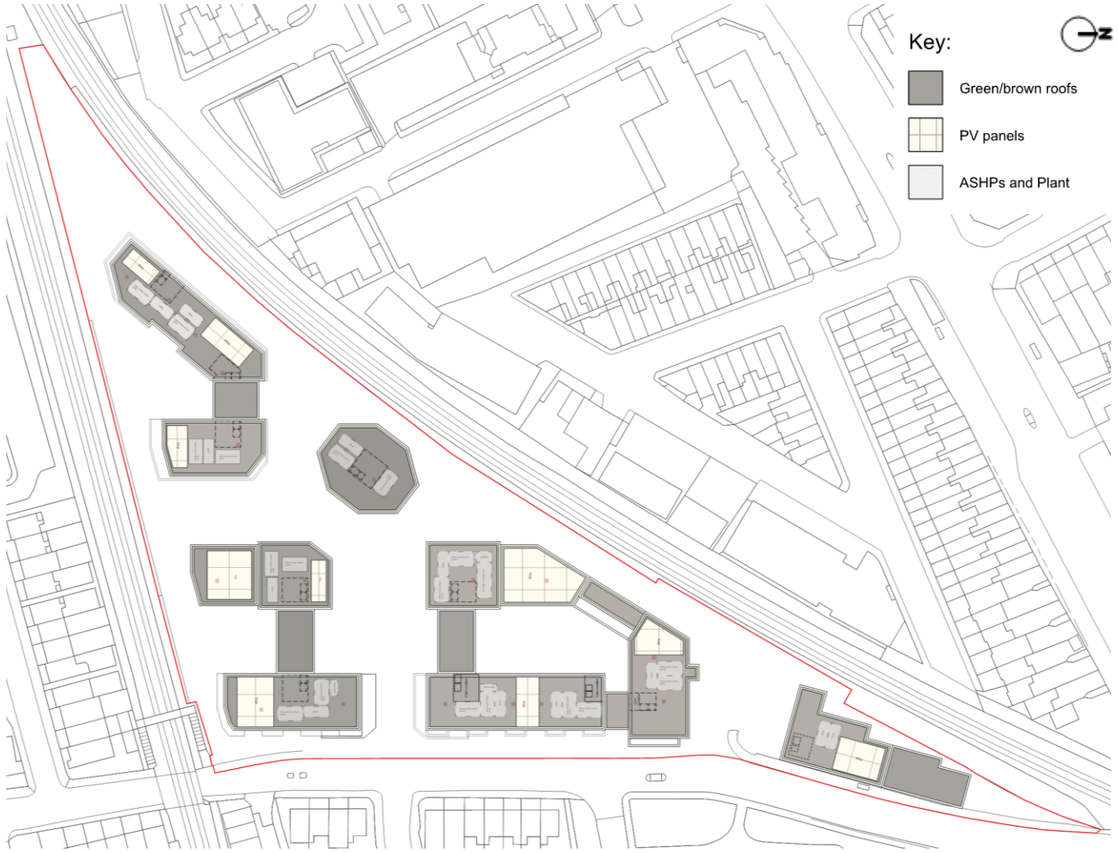
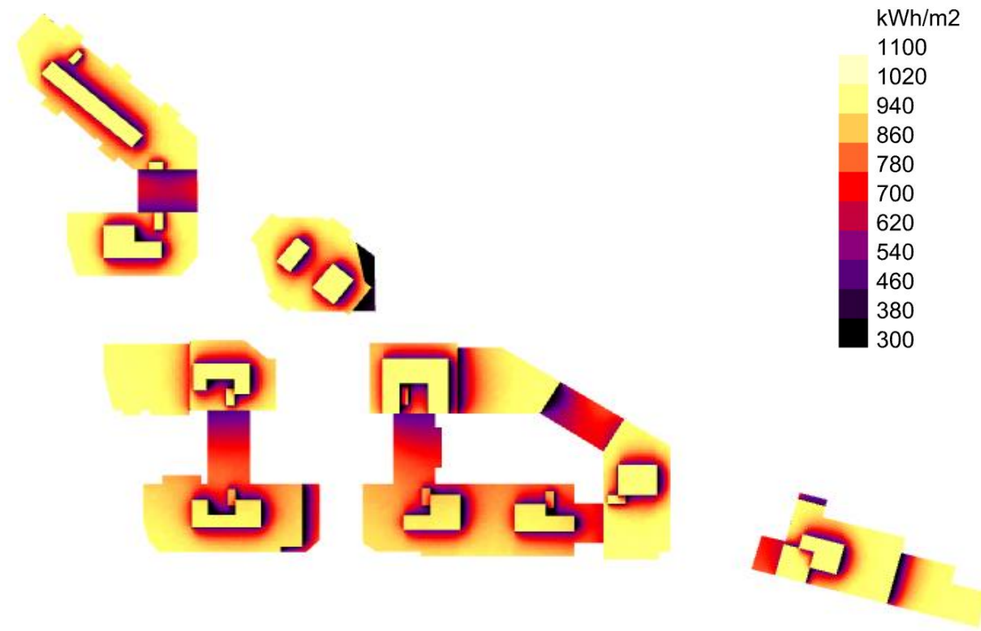
Appendix G: Roof area appraisal.

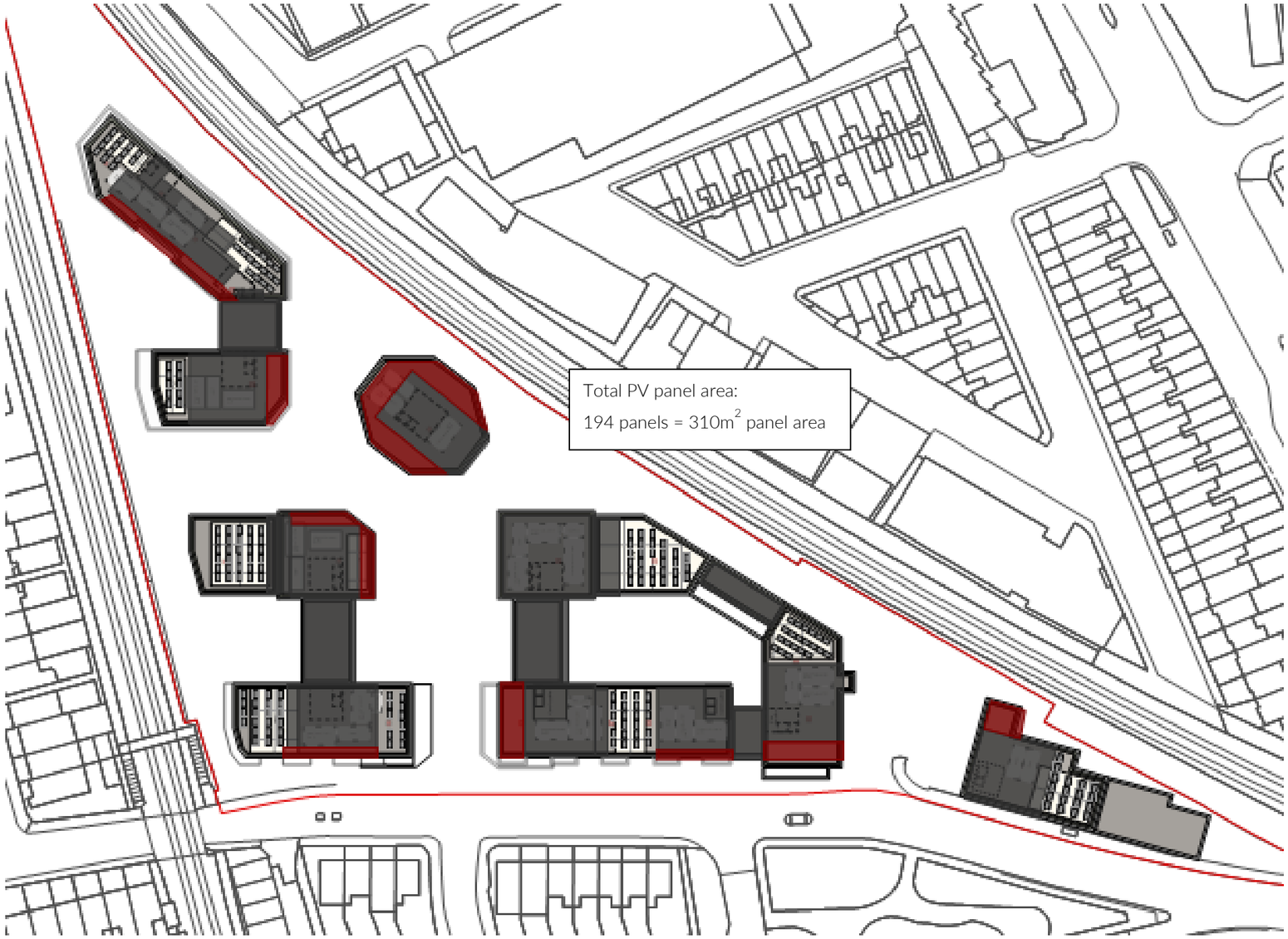


Proposed Development Roof Plan (source: Assael Architecture)



Annual solar irradiance on roofs

Total PV panel area:
194 panels = 310m^2 panel area



Legend:

- Roof area allocated for plant, or overshaded area
- Green / brown roof / PVs
- Roof area deemed too small for PV panel array

Resulting Proposed PV array

Appendix H: SAP worksheets.

Be Lean example data sheet – DER & TER

DER Worksheet
Design - Draft

NHER

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Miss Michelle Wang	Assessor number	2018
Client		Last modified	23/10/2019
Address	Manor Road Richmond Block 1, Richmond, TW9		

1. Overall dwelling dimensions

	Area (m²)		Average storey height (m)		Volume (m³)	
Lowest occupied	70.28	(1a) x	2.65	(2a) =	186.24	(3a)
Total floor area (1a) + (1b) + (1c) + (1d)...(1n) =	70.28	(4)				
Dwelling volume				(3a) + (3b) + (3c) + (3d)...(3n) =	186.24	(5)

2. Ventilation rate

			m³ per hour	
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	0	x 10 =	0	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of flueless gas fires	0	x 40 =	0	(7c)
			Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs (6a) + (6b) + (7a) + (7b) + (7c) =	0	÷ (5) =	0.00	(8)
If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)				
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area			3.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)			0.15	(18)
Number of sides on which the dwelling is sheltered			2	(19)
Shelter factor		1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor		(18) x (20) =	0.13	(21)

Infiltration rate modified for monthly wind speed:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly average wind speed from Table U2	5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4	1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m	0.16	0.16	0.16	0.14	0.14	0.12	0.12	0.12	0.13	0.14	0.14	0.15	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	0.50	(23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h	76.50	(23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (22b)m + (23b) x [1 - (23c) ÷ 100]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(24a)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)

	0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(25)

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3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²		U-value W/m²K		A x U W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Window			21.01	x	1.33	=	27.85			(27)
External wall			39.72	x	0.15	=	5.96			(29a)
External wall			5.37	x	0.01	=	0.05			(29a)
Party wall			33.79	x	0.00	=	0.00			(32)
Total area of external elements ∑A, m²			66.10							(31)
Fabric heat loss, W/K = ∑(A x U)								(26)...(30) + (32) =	33.87	(33)
Heat capacity Cm = ∑(A x κ)								(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K									100.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K									11.02	(36)
Total fabric heat loss								(33) + (36) =	44.89	(37)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)	17.21	17.02	16.82	15.84	15.65	14.67	14.67	14.47	15.06	15.65	16.04	16.43	(38)
Heat transfer coefficient, W/K (37)m + (38)m	62.10	61.90	61.71	60.73	60.53	59.55	59.55	59.36	59.94	60.53	60.92	61.31	
Average = ∑(39)1...12/12 =												60.68	(39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)	0.88	0.88	0.88	0.86	0.86	0.85	0.85	0.84	0.85	0.86	0.87	0.87	
Average = ∑(40)1...12/12 =												0.86	(40)
Number of days in month (Table 1a)	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	2.25	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	87.71	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)	96.48	92.97	89.46	85.95	82.44	78.94	78.94	82.44	85.95	89.46	92.97	96.48	
∑(44)1...12 =												1052.48	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	143.07	125.13	129.13	112.57	108.02	93.21	86.37	99.12	100.30	116.89	127.59	138.56	
∑(45)1...12 =												1379.96	(45)
Distribution loss 0.15 x (45)m	21.46	18.77	19.37	16.89	16.20	13.98	12.96	14.87	15.04	17.53	19.14	20.78	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	194.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	1.61	(48)
Temperature factor from Table 2b	0.60	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.97	(50)
Enter (50) or (54) in (55)	0.97	(55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m	29.95	27.05	29.95	28.98	29.95	28.98	29.95	29.95	28.98	29.95	28.98	29.95	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)	29.95	27.05	29.95	28.98	29.95	28.98	29.95	29.95	28.98	29.95	28.98	29.95	(57)

Primary circuit loss for each month from Table 3

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	23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss for each month from Table 3a, 3b or 3c

	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)

Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m

	196.28	173.19	182.33	164.07	161.23	144.70	139.58	152.32	151.79	170.10	179.09	191.77	(62)

Solar DHW input calculated using Appendix G or Appendix H

	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)

Output from water heater for each month (kWh/month) (62)m + (63)m

	196.28	173.19	182.33	164.07	161.23	144.70	139.58	152.32	151.79	170.10	179.09	191.77	
∑(64)1...12 =												2006.45	(64)

Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]

	90.14	80.05	85.50	78.62	78.48	72.19	71.29	75.52	74.54	81.43	83.62	88.64	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	17.65	15.67	12.75	9.65	7.21	6.09	6.58	8.55	11.48	14.58	17.01	18.14	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	197.95	200.00	194.83	183.81	169.90	156.82	148.09	146.04	151.21	162.23	176.14	189.22	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	(69)
Pump and fan gains (Table 5a)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(70)
Losses e.g. evaporation (Table 5)	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	(71)
Water heating gains (Table 5)	121.15	119.13	114.92	109.20	105.49	100.26	95.81	101.51	103.53	109.45	116.14	119.14	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	393.54	391.60	379.29	359.45	339.39	319.97	307.28	312.89	323.02	343.05	366.09	383.28	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
SouthEast	0.77	x	5.25	x	36.79	x 0.9 x	0.40	x	0.90	=	48.19	(77)
SouthWest	0.54	x	3.68	x	36.79	x 0.9 x	0.40	x	0.90	=	23.69	(79)
SouthWest	0.77	x	5.78	x	36.79	x 0.9 x	0.40	x	0.90	=	53.06	(79)
NorthWest	0.77	x	6.30	x	11.28	x 0.9 x	0.40	x	0.90	=	17.73	(81)

Solar gains in watts ∑(74)m...(82)m

	142.67	248.91	356.22	467.60	547.69	554.25	529.98	468.62	394.54	279.32	171.96	121.40	(83)

Total gains - internal and solar (73)m + (83)m

	536.22	640.51	735.51	827.05	887.08	874.22	837.26	781.51	717.56	622.37	538.05	504.69	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1(°C)	21.00	(85)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Utilisation factor for gains for living area n1,m (see Table 9a)												

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0.93	0.89	0.83	0.71	0.57	0.42	0.31	0.34	0.53	0.76	0.90	0.94	(86)

Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)

19.50	19.81	20.19	20.59	20.84	20.96	20.99	20.98	20.90	20.56	19.97	19.44	(87)

Temperature during heating periods in the rest of dwelling from Table 9, Th2(°C)

20.18	20.18	20.19	20.20	20.20	20.21	20.21	20.21	20.21	20.20	20.20	20.19	(88)

Utilisation factor for gains for rest of dwelling n2,m

0.92	0.88	0.81	0.68	0.53	0.37	0.25	0.29	0.48	0.73	0.88	0.93	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

18.17	18.61	19.15	19.70	20.02	20.17	20.20	20.20	20.11	19.68	18.86	18.10	(90)

Living area fraction — Living area ÷ (4) = 0.51 (91)

Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2

18.84	19.22	19.68	20.15	20.43	20.57	20.60	20.60	20.51	20.13	19.42	18.78	(92)

Apply adjustment to the mean internal temperature from Table 4e where appropriate

18.84	19.22	19.68	20.15	20.43	20.57	20.60	20.60	20.51	20.13	19.42	18.78	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	0.91	0.86	0.79	0.68	0.54	0.39	0.28	0.31	0.50	0.73	0.87	0.92	(94)
Useful gains, ηmGm, W (94)m x (84)m	487.02	552.42	583.41	564.02	481.32	343.16	235.12	244.69	357.84	453.98	466.36	463.94	(95)
Monthly average external temperature from Table U1	4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature, Lm, W [(39)m x [(93)m - (96)m]	903.03	886.28	813.22	683.18	528.69	355.44	238.25	249.13	384.49	576.79	750.84	893.76	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	309.52	224.35	170.98	85.80	35.24	0.00	0.00	0.00	0.00	91.37	204.82	319.78	

∑(98)1...5, 10...12 = 1441.87 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) = 20.52 (99)

8c. Space cooling requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Heat loss rate Lm	0.00	0.00	0.00	0.00	0.00	559.78	440.68	451.10	0.00	0.00	0.00	0.00	(100)
Utilisation factor for loss ηm	0.00	0.00	0.00	0.00	0.00	0.94	0.96	0.95	0.00	0.00	0.00	0.00	(101)
Useful loss ηmLm (watts) (100)m x (101)m	0.00	0.00	0.00	0.00	0.00	526.03	424.47	430.53	0.00	0.00	0.00	0.00	(102)
Gains	0.00	0.00	0.00	0.00	0.00	1102.90	1057.93	992.99	0.00	0.00	0.00	0.00	(103)
Space cooling requirement, whole dwelling, continuous (kWh) 0.024 x [(103)m - (102)m] x (41)m	0.00	0.00	0.00	0.00	0.00	415.35	471.29	418.47	0.00	0.00	0.00	0.00	

∑(104)6...8 = 1305.12 (104)

Cooled fraction — cooled area ÷ (4) = 0.51 (105)

Intermittency factor (Table 10)

0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.00	0.00	0.00	0.00	

∑(106)6...8 = 0.75 (106)

Space cooling requirement (104)m x (105) x (106)m

0.00	0.00	0.00	0.00	0.00	52.61	59.70	53.01	0.00	0.00	0.00	0.00	

∑(107)6...8 = 165.32 (107)

Space cooling requirement kWh/m²/year — (107) ÷ (4) = 2.35 (108)

9b. Energy requirements - community heating scheme

Fraction of space heat from secondary/supplementary system (table 11)	'0' if none	0.00	(301)
Fraction of space heat from community system	1 - (301) =	1.00	(302)
Fraction of community heat from boilers		1.00	(303a)
Fraction of total space heat from community boilers	(302) x (303a) =	1.00	(304a)
Factor for control and charging method (Table 4c(3)) for community space heating		1.00	(305)
Factor for charging method (Table 4c(3)) for community water heating		1.00	(305a)
Distribution loss factor (Table 12c) for community heating system		1.05	(306)

Space heating

Annual space heating requirement	1441.87		(98)
Space heat from boilers	(98) x (304a) x (305) x (306) =	1513.96	(307a)

Water heating

Annual water heating requirement	2006.45		(64)
Water heat from boilers	(64) x (303a) x (305a) x (306) =	2106.77	(310a)
Electricity used for heat distribution	0.01 × [(307a)...(307e) + (310a)...(310e)] =	36.21	(313)
Cooling System Energy Efficiency Ratio		4.05	(314)
Space cooling (if there is a fixed cooling system, if not enter 0)	(107) ÷ (314) =	40.82	(315)
Electricity for pumps, fans and electric keep-hot (Table 4f)			
mechanical ventilation fans - balanced, extract or positive input from outside	174.96		(330a)
Total electricity for the above, kWh/year		174.96	(331)
Electricity for lighting (Appendix L)		311.66	(332)
Total delivered energy for all uses	(307) + (309) + (310) + (312) + (315) + (331) + (332)...(337b) =	4148.17	(338)

10b. Fuel costs - community heating scheme

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating from boilers	1513.96	x	4.24	x 0.01 =	64.19	(340a)
Water heating from boilers	2106.77	x	4.24	x 0.01 =	89.33	(342a)
Space cooling	40.82	x	13.19	x 0.01 =	5.38	(348)
Pumps and fans	174.96	x	13.19	x 0.01 =	23.08	(349)
Electricity for lighting	311.66	x	13.19	x 0.01 =	41.11	(350)
Additional standing charges					120.00	(351)
Total energy cost			(340a)...(342e) + (345)...(354) =		343.09	(355)

11b. SAP rating - community heating scheme

Energy cost deflator (Table 12)	0.42	(356)
Energy cost factor (ECF)	1.25	(357)
SAP value	82.56	
SAP rating (section 13)	83	(358)
SAP band	B	

12b. CO_2 emissions - community heating scheme

	Energy kWh/year		Emission factor		Emissions (kg/year)	
Emissions from other sources (space heating)						
Efficiency of boilers	89.50					(367a)
CO2 emissions from boilers [(307a)+(310a)] x 100 ÷ (367a) =	4045.52	x	0.216	=	873.83	(367)
Electrical energy for community heat distribution	36.21	x	0.519	=	18.79	(372)
Total CO2 associated with community systems					892.62	(373)
Total CO2 associated with space and water heating					892.62	(376)
Space cooling	40.82	x	0.519	=	21.19	(377)
Pumps and fans	174.96	x	0.519	=	90.80	(378)
Electricity for lighting	311.66	x	0.519	=	161.75	(379)
Total CO_2, kg/year				(376)..(382) =	1166.36	(383)
Dwelling CO_2 emission rate				(383) ÷ (4) =	16.60	(384)
EI value					86.44	
EI rating (section 14)					86	(385)
EI band					B	

13b. Primary energy - community heating scheme

	Energy kWh/year		Primary factor		Primary energy (kWh/year)	
Primary energy from other sources (space heating)						
Efficiency of boilers	89.50					(367a)
Primary energy from boilers [(307a)+(310a)] x 100 ÷ (367a) =	4045.52	x	1.22	=	4935.53	(367)
Electrical energy for community heat distribution	36.21	x	3.07	=	111.16	(372)
Total primary energy associated with community systems					5046.69	(373)
Total primary energy associated with space and water heating					5046.69	(376)
Space cooling	40.82	x	3.07	=	125.32	(377)
Pumps and fans	174.96	x	3.07	=	537.11	(378)
Electricity for lighting	311.66	x	3.07	=	956.79	(379)
Primary energy kWh/year					6665.91	(383)
Dwelling primary energy rate kWh/m2/year					94.85	(384)

TER Worksheet
Design - Draft

NHER

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Miss Michelle Wang	Assessor number	2018
Client		Last modified	23/10/2019
Address	Manor Road Richmond Block 1, Richmond, TW9		

1. Overall dwelling dimensions

		Area (m²)		Average storey height (m)		Volume (m³)	
Lowest occupied		70.28 (1a)	x	2.65 (2a)	=	186.24	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	70.28 (4)					
Dwelling volume				(3a) + (3b) + (3c) + (3d)...(3n) =		186.24	(5)

2. Ventilation rate

			m³ per hour	
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	3	x 10 =	30	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of flueless gas fires	0	x 40 =	0	(7c)
			Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs	(6a) + (6b) + (7a) + (7b) + (7c) = 30	÷ (5) =	0.16	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		5.00 (17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)		0.41 (18)
Number of sides on which the dwelling is sheltered		2 (19)
Shelter factor	1 - [0.075 x (19)] =	0.85 (20)
Infiltration rate incorporating shelter factor	(18) x (20) =	0.35 (21)

Infiltration rate modified for monthly wind speed:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly average wind speed from Table U2												
5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4												
1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m												
0.45	0.44	0.43	0.38	0.38	0.33	0.33	0.32	0.35	0.38	0.39	0.41	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system		N/A (23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h		N/A (23c)
d) natural ventilation or whole house positive input ventilation from loft		

0.60	0.60	0.59	0.57	0.57	0.56	0.56	0.55	0.56	0.57	0.58	0.58	(24d)
Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)												
0.60	0.60	0.59	0.57	0.57	0.56	0.56	0.55	0.56	0.57	0.58	0.58	(25)

3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²		U-value W/m²K		A x U W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Window			17.57	x	1.33	=	23.29			(27)
External wall			48.50	x	0.18	=	8.73			(29a)
Party wall			33.79	x	0.00	=	0.00			(32)
Total area of external elements ∑A, m²			66.07							(31)
Fabric heat loss, W/K = ∑(A x U)							(26)...(30) + (32) =		32.02	(33)
Heat capacity Cm = ∑(A x κ)							(28)...(30) + (32) + (32a)...(32e) =		N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K									250.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K									5.69	(36)
Total fabric heat loss								(33) + (36) =	37.71	(37)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)												
36.83	36.59	36.36	35.27	35.07	34.12	34.12	33.94	34.48	35.07	35.48	35.91	(38)
Heat transfer coefficient, W/K (37)m + (38)m												
74.54	74.31	74.07	72.98	72.78	71.83	71.83	71.65	72.20	72.78	73.19	73.62	
										Average = ∑(39)1...12 =		72.98 (39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)												
1.06	1.06	1.05	1.04	1.04	1.02	1.02	1.02	1.03	1.04	1.04	1.05	
										Average = ∑(40)1...12 =		1.04 (40)
Number of days in month (Table 1a)												
31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	2.25	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	87.71	(43)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)												
96.48	92.97	89.46	85.95	82.44	78.94	78.94	82.44	85.95	89.46	92.97	96.48	
										∑(44)1...12 =		1052.48 (44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)												
143.07	125.13	129.13	112.57	108.02	93.21	86.37	99.12	100.30	116.89	127.59	138.56	
										∑(45)1...12 =		1379.96 (45)
Distribution loss 0.15 x (45)m												
21.46	18.77	19.37	16.89	16.20	13.98	12.96	14.87	15.04	17.53	19.14	20.78	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	194.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	1.62	(48)
Temperature factor from Table 2b	0.54	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.88	(50)
Enter (50) or (54) in (55)	0.88	(55)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m												
27.16	24.54	27.16	26.29	27.16	26.29	27.16	27.16	26.29	27.16	26.29	27.16	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)												
27.16	24.54	27.16	26.29	27.16	26.29	27.16	27.16	26.29	27.16	26.29	27.16	(57)
Primary circuit loss for each month from Table 3												
23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss for each month from Table 3a, 3b or 3c

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)
Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m												
193.50	170.68	179.55	161.38	158.45	142.01	136.80	149.54	149.10	167.32	176.39	188.99	(62)
Solar DHW input calculated using Appendix G or Appendix H												
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)
Output from water heater for each month (kWh/month) (62)m + (63)m												
193.50	170.68	179.55	161.38	158.45	142.01	136.80	149.54	149.10	167.32	176.39	188.99	
											∑(64)1...12 =	1973.70 (64)
Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]												
87.91	78.04	83.28	76.47	76.26	70.03	69.06	73.30	72.39	79.21	81.47	86.41	(65)

5. Internal gains

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)												
112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5												
17.65	15.67	12.75	9.65	7.21	6.09	6.58	8.55	11.48	14.58	17.01	18.14	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5												
197.95	200.00	194.83	183.81	169.90	156.82	148.09	146.04	151.21	162.23	176.14	189.22	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5												
34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	(69)
Pump and fan gains (Table 5a)												
3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	(70)
Losses e.g. evaporation (Table 5)												
-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	(71)
Water heating gains (Table 5)												
118.16	116.14	111.93	106.21	102.50	97.27	92.82	98.52	100.54	106.46	113.15	116.15	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m												
393.55	391.61	379.30	359.46	339.40	319.98	307.29	312.90	323.03	343.06	366.10	383.29	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
SouthEast	0.77	x	4.39	x	36.79	x 0.9 x	0.63	x	0.70	=	49.36	(77)
SouthWest	0.54	x	3.08	x	36.79	x 0.9 x	0.63	x	0.70	=	24.29	(79)
SouthWest	0.77	x	4.84	x	36.79	x 0.9 x	0.63	x	0.70	=	54.42	(79)
NorthWest	0.77	x	5.26	x	11.28	x 0.9 x	0.63	x	0.70	=	18.14	(81)

Solar gains in watts ∑(74)m...(82)m

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
146.21	255.08	365.02	479.10	561.11	567.82	542.96	480.13	404.26	286.23	176.23	124.42	(83)
Total gains - internal and solar (73)m + (83)m												
539.77	646.69	744.31	838.56	900.51	887.80	850.25	793.03	727.29	629.30	542.32	507.71	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1(°C)	21.00	(85)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains for living area n1,m (see Table 9a)												
0.99	0.98	0.95	0.87	0.71	0.51	0.37	0.41	0.66	0.91	0.98	1.00	(86)

Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)

20.04	20.24	20.50	20.79	20.94	20.99	21.00	21.00	20.97	20.75	20.34	20.00

(87)

Temperature during heating periods in the rest of dwelling from Table 9, Th2(°C)

20.03	20.04	20.04	20.05	20.05	20.06	20.06	20.07	20.06	20.05	20.05	20.04

(88)

Utilisation factor for gains for rest of dwelling n2,m

0.99	0.98	0.94	0.83	0.65	0.44	0.29	0.33	0.58	0.88	0.98	0.99

(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

18.76	19.06	19.43	19.82	20.00	20.06	20.06	20.07	20.04	19.79	19.22	18.72

(90)

Living area fraction — Living area ÷ (4) = 0.51 (91)

Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2

19.41	19.65	19.98	20.31	20.48	20.53	20.54	20.54	20.51	20.27	19.79	19.37

(92)

Apply adjustment to the mean internal temperature from Table 4e where appropriate

19.41	19.65	19.98	20.31	20.48	20.53	20.54	20.54	20.51	20.27	19.79	19.37

(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	0.99	0.98	0.94	0.84	0.67	0.48	0.33	0.37	0.62	0.89	0.98	0.99	(94)
Useful gains, ηmGm, W (94)m x (84)m	534.28	630.63	698.39	706.21	607.11	422.26	282.43	295.73	448.15	559.29	529.87	503.83	(95)
Monthly average external temperature from Table U1	4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature, Lm, W [(39)m x [(93)m - (96)m]	1126.31	1096.35	998.21	832.70	638.98	426.11	282.86	296.53	462.91	704.11	928.54	1117.04	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	440.46	312.97	223.07	91.07	23.71	0.00	0.00	0.00	0.00	107.75	287.04	456.23	

∑(98)1...5, 10...12 = 1942.29 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) = 27.64 (99)

9a. Energy requirements - individual heating systems including micro-CHP

Space heating

Fraction of space heat from secondary/supplementary system (table 11) — 0.00 (201)

Fraction of space heat from main system(s) — 1 - (201) = 1.00 (202)

Fraction of space heat from main system 2 — 0.00 (202)

Fraction of total space heat from main system 1 — (202) x [1- (203)] = 1.00 (204)

Fraction of total space heat from main system 2 — (202) x (203) = 0.00 (205)

Efficiency of main system 1 (%) — 93.50 (206)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating fuel (main system 1), kWh/month	471.08	334.72	238.57	97.40	25.36	0.00	0.00	0.00	0.00	115.24	307.00	487.95	

∑(211)1...5, 10...12 = 2077.32 (211)

Water heating

Efficiency of water heater	86.94	86.41	85.39	83.36	81.05	79.80	79.80	79.80	79.80	83.68	86.11	87.08	(217)
Water heating fuel, kWh/month	222.56	197.52	210.26	193.60	195.50	177.96	171.43	187.40	186.84	199.96	204.86	217.03	

∑(219a)1...12 = 2364.91 (219)

Annual totals

Space heating fuel - main system 1 — 2077.32

Water heating fuel — 2364.91

Electricity for pumps, fans and electric keep-hot (Table 4f)

central heating pump or water pump within warm air heating unit — 30.00 (230c)

boiler flue fan — 45.00 (230e)

Total electricity for the above, kWh/year — 75.00 (231)

Electricity for lighting (Appendix L) — 311.66 (232)

Total delivered energy for all uses — (211)...(221) + (231) + (232)...(237b) = 4828.89 (238)

10a. Fuel costs - individual heating systems including micro-CHP

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating - main system 1	2077.32	x	3.48	x 0.01 =	72.29	(240)
Water heating	2364.91	x	3.48	x 0.01 =	82.30	(247)
Pumps and fans	75.00	x	13.19	x 0.01 =	9.89	(249)
Electricity for lighting	311.66	x	13.19	x 0.01 =	41.11	(250)
Additional standing charges					120.00	(251)
Total energy cost			(240)...(242) + (245)...(254) =		325.59	(255)

11a. SAP rating - individual heating systems including micro-CHP

Energy cost deflator (Table 12)	0.42	(256)
Energy cost factor (ECF)	1.19	(257)
SAP value	83.45	
SAP rating (section 13)	83	(258)
SAP band	B	

12a. CO_2 emissions - individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO_2/kWh		Emissions kg CO_2/year	
Space heating - main system 1	2077.32	x	0.216	=	448.70	(261)
Water heating	2364.91	x	0.216	=	510.82	(264)
Space and water heating			(261) + (262) + (263) + (264) =		959.52	(265)
Pumps and fans	75.00	x	0.519	=	38.93	(267)
Electricity for lighting	311.66	x	0.519	=	161.75	(268)
Total CO_2, kg/year				(265)...(271) =	1160.20	(272)
Dwelling CO_2 emission rate				(272) ÷ (4) =	16.51	(273)
EI value					86.51	
EI rating (section 14)					87	(274)
EI band					B	

13a. Primary energy - individual heating systems including micro-CHP

	Energy kWh/year		Primary factor		Primary Energy kWh/year	
Space heating - main system 1	2077.32	x	1.22	=	2534.33	(261)
Water heating	2364.91	x	1.22	=	2885.20	(264)
Space and water heating			(261) + (262) + (263) + (264) =		5419.53	(265)
Pumps and fans	75.00	x	3.07	=	230.25	(267)
Electricity for lighting	311.66	x	3.07	=	956.79	(268)
Primary energy kWh/year					6606.57	(272)
Dwelling primary energy rate kWh/m2/year					94.00	(273)

Be Green example data sheet – DER & TER

DER Worksheet
Design - Draft

NHER

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Miss Michelle Wang	Assessor number	2018
Client		Last modified	05/11/2019
Address	Manor Road Richmond Block 1, Richmond, TW9		

1. Overall dwelling dimensions

		Area (m²)		Average storey height (m)		Volume (m³)	
Lowest occupied		70.28	(1a)	x 2.65	(2a) =	186.24	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	70.28	(4)				
Dwelling volume				(3a) + (3b) + (3c) + (3d)...(3n) =		186.24	(5)

2. Ventilation rate

			m³ per hour	
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	0	x 10 =	0	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of flueless gas fires	0	x 40 =	0	(7c)
			Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs	(6a) + (6b) + (7a) + (7b) + (7c) = 0	÷ (5) =	0.00	(8)
If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)				
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area			3.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)			0.15	(18)
Number of sides on which the dwelling is sheltered			2	(19)
Shelter factor		1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor		(18) x (20) =	0.13	(21)

Infiltration rate modified for monthly wind speed:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly average wind speed from Table U2	5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4	1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m	0.16	0.16	0.16	0.14	0.14	0.12	0.12	0.12	0.13	0.14	0.14	0.15	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	0.50	(23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h	76.50	(23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (22b)m + (23b) x [1 - (23c) ÷ 100]

	0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(24a)
Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)													
	0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(25)

3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²		U-value W/m²K		A x U W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Window			21.01	x	1.33	=	27.85			(27)
External wall			39.72	x	0.15	=	5.96			(29a)
External wall			5.37	x	0.01	=	0.05			(29a)
Party wall			33.79	x	0.00	=	0.00			(32)

Total area of external elements ∑A, m²	66.10	(31)
Fabric heat loss, W/K = ∑(A x U)	(26)...(30) + (32) = 33.87	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) = N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K	100.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K	11.02	(36)
Total fabric heat loss	(33) + (36) = 44.89	(37)

Ventilation heat loss calculated monthly 0.33 x (25)m x (5)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
17.21	17.02	16.82	15.84	15.65	14.67	14.67	14.47	15.06	15.65	16.04	16.43	(38)

Heat transfer coefficient, W/K (37)m + (38)m

62.10	61.90	61.71	60.73	60.53	59.55	59.55	59.36	59.94	60.53	60.92	61.31	
									Average = ∑(39)1...12/12 =		60.68	(39)

Heat loss parameter (HLP), W/m²K (39)m ÷ (4)

0.88	0.88	0.88	0.86	0.86	0.85	0.85	0.84	0.85	0.86	0.87	0.87	
									Average = ∑(40)1...12/12 =		0.86	(40)

Number of days in month (Table 1a)

31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	2.25	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	87.71	(43)

Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
96.48	92.97	89.46	85.95	82.44	78.94	78.94	82.44	85.95	89.46	92.97	96.48	
										∑(44)1...12 =	1052.48	(44)

Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)

143.07	125.13	129.13	112.57	108.02	93.21	86.37	99.12	100.30	116.89	127.59	138.56	
										∑(45)1...12 =	1379.96	(45)

Distribution loss 0.15 x (45)m

21.46	18.77	19.37	16.89	16.20	13.98	12.96	14.87	15.04	17.53	19.14	20.78	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	194.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	1.61	(48)
Temperature factor from Table 2b	0.60	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.97	(50)
Enter (50) or (54) in (55)	0.97	(55)

Water storage loss calculated for each month (55) x (41)m

29.95	27.05	29.95	28.98	29.95	28.98	29.95	29.95	28.98	29.95	28.98	29.95	(56)

If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)

29.95	27.05	29.95	28.98	29.95	28.98	29.95	29.95	28.98	29.95	28.98	29.95	(57)

Primary circuit loss for each month from Table 3

23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss for each month from Table 3a, 3b or 3c

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)

Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m

196.28	173.19	182.33	164.07	161.23	144.70	139.58	152.32	151.79	170.10	179.09	191.77	(62)

Solar DHW input calculated using Appendix G or Appendix H

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)

Output from water heater for each month (kWh/month) (62)m + (63)m

196.28	173.19	182.33	164.07	161.23	144.70	139.58	152.32	151.79	170.10	179.09	191.77	
											∑(64)1...12 = 2006.45	(64)

Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]

90.14	80.05	85.50	78.62	78.48	72.19	71.29	75.52	74.54	81.43	83.62	88.64	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	17.65	15.67	12.75	9.65	7.21	6.09	6.58	8.55	11.48	14.58	17.01	18.14	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	197.95	200.00	194.83	183.81	169.90	156.82	148.09	146.04	151.21	162.23	176.14	189.22	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	(69)
Pump and fan gains (Table 5a)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(70)
Losses e.g. evaporation (Table 5)	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	(71)
Water heating gains (Table 5)	121.15	119.13	114.92	109.20	105.49	100.26	95.81	101.51	103.53	109.45	116.14	119.14	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	393.54	391.60	379.29	359.45	339.39	319.97	307.28	312.89	323.02	343.05	366.09	383.28	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
SouthEast	0.77	x	5.25	x	36.79	x 0.9 x	0.40	x	0.90	=	48.19	(77)
SouthWest	0.54	x	3.68	x	36.79	x 0.9 x	0.40	x	0.90	=	23.69	(79)
SouthWest	0.77	x	5.78	x	36.79	x 0.9 x	0.40	x	0.90	=	53.06	(79)
NorthWest	0.77	x	6.30	x	11.28	x 0.9 x	0.40	x	0.90	=	17.73	(81)

Solar gains in watts ∑(74)m...(82)m

142.67	248.91	356.22	467.60	547.69	554.25	529.98	468.62	394.54	279.32	171.96	121.40	(83)

Total gains - internal and solar (73)m + (83)m

536.22	640.51	735.51	827.05	887.08	874.22	837.26	781.51	717.56	622.37	538.05	504.69	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1(°C) 21.00 (85)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Utilisation factor for gains for living area n1,m (see Table 9a)

0.93	0.89	0.83	0.71	0.57	0.42	0.31	0.34	0.53	0.76	0.90	0.94	(86)

Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)

19.50	19.81	20.19	20.59	20.84	20.96	20.99	20.98	20.90	20.56	19.97	19.44	(87)

Temperature during heating periods in the rest of dwelling from Table 9, Th2(°C)

20.18	20.18	20.19	20.20	20.20	20.21	20.21	20.21	20.21	20.20	20.20	20.19	(88)

Utilisation factor for gains for rest of dwelling n2,m

0.92	0.88	0.81	0.68	0.53	0.37	0.25	0.29	0.48	0.73	0.88	0.93	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

18.17	18.61	19.15	19.70	20.02	20.17	20.20	20.20	20.11	19.68	18.86	18.10	(90)

Living area fraction — Living area ÷ (4) = 0.51 (91)

Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2

18.84	19.22	19.68	20.15	20.43	20.57	20.60	20.60	20.51	20.13	19.42	18.78	(92)

Apply adjustment to the mean internal temperature from Table 4e where appropriate

18.84	19.22	19.68	20.15	20.43	20.57	20.60	20.60	20.51	20.13	19.42	18.78	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	0.91	0.86	0.79	0.68	0.54	0.39	0.28	0.31	0.50	0.73	0.87	0.92	(94)
Useful gains, ηmGm, W (94)m x (84)m	487.02	552.42	583.41	564.02	481.32	343.16	235.12	244.69	357.84	453.98	466.36	463.94	(95)
Monthly average external temperature from Table U1	4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature, Lm, W [(39)m x [(93)m - (96)m]	903.03	886.28	813.22	683.18	528.69	355.44	238.25	249.13	384.49	576.79	750.84	893.76	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	309.52	224.35	170.98	85.80	35.24	0.00	0.00	0.00	0.00	91.37	204.82	319.78	

∑(98)1...5, 10...12 = 1441.87 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) = 20.52 (99)

8c. Space cooling requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Heat loss rate Lm	0.00	0.00	0.00	0.00	0.00	559.78	440.68	451.10	0.00	0.00	0.00	0.00	(100)
Utilisation factor for loss ηm	0.00	0.00	0.00	0.00	0.00	0.94	0.96	0.95	0.00	0.00	0.00	0.00	(101)
Useful loss ηmLm (watts) (100)m x (101)m	0.00	0.00	0.00	0.00	0.00	526.03	424.47	430.53	0.00	0.00	0.00	0.00	(102)
Gains	0.00	0.00	0.00	0.00	0.00	1102.90	1057.93	992.99	0.00	0.00	0.00	0.00	(103)
Space cooling requirement, whole dwelling, continuous (kWh) 0.024 x [(103)m - (102)m] x (41)m	0.00	0.00	0.00	0.00	0.00	415.35	471.29	418.47	0.00	0.00	0.00	0.00	

∑(104)6...8 = 1305.12 (104)

Cooled fraction — cooled area ÷ (4) = 0.51 (105)

Intermittency factor (Table 10)

0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.00	0.00	0.00	0.00	

∑(106)6...8 = 0.75 (106)

Space cooling requirement (104)m x (105) x (106)m

0.00	0.00	0.00	0.00	0.00	52.61	59.70	53.01	0.00	0.00	0.00	0.00	

∑(107)6...8 = 165.32 (107)

Space cooling requirement kWh/m²/year — (107) ÷ (4) = 2.35 (108)

9b. Energy requirements - community heating scheme

Fraction of space heat from secondary/supplementary system (table 11)	'0' if none 0.00	(301)
Fraction of space heat from community system	1 - (301) = 1.00	(302)
Fraction of community heat from heat pump	1.00	(303a)
Fraction of total space heat from community heat pump	(302) x (303a) = 1.00	(304a)
Factor for control and charging method (Table 4c(3)) for community space heating	1.00	(305)
Factor for charging method (Table 4c(3)) for community water heating	1.00	(305a)
Distribution loss factor (Table 12c) for community heating system	1.07	(306)
Space heating		
Annual space heating requirement	1441.87	(98)
Space heat from heat pump	(98) x (304a) x (305) x (306) = 1542.80	(307a)
Water heating		
Annual water heating requirement	2006.45	(64)
Water heat from heat pump	(64) x (303a) x (305a) x (306) = 2146.90	(310a)
Electricity used for heat distribution	0.01 × [(307a)...(307e) + (310a)...(310e)] = 36.90	(313)
Cooling System Energy Efficiency Ratio	4.05	(314)
Space cooling (if there is a fixed cooling system, if not enter 0)	(107) ÷ (314) = 40.82	(315)
Electricity for pumps, fans and electric keep-hot (Table 4f)		
mechanical ventilation fans - balanced, extract or positive input from outside	174.96	(330a)
Total electricity for the above, kWh/year	174.96	(331)
Electricity for lighting (Appendix L)	311.66	(332)
Total delivered energy for all uses	(307) + (309) + (310) + (312) + (315) + (331) + (332)...(337b) = 4217.14	(338)

10b. Fuel costs - community heating scheme

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating from heat pump	1542.80	x	4.24	x 0.01 =	65.41	(340a)
Water heating from heat pump	2146.90	x	4.24	x 0.01 =	91.03	(342a)
Space cooling	40.82	x	13.19	x 0.01 =	5.38	(348)
Pumps and fans	174.96	x	13.19	x 0.01 =	23.08	(349)
Electricity for lighting	311.66	x	13.19	x 0.01 =	41.11	(350)
Additional standing charges					120.00	(351)
Total energy cost			(340a)...(342e) + (345)...(354) =		346.01	(355)

11b. SAP rating - community heating scheme

Energy cost deflator (Table 12)	0.42	(356)
Energy cost factor (ECF)	1.26	(357)
SAP value	82.41	
SAP rating (section 13)	82	(358)
SAP band	B	

12b. CO_2 emissions - community heating scheme

	Energy kWh/year		Emission factor		Emissions (kg/year)	
Emissions from other sources (space heating)						
Efficiency of heat pump	180.00					(367a)
CO2 emissions from heat pump [(307a)+(310a)] x 100 ÷ (367a) =	2049.84	x	0.519	=	1063.86	(367)
Electrical energy for community heat distribution	36.90	x	0.519	=	19.15	(372)
Total CO2 associated with community systems					1083.01	(373)
Total CO2 associated with space and water heating					1083.01	(376)
Space cooling	40.82	x	0.519	=	21.19	(377)
Pumps and fans	174.96	x	0.519	=	90.80	(378)
Electricity for lighting	311.66	x	0.519	=	161.75	(379)
Total CO_2, kg/year				(376)..(382) =	1356.75	(383)
Dwelling CO_2 emission rate				(383) ÷ (4) =	19.30	(384)
EI value					84.23	
EI rating (section 14)					84	(385)
EI band					B	

13b. Primary energy - community heating scheme

	Energy kWh/year		Primary factor		Primary energy (kWh/year)	
Primary energy from other sources (space heating)						
Efficiency of heat pump	180.00					(367a)
Primary energy from heat pump [(307a)+(310a)] x 100 ÷ (367a) =	2049.84	x	3.07	=	6292.99	(367)
Electrical energy for community heat distribution	36.90	x	3.07	=	113.27	(372)
Total primary energy associated with community systems					6406.27	(373)
Total primary energy associated with space and water heating					6406.27	(376)
Space cooling	40.82	x	3.07	=	125.32	(377)
Pumps and fans	174.96	x	3.07	=	537.11	(378)
Electricity for lighting	311.66	x	3.07	=	956.79	(379)
Primary energy kWh/year					8025.49	(383)
Dwelling primary energy rate kWh/m2/year					114.19	(384)

TER Worksheet
Design - Draft

NHER

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Miss Michelle Wang	Assessor number	2018
Client		Last modified	05/11/2019
Address	Manor Road Richmond Block 1, Richmond, TW9		

1. Overall dwelling dimensions

	Area (m²)		Average storey height (m)		Volume (m³)	
Lowest occupied	70.28 (1a)	x	2.65 (2a)	=	186.24	(3a)
Total floor area (1a) + (1b) + (1c) + (1d)...(1n) =	70.28 (4)					
Dwelling volume			(3a) + (3b) + (3c) + (3d)...(3n) =		186.24	(5)

2. Ventilation rate

			m³ per hour	
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	3	x 10 =	30	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of flueless gas fires	0	x 40 =	0	(7c)
			Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs (6a) + (6b) + (7a) + (7b) + (7c) =	30	÷ (5) =	0.16	(8)
If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)				
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area			5.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)			0.41	(18)
Number of sides on which the dwelling is sheltered			2	(19)
Shelter factor		1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor		(18) x (20) =	0.35	(21)

Infiltration rate modified for monthly wind speed:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly average wind speed from Table U2												
5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4												
1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m												
0.45	0.44	0.43	0.38	0.38	0.33	0.33	0.32	0.35	0.38	0.39	0.41	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	N/A	(23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h	N/A	(23c)
d) natural ventilation or whole house positive input ventilation from loft		

0.60	0.60	0.59	0.57	0.57	0.56	0.55	0.56	0.57	0.58	0.58		(24d)
Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)												
0.60	0.60	0.59	0.57	0.57	0.56	0.56	0.55	0.56	0.57	0.58	0.58	(25)

3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²		U-value W/m²K		A x U W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Window			17.57	x	1.33	=	23.29			(27)
External wall			48.50	x	0.18	=	8.73			(29a)
Party wall			33.79	x	0.00	=	0.00			(32)
Total area of external elements ∑A, m²			66.07							(31)
Fabric heat loss, W/K = ∑(A x U)							(26)...(30) + (32) =		32.02	(33)
Heat capacity Cm = ∑(A x κ)							(28)...(30) + (32) + (32a)...(32e) =		N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K									250.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K									5.69	(36)
Total fabric heat loss									(33) + (36) = 37.71	(37)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)												
36.83	36.59	36.36	35.27	35.07	34.12	34.12	33.94	34.48	35.07	35.48	35.91	(38)
Heat transfer coefficient, W/K (37)m + (38)m												
74.54	74.31	74.07	72.98	72.78	71.83	71.83	71.65	72.20	72.78	73.19	73.62	
										Average = ∑(39)1...12/12 =		72.98 (39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)												
1.06	1.06	1.05	1.04	1.04	1.02	1.02	1.02	1.03	1.04	1.04	1.05	
										Average = ∑(40)1...12/12 =		1.04 (40)
Number of days in month (Table 1a)												
31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	2.25	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	87.71	(43)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)												
96.48	92.97	89.46	85.95	82.44	78.94	78.94	82.44	85.95	89.46	92.97	96.48	
										∑(44)1...12 =		1052.48 (44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)												
143.07	125.13	129.13	112.57	108.02	93.21	86.37	99.12	100.30	116.89	127.59	138.56	
										∑(45)1...12 =		1379.96 (45)
Distribution loss 0.15 x (45)m												
21.46	18.77	19.37	16.89	16.20	13.98	12.96	14.87	15.04	17.53	19.14	20.78	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	194.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	1.62	(48)
Temperature factor from Table 2b	0.54	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.88	(50)
Enter (50) or (54) in (55)	0.88	(55)

Water storage loss calculated for each month (55) x (41)m

27.16	24.54	27.16	26.29	27.16	26.29	27.16	27.16	26.29	27.16	26.29	27.16	(56)

If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)

27.16	24.54	27.16	26.29	27.16	26.29	27.16	27.16	26.29	27.16	26.29	27.16	(57)
Primary circuit loss for each month from Table 3												
23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss for each month from Table 3a, 3b or 3c

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)
Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m												
193.50	170.68	179.55	161.38	158.45	142.01	136.80	149.54	149.10	167.32	176.39	188.99	(62)
Solar DHW input calculated using Appendix G or Appendix H												
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)
Output from water heater for each month (kWh/month) (62)m + (63)m												
193.50	170.68	179.55	161.38	158.45	142.01	136.80	149.54	149.10	167.32	176.39	188.99	
											∑(64)1...12 =	1973.70 (64)
Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]												
87.91	78.04	83.28	76.47	76.26	70.03	69.06	73.30	72.39	79.21	81.47	86.41	(65)

5. Internal gains

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)												
112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5												
17.65	15.67	12.75	9.65	7.21	6.09	6.58	8.55	11.48	14.58	17.01	18.14	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5												
197.95	200.00	194.83	183.81	169.90	156.82	148.09	146.04	151.21	162.23	176.14	189.22	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5												
34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	(69)
Pump and fan gains (Table 5a)												
3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	(70)
Losses e.g. evaporation (Table 5)												
-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	(71)
Water heating gains (Table 5)												
118.16	116.14	111.93	106.21	102.50	97.27	92.82	98.52	100.54	106.46	113.15	116.15	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m												
393.55	391.61	379.30	359.46	339.40	319.98	307.29	312.90	323.03	343.06	366.10	383.29	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
SouthEast	0.77	x	4.39	x	36.79	x 0.9 x	0.63	x	0.70	=	49.36	(77)
SouthWest	0.54	x	3.08	x	36.79	x 0.9 x	0.63	x	0.70	=	24.29	(79)
SouthWest	0.77	x	4.84	x	36.79	x 0.9 x	0.63	x	0.70	=	54.42	(79)
NorthWest	0.77	x	5.26	x	11.28	x 0.9 x	0.63	x	0.70	=	18.14	(81)

Solar gains in watts ∑(74)m...(82)m

146.21	255.08	365.02	479.10	561.11	567.82	542.96	480.13	404.26	286.23	176.23	124.42	(83)
Total gains - internal and solar (73)m + (83)m												
539.77	646.69	744.31	838.56	900.51	887.80	850.25	793.03	727.29	629.30	542.32	507.71	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1(°C)	21.00	(85)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains for living area n1,m (see Table 9a)												
0.99	0.98	0.95	0.87	0.71	0.51	0.37	0.41	0.66	0.91	0.98	1.00	(86)

Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)

20.04	20.24	20.50	20.79	20.94	20.99	21.00	21.00	20.97	20.75	20.34	20.00

(87)

Temperature during heating periods in the rest of dwelling from Table 9, Th2(°C)

20.03	20.04	20.04	20.05	20.05	20.06	20.06	20.07	20.06	20.05	20.05	20.04

(88)

Utilisation factor for gains for rest of dwelling n2,m

0.99	0.98	0.94	0.83	0.65	0.44	0.29	0.33	0.58	0.88	0.98	0.99

(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

18.76	19.06	19.43	19.82	20.00	20.06	20.06	20.07	20.04	19.79	19.22	18.72

(90)

Living area fraction — Living area ÷ (4) = 0.51 (91)

Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2

19.41	19.65	19.98	20.31	20.48	20.53	20.54	20.54	20.51	20.27	19.79	19.37

(92)

Apply adjustment to the mean internal temperature from Table 4e where appropriate

19.41	19.65	19.98	20.31	20.48	20.53	20.54	20.54	20.51	20.27	19.79	19.37

(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	0.99	0.98	0.94	0.84	0.67	0.48	0.33	0.37	0.62	0.89	0.98	0.99	(94)
Useful gains, ηmGm, W (94)m x (84)m	534.28	630.63	698.39	706.21	607.11	422.26	282.43	295.73	448.15	559.29	529.87	503.83	(95)
Monthly average external temperature from Table U1	4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature, Lm, W [(39)m x [(93)m - (96)m]	1126.31	1096.35	998.21	832.70	638.98	426.11	282.86	296.53	462.91	704.11	928.54	1117.04	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	440.46	312.97	223.07	91.07	23.71	0.00	0.00	0.00	0.00	107.75	287.04	456.23	

∑(98)1...5, 10...12 = 1942.29 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) = 27.64 (99)

9a. Energy requirements - individual heating systems including micro-CHP

Space heating

Fraction of space heat from secondary/supplementary system (table 11) — 0.00 (201)

Fraction of space heat from main system(s) — 1 - (201) = 1.00 (202)

Fraction of space heat from main system 2 — 0.00 (202)

Fraction of total space heat from main system 1 — (202) x [1- (203)] = 1.00 (204)

Fraction of total space heat from main system 2 — (202) x (203) = 0.00 (205)

Efficiency of main system 1 (%) — 93.50 (206)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating fuel (main system 1), kWh/month	471.08	334.72	238.57	97.40	25.36	0.00	0.00	0.00	0.00	115.24	307.00	487.95	

∑(211)1...5, 10...12 = 2077.32 (211)

Water heating

Efficiency of water heater	86.94	86.41	85.39	83.36	81.05	79.80	79.80	79.80	79.80	83.68	86.11	87.08	(217)
Water heating fuel, kWh/month	222.56	197.52	210.26	193.60	195.50	177.96	171.43	187.40	186.84	199.96	204.86	217.03	

∑(219a)1...12 = 2364.91 (219)

Annual totals

Space heating fuel - main system 1 — 2077.32

Water heating fuel — 2364.91

Electricity for pumps, fans and electric keep-hot (Table 4f)

central heating pump or water pump within warm air heating unit — 30.00 (230c)

boiler flue fan — 45.00 (230e)

Total electricity for the above, kWh/year — 75.00 (231)

Electricity for lighting (Appendix L) — 311.66 (232)

Total delivered energy for all uses — (211)...(221) + (231) + (232)...(237b) = 4828.89 (238)

10a. Fuel costs - individual heating systems including micro-CHP

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating - main system 1	2077.32	x	3.48	x 0.01 =	72.29	(240)
Water heating	2364.91	x	3.48	x 0.01 =	82.30	(247)
Pumps and fans	75.00	x	13.19	x 0.01 =	9.89	(249)
Electricity for lighting	311.66	x	13.19	x 0.01 =	41.11	(250)
Additional standing charges					120.00	(251)
Total energy cost			(240)...(242) + (245)...(254) =		325.59	(255)

11a. SAP rating - individual heating systems including micro-CHP

Energy cost deflator (Table 12)	0.42 (256)
Energy cost factor (ECF)	1.19 (257)
SAP value	83.45
SAP rating (section 13)	83 (258)
SAP band	B

12a. CO_2 emissions - individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO_2/kWh		Emissions kg CO_2/year	
Space heating - main system 1	2077.32	x	0.216	=	448.70	(261)
Water heating	2364.91	x	0.216	=	510.82	(264)
Space and water heating			(261) + (262) + (263) + (264) =		959.52	(265)
Pumps and fans	75.00	x	0.519	=	38.93	(267)
Electricity for lighting	311.66	x	0.519	=	161.75	(268)
Total CO_2, kg/year				(265)...(271) =	1160.20	(272)
Dwelling CO_2 emission rate				(272) ÷ (4) =	24.02	(273)
EI value					86.51	
EI rating (section 14)					87	(274)
EI band					B	

13a. Primary energy - individual heating systems including micro-CHP

	Energy kWh/year		Primary factor		Primary Energy kWh/year	
Space heating - main system 1	2077.32	x	1.22	=	2534.33	(261)
Water heating	2364.91	x	1.22	=	2885.20	(264)
Space and water heating			(261) + (262) + (263) + (264) =		5419.53	(265)
Pumps and fans	75.00	x	3.07	=	230.25	(267)
Electricity for lighting	311.66	x	3.07	=	956.79	(268)
Primary energy kWh/year					6606.57	(272)
Dwelling primary energy rate kWh/m2/year					94.00	(273)

Appendix I: BRUKL summary

Be lean BRUKL

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Manor Road - Retail A1 (Lean) As designed

Date: Fri Jan 25 17:34:01 2019

Administrative information

Building Details
Address: Richmond, London, TW9

Certification tool
Calculation engine: Apache
Calculation engine version: 7.0.10
Interface to calculation engine: IES Virtual Environment
Interface to calculation engine version: 7.0.10
BRUKL compliance check version: v5.4.b.0

Owner Details
Name: Avanton Richmond Development Ltd.
Telephone number:
Address: , ,

Certifier details
Name:
Telephone number:
Address: , ,

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	43.8
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	43.8
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	33.6
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{b\text{-}Limit}$	$U_{b\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.15	0.15	00000001:Surf[2]
Floor	0.25	0.13	0.13	00000001:Surf[0]
Roof	0.25	0.16	0.16	00000001:Surf[1]
Windows***, roof windows, and rooflights	2.2	1.4	1.4	00000001:Surf[3]
Personnel doors	2.2	1.4	1.4	00000001:Surf[4]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{b\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$]
$U_{b\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$] $U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	3

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Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	434.5	434.5
External area [m^2]	965.6	965.6
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	3	3
Average conductance [W/K]	311.82	399.49
Average U-value [W/m^2K]	0.32	0.41
Alpha value* [%]	10	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
100	**A1/A2 Retail/Financial and Professional services**
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	11.55	13.15
Cooling	5.88	8.82
Auxiliary	16.97	17.66
Lighting	37.77	53.7
Hot water	1.86	1.86
Equipment*	20.26	20.26
TOTAL**	**74.04**	**95.19**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	127.99	161.17
Primary energy* [kWh/m^2]	197.83	258.32
Total emissions [kg/m^2]	33.6	43.8

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

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Be green BRUKL

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Manor Road - Retail A1 (Green)

As designed

Date: Fri Jan 25 17:39:38 2019

Administrative information

Building Details

Address: Richmond, London, TW9

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.10

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.10

BRUKL compliance check version: v5.4.b.0

Owner Details

Name: Avanton Richmond Development Ltd.

Telephone number:

Address: , ,

Certifier details

Name:

Telephone number:

Address: , ,

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	36
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	36
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	27.3
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{k\text{-}Limit}$	$U_{k\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.15	0.15	00000001:Surf[2]
Floor	0.25	0.13	0.13	00000001:Surf[0]
Roof	0.25	0.16	0.16	00000001:Surf[1]
Windows***, roof windows, and rooflights	2.2	1.4	1.4	00000001:Surf[3]
Personnel doors	2.2	1.4	1.4	00000001:Surf[4]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{k\text{-}Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
$U_{k\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]
$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	3

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Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	434.5	434.5
External area [m²]	965.6	965.6
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	311.82	399.49
Average U-value [W/m²K]	0.32	0.41
Alpha value* [%]	10	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
100	**A1/A2 Retail/Financial and Professional services**
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	1.98	4.43
Cooling	5.32	8.82
Auxiliary	7.13	3.06
Lighting	37.77	53.7
Hot water	1.7	1.86
Equipment*	20.26	20.26
TOTAL**	**53.9**	**71.88**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	127.99	161.17
Primary energy* [kWh/m²]	167.27	224.88
Total emissions [kg/m²]	27.3	36

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

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Appendix J: Boiler and ASHP operational cost analysis

	Communal gas boiler				**ASHP + local storage with immersion**				**ASHP + local storage with immersion**		
	Communal gas boiler				**Building-by-building ASHP**				**Building-by-building ASHP**		
	Equivalent heat price	p/kWh	**4.0**		Equivalent heat price (inc. RHI)	p/kWh	**2.4**		Equivalent heat price (excl. RHI)	p/kWh	**5.2**
System Inputs	Tenant heat demand	kWh/yr	1		Tenant heat demand	kWh/yr	1		Tenant heat demand	kWh/yr	1
	Proportion of demand is space heat	-	0.50		Proportion of demand is space heat	-	0.33		Proportion of demand is space heat	-	0.33
	Proportion of demand is DHW	-	0.50		Proportion of demand is DHW	-	0.67		Proportion of demand is DHW	-	0.67
	Communal distribution heat losses	-	0.30		Building by Building distribution heat losses	-	0.11		Building by Building distribution heat losses	-	0.11
	Communal storage heat losses	-	0.00		Communal storage heat losses	-	0.00		Communal storage heat losses	-	0.00
	Gas boiler efficiency	-	0.95		Gas boiler efficiency	-	-		Gas boiler efficiency	-	-
	Pumping energy % of heat generated	-	0.01		Pumping energy % of heat generated	-	0.01		Pumping energy % of heat generated	-	0.01
	Cold water flow temp	C	10		Cold water flow temp	C	10		Cold water flow temp	C	10
	Hot water storage temp	C	-		Hot water storage temp	C	60		Hot water storage temp	C	60
	Communal distribution flow temp	C	70		Communal distribution flow temp	C	55		Communal distribution flow temp	C	55
	Communal distribution return temp	C	40		Communal distribution return temp	C	30		Communal distribution return temp	C	30
					Electric heating efficiency	-	1.00		Electric heating efficiency	-	1.00
					ASHP heating efficiency	-	2.90		ASHP heating efficiency	-	2.90
Calculation	Heat generated	kWh/yr	1.429		Percentage of communal hot water	-	0.90		Percentage of communal hot water	-	0.90
					Percentage of local storage hot water	-	0.10		Percentage of local storage hot water	-	0.10
					ASHP heat generated	kWh/yr	1.049		ASHP heat generated	kWh/yr	1.049
					Electric heat generated	kWh/yr	0.067		Electric heat generated	kWh/yr	0.067
Output (heat system)	Landlord gas consumption	kWh/yr	1.504		Landlord gas consumption	kWh/yr	0.000		Landlord gas consumption	kWh/yr	0.000
	Landlord electricity consumption	kWh/yr	0.014		Landlord electricity consumption	kWh/yr	0.372		Landlord electricity consumption	kWh/yr	0.372
	Tenant electricity consumption	kWh/yr	0.000		Tenant electricity consumption	kWh/yr	0.067		Tenant electricity consumption	kWh/yr	0.067
	Total net energy consumption	kWh/yr	1.518		Total net energy consumption	kWh/yr	0.439		Total net energy consumption	kWh/yr	0.439
	Landlord gas consumption	p	3.865		Landlord gas consumption	p	0.000		Landlord gas consumption	p	0.000
	Landlord electricity consumption	p	0.158		Landlord electricity consumption	p	4.108		Landlord electricity consumption	p	4.108
	Landlord RHI	p	0.000		Landlord RHI	p	-2.821		Landlord RHI	p	0.000
	Tenant gas consumption	p	0.000		Tenant gas consumption	p	0.000		Tenant gas consumption	p	0.000
	Tenant electricity consumption	p	0.000		Tenant electricity consumption	p	1.099		Tenant electricity consumption	p	1.099
	Total energy consumption	p	4.022		Total energy cost	p	2.386		Total energy cost	p	5.207

Table 24: Boiler & ASHP operational cost analysis inputs and results

Appendix K: Centralised vs decentralised analysis

Centralised vs decentralised energy strategy analysis.
Manor Road, Richmond.

Introduction.

This report has been produced on behalf of Avanton Richmond Development Ltd to assess the implications of providing a centralised district heating network for the proposed development at Manor Road, Richmond.

The energy strategy is based upon a number of decentralised air source heat pumps, which are utilised to generate the heating and hot water for the residential elements of the development.

This report assesses the approximate additional heat losses and power consumption involved in providing a district network, and discusses how a future district heating network could be planned for within the development.

Development proposals.

The proposal for the development is to provide a decentralised energy strategy, with a 'bank' of heat pumps per core. This is primarily due to the absence of a single roof area which can accommodate the heating requirements for the whole development. This is demonstrated in Figure 1. In addition, centralising the heating generation would have other planning implications, including massing, views and acoustics. The heat pump configuration is generally modular, and as such limited benefit is gained from utilising larger central plant.

Therefore, the current proposed strategy includes space allocation which has been made for future plate heat exchangers at the ground floor to each building, and the pipework in all risers appropriately sized to be able to serve each building bottom-up in future, in addition to the current top-down arrangement. It is further proposed to include full trenching between all buildings, with space allocation made for future district heating pipework. A further space allocation has been made for a plate heat exchanger at the ground floor near to the site entrance, so that a future potential district energy network would only require one connection point. Pipework sleeves will be included through the building envelope at the location of each future plate heat exchanger to further ease future connection, should a viable option become available in the vicinity of the site in future. This is shown in Figure 2.

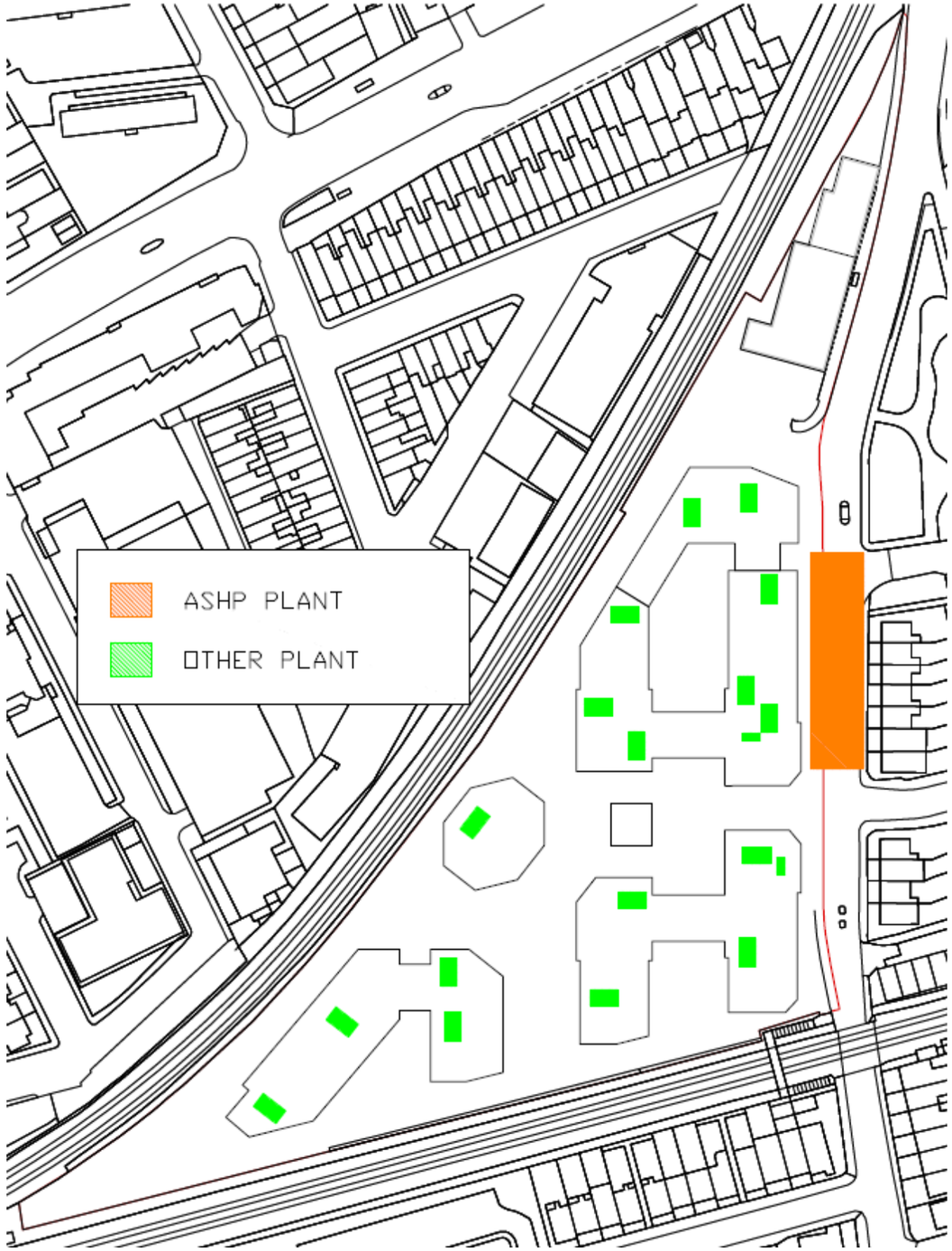

Figure 1: Approximate centralised ASHP plant space requirements

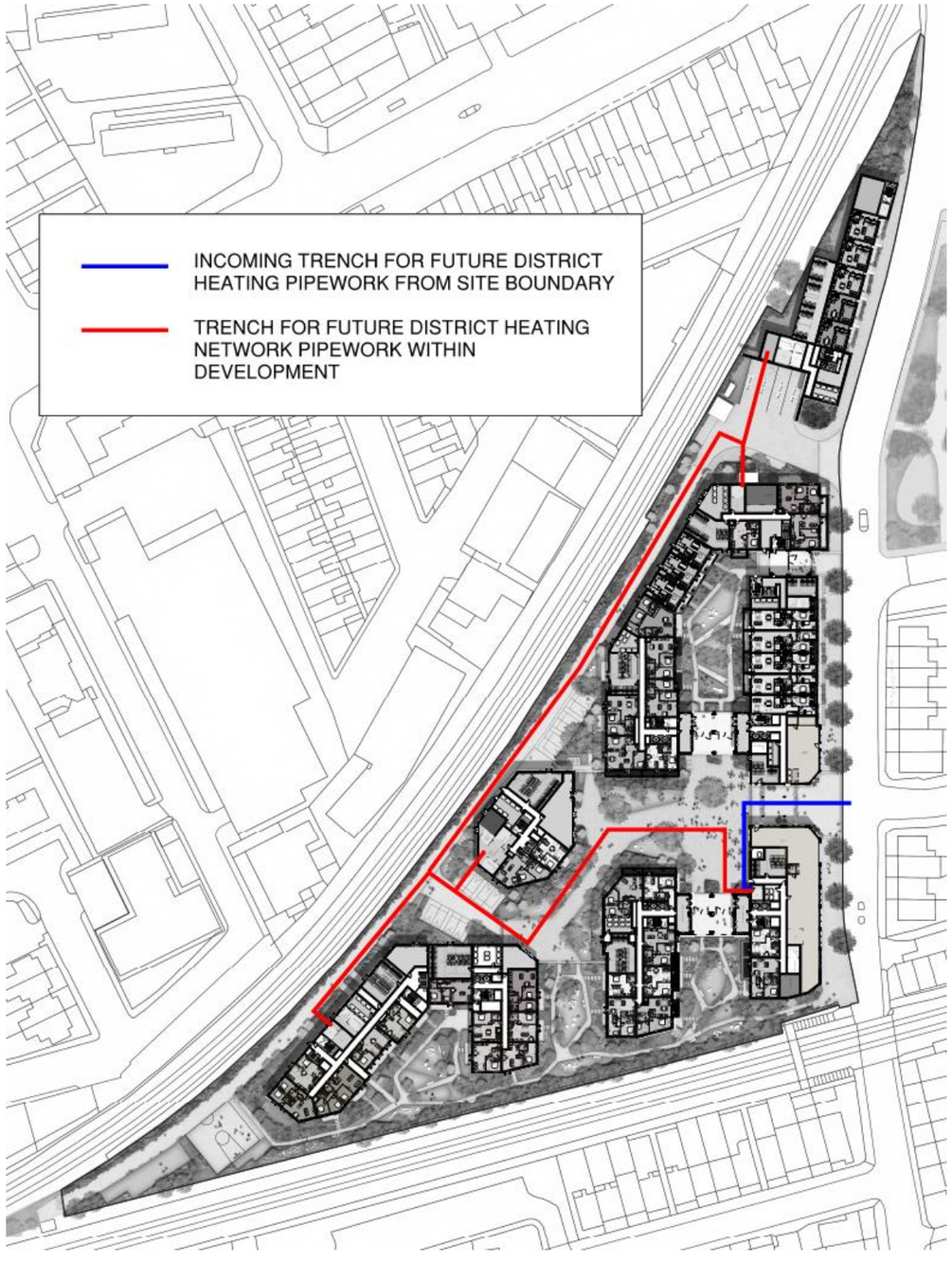

Figure 2: Indicative trench route for future district heating pipework

District network assessment.

This section assesses the viability and the implications of providing a district heating network at day one.

Inter-connectivity

A route has been planned through the development which would allow inter-connectivity between each of the blocks, which would facilitate connection to a district heating network.

A pre-built trench has been planned and safeguarded from the site boundary which allows a single point of connection from a future district heat network to a central future plate heat exchanger. Trenching has been allowed between each of the future district heating plate heat exchangers, which would allow interconnectivity of the blocks in the event of a district network coming on line. Additionally, builderswork has been considered at the boundary of each building, and it is proposed that pre-cast/ pre-installed sleeves will be provided, to allow the pipework to enter the building with minimal disruption, and minimum additional cost incurred to a future network energy provider.

Hydraulic considerations.

It has been considered whether connecting capped pipework between all buildings could be provided at day one. However, this option has been disregarding for the following reasons:

- the risk that the pipework may never be used, therefore the embodied carbon associated with the installed pipework would be spent at no additional benefit to the scheme
- the difficulty in stopping the pipework corroding/ deteriorating over time
- potential warranty issues with connecting to the pipework when it has been left unused for a period of time.

Additional energy consumption

It has also been considered whether connecting, 'live' distribution pipework between all buildings could be provided at day one. However, this option has been disregarding for the following reasons:

Owing to the nature of air source heat pumps being located locally at roof level of each building, for the reasons outlined in the previous section, providing interconnecting pipework at day one will not yield a saving in terms of energy or carbon emissions. The below summary table shows the approximate additional heat and energy demand to the scheme that would be expected to result from inter-connecting the buildings.

Also, given there is very limited non-domestic uses at this development, there is little likelihood of achieving an energy-sharing scenario.

In summary, this would mean that the additional energy lost in the distribution pipework would not be expected to be made up for by any savings from a sitewide connection.

Building Distribution Heat Losses		
Estimated Heat Loss per metre (vertical pipework)	6	W
Estimated Heat Loss per metre (lateral pipework)	4	W
Estimated Annual Heat Loss per core	12089	kWh
Estimated Annual Heat Loss	120888	kWh
District Network Distribution Heat Losses		
Estimated Buried Pipework Length	800	m
Estimated Heat Loss per metre	15	W
Estimated Heat Loss per PHX	750	W
Total Annual Heat Loss	137970	kWh
Estimated additional pump power	5000	W
Total Annual Energy Loss	181770	kWh
Estimated annual total heat demand	1670400	kWh
Estimated district heating distribution losses (without centralised network)	7%	
Estimated district heating distribution losses (with centralised network)	18%	

Table 1: Summary of energy losses in centralised and decentralised distribution networks

Summary

In summary, it is expected that the operational energy lost in any installed distribution pipework would not be counter-acted by any savings resulting from such a sitewide connection.

It is also not proposed to install capped pipework on day one, as it is known from experience that such pipework often is not fit for purpose once it may come to be used. Further, additional embodied carbon would be expected to result from installing such district energy pipework.

Instead it is proposed to make allocations for heat exchangers, full trenching, and pipework sleeves as described above, in order to facilitate a future energy network connection at minimal disruption to residents, and minimal cost to the installer.

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