Removing Cross-Border Capacity Bottlenecks in the European Natural Gas Market
A Proposed Merchant-Regulatory Mechanism

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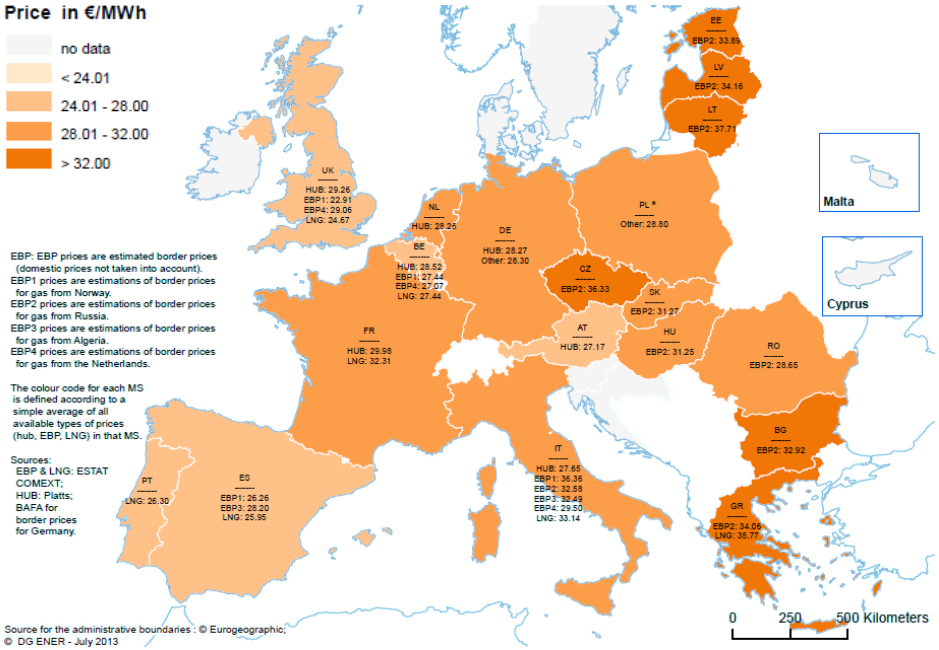
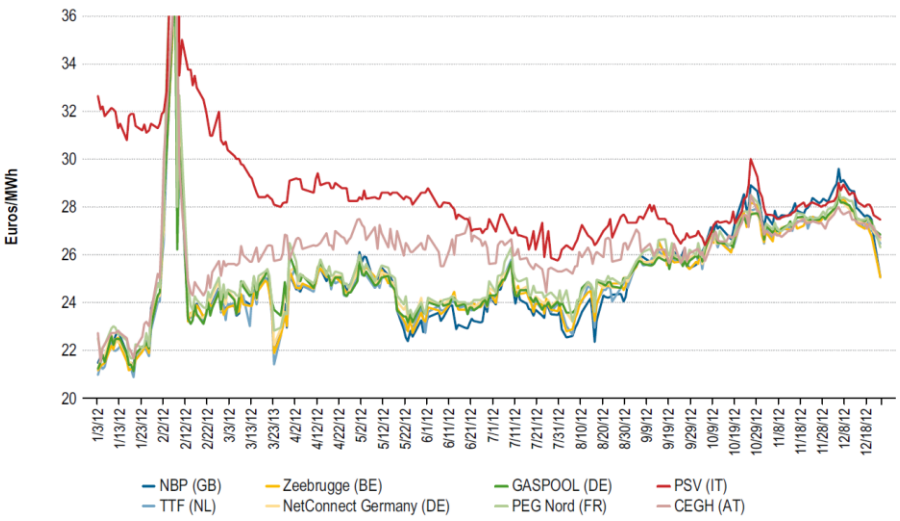
FoNEW Forschungsstelle für Nachhaltige Energie- und Wasserversorgung

Agenda

1. European Natural Gas Network
2. Regulatory Approach
3. Model
4. Scenarios
5. Conclusio

EU Gas Price Differences



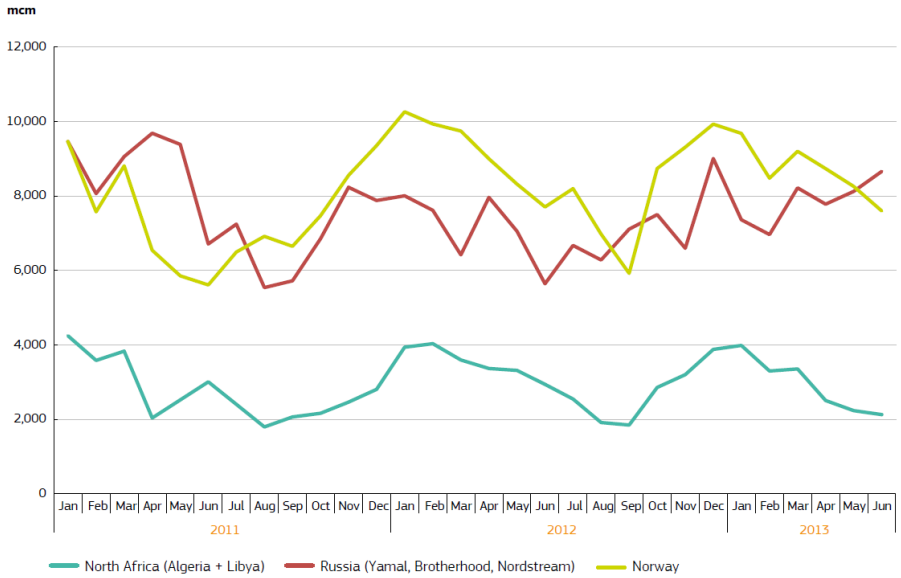


Market Integration is progressing

→ more liquidity and trade activity brings prices together (but dynamic influences)

Source: EC 2013, ACER 2013

Import Dependence



Major import routes (Russia, Norway, Africa) relatively stable shares in recent years

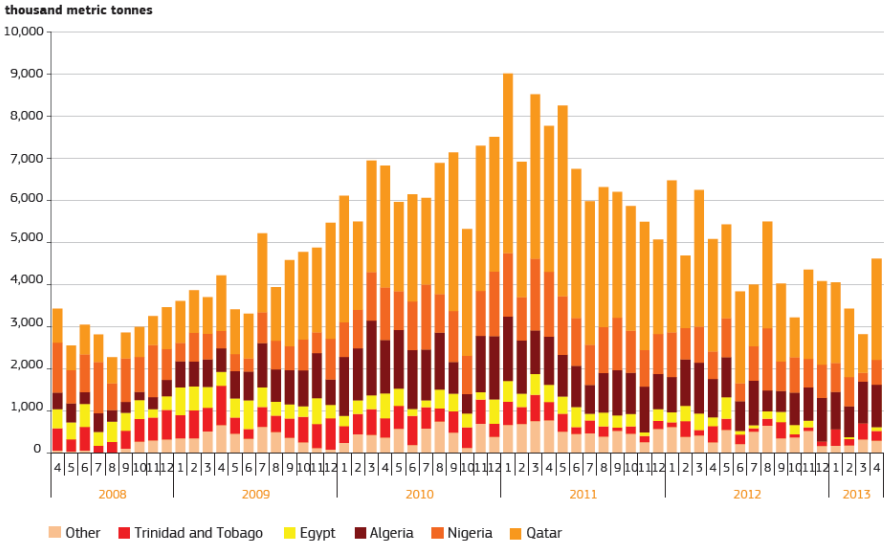
→ Current developments in Russia?

LNG plays an important role for Spain and UK

→ Important source for diversification

Currently declining trend

→ unclear future development (also globally)



Source: EC 2013

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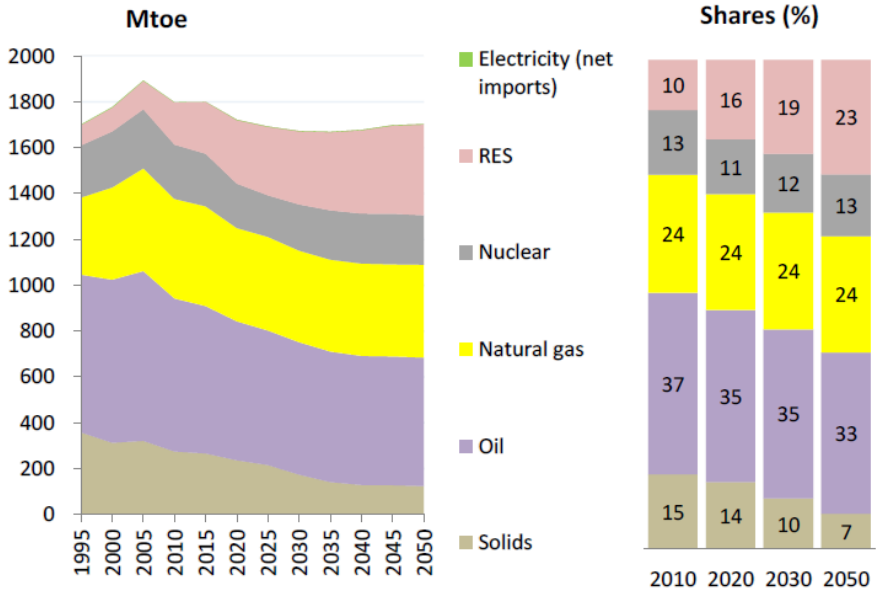
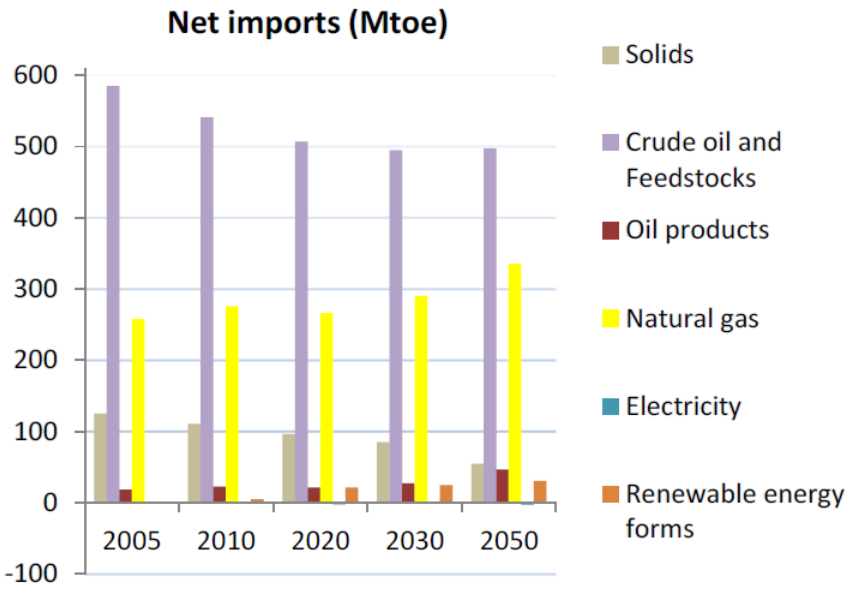
Outlook 2050





The future of natural gas is currently unclear:

- Gas important fossil fuel due to low CO2 content and flexible operation in electricity → should replace coal in the long run
- RES and Energy Efficiency should lead to an overall reduction of fossil fuels → will also reduce need for natural gas

Source: EC 2013

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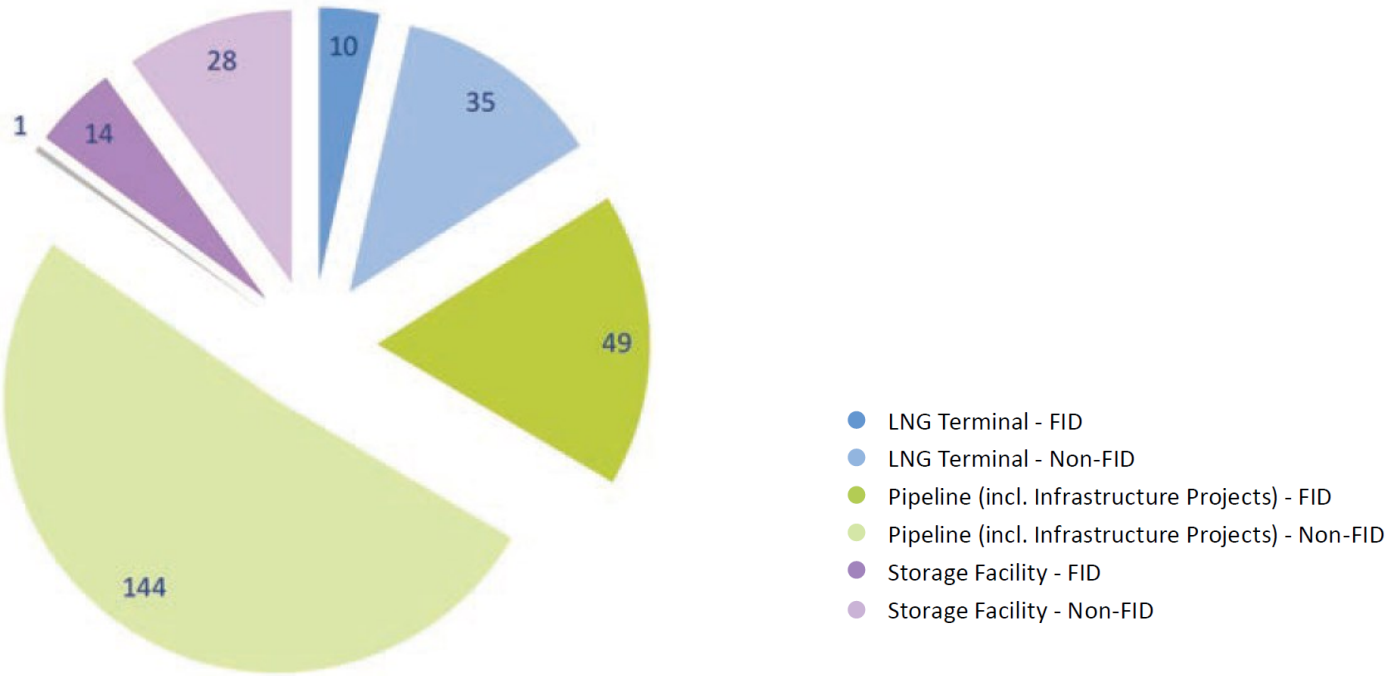
Network Utilization

Market clustered according to import directions with Central EU as mixed zone

With Nord Stream German market can achieve a European hub function in the long run

Network Extension



Network extensions/upgrades represent the majority of planned extensions in the next decade

→ Cross-Border coordination important for optimal investment decisions

→ Interaction with electricity (network) market highly relevant

Source: ENTSOG 2013

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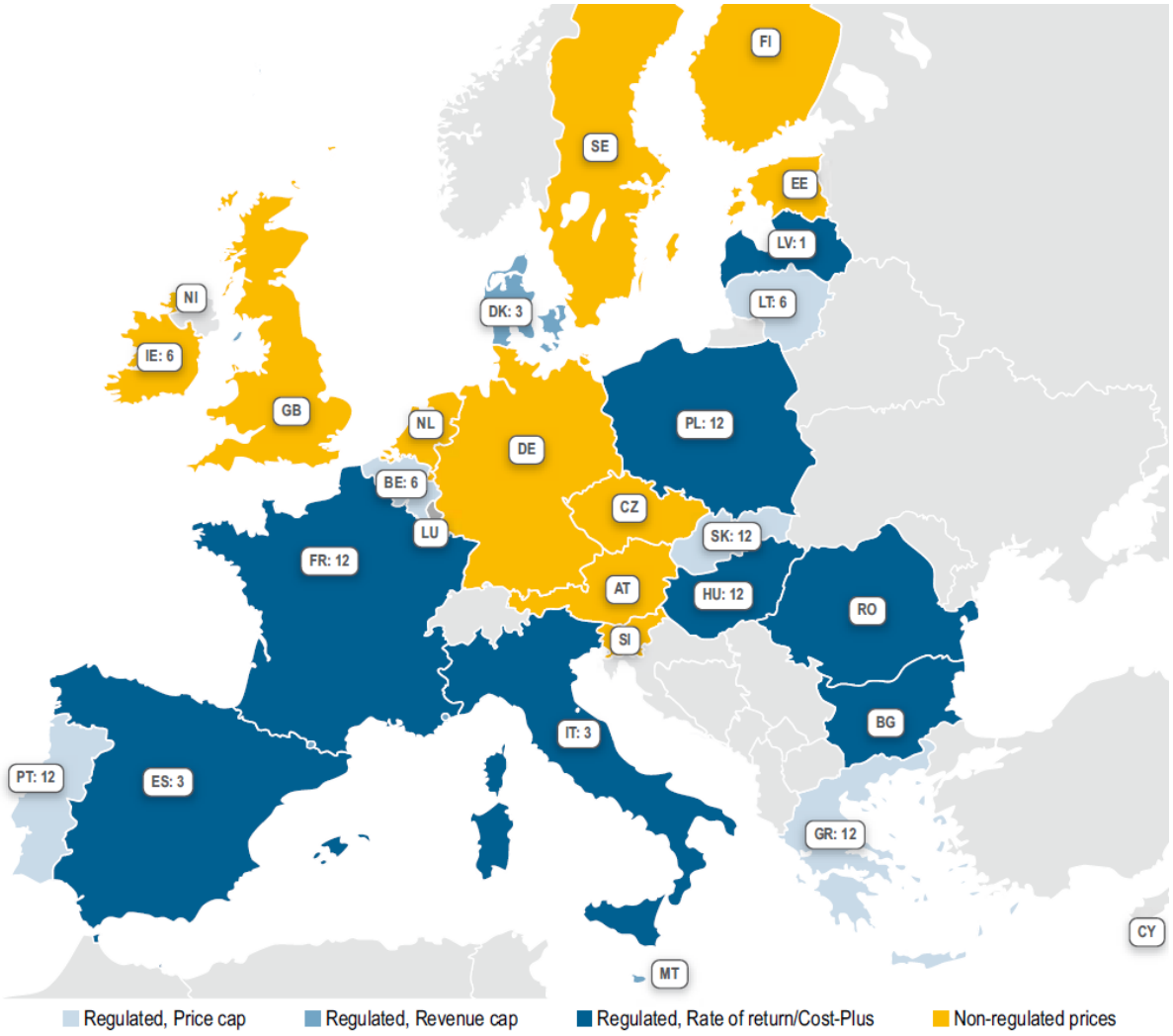
European Regulatory Potpourri



Currently no harmonized regulatory regime in Europe

Transmission system development towards (several) Entry-Exit systems

Cross-border coordination via ENTSOG, but not 'legal' coordination

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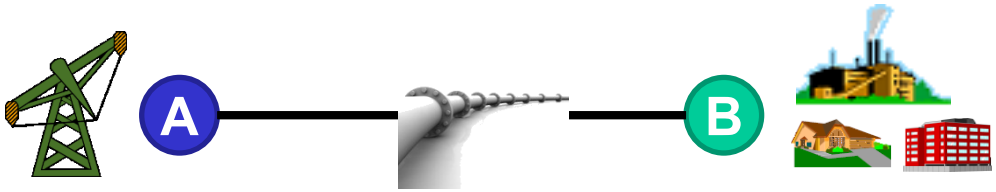
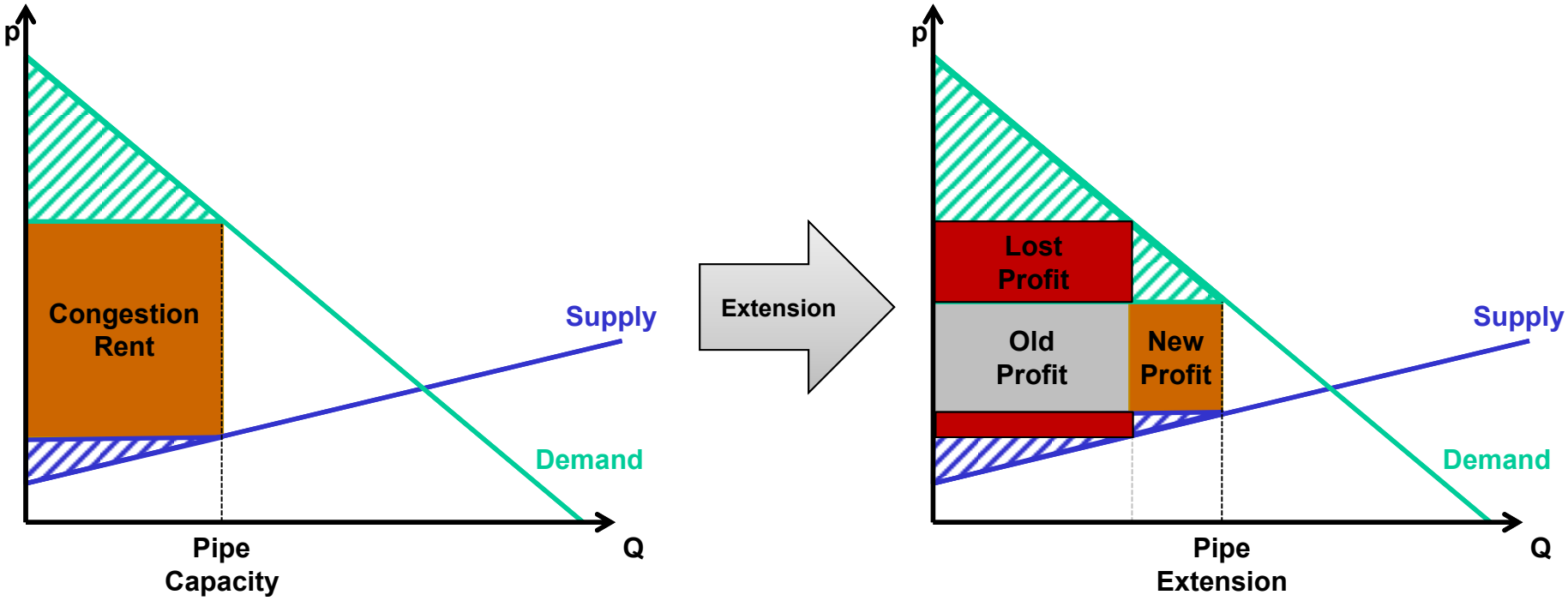
The Basic Problem of Network Extension





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The Two-Part-Tariff Approach

Main Problem: Congestion Revenue insufficient to obtain social optimal investments

→ **Transferring a share of the forgone revenue from consumers/producers to the Transco can provide higher investment incentives**

→ **Vogelsang (2001) proposes the following approach:**

1. The Transco should be allowed to price in a way that capacity is best utilized
2. The Transco should rise enough money to invest

$$\frac{p^t q^w + F^t N^w}{p^{t-1} q^w + F^{t-1} N^w} \leq 1 + i - X$$

p	**transmission price**	q	**transmission output**
F	**fixed fee**	N	**number of consumers**
i	**interest rate**	X	**regulatory X-factor**

→ **Incentive regulation approach with a capacity restriction**

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Transco maximizes Profit subject to Regulatory Constraint

$$\pi = \sum_{n,m,y,s} (P_m - P_n) T^{pipe}_{n,m,y,s} + \sum_{y} F_y - \sum_{n,m,y,s} tc^{pipe}_{n,m} T^{pipe}_{n,m,y,s} - \sum_{n,m,y,s} cinv_{n,m} CAP^{new}_{n,m,y,s}$$

Transco Profit | **Congestion Revenue** | **Fixed Fee** | **Transport Costs** | **Investment Costs**

s.t. regulatory constraint:

Revenue with actual prices and last periods quantities

$$\frac{\sum_{n,m} (P_{m,y,s} - P_{n,y,s} - tc_{n,m}) T^{pipe}_{n,m,y-1,s} + F_y}{\sum_{n,m} (P_{m,y-1,s} - P_{n,y-1,s} - tc_{n,m}) T^{pipe}_{n,m,y-1,s} + F_{y-1}} \leq 1 + RPI - X$$

Congestion revenue last period

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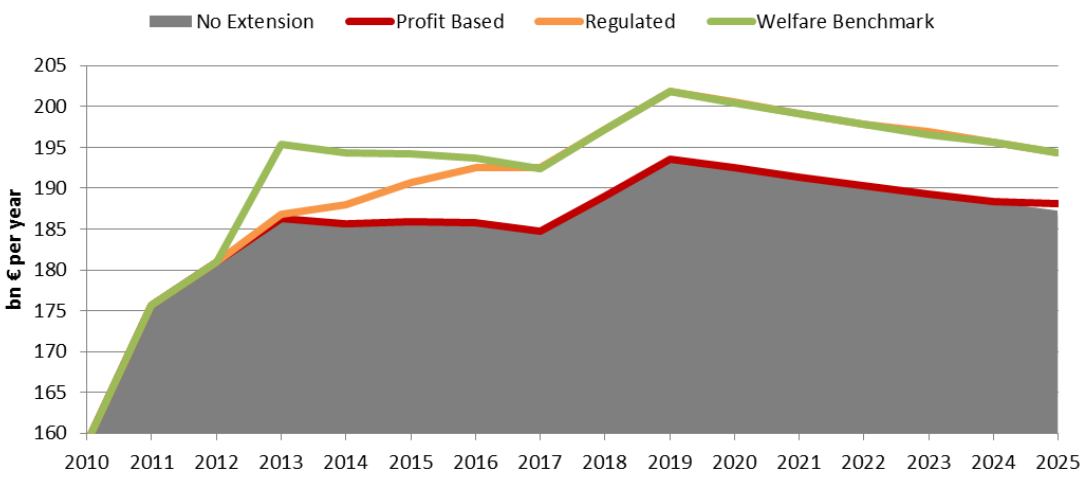
Scenario Overview

1. **Base Case Welfare Properties:**
   - Test the general performance of the reg. approach
   - Provide benchmark results
2. **Regional vs. European Regulation:**
   - Test the performance if regulation is only harmonized in a regional subset of Europe (Central-West EU/Central-East EU)
3. **Impact of Caspian Gas:**
   - Impact of Trans-Adriatic-Pipeline (TAP) on performance and market results
4. **Impact of Global Market Conditions:**
   - Impact of an significant increase in free global LNG capacities and increased LNG import capacity on market

Base Case Performance

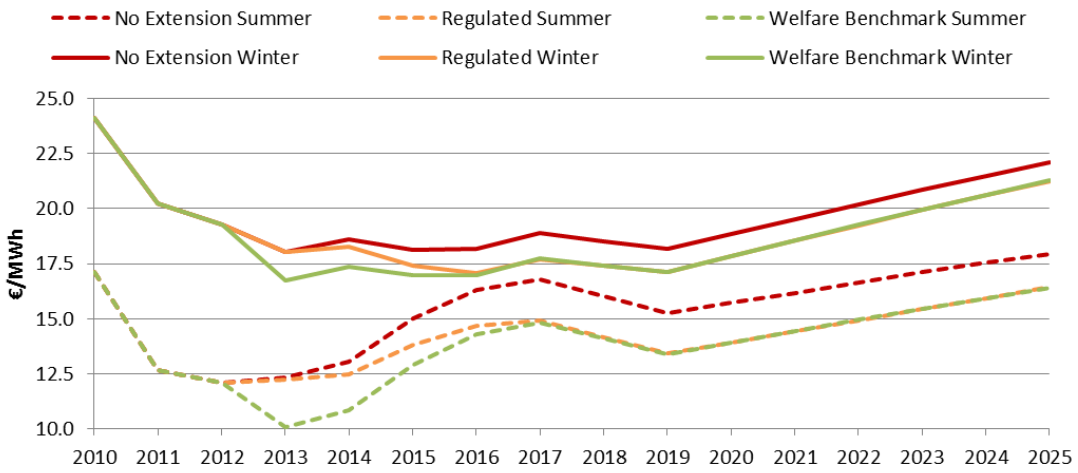


Welfare properties as expected:

- Regulatory Approach approaches welf. optimum
- Unregulated investment provides basically no benefits

Price trends driven by two main influences:

1. Initial congestion (eased by investments)
2. Long term increase due to reduced EU production and assumed demand increase



Regional Extend

Harmonized EU regulation unlikely in short term:

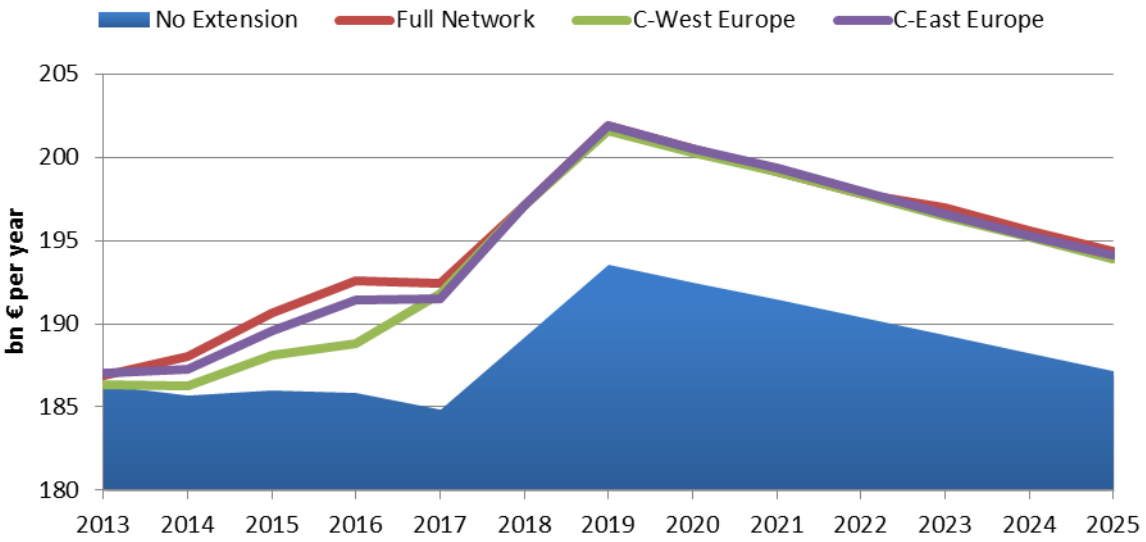
→ **Regional coordination maybe possible**

→ **2 Test Cases:** Coordinated regulatory approach in

1. **Central-West Europe** (Austria, Belgium, France, Germany, Luxemburg, Netherlands)
2. **Central-East Europe** (Czech Republic, Hungary, Poland, Slovakia)

Both cases still provide welfare enhancing investments

→ **Regional coordination a feasible first implementation**



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Import corridors play an important role on needed inner-European network extension:

- → Gas from the Caspian region has been in constant discussion on recent years (Nabucco vs. Southstream vs. TAP)
- → Final decision for one corridor may jeopardize previous investments
- → Tested via a two-stage approach

	Base Case (Regulated)		Caspian Scenario Regulated		Caspian Scenario Welfare Benchmark	
Period	2010-18	2019-25	2010-18	2019-25	2010-18	2019-25
Average Price [€/MWh]	16.3	17.1	16.3	15.8	15.9	15.8
Average Price N-Europe [€/MWh]	15.8	16.6	15.8	15.7	15.4	15.7
Average Price S-Europe [€/MWh]	17.5	18.0	17.5	16.0	16.8	15.9
Consumer Costs [bn per year]	134.0	156.0	134.0	149.8	132.0	149.8
Producer Rent [bn per year]	35.0	35.2	34.7	31.6	33.1	31.5
Congestion Rent [bn per year]	7.3	2.5	7.2	1.3	3.1	1.1
Total Extension [bcm/a]	77.7		95.2		79.4	
Extension NW-Europe [bcm/a]	31.7		25.7		28.0	
Extension NE-Europe [bcm/a]	32.4		34.7		28.6	
Extension S-Europe [bcm/a]	13.7		34.8		22.8	

Change in Global Market Conditions

Similar to external network options the global market developments impact European gas markets:

- → Current Shale Gas development sets LNG capacities free, potential US export may further increase import options
- → Similar setting as in Caspian Case (two-stage approach)

	Base Case (Regulated)		LNG Scenario Regulated		LNG Scenario Welfare Benchmark	
Period	2010-16	2017-25	2010-16	2017-25	2010-16	2017-25
Average Price [€/MWh]	16.4	16.8	16.4	13.8	15.8	13.8
Average Price N-Europe [€/MWh]	15.8	16.4	15.8	13.4	15.3	13.4
Average Price S-Europe [€/MWh]	17.7	17.8	17.7	14.6	16.9	14.7
Consumer Costs [bn per year]	132.2	152.4	132.1	136.5	129.7	136.6
Producer Rent [bn per year]	35.6	34.7	35.5	25.4	33.7	25.3
Congestion Rent [bn per year]	7.1	3.8	7.1	0.9	3.7	0.9
Total Extension [bcm/a]	77.7		96.1		82.0	
Extension NW-Europe [bcm/a]	31.9		36.4		33.4	
Extension NE-Europe [bcm/a]	32.1		38.7		31.3	
Extension S-Europe [bcm/a]	13.7		21.0		17.3	

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Conclusions

- **Proposed regulatory approach suitable to achieve optimal capacity investments while keeping information requirements for regulators low**
- **Approach provides robust welfare properties under varying market conditions**

Policy Insights:

→ **Harmonization** of cross-border investments (basically = Transco regulation) **beneficiary** for optimal investments

→ Current market **uncertainties** don't 'destroy' the incentive approach but will likely lead to sub-optimal investments (that consumers will likely pay for) → adjustment of fixed fee needed

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Transco Model

$$\pi = \sum_{n,m,y,s} (P_m - P_n) T^{pipe}_{n,m,y,s} + \sum_y F_y - \sum_{n,m,y,s} tc^{pipe}_{n,m} T^{pipe}_{n,m,y,s} - \sum_{n,m,y,s} cinv_{n,m} CAP^{new}_{n,m,y,s}$$

$$\frac{\sum_{n,m} (P_{m,y,s} - P_{n,y,s} - tc_{n,m}) T^{pipe}_{n,m,y-1,s} + F_y}{\sum_{n,m} (P_{m,y-1,s} - P_{n,y-1,s} - tc_{n,m}) T^{pipe}_{n,m,y-1,s} + F_{y-1}} \leq 1 + RPI - X$$

Regulatory cap

$$T^{pipe}_{n,m,y,s} \leq cap^{pipe}_{n,m,y} + CAP^{new}_{n,m,y}$$

New pipeline constraint

$$CAP^{new}_{n,m,y} = CAP^{new}_{n,m,y-1} + CAP^{add}_{n,m,y}$$

New capacity balance

Market Model

$$\max_{D,G,T,S} \quad W = \sum_{n,y,s} \int_0^{D^*_{n,y,s}} P(D)\,\mathrm{d}D_{n,y,s} - \sum_{n,y,s} c_{n,y} G_{n,y,s} - \sum_{n,m,y,s} tc^{pipe}_{n,m} T^{pipe}_{n,m,y,s} - \sum_{n,m,y,s} tc^{LNG}_{n,m} T^{LNG}_{n,m,y,s}$$

$G_{n,y,s} \le cap^{prod}_{n,y}$	Production constraint	(1)
$T^{pipe}_{n,m,y,s} \le cap^{pipe}_{n,m,y}$	Pipeline constraint	(2)
$T^{LNG}_{n,m,y,s} \le cap^{LNG}_{n,m,y}$	LNG route constraint	(3)
$\sum_m \frac{1}{\eta^{liq}} T^{LNG}_{n,m,y,s} \le cap^{liq}_{n,y}$	Liquefaction constraint	(4)
$\sum_m \eta^{reg} T^{LNG}_{m,n,y,s} \le cap^{reg}_{n,y}$	Regasification constraint	(5)
$S_{n,y,s} = S_{n,y,s-1} + \eta^{store} S^{in}_{n,y,s} - S^{out}_{n,y,s}$	Storage balance	(6)
$S_{n,y,s} \le cap^{store}_{n,y}$ $S^{in}_{n,y,s} \le cap^{store\_in}_{n,y}$ $S^{out}_{n,y,s} \le S_{n,y,s}$	Storage constraints	(7)
$G_{n,y,s} + S^{out}_{n,y,s} + \sum_m T^{pipe}_{m,n,y,s} + \sum_m T^{LNG}_{m,n,y,s}$ $\ge D_{n,y,s} + S^{in}_{n,y,s} + \sum_m T^{pipe}_{n,m,y,s} + \sum_m T^{LNG}_{n,m,y,s}$	Energy balance	(8)

Welfare Model

$$\max_{D,G,T,S,CAP} \quad W = \sum_{n,y,s} \int_0^{D^*_{n,y,s}} P(D)\,\mathrm{d}D_{n,y,s} - \sum_{n,y,s} c_{n,y} G_{n,y,s}$$
$$- \sum_{n,m,y,s} tc^{pipe}_{n,m} T^{pipe}_{n,m,y,s} - \sum_{n,m,y,s} tc^{LNG}_{n,m} T^{LNG}_{n,m,y,s}$$
$$- \sum_{n,m,y,s} cinv_{n,m} CAP^{new}_{n,m,y,s}$$

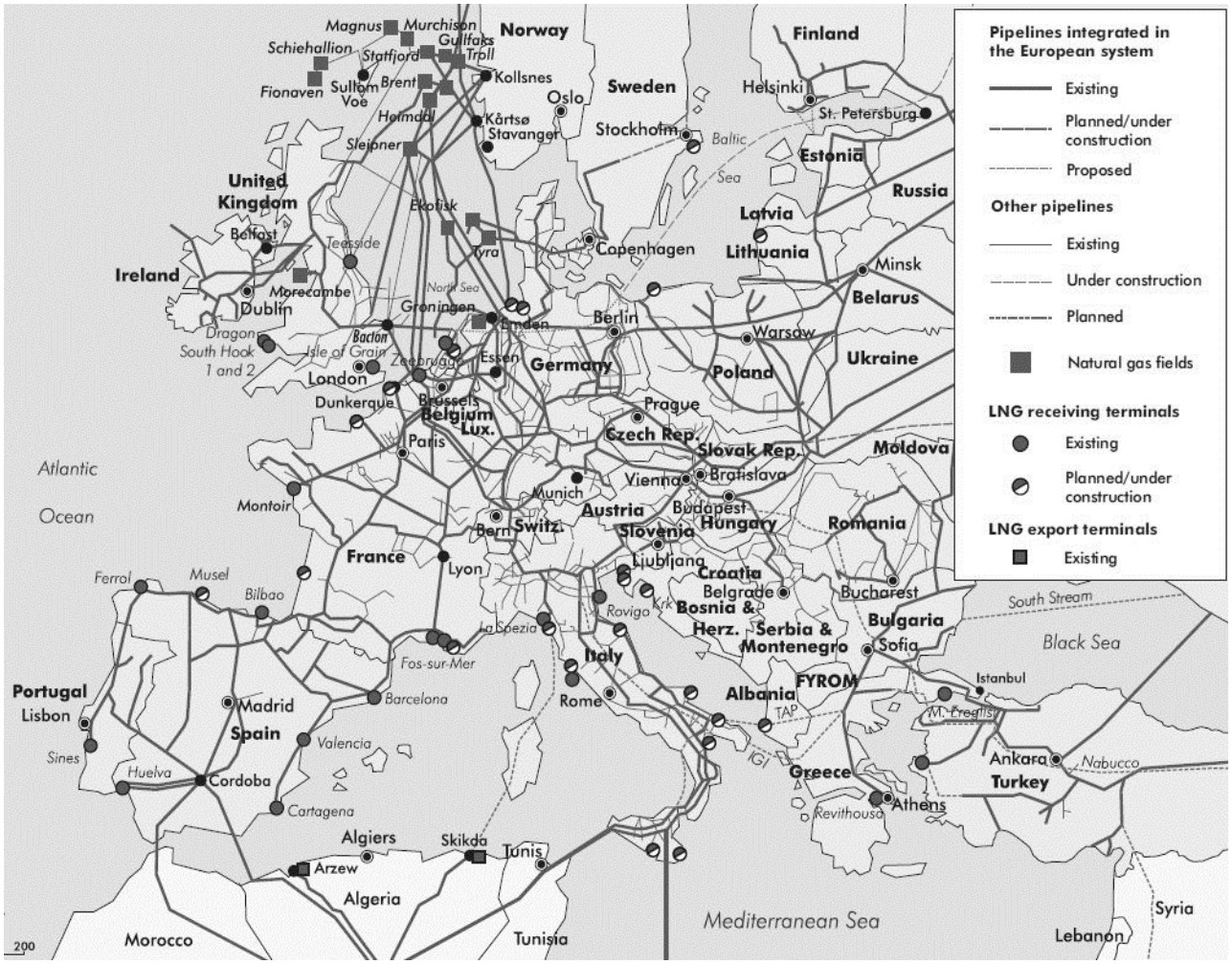
Base Case Results

	No Extension			Profit Based			Regulated			Welfare Benchmark		
Period	10-15	16-20	21-25	10-15	16-20	21-25	10-15	16-20	21-25	10-15	16-20	21-25
Average Price [€/MWh]												
North	13.2	15.3	17.3	12.9	14.1	15.8	13.1	13.9	15.4	12.4	13.4	15.2
North-East	6.4	6.5	6.9	6.4	6.5	6.9	6.4	6.5	6.9	6.4	6.5	6.9
North-West	17.0	17.5	19.4	17.0	17.4	19.3	16.7	16.3	18.3	16.1	16.2	18.3
Central-East	11.8	12.2	13.4	11.8	13.1	14.3	12.0	13.1	16.0	12.7	14.3	16.1
Central-West	17.1	17.3	18.9	17.1	17.2	18.8	16.9	15.8	17.5	16.2	15.7	17.5
South	18.2	18.8	20.6	18.2	18.6	20.4	17.9	16.9	18.5	17.0	16.4	18.3
South-East	18.4	19.9	22.0	18.4	19.7	21.7	17.6	16.6	18.9	17.0	17.1	19.3
Average Costs and Rents [bn per year]												
Consumer Costs	132.7	145.7	165.1	132.7	145.8	165.2	131.7	140.1	161.3	128.9	140.0	161.3
Producer Rent	36.9	36.3	40.8	36.9	35.8	40.2	36.2	31.9	37.0	34.2	31.6	36.9
Congestion Rent	6.6	7.0	8.4	6.6	7.1	8.6	6.9	6.8	1.6	4.2	1.2	1.1
Total Extension [bcm/a]												
North				0.7	0.7	0.1	0.0	2.4	0.3	0.8	1.8	0.1
North-East				0.2	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0
North-West				0.0	0.0	0.0	0.0	1.3	0.0	0.0	1.2	0.0
Central-East				0.0	2.6	4.6	14.2	15.3	2.6	24.6	2.8	2.6
Central-West				0.7	2.4	0.1	9.7	14.0	4.1	22.9	4.5	1.3
South				0.0	0.0	0.0	0.0	0.3	1.3	1.9	0.6	1.3
South-East				0.0	1.3	0.3	2.9	7.9	1.3	6.8	2.9	0.1

Regional Coverage

Period	Full Coverage			Central-West EU			Central-East EU		
	10-15	16-20	21-25	10-15	16-20	21-25	10-15	16-20	21-25
Average Price [€/MWh]	14.4	14.2	15.9	14.5	14.5	16.1	14.4	14.4	16.1
Consumer Costs [bn €/a]	131.7	140.1	161.3	132.3	140.3	160.5	132.0	140.2	161.1
Producer Rent [bn €/a]	36.2	31.9	37.0	36.6	32.1	36.3	36.4	32.0	36.8
Congestion Rent [bn €/a]	6.9	6.8	1.6	6.7	6.9	3.0	6.9	7.1	2.5
Total Extension [bcm/a]	27.0	41.1	9.7	13.5	42.0	3.5	42.6	35.8	15.1

EU Network



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