

Calculations for Part L 2018 TGD: Dwellings

Department of Housing, Planning and Local Government

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Quality information

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Executive Summary

The Department of Housing Planning Community and Local Government appointed consultants AECOM and Currie and Brown to carry out the following tasks:

- Energy and carbon performance modelling for five typical new dwelling designs to be constructed to the proposed Energy Performance of Buildings Directive (EPBD) Nearly Zero Energy Building (NZEB) performance levels using advanced fabric performance specifications with a range of heating, ventilation and renewable systems;
- To identify the uplift in capital cost for NZEB performance over and above existing construction costs;
- To assess the overheating risk that may occur in new dwellings in the summer as an unintended consequence of the new performance requirements;
- To identify the additional capital cost of major renovations to a cost optimal level as required under EPBD.
- To review the performance of renewable energy systems in multi-storey apartment blocks.

The results of the study show that the five dwelling types modelled were able to achieve compliance with the proposed NZEB specification using a combination of different design solutions.

The average uplift in cost across all dwelling types modelled was 1.9%. The range of uplift was 0.7% to 4.2% over current construction costs depending on the dwelling archetype and design specification applied.

The overheating analysis indicated a relatively small increase in overheating risk based on the CIBSE TM 59 overheating assessment methodology and criteria. It suggested that the mitigation package can be fairly limited, given that there were only marginal exceedances in selected rooms. The adopted mitigation strategy assumes occupant controlled curtain/ blinds on the east, west and/or south façade. When this mitigation strategy was adopted all dwellings passed the CIBSE TM 59 overheating risk assessment criteria.

The additional cost of major renovations to a cost optimal level is designed to have minimal capital cost impact and aligns with the new DCCAE grant for heat pumps.

An analysis of the feasibility of photovoltaics and heat pumps was carried on multi-storey apartment blocks. Heat pumps have been found to be a viable solution to meet the renewables contribution on all multi storey apartment blocks. Photovoltaics are a viable option for apartment blocks up to 12 storeys in height.

1. Introduction

This report presents DEAP modelling calculations and associated costings to support proposed changes to Building Regulations Part L 2018 Technical Guidance Document (TGD).

The report is structured in two Parts: Parts A and B present the evaluation of the changes for new and existing residential buildings respectively.

- New build: DEAP calculations have been provided to achieve a Maximum Permitted Energy Performance Coefficient of 0.30 and a Maximum Permitted Carbon Performance Coefficient of 0.35. This represents an improvement of 70% over 2005 building regulations and the proposed Nearly Zero Energy Building (NZEB) standard required by the Energy Performance of Buildings Directive. Capital costs associated with meeting the proposed changes have been determined.
- Existing build: This analysis evaluates the implementation of requirements around Major Renovation in Part L. It considers the energy efficiency measures necessary and the capital costs to comply with the new requirement.

The version of DEAP used for modelling is a draft release to support TGD L 2018. Included in the results of this modelling is the Renewable Energy Ratio which is calculated in line with ISO 52000-1:2017 Energy performance of buildings -- Overarching EPB assessment -- Part 1: General framework and procedures

The cost data used to provide the increase in cost for the improvement in energy performance is based on 2017 Dublin Cost data provided by cost consultants Currie and Brown.

A range of example dwellings have been modelled including detached, semi-detached and apartment dwellings.

Part A – New Dwellings

2. Specifications to meet Part L 2018

2.1 Introduction

Modelling was undertaken to identify and evaluate a set of improvements to fabric, services and renewables to achieve an improvement in the order of 70% for a set of typical new residential buildings compared to Building Regulations Part L 2005. The modelling was undertaken using a development version of the DEAP methodology and software. The modelling was carried out using a Primary Energy Factor (PEF) of 1.94 and a CO₂ emissions factor (CEF) of 0.323 kgCO₂/kWh.

A summary of the residential buildings modelled is shown in Table 1. These building types were previously used for the 2013 EPBD Cost Optimal Study with updates on their dimensions provided by DHPLG.

Table 1: Building Models

Building Category	Building Type	Floor Area
Single Family Buildings	Semi-Detached House	126 m ²
	Detached House	160 m ²
	Bungalow	104 m ²
Apartment Block	Mid-Floor Flat	80 m ²
	Top-Floor Flat	80 m ²

A baseline specification was derived for each of the building types to meet current regulations. This built on Appendix E of TGD 2011 and was particularly used to support the cost analysis.

An initial specification was developed to achieve the 70% improvement for the semi-detached house using photovoltaic (PV) technology. Further specifications were then developed for all five building types to achieve the 70% improvement, using a range of service and renewable options, but keeping the fabric specification the same.

2.2 Baseline specifications to meet current Part L

Baseline specifications were developed for each of the 5 building types to meet current Part L. These were based on Appendix E of TGD 2011 with only the amount of PV varying by building type.

The baseline specification for the semi-detached building is shown in Table 2. The amount of PV for each building type was as follows:

- Detached: 0.9 kWp (kilowatt peak)
- Semi-Detached: 0.7kWp
- Bungalow: 0.6kWp
- Mid-floor flat: 0.5kWp
- Top-floor flat: 0.5kWp

2.3 Initial specification to achieve 70% improvement on Part L 2005

An initial specification was developed for the semi-detached building to achieve a 70% improvement in EPC compared to Building Regulations Part L 2005. A fabric and services specification was agreed with DHPLG and SEAI to ensure that it was technically feasible and it was a reasonable approach to achieve this level of improvement. AECOM then varied the amount of photovoltaics to achieve the 70% improvement.

Table 2 shows the current specification to meet Part L (taken from Appendix E of TGD L 2011) and the new specification to achieve the 70% improvement. In particular, the new specification includes triple glazing, no secondary space heating system, and approximately 10% more PV installed in order to achieve the MPEPC of 0.30. The improvement in performance is shown in Table 3.

Table 2: Initial specification to achieve 70% improvement for semi-detached house

Elements	Part L 2011 compliant specification	Proposed Part L 2018 specification
External Wall U-value (W/m ² .K)	0.13	0.13
Floor U-value (W/m ² .K)	0.14	0.14
Roof U-value (W/m ² .K)	0.11	0.11
Party wall U-value (W/m ² .K)	0.0	0.0
Windows and glazed doors U-value (W/m ² .K)	1.3	0.9
Window type	Double glazed, low E (En = 0.05, soft coat), argon filled, PVC frames	Triple glazed, low E (En = 0.05, soft coat), argon filled, PVC frames
Windows and glazed doors g-value	0.63	0.6
External door U-value (W/m ² .K)	1.5	1.5
Thermal Bridging Y-value	0.05	0.05
Thermal mass	Medium	Medium
Air Permeability (m ³ /hm ² @ 50Pa)	5	5
Ventilation strategy	Natural ventilation with intermittent extract fans in wet rooms	Natural ventilation with intermittent extract fans in wet rooms ¹
Space heating and hot water system	Mains gas condensing gas boiler, room sealed, flue fan	Mains gas condensing gas boiler, room sealed, flue fan
Heating system efficiency	91.3%	91.3%
Secondary space heating system	Gas fire, closed front, fan assisted, balanced flue	None
Secondary space heating efficiency	80%	na
Controls	Boiler interlock Time and temperature zone control	Boiler interlock Time and temperature zone control
Central heating pump	High efficiency pump (energy consumption of 52kWh/yr)	High efficiency pump (energy consumption of 52kWh/yr)
Hot water demand	Based on floor area	1 shower with 6 litres/min flow restrictor 1 Bath No electric showers Overall target of 125 litres/person/day
Hot water cylinder size	120 litres	120 litres
Hot water cylinder insulation	100mm factory insulated	100mm factory insulated

Elements	Part L 2011 compliant specification	Proposed Part L 2018 specification
Lighting	100% low energy lighting – Achieves a saving of 75% over a standard (non-low energy) lamp	100% low energy lighting, conforming to the following specification: · A+ Rated Bulbs · 94 lumen/cW · 4 W/m ²
PV panels orientation	East/ West	East/ West
PV system tilt	30°	30°
PV system over-shading	None	None
PV system size (kWp)	1.05	1.15

¹ An alternative to modelling natural ventilation (and intermittent extract fans) with a fabric air permeability of 5m³/hr/m² is to model continuous Mechanical Extract Ventilation (cMEV) with SFP of 0.2W/l/s and an air permeability of 3m³/hr/m². The latter will achieve approximately the same performance as the natural ventilation specification.

Table 3: Summary of performance

Dwelling types	Part L 2011 compliant specification	Proposed Part L 2018 specification
Primary energy (kWh/yr/m²)	56.3	43.4
CO₂ emissions (kg/yr/m²)	10.4	8.1
Energy Performance Coefficient	0.40	0.30
Carbon Performance Coefficient	0.37	0.28
Building Energy Rating	A3	A2
Delivered renewable energy (kWh/m²)	-5.9	-6.5
RER	0.18	0.22

2.4 Range of specifications to achieve 70% improvement on Part L 2005

Further specifications were then developed for all five building types to achieve the 70% improvement, using a range of service and renewable options, but keeping the fabric specification generally the same. A summary of the buildings modelled and the results obtained are shown in Table 4.

- For all options, the fabric specification was as in Table 2, except that air permeability was assumed to be 3 m³/hm² at 50Pa where a MVHR system was used.
- Where a gas boiler was used, its specification is as in Table 2. Where photovoltaics were used, the orientation, tilt and overshadowing are as in Table 2.
- Details of the heat pumps, MVHR systems and solar thermal system used are summarised in Table 5.

It can be seen from Table 4 that for the single family buildings, there is no reliance on a single technology type. In particular, compliant solutions have been identified using PV, solar thermal or heat pumps (or a combination of these technologies). The use of MVHR with improved airtightness does reduce demand and, for example, the amount of PV (if any) that is required to comply. The use of heat pumps with MVHR in apartments removes the need for photovoltaics.

A natural ventilation specification with intermittent extract fans and a fabric air permeability of $5\text{m}^3/\text{hr}/\text{m}^2$ can be replaced with centralised continuous mechanical extract ventilation (cMEV) with specific fan power of $0.2\text{W}/\text{l/s}$ and air permeability of $3\text{m}^3/\text{hr}/\text{m}^2$ to achieve a similar energy performance. To ensure effective ventilation rates from mechanical ventilation systems, these should be installed by competent installers and commissioned by competent persons with calibrated equipment as per Technical Guidance Document F.

Table 4: Full set of options to achieve 70% improvement

	Heating and Ventilation	PV (kWp)	PV (m ²) 1kWp=7.5m ²	PV (% of roof area)	Solar thermal (m ²)	Solar fraction (%)	Energy Performance Coefficient	Carbon Performance Coefficient	Primary energy (kWh/yr/m ²)	CO ₂ emissions (kg/yr/m ²)	Building Energy Rating	Delivered renewable energy (kWh/yr/m ²)	RER
Semi Detached	Gas Boiler NV ¹	1.15	8.6	7%	n/a	n/a	0.30	0.28	43.4	8.1	A2	12.55	0.22
	Gas Boiler MVHR + AP of 3	0.85	6.4	5%	n/a	n/a	0.26	0.24	37.9	7.0	A2	9.28	0.20
	Heat Pump NV ¹	0	0	0%	n/a	n/a	0.25	0.21	36.5	6.1	A2	26.24	0.42
	Heat Pump MVHR + AP of 3	0	0	0%	n/a	n/a	0.25	0.20	35.9	6.0	A2	17.85	0.33
Detached	Gas Boiler NV ¹	1.45	10.9	7%	n/a	n/a	0.30	0.28	44.3	8.3	A2	12.46	0.22
	Gas Boiler MVHR + AP of 3	1.1	8.3	5%	n/a	n/a	0.26	0.23	37.7	6.9	A2	9.45	0.20
	Gas Boiler MVHR + AP of 3	n/a	n/a	n/a	8	60%	0.25	0.22	36.7	6.6	A2	9.09	0.20
	Heat Pump NV ¹	0	0	0%	n/a	n/a	0.24	0.20	35.4	5.9	A2	27.49	0.44
	Heat Pump MVHR + AP of 3	0	0	0%	n/a	n/a	0.23	0.19	34.4	5.7	A2	18.57	0.35
Bungalow	Gas Boiler NV ¹	1.25	9.4	9%	n/a	n/a	0.30	0.28	53.1	10.0	A3	16.53	0.24
	Gas Boiler MVHR + AP of 3	0.9	6.8	6%	n/a	n/a	0.27	0.25	47.9	8.9	A2	11.90	0.2
	Gas Boiler MVHR + AP of 3	n/a	n/a	n/a	7	64% ²	0.27	0.24	46.9	8.4	A2	11.48	0.20
	Heat Pump NV ¹	0	0	0%	n/a	n/a	0.25	0.20	43.3	7.2	A2	33.93	0.44
	Heat Pump MVHR + AP of 3	0	0	0%	n/a	n/a	0.24	0.20	42.3	7.1	A2	24.94	0.37

	Heating and Ventilation	PV (kWp)	PV (m ²) 1kWp=7.5m ²	PV (% of roof area)	Solar thermal (m ²)	Solar fraction (%)	Energy Performance Coefficient	Carbon Performance Coefficient	Primary energy (kWh/yr/m ²)	CO ₂ emissions (kg/yr/m ²)	Building Energy Rating	Delivered renewable energy (kWh/yr/m ²)	RER
Top Floor Apartment	Gas Boiler NV ¹	1	7.5	19%	n/a	n/a	0.30	0.28	46.7	8.8	A2	16.98	0.27
	Gas Boiler MVHR + AP of 3	0.63	4.7	12%	n/a	n/a	0.27	0.25	42.0	7.7	A2	10.61	0.20
	Air to water Heat Pump for space heating and hot water for each apartment NV ¹	0	0	0%	n/a	n/a	0.28	0.23	43.0	7.2	A2	29.24	0.40
	Air to water Heat Pump for each apartment MVHR + AP of 3	0	0	0%	n/a	n/a	0.27	0.22	41.4	6.9	A2	19.59	0.32
Mid Floor Apartment	Gas Boiler NV ¹	0.85	6.4	16%	n/a	n/a	0.30	0.29	40.0	7.5	A2	14.43	0.27
	Gas Boiler MVHR + AP of 3	0.55	4.1	10%	n/a	n/a	0.27	0.26	36.7	6.7	A2	9.34	0.20
	Air to water Heat Pump for space heating and hot water for each apartment NV ¹	0	0	0%	n/a	n/a	0.29	0.25	39.3	6.5	A2	23.53	0.37
	Air to water Heat Pump for each apartment MVHR+ AP of 3	0	0	0%	n/a	n/a	0.29	0.25	38.8	6.5	A2	15.67	0.29

¹NV with intermittent extract at air permeability=5m³/m²/hr or alternatively cMEV at air permeability=3m³/m²/hr.

²The technology option consisting of gas boiler, MVHR and solar thermal tested for the bungalow exceeds the maximum recommended solar fraction of 60%. This scenario may however still be suitable for bungalows with larger floor area (and therefore higher hot water demand) than modelled for this study.

Table 5: MVHR, heat pump and solar thermal specifications

MVHR	Specific fan power: 0.8 W/l/s Heat recovery efficiency: 85%
Heat pumps	Assumes air to water source heat pumps modelled with low temperature underfloor heating Efficiency for Space heating: 400% Efficiency for domestic hot water: 200% Hot water cylinder of 250 litres
Solar thermal	Evacuated tube collector sized to provide 60% of the hot water demand East/ West facing 30° inclination No shading η_0 (zero-loss collector efficiency) 0.6 a_1 (linear heat loss coefficient of collector) 3W/m ² K
Hot water cylinder for solar thermal	Dedicated solar storage volume to be at least 25 litres per m ² of collector absorber area (in addition to hot water storage of 120 litres) with 100mm factory insulation

3. Capital costs to meet Part L 2018

3.1 Introduction

The capital cost uplift was evaluated for all of the options shown in Table 4.

The costs for building fabric elements (where the specifications differ from those in TGD L 2011), building services and renewable energy technologies, are included in Appendix A.

3.2 Overall building CAPEX

Capital costs of current residential developments have been used to develop reference costs for Table 6. These costs are based on 2017 Dublin cost data and were provided by Currie and Brown. Costs have been based on their internal cost database, which has been developed and updated with real-world cost information from live projects they are providing cost support on. These costs were cross-checked with peers who have independent experience of the Irish construction market, to verify cost ranges. They were also cross-referenced with a third party database in the Irish market. These comparisons show that the presented costs are consistent with the mid-to-lower end of the cost ranges identified.

The costs per m² are based on construction costs only and include for external and site development works. Please note the costs exclude Preliminaries, VAT and also in respect of the apartments are exclusive of a basement provision.

3.3 Results

The uplift in capital costs for the various options is summarised in Table 6 below.

Table 6: Summary of cost modelling output excluding Prelims, Overheads and VAT

Dwelling type	Technology scenario	delta CAPEX		
		€	€/m2	%
Semi Detached	2011 baseline - Gas boiler, NV + 0.7kWp PV	-	-	-
	Gas Boiler NV + 1.15kWp PV	€1,483	€12	0.9%
	Gas Boiler cMEV + AP of 3 + 1.15kWp PV	€3,375	€27	2.0%
	Gas Boiler MVHR + AP of 3 + 0.85kWp PV	€3,822	€30	2.2%
	Heat Pump NV	€1,765	€14	1.1%
	Heat Pump cMEV + AP of 3	€3,656	€29	2.2%
	Heat Pump MVHR + AP of 3	€4,853	€39	2.9%
Detached	2011 baseline - Gas boiler, NV + 0.9kWp PV	-	-	-
	Gas Boiler NV + 1.45kWp PV	€2,141	€13	1.0%
	Gas Boiler cMEV + AP of 3 + 1.45kWp PV	€4,002	€25	1.8%

Dwelling type	Technology scenario	delta CAPEX		
		€	€/m2	%
	Gas Boiler MVHR + AP of 3+ 1.1kWp PV	€4,513	€28	2.0%
	Gas Boiler MVHR + AP of 3 + 8m ² SHW	€7,800	€49	3.5%
	Heat Pump NV	€2,278	€14	1.1%
	Heat Pump cMEV + AP of 3	€4,139	€26	1.9%
	Heat Pump MVHR + AP of 3	€5,524	€35	2.6%
Bungalow	2011 baseline - Gas boiler, NV + 0.6kWp PV	-	-	-
	Gas Boiler NV + 1.25kWp PV	€1,569	€15	1.0%
	Gas Boiler cMEV + AP of 3 + 1.25kWp PV	€3,406	€33	2.1%
	Gas Boiler MVHR + AP of 3+ 0.9kWp PV	€3,607	€35	2.2%
	Gas Boiler MVHR + AP of 3 + 7m ² SHW	€6,740	€65	4.2%
	Heat Pump NV	€1,411	€14	1.0%
	Heat Pump cMEV + AP of 3	€3,248	€31	2.1%
	Heat Pump MVHR + AP of 3	€4,324	€42	2.8%
Top Floor Apartment	2011 baseline - Gas boiler, NV + 0.5kWp PV	-	-	-
	Gas Boiler NV + 1kWp PV	€1,038	€13	0.7%
	Gas Boiler cMEV + AP of 3 + 1kWp PV	€2,544	€32	1.8%
	Gas Boiler MVHR + AP of 3 + 0.63kWp PV	€2,561	€32	1.8%
	Heat Pump NV	€1,510	€19	1.2%
	Heat Pump cMEV + AP of 3	€3,015	€38	2.2%
	Heat Pump MVHR + AP of 3	€3,958	€49	2.9%
Mid Floor Apartment	2011 baseline - Gas boiler, NV + 0.5kWp PV	-	-	-
	Gas Boiler NV + 0.85kWp PV	€663	€8	0.5%
	Gas Boiler cMEV + AP of 3 + 0.85kWp PV	€2,169	€27	1.5%

Dwelling type	Technology scenario	delta CAPEX		
		€	€/m2	%
	Gas Boiler MVHR + AP of 3 + 0.55kWp PV	€2,361	€30	1.7%
	Heat Pump NV	€1,510	€19	1.2%
	Heat Pump cMEV + AP of 3	€3,015	€38	2.2%
	Heat Pump MVHR+ AP of 3	€3,958	€49	2.9%

4. Evaluating the risk of overheating

4.1 Introduction

An assessment was undertaken of the risk of the buildings overheating during the summer using a proposed set of specifications to Part L 2018. This is to better understand the wider consequences of implementing Part L 2018.

4.2 Methodology

CIBSE TM59 was used to assess the risk of overheating. It is a new methodology specifically developed to assess the risk of overheating in residential buildings. It is based on the use of thermal modelling; IES Virtual Environment software was used for this evaluation.

An overheating assessment was undertaken on each of the 5 building types considered in the earlier sections. More detailed layouts for the buildings were provided by DHPLG and SEAI for this evaluation. The compliant specifications adopted were the first option for each building type in Table 4.

The modelling assumptions are included in Appendix A; these were agreed between AECOM, DHPLG and SEAI. In particular, it is noted that the TM59 methodology recommends using 2020s high emission scenario weather data that has been developed by CIBSE and the University of Exeter to account for changes in temperature and weather patterns due to climate change. The weather files available are limited to 14 locations in the UK. It was agreed to use the Manchester weather file for the 2020s as it appeared the average Manchester temperature profile was closest to temperatures currently experienced in Dublin.

TM59 sets out two compliance criteria which both need to be met for the risk of overheating to be deemed acceptable.

- Criterion A applies to living rooms, kitchens and bedrooms. It requires that the internal temperature does not exceed a defined comfort temperature by 1°C or more for more than 3% of occupied hours over the summer period (1 May to 30 September).
- Criterion B applies to bedrooms only and requires that the internal temperature between 10 pm and 7 am shall not exceed 26°C for more than 1% of annual hours.

For the building types that failed the TM59 compliance thresholds, a mitigation strategy was adopted.

4.3 Results

Table 7 and Table 8 show the results of the analysis pre and post mitigation.

The detached property complies with the TM59 overheating criteria without any mitigation measures. The results for the other dwellings suggest that the mitigation package can be fairly limited, given that there were only marginal exceedances in selected rooms. The rooms that fail are all west facing, and in case of the living rooms the high risk of overheating is attributable to the late afternoon/ evening solar gains from west facing windows which coincide with high internal gains from occupants.

The adopted mitigation strategy assumes occupant controlled curtain/ blinds that will be drawn on the east, west and/or south façade when solar radiation is falling on that particular façade, and raised when the sun has moved further along in the sky. This has been modelled using the following profile:

- Incident radiation to lower shade - 200 W/m²

- Incident radiation to raise shade - 150 W/m^2 (Note that the lower value is to ensure the software works okay and also reflects a potential time delay in terms of when occupants might raise the shade).

The adopted mitigation strategy is sufficient to mitigate the risk of overheating in all of the dwellings modelled.

Table 7: Results of the overheating assessment

Building Type	Room	TM59 Criteria A		TM59 Criteria B	
		% of hours exceeded	Pass/Fail	% of hours exceeded	Pass/Fail
Semi Detached	Living Room	2.8%	Pass	-	-
	Bedroom 1	1.6%	Pass	0.58%	Pass
	Bedroom 2	1.0%	Pass	0.55%	Pass
	Bedroom 3	3.5%	Fail	0.79%	Pass
Detached	Living Room	2.7%	Pass	-	-
	Bedroom 1	1.4%	Pass	0.94%	Pass
	Bedroom 2	1.4%	Pass	0.91%	Pass
	Bedroom 3	1.8%	Pass	0.85%	Pass
	Bedroom 4	1.8%	Pass	0.88%	Pass
Bungalow	Living Room	3.4%	Fail	-	-
	Bedroom 1	0.8%	Pass	0.52%	Pass
	Bedroom 2	2.0%	Pass	0.85%	Pass
	Bedroom 3	2.2%	Pass	0.85%	Pass
Top Floor Apartment	Living Room / Kitchen	3.3%	Fail	-	-
	Bedroom 1	0.7%	Pass	0.49%	Pass
	Bedroom 2	1.1%	Pass	0.55%	Pass
Mid Floor Apartment	Living Room / Kitchen	4.1%	Fail	-	-
	Bedroom 1	0.9%	Pass	0.64%	Pass
	Bedroom 2	1.4%	Pass	0.70%	Pass

Table 8: Results of the overheating assessment with mitigation measures

Building Type	Room	TM59 Criteria A		TM59 Criteria B	
		% of hours exceeded	Pass/Fail	% of hours exceeded	Pass/Fail
Semi Detached	Living Room	1.7%	Pass	-	-
	Bedroom 1	1.2%	Pass	0.49%	Pass
	Bedroom 2	0.8%	Pass	0.49%	Pass
	Bedroom 3	2.6%	Pass	0.70%	Pass
Detached	Living Room	1.7%	Pass	-	-
	Bedroom 1	1.0%	Pass	0.79%	Pass
	Bedroom 2	1.0%	Pass	0.82%	Pass
	Bedroom 3	1.5%	Pass	0.79%	Pass
	Bedroom 4	1.5%	Pass	0.79%	Pass
Bungalow	Living Room	2.8%	Pass	-	-
	Bedroom 1	0.5%	Pass	0.37%	Pass
	Bedroom 2	1.5%	Pass	0.73%	Pass
	Bedroom 3	1.52%	Pass	0.76%	Pass
Top Floor Apartment	Living Room / Kitchen	2.0%	Pass	-	-
	Bedroom 1	0.3%	Pass	0.43%	Pass
	Bedroom 2	0.7%	Pass	0.43%	Pass
Mid Floor Apartment	Living Room / Kitchen	2.5%	Pass	-	-
	Bedroom 1	0.5%	Pass	0.46%	Pass
	Bedroom 2	0.8%	Pass	0.55%	Pass

5. Evaluation of city centre apartment blocks

City centre apartment blocks were evaluated to understand if they could be designed to achieve a RER of 20% using a combination of heat pumps and/or PVs. Two apartment blocks of 6 and 14 stories respectively were analysed using the same unit types as in Section 2. The blocks were assumed to have 12 apartments on each floor.

Where the apartments were modelled with heat pumps (as per the system efficiencies in Table 5), there was no requirement to install additional PVs to meet the required RER target. In case of gas boiler, additional PV area was required. It was assumed that PV would be installed on the roof only and the potential for additional installation on the façade was not assessed.

To work out the maximum available roof area for PVs, the following assumptions were made:

- An allowance of 20% communal areas has been made relative to the gross internal floor area for apartments. This was then used to calculate the total roof area
- 70% of the total roof area is available for PVs, after allowing for services and over-shading
- Of the remaining roof area, a 20% allowance has been made for spacing between panels and for access. This gives a net available area of 56% of the total roof area.

This limits the maximum available PV capacity per apartment to:

- 0.5kWp for the 14 storey apartment block
- 1.2kWp for the 6 storey apartment block

The tables below summarise the area-weighted block performance for the 6 storey and 14 storey blocks of apartments for different combination of heating and ventilation packages.

Based on the analysis, and the assumptions outlined above, gas boilers and PVs should be a viable technical solution for apartment block up to 12 stories for them to meet the RER target of 20%. Heat pumps are a viable technical solution for apartment blocks of all heights. The final technical solution suitable for each development will depend on the site context, design specifications and the client requirements.

Table 9: Area-weighted average performance for a 6-storey apartment block

Ventilation Package	Heating Package	kWp per apartment	EPC	CPC	RER	Compliant
Natural ventilation, air permeability of 5m ³ /hr.m ²	Gas boiler	0.80	0.30	0.29	0.24	Yes
Natural ventilation, air permeability of 5m ³ /hr.m ²	Heat pump	-	0.28	0.24	0.37	Yes
MVHR, air permeability of 3m ³ /hr.m ²	Gas boiler	0.55	0.27	0.25	0.20	Yes
MVHR, air permeability of 3m ³ /hr.m ²	Heat pump	-	0.28	0.24	0.29	Yes

Table 10: Area-weighted average performance for a 14-storey apartment block

Ventilation Package	Heating Package	kWp per apartment	EPC	CPC	RER	Compliant
Natural ventilation, air permeability of 5m ³ /hr.m ²	Gas boiler	0.50	0.33	0.31	0.16	No
Natural ventilation, air permeability of 5m ³ /hr.m ²	Heat pump	-	0.28	0.24	0.37	Yes
MVHR, air permeability of 3m ³ /hr.m ²	Gas boiler	0.50	0.28	0.26	0.18	No
MVHR, air permeability of 3m ³ /hr.m ²	Heat pump	-	0.28	0.24	0.29	Yes

Part B – Existing dwellings

6. Major renovation for existing dwellings

6.1 Introduction

Article 7 of EPBD Recast requires that upon Major Renovation, the energy performance of the building or the renovated part is upgraded to meet minimum energy efficiency performance requirements in so far as they are technically, functionally and economically feasible. Furthermore, Article 7 of EPBD Recast requires these performance requirements to be set with a view to achieving cost optimal levels. EPBD Recast provides two optional definitions of Major Renovation – Ireland has adopted the definition that it is met where more than 25% of the surface area of the building envelope undergoes renovation.

This analysis evaluates the implementation of requirements around Major Renovation in Part L. It considers the energy efficiency measures necessary and the capital costs to comply with the new requirement.

6.2 Building works that trigger Major Renovation

The draft TGD L identifies works to the surface area for which it is technically, functionally and economically feasible to improve the energy performance of the whole building to cost optimal level. These works include the following:

- Cladding the external surface of the wall
- Drylining the internal surface of a wall

Building works were identified which would result in 'Major Renovation' for the 5 residential building designs considered in Section 2.

- Initially, the total building envelope area was determined for each of the five buildings. The building envelope area was defined as comprising the thermal elements i.e. it included external walls, floor, roof, windows, doors etc. but does not include party walls where the building spaces are conditioned on either side of the wall.
- The next step was to determine the potential renovations of wall elements that would result in renovation of greater than 25% of the surface area of the building envelope – in any renovation it was assumed that the geometry of the building remains the same. For simplicity, in this analysis, any renovation was to the wall element as a whole.

The results are shown in [Table 11](#). The top half of the table shows the build-up of envelope area. The lower half of the table highlights in red where renovation of a thermal wall element would exceed 25% of the total area.

Table 11: Percentage surface area by fabric elements for existing dwellings

	Bungalow	Detached House	Semi-Detached House	Mid-Floor Flat	Top-Floor Flat
Building envelope area (thermal elements)					
External Wall (m ²)	80.9	143.6	85.7	36.9	36.9
Floor (m ²)	104.0	80.0	63.0	0	0
Roof (m ²)	104.0	80.0	63.0	0	54.0
Windows and doors (m ²)	25.8	40.1	31.6	13.6	13.6
Total (m ²)	314.7	343.7	243.3	50.5	104.5
Works that trigger Major Renovation¹,					
External Wall (%)	26%	42%	35%	73%	35%

¹ The percentages shown in the table are for the specific dwellings and typologies used for the analysis. It will be necessary to work out percentages for actual dwelling in line with the guidance in TGD L.

6.3 Energy efficiency measures triggered by Major Renovation

Table 12 summarises the Cost Optimal Works activated by Major Renovation. **Table 13** provides the costs for these works. These costs are based on 2017 Dublin cost data and were provided by Currie and Brown.

Table 12: Cost Optimal Works activated by Major Renovation

Major Renovation > 25% surface area^{1,2,3}	Works to bring dwelling to cost optimal level
External wall renovation	a. Upgrade of insulation at ceiling level with U Values greater than those in current TGD Part L, Table 5 b. Oil or gas boiler replacement & controls upgrade where the oil or gas boiler is more than 15 years old and efficiency less than 86% c. Replacement of electric storage heating systems where more than 15 years and with heat retention not less than 45% measured according to IS EN 60531.
¹ Where works are planned as a single project. ² Where major renovations to walls, roofs and ground floors constitute essential repairs e.g. repair or renewal of works due to fire, storm or flood damage or as a result of a material defect e.g. reactive pyrite in sub-floor hardcore, it is not considered economically feasible to bring these renovations to a cost optimal level. ³ Major Renovation of external wall elements should also meet the requirements of TGD Part L, Table 5	

Table 13: Costs for cost-optimal works

Major Renovation works >25% of surface area	Cost Optimal Works-ceiling insulation, gas boiler replacement & controls	Cost Optimal Works-ceiling insulation, oil boiler replacement & controls	Cost Optimal Works-ceiling insulation, new electric storage heating and controls*
External or internal Insulation			
Detached house	€5,636	€6,096	-
Semi-detached house	€5,202	€5,622	-
Bungalow	€5,556	€5,946	-
Mid-Floor Flat	€4,028	€4,368	€1,518
Top-Floor Flat (pitched roof)	€5,111	€5,471	€2,501

* Replacement electric storage heaters assumed for apartments only

Appendix A – Unit costs for new building elements

A.1 Building Fabric and enhanced air tightness

The table below shows the costs per unit for building fabric elements, where the specifications differ from those in TGD L 2011. Note that with the exception of glazing and air permeability, the specifications for all other building elements remain the same between TGD L 2011 and the draft TGD L 2018.

Table 14: Cost of building fabric specifications and enhanced air tightness

Element	Specification	Unit	Rate (€/m ² elemental area)
Windows and glazed doors	1.3	W/m ² .K	€250
Windows and glazed doors	0.9	W/m ² .K	€310
Rate (€/m ² floor area)			
Air Permeability	5	m ³ /hm ² at 50Pa	€5.4
Air Permeability	3	m ³ /hm ² at 50Pa	€7.6

A.2 Building services and renewable energy

Table 15: Cost of building services elements

Building services component	Specification	Dwelling type	kW capacity	Total Cost (€/unit)
Space heating	Mains gas condensing gas boiler	Detached house	9.0	€8,427
		Semi-detached house	6.7	€6,925
		Bungalow	6.4	€5,933
		Top-floor flat	5.4	€4,864
		Mid floor flat	5.1	€4,764
Secondary space heating (baseline 2011 specification only)	Gas fire, closed front, fan assisted, balanced flue			€1,400
Water heating	120 litres hot water cylinder with 100mm factory insulation			€600
Lighting	100% Low Energy Lighting			€3,500
Ventilation				
Natural ventilation	Intermittent extract fans in wet rooms			€250 (per extract fan)
Centralised Mechanical Extract Ventilation (cMEV)	Specific Fan Power of 0.20 W/l/s	Detached house		€2,745
		Semi-detached house		€2,353
		Bungalow		€2,099
		Top-floor flat		€1,823
		Mid floor flat		€1,823
Mechanical ventilation with heat recovery (MVHR)	Specific Fan Power of 0.8 W/l/s 85% heat recovery efficiency	Detached house		€4,130
		Semi-detached house		€3,550
		Bungalow		€3,175
		Top-floor flat		€2,765
		Mid floor flat		€2,765

Table 16: Cost of renewable energy technologies

Element/Component	Specification	Description/ typology	Capacity	Total Cost (€/unit)
Photovoltaics	Photovoltaic panels		per kWp	€2,500
Heat pump	Air to water source heat pump	Detached house	9.0kW	€12,189
		Semi-detached house	6.7kW	€10,082
		Bungalow	6.4kW	€8,899
		Top-floor flat	5.4kW	€7,835
		Mid floor flat	5.1kW	€7,735
Solar thermal	Evacuated tube collector		per m ² panel area	€655
			other associated costs per unit	€800

Appendix B – Overheating modelling assumptions

TM59 overheating criteria for dwellings that are predominantly naturally ventilated:

- **Criterion A - For living rooms, kitchens and bedrooms:** Operative temperature not to exceed the threshold comfort temperature (upper limit of the range of comfort temperature) by 1 K or more during the occupied hours of a typical non-heating season (1 May to 30 September) for more than 3% of occupied hours. (CIBSE TM52 Criterion 1: Hours of exceedance).
- **Criterion B - For bedrooms only:** Operative temperature in the bedroom from 10 pm to 7 am not to exceed 26 °C for more than 1% of annual hours.

Assessment of overheating risk was based on Category II buildings (i.e. new buildings with normal occupancy as per EN15251)

Modelling software	IES Virtual Environment (2016 version)
Weather file	Manchester DSY1 (Design Summer year 1) data for 2020s (high emissions 50% percentile scenario in line with TM59 methodology)
Dwelling dimensions and layouts	As provided by DHPLG/ SEAI Roof pitch of 30° has been assumed for the bungalow and 45° for the semi-detached and detached houses. Dimensions of internal doors have been assumed to be 0.8m x 1.8m.
Design occupancy	Based on the size of the bedrooms in the drawings, the following design occupancy has been assumed: Detached house: 4 bed 8 person Semi-detached house: 3 bed 5 person Bungalow: 3 bed 6 person Apartments: 2 bed 4 people
Fabric thermal performance standards	As per the proposed Part L 2018 specifications in Table 2
Building services and percentage low energy lighting	As per the proposed Part L 2018 specifications in Table 2
Heating regime	18°C set point temperature for heating throughout the year with the exception of June, July and August.
Thermal mass parameter (TMP)	Medium. TMP to be calculated based on suspended beam and block floor, masonry external walls with cavity fill insulation and wet plaster, solid masonry party walls, and plasterboard on steel stud internal partitions
Ventilation strategy	Purge ventilation through openable windows.
Openable window and door area (excludes front door)	Total window and door openable area to be 1/20 th of the floor area of each habitable room (as per Part F requirements)
Glazing/ window type	Side hung, assumed 90° open when fully open
Window g-value	0.6 (triple glazed, low E, soft coat)
Window opening regime	Windows, patio and balcony doors to be modelled to start to open in occupied rooms when indoor operative temperature exceeds 22°C and are fully open when temperature exceeds 26°C. Similarly, window and door openings to be modelled to start closing as internal temperature

	<p>drop below 26°C and are fully closed when internal temperature drops below 22°C.</p> <p>Consideration was given to an enhanced window regime that allows for windows to be closed where external temperature exceeds the internal temperature (for instance, during a heat wave). This is proposed to be included as a mitigation strategy.</p> <p>The windows in unoccupied rooms (bathrooms, toilets, cloak room, utility room, etc.) are assumed to be closed.</p>																																																																																										
Percentage of window that is frame	Houses – 35% Apartments – 25%																																																																																										
Orientation and solar gains	<p>Living rooms in all dwelling types assumed to face west (which is expected to be the worst case orientation for summer overheating). Apartments assumed to be west and south facing.</p> <p>No external shading or internal blinds/ curtains assumed for the base-case scenario.</p>																																																																																										
Occupancy, lighting and equipment gains	<p>In line with TM59 guidelines.</p> <p>TM59 requires that bedrooms are modelled as being occupied 24 hrs a day, with relatively lower occupancy levels during the day compared to night. Living rooms and kitchens are assumed to be occupied between 9am in the morning to 10pm in the night. Equipment and lighting gains vary with occupancy and time of the day.</p> <p>Maximum occupancy in a dwelling to be limited to the design occupancy.</p> <p>Any assumptions not explicit in the TM59 document are highlighted in red below.</p> <table><thead><tr><th>Room types</th><th>Max. no. of people</th><th>Occupancy (Sensible) - W</th><th>Lighting – W/m²</th><th>Equipment – W</th></tr></thead><tbody><tr><td>Bedrooms - Double</td><td>2</td><td>150</td><td>2</td><td>80</td></tr><tr><td>Bedrooms - Single</td><td>1</td><td>75</td><td>2</td><td>80</td></tr><tr><td>Living room/Kitchen – 1bed</td><td>1</td><td>75</td><td>2</td><td>450</td></tr><tr><td>Living room – 2b4p</td><td>2</td><td>150</td><td>2</td><td>150</td></tr><tr><td>Living room – 3b5p</td><td>2</td><td>150</td><td>2</td><td>150</td></tr><tr><td>Living room – 3b6p</td><td>3</td><td>150</td><td>2</td><td>150</td></tr><tr><td>Living room – 4b8p</td><td>4</td><td>150</td><td>2</td><td>150</td></tr><tr><td>Kitchen – 2b4p</td><td>2</td><td>150</td><td>2</td><td>300</td></tr><tr><td>Kitchen– 3b5p</td><td>2</td><td>150</td><td>2</td><td>300</td></tr><tr><td>Kitchen– 3b6p</td><td>3</td><td>150</td><td>2</td><td>300</td></tr><tr><td>Kitchen– 4b8p</td><td>4</td><td>150</td><td>2</td><td>300</td></tr><tr><td>Kitchen/ dining</td><td>as per kitchen</td><td></td><td></td><td></td></tr><tr><td>Lounge (in detached property)</td><td>-</td><td>-</td><td>-</td><td>-</td></tr><tr><td>Hallway</td><td>-</td><td>-</td><td>-</td><td>-</td></tr><tr><td>Bathroom, cloak room</td><td>-</td><td>-</td><td>-</td><td>-</td></tr><tr><td>Toilet</td><td>-</td><td>-</td><td>-</td><td>-</td></tr><tr><td>Utility room</td><td>-</td><td>-</td><td>-</td><td>-</td></tr></tbody></table>	Room types	Max. no. of people	Occupancy (Sensible) - W	Lighting – W/m ²	Equipment – W	Bedrooms - Double	2	150	2	80	Bedrooms - Single	1	75	2	80	Living room/Kitchen – 1bed	1	75	2	450	Living room – 2b4p	2	150	2	150	Living room – 3b5p	2	150	2	150	Living room – 3b6p	3	150	2	150	Living room – 4b8p	4	150	2	150	Kitchen – 2b4p	2	150	2	300	Kitchen– 3b5p	2	150	2	300	Kitchen– 3b6p	3	150	2	300	Kitchen– 4b8p	4	150	2	300	Kitchen/ dining	as per kitchen				Lounge (in detached property)	-	-	-	-	Hallway	-	-	-	-	Bathroom, cloak room	-	-	-	-	Toilet	-	-	-	-	Utility room	-	-	-	-
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Air infiltration	<p>Air infiltration rates assumed to be continuous, and calculated based on CIBSE Guide A empirical values for normally exposed sites (Table 4.24) and the air permeability rates as per the proposed Part L 2018 specifications in Table 2.</p> <p>Unheated loft spaces in houses assumed to have infiltration rate of 1.0 air change per hour (ach).</p>
Internal doors	<p>Internal doors to be assumed open all the time, with the exception of bedroom doors which are to be closed 22:00 – 9:00.</p> <p>Bedrooms doors to be modelled with 10mm undercut in line with Part F requirements (clause 1.2.1.2).</p>
External doors	The external entrance door to be assumed shut all the time.
Heat gains from hot water storage	Hot water storage of 120 litres assumed for houses and flats, with continuous standing loss of 50W.

Appendix C – Unit costs for existing building elements

Table 17: Costs of fabric energy efficiency measures in existing buildings

	Supply & Install Rate (€/m ²)	Detached House		Semi-Detached House		Bungalow		Mid-Floor Flat		Top-Floor Flat	
		Area (m ²)	Cost (€)	Area (m ²)	Cost (€)	Area (m ²)	Cost (€)	Area (m ²)	Cost (€)	Area (m ²)	Cost (€)
External Wall insulation	€126.6	161.7	€20,466	85.7	€10,847	80.6	€10,201	35.8	€4,531	35.8	€4,531
Internal wall insulation - Houses	€109.2	161.7	€17,655	85.7	€9,357	80.6	€8,800				
Internal wall insulation - Flats	€167.3							35.8	€5,990	35.8	€5,990
Roof - Pitched	€12.3	82	€1,008	63	€774	104	€1,278	n/a	n/a	n/a	n/a
Roof - Flat	€120.5									80	€9,638

Table 18: Costs of heating system upgrades in existing buildings

	Detached House	Semi-Detached House	Bungalow	Mid-Floor Flat	Top-Floor Flat
	Cost (€)	Cost (€)	Cost (€)	Cost (€)	Cost (€)
Main gas boiler	€3,035	€2,390	€1,973	€1,518	€1,518
Electric heating	€4,278	€3,633	€3,215	€2,761	€2,761
Oil boiler	€5,088	€4,848	€4,668	€4,488	€4,368

