



Building performance assessment
towards Next generation EPCs

Making building stock energy analysis robust

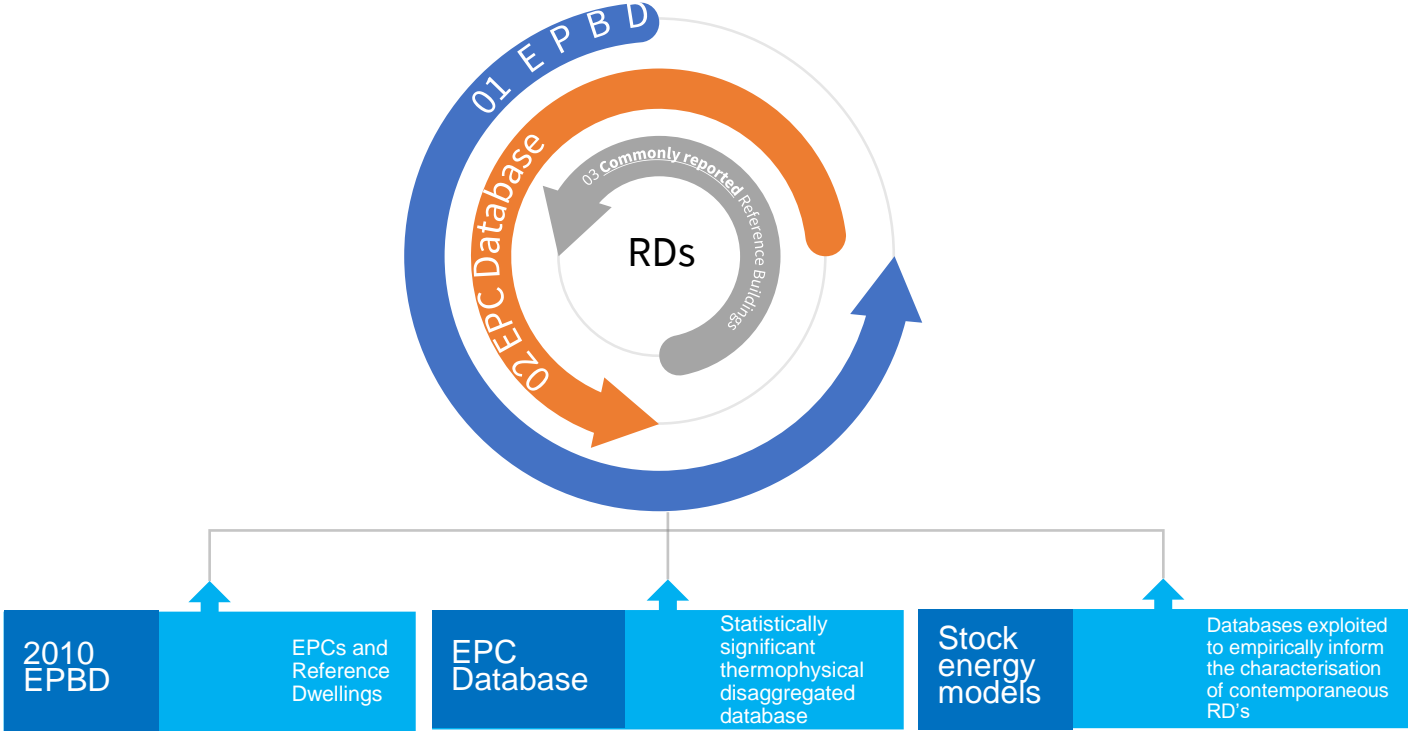
Kumar Raushan

TU Dublin

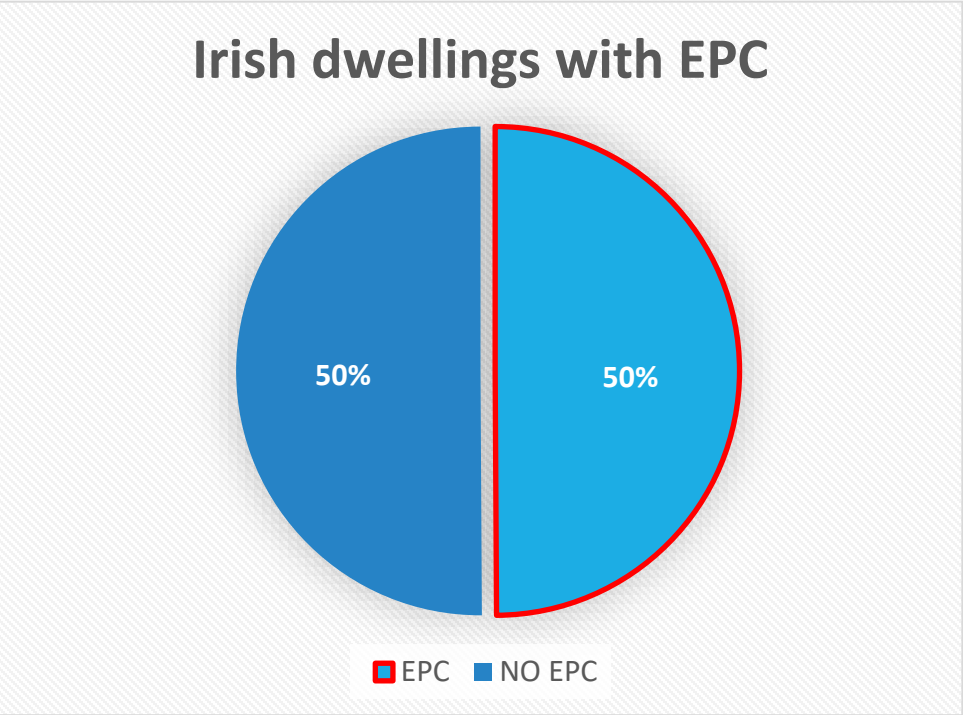
Session 3: Advancements in buildings sustainability
assessment.



Policy context - Europe's Answer



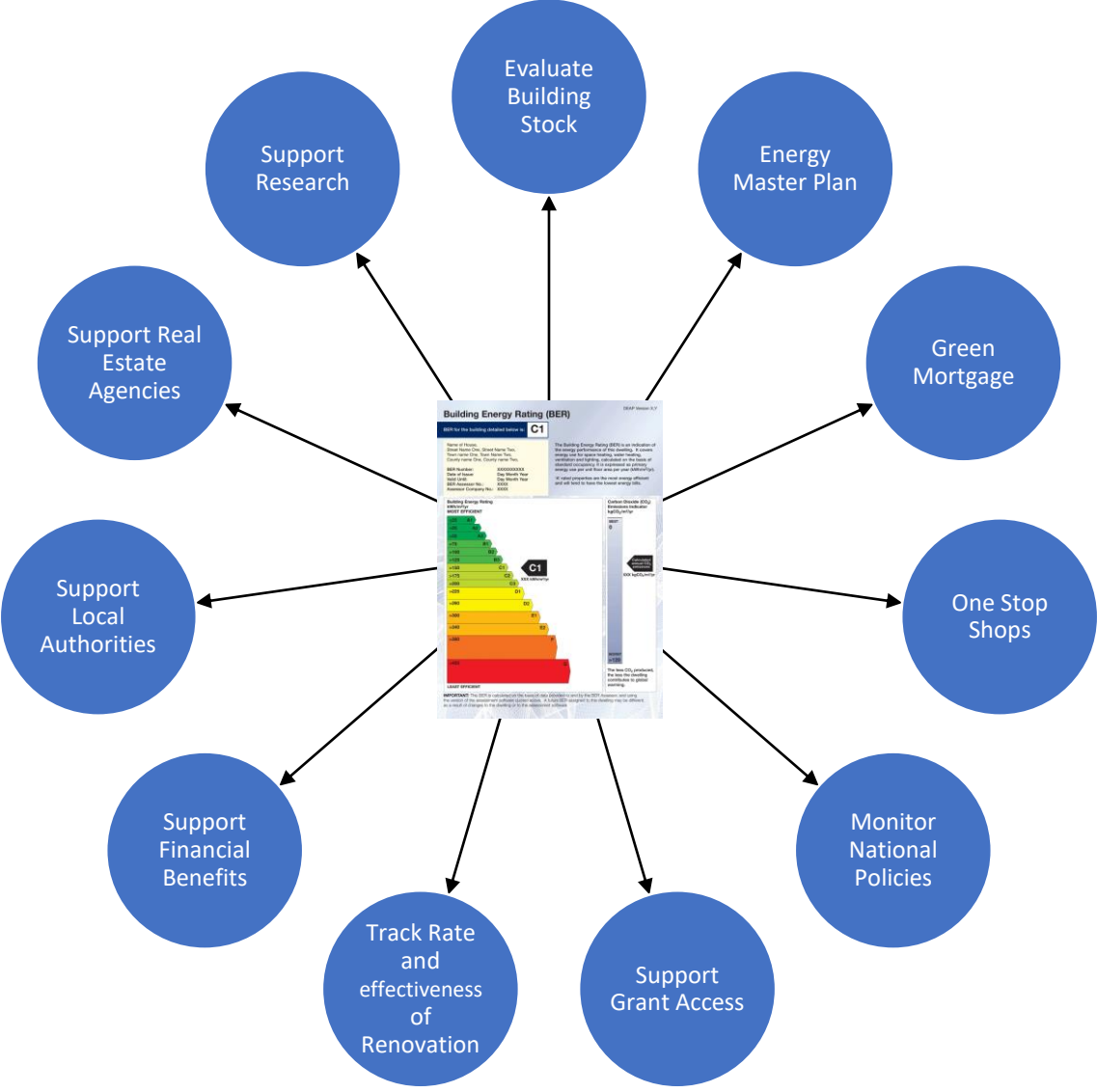
Irish EPC database



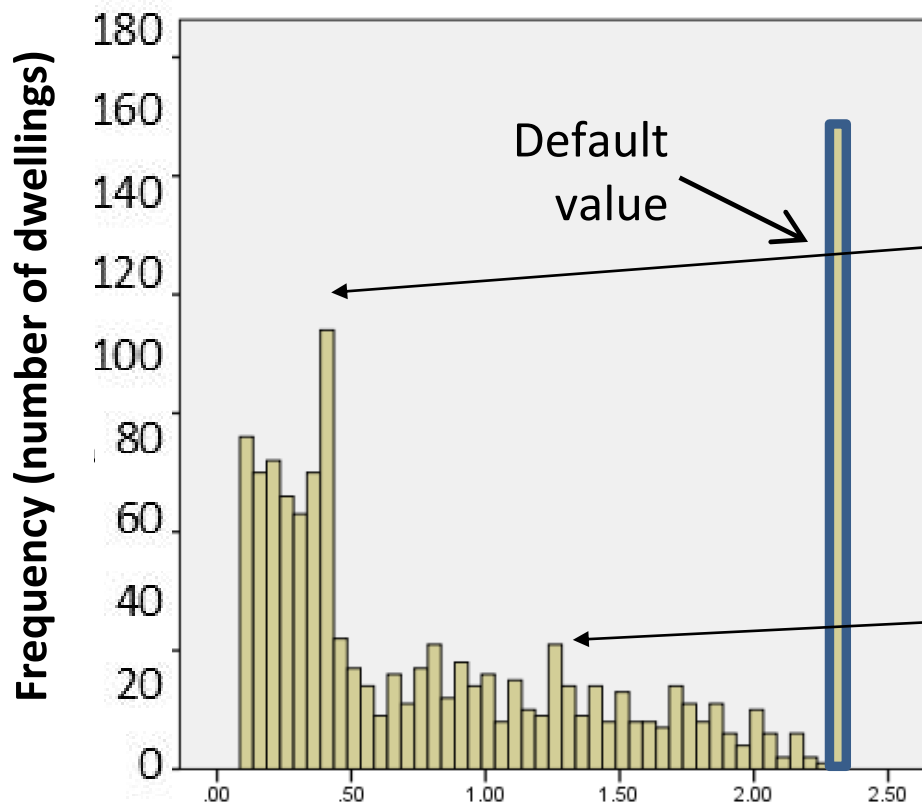
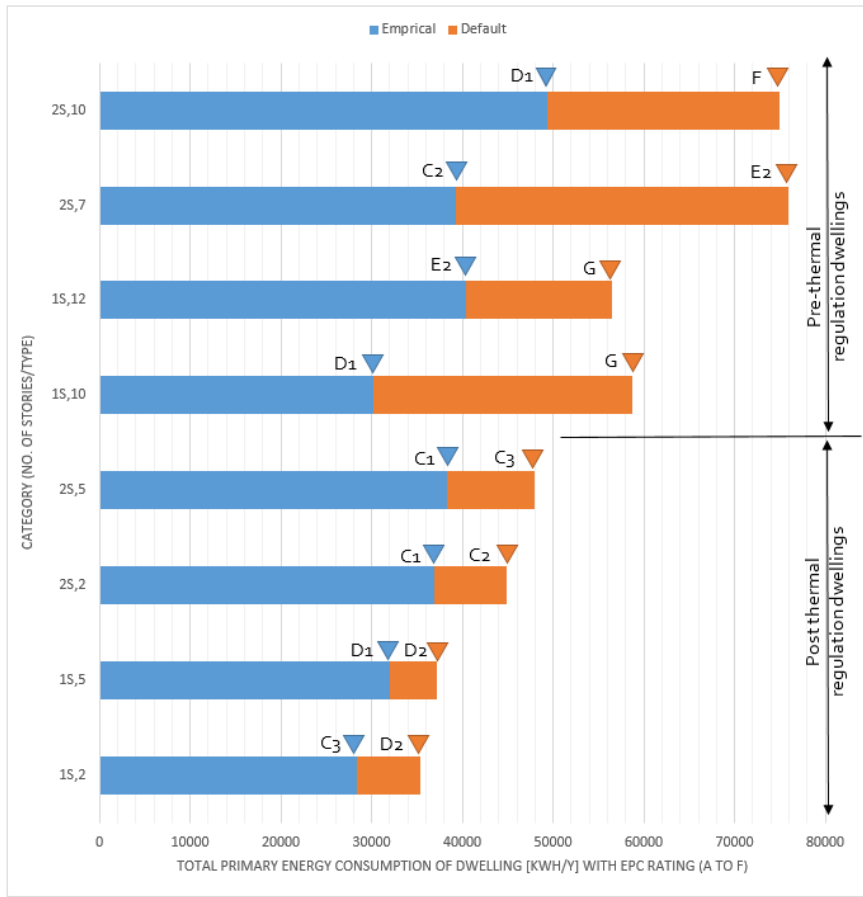
- Public access with protected privacy
- Access for some organisations
- Depends on Region
- No public access
- No registry available
- Provision of aggregated statistics



Why reliability of EPC database matters?



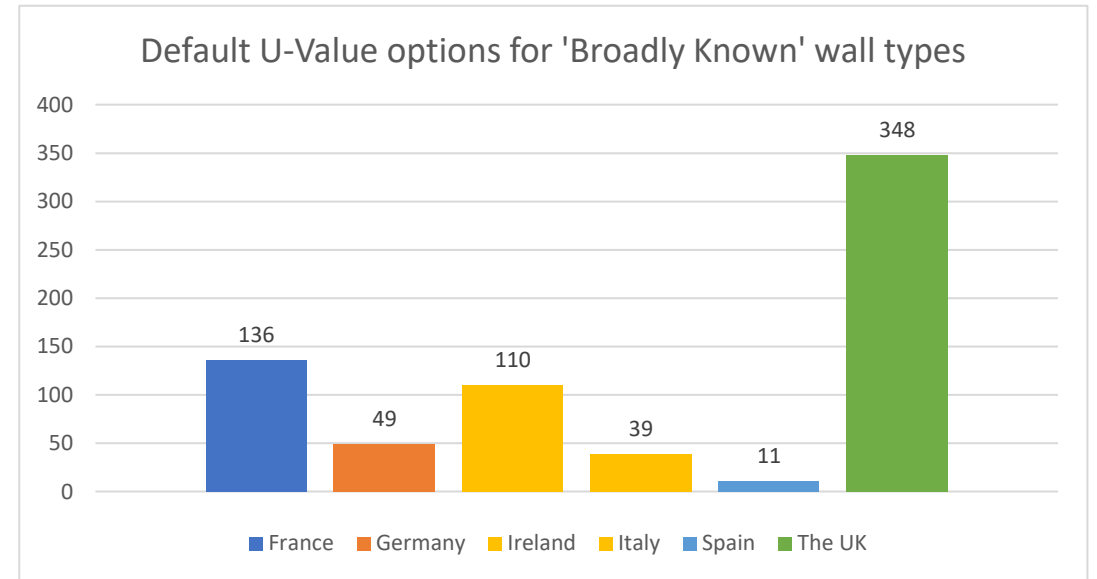
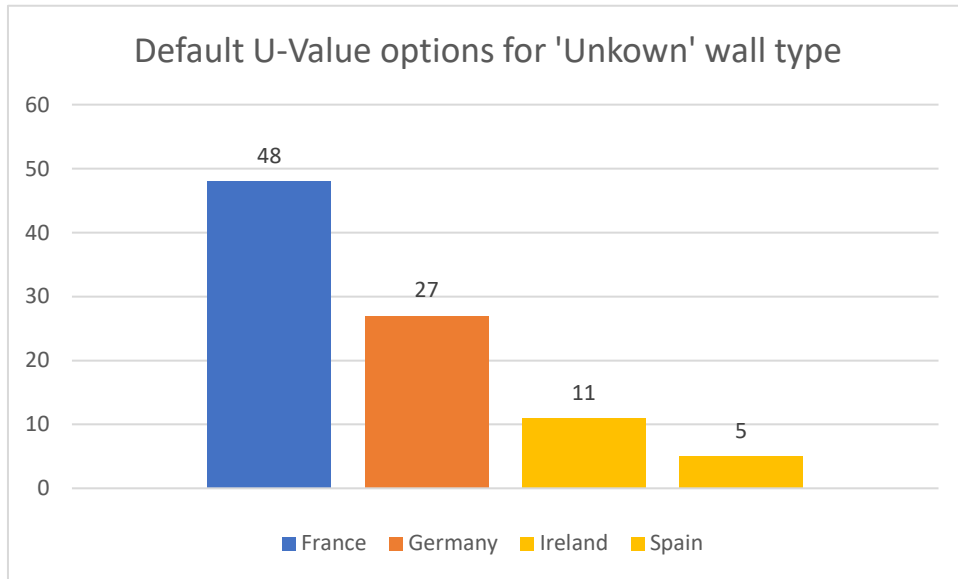
1 in 3 Dwelling in the EPC database is characterised on unrealistic thermal defaults values



Mode 1 dwellings show a tighter, more pronounced distribution profile due to thermal retrofits achieving a more harmonised level of thermal insulation.

Mode 2 – As-built building element

Default use landscape across MSs



Broadly known and unknown wall U-values by wall type and construction period

Age band	A	B	C	D	E	F	G	H	I	J	K
Construction Period	before 1900	1900-1929	1930-1949	1950-1966	1967-1977	1978-1982	1983-1993	1994-1999	2000-2004	2005 -2009	2010 onwards
Wall type											
Stone	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37	0.27
225mm solid brick	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37	0.27
325mm solid brick	1.64	1.64	1.64	1.64	1.64	1.1	0.6	0.55	0.55	0.37	0.27
300mm cavity	2.1	1.78	1.78	1.78	1.78	1.1	0.6	0.55	0.55	0.37	0.27
300mm filled cavity	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.55	0.55	0.37	0.27
solid mass concrete	2.2	2.2	2.2	2.2	2.2	1.1	0.6	0.55	0.55	0.37	0.27
concrete hollow block	2.4	2.4	2.4	2.4	2.4	1.1	0.6	0.55	0.55	0.37	0.27
timber frame	2.5	1.9	1.9	1.1	1.1	1.1	0.6	0.55	0.55	0.37	0.27
Unknown	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37	0.27
425 mm Cavity Wall	1.73	1.51	1.51	1.51	1.51	1.1	0.6	0.55	0.55	0.37	0.27
425 mm filled cavity	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.55	0.55	0.37	0.27

Broadly known and unknown wall U-values by wall type and construction period

Age band	A	B	C	D	E	F	G	H	I	J	K
Construction Period	before 1900	1900-1929	1930-1949	1950-1966	1967-1977	1978-1982	1983-1993	1994-1999	2000-2004	2005 -2009	2010 onwards
Wall type											
Stone	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37	0.27
225mm solid brick	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37	0.27
325mm solid brick	1.64	1.64	1.64	1.64	1.64	1.1	0.6	0.55	0.55	0.37	0.27
300mm cavity	2.1	1.78	1.78	1.78	1.78	1.1	0.6	0.55	0.55	0.37	0.27
300mm filled cavity	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.55	0.55	0.37	0.27
solid mass concrete	2.2	2.2	2.2	2.2	2.2	1.1	0.6	0.55	0.55	0.37	0.27
concrete hollow block	2.4	2.4	2.4	2.4	2.4	1.1	0.6	0.55	0.55	0.37	0.27
timber frame	2.5	1.9	1.9	1.1	1.1	1.1	0.6	0.55	0.55	0.37	0.27
Unknown	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37	0.27
425 mm Cavity Wall	1.73	1.51	1.51	1.51	1.51	1.1	0.6	0.55	0.55	0.37	0.27
425 mm filled cavity	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.55	0.55	0.37	0.27

Broadly known and unknown wall U-values by wall type and construction period

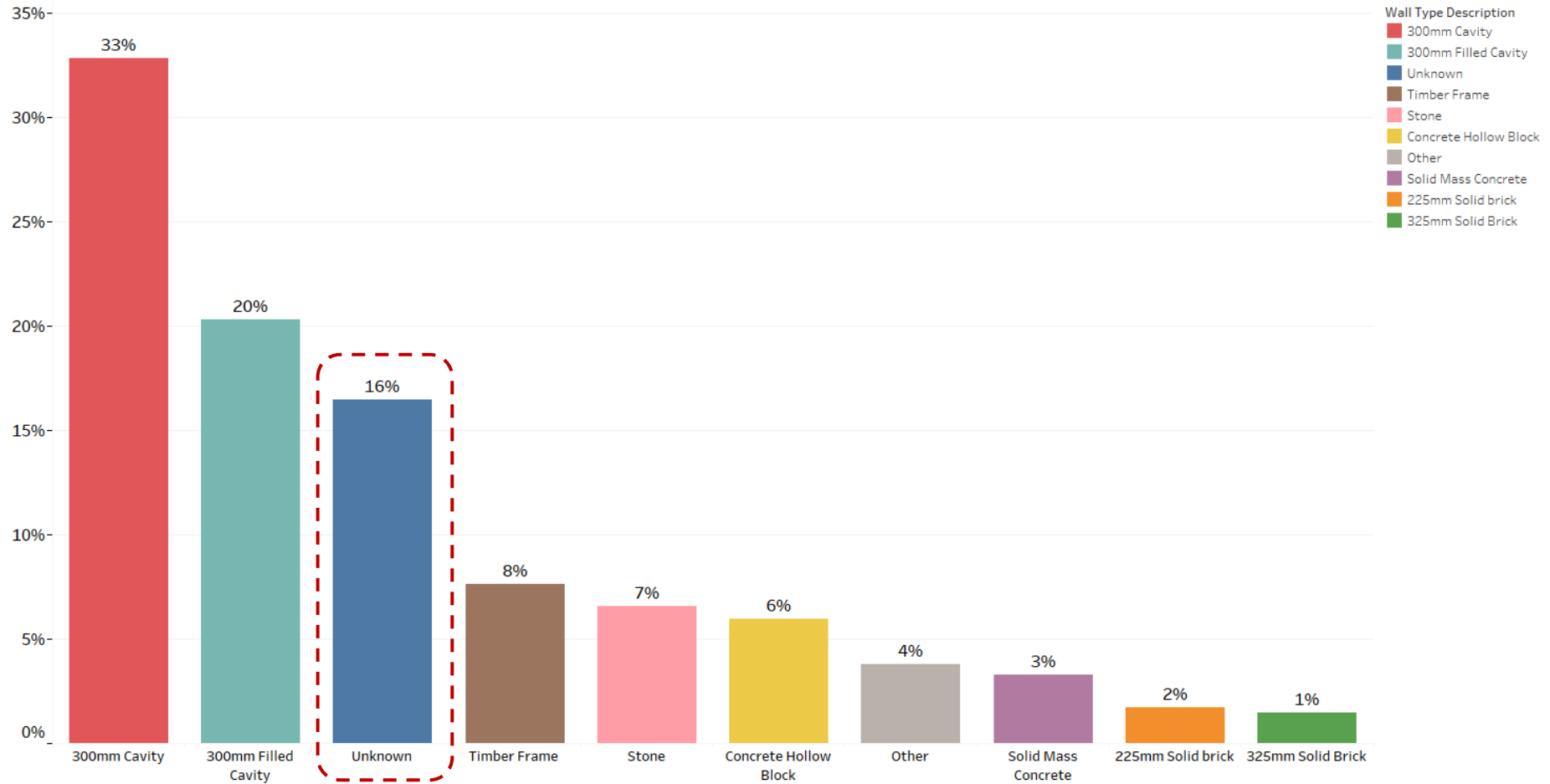
Age band	A	B	C	D	E	F	G	H	I	J	K
Construction Period	before 1900	1900-1929	1930-1949	1950-1966	1967-1977	1978-1982	1983-1993	1994-1999	2000-2004	2005 -2009	2010 onwards
Wall type											
Stone	2.1					1.1	0.6	0.55	0.55	0.37	0.27
225mm solid brick											
325mm solid brick	1.64										
300mm cavity	2.1	1.78									
300mm filled cavity	0.6										
solid mass concrete	2.2										
concrete hollow block	2.4										
timber frame	2.5	1.9	1.1								
Unknown	2.1										
425 mm Cavity Wall *	1.73	1.51			1.1						
425 mm filled cavity *	0.6										

Pre-thermal regulation “unknown” or base-default U-values are presumed pessimistically to be the same as that of uninsulated walls with a given construction.

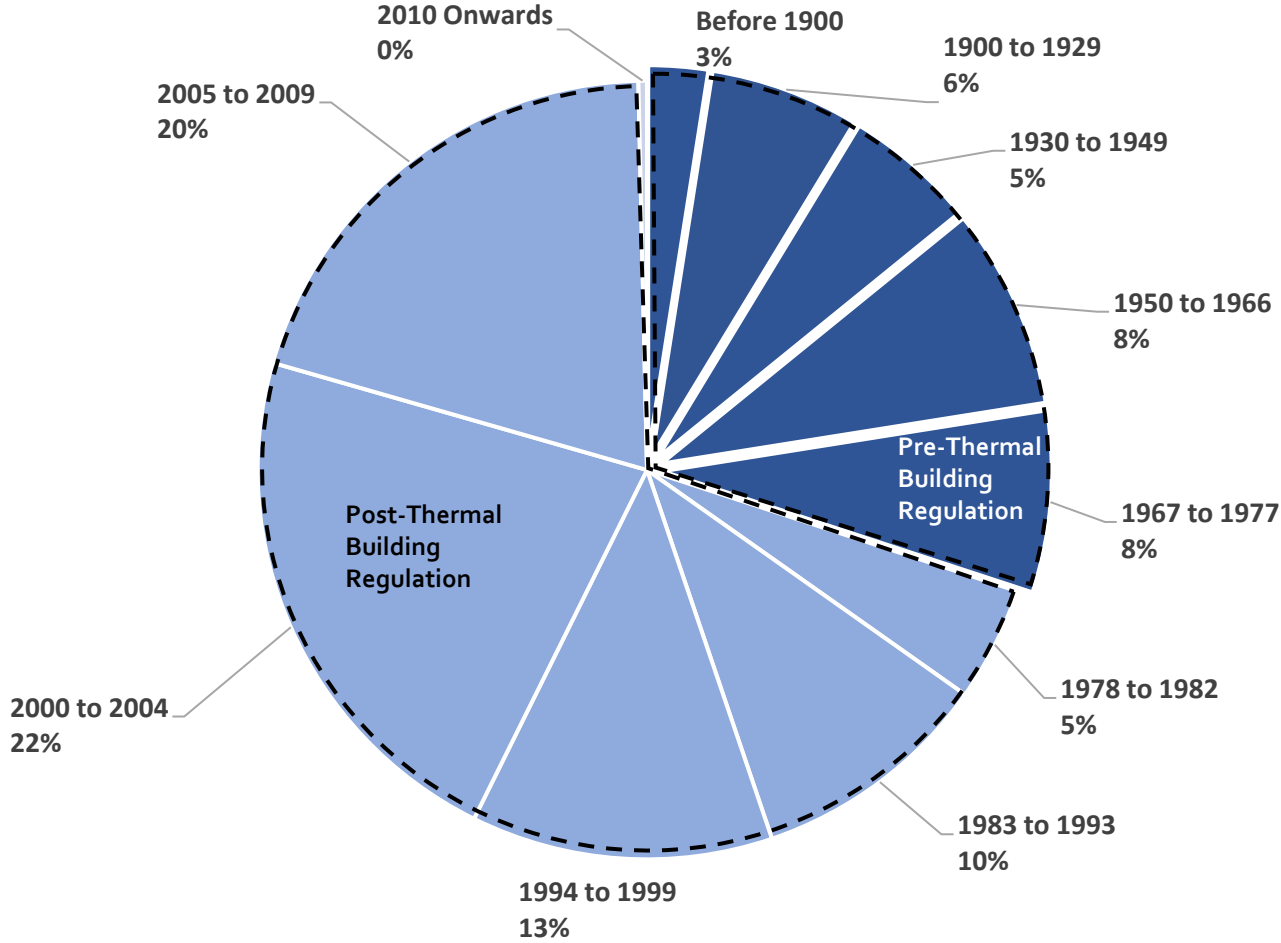
* Not typical construction types

Irrespective of wall type Post-thermal regulations defaults are led by the prevailing building regulation of the time.

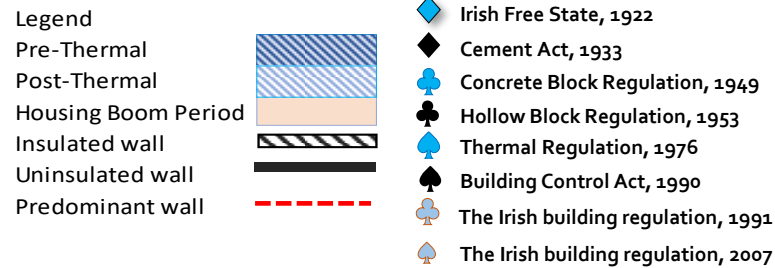
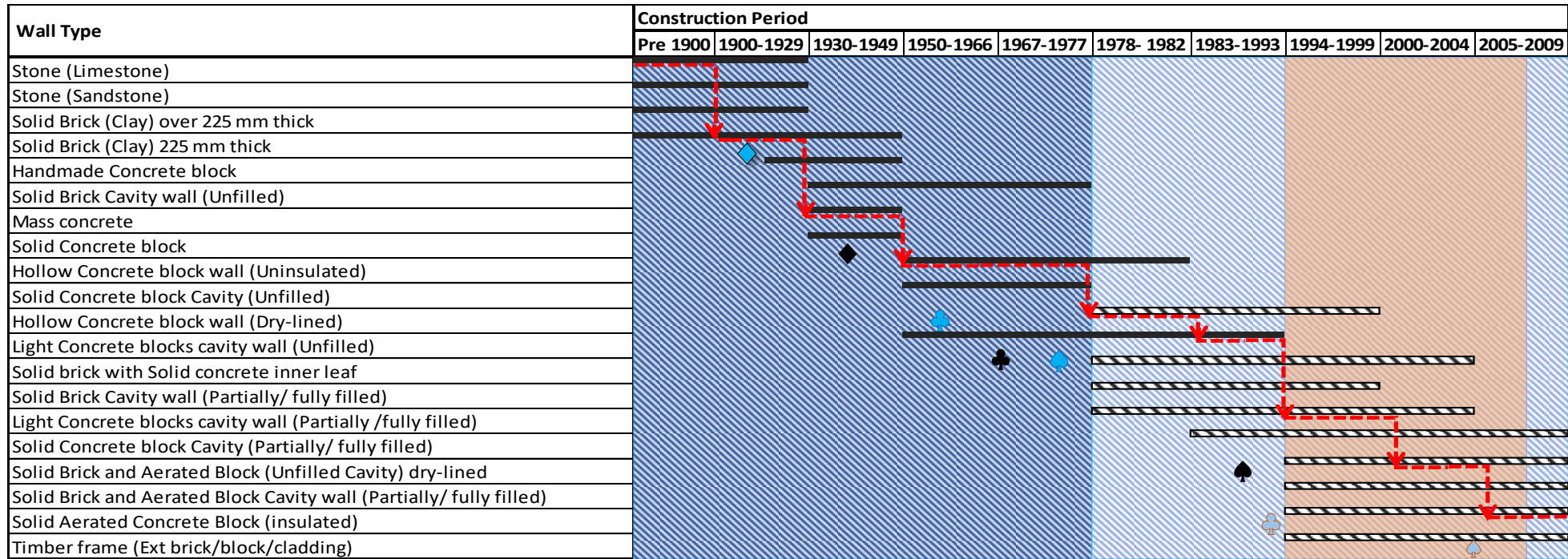
Distribution of wall types in EPC database



1 in 6 EPC entry is based of 'Unknown' wall type construction



Evolution of wall types by construction period in Ireland

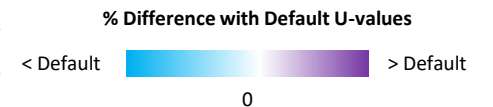
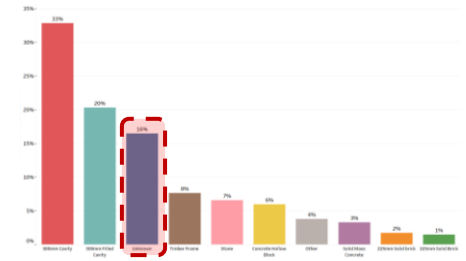


Evolution of wall types and associated U-values

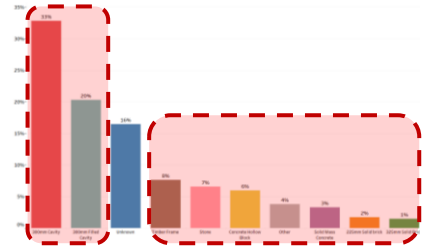
Construction type	Wall type	Construction period	Thickness (mm)	Typical section	Construction details	Default U-value for 'Broadly known' (W/m ² K)	Default U-value for 'Unknown' (W/m ² K)	Difference between Unknown default and Likely actual U-value (%)	Calculated likely actual U-value (W/m ² K)	Statistically derived likely U-value from Ahern (2019) (W/m ² K)	Supplementary data reference
	1	2	4	5	6	7	8	9	10	11	12
Stone wall	Limestone	<1900	475		Wall depth ranged from 300mm to 500mm typically. Usually rendered externally but stone finish is not uncommon with 13mm internal lime plaster.	2.1	2.1	28%	2.69	1.82	A1
		1900-1929	350					44%	3.02	1.41	
	Sandstone	<1900	475					49%	3.13	1.82	
		1900-1929	350					63%	3.42	1.41	
Solid wall	Solid brick (>225 mm)	<1900	325		Houses constructed before 1900s used variable brick sizes, after 1900s 225mm brick became standard size. Up till 1930s typically brick walls rendered externally and with 13mm lime plaster internally. Concrete blocks walls, finished externally with rendering and internally with sand & cement plaster. Typically finished externally with 19mm dense sand & cement plaster to stop water ingress and internally with 13mm light plaster or dry-lined.	1.64	2.1	-5%	1.55	1.82	A2
		1900-1929	325					10%	2.21	1.41	
	Solid brick (225 mm)	1900-1929	225			2.1	-17%	1.75	1.46	A3	
		1930-1949	300			-4%	2.12	1.46			
	Mass concrete	1930-1949	325			2.2	2.1	0%	2.21	1.29	
		1950-1966	225			10%	2.41	1.29			
	Solid concrete block	1900-1929	325			2.2	2.1	-24%	1.68	1.41	
		1930-1949	275			-15%	1.86	1.46			
	Handmade concrete block	1994-1999	215			NA	0.55	35%	0.74	0.43	
		2000-2004	215			0.37	7%	0.59	0.42		
2005-2009		215	0.37	59%	0.59	0.49					
Hollow block	Hollow concrete block (uninsulated)	1950-1966	225		Rendering externally with cement/sand and internally plastered. With introduction of thermal regulation dry-lining was added to improve the performance.	2.4	2.1	14%	2.74	1.29	A4
		1967-1977						-8%	2.20	0.66	
	Hollow concrete block (dry-lined)	1978-1982				0.72	1.1	160%	1.87	0.66	
		1983-1993				0.47	0.6	274%	1.76	0.48	
Unfilled cavity	Solid brick cavity (ext. leaf 225 mm)	1930-1949	390		Based on evolution of materials and construction skill, over time it evolved in a variety of composition and finishes. The most common external finishes are rendered with cement/sand or exposed brick, internal finishes have also evolved over time from lime plaster to light plaster. Predominantly constructed using concrete blocks.	1.78	2.1	-37%	1.13	1.46	A5
		1950-1966								1.29	
		1967-1977								0.66	
		1930-1949								1.46	
	Solid brick cavity (ext. leaf 115 mm)	1950-1966				1.29					
		1967-1977				0.66					
	Solid concrete block cavity	1950-1966				280	4%	1.85	1.29		
		1967-1977				275	0.66				
	Solid brick and aerated block cavity	1994-1999				275	0.55	145%	1.35	0.43	
		1950-1966				300	1.78	2.1	-20%	1.43	
Solid brick and solid concrete block cavity	1967-1977	300	1.1	30%	0.66						
	1978-1982	280	0.6	1.1	-12%	0.53					
Filled cavity	Solid brick cavity	1978-1982	280		During 1980s partially filled cavity was considered best practice. In 1980s Cavity width increased to 80-100 mm to accommodate 40 mm insulation boards. In 1991, 50 mm insulation in 100 mm cavity was considered as a best practice. Insulation materials used in cavity wall includes insulation batts, mineral wool, beads, foamed insulation, Expanded polystyrene (EPS), Extruded polystyrene (XPS) etc.	0.6	1.1	-12%	0.53	0.48	A6 & A7
		1983-1993	300					-18%	0.49	0.48	
	Solid brick and solid concrete block cavity	1983-1993	250			0.6	0.59	0.48			
		1994-1999	270			-2%	0.54	0.43			
	Solid brick and aerated block cavity	2000-2004	270			0.55	-29%	0.39	0.42		
		2005-2009	300			0.37	-24%	0.28	0.49		
	Solid brick and aerated block cavity	1994-1999	250			0.55	0.37	-38%	0.34	0.43	
		2000-2004	270			0.55	-47%	0.29	0.42		
		2005-2009	300			0.37	-27%	0.27	0.49		
		2010- onwards	300			0.27	-22%	0.21	-		
Solid concrete block cavity	1978-1982	250	0.6	1.1	-10%	0.54	0.66				
	1983-1993	270	0.6	0.6	-	0.48					
	1994-1999	270	0.55	-29%	0.39	0.43					
	2000-2004	270	0.55	-49%	0.28	0.42					
Timber frame	Timber frame (ext. brick/block/cladding)	1994-1999	350		Timber frame wall is designed as a pre-fabricated system with several options available for external finishes, e.g. exposed masonry, lightweight cladding, wooden panels, render on lathe etc.	0.55	0.37	-27%	0.40	0.43	-
		2000-2004						-36%	0.35	0.42	
		2005-2009				0.37	-19%	0.30	0.49		
		2010- onwards				0.27	0%	0.27	-		

Predominant wall types and associated U-values by construction period

Construction Period	Predominant wall Type	U-values (W/m ² K)		
		Predominant Wall U-value	Default U-value for Unknown Wall	% Difference
1	2	3	4	5
Pre 1900	Stone Wall	2.69	2.10	28%
1900-1929	225mm Solid Brick	1.75		-17%
1930-1949	Solid Mass Concrete	2.12	2.20	-4%
1950-1966	Concrete Hollow Block	2.74	2.40	14%
1967-1977		2.20	2.40	-8%
1978-1982	Concrete Hollow Block (Dry-lined)	1.87	1.10	70%
1983-1993	300mm Cavity (Uninsulated)	1.35	0.60	125%
1994-1999	300mm Cavity (Insulated)	0.39	0.55	-31%
2000-2004		0.28		-47%
2005-2009		0.27		-27%
2010 onwards	Timber frame	0.27	0.27	0%



Summary of associated U-values of broadly known wall types by construction period

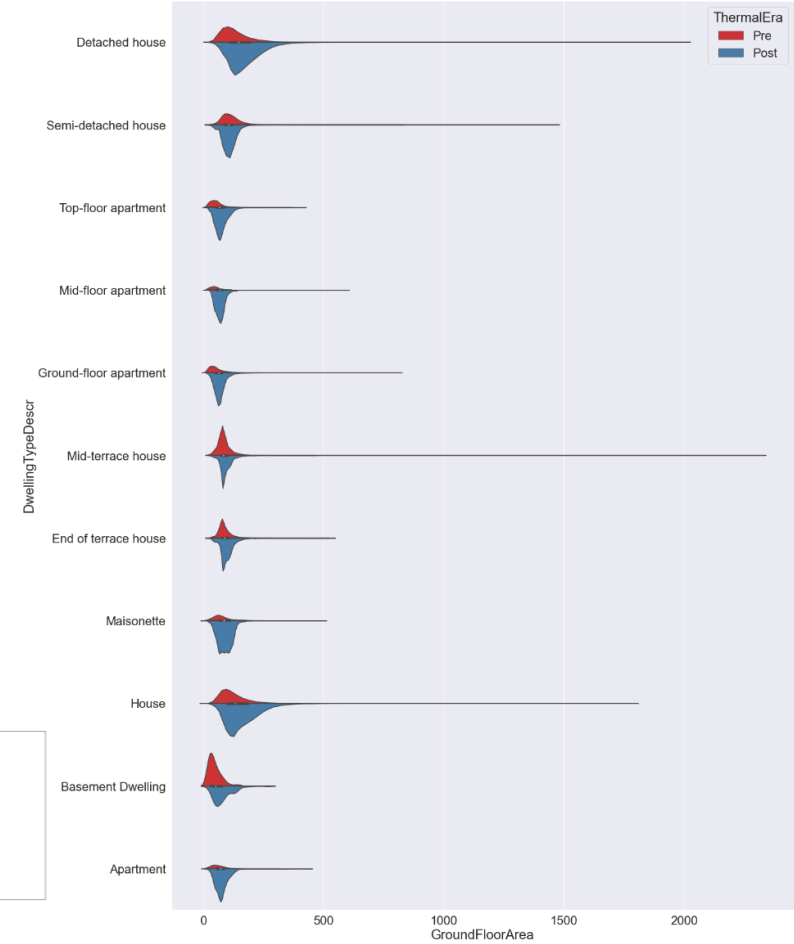
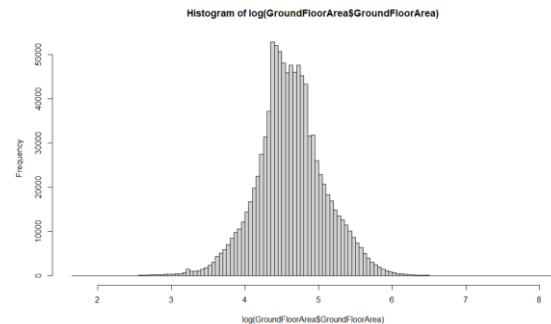
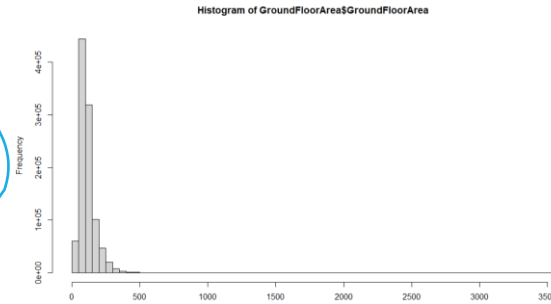
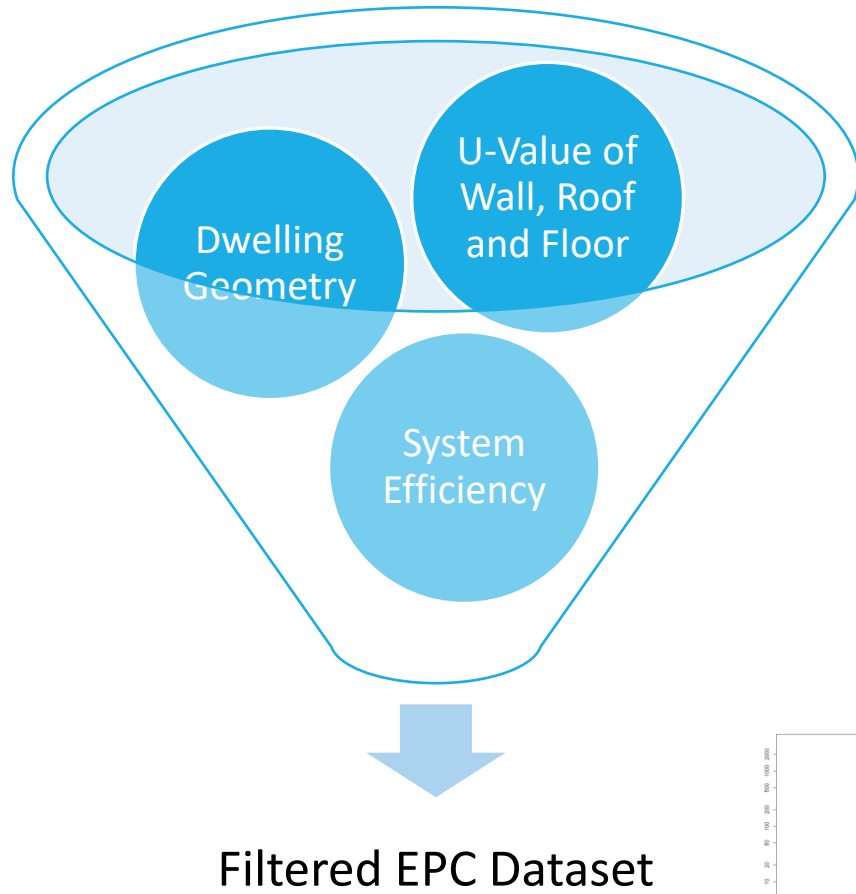


Wall type		Construction Period																																
		Pre 1900			1900-1929			1930-1949			1950-1966			1967-1977			1978-1982			1983-1993			1994-1999			2000-2004			2005-2009			2010 onwards		
		Default	Calculated	% Difference	Default	Calculated	% Difference	Default	Calculated	% Difference	Default	Calculated	% Difference	Default	Calculated	% Difference	Default	Calculated	% Difference	Default	Calculated	% Difference	Default	Calculated	% Difference	Default	Calculated	% Difference	Default	Calculated	% Difference	Default	Calculated	% Difference
U-value (W/m ² K)																																		
1		2		3		4		5		6		7		8		9		10		11		12												
Stone	Limestone	2.10	2.69	28%	2.10	3.13	49%																											
	Sandstone		3.02	44%		3.42	63%																											
Solid Brick	325mm	1.64	1.55	-5%	1.64	1.55	-5%																											
	225mm				2.10	1.75	-17%	2.10	1.75	-17%																								
Solid Mass concrete								2.12	-4%	2.20	2.12	-4%																						
Concrete Hollow Block	Uninsulated									2.40	2.74	14%	2.40	2.20	-8%	1.10	1.87	70%	0.60	1.76	193%													
	Dry-lined																		0.55	0.55	0%													
300mm Cavity (Uninsulated)					1.78	1.20	-33%	1.78	1.52	-15%	1.78	1.37	-23%	1.10	1.43	30%	0.60	1.35																
300mm Cavity (Insulated)													0.60	0.54	-10%	0.60	0.54	-10%	0.55	0.38	-31%	0.55	0.29	-47%	0.37	0.27	-27%	0.27	0.21	-22%				
Timber Frame																			0.40	-27%	0.55	0.35	-36%	0.37	0.30	-19%	0.27	0.27	0%					

% Difference with Default U-values



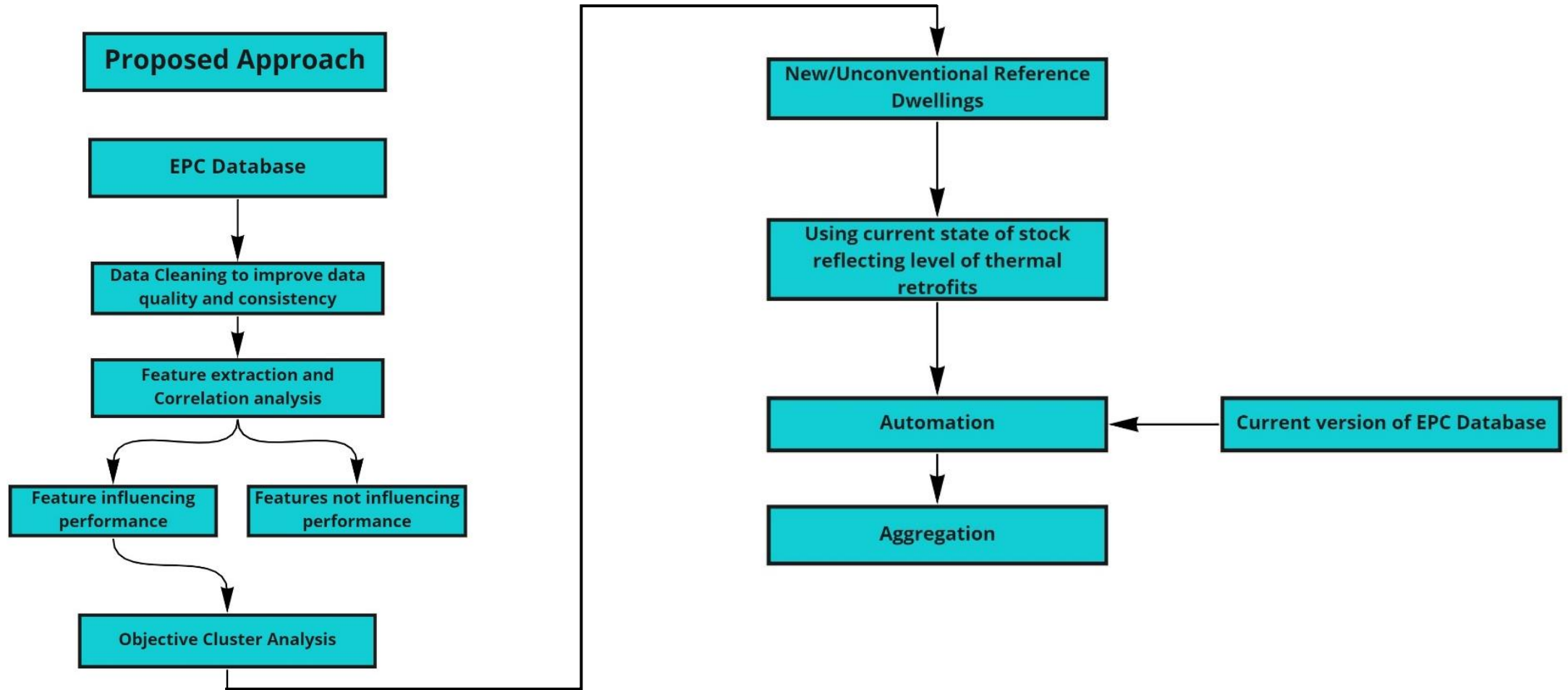
Data-driven filters to clean erroneous data entries and outliers



Research Impact

- 'Find & Replace' will mitigate the discrepancies due to unrealistic selected default values for parameters.
- Reduce thermal energy performance gap.
- Improving the reliability of EPC database, making it representative of actual dwelling stock.
- Automate the method to make it reproducible.

Future Work



Questions?



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