

Natural Gas Game facing Low-carbon Transition

Scenarios on America Gas Exportation Strategies with Agent-based Modelling

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Introduction

Natural Gas is low carbon emission fossil fuel, hence is crucial in Energy Transition Phase. Supply exporters play game to benefit optimally from their gas resources. [1]
After its shale gas boom, America developed aggressively in its Liquefied Natural Gas (LNG) projects and is expected to bring on-line large volumes of gas which may lead to global gas glut. [2]
This work investigates America's future exportation strategies facing the low-carbon transition agenda and the reaction of other exporters towards America's LNG expansion.

Agent-Based Global Natural Gas Model

General description: Multi-period model studying global gas import-export relationships

Agents: Supply agents — Export Regions & Demand agents — Import Markets

Transmission routes: Pipeline & LNG

Structure: Two-modular structure

MEM: single time-period *Market Equilibrium Module* & **IEM:** Future-forward *Infrastructure Expansion Module*

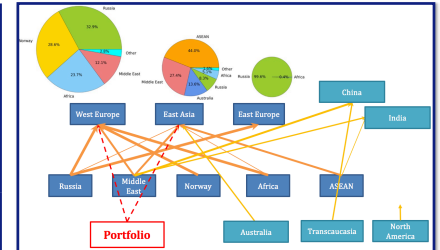


Figure 1: Global Natural Gas Trade

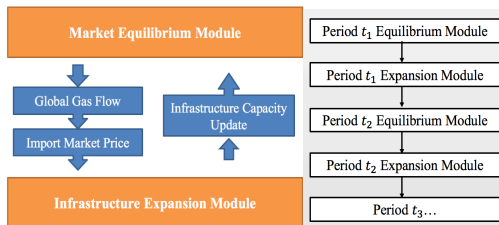


Figure 2: Model Structure and Modular Sequential Flow

Market Equilibrium Module

Supply agent: Each optimizes its own gas sale profit & **Demand agent:** Price-Demand relationship

Method: Mixed Complementarity Problem – Simultaneously optimize all players' objectives

Results: Gas Flow & Price - Game theoretic Nash-Cournot Equilibrium in each time period t

$$\sum_{j \in D} [SAL_{i,j,t}^{PIPE} (\pi_{j,t} - C_{i,t}^{PRD} - C_{i,j,t}^{PIPE} - C_{EX,i,j,t}^{PIPE}) + SAL_{i,j,t}^{LNG} (\pi_{j,t} - C_{i,t}^{PRD} - C_{i,j,t}^{LNG} - C_{EX,i,j,t}^{LNG})]$$

Infrastructure Expansion Module

Demand – Supply Contracting Section: Confirm future contracts on import request and supply economic evaluation.

Contractual Based Expansion Section: Expand to fulfil contract required infrastructure capacities

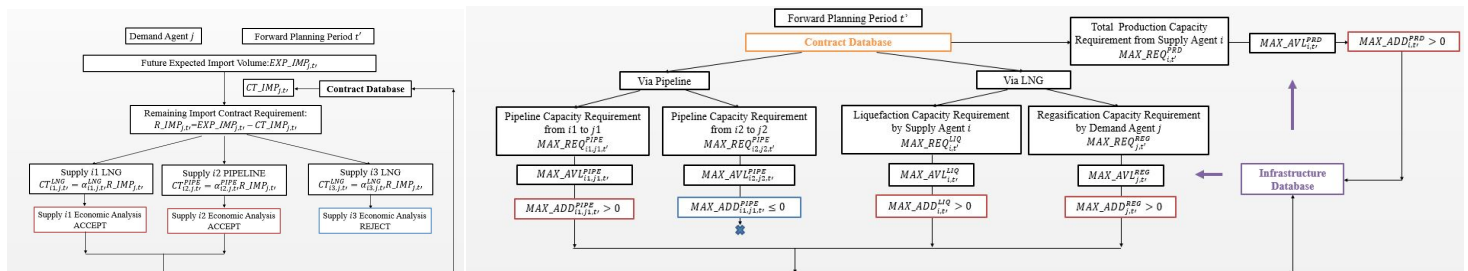
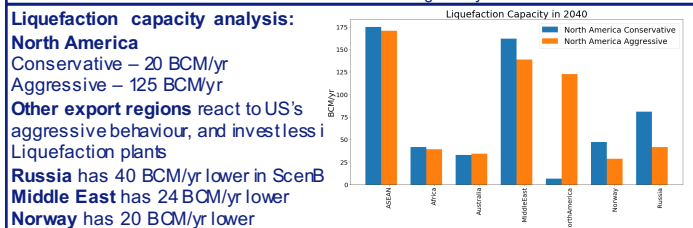
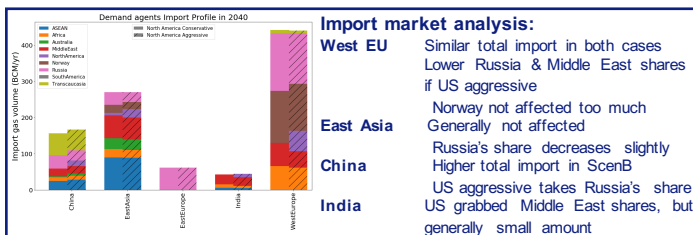


Figure 3: Demand-Supply Contracting Section Algorithm (Left) & Contract-based Capacity Expansion Section Algorithm (Right)

Case Study on America Gas Exportation Strategy

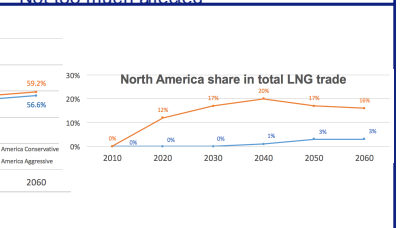
Scenario A: North America stays **Conservative** for contract agreement and capacity expansion

Scenario B: North America **Aggressively** agrees on contract request and expand exportation capacities



Conclusion

1. **Agent-based** model incorporating short-term **Nash-Cournot equilibrium** and long-term **contract-driven expansion**, allowing import and export imperfect foresight and decision **flexibilities**
2. **Russia and Middle East's** shares in West Europe markets would decrease in 2040 if US export LNG aggressively. But **they consider US's strategy and invest less** to control gas oversupply and keep prices at economic levels.
3. Though being aggressive, **America's share** in total LNG trade **peaks in 2040** and then stays steady afterwards.



Reference

- [1] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014. Washington, DC: U.S. Environmental Protection Agency; 2016.
- [2] Key World Energy Statistics. International Energy Agency; 2015.

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