

1 417 278 48XL

to Resources
Reserves
2013

***Oil, Gas and Coal Technologies
for the Energy Markets
of the Future***



**International
Energy Agency**

TABLE OF CONTENTS

Executive Summary	17
Chapter 1	Setting the scene
	25
	Global energy demand
	25
	Implications of a low-carbon scenario
	27
	Classifying resources and reserves
	28
	Oil and gas
	29
	Coal
	33
	Resources and reserves
	35
	Oil resources and reserves
	35
	Conventional oil resources
	38
	Unconventional oil resources
	38
	Natural gas resources and reserves
	39
	Conventional gas resources
	40
	Unconventional gas resources
	41
	Coal resources and reserves
	42
	Recent trends
	45
	The impact of declining oilfield production
	45
	Upstream oil and gas: volatility in oil price and impact on investments
	47
	The impact of policies on oil forecast
	47
	Growth of coal consumption in China
	48
	The need to manage water production
	50
	Recent developments in technology
	51
	Innovations in oil and gas exploration and production
	51
	Developments in coal mining technology
	52
	Gaps in clean energy RD&D funding
	52
Chapter 2	Raising recovery efficiency from oilfields
	55
	Lifecycle of a petroleum reservoir
	55
	Exploration
	57
	Appraisal, planning and construction
	59
	Production
	60
	Abandonment
	61
	Developing new reserves: getting the most for the lowest cost
	61
	Making a plan using integrated reservoir modelling
	61
	Drilling technology for new reserves and lower costs
	63
	Going offshore: developments in subsea wells and facilities
	65
	Applying technologies for IOR
	67
	IOR techniques and their potential
	68
	Improvements in the North Sea and Norwegian Continental Shelf
	68
	Experience with 4-D seismic
	71
	Potential improvements in recovery in the Middle East
	72

	Using well technology to boost recovery from thin oil rims	73
	Mature reserves: technologies for EOR	74
	The move towards EOR technologies	75
	CO ₂ injection for EOR	81
	CO₂-EOR for greenhouse gas mitigation: a future win-win situation?	82
	Storage aspects	83
	The Weyburn-Midale project	84
	Costs and carbon credits	89
	Being smart with smart fields	90
	Smart field technologies	91
	Smart field collaboration	92
	The advantages of smart field	92
	Importance of future technology RD&D	93
Chapter 3	The growing importance of natural gas.....	99
	Natural gas sources and lifecycle aspects	99
	More natural gas developments	101
	Key element: getting gas to markets	102
	The LNG value chain	103
	Liquefaction	103
	Cost of liquefaction	104
	Plans for major liquefaction plants	105
	Shipping	106
	Cost of shipping	108
	Regasification and storage	108
	Going offshore: floating LNG systems	109
	Offshore liquefaction from concept to operation	110
	Offshore floating regasification and storage units	111
	GTL: an alternative way to bring gas to market	111
	GTL conversion process	112
	Commercial developments	113
	Compressed natural gas for smaller accumulations	114
	Sour gas and contaminated gas resources	116
	Processing sour gas	117
	Sour gas and public safety	118
	NGL: a key contributor to global oil production	119
	Impact on the lifecycle of a gas development	119
	Trends in global NGL production	119
Chapter 4	Trends and challenges of frontier oil and gas	123
	Main challenges of frontier oil and gas exploration	123
	Potential of deepwater reserves	124
	Developing deepwater reserves: applying new technology	126

Evolution of deepwater offshore production surface facilities	127
Evolution of seabed facilities	129
Subsea processing	129
Increase in subsea flowlines	131
Multiphase flow assurance	132
Phasing a development and leveraging technology along the way	134
Technologies for meeting the Arctic challenge	135
Trends in Arctic frontier exploration and production	137
Technological challenges for the Arctic	138
Technological challenges for ice-prone areas	138
Long-range, multiphase transportation of Arctic wellstreams	142
Protecting the Arctic environment	143
Minimising the environmental footprint	144
The Endicott Field	144
The Alpine Oilfield	144
Challenges to risk and response capabilities	146
Environmental impact assessment	146
Approaches to EIA	147
Going beyond standard practice	148
Key references for Arctic EIAs	150
Legal aspects	150
Future directions	151
Chapter 5 Making light of unconventional oil	155
Heavy oil and oil-sands	155
Upgrading viscous oil	157
Mining oil-sands	158
Technologies for <i>in situ</i> production of heavy oil and oil-sands	158
Environmental issues associated with heavy oil and oil-sands production	162
Impact on the landscape	162
Water usage	162
Bitumen slurry	163
Sulphur	163
Greenhouse gases (GHGs)	163
Steam and hydrogen sources	164
The future of heavy oil and oil-sands	164
Kerogen oil	165
Light tight oil	166
Extraction of LTO	167
LTO production	168
Environmental impact	169

Chapter 6	The unconventional gas revolution	173
	The potential of unconventional gas resources	173
	Tight gas	175
	Extraction of tight gas	176
	Shale gas	176
	Extraction of shale gas	177
	Barnett Shales gas development	178
	Distinctive features of shale gas plays	180
	The economics of shale gas production	180
	Coal-bed methane	182
	Production of CBM	183
	The potential for methane hydrates	185
	Environmental impact	189
	Tight gas and shale gas	190
	CBM	191
	Methane hydrates: impact on the environment and climate change	192
	Technology development	193
	Tight gas, shale gas and coal-bed methane	194
	Exploration	194
	Drilling and stimulation	194
	Gas compression	194
	Methane hydrates: the need for technological innovation	195
Chapter 7	Coal in the 21st century.....	201
	Types of coal	201
	Coal rank and content	201
	Carbon content	202
	Calorific value (or heat content)	202
	Moisture content	202
	Ash content	202
	Coal classifications	202
	Demand for coal	203
	Classification of traded hard coals	205
	Steam coals	205
	Coking coals	205
	PCI coals	205
	Anthracite	205
	Calculating coal deposits	206
	Global surveys of coal deposits and associated difficulties	206
	Coal extraction	207
	Surface mining	207
	Underground mining	208
	Longwall mining	208
	Room-and-pillar mining	208

	Coal use	210
	Coal for electricity generation	211
	Efficiency of electricity generation	212
	Coal-fired plants in China	213
	Coal-fired plants in India	213
	Coal-fired capacity in OECD countries	214
	Technologies to improve efficiency of coal-fired plants	214
	PC combustion	214
	Fluidised bed combustion	215
	Integrated gasification combined cycle	215
	Co-generation	216
	Coal-to-liquids	216
	Indirect liquefaction	217
	Direct liquefaction	217
	New technologies for CTL	218
	Environmental impact	219
Chapter 8	Production costs of fossil fuels.....	225
	Factors influencing production costs	225
	Production cost curve for oil	227
	Production cost curve for gas	231
	Production cost curve for coal	232
Chapter 9	Meeting the environmental challenges	237
	Production-related GHG emissions from oil resources	237
	Factors influencing GHG emissions from oil production	238
	Competing fuels	239
	Options for mitigation	239
	Upstream GHG emissions	243
	Comparison of fuel cycle GHG emissions from different liquid fuels	243
	Trends for the future	248
	Impact of carbon pricing	249
	Energy sector methane releases	253
	Anthropogenic hydrocarbon sources of methane emissions	254
	Reducing methane emissions in the oil and gas sectors	256
	Dealing with methane emissions: opportunities and constraints	257
	List of abbreviations, acronyms and units of measure	261
	Abbreviations and acronyms	261
	Units of measure	266
References	A list of references can be found at the end of each chapter	