

TABLE OF CONTENTS

PART A: GLOBAL ENERGY TRENDS

Overview and key findings	1
Energy and the Sustainable Development Goals	2
Outlook for oil	3
Outlook for natural gas	4
Outlook for coal	5
Outlook for electricity	6
Outlook for energy efficiency and renewables	7

PART B: SPECIAL FOCUS ON AFRICA

Africa today	8
Urbanisation, industrialisation and clean cooking	9
Access to electricity and reliable power	10
Natural gas and resource management	11
Implications for Africa and the world	12

PART C: WEO INSIGHTS

Prospects for gas infrastructure	13
Outlook for offshore wind	14

ANNEXES

Foreword	3
Acknowledgements	5
Executive summary	23
Introduction	29
Part A: Global Energy Trends	33
1 Overview and key findings	35
Introduction	37
Scenarios	38
1.1 Overview	38
1.2 Primary energy demand by region	40
1.3 Final energy consumption and efficiency	42
1.4 Power generation and energy supply	44
1.5 Emissions	46
1.6 Trade	48
1.7 Investment	50
1.8 Differences between the <i>WEO-2019</i> and <i>WEO-2018</i>	52
Exploring the pace of change	54
1.9 Sustainability	54
1.10 Security	63
1.11 Affordability	70
2 Energy and the Sustainable Development Goals	79
Introduction	81
Sustainable Development Scenario	82
2.1 Scenario overview	82
2.2 Scenario outcomes: Universal energy access	86
2.3 Scenario outcomes: Air pollution	87
2.4 Scenario outcomes: CO ₂ emissions	88
2.5 Energy sector transformation in the Sustainable Development Scenario	89
2.6 Investment in the Sustainable Development Scenario	93
Key themes	96
2.7 How are we doing?	96
2.8 Where do we need to get to?	102
2.9 How much further can we go?	121
3 Outlook for oil	129
Introduction	131

Scenarios	132
3.1 Overview	132
3.2 Oil demand by region	134
3.3 Oil demand by sector	136
3.4 Oil supply by type	138
3.5 Oil supply by region	140
3.6 Oil product demand and refining	143
3.7 Trade	145
3.8 Investment	146
Key themes	147
3.9 Passenger cars: are we approaching the peak of the “ICE age”?	147
3.10 Pushing the boundaries of US tight oil	155
3.11 Can the world afford to relax about security of oil supply?	165

4

Outlook for natural gas **175**

Introduction	177
Scenarios	178
4.1 Overview	178
4.2 Natural gas demand by region and sector	180
4.3 Natural gas production	183
4.4 Trade and investment	186
Key themes	188
4.5 Associated gas: the upstream link between oil and gas markets	188
4.6 How does innovation affect the outlook for LNG?	197
4.7 Understanding the global potential for coal-to-gas switching	209

5

Outlook for coal **219**

Introduction	221
Scenarios	222
5.1 Overview	222
5.2 Coal demand by region and sector	224
5.3 Coal production by region	226
5.4 Trade	228
5.5 Investment	229
Key themes	230
5.6 A view beyond power: industrial coal use	230
5.7 Who will invest in coal supply?	236
5.8 Coal mine methane	245

6	Outlook for electricity	253
	Introduction	255
	Scenarios	256
	6.1 Overview	256
	6.2 Electricity demand by region	258
	6.3 Electricity demand by sector	261
	6.4 Electricity supply by source	264
	6.5 Installed capacity by source	266
	6.6 Electricity supply by region	268
	6.7 Power sector investment	271
	6.8 Competitiveness of power generation technologies	273
	6.9 Power sector emissions	275
	Key themes	278
	6.10 Affordability of electricity	278
	6.11 Tackling emissions from coal-fired power plants	283
	6.12 Exploring the new frontiers of flexibility	291
7	Outlook for energy efficiency and renewables	299
	Introduction	301
	Scenarios	302
	7.1 Energy efficiency overview	302
	7.2 Renewables overview	304
	7.3 Efficiency by sector and investments	306
	7.4 Renewables policies and investments	308
	Key themes	310
	7.5 Material efficiency in heavy industries	310
	7.6 Smart electricity use: the power of the hour in reducing emissions	320
	7.7 Biogas: turning organic matter into renewable energy	328
	Part B: Special Focus on Africa	337
	Introduction	339
8	Africa today	347
	8.1 Context	349
	8.1.1 Economic growth and industrialisation	349
	8.1.2 Demographics and urbanisation	351
	8.1.3 Infrastructure and investment	352

8.2	Access to modern energy	355
8.2.1	Clean cooking	357
8.2.2	Electricity	361
8.2.3	Affordability: energy prices and fossil fuel subsidies	367
8.3	Energy trends in Africa today	369
8.3.1	Energy demand	369
8.3.2	Power sector	375
8.3.3	Fossil fuel resources and supply	386
8.3.4	Renewable resources and supply	392
8.3.5	Environment	395
9	Urbanisation, industrialisation and clean cooking	399
9.1	Introduction	401
9.2	Urbanisation and industrialisation, drivers of growth	403
9.2.1	Residential sector	408
9.2.2	Transport sector	412
9.2.3	Productive uses	416
9.3	Clean cooking: the role of cities and higher incomes	422
9.3.1	Increasing access to clean cooking options	424
9.3.2	Rapid urbanisation requires better use of charcoal	427
9.3.3	Rural areas – how to unleash the potential of biogas?	430
10	Access to electricity and reliable power	433
10.1	Introduction	435
10.2	Outlook for electricity access	436
10.3	Outlook for electricity demand	438
10.3.1	Electricity demand growth by sector	440
10.3.2	Electricity demand growth by region	442
10.4	Outlook for electricity supply	446
10.4.1	On-grid supply	448
10.4.2	Role of decentralised systems to reach universal access to electricity	454
10.5	Reliability	455
10.6	Affordability	459
10.7	Investment needs for reliable, sustainable and affordable power	461
10.8	Sources of finance for power investment in sub-Saharan Africa	463
10.8.1	Investment framework and market structure	463
10.8.2	Private financing is concentrated in IPPs, mostly in South Africa	465

10.9	Closing the investment and financing gap	467
10.9.1	Improve the financial and operational performance of utilities	467
10.9.2	Enhance policy and regulatory frameworks to improve bankability	469
10.9.3	Create supportive enabling environments for rural electricity access	470
10.9.4	Strengthen provision of long-term finance	472

11

Natural gas and resource management **475**

11.1	Introduction	477
11.2	The role of natural gas in Africa's energy mix	479
11.2.1	Prospects for gas in key regions	481
11.2.2	Outlook for natural gas demand, production and infrastructure developments in Africa	488
11.2.3	Conclusions	490
11.3	Maximising the value of Africa's resources	491
11.3.1	Outlook for fossil fuel production	493
11.3.2	Strategic responses for resource-holders in Africa	496
11.3.3	Conclusions	504

12

Implications for Africa and the world **507**

	Introduction	507
	Implications for the world	507
	Regional and country profiles for Africa	524
12.1	Sub-Saharan Africa	526
12.2	Angola	530
12.3	Côte d'Ivoire	534
12.4	Democratic Republic of the Congo	538
12.5	Ethiopia	542
12.6	Ghana	546
12.7	Kenya	550
12.8	Mozambique	554
12.9	Nigeria	558
12.10	Senegal	562
12.11	South Africa	566
12.12	Tanzania	570

13	Prospects for gas infrastructure	577
	13.1 Introduction	579
	13.1.1 Role of gas infrastructure today	580
	13.1.2 Role of natural gas in energy transitions	581
	13.1.3 Need for gas supply to evolve	585
	13.2 Low-carbon hydrogen	587
	13.2.1 Hydrogen use today	587
	13.2.2 Costs and potential to blend hydrogen into gas networks	589
	13.3 Biomethane	594
	13.3.1 Biomethane use today	595
	13.3.2 Blending biomethane into gas networks: costs and potential	596
	13.4 Outlook for low-carbon hydrogen and biomethane	600
	13.4.1 Stated Policies Scenario	600
	13.4.2 Sustainable Development Scenario	601
	13.5 Implications for emissions and energy security	603
	13.5.1 Reducing CO ₂ emissions	603
	13.5.2 Avoiding methane emissions	605
	13.5.3 Energy security	607
	13.6 Implications for policy makers and industry	609
14	Outlook for offshore wind	613
	14.1 Introduction	615
	14.2 Offshore wind power today	615
	14.2.1 Current status	615
	14.2.2 Market size and key players	617
	14.2.3 Offshore wind technology and performance	619
	14.2.4 Offshore wind costs for projects commissioned in 2018	624
	14.3 Offshore wind outlook to 2040	627
	14.3.1 Global outlook	627
	14.3.2 Regional outlook	628
	14.3.3 Offshore wind costs, value and competitiveness	635
	14.4 Opportunities for faster growth of offshore wind	648
	14.4.1 Global technical potential for offshore wind	648
	14.4.2 Improved economics for offshore wind	654
	14.4.3 Increased demand for renewable hydrogen	655
	14.4.4 Public acceptance	656

14.5	Uncertainties that could slow offshore wind growth	657
14.5.1	Developing efficient supply chains in new markets	657
14.5.2	Environmental concerns	657
14.5.3	Onshore grid development	658
14.6	Implications	661
14.6.1	Achieving environmental goals	661
14.6.2	Synergies with oil and gas activities	662
14.6.3	Enhanced energy security and affordability	664

Annexes **667**

Annex A.	Tables for scenario projections	669
Annex B.	Design of the scenarios	751
Annex C.	Definitions	771
Annex D.	References	785