Long Term Contracting and Import Infrastructure Investments in Liberalized Natural Gas Markets

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Franziska Holz
Anne Neumann
Sophia Ruester
Christian von Hirschhausen

German Institute for Economic Research

Chair of Energy Economics
and Public Sector Management

Background: EE² / DIW Program "Resource Markets" (2007-2010)

- Jointly between TU Dresden, Chair of Energy Economics and Public Sector Management (EE²) and DIW Berlin, with external cooperations
- Research and advice to policy makers and the corporate sector, four modules:

Computational models of resource markets (gas, coal, oil)

- Competition/oligopoly, effect on prices and quantities
- Infrastructure bottlenecks (pipelines, LNG-terminals)

Role of Russia …

Econometric analysis of energy price developments

- Relation between North American, European, Asian gas, oil, and coal prices
- Cointegration and/or convergence of international energy prices?

Institutional economic modeling on governance structures and contracts, competition policy

- Nexus between regulation and contracts
- Changing role of long-term contracts
- Vertical integration

R&D&Innovation in a Carbon-Constrained World

- Nexus between energy technologies and RD3I
- E.g. development of CCS-technologies

EE²

DIW BERLIN

http://www.ee2.biz
http://www.tu-dresden.de/wwbwleeg/projekte/rm.html

EE^2 / DIW Program Resource Markets” (2007-2010): Publications

- *WP-RM-15 Ruud Egging, Franziska Holz, Christian von Hirschhausen, Steven A. Gabriel*
  “Representing GASPEC with the World Gas Model”
- WP-RM-14 *Clemens Haftendorn and Franziska Holz*
  “Analysis of the World Market for Steam Coal Using a Complementarity Model“
- WP-RM-13 *Clemens Haftendorn, Christian von Hirschhausen, and Franziska Holz*
  “Moving towards a "Coal-PEC"?“
- WP-RM-12 *Anne Neumann*
  “Linking Natural Gas Markets - Is LNG Doing Its Job?“
- WP-RM-11 *Marcus Stronzik, Margarethe Rammerstorfer, Anne Neumann*
  “Theory of Storage - An Empirical Assessment of the European Natural Gas Market“
- WP-RM-10 *Ruud Egging, Franziska Holz, Christian von Hirschhausen, Daniel Huppmann, Sophia Ruester, Steven A. Gabriel*
  “The World Gas Market in 2030 - Calculation of Development Scenarios Using the World Gas Model”
- WP-RM-09 *Ruud Egging*
  “World Gas Model (WGM)“
- _WP-RM-08 *Franziska Holz, Christian von Hirschhausen, Claudia Kemfert*
  “Perspectives of the European Natural Gas Markets until 2025“
- WP-RM-07 *Sophia Ruester*
  “Changing Contract Structures in the International Liquefied Natural Gas Market - A First Empirical Analysis“
- WP-RM-06 *Anne Neumann and Christian von Hirschhausen*
  “How to Measure Security of Supply?“
- WP-RM-05 *Christian von Hirschhausen, Clemens Haftendorn and Anne Neumann*
  “It's coal, stupid! Is it?“
- WP-RM-04 *Sophia Ruester and Anne Neumann*
  “Next Year, Next Decade, Never? The Prospects of Liquefied Natural Gas Development in the US“
- WP-RM-03 *Anne Neumann*
- “Transatlantic Natural Gas Price Convergence - Is LNG Doing Its Job?“
- WP-RM-02 *Christian von Hirschhausen and Franziska Holz*

Agenda: What the Electricity Sector Can Learn from Long-Term Contracts in the Upstream Natural Gas Markets

1. Introduction

2. Importance of Long-term Contracts is Reduced

   ➔ In liberalized markets, companies use more short-term trading

3. Infrastructure Investment is Forthcoming

   ➔ No inherent conflict between liberalization and infrastructure investments (both Europe and the U.S.)

4. A Different Ballgame: Supply In-Security in Eastern Europe

   ➔ Specific instruments (public policy) may be justified

5. Conclusions

Natural Gas Value Chain: Import Infrastructure for Secure Supplies

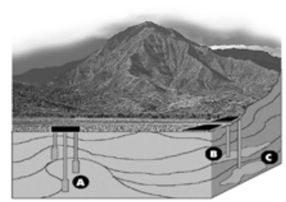
a) Production

b) Liquefaction

c) Shipping

d) LNG-Regasification

e) Pipeline



f) Storage

g) Distribution

Agenda

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Structural Changes in the International Natural Gas Industry

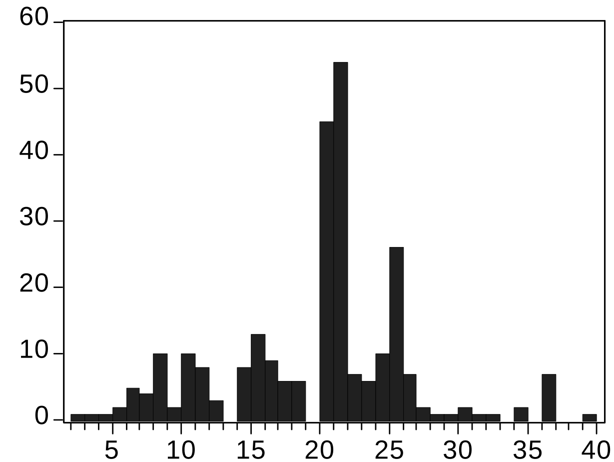
- Relative cost reduction in the LNG value-added chain
  - Economies of scale in liquefaction
  - Lower costs for shipping
  - Economies of scale in regas
- Diminishing asset specificity of investments
  - Formerly: field-specific contracts
  - Nowadays: infrastructure developed, less hold-up risk, more general country-focused contracts
  - More players on both sides (producers, traders, importers)
- Development of spot markets and shorter-term trading
- Increased number of market participants
  - Producers
  - Buyers

➔ Less need for long-term contracts to overcome the hold-up problem

Contract Data Base

All contracts

Number of contracts

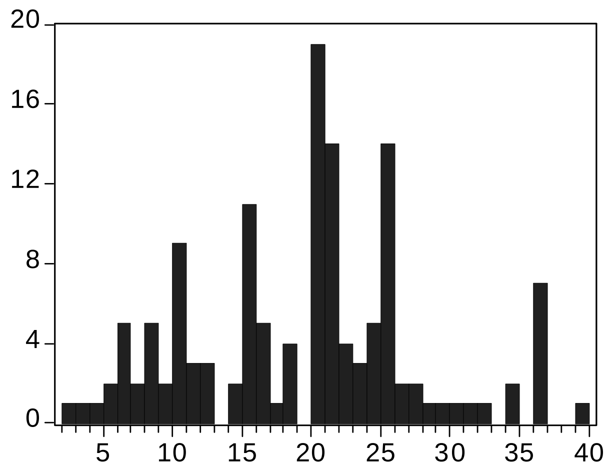


Series: CD	
Sample 1 262	
Observations 262	
Mean	19.28435
Median	20.00000
Maximum	39.00000
Minimum	2.000000
Std. Dev.	6.678600
Skewness	-0.084494
Kurtosis	3.464052
Jarque-Bera	2.662583
Probability	0.264136

Contract duration (in years)

European contracts

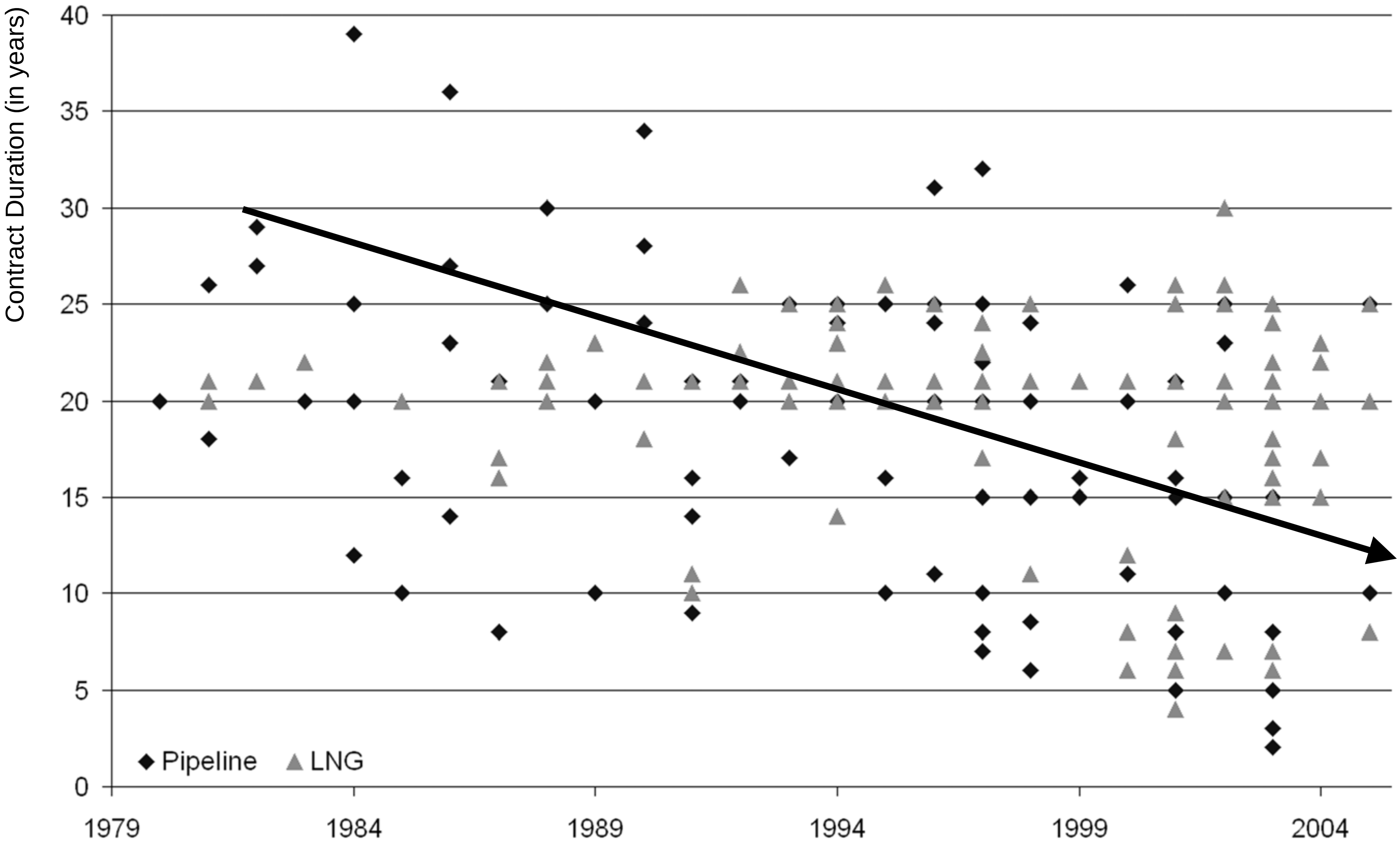
Number of contracts



Series: CD	
Sample 1 135	
Observations 135	
Mean	18.95926
Median	20.00000
Maximum	39.00000
Minimum	2.000000
Std. Dev.	8.170079
Skewness	0.165087
Kurtosis	2.697388
Jarque-Bera	1.128311
Probability	0.568840

Contract duration (in years)

Diminishing Contract Duration in the Last Decades



Econometric Model to Explain Contract Duration

- **Analogous to Joskow (1987)**

(1) $\text{Contract Duration}_i = c_i + \beta_1 \text{YVol}_i + \beta_2 \text{Dummy}(1990\text{-}1998) + \beta_3 \text{Dummy}(1999\text{-}2005)$

$+ \beta_4 \text{PROJECT} + \beta_5 \text{TRAD} + \beta_6 \text{LNGDummy} + \beta_7 \text{Spot} + \varepsilon_i$

(2) $\text{Contract Duration}_i = c_i + \beta_1 \log(\text{YVol}_i) + \beta_2 \text{Dummy}(1990\text{-}1998) + \beta_3 \text{Dummy}(1999\text{-}2005) + \beta_4 \text{PROJECT} + \beta_5 \text{TRAD} + \beta_6 \text{LNGDummy} + \beta_7 \text{Spot} + \varepsilon_i$

(3) $\text{Log}(\text{Contract Duration}_i) = c_i + \beta_1 \log(\text{YVol}_i) + \beta_2 \text{Dummy}(1990\text{-}1998) + \beta_3 \text{Dummy}(1999\text{-}2005) + \beta_4 \text{PROJECT} + \beta_5 \text{TRAD} + \beta_6 \text{LNGDummy} + \beta_7 \text{Spot} + \varepsilon_i$

CD – contract duration (years)
YVol – yearly contracted volume (in bcm)
PROJECT – contract concluded in greenfield infrastructure project and extension (LNG)
TRAD – traditional player vs. incumbent
LNGDummy – identifies LNG contracts
SPOT – share of LNG spot trade in worldwide LNG trade (percentage per year)

Results Europe: Structural Change and Project Specificity

	OLS	ML		
Specification	**(1)**	**(1)**	**(2)**	**(3)**
C	**20.90***** (0.0000)	**21.18***** (0.0000)	13.15 (0.9913)	2.54 (0.9995)
YVOL	**0.95***** (0.0000)	**0.98***** (0.0000)	**3.12***** (0.0000)	**0.22***** (0.0000)
D1990-1998	**-5.08***** (0.0055)	**-5.97***** (0.0012)	3.84 (0.9975)	0.16 (1.0000)
D1999-2005	**-9.21***** (0.0050)	**-9.99*** (0.0504)	-0.99 (0.9993)	-0.21 (1.0000)
PROJECT	**5.34***** (0.0001)	**5.97***** (0.0000)	**3.97***** (0.0020)	**0.28**** (0.0115)
TRAD	-1.01 (0.4472)	-0.48 (0.7539)	-0.37 (0.7714)	-0.04 (0.7125)
LNGDUMMY	0.96 (0.4228)	0.99 (0.5159)	1.08 (0.4043)	0.13 (0.1888)
SPOT	-0.14 (0.6939)	-0.17 (0.7738)	-0.44 (0.7298)	-0.02 (0.8760)
R^2		0.429	0.388	0.343
Adj. R^2		0.393	0.338	0.289

Reported are estimated coefficients and p-values. ***, **,* indicate significance at 1%, 5%, and 10% level

Conclusions 1

- Long-term contracts tend to loose importance in liberalized markets

- Decreasing asset-specificity along the value chain of natural gas

- Contract duration is for specific investments

➔ In liberalized markets, companies want to use more short-term trading

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3. Infrastructure Investment is Forthcoming (Europe and U.S.)
4. A Different Ballgame: Supply In-Security in Eastern Europe
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Holding Back Regasification Investments May Have Strategic Reasons

- „Traditional“ Cournot strategy, i.e. withholding of capacity
  - e.g. E.ON Ruhrgas terminal in Wilhemshaven
  - Unused for 30 years now
  - If built, BNetzA would require a significant share of TPA
  - Company prefers to benefit from dominant position with dominantly Russian pipeline gas

- Real option value of „waiting“, it may pay of to delay investment
  - In times of high uncertainty, e.g. on natural gas prices or investment costs, there is a „real option“ of waiting with sunk investments, because one might benefit from NOT investing
  - If the „option value“ is positive, traditional NPV calculations do not indicate the optimal solution
  - E.g. South Hook (Milford Heaven)

South Hook (Milford Haven) – Construction Site

- **South Hook Terminal Company Ltd.**
- **Shareholders: ExxonMobil (30%), Qatar Petroleum (70%)**
- **Planned start up: 2008**
- **Capacity: up to 10.5 bcm/a**

Results (in million EUR)

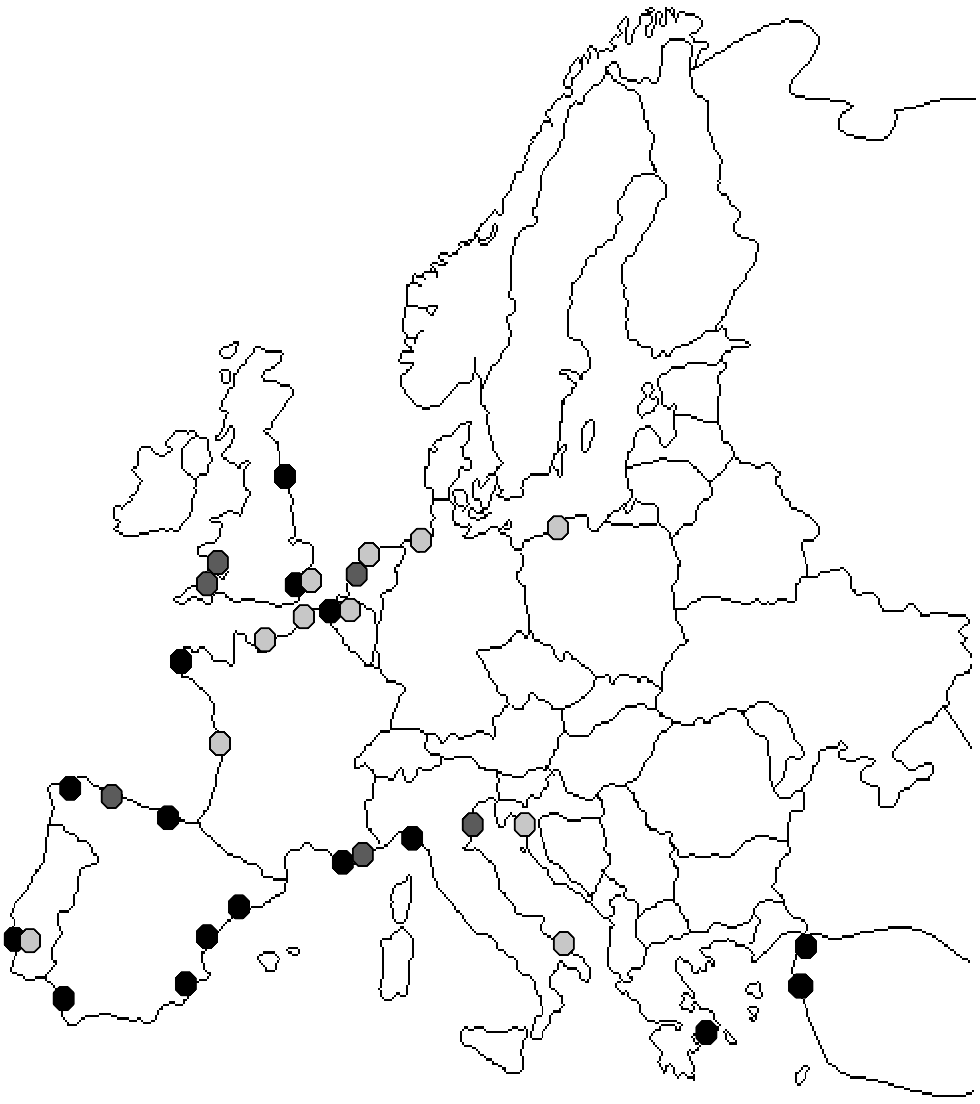
	Traditional assessment	2010 high	2015 high high	2015 high medium	2015 high low	2015 medium high
Net present value (NPV)	165.7	509.5	676.5	338.0	-0.48	338.0
Value of the real option	n/a	**343.8**	**510.8**	**172.3**	**0**	**172.3**

The ability to wait and hence the ability to delay the realization of the project has a value of up to 510 million EUR. So it would have been profitable to postpone the investment.

Europe: Investment is Forthcoming, even though LTCs are less Important than Before

- “Money (rate-of-return) plays no role”
- UK and Spain examples show that investments in LNG terminals are forthcoming
- This holds most likely for other countries/terminals as well

European LNG Import Capacities



Existing

Under construction

Planned

EE²

Development of LNG Import Capacities in Spain and the UK has taken off

Terminal	MS	Start up	Cap. (mtpa)	Storage (m^3)	Operator
Huelva Phase I	**ES**	**1988**	**2.6**	**160,000**	**Enagas**
Huelva Phase II		**2004**	**1**	**150,000**	**Enagas**
Huelva Phase III		**2006**	**2.8**	**150,000**	**Enagas**
Cartagena Phase I		**1989**	**3.8**	**160,000**	**Enagas**
Cartagena Phase II		**2004**	**2**	**135,000**	**Enagas**
Cartagena Phase III		**2007**	**1.1**	**135,000**	**Enagas**
Barcelona Phase I		**1969**	**7.6**	**240,000**	**Enagas**
Barcelona Phase II		**2005**	**2.9**	**150,000**	**Enagas**
Bilbao		**2003**	**2.2**	**300,000**	**Bahia de Bizkaia Gas**
El Ferrol		**2007**	**2.7**	**300,000**	**Regasificadora del Noreste SA**
Sagunto		**2006**	**4.8**	**300,000**	**Planta de Regasification de Sagunto**
Dragon/ Milford Haven	**UK**	**2008**	**4.5**	**336,000**	**Dragon LNG Ltd.**
Isle of Grain Phase I		**2005**	**3.5**	**200,000**	**Grain LNG Ltd.**
Isle of Grain Phase II		**2010**	**7**	**500,000**	**Grain LNG Ltd.**
Teeside (offshore)		**2007**	**tba**	**tba**	**Excelerate**
South Hook Phase I		**2008**	**7.8**	**465,000**	**South Hook Terminal Company Ltd.**
South Hook Phase II		**2010**	**7.8**	**310,000**	**South Hook Terminal Company Ltd.**
Canvey Island		**Under study**	**tba**	**tba**	**Calor Gas**

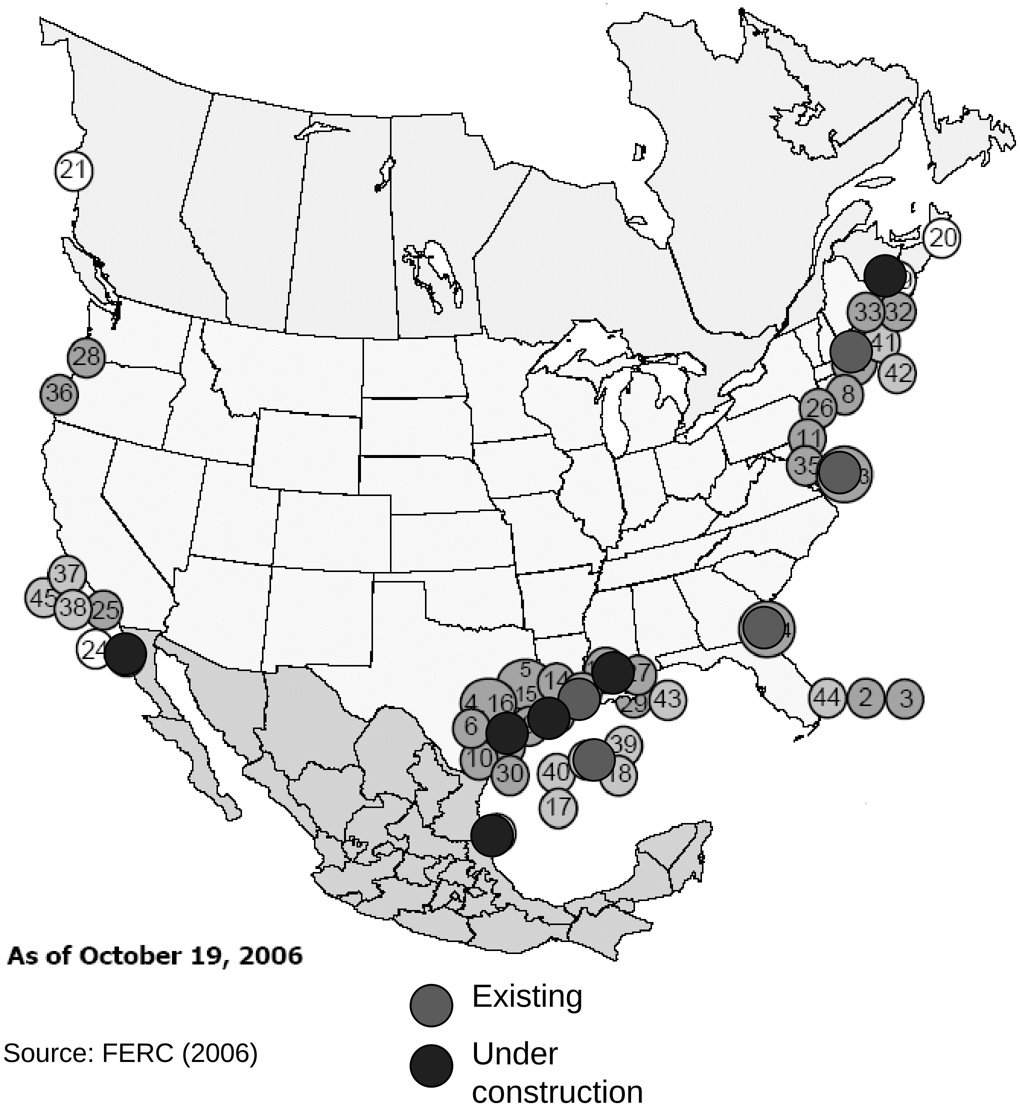
Pipeline Capacity Expansions in Europe 2005-08

From	To	Border point/ Project	Capacity 2005 (in m³/h)	Capacity 2008 (in m³/h)	Expansion (in m³/h)
Norway	UK	Langeled pipe	0	2.74	2.74
		Tampen link	0	1.0	1.0
Netherlands	UK	Interconnector	0	1.62	1.62
Belgium	UK	Interconnector	1.0	2.7	1.7
Spain	France	Biriatou (Irun)	no data	0.01	0.01
France	Belgium	Taisnières	0	0.26	0.26
Austria	Slovakia	Baumgarten	no transit	2.67	2.67
Germany	Czech Rep.	Deutsch Neudorf	0	0.76	0.76

Source: GTE, 2005 and 2008

www.gte.be

Similar Dynamic is Prevalent in North American LNG



As of October 19, 2006

Source: FERC (2006)

CONSTRUCTED

A. Everett, MA : 1.035 Bcfd (SUEZ/Tractebel - DOMAC)
B. Cove Point, MD : 1.0 Bcfd (Dominion - Cove Point LNG)
C. Elba Island, GA : 1.2 Bcfd (El Paso - Southern LNG)
D. Lake Charles, LA : 2.1 Bcfd (Southern Union - Trunkline LNG)
E. Gulf of Mexico: 0.5 Bcfd (Gulf Gateway Energy Bridge - Excelerate Energy)

APPROVED BY FERC

1. Hackberry, LA : 1.5 Bcfd (Cameron LNG - Sempra Energy) ←
2. Bahamas : 0.84 Bcfd (AES Ocean Express)*
3. Bahamas : 0.83 Bcfd (Calypso Tractebel)*
4. Freeport, TX : 1.5 Bcfd (Cheniere/Freeport LNG Dev.) ←
5. Sabine, LA : 2.6 Bcfd (Sabine Pass Cheniere LNG)
6. Corpus Christi, TX: 2.6 Bcfd (Cheniere LNG)
7. Corpus Christi, TX : 1.1 Bcfd (Vista Del Sol - ExxonMobil)
8. Fall River, MA : 0.8 Bcfd (Weaver's Cove Energy/Hess LNG)
9. Sabine, TX : 2.0 Bcfd (Golden Pass - ExxonMobil) ←
10. Corpus Christi, TX: 1.0 Bcfd (Ingleside Energy
11. Logan Township, NJ : 1.2 Bcfd (Crown Landing LNG - BP)
12. Port Arthur, TX: 3.0 Bcfd (Sempra)
13. Cove Point, MD : 0.8 Bcfd (Dominion)
14. Cameron, LA: 3.3 Bcfd (Creole Trail LNG - Cheniere LNG)
15. Sabine, LA: 1.4 Bcfd (Sabine Pass Cheniere LNG - Expansion)
16. Freeport, TX: 2.5 Bcfd (Cheniere/Freeport LNG Dev. - Expansion)

APPROVED BY MARAD/COAST GUARD

17. Port Pelican: 1.6 Bcfd (Chevron Texaco)
18. Louisiana Offshore : 1.0 Bcfd (Gulf Landing - Shell)

CANADIAN APPROVED TERMINALS

19. St. John, NB : 1.0 Bcfd (Canaport - Irving Oil) ←
20. Point Tupper, NS 1.0 Bcf/d (Bear Head LNG - Anadarko)
21. Kitimat, BC: 0.61 Bcfd (Galveston LNG)

MEXICAN APPROVED TERMINALS

22. Altamira, Tamulipas : 0.7 Bcfd (Shell/Total/Mitsui) ←
23. Baja California, MX : 1.0 Bcfd (Energy Costa Azul - Sempra) ←
24. Baja California - Offshore : 1.4 Bcfd (Chevron Texaco)

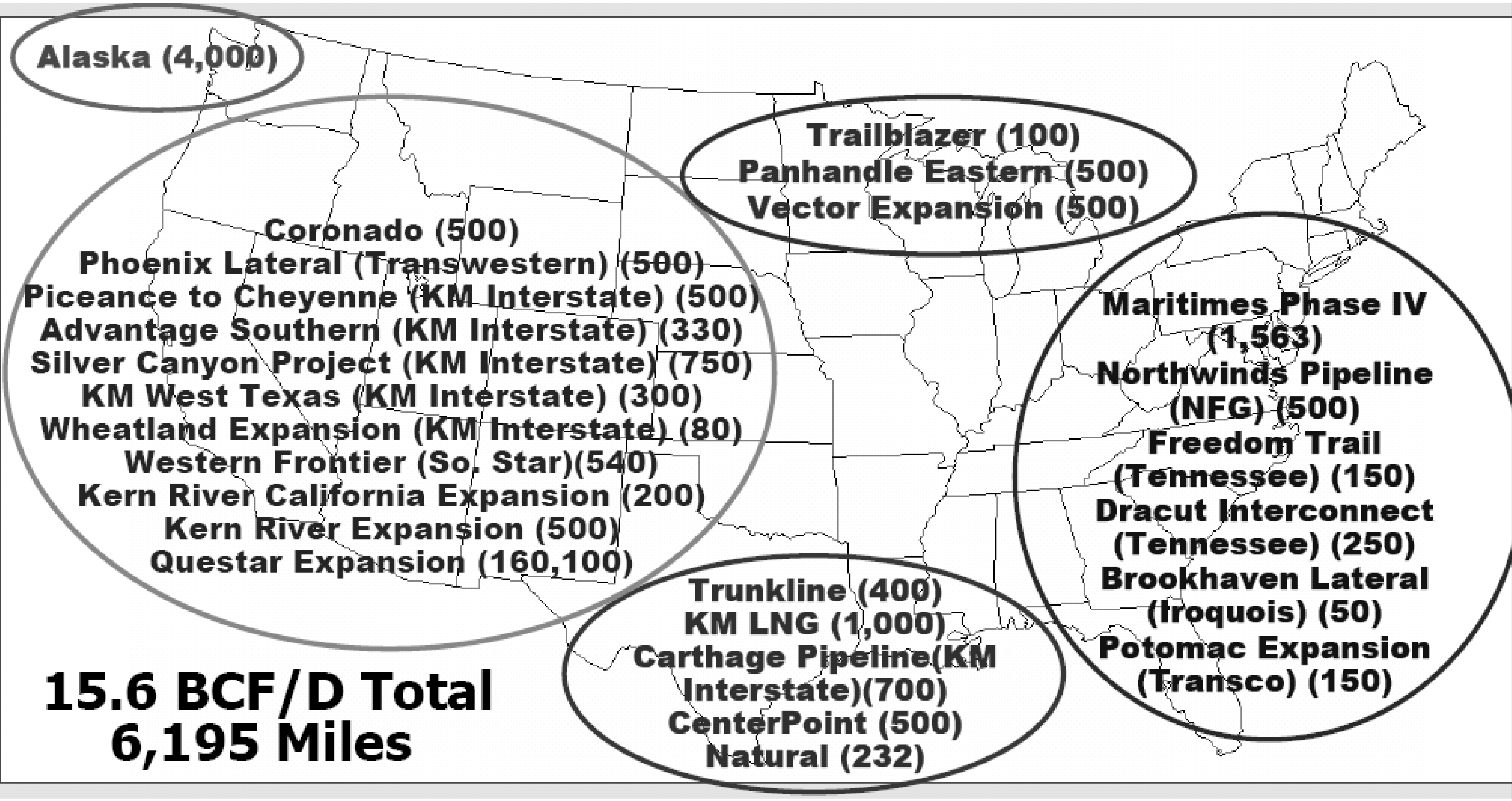
PROPOSED TO FERC

25. Long Beach, CA : 0.7 Bcfd, (Mitsubishi/ConocoPhillips
26. LI Sound, NY: 1.0 Bcfd (Broadwater Energy - TransCanada/Shell)
27. Pascagoula, MS: 1.5 Bcfd (Gulf LNG Energy LLC)
28. Bradwood, OR: 1.0 Bcfd (Northern Star LNG
29. Pascagoula, MS: 1.3 Bcfd (Casotte Landing - ChevronTexaco)
30. Port Lavaca, TX: 1.0 Bcfd (Calhoun LNG - Gulf Coast LNG Partners)
31. Hackberry, LA : 1.15 Bcfd (Cameron LNG - Sempra Energy - Expansion)
32. Pleasant Point, ME : 2.0 Bcfd (Quoddy Bay, LLC)
33. Robbinston, ME: 0.5 Bcfd (Downeast LNG - Kestrel Energy)
34. Elba Island, GA: 0.9 Bcfd (El Paso - Southern LNG)
35. Baltimore, MD: 1.5 Bcfd (AES Sparrows Point – AES Corp.)
36. Coos Bay, OR: 1.0 Bcfd (Jordan Cove Energy Project)

PROPOSED TO MARAD/COAST GUARD

37. Offshore California : 1.5 Bcfd (Cabrillo Port - BHP Billiton)
38. Offshore California : 0.5 Bcfd, (Clearwater Port LLC - NorthernStar NG LLC)
39. Offshore Louisiana : 1.0 Bcfd (Main Pass McMoRan Exp.)
40. Gulf of Mexico: 1.5 Bcfd (Beacon Port Clean Energy Terminal - ConocoPhillips)
41. Offshore Boston: 0.4 Bcfd (Neptune LNG - SUEZ LNG)
42. Offshore Boston: 0.8 Bcfd (Northeast Gateway - Excelerate Energy)
43. Gulf of Mexico: 1.4 Bcfd (Bienville Offshore Energy Terminal - TORP)
44. Offshore Florida: ? Bcfd (SUEZ Calypso - SUEZ LNG)
45. Offshore California: 1.2 Bcfd (OceanWay - Woodside Natural Gas)

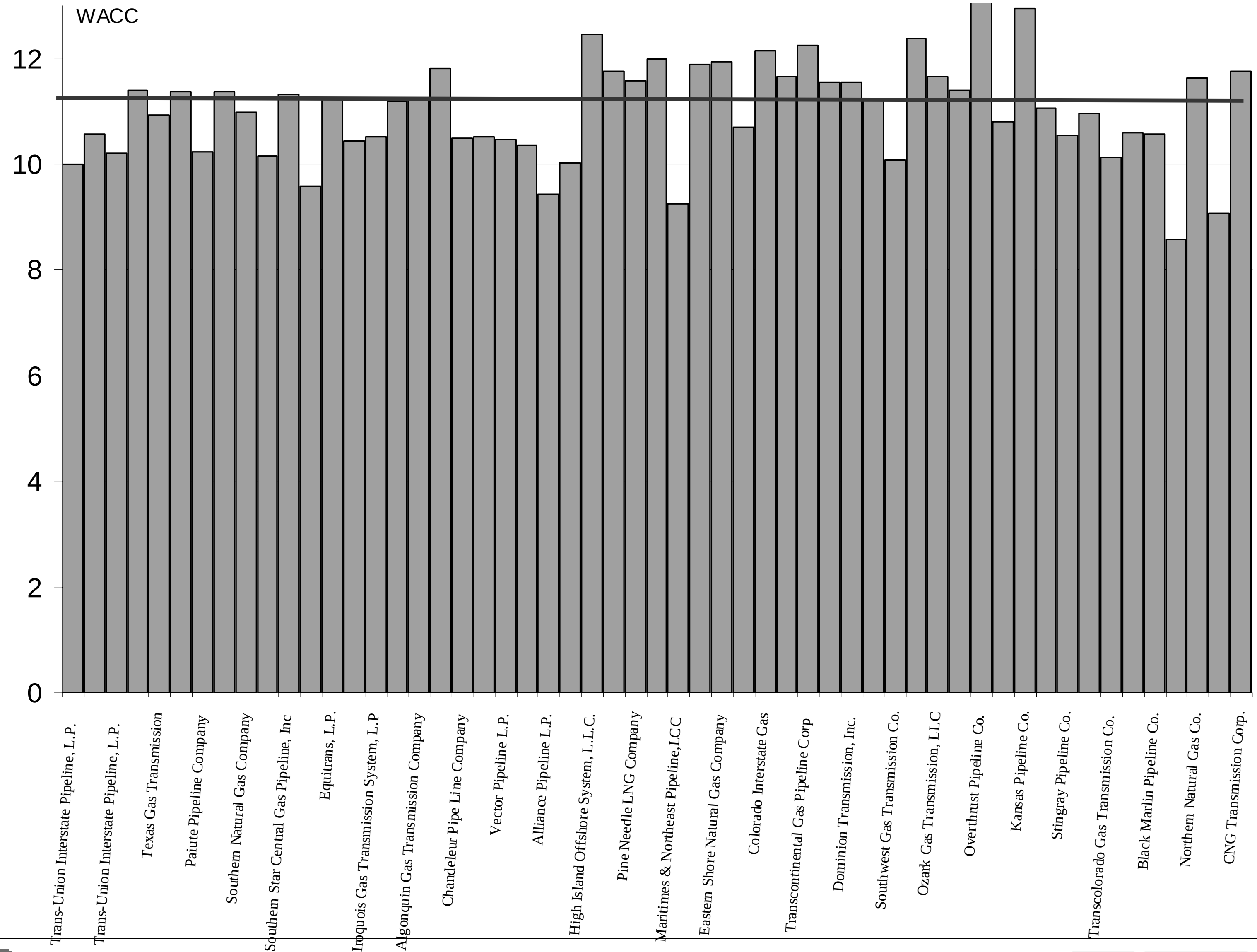
U.S.: Strong Pipeline Investments



Source: FERC

… Albeit at „Generous“ Rates of Return (~11.6%)

(Loeffler, 2005)



Conclusions 2: A „False“ Opposition?

- Traditional „opposition“ between liberalization and investment is not so much an issue in natural gas

- Investment in LNG and pipeline infrastructure is forthcoming, both in Europe and the US

- ➔ No inherent conflict between liberalization and infrastructure investments (both Europe and the U.S.)

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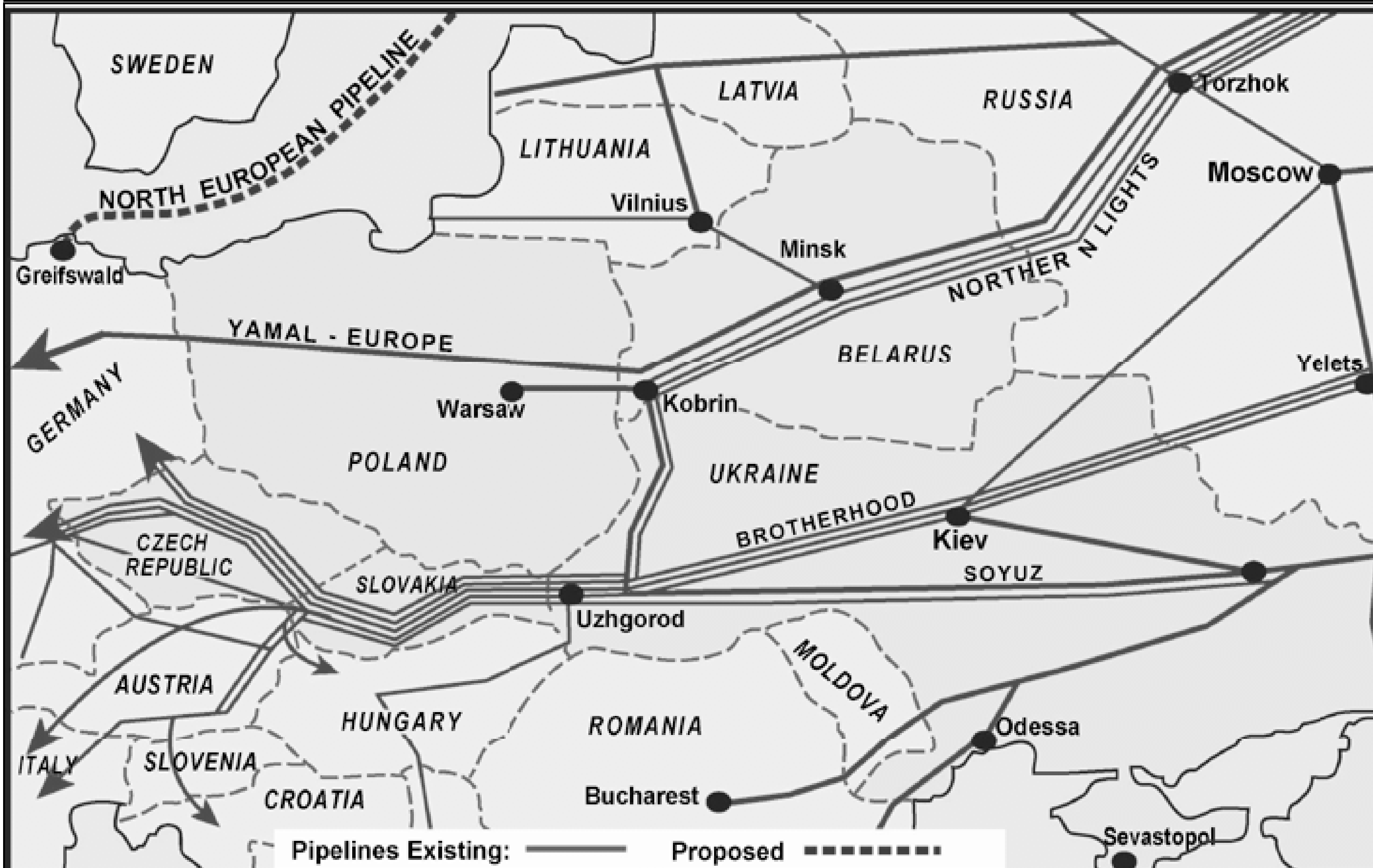
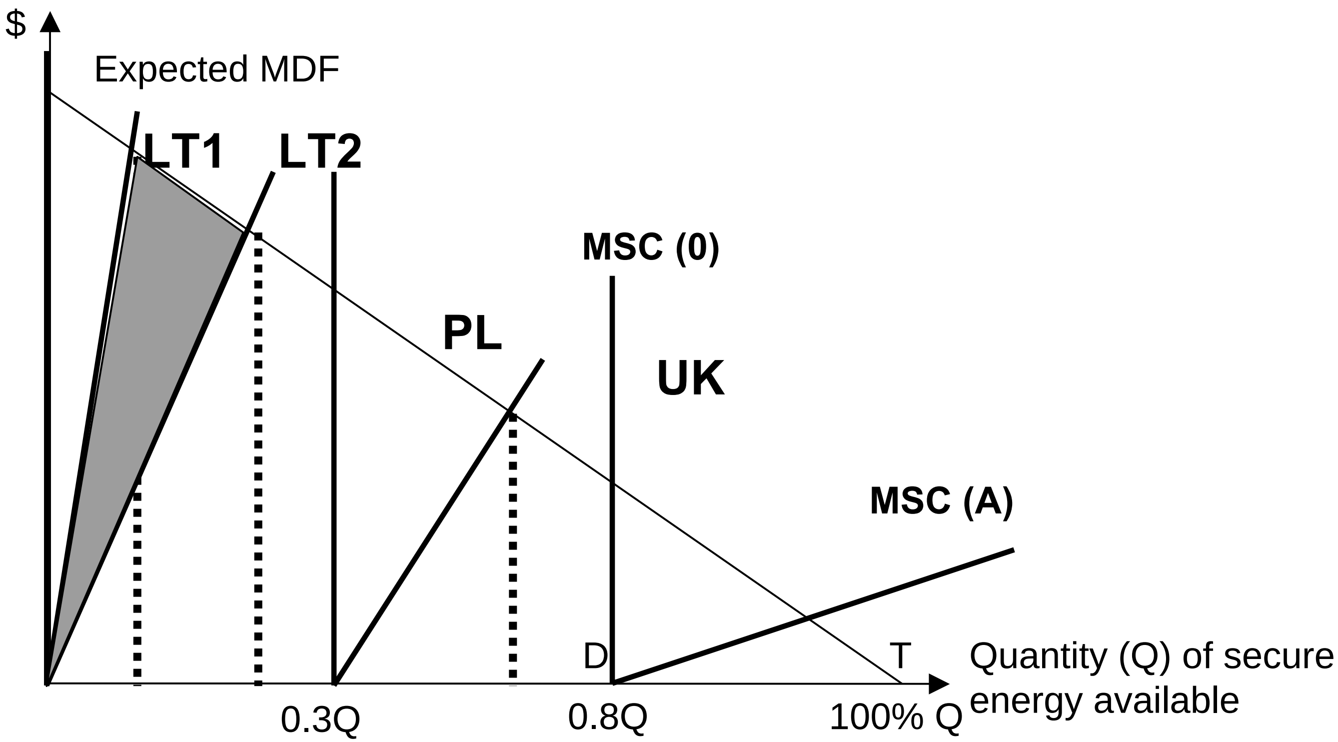
Russia-Ukrainian Gas Crisis (Jan. 2009): So What?; or: „Storm in the Samowar“

Source: AP
www.mosnews.com

Map of Eastern European Pipeline System



Specific Action May be Useful for Particular Countries to Reduce Damage from Short-Term Supply Disruptions



- UK: well diversified, no need for SoS action
- Poland: supply security strategy: storage is used, domestic supply is increased, additional volumes are imported from the importer without disruption (e.g. the case of Poland: reverse the Yamal-Europe Pipeline)
- Lithuania: No domestic resources, + Ignalina nuclear power plant shutdown

➔ Specific action (infrastructure support) may be justified from a social welfare point of view

Conclusion 3: EU Countries Face Different Situations

- „ Old“ European countries (Italy, Spain, UK):
  - No specific worry about natural gas for supply security
- „New“ member countries (e.g. Lithuania, Poland, Hungary) may face a different situation:
  - Dependent upon one country
  - Gas plays a major role
  - Diversification has a particularly high „social value“
- Investment in „more secure“ supply infrastructure yields a social benefit

➔ Some justification for public action, in particular for countries with a sensitive supply situation

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Conclusions: What the Electricity Sector Can Learn from Long-Term Contracts in the Upstream Natural Gas Markets

1. **Importance of Long-term Contracts is Reduced**

   ➔ **In liberalized markets, companies want to use more short-term trading**

2. **Infrastructure Investment is Forthcoming**

   ➔ **No inherent conflict between liberalization and infrastructure investments (both Europe and the U.S.)**

3. **A Different Ballgame: Supply In-Security in Eastern Europe**

   ➔ **Specific instruments (public policy) may be justified**

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Existing Literature

- **Transaction cost economics and agency theory:**
- \- Long-term contracts minimize transaction cost when significant specific assets are required
- Overcome the hold-up problem without vertical integration (Klein, Crawford, and Alchian, 1978, Williamson, 1979)
- Asset-specificity, uncertainty, opportunism, bounded rationailty (Williamson, 1975, 1985)
- Sufficient investment incentives and inexpensive <u>ex- post</u> renegotiation

• **Incomplete contracts:**

- Reduce inefficiencies in <u>ex- ante</u> investments or ex-post exchange (Grossmann / Hart, 1986, Hart / Moore, 1988)
- **Empirical Evidence:**
- Work by Joskow (1987) on contract duration and asset-specificity in American coal industry
- Masten / Crocker (1985) and Crocker / Masten (1988) focus on the US natural gas industry, contractual take-obligations relate negatively with contract duration
- Influence of US governmental regulation on long-term contracts in natural gas sector (Mulherin, 1986, Hubbard / Weiner, 1986, Doane / Spulber, 1994)
- Increasing use of spot transactions in LNG industry (Hartley / Brito, 2002)

Data
(as of August 2007)

Prices		
Price for LNG	**4.20**	**EUR/MBtu**
Price increase p.a.	**0.96**	**%**
Price for natural gas	**4.88**	**EUR/MBtu**
Price increase p.a.	**0.96**	**%**
Volume p.a.		
Natural gas quantity	**150,000,000**	**MBtu**
Costs		
Investment costs	**535**	**million EUR**
Variable costs	**0.0488**	**EUR/MBtu**
Cost increase p.a.	**0.96**	**%**
Staff needed	**15**	**employees**
Staff cost rate	**40,000**	**EUR/a**
Other		
Tax rate	**35**	**%**
Calculatory interest rate	**10.0**	**%**
Running period	**40**	**years**

Sources: IEA Natural Gas Market Review 2007, Prognos, South Hook Terminal Company Ltd.

Results

Economic key data

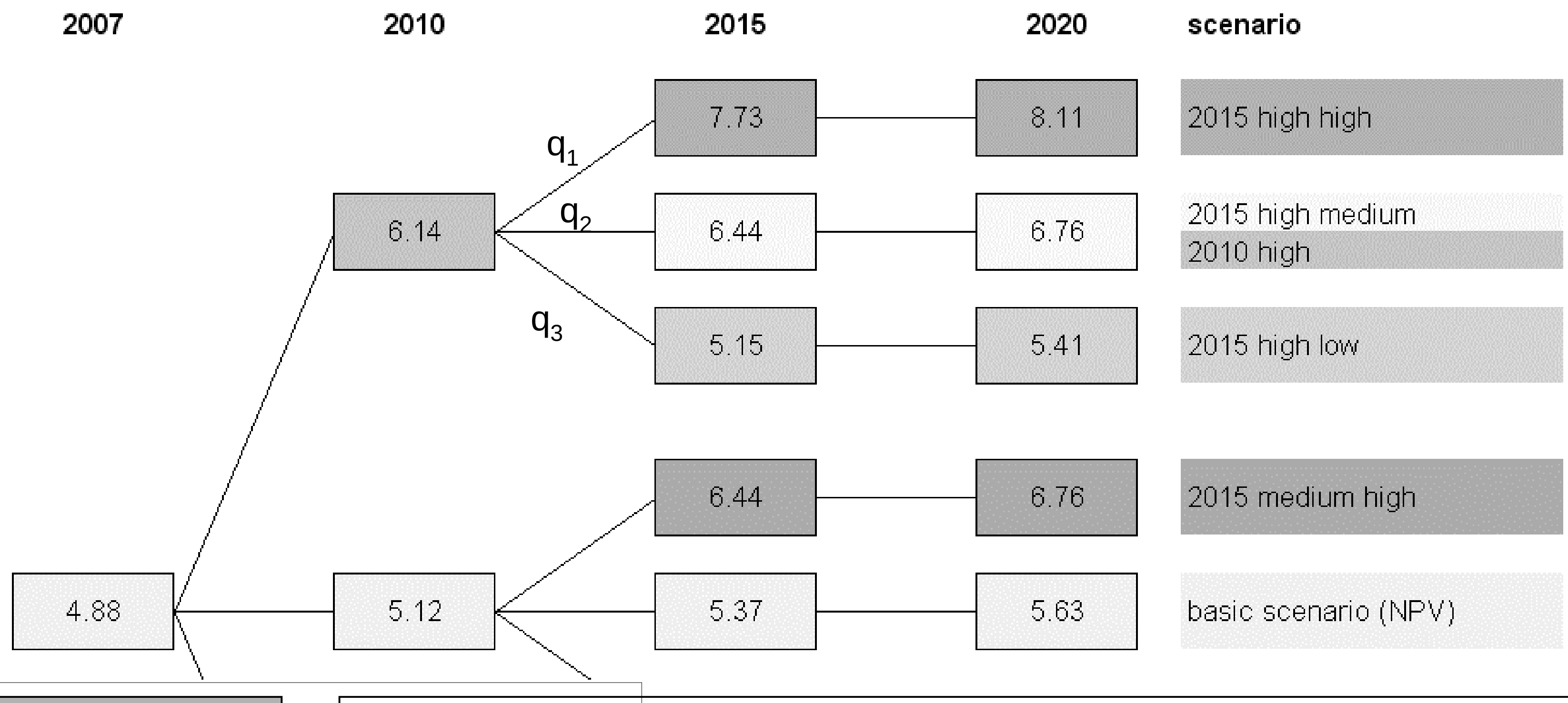
Net present value (NPV)	165.7 million EUR (over 40 years running time)
Internal rate of return[1)] (IRR)	13.08%

Due to the positive NPV the investment in the LNG-Terminal is economical expedient and justifies the project.

1) The IRR is the annualized effective compounded return rate which can be earned on the invested capital, i.e. the yield on the investment.

According to the Real Option Estimation (Value of Waiting) the NPV will be still higher

Effects on natural gas prices

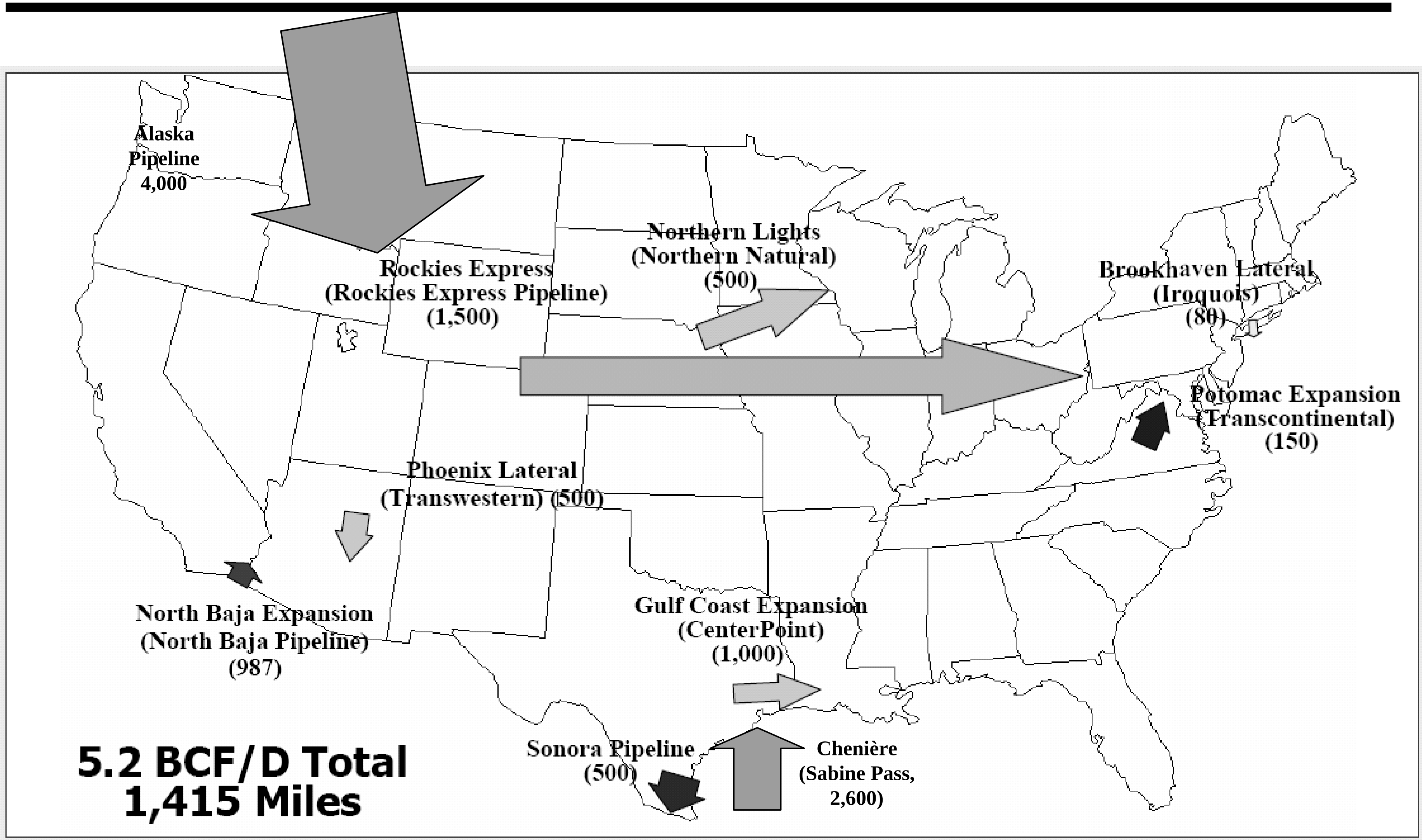


Assumptions of application

- Price volatility: 20% (price rises or falls 20% until 2015)
- Volatility additional to regular price rises per year
- Probability of price rise: q = 50%
- Probability of price decline: q_2 = 25% (constant: q_2 = 25%)

Major Pipeline Projects Pre-Filing (MMcf/d), 2005

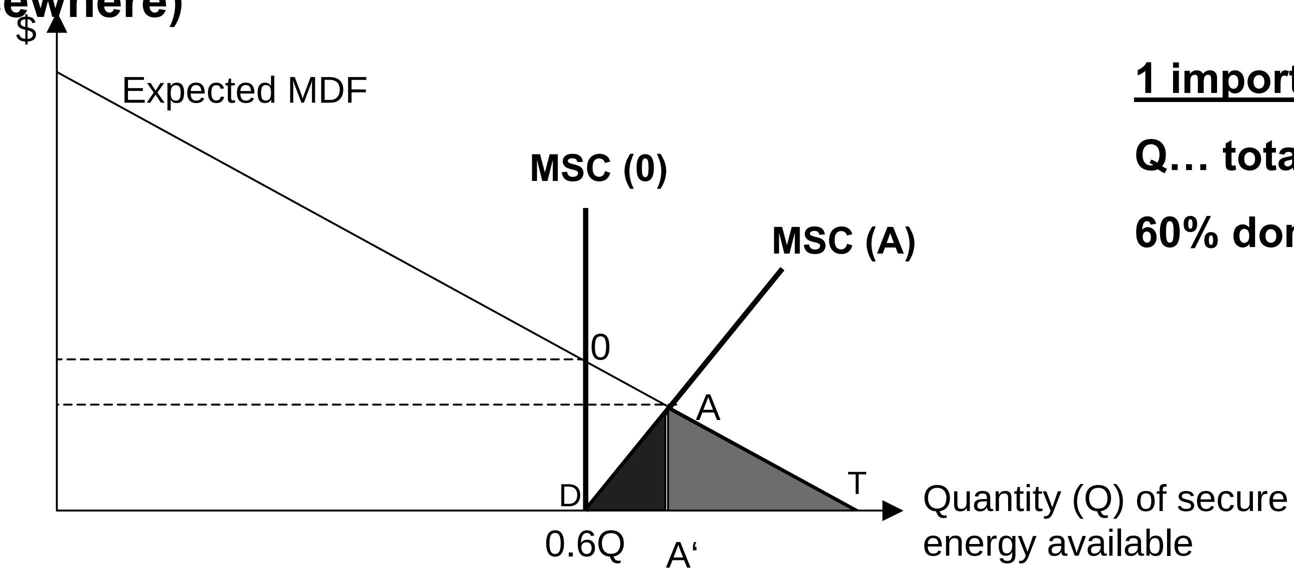
(Court, 2005)



Security of Supply is a Relative Concept
One Should Target the "Optimal" SoS-level

Optimal level of supply security is defined as the situation where the sum of damage, security, and administrative costs is minimized.

Marginal security costs (MSC): providing extra supplies causing additional costs (e.g. use of storage; increase of domestic production, imports from elsewhere)



<u>1 importer – 1 exporter case</u>

Q… total demand

60% domestic production

MSC (0): situation without any supply security strategy, a disruption of imports would reduce total supply to the level of 60%
→ Total costs = damage costs = area DOT

MSC (A): storage is used, domestic supply increased
→ Remaining damage = area A'AT
→ Security costs = DAA'