ZERO CARBON HUB

Carbon Compliance Standard
Technical Working Group

SUMMARY OF OUTPUTS:

Technical Feasibility Matrix

Items to note

Technical Work Group discussions have led to the following recommendations for the Task Group:

- For houses, decision on level should be based on having technically feasible individual technology options available
- For apartment blocks, decision on level could be based on having technically feasible individual or shared technology options available
- Apartment blocks above 4-storey could be seen as exceptional cases

In the context of this paper, the cut-off for technical feasibility is defined as requiring maximum PV panel area of 40% ground floor area of dwelling* (i.e. prior to requiring solar design). 40% was considered a practical limit for PV within a policy that describes a minimum performance standard applicable to every new home.

* PV figures have been updated to take into account output from SE/SW facing panels at 45deg pitch (rather than S facing at 30deg pitch)

Houses

Core technology options modelled

Individual

- Instantaneous electric
- Gas combi boiler
- Gas boiler
- Gas boiler + SHW
- ASHP

Communal

- GSHP
- Biomass boiler
- Gas CHP + Gas boiler

Tech options on which to base decision

Individual

- Gas boiler
- Gas boiler + SHW
- ASHP
- ASHP + SHW

Communal

- [none]

Why?

- Level must work at individual house development scale (availability of comm. solutions are ‘upside’)
- Inst. elec not feasible in most cases
- Therefore makes sense to focus on two gas options and two elec options (one with & one without SHW)
- Noting indiv. biomass boiler always another option

Apartment blocks

Core technology options modelled

Individual

- Instantaneous electric
- Gas combi boiler
- Gas boiler
- Gas boiler + SHW
- ASHP

Communal

- GSHP
- Biomass boiler
- Gas CHP + Gas boiler

Tech options on which to base decision

Individual

- Gas combi boiler
- Gas boiler + SHW
- ASHP
- ASHP + SHW

Shared

- GSHP
- Biomass boiler
- Gas CHP + Gas boiler

Why?

- Level must work at an apartment block scale, therefore individual and/ or ‘shared’ in-block solutions OK as part of this
- Inst. elec not feasible in most cases
- Therefore makes sense to focus on same individual solutions as houses, but with the additional possibility of ‘shared’ solutions

Houses (East Pennines)

		Carbon Target = 14 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
Detached House	FEES	6.2	1.6	7.8	1.3			
	Spec C	-1.9	-6.6	0.5	-6.1			
End Terrace House	FEES	7.6	3.4	9.4	3.5			
	Spec C	1.0	-3.4	3.3	-2.7			
Mid Terrace House	FEES	5.7	1.5	7.6	1.7			
	Spec C	-0.2	-4.6	2.2	-3.8			

- Technically feasible gas and electric options available for all house types at FEES and Spec C
- No PV required for many standard individual technology combinations with Spec C

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Houses (East Pennines)

		Carbon Target = 12 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
Detached House	FEES	10.1	5.5	11.6	5.1			
	Spec C	2.0	-2.8	4.3	-2.2			
End Terrace House	FEES	10.1	5.9	11.9	6.0			
	Spec C	3.5	-0.9	5.8	-0.2			
Mid Terrace House	FEES	8.2	4.0	10.1	4.2			
	Spec C	2.3	-2.1	4.7	-1.3			

- Technically feasible gas and electric options available for all house types at FEES and Spec C
- No PV required for some standard individual technology combinations with Spec C

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Houses (East Pennines)

		Carbon Target = 10 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
Detached House	FEES	14.0	9.3	15.5	9.0			
	Spec C	5.9	1.1	8.2	1.6			
End Terrace House	FEES	12.6	8.4	14.4	8.5			
	Spec C	6.0	1.6	8.3	2.3			
Mid Terrace House	FEES	10.7	6.5	12.6	6.7			
	Spec C	4.8	0.4	7.2	1.2			

- Technically feasible gas and electric options available for all house types at FEES and Spec C
- Some PV required for all standard individual technology combinations

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Houses (East Pennines)

		Carbon Target = 8 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
Detached House	FEES	17.8	13.2	19.4	12.9			
	Spec C	9.7	5.0	12.1	5.5			
End Terrace House	FEES	15.1	10.9	16.9	11.0			
	Spec C	8.5	4.1	10.8	4.8			
Mid Terrace House	FEES	13.2	9.0	15.1	9.2			
	Spec C	7.3	2.9	9.7	3.7			

- Technically feasible gas and electric options available for all house types
- Starting to see restrictions on electric options on FEES end of terrace house
- Some PV required for all standard individual technology combinations

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Houses (East Pennines)

		Carbon Target = 6 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
Detached House	FEES	21.7	17.1	23.2	16.7			
	Spec C	13.6	8.8	15.9	9.4			
End Terrace House	FEES	17.6	13.4	19.4	13.5			
	Spec C	11.0	6.6	13.3	7.3			
Mid Terrace House	FEES	15.7	11.5	17.6	11.7			
	Spec C	9.8	5.4	12.2	6.2			

- Technically feasible gas and electric options available for all house types at Spec C
- No standard individual technology options feasible at FEES for end and mid terrace houses without assuming solar design (i.e. PV area >40%)

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Houses (East Pennines)

		Carbon Target = 4 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
Detached House	FEES	25.6	20.9	27.1	20.6			
	Spec C	17.5	12.7	19.8	13.2			
End Terrace House	FEES	20.1	15.9	21.9	16.0			
	Spec C	13.5	9.1	15.8	9.8			
Mid Terrace House	FEES	18.2	14.0	20.1	14.2			
	Spec C	12.3	7.9	14.7	8.7			

- Technically feasible gas and electric options available for all house types at Spec C
- No standard individual technology options feasible at FEES for any house types without assuming solar design

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Houses (East Pennines)

		Carbon Target = 2 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
Detached House	FEES	29.4	24.8	31.0	24.4			
	Spec C	21.3	16.6	23.7	17.1			
End Terrace House	FEES	22.6	18.5	24.4	18.5			
	Spec C	16.0	11.6	18.3	12.3			
Mid Terrace House	FEES	20.7	16.5	22.6	16.7			
	Spec C	14.8	10.4	17.2	11.2			

- Severe restrictions on feasible standard individual technology options
- No standard individual technology options feasible at FEES for any house types without assuming solar design
- No standard individual technology options feasible for end terrace house without assuming solar design

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Houses (East Pennines)

		Carbon Target = 0 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
Detached House	FEES	33.3	28.7	34.8	28.3			
	Spec C	25.2	20.4	27.5	21.0			
End Terrace House	FEES	25.1	21.0	26.9	21.0			
	Spec C	18.5	14.1	20.8	14.8			
Mid Terrace House	FEES	23.2	19.0	25.1	19.2			
	Spec C	17.3	12.9	19.7	13.7			

- No standard individual technology options feasible at FEES or Spec C for any house types without assuming solar design

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Apartment blocks (East Pennines)

		Carbon Target = 14 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas combi boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
4-Storey Apt Block	FEES	157	51	219	68	-5	-282	-40
	Spec C	33	-68	105	-41	-96	-268	-191
8-Storey Apt Block	FEES	281		414		-37	-567	-120
	Spec C	44		192		-209	-539	-406
20-Storey Apt Block	FEES	652		999		-132	-1424	-362
	Spec C	76		453		-548	-1351	-1052

- Technically feasible individual gas and electric options available for 4-storey block at FEES and Spec C
- Severe restrictions on standard individual technically feasible options for 8 and 20-storey blocks
- For all blocks, shared solutions are technically feasible and those listed do not require PV

Key

Area of PV required, as percentage of Ground Floor area:

None	0% - 25%	25% - 40%	40% - 60%	60% - 80%	> 80%

Apartment blocks (East Pennines)

		Carbon Target = 12 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas combi boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
4-Storey Apt Block	FEES	215	109	276	125	52	-224	17
	Spec C	90	-11	162	17	-39	-211	-134
8-Storey Apt Block	FEES	395		528		78	-453	-6
	Spec C	158		306		-95	-425	-292
20-Storey Apt Block	FEES	938		1286		154	-1138	-75
	Spec C	363		739		-261	-1065	-765

- Technically feasible gas and electric options available for 4-storey block at Spec C without assuming solar design
- Severe restrictions on standard individual technically feasible options for 8-storey blocks
- No technically feasible standard individual options available for 20-storey blocks without assuming solar design / façade PV
- For all blocks, shared solutions are technically feasible and many listed do not require PV

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Apartment blocks (East Pennines)

		Carbon Target = 10 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas combi boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
4-Storey Apt Block	FEES	272	166	333	182	109	-167	74
	Spec C	147	47	219	74	18	-154	-76
8-Storey Apt Block	FEES	510		643		192	-338	109
	Spec C	273		421		20	-310	-177
20-Storey Apt Block	FEES	1224		1572		440	-852	211
	Spec C	649		1026		25	-779	-479

- Technically feasible gas and electric options available for 4-storey block, but at Spec C only without assuming solar design
- No technically feasible standard individual options available for 8 and 20-storey blocks without assuming solar design / façade PV
- For all blocks, most shared solutions are technically feasible and some do not require PV

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Apartment blocks (East Pennines)

		Carbon Target = 8 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas combi boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
4-Storey Apt Block	FEES	329	223	390	240	167	-110	132
	Spec C	205	104	277	131	76	-96	-19
8-Storey Apt Block	FEES	624		757		307	-224	223
	Spec C	387		535		134	-195	-62
20-Storey Apt Block	FEES	1511		1858		727	-565	497
	Spec C	935		1312		311	-492	-193

- Severe restrictions on technically feasible standard individual options for 4-storey block without assuming solar design
- No technically feasible standard individual options available for 8 and 20-storey blocks without assuming solar design / façade PV
- All listed shared solutions technically feasible for 4-storey block at FEES and Spec C
- For 8+ storey blocks, shared solutions are becoming restricted but some still do not require PV

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Apartment blocks (East Pennines)

		Carbon Target = 6 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas combi boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
4-Storey Apt Block	FEES	386	280	448	297	224	-53	189
	Spec C	262	161	334	188	133	-39	38
8-Storey Apt Block	FEES	739		872		421	-109	338
	Spec C	502		650		249	-81	52
20-Storey Apt Block	FEES	1797		2145		1013	-279	783
	Spec C	1222		1598		597	-206	94

- No technically feasible standard individual options available for any blocks without assuming solar design / façade PV
- For 4-storey blocks, restrictions seen for listed shared solutions at FEES without assuming solar design, but all shared options available at Spec C
- For 8+ storey blocks, shared solutions are severely restricted (without assuming solar design / façade PV), but biomass still a solution without the need for PV

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Apartment blocks (East Pennines)

		Carbon Target = 4 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas combi boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
4-Storey Apt Block	FEES	444	338	505	354	281	5	246
	Spec C	319	218	391	246	190	18	95
8-Storey Apt Block	FEES	854		986		536	5	452
	Spec C	616		764		363	34	167
20-Storey Apt Block	FEES	2083		2431		1299	7	1070
	Spec C	1508		1884		884	80	380

- No technically feasible standard individual options available for any blocks
- For all blocks, shared solutions are mainly restricted to only biomass (without assuming solar design / façade PV), and even then require the addition of PV

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Apartment blocks (East Pennines)

		Carbon Target = 2 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas combi boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
4-Storey Apt Block	FEES	501	395	562	411	338	62	304
	Spec C	376	276	448	303	247	75	153
8-Storey Apt Block	FEES	968		1101		650	120	567
	Spec C	731		879		478	148	281
20-Storey Apt Block	FEES	2370		2717		1586	293	1356
	Spec C	1794		2171		1170	366	666

- No technically feasible standard individual options available for any blocks
- For 4 and 8-storey blocks, shared solutions are mainly restricted to only biomass (without assuming solar design / façade PV), and even then require the addition of PV
- No technically feasible standard solutions available for 20-storey block

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%

Apartment blocks (East Pennines)

		Carbon Target = 0 $kgCO_{2(e)}/m^2/yr$						
		Individual solutions				Shared solutions		
		Gas combi boiler	Gas boiler + SHW	ASHP	ASHP + SHW	GSHP	Biomass boiler	Gas CHP
4-Storey Apt Block	FEES	558	452	619	469	396	119	361
	Spec C	434	333	506	360	305	133	210
8-Storey Apt Block	FEES	1083		1215		765	234	681
	Spec C	845		994		593	263	396
20-Storey Apt Block	FEES	2656		3003		1872	580	1642
	Spec C	2080		2457		1456	653	953

- No technically feasible standard individual options available for any blocks
- For 4-storey blocks, shared solutions are restricted to only biomass, and even then require the addition of PV
- No technically feasible standard solutions available for 8+ storey blocks

Key: **Area of PV required, as percentage of Ground Floor area** (SE/SW facing, 45deg pitch, none/ v. little overshading)**:**

None	Up to 25%	25% - 40%	40% - 60%	60% - 80%	Greater than 80%