ENERGY & CARBON EFFICIENCY

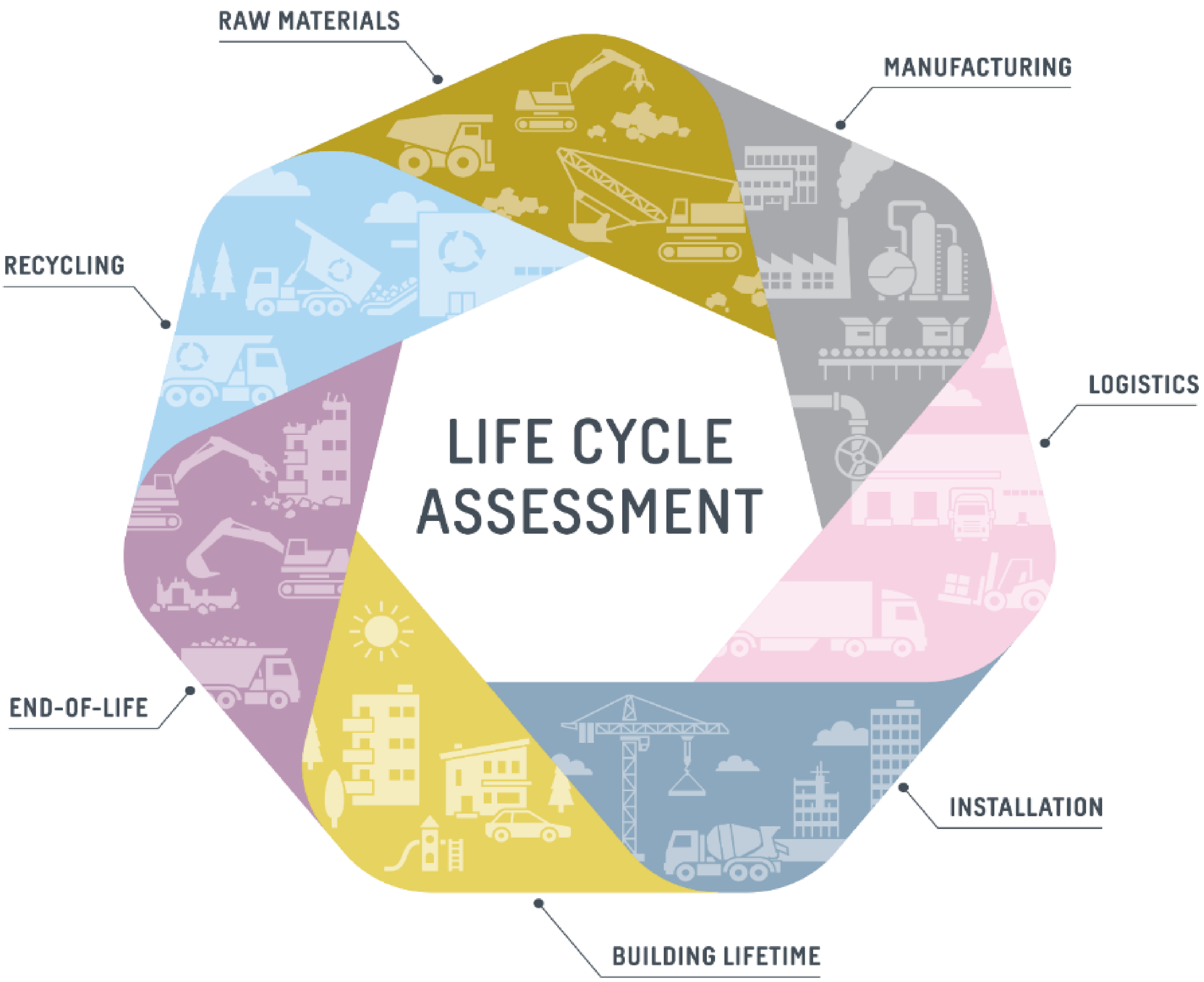
WHAT PART CAN LIFTS PLAY?

Prepared for:

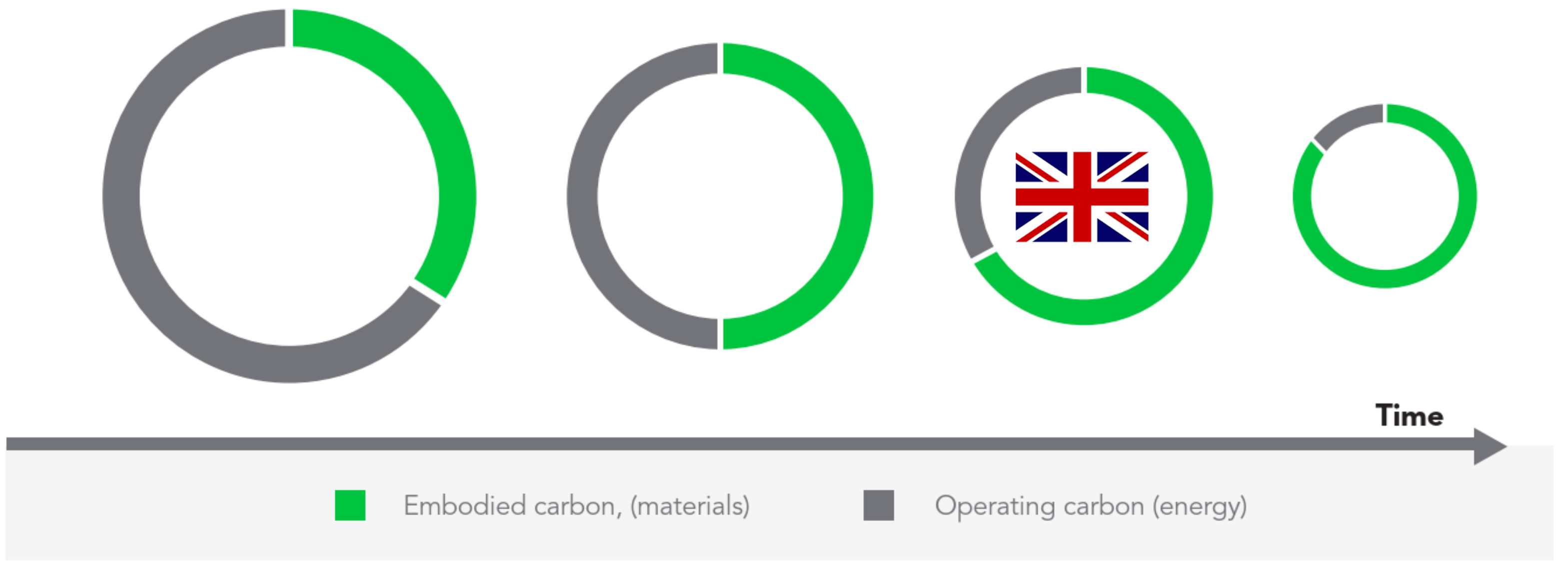
CIBSE Lifts Group

2021-07-02

EMBODIED CARBON

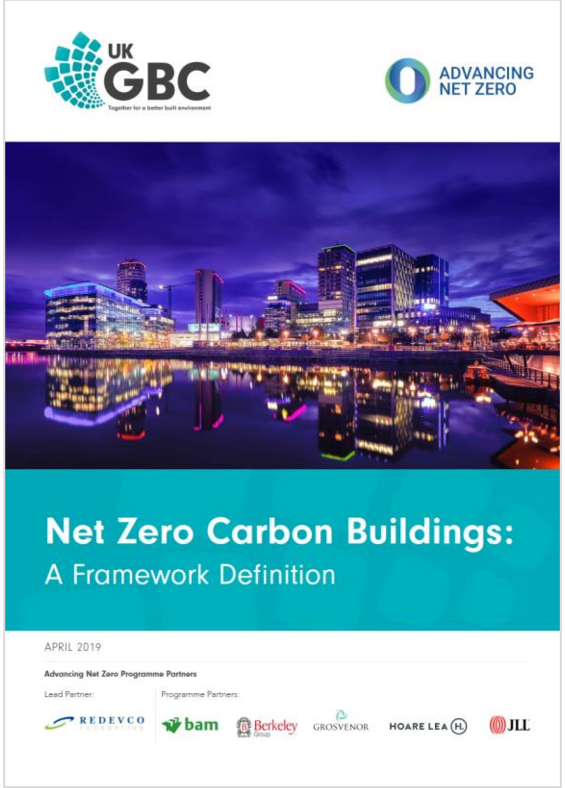

RAW MATERIALS
MANUFACTURING
LOGISTICS
INSTALLATION
BUILDING LIFETIME
END-OF-LIFE
RECYCLING
LIFE CYCLE ASSESSMENT

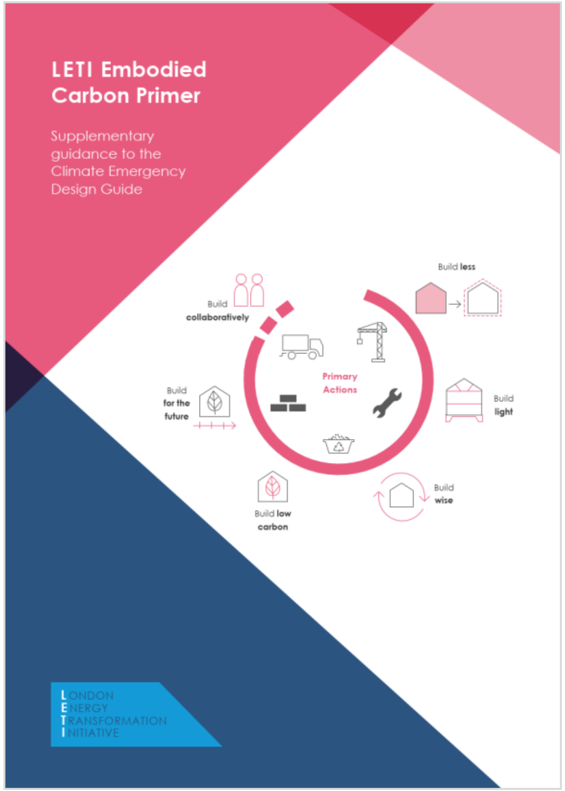
A changing carbon story

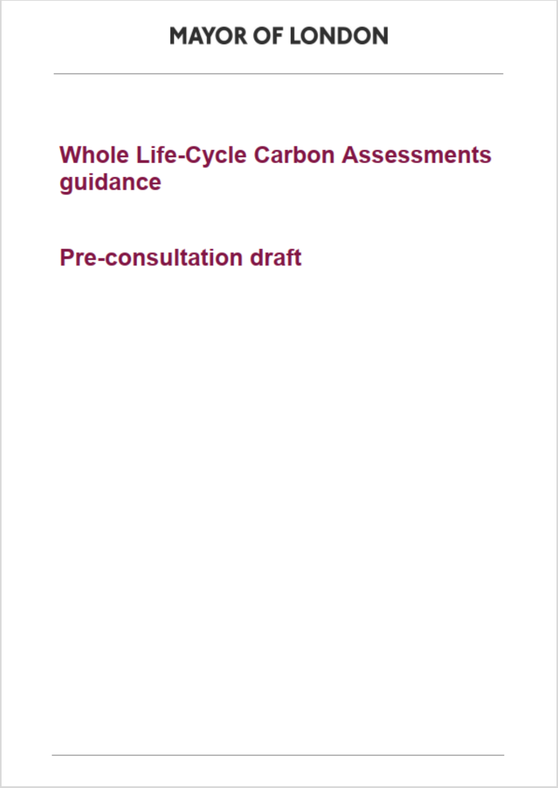


A "best in class", low-carbon sustainable development **must** consider embodied carbon impacts.

Industry Frameworks & Targets





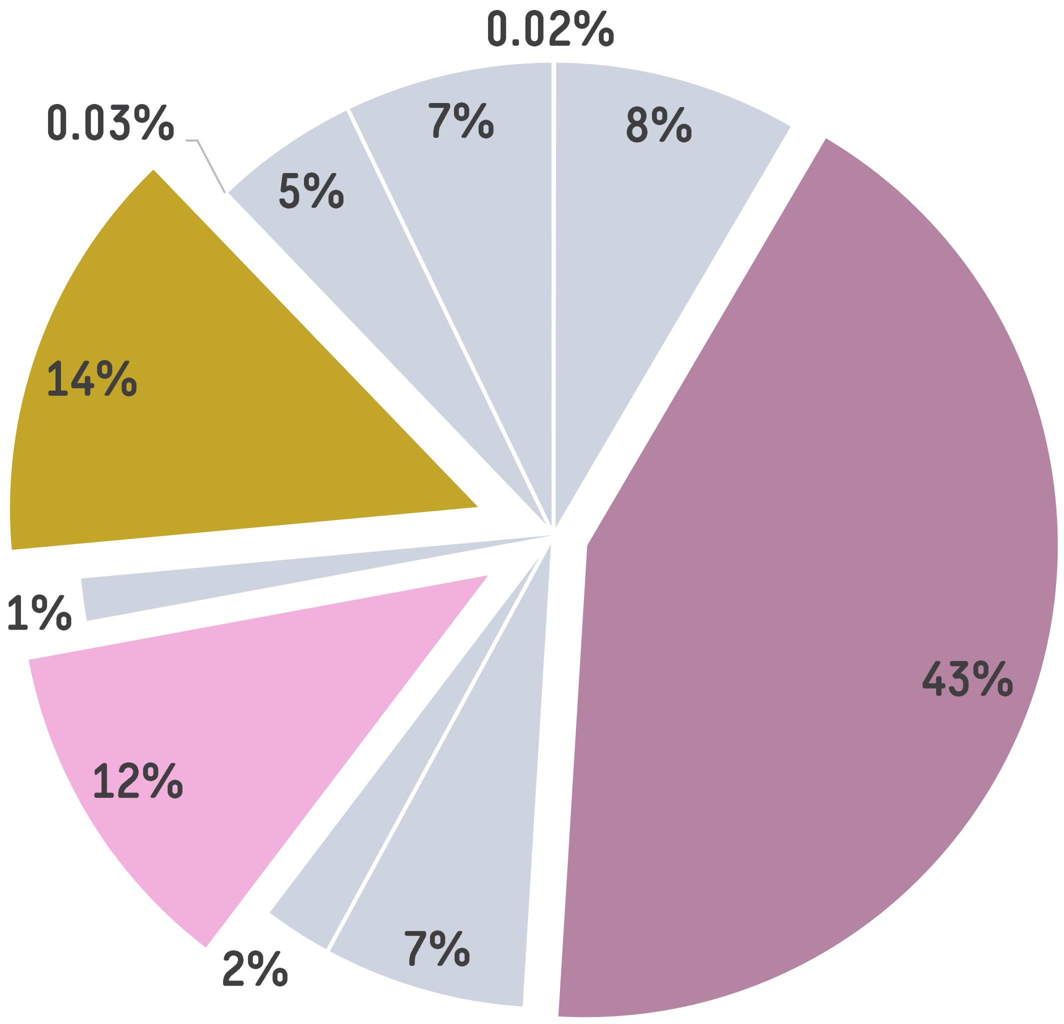


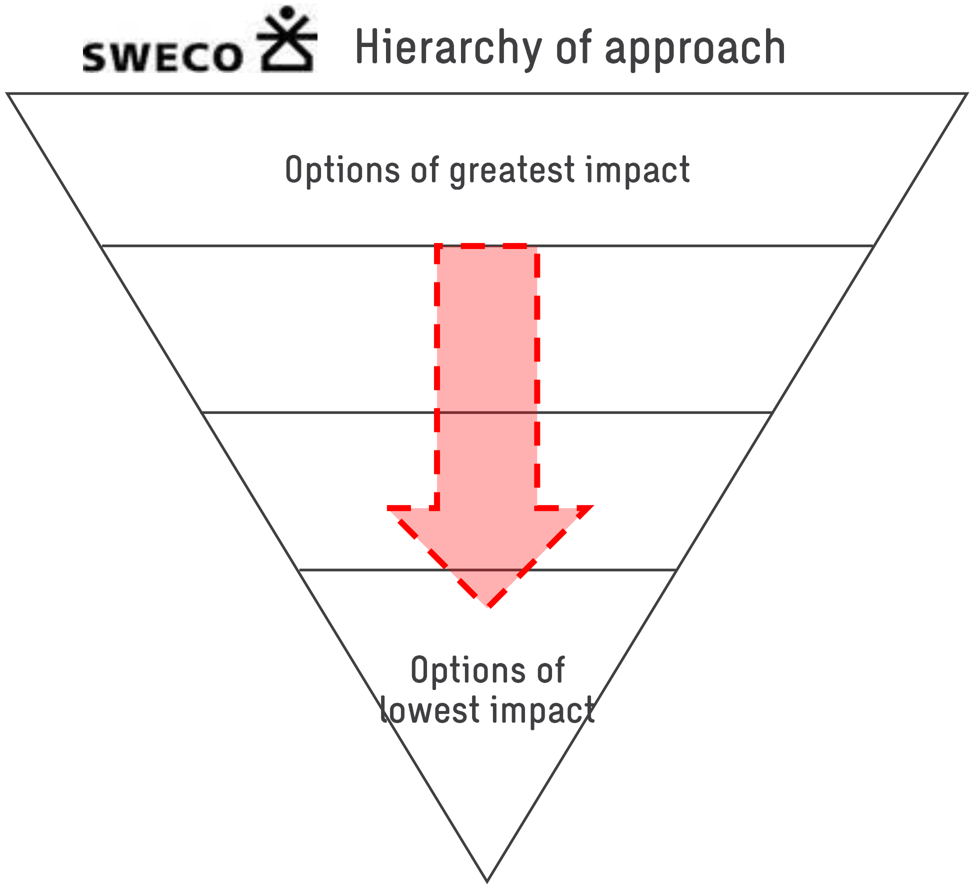
Greater London Authority (GLA) Whole Life Carbon Assessment

GLA WLCAG Benchmarks and Targets - Commercial

Benchmark Type	EN 15978 Modules	Commercial EC Intensity ($kgCO_2e/m^2$ GIA)
Typical Benchmark	A-C	1,300-1,500
	A1-A5	900-1,000
	B & C	400-500
GLA Aspirational Benchmark	A-C	800-900
	A1-A5	550-600
	B & C	250-300

LCA process focuses approach





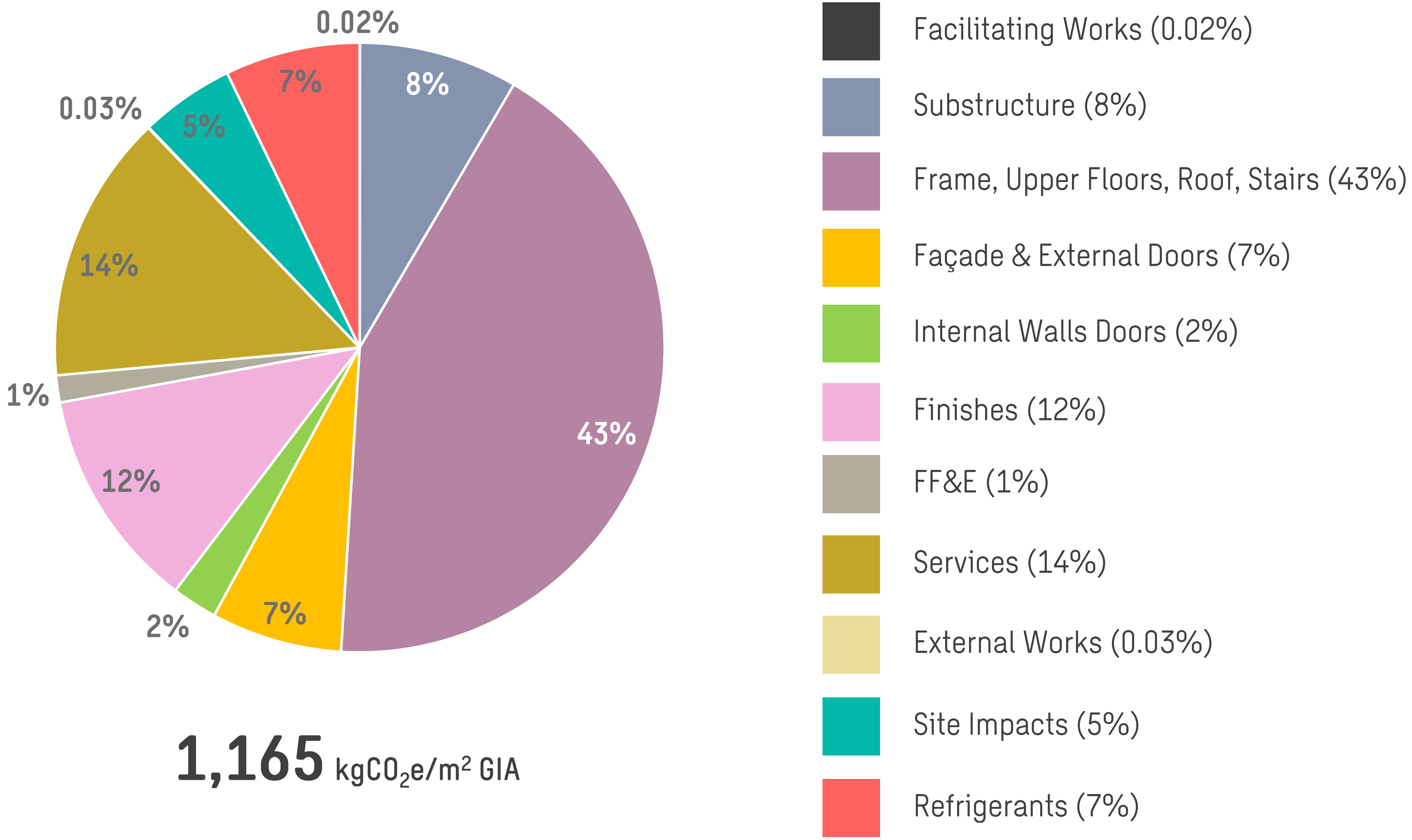
105 Victoria Street

Westminster, London

Office, retail & amenity
60,000 m^2 GIA
2 levels of RC basement
15 storeys above ground
Steel frame & precast concrete plank
Terracotta unitised curtain walling
2,500 m^2 of urban greening
Heat-pump-led all-electric building services approach.
BREEAM & WELL assessments.
Net-zero carbon aims.

Baseline embodied carbon

1,165 $kgCO_2e/m^2$ GIA

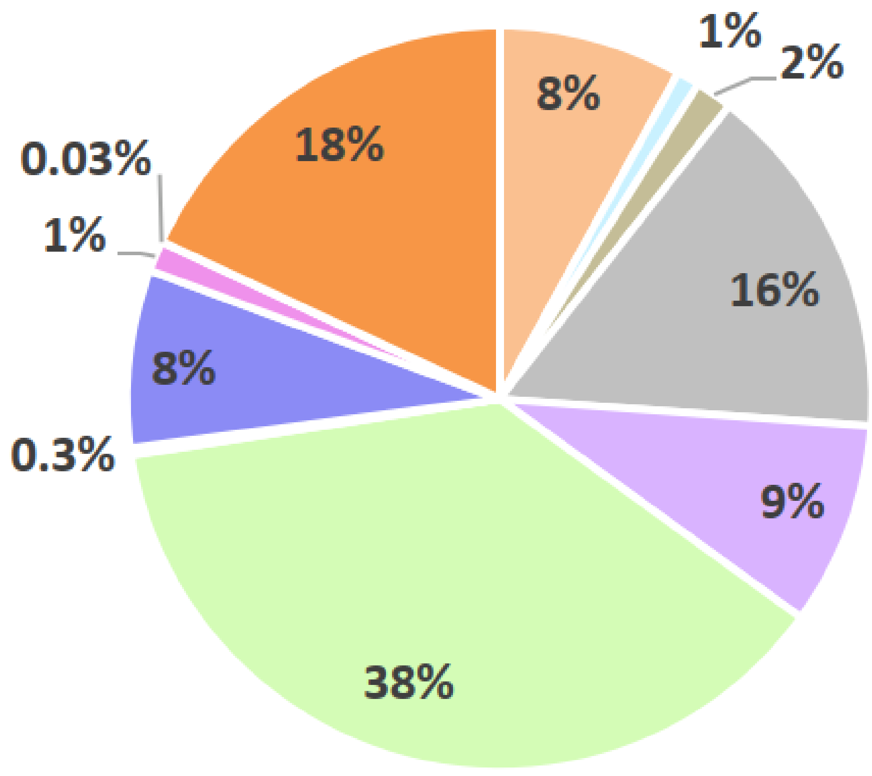

0.02%
8%
7%
0.03%
5%
14%
1%
43%
12%
2%
7%
1,165 $kgCO_2e/m^2$ GIA
Facilitating Works (0.02%)
Substructure (8%)
Frame, Upper Floors, Roof, Stairs (43%)
Façade & External Doors (7%)
Internal Walls Doors (2%)
Finishes (12%)
FF&E (1%)
Services (14%)
External Works (0.03%)
Site Impacts (5%)
Refrigerants (7%)

Building Services & Lifts

Example split of MEPH embodied carbon

Example – broken down by RICS NRM 1 categories

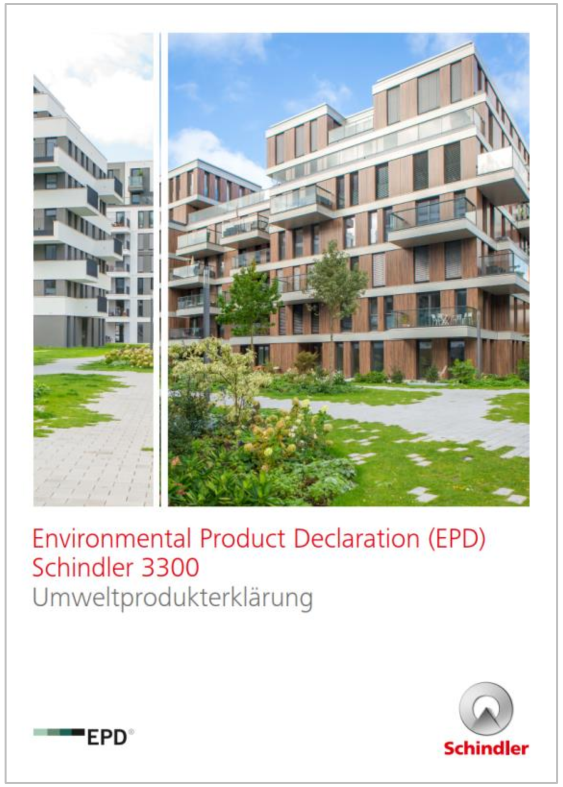
RICS NRM Element	Impact (tCO2e/60 years, A-C)	% of total
5.1 - Sanitaryware	805	8%
5.3 – Disposal Installations	97	1%
5.4 – Water Installations	164	2%
5.6 – Space Heating & AC	1,569	16%
5.7 – Ventilation	889	9%
5.8 – Electrical Installations	3,788	38%
5.9 – Fuel Installations	31	0.3%
5.10 – Lifts & Conveyors	777	8%
5.11 – Fire & Lightning	130	1%
5.12 – Comms, security & controls	3	0.03%
B1 – Refrigerants	1,819	18%



Building services equipment & products have the poorest availability of EPD data

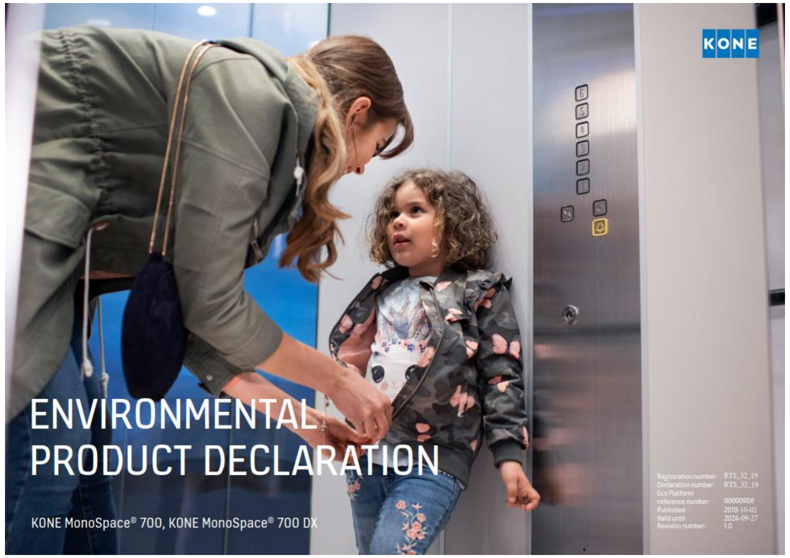
Availability of EPD for Lifts

Better availability than typical MEP equipment



Schindler 3300

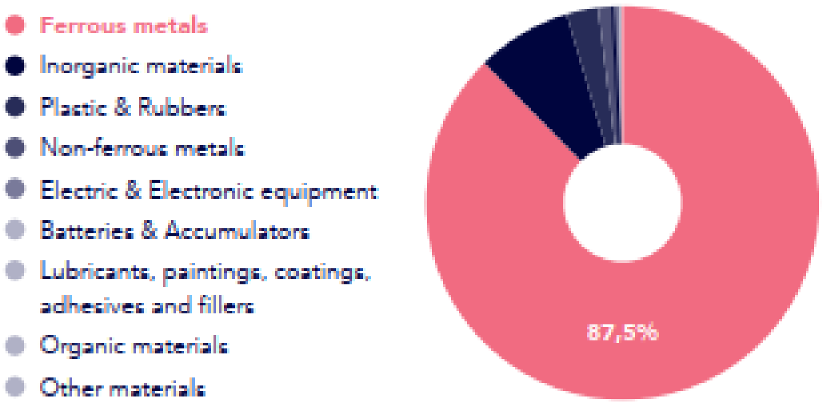
Otis GEN2

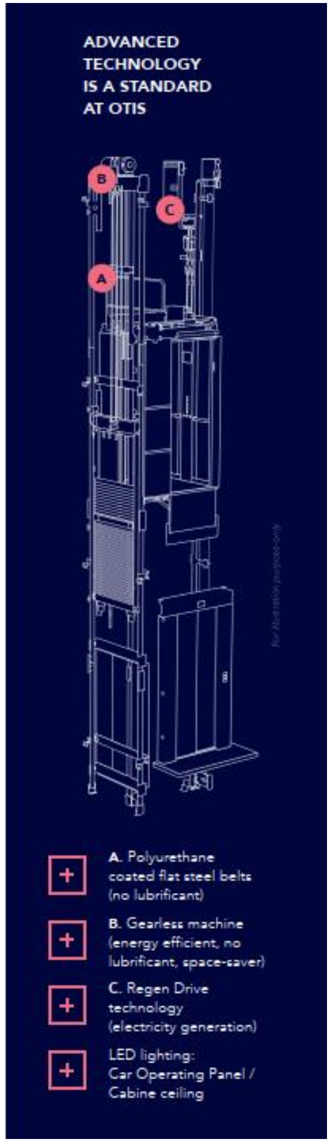


KONE Monospace

Material Breakdowns

MATERIAL	MASS [kg]	MASS [%]
Ferrous metals (zinc coated steel, stainless steel, cast iron)	10 995,3	87,5
Inorganic materials (concrete, glass)	984,4	7,8
Plastics & Rubbers	323,8	2,6
Non-ferrous metals (aluminum, copper)	152,17	1,2
Electric & Electronic equipment	74,6	0,6
Batteries & Accumulators	17,2	0,1
Lubricants (oils, greases), **paintings, coatings, adhesives and fillers** (glues)	7,7	0,1
Organic materials (paper, wood, cardboard)	6,0	0,0
Other materials	2,2	0,0
Total mass	**12 563**	
Mass per 1 tkm	**1,48**	





Otis GEN2 Example

Assess options for reduction

11 tCO_2e/tonne

Global average aluminium impact

ES Process

RUSAL Hydro ALCOA RioTinto

Interrogate supply chain to find alternatives

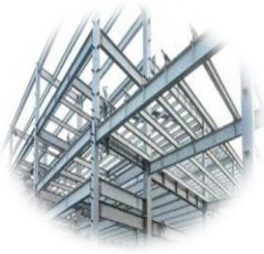
0.18 tCO_2e/tonne

C40/50 CEM1 UK-sourced

GGBS replace OPC

Cemfree™ WAGNERS

Options for cement-free?



2.5 tCO_2e/tonne

UK BF/BOF steel ~20-25% scrap

BOF vs EAF

Rolled vs. plate

ArcelorMittal
HISTAR®
Innovative high strength steels for economical steel structures

Source, manufacturers & supply chain

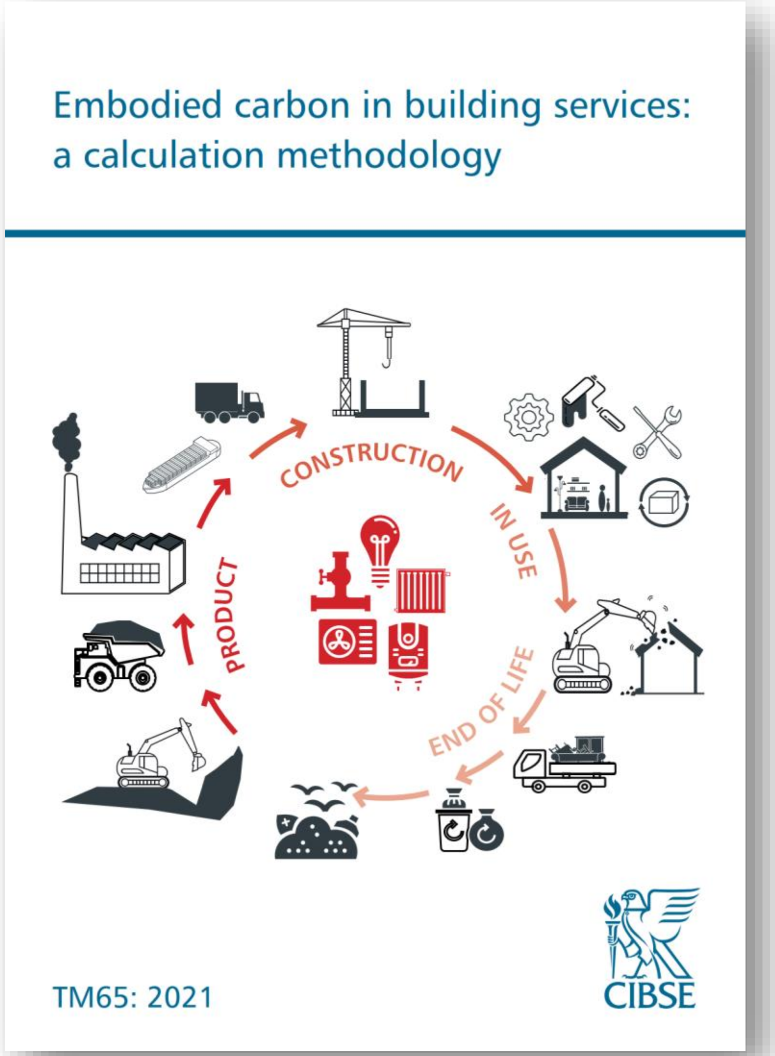
Working to improve MEPH LCA at Sweco

- Working to create **Sweco database** to establish baseline impacts for generalized typical services solutions to inform clients.

- **Better utilization of BIM** – services engineers providing Revit takeoffs as part of RIBA stage processes

- **Integrating LCA into our early-stage optioneering studies** and making it a key factor in the decision-making process

- Taking advantage of the advent of new tools in early 2021 – recent release of **CIBSE TM65**.



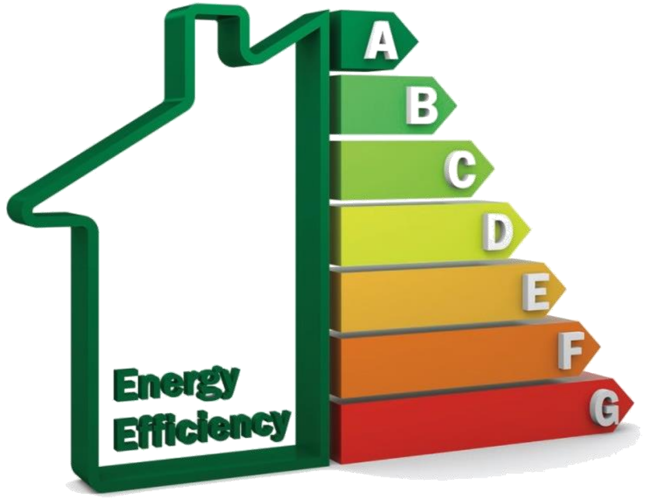
OPTIMIZATION OF OPERATIONAL ENERGY
(PART L / DFP / CIBSE TM54 FRAMEWORKS)

UK PERFORMANCE GAP EXPLAINED

Part L Regulation carbon emission is based upon “Regulated Energy”

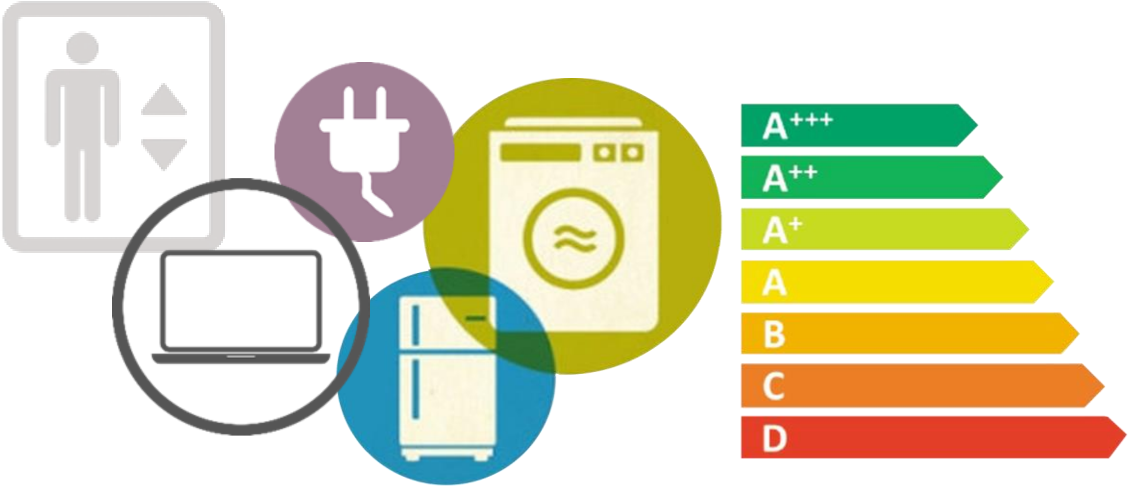
What is Regulated Energy ?
“Fixed Building Services”

- Lighting Energy
- Pumps & Fans Energy
- Cooling Energy
- Heating Energy
- Domestic Hot Water



What is Un-Regulated Energy ?
“ Small Power or Process Power or End User Energy”

- Computers and Data centres equipment
- Microware, Ovens & Gas hobs
- Lifts and Escalators
- Printers & Photocopiers
- Process plants e.g. commercial kitchens / Laundry

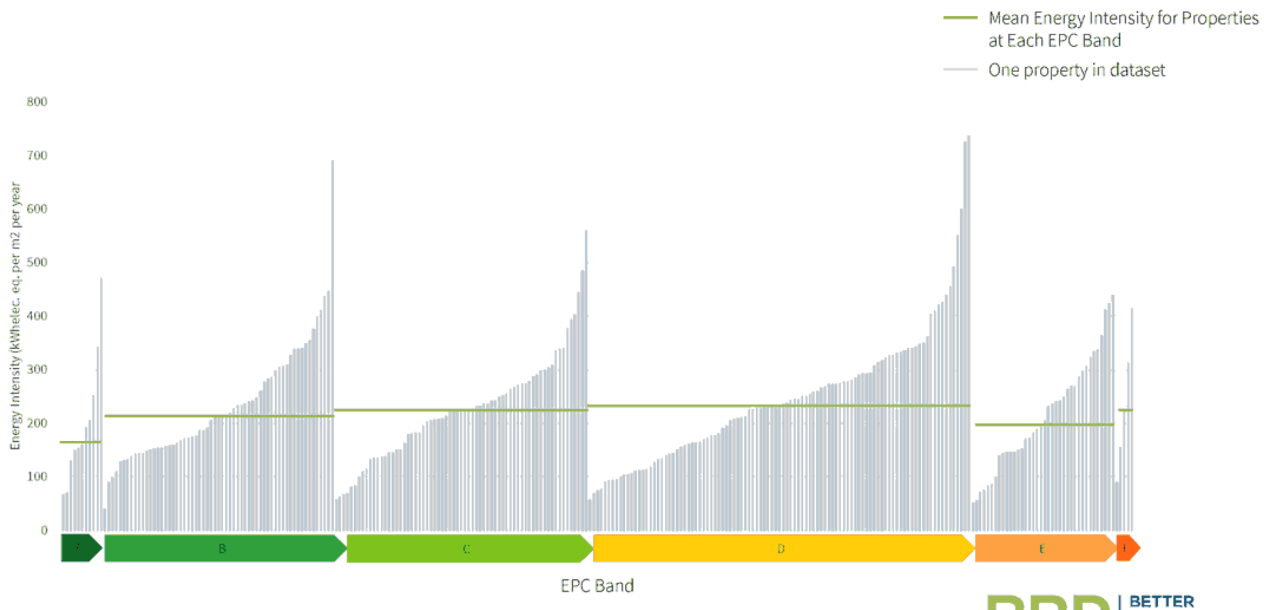


Design for Performance

Part L Performance Gap

Office Energy Intensity by EPC rating 2018/19

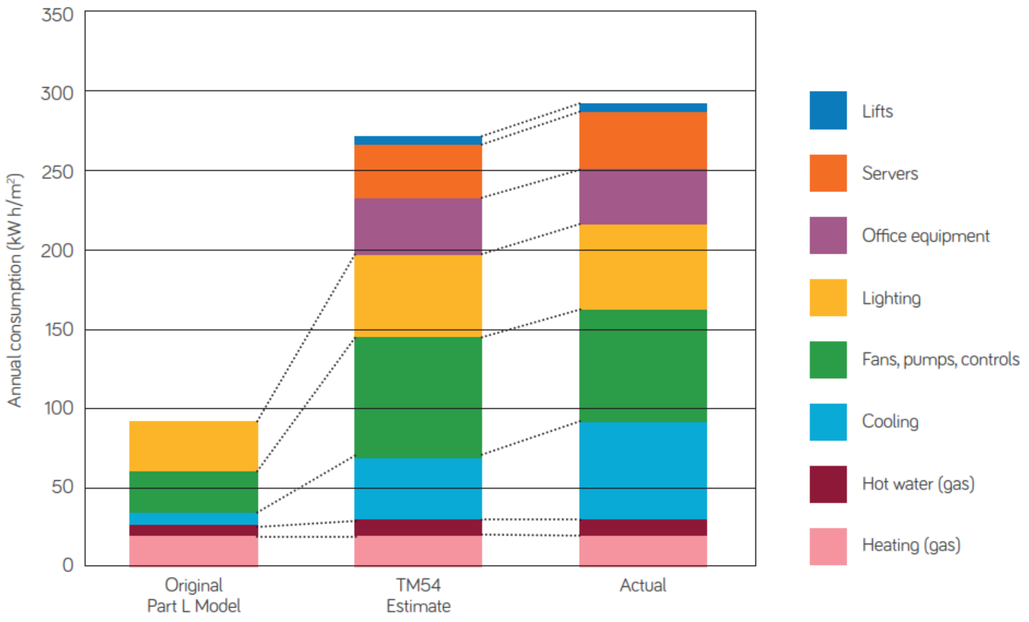
Energy Intensity (kWh$_{elec\ eq}$ per m^2 per year)



*Energy intensity measured in kWh$_{elec.\ eq.}$ per m^2 per year. Dataset includes 1,038 properties.

Part L Model versus TM54 Estimate versus Actual

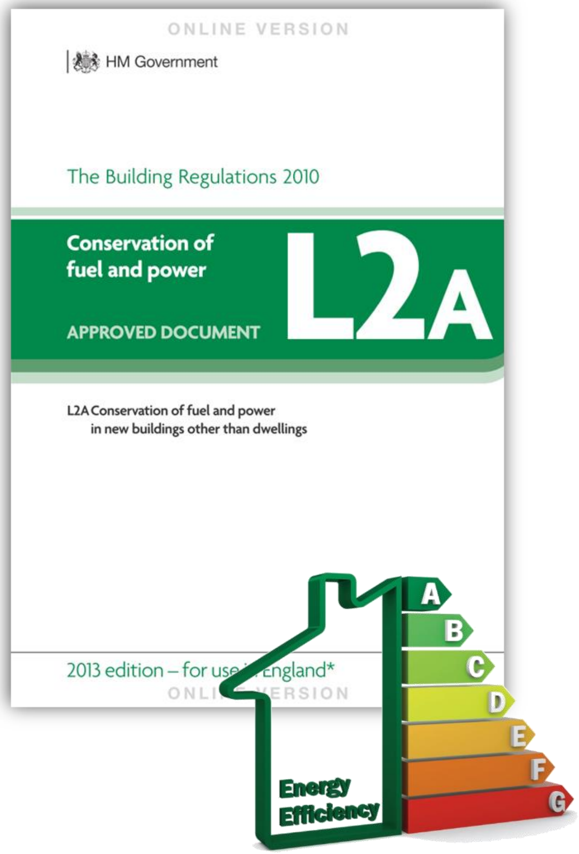
Source CIBSE



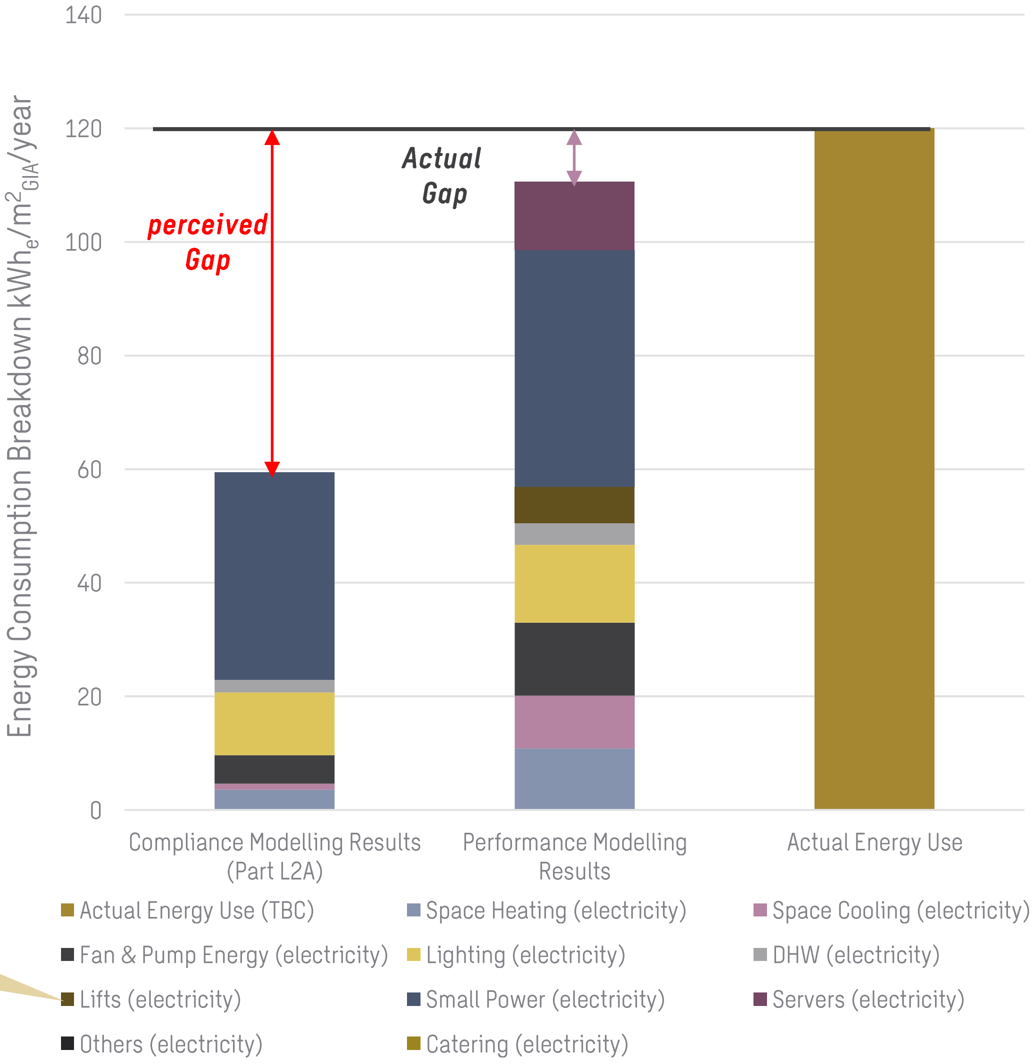
Performance Calculations and Associated Gaps

Understanding the Performance Gap – Case Study, Office Building in London -2017

Compliance modelling



Performance modelling



6 kWh/m2/yr.

Note: Example of results shown on the slides are based on CIBSE TM54 predication calcs done at RIBA stage 3 based on general assumptions and ASHRE profiles with error margin +15% subject to review at later stage.

Metrics

%

reduction CO_2 emissions
(vs notional building)

Includes energy supply type
Comparison with a fixed building specification
Multiple influencing factors

kWh/m²/yr.

Energy Use Intensity
(EUI)

Energy supply agnostic
Measures energy 'at the meter'

UNDERSTANDING INDUSTRY BENCHMARKING FOR OFFICES

Energy Performance Targets

Industry Benchmarks

Defining net zero carbon

A new approach: LETI

Low energy use

1. Total Energy Use Intensity (EUI) - Energy use measured at the meter should be equal to or less than:
   - **35 kWh/m²/yr** (GIA) for residential[1]

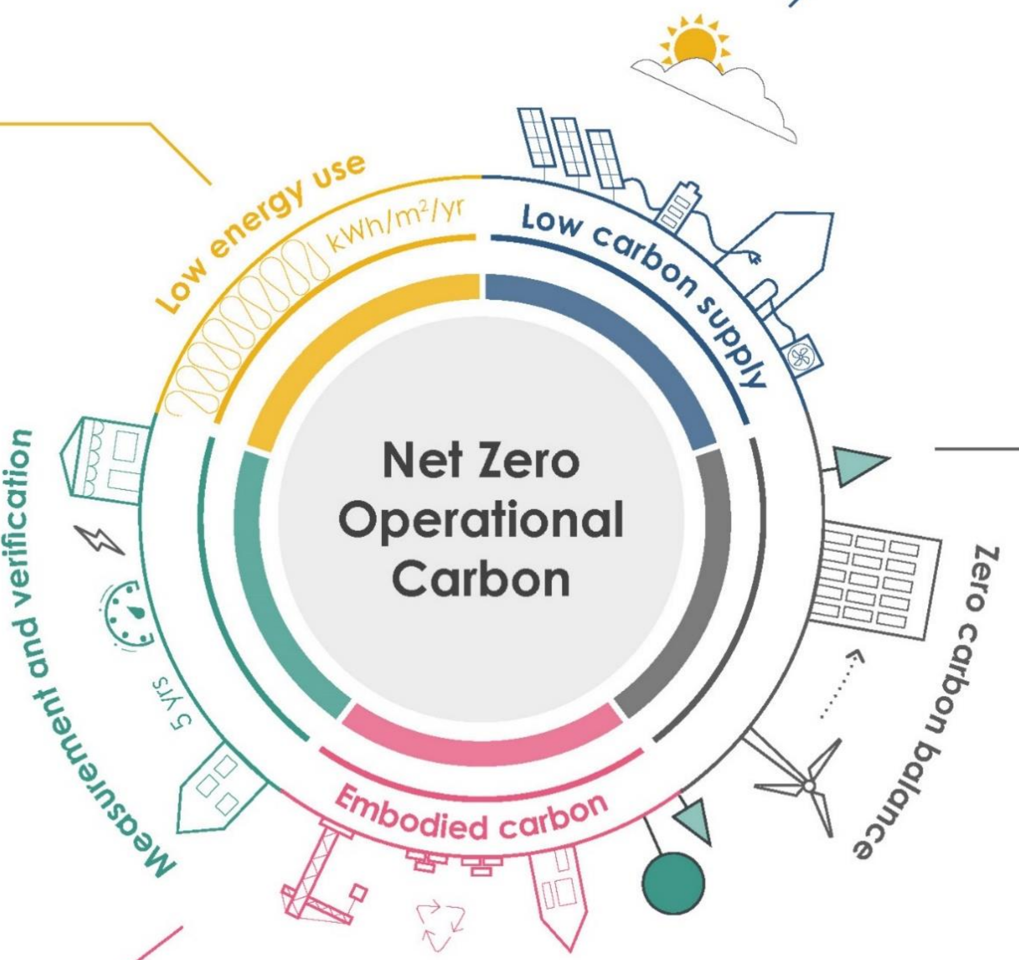
   For non-domestic buildings a minimum DEC B (40) rating should be achieved and/or an EUI equal or less than:
   - **65 kWh/m²/yr** (GIA) for schools[1]
   - **70 kWh/m²/yr** (NLA) or **55 kWh/m²/yr** (GIA) for commercial offices[1,2]
2. Building fabric is very important therefore space heating demand should be less than **15 kWh/m²/yr** for all building types.

Measurement and verification

3. Annual energy use and renewable energy generation on-site must be reported and independently verified in-use each year for the first 5 years. This can be done on an aggregated and anonymised basis for residential buildings.

Reducing construction impacts

4. Embodied carbon should be assessed, reduced and verified post-construction.[3]



Low carbon energy supply

5. **Heating and hot water should not be generated using fossil fuels.**
6. The average annual carbon content of the heat supplied (gCO_2/kWh) should be reported.
7. On-site renewable electricity should be maximised.
8. Energy demand response and storage measures should be incorporated and the building annual peak energy demand should be reported.

Zero carbon balance

9. A carbon balance calculation (on an annual basis) should be undertaken and it should be demonstrated that the building achieves a net zero carbon balance.
10. Any energy use not met by on-site renewables should be met by an investment into additional renewable energy capacity off-site OR a minimum 15 year renewable energy power purchase agreement (PPA). A green tariff is not robust enough and does not provide 'additional' renewables.

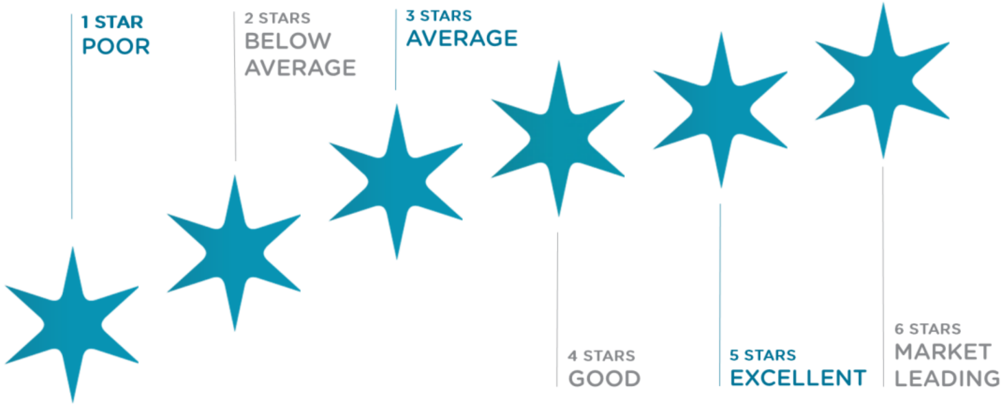
LONDON ENERGY TRANSFORMATION INITIATIVE

Design for Performance

Background to Initiative

Australia's Design for Performance Culture: NABERS

- Launched in 1999, an operational energy performance assessment.
- Provides a simple metric to investors, owners and occupiers on how efficiently a building is being operated in-use.



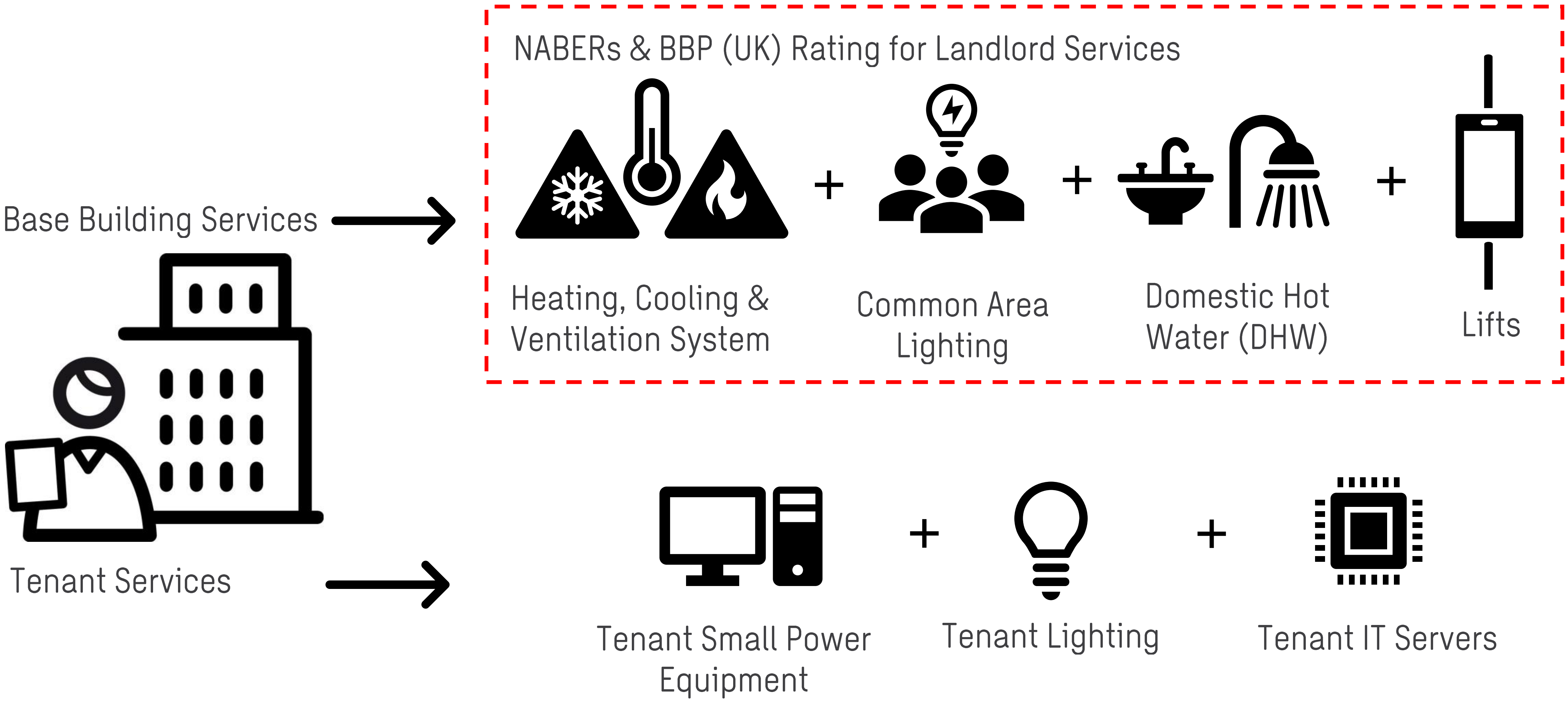
Resulted in *Design for Performance* not compliance

BBP BETTER BUILDINGS PARTNERSHIP

NABERS: National Australian Built Environment Rating System

Better Building Partnership UK & NABERs

Office Building Benchmarking targets & terminology



Energy performance targets

UK GBC interim targets Vs Standard BCO 2014 Building

225 kWhe/m²/annum
(Real Estate Environmental Benchmark)

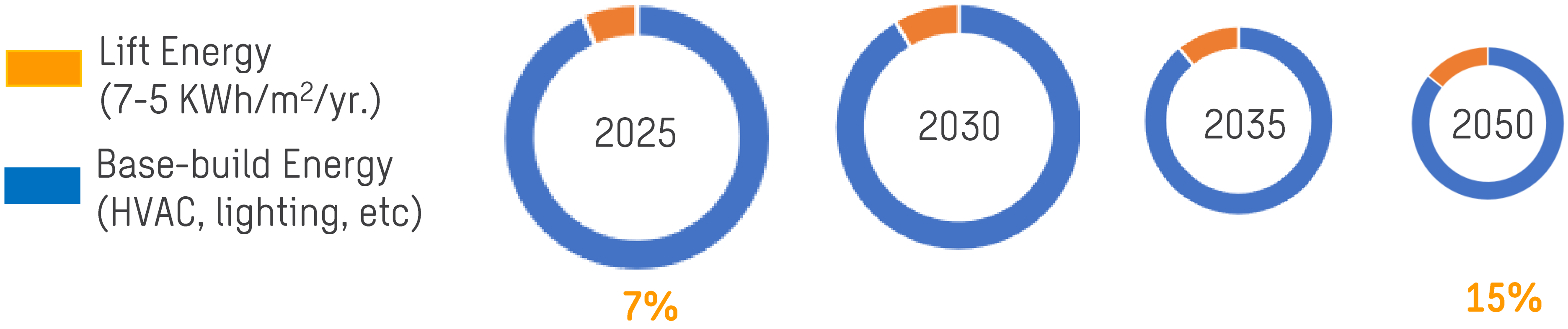
Scope	Metric	Interim Targets 2020-2025	Interim Targets 2025-2030	Interim Targets 2030-2035	Paris Proof Target 2035-2050
Whole building energy	kWh_e/m^2 (NLA) / year	160	115	90	70
	kWh_e/m^2 (GIA) / year	130	90	70	55
	DEC rating	C90	C65	B50	B40
Base building energy	kWh_e/m^2 (NLA) / year	90	70	55	35
	kWh_e/m^2 (GIA) / year	70	55	45	30
	NABERS UK star rating	4.5	5	5.5	6
Tenant energy	kWh_e/m^2 (NLA) / year	70	45	35	35

NLA = net lettable area GIA = gross internal area

How Ambitious are These Targets?

Understanding Lift Contribution

		Interim Targets			Paris Proof Target
Scope	Metric	2020-2025	2025-2030	2030-2035	2035-2050
Whole building energy	kWh$_e$/m^2 (NLA) / year	160	115	90	70
	kWh$_e$/m^2 (GIA) / year	130	90	70	55
	DEC rating	C90	C65	B50	B40
Base building energy	kWh$_e$/m^2 (NLA) / year	90	70	55	35
	kWh$_e$/m^2 (GIA) / year	70	55	45	30
	NABERS UK star rating	4.5	5	5.5	6



Operational Energy (kWh/m^2 $_{(NLA)}$ /yr.)

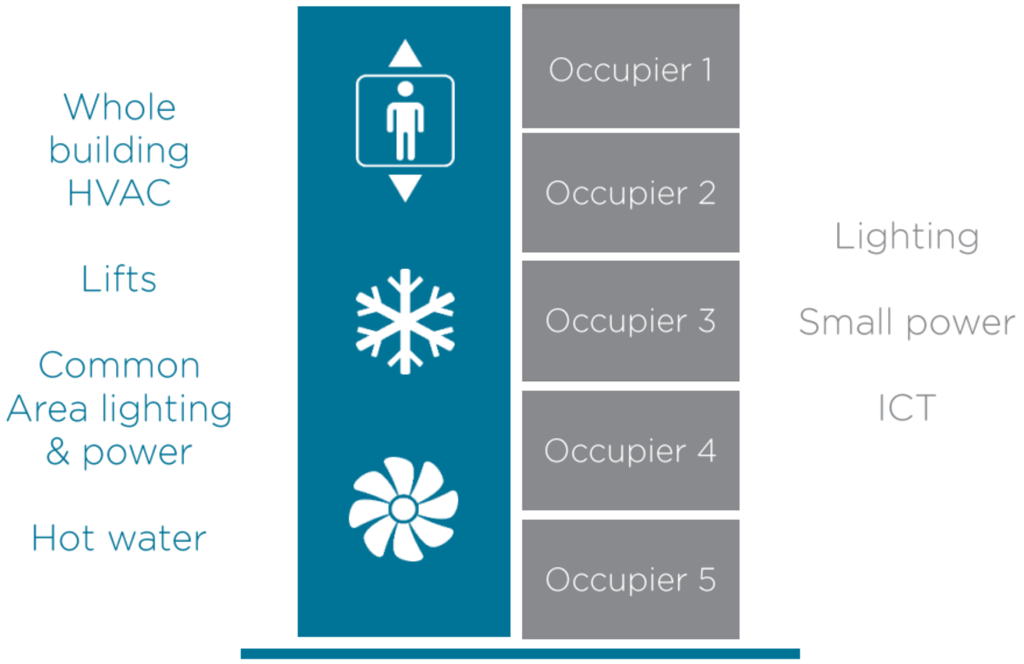
What This Means for Lift Industry ?

Change in the energy story

- Moving from unregulated to regulated energy consumption as part of Base-build Energy in NABERS-UK;
- Higher % of the annual energy usage as HVAC systems and small power are challenged to reduce energy consumption;
- More focus on how to precited operational energy at design stage using different framework and methods;
- Additional optimization and post occupancy evaluation (POE) data will be available as a result of the NABERS-UK validation process and the GLA Be Seen Policy

Base Building Rating

5★ NABERS ENERGY

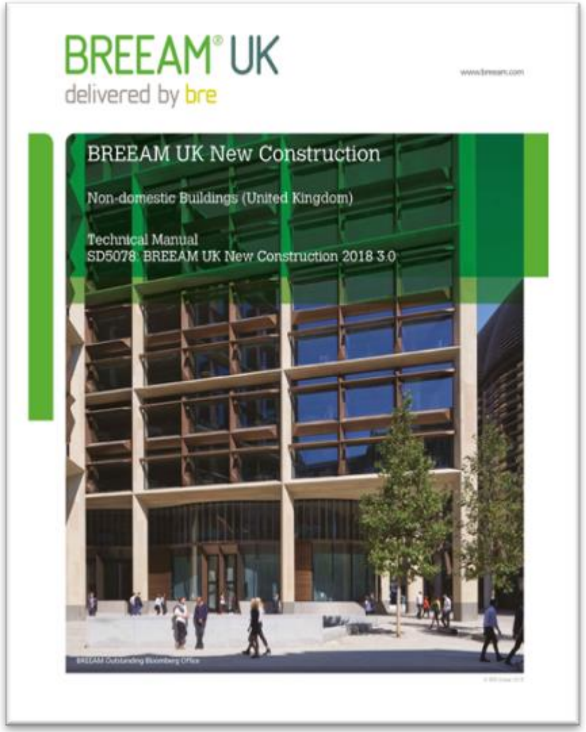


Operational Energy Consumption Prediction Framework

CIBSE TM54 -2013

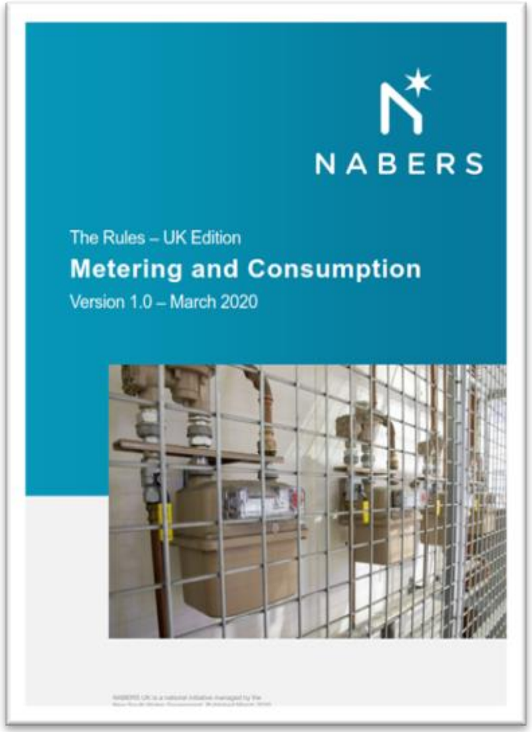
Based on CIBSE Guide D &
BS ISO DIS 25745-1 (2012)

BREEAM 2018 – ENE06



Focusing on motor drivers
optimization using
ISO DIS 25745-2 (2015)

NABERS UK -2020



Based on
ISO DIS 25745-2 (2015)
With simplified equations

Lift energy consumption in **a single lift approach** without considering of controlling and grouping algorithms

LIFT ENERGY CONSUMPTION – CASE STUDY

Case Study – TM54 Approach

7.4 Step 4: Evaluating energy use for lifts and escalators

7.4.1 Lifts

CIBSE Guide D (CIBSE, 2012) includes a calculation for lift energy use. This methodology requires some detailed information that may not be readily available for designers.

Alternatively, many lift manufacturers have proprietary energy calculators that can estimate annual energy use with fairly straightforward inputs.

The calculation quoted in CIBSE Guide D is from BS ISO/DIS 25745-1 (BSI, 2012). This calculation method uses the following formula to estimate lift energy use:

$$E_L = (S\,P\,t_h / 4) + E_{standby}$$

where E_L is the energy used by a single lift in one year (kW·h), S is the number of starts made per year, P is the rating of the drive motor (kW), t_h is the time to travel between the main entrance floor and the highest served floor from the instant the doors have closed until the instant they start to open (i.e. one half of a reference trip cycle) (h) and $E_{standby}$ is the standby energy used by a single lift in one year (kW·h).

This equation relies on a number of assumptions:

- the building has a uniform floor population
- the number of up stops is equal to the number of down stops
- no allowance is made for regeneration
- no allowance is made for the actions of the traffic controller (single units only are considered)
- no significant number of stops are made below the main entrance floor.

The number of starts per day can be estimated from Table 3.

The location of the lifts and the accessibility of the stairs will make a difference to how frequently the lift is used.

Table 3 Lift duty (source: BS ISO/DIS 25745-1)

Lift duty	Rating (starts/h)	Starts/day	Examples (days/week)
Low	60	<100	Residential care (7), goods (5), library (6), entertainment centre (7), stadia (intermittent)
Medium	120	300	Office car parks (5), general car parks (7), residential (7), university (5), hotel (7), low-rise hospital (7), shopping centre (7)
High	180	750	Office (5), airport (7), high-rise hospital (7)
Intensive	240	1000	Headquarters office (5)

This could be taken into account by adjusting the number of starts per day accordingly.

Case Study – TM54 Approach

Name	Type	Speed (m/s)	Lift travel (m)	Lift Duty	Starts per day	Number of starts/year	Motor (kW)	Time to travel lowest to highest floor (s)	Travel Time (h)	Time Spent Travelling (h)	Time Spent Standby (h)	Standby (kW)	Standby (kWh / yr)	Travelling (kWh / yr)	Total (kWh / yr)
PFL 01	High Rise Passenger /	4.0	94.300	Intensive	1000	260000	45	23.575	0.006549	1702.64	7057.36	0.10	706	19,155	19,860
PL 02	High Rise Passenger	4.0	84.550	Intensive	1000	260000	45	21.138	0.005872	1526.60	7233.40	0.10	723	17,174	17,898
PL 03	High Rise Passenger	4.0	80.325	Intensive	1000	260000	45	20.081	0.005578	1450.31	7309.69	0.10	731	16,316	17,047
PFL 04	High Rise Passenger /	4.0	99.175	Intensive	1000	260000	45	24.794	0.006887	1790.66	6969.34	0.10	697	20,145	20,842
PL 05	Mid Rise Passenger	2.5	53.550	Intensive	1000	260000	35	21.420	0.005950	1547.00	7213.00	0.10	721	13,536	14,258
PL 06	Mid Rise Passenger	2.5	53.550	Intensive	1000	260000	35	21.420	0.005950	1547.00	7213.00	0.10	721	13,536	14,258
PL 07	Mid Rise Passenger	2.5	49.325	Intensive	1000	260000	35	19.730	0.005481	1424.94	7335.06	0.10	734	12,468	13,202
PL 08	Mid Rise Passenger	2.5	49.325	Intensive	1000	260000	35	19.730	0.005481	1424.94	7335.06	0.10	734	12,468	13,202
PL 09	Low Rise Passenger	1.6	34.175	Intensive	1000	260000	20	21.359	0.005933	1542.62	7217.38	0.10	722	7,713	8,435
PL 10	Low Rise Passenger	1.6	34.175	Intensive	1000	260000	20	21.359	0.005933	1542.62	7217.38	0.10	722	7,713	8,435
PL 11	Low Rise Passenger	1.6	29.950	Intensive	1000	260000	20	18.719	0.005200	1351.91	7408.09	0.10	741	6,760	7,500
PL 12	Low Rise Passenger	1.6	29.950	Intensive	1000	260000	20	18.719	0.005200	1351.91	7408.09	0.10	741	6,760	7,500
PL 13	Low Rise Passenger	1.6	29.950	Intensive	1000	260000	20	18.719	0.005200	1351.91	7408.09	0.10	741	6,760	7,500
GL01	Goods Lift	1.6	49.925	High	750	195000	35	31.203	0.008668	1690.17	7069.83	0.10	707	14,789	15,496
GL02	Goods Lift	2.0	99.175	High	750	195000	40	49.588	0.013774	2685.99	6074.01	0.10	607	26,860	27,467
CL01	Cycle Lift	1.0	4.225	Medium	50	13000	10	4.225	0.001174	15.26	8744.74	0.10	874	38	913
LL01	Lorry Lift	0.275	10.100	Medium	66	20592	180	36.727	0.010202	210.08	8549.92	0.50	4,275	9,454	13,729
LL02	Lorry Lift	0.275	10.100	Medium	66	20592	220	36.727	0.010202	210.08	8549.92	0.50	4,275	11,554	15,829
SL 01	Shuttle Passenger	1.6	14.800	High	750	195000	20	9.250	0.002569	501.04	8258.96	0.10	826	2,505	3,331
SL 02	Shuttle Passenger	1.6	14.800	High	750	195000	20	9.250	0.002569	501.04	8258.96	0.10	826	2,505	3,331
PL 13	High Rise Passenger	6.0	13.450	Intensive	1000	260000	55	2.242	0.000623	161.90	8598.10	0.10	860	2,226	3,086
PL 14	High Rise Passenger	6.0	13.450	Intensive	1000	260000	55	2.242	0.000623	161.90	8598.10	0.10	860	2,226	3,086
PL 15	High Rise Passenger	6.0	131.750	Intensive	1000	260000	55	21.958	0.006100	1585.88	7174.12	0.10	717	21,806	22,523
PL 16	High Rise Passenger	6.0	131.750	Intensive	1000	260000	55	21.958	0.006100	1585.88	7174.12	0.10	717	21,806	22,523
PL 17	Mid Rise Passenger	5.0	89.125	Intensive	1000	260000	45	17.825	0.004951	1287.36	7472.64	0.10	747	14,483	15,230
PL 18	Mid Rise Passenger	5.0	89.125	Intensive	1000	260000	45	17.825	0.004951	1287.36	7472.64	0.10	747	14,483	15,230
PL 19	Mid Rise Passenger	5.0	89.125	Intensive	1000	260000	45	17.825	0.004951	1287.36	7472.64	0.10	747	14,483	15,230
PL 20	Mid Rise Passenger	5.0	89.125	Intensive	1000	260000	45	17.825	0.004951	1287.36	7472.64	0.10	747	14,483	15,230
FFL 01	Passenger / Firefighters ,	3.0	148.575	Medium	300	78000	25	49.525	0.013757	1073.04	7686.96	0.10	769	6,707	7,475
FFL 02	Passenger / Firefighters ,	3.0	142.595	Medium	300	78000	25	47.532	0.013203	1029.85	7730.15	0.10	773	6,437	7,210
GL03	Goods / Passenger	3.0	161.295	High	750	195000	60	53.765	0.014935	2912.27	5847.73	0.10	585	43,684	44,269

Escalators	27,697
Total kWh/yr	448,822
Area m^2	66,707
$kWh/m^2/yr$	**6.73**

Case Study – Modelling Approach

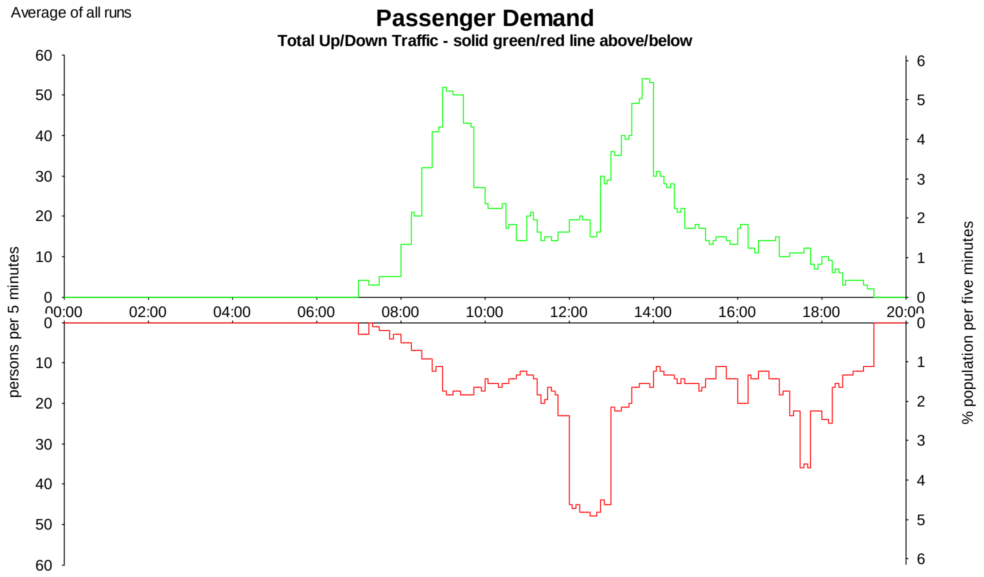
High-rise lift group

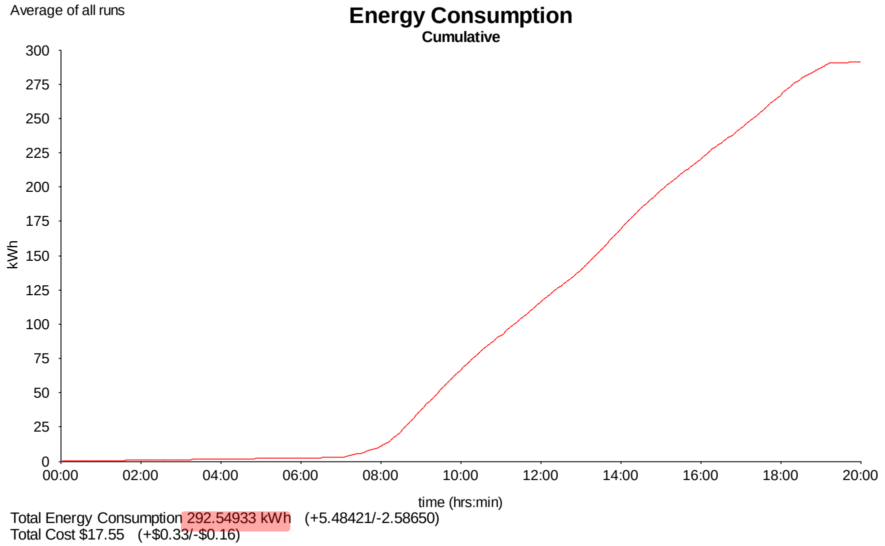
Name	Speed (m/s)	Lift travel (m)	Lift Duty	Starts per day	Number of starts/year	Motor (kW)	Time Spent Travelling (h)	Time Spent Standby (h)	Standby (kW)	Standby (kWh / yr)	Travelling (kWh / yr)	Total (kWh / yr)	kWh / operational d
PFL 01	4.0	94.300	Intensive	1000	260000	45	1702.64	7057.36	0.10	706	19,155	19,860	76
PL 02	4.0	84.550	Intensive	1000	260000	45	1526.60	7233.40	0.10	723	17,174	17,898	68
PL 03	4.0	80.325	Intensive	1000	260000	45	1450.31	7309.69	0.10	731	16,316	17,047	65
PFL 04	4.0	99.175	Intensive	1000	260000	45	1790.66	6969.34	0.10	697	20,145	20,842	79
													288

Case Study – Modelling Approach

- Group control
- Regenerative drives
- Siikonen full day (24-hr) office demand template
- Occupancy set to 70% of base build design (NABERS)

	Car 1	Car 2	Car 3	Car 4
kW drive off	0.1	0.1	0.1	0.1
kW drive on	0.1	0.1	0.1	0.1
kW 0% load Up	-11	-11	-11	-11
kW 25% load Up	-0.2	-0.2	-0.2	-0.2
kW 50% load Up	13.4	13.4	13.4	13.4
kW 75% load Up	28.3	28.3	28.3	28.3
kW 100% load Up	43.1	43.1	43.1	43.1
kW 0% load Down	34.3	34.3	34.3	34.3
kW 25% load Down	19.5	19.5	19.5	19.5
kW 50% load Down	5.1	5.1	5.1	5.1
kW 75% load Down	-6.7	-6.7	-6.7	-6.7
kW 100% load Down	-17.1	-17.1	-17.1	-17.1





The ISO energy classification of a lift
ISO energy labels
Calculating the energy consumed

The UK and the EU enact new energy labels in September 2021.

Lifts are left out does it matter?

Presented by

Dr Gina Barney

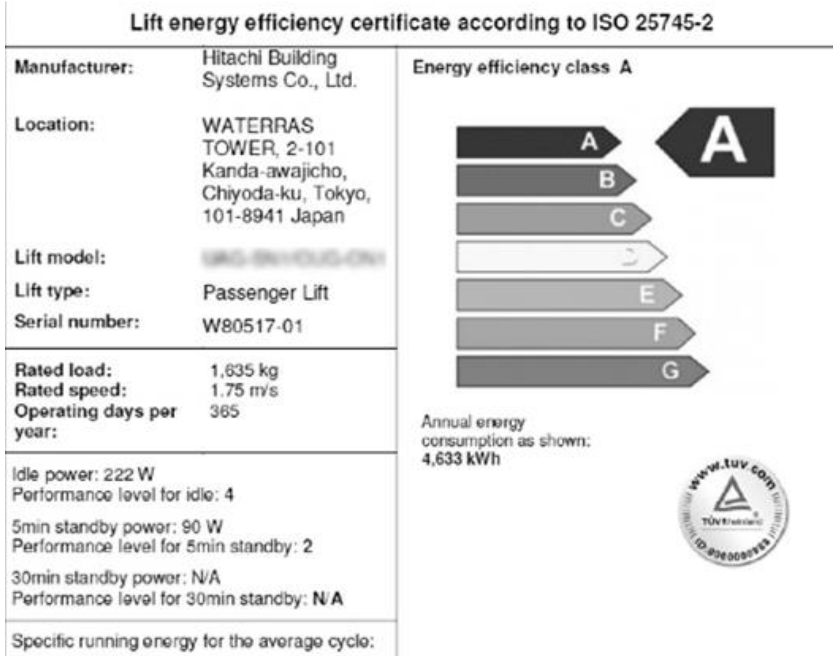
Principal, *Gina Barney* Associates

Vertical transportation
In a Nutshell

Summary & Questions

Are you ready?

- Introduction of maximum target values for lift motor rating similar based on type similar to air handling units;
- Participate in writing the new CIBSE TM54 and refining the NABERS UK approach to lifts;
- Define an approach to model the lift energy consumption;
- Introduction of Energy Performance Certificates verified by independent third party as part of lift technical submission;
- Detailed review of sub-metering data and POE results to understand the impact of operation and maintenance.



Lift energy efficiency certificate according to ISO 25745-2

Manufacturer:	Hitachi Building Systems Co., Ltd.	**Energy efficiency class A**
Location:	WATERRAS TOWER, 2-101 Kanda-awajicho, Chiyoda-ku, Tokyo, 101-8941 Japan	
Lift model:		
Lift type:	Passenger Lift	
Serial number:	W80517-01	
Rated load:	1,635 kg	
Rated speed:	1.75 m/s	
Operating days per year:	365	Annual energy consumption as shown: **4,633 kWh**

Idle power: 222 W
Performance level for idle: 4

5min standby power: 90 W
Performance level for 5min standby: 2

30min standby power: N/A
Performance level for 30min standby: N/A

Specific running energy for the average cycle:
0.553 mWh/kg*m
Performance levels for running: 1

Usage category 5 according to ISO 25745-2:2015
Comparisons of energy efficiency classes are possible under equal usage only.

Date: 27.09.2016
Reference: ISO 25745-2:2015