Appendix A1. Frascati classification of research and development

In examining government spending on research and development (R&D), key factors are the definition of R&D, how spending data is collected by the government, and the reliability of the data.

To enable a robust process to be applied, the UK government complies with the 'Frascati' guidelines for the categorisation of R&D. These have been compiled in the Frascati Manual, published by the intergovernmental body, the Organisation for Economic Co-operation and Development (OECD, 2002). Official use of these guidelines enables reliable comparisons to be made of spending and other related data across government departments and between OECD member countries.

The Frascati Manual defines R&D as: "Creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications" (OECD, 2002). This is interpreted to mean that R&D activity is distinguished by the presence of an appreciable element of novelty. So if the activity follows an established pattern, it is excluded; if it departs from routine and breaks new ground, it is included. For example, activities such as routine testing, patent applications and trial production runs are excluded. It is also notably that overheads of R&D projects are included, VAT is excluded (Office for National Statistics, 2013).

The Frascati guidelines divide R&D expenditure into three main categories (OECD, 2002):

- *Basic Research*: "Basic Research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view."
- *Applied Research*: "Applied Research is also original investigation in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective."
- *Experimental Development*: "Experimental Development is systematic work, drawing on existing knowledge gained from research and practical experience, that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed."

These categories are then sub-divided further. The Frascati Manual splits Basic Research into 'Pure' and 'Orientated' categories. In addition, in the UK, Applied Research is further split into 'Strategic-Applied Research' and 'Specific-Applied Research', depending on how broad or narrow the work is. These latter terms are sympathetic to the previous classification system used by UK military industry and therefore provide both more information and help to make the data more reliable.

Although effort is made to apply the classifications systematically, it is acknowledged that the process is subjective. The Defence Analytical Services Agency (DASA) – which compiles data on behalf of the Ministry of Defence – has admitted that one weakness in its system is that it allows the classification of projects within the Frascati framework to be carried out by the project teams themselves rather than by third party assessors (DASA, 2011). This can be

a particular problem in MoD-funded projects as, in practice, project teams will take a project throughout its life without appreciating where changes in categorisation of funding occurs. The Frascati Manual provides detailed guidance on these matters, but a specialist assessor is likely to provide more reliable data.

R&D across government is also categorised into intramural and extramural elements. Regarding military R&D, intramural work is undertaken within the MoD and its Agencies, such as the Defence Science and Technology Laboratory, Defence Scientific Advisory Council, and DASA. Although these are established as Trading Funds, they are wholly owned by the MoD and staffed by civil servants. Extramural R&D is commissioned by MoD within UK industry, universities, research councils and overseas organisations (DASA, 2004).

Appendix A2. Data gathering using freedom of information requests

In order to analyse the detail of the UK's public spending on security-related R&D, we gathered data at a programme/ project level held by government departments and other public bodies such as research councils. Where such material could not easily be found in open databases and official reports, we used freedom of information (FOI) requests to the appropriate departments.

We submitted FOI requests to the Ministry of Defence, Home Office, Department for Energy and Climate Change, Department for International Development, Department for the Environment, Food and Rural Affairs and Foreign and Commonwealth Office.

The FOI requests asked for "the full Frascati defined research and development spend... by project or project area." For each project, we also asked for:
"1. The name of the project/ project area;
2. Any relevant identifying code;
3. A description of the project if available;
4. The spend on the project each year."
For each project, we also asked for the spending to be "disaggregated into the amounts of:
a. Intramural and extramural spending;
b. Basic research, applied research and experimental development."

We initially phrased our questions in terms of security-related R&D, including understanding and tackling the roots of conflict, but given differing uses of the term 'security-related', we decided that it would be more robust if we re-phrased our requests to obtain the widest set of R&D data and made these judgements ourselves in a consistent fashion (see chapters four and five).

We obtained data on the four financial years, 2007-11, eventually settling on the three year period 2008-11 for analysis, given the better quality of the data available in those years.

Most departments provided adequate and timely responses and indeed were happy to work to find helpful resolutions to our requests where possible.

As discussed in section 3.3, particular problems emerged in trying to gather a complete record of R&D spending by the MoD. Military R&D is carried out within project teams, and estimates are made of the proportion of each project budget that is considered to fall under Frascati definitions (see appendix A1). Supplemental data is collected through an annual survey carried out by the MoD. All this information is stored centrally within the Ministry. The MoD's total annual R&D spending is then published along with that by civilian public funders in Science Engineering and Technology (SET) Statistics (see box 1.1). Through our FOI requests, we were supplied with the annual R&D breakdown by project for Defence Equipment and Support (DE&S) and for nuclear weapons. This is presented in detail in appendix A3. While there were some discrepancies in the data with which we were supplied, and accessing project information beyond the name and code could be difficult, the largest problem was undoubtedly that approximately £500m a year of the MoD's R&D

spending was not accounted for within these areas. We were given no adequate explanation for this, despite repeated questioning.

The other public funder which proved problematic was the Home Office, where much of our data request was refused on the grounds of national security. As discussed in section 3.4, we viewed this as a harsh decision.

Appendix A3. Additional Ministry of Defence R&D data

Tables A3.1-A3.3 show the detailed spending figures for the MoD's Defence Equipment and Support R&D programmes for the three financial years, 2008-11, as discussed in section 3.3. Each table includes the name of the programme/ technology, its MoD abbreviations and numerical codes (used by the MoD to identify the programme), our classification of the programme (offensive/ defensive/ general) as discussed in chapter four, and the spending in that financial year. These tables do not include nuclear weapons R&D spending which was supplied in a separate format by the MoD and is given in table A3.4.

The programme names were either drawn from the data files supplied by the MoD or through reference to other open sources, e.g. RAF (2013). Information on particular programmes could be quite sparse. For a small number of programmes, no numerical codes were supplied by the MoD, while in others, more than one code or abbreviation was supplied. In two cases – Long Range Submarines and Unmanned Aerial Vehicles – we summed together spending on programmes that were very closely related.

Table A3.1. MoD Defence Equipment and Support R&D spending programmes 2008-09 *(MoD, 2012; 2012b) (cash terms)*

Name	*Abbreviations*	*Codes*	*Offensive/ Defensive/ General*	*Total spending (£m)*
Combat/ Attack Helicopters	D HELS	na	Offensive	242.42
Typhoon (Eurofighter)	TYPHOON	na	Offensive	238.22
Unmanned Aerial Vehicles (drones)	UAS; TACTICAL UAV	8164; 8176	Offensive	136.11
Joint Combat Aircraft (F-35)	JCA IPT	8165	Offensive	99.90
Long Range Submarines (hunter-killer and nuclear armed)	STRATEGIC OPTIONS GROUP; IPT – ASTUTE; IPT – TORPEDOES; SUB IPT	8367; 8140; 8095; 8086	Offensive	77.95
Nuclear Propulsion (for submarines)	NUCLEAR PROPULSION	8151	Offensive	65.57
Nimrod	MRA4 EPP	8446	Defensive	62.69
Sea Technology Group	SEA TECHNOLOGY GROUP; DGS + E	7931	General	53.86
Long Range Transport (A400M)	A400M PT	8341	Offensive	48.69
Indirect Fire Precision Attack	IFPA PIPELINE	8460	General	44.82
Beyond Visual Range Air-to-Air Missile	BVRAAM PIPELINE	8162	Offensive	39.38
Vehicle-borne and man-pack Electronic Countermeasures capabilities	FORCE PROTECTION IPT	6370	General	34.82
Maritime Gunnery and Missiles	MGMS IPT	8150	General	24.92
Satellite Simulator Validation Test	SSVT	8345	General	23.01
Intelligence, Surveillance, Target Acquisition and Reconnaissance	ISTAR SPARE BLB	7960	General	16.73
Special Projects Communications, Information, Surveillance and Reconnaissance	SPCISR IPT	8073	General	14.21
Bridging for advance forces	MANOEUVRE SUPPORT TEAM	8326	Offensive	12.57
Training Aircraft	UK MFTS	8340	General	12.39
Naval Electronic Warfare	NAVAL EW IPT	8094	General	10.78
Surface to Air Missile	SAM PIPELINE	8461	Defensive	10.17
Medical and General Supplies	MED AND GS PT PROJECTS	8471	General	9.80

Defence Fixed Networks	NT Fixed	6177	General	9.34
[Unknown]	DM24	na	General	8.29
Lightweight Missile	LIGHTWEIGHT MISSILE	8308	Defensive	7.63
Future Business Group	FBG SPARE 2	8347	General	6.18
Imagery and Geospatial Systems	IMAGE	8118	General	4.77
Artillery	FUTURE ARTILLERY WPN SYS	8321	General	3.53
Long Range Transport (Hercules/ Tristar)	C130J - HRR1	8197	Offensive	3.46
Dismounted Close Combat	DCC	8090	General	3.37
Chemical, Biological, Radiological and Nuclear	CBRN	8200	General	3.28
Special Projects SCM, tapes, rope ascenders	SPSCM	8312	General	3.22
Flight Simulation Training Systems	FLIGHT SIM+SYNTH TRAINER	8121	General	3.17
Defensive General Munitions	DGM IPT; DPA/DLO 4.5 IM	8359	General	3.07
Defence Clothing Integrated Project Team	DCIPT	2067	General	2.67
Conventionally Armed Stand Off Missile	CASOM	8158	Offensive	2.44
Ship Support equipment	SHIP SUPPORT (ALLIANCE)	8067	General	1.93
Air Command and Control Systems (air traffic management)	ACCS	8122	General	1.84
Joint Electronic Surveillance (land/ maritime)	JES IPT	8075	General	1.82
Combat Vehicle Reconnaissance (Tracked)	IPT - CVR(T)	8091	General	1.53
Aircraft Identification Equipment	IDENTIFICATION EQUIPMENT	8172	General	1.07
Programmes with spending below £1m				5.75
Total				*1,357.37*

Table A3.2. MoD Defence Equipment and Support R&D spending programmes 2009-10 *(MoD, 2012; 2012b) (cash terms)*

Name	*Abbreviations*	*Codes*	*Offensive/ Defensive/ General*	*Total spending (£m)*
Long Range Submarines (hunter-killer and nuclear armed)	FSM IPT; UWS; IPT – ASTUTE	8367; 6321; 8140	Offensive	190.31
Typhoon (Eurofighter)	TYPHOON – ACQUISTION	8426	Offensive	169.71
Attack Helicopters (Future Lynx)	IPT – LYNX	8083	Offensive	107.11
Nuclear Propulsion (for submarines)	NUCLEAR PROPULSION	8151	Offensive	101.27
Joint Combat Aircraft (F-35)	JCA IPT	8165	Offensive	83.49
Indirect Fire Precision Attack	IFPA PIPELINE	8460	General	60.84
Short Range Air Defence	SHORAD F	8150	Defensive	47.70
Satellite Simulator Validation Test	SSVT	8345	General	45.96
Defensive General Munitions	DM3C	na	General	43.06
Long Range Transport (A400M)	A400M PT	8341	Offensive	40.64
Surface to Air Missile	SAM PIPELINE	8461	Defensive	29.28
Unmanned Aerial Vehicles (drones)	UAS	8164	Offensive	25.86
Conventionally Armed Stand Off Missile	CASOM	8158	Offensive	19.10
Force Protection	FP	6370	General	18.62
Bridging for advance forces	MANOEUVRE SUPPORT TEAM; MS T	8326	Offensive	16.48
Special Projects Communications, Information, Surveillance and Reconnaissance	SPCISR IPT	8073	General	14.07
Beyond Visual Range Air-to-Air Missile	BVRAAM PIPELINE	8162	Offensive	13.75
Medical and General Supplies	MED AND GS PT PROJECTS	8471	General	11.48
Nimrod	MRA4 EPP	8446	Defensive	11.46
Communications Messaging	COMMS MESSAGING	8074	General	10.73
Technology Demonstrators	FBGP; TECHNOLOGY DEMONSTRATOR	8329	General	10.73
Dismounted Close Combat	DCC	8090	General	7.77

Salvage and Marine Operations	SALMO	366	General	6.98
Long Range Transport (Hercules/ Tristar)	C130J - HRR1; HERCULES	8197	Offensive	5.90
Defence Clothing Integrated Project Team	DCIPT	2067	General	5.00
Naval Electronic Warfare	NAVAL EW IPT	8094	General	4.45
Joint Electronic Surveillance (land/ maritime)	JES IPT	8075	General	3.72
Bowman and Tactical Communications & Information Systems (radios)	BATCIS	8561	General	3.44
Long Range Land Attack Projectile/ Information Integration	LRLEP	8347	General	3.10
Chemical, Biological, Radiological and Nuclear	CBRN	8200	General	3.08
Combat Support Equipment	COMBAT SUPPORT EQUIP IPT	6347	General	3.04
Imagery and Geospatial Systems	IMAGE	8118	General	3.02
Helicopter Support Team	HST	6325	Offensive	2.64
Artillery	FUTURE ARTILLERY WPN SYS	8321	General	2.57
Special Projects SCM, tapes, rope ascenders	SPSCM	8312	General	2.57
Scorpion Armoured Vehicles	IPT – CVR(T)	8091	Offensive	2.46
Networks	na	na	General	2.04
Director Programmes Support	DIRECTOR PROGRAMMES SUPP	8451	General	1.78
Specialist & Logistic Vehicles	SLV	8154	General	1.46
Ground Based Air Defence	GBAD	8127	Defensive	1.03
Air Command and Control Systems (air traffic management)	ACCS	8122	General	1.01
Programmes with spending below £1m				8.98
Total				*1,147.68*

Table A3.3. MoD Defence Equipment and Support R&D spending programmes 2010-11 *(MoD, 2012b) (cash terms)*

Name	*Abbreviation*	*Code*	*Offensive/ Defensive/ General*	*total spending (£m)*
Attack Helicopters (Future Lynx)	IPT – LYNX	8083	Offensive	249.14
Tornado	TORNADO CAPABILITY	8421	Offensive	127.35
Long Range Submarines (hunter-killer and nuclear armed)	FSM; IPT – TORPEDOES; SUB IPT; IPT ASTUTE; UWS	8367; 8095; 8086; 8140; 6321	Offensive	123.81
Nuclear Propulsion (for submarines)	NUCLEAR PROPULSION	8151	Offensive	115.03
Joint Combat Aircraft (F-35)	JCA IPT	8165	Offensive	52.80
Short Range Air Defence	SHORAD NON-PIPE FLEET; SHORAD NON-PIPELINE-AIR-	8457; 8458; 8150	Defensive	35.46
Unmanned Aerial Vehicles (drones)	UAS	8164	Offensive	33.03
Systems Engineering and Integration Group	SEIG	8119	General	25.09
Long Range Transport (A400M)	A400M PT	8341	Offensive	22.96
Armoured vehicles and bridging	COMBAT WHEELS GROUP; PPVs UORs; MANOEUVRE SUPPORT TEAM	8573; 8155; 8326	Offensive	21.30
Beyond Visual Range Air-to-Air Missile	BVRAAM PIPELINE	8162	Offensive	19.96
Surface to Air Missile	SAM PIPELINE	8461	Defensive	19.67
Dismounted Soldier Systems and Light Weapons, Photographic and Batteries	INDIVIDUAL GROUP; DCC; COMBAT SUPPORT EQUIP IPT	8574; 8090; 6347	General	15.73
Special Projects Communications, Information, Surveillance and Reconnaissance	SPCISR IPT	8073	General	14.32
Technology Demonstrator	FBGP	8329	General	13.50
Heavy Helicopters	IPT - CHINOOK	8089	Offensive	9.86
Satellite Simulator Validation Test	SSVT	8345	General	9.47
Bowman and Tactical Communications & Information Systems (radios)	BATCIS	8561	General	9.11
Vehicle-borne and man-pack Electronic Countermeasures capabilities	FORCE PROTECTION IPT	6370	General	8.20

Medical and General Supplies	MED AND GS PT PROJECTS	8471	General	7.20
Chemical, Biological, Radiological and Nuclear	CBRN	8200	General	7.15
Naval Electronic Warfare	NAVAL EW IPT	8094	General	5.83
Conventionally Armed Stand Off Missile	CASOM	8158	Offensive	4.65
Future Business Group	FBG SPARE 2	8347	General	3.95
Artillery	FUTURE ARTILLERY WPN SYS	8321	General	3.50
Imagery and Geospatial Systems	IMAGE	8118	General	3.32
Special Projects SCM, tapes, rope ascenders	SPSCM	8312	General	3.05
Joint & Battlefield Trainers Simulations & Synthetic Environments	IPT - BJTSSE	8168	General	2.53
Air Command and Control Systems (air traffic management)	ACCS	8122	General	2.46
Medium Range Air Defence	MRAD PIPELINE	8456	Defensive	2.20
Armoured Fighting Vehicles	AFV TEAM	8175	Offensive	2.10
Joint Electronic Surveillance (land/ maritime)	JES IPT	8075	General	1.78
Major Warships	MAJOR WARSHIPS	8072	General	1.64
Ship Support	SHIP SUPPORT (ALLIANCE)	8067	General	1.23
Tactical Data Links	TACTICAL DATA LINKS	8116	General	1.17
Test & Evaluation and Training Capabilities	TEST LTPA	8466	General	1.02
Programmes with spending below £1m				4.36
Total				*984.30*

Table A3.4. MoD Nuclear Weapons R&D spending 2006-2011 *(MoD, 2012) (cash terms)*

	2006-07	2007-08	2008-09	2009-10	2010-11
£m	100	100	104	110	103

Note: 2010-11 figure is estimated to be the average (mean) of the four preceding annual figures.

Appendix A4. Sustainable security challenge: climate change

A4.1 Understanding the threat

Climate change is one of the greatest threats to human society over the foreseeable future. As David King – Chief Scientific Advisor to the UK government from 2000 to 2007 – famously said, "climate change is the most severe problem that we are facing... more serious even than the threat of terrorism" (King, 2004).

Rising global temperatures are leading to an increase in extreme weather – including heat waves, droughts, storms and floods – which, in turn, can cause crop failures, shortages of clean water and increases in some infectious diseases. Millions, if not billions, of people are likely to be threatened in the coming years and decades (IPCC, 2007).

The early effects are starting to be seen already, although the complexity of the climate system means that unambiguous attribution can sometimes be difficult (IPCC, 2007). Some effects are clearly linked to rising temperatures – such as the major increase in sea level, the large-scale shrinking of the Arctic ice cap or the widespread increase in storm incidence. However, others are still a subject of debate, especially individual events such as 'Superstorm' Sandy which caused considerable damage to New York in 2012. Nevertheless, the World Health Organisation has estimated that climate change could already be claiming 150,000 lives per year around the globe, especially through additional heat stress and increases in infectious diseases (WHO, 2003).

There is overwhelming agreement among climate scientists that human action is the main cause of climate change – as indicated by a series of in-depth reports by the UN advisory body, the Intergovernmental Panel on Climate Change (IPCC, 2007). Human activities – especially the burning of fossil fuels, deforestation and a range of other industrial and agricultural activities – are releasing billions of tonnes of greenhouse gases (especially carbon dioxide) into the atmosphere. These trap the Sun's heat and cause the Earth's surface to warm. Observations suggest that the global temperature rose by 0.6°C during the 20th century and, during this century, it will rise a lot more rapidly – between 1.1°C and 6.4°C (IPCC, 2007). These numbers sound small, but a rise even at the low end of this range would be a greater change than any experienced by human civilisation since the end of the last Ice Age (IPCC, 2007). The ability of human society – especially those people in poverty – and natural ecosystems to adapt to changes greater than at the lower end of this scale is extremely limited. In a highly influential report in 2006, the UK government advisor Lord Stern argued that the economic costs of failing to markedly reduce greenhouse gas emissions would be far greater than the costs of taking action (Stern, 2006).

The Copenhagen Accord, agreed by the world's leading nations in 2009, recognised that action should be taken to keep global temperature change below 2°C above the pre-industrial level in order to minimise the risks to human society (UN FCCC, 2009). Above this, the scientific evidence suggests that the chances of rapid, major and irreversible change become much more likely. To keep below the 2°C target, however, will require human emissions of greenhouse gases to peak by about 2015 (IPCC, 2007). However, international commitments so far fall well short of this target (UNEP, 2012).

While not a direct threat to national security in the traditional sense, it is clear that climate change has huge security implications. The jeopardising of water or food supplies, for example, obviously affects security on an individual basis and can lead to conflict – including armed conflict – if it happens on a large-scale. Climate change is often described as a 'threat multiplier', and the major potential for climate-driven political instability was highlighted by the Foreign Office's new climate envoy in a recent interview (Carrington, 2013). There is also some recognition of the threat in the NSS and SDSR (see chapter three), but the assessment in these documents does not adequately match the seriousness of the climate problem.

Major action to tackle climate change – both by the UK and other leading nations – will thus make an extremely important contribution to improved international security and reduce the risks of future wars. Obviously, further scientific research and technological development will make a key contribution to this effort.

A4.2 UK policies to tackle climate change

The UK has put in place a wide range of policies and measures to help tackle climate change in recent years. Some have been exemplary, while others have been either ineffective or counter-productive. Of particular concern at the time of writing is the way in which the Coalition government is watering down its climate-related policies.

A cornerstone of UK climate policy has been the establishment of national targets for reducing greenhouse gas emissions. These have been given legal force, first through the UK ratification of the Kyoto Protocol – the international treaty which set targets for industrialised countries up until 2012 – and latterly through the Climate Change Act – which set national targets up until 2050. Under the Act, emissions are to be reduced by at least 34% by 2020 and by 80% by 2050 relative to 1990 levels (DECC, 2011). The UK was among the first countries to set legally binding emissions targets of this scale.

Figures for 2011 indicate the UK's domestic greenhouse gas emissions were 29% below 1990 levels (DECC, 2013). On the face of it, this seems an impressive reduction, but these figures do not tell the whole story. For example, a large fraction of this reduction has been achieved by non-climate change policies and events – such as the 'dash for gas' in the 1990s, where about half of coal combustion was replaced by less polluting natural gas in the electricity generation sector as a cost-saving measure, and latterly by the economic downturn from 2008 onwards (DECC, 2012; CCC, 2012). The most successful measures which have intentionally reduced emissions have been industrial changes, which have reduced non-carbon dioxide greenhouse gases, and some energy efficiency improvements. Other smaller positive and negative trends in the electricity sector have largely cancelled each other out to date. Disturbingly, new analysis has revealed that the UK has effectively exported much of its high emissions activity. The Committee on Climate Change, a government advisory body, has demonstrated that the increase over the last 20 years in the emissions arising from the production of goods imported into the UK has almost entirely offset the reduction which occurred within UK borders (CCC, 2013). The CCC has pointed out that a "step change" in action is needed from government (CCC, 2012).

Over this period, the UK government has also made important contributions to international negotiations on tackling climate change, and run programmes on 'cleaner' technology transfer to developing countries.

A4.3 UK energy sector policies

As the carbon dioxide emissions from energy use make up the largest contribution to climate change – it is worth looking at the effectiveness of the UK's policies in this area in more detail. These also are critical from an energy security perspective (which we also cover in appendix A6). These policies are the responsibility of the Department of Energy and Climate Change (DECC).

Under agreement with the EU, the UK has a target of generating 15% of its 'final energy consumption' from renewable sources by 2020. This target includes electricity consumption, transport and heating – and the technologies and fuels mainly include wind (onshore and offshore), bioenergy (solid biomass, liquid biofuels and biogas), hydro, solar (photovoltaics and hot water panels), marine (tidal and wave) and geothermal.

In the electricity sector, the main UK policy measure over the past decade or so has been the Renewables Obligation, whereby electricity suppliers are legally obliged to source a growing percentage of their electricity from renewable sources. In 2010, a feed-in tariff was added for small-scale technologies. These have helped drive up the proportion of UK electricity sales from renewable energy sources to 9.7% in 2011 – only narrowly missing the national target (DECC, 2012).

In the transport sector, the main policy has been the Renewable Transport Fuel Obligation which has been aimed at increasing the proportion of biofuels (such as bio-diesel and bio-ethanol) sold in automotive fuels.[*] In the heat sector, there have been increases in the use of biomass (including wood chips) and solar hot water panels.

While there have been important increases in renewable energy generation in the UK over the past ten years, the overall progress has still been rather limited. The figure for 2011 shows that only 3.8% of the UK's final energy consumption came from renewable sources – still one of the lowest levels in the EU (DECC, 2012).

A critical aspect of energy policy, which often receives lower priority, is energy efficiency. However, there has also been important progress in this area in recent years. Significant efficiency improvements have been made in industry, the service sector and households. In particular, between 2008 and 2012, there has been a 31% increase in the number of households with cavity wall insulation and a 47% increase in those with loft insulation – driven by government schemes and an improvement in building regulations (DECC, 2012).

Another aspect of low carbon energy policy in the UK has been to support the building of new nuclear power stations. Permits for eight sites were granted to industry in October

[*] Biofuels from crops have become very controversial due to the high potential to compete for land with food production, thus undermining food security – see appendix A6.

2010 (BBC News, 2010b). However, progress since then has been slow, delayed by safety assessments and negotiations over subsidies via the incoming legislation on Electricity Market Reform. Given lengthy construction periods, the earliest likely completion date for the first power station would be beyond the end of the decade. Indeed, nuclear power is especially controversial as a climate change mitigation option, and the government's continued support for it raises serious security concerns – see appendix A5.

The Coalition government's new strategy to reduce greenhouse gas emissions was laid out in its 2011 Carbon Plan (DECC, 2011). The policies and measures include:

- Expansion of renewable energy, nuclear power and carbon capture and storage (the latter mainly linked to fossil fuel power stations), through measures such as Electricity Market Reform;
- Energy efficiency and renewable heat programmes in buildings, through measures including the Green Deal and the Energy Company Obligation;
- Low carbon transport programmes, including expansion in the use of electric cars;
- Specific programmes to reduce emissions in the industrial, agricultural and waste sectors.

Many of the policies areas were similar to that of the previous government, but numerous structural changes have been made in this plan and its subsequent delivery. Of particular significance are Electricity Market Reform, a new system through which major subsidies are paid to low carbon generators, and the Green Deal, to support energy efficiency improvements. However, there is a lot of doubt about whether these policies will provide the scale of action needed (e.g. CCC, 2012; Webber, 2012). Of greatest concern, however, is a series of further policy changes – including a new Gas Generation Strategy (DECC, 2012b), increased subsidies for the offshore oil and gas sector (DECC, 2013b), and an unwillingness to put carbon emissions targets in the latest Energy Bill (BBC, 2013b) – which indicate that the government is watering down action on climate change.

Effective climate change policies and technologies obviously require robust R&D to support them. While the UK has world-leading climate research institutes such as the Met Office Hadley Centre and is playing a leading role in the development of some renewable energy technologies (especially in marine energy), the overall picture is much more mixed (see section 5.2).

Addendum

As this appendix went to press, the IPCC published its latest assessment report on climate change science (IPCC, 2013). It expressed even greater certainty regarding the human contribution to climate change, and its projections were broadly in line with those of earlier reports.

IPCC (2013). http://www.ipcc.ch/report/ar5/wg1/