



GERG

Young Researcher's Prize

Nov 26, 2015



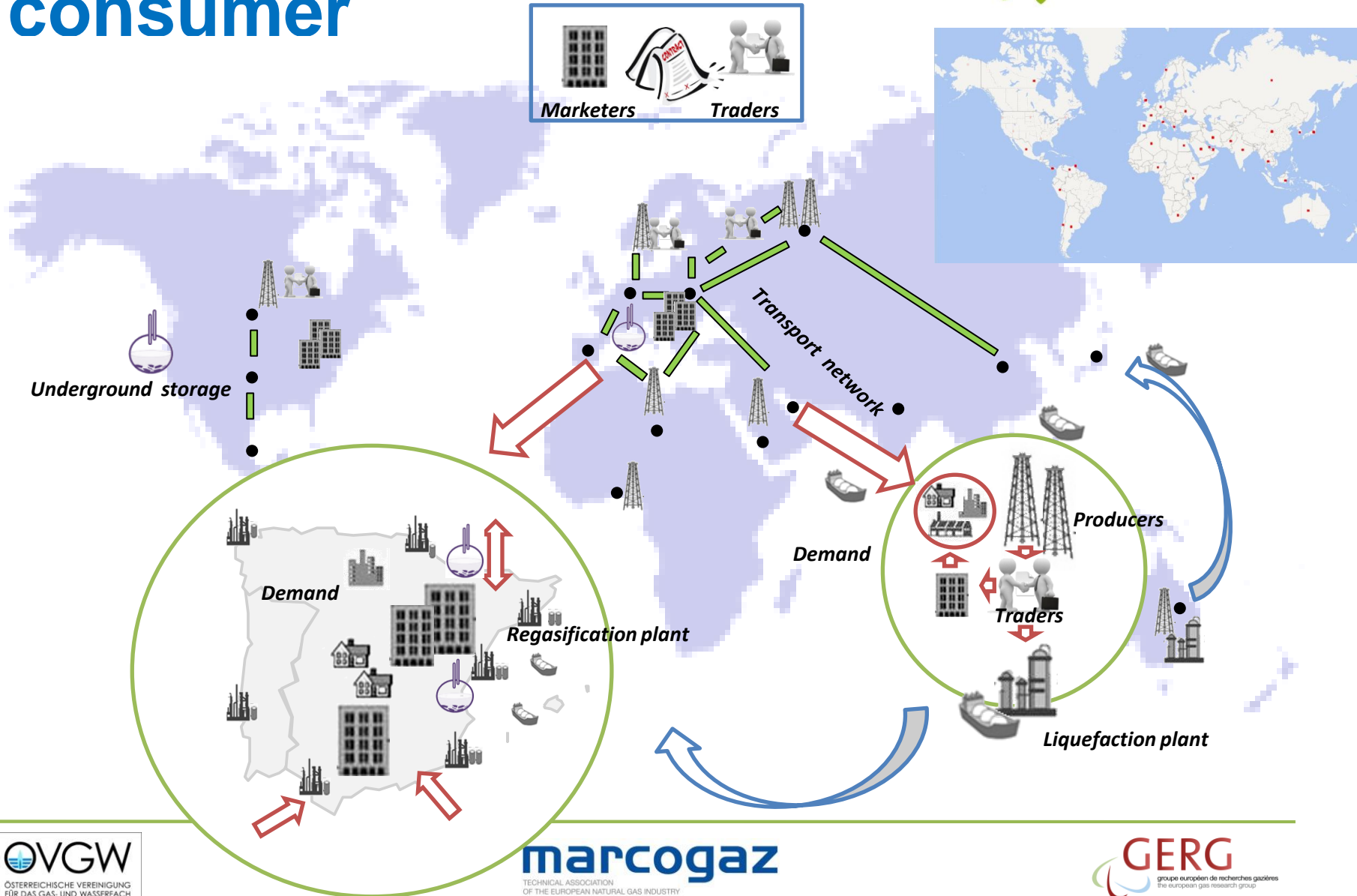
Aurora del Valle

Global gas market simulation model

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From the **well** to the consumer



Optimization model

Modeled as a global **cost minimization optimization problem**
Production cost, Operation cost, Long-Term Contract (LTC)

GAMS

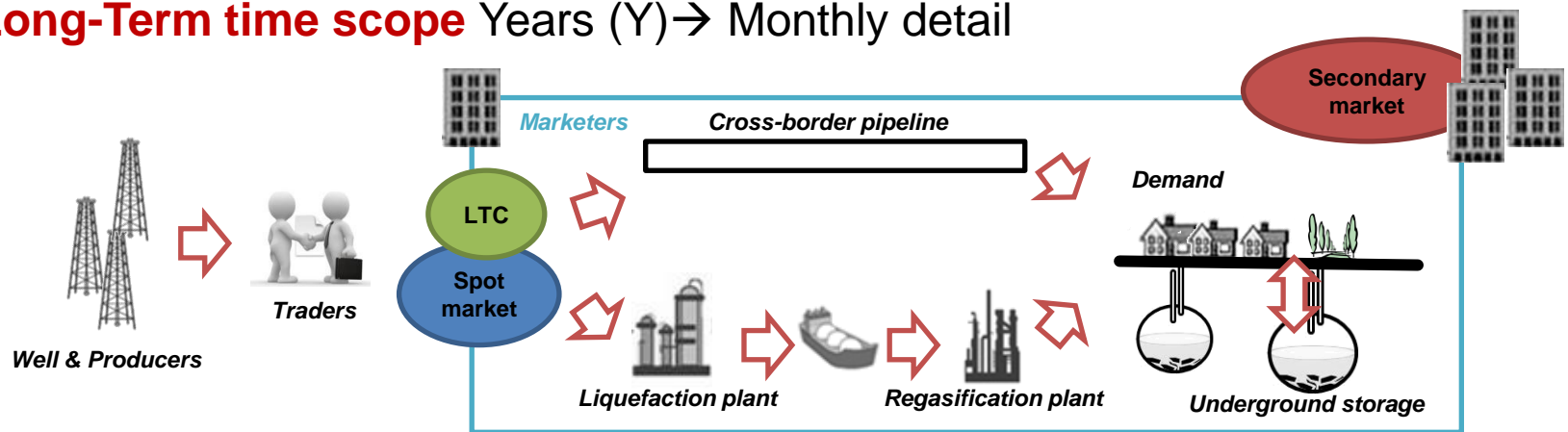
Agents

- Producers
- Traders
- Marketers
- Consumers

Infrastructures

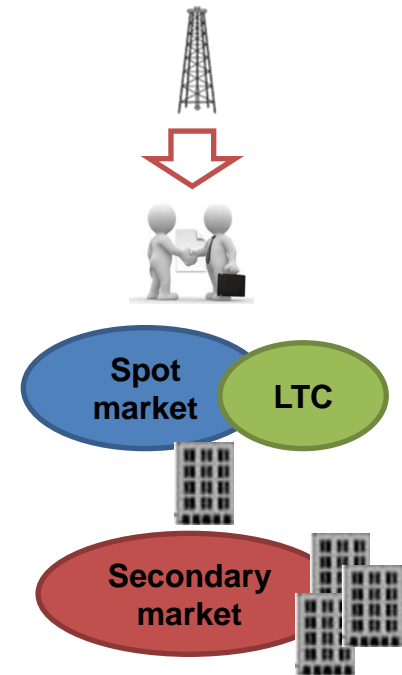
- Well
- Liquefaction plant
- Regasification plant
- Cross-border pipelines
- Underground storage

Mid-Long-Term time scope Years (Y) → Monthly detail



Agents

- **Producer**
 - How much to produce
- **Trader**
 - Dedicated trading companies for each producer
 - Interfaces between producers and marketers
- **Marketer**
 - One marketer per demand area
 - Fixed markup
 - **Long-Term Contracts** (Trader-Marketer)
 - Liquefied Natural Gas (Ex-ship, FOB)
 - Natural Gas
 - **Spot market** (Trader-Marketer)
 - **Secondary market** (Marketer-Marketer)
- **Demand**
 - **Inelastic** demand per country

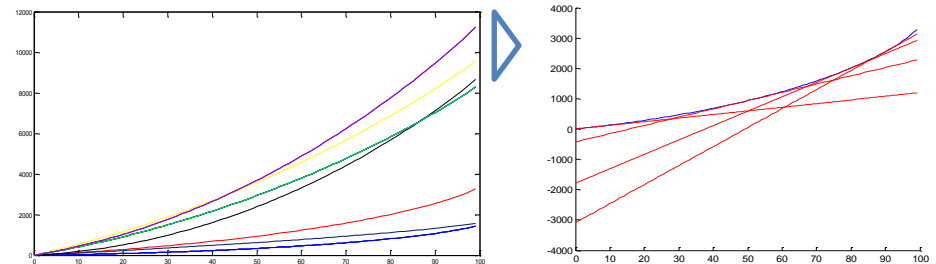


Infrastructure

- **Well**

- **Golombek cost function** (increasing and convex) →
- Bounds in productions rates
- Stocks

Piecewise linear approximation



- **Pipelines**

- Capacity bound on flow

- **Liquefaction plant**

- Bounds in liquefaction rates

- **Regasification plant**

- Bounds in regasification rates and LNG storage capacity
- LNG stocks

- **Underground storage**

- Bounds in injection / extraction rates and NG storage capacity
- NG stocks

Long-Term Contracts (LTCs) vs. Market Pricing

- **Long-Term Contracts (LNG & NG) → (Trader-Marketer)**



Marketers

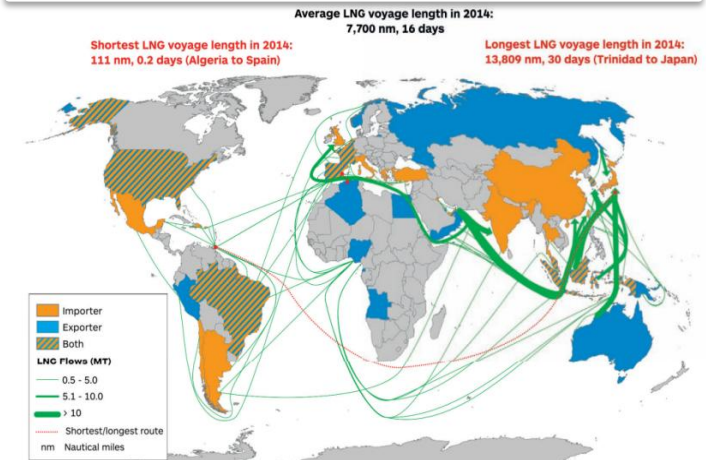


Traders

About half the gas supplied is contracted

- **Formula based:** Negotiated between buyer and seller $P = A * P(\text{Index}) + Cst$
 - Oil indexation pricing vs. Gas market pricing
 - **Oil indexation pricing:** Asia: **JCC** (Japanese crude cocktail); **Southern Europe:** oil products (gasoil or fuel oil) or **Brent** crude oil
 - **Market based:** **Northern Europe:** UK → National Balancing Point (**NBP**), Belgium → Zeebrugge Hub, Netherlands → Title Transfer Facility (**TTF**), **N. America/Caribbean/Mexico** → Henry Hub (**HH**)
- **Take-or-Pay commitments**
- **Ex-ship / FOB** (Possibility to divert)
- **Spot price → (Trader-Marketer)**
 - Market pricing (**HH**), (**NBP**), etc.
 - $P = \text{Market pricing} \pm \text{Freights costs}$
- **Secondary market → (Marketer-Marketer)**
 - Gas cost + Fixed markup

Major LNG Shipping Routes, 2014



Sources: IGU World Report – 2015 Edition I. IHS

Optimization Problem

• Minimize operation costs

Perfectly competitive environment

Gas Index Price

- Exogenous

Balance equations

- Flow conservation constraints

Variables:

q_{pw}^{pro} : Produced gas in the wells

q_{pz}^{liq} : Liquefied gas

q_{pzma}^{reg} : Regasified gas

$q_{pmazz_1}^{irs}$: Flows through pipelines

$q_{pmazz_1}^{shp}$: LNG transport

q_{psma}^{sto} : Gas storage

Price and Flows at each node

q_{pbtma}^{QLNG} : Supplied LNG LTC gas

q_{pstma}^{QNG} : Supplied NG LTC gas

$q_{pbtma}^{SpotLNG}$: LNG gas traded in Spot markets

q_{pstma}^{SpotNG} : NG gas traded in Spot markets

$q_{pbmama_1}^{SpotLNG}$: LNG gas traded in Secondary markets

$q_{psmama_1}^{SpotNG}$: NG gas traded in Secondary markets

$$\begin{aligned} \text{Min}_q \sum_{p,w} C_w^{pro} \cdot q_{pw}^{pro} &+ \sum_{p,z} C_z^{liq} \cdot q_{pz}^{liq} + \sum_{p,z,ma} (C_z^{reg} \cdot q_{pzma}^{reg} + C_z^{regsto} \cdot q_{pzma}^{regsto}) + \sum_{p,ma,z,z_1} C_{zz_1}^{pipe} \cdot q_{pmazz_1}^{pipe} \\ &+ \sum_{p,ma,z,z_1} C_{zz_1}^{shp} \cdot q_{pmazz_1}^{shp} + \sum_{p,z,ma} (C_z^{usto} \cdot q_{pzma}^{usto} + C_z^{isto} \cdot q_{pzma}^{isto} + C_z^{esto} \cdot q_{pzma}^{esto}) \\ &+ \sum_{p,z,t} C_t^{traders} \cdot q_{pzt}^{traders} + \sum_{p,z,ma} C_{ma}^{marketers} \cdot q_{pzma}^{marketers} \end{aligned}$$

Questions?

감사합니다 Natick
Grazie Danke Ευχαριστίες Dalu
Thank You Köszönöm
Спасибо Dank Gracias
谢谢 Merci Seé
TEŞEKKÜR EDERİM
Obrigado