

# TABLE OF CONTENTS

## Introduction

## Executive Summary

### 1. Project Description

### 2. Market & Economics

2.1. Natural Gas Market Analysis.....	5
2.1.1 Introduction.....	5
2.1.2 Market Modeling Approach.....	7
2.1.3 Key Factor Inputs for the Business-as-Usual Case.....	8
2.1.4 Natural Gas Supply in North America.....	9
2.1.5 LNG Import Terminals .....	15
2.1.6 New LNG Import Terminals.....	17
2.1.7 Interstate Pipeline Network.....	18
2.1.8 Regional Natural Gas Demand .....	22
2.1.9 Alternate Infrastructure Cases Tested in GPCM .....	26
2.1.10 Backcast Analysis to Ensure Model Validity .....	26
2.2. Electric Market Simulation Analysis.....	27
2.2.1 Role of Market Simulation in Overall Market Analysis.....	27
2.2.2 MarketSym Topology .....	28
2.2.3 Transmission Linkages .....	29
2.2.4 Generation and Load Data .....	30
2.2.5 Regional Transmission Expansion Plans .....	31
2.2.6 Capacity Values and Entry / Exit.....	31
2.2.7 NYISO ICAP Demand Curve Mechanism .....	32
2.2.8 PJM Reliability Pricing Model .....	33
2.2.9 ISO-NE Capacity Market.....	33
2.2.10 New York Renewable Portfolio Standard.....	34
2.2.11 Emissions Assumptions and Allowance Prices .....	34
2.3. Market Analysis Results .....	36
2.4. Benefits Attributable to Broadwater .....	42
2.4.1 Gas Utility and Electric Utility Benefits on Long Island, NYC and Rest of State.....	42
2.4.2 Economic Multiplier Analysis .....	46
2.4.3 Discussion of Net Benefits.....	47
2.4.4 Benefits Reconciliation.....	47
2.4.5 Omitted Variables .....	48

### **3. Technology Review**

3.1. Offshore LNG Technology Options .....	50
3.1.1 Cabrillo Port.....	53
3.1.2 Excelerate Gulf Gateway .....	54
3.1.3 Gulf Landing.....	56
3.2. Technology Components .....	57
3.2.1 Containment System.....	59
3.2.2 Mooring System Technology.....	63
3.2.3 Cargo Transfer .....	65
3.2.4 Regasification Process .....	68
3.2.5 Boil-off.....	70
3.2.6 Emergency Shutdown System .....	71
3.2.7 Custody Transfer.....	71
3.3. Summary of Findings.....	72

### **4. Environmental Review**

4.1. Potential Impacts to Marine Plants and Animals.....	75
4.1.1 Overview of Marine Plant and Animal Resources in Long Island Sound.....	75
4.1.2 Potential Construction Related Impacts.....	81
4.1.3 Potential Impacts During Project Operations .....	88
4.2. Potential Impacts to Commercial and Recreational Fishing.....	93
4.2.1 Commercially Important Marine Resources.....	93
4.2.2 Potential Impacts from Construction and Operation .....	94
4.3. Commercial Shipping in Long Island Sound.....	95

### **5. Safety Review**

5.1. LNG Properties .....	100
5.2. LNG Hazards .....	103
5.3. LNG Accident History .....	107
5.4. Sandia Report.....	109
5.4.1 LNG Spill and Dispersion Experiments .....	114
5.4.2 Recent LNG Spill Modeling Review.....	115
5.4.3 Sandia Report Recommended Safety Zones.....	116
5.5. Safety and Security Implementation.....	117
5.5.1 Gulf Landing Hazard Analysis .....	118
5.5.2 Gulf Gateway Hazard Analysis .....	118
5.5.3 Main Pass Energy Hub Hazard Analysis.....	119

5.6. Analysis of Revised Cabrillo Port DEIS (March 2006).....	119
5.6.1 Public Safety: Overview .....	120
5.6.2 Independent Risk Assessment.....	121
5.6.3 Sandia Review of Independent Risk Assessment .....	125
5.7. Resource Report 11 – Safety and Reliability .....	127
5.7.1 LNG Safety .....	128
5.8. Other Technical Experts on LNG Safety .....	132
5.9. Safety Review Issues .....	132
5.9.1 Safety Parameter Modeling Issues.....	132
5.9.2 Cascading Event Analysis.....	133
5.9.3 LAI Extrapolations to Worst-Case Scenario.....	134
5.10. Safety Review Findings .....	135
<b>6. Regulatory Status Update</b>	
6.1. Interventions .....	138
6.1.1 County of Suffolk Intervention.....	138
6.2. Conferences and Meetings.....	139
6.3. U.S. Coast Guard Waterways Suitability Report.....	139
6.3.1 LAI Review of USCG Findings.....	139
6.4. Draft Environmental Impact Statement (November 17, 2006).....	147
6.4.1 FSRU Reliability and Safety Issues.....	148
6.4.2 LNG Carrier Reliability and Safety Issues .....	149
6.4.3 Environmental.....	150
6.5. GAO Report (released on March 14, 2007).....	153
6.6. MARAD’s Decision on the Cabrillo Port Project.....	154
6.7. New York State Department of State Request for Additional Alternatives Analysis .	155
6.8. Certifying Entity .....	157

## **LIST OF EXHIBITS**

1. North-South Supply Breakdown for New York State
2. Relative Trends in Shallow and Deepwater Gulf Production
3. Production Isograms for Selected Producing Regions
4. Capital Cost for a New Plant in New York City or Long Island
5. Resource Additions Included in Electric Simulation Model
6. RPS Capacity Additions and Annual Targets
7. Price Effects at Regional Pricing Points
8. Calculation Framework for Economic Benefits
9. Cabrillo Port Summary of FSRU Accident Consequences

## **LIST OF APPENDICES**

1. GPCM Model Theory and Structure
2. Basin Production Curves
3. Fuel Price Forecasts
4. Emissions Allowance Price Forecasts
5. Application Review, including Resource Reports
6. Det Norske Veritas: Broadwater Response to USCG Letter
7. Det Norske Veritas Fire Modeling
8. List of FERC Interveners

## TABLE OF FIGURES\*

Figure 1 – FSRU Location and Area Infrastructure.....	1
Figure 2 – Broadwater FSRU Offshore Terminal.....	2
Figure 3 – Overview of Broadwater Market Analysis Modeling Process .....	7
Figure 4 –U.S. Natural Gas Production, Consumption and Imports .....	11
Figure 5 – Normalized Gas Production per Well from Gas Wells .....	12
Figure 6 – Basin Production Curves .....	14
Figure 7 – Proved Natural Gas Reserves (2004, Tcf).....	16
Figure 8 – Gas Pipelines Serving New York State and the Greater Northeast.....	19
Figure 9 – Average Monthly Iroquois Deliveries to Long Island and New York City .....	20
Figure 10 – New York State Gas Use by Sector (2005).....	23
Figure 11 – GPCM Backcast Analysis of TZ6-NY Prices .....	27
Figure 12 – Power System Model Interfaces.....	28
Figure 13 – Geographic Overview of Market Topology .....	29
Figure 14 – Estimated Transfer Capabilities, Peak Loads, and Capacities .....	30
Figure 15 – Commodity Price Changes at the Henry Hub: BAU v. Alternative Cases .....	37
Figure 16 – Commodity Price Changes at the Dawn Storage Hub: BAU v. Alternative Cases..	38
Figure 17 – TZ6-NY Price Change: BAU v. Alternative Cases.....	38
Figure 18 – IGTS-Z2 Price Change: BAU v. Alternative Cases .....	39
Figure 19 – Henry Hub Price Comparison: LNG Overbuild Case.....	40
Figure 20 – Dawn Price Comparison: LNG Overbuild Case .....	40
Figure 21 – TZ6-NY Price Comparison: LNG Overbuild Case.....	41
Figure 22 – IGTS Z2 Price Comparison: LNG Overbuild Case.....	41
Figure 23 – Core Benefits Attributable to Broadwater by Year .....	44
Figure 24 – Core Benefits Attributable to Broadwater by Sub-Area.....	44
Figure 25 – Non-Core Benefits Attributable to Broadwater by Year .....	45
Figure 26 – Non-Core Benefits Attributable to Broadwater by Sub-Area .....	46
Figure 27 – Illustration of Offshore LNG Facility Types.....	51
Figure 28 – Growth Pattern for LNG Vessel Size .....	52

---

\* Does not include Executive Summary.

Figure 29 – Cabrillo Deepwater Port FSRU .....	54
Figure 30 – Illustration of STL Technology .....	55
Figure 31 – LNG Tanker Serving Gulf Gateway Terminal .....	56
Figure 32 – Illustration of Gulf Landing Terminal .....	57
Figure 33 – Detail of Broadwater FSRU Offshore Terminal .....	58
Figure 34 – Proposed Yoke Mooring System .....	63
Figure 35 – Turret Mooring System .....	64
Figure 36 – Proposed Mooring Tower Structure .....	65
Figure 37 – FSRU with Moored LNG Carrier .....	66
Figure 38 – Chicksan Unloading Arms .....	68
Figure 39 – Closed-Loop Shell and Tube Vaporizer Configuration .....	69
Figure 40 – Generalized Boil-Off Process .....	70
Figure 41 – Vessel Traffic Density .....	96
Figure 42 – Vessel Tracks in the Vicinity of the FSRU .....	97
Figure 43 – Shipments To or From Long Island Sound Ports .....	98
Figure 44 – Flammability Limits for Selected Fuels .....	102
Figure 45 – Relative Detonation Properties of Common Fuels .....	103
Figure 46 – Sequence of Events Following a Spill .....	104
Figure 47 – Radiation Effects on Naked Skin .....	105
Figure 48 – LNG tanker in Charlestown on its way out of Boston .....	107
Figure 49 – Sandia Report Radiative Flux .....	112
Figure 50 – Sandia Report Vapor Dispersion Distances to LFL .....	114
Figure 51 – Sandia Report Safety Zones .....	117
Figure 52 – Cabrillo Deepwater Port: Consequence Distances .....	121
Figure 53 – Sandia Calculation of Pool Fire Hazards .....	126
Figure 54 – View of FSRU from Roanoke Landing .....	127
Figure 55 – Anticipated LNG carrier transit route with Zone 1, Zone 2 and Zone 3 .....	141
Figure 56 – LNG Carrier Anticipated Transit Route and Hazard Zones – The Race .....	143
Figure 57 – LNG Carrier Anticipated Transit Route and Hazard Zones .....	144
Figure 58 – Alternative Terminal Sites and Pipeline Routes Considered by Broadwater .....	156

## TABLE OF TABLES\*

Table 1 – North American Supply Region and Basin Production and Proved Reserves .....	15
Table 2 – LNG Import Terminals in the Business-as-Usual Case.....	18
Table 3 – Delivery Areas of Gas Pipelines Serving New York State.....	19
Table 4 – Gas Customers by Utility in New York State.....	23
Table 5 – Gas Sales by Utility in New York State .....	24
Table 6 – Sources of Load Data Information.....	31
Table 7 – Average 10-Year Price Results by Case.....	42
Table 8 – Market Center Pricing Points.....	43
Table 9 – Summary of LAI’s Economic Findings.....	47
Table 10 – Summary of Offshore LNG Project Specifications .....	53
Table 11 – Containment System Parameters .....	61
Table 12 – 2003 Commercial Vessel Traffic To and From Ports in CT and Long Island.....	99
Table 13 – LNG Compositions by Source.....	101
Table 14 – Common Approximate Thermal Radiation Damage Levels .....	106
Table 15 – Sandia Report Thermal Intensity Level Distances .....	111
Table 16 – Sandia Report Vapor Dispersion Distances to LFL.....	113
Table 17 – Sandia Report Safety Zones.....	116
Table 18 – Safety Implementation for other Offshore Projects.....	118
Table 19 – Summary of Consequence Distances.....	125
Table 20 – Populations in Proximity to LNG Terminals.....	128
Table 21 – Weather and Sea Condition Limits for LNG Carrier Transit .....	131
Table 22 – Broadwater Hazard Zones .....	140
Table 23 – Ranked Navigation Safety Events .....	146

---

\* Does not include Executive Summary.

## GLOSSARY

<b>ABS</b>	American Bureau of Shipping	<b>DEIS</b>	Draft Environmental Impact Statement
<b>ACE</b>	Analytical and Computational Energetics, Inc.	<b>DNV</b>	Det Norske Veritas
<b>ADRP</b>	Acid Deposition Reduction Program	<b>DO</b>	Dissolved Oxygen
<b>AEO</b>	Annual Energy Outlook	<b>DOE</b>	Department of Energy
<b>AEP</b>	American Electric Power	<b>DP</b>	Dynamically Positioned
<b>APE</b>	Area of Potential Effect	<b>Dth</b>	Dekatherm
<b>APS</b>	Allegheny Power System	<b>DTI-SP</b>	Dominion South Point
<b>AQCR</b>	Air Quality Control Act	<b>E&amp;P</b>	Exploration and Production
<b>ATBA</b>	Area to be Avoided	<b>EBP</b>	Early Benthic Phase
<b>BAU</b>	Business-as-Usual	<b>EEA</b>	Energy and Environmental Analysis, Inc.
<b>Bcf/(d)</b>	Billion cubic feet (per day)	<b>EFH</b>	Essential Fish Habitat
<b>BLEVE</b>	Boiling Liquid Expanding Vapor Explosion	<b>EIA</b>	Energy Information Agency
<b>BP</b>	Beyond Petroleum (formerly British Petroleum)	<b>EIS</b>	Environmental Impact Statement
<b>CAA</b>	Clean Air Act	<b>EPA</b>	Environmental Protection Agency
<b>CAIR</b>	Clean Air Interstate Rule	<b>ESA</b>	Endangered Species Act
<b>CAPP</b>	Central Appalachia	<b>FCM</b>	Forward Capacity Market
<b>CCMP</b>	Comprehensive Conservation and Management Plan	<b>FDS</b>	Fire Dynamics Simulator
<b>CEC</b>	California Energy Commission	<b>FEIS</b>	Final Environmental Impact Statement
<b>CFD</b>	Computational Fluid Dynamics	<b>FERC</b>	Federal Energy Regulatory Commission
<b>CFR</b>	Code of Federal Regulations	<b>FDG</b>	Flue Gas Desulfurization
<b>CHG&amp;E</b>	Central Hudson Gas and Electric	<b>FOB</b>	Free on Board
<b>CO<sub>2</sub></b>	Carbon Dioxide	<b>FPSO</b>	Floating Production, Storage and Offloading
<b>CSLC</b>	California State Lands Commission	<b>FRU</b>	Floating Regasification Unit
<b>CTDEP</b>	Connecticut Department of Environmental Protection	<b>FSRU</b>	Floating Storage and Regasification Unit
<b>DAM</b>	Day-Ahead Market	<b>FSU</b>	Former Soviet Union
<b>DEIR</b>	Draft Environmental Impact Report	<b>GAO</b>	Government Accountability Office

<b>GBS</b>	Gravity-Based Structure	<b>MAAC</b>	Mid-Atlantic Area Council
<b>GPCM</b>	Gas Pipeline Competition Model	<b>MACT</b>	Maximum Achievable Control Technology
<b>HAP</b>	Hazardous Air Pollutant	<b>MADMF</b>	Massachusetts Division of Marine Fisheries
<b>HAZID</b>	Hazard Identification Study	<b>MARAD</b>	Maritime Administration
<b>HDD</b>	Horizontal Directional Drilling	<b>MDth(/d)</b>	Thousand Dekatherms (per day)
<b>ICAP</b>	Installed Capacity	<b>mg/L</b>	Milligrams per liter
<b>IGTS-Z2</b>	Iroquois Gas Transmission System Zone 2	<b>MMBtu</b>	Million British thermal units
<b>IRA</b>	Independent Risk Assessment	<b>MMcf(/d)</b>	Million cubic feet (per day)
<b>ISO</b>	Independent System Operator	<b>MPA</b>	Marine Protected Area
<b>ISO-NE</b>	Independent System Operator – New England	<b>MW</b>	Megawatt
<b>KEDLI</b>	KeySpan Energy Delivery – Long Island	<b>MWh</b>	Megawatt hour
<b>KEDNY</b>	KeySpan Energy Delivery – New York	<b>NAA</b>	No Anchoring Area
<b>km</b>	Kilometer	<b>NAPP</b>	Northern Appalachia
<b>kW</b>	kilowatt	<b>NEB</b>	National Energy Board
<b>kW/m<sup>2</sup></b>	kilowatts per meter squared	<b>NEI</b>	Nuclear Energy Institute
<b>LAI</b>	Levitan & Associates, Inc.	<b>NEPA</b>	National Environmental Policy Act
<b>LDC</b>	Local Distribution Company	<b>NFGDC</b>	National Fuel Gas Distribution Corporation
<b>LFL</b>	Lower Flammability Limit	<b>NFPA</b>	National Fire Protection Association
<b>LICAP</b>	Locational Installed Capacity	<b>NGA</b>	Northeast Gas Association
<b>LIPA</b>	Long Island Power Authority	<b>NGPA</b>	Natural Gas Policy Act
<b>LISS</b>	Long Island Sound Study	<b>NMFS</b>	National Marine Fisheries Service
<b>LLNL</b>	Lawrence Livermore National Laboratory	<b>NMPC</b>	Niagara Mohawk Power Corporation
<b>LNG</b>	Liquefied Natural Gas	<b>NOAA</b>	National Oceanic and Atmospheric Administration
<b>LP</b>	Linear Programming	<b>NO<sub>x</sub></b>	Nitrogen oxides
<b>LSE</b>	Load-Serving Entity	<b>NWC</b>	Naval Weapons Center
<b>M&amp;N</b>	Maritimes and Northeast	<b>NYCA</b>	New York Control Area
<b>m</b>	Meter		
<b>m<sup>2</sup></b>	Square meters		
<b>m<sup>3</sup></b>	Cubic meters		

<b>NYCRR</b>	New York State Codes Rules and Regulations	<b>RGGI</b>	Regional Greenhouse Gas Initiative
<b>NYFS</b>	New York Facilities System	<b>RPM</b>	Reliability Pricing Model
<b>NYH</b>	New York Harbor	<b>RPS</b>	Renewable Portfolio Standard
<b>NYISO</b>	New York Independent System Operator	<b>RPT</b>	Rapid Phase Transition
<b>NYMEX</b>	New York Mercantile Exchange	<b>RTEP</b>	Regional Transmission Expansion Plan
<b>NYPSC</b>	New York Public Service Commission	<b>Sandia</b>	Sandia National Laboratories
<b>NYSDEC</b>	New York State Department of Environmental Conservation	<b>SCADA</b>	Supervisory Control and Data Acquisition
<b>NYSDOS</b>	New York State Department of State	<b>SCR</b>	Selective Catalytic Reduction
<b>NYSEG</b>	New York State Electric and Gas	<b>SCV</b>	Submerged Combustion Vaporizer
<b>NYSERDA</b>	New York State Energy Research and Development Authority	<b>SEQRA</b>	State Environmental Quality Review Act
<b>NYSOGS</b>	New York State Office of General Services	<b>SIP</b>	State Implementation Plan
<b>O&amp;R</b>	Orange and Rockland	<b>SNCR</b>	Selective Non-Catalytic Reduction
<b>OPEC</b>	Organization of the Petroleum Exporting Countries	<b>SPCC</b>	Spill Prevention, Control and Countermeasure
<b>ORV</b>	Open Rack Vaporizer	<b>SPDES</b>	State Pollutant Discharge Elimination System
<b>OTC</b>	Ozone Transport Commission	<b>SRV</b>	Shuttle Regasification Vessel
<b>PFSP</b>	Preliminary Facility Security Plan	<b>STL</b>	Submerged Turret Loading
<b>PJM</b>	PJM Interconnection	<b>STV</b>	Shell and Tube Vaporizer
<b>PILOT</b>	Payments in Lieu of Taxes	<b>SVA</b>	Security and Vulnerability Assessment
<b>ppm</b>	Parts per million	<b>Tcf</b>	Trillion cubic feet
<b>PSD</b>	Prevention of Significant Deterioration	<b>tpy</b>	Tons per year
<b>psi</b>	Pounds per square inch	<b>TSS</b>	Total Suspended Solids
<b>PSVA</b>	Preliminary Security and Vulnerability Assessment	<b>TZ6-NY</b>	Transco Zone 6 – New York
<b>R/P</b>	Reserves to Production ratio	<b>UCAP</b>	Unforced Capacity
<b>RFO</b>	Residual Fuel Oil	<b>UFL</b>	Upper Flammability Limit
<b>RG&amp;E</b>	Rochester Gas & Electric	<b>USACE</b>	U.S. Army Corps of Engineers
		<b>USCG</b>	U.S. Coast Guard

**VOC** Volatile Organic Compound  
**VP** Virginia Power  
**WCSB** Western Canada Sedimentary  
Basin

**WHRU** Waste Heat Recovery Unit  
**WSR** Waterways Suitability Report  
**WTI** West Texas Intermediate  
**YMS** Yoke Mooring System