10. MONITORING PROGRESS AND IMPACTS

10. Monitoring progress and impacts

10.1 The Scottish Government's Low Carbon Management System

10.1.1 The Climate Change Delivery Board[275], previously known as the Emissions Reduction Programme Board, has responsibility for monitoring the Scottish Government's progress on both climate change mitigation and adaptation. In terms of mitigation, its purpose is to ensure delivery of the programme of policies and proposals in RPP2 and subsequent reports required to meet the statutory greenhouse gas emissions reductions targets.

10.1.2 The Board is chaired by the Director General for Enterprise, Environment and Digital. Members of the Board include the Directors in the Scottish Government responsible for the key sectors detailed in this document. Current membership is likely to expand following the recent inclusion of climate change adaptation to the Board's remit. To introduce greater scrutiny and challenge, and in response to the 2011 Audit Scotland review (see below), two non-executive members have joined the Board: James Curran, Chief Executive of the Scottish Environment Protection Agency; and Alan Thompson. In addition, we have had discussions with COSLA about their potential future membership of the Board.

10.1.3 Robust accountability and monitoring mechanisms are an essential aspect of our low carbon management system. Since the publication of RPP1, we have continued to develop these mechanisms to help us track progress. We will further develop them using a system of Check Point Reports and Exception Reports. Risk identification and management will be a significant part of the system.

10.1.4 An important aspect of this approach involves the use of milestones. While there are some milestones in RPP2, we recognise that more needs to be done. We are, therefore, developing milestones for RPP2 that will be used by the Board to measure progress against both policies and proposals. The nature of the milestones will vary. However, they will all signify the completion of a significant deliverable, for example a key decision, an element of new infrastructure, the development of legislation, or the securing of finance. The milestones will help the Board assess progress and, importantly, provide an early warning system to identify where delivery is not as originally envisaged.

[275] The Scottish Government, Climate Change Delivery Board: www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/EmissionReduction

10.1.5 To ensure transparency, and in response to the 2011 Audit Scotland review report, we publish information about the Board on our climate change webpages. This includes details of the Board's meeting agendas, its meeting notes, and the **Carbon Reduction Activity Reports**[276] (previously referred to as scorecards during their development phase).

10.2 Public Sector Climate Leaders Forum

10.2.1 We believe that the key to driving down climate change emissions is strong and visible leadership. This is particularly important in the Scottish public sector. To this end we propose to establish a Public Sector Climate Leaders Forum. This Forum will be chaired by the Minister for Environment and Climate Change, with COSLA's political leadership playing a key role. Membership will compose of leaders from across the public sector.

10.2.2 The remit of the Forum will include oversight of climate change governance for public bodies, oversight of progress on emission reductions delivery and implementation, and a strong relationship with SSN (Sustainable Scotland Network). The focus of the Forum in the first instance will include our RPP2 proposal to ramp up emission reductions in the public sector (see para 6.5.6) but it will have also have a key role in encouraging the sharing of good practice through to identifying and overcoming barriers to progress. We will publish our proposals in October 2013.

10.3 Independent assessments

10.3.1 Since the publication of RPP1, a number of independent progress or review reports have been undertaken and published. In December 2011, Audit Scotland published a review report on the Scottish Government's progress in reducing greenhouse gas emissions.[277] As stated above we responded to the transparency recommendation in that report by appointed non-executive members to the Climate Change Delivery Board, and setting up a new web page[278] with information about the Board.

10.3.2 The CCC has also published two statutory annual reports assessing Scotland's progress in reducing greenhouse gas emissions. The first was

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[276] Scottish Government, Carbon Reduction Activity Reports: www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/EmissionReduction/ActivityReports

[277] Audit Scotland, Reducing Scotland's Greenhouse Gas Emissions: www.audit-scotland.gov.uk/docs/central/2011/nr_111208_greenhouse_gases.pdf

[278] The Scottish Government, Climate Change Delivery Board: www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/EmissionReduction

published in January 2012[279], and the second in March 2013[280] We welcome the findings of both reports that Scotland has made good progress in delivering on emission reduction measures to date.

10.4 The Scottish Parliamentary scrutiny process

10.4.1 This document is the final version of the second report on proposals and policies for meeting annual targets that the Scottish Ministers must lay before the Scottish Parliament in accordance with the requirements in section 35 of the Climate Change (Scotland) Act 2009.

10.4.2 A draft version of the report was laid before the Scottish Parliament on 29 January 2013 and underwent a 60-day period for Parliamentary consideration. During this period, the following four Parliamentary subject committees took evidence on the draft report:

- Rural Affairs, Climate Change and Environment Committee
- Economy, Energy and Tourism Committee
- Infrastructure and Capital Investment Committee
- Local Government and Regeneration Committee

10.4.3 The reports of these committees were published on 22 March 2013 and are available from the Scottish Parliament Information Centre and on the Scottish Parliament's website.[281] [282] [283] [284]

10.4.4 The Official Report of the Parliamentary debate on the draft RPP2, which took place on 26 March 2013, is also available on the Scottish Parliament website.[285]

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[279] Committee on Climate Change, 1st Scottish Progress Report: http://downloads.theccc.org.uk.s3.amazonaws.com/1552_CCC_Scotland%20report.pdf

[280] Committee on Climate Change, 2nd Scottish Progress Report: www.theccc.org.uk/wp-content/uploads/2013/03/1674_CCC_Scots-Report_bookmarked_2.pdf

[281] Scottish Parliament, Rural Affairs, Climate Change and Environment Committee Report on the Draft Second Report on Proposals and Policies (SP Paper 289, RACCE/S4/13/R2): www.scottish.parliament.uk/parliamentarybusiness/CurrentCommittees/61495.aspx

[282] Scottish Parliament, Economy, Energy and Tourism Committee Report on the Draft Second Report on Proposals and Policies (SP Paper 288, EET/S4/13/R4): www.scottish.parliament.uk/parliamentarybusiness/CurrentCommittees/61496.aspx

[283] Scottish Parliament, Infrastructure and Capital Investment Committee Report on the Draft Second Report on Proposals and Policies (SP Paper 291, ICI/S4/13/R3): www.scottish.parliament.uk/parliamentarybusiness/CurrentCommittees/61494.aspx

[284] Scottish Parliament, Local Government and Regeneration Committee Report on the Draft Second Report on Proposals and Policies (SP Paper 292, LGR/S4/13/R6): www.scottish.parliament.uk/parliamentarybusiness/CurrentCommittees/61493.aspx

[285] The Scottish Government, RPP Parliamentary Consideration: www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/lowcarbon/meetingthetargets/parliamentaryconsideration

10.4.5 The Scottish Government also received direct representations on the draft RPP2. These have been published on the Scottish Government's website.[286]

10.4.6 The Scottish Ministers laid a written statement before the Scottish Parliament together with this final report, setting out details of the representations etc. made to them in respect of the draft report and indicating the changes that were made as a result of those representations.

10.5 Strategic environmental assessment

10.5.1 The Environmental Assessment (Scotland) Act 2005 sets out statutory requirements for the preparation and publication of Strategic Environmental Assessments (SEA) by public bodies. The purpose of SEA is to ensure that the likely significant environmental effects of Scottish plans, programmes and strategies are assessed and taken into account during their preparation.

10.5.2 The Environmental Report is the key medium for outlining the outputs of the Strategic Environmental Assessment process. The Environmental Report on the proposals and policies set out in the draft RPP2 details the results of the environmental assessment of these measures, identifying and evaluating the likely significant environmental effects of implementing them, as well as identifying the means to prevent or avoid significant adverse effects and enhance positive ones, while also considering reasonable alternatives where appropriate.[287]

10.5.3 The Environmental Report was available for comment during the 60-day period for Parliamentary consideration of the draft RPP2 detailed above.

10.5.4 The last output of the SEA process is the preparation and publication of an SEA Statement that will, in due course, set out how the findings of the SEA have been considered, and how views expressed during the consultation period were taken into account.

10.5.5 More information about the SEA of the proposals and policies set out in this report is available on the Scottish Government's website.

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[286] ibid

[287] Scottish Government, SEA Environmental Report for RPP2: www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/lowcarbon/meetingthetargets/SEAEnvironmentalReport

Annex A: Greenhouse Gas Business as Usual Projections and Emissions Abatement ($ktCO_2e$) and Cost (£m) Estimates

Business as Usual Projections	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Traded Sector Net Emissions (20% EU Target) **Includes Energy Supply**	19,099	18,749	18,399	18,048	17,698	17,348	16,986	16,618	12,960	12,635	12,310	11,987	11,197	10,897	10,181
Traded Sector Net Emissions (30% EU Target) **Includes Energy Supply**	18,267	17,639	17,012	16,385	15,757	15,130	14,502	13,875							
Non-Traded Sector Business As Usual	29,846	29,902	30,138	30,364	30,563	30,730	31,032	31,436	31,810	32,225	32,551	32,936	33,398	33,780	34,091
Total Business As Usual Projection (20% EU Target)	48,945	48,651	48,537	48,412	48,261	48,079	48,019	48,054	44,770	44,860	44,861	44,923	44,595	44,677	44,272
Total Business As Usual Projection 30% EU Target)	48,113	47,541	47,150	46,748	46,320	45,860	45,535	45,311	44,770	44,860	44,861	44,923	44,595	44,677	44,272

Up to 2020, the net Scottish emissions account will measure Scotland's share of EU ETS allowances. The overall number of allowances is assumed to be lower if the EU strengthens its 2020 target from 20% to 30%. Phase III of the EU ETS runs from 2013-2020. It is our proposal to review our emissions accounting methodology after Phase III and measure actual emissions from the traded sector.

Because of the change in methodology partway through the time series, this table differs from the other tables in this annex in that it presents an estimated scenario of *actual emissions* from the traded sector, which includes energy supply, rather than a projected Business as Usual baseline from which emissions abatement is deducted.

Homes & Communities	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Business as Usual Emissions	6,410	6,309	6,214	6,129	6,075	6,089	6,116	6,146	6,201	6,254	6,300	6,330	6,354	6,366	6,344
Policies (emissions abatement ktCO_2e)															
Smart Metering	7	17	33	49	66	80	86	88	89	90	91	92	94	94	95
Domestic Buildings Energy Standards (2010) - New Build Properties	16	24	32	41	49	58	67	76	84	93	103	113	122	132	142
Renewable Heat Incentive (Domestic)	11	19	27	35	46	57	68	78	79	79	79	80	80	80	80
Energy Company Obligation (ECO) and Green Deal (GD)	13	24	33	42	52	62	89	104	114	132	132	132	132	132	132
National Retrofit Programme: Scottish Government Fuel Poverty & Energy Efficiency Programmes	59	99	137	173	207	207	207	207	207	207	207	207	207	207	207
Warm Homes Fund	7	12	17	21	25	24	23	23	23	22	22	22	22	22	22
District Heating Loan Fund	24	36	36	36	36	36	36	36	36	36	36	36	36	36	36
Total Abatement from policies	**138**	**231**	**315**	**397**	**481**	**524**	**576**	**612**	**631**	**659**	**670**	**682**	**692**	**703**	**713**
Proposals (emissions abatement ktCO_2e)															
Domestic Buildings Energy Standards (2014) - New Build Properties	0	0	1	4	8	13	17	22	26	31	35	40	45	50	55
Regulation of Private and Social Housing	0	1	13	20	27	38	51	63	74	85	102	118	130	141	152
National Retrofit Programme: Insulation and Heat Programme	0	0	0	0	0	22	27	33	43	49	71	91	117	143	167
Low Carbon Heat (Domestic)	0	0	7	25	39	57	76	99	135	186	247	336	424	513	609
Additional Technical Potential in Fabric and Energy Efficiency	0	0	0	0	0	72	142	210	278	343	407	470	531	591	650
Total abatement from Proposals	**0**	**1**	**21**	**49**	**74**	**203**	**314**	**428**	**555**	**694**	**861**	**1,055**	**1,248**	**1,438**	**1,634**
Total abatement from Policies and Proposals	**138**	**232**	**336**	**446**	**555**	**727**	**889**	**1,040**	**1,186**	**1,353**	**1,531**	**1,737**	**1,940**	**2,141**	**2,347**
Net Emissions after Policies and Proposals	6,272	6,077	5,878	5,684	5,521	5,362	5,227	5,106	5,014	4,901	4,769	4,593	4,414	4,225	3,997
% Change against 1990	-23%	-26%	-28%	-31%	-33%	-34%	-36%	-38%	-39%	-40%	-42%	-44%	-46%	-48%	-51%
Total cost of Policies	**405**	**415**	**392**	**413**	**418**	**306**	**305**	**303**	**300**	**297**	**155**	**153**	**150**	**148**	**146**
Total cost of Proposals	**0**	**102**	**133**	**167**	**162**	**291**	**290**	**294**	**304**	**301**	**438**	**435**	**431**	**427**	**424**
Total cost of Policies and Proposals	**405**	**517**	**524**	**580**	**580**	**597**	**595**	**598**	**604**	**598**	**593**	**588**	**581**	**576**	**571**

Business, Industry & Public Sector	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Business as Usual Emissions	5,072	5,073	5,074	5,071	5,066	5,036	5,005	4,975	4,960	4,944	4,929	4,913	4,898	4,896	4,894
Policies (emissions abatement ktCO_2e)															
Smart Metering	2	8	19	30	42	49	52	53	52	51	50	49	48	47	46
CRC Energy Efficiency Scheme	30	41	54	68	83	98	114	130	149	169	184	200	216	187	154
Non Domestic Buildings Energy Standards (2010) - New Build Properties	13	19	25	32	38	44	51	57	63	70	76	82	89	95	101
Green Deal & Supporting Policy	2	4	18	38	58	74	85	92	97	98	73	55	41	31	24
EU Products Policy	-6	-10	-7	-8	-9	-10	-11	-11	-11	-10	-10	-9	-9	-8	-8
Renewable Heat Incentive (Non Domestic)	106	171	256	375	532	641	768	896	869	849	877	893	902	909	914
Total Abatement from policies	**147**	**233**	**365**	**535**	**743**	**896**	**1,060**	**1,217**	**1,220**	**1,227**	**1,250**	**1,270**	**1,288**	**1,260**	**1,231**
Proposals (emissions abatement ktCO_2e)															
Non Domestic Buildings Energy Standards (2014) - New Build Properties	0	0	2	5	10	15	20	25	30	35	40	45	50	55	60
Assessment of Energy Performance and Emissions Regulations (Non Domestic Buildings)	0	6	12	18	24	30	36	42	56	70	85	99	113	128	142
Public Sector	87	109	130	152	174	195	217	239	245	252	259	265	272	278	285
Low Carbon Heat (Non Domestic)	16	74	112	116	81	95	90	101	269	459	602	777	960	1,145	1,334
Total abatement from proposals	**103**	**189**	**256**	**290**	**289**	**335**	**363**	**406**	**600**	**816**	**985**	**1,186**	**1,395**	**1,606**	**1,821**
Total abatement from policies and proposals	**250**	**422**	**621**	**826**	**1,032**	**1,232**	**1,423**	**1,623**	**1,820**	**2,043**	**2,235**	**2,456**	**2,682**	**2,866**	**3,051**
Net Emissions after Policies and Proposals	4,822	4,652	4,453	4,246	4,034	3,804	3,582	3,352	3,139	2,901	2,694	2,457	2,216	2,030	1,843
% Change from 1990 (including 20% EU ETS)	-36%	-37%	-39%	-40%	-42%	-43%	-45%	-46%	-57%	-58%	-60%	-61%	-64%	-65%	-68%
% Change from 1990 (including 30% EU ETS)[288]	-38%	-40%	-42%	-45%	-47%	-49%	-51%	-54%	-57%	-58%	-60%	-61%	-64%	-65%	-68%
Total cost of policies (£m)	**141**	**164**	**171**	**184**	**198**	**204**	**198**	**216**	**198**	**181**	**168**	**150**	**139**	**124**	**131**
Total cost of proposals (£m)	**24**	**72**	**91**	**95**	**81**	**80**	**75**	**76**	**157**	**173**	**188**	**198**	**207**	**206**	**232**
Total cost of policies and proposals (£m)	**165**	**236**	**262**	**278**	**280**	**284**	**274**	**291**	**355**	**355**	**356**	**348**	**346**	**331**	**363**

[288] The percentage change shown for the Business, Industry and Public Sector includes emissions from the traded sector as it has not been possible to split emissions into 'traded' and 'non-traded' prior to the start of the EU Emissions Trading System in 2005.

Transport	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Business as Usual Emissions	13,236	13,256	13,289	13,420	13,527	13,622	13,720	13,822	13,906	13,992	14,083	14,176	14,253	14,374	14,494
Policies (emissions abatement $ktCO_2e$)															
Decarbonising Vehicles (EU Directives)	157	267	381	500	642	811	1,009	1,243	1,328	1,408	1,483	1,553	1,619	1,676	1,727
Total Abatement from policies	**157**	**267**	**381**	**500**	**642**	**811**	**1,009**	**1,243**	**1,328**	**1,408**	**1,483**	**1,553**	**1,619**	**1,676**	**1,727**
Proposals (emissions abatement $ktCO_2e$)															
Decarbonising Vehicles	1	7	47	76	110	151	209	282	441	453	564	676	689	793	798
Sustainable Communities	0	12	56	70	82	103	122	139	158	179	198	219	241	259	277
Business Efficiencies	26	29	58	67	76	91	106	121	173	227	270	306	357	409	462
Network Efficiencies	2	4	31	32	33	34	35	36	35	35	34	33	33	33	32
Lower Emission Potential in Transport	0	0	0	0	0	0	0	0	0	0	0	0	250	500	750
Total abatement from proposals	**29**	**53**	**192**	**245**	**301**	**379**	**473**	**579**	**808**	**894**	**1,065**	**1,235**	**1,569**	**1,994**	**2,320**
Total abatement from policies and proposals	**186**	**320**	**574**	**745**	**943**	**1,190**	**1,482**	**1,822**	**2,135**	**2,301**	**2,548**	**2,788**	**3,188**	**3,671**	**4,046**
Net Emissions after Policies and Proposals	13,050	12,937	12,715	12,675	12,584	12,433	12,239	12,000	11,770	11,691	11,534	11,388	11,065	10,703	10,448
% Change from 1990	1%	0%	-2%	-2%	-3%	-4%	-5%	-7%	-9%	-10%	-11%	-12%	-15%	-17%	-19%
Total cost of policies (£m)	**9**	**17**	**24**	**31**	**40**	**52**	**68**	**88**	**90**	**90**	**91**	**92**	**93**	**94**	**95**
Total cost of proposals (£m)	**47**	**43**	**168**	**177**	**181**	**158**	**141**	**146**	**151**	**162**	**127**	**130**	**137**	**132**	**134**
Total cost of policies and proposals (£m)	**55**	**59**	**192**	**208**	**222**	**210**	**209**	**233**	**241**	**252**	**218**	**222**	**230**	**226**	**229**

Waste and Resource Efficiency	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Business as Usual Emissions	2,121	2,105	2,088	2,073	2,059	2,044	2,029	2,014	2,003	1,992	1,981	1,969	1,958	1,958	1,958
Policies (emissions abatement ktCO_2e)															
Zero Waste Policies (pre May-2010)	484	533	579	622	659	693	722	748	774	795	813	827	837	856	871
Zero Waste Plan	13	26	41	58	77	97	119	141	163	185	206	228	249	270	290
Total Abatement from policies	**497**	**559**	**620**	**680**	**737**	**790**	**841**	**889**	**937**	**980**	**1,019**	**1,055**	**1,086**	**1,126**	**1,161**
Proposals (emissions abatement ktCO_2e)															
Enhanced Capture of Landfill Gas	22	44	67	90	112	133	154	163	161	158	155	151	148	144	140
Total abatement from proposals	22	44	67	90	112	133	154	163	161	158	155	151	148	144	140
Total abatement from policies and proposals	**519**	**603**	**687**	**769**	**848**	**924**	**995**	**1,052**	**1,098**	**1,138**	**1,174**	**1,206**	**1,234**	**1,270**	**1,302**
Net Emissions after Policies and Proposals	1,602	1,502	1,401	1,304	1,210	1,120	1,034	963	906	854	806	763	724	689	656
% Change from 1990	-76%	-78%	-79%	-81%	-82%	-83%	-85%	-86%	-87%	-87%	-88%	-89%	-89%	-90%	-90%
Total cost of policies (£m)	**172**	**161**	**163**	**163**	**163**	**164**	**162**	**163**	**164**	**165**	**164**	**165**	**165**	**165**	**165**
Total cost of proposals (£m)	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total cost of policies and proposals (£m)	**173**	**162**	**164**	**164**	**164**	**165**	**163**	**164**	**164**	**165**	**164**	**165**	**165**	**165**	**165**

Rural Land Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Business as Usual Emissions	3,007	3,158	3,473	3,670	3,836	3,939	4,161	4,478	4,741	5,043	5,258	5,548	5,936	6,187	6,401
Policies (emissions abatement ktCO_2e)															
Farming for a better climate	50	62	75	87	100	101	103	103	104	104	105	106	106	107	107
Increase afforestation rate to 10 kh per year	15	16	45	92	144	195	248	310	373	435	477	529	582	634	687
Total Abatement from policies	**65**	**78**	**120**	**179**	**244**	**296**	**351**	**413**	**477**	**539**	**582**	**635**	**688**	**741**	**794**
Proposals (emissions abatement ktCO_2e)															
90% Uptake of Fertiliser Efficiency Measures	0	0	0	0	0	260	260	260	260	260	260	260	260	260	260
Developments in agricultural technology from 2020	0	0	0	0	0	0	0	310	310	310	310	310	310	310	310
Accelerated restoration of degraded peatland	0	9	25	47	73	104	139	177	218	263	309	358	410	462	515
Wood First - Timber Construction Programme	0	0	0	0	0	0	0	0	0	89	89	89	89	125	125
Additional technical potential from low carbon land use	0	0	0	0	0	0	0	0	0	0	0	0	250	500	750
Total abatement from proposals	**0**	**9**	**25**	**47**	**73**	**364**	**399**	**747**	**788**	**922**	**968**	**1,017**	**1,319**	**1,657**	**1,960**
Total abatement from policies and proposals	**65**	**87**	**145**	**226**	**317**	**660**	**749**	**1,160**	**1,265**	**1,461**	**1,550**	**1,652**	**2,007**	**2,397**	**2,754**
Net Emissions after Policies and Proposals	2,942	3,071	3,328	3,444	3,519	3,279	3,412	3,318	3,476	3,582	3,708	3,896	3,929	3,790	3,648
% Change from 1990	-63%	-61%	-58%	-56%	-55%	-58%	-57%	-58%	-56%	-54%	-53%	-50%	-50%	-52%	-54%
Total cost of RLU policies (£m)	37	42	47	49	51	53	54	56	57	58	58	59	60	60	60
Total cost of RLU proposals (£m)	19	18	17	16	16	16	16	321	321	361	321	321	328	318	318
Total cost of RLU policies and proposals (£m)	55	59	63	64	67	69	70	377	378	419	379	380	389	379	379

Annex B: Emissions targets and projections for policies and proposals (ktCO_2e)

YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Emissions targets	*47,976*	*46,958*	*45,928*	*44,933*	*43,946*	*42,966*	*41,976*	*40,717*	*39,495*	*38,310*	*37,161*	*35,787*	*34,117*	*32,446*	*30,777*
% change from 1990 baseline	*-34.26%*	*-35.65%*	*-37.06%*	*-38.43%*	*-39.78%*	*-41.12%*	*-42.48%*	*-44.20%*	*-45.88%*	*-47.50%*	*-49.08%*	*-50.96%*	*-53.25%*	*-55.54%*	*-57.82%*
Margin by which target hit (+ve) or missed (-ve)															
Implementation of RPP2 Policies only (EU ETS 20%)	+35	-324	-809	-1,188	-1,469	-1,795	-2,207	-2,963	-683	-1,737	-2,696	-3,942	-5,105	-6,725	-7,868
Implementation of RPP2 Policies & Proposals (EU ETS 20%)	+189	-29	-247	-468	-620	-381	-505	-641	+2,229	+1,746	+1,339	+702	+572	+114	+5
Implementation of RPP2 Policies and move to EU ETS 30%	+867	+785	+578	+476	+472	+424	+277	-220	-683	-1,737	-2,696	-3,942	-5,105	-6,725	-7,868
Implementation of RPP2 Policies & Proposals and move to EU ETS 30%	+1,021	+1,081	+1,140	+1,196	+1,321	+1,838	+1,979	+2,103	+2,229	+1,746	+1,339	+702	+572	+114	+5

Annex C: Annual reduction in projected Scottish emissions against 1990 Base Year (2011 GHG Inventory)

YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Implementation of RPP2 Policies only (EU ETS 20%)	-34.3%	-35.2%	-36.0%	-36.8%	-37.8%	-38.7%	-39.5%	-40.1%	-44.9%	-45.1%	-45.4%	-45.6%	-46.3%	-46.3%	-47.0%
Implementation of RPP2 Policies and Proposals (EU ETS 20%)	-34.5%	-35.6%	-36.7%	-37.8%	-38.9%	-40.6%	-41.8%	-43.3%	-48.9%	-49.9%	-50.9%	-51.9%	-54.0%	-55.7%	-57.8%
Implementation of RPP2 Policies only (EU ETS 30%)	-35.4%	-36.7%	-37.9%	-39.1%	-40.4%	-41.7%	-42.9%	-43.9%	-44.9%	-45.1%	-45.4%	-45.6%	-46.3%	-46.3%	-47.0%
Implementation of RPP2 Policies and Proposals (EU ETS 30%)	-35.7%	-37.1%	-38.6%	-40.1%	-41.6%	-43.6%	-45.2%	-47.1%	-48.9%	-49.9%	-50.9%	-51.9%	-54.0%	-55.7%	-57.8%

Low Carbon Scotland:

Meeting our Emissions Reduction Targets 2013-2027

The Second Report on Proposals and Policies

Technical Appendix

Table of Contents

1. Introduction

1.1 Context

1.1.1 The purpose of this technical appendix is to present the methodological and technical detail underpinning the information presented in the main document of the Second Report on Policies and Proposals (RPP2).

1.1.2 Scotland's annual climate change targets are explicit in the rate of greenhouse gas (GHG) emissions reduction required each year and the target level of annual emissions that is permitted under the Climate Change (Scotland) Act 2009 over the period 2010 and 2027. The robustness of the evidence base that underpins the potential impacts of policies and proposals is key to ensuring that appropriate decisions can be made on the most effective means of meeting the targets.

1.1.3 This technical appendix provides information on historical GHG emissions in Scotland, the methodology used to estimate future business-as-usual (BAU) emissions projections and the emissions abatement potential from implementation of policies and proposals. It also provides the basis on which estimates of the required financial investments to deliver the policies and proposals have been derived.

1.1.4 This appendix has three parts:

- Part 1 presents the context in which the RPP2 is set, the statutory targets that are to be achieved and how progress against those targets is measured.

- Part 2 presents historical emissions data for Scotland and the methodology adopted to estimate a BAU future emissions projection for Scotland. It also explains the degree to which there are uncertainties associated with estimating future emission projections.

- Part 3 presents the methodologies adopted to estimate the emissions savings, investments and benefits identified for the policies and proposals within each sector.

2. Part 1: RPP2 and the Statutory Greenhouse Gas Emissions Targets

2.1 Background to RPP2

2.1.1 The RPP2 demonstrates how Scotland can reduce its GHG emissions and meet its climate change targets each year from 2013 to 2027. It builds on the work undertaken and presented in the first 2011 Report on Policies and Proposals - *Low Carbon Scotland: Meeting the Emissions Reduction Targets 2010-2022*[1] *(RPP1)* – which set out the Scottish Government's approach to meeting its statutory annual GHG emissions targets from 2010 to 2022. RPP2 provides both an update to RPP1 for the period 2013 to 2022 and for the first time sets out a path for meeting the 2023 to 2027 annual targets. This fulfils the requirements of both Sections 35 and 36 of the Act.

2.2 Scotland's Emissions Targets

2.2.1 The Climate Change (Scotland) Act 2009 creates a statutory framework for GHG emissions reductions in Scotland by setting an interim target of at least a 42 per cent reduction for 2020, and at least an 80 per cent reduction target for 2050 against a 1990/1995 baseline.[2]

2.2.2 The Committee on Climate Change (CCC) advised the Scottish Government on the level of emission reduction targets which included a minimum saving of 3% per annum over the 2023-27 period to put Scotland on a path to an emissions reduction of around 60% in 2030 relative to 1990 levels.[3] Table 1 below provides the annual emissions targets for Scotland. Achievement of Scotland's annual targets is measured against the level of the Net Scottish Emissions Account (NSEA). This is undertaken annually with the most recent 2013 publication presenting the 2011 emissions data against Scotland's annual target.[4]

[1] http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/lowcarbon/rpp
[2] Scotland's targets use the level of emissions in 1990 (for carbon dioxide, methane and nitrous oxide) and 1995 (for fluorine-based gases) as the baseline from which reductions are calculated.
[3] http://theccc.org.uk/topics/uk-and-regions/scotland/beyond-2020
[4] http://www.scotland.gov.uk/Publications/2013/06/1558/downloads#res-1

Table 1: Annual Scottish Emissions Targets, 2010 – 2027 ($ktCO_2e$)

Year	Emissions Targets
2010	53,652
2011	53,404
2012	53,226
2013	47,976
2014	46,958
2015	45,928
2016	44,933
2017	43,946
2018	42,966
2019	41,976
2020	40,717
2021	39,495
2022	38,310
2023	37,161
2024	35,787
2025	34,117
2026	32,446
2027	30,777

3. Part 2: Historical Emissions Data and the Business-as-Usual Future Emissions Projections

3.1 Historical Emissions Data

3.1.1 The official source of GHG emissions data that is used by the Scottish Government is the National Atmospheric Emissions Inventory (NAEI).[5] The NAEI compiles estimates of emissions to the atmosphere from UK sources. This data is disaggregated to a regional level and the Scottish estimates are published annually with approximately an 18 month lag in the Greenhouse Gas Inventory.[6] The time series of data runs from 1990 with the latest Scottish GHG emissions estimates for 2011 published in June 2013. Data from the NAEI has been used as the basis for setting the Scottish annual GHG emissions targets and for assessing progress against the targets.

Traded and Non-Traded Emissions

3.1.2 The advent of the European Union Emissions Trading Scheme (EU ETS) in 2005 meant that emissions were split into those accounted in the 'Traded' sector and those in the 'Non-Traded' sector. Emissions in the traded sector (EU ETS) include GHG emissions from the generation of electricity, energy intensive business and industrial processes such as production of steel and iron, and energy intensive parts of the public sector such as large hospitals. In 2011, 98% of GHG emissions from the Energy Supply sector were estimated to be traded, alongside 49% of the business and industry sector's emissions and 21% of the public sector's emissions.

3.1.3 The non-traded sector emissions include all other GHG emissions captured in the NAEI in Scotland that are not in the traded sector. These are disaggregated into the following sources of emissions: residential, non-traded business, industry and public sector, transport, agriculture and related land use, forestry, waste sector, and development (land use).

3.1.4 Chart 1 below shows historical Scottish emissions by sector. The start of the EU ETS can be seen in 2005 when more than half the emissions from the Business, Industry and Public Sector category moved into the Traded Sector.

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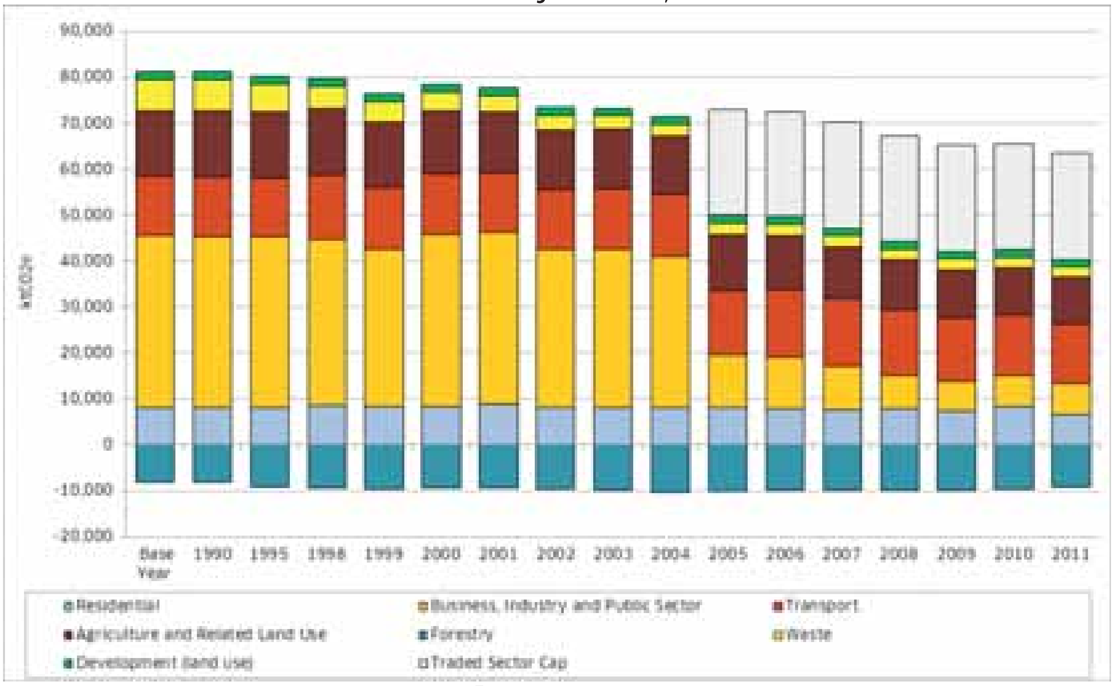
[5] http://naei.defra.gov.uk/index.php
[6] http://naei.defra.gov.uk/reports/reports?report_id=756

Chart 1: Scottish GHG Emissions by Sector, 1990 - 2011



Source: GHG Inventory (NAEI), 2013[7]

3.2 Future Emissions Projections

Non-Traded Sector

3.2.1 The BAU GHG emissions projection for Scotland is the first step in establishing the scale of abatement that is required to meet future annual GHG emissions targets. The full process is to construct a BAU GHG emissions profile for Scotland then net off the abatement potential from the policies and proposals identified in order to meet the emissions targets that have been set. Details of the abatement potential from policies and proposals are set out in Part 3 of this appendix.

3.2.2 The BAU scenario is an estimate of what emissions in Scotland are most likely to be each year between 2013 and 2027 based on NAEI data and the on-going effects of policies implemented up to the 2006 UK and Scottish Climate Change Programmes.

3.2.3 The non-traded sector BAU emissions projections are estimated at a sectoral level as detailed above. The basis of the BAU projections is the 2010 'outturn' data from the NAEI. An estimate of 2011 Scottish sectoral emissions was calculated by applying the percentage change in emissions observed at a UK level between 2010

[7] Non-Traded sector estimate for Business, Industry and Public Sector post 2004 is based on 2011 EU ETS verified emissions.

and 2011.[8] From 2012 to 2027 BAU emissions were calculated for each sector, for CO_2 and non-CO_2 emissions, using a range of projection tools and sources. Details of these are set out below.

Scenario Tool of Emissions Projections for Scotland (STEPS)

3.2.4 The STEPS model was commissioned by the CCC and developed by Cambridge Econometrics (CE). The model provides Scottish BAU CO_2 projections for the non-traded sector out to 2030.[9]

3.2.5 The STEPS model has been used to create CO_2 BAU projections from 2013 to 2027 for the Residential sector, non-traded Business, Industry and Public sector, and Transport (not including aviation).

3.2.6 To generate the most robust estimates possible for Scotland, the STEPS model is informed by two Scottish Government models: Domestic Emissions Model for Scotland (DEMScot), which is particularly geared for the Scottish residential sector, and the Transport Model for Scotland (TMfS), which inputs Scottish specific data on vehicle fleet mix and efficiency.

3.2.7 Aviation is the only mode of transport for which projected GHG emissions are not estimated by the STEPS model. From 2012, aviation CO_2 emissions are captured in the EU ETS. As such, for the purposes of modelling their impact on Scotland's GHG emissions, aviation BAU emissions have been assumed to follow the capped trading amount of 97% of the 2004 – 2006 average aviation emissions in 2012 falling to 95% of the same average from 2013 onwards.[10]

Non-CO_2 Emissions Projections

3.2.8 The CCC commissioned AEA to provide non-CO_2 BAU projections for Scotland and the other countries within the UK.[11] This analysis provides projections for 2010, 2015, 2020 for all non-CO_2 emissions arising in Scotland. To derive the annual projection, the 5-yearly results have been linearly interpolated over the years to 2027.

[8] 2011 Scottish data was not available at the time the analysis was undertaken. http://www.decc.gov.uk/en/content/cms/statistics/climate_stats/gg_emissions/uk_emissions/uk_emissions.aspx
[9] http://downloads.theccc.org.uk.s3.amazonaws.com/ScotlandLetter/STEPS%20update%20-%20final%20report%20-%20march%202011.pdf
[10] http://ec.europa.eu/clima/policies/transport/aviation/index_en.htm
[11] "Non-CO_2 Greenhouse Gas Projections for England, Scotland, Wales and Northern Ireland", October 2009, http://www.naei.org.uk/reports.php

3.2.9 The AEA projections are used to provide non-CO_2 projections for Residential, Business, Industry and Public Sector, the Agriculture Industry element of Agriculture and Related Land Use, Transport and Waste.

Land Use, Land Use Change and Forestry (LULUCF)

3.2.10 The LULUCF[12] emissions projections are based on the work of the Centre for Ecology and Hydrology (CEH)[13] which produces a national inventory and projections of emissions by sources and removals of GHGs at a range of spatial scales. This feeds into the NAEI.

3.2.11 Its latest report provides projections to 2050 on carbon stock changes (resulting in net CO_2 emissions) and CO_2, Carbon Monoxide (CH_4) and Nitrous Oxide (N_2O) emissions arising from LULUCF activities reported in the latest NAEI.[14] Following a request by the Scottish Government, the scenarios were modified to include continuing cropland-grassland turnover (crop-rotation). In RPP2 the CEH projections were used to provide CO_2 and non-CO_2 projections for Agriculture Related Land Use, Forestry and Development (land use).

Food and Agriculture Policy Research Institute (FAPRI)

3.2.12 The FAPRI UK modelling system captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland.[15] The model consists of a system of equations covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and bio-fuel sectors and generates annually-determined, 10-year baseline projections of all the major agricultural commodity prices, production levels and GHG emissions, against which policy scenarios can be compared.

3.2.13 In RPP2, FAPRI is used to generate non-CO_2 emission projections for the Scottish Agriculture sector.

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[12] The LULUCF sector is divided into six land use types for reporting of emissions/removals: 5A Forest Land, 5B Cropland, 5C Grassland, 5D Wetlands, 5E Settlements, 5F Other Land.

[13] http://naei.defra.gov.uk/report_link.php?report_id=713

[14] Emissions of greenhouse gases to the atmosphere are expressed as positive quantities, and removals of carbon dioxide as negative quantities. The net LULUCF emission is the balance of emissions and removals.

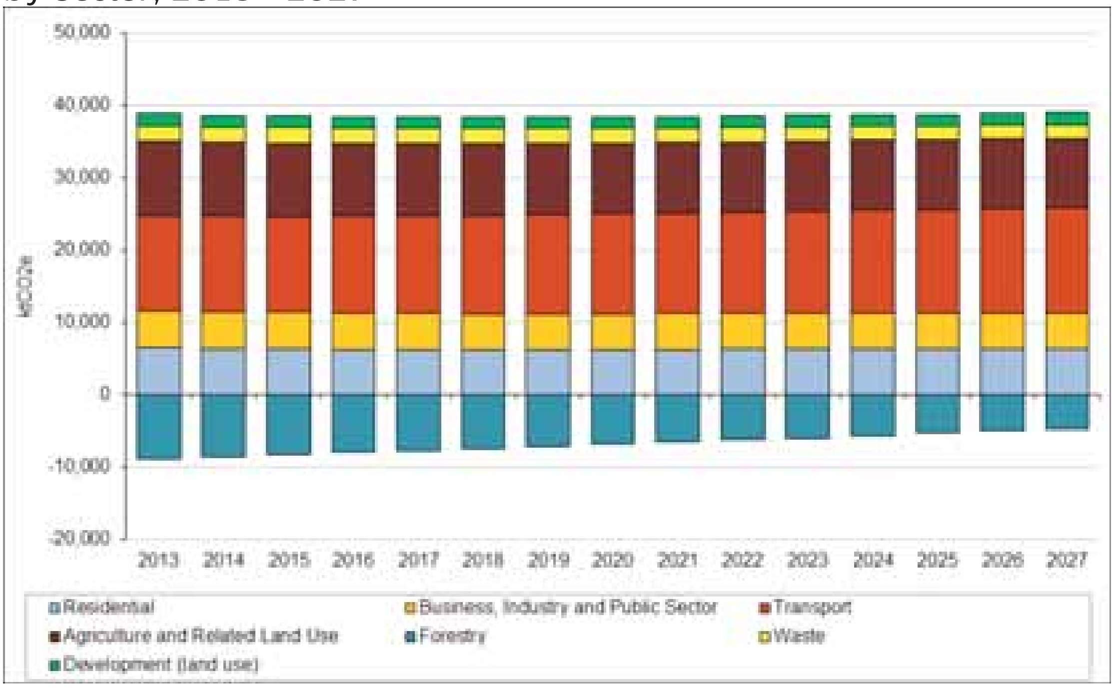
[15] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17569

3.2.14 Table 2 presents a summary of the tools used to project non-traded BAU emissions in RPP2 and Chart 2 illustrates the non-traded BAU projections by sector.

Table 2: Summary of Sources used to Estimate Non-Traded Scottish Business-as-Usual Emissions

Sector	**CO_2**	**Non-CO_2**
Residential	STEPS	AEA
Business, Industry and Public Sector	STEPS	AEA
Transport	STEPS	AEA
Agriculture and Related Land Use	STEPS and LULUCF	FAPRI and LULUCF
Forestry	LULUCF	LULUCF
Waste	AEA	AEA
Development (land Use)	LULUCF	LULUCF

Chart 2: Non-Traded Scottish Business-as-Usual Emissions Projection by Sector, 2013 - 2027



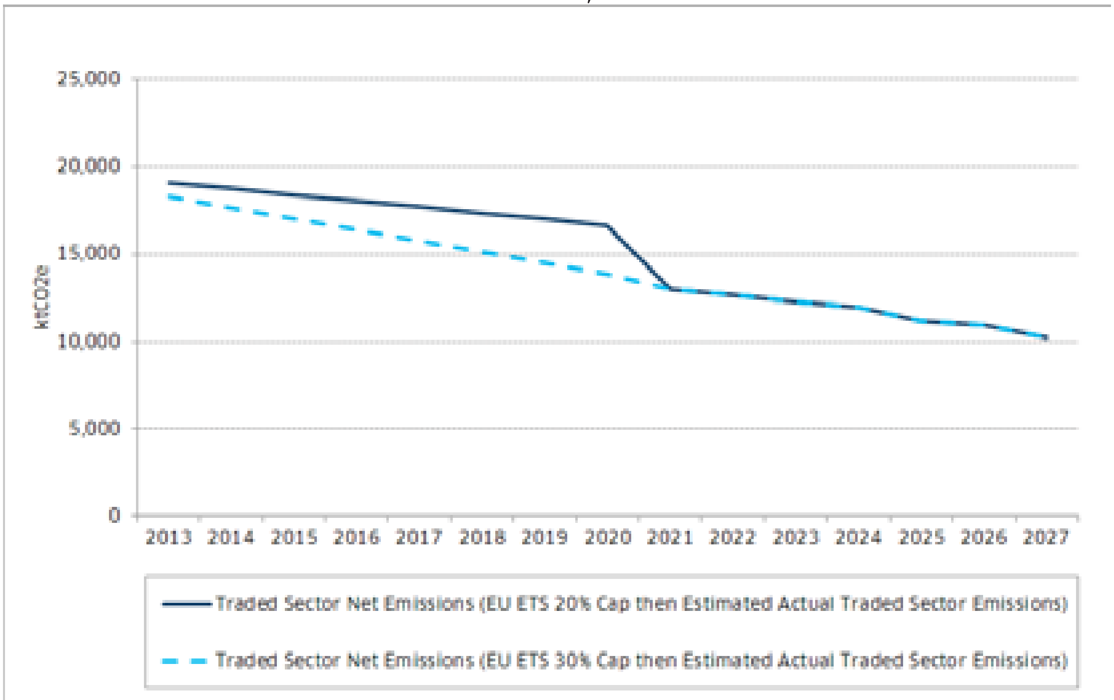
Source: Scottish Government, 2012/13

The Traded Sector

3.2.15 Estimating a future emissions projection for the traded sector has been split into two parts. From 2013 to 2020, the traded sector is presented as per the EU ETS and Scotland's share of the trading scheme's declining permit allocation is used as the emissions profile for the traded sector. From 2021 to 2027, there are no details on the nature of the EU ETS, and so an estimate of 'net traded sector emissions' has been presented. This is constructed from a projection of actual electricity generation emissions in Scotland in its transition to a sectoral emissions intensity of 50g/kWh in 2030 and from the CCC second target advice that identifies abatement from non-electricity generation traded industry (e.g. refineries). The traded sector emissions profile already builds in abatement, initially through the assumed price mechanism and permit supply in the EU ETS up to 2020, and thereafter as a result of progressing on to 50g/kWh. As such, no additional emissions abatement is deducted from the traded sector profile.

3.2.16 Chart 3 illustrates the traded sector emissions profile for Scotland.

Chart 3: Net Traded Sector Emissions, 2013 - 2027



Source: Scottish Government, 2012

3.3 Uncertainty of Emissions Projections

3.3.1 The BAU emissions projections for the traded and non-traded sectors have a significant level of uncertainty around them, which naturally increases the further into the future the projection stretches. The projections out to 2027 are based on a wide range of assumptions associated with issues such as future economic circumstances, energy consumption, land use changes, consumer behaviours and natural uptake of current policies. All assumptions made have been based on the most up to date emissions data available at a Scottish level and our best understanding of future circumstances through the projection tools used. However, the research and data associated with GHG emissions and their sources are fast evolving, which can have a significant effect on the profile of BAU emissions projections as the updates are incorporated.[16]

3.3.2 This high level of uncertainty also feeds into the abatement potential of policies and proposals that are set out in Part 3. A range of assumptions have had to be made about the potential uptake of measures and the financial investments that could be required to achieve the abatement potential detailed. Some of the policies and proposals are very much dependent upon changes in consumer behaviour, which is a particular source of uncertainty. The next section makes clear the sector specific uncertainties that exist with the emission abatement and investment projections and the assumptions (and sources) that have been used to provide credible emissions profiles.

[16] http://www.scotland.gov.uk/Resource/0042/00424034.pdf (pages 6 and 7)

4. Part 3: Sectoral Emissions Abatement, Financial Costs and Benefits

4.1 Energy and the Traded Sector

4.1.1 The Traded Sector consists of CO_2 emissions from the following categories in the NAEI: industry, commercial and the public sector; industrial process, power stations, refineries, and other energy supply. As set out above, the approach to providing an emissions projection for the traded sector from 2013 to 2020 is based on phase three of the EU ETS. The estimate of a 20% cap is based on an estimate of what Scotland's share of free allocation permits, auctioned permits and new entrants reserve will be in phase three. Whilst the 20% cap refers to a reduction of EU wide emissions of 20% by 2020 compared to a 2005 baseline, the Scottish share of that is estimated to represent a 25% reduction compared to 2005 traded emissions. To estimate the 30% reduction at an EU level, the Scottish share is assumed to be a 37.5% reduction against the 2005 traded emissions.

4.1.2 Post 2020, in the absence of an agreed EU ETS, the approach to estimating traded emissions has been to consider the abatement potential that is likely to occur from the different aspects of the traded sector. For emissions from the electricity generation sector (power stations), a Scottish Government estimate of future emissions from the sector has been used and for the non-electricity generation component of the traded sector (refineries, industry, commerce and public sector, and other energy supply), the methodology used by the CCC for the 2023 to 2027 target advice has been adopted.

Electricity Generation Sector

4.1.3 Projections of future emissions from the electricity generation sector are highly uncertain. A number of complex and competing factors govern generators hourly dispatch decisions, including relative fossil fuel prices, demand, system constraints and wind speed. Future investment decisions relating to the building, extension and closure of generating plant are also subject to this uncertainty.

4.1.4 The electricity sector generation scenario presents one plausible generation scenario to 2027, which make assumptions about thermal plant build and closure dates, average annual running times and the deployment of carbon capture & storage (CCS) at demonstration and/or at scale. This scenario is designed to give an indication of emissions from the sector by varying the amount of coal, gas and carbon capture & storage on the system. Emissions factors for thermal generating assets were applied to the estimated output from stations in the scenario to provide an emissions trajectory to 2027.

4.1.5 The analysis presented here is broadly consistent with that adopted for the Electricity Generation Policy Statement[17] with any minor variations reflecting the many uncertainties associated with the future generation mix.

4.1.6 There are limitations to this approach. The model used does not allow for dynamic dispatch decisions to be well represented. Load factors for thermal plants will vary according to market wide conditions, whereas in this model thermal load factors remain fixed. There is also no reduction in efficiency as plants age, nor does the approach consider any emissions associated with grid balancing services provided by National Grid as system operator.

4.1.7 The model assumes that there are no changes to peak and aggregate demand over time. We have also modelled unabated gas plant capacity into each scenario, to act as peaking plant, largely because the economics of CCS suggest they will have to provide base-load services.

4.1.8 The scenario presented sees Combined Cycle Gas Turbine (CCGT) as the dominant CCS technology but we would not rule out a role for clean coal once the technology is technologically proven.

4.1.9 The generation scenario will benefit from the future role for [non-pumped] electricity storage at scale and increased interconnection. While still in their infancy, there are numerous electricity storage solutions currently under development across the globe. Synergies between storage and intermittent renewables can significantly reduce the need for flexible, typically unabated fossil fuel, generation capacity leading to savings for consumers as well as emissions reductions. We are working with the Institute of Mechanical Engineers in Scotland to critically assess the viability and efficacy of these storage options including their potential application across Scotland. Successful delivery of storage solutions in Scotland will help us achieve the targets, and could lead to lower levels of emissions than those set out here.

[17] http://www.scotland.gov.uk/Topics/Business-Industry/Energy/EGPS2012

Non-Electricity Generation

4.1.10 The net emissions that are projected for refineries, industry, commerce and public sector, and other energy supply is based on the projections used by the CCC when providing advice on the 2023 - 2027 targets.[18]

4.2 Homes and Communities

4.2.1 Different approaches to modelling abatement and costs are taken for the five policy groups – (1) fabric improvements and heating efficiency, (2) behaviour change, (3) renewable heat incentive, district heating, and other low carbon heat measures, (4) building standards, and (5) additional technical potential in fabric and energy efficiency.

Group 1: Fabric Improvements and Heating Efficiency

4.2.2 The fabric improvement policies are designed to drive an increase in the energy efficiency of the household sector, for example through installing insulation and improving the efficiency of heating systems in homes. This group of policies and proposals includes the Energy Company Obligation (ECO) and Green Deal; the Home Energy Efficiency Programmes for Scotland (HEEPS) and Warm Homes Fund; and proposals for regulation of private and social housing.

4.2.3 There is general consensus that homes need to be more energy efficient and also, in most cases, a general consensus on the required measures to achieve this. The challenge to the sector is the degree and speed of penetration of the energy efficiency measures required to be installed in homes by owners, landlords and residents. This will depend on the societal and infrastructure context as well as individual decisions responding to income, motivations, barriers and lifestyle choices.

4.2.4 Policies include those which operate at the GB level, such as the ECO and the Green Deal, complemented by Scottish Government policies such as the HEEPS and Warm Homes Fund. The ECO will concentrate on external and internal wall insulation and heating systems for lower income households, while the Green Deal is a market-based mechanism which aims to remove the up-front cost barrier of energy efficiency improvements.[19]

[18] http://www.theccc.org.uk/topics/uk-and-regions/scotland
[19] http://www.decc.gov.uk/en/content/cms/consultations/green_deal/green_deal.aspx

4.2.5 Fabric improvement is modelled based on an estimated number of measures delivered by policies to homes per annum. The abatement is calculated through the DEMScot model. Modelling assumes Scottish Government programmes are funded up to 2017. Up to 2013, measures have been provided through the Universal Home Insulation Scheme, Boiler Scrappage scheme and Energy Assistance Package. From April 2013 these will be replaced by the HEEPS and Warm Homes Fund. Further modelling to fully account for the effect of these programmes will be undertaken once their development is finalised and data has started to be recorded.

4.2.6 The Climate Change (Scotland) Act provides for Ministers to consider regulating homes to improve energy efficiency. The Scottish Government has consulted on detailed proposals for a new Energy Efficiency Standard for Social Housing, which will build on the Scottish Housing Quality Standard. Alongside this, the consultation on the Sustainable Housing Strategy included consideration of if, how and when to regulate for minimum energy efficiency standards in privately owned and rented housing.

Methodology for Estimating Emissions Abatement Potential of Fabric Improvement and Heating Efficiency Measures

4.2.7 The first step in calculating abatement potential was to estimate a baseline of measures. Current knowledge on the delivery of measures from existing policy programmes was taken as the basis to project forward. The baseline assumes that there is a natural uptake[20] of policy measures alongside measures installed as a result of past policies. The most important of these was CERT.[21] The measures due to the policies and proposals set out below were added to this baseline.

Green Deal and ECO (Domestic Buildings)

4.2.8 Estimation of measures to be installed under ECO and Green Deal modelling has been informed by interim and final impact assessments published by DECC,[22] assuming that Scotland achieves a pro rata share (9%) of the programme. Measures included in the UK

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[20] This is where households install an energy efficiency measure without any policy inducement. For example boilers tend to have a life span of 8-10 years so it would be reasonable to expect households to replace their boilers after this period.

[21] http://webarchive.nationalarchives.gov.uk/20121217150421/www.decc.gov.uk/en/content/cms/funding/funding_ops/cert/cert.aspx

[22] http://www.decc.gov.uk/assets/decc/11/consultation/green-deal/5533-final-stage-impact-assessment-for-the-green-deal-a.pdf
http://www.decc.gov.uk/assets/decc/11/consultation/green-deal/3603-green-deal-eco-ia.pdf

Government impact assessments are external and/or internal wall insulation, cavity wall insulation and loft insulation. As noted by the UK Government, due to the innovative and market-based nature of the new Green Deal mechanism, it is difficult at this stage to model likely uptake with confidence. In three to five years' time there will be a much better sense of the additional abatement that Green Deal is bringing forward and the interaction with both ECO and Scottish Government programmes.

Scottish Government's Home Energy Efficiency Programmes for Scotland 2012-2017 and Warm Homes Fund

4.2.9 It is assumed that the current pattern of delivery in terms of installed measures continues from 2012 until 2017. This will prioritise installation of loft and wall insulation along with draught-proofing and heating systems with a total spend of £60m-£65m per annum for five years (2012-2017). The HEEPS is expected to leverage significant investment from the ECO and other sources as demonstrated by pilot schemes. It is assumed that a separate fund of £50m over the period up to May 2016 will be targeted specifically at renewable heat measures and renewable energy projects through the Warm Homes Fund. The breakdown of measures to be delivered from this programme is not known at this stage. For modelling purposes, it is assumed that half of the money goes to communal heating and the remaining half is equally distributed between air source heat pumps, ground source heat pumps and biomass boilers – upgrading a total of 20,000 homes.

Private and Social Housing Regulation

4.2.10 Only measures that are currently most cost effective for private households (i.e. loft insulation, cavity wall insulation, floor insulation and efficient boilers) have been included in the modelling. Modelling for social regulation has been informed by on-going work on formulating an Energy Efficiency Standard for Social Housing.[23]

[23] For further information, see http://www.scotland.gov.uk/Topics/Built-Environment/Housing/sustainable/standard

The Home Energy Efficiency Programmes for Scotland 2018-2027

4.2.11 The on-going structure and delivery of the HEEPS will depend on future spending decisions. For modelling purposes it is assumed that the programme will include continued support for insulation and heating efficiency measures for the period 2018 to 2027. These proposals are expected to be followed by a programme of solid wall insulation which will continue the ECO (or successor) programme and a further heating efficiency programme. Given that they will be building on a market where new technologies are likely, costs may be substantially lower and there may be a backdrop of regulation.

4.2.12 Once the above assumptions on the measures to be delivered in Scotland were made, the abatement potential of policies and proposals was modelled using the Cambridge Architectural Research DEMScot tool,[24] which uses a Scottish specific set of assumptions based on the housing stock and weather to calculate abatement.

4.2.13 The abatement from DEMScot was calibrated against the STEPS reference projection to ensure comparability. A sectoral rebound rate of 15% was assumed to take account of ‘comfort taking’ in the residential sector. The resultant energy demand was multiplied by emission factors to assess GHG emissions.

The DEMScot Model and Estimation Uncertainty

4.2.14 The Domestic Energy Model for Scotland (DEMScot),[25] was developed in 2009 for the Scottish Government by a partnership led by Cambridge Architectural Research Ltd. It was designed to inform the Scottish Government about the carbon and financial impacts of improving the housing stock.

4.2.15 The modelling is based on a building stock database abstracted from the Scottish House Condition Survey, specified building physics parameters and Scottish weather variables. It models total energy use, including space and water heating, cooking, lighting and appliances.

4.2.16 DEMScot allows users to model 19 different upgrades to houses, where such upgrades are technically feasible. These upgrades

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[24] Scottish Government, 2009, Modelling Greenhouse Gas Emissions from Scottish Housing: Final Report, http://www.scotland.gov.uk/Publications/2009/10/08143041/0

[25] The DEMScot model along with relevant reports and manuals are available to download at: http://www.scotland.gov.uk/Topics/Built-Environment/Housing/supply-demand/chma/marketcontextmaterials

include a range of insulation measures, heating systems, and renewable technologies, and allows for behaviour change. The model shows the effect that implementing upgrades has on energy use and GHG emissions as well as the associated costs of installing upgrades and savings in energy costs. In 2010 DEMScot was extended to include maintenance costs of upgrades and to model price elasticity and rebound effects.

4.2.17 The following bullet points detail the key sources of uncertainties in the abatement potential and cost estimates:

- Estimates of the number of measures delivered under each programme are generally based on limited data of actual performance and assumptions on future uptake rates, combined with assumptions about distribution of UK-wide policies (such as the ECO and Green Deal). As experience with Scottish programmes develops further and data on UK programmes becomes available it should be possible to improve these estimates.

- The natural uptake of a measure is an estimate of what would happen without Government intervention. As with the overall BAU, there is uncertainty in making this estimate.

- Estimates of future abatement are modelled from the assumed application of specific measures to the housing stock in Scotland. The relationship of this abatement to the reference projection, where results are from an econometric model based on past trends of consumption, is complex because of the different methodologies involved.

Methodology for Estimating Costs and Benefits of Fabric Improvement and Heating Efficiency Measures[26]

4.2.18 Current policies running to 2027 are estimated to incur costs of approximately £2.1bn in total. Costs identified are additional to the costs of the policy contained in the BAU projection (of £5.4bn from 2010 to 2027).

4.2.19 The costs of proposals up to 2027 are estimated to be around £3.1bn. This is additional to the cost of the policy package in place and based on the capital and maintenance costs of the measures estimated to be delivered by the proposals over that period. The basis

[26] Financial figures presented in 2011 prices unless otherwise stated.

of the cost data is from DEMScot but where available these figures have been updated with figures published in the ECO/Green Deal Impact Assessments. They do not take account of the reduced costs that may be gained from capital programmes levering economies of scale, or from reduced costs of technologies over time.

4.2.20 It is assumed that the total costs of these measures will fall on government, consumers and energy suppliers as described below.

4.2.21 Upgrades delivered through Green Deal will be paid for by the household through a charge on the meter. While the ECO places an obligation on energy suppliers to install energy efficiency measures in homes, energy customers effectively pay for the cost of their energy supplier's meeting its target through their fuel bills. It is estimated that in 2008 residential customers paying for both gas and electricity contributed an additional average of £38 to fund the CERT programme.[27]

4.2.22 The cost to the Scottish Government of investment in the HEEPS and Warm Homes fund over the period 2012 to 2017 is £375m.

4.2.23 Investment in energy efficiency measures in the home will also save money over the lifetime of the upgrade and in many cases is likely to pay back the initial investment through savings in fuel consumption. It is estimated that measures detailed in this section could produce savings in fuel bills of £2.4bn by 2027 with continued savings accumulating after this date. This is in keeping with the CCC's report Building a Low Carbon Economy, which presented a Marginal Abatement Cost Curve (MACC)[28] for the residential sector showing that most insulation measures and use of energy efficient appliances achieve savings over their lifetime.

4.2.24 These estimated benefits do not include the benefits associated with preventing harmful climate change as well as addressing the ill-health related to fuel poverty. A large body of research shows that improvements in housing conditions can lead to improved physical and mental health. For example, warm, dry homes can improve respiratory conditions.[29]

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[27] Ofgem, Household energy bills explained, (updated), Jan 2008 (www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=73&refer=Media/FactSheets).

[28] Figure 6.10, http://www.theccc.org.uk/reports/building-a-low-carbon-economy

[29] See "A Select Review of Literature on the Relationship between Housing and Health", available at http://www.scotland.gov.uk/Topics/Built-Environment/Housing/supply-demand/chma/marketcontextmaterials under the Research category

Table 3: Abatement Potential and Costs of Fabric Improvement Policies and Proposals, 2013 - 2027

	Annual emissions abatement from policies ($ktCO_2e$)	Annual total costs of policies (£m)	Annual emissions abatement from proposals ($ktCO_2e$)	Annual total costs of proposals (£m)
2013	79	275	0	0
2014	136	275	1	79
2015	187	275	13	79
2016	236	275	20	79
2017	283	265	27	79
2018	293	140	60	204
2019	319	140	78	204
2020	334	140	96	204
2021	344	140	117	204
2022	361	140	134	204
2023	361	0	172	344
2024	361	0	209	344
2025	361	0	247	344
2026	361	0	284	344
2027	361	0	320	344

Group 2: Behaviour Change - Smart Metering (Domestic Buildings)

4.2.25 Behaviour change is led by UK policies and hence the modelling is based on estimates provided by the Department of Energy and Climate Change (DECC). A wide range of policies aim to stimulate behaviour change, so to avoid double counting the only abatement included in the modelling is from installation of smart meters.

4.2.26 Smart meters are able to display real-time information about energy use and costs, thereby encouraging better household energy management. The UK Government expects mass roll-out of smart meters to start in 2014 and be complete by 2019.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits from Smart Metering

4.2.27 In the absence of Scottish-specific data for this scheme, the abatement potential estimated as part of the DECC Updated Emission Projections (October 2011) at the UK level was apportioned to Scotland as a share of UK households. Scotland's share is 9% of total UK households. In 2027 this policy is expected to reduce emissions in Scotland by $95ktCO_2e$.

4.2.28 In the DECC impact assessment for smart meter roll-out for the domestic sector,[30] it's assumed that the total cost of rolling out this policy to 2030 is £10.85bn (PV, 2012), with associated benefits of £15.69bn. Costs include the capital cost associated with the installation of meters and their operation and maintenance, the cost of communication systems and the cost of disposal. Consumer benefits are largely from reduced energy consumption. Supplier benefits include avoided site visits and reduced inquiries and customer overheads.

4.2.29 The costs presented are cumulative to 2030. To remain consistent with the emissions savings that these actions are estimated to deliver, Scotland's proportional cost/benefit share is also based on the proportion of UK households in Scotland.

4.2.30 The smart meter rollout in the Scottish domestic sector is therefore estimated to cost approximately £1.13bn (undiscounted), with benefits totalling £1.58bn over the RPP2 period.

4.2.31 The cost of the smart meter roll out is expected to fall on the consumer through their energy bills from their energy supplier.

[30] http://www.decc.gov.uk/assets/decc/11/consultation/smart-metering-imp-prog/4907-smart-meter-rollout-non-domestic-ia-resp.pdf

Table 4: Abatement Potential and Costs of Residential Smart Metering, 2013 - 2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	7	9.5
2014	17	20.9
2015	33	40.9
2016	49	63.0
2017	66	80.4
2018	80	94.2
2019	86	95.3
2020	88	94.4
2021	89	91.9
2022	90	90.9
2023	91	89.8
2024	92	89.2
2025	94	88.4
2026	94	87.5
2027	95	86.4

Group 3: Domestic Renewable Heat Incentive, District Heating Loans Fund Policies and other Low Carbon Heat Proposals

Renewable Heat Incentive (Domestic Buildings)

4.2.32 The Renewable Heat Incentive (RHI) is a UK wide policy offering payments to those who install and obtain heat from renewable sources. This incentive payment is already available to renewable heat technologies in the non-domestic sector. The domestic scheme has been delayed until 2013, with the Renewable Heat Premium Payment providing short term support to renewable heat technologies in the domestic sector in the interim. DECC is currently consulting on cost control measures, and any changes in expected abatement and cost will be reflected in any updates.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of RHI Policy

4.2.33 The abatement potential for the RHI was estimated at the UK level in DECC's Updated Emission Projections (October 2011) according to the 9% proportion of UK households in Scotland. In 2027 this policy could potentially reduce emissions in Scotland by 80$ktCO_2e$. However, as this policy incentivises market demand through the opportunity to collect an output based tariff, the uptake will be driven by a number of market, regional and environmental factors.

4.2.34 Due to the uncertainty surrounding the domestic RHI, no cost or benefit information has been included. However, under the RHI, it is likely that up-front costs for the installation of renewable heat generation will be met by property owners, with the incentive guaranteeing them a reasonable return on investment.

District Heating Loan Scheme

4.2.35 The Scottish Government's district heating loan fund provides loans for both low carbon and renewable technologies to help organisations implement district heating projects to benefit local communities. Low interest loans of up to £400,000 per project will be made available to be repaid over a period of up to 10 years. The scheme is open to local authorities, registered social landlords, small and medium sized enterprises and energy services companies.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of District Heating Loan scheme

4.2.36 There are a number of factors which impact the abatement potential of a district heating network, including the mix of the housing stock and the density of the network. The abatement potential for the District Heating Loan Scheme applies estimates from Poyry's "The Potential and Costs of District Heating Networks"[31] to the number of homes currently connected, and the number estimated to connect, to district heating networks through the scheme.

4.2.37 To 2014, this proposal could potentially reduce annual emissions in Scotland by up to 50ktCO_2e, across both the domestic and non-domestic sector.

Domestic Low Carbon Heat

4.2.38 The proposal for decarbonising heat will include both the domestic and non-domestic sectors. As the majority of the emissions abatement is likely to fall in the non-domestic sector, the final abatement split between the Homes and Communities sector and the Business, Industry and Public Sectors may change.

31 http://webarchive.nationalarchives.gov.uk/20121205174605/http://decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/distributed%20energy%20heat/1467-potential-costs-district-heating-network.pdf

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of Low Carbon Heat

4.2.39 Estimates of the Scottish abatement potential for low carbon heat are derived from the detailed cost effectiveness model developed for the CCC. This model looks at the potential scenarios for low carbon heat technologies to replace fossil fuel use up to 2030. The model has drawn upon and extended the evidence base used for previous low carbon heat modelling in DECC, and includes technology assumptions and input data that have been extended to 2030. Additional technologies have been incorporated to reflect a wider range of possible future developments (e.g. synthetic biogas from the gasification of biomass, and heat pumps with heat storage that can shift electricity load profiles).

4.2.40 There are a number of credible scenarios for future low carbon heat generation, and this analysis represents one scenario. Estimates of abatement potential include all forms of low carbon heating. To avoid double counting, the abatement potential from policies which deliver low carbon heating (i.e. the Warm Homes Fund, the domestic Renewable Heat Incentive and the District Heating Loans Fund) has been subtracted from the overall abatement this proposal can potentially deliver.

4.2.41 The costs of the Low Carbon Heat proposal have been proportionately reduced from the costs produced by the CCC modelling, although the high level of uncertainty should be noted since the costs are not uniform across the proposal but will depend on the particular mix of measures.

4.2.42 In order to achieve our vision of decarbonising heat supply, we will develop a longer term strategy that looks at heat in the wider context of available energy resources, and demand. In this respect, we have developed a draft heat hierarchy of use and will publish a Heat Generation Policy Statement (HGPS) by the end of 2013, which will look in detail at possible generation scenarios. The HGPS will sit alongside the Electricity Generation Policy Statement providing a comprehensive energy policy view.

Table 5: Abatement Potential and Costs of Domestic Renewable Heat Incentive and District Heating Loan Scheme, 2013 - 2027

	Renewable Heat Incentive (Domestic)[32]	District Heating Loans Fund		Low Carbon Heat proposals	
	Annual emissions abatement ($ktCO_2e$)	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	11	24	41	0	0
2014	19	36	41	0	0
2015	27	36	0	7	10
2016	35	36	0	25	23
2017	46	36	0	39	19
2018	57	36	0	57	25
2019	68	36	0	76	25
2020	78	36	0	99	30
2021	79	36	0	135	42
2022	79	36	0	186	40
2023	79	36	0	247	38
2024	80	36	0	336	36
2025	80	36	0	424	33
2026	80	36	0	513	30
2027	80	36	0	609	28

Group 4: Domestic Building Standards

4.2.43 New energy standards for new homes came into force in October 2010. These revisions deliver an aggregate 30% reduction in CO_2 emissions from new dwellings when compared to those constructed to the 2007 building standards. This equates to a reduction of around 70% compared to the standards that existed in 1990. A further review of domestic energy building standards is underway and has investigated further improvements up to and including the 60% reduction on 2007 emissions recommended in the Sullivan Report.[33] A consultation containing proposals for the next set of energy standards based on a 45% reduction on 2007 emissions took place between January and April 2013.

[32] Costs for the RHI have not been included since insufficient detail is available to estimate these.
[33] http://www.scotland.gov.uk/Resource/Doc/917/0098823.pdf

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of New Building Standards

4.2.44 By 2027, the cumulative abatement potential of the new building standards, already in force in 2010 and introduced beyond 2013, have been assessed as 1.5 $MtCO_2e$. This is considered separately from the existing stock of housing but has a smaller abatement impact as the number of new buildings per annum currently accounts for less than 1% of the overall housing stock and also due to the previous 2007 standard already requiring new homes to be energy efficient, with relatively low emissions.

4.2.45 The analysis assumes that the BAU projections for the residential sector include the 2007 building standards. The 2010 building standards deliver a 30% reduction in CO_2 emissions from new dwellings when compared with BAU. The annual abatement figure is the sum of the emissions reduction from both the new housing built in the relevant year and from housing built each year since the 2010 base date. Consultation on the next set of energy standards proposes a 45% reduction on 2007 emissions from new dwellings, or approximately a 22% improvement on 2010 standards. Following consultation, Ministers will confirm both the level of improvement to be implemented and when new standards will be introduced. Projections are currently based upon the consultation proposal to introduce improved standards in 2014.

4.2.46 The abatement results from the non-traded sector only and assumes that 85% of total abatement from the building standards falls in the non-traded sector. The remaining 15% is assumed by the traded sector as a result of electricity demand reduction.

4.2.47 The abatement potential calculations include assumptions about the number of new dwellings built per annum and the CO_2 that they will release per year. It is assumed an annual build rate will drop from almost 17,000 units in 2010 to between 15-16,000 units and then rise gradually to approximately 19,000 units per annum by 2027. Assessment is based upon a notional fuel type mix applied to a range of typical example dwellings. It is assessed that the average dwelling built to 2007 standards will release approximately two tonnes of CO_2 annually. Emissions reported on in this policy area are those calculated, using the 2009 edition of the UK Standard Assessment Procedure, from a standardised assessment of 'regulated energy use' arising from fixed building services within new dwellings - emissions arising from heating/cooling, hot water, lighting, ventilation and auxiliary equipment (e.g. circulating pumps). Energy used for domestic appliances and cooking fall out with the scope of building regulations

4.2.48 The emission savings from the new standards are phased in over three years to reflect the delay period between the introduction of new standards and the delivery of almost all new housing built to those standards.

4.2.49 In terms of the financial costs and benefits, analysis within the Regulatory Impact Assessment[34] for the 2010 changes to energy standards within building regulations identifies a mid-range additional cost to development of £129m per annum. The same assumptions about the annual build rate and rate of introduction of new standards as set above are used. The annual costs shown in the table below represent the cost of implementation of the new standards, before deduction of energy savings. Net present value is calculated using 2010 prices. The cumulative cost to development in application of the 2010 and proposed 2014 standards (to 2027) is assessed as £1.8 billion at current NPV. These are additional costs over and above the costs of the 2007 building standards in the baseline.

4.2.50 The costs should be assumed to be broadly indicative as they represent the most cost effective application of a limited range of improvement scenarios and may not represent the actual solutions adopted. Financial savings from reduced fuel consumption as a result of the 2010 and proposed 2014 standards is estimated at £960m.

4.2.51 The majority of the additional cost of the new building standards will be borne by those funding the housing development – businesses and consumers. The Scottish Government may also face higher costs through its funding of social housing. Savings from reduced energy costs will accrue to bill payers who will normally be the householders.

[34] http://www.scotland.gov.uk/Resource/Doc/917/0098823.pdf

Table 6: Abatement Potential and Costs of Building Standards Policies and Proposals, 2013 – 2027

	2010 Standards		2014 Standards	
	Annual emissions abatement ($ktCO_2$)	Annual total cost (£m)	Annual emissions abatement ($ktCO_2$)	Annual total cost (£m)
2013	16	80	0	0
2014	24	78	0	23
2015	32	76	1	44
2016	41	75	4	65
2017	49	73	8	64
2018	58	72	13	62
2019	67	70	17	61
2020	76	69	22	60
2021	84	68	26	58
2022	93	66	31	57
2023	103	65	35	56
2024	112	64	40	55
2025	122	62	45	54
2026	132	61	50	53
2027	142	60	55	52

Abatement Potential Compared to RPP1

4.2.52 Annual emissions abatement from domestic building standards differ from those reported under RPP1 due to the following factors. Overall abatement for the 2010 policy and 2014 proposal is now based upon an annual build rate more than 40% lower than originally anticipated. Revision of the 2014 proposal from a 60% reduction on 2007 emissions to 45% reduction reduces the abatement potential of this proposal by half (a 22% emissions reduction over 2010 policy compared to a 44% reduction).

Group 5 – Additional Technical Potential in Fabric and Energy Efficiency

4.2.53 Our modelling suggests that there is also an additional technical abatement potential of approximately 0.65 Mt which could be achieved by 2027 through improvements to the carbon efficiency of the housing stock. We have not put forward a fully-fledged proposal at this stage as further work is required to analyse and consider a range of options. Many of these upgrades would be in the owner-occupied and private rented sectors, where energy efficiency policies have not advanced as much as in the social sector, and for which the optimum blend of regulation and incentives is currently being investigated and developed in Scotland and the rest of the UK.

4.2.54 As we develop future policies, we will also need to assess the impact of action to encourage market transformational change. As options, costs and technical solutions develop in future years, more efficient and cost-effective approaches may emerge. In particular, if more cost-effective options emerge in other sectors then it may be preferable for some or all of this abatement to be delivered from other parts of the economy. But in the case that further abatement is required from the homes and communities sector, we intend to produce a detailed proposal in RPP3 of how we may realise some or all of this remaining technical potential.

4.2.55 At this stage the estimated additional abatement has been modelled in a similar way to our other housing proposals. Using DEMScot, we first modelled upgrades for the ‘business as usual’, as well as for the various policies and proposals. The model then provides an estimate of how many upgrades to the existing housing stock are still technically feasible. These upgrades include measures such as solid wall insulation, loft and floor insulation and a range of other upgrades which also form part of our current policies and proposals. The difference is that there is a greater proportion of higher cost upgrades in the further potential, since our policies and proposals typically start with the most cost-effective measures.

Table 7: Abatement from Additional Technical Potential in Fabric and Energy Efficiency, 2013 – 2027

	Annual emissions abatement ($ktCO_2e$)
2013	0
2014	0
2015	0
2016	0
2017	0
2018	72
2019	142
2020	210
2021	278
2022	343
2023	407
2024	470
2025	531
2026	591
2027	650

4.3 Business, Industry and the Public Sector

Smart Metering (Non-Domestic Buildings)

4.3.1 Smart meters will be rolled out in non-domestic small and medium sized business buildings. Smart meters help customers understand in real-time their energy consumption patterns, promoting better energy management. This is a UK Government policy, with mass roll-out of smart meters expected to start in 2014 and to be complete by 2019.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of Smart Metering

4.3.2 There is no Scottish specific data for this scheme. As such, the abatement potential estimated as part of the DECC Updated Emission Projections (Oct 2011) was apportioned to Scotland, according to the proportion of UK small and medium sized enterprises in Scotland, which is 7.1%. On this basis, this policy is expected to reduce annual emissions in Scotland by 46$ktCO_2e$ in 2027.

4.3.3 In the DECC Smart Meter roll-out for the non-domestic sector (GB) impact assessment,[35] DECC assumes the total cost of rolling out this policy to 2030 is £608m (PV, 2012), with associated benefits of £2.95bn. Costs include the capital cost associated with the installation of meters and their operation and maintenance, the cost of communication systems and the cost of disposal. Benefits include energy and carbon savings through efficient energy use, as well as process savings to the energy suppliers and network operators.

4.3.4 These costs are cumulative to 2030. To remain consistent with the emissions savings that these actions are estimated to achieve, it is intended that Scotland's proportional cost/benefit share should be based on the proportion of UK small and medium sized enterprises in Scotland. The smart meter rollout in the Scottish non-domestic sector is therefore estimated to cost approximately £54m (undiscounted), with benefits totalling £242m over the RPP2 period.

4.3.5 In terms of distribution of costs and benefits, DECC estimates that both the costs and benefits from the non-domestic smart metering programme are expected to fall principally on the consumer, in this case small and medium sized enterprises.

Table 8: Abatement Potential and Costs of Non-Domestic Smart Metering Programme, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	2	-0.3
2014	8	0.0
2015	19	1.5
2016	30	3.2
2017	42	4.8
2018	49	5.9
2019	52	5.8
2020	53	5.5
2021	52	5.2
2022	51	4.7
2023	50	4.3
2024	49	3.9
2025	48	3.5
2026	47	3.1
2027	46	2.7

[35] http://www.decc.gov.uk/assets/decc/11/consultation/smart-metering-imp-prog/4907-smart-meter-rollout-non-domestic-ia-resp.pdf

Renewable Heat Incentive (Non-Domestic Buildings)

4.3.6 The Renewable Heat Incentive (RHI) is a UK wide policy that offers reduced tariffs to those who install and obtain heat from renewable sources.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of Non-Domestic RHI

4.3.7 The abatement potential estimated for Scotland was derived as part of the UK DECC Updated Emission Projections (Oct 2011) and apportioned to Scotland, according to the proportion of UK non-domestic consumption in Scotland, which is 10.1%. In 2027 this policy is expected to reduce annual emissions in Scotland by 914 ktCO_2e.

4.3.8 In the DECC renewable heat impact assessment on the final proposals of renewable heat support for the non-domestic sector,[36] it is assumed that the cumulative lifetime cost of this policy is £14bn (PV, 2010), with associated benefits of £9.8bn. Benefits will include both traded and non-traded sector carbon costs, though the majority of installations will be outside the scope of the EU-ETS.

4.3.9 To remain consistent with the emissions savings that these actions are estimated to achieve, it is assumed that Scotland's proportional cost/benefit share is the proportion of UK non-domestic consumption in Scotland. The non-domestic RHI arising from Scottish installations is therefore estimated to cost approximately £1.34bn (undiscounted), with benefits totalling £705m over the RPP2 period.

4.3.10 In terms of distribution of costs and benefits, up-front installation and operating costs fall to the business and industrial asset owners. The RHI tariff compensates for the difference in the costs of a renewable system compared with a fossil fuel heat system, whilst paying a reasonable return to generators to compensate for the financial opportunity cost of this additional capital expenditure.

[36] http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/3775-renewable-heat-incentive-impact-assessment-dec-20.pdf

Table 9: Abatement Potential and Costs of Non-Domestic Renewable Heat Incentive, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	106	52
2014	171	82
2015	256	82
2016	375	90
2017	532	102
2018	641	102
2019	768	105
2020	896	122
2021	869	104
2022	849	91
2023	877	95
2024	893	88
2025	902	81
2026	909	69
2027	914	78

Carbon Reduction Commitment (CRC) Energy Efficiency Scheme

4.3.11 The CRC is a mandatory UK-wide trading scheme covering large business and public sector organisations and designed to reduce emissions through incentivising increased energy efficiency. The policy covers organisations with at least one half hourly meter that use more than 6,000MWh/annum of equivalently metered electricity.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of CRC

4.3.12 As part of the ongoing consultation process into streamlining the CRC scheme, DECC published an impact assessment setting out simplification options for this scheme,[37] which contained an estimate of the emissions savings and cost impacts of the policy under a BAU case. This has been apportioned to Scotland, according to the proportion of UK non-domestic consumption in Scotland, which is 10.1%. In 2027 this policy is expected to reduce annual emissions in Scotland by 154 $ktCO_2e$.

4.3.13 The same DECC consultation document suggests that the BAU of the CRC scheme is approximately £801m to 2030 (PV, 2011), with

[37] http://www.decc.gov.uk/assets/decc/11/consultation/CRC/4758-ia-simp-crc-energy-efficiency-scheme.pdf

associated energy and non-traded carbon benefits estimated at approximately £5bn.

4.3.14 To remain consistent with the emissions savings that the CRC is estimated to achieve it is assumed that Scotland's proportional cost/benefit share is the proportion of UK non-domestic consumption in Scotland. The CRC energy efficiency scheme is therefore estimated to cost approximately £98m (undiscounted), with benefits totalling £682m over the RPP2 period.

4.3.15 In terms of the distribution of costs and benefits, there is an administrative cost to organisations of complying and reporting within the CRC scheme. Subsequent simplifications to the scheme may reduce these costs. However, relative to a world without the CRC Scheme, organisations now have to pay for their emissions where previously they did not. The cost of emissions to firms has the potential to reduce the more firms act to reduce their emissions. The benefit of the CRC scheme is the cost of emissions avoided due to putting a price on the emissions externality.

Table 10: Abatement Potential and Costs of CRC Energy Efficiency Scheme, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	30	10.7
2014	41	4.7
2015	54	4.7
2016	68	4.9
2017	83	4.8
2018	98	11.3
2019	114	6.9
2020	130	6.1
2021	149	6.1
2022	169	5.3
2023	184	12.4
2024	200	5.8
2025	216	2.6
2026	187	2.6
2027	154	2.6

New Non-Domestic Building Standards

4.3.16 Energy standards for new non-domestic buildings came into force in October 2010. These revisions deliver a 30% reduction in CO_2 emissions from new non-domestic buildings when compared to those constructed to the 2007 building standards. This equates to a reduction of 65-70% compared to the standards that existed in 1990. A further review of non-domestic energy standards is underway and has investigated further improvements up to and including the 75% reduction on 2007 emissions recommended in the Sullivan Report[38]. A consultation containing proposals for the next set of energy standards based upon a 60% reduction on 2007 emissions took place between January and April 2013.

4.3.17 The cumulative abatement potential of the new building standards, already in force in 2010 and introduced beyond 2013, have been assessed as 1.2 $MtCO_2$ by 2027. This is considered separately from the existing stock of buildings but has a smaller abatement impact as the square metreage of new buildings per annum currently accounts for less than 1% of the existing public and commercial stock and also due to the previous 2007 standard already requiring new buildings to be energy efficient, with relatively low emissions.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits from New Non-Domestic Building Standards

4.3.18 The BAU projections for the non-domestic sector include the 2007 building standards. The 2010 building standards deliver a 30% reduction in CO_2 emissions from new dwellings when compared with BAU. The annual abatement figure is the sum of the emissions reduction from both the new buildings constructed in the relevant year and from those constructed each year since the 2010 base date. Consultation on the next set of energy standards proposes a 60% reduction on 2007 emissions from new dwellings, or approximately a 43% improvement on 2010 standards. Following consultation, Ministers will confirm both the level of improvement to be implemented and when new standards will be introduced. Until this is confirmed, the introduction of new standards is assumed for 2018, as a worst case, given obligations under the EU Directive on the Energy Performance of Buildings which must be met.

4.3.19 The abatement results from the non-traded sector only and assumes that 54.9% of total abatement from the building standards falls in the non-traded sector. The remaining 45.1% is assumed by the traded sector as a result of electricity demand reduction.

[38] http://www.scotland.gov.uk/Resource/Doc/217736/0092637.pdf

4.3.20 The abatement potential calculations are based upon a broad assumption about the overall metreage of new buildings delivered per annum and the CO_2 that they will generate per year. There is very little information on the current annual build rate for commercial premises. Accordingly, an assumption of a constant annual build rate of 700,000m² is applied, extrapolated from recent UK statistics. Assessment is currently based upon a notional fuel type mix applied to a range of nine different example building types. Emissions reported on in this policy area are those calculated using the 2009 edition of the UK National Calculation Methodology, implemented through iSBEM v4.1a using carbon factors for fuels applicable in 2010.[39] This implements a standardised assessment of 'regulated energy use' arising from fixed building services within new buildings - emissions arising from heating/cooling, hot water, lighting, ventilation and auxiliary equipment (e.g. circulating pumps). Energy used for business equipment or industrial process fall out with the scope of building regulations.

4.3.21 The emission savings from the new standards are phased in over four years to reflect the delay period between the introduction of new standards and the delivery of almost all new buildings built to those standards.

4.3.22 Analysis within the Regulatory Impact Assessment[40] for the 2010 changes to energy standards within building regulations identifies a mid-range additional cost to development of £84.5m per annum. The same assumptions about the annual build rate and rate of introduction of new standards as set out in the paragraphs above have been used. The annual costs shown in the table below represent the cost of implementing current 2010 standard and proposed new standards, before deduction of energy savings. Net Present Value (NPV) is calculated using 2010 (policy) & 2012 (proposal) prices. The cumulative cost to development to 2027 is assessed as £1.3bn at current NPV. These are additional costs over and above the costs of the 2007 building standards in the baseline.

4.3.23 The costs should be assumed to be broadly indicative as they represent the most cost effective application of a limited range of improvement scenarios and may not represent the actual solutions subsequently adopted. Financial savings from reduced fuel consumption as a result of the 2010 standards and further improvements to standards, are assessed at £553 million.

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[39] Table 6, NCM Modelling Guide (Scotland) - http://www.scotland.gov.uk/Resource/Doc/217736/0117285.pdf

[40] http://www.scotland.gov.uk/Resource/Doc/917/0098823.pdf

4.3.24 The majority of the additional cost of the new building standards will be borne by those funding development – businesses and consumers. Savings due to reduced energy demand will benefit those owning or occupying buildings that are responsible for energy bills.

Table 11: Abatement Potential and Costs of Building Standards, 2013-2027

	Annual emissions abatement ($ktCO_2$) 2010 standards	Annual cost (£m) 2010 standards	Annual emissions abatement ($ktCO_2$) beyond 2013	Annual cost (£m) beyond 2013
2013	13	76		
2014	19	73	0	14
2015	25	71	2	26
2016	32	68	5	38
2017	38	66	10	37
2018	44	64	15	36
2019	51	61	20	34
2020	57	59	25	33
2021	63	57	30	32
2022	70	55	35	31
2023	76	53	40	30
2024	82	51	45	29
2025	89	50	50	28
2026	95	48	55	27
2027	101	46	60	26

Abatement Potential Compared to RPP1

4.3.25 Annual emissions abatement from non-domestic building standards differ from those reported in RPP1 due to the following factors. Revision of the 2014 proposal from 75% reduction on 2007 emissions to 60% reduction reduces the impact of this proposal by one third (a 43% emissions reduction over 2010 policy compared to a 64.5% reduction).

Green Deal (Non-Domestic Buildings)

4.3.26 The Green Deal is a UK energy efficiency measure which will be offered by the private sector to enable homeowners and businesses to implement energy efficiency improvements at little or no upfront cost with payment recouped through customers' energy bills.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of Green Deal

4.3.27 The abatement potential for this scheme in Scotland was estimated using the UK final stage impact assessment for the Green Deal and Energy Company Obligation[41] (June 2012). Abatement was apportioned to Scotland based on the proportion of UK non-domestic consumption in Scotland, which is 10.1%. In 2027 this policy is expected to reduce annual emissions in Scotland by 24ktCO_2e.

4.3.28 DECC's Green Deal impact assessment assumes that the cumulative lifetime cost of this policy is £17.3bn (PV, 2011), with associated benefits of £25.6bn. This is the total domestic and non-domestic cost. To remain consistent with the emissions savings that these actions are estimated to achieve it is assumed that Scotland's proportional cost/benefit share is the proportion of UK non-domestic consumption in Scotland. Non-domestic green deal in Scotland is therefore estimated to cost approximately £182m (undiscounted), with benefits totalling £373m over the RPP2 period.

4.3.29 In terms of distribution of costs and benefits, installation and financing costs will fall largely to those organisations benefiting from energy efficiency measures. There will also be costs to energy companies of administering the ECO scheme, though these are expected to be passed on to energy consumers.

[41] http://www.decc.gov.uk/en/content/cms/consultations/green_deal/green_deal.aspx

Table 12: Abatement Potential and Costs of Green Deal & Supporting policies, 2013-2027

	Annual emissions abatement (ktCO_2e)	Annual total costs (£m)
2013	2	3.2
2014	4	4.4
2015	18	12.6
2016	38	17.8
2017	58	20.9
2018	74	20.4
2019	85	19.8
2020	92	23.2
2021	97	25.4
2022	98	24.8
2023	73	3.0
2024	55	1.6
2025	41	1.6
2026	31	1.7
2027	24	1.7

EU Products Policy

4.3.30 EU Products policy refers to an EU wide minimum energy efficiency standard that provides energy and emissions savings. Examples of items affected by these measures are non-domestic information & communication technology and commercial appliances.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of EU Products Policy

4.3.31 To calculate an abatement potential in Scotland from this measure, the estimated UK abatement potential as part of the DECC Updated Emission projections (Oct 2011) was apportioned to Scotland based on the proportion of UK small and medium sized enterprises in Scotland of 7.1%. In 2027 this policy is expected to increase emissions in Scotland by 8ktCO_2e. The increase in emissions results from the heat replacement effect. Appliances and lighting consume energy which is in part converted to heat. As appliances become more energy efficient, heating systems compensate for this reduction in heat. Emissions in the traded sector are estimated to fall as a result of reduced electricity demand.

4.3.32 DECC's Carbon Plan[42] (December 2011) assumes that the cumulative lifetime cost of tranche 1 of this policy is £3.9bn (PV, 2011), with associated benefits of £14.1bn. This is the total domestic and non-domestic cost. Annualised cost information for the non-domestic sector is not available.

4.3.33 In terms of distribution of costs and benefits, it is estimated that both the costs and benefits from these measures are expected to fall principally on the consumer, in this case small and medium sized enterprises.

Table 13: Additional Emissions Potential of EU Products Policy, 2013-2027

	Annual emissions (ktCO_2e)
2013	6
2014	10
2015	7
2016	8
2017	9
2018	10
2019	11
2020	11
2021	11
2022	10
2023	10
2024	9
2025	9
2026	8
2027	8

Public Sector Extended Ambition

4.3.34 Commissioned research has shown that the Scottish public sector could potentially achieve significant reductions in CO_2e emissions.[43] The study used the Carbon Management Plans (CMP) of Scottish public sector bodies and the Carbon Trust's proprietary database of carbon reduction recommendations made to the public sector to assess the potential for emissions reductions across the public sector. Behaviour change, renewables, HVAC and building fabric are the areas offering the largest potential reduction in terms of total emissions.

[42] http://www.decc.gov.uk/en/content/cms/emissions/carbon_budgets/carbon_budgets.aspx
[43] http://www.scotland.gov.uk/Publications/2012/12/3885

4.3.35 Possible options for achieving the identified abatement potential from CMPs and other recommendations made by Carbon Trust to the public sector in Scotland are at an early stage of development. Options will need to tackle the barriers in areas of: senior leadership and performance management; engaging procurement functions; availability of financing; lack of skilled resources; and split incentives. These could include a significant expansion of the existing CMP across the public sector targeted at all local authorities, NHS, Higher and Further Education and others to maximise opportunities for decisive action, set targets for the public sector to reduce emissions and go further than BAU projections will deliver.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of Reducing Emissions in the Public Sector

4.3.36 To calculate an abatement potential in Scotland from this measure, research was commissioned which identified a baseline for Scottish public sector emissions using public sector CMPs. An assessment has been made of the potential reduction in non-traded emissions from this baseline. It's assumed that abatement comes as a result of delivering previously identified but not implemented emissions reductions measures earlier, and extending the ambition out to 2030.

4.3.37 In 2027 this proposal is estimated to reduce emissions in Scotland by 285ktCO_2e. Initial estimates suggest that this proposal could cost public sector bodies approximately £216m per annum in total by 2027.

Table 14: Abatement Potential and Costs of Public Sector Extended Ambition, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	87	16
2014	109	16
2015	130	16
2016	152	16
2017	174	16
2018	195	16
2019	217	16
2020	239	16
2021	245	16
2022	252	5
2023	259	5
2024	265	5
2025	272	5
2026	278	5
2027	285	5

Non-Domestic Buildings: Assessment of Energy Performance and Regulations (AEPR)

4.3.38 Buildings account for over 40% of the GHG emissions in the UK but less than 1% of the existing stock is replaced by new buildings each year. Regulations would be introduced through Section 63 of the Climate Change (Scotland) Act for the assessment of the energy performance of existing non-domestic buildings and their emissions and for owners to improve the energy performance of their buildings and to reduce emissions.

4.3.39 Initially, the proposal would be implemented broadly in line with the consultation with assessments to be carried out every 10 years. Owners would then either have to implement building improvements or annually report the building's operational carbon and energy performance. The proposal would be reviewed within 10 years and the scope could be widened by requiring the building improvements be carried out or alternatively go further by also including all buildings down to 250 m^2 and increasing the assessment frequency to every five years.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of AEPR

4.3.40 The abatement potential and costs of this proposal are based on the 2008 consultation: Action on Climate Change Proposals for improving the Energy Performance of existing Non-Domestic Buildings.[44] This was carried out for section 50 of the Climate Change (Scotland) Bill (now Section 63 of the CCSA). Due to the early stage of development, the partial RIA contained 7 options.

4.3.41 For the years 2014 to 2020, abatement potential is based on a scenario in which it is assumed the proposal is implemented broadly in line with the consultation for the assessment. Post 2022, abatement potential has been estimated by taking the mid-point of two possible emission abatement scenarios:

- Scope of regulations widened by mandating the implementation of Assessments of the Carbon and Energy Performance of buildings recommendations and retaining assessment frequency at 10 years.

- Scope of regulations widened for mandatory improvements by reducing the eligible building size to 250 m^2 and reducing the assessment frequency to five years.

4.3.42 The costs of the proposal are based on the Partial Regulatory Impact Assessment (RIA) that was prepared for the 2008 consultation. The partial RIA contained costing's for seven options. This cost base has been maintained to allow comparison with earlier costings.

4.3.43 Benefits associated with each of the options described in the above consultation were calculated assuming that the policy commenced in 2009 and is delivered to 2020. Costs are assumed to be incurred by Government and building owners over those years. However savings arising from additional energy saving actions taken within that period are assumed to persist beyond the 2020 and these have been taken into account by assuming that energy savings will typically persist for 10 years.[45] All monetary costs and benefits have been discounted at 3.5% in order to calculate the Net Present Value (NPV) of each option.

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[44] http://www.scotland.gov.uk/Publications/2008/08/15155233/0
[45] http://www.scotland.gov.uk/Publications/2008/08/15155233/11

Table 15: Abatement Potential and Costs of Energy Performance Assessments of Non-Domestic Buildings, 2013-2027[46]

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	0	0
2014	6	6
2015	12	13
2016	18	13
2017	24	13
2018	30	13
2019	36	13
2020	42	13
2021	56	88
2022	70	88
2023	85	88
2024	99	88
2025	113	88
2026	128	88
2027	142	88

Low Carbon Heat

4.3.44 The proposal for decarbonising heat will include both the domestic and non-domestic sectors. As the majority of the emissions abatement is likely to fall in the non-domestic sector, the final abatement split between the Homes and Communities sector and the Business, Industry and Public Sectors may change.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of Low Carbon Heat

4.3.45 Estimates of the Scottish abatement potential for low carbon heat are derived from a detailed cost effectiveness model developed for the CCC. This model looks at the potential scenarios for low carbon heat technologies to replace fossil fuel use up to 2030. The model has drawn upon and extended the evidence base used for previous low carbon heat modelling in DECC, and includes technology assumptions and input data that have been extended to 2030. Additional technologies have been incorporated to reflect a wider range of possible future developments (e.g. synthetic biogas from the gasification of biomass, and heat pumps with heat storage that can shift electricity load profiles). There are a number of credible

[46] Further recent work carried out on existing non-domestic buildings indicates that emission abatement could be greater than that shown in the table.

scenarios for future low carbon heat generation, and this analysis represents one such scenario. In order to achieve our vision of decarbonising heat supply, we will develop a longer term strategy that looks at heat in the wider context of available energy resources, and demand. In this respect, we have developed a draft heat hierarchy of use and will publish a Heat Generation Policy Statement (HGPS) by the end of 2013, which will look in detail at possible generation scenarios. The HGPS will sit alongside the Electricity Generation Policy Statement providing a comprehensive energy policy view.

Table 16: Abatement Potential and Costs of Low Carbon Heat, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	16	8
2014	74	36
2015	112	36
2016	116	28
2017	81	16
2018	95	15
2019	90	12
2020	101	14
2021	269	32
2022	459	49
2023	602	65
2024	777	76
2025	960	86
2026	1,145	87
2027	1,334	113

4.4 Transport

4.4.1 Abatement estimates for transport have been informed by a number of published studies assessing the feasibility and likely form of policies aimed at reducing emissions from the sector. The majority of the analysis of the policy and proposals draws upon the published findings of the Atkins/Aberdeen study,[47] with further additional internal analysis bringing the findings into line with the latest available set of economic circumstances and information.

[47] http://www.scotland.gov.uk/Publications/2009/08/26141950/0

4.4.2 Cost information is presented as undiscounted annual total costs across all measures. Not all costs have been broken down across public/private sectors given that delivery mechanisms are not yet fully specified in every case but where the position is clearer, it has been explained in the relevant text.

Group 1: Decarbonising Vehicles

4.4.3 This group of policies and proposals sets Scotland on the pathway to achieve the almost complete decarbonisation of road transport in Scotland by 2050. This will be achieved through a combination of a number of policies:

- Further improvement in conventional vehicle efficiency.
- The scaling up of electric vehicle (EVs) and plug-in hybrid (PIH) penetration.
- Scope for increased use of biofuels.
- Fuel efficient driving (cars).

Improvements in Conventional Vehicles and Fuel Efficiency

4.4.4 Transport technologies and fuel have made some significant advances since the 1990s through greater efficiencies in use of fuel and lowering the emissions content of a unit of fuel. These improvements have been driven by two main factors: European regulations on emissions and by rising fuel prices increasing the demand for improved fuel economy in vehicles.

4.4.5 Since 1995 the average car emissions per kilometre has fallen by 18 % from 194 to 159 gCO_2e/km today.[48] This level will fall further as the EU is in the middle of a process that will see emissions level from new cars reduced to 95gCO_2e/km by 2020.

4.4.6 In 2012, 65% of each manufacturer's newly registered cars must on average comply with the target set by the legislation. This rises to 75% in 2013, 80% in 2014, and 100% from 2015 onwards. Our estimates assume that manufacturers will meet their targets by 2015 and then increase the annual rate of improvement from 2015 onwards in order to meet their 2020 targets.

4.4.7 Beyond 2020 available evidence suggests that an emissions range in cars of 50-70gCO_2e/km is possible by 2030. For vans, which account for around 10% of all transport emissions and 15% of road

[48] Own calculation for car fleet as a whole using total car emissions from NAEI and total car kilometres from Scottish Transport Statistics.

emissions, evidence suggests that an emissions range of 75-105gCO_2e/km is possible, but over a longer timescale.

4.4.8 While conventionally fuelled vehicles remain dominant in the fleet and in the proportion of total driven kilometres, this policy can deliver significant emissions savings in Scotland. Thereafter, the importance and impact of further efficiencies in conventionally fuelled road travel in the late 2020s will reduce provided the electric and plug-in hybrid electric vehicle begins to penetrate deep into the car market by the late 2020s. Larger vans and heavy goods vehicles are though still likely to be dependent on conventional fuel out to 2030.

4.4.9 Costs from meeting the tighter standards are expected to be borne by firms initially through additional R&D and product development expenditure. It is anticipated that at least some of these costs will be passed on to consumers through the vehicle purchase price. The extent to which the fuel efficiency saving from the more efficient vehicle is captured by the consumer will depend on the competition within and maturity of the market.

Bio-Fuels

4.4.10 The Renewables Transport Fuel Obligation introduced in the UK as a way to transpose the EU biofuels directive is a UK wide policy. No funding for this policy is required from the Scottish Government – DfT funds and supports the RTFO, with the function of the Renewable Fuels Agency now transferred to the Secretary of State for Transport.

4.4.11 An increased penetration of biofuels up to 8% of total liquid fuel consumption (by energy) is consistent with broader sustainability limits, as recommended by the Gallagher Review. There will be some cost implications in relation to infrastructure costs which will result from the introduction and use of bio-gasoline in remote and rural areas (for Scotland the Highlands and Islands region).

4.4.12 By volume, biofuels are on average more expensive than fossil fuels and also typically have lower energy content than fossil fuel. As such, a rise in biofuel use increases the number of litres of fuel required to travel a given distance and thus increases fuel costs. The cost of increasing the percentage of biofuels in petrol/diesel will eventually feed through to consumers in the form of relatively higher fuel prices which should cause motorists to marginally decrease their mileage relative to an outcome without the RTFO.

4.4.13 While biofuels will not provide the sole basis for transport decarbonisation in the 2020s, second generation biofuels could have a significant niche role to play in those parts of transport where there is limited scope for a move away from oil based fuels, notably with HGVs, buses and coaches.

Hybrid Buses

4.4.14 The first two rounds of the Scottish Government's Green Bus Fund will lead to 71 new low carbon buses replacing conventional buses with the third round expected to increase the total beyond 90. Early adopters are seeing significant levels of fuel savings but as yet the additional up front purchase costs remain a barrier to solely market based purchasing, particularly when there is a divergence between social and private discount rates.

4.4.15 A continuation of Government support to assist the purchase of cleaner low carbon engine buses, coupled with a demonstration of a significant reduction in fuel costs and supply side economies of scale for producers, should lead to cost comparability over the medium term between the two types and see low carbon buses accounting for half of the Scottish bus fleet by 2027.

Low Carbon Vehicles

4.4.16 Up to 2022 we expect to see a small but significant increase in the penetration of plug-in hybrid electric vehicles (PIHs) into Scotland, initially through the public sector and then through businesses. This roll-out will demonstrate demand for hybrids and help generate supply side economies of scale to kick-start the process of closing the price gap between the purchase price of normally aspirated and electric vehicles.

4.4.17 Under the Committee on Climate Change's assessment the likely impact in the transport sector from actions broadly in line with the statements and commitments made suggests that by 2020 plug-in hybrid cars could account for 16% of new cars and around 5% of the total fleet. This outcome is based on the assumption that the level of fuel duty remains at current or even higher levels and that electric battery costs fall in line with current expectations. For EVs to dominate fleet sales in the late 2020s the reduction in battery cost and increase in battery range are key.

4.4.18 Data on the profile of battery cost (past, present and future projections) is however very uncertain. What is clearer is the commitment of the industry in the three main markets (North America, Europe and Japan) to bring about significant reductions in battery costs by 2020. The working assumption in the CCC's 2009 report is that costs will fall to around £200 per kWh by 2020 and £130 per kWh by 2030. Taking account of forecast costs for petrol, electricity, battery development and the relative fuel efficiency of conventional and electric cars (EVs require far less energy than an equivalent conventional petrol car) then EVs will become significantly cheaper to run than conventional vehicles. Further, the CCC's assessment is that EVs and PIHs are cost effective relative to the projected carbon price in 2030.

4.4.19 Given these outcomes it will be possible for there to be a significant roll out of electric cars in the 2020s.[49] Under its central scenario the CCC estimates that by 2030 60% of new car sales (over 30% of fleet) will be PIH or EV.

4.4.20 While overcoming the cost differential and increasing battery range are key barriers to the mass uptake of electric vehicles, there are other important factors that need to be addressed:

- Domestic infrastructure for charging.
- Publicly available charging infrastructure.
- Capabilities for fast charging.
- Battery reliability and replacement – including a network of locations.
- Uncertainty surrounding being a first mover/adopter.
- General added 'hassle' factor.
- Incomplete understanding of personal/family mileage pattern or concern over inability to undertaking 'spur of the moment' or emergency long journeys.

4.4.21 Each of these factors will need to be addressed and solved by industry, individuals or Government (or a combination of them all) before battery electric vehicles can dominate Scottish car sales.

[49] Research work [by Element Energy – http://hmccc.s3.amazonaws.com/Element_Energy_-_EV_infrastructure_report_for_CCC_2009_final.pdf] indicates that 96% of car trips and 73% of total car distance travelled are covered by individuals travelling less than 160 kilometres a day – the range of current batteries.

Fuel Efficient Driving

4.4.22 While not strictly a decarbonising measure this will reduce the level of emissions per kilometre travelled.

4.4.23 Commencing in 2012, it is assumed an on-going promotional and awareness raising campaign will eventually reach all driving licence holders. It is assumed that this campaign would result in 85% of the driving population undertaking face-to-face eco-driving training sessions by 2027 with a refresher update every five years.

4.4.24 The emissions abatement from this initiative is assumed to flow from reduced fuel consumption, the extent of which depends on fuel type and degree of adjustment in driving style. Average emissions rates of vehicles have also been adjusted over time to reflect the on-going improvement in new vehicle fuel efficiency, and a rebound effect has been included to account for the increase in demand resulting from a lowering of the cost per kilometre driven.

Impact on Emissions from Decarbonising Vehicles Group

4.4.25 Together, these policies and proposals are expected to significantly reduce emissions over the period to 2027.

Table 17: Abatement Potential and Costs of Decarbonising Vehicles, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	157	25
2014	274	32
2015	429	39
2016	576	51
2017	752	61
2018	962	72
2019	1218	91
2020	1526	111
2021	1769	114
2022	1861	115
2023	2047	116
2024	2230	121
2025	2308	124
2026	2470	121
2027	2525	122

Group 2: Sustainable Communities

4.4.26 Low carbon vehicles are not expected to reach a critical mass for commercial scale roll-out until the mid to late 2020s. Until then there is a need to encourage changes to individual and household travel behaviours and patterns. The sustainable communities' policy grouping looks to help people understand the options and plan in favour of more carbon friendly modes of travel where possible through travel planning, providing infrastructure to support increased cycling and walking and introducing car clubs in larger towns and cities. The proposals in this group include:

- Domestic and school travel planning.
- Investment in active travel infrastructure.
- Car clubs.

Travel Planning

4.4.27 This proposal undertakes the widespread roll out of travel planning targeting the workplace, schools and households. It aims to identify travel options and particularly aims to encourage modal shift and reduce car use. A full roll out is expected to reduce urban car commuting trips, with a smaller reduction in rural car commuting trips. Business trips, school escort trips and leisure escort trips are also expected to decline.

4.4.28 The cost of delivering this programme and rolling out travel planning to all households and schools is expected to fall entirely on the public sector.

Cycling and Walking Infrastructure

4.4.29 Active travel in the form of cycling and walking already plays a significant role in shorter journeys in Scotland, although there is potential to marginally increase its share, particularly on distances of between one and two miles where the proportion of car journeys increases dramatically compared to the position on the shortest trips. More generally this distance range also sees a dramatic fall in the number of active travel trips.

Table 18: Number of Trips taken by Scottish Residents 2009/10 by Mode and Distance

	< 1 mile	1-2 miles	2-5 miles	5-10 miles	10-25 miles	25-50 miles	> 50 miles	All length
Walk	151	53	12	1	-	-	-	216
Driver of car, van or lorry	21	63	131	82	77	19	7	399
Passenger in car, van or lorry	13	34	67	41	34	9	5	201
Other Private (e.g. bicycle, m/cycle)	2	4	7	3	3	1	1	21
Public Transport (e.g. bus, rail, taxi)	4	18	47	26	18	4	3	119
All Modes	191	171	263	153	131	32	16	957

4.4.30 Investment by Government and local authorities in the active travel infrastructure will include improvements to lighting, surfaces, crossings and signage for pedestrians. For cycling, investment will be in facilities such as cycle lanes and paths, advanced stop lines and cycle parking, as well as potential new initiatives to support the integration of active travel and public transport, and enhance access to bikes in urban areas.

4.4.31 For walking, it is assumed that the package of measures will increase the number of walking trips by 50% with a third of these trips replacing journeys by car by 2022. For cycling, it is assumed that the package of measures achieves an outcome of 10% of all journeys being made by bicycle, with 33% of those additional trips being switches from car journeys.

4.4.32 Investment in cycling and walking infrastructure is based on evidence of intensive cycle programmes in Europe which have involved expenditure in the order of £5 per person per year over a 10 to 15 year period. A further assumption made is that the investment will be front loaded to help change the current culture of very low cycle use and to further increase the number of walking trips.

Car Clubs

4.4.33 The proposal is for a fully integrated national network of car clubs across Scotland to help reduce vehicle numbers and kilometres travelled by cars, and improve the fuel efficiency of the car fleet. Scheme funding would initially come from the taxpayer via Government expenditure to establish the schemes and purchase low carbon vehicles (LCVs). Membership would then provide an income stream to help pay for maintenance and replacement vehicles. Local authorities would have dual roles in supporting and funding the provision of infrastructure (establishing designated locations for cars and a good coverage of exclusive parking bays) as well as potentially offering corporate membership for local businesses.

4.4.34 Households would gain from having access to a fuel efficient car without the up-front purchase costs and benefit from the opportunity to drive and experience the practicality of a new LCV. On the supply side car manufacturers will benefit from having a route to roll out and test newer LCVs or Ultra-LCVs.

4.4.35 It is assumed that the network of car clubs will be rolled out over a 10-year period so that by 2022 there is one in every town in Scotland with a population over 25,000.[50] It is further assumed that over time up to 10% of households in larger, more established cities and towns become members of a car club. Emissions from equivalent journeys switched to car clubs are assumed to be lower as car club cars are on average around 30% more fuel efficient than the average fleet.

Impact on Emissions from Sustainable Communities' Group

4.4.36 Together, these proposals are expected to have a significant impact on emissions over the period to 2027.

[50] The latest projections estimate there are 29 such towns in Scotland currently, although this is likely to change out to 2022.

Table 19: Abatement Potential and Costs of Sustainable Communities Group, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	0	17
2014	12	13
2015	56	84
2016	70	84
2017	82	84
2018	103	85
2019	122	63
2020	139	63
2021	158	67
2022	179	72
2023	198	55
2024	219	53
2025	241	55
2026	259	56
2027	277	58

Group 3: Business Engagement around Sustainable Transport

4.4.37 The business efficiencies proposals grouping covers behaviour change at the organisational level and encompasses:

- Freight modal shift.
- Fuel efficient driving for freight and van travel.
- Ferry investment.
- The productivity and financial benefits of mobile and flexible working from expanding digital and broadband technologies.
- Corporate travel plans supporting employees and visitors in reducing business travel emissions.

Freight - HGV Modal Shift

4.4.38 The aim of the proposal under Freight Modal Shift is to assist the redistribution of freight from road to rail and water where appropriate and to rationalise the movement of freight more generally. This is done through the direct payment of a grant to cover the cost differential between road and the nearest cost alternative.

4.4.39 The emissions abatement achieved from these measures flows from reduced vehicle kilometres travelled by road and reduced fuel consumption. A 5% modal shift from HGVs in 2022 has been assumed.

This is based on a moderately ambitious scenario; since 1997 Freight Facility Grants alone have removed approximately 33 million lorry miles per annum from roads in Scotland.

4.4.40 The expenditure is based on a continued expansion of current Freight Modal Shift Grants. Additional costs for the full roll out of load consolidation centres and to facilitate Freight Quality Partnerships across Scotland have been factored in.

Fuel Efficient Driving - Freight and Van

4.4.41 This proposal covers a range of measures to train drivers of HGVs and LGVs to drive in a more fuel-efficient manner.

4.4.42 While there are already on-line resources to help with fuel efficient driving, this policy aims to provide practical training for drivers of goods vehicles. It is assumed that it will cost around £400 to train each driver once, with a retraining event five years later adding to that cost. This policy assumes a 100% take up of Safe and Fuel Efficient Driving (SAFED) by HGV drivers between 2015 and 2002 and 30% take up by van users by 2027.

4.4.43 A combined implementation of the current policy activity and proposals is assumed to reduce emissions from HGVs by 5% in 2022. For vans it is assumed that an average efficiency improvement of 4% per vehicle can be achieved from the proposals.

Maritime – Introduction of Hybrid Ferries

4.4.44 This proposal will improve the fuel efficiency of engines within the ferry fleet through public procurement of new vessels that have both an improved more efficient diesel engine along with a battery to help with propulsion. The costs of purchasing the new ferries will fall to the Government and taxpayer as the services and fares are still controlled to some extent as a support service to the island communities. The first ferry is expected to be brought into service in 2013.

Work Smart

4.4.45 Mobile and flexible working involves a range of new, often technology assisted processes such as working from home, working from multiple offices and non-office mobile working. Shifting to this flexible way of working is expected to reduce both commuting and business travel as well as potentially rationalising the business estate.

Very little funding is required from the public sector beyond facilitating the exchange of information while both consumers and businesses should expect to see reduced travel costs. More generally, the level of congestion on roads at locations near to the organisations taking part is likely to be reduced. If the remote working includes the possibility of working at home employees are likely to see some increase on average in their heating bills through the winter offsetting some of the cost savings made by the change in working pattern.

4.4.46 We are currently undertaking a short study into the potential impacts of the work smart programme and the outcome and result of the study will be reported in due course.

Impact on Emissions from Policies to Improve Business Transport

4.4.47 Together, these proposals are expected to have a small but significant impact on emissions over the period to 2027.

Table 20: Abatement Potential and Costs of Business Transport Measures, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	26	3
2014	29	6
2015	58	22
2016	67	21
2017	76	21
2018	91	21
2019	106	22
2020	121	25
2021	173	25
2022	227	29
2023	270	28
2024	306	29
2025	357	32
2026	409	30
2027	462	30

Group 4: Network Efficiencies

4.4.48 This group of proposals aims to improve traffic flows across the different transport networks and the connection between them. It consists of:

- Intelligent transport systems (ITS).
- Some enhancement of speed limit enforcement through further rolling out of average speed cameras on targeted sections of the trunk road network.

4.4.49 Deployment of these measures across the networks will require significant up front capital investment by the public sector. This expenditure will, though, increase the resilience of the network and improve journey times and reliability.

Intelligent Transport Systems

4.4.50 Intelligent Transport Systems (ITS) will enhance the capacity and operation of the current trunk road network. Measures such as overhead gantries with the capability to vary messages and speed limits could be introduced on up to 170 kilometres of the most congested parts of the trunk road network to smooth traffic flow. Research suggests that the cost of implementing ITS could be in the order of £630,000 per kilometre. This cost covers both the capital costs of installation and maintenance of the system.

4.4.51 In addition, interactive information boards within bus stops, with real time information on services using it, will develop confidence in public transport, while hand held devices with access to similar information offer the potential to limit time spent waiting for buses at stops – seen as one of the major costs of using public transport. Such apps for technology could be developed by the private sector, although would be dependent upon the public investment in the vehicles and infrastructure to allow this to happen.

Speed limit Enforcement through Greater Deployment of Average Speed Cameras on the Trunk Road Network

4.4.52 It is assumed that average speed cameras would be used to enforce the speed limit on the trunk road network.

4.4.53 Average speed camera installations cost around £40,000 per kilometre with an annual maintenance cost of £4,000 per km. It is important to note that the costs only cover the implementation and maintenance of the infrastructure and do not include consequential costs incurred by bodies such as the police or the judicial system as a result of strict policy enforcement.

4.4.54 Emissions abatement and cost savings would be achieved through people adhering to the speed limit, lowering average speeds and decreasing fuel consumption. Air quality would see a marginal improvement and there are likely to be fewer road accidents as a result of lower average speeds. However, there would be a consequential reduction in fuel sales and revenue to the exchequer through fuel duty and VAT.

Impact on Emissions from Network Efficiencies Group

4.4.55 Together, these proposals are expected to have a significant then declining impact on emissions over the period to 2027.

Table 21: Abatement Potential and Costs of Network Efficiencies Measures, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	2	10
2014	4	9
2015	31	47
2016	32	52
2017	33	56
2018	34	32
2019	35	33
2020	36	34
2021	35	35
2022	35	36
2023	34	19
2024	33	19
2025	33	19
2026	33	19
2027	32	19

Potential Future Abatement from Transport

4.4.56 Current modelling and research suggests that the future projection of transport emissions could be reduced by up to 0.75 $MtCO_2e$ by 2027. At this stage the potential is highly uncertain due to volatility in a number of key factors including projecting traffic growth during the current economic uncertainties, fuel prices, the rate of adoption of new technologies into the car fleet in particular and the possibility to manage reductions in the use of the road network in favour of public transport, active travel and through a greater impact from travel planning. These potential impacts have not yet been appraised in a way consistent with the above analysis but we aim to assess and appraise these impacts in future work.

Table 22: Potential Future Abatement from Transport, 2025-2027

	Annual emissions abatement ($ktCO_2e$)
2025	250
2026	500
2027	750

Uncertainties in Transport Emissions Analysis

4.4.57 Emissions in the sector are not recorded directly but instead calculated using information on aircraft movement, port movement data and local road traffic data. While this data is subject to some uncertainty and methodological change, particularly in the case of shipping, the fact that the sector's emissions calculation is predominantly based on fuel consumption data means the resultant emissions calculation from the movement data is relatively straightforward.

4.4.58 Uncertainty also arises when estimating the impact of policy changes on emissions from transport. Calculating this impact requires the modelling of scenarios to estimate the way in which transport supply and demand are affected. These changes further rely on a wide range of assumptions and complex interactions concerning changed driver behaviour, changed car and trip purchase behaviour and modal switching.

4.4.59 There are further uncertainties surrounding the costs incurred during implementation. The costs will depend on what exactly is to be delivered, the extent, method and speed of implementation. Whether the costs fall on businesses, consumers, taxpayers, or a combination of all three depends on the precise way that the policy is delivered.

4.4.60 Where possible the assumptions on which estimated abatement and costs have been derived have been explicitly stated. Where drawn from available published evidence, this has been referenced.

4.5 Waste and Resource Efficiency

4.5.1 The abatement potential from Waste policies and proposals in RPP2 were calculated using the 2006 model developed by the Intergovernmental Panel on Climate Change (IPCC).[51] The model uses a first-order decay method, which approximates the steady decomposition of organic matter across a number of decades assuming constant conditions. This results in a declining output of waste products, including methane.

4.5.2 The assumptions within the IPCC model were deemed sufficient and representative of Scottish landfills relating to default location (Western Europe), climate (wet temperate), types of landfills, and other constants such as the lag time before anaerobic decay begins (six months).

4.5.3 The IPCC Waste Model:

- Provides default values for landfill conditions (Western Europe, wet temperate climate, rate of methane production per waste type, plus others).
- Allows customisation of input factors such as amount and composition of waste, amount landfilled, and amount of methane captured.
- Provides values for total methane emissions per year.

Zero Waste Policy Measures – pre-2010

4.5.4 In the period before the Zero Waste Plan (ZWP) was introduced in Scotland, there was a policy framework which promoted waste efficiency and introduced targets for recycling (National Waste Plan for Scotland, 2003). These targets were refined in 2008 before being absorbed into the ZWP. It is therefore the case that much of the abatement being reported after 2013 is due to changes made before the introduction of the ZWP.[52]

[51] http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html
[52] These emissions are not captured in the BAU profile.

Zero Waste Plan

4.5.5 The Zero Waste Plan (ZWP) is the Scottish Government's vision for a zero waste society. It was published in June 2010 and set out 22 actions to influence resource streams, economic opportunity, resource management and education and awareness; all relevant to the removal of barriers to the minimisation of landfill. This Plan works within the wider EU Waste Framework and Landfill Directives. A further update to the ZWP was published in 2011,[53] and this introduced a wider remit to include all waste types within the plan.

Methodology for Estimating Emissions Abatement Potential, Costs and Benefits of the Zero Waste Plan

4.5.6 The main assumption with the Zero Waste Plan is that it broadly succeeds in its aims. The aims that relate to landfill, and how they are modelled, are detailed below:

- Maximum 5% waste sent to landfill by 2025: assumption that municipal waste achieves 10% landfilled by 2030, and industrial waste achieves 10% landfilled by 2025.

- Biodegradable waste banned from landfill in 2020: assumption that municipal waste contains only 5% food by 2020 and thereafter. Other bio-waste such as paper assumed to be more difficult to remove from waste stream, reduced to 10% by 2030.

- Waste prevention programme: assumption that there is a general reduction in the amount of waste per person arising. This is partially offset by a predicted increase in the population.

4.5.7 A more general assumption is that the wider pre-existing policy environment which promotes resource efficiency and waste sorting also encourages a reduction in waste arising and of recycling. Furthermore, landfill tax provides a strong financial incentive to find other ways to treat waste.

4.5.8 These assumptions in the model all interact, and their general outcomes are that there is less waste being landfilled, and less of that waste is biodegradable, resulting in lower methane emissions over the upcoming years and decades.

[53] http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Waste-1/wastestrategy

4.5.9 The Economic Assessment of the Zero Waste Plan for Scotland,[54] commissioned by Zero Waste Scotland, presents costs and benefits relative to a BAU profile for Scotland, and is used as the basis of the cost figures included in the RPP2.

4.5.10 The costs are summarized in the model in the following categories:

- Change in collection costs: It is more expensive to collect separated waste streams than waste from one residual bin.
- Change in material revenues: Increased recycling leads to increased revenues from sale of the resulting materials.
- Change in organic treatment fees: Increased use of e.g. anaerobic digestion facilities.
- Change in residual waste management costs: source separation of waste has financial benefits through selling inputs for other processes, and waste auditing and segregation allow businesses to identify precisely where their waste is produced and how it could be reduced. Reducing waste not only avoids any costs of waste treatment, but can also reduce costs through lower overall material consumption.
- Change in sorting fee: increased use of materials recovery facilities to sort residual waste as thoroughly as possible.
- Change in regulatory costs: additional costs incurred through monitoring application of stricter rules under the ZWP.

4.5.11 These costs will mainly fall to the bodies that deal with the waste as it comes through the system, the local authorities and/or their contractors who deal with household waste, and the commercial waste producers themselves. Whether any costs are passed on to households depends on how local authorities plan to fund their waste collections.

4.5.12 A lot of the modelling will depend on market conditions for the sales of recycled materials, as well as the costs of waste processing such as energy use and staffing.

[54] Zero Waste Scotland/Eunomia Economic Assessment of the Zero Waste Plan For Scotland http://www.zerowastescotland.org.uk/ZWPcostbenefit

Table 23: Abatement Potential of Pre-2010 Waste Policy and Abatement Potential and Costs of the Zero Waste Plan, 2013-2027

	Annual emissions abatement from pre-2010 Waste Policy ($ktCO_2e$)	Annual emissions abatement from ZWP ($ktCO_2e$)	Annual total costs of ZWP (£m)
2013	484	13	172
2014	533	26	161
2015	579	41	163
2016	622	58	163
2017	659	77	163
2018	693	97	164
2019	722	119	162
2020	748	141	163
2021	774	163	164
2022	795	185	165
2023	813	206	164
2024	827	228	165
2025	837	249	165
2026	856	270	165
2027	871	290	165

Enhanced Methane Capture from Landfill

4.5.13 This proposal is to capture extra methane emissions from landfill sites by focussing efforts on closed facilities, most of which will be emitting methane for many years to come. This would be above and beyond the responsibilities currently upon the bodies that own landfill sites.

Methodology for Estimating Emissions Abatement Potential and Costs of Enhanced Methane Capture from Landfill

4.5.14 The amount of available methane for electricity generation from closed landfill sites was modelled, and an assumption was made of an increasing proportion of this gas being captured to 2020, the proportion captured remaining constant thereafter. As the amount of available methane generally declines over time, this source of abatement diminishes too.

4.5.15 The following assumptions are used:

- The available power generation capacity from landfill gas in Scotland for 2006 (70MW).[55]

- The emission profiles of a selection of closed landfill sites were modelled, assuming exponential decline of gas output from 100% at the date of closure.

- The proportion of total emissions from closed landfill sites increases steadily from a baseline of 25% in 2013 to over 50% in 2027.

- The amount of viable closed sites being used for landfill gas capture rises linearly from 0% in 2012 to 75% in 2020.

4.5.16 These factors combine to give a value for additional MW capacity captured each year which is then converted into mass of methane and ktCO_2 equivalent.

4.5.17 Cost information draws on 2010 advice from the US Environmental Protection Agency which assumes that the generation from closed landfill sites will be more expensive than active sites due to the smaller scale and dwindling supplies of extant gas.

[55] The Power of Scotland: Cutting Carbon with Scotland's Renewable Energy

Table 24: Abatement Potential and Costs of Landfill Gas Capture, 2013-2027[56]

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	22	1.0
2014	44	1.1
2015	67	1.2
2016	90	1.2
2017	112	1.3
2018	133	1.3
2019	154	1.4
2020	163	1.3
2021	161	0.3
2022	158	0.3
2023	155	0.3
2024	151	0.3
2025	148	0.3
2026	144	0.3
2027	140	0.3

4.6 Rural Land Use

4.6.1 Rural land use is made up of agriculture and related land use, peatland and forestry.

Agriculture

4.6.2 Abatement and cost estimates for the policies assessed are based upon economic analysis undertaken by the Scottish Agricultural College (SAC)[57] which produced a revised marginal abatement cost curve (MACC) in conjunction with RESAS[58] in 2011. This was an update of work carried out in 2008[59] and 2010,[60] which derived MACCs for agriculture, related land use and forestry in the UK and constituent countries to assess the abatement potential and cost effectiveness of measures aimed at mitigating GHG emissions. The updated MACCs for Scotland reassessed the underlying assumptions which form the

[56] Does not include the change in environmental costs, or the effect of related measures enacted before the Zero Waste Plan came into effect.
[57] SAC is now known as Scotland's Rural College (SRUC)
[58] Scottish Government Rural and Environment Science and Analytical Services division
[59] SAC (2008) - UK Marginal Abatement Cost Curves for the Agriculture and Land Use, Land-Use Change and Forestry Sectors out to 2022, with Qualitative Analysis of Options to 2050. Report to the CCC: http://hmccc.s3.amazonaws.com/pdfs/SAC-CCC;%20UK%20MACC%20for%20ALULUCF;%20Final%20Report%202008-11.pdf
[60] SAC (2010) - Review and update of UK marginal abatement cost curves for agriculture. http://downloads.theccc.org.uk.s3.amazonaws.com/0610/pr_supporting_research_SAC_agriculture.pdf

foundations of the model. This included: the Food and Agriculture Policy Research Institute (FAPRI) baseline; estimates of applicability and effectiveness; and the method for calculating interactions.

Applicability and Effectiveness Assumptions

4.6.3 RPP1 was based on the original MACC that SAC produced in 2008. This was the first attempt at modelling abatement for UK agriculture, and hence there was a high degree of uncertainty over the final estimates. In 2010, SAC, in conjunction with ADAS Ltd, published an update to the 2008 model which demonstrated this uncertainty. The main issues identified were to do with the underlying assumptions of applicability (how many hectares/livestock the measure can be applied to) and effectiveness (how much CO_2 equivalent could be abated by adopting this measure per hectare/livestock unit).

4.6.4 Two versions of the MACC were produced within the 2010 MACC publication, one using more optimistic versions of the underlying assumptions, and one more pessimistic. The degree of uncertainty, and hence the difference between optimistic and pessimistic assumptions, varied for each measure. For some measures, there was less uncertainty, and a central assumption was agreed on by the expert group that helped to develop the 2010 MACC.[61] However, even where there was agreement on the underlying assumptions, there remains a large degree of uncertainty around how the measures interact with different field environments, which could lead to large fluctuations in effectiveness of the particular measure in practice.

4.6.5 These issues demonstrate the difficulty of estimating abatement potential from measures in this sector and the 'real world effects' that will influence the level of abatement delivered in practice. However, the MACC offers the best evidence on which to base our abatement estimates for this sector.

4.6.6 For each measure, in conjunction with the Agriculture and Climate Change Stakeholder Group[62] and using evidence provided in the MACC 2010 documentation, an appropriate level of abatement and effectiveness was agreed. The benefit of this process is to derive the most appropriate figures for the Scottish context, rather than the

[61] For a list of members of expert group see Appendix A of 'SAC 2010 – Review and update of UK marginal abatement cost curves for agriculture'

[62] Membership of the stakeholder group is representative of the various industry and environmental stakeholder bodies in Scotland.

UK as a whole on which the underlying assumptions were originally based. Involving the stakeholder group at this early stage has ensured the industry is involved in forming estimates.

4.6.7 SAC incorporated the estimates into the MACC model to provide a maximum technical potential (MTP) for each measure. Final estimated abatement figures for each policy were calculated following the method used in ADAS (2009).[63] An "achievement" against the maximum technical potential (MTP)[64] for the mitigation options relevant to each policy was estimated based upon two assumptions:

- The "coverage" of the policy, in terms of the percentage of on-farm emissions relevant to the options targeted by the policy.
- The estimated uptake of each option under the policy in 2022.

4.6.8 Estimates of achievable uptake of each option are based upon: assumptions in ADAS (2009); the nature of each option (particularly cost and other barriers to uptake); and discussions with Scottish Government Agriculture and Climate Change Stakeholder Group.

Estimated abatement for mitigation option X under policy Y as a stand-alone policy	=	MTP of mitigation option X	x	% of emissions targeted by option X covered by policy Y	x	% of farmers adopting option X covered by policy Y

Policy Interactions

4.6.9 Repeating the calculation above for each mitigation option targeted by a given policy, produces estimated abatement on a stand-alone policy basis. However, potential for interaction has been identified between Farming for a Better Climate (FFBC) and the proposed 90% uptake of fertiliser efficiency measures. Where the policy and the proposal target the same mitigation measure, abatement realised by FFBC is likely to reduce the potential for abatement from the proposal. This has been accounted for so that abatement from FFBC and the proposal for 90% uptake of fertiliser measures can be added together without double counting.

[63] ADAS (2009) RMP/5142 Analysis of Policy Instruments for Reducing Greenhouse Gas Emissions from Agriculture, Forestry and Land Management. Report to DEFRA: http://archive.defra.gov.uk/foodfarm/landmanage/climate/documents/climate-ag-instruments.pdf

[64] Maximum technical potential refers to the level of abatement that would be achieved if all farmers who could technically implement a given measure did so fully.

4.6.10 For those measures targeted by both FFBC and the proposal, abatement is allocated from 2010-2017 to FFBC, according to the increasing linear profile of uptake described above. From 2018, uptake is expected to move to 90%, as a result of voluntary action or, if necessary, through a mandatory framework. Beyond 2018, the additional uptake up to 90% is realised through the proposal. Annual abatement from these measures under FFBC from 2018-2022 is held at the 2017 level, on the basis that uptake of these options is realised as a result of provisions under FFBC and that these provisions (and associated funding) are maintained.

4.6.11 For the mitigation options included in the proposal from 2018, abatement equals the expected level of 90% abatement for each option minus the level of abatement already achieved by FFBC.

Additional abatement under 90% uptake proposal	equals	Estimated achievement of 90% uptake as a stand-alone proposal	minus	Estimated achievement of MTP already achieved under FFBC to 2017 for these measures

4.6.12 For those measures targeted by FFBC only, there are no policy interactions to consider and abatement continues along a linear trajectory to the 2022 level.

4.6.13 A similar process was used for interactions between FFBC measures, and measures outlined as ‘additional proposals post 2020’.

Measure Interactions

4.6.14 Accounting for policy interactions avoids double counting of abatement where two separate delivery vehicles operate at the same time. Measure interactions occur at the farm level where two measures will interact if they are implemented simultaneously. For example, the use of nitrogen fixing plants interacts with other fertiliser efficiency measures as it reduces the level of fertiliser that a farmer will need to apply and the resulting abatement potential.

Policy Costs

4.6.15 Both private costs and costs to Government are estimated, in addition to total policy cost effectiveness in GHG mitigation.

4.6.16 Private costs (i.e. those incurred by farmers) account for changes in input costs (fertiliser, labour and machinery costs) and changes in yield arising from the application of mitigation measures. Most measures estimated to be cost-effective by SAC (2008) relate to changes in farm management practices requiring no upfront investment. For these measures, annual costs are calculated by multiplying annual abatement by cost effectiveness values given in SAC (2008).

4.6.17 Costs to Government generally arise from the administration of policies and the provision of direct support.

4.6.18 Policy cost effectiveness is total cumulative costs (private costs plus costs to Government) divided by total GHG abated by the policy over the assessment period (2010-2022). Cost-effectiveness estimates do not take account of wider environmental and societal benefits (e.g. changes in water quality) due to a lack of suitable data. All costs are in 2011 prices.

Individual Policy Assessments

Farming for a Better Climate

4.6.19 Farming for a Better Climate (FFBC)[65] is an on-going policy which targets five key areas of action for farmers to reduce GHG emissions from agricultural production. These relate primarily to mitigation options identified in the SAC MACC that improve the

[65] See http://www.sac.ac.uk/climatechange/farmingforabetterclimate/ for more details.

productivity of the farm business as well as reducing GHG emissions. The relevant measures are:[66]

- Improved timing of mineral fertiliser application.*
- Improved timing of slurry and poultry manure application.*
- Adding maize to silage.
- Full allowance on manure nitrogen supply.*
- Plant varieties with improved nitrogen use efficiency.
- Avoiding nitrogen excess.*
- Use composts and straw based manures in preference to slurry.*
- Separate slurry applications from fertiliser applications by several days.*
- Selecting beef cattle for breeding based on productivity.
- Selecting dairy cattle for breeding based on productivity.
- Selecting dairy cattle for breeding based on fertility.

4.6.20 It is assumed that FFBC targets 90% on-farm GHG emissions. This takes account of the concentration of GHG emissions among a relatively small number of large farms. FFBC is assumed to target 50% of farms comprising of the largest GHG emitters, which are estimated to account for around 90% total farm business GHG emissions.

4.6.21 FFBC is expected to reduce emissions by up to 107 ktCO_2e per annum in 2027 relative to the baseline, and deliver cumulative savings of close to 1.5 MtCO_2e between 2010 and 2027.

4.6.22 Due to the cost effective nature of those measures promoted by FFBC, the policy is estimated to result in savings to farm businesses of around £250 million (undiscounted over the period out to 2027). These savings arise largely from productivity increases resulting from improved efficiency in input use. With negative overall costs and emissions savings, the overall cost effectiveness of FFBC works out on an undiscounted basis, at around -£160 per tonne of saved emissions.

4.6.23 Costs to Government are estimated at around £0.25 million per annum or around £4.5m (undiscounted) between 2010 and 2027. These costs arise from knowledge provision and exchange services provided through the SAC, such as workshops and demonstration farms.

[66] '*' indicate measures targeted by both FFBC and proposed for inclusion in mandatory requirements.

Table 25: Abatement Potential and Costs of FFBC, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	50	0.3
2014	62	0.3
2015	75	0.3
2016	87	0.3
2017	100	0.3
2018	101	0.3
2019	103	0.3
2020	103	0.3
2021	104	0.3
2022	104	0.3
2023	105	0.3
2024	106	0.3
2025	106	0.3
2026	107	0.3
2027	107	0.3

90% Uptake of Fertiliser Efficiency Measures

4.6.24 The climate change-related actions proposed for inclusion in the 90% uptake of fertiliser efficiency measure from 2018 are a subset of those promoted by FFBC. Under this proposal, measures associated with the application of nitrogenous fertilisers were deemed to be most effective in terms of abatement potential and cost savings to farmers. They are:

- Improved timing of mineral fertiliser application.
- Improved timing of slurry and poultry manure application.
- Full allowance on manure nitrogen supply.
- Avoiding nitrogen excess.
- Use composts and straw based manures in preference to slurry.
- Separate slurry applications from fertiliser applications by several days.

4.6.25 GHG emissions abatement for each targeted mitigation option is calculated using the same method as for FFBC. It is estimated that for these mandatory measures, an 81% achievement of Maximum Technical Potential (MTP) can be achieved. This is based upon a 90% emissions coverage (as for FFBC), and an assumption that 90% of those farms adhere to requirements, i.e. uptake is 90% (based upon ADAS 2009).

4.6.26 Abatement allocated to the 90% uptake of fertiliser efficiency measure takes account of uptake already achieved from the same options under FFBC. The inclusion of the above options as mandatory requirements is estimated to result in additional achievement of 61% of MTP (81% minus abatement achieved by FFBC to 2017).

4.6.27 The additional 61% achievement of MTP equates to annual abatement of 260 ktCO_2e from 2018, or 2.6 MtCO_2e cumulatively between 2018 and 2027. As the measures are essentially extensions to FFBC they also result in lower overall costs to the private sector of around £240 million (undiscounted) over the period 2018-2027. Cost to Government of the requisite monitoring and enforcement regime is as yet unknown.

Table 26: Abatement Potential and Costs of 90% Uptake of Fertiliser Efficiency Measures, 2018-2027

	Annual emissions abatement (ktCO_2e)	Annual total costs (£m)
2018	260	0.4
2019	260	0.4
2020	260	0.4
2021	260	0.4
2022	260	0.4
2023	260	0.4
2024	260	0.4
2025	260	0.4
2026	260	0.4
2027	260	0.4

4.6.28 The incorporation of 90% uptake of fertiliser efficiency measures is currently a proposal, and its introduction as a mandatory policy would be dependent on the degree to which the industry has taken forward these fertiliser efficiency measures on a voluntary basis.

Additional Proposals Post-2020

4.6.29 It is very difficult to determine factors such as the rate of technological change and how this will affect farming practices in the time period to 2027. An additional uncertainty is the price of key inputs, such as oil. However, it is anticipated that farming methods will progress and it is more than likely that the price of oil based inputs (including fertiliser) will continue to rise due to resource constraints and population growth.

4.6.30 Some measures which seem impractical or unacceptable by the farming industry today could become widespread in the next decade. Although impossible to predict, a judgement can be made of which measures may be implemented post-2020. There is no commitment from the Government to deliver these 'possibilities' by 2027, however it is reasonable to expect that these measures will be more feasible by 2020 and that they will be taken up by the industry to some extent.

4.6.31 Further analysis was commissioned through the Centre of Expertise for Climate Change (ClimateXChange) to seek advice on additional measures that could offer abatement in the future. This work identified precision farming as a potentially cost effective measure, providing that the cost of technology falls to a pre-determined level.

4.6.32 It is also suggested here that other 'expensive' measures may become more viable by 2020. For example, anaerobic digestion, which is assumed will reduce in price sufficiently to make it viable for a small number of large and medium farms after 2020. Also, the use of biological fixation, which currently has a large yield cost, might experience a reduction in costs through introduction of new species and better understanding of effective implementation techniques on the farm.

4.6.33 Assumptions have also been made on how uptake for livestock management could change for measures that are in FFBC but currently have relatively low associated uptake estimates. Improved breeding for productivity (beef and dairy) and fertility (dairy) are likely to become more established in normal practice over time, and it is anticipated that the benefits of adding maize to silage will also become better understood and more widely implemented. For these reasons, beyond 2020, it is predicted that uptake will increase to around 50%.

4.6.34 The combination of precision farming, anaerobic digestion, biological fixation and increased uptake for livestock management measures could contribute to approximately 310 ktCO_2e of additional abatement in 2027. The financial costs from these measures currently outweigh the financial benefits (costs of £305 million in 2027 against financial benefits of £51 million). The prices of key inputs and technology between now and the period 2020-27 will be the main determinant of the scale of adoption of these measures, and these factors are largely outside the control of policy makers.

Table 27: Abatement Potential and Costs of Additional Proposals Post 2020, 2020 - 2027

	Annual emissions abatement (ktCO_2e)	Annual total costs (£m)
2020	310	305
2021	310	305
2022	310	305
2023	310	305
2024	310	305
2025	310	305
2026	310	305
2027	310	305

Peatland

Accelerated Restoration of Degraded Peatland

4.6.35 Since 1990, on average 1,000 hectares of peatland have been restored per year. Through better co-ordination of effort and increased funding this proposal increases restoration levels to up to 20,000 hectares per year. This could give an annual abatement by 2027 in the range 0.47 – 0.58 MtCO_2e per annum, which would continue to increase as the peatlands recover.

4.6.36 The abatement consists of two elements. First, restoration prevents further degradation and oxidation of soil carbon. Secondly, as peatland recovers, it can again become a carbon sink as mosses (Sphagnum) absorb carbon in their growth which, over time, is accumulated in the peat layer. Counteracting the emission savings there is an initial spike in methane emissions caused by anaerobic digestion of re-wetted peat – this may offset the emissions savings by 10-20% in the early years. There is considerable uncertainty regarding these numbers.

4.6.37 Both the scope for emission reductions and the financial costs of peatland restoration are highly uncertain, since so much depends upon the level of intervention required, remoteness and terrain. We have assumed an average cost of £880 per hectare. The proposal is based on the assumption that different types of peatland are being treated simultaneously and costs decrease over time when the whole available area of some types of peatland has been restored. Emissions abatement is low for newly restored areas but increases as the peatland recovers.

Table 28: Abatement Potential and Costs of Accelerated Restoration of Degraded Peatland, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	0	19
2014	9	18
2015	25	17
2016	47	16
2017	73	16
2018	104	16
2019	139	16
2020	177	16
2021	218	16
2022	263	16
2023	309	16
2024	358	16
2025	410	13
2026	462	13
2027	515	13

Forestry

Increase Afforestation Rate to 10 khpa

Methodology for Estimating Emissions Abatement Potential and Costs of Increasing the Afforestation Rate

4.6.38 The Scottish Ministers have a target to increase woodland cover by 100,000ha in the period to 2020 (WEAG, 2012). This requires woodland planting rates to increase to an average of 10,000 hectares per year (ha/yr).

4.6.39 For comparison, the average new planting rate between 1998 and 2010 was just over 6,500 ha/yr (rates fell during this period), so current policy requires a significant increase in planting rates.

4.6.40 The increased planting rate will be backed by grant support to private land-owners and will also include further plantings on the National Forest Estate. There will also be stakeholder engagement to remove barriers and ensure that new woodlands are appropriately cited and designed.

4.6.41 Woodland expansion needs to be integrated with agricultural production and other land management objectives. On the basis of private returns, where emission from agricultural activity or the sequestration of carbon dioxide by trees are not valued and not part of the private decision making process, greater profits are usually derived from agricultural production. However, taking into account wider societal costs and benefits (from the emission of greenhouse gases and the sequestration of CO_2) brings the returns from the two enterprises closer together, particularly on more marginal land where the returns from agricultural production are lower, and paying a grant to encourage the planting of woodland is one way of bringing the wider societal benefits into the private balance sheet.

4.6.42 Based on an assumed constant rate of planting of 10,000 ha per annum, this will lead to lifetime emissions savings of 4.8 $MtCO_2e$ by 2027 and impose costs of up to £60 million per annum in 2027.[67]

[67] http://www.forestry.gov.uk/scotland

Table 29: Abatement Potential and Costs of Increasing the Annual Planting Rate to 10,000ha, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	15	36
2014	16	41
2015	45	47
2016	92	49
2017	144	51
2018	195	53
2019	248	54
2020	310	56
2021	373	57
2022	435	58
2023	477	58
2024	529	59
2025	582	60
2026	634	60
2027	687	60

Wood First – Timber Construction Programme

4.6.43 Increasing the use of timber in construction will bring about carbon benefits through sequestration of the harvested wood products and the substitution impacts of replacing more energy intensive materials such as steel, brick and block, and concrete.

4.6.44 Planning authorities would require developers to adopt a Wood First approach i.e. to consider timber as the first choice building material for a development and only specify other, more carbon intensive materials if timber is unsuitable. This approach could build upon the recent local planning guidance on the use of home grown timber in construction which has been adopted by a number of local authorities in Scotland.

Methodology for Estimating Emissions Abatement Potential and Costs of Wood First

4.6.45 The models used in Scotland are relatively crude in terms of estimating carbon savings from increased use of Scottish (home-grown) timber in construction. Work is ongoing to improve these models and their accuracy/sensitivity.

4.6.46 Much of the timber used in construction in Scotland comes from other parts of Europe, in part, for historical reasons. Because these timber products are harvested from forests abroad it is likely that the carbon savings from the use of harvested wood products such as construction timber will be accounted against the emissions inventory in the country in which the tree grew.

4.6.47 Likewise in relation to substitution benefits, where timber substitutes for e.g. steel or concrete, a saving will only show up in Scotland's emissions inventory if the concrete or steel was produced here and there was a saving because that steel or concrete was not now used.

4.6.48 This policy would bring real carbon savings globally from greater stored carbon and substitution of more carbon intensive construction products such as concrete and steel. But the allocation of the carbon savings in emissions inventories will be dependent on where the product was produced.

4.6.49 Timber in construction is a low cost carbon abatement technology. There is no cost penalty in construction costs for the use of timber frame for new housing. For cross-laminated timber (CLT), anecdotally, the total build costs are similar to traditional methods of construction, with the higher costs of CLT balanced by reduced construction times.

4.6.50 In terms of realising an increased use of timber in low carbon construction, alongside reviewing the role of planning, building standards and design, investment (largely private sector) in CLT production facilities using Scottish timber may offer an opportunity for significant market development. In this case an investment in two new plants of around £40 million by 2022 and around a further £10 million by 2025 to expand production capacity, could potentially achieve cumulative abatement of around 600 ktCO_2e by 2027.

Table 30: Abatement Potential and Costs of the Timber Construction Programme, 2013-2027

	Annual emissions abatement ($ktCO_2e$)	Annual total costs (£m)
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020	0	0
2021	0	0
2022	89	40
2023	89	0
2024	89	0
2025	89	10
2026	125	0
2027	125	0

Additional Technical Potential in Peatland Restoration and Woodland Creation

4.6.51 Our sensitivity analysis suggests that there is an additional abatement potential of approximately 0.75 Mt by 2027 associated with a package of low carbon land use policies from measures such as peatland restoration and woodland creation (e.g. Woodlands In and Around Towns).

Table 31: Additional Technical Abatement Potential in Rural Land Use, 2025 - 2027

	Annual emissions abatement ($ktCO_2e$)
2025	250
2026	500
2027	750

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