



www.worldenergyoutlook.org

PART A
**GLOBAL
ENERGY TRENDS**

PART B
**OUTLOOK
FOR RUSSIAN
ENERGY**

PART C
**OUTLOOK FOR
COAL MARKETS**

PART D
SPECIAL TOPICS

ANNEXES

CONTEXT AND ANALYTICAL FRAMEWORK	1
ENERGY PROJECTIONS TO 2035	2
OIL MARKET OUTLOOK	3
NATURAL GAS MARKET OUTLOOK	4
POWER AND RENEWABLES OUTLOOK	5
CLIMATE CHANGE AND THE 450 SCENARIO	6
RUSSIAN DOMESTIC ENERGY PROSPECTS	7
RUSSIAN RESOURCES AND SUPPLY POTENTIAL	8
IMPLICATIONS OF RUSSIA'S ENERGY DEVELOPMENT	9
COAL DEMAND PROSPECTS	10
COAL SUPPLY AND INVESTMENT PROSPECTS	11
THE IMPLICATIONS OF LESS NUCLEAR POWER	12
ENERGY FOR ALL	13
DEVELOPMENTS IN ENERGY SUBSIDIES	14
ANNEXES	

Foreword	3
Acknowledgements	5
List of figures	21
List of tables	31
List of boxes	34
List of spotlights	36
Executive summary	39

Part A: GLOBAL ENERGY TRENDS 47

1	Context and analytical framework	49
	Highlights	49
	Introduction	50
	Defining the scenarios	51
	Main non-policy assumptions	55
	<i>Economic growth</i>	55
	<i>Population</i>	58
	<i>Energy prices</i>	61
	<i>CO₂ prices</i>	65
	<i>Technology</i>	67
2	Energy projections to 2035	69
	Highlights	69
	Overview of energy trends by scenario	70
	Energy trends in the New Policies Scenario	74
	<i>Primary energy mix</i>	74
	<i>Regional trends</i>	80
	<i>Sectoral trends</i>	85
	<i>Energy production and trade</i>	88
	<i>Investment in energy-supply infrastructure</i>	96
	<i>Energy-related emissions</i>	99
3	Oil market outlook	103
	Highlights	103
	Demand	104
	<i>Primary oil demand trends</i>	104
	<i>Regional trends</i>	106
	<i>Sectoral trends</i>	108
	<i>Focus on the transport sector</i>	109
	Supply	119
	<i>Resources and reserves</i>	119
	<i>Production prospects</i>	122

<i>Trade</i>	136
<i>Trends in oil and gas production costs</i>	138
<i>Oil and gas investment</i>	141
Impact of deferred upstream investment in the Middle East and North Africa	145
<i>A time of great uncertainty</i>	145
<i>The Deferred Investment Case</i>	146
<i>Results of the Deferred Investment Case</i>	147

4	Natural gas market outlook	155
	Highlights	155
	Demand	156
	<i>Primary gas demand trends</i>	156
	<i>Regional and sectoral trends</i>	158
	Supply	161
	<i>Resources and reserves</i>	161
	<i>Production prospects</i>	162
	Inter-regional trade	167
	Investment	169
	Are we entering a Golden Age of Gas?	170

5	Power and renewables outlook	175
	Highlights	175
	Electricity demand	176
	Electricity supply	177
	<i>Coal</i>	180
	<i>Natural gas</i>	182
	<i>Nuclear power</i>	183
	<i>Renewables</i>	184
	<i>CO₂ emissions</i>	186
	<i>New capacity additions and retirements</i>	187
	<i>Investment</i>	193
	Focus on T&D infrastructure	195
	<i>Grid expansion</i>	195
	<i>T&D investment needs</i>	197

6	Climate change and the 450 Scenario	205
	Highlights	205
	Introduction	206
	Recent developments	207
	Overview of trends in the 450 Scenario	210
	<i>Primary energy demand in the 450 Scenario</i>	212
	<i>Energy-related emissions and abatement</i>	213
	<i>Investment in the 450 Scenario</i>	224
	<i>Other spending in the 450 Scenario: fuel costs and subsidies</i>	225
	<i>Benefits of the 450 Scenario</i>	226

Implications of delayed action	229
<i>Lock-in in the energy sector</i>	229
<i>The cost of lock-in</i>	235
<i>What if CCS does not deliver?</i>	236

Part B: OUTLOOK FOR RUSSIAN ENERGY **243**

7 Russian domestic energy prospects	245
Highlights	245
Introduction	246
<i>Trends in energy demand and supply</i>	247
<i>Trends in policies and governance</i>	251
Key assumptions for the Russian energy outlook	251
<i>GDP and population</i>	251
<i>Energy and climate policies</i>	253
<i>Energy pricing</i>	255
<i>Energy savings potential</i>	257
Russian domestic energy outlook	261
<i>Overview</i>	261
<i>Energy savings</i>	262
<i>Domestic energy trends by fuel</i>	264
<i>Domestic energy trends by sector</i>	267

8 Russian resources and supply potential	283
Highlights	283
Overview	284
Oil	288
<i>Resources</i>	288
<i>Production</i>	292
<i>Investment and costs</i>	300
<i>Exports</i>	301
Natural gas	303
<i>Resources</i>	303
<i>Production</i>	304
<i>Investment and costs</i>	310
<i>Flaring</i>	311
<i>Transportation and storage</i>	312
<i>Prospects for natural gas export flows</i>	312
Unconventional resources	315
Coal	318
Nuclear	320
Hydropower and other renewables	323
<i>Hydropower</i>	324
<i>Other renewables</i>	325

9 Implications of Russia's energy development	329
Highlights	329
Energy and national economic development	330
<i>Investment</i>	334
<i>Revenues</i>	335
Eurasian and global energy security	336
<i>Regional energy relationships and oil and gas transit</i>	337
<i>Russia in global oil markets</i>	339
<i>Russia in global gas markets</i>	341
<i>Russia in global coal markets</i>	346
Environment and climate change	346
Comparing this <i>Outlook</i> with Russian scenarios and objectives	349

Part C: OUTLOOK FOR COAL MARKETS **351**

10 Coal demand prospects	353
Highlights	353
Overview	354
Understanding the drivers of coal demand	358
<i>Economic activity</i>	359
<i>Coal prices and inter-fuel competition</i>	361
<i>Energy and environmental policies</i>	373
<i>Technological innovation</i>	376
Regional Analysis	380
<i>China</i>	382
<i>India</i>	387
<i>United States</i>	390
<i>Other non-OECD Asia</i>	392
<i>Eastern Europe/Eurasia</i>	392
<i>OECD Asia Oceania</i>	393
<i>OECD Europe</i>	394
<i>Africa</i>	395
<i>Rest of the world</i>	395

11 Coal supply and investment prospects	397
Highlights	397
Overview of projections	398
Understanding the drivers of coal supply	401
<i>Resources and reserves</i>	402
<i>Cost trends and technology</i>	404
<i>Government policies</i>	413
Coal market and industry structure	416
<i>International markets</i>	416
<i>Industry concentration</i>	417

Current investment trends	418
Focus on the New Policies Scenario	420
Production prospects	420
Trade prospects	421
Investment outlook	423
Regional analysis	424
China	424
United States	430
India	431
Indonesia	434
Australia	436
South Africa	439
Russia	441
Rest of the world	441

Part D: SPECIAL TOPICS 445

12 The implications of less nuclear power 447

Highlights	447
Why the Low Nuclear Case?	448
The role of nuclear energy today	449
What might cause expansion of nuclear capacity to slow?	451
Possible changes in policy concerning nuclear power	451
Possible changes to the economics of nuclear power	455
Implications of the Low Nuclear Case for the global energy landscape	458
Power sector	458
International fuel markets	461
CO ₂ emissions	462
Meeting the global climate goal with less nuclear power generation	464
The Low Nuclear 450 Case	465

13 Energy for all 469

Highlights	469
Introduction	470
Current status of modern energy access	472
Current status of investment in modern energy access	474
Outlook for energy access and investment in the New Policies Scenario	476
Access to electricity	477
Access to clean cooking facilities	480
Investment needed to achieve modern energy access for all	481
Investment in electricity access	482
Investment in access to clean cooking facilities	485
Broader implications of achieving modern energy access for all	487
Financing to achieve modern energy access for all	489

Electricity access – financing on-grid electrification	491
Electricity access – financing mini-grid electrification	493
Electricity access – financing off-grid electrification	494
Clean cooking facilities – financing LPG stoves	495
Clean cooking facilities – financing biogas systems	496
Clean cooking facilities – financing advanced cookstoves	497
Sources of financing and barriers to scaling up	498
Multilateral and bilateral development sources	499
Developing country government sources	501
Private sector sources	503
Implications for policy	505

14 Developments in energy subsidies 507

Highlights	507
Overview of energy subsidies	508
Fossil-fuel subsidies	510
Measuring fossil-fuel consumption subsidies	512
Fossil-fuel subsidies and the poor	518
Implications of phasing out fossil-fuel consumption subsidies	520
Implementing fossil-fuel subsidy reform	522
Recent developments in fossil-fuel subsidies	526
Renewable-energy subsidies	527
Measuring renewable-energy subsidies	529
Implications for CO ₂ emissions and import bills	536
Impact of renewable-energy subsidies on end-user electricity prices	538
Recent developments in renewable-energy subsidies	539

ANNEXES 541

Annex A. Tables for scenario projections	543
Annex B. Policies and measures by scenario	617
Annex C. Units, definitions, regional and country groupings, abbreviations and acronyms	629
Annex D. References	645

List of figures

Part A: GLOBAL ENERGY TRENDS

Chapter 1: Context and analytical framework

1.1	Average IEA crude oil import price	62
1.2	Ratio of average natural gas and coal import prices to crude oil prices in the New Policies Scenario	65
1.3	Typical lifetime of energy-related capital stock	68

Chapter 2: Energy projections to 2035

2.1	World primary energy demand by scenario	70
-----	---	----

2.2	World primary energy demand by fuel and scenario, 2009 and 2035	72	3.5	Average annual change in transport oil demand and GDP by region and transport mode in the New Policies Scenario, 2010-2035	110
2.3	Shares of energy sources in world primary demand by scenario, 2035	72	3.6	World non-oil-based fuel use by transport mode in the New Policies Scenario	111
2.4	World energy-related CO ₂ emissions by scenario	73	3.7	World PLDV oil demand in the New Policies Scenario	113
2.5	Average annual percentage change in global primary energy intensity by scenario and region	73	3.8	Change in road vehicle travel in relation to changes in GDP per capita and oil price in the United States, 1985-2010	114
2.6	World primary energy demand by fuel in the New Policies Scenario	76	3.9	PLDV sales in selected markets, 2000-2010	114
2.7	Shares of energy sources in world primary energy demand in the New Policies Scenario	79	3.10	PLDV ownership in selected markets in the New Policies Scenario	115
2.8	World primary energy demand by region in the New Policies Scenario	80	3.11	PLDV sales and stocks in the New Policies Scenario	116
2.9	Energy intensity in selected countries and regions in the New Policies Scenario, 1990-2035	82	3.12	Oil savings through electric vehicle sales: country targets, industry plans and in the New Policies Scenario	118
2.10	Energy mix in selected countries and regions in the New Policies Scenario, 2035	84	3.13	Liquid fuel schematic	120
2.11	World primary energy demand by fuel and sector in the New Policies Scenario, 2035	85	3.14	Recoverable oil resources and production by region and type in the New Policies Scenario	121
2.12	Incremental energy demand by sector and region in the New Policies Scenario, 2009-2035	87	3.15	World oil production in the New Policies Scenario, 2010 and 2035	123
2.13	Number of PLDVs per thousand people by region, 2009 and 2035, and the change in oil demand in road-transport	88	3.16	World liquids supply by type in the New Policies Scenario	123
2.14	Incremental world energy supply by fuel in the New Policies Scenario, 2009-2035	89	3.17	Major changes in liquids supply in the New Policies Scenario, 2010-2035	124
2.15	Oil production in selected regions in the New Policies Scenario, 2010 and 2035	90	3.18	Light tight oil production potential from selected plays	129
2.16	Largest producers of electricity from renewables in the New Policies Scenario, 2035	91	3.19	Regional oil demand and net trade in the New Policies Scenario	137
2.17	Oil demand and the share of imports by region in the New Policies Scenario, 2010 and 2035	92	3.20	IEA upstream investment cost index, oil price index and drilling activity	138
2.18	Natural gas demand and the share of imports by region in the New Policies Scenario, 2009 and 2035	93	3.21	Breakeven costs, budget breakeven and commercially attractive prices for current oil production for selected producers, mid-2011	140
2.19	Expenditure on net imports of oil and gas as a share of real GDP by region in the New Policies Scenario, 1980-2035	96	3.22	Oil and gas production and breakeven costs in the New Policies Scenario	141
2.20	Cumulative investment in energy-supply infrastructure by fuel in the New Policies Scenario, 2011-2035	97	3.23	Worldwide upstream oil and gas investment and capital efficiency by company type	143
2.21	Cumulative investment in energy-supply infrastructure by region in the New Policies Scenario, 2011-2035	98	3.24	Average IEA crude oil import price in the New Policies Scenario and Deferred Investment Case	148
2.22	Energy-related CO ₂ emissions in the New Policies Scenario by fuel, 1980-2035	99	3.25	Change in average IEA crude oil import price after initial fall in investment in the Deferred Investment Case, compared to past price shocks	148
2.23	Cumulative energy-related CO ₂ emissions in selected countries and regions, 1900-2035	100	3.26	World primary oil demand in the New Policies Scenario and the Deferred Investment Case	149
2.24	Energy-related CO ₂ emissions by region in 2035 in the New Policies Scenario and the change from 2010	101	3.27	Reduction in global oil demand in the transport sector by source in the Deferred Investment Case relative to the New Policies Scenario	150
Chapter 3: Oil market outlook			3.28	Changes in global oil production and demand in the Deferred Investment Case relative to the New Policies Scenario	151
3.1	World primary oil demand and oil price by scenario	104	3.29	Profile of oil production recovery after disruption in Deferred Investment Case and past events	152
3.2	Primary oil intensity by region in the New Policies Scenario	106	3.30	Oil and gas export cash flows and import costs by region in the New Policies Scenario and Deferred Investment Case, 2011-2035	153
3.3	Change in primary oil demand by sector and region in the New Policies Scenario, 2010-2035	108	Chapter 4: Natural gas market outlook		
3.4	World transportation oil demand by mode in the New Policies Scenario	109	4.1	World primary natural gas demand by scenario	157
			4.2	Natural gas demand by selected region in the New Policies Scenario, 2009 and 2035	158

4.3	Incremental primary natural gas demand by region and sector in the New Policies Scenario, 2009-2035	160
4.4	Primary natural gas demand by sector in the New Policies Scenario, 2009 and 2035	161
4.5	Recoverable gas resources and production by region and type, end-2010	162
4.6	Change in annual natural gas production in selected countries in the New Policies Scenario	166
4.7	Net gas trade by major region in the New Policies Scenario	168
4.8	Cumulative investment in natural gas supply infrastructure by region and activity in the New Policies Scenario, 2011-2035	170
4.9	Comparison of average annual natural gas demand growth between the New Policies Scenario and the GAS Scenario, 2009-2035	172

Chapter 5: Power and renewables outlook

5.1	World electricity supply and demand by sector in the New Policies Scenario	177
5.2	Share of world electricity generation by fuel in the New Policies Scenario	179
5.3	Typical levelised cost by plant type and carbon price in the OECD in the New Policies Scenario, 2020	180
5.4	Incremental global coal-fired electricity generation relative to 2009 by region in the New Policies Scenario	181
5.5	World coal-fired electricity generation by plant type in the New Policies Scenario	181
5.6	Gas-fired electricity generation in selected countries and regions in the New Policies Scenario	182
5.7	Additions and retirements of nuclear power capacity by region in the New Policies Scenario	184
5.8	Incremental global renewables-based electricity generation relative to 2009 by technology in the New Policies Scenario	184
5.9	Solar PV and wind power capacity by region in the New Policies Scenario	185
5.10	Global CO ₂ emission savings in power generation relative to the 2009 fuel mix in the New Policies Scenario	186
5.11	Global installed power generation capacity and additions by technology in the New Policies Scenario	187
5.12	Capacity of wind and solar PV and their system effects for the United States and OECD Europe, 2035	192
5.13	Investment in new power plants and infrastructure in the New Policies Scenario	193
5.14	Expansion of T&D grids 1970-2009, and regional shares of global grid investment in 2009	196
5.15	Share of T&D infrastructure in place in 2009 reaching 40 years of age	196
5.16	T&D grid length and per-capita generation for selected regions in the New Policies Scenario	197
5.17	Annual average investment in T&D infrastructure in the New Policies Scenario	198
5.18	T&D infrastructure costs as a share of residential end-user price in the New Policies Scenario, 2035	200

5.19	Renewables grid integration costs as a share of global T&D investment costs in the New Policies Scenario by integration cost, 2011-2035	202
5.20	Effect of a super-grid on the capacity credit for wind and solar PV for the United States and OECD Europe, 2035	203

Chapter 6: Climate change and the 450 Scenario

6.1	Energy-related CO ₂ emissions by country, 2008-2010	208
6.2	World energy-related CO ₂ emissions by scenario	210
6.3	World energy-related CO ₂ emissions by fossil fuel in the 450 Scenario	213
6.4	World energy-related CO ₂ emissions abatement in the 450 Scenario relative to the New Policies Scenario	214
6.5	Emissions of major air pollutants by region in the 450 Scenario	216
6.6	Energy-related CO ₂ emissions in the 450 Scenario and abatement relative to the New Policies Scenario by region, 2009 and 2035	217
6.7	Energy-related CO ₂ emissions per capita in the 450 Scenario by region	218
6.8	World energy-related CO ₂ abatement by sector in the 450 Scenario compared with the New Policies Scenario	220
6.9	Change in world energy-related CO ₂ emissions from the power generation sector in the 450 Scenario compared with the New Policies Scenario	221
6.10	Cumulative energy sector investment by scenario, 2011-2035	225
6.11	Oil-import bills in selected regions by scenario	228
6.12	World energy-related CO ₂ emissions from locked-in infrastructure in 2010 and room for manoeuvre to achieve the 450 Scenario	230
6.13	World energy-related CO ₂ emissions in the 450 Scenario and from locked-in infrastructure in 2010 and with delay	231
6.14	World energy-related CO ₂ emissions in the 450 Scenario and from locked-in infrastructure in 2010 and with delay to 2015 in the power sector	232
6.15	World energy-related CO ₂ emissions in the 450 Scenario and from locked-in infrastructure in 2010 and with delay to 2015 in industry	233
6.16	Change in investment in power generation by technology in the Delayed 450 Case, relative to the 450 Scenario	236
6.17	Potential CO ₂ emissions from remaining fossil-fuel reserves and in the 450 Scenario, compared with the emissions budget to achieve 2°C	237
6.18	Cumulative share of abatement relative to the New Policies Scenario in the 450 Scenario, Delayed CCS 450 Case and Low Nuclear 450 Case	239
6.19	Change in global energy demand by fuel in the Delayed CCS 450 Case compared with the 450 Scenario	241
6.20	Additional investment in the Delayed CCS 450 Case	241

Part B: OUTLOOK FOR RUSSIAN ENERGY

Chapter 7: Russian domestic energy prospects

7.1	Primary energy demand in Russia by fuel and GDP, 1990-2009	247
7.2	Energy production in Russia by fuel, 1990-2009	249

7.3	Share of Russia's population, energy consumption and fossil-fuel production by federal district, 2009	250
7.4	Total energy costs as a percentage of GDP	257
7.5	Primary energy savings potential in Russia based on comparable OECD efficiencies, 2008	258
7.6	Energy savings potential in Russia by sector, 2008	259
7.7	Natural gas savings potential in Russia, 2008	260
7.8	Total primary energy demand by scenario	261
7.9	Primary energy savings potential in Russia based on comparable OECD efficiencies in the New Policies Scenario, 2008 and 2035	263
7.10	Primary energy intensity in Russia and other selected regions in the New Policies Scenario	264
7.11	Primary energy demand in Russia by fuel in the New Policies Scenario	265
7.12	Incremental energy demand by sector and fuel in the New Policies Scenario, 2009-2035	267
7.13	Breakdown of installed electricity and CHP capacity in Russia, 2009	269
7.14	Electricity generation by fuel in Russia in the New Policies Scenario, 1990-2035	270
7.15	Age profile of installed thermal and nuclear capacity in Russia, comparison with selected countries and regions, 2010	271
7.16	Cumulative power sector investment in Russia by type in the New Policies Scenario, 2011-2035	272
7.17	District heat supply by sector in the New Policies Scenario, 1990-2035	273
7.18	Industry energy demand by fuel in Russia in the New Policies Scenario, 2000-2035	276
7.19	Energy consumption in the transport sector by type in the New Policies Scenario, 2000-2035	277
7.20	Efficiency of energy consumption for space heating in the residential sector, 2009-2035	281

Chapter 8: Russian resources and supply potential

8.1	Russian share in global resources, production and export of fossil fuels, 2010	284
8.2	Russian oil balance in the New Policies Scenario	285
8.3	Russian gas balance in the New Policies Scenario	285
8.4	Russian coal balance in the New Policies Scenario	285
8.5	Russian nuclear and renewables output in the New Policies Scenario	286
8.6	Estimated Russian oil and gas production by type of company, 2010	287
8.7	Oil and gas basins in Russia	290
8.8	Recent evolution of Russian oil production by region	293
8.9	Major oil fields and supply infrastructure in Russia	297
8.10	Changes in Russian oil production by region in the New Policies Scenario	298
8.11	Russian oil production by type in the New Policies Scenario	300
8.12	Recent gas production trends by region	305

8.13	Changes in Russian natural gas production by region in the New Policies Scenario	309
8.14	Production of associated gas, expressed in volumes and as a ratio to oil production, 2002-2010	311
8.15	Major gas fields and supply infrastructure in Russia	313
8.16	Russian coal production and exports	319
8.17	Installed nuclear capacity and share of electricity generation in the New Policies Scenario	321
8.18	Share of renewable energy in Russian total primary energy demand, electricity and heat production, 2009	324
8.19	Share of renewables in power generation in Russia in the New Policies Scenario	326

Chapter 9: Implications of Russia's energy development

9.1	Structure of Russian exports by value, 2009	331
9.2	Estimated share of oil and gas in Russian GDP in the New Policies Scenario	332
9.3	Cumulative investment requirement in coal, oil, gas and power supply in the New Policies Scenario, 2011-2035	334
9.4	Sources of revenue from fossil fuel export sales, 2010 and 2035	336
9.5	Estimated share of Russian gas sales revenue from domestic and international gas sales in the New Policies Scenario	336
9.6	Projected gas flows from Russia to Europe and potential growth in gas-export pipeline capacity	338
9.7	Oil production in Russia and selected countries in the New Policies Scenario	340
9.8	Gas production in selected countries in the New Policies Scenario, 2009 and 2035	342
9.9	Russian share of natural gas imports and consumption in the European Union and China in the New Policies Scenario	343
9.10	Energy-related CO ₂ emissions abatement in Russia by source in the 450 Scenario compared with the New Policies Scenario	348

Part C: OUTLOOK FOR COAL MARKETS

Chapter 10: Coal demand prospects

10.1	Incremental world primary energy demand by fuel, 2000-2010	354
10.2	World primary coal demand by region and scenario	356
10.3	Incremental world primary coal demand by region and scenario	357
10.4	Primary coal intensity by region as a percentage of 2009 world average in the New Policies Scenario	360
10.5	World crude steel production, and iron and steel coal use versus GDP in the New Policies Scenario	361
10.6	Average OECD steam coal import price by scenario	363
10.7	Ratio of average OECD steam coal import price to average regional natural gas and IEA crude oil import prices in the New Policies Scenario	363
10.8	World coal-fired generating capacity by type and major region	366

10.9	New additions of coal-fired electricity generating capacity by technology and region in the New Policies Scenario	366
10.10	Levelised electricity generating costs by component for selected technologies and countries in the New Policies Scenario, 2020	370
10.11	World iron and steel sector energy consumption by type in the New Policies Scenario	371
10.12	Coal-to-liquids inputs by country in the New Policies Scenario	373
10.13	Reduction in world primary coal demand by sector and scenario	374
10.14	World primary coal demand by region and scenario	375
10.15	Coal consumption subsidies for selected countries, 2010	376
10.16	Coal-fired generating capacity equipped with CCS by scenario, 2035	379
10.17	Incremental primary coal demand by region in the New Policies Scenario	381
10.18	Coal demand in China by sector in the New Policies Scenario	382
10.19	Breakeven price of coal versus natural gas for power generation in China, 2020	384
10.20	New additions of power-generating capacity in China by type in the New Policies Scenario	385
10.21	Electricity generation in China by type in the New Policies Scenario	385
10.22	Non-power generation coal demand in China by sector in the New Policies Scenario	386
10.23	Coal demand in India by sector in the New Policies Scenario	388
10.24	Coal-fired generating capacity in India by type in the New Policies Scenario	389
10.25	Coal demand in the United States by sector in the New Policies Scenario	390
10.26	Electricity generation in the United States by type in the New Policies Scenario	392
10.27	Electricity generation in Russia by type in the New Policies Scenario	393

Chapter 11: Coal supply and investment prospects

11.1	Incremental coal production by scenario and region, 2009-2035	400
11.2	China's coal trade balance, 2000-2011	401
11.3	Coal reserves by country and type, end-2009	404
11.4	Change in average FOB supply cash costs relative to 2005 for internationally traded steam coal by selected country and component	405
11.5	Average FOB supply cash costs and prices for internationally traded steam coal, 2010	406
11.6	Average FOB supply cash costs and prices for internationally traded coking coal, 2010	407
11.7	Share of key input factors in coal mining costs by technique, 2009	409
11.8	Coal mining productivity in Australia and the United States, 2004-2008	410
11.9	Coal export port utilisation rates for selected countries	411
11.10	Steam coal supply cash costs to northwest Europe by component for selected exporters, 2007 and 2009	413
11.11	Dry bulk carrier market evolution, 2011-2015	413
11.12	World inter-regional hard coal net trade by major region in the New Policies Scenario	422
11.13	Major hard coal importers in the New Policies Scenario	423

11.14	Cumulative coal-supply investment by region in the New Policies Scenario, 2011-2035	424
11.15	Average coal production costs of major state-owned enterprises in Shanxi province, 2000-2009	425
11.16	Major coal production centres and transport routes in China, 2009	427
11.17	China's steam coal import volumes from selected countries	428
11.18	Cumulative coal production in China by period and type in the New Policies Scenario	429
11.19	China's hard coal net trade by type in the New Policies Scenario	429
11.20	Coal production in the United States in the New Policies Scenario	431
11.21	Coal production in India by type in the New Policies Scenario	433
11.22	Hard coal net imports in India by type in the New Policies Scenario	434
11.23	Coal production in Indonesia in the New Policies Scenario	436
11.24	Coal production in Australia in the New Policies Scenario	439
11.25	Coal production in South Africa in the New Policies Scenario	441
11.26	Hard coal net exports from selected smaller exporters in the New Policies Scenario	443

Part D: SPECIAL TOPICS

Chapter 12: The implications of less nuclear power

12.1	Nuclear reactor construction starts, 1951-2011	450
12.2	Sensitivity of long-run marginal cost of nuclear generation to various parameters	457
12.3	Nuclear power capacity in the Low Nuclear Case	459
12.4	Power generation by fuel in the New Policies Scenario and Low Nuclear Case	461
12.5	Global primary coal and gas demand and annual spending on imports in the Low Nuclear Case	462
12.6	Energy-related CO ₂ emissions from the power sector in the New Policies Scenario and the Low Nuclear Case	463
12.7	World energy-related CO ₂ emissions abatement in the Low Nuclear Case relative to the New Policies Scenario	465
12.8	Share of world power generation by source in the 450 Scenario and Low Nuclear Case	466
12.9	Incremental energy-related investment in the Low Nuclear Case relative to the 450 Scenario	467

Chapter 13: Energy for all

13.1	Oil-import bills in net-importing less developed countries	470
13.2	Financing modern energy access	472
13.3	Investment in energy access by source, 2009	476
13.4	Average annual investment in modern energy access by scenario	482
13.5	Average annual investment in access to electricity by type and number of people connected in the Energy for All Case	484
13.6	Average annual investment in access to clean cooking facilities by type and region, 2010-2030	485

13.7	Average annual investment required by region and technology in the Energy for All Case, 2010-2030	486
13.8	Additional electricity generation by grid solution and fuel in the Energy for All Case compared with the New Policies Scenario, 2030	487
13.9	Additional global energy demand and CO ₂ emissions in the Energy for All Case compared with the New Policies Scenario, 2030	488
13.10	Premature annual deaths from household air pollution and selected diseases in the New Policies Scenario	489
13.11	Average annual investment in modern energy access by source of financing and scenario	490
13.12	Fossil-fuel subsidies in selected countries, 2010	502

Chapter 14: Developments in energy subsidies

14.1	Illustration of the price-gap methodology: average reference and retail prices of oil products	512
14.2	Global economic cost of fossil-fuel consumption subsidies by fuel	513
14.3	Economic cost of fossil-fuel consumption subsidies by fuel for top twenty-five economies, 2010	515
14.4	Fossil-fuel consumption subsidies per capita and as a percentage of total GDP in selected economies, 2010	516
14.5	Rates of subsidisation for fossil-fuel consumption subsidies, 2010	517
14.6	Fossil-fuel consumption subsidies by net oil and gas importer and exporter, 2007-2010	518
14.7	Share of fossil-fuel subsidies received by the lowest 20% income group in selected economies, 2010	519
14.8	Share of fossil-fuel subsidies received by the lowest 20% income group by fuel in surveyed economies, 2010	520
14.9	Impact of fossil-fuel consumption subsidy phase-out on global fossil-energy demand and CO ₂ emissions	521
14.10	Summary of common barriers to fossil-fuel subsidy reform and strategies for successful implementation	524
14.11	Illustration of the drivers of unit subsidy costs for renewable energy	529
14.12	Global subsidies to renewables-based electricity and biofuels by technology and fuel in the New Policies Scenario	531
14.13	Global subsidies to renewables-based electricity and biofuels by region in the New Policies Scenario	531
14.14	Renewable electricity production cost relative to wholesale prices for selected technologies and regions in the New Policies Scenario	534
14.15	Indicative biofuels production costs and spot oil product prices	536
14.16	CO ₂ emissions and import bill savings due to renewables subsidies in 2035 in the 450 Scenario relative to the New Policies Scenario	537
14.17	Cost of renewables-based electricity subsidies as a percentage of average end-user electricity price in the New Policies Scenario	538

List of tables

Part A: GLOBAL ENERGY TRENDS

Chapter 1: Context and analytical framework

1.1	Selected key policy assumptions by scenario and region	52
1.2	Real GDP assumptions by region	58
1.3	Population and urbanisation assumptions by region	59
1.4	Fossil-fuel import price assumptions by scenario	64
1.5	CO ₂ price assumptions in selected regions by scenario	66

Chapter 2: Energy projections to 2035

2.1	World primary energy demand by fuel and scenario	71
2.2	World primary energy demand by fuel in the New Policies Scenario	74
2.3	World primary energy demand by region in the New Policies Scenario	81
2.4	Cumulative investment in energy-supply infrastructure by fuel and region in the New Policies Scenario, 2011-2035	98

Chapter 3: Oil market outlook

3.1	Primary oil demand by region and scenario	105
3.2	Primary oil demand by region in the New Policies Scenario	107
3.3	Factors affecting fuel choices for future road transport technologies	112
3.4	Oil production and supply by source and scenario	122
3.5	Non-OPEC oil production in the New Policies Scenario	126
3.6	OPEC oil production in the New Policies Scenario	134
3.7	Oil production, indicative development activity and investment in the United States, Russia and Saudi Arabia, 2010	139
3.8	Oil and gas industry investment by company	142
3.9	Cumulative investment in oil and gas supply infrastructure by region in the New Policies Scenario, 2011-2035	144
3.10	The role of MENA in global oil and gas production in the New Policies Scenario	146

Chapter 4: Natural gas market outlook

4.1	Primary natural gas demand by region and scenario	156
4.2	Primary natural gas demand by region in the New Policies Scenario	159
4.3	Primary natural gas production by region, type and scenario	163
4.4	Primary natural gas production by region in the New Policies Scenario	165

Chapter 5: Power and renewables outlook

5.1	Electricity demand by region and scenario	176
5.2	Electricity generation by plant type and scenario	178
5.3	Cumulative capacity retirements by region and source in the New Policies Scenario, 2011-2035	188
5.4	Cumulative gross capacity additions by region and source in the New Policies Scenario, 2011-2035	189

5.5	Investment in new power plants in the New Policies Scenario, 2011-2035	194
5.6	Investment in T&D infrastructure in the New Policies Scenario, 2011-2035	199
Chapter 6: Climate change and the 450 Scenario		
6.1	World anthropogenic greenhouse-gas emissions by scenario	211
6.2	World primary energy demand by fuel in the 450 Scenario	212
6.3	Top ten sources of abatement in the 450 Scenario relative to the New Policies Scenario by policy area	222
6.4	Fossil-fuel import prices in the 450 Scenario	227
6.5	Cost of pollution control by region and scenario	228
6.6	Consumption, capacity and stock of selected technologies by scenario	240
Part B: OUTLOOK FOR RUSSIAN ENERGY		
Chapter 7: Russian domestic energy prospects		
7.1	Key energy-related indicators for Russia	246
7.2	Indicators and assumptions for population and GDP in Russia	252
7.3	Main assumptions for Russia by scenario	254
7.4	Passenger light-duty vehicle ownership in selected countries in the New Policies Scenario	278
Chapter 8: Russian resources and supply potential		
8.1	Conventional oil resources in various Russian regions, end-2010	289
8.2	Conventional hydrocarbon resources in various Russian regions, end-2009, according to the Russian system of classification	292
8.3	Projections for oil production by main basins	295
8.4	Conventional gas resources in various Russian regions, end-2010	303
8.5	Projections for gas production by main basins	306
8.6	Coal production in Russia by type in the New Policies Scenario	319
Chapter 9: Implications of Russia's energy development		
9.1	Main gas trade flows from Russia and the Caspian region in the New Policies Scenario	343
9.2	Energy-related CO ₂ emissions in Russia by scenario	347
9.3	Emissions of major air pollutants in Russia by scenario	348
9.4	WEO-2011 projections (in 2030) compared with selected forecasts from the Russian Energy Strategy to 2030	349
Part C: OUTLOOK FOR COAL MARKETS		
Chapter 10: Coal demand prospects		
10.1	Coal demand by region and scenario	357
10.2	World coal demand by sector and scenario	358
10.3	Summary of the main drivers of coal demand by sector	359
10.4	Levelised electricity generating cost assumptions in the New Policies Scenario, 2020	369

10.5	CO ₂ emissions from coal combustion by region and scenario	374
10.6	Coal demand by region in the New Policies Scenario	381
Chapter 11: Coal supply and investment prospects		
11.1	Coal production by type and scenario	399
11.2	World inter-regional hard coal trade by type and scenario	401
11.3	Coal resources and reserves by region and type, end-2009	402
11.4	Coal export port capacities for selected countries	412
11.5	Government support to coal production in OECD countries	415
11.6	Key figures for the 30 leading coal companies	419
11.7	Coal production by region in the New Policies Scenario	420
11.8	Inter-regional hard coal net trade by country in the New Policies Scenario	421
11.9	Major railway-to-port coal routes in China	426
Part D: SPECIAL TOPICS		
Chapter 12: The implications of less nuclear power		
12.1	Key nuclear power statistics by region, end-2010	451
12.2	Recent announcements by selected countries regarding nuclear power	452
12.3	Key projections for nuclear power in the New Policies Scenario and the Low Nuclear Case	458
Chapter 13: Energy for all		
13.1	People without access to modern energy services by region, 2009	473
13.2	People without access to electricity by region in the New Policies Scenario	478
13.3	Major programmes and targets for improving access to electricity in selected countries	479
13.4	People without clean cooking facilities by region in the New Policies Scenario	480
13.5	Additional investment required to achieve universal access to electricity in the Energy for All Case compared with the New Policies Scenario	483
13.6	Additional energy demand in the Energy for All Case compared with the New Policies Scenario, 2020 and 2030	488
13.7	Additional financing for electricity access in the Energy for All Case compared with the New Policies Scenario, 2010-2030	492
13.8	Additional financing for clean cooking facilities in the Energy for All Case compared with the New Policies Scenario, 2010-2030	495
13.9	Sources of financing and the financing instruments they provide	498
Chapter 14: Developments in energy subsidies		
14.1	Estimated energy subsidies, 2007-2010	508
14.2	Recent developments in fossil-fuel consumption subsidy policies in selected economies	526
14.3	Common mechanisms for subsidising renewable energy	528
14.4	Recent developments in renewable-energy subsidies in selected economies	539

List of boxes

Part A: GLOBAL ENERGY TRENDS

Chapter 1: Context and analytical framework

1.1	How does the IEA model long-term energy trends?	60
-----	---	----

Chapter 2: Energy projections to 2035

2.1	The impact of lower near-term economic growth on energy demand	75
2.2	China's 12 th Five-Year Plan (2011-2015)	78

Chapter 3: Oil market outlook

3.1	The future of car making	117
3.2	Definitions of different types of liquid fuels	120
3.3	The long-term implications of the Deepwater Horizon disaster	130
3.4	Prospects for increased oil production in Iraq	132
3.5	Assumptions and methodology of the Deferred Investment Case	147

Chapter 4: Natural gas market outlook

4.1	Environmental impact of unconventional gas	164
4.2	North America: net gas importer or exporter?	169

Chapter 5: Power and renewables outlook

5.1	Costs of integrating variable renewables into the electricity system	191
-----	--	-----

Chapter 6: Climate change and the 450 Scenario

6.1	What is special about 2°C?	207
6.2	Updates to the 450 Scenario policy framework	211
6.3	Reaping abatement through efficiency in the 450 Scenario	214
6.4	The implications of less nuclear power for the 450 Scenario	238

Part B: OUTLOOK FOR RUSSIAN ENERGY

Chapter 7: Russian domestic energy prospects

7.1	Policy making and regulation in the Russian energy sector	248
7.2	Counting the benefit of increased energy efficiency	262
7.3	Higher gas prices, efficiency and fuel switching	266
7.4	Keeping Russia cool: heat waves and demand for air-conditioning	271
7.5	As efficient as... Moscow?	280

Chapter 8: Russian resources and supply potential

8.1	Russian reserves system versus the Petroleum Resources Management System	291
8.2	A balancing act of tax and economics	294
8.3	What's in a bcm?	304
8.4	The curious case of the missing natural gas liquids...	309

8.5	The "Northern Route" to market	315
8.6	Methane hydrates and climate risks	318

Chapter 9: Implications of Russia's energy development

9.1	Oil and gas in the Russian economy	330
9.2	The Russian route to market for Caspian oil	339
9.3	Russian role in co-operation among oil and gas producers	341
9.4	Europe versus Asia: competing for Russian gas?	344

Part C: OUTLOOK FOR COAL MARKETS

Chapter 10: Coal demand prospects

10.1	A decade of booming coal use	355
10.2	The shift to Asia	356
10.3	Coal-fired power generating technologies	365

Chapter 11: Coal supply and investment prospects

11.1	Classification and definition of coal types	398
11.2	WEO-2011 coal supply modelling enhancements	400
11.3	Coal resources and reserves definitions	403
11.4	Coal mining techniques	408

Part D: SPECIAL TOPICS

Chapter 12: The implications of less nuclear power

12.1	The Fukushima Daiichi nuclear power station	449
12.2	Human capital and the nuclear industry	463

Chapter 13: Energy for all

13.1	Defining modern energy access	473
13.2	Measuring investment in modern energy access	475
13.3	What is the role of hydropower in increasing energy access?	484
13.4	International Energy and Climate Partnership – Energy+	500

Chapter 14: Developments in energy subsidies

14.1	What is an energy subsidy?	509
14.2	Support to fossil-fuel production in OECD countries	511
14.3	Recent experiences implementing subsidy reform	525
14.4	Why is our estimate of renewables-based electricity subsidies higher in this year's Outlook?	533

List of spotlights

Part A: GLOBAL ENERGY TRENDS

Chapter 2: Energy projections to 2035

What are the economic impacts of high oil prices?	77
China's role in traded coal markets – the ultimate uncertainty?	94

Chapter 3: Oil market outlook

The new American revolution: light tight oil	127
--	-----

Chapter 4: Natural gas market outlook

Do all roads lead to a Golden Age of Gas?	173
---	-----

Chapter 6: Climate change and the 450 Scenario

The International Year of Sustainable Energy for All: can universal access be achieved without increasing CO ₂ emissions?	219
--	-----

Part B: OUTLOOK FOR RUSSIAN ENERGY

Chapter 7: Russian domestic energy prospects

What future for district heating in Russia?	274
---	-----

Chapter 8: Russian resources and supply potential

The last of the mega-projects?	307
--------------------------------	-----

Chapter 9: Implications of Russia's energy development

What would higher GDP growth imply for the energy sector?	333
---	-----

Part C: OUTLOOK FOR COAL MARKETS

Chapter 10: Coal demand prospects

What is impeding the deployment of more efficient coal-fired generation?	367
--	-----

Part D: SPECIAL TOPICS

Chapter 12: The implications of less nuclear power

How did Fukushima Daiichi impact Japanese and global energy markets?	453
Will Fukushima Daiichi affect the industry as severely as Three Mile Island and Chernobyl?	460

Chapter 14: Developments in energy subsidies

Are the G-20 and APEC commitments being met?	523
--	-----