. This study should take account of gas, oil, electricity use etc and should separate out EPC/BER energy use (space and water heating, lighting and pumps & fans) from other energy use such as appliances etc. The survey should also consider the use of temperature monitors to compare achieved and assumed room temperatures.
- Where possible, in future revisions of the National Energy Efficiency Action Plan, most recently revised in 2104, [NEEAP 2014], specific targets for reduction in energy demand and CO_2 should be set for the residential sector for 2020, 2030 and 2050. The setting of these sector-specific targets will provide a greater focus on the achievement of energy saving measures in the sector.
- The analysis conducted on the EPC database for the EPISCOPE Pilot Action should also be continued, further developed and cross-referenced to the recommended field survey and measured energy consumption data processes. The EPC database will continue to grow and will form a crucial element of future energy trend modelling.

- It will also be important to establish a clear reporting system for the residential building sector to establish progress over time.

6 EPC Mapping Application

At the outset of the project, the Irish partners identified the significant potential that an EPC mapping tool [EPC Mapping Tool] could add to the objectives of the EPISCOPE project.

The EPC mapping tool was developed by Energy Action in partnership with Gamma Limited a geo-directory mapping specialist company appointed under subcontract. The tool can be viewed at http://energyaction-static.s3-website-eu-west-1.amazonaws.com/index.html

A separate Quick Guide is also available at http://episcope.eu/monitoring/pilot-actions/ie-ireland/ to assist first time user of the mapping application.

The EPC mapping tool uses the latest EPC records from the national EPC database managed by SEAI. From the outset, SEAI were extremely supportive of the aims of the EPISCOPE mapping tool.

The first major task was to establish a formal process for transferring the EPC records. To address data protection, SEAI required that EPC data should not be presented a building level. Thus it was agreed that data would be aggregated to census defined boundaries, namely *small areas* and *electoral divisions*. Small areas typically comprise 50-200 dwellings and electoral divisions include clusters of small areas.

For the pilot action area of 134,000 dwellings, there are:

- 1,242 **Small Areas** (50-200 dwellings. Lowest level for compilation of statistics in line with data protection. Must nest within Electoral Divisions)
- 93 **Electoral Divisions** (Smallest legally defined administrative areas in the State for which Small Area Population Statistics are published from the Census)

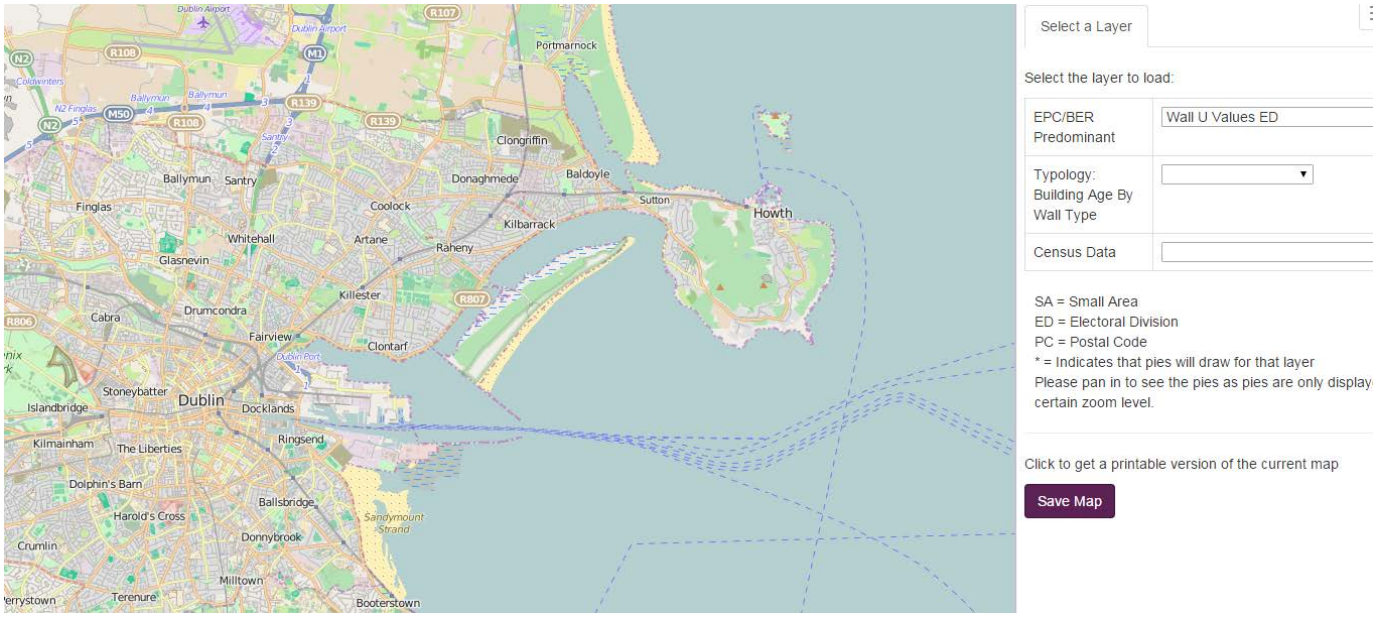
The EPC data transfer process involved the following steps:

- SEAI provided the list of 37,000 addresses for which EPC records were available
- Gamma Ltd added the geo-coordinates and the respective small areas codes and electoral divisions codes for each dwelling address and supplied these to SEAI
- SEAI added the selected EPC variable data for each dwelling and then return the final dataset less the actual dwelling addresses to Gamma Ltd to enable the mapping task to get underway

	MPRN	Latitude	Longitude	Small Area Code	Dwelling Type	Age band simpl	Primary Energ	BER Ra	Main wall type descrip
2	10001405348	53.3504408752907	-6.25733234141105	268106019	Mid-floor apartment	before 1949	919.51	G	Stone
3	10000469204	53.3642118540795	-6.23625417391002	268049003	Ground-floor apartment	before 1949	592.76	G	Stone
4	10303931315	53.3627996730301	-6.29007370110146	268031015	Top-floor apartment	2005 onwards	291.94	D2	Other
5	10303931372	53.3630468653756	-6.28998799411817	268031015	Top-floor apartment	2005 onwards	265.44	D2	Solid Mass Concrete
18	10000323722	53.3716521943718	-6.25918496052188	268060010	Mid-terrace house	before 1949	845.25	G	Solid Mass Concrete
19	10000478445	53.3679643267625	-6.22850108288015	268050009	Semi-detached house	before 1949	398.18	F	225mm Solid brick
20	10003852516	53.3989781881589	-6.17347689945868	268071012	Semi-detached house	1994-2004	203.11	C3	300mm Cavity

Energy Action defined the mapping views to be created and worked closely with Gamma Ltd in developing and refining the mapping tool. 3 sets of layer options can be selected as shown in Figure 8. The first layer tier contains the EPC/BER predominant maps. The second layer tier contains building typologies by wall type. The third layer tier contains Census data.

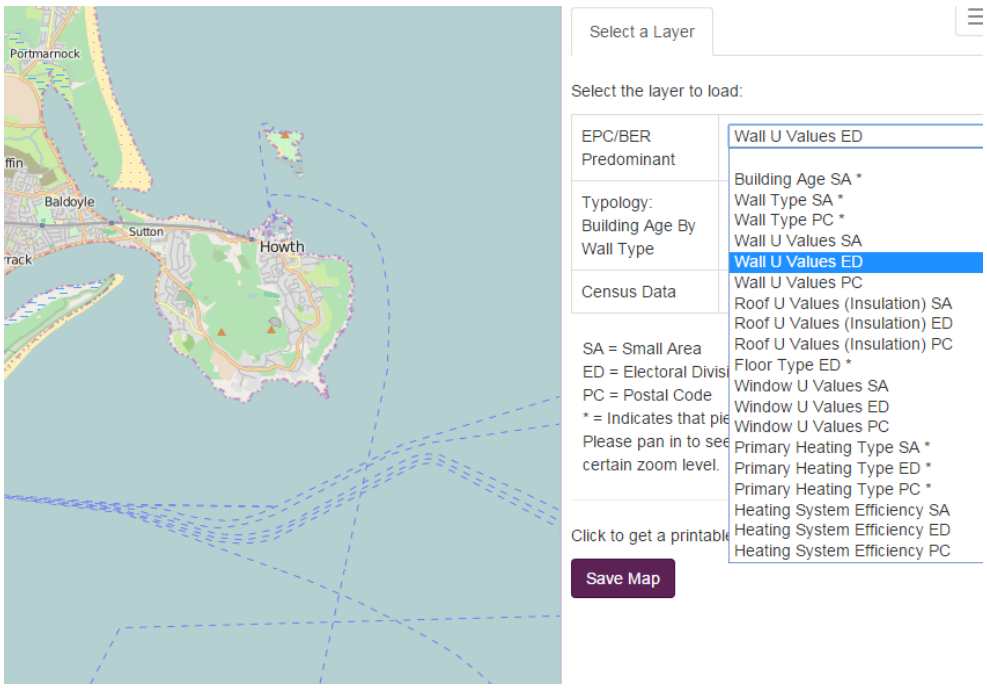
Figure 8: Layer Selection on EPC Mapping Tool



Map Data [© OpenStreetMap contributors]

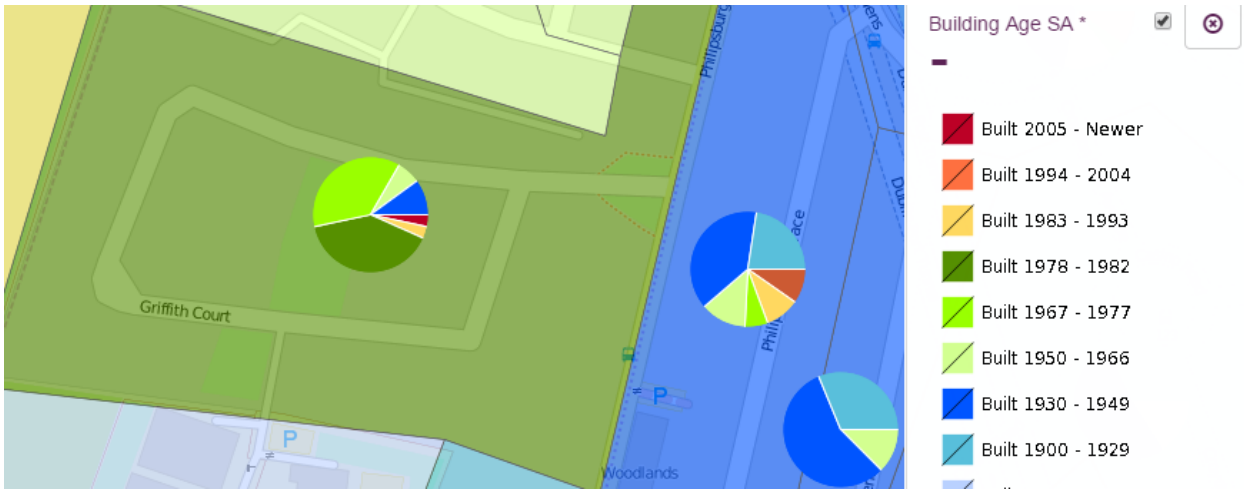
The EPC/BER predominant tiers contain 27 layers options within 11 main map types as shown in Figure 9.

Figure 9: Layer Selection on EPC Mapping Tool



Where an asterisk is placed next to the layer description, more detailed data is available within the mapping views. Firstly, as one pans in closer on the maps, pies will appear as shown in Figure 10. While the predominant type is indicated by the colour coding of each small area, the pie will show the overall composition of types for that small area.

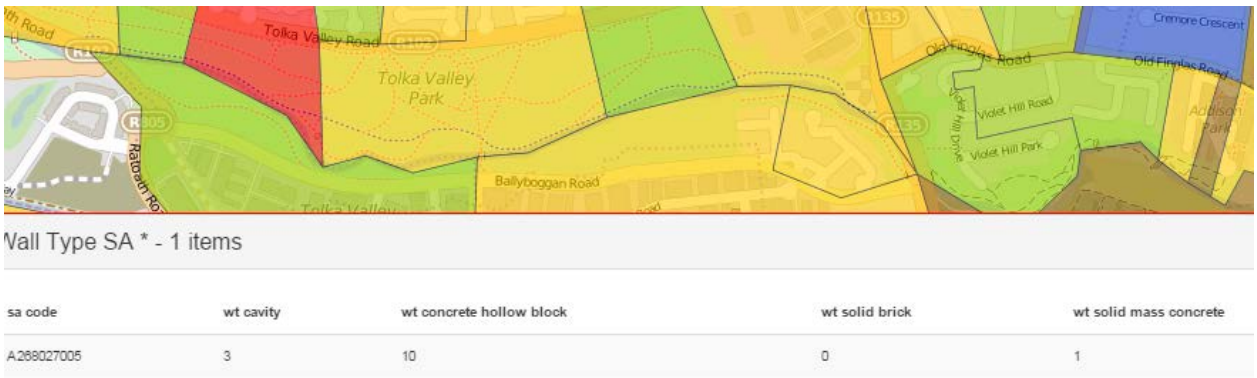
Figure 10: EPC Mapping Tool Pies



Map Data [© OpenStreetMap contributors]

In addition, if the user clicks into a small area, counts of the relevant types are given as shown in Figure 11.

Figure 11: EPC Mapping Tool Counts

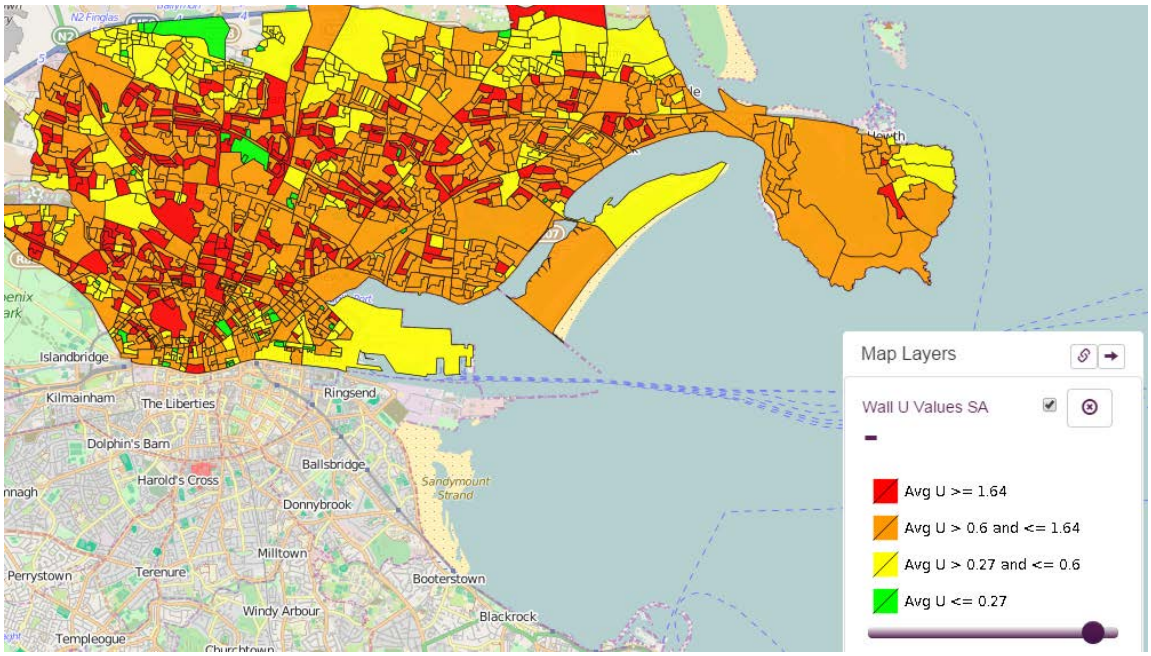


Map Data [© OpenStreetMap contributors]

The maps showing U values ranges (for walls, roofs and windows) are effectively visual status indicators of the stock. As can be seen in Figure 12, the wall U value map shows indicates which of four U value bands apply to each small area. The bands range from the best, i.e. less than or equal to U=0.027 W/m^{2}K to the worst, i.e. equal to or greater than U=1.64 W/m^{2}K. The EPC colour coding has been adopted for these maps where green is best and red is worst.

What the U value maps shows is that, based on current EPC data, most of the map is brown or red, indicating that the majority of the housing stock has poorly insulated or non-insulated walls. This map format is repeated also for roofs and windows.

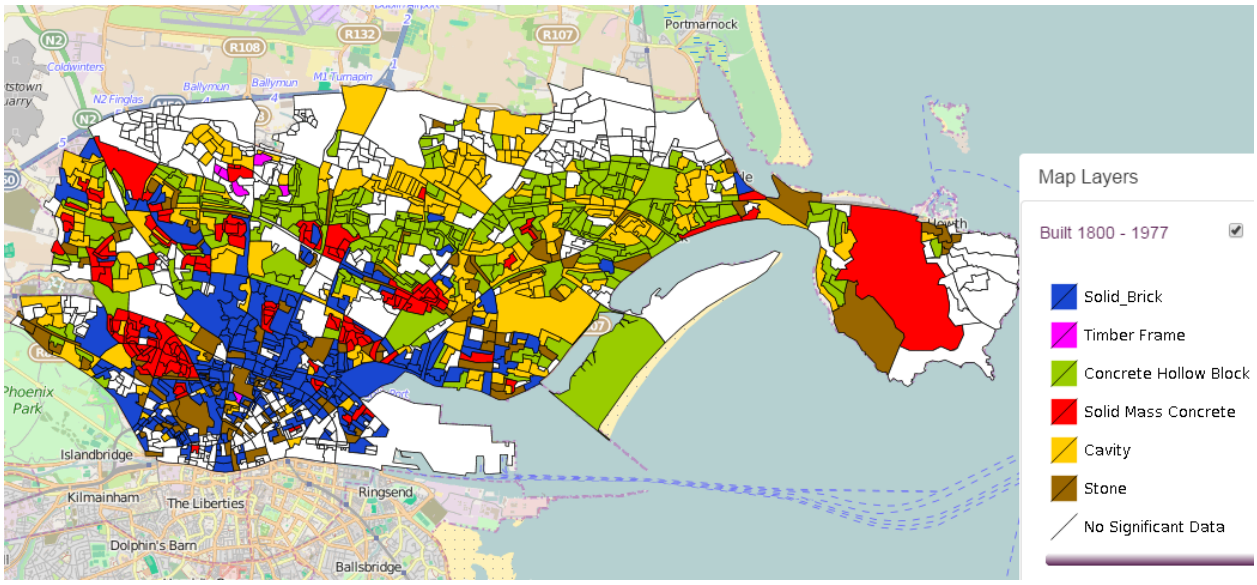
Figure 12: Wall U value Map



Map Data [© OpenStreetMap contributors]

On the second tier, building typology maps have been developed based on the Irish TABULA building typology approach. The building typology map for the age band 1800-1977 is shown in Figure 13. The areas shaded white had insignificant counts – essentially these areas were not developed for the defined time period.

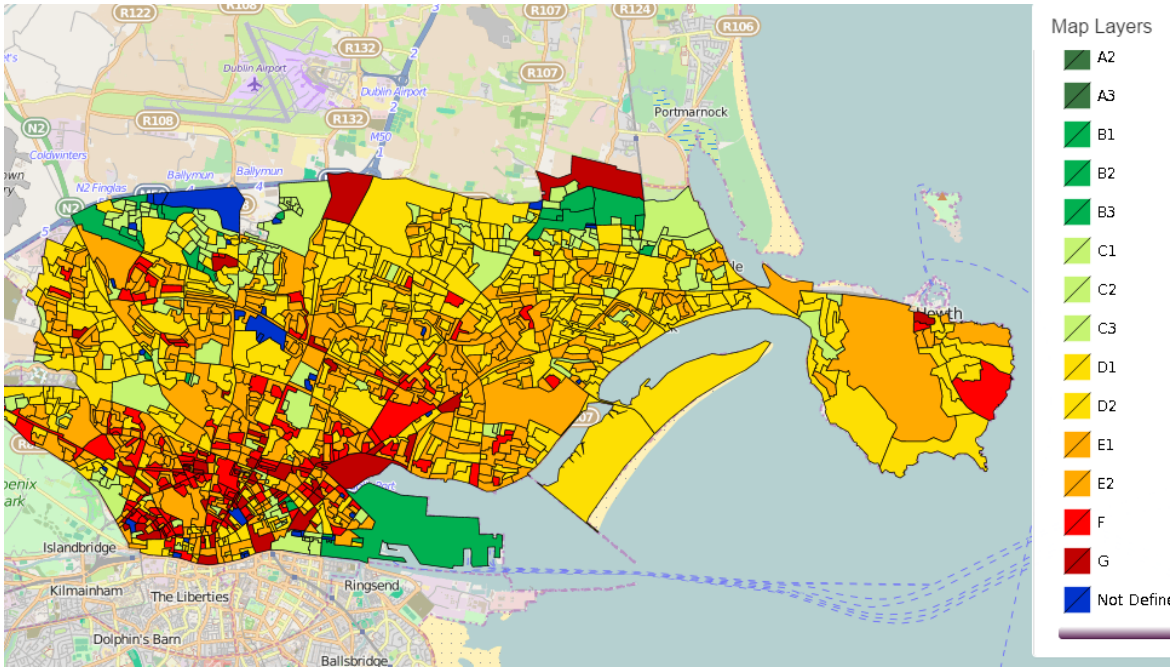
Figure 13: Building Typology Map (1800-1977)



Map Data [© OpenStreetMap contributors]

The average EPC for each small area is shown in Figure 14. The average EPC for the pilot action area is D2.

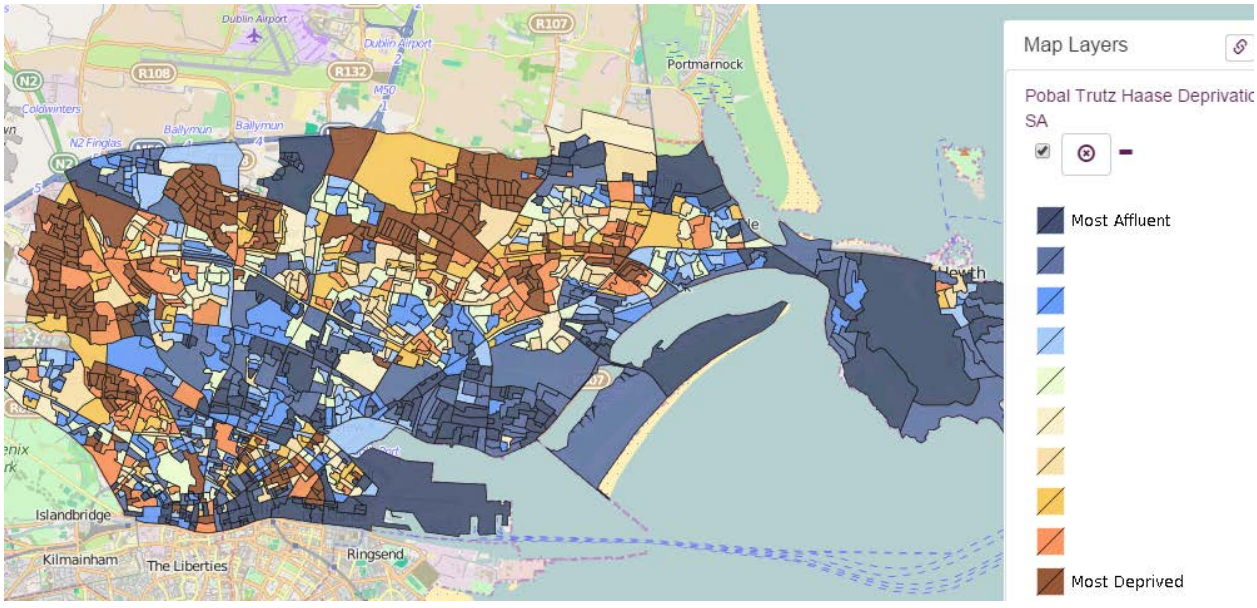
Figure 14: EPC Map



Map Data [© OpenStreetMap contributors]

In addition to EPC data, additional Census data was added to the mapping tool. The Pobal Trutz Haase Deprivation Index is shown in Figure 15. This index shows which of the 10 income deciles apply to each small area.

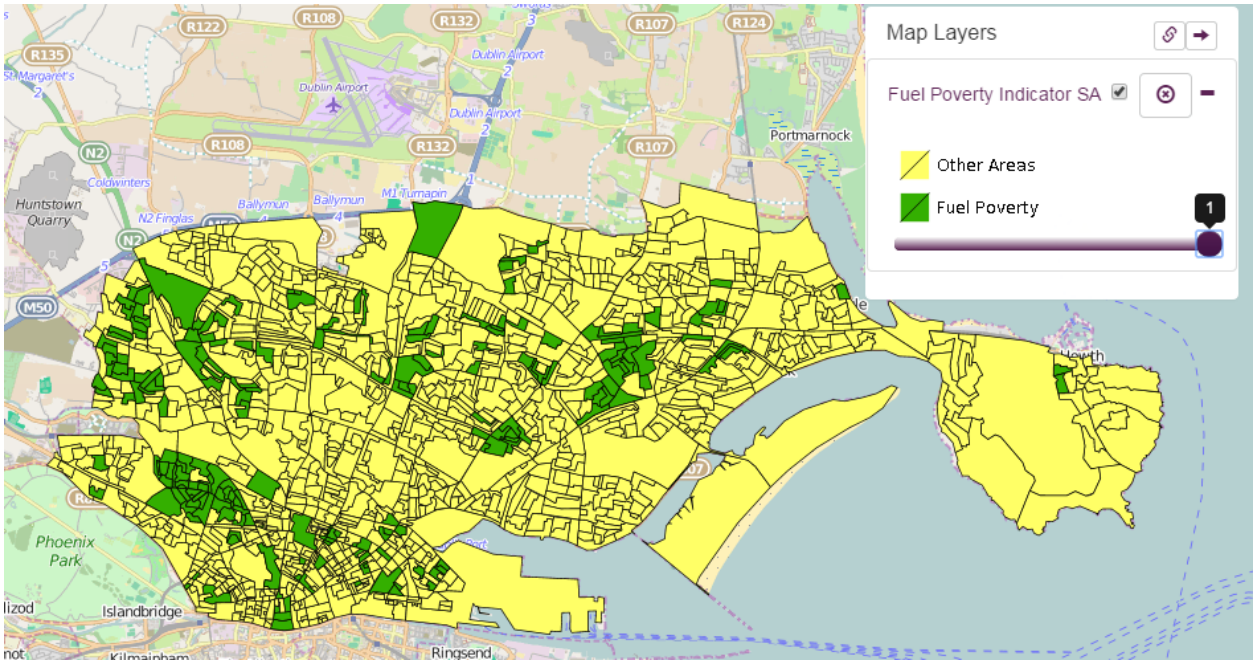
Figure 15: Pobal Trutz Haase Deprivation Index



Map Data [© OpenStreetMap contributors]

While outside the scope of EPISCOPE, a fuel poverty indicator map (Figure 16) was created by overlaying small areas with EPCs in the E, F and G bands with those small areas in the lowest three income deciles. The exercise demonstrates the potential there is to create many additional mapping views by cross-referencing EPC data to other data sources.

Figure 16: Fuel Poverty Indicator Map



Map Data [© OpenStreetMap contributors]

Table 1: **Sources / References** Error! Use the Home tab to apply Überschrift 2 to the text that you want to appear here.

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Census 2011]	National Census 2011, issued by Central Statistics Office, www.cso.ie	National Census 2011
[BER Research Tool]	SEAI National BER Research Tool. Available at http://www.seai.ie/Your_Building/BER/National_BER_Research_Tool/	National online BER(EPC) Research Tool
[SEAI grants]	SEAI Energy Efficiency Grants schemes. Available at http://www.seai.ie/Grants/	Link to national SEAI energy efficiency grant schemes
[EPA 2011]	Greenhouse gas emission by sector (kt CO2 eq.), Environmental Protection Agency. Available at http://www.epa.ie/irelandsenvironment/environmentalindicatorsdashboard/greenhousegasemissionsbysector/#.VaOTaPlVikp	
[NEEAP 2014]	Department of Communications, Energy and Natural Resources (2014). Available at http://www.dcenr.gov.ie/NR/rdonlyres/20F27340-A720-492C-8340-6E3E4B7DE85D/0/DCENRNEEAP2014publishedversion.pdf	National Energy Efficiency Action Plan 2014

Appendix A

EPISCOPE Field Survey

	EPISCOPE Refubishment Tracking Survey							
	ID Reference Nr:		**Date**					
	Address						**Surveyor**	
1	**Tenure**	owner occupied	private rented	Local Authority	Housing Association			
1a	**Dwelling Type**	end terrace	mid tce	semi det	detached	apartment	bedsit	
1b	**Original Building Age**	1700-1977	1978-1982	1983-1993	1994-1999	2000-2005	2005-2010	post 2010
1c	**Is there an extension?**	Y/ N	If Yes, enter age of extension?					
2	**Occupancy**	occupied	vacant					
2a	**Since when has householder lived there?**							
3	**Postal District**							
4	**Number of persons by age in the household**	under 18	18 to 44	45 to 64	65+			
4a	**Number with third level qualifications**							
4b	**Number of working adults in employment**							
5	**Floors - have floors been retrofitted with insulation?**			Y / N	If No, go to section 6.		No heat loss floor	
5A	**Floors - upgade details (ignore extensions)**	If yes, in what year was upgrade done?						
5B	**Type of floor insulated**	suspended timber	solid					
6	**Walls - have walls had insulation added? (90% rule)**			Y / N	If No, go to section 7.			
6A	**Walls - upgrade details (ignore extensions)**	If yes, in what year were walls insulated?		Was upgrade done with SEAI grant since 2008? (Y/N)	Was work done under Warmer Homes Scheme? (Y/N)	If rented, was work done by Local Authority or building owner? (Y/N)		Was work done outside of all grants or programmes? (Y/N)
6B	**Type of wall insulation (circle as reqd)**	CWI	EWI	IWI				
6C	**Insulation Level**							
7	**Roofs - has main roof had insulation added?**			Y /N	If No, go to section 8			
7A	**Roof type (circle as reqd)**	pitched-ceiling level	rafter level	Flat	room-in-roof	no heat loss roof		
7B	**If room-in-roof, when built?**							
7C	**Roof insulation level (mm)**							
7D	**Roof - upgrade details (ignore extensions)**	If yes, in what year was roof insulated?		Was upgrade done with SEAI grant since 2008? (Y/N)	Was work done under Warmer Homes Scheme? (Y/N)	If rented, was work done by Local Authority or building owner? (Y/N)		Was work done outside of all grants or programmes? (Y/N)
8	**Windows - have windows been upgraded (>90%)?**			Y / N	If No, go to section 9			
8A	**Windows - upgrade details (ignore extensions)**	If yes, in what year were windows upgraded?		If rented, was work done by Local Authority or building owner? (Y/N)		If you own the house, did you get any grant support towards the costs ? (Y/N)		Was work done outside of all grants or programmes? (Y/N)
8B	**Window types - dominant (do site check)**	Single/ double	Frame type	Gap	Low e - 2004 and after	post 2011 (U=1.6)		

9	**Primary Heating fuel (circle)**	gas	oil	electricity	coal/other solid fuels	wood/ biomass		
9A	**Did you change fuel type for heating in last 5 years? If Yes, state previous fuel**							
10	**Main space heating system (circle)**	regular boiler	condensing boiler	electric storage/ direct acting	room heaters only	electric heat pumps	biomass systems	community heating
10A	**Boiler Model**							
10B	**Main space heating system - has it been upgraded? (circ)**			Y / N	If No, go to section 11			
10C	**Space Heating system upgrade details**	If yes, in what year was boiler/ heating system upgraded?		Was upgrade done with SEAI grant since 2008? (Y/N)	Was work done under Warmer Homes Scheme? (Y/N)	If rented, was work done by Local Authority or building owner? (Y/N)		Was work done outside of all grants or programmes? (Y/N)
10D	*Do you use your primary heating system to heat your dwelling during winter, or do you use portable 'Stand alone' appliances?*							*(main/stand alone)*
11	**HW: Does primary heating also provide hot water?**	Y / N	If No, go to section 12					
11A	**If no, state separate HW system. (Circle or insert other)**	electric immersion or other	gas point-of-use WH					
12	**Heating controls**	programmer only	programmr & room stat	prog, room stat & trvs	full zone control	prog & trvs	Manual charge (storage)	Automatic charge (storage)
12A	**Heating controls - have they been upgraded? (circ)**			Y / N	If No, go to section xx			
12B	**Heating controls**	If yes, in what year were heating controls upgraded?		upgrade done with SEAI grant since 2008? (Y/N)	done under Warmer Homes Scheme? (Y/N)	If rented, was work done by Local Authority or building owner? (Y/N)		Was work done outside of all grants or programmes? (Y/N)
	Special Systems							
13	**Solar thermal**	Present (Y/N)	Installed as new/ or retrofitted?	Installed in the last 5 years? (Y/N)	SEAI Grant availed of?			
14	**PV**	Present (Y/N)	Installed as new/ or retrofitted?	Installed in the last 5 years? (Y/N)				
15	**Heat Recovery Ventilation/ or DCV or similar**	Present (Y/N)	Installed as new/ or retrofitted?	Installed in the last 5 years? (Y/N)				
	with heat recovery							
	without heat recovery							
16	**BER rating available?**	Y / N						
16A	**If BER available, cert nr or MPRN?**							
16B	**If BER available, would you provide 12 months billing data on fuel use in kWh to compare BER to actual?**							Y / N
16C	**Name & Contact details of volunteer of consumption data**							
17	**Temperature Monitoring (20 houses needed). We need houses with mix of typical C,D,E,F,Gs where occupant has been living for 2 or more years (ideally) and with no changes upgrades carried out over that period. Ask client if they fit that description and are willing to participate. (We would do free BER if they don't have one).**							
17A	**Name & Contact details of volunteer for temp & billing monitoring**							
18	**Upgrade plans in next 2-5 years?**	Y/N	If No, end of survey					
18A	**Upgrade plans (circle as reqd)**	Walls	Roof	Windows	Floor	Boiler/ controls	Rene' wables	Extension or Deep Retrofit

Appendix B

Monitoring Indicators

The EPC state and monitoring indicators developed for the Irish Pilot Action are listed below. These indicators are based on the EPC dataset only.

The scenario analyses in Section 3 take account of the field survey findings and predictions about future refurbishment rates and levels, new building growth rates and decarbonisation of the electricity grid. As the state and trend indicators developed from the EPC database are area weighted, and other data sources cannot be presented on a similar basis, the EPC-based data will form the core state and trend indicators for the Irish pilot action.

M.1 Basic data of the building stock	Complete building stock	Old building stock	New buildings
	bs…2013/2013	bs…2010/2013	bs…2011-2013/2013
number of dwellings	30720	30552	168
number of houses	16965	16848	117
number of apartments	13755	13704	51
national reference area [m²]	84.00	83.92	98.48
sources: SEAI BER Research Tool			

M.2.2 Building insulation: Detailed information of the actual state			
	Complete building stock	Old building stock	New buildings
levels of wall insulation (area-weigthed):			
level 0 (U > 0,6 W/m²K)	49.0%	49.3%	0.0%
level 1 (0,6 W/m²K >= U > 0,27 W/m²K)	40.2%	40.3%	17.5%
level 2 (0,27 W/m²K >= U > 0,21 W/m²K)	9.6%	9.5%	18.7%
level 3 (U <= 0,21 W/m²K)	1.2%	0.9%	63.9%
roofs			
level 0 (U > 0,4 W/m²K)	36.1%	36.4%	0.0%
level 1 (0,4 W/m²K >= U > 0,16 W/m²K)	50.5%	50.5%	40.1%
level 2 U < 0,16 W/m²K)	13.4%	13.1%	59.9%
ground floors			
level 0 (U > 0.25 W/m²K)	92.3%	92.8%	16.0%
level 2 (U <=0,25 W/m²K)	7.7%	7.2%	84.0%
windows			
level 0 (U > 3,7 W/m²K)	15.3%	15.4%	0.0%
level 1 (3,6 W/m²K >= U > 2,2 W/m²K)	56.5%	56.8%	3.7%
level 2 (U <= 2.2 W/m²K)	28.2%	27.9%	96.3%
sources / remarks			
SEAI BER Research Tool			

M.3.1 Main Heat Supply Systems for Space Heating					
	state of the building stock			modernisation trends	
	Complete building stock	Old building stock	New buildings	Complete building stock	Old building stock
M.3.1.1 Centralisation of space heating system	30720	30552	168	net modernisation rates	
district heating	0.00%	0.00%	0.00%	0.00%	0.00%
building / apartment heating	75.39%	75.26%	100.00%	1.59%	
room heating	24.61%	24.74%	0.00%	-1.59%	-1.56%
	100.00%	100.00%	100.00%		
M.3.1.2 Main energy carrier for space heating				net modernisation rates	
district heating	0.00%	0.00%	0.00%	0.00%	0.00%
gas (natural / liquid gas)	63.95%	63.76%	97.62%	2.01%	1.97%
oil	4.93%	4.96%	0.00%	0.37%	0.38%
coal, peat, anthracite, mfg. smokeless, solid m/fuel	0.91%	0.91%	0.00%	0.04%	0.04%
wood/biomass	0.08%	0.08%	0.00%	sample is too small to establish trends	
electricity	24.32%	24.44%	2.38%	-1.76%	-1.74%
community htg	5.81%	5.84%	0.00%	-0.68%	-0.67%
	100.00%	100.00%	100.00%		
M.3.1.3. Main heat generation system for space heating				gross modernisation rates	
combustion of fossil fuels: "level 0" systems: gas / oil non-condensing boilers	44.46%	44.71%	0.00%	0.40%	0.45%
combustion of fossil fuels: "level 1" systems: gas/oil condensing boilers	23.90%	23.50%	97.62%	1.98%	1.90%
combustion of fossil fuels: "level 2" - not defined yet	0.00%	0.00%	0.00%	0.00%	0.00%
direct electric heating / storage heating	24.24%	24.37%	0.00%	-1.76%	-1.73%
solid fuel non-centralised system (room heating)	0.65%	0.66%	0.00%	0.04%	0.04%
biomass systems	0.08%	0.08%	0.00%	sample is too small to establish trends	
electric heat pumps	0.08%	0.07%	2.38%	sample is too small to establish trends	
community htg	5.81%	5.84%	0.00%	-0.68%	-0.67%
other	0.77%	0.78%	0.00%		
	100.0%	100.0%	100.0%		

M.3.2 Special Systems (additional systems of special interest for space heating, hot water supply, ventilation, including photovoltaics)					
	state of the building stock			modernisation trends (gross rates)	
	Complete building stock	Old building stock	New buildings	Complete building stock	Old building stock
solar thermal systems					
...for hot water supply only	*1.60%*	1.50%	20.83%	0.25%	0.27%
...for heating and hot water supply					
photovoltaic systems					
ventilation systems *(for buildings/apartments, not only kitchen/WC ventilation)*					
....with heat recovery	*0.88%*	0.88%	0.60%	inconsistent data	
...without heat recovery	*0.35%*	0.04%	58.33%	0.06%	0.06%
sources / remarks					
SEAI BER Research Tool					

M.3.3 Main System of Hot Water Supply apart from additional solar thermal systems (see above)			
	Complete building stock	Old building stock	New buildings
M.3.3.1 Main Energy carrier for hot water supply	30720	30552	168
district heating	0.00%	0.00%	0.00%
gas	63.16%	62.97%	97.62%
oil	4.78%	4.81%	0.00%
coal + all solid fossil	0.48%	0.48%	0.00%
wood/biomass	0.08%	0.09%	0.00%
electricity	25.69%	25.82%	2.38%
community htg	5.81%	5.84%	0.00%
	100.00%	100.00%	100.00%
M.3.3.2 Main heat generation system for hot water supply			
hot water generation combined with heating system:	98.56%	98.54%	100.00%
separate system of hot water generation:			
- direct electric heat generation	1.33%	1.34%	0.00%
- electric heat pump	0.00%	0.00%	0.00%
- combustion of fossil fuels	0.05%	0.05%	0.00%
- other	0.00%	0.00%	0.00%
	100%	*100%*	*100%*
sources / remarks			
SEAI BER Research Tool			

M.2.1 Building insulation: Basic information state and trends of modernisation			
	Complete building stock	Old building stock	percentages related to....
walls			
insulation improved (from original state)	14.2%	13.9%	building number
insulation improved (area-weighted)	16.7%	16.4%	elemental area
average thickness of improved insulation	8.8cm		avg thickness cm
annual rate of insulation improvement	2.51%	2.45%	
annual rate of insulation improvement (area-weighted)	2.99%	2.93%	
average thickness of insulation (recent modernisation)	8.9cm		surveyed 2011-2013
roofs / upper floor ceilings			based on properties with exposed roofs
insulation improved (from original state)	34.7%	34.9%	building number
insulation improved (area-weighted)	34.4%	34.5%	elemental area
average thickness of improved insulation	17cm		avg thickness mm
annual rate of insulation improvement	2.60%	2.65%	
annual rate of insulation improvement (area-weighted)	2.64%	2.69%	
average thickness of insulation (recent modernisation)	18.1 cm		surveyed 2012-2013
ground floors / cellar ceilings			based on properties with exposed floors
insulation improved (from original state)	5.99%	5.47%	building number
insulation improved (area-weighted)	6.18%	5.69%	elemental area
average thickness of improved insulation	100		estimate
annual rate of insulation improvement	xx	xx	inconsistent data in SRT
annual rate of insulation improvement (area-weighted)	xx	xx	inconsistent data in SRT
average thickness of insulation (recent modernisation)	100		estimate
windows			
insulation improved (from original state)	60.3%	60.2%	building number
insulation improved (area-weighted)	63.8%	63.0%	elemental area
average quality of improved windows	2.75	2.76	building number
annual rate of insulation improvement	2.18%	2.17%	building number
annual rate of insulation improvement (area-weighted)	2.87%	2.86%	elemental area
average quality of improved windows (recent modernisatic	U = 1.6 W/m2K		estimate
sources / remarks			
SEAI BER Research Tool			