OXFORD ECONOMIC RESEARCH ASSOCIATES

DEPARTMENT OF TRADE AND INDUSTRY

RESULTS OF RENEWABLES MARKET MODELLING

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Blue Boar Court
Alfred Street
Oxford OX1 4EH
Tel: +44 (0) 1865 253000
Fax: +44 (0) 1865 251172
Email: Enquiries@oxera.co.uk
www.oxera.co.uk

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1. Introduction

1.1 Description of the study

This study contributed to the DTI's and the Carbon Trust's joint Review of Renewables Innovation Spending. The review was divided into several workstreams: objectives; identifying market barriers (market failures) to the development of renewables technologies; possible government interventions to remove or counteract these failures; and policy targets. This study contributed to the workstream on government interventions (measures). It was divided into three phases:

- phase one involved advising the technology teams on the data required to carry out the policy measures analysis;
- phase two was baseline modelling of renewables generation, projecting future new build, technology prices, atmospheric emissions and UK employment;
- phase three involved further modelling of renewables generation, providing scenarios for new build in response to government measures, technology prices, atmospheric emissions and UK employment. The measures included the Renewables Obligation (RO), the co-firing regulations, and others that the DTI/Carbon Trust team suggested.

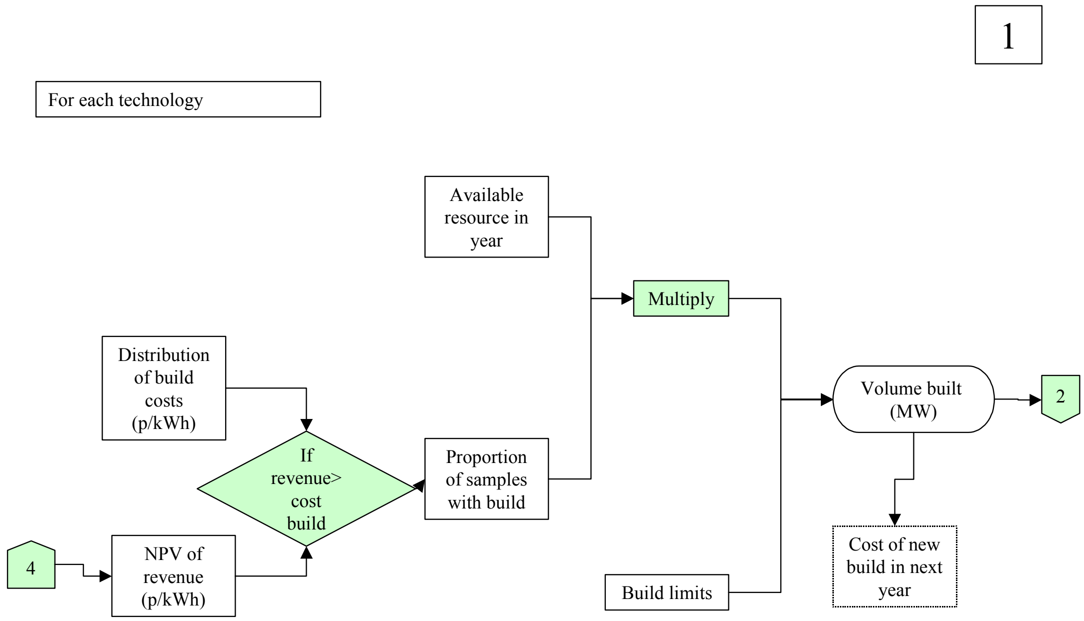
This report is a brief record of the approach, assumptions and results:

- section 1 describes the structure of the model;
- section 2 lists the key policy indicators estimated by the model;
- section 3 sets out the main assumptions used in the modelling of the Baseline Scenario;
- section 4 presents detailed results for the Baseline Scenario;
- section 5 presents summary results for a range of alternative scenarios.

1.2 The model

OXERA used its renewables market model to simulate scenarios and estimate results. The structure of this model is shown in Figures 1.1 to 1.4.

Figure 1.1: Estimation of new build by year



Note: NPV, net present value.

Figure 1.2: RO-eligible renewable generation

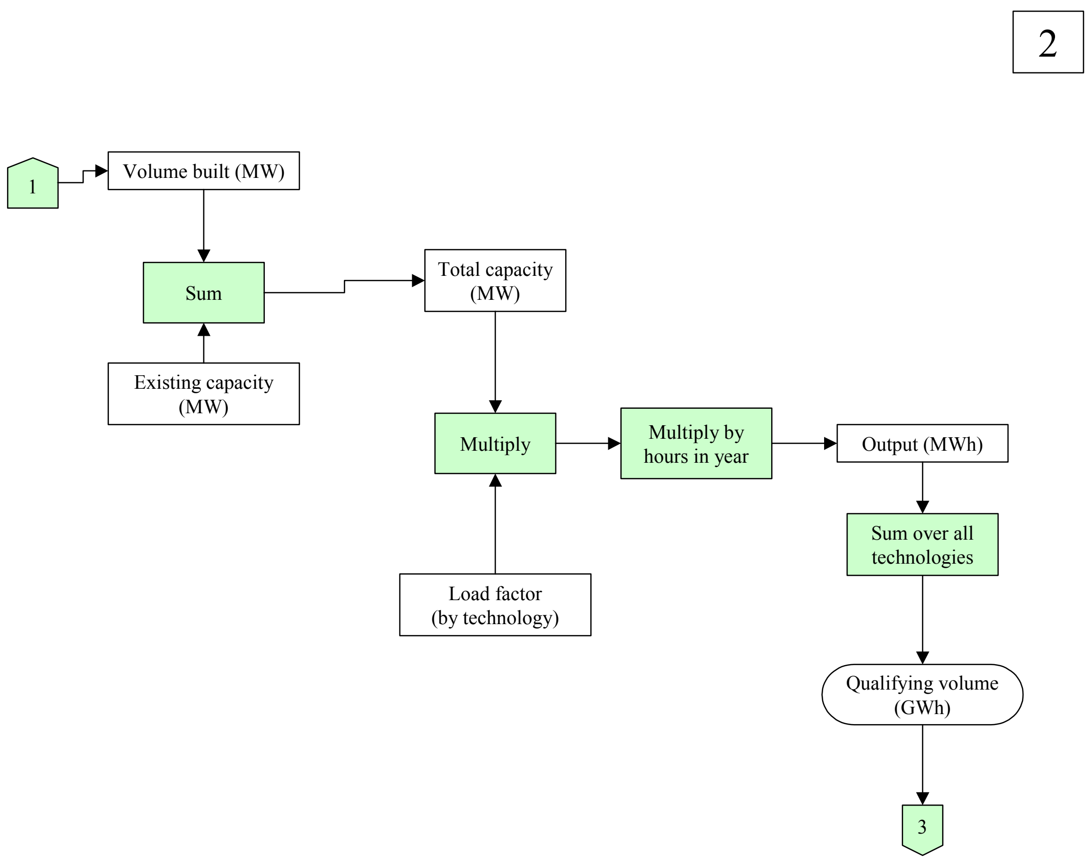


Figure 1.3: Renewables Obligation Certificate price

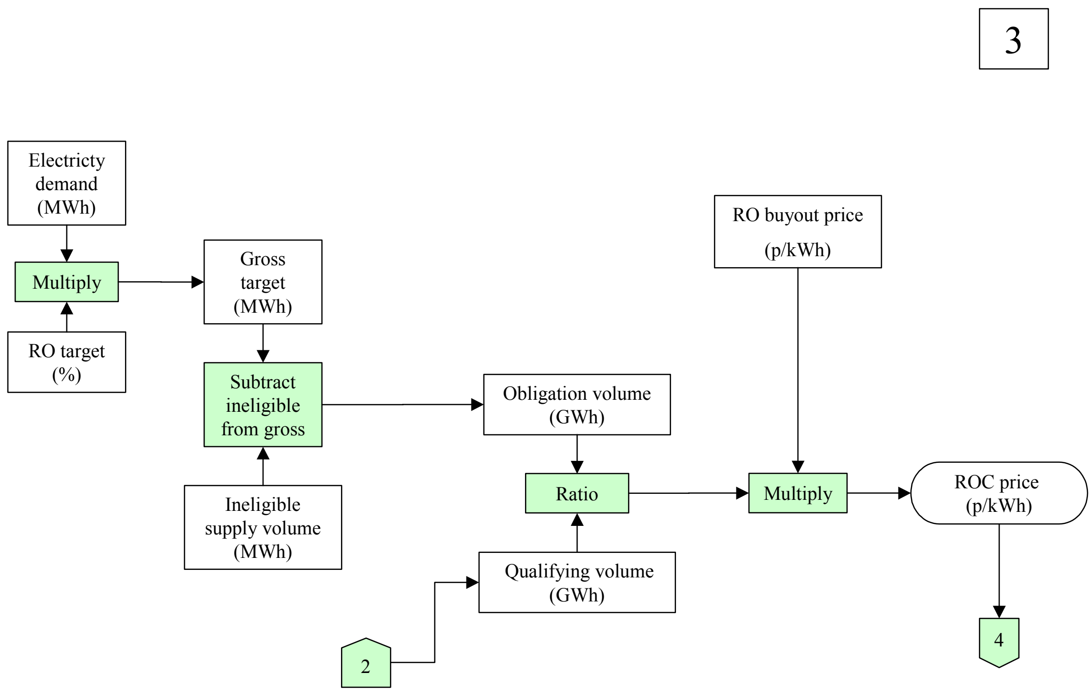
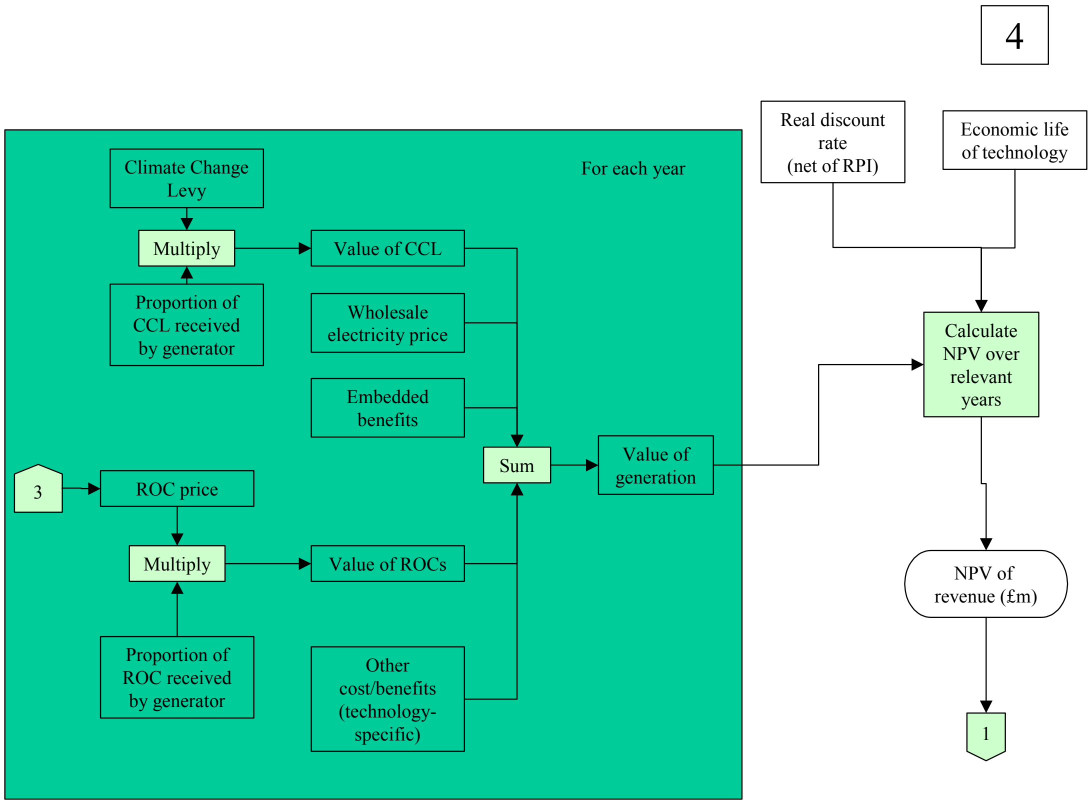


Figure 1.4: NPV cost of generation



OXERA's model determines a consistent set of Renewables Obligation Certificate (ROC) prices and development in renewable generation to 2025.

2. Outputs

The following basic policy-relevant measures were estimated.

Total subsidy

(1) £m = capital grants (£/MW * MW entry) + ROC price * eligible volume + cross-subsidised cost of network reinforcements

This shows total public cost of policy.

Cost to customers as percentage of bill

(2) % of bill = (ROC price * eligible volume) / (price to customers * total supply)

This shows the impact on household and industrial and commercial bills, which can be compared with the impact of other policies, and gives an idea of the impact on competitiveness of some sensitive sectors.

Emissions avoided

(3) $MtCO_2$ per annum = CO_2 displaced per MWh * MWh generated

Resource cost

(4) £m = total costs of renewable generation (including cost of intermittence and network reinforcements) – (wholesale price including emissions trading price premium* renewable eligible volume)

then:

(5) resource cost per tonne CO_2 = resource cost / emissions avoided

This shows whether the policy is worth pursuing; if shown by technology, it will show which technologies are worth supporting.

Total resource cost over time

(6) TRC = sum over t (resource cost * discount factor), using social time preference rate

3. Assumptions for the Baseline Scenario

Table 3.1: Accessible resource, initial capacity, build rates

	Accessible resource (MW)			Initial capacity (MW)	Maximum build rate		
	Northern Ireland	Scotland	England & Wales		2004	2010	2020
Wind–onshore	2,000	12,000	3,000	681	300	600	600
Wind–offshore	2,000	6,000	17,000	94	100	1,250	1,000
Energy crops	1,000	3,000	10,000	8	0	50	270
Waste	150	250	600	310	0	0	0
Marine	500	2,500	3,000	3	0	50	500
Landfill	20	60	600	561	50	50	50
Co-firing	50	100	1,050	599	0	0	0

Table 3.2: Load factors: eligibility for the RO

Resources	Load factor	Proportion eligible for RO (%)	
		2004	2010
Wind–onshore	0.30	100	100
Wind–offshore	0.35	100	100
Energy crops	0.85	100	100
Waste	0.34	0	0
Marine	0.30	100	100
Landfill	0.63	100	100
Co-firing	0.43	100	100

Table 3.3: Existing plant costs

	Fixed costs (£/kW)	O&M (£/kW/yr)	Fuel cost (£/MWh)	Balancing cost (£/MWh)
Wind–onshore	1,000	15	0	2
Wind–offshore	1,100	35	0	2
Energy crops	1,350	40.5	3.5	0
Waste	50	15	0	0
Marine	1,500	60	0	2
Landfill	1,464	44.4	0	0
Co-firing	5	0.15	16	0

Note: O&M, operations and maintenance.

Table 3.4: New plant costs, 2004

	Fixed costs (£/kW)	O&M (£/kW/yr)	Fuel cost (£/MWh)	Balancing cost (£/MWh)	Capital grants in 2004 (£/kW)	Cost of capital (%)
Wind–onshore	605–800	15–20	0	2	0	8
Wind–offshore	1,100–1,430	35–42	0	2	110	11
Energy crops	1,350–1,620	40.5–49	18–36	0	202	14
Waste	500–600	15–18	0	0	0	6
Marine	1,500–1,800	60–72	0	2	0	14
Landfill	1,220–1,464	37–44	0	0	0	6
Co-firing	100–120	10–12	0	0	0	6

Table 3.5: New plant costs, 2010

	Fixed costs (£/kW)	O&M (£/kW/yr)	Fuel cost (£/MWh)	Balancing cost (£/MWh)
Wind–onshore	553–744	13–18	–	2
Wind–offshore	863–1,122	31–37	–	2
Energy crops	1,350–1,620	41–49	18–36	–
Waste	500–600	15–18	–	–
Marine	964–1,157	39–46		2
Landfill	1,220–1,464	37–44	–	–
Co-firing	100–120	10–12	5–9	0

Table 3.6: New plant costs, 2020

	Fixed costs (£/kW)	O&M (£/kW/yr)	Fuel cost (£/MWh)	Balancing cost (£/MWh)
Wind–onshore	509–659	12–16	–	2
Wind–offshore	753–979	29–35	–	2
Energy crops	1,072–1,286	32–39	14–29	–
Waste	500–600	15–18	–	–
Marine	866–1,039	35–42	–	2
Landfill	1,220–1,464	37–44	–	–
Co-firing	100–120	10–12	–	–

Table 3.7: Entry costs, £/MWh

Year	Wind–onshore	Wind–offshore	Energy crops	Waste	Marine	Landfill	Co-firing
2004	31	55	45	20	109	27	9
2005	30	55	45	20	59	27	10
2006	29	55	44	20	51	27	10
2007	28	53	43	20	47	27	12
2008	27	51	43	20	45	27	15
2009	27	47	42	20	43	27	17
2010	27	44	43	20	41	27	19
2011	27	42	41	20	38	27	21
2012	26	41	40	20	37	27	21
2013	26	40	38	20	57	27	19
2014	26	40	37	20	57	27	17
2015	26	39	36	20	56	27	14
2016	25	39	38	20	55	27	12
2017	25	38	37	20	55	27	9
2018	25	38	37	20	54	27	9
2019	25	37	38	20	53	27	9
2020	25	37	37	20	52	27	9

Note: Assuming 20-year straight-line depreciation of fixed cost, figures represent the lower bound of cost estimates. The upper bound can be obtained in most cases by multiplying the figures above by 1.2.

Table 3.8: Global installed capacity, MW

Year	Wind–onshore[1]	Wind–offshore[2]	Energy crops	Waste	Marine	Landfill	Co-firing
2004	41,000	900	8	310	3	611	600
2005	47,000	1,400	8	322	7	661	769
2006	54,000	2,000	8	335	17	711	635
2007	61,000	2,600	8	347	27	761	51
2008	68,000	3,500	58	359	37	811	62
2009	76,000	4,500	108	372	47	842	81
2010	84,000	5,700	158	384	57	874	138
2011	92,000	7,100	258	448	117	905	141
2012	101,000	8,800	408	511	167	936	0
2013	110,000	10,900	608	575	167	968	0
2014	120,000	13,400	878	638	167	999	0
2015	131,000	16,300	1,148	702	167	1,030	0
2016	141,000	19,900	1,416	766	167	1,061	0
2017	153,000	24,200	1,535	829	167	1,073	0
2018	164,000	29,300	1,555	893	167	1,054	0
2019	177,000	35,500	1,574	956	167	1,035	0
2020	190,000	42,900	1,594	1,020	167	1,017	0

Notes: [1] From Garrad Hassan Ltd, and the DTI. [2] Based on Garrad Hassan Ltd and OXERA calculations.

Table 3.9: Learning rates for capital costs, %

Year	Wind–onshore	Wind–offshore	Energy crops	Waste	Marine	Landfill	Co-firing
2004	10	0	0	0	15	0	0
2005	10	0	0	0	15	0	0
2006	10	0	0	0	15	0	0
2007	10	0	0	0	15	0	0
2008	10	10	0	0	15	0	0
2009	10	10	0	0	15	0	0
2010	10	10	10	0	15	0	0
2011	10	10	10	0	15	0	0
2012	10	10	10	0	15	0	0
2013	10	10	10	0	15	0	0
2014	10	10	10	0	15	0	0
2015	10	10	10	0	15	0	0
2016	10	10	10	0	15	0	0
2017	10	10	10	0	15	0	0
2018	10	10	10	0	15	0	0
2019	10	10	10	0	15	0	0
2020	10	10	0	0	15	10	10

Table 3.10: Learning rates for operating and maintenance costs, %

Year	Wind–onshore	Wind–offshore	Energy crops	Waste	Marine	Landfill	Co-firing
2004	10	0	0	0	15	0	0
2005	10	0	0	0	15	0	0
2006	10	0	0	0	15	0	0
2007	10	0	0	0	15	0	0
2008	10	10	0	0	15	0	0
2009	10	10	0	0	15	0	0
2010	10	10	10	0	15	0	0
2011	10	10	10	0	15	0	0
2012	10	10	10	0	15	0	0
2013	10	10	10	0	15	0	0
2014	10	10	10	0	15	0	0
2015	10	10	10	0	15	0	0
2016	10	10	10	0	15	0	0
2017	10	10	10	0	15	0	0
2018	10	10	10	0	15	0	0
2019	10	10	10	0	15	0	0
2020	10	10	0	0	15	10	10

Table 3.11: System back-up capital costs and transmission and distribution reinforcement and additional system operating costs, £m

	System back-up costs			Network reinforcement costs			
Year	**Wind–onshore**	**Wind–offshore**	**Marine**	**Wind onshore**	**Wind–offshore**	**Marine**	**Energy crops**
2004	–	–	–	–	–	–	–
2005	–	–	–	–	–	–	–
2006	–	–	–	–	–	–	–
2007	–	–	–	30	–	–	1
2008	–	–	–	59	–	–	1
2009	–	–	–	89	4	–	2
2010	15	10	0	97	7	–	3
2011	15	10	0	97	7	–	3
2012	15	10	0	97	7	–	3
2013	15	10	0	112	7	–	3
2014	15	10	0	112	24	4	3
2015	15	10	0	126	34	7	5
2016	15	10	0	143	34	11	7
2017	15	10	0	143	49	12	7
2018	15	10	0	150	49	12	7
2019	15	10	0	150	49	12	7
2020	15	10	0	150	49	12	7
2021	15	10	0	150	49	12	7
2022	15	10	0	150	49	12	7
2023	15	10	0	150	49	12	7
2024	15	10	0	150	49	12	7
2025	15	10	0	150	49	12	7

Note: These figures are equivalent to £1.2 billion capital expenditure (CAPEX) in transmission reinforcement by 2010; £0.4 billion expenditure in distribution by 2010; and in the period 2010–20, £1.1 billion CAPEX in transmission and £0.33 billion in distribution. The system back-up costs represent the capital costs of open-cycle gas-fired plant predicted in Ilex Energy Consulting (2002).

Table 3.12: Electricity supplied and generated

Year	Total electricity generated TWh	Losses %	Losses TWh	Auto generation TWh	Total electricity supplied TWh	Demand growth
2004	386.5	8.5	32.85	35	318.6	
2005	392.1	8.5	33.33	37	321.8	1.5
2006	397.8	8.5	33.81	39	325.0	1.4
2007	403.4	8.5	34.29	42	327.1	1.4
2008	409.1	8.5	34.77	45	329.3	1.4
2009	414.7	8.5	35.25	47	332.5	1.4
2010	420.4	8.5	35.73	49	335.6	1.4
2011	425.4	8.5	36.16	47	342.3	1.2
2012	430.5	8.5	36.59	47	346.9	1.2
2013	435.6	8.5	37.03	47	351.6	1.2
2014	440.7	8.5	37.46	47	356.2	1.2
2015	445.8	8.5	37.89	47	360.9	1.2
2016	450.9	8.5	38.32	47	365.5	1.1
2017	455.9	8.5	38.76	47	370.2	1.1
2018	461.0	8.5	39.19	47	374.8	1.1
2019	466.1	8.5	39.62	47	379.5	1.1
2020	471.2	8.5	40.05	47	384.1	1.1
2021	476.3	8.5	40.48	47	388.8	1.1
2022	481.4	8.5	40.92	47	393.4	1.1
2023	486.4	8.5	41.35	47	398.1	1.1
2024	491.5	8.5	41.78	47	402.8	1.0
2025	496.6	8.5	42.21	47	407.4	1.0

Source: DTI (2003), *Digest of UK Energy Statistics*, and OXERA calculations.

Table 3.13: Electricity prices, £/MWh

Year	Wholesale electricity price	Embedded benefits	EU ETS premium included in wholesale price	CCL Exemption Certificates[1]
2004	20	2.5	0	4.3
2005	23	2.5	3	4.3
2006	23	2.5	3	4.3
2007	23	2.5	3	4.3
2008	23	2.5	3	4.3
2009	24	2.5	4	4.3
2010	24	2.5	4	4.3
2011 & thereafter	25	2.5	5	4.3

Note: EU ETS, EU Emissions Trading Scheme; CCL, Climate Change Levy. [1] It is assumed that the generator receives only 90% of the value of the CCL Exemption Certificates.

Table 3.14: Employment and UK share of sales

	Jobs/MW CAPEX	Jobs/MW OPEX
Wind–onshore	11.1	0.20
Wind–offshore	12.9	0.20
Energy crops	24.2	6.60
Waste	24.2	4.50
Co-firing	5.0	1.00
Marine	10.0	0.10
Landfill	24.2	3.10
Small hydro	5.0	1.00
Sewage sludge	5.0	1.00
Solar PV	151.8	0.50

Note: OPEX, operating efficiency; PV, photovoltaic.
Source: DTI Renewables Innovation Review team.

Table 3.15: Non-fossil fuel obligation, estimate of GWh generated per annum in 2004

NFFO order	Date	Biomass	Hydro	Landfill gas	Energy from waste	Other	Sewage gas	Wind
1	1990	–	10	124	332	189	65	5
2	1991	–	–	166	235	93	106	138
3	1995	–	225	87	611	576	305	28
4	1997	–	7	1,055	249	97	25	4
5	1998	–	2	853	–	–	–	10
SRO 1	1994	73	25	–	28	–	–	66
SRO 2	1997	–	5	–	112	–	–	82
SRO 3	1999	–	–	–	77	–	–	28
NI 1	1994		2.3					12.7
NI 2	1996	0.3						2.6

Note: NFFO, Non-fossil Fuel Order.

Table 3.16: Non-fossil fuel obligation, estimate of average contract prices, £/MWh

NFFO order	Biomass	Hydro	Landfill gas	Energy from waste	Other	Sewage gas	Wind
1	60	67.5	58	60	54	60	100
2	60	60	57	66	59	59	110
3	43.5	44	37	38	50	50	43
4	34.6	44	32	30	50	34.6	38
5	55	27.1	27.1	27.1	50	27.1	27.1
SRO 1	43.5	44	37	38	50	50	43
SRO 2	34.6	44	32	30	50	34.6	38
SRO 3	55	27.1	27.1	27.1	50	27.1	27.1
NI 1	43.5	44	37	38	50	50	43
NI 2	34.6	44	32	30	50	34.6	38

Table 3.17: Suppliers' obligation

Year	Percentage of electricity supplied to be sourced from renewables
2004	4.3
2005	4.9
2006	5.5
2007	6.7
2008	7.9
2009	9.1
2010	10.4
2011	11.4
2012	12.4
2013	13.4
2014	14.4
2015	15.4
2016	15.4
2017	15.4
2018	15.4
2019	15.4
2020	15.4
2021	15.4
2022	15.4
2023	15.4
2024	15.4
2025	15.4

Table 3.18: Other assumptions

Item	Assumed value
Proportion of ROC value received by generator	90%
Proportion of CCL Exemption Certificate value received by generator	90%
Plant lifetime	20 years
Depreciation	Straight line
Tax payable	30% on post-tax operating profit
Enhanced capital allowances or accelerated depreciation	None
Rate of inflation used to estimate real cost of capital from nominal cost of capital	2.5%

4. Baseline Results

Table 4.1: New build, MW

Year	Wind–onshore	Wind–offshore	Energy crops	Waste	Landfill	Co-firing	Marine
2004	300	100	–	–	50	500	–
2005	450	473	–	12	50	169	4
2006	450	0	–	12	50	–134	10
2007	500	250	0	12	50	–584	10
2008	500	224	50	12	50	11	10
2009	600	1,250	50	12	31	19	10
2010	600	1,250	50	12	31	57	10
2011	600	1,000	100	64	31	3	60
2012	600	1,249	150	64	31	–141	50
2013	600	987	200	64	31	–	–
2014	600	0	270	64	31	–	–
2015	600	0	270	64	31	–	–
2016	600	0	267	64	31	–	–
2017	600	0	120	64	11	–	–
2018	600	0	20	64	–19	–	–
2019	600	0	19	64	–19	–	–
2020	600	0	19	64	–19	–	–

Table 4.2: Size of the buyout fund, £m

Year	Size of fund
2004	130
2005	92
2006	127
2007	248
2008	295
2009	256
2010	225
2011	193
2012	144
2013	98
2014	123
2015	150
2016	71
2017	24
2018	2
2019	–
2020	–
2021	–
2022	–
2023	–
2024	–
2025	–

Table 4.3: Estimate of profits (liabilities) for Non-Fossil Purchasing Agency on NFFO contracts, £'000s

NFFO	1	2	3	4	5	SRO 1	SRO 2	SRO 3	NI 1	NI 2	Total
2004	0	(26,424)	1,039	31,490	31,120	1,775	1,154	792	215	66	41,227
2005	0	0	(855)	28,619	28,486	1,359	1,224	937	170	57	59,997
2006	0	0	1,479	30,886	30,135	1,673	1,390	990	198	62	66,814
2007	0	0	11,145	40,277	36,969	2,971	2,079	1,211	317	85	95,055
2008	0	0	11,190	40,321	37,002	0	2,082	1,212	0	86	91,893
2009	0	0	0	34,900	32,875	0	1,778	1,155	0	72	70,779
2010	0	0	0	31,096	30,107	0	1,499	1,066	0	0	63,769
2011	0	0	0	0	29,181	0	0	1,113	0	0	30,294
2012	0	0	0	0	0	0	0	1,060	0	0	1,060
2013	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0
Total											**520,888**

Table 4.4: Network and system back-up costs, present value sum to date of annuitised costs, £m

	Wind–onshore	Wind–offshore	Energy crops	Marine
2004	0	0	0	0
2010	232	9	6	0
2015	630	65	18	7
2020	1,085	206	39	43
Whole period to 2027	1,476	333	58	73

Table 4.5: Total subsidy to date, present value, £m

	Wind–onshore	Wind–offshore	Energy crops	Waste	Co-firing	Marine	Landfill	Small hydro	Sewage sludge
2004	109	29	3	–	98	0	145	13	14
2010	1,774	970	99	–	334	29	1,062	76	152
2015	3,915	3,110	668	–	349	99	1,680	111	261
2020	6,147	4,937	1,530	–	349	169	2,127	135	335
Whole period to 2027	6,960	5,072	1,619	–	349	131	2,186	139	345

Table 4.6: Emissions avoided, undiscounted, $MtCO_2$

	Wind–onshore	Wind–offshore	Energy crops	Waste	Co-firing	Marine	Landfill	Small hydro	Sewage sludge	Solar PV
2,004	1	0	0	0	1	0	1	0	0	0
2,010	13	9	1	2	3	0	9	1	1	0
2,015	36	36	8	5	3	1	17	1	3	0
2,020	70	67	24	9	3	1	26	2	4	0
Whole period to 2027	115	97	42	15	3	2	34	2	6	0

Note: Assumes carbon intensity of electricity displaced is 0.32 tCO_2/MWh.

Table 4.7: Cumulative resource cost, discounted, £m

	Wind–onshore	Wind–offshore	Energy crops	Waste	Co-firing	Marine	Landfill	Small hydro	Sewage sludge	Solar PV
2004	48	22	0	–	14	1	7	–3	–	–0
2010	822	780	68	–	14	39	78	–20	–	–0
2015	1,912	2,569	500	–	20	122	163	–32	–	–1
2020	3,160	4,301	1,199	–	20	209	254	–41	–	–1
Whole period	4,362	5,768	1,762	–	20	284	329	–154	–	–1

Table 4.8: Average resource cost to date, £/MWh

	Wind–onshore	Wind–offshore	Energy–crops	Waste	Co-firing	Marine	Landfill	Small hydro	Sewage sludge	Solar PV
2004	19	40	8	0	(6)	64	2	(11)	0	(20)
2010	22	34	33	0	2	88	3	(11)	0	(20)
2015	22	30	28	0	2	65	4	(11)	0	(20)
2020	21	30	24	0	2	67	4	(11)	0	(20)

Table 4.9: Average resource cost to date, £/tCO_2

	Wind–onshore	Wind–offshore	Energy crops	Waste	Co-firing	Marine	Landfill	Small hydro	Sewage sludge	Solar PV
2004	59	124	24	0	(19)	199	6	(34)	0	(64)
2010	62	91	87	0	5	237	9	(31)	0	(58)
2015	53	71	64	0	7	155	10	(28)	0	(53)
2020	45	65	49	0	7	145	10	(26)	0	(49)
Whole period	60	93	70	0	7	210	14	(106)	0	(64)

Note: The tonnage of CO_2 emissions has not been discounted in this calculation, at Defra's request.

Table 4.10: Resource cost of new entry, excluding system back-up and network reinforcement costs, £/MWh

	Wind–onshore	Wind–offshore	Energy crops	Waste	Co-firing	Marine	Landfill	Small hydro
2004	15	50	59	(0)	(12)	87	7	(8)
2010	11	26	43	(0)	2	89	7	(8)
2015	9	20	31	(0)	(5)	34	7	(8)
2020	7	17	15	(0)	(12)	30	7	(8)

Table 4.11: Resource cost of new entry, excluding system back-up and network reinforcement costs, £/tCO_2

	Wind–onshore	Wind–offshore	Energy crops	Waste	Co-firing	Marine	Landfill	Small hydro
2004	47	156	186	(1)	(38)	270	21	(26)
2010	33	81	133	(1)	8	277	21	(26)
2015	28	61	96	(1)	(15)	105	21	(26)
2020	23	52	47	(1)	(39)	92	21	(26)

Table 4.12: System back-up and network reinforcement costs associated with new build, £/MWh

Year	Wind–onshore	Wind–offshore	Energy crops
2020	6.9	3.1	0.7

Table 4.13: Percentage increase in industrial customer bills

	Percentage increase in industrial customer bill
2004	3
2010	8
2015	12
2020	6

Note: Assumes that the industrial customer pays £40/MWh for power.

Figure 4.1: New-build costs, after capital grants, £/MWh

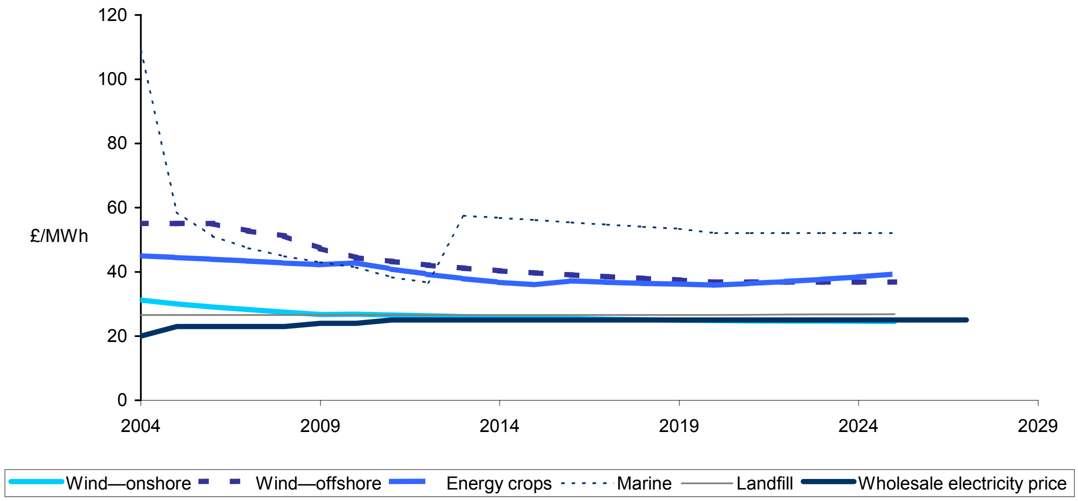


Figure 4.2: Rate of capital investment and rate of new build, £m/yr and MW/yr

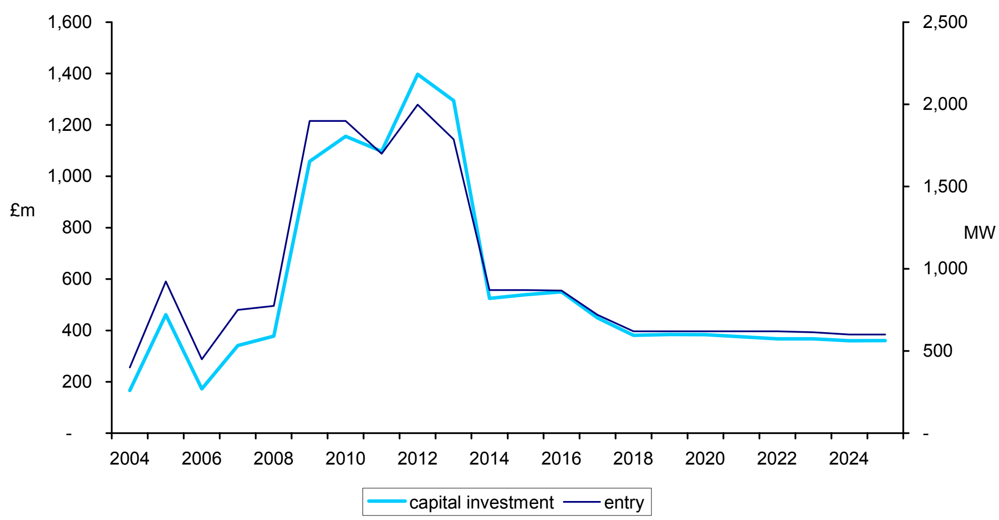


Figure 4.3: Proportion of electricity supplied and obligation, %

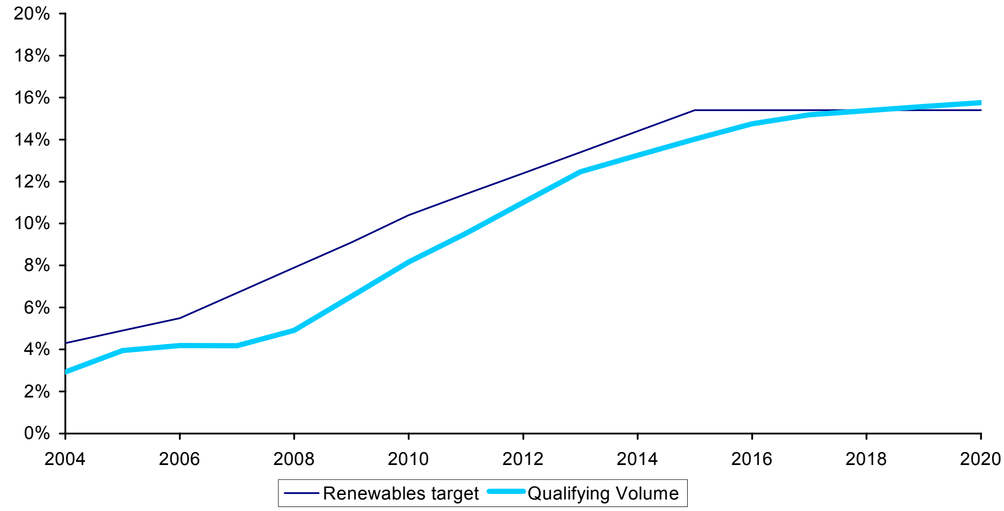


Figure 4.4: Capacity installed, MW

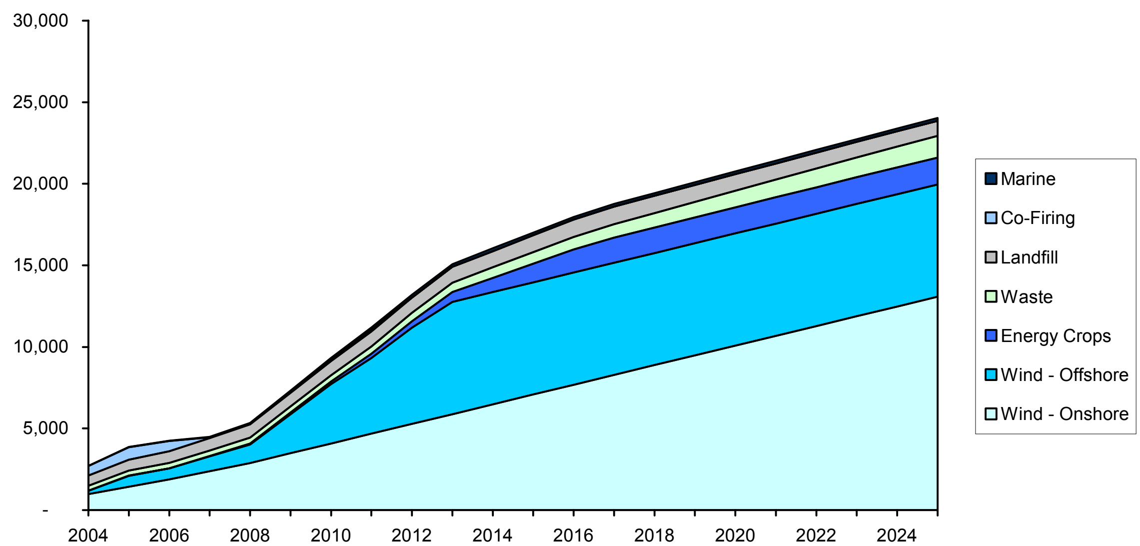


Figure 4.5: CO_2 displaced, $MtCO_2$

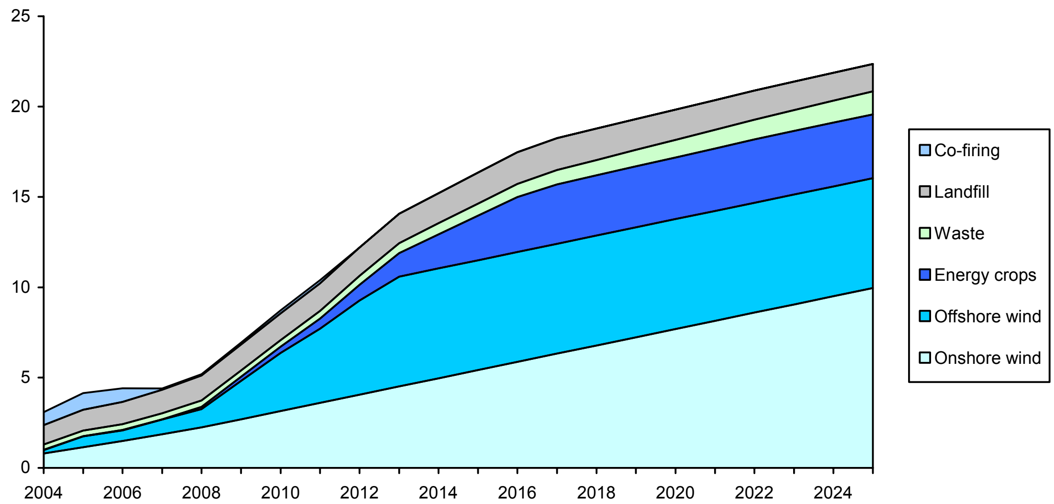
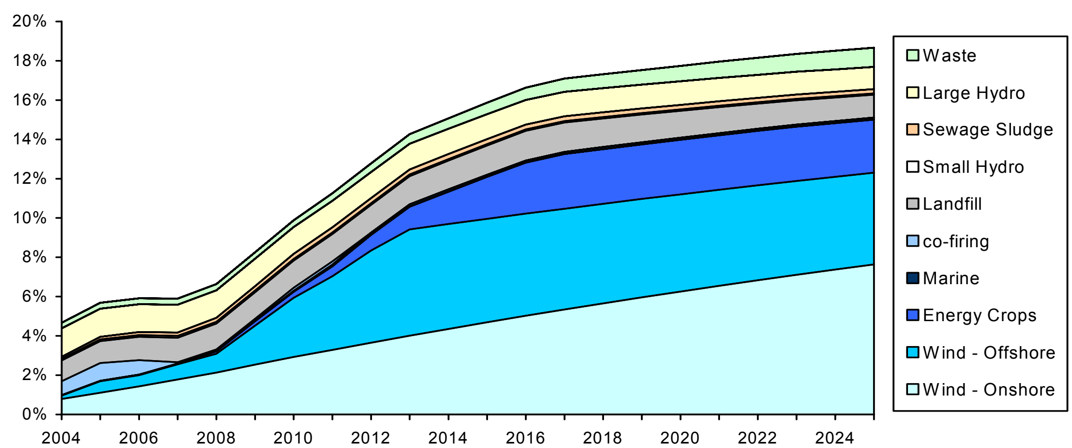


Figure 4.6: Proportion of electricity supplied from renewable sources, %



5. Results from Alternative Scenarios

5.1 Introduction

The model was run with a series of alternative assumptions, as set out in Table 5.1. The results in terms of capacity built, and percentage of electricity supplied, are presented in graphical form for each of these scenarios.

Table 5.1: Alternative scenarios and their assumptions

Scenario	Assumptions
20% target in 2020	Linear increase in the suppliers' obligation from 15.4% in 2015 to 20% in 2020
15% obligation with enhanced co-firing	Co-firing extension as announced by DTI in December 2003, using the Ilex estimate of GWh generated from co-firing in this scenario
20% obligation with enhanced onshore wind	2 GW/yr maximum build rate for onshore wind
20% obligation with enhanced offshore wind	Learning rate increased from 10% to 15%
20% obligation with enhanced energy crops	Learning enhanced by assuming increased global build
20% obligation with enhanced marine	Capital grants enhanced to 50% to 2009, and extended to 2015 at 20% of capital cost, learning rates increased to 18% up to 2010
20% obligation with enhanced waste	Energy from waste increases to 3GW in 2020
15% obligation with enhanced onshore wind	2 GW/yr maximum build rate for onshore wind

5.2 20% obligation in 2020

Figure 5.1: 20% obligation, capacity built, MW

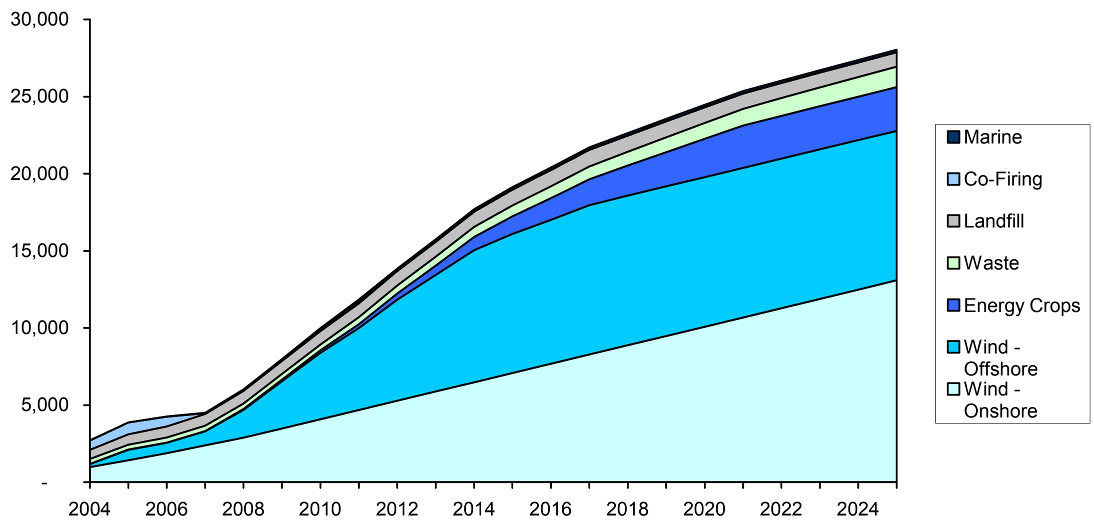
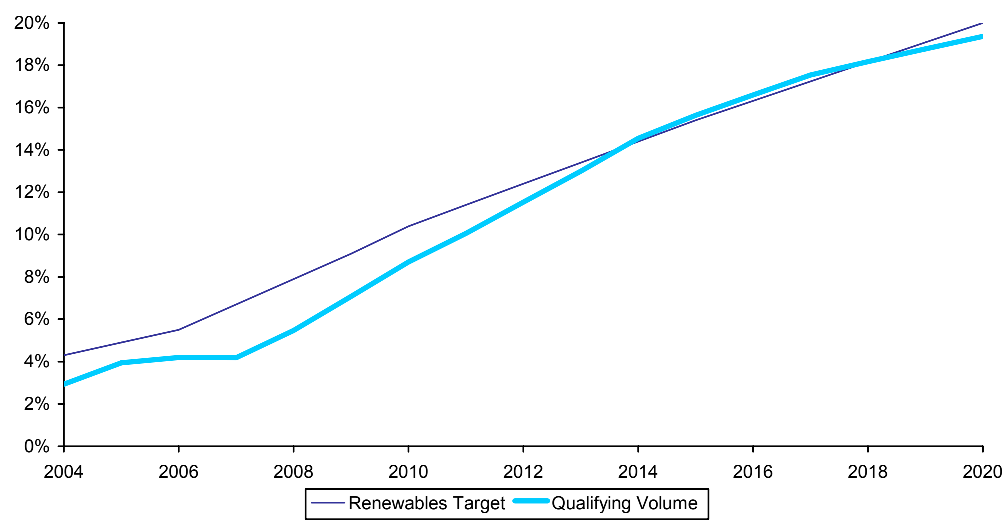


Figure 5.2: 20% obligation, percentage of electricity supplied



5.3 15% obligation with enhanced co-firing

Figure 5.3: 15% obligation with enhanced co-firing, capacity built, MW

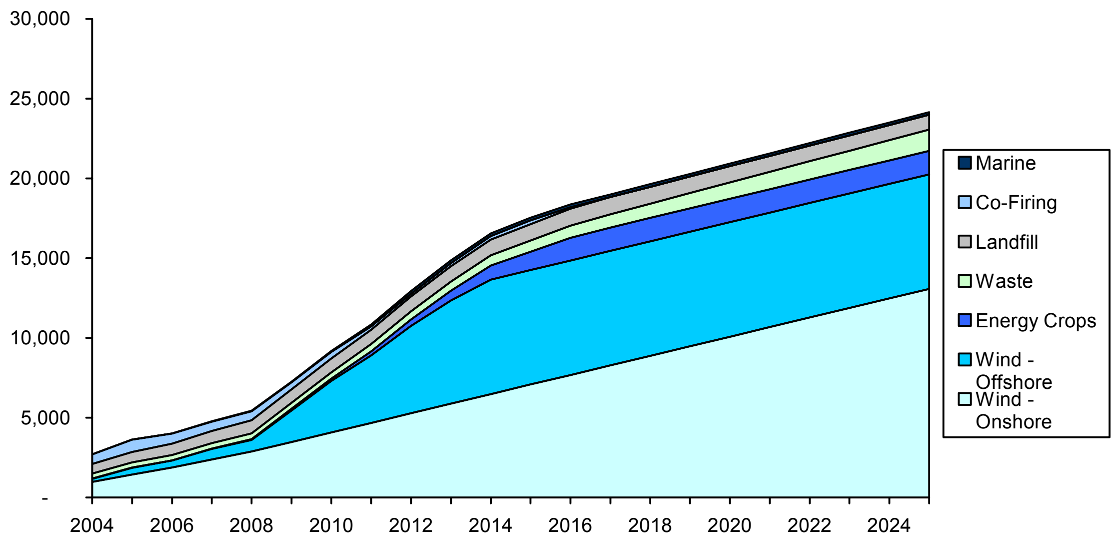
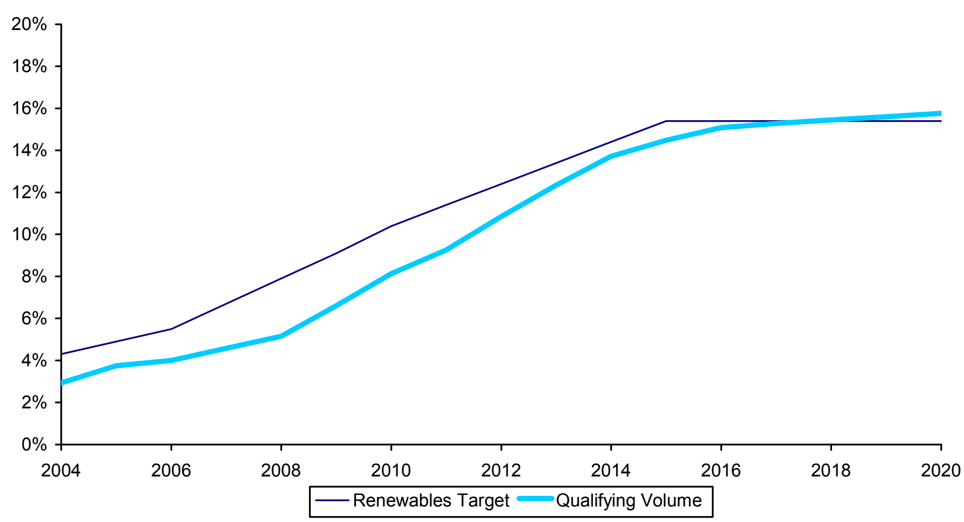


Figure 5.4: 15% obligation with enhanced co-firing, percentage of electricity supplied



5.4 20% obligation with enhanced onshore wind

Figure 5.5: 20% obligation with enhanced onshore wind, capacity built, MW

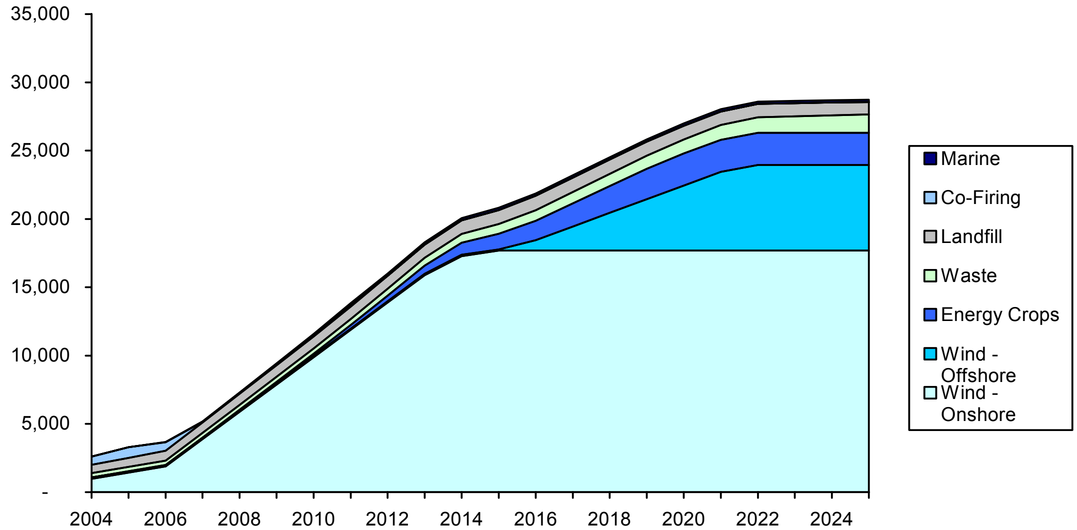
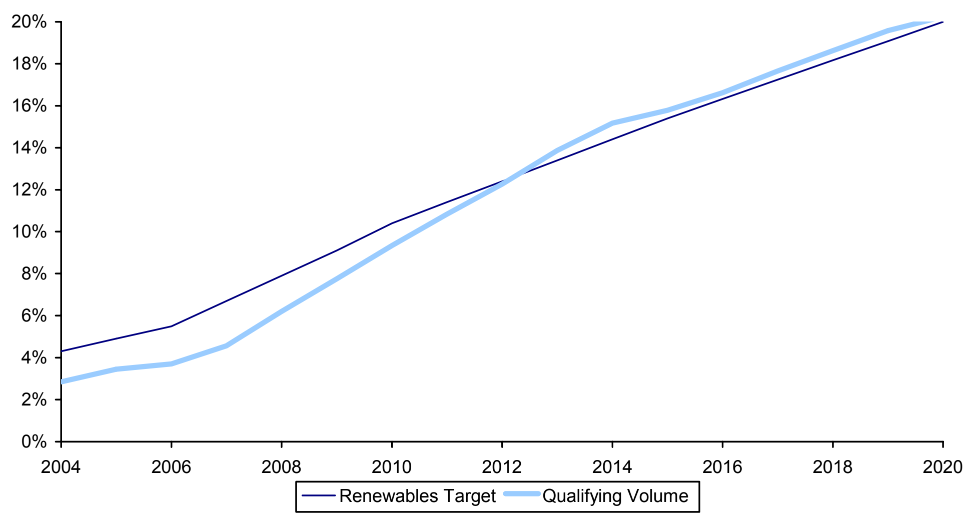


Figure 5.6: 20% obligation with enhanced onshore wind, percentage of electricity supplied



5.5 20% obligation with enhanced offshore wind

Figure 5.7: 20% obligation with enhanced offshore wind, capacity built, MW

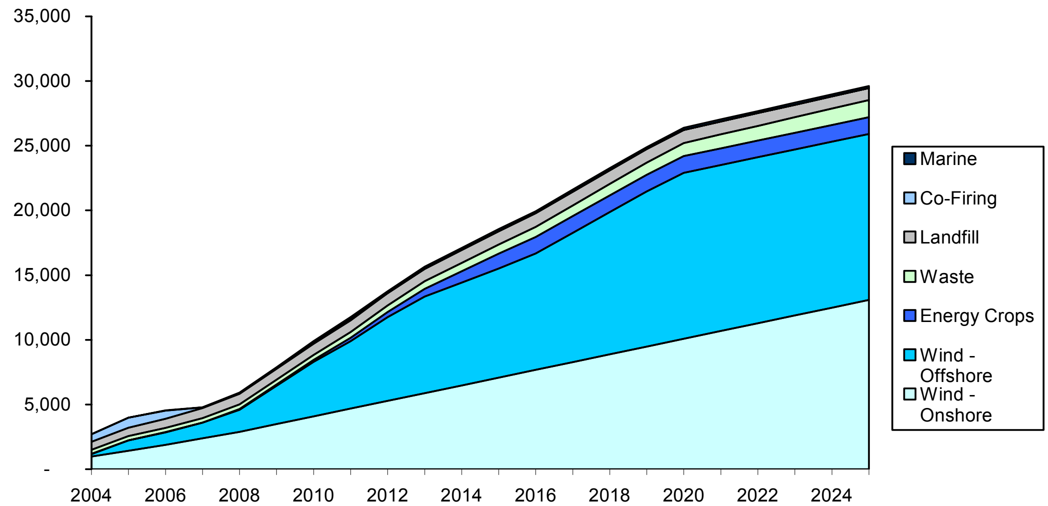
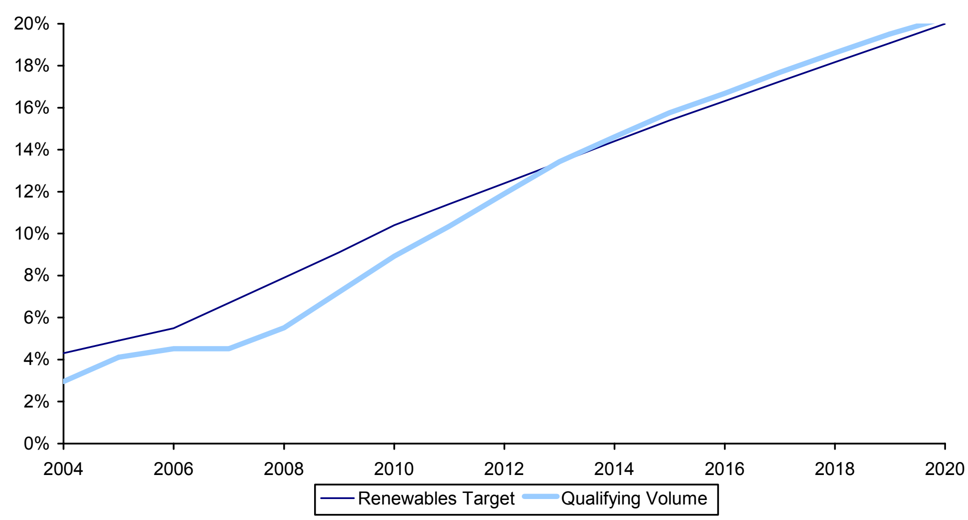


Figure 5.8: 20% obligation with enhanced offshore wind, percentage of electricity supplied



5.6 20% obligation with enhanced energy crops

Figure 5.9: 20% obligation with enhanced energy crops, capacity built, MW

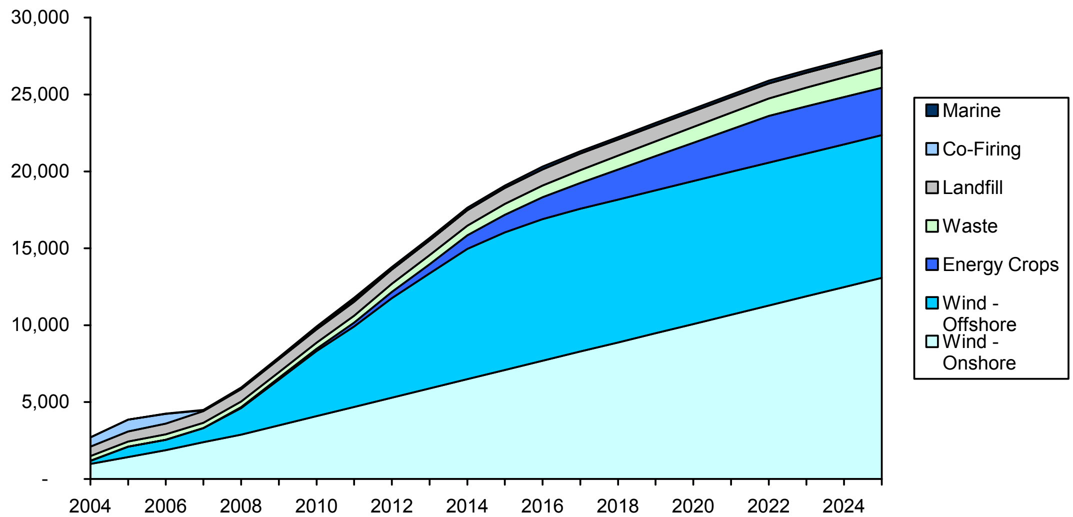
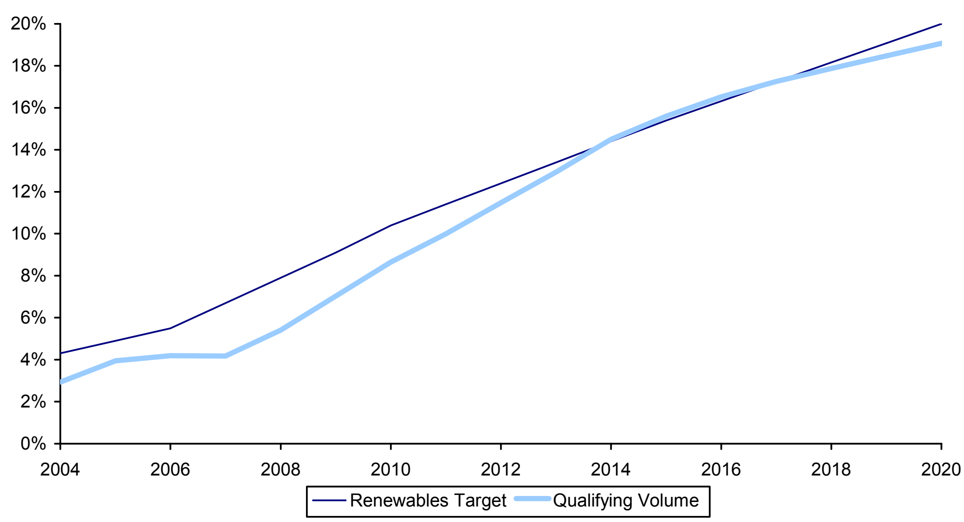


Figure 5.10: 20% obligation with enhanced energy crops, percentage of electricity supplied



5.7 20% obligation with enhanced marine

Figure 5.11: 20% obligation with enhanced marine, capacity built, MW

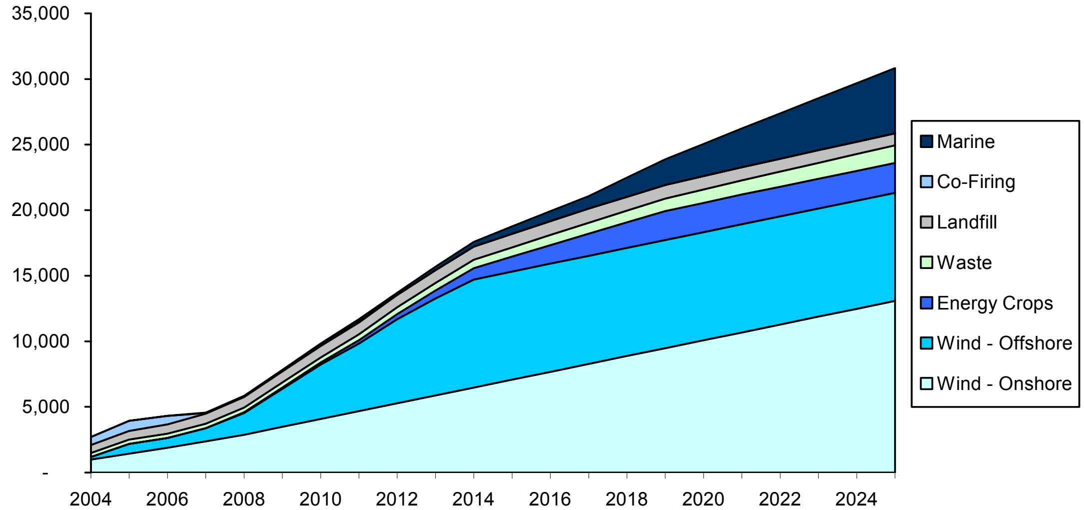
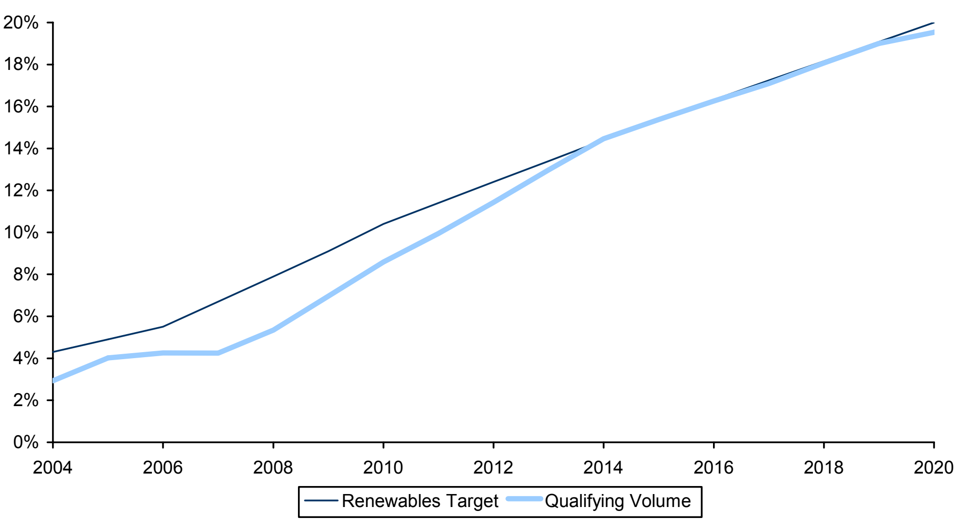


Figure 5.12: 20% obligation with enhanced marine, percentage of electricity supplied



5.8 20% obligation with enhanced waste

Figure 5.13: 20% obligation with enhanced waste, capacity built, MW

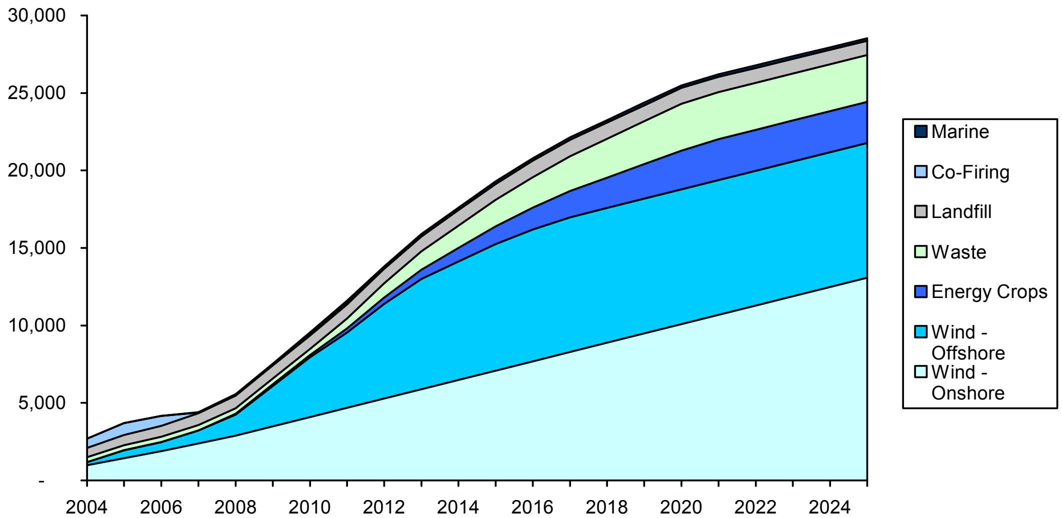
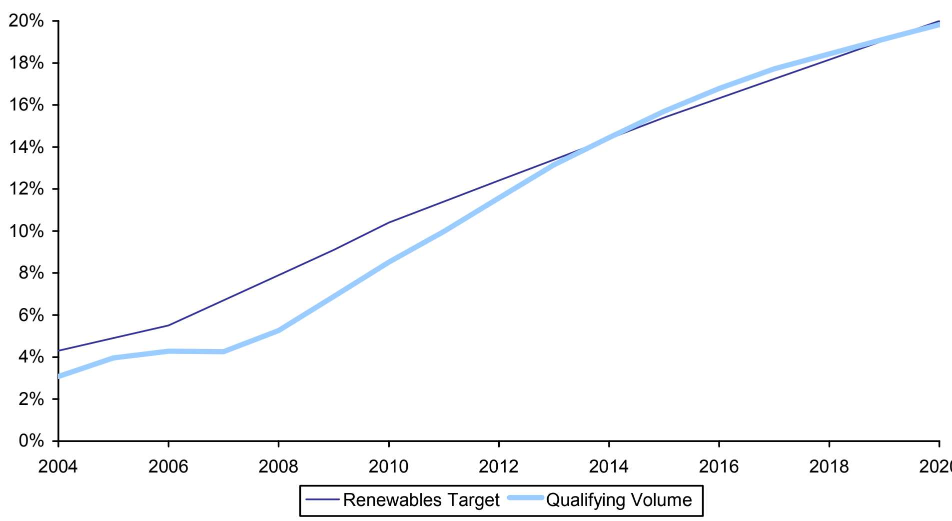


Figure 5.14: 20% obligation with enhanced waste, percentage of electricity supplied



5.9 15% obligation with enhanced onshore wind

Figure 5.15: 15% obligation with enhanced onshore wind, capacity built, MW

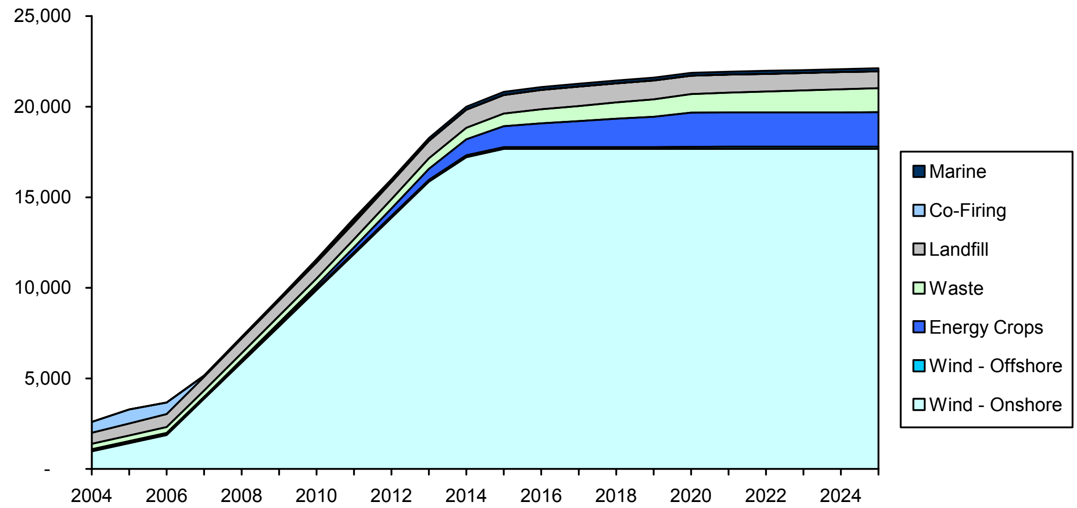
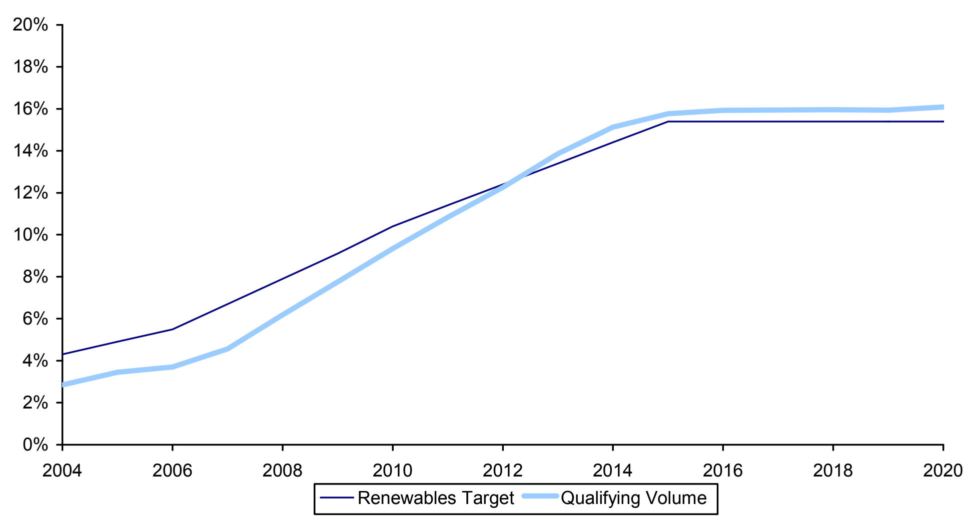


Figure 5.16: 15% obligation with enhanced onshore wind, percentage of electricity supplied



Appendix 1: Bibliography

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Appendix 2: Energy from Waste Assumptions

Volume of municipal solid waste (MSW) arising

A reasonable assumption is that the historic rate of growth in arisings (2.75% per year) will continue. If growth continues at this rate until 2015, and ceases thereafter, the volume will be 36mtpa in 2010 and 41mtpa in 2020 (these figures are for England only). Figures for Great Britain would be 17% higher, based on number of households.

MSW and other wastes

MSW is only a small fraction of total waste arisings. OXERA's modelling of anaerobic digestion (primarily a 'recycling' technology), and energy from waste, has been confined to MSW.

MSW policy targets

There is a statutory target (in the Landfill Directive) to reduce the tonnage of waste sent to landfill for disposal. The UK government has self-imposed targets, implemented through the local government finance and performance-management systems, and through the Waste and Emissions Trading Act 2003, to achieve target levels of recycling and composting of household waste, and of recovery from MSW.

Collection and disposal systems

The costs of collection and disposal of waste are interdependent. A collection system designed to deliver waste streams suitable for one disposal method may not be optimal for another disposal method. For schemes of kerbside collection of recyclables and green waste (garden waste), industry experts suggest that it is unlikely to be possible to achieve an overall rate of participation of households exceeding 55%.

The cost of disposal

The cost of disposal routes (inclusive of landfill tax), including collection, indicates that collection of dry recyclables and sorting at a clean materials-recovery facility is cheaper than composting, anaerobic digestion and energy from waste. Given the focus of waste policy targets on biodegradeable MSW (a large fraction of which can be captured within dry recyclables) and on recycling, the collection of dry recyclables is likely to be the disposal route of choice for waste disposal authorities.

Volumes of waste sent for energy from waste

If the maximum potential for dry recycling collection were achieved, the Landfill Directive (biodegradeable municipal waste landfill diversion) targets would still require, some time after 2010, an increase in the tonnage of waste processed by composting, anaerobic digestion, or energy from waste. Composting, which is limited to the green fraction of waste—a small fraction—can never absorb much of this diverted waste stream.

If 50% of green waste was recovered for composting, and dry recyclables were collected at the maximum feasible rate, anaerobic digestion and energy from waste would still have to handle 6mpta in 2010 and 19mpta in 2020 to satisfy the Landfill Directive targets. If much less recycling and composting were to take place, the figures would be 8mtpa and 23mtpa. These figures apply to England only; Great Britain figures would be 22mtpa and 27mtpa.

Choice of disposal technology

The disposal options for this 22–27mtpa of waste are anaerobic digestion, incineration, or gasification. Within incineration and gasification, there is the choice of separating out the organic fraction of the waste or not separating it out.

The total cost of anaerobic digestion post-2010 is approximately £60/t, including landfill tax on residues. The total cost for incineration is around £52/t. If incineration is prohibited by the land-use planning process, the options are reduced to anaerobic digestion and gasification.

The question of eligibility for the RO is decided by the balance of the cost of sorting organic waste and non-organic residue, and the value of ROC revenue from electricity sales. E4 Tech Ltd estimates the electricity obtained from waste at approximately 0.37–0.47 MWh/t, which translates into a ROC revenue value of £11–£14/t at a ROC price of £30/MWh.

If the cost of sorting is £8/t, it suggests that it may be worthwhile sorting waste prior to incineration, gasification or anaerobic digestion. In any case, the waste is expected to be sorted prior to anaerobic digestion. This means that waste companies may register their energy from waste plant as eligible (ie, consuming 98% organic waste).