

# Contents

<b>EXECUTIVE SUMMARY .....</b>	<b>14</b>
<b>PART ONE – TECHNOLOGY AND DRIVERS FOR LNG AS A TRANSPORT FUEL .....</b>	<b>16</b>
<b>1.0 THE GLOBAL LNG SUPPLY CHAIN .....</b>	<b>17</b>
<b>1.1 Introduction.....</b>	<b>17</b>
1.1.1 The LNG supply chain.....	17
1.1.2 FLNG and FSRUs .....	20
1.1.3 LNG producers and supplies .....	21
1.1.4 LNG markets.....	24
1.1.5 LNG trading and diversion .....	30
1.1.6 Regional variation of LNG price structure and levels.....	31
1.1.7 LNG peak-shaving facilities and other small-scale liquefaction.....	33
1.1.8 Interactions between the global LNG supply chain and LNG as a transport fuel .....	34
1.1.9 Future LNG supply and demand .....	34
<b>2.0 LNG AS MARINE TRANSPORT FUEL .....</b>	<b>37</b>
<b>2.1 Introduction to the sector.....</b>	<b>37</b>
<b>2.2 Marine regulatory overview .....</b>	<b>38</b>
2.2.1 The MARPOL Treaty .....	38
2.2.2 Emission Control Areas under MARPOL .....	40
2.2.3 Emissions limits under MARPOL and the ECAs .....	42
2.2.4 Implications of MARPOL for the global marine bunker fuels market and LNG .....	44
<b>2.3 Technology and Infrastructure Overview .....</b>	<b>47</b>
2.3.1 Engine and vessel design .....	47
2.3.2 Refuelling infrastructure .....	51
<b>2.4 Overview of the economic and environmental advantages of LNG in marine .....</b>	<b>54</b>
2.4.1 The economic advantages .....	55
2.4.2 The environmental advantages .....	58
<b>2.5 Current size of the market .....</b>	<b>62</b>
2.5.1 The global shipping fleet.....	62
2.5.2 Global shipping movements and fuel demand.....	66

2.5.3 Current pattern of bunkerage facilities .....	69
<b>2.6 Key drivers in the marine and inland waterway transport sector .....</b>	<b>70</b>
2.6.1 Key stakeholder perspectives .....	70
2.6.2 Ship-owners and operators.....	71
2.6.3 Shipbuilders and engine manufacturers.....	72
2.6.4 Fuelling infrastructure and fuel suppliers.....	72
2.6.5 National and international policy makers.....	73
<b>2.7 Key challenges in the marine/IWT sector .....</b>	<b>74</b>
2.7.1 Logistical and operational challenges.....	74
2.7.2 Costs.....	75
2.7.3 Safety concerns and Standards.....	75
<b>2.8 Conclusions for the marine sector.....</b>	<b>76</b>
<b>3.0 LNG AS A ROAD TRANSPORT FUEL.....</b>	<b>77</b>
<b>3.1 Introduction to the sector.....</b>	<b>77</b>
<b>3.2 Technology and Infrastructure Overview .....</b>	<b>77</b>
3.2.1 Engine and vehicle design.....	77
3.2.2 Refuelling infrastructure .....	79
<b>3.3 Overview of the economic and environmental advantages of LNG in road transport.....</b>	<b>82</b>
3.3.1 The economic advantages .....	83
3.3.2 The environmental advantages .....	88
<b>3.4 Current size of the market .....</b>	<b>92</b>
3.4.1 The global HDV fleet .....	92
3.4.2 Current HDV re-fuelling facilities .....	95
<b>3.5 Key drivers in the HDV sector .....</b>	<b>96</b>
3.5.1 Key stakeholder perspective.....	96
3.5.2 Vehicle owners and operators.....	99
3.5.3 Vehicle and engine manufacturers.....	100
3.5.4 Fuelling infrastructure and fuel suppliers.....	102
3.5.5 National and international policy makers.....	103
<b>3.6 Key challenges in the HDV sector .....</b>	<b>105</b>
3.6.1 Logistical and operational challenges .....	105
3.6.2 Capital expenditure and other costs.....	106

3.6.3 Reliability of fuel price differentials .....	106
3.6.4 Competition from other fuels .....	107
3.6.5 Standards .....	107
<b>3.7 Conclusions for LNG in the HDV Sector.....</b>	<b>107</b>
<b>4.0 LNG IN THE RAIL SECTOR .....</b>	<b>110</b>
4.1 Introduction to the sector.....	110
4.2 Technology and Infrastructure Overview .....	110
4.2.1 Locomotive design .....	110
4.2.2 Refuelling infrastructure .....	111
<b>4.3 Overview of the economic and environmental advantages of LNG in rail transport .....</b>	<b>111</b>
4.3.1 The economic advantages .....	111
4.3.2 The environmental advantages .....	114
<b>4.4 Current size of the market .....</b>	<b>114</b>
4.4.1 The global rail industry.....	114
4.4.2 Global rail movements and fuel demand.....	115
4.4.3 Current rail fuelling facilities.....	116
<b>4.5 Key drivers in the rail sector .....</b>	<b>116</b>
<b>4.6 Key challenges in the rail sector.....</b>	<b>117</b>
<b>4.7 Conclusion for the rail sector .....</b>	<b>118</b>
<b>PART TWO – GROWTH PROJECTIONS FOR LNG AS A TRANSPORT FUEL.....</b>	<b>119</b>
<b>5.0 INTRODUCTION .....</b>	<b>119</b>
5.1 General introduction to LNG growth projections in marine, road and rail .....	119
5.2 Some key challenges .....	119
5.3 Projections not forecasts .....	119
5.4 Timeframe .....	120
5.5 Defining regions and identifying relevant countries.....	120

<b>6.0 MODELLING THE FUTURE USAGE OF LNG IN THE GLOBAL MARINE BUNKER FUELS MARKET, 2015-2035.....</b>	<b>123</b>
<b>6.1 A brief introduction to the global marine bunker fuels market .....</b>	<b>123</b>
6.1.1 General description of the global marine bunker fuels market .....	123
6.1.2 An overview of the fuels sold in the global marine bunker fuels market.....	124
6.1.3 An overview of the changing emissions regulation regime.....	125
6.1.4 A review of the fuel and technology choices open to ship owners following the introduction of MARPOL Annex VI.....	127
<b>6.2 An overview of the modelling framework .....</b>	<b>129</b>
6.2.1 A description of the type and role of scenarios used .....	129
6.2.2 Understanding and modelling the size of the global marine bunker fuels market .....	131
6.2.3 Understanding and modelling different types, sizes and ages of vessel .....	134
6.2.4 Understanding and modelling the impact of the change of regulatory regime .....	138
6.2.5 Understanding and modelling the impact of fuel prices on fuel and technology choices.....	142
<b>6.3 A description of the modelling process .....</b>	<b>148</b>
6.3.1 Preparatory work required .....	148
6.3.2 Steps required in running the model.....	149
6.3.3 Summary of results from model .....	150
<b>6.4 Overview of stakeholder projections of LNG usage in the global marine bunker fuels market.....</b>	<b>151</b>
6.4.1 Overall approach and methodology for developing comparable projections.....	151
6.4.2 Review of studies from a maritime perspective .....	152
6.4.3 Review of reports by international oil companies (IOCs) .....	155
6.4.4 Reports by international consultancies and academic institutes .....	157
6.4.5 Summary and analysis of stakeholder projections for the global marine bunker fuels market .....	158
<b>6.5 Conclusions - an analysis of the combined results .....</b>	<b>161</b>
<b>7.0 MODELLING THE FUTURE USAGE OF LNG IN THE GLOBAL ROAD TRANSPORT FUELS MARKET, 2015-2035.....</b>	<b>163</b>
<b>7.1 A brief introduction to the global road transport fuels market.....</b>	<b>163</b>
7.1.1 General description of the global road transport fuels market.....	163
7.1.2 An overview of the fuels sold in HDV sector.....	164
7.1.3 An overview of HDV emissions regulations .....	164
<b>7.2 An overview of the modelling framework .....</b>	<b>165</b>

7.2.1	A description of the type and role of scenarios used .....	165
7.2.2	Understanding and modelling the size of the road transport fuels market.....	167
7.2.3	Modelling the impact of LNG refuelling infrastructure coverage.....	169
7.2.4	Modelling replacement rates.....	170
7.2.5	Understanding and modelling the impact of fuel prices on fuel and technology choices.....	170
<b>7.3</b>	<b>A description of the modelling process .....</b>	<b>173</b>
7.3.1	Preparatory work required .....	173
7.3.2	Steps required in running the model.....	174
7.3.3	Summary of results from model .....	174
<b>7.4</b>	<b>Overview of stakeholder projections of LNG usage in the global road transport fuels market.....</b>	<b>177</b>
7.4.1	Review of global forecast - Shell .....	178
7.4.2	Review of regional forecasts.....	178
7.4.3	Regional projections .....	181
7.4.4	Conclusions drawn from analysis of reports.....	188
<b>7.5</b>	<b>Conclusions - an analysis of the combined results .....</b>	<b>191</b>
<b>8.0</b>	<b>LNG AS RAIL TRANSPORT FUEL .....</b>	<b>195</b>
<b>8.1</b>	<b>Introduction.....</b>	<b>195</b>
<b>8.2</b>	<b>Defining fuels in the rail transport market.....</b>	<b>195</b>
<b>8.3</b>	<b>Review of LNG usage for rail transportation in the United States.....</b>	<b>195</b>
<b>8.4</b>	<b>Overview of the Cedigaz analysis .....</b>	<b>199</b>
8.4.1	General issues .....	200
8.4.2	A description of the modelling process .....	200
<b>8.5</b>	<b>Results from the model .....</b>	<b>212</b>
8.5.1	Projections of global LNG demand from the rail transport liquid fuels market .....	212
8.5.2	Projections of LNG demand by country from the rail transport liquid fuels market.....	213
<b>8.6</b>	<b>Conclusions.....</b>	<b>215</b>
<b>10.0</b>	<b>OVERVIEW OF DATA ANALYSIS.....</b>	<b>218</b>
<b>10.1</b>	<b>Defining regions and identifying relevant countries .....</b>	<b>218</b>
10.1.1	Choice of countries.....	218

<b>10.2 Country data – Summary .....</b>	<b>219</b>
10.2.1 Key country statistics.....	219
10.2.2 The LNG suitability matrix .....	220
10.2.3 Bulk LNG supply data.....	222
10.2.4 LNG refuelling station data.....	222
 <b>11.0 EUROPE .....</b>	 <b>224</b>
<b>11.1 Regional summary.....</b>	<b>224</b>
<b>11.2 COUNTRY SUMMARY – BELGIUM.....</b>	<b>226</b>
<b>11.3 COUNTRY SUMMARY – DENMARK.....</b>	<b>228</b>
<b>11.4 COUNTRY SUMMARY – ESTONIA .....</b>	<b>230</b>
<b>11.5 COUNTRY SUMMARY – FINLAND .....</b>	<b>232</b>
<b>11.6 COUNTRY SUMMARY – FRANCE.....</b>	<b>234</b>
<b>11.7 COUNTRY SUMMARY – GERMANY .....</b>	<b>237</b>
<b>11.8 COUNTRY SUMMARY – ITALY .....</b>	<b>240</b>
<b>11.9 COUNTRY SUMMARY – LATVIA.....</b>	<b>243</b>
<b>11.10 COUNTRY SUMMARY – LITHUANIA.....</b>	<b>245</b>
<b>11.11 COUNTRY SUMMARY – NETHERLANDS .....</b>	<b>247</b>
<b>11.12 COUNTRY SUMMARY – NORWAY .....</b>	<b>249</b>
<b>11.13 COUNTRY SUMMARY – POLAND.....</b>	<b>251</b>
<b>11.14 COUNTRY SUMMARY – PORTUGAL.....</b>	<b>253</b>
<b>11.15 COUNTRY SUMMARY – SPAIN .....</b>	<b>255</b>
<b>11.16 COUNTRY SUMMARY – SWEDEN .....</b>	<b>258</b>
<b>11.17 COUNTRY SUMMARY – TURKEY .....</b>	<b>261</b>
<b>11.18 COUNTRY SUMMARY – UNITED KINGDOM .....</b>	<b>263</b>
 <b>12.0 NORTH AMERICA .....</b>	 <b>267</b>
<b>12.1 Regional summary.....</b>	<b>267</b>
<b>12.2 COUNTRY SUMMARY – USA.....</b>	<b>268</b>

12.3 COUNTRY SUMMARY – CANADA.....	278
12.4 COUNTRY SUMMARY – MEXICO .....	282
13.0 CENTRAL AND SOUTH AMERICA .....	285
13.1 Regional summary.....	285
13.2 COUNTRY SUMMARY – ARGENTINA.....	286
13.3 COUNTRY SUMMARY – BRAZIL .....	288
13.4 COUNTRY SUMMARY – TRINIDAD AND TOBAGO.....	290
13.5 COUNTRY SUMMARY – CHILE .....	292
13.6 COUNTRY SUMMARY – PERU.....	294
13.7 COUNTRY SUMMARY – PUERTO RICO .....	296
13.8 COUNTRY SUMMARY – ECUADOR.....	298
14.0 RUSSIA AND THE CIS .....	301
14.1 Regional summary.....	301
14.2 COUNTRY SUMMARY – RUSSIA.....	302
14.3 COUNTRY SUMMARY – UKRAINE .....	306
15.0 MIDDLE EAST .....	309
15.1 Regional summary.....	309
15.2 COUNTRY SUMMARY – IRAN .....	310
15.3 COUNTRY SUMMARY – ISRAEL.....	312
15.4 COUNTRY SUMMARY – KUWAIT .....	314
15.5 COUNTRY SUMMARY – OMAN.....	316
15.6 COUNTRY SUMMARY – QATAR .....	318
15.7 COUNTRY SUMMARY – UNITED ARAB EMIRATES (UAE) .....	320
16.0 ASIA OCEANIA .....	324
16.1 Regional summary.....	324
16.2 COUNTRY SUMMARY – AUSTRALIA.....	325

16.3 COUNTRY SUMMARY – CHINA .....	328
16.4 COUNTRY SUMMARY – INDIA .....	333
16.5 COUNTRY SUMMARY – INDONESIA.....	335
16.6 COUNTRY SUMMARY – JAPAN .....	337
16.7 COUNTRY SUMMARY – KOREA .....	340
16.8 COUNTRY SUMMARY – MALAYSIA.....	342
16.9 COUNTRY SUMMARY – SINGAPORE .....	344
17.0 AFRICA .....	347
17.1 Regional summary.....	347
17.2 COUNTRY SUMMARY – ALGERIA.....	348
17.3 COUNTRY SUMMARY – EGYPT .....	350
17.4 COUNTRY SUMMARY – NIGERIA .....	352
APPENDICES – STAKEHOLDER VIEWS ON LNG AS A MARINE BUNKER FUEL .....	354
APPENDIX I – VIEWS FROM THE MARINE INDUSTRY.....	354
Stakeholder 1 – The Danish Maritime Authority.....	354
Stakeholder 2 – Lloyd’s Register .....	360
Stakeholder 3 – DNV (Det Norske Veritas) .....	364
APPENDIX II – VIEWS FROM INTERNATIONAL OIL COMPANY.....	372
Stakeholder 4 – Total Gas and Power (Total).....	372
Stakeholder 5 – Shell.....	377
Stakeholder 6 – Gazprom .....	380
APPENDIX III – VIEWS FROM INTERNATIONAL CONSULTANCIES AND ACADEMIC INSTITUTES .....	382
Stakeholder 7 - IHS.....	383
Stakeholder 8 - Poten and Partners .....	385
Stakeholder 9 – The IEA.....	386

<b>GLOSSARY .....</b>	<b>387</b>
<b>Abbreviations used in the report: .....</b>	<b>387</b>
<b>Definitions used in the report:.....</b>	<b>392</b>
<b>Different marine fuel types in comparison .....</b>	<b>394</b>
<b>BIBLIOGRAPHY.....</b>	<b>395</b>
<b>Published reports:.....</b>	<b>395</b>
<b>Conference papers/presentations: .....</b>	<b>398</b>
<b>Online articles:.....</b>	<b>400</b>