

OFR

A Survey of Fire Loads on Private Residential Balconies in England

Sam Bryant
Senior Fire Engineer at OFR Consultants

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Why look at balcony fuel loads?

- As part of the wider Balconies, Spandrels and Laminated Glass project, it was found there was a gap in knowledge
- Fuels loads on a balcony can contribute to external fire spread
- There is no current guidance on the design fuel load on balconies or terraces

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Existing Fire Load Surveys

TABLE A1.3.1
Variable fire load densities in dwellings (MJ/m²) fire load density q_f per unit floor area (m²)

	Single value	Average	Standard deviation	Fractile			Remarks
				80%	90%	95%	
Swedish data [1.1 - 1.3]							$q_f = q_t \times 5.2$ Characteristic value (0.8 fr.)
3 rooms		720	104	770			- Bedroom 630
2 rooms		780	128	870			- Living room 610
European data [2]							$q_f = q_t \times 5.2$ 5.2 = cubic measure
6 rooms		500	180				3.2 x 4.3 x 2.9
5 rooms		540	125				
3 rooms		670	133	760	780	830	
2 rooms		780	129	870	1020	950	
1 room		720	104	760	780	890	
Swiss risk evaluation [6]							
Flat		330					

(continued)

TABLE 1 SUMMARY OF DATA USED TO DEVELOP TRANSFER FUNCTION FOR OFFICE (Continued)

Material Type	Desk Type	Surface Area, (ft ²)	Manufacturer	Catalog Weight Range (lb)		Catalog Minimum and Maximum Surface Area Group (ft ²)		Number of Observations	80% of Sales Value Weight Range (lb)	
				Min.	Max.	Min.	Max.		Min.	Max.
Wood	Double (Continued)	214.6	C	220	230	131	324	216	228	238
			D	111	275	131	324	216	228	238
			E	220	225	131	324	216	228	238
			F	220	225	131	324	216	228	238
			G	183	264	153	309	476	163	248
			H	185	309	153	309	185	225	225
			I	226	269	153	309	185	225	225
Wood	Legs	9.6-12	D	111	111	111	111	5	-	-
			E	-	-	-	-	-	-	-
			F	-	-	-	-	-	-	-

TABLE 15 FIRE LOAD VALUES FOR FURNITURE

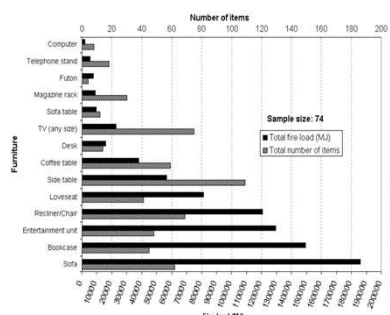
Item	Material Type	% Total Item Weight combustible	Calorific Value (Btu/lb)	Cellulose Conversion Factor (Calorific Value/8000)
Desk	Wood	100	8000	1.00
	Metal	0	0	0.00
Table	Wood	100	8000	1.00
	Metal	0	0	0.00
Cabinet	Wood	100	8000	1.00
	Metal	0	0	0.00
Shelving	Wood	100	8000	1.00
	Metal	0	0	0.00
Seating	Wood Frame	100	8000	1.00
	Metal Frame	0	0	0.00

$$\text{Fire load} = \left[\frac{\text{Weight in lb from transfer function}}{\text{Area in sq ft}} \right] \times \left[\frac{\text{Fraction total item weight combustible}}{\text{Calorific value (Btu/lb)}} \right] \times \left[\frac{\text{Cellulose Conversion Factor}}{\text{Calorific value (Btu/lb)}} \right]$$

Thomas PH (1986) Design guide: structure fire safety CIB W14 Workshop report. Fire Saf J 10(2):77-137. [https://doi.org/10.1016/0379-7112\(86\)90041-X](https://doi.org/10.1016/0379-7112(86)90041-X)
Culver C and Kushner J (1975) A program for survey of fire loads and live loads in office buildings. National Bureau of Standards, NBS Technical Note 3



Existing Fire Load Surveys



Appendix A: Survey Questionnaire

GENERAL:

- Type of home
- Approximate square footage of home (excluding basement)
- What is the approximate area of the exit corridor from the bedroom area?
- Please specify the number of exits from the main level of your home.
- Where are the stairs to the second floor located? (Answer only if applicable)

MAIN FLOOR LIVING SPACE:

- Which room (living room/family room) on your main floor do you use most often? (For some homes this could be on the second floor.)
- The next 10 questions are about the room, which you have selected in the previous question.
- Room dimensions (Length (L), Width (W)):
- Number of windows
- Size of largest window (Width (W), Length (L))

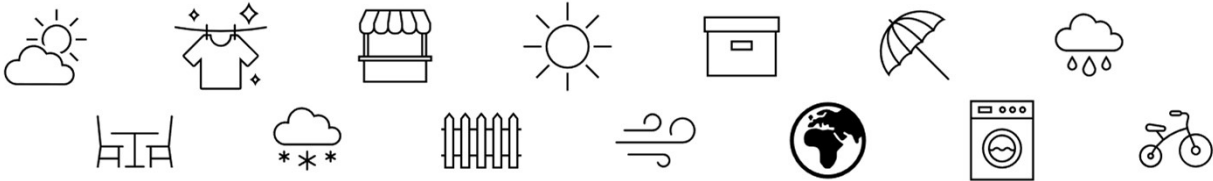
TABLE 3. Movable fire load in respective spaces within dwelling units.

Purpose of the space	Number	Average total fire load	Average fire load	Unit fire load	S.D.
		kg	kg/m ²	kg/m ²	kg/m ²
Living Room	74	305.5	8.4	36.3	25.2
Dining Room	13	278.7	8.4	33.1	16.5
Kitchen	54	147.8	5.4	28.4	20.2
L/D	42	414.4	16.7	26.7	13.8
D/R	75	326.4	10.6	31.2	12.7
L/D/K	86	370.5	12.1	30.9	14.6
L-Main Bedroom	46	290.7	8.1	35.4	15.4
L-Wife's Bedroom	20	391.2	8.1	48.4	26.7
Main Bedroom	86	351.1	8.8	39.8	19.1
Bedroom for Male	25	449.1	7.9	57.3	26.2
Bedroom for Female	27	444.4	8.0	58.1	32.4
Children's (12-18)	53	414.0	7.6	54.8	22.0
Children's (<11)	37	375.9	7.9	48.0	17.2
Master's Room	42	381.7	7.8	50.9	45.8
Family Bedroom	39	279.2	8.5	33.5	16.1
Study Room	29	455.8	8.2	56.7	25.0
Other Room	144	441.2	7.6	58.1	40.5
Bathroom	59	19.7	2.3	8.9	7.4
Toilet	125	11.6	1.1	11.5	14.0
Washroom	123	55.3	3.1	18.6	34.0
Entrance, Corridor	179	76.6	4.2	23.7	46.7
Corridor, Stairs	7	80.1	4.0	29.7	45.4
Storage					
Living Room	61	69.6	1.2	64.9	42.6
L/D	2	290.6	0.6	518.9	280.2
L/D/K	4	58.9	1.3	66.8	45.3
L-Main Bedroom	44	76.4	1.2	65.3	55.2
L-Wife's Bedroom	14	84.3	1.3	65.8	32.8
Main Bedroom	87	76.8	1.4	58.7	41.5
Male Bedroom	21	62.5	1.3	48.6	28.6
Female Bedroom	21	47.7	1.2	40.1	23.5
Children's (12-18)	46	76.9	1.3	63.4	40.5
Children's (<11)	27	92.1	1.3	83.9	67.3
Master's Room	40	77.2	1.4	59.5	39.7
Family Bedroom	38	88.7	1.4	69.7	60.1
Study	21	85.3	1.3	81.4	63.9
Other Room	113	72.1	1.3	60.2	48.2
Washroom	31	59.1	0.4	142.0	123.8
Entr., Corridor	110	65.9	0.6	132.2	103.4
Corridor, Stairs	5	121.6	1.3	93.4	27.5
Balcony	139	58.8	5.7	11.5	10.3
External Storage	71	39.3	0.5	118.5	69.4
Total	2283	179.5	4.8	48.5	57.3

Bwalya A, Sultan M and Benichou N (2004) A pilot survey of fire loads in Canadian homes, National Research Council Canada, p. 159
Elhami-Khorasani N, Gustavo Salado Castillo J, Saula E, Josephs T, Nurlybekova G, Gernay T (2019) Digitized fuel load survey methodology using machine vision. Fire Technol. <https://doi.org/10.1007/s10694-020-00989-9>

How do people use their balconies?

- The use of balconies could be influenced by:
 - The dimensions
 - The orientation in relation to the sun
 - The exposure to external elements such as winds and rain
 - The local climate
 - The time of year



Building Specifier (2018) 'Britain sees increase in number of high rise buildings', buildingspecifier.com. <https://buildingspecifier.com/britain-sees-increase-in-number-of-high-rise-buildings/>. Accessed 17 Jan 2022

Mayor of London (2010) London housing design guide, London development agency. [Online]. Available: https://www.london.gov.uk/sites/default/files/interim_london_housing_design_guide.pdf

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Recent Balcony Fires



Lacrosse Docklands, Melbourne 2014



Poplar, London 2021



Northern Quarter Lighthouse, Manchester 2017

Metropolitan Fire Brigade (2014) Post incident analysis report, Melbourne, Report No: 1403134A Britton P (2018) 'Fire alarm systems were operational and activated at blaze-hit Northern Quarter tower block', Manchester Evening News, Manchester. [Online]. Available: <https://www.manchestereveningnews.co.uk/news/greater-manchester-news/fire-alarm-systems-were-operational-14109692>. Accessed 14 Jan 2022

Price D (2022) Poplar fire spread "due to timber balconies", not ACM, Construction News. <https://www.constructionnews.co.uk/buildings/poplar-fire-spread-due-to-timber-balconies-not-acm-02-06-2021/>. Accessed 14 Jan 2022

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Methodology



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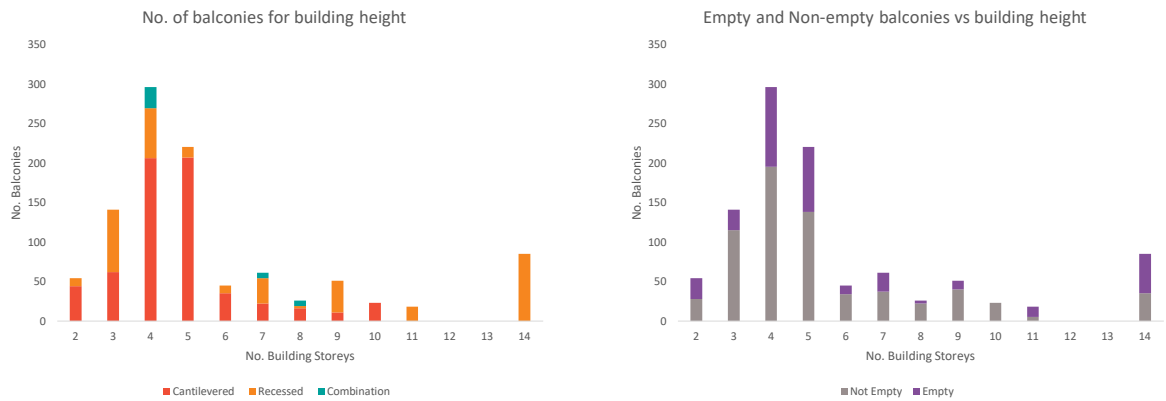


-  Surveyed Area
-  No balconies surveyed

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Building Characteristics



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Recorded Parameters

- Urban Area
- Postcode
- Approximate building age
- Number of storeys
- Occupation status
- Balcony depth and width
- Recessed or cantilevered
- Google Street View data
- Balcony contents

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Data Collection

City	Postcode	Approx. Age	No. Stories	Width	Depth	Recessed/Cantilevered	Small Table (metal)	Chair (metal)	Small Table (wood)	Chair (wood)	Small table (plastic)	Chair (plastic)	Clothes Aired	Plastic Boxes
York	YO1 9PP	2000s	5	2	1	Cantilevered	1	2						
York	YO1 9PP	2000s	4	3	2	Cantilevered				2				
York	YO1 7PD	2010s	4	1.5	1	Cantilevered			1	2			1	
York	YO1 7PD	2010s	4	1.5	1	Cantilevered								
Nottingham	NG7 1HH	2000s	2	4	1.5	Recessed			1					1
Nottingham	NG7 1HH	2000s	3	5	1.5	Recessed	2	2				2		
Bristol	B55 0FJ	2010s	4	3	1.5	Mix of both								
Bristol	B55 0FJ	2010s	4	2.5	1.5	Mix of both								
Sheffield	S3 7GG	1960s	4	4	1.5	Cantilevered							1	
Sheffield	S3 7GG	1960s	4	4	1.5	Cantilevered		2					1	
London	E16 1AR	1990s	9	4	1.5	Recessed			1	2			1	
London	E16 1AR	1990s	9	4	1.5	Recessed	1	2						11

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Fuel Load Density Calculation

- Google maps were used to find images of balconies
- Similar products were found on homeware websites
- From product listings, the mass of items were estimated, 22 kg for large wooden table and 5.7 kg for a wooden chair
- Heat of combustion for wood was taken from SPFE Handbook to be 20 MJ/kg

$$20 * (22 + 4 * 5.7) = 896 \text{ MJ}$$
- Total energy output is divided by the area of the balcony

$$\frac{896}{2 * 3} = 149 \text{ MJ/m}^2$$

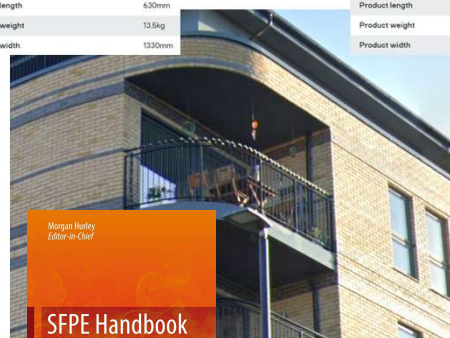


22 kg



Product height	740mm
Product length	630mm
Product weight	13.5kg
Product width	1330mm


Product height	750mm
Product length	1500mm
Product weight	36kg
Product width	900mm

5.7 kg
(per chair)


Product depth	490mm
Product height	790mm
Product width	12 380mm
Weight (kg)	6.3kg

Bwalya A, Sultan M and Benichou N (2004) A pilot survey of fire loads in Canadian homes, National Research Council Canada, p. 159
 Babrauskas V (1991) Tables and charts. In: Shai V (ed) Fire Protection handbook National Fire Protection Association, Quincy

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		Large Table (metal)	Small Table (metal)	Chair (metal)	Large Table (wood)	Small Table (wood)	Chair (wood)	Large Table (plastic)	Small table (plastic)	Chair (plastic)	Clothes Airing	Plastic Boxes		
Mass (kg)		17	5	3	22	9.3	5.7	7.0	2.5	3.0	7.5	1.2		
Calorific Value (MJ/kg)		0	0	0	20	20	20	46.37	46.37	46.37	18.4	46.37		
Calorific Value (MJ/item)		0	0	0	440	185	113	315	118	135	138	56		
Postcode	Balcony Area (m ²)												Total Fuel Load (MJ)	Fuel Load density (MJ/m ²)
YO1 9PP	3		0	0									0	0
YO1 9PP	6						226						226	37.7
YO1 7PD	1.5					185	226				138		549	366.0
YO1 7PD	1.5												0	0
NG7 1HH	6		0	0								56	56	9.3
NG7 1HH	7.5									270			270	36.0
B55 0FJ	4.5												0	0
B55 0FJ	3.75												0	0
S3 7GG	6										138		138	23.0
S3 7GG	6			0							138		138	23.0
E16 1AR	6					185	226				138		549	91.5
E16 1AR	6		0	0									0 ¹³	0

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Assumptions

- All plant pots present were polyethylene
- Clothes airers or washing lines held 7kg of laundry
- Smaller items such as candles, magazines or disposable barbeques were not present.
- Influence of seasonality on the fire load was mitigated by images from Google Street View being from throughout the year

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Limitations

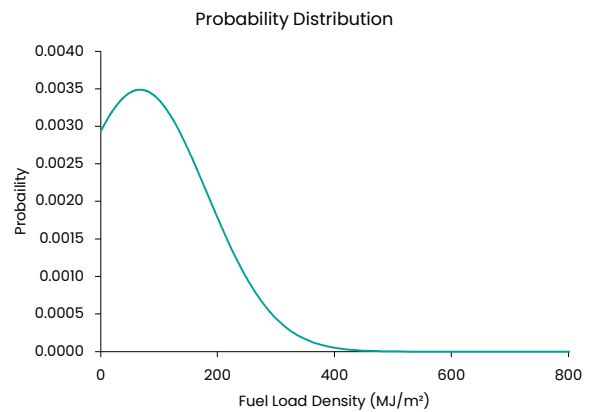
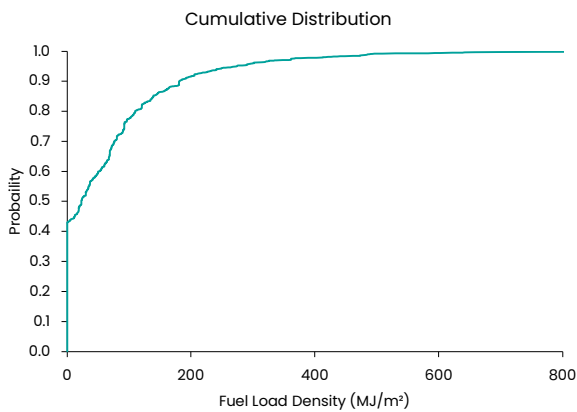
- Buildings with opaque balustrades meant that contents of balconies could not be observed
- Higher balconies could not be viewed from street level
- Use of privacy screens
- Balcony floor construction was not included

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Fire Load Density: Results Overall

- $\mu = 67 \text{ MJ/m}^2$, 80th% 110 MJ/m^2



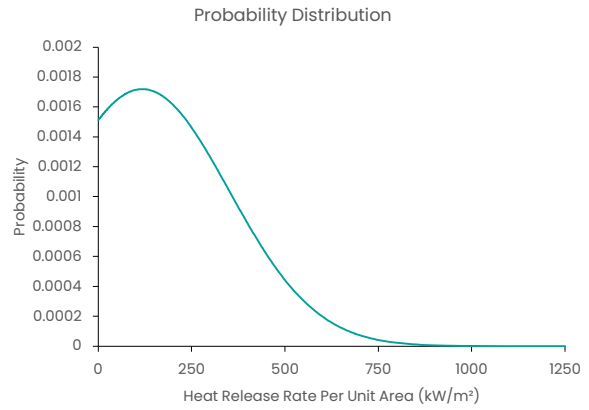
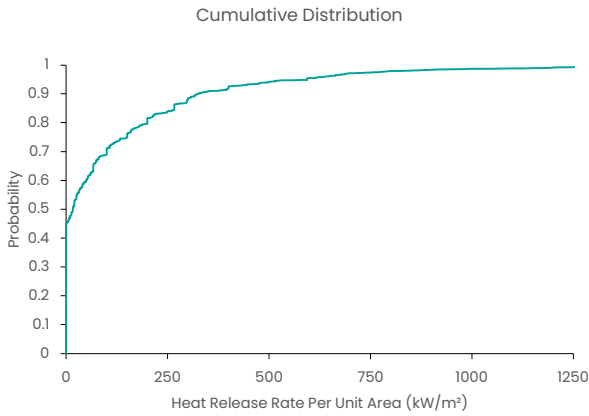
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Heat release rate per unit area

- $\mu = 105 \text{ kW/m}^2$, 80% 173 kW/m^2

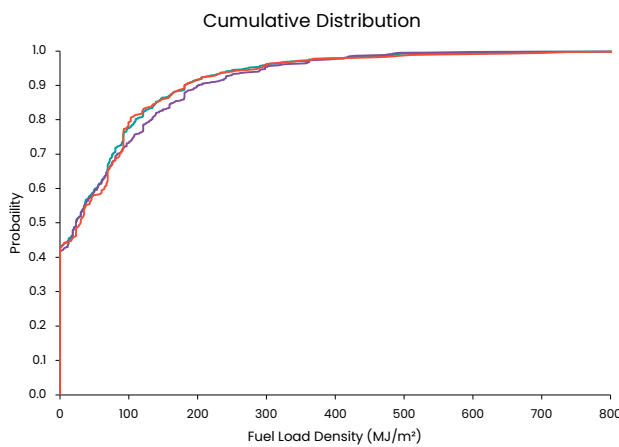


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Fuel Load Density: Cantilevered vs Recessed

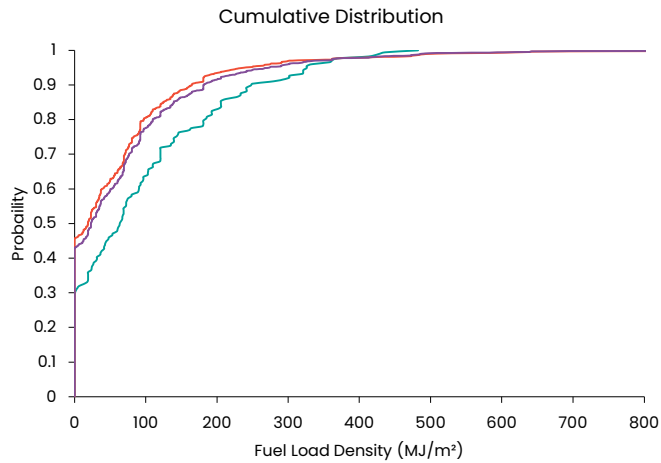


	All Areas	Cantilevered	Recessed
No. Balconies	1020	618	353
μ (MJ/m ²)	67	70	65
80% (MJ/m ²)	110	121	92

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Fuel Load Density: London vs England



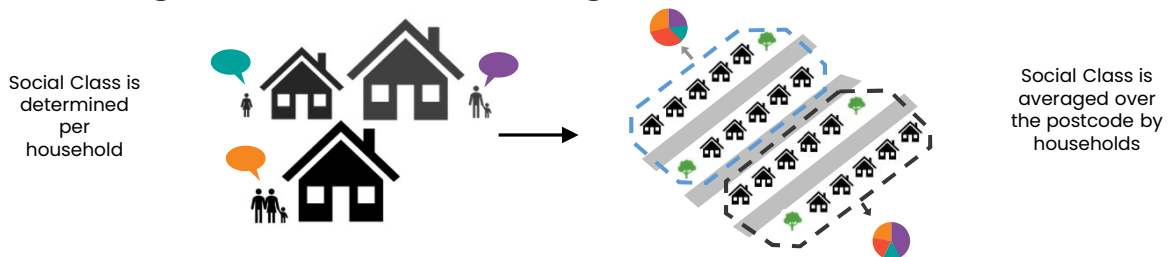
	London	Outside London	All Areas
No. Balconies	178	842	1020
μ (MJ/m ²)	95	61	67
80% (MJ/m ²)	183	105	110

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Social Grade

- Social grade for the postcodes sampled were taken from Market Research Society, based on data from the 2011 Census
- Based on the job of the head of the household
- Cities sampled to give a reasonable representation of the social grade distribution of England



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Social Grade breakdowns in England

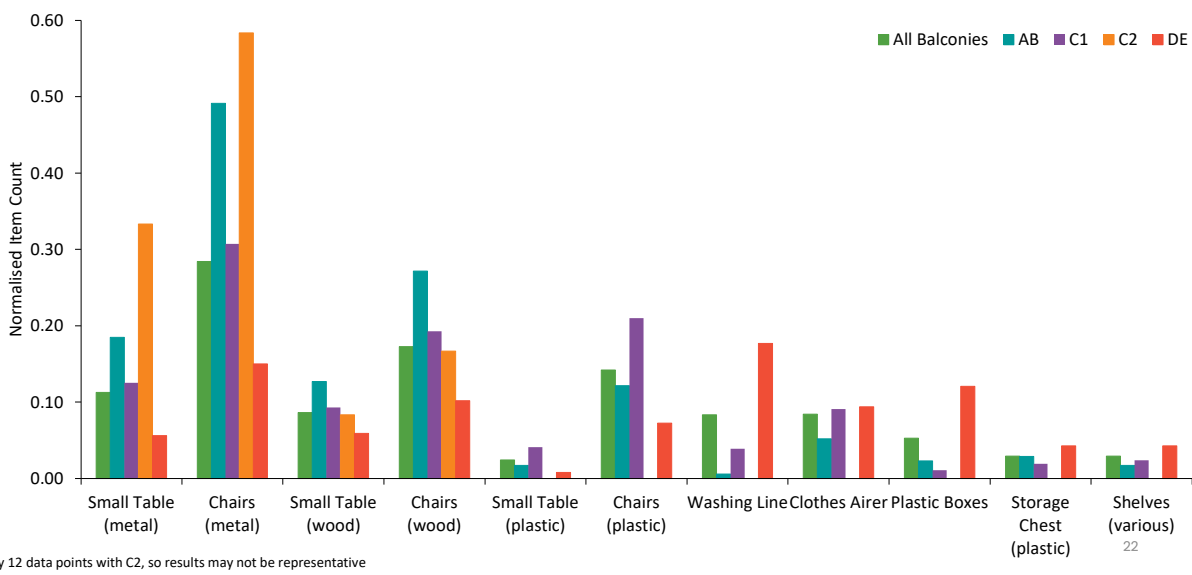
Area	%AB	%C1	%C2	%DE
England	23%	31%	21%	25%
Urban vs Rural				
Urban England	22%	31%	20%	27%
Rural England	28%	30%	24%	20%
London vs Outside of London				
Within London	32%	33%	13%	22%
Outer London	22%	31%	22%	26%
Sampled Areas				
Sampled Cities	22%	31%	19%	27%

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Effect of Social Grade



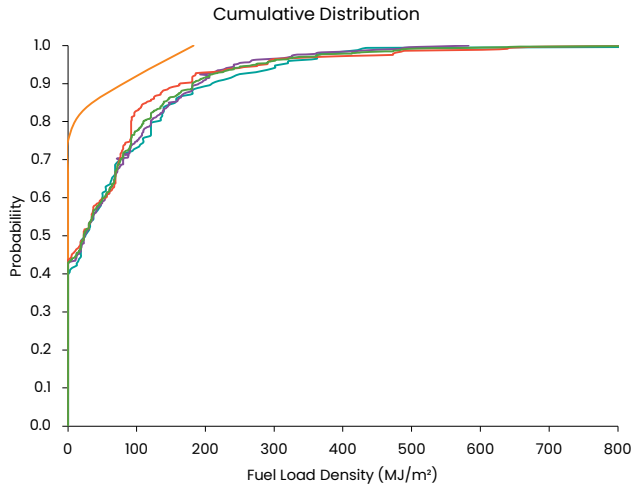
*Only 12 data points with C2, so results may not be representative

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Fuel Load Results: Social Grade Depending



	All Areas	AB	C1	C2*	DE
No. Balconies	1020	173	462	12	373
μ (MJ/m ²)	67	78	66	16	66
80% (MJ/m ²)	110	129	121	19	92

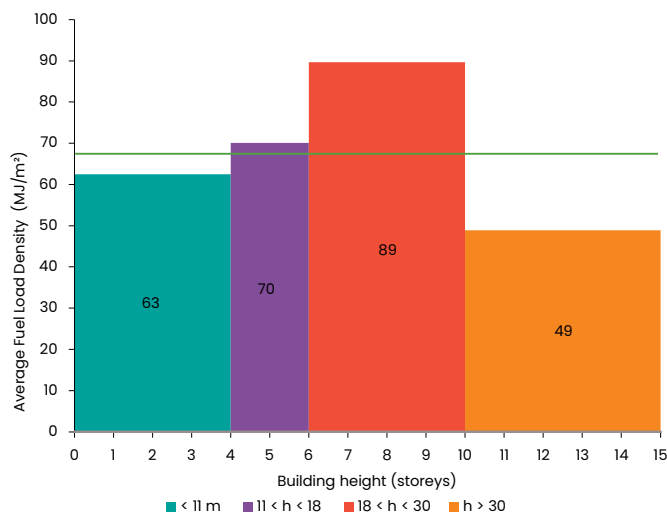
*Only 12 data points with C2, so results may not be representative

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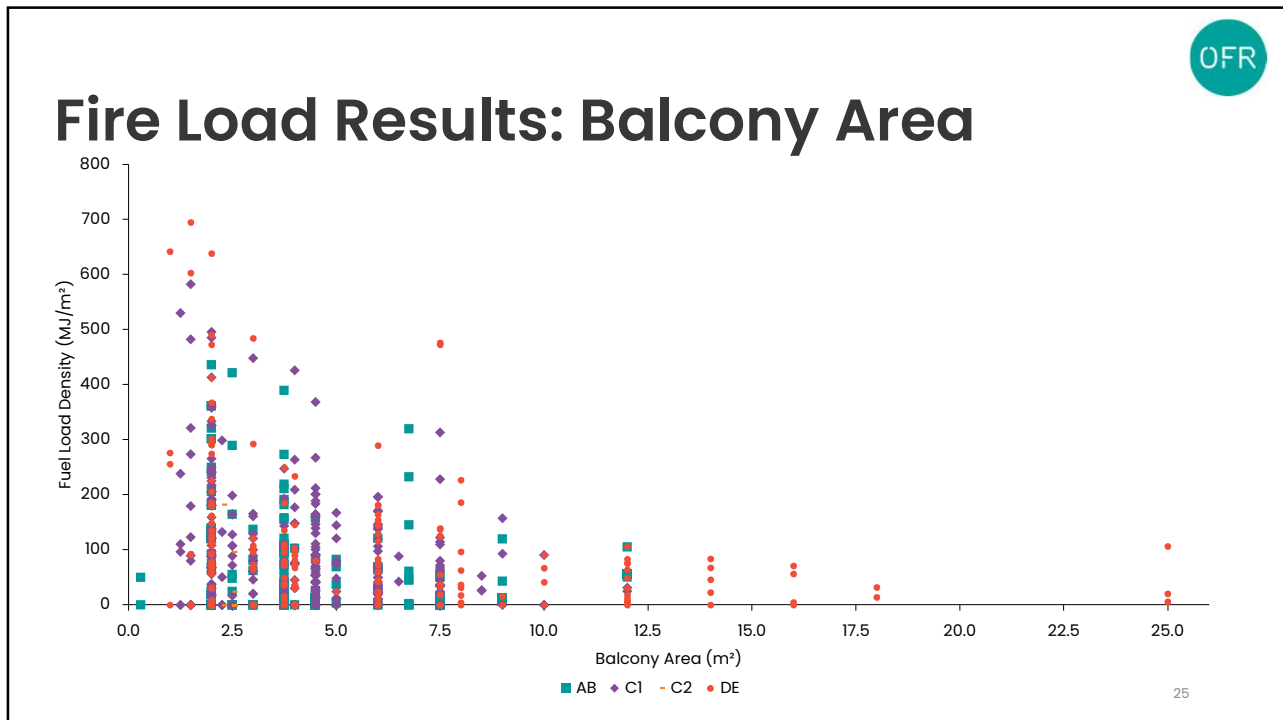


Fire Load Results: Trigger Heights

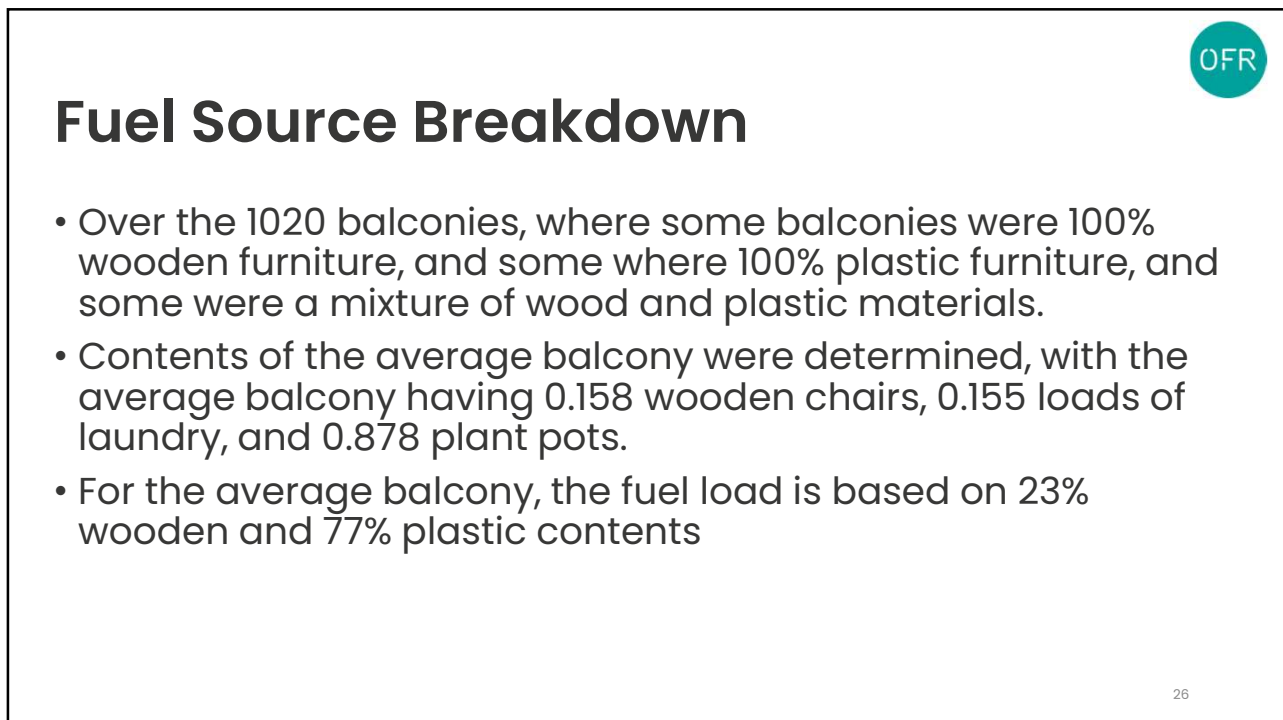


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Summary

- Fuel Load density mean of 67 MJ/m², with a 80th% of 110 MJ/m²
- Heat release rate density mean of 118 kW/m², with a 80th% of 200 kW/m²
- Fuel sources on balconies are 77% plastic and 23% wood

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Thank you

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